Ship's Ballast Discharge Dispersion Benchmark Dye Tracer Test

Prepared for
Vitamar, LLC
Germantown, Tennessee

File No. 03104
January 2005

THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

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KEVIN J. REYNOLDS
STATE OF WASHINGTON
36584
REGISTERED
PROFESSIONAL ENGINEER

18 Jan 2009

EXPIRES 14 Oct 2006

Kevin J. Reynolds, P.E.
Project Engineer

Paul S. Smith
Principal-in-Charge

THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

1201 Western Avenue, Suite 200, Seattle, Washington 98101-2921 | **TEL** 206.624.7850 | **FAX** 206.682.9117 | **www.**glosten.com

SHIP'S BALLAST DISCHARGE DISPERSION
BENCHMARK DYE TRACER TEST

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EXECUTIVE SUMMARY

A field test was conducted on the *MT Seabulk Arctic* at anchorage in Port Angeles Harbor, Washington State, to measure the near-field dispersion of the vessel's ballast water discharge. Near-field measurements were made radially within 54 feet from the end-of-pipe. Ballast was discharged at typical rates. Weather was calm and current was slow. The temperature of the discharge was higher than the harbor. It is reasonable that if follow-on testing efforts are conducted under similar discharge conditions and similar or rougher environmental conditions, then follow-on testing would expect similar or lower concentrations of ballast water in the discharge plume.

The measured concentrations of dyed ballast water in this near field, as well as general observations of the discharge plume, are intended to allow others to evaluate the environmental soundness of subsequent testing of a ballast water biocide on vessels of similar characteristics. The ballast water biocide test, not part of this study, will target inactivating potential non-indigenous species (NIS) contained within the ballast tanks on the vessel with a biocide such as SeaKleen®. Following inactivation of the NIS, the vessel will discharge the biocide-treated ballast water.

The three analysis methods employed in this effort indicate that at all depths at 54 feet radially from the overboard, concentrations were at most 1:17, 1:18 and 1:20 parts dyed ballast water to parts harbor water (dispersion ratio). Visual observations indicate that dispersion ratios will approach 1:44 at a radial distance of 100 feet from the overboard and continue to disperse until difficult to detect visually at a 250-foot distance. Inside the 54-foot radius, indicated concentrations were variable, probably due to turbulent flows.

These results can be applied with confidence to the *MT Seabulk Arctic* or any of its sister vessels under similar conditions. The below list includes environmental and operating conditions which are normal for a sheltered anchorage and would assure that the ballast concentrations indicated here will not be exceeded. This guidance, provided to support future testing efforts, does not however mean that ballast concentration will be higher, just that we can't predict them with the information in hand.

- Ballast should be discharged through the overboard (a pipe in the vessel side shell) and not the seachest (box shaped opening at the bilge turn). A seachest discharge was not studied.

- Density difference between ballast and harbor water should not be significantly more than test parameters. In the test the ballast water was less dense than the harbor by 0.0006 lb-sec^2/ft^4. A greater density difference could make the ballast plume more cohesive.

- The current vector perpendicular to the vessel's centerline (that is, opposite to the overboard flow) should be low in order to avoid significant local recirculation of discharged ballast. A vessel at anchor will tend to keep its centerline parallel to the current vector. (Note: Visual observations indicated

that a 0.21 knot current did not dominate plume characteristics until nearly 100 feet from the ballast overboard.)

- There should be no obstruction to the discharge for about 500 feet. In other words, discharges into pilings or on the land side of a dock could interfere with the ballast dispersion.

I. OBJECTIVE/OVERVIEW

A field test was conducted on the *MT Seabulk Arctic* at anchorage in Port Angeles Harbor, Washington State, to measure the near-field dispersion of the vessel's ballast water discharge. Near-field measurements were made radially within 54 feet from the end-of-pipe. Ballast was discharged at typical rates. Weather was calm and current was slow. The temperature of the discharge was higher than the harbor. It is reasonable that if follow-on testing efforts are conducted under similar discharge conditions and similar or rougher environmental conditions, then follow-on testing would expect similar or lower concentrations of ballast water in the discharge plume.

The measured concentrations of dyed ballast water in this near-field, as well as general observations of the discharge plume, are intended to allow others to evaluate the environmental soundness of subsequent testing of a ballast water biocide on vessels of similar characteristics. The ballast water biocide test, not part of this study, will target inactivating potential non-indigenous species (NIS) contained within the ballast tanks on the vessel using a biocide such as SeaKleen®. Following inactivation of the NIS, the vessel will discharge the biocide-treated ballast water.

II. PURPOSE

It is recognized that there have been extensive dispersion studies conducted to date. Applicable to near-field dispersion and boundary interactions of ballast water are studies involving waste water discharges from vessels while underway and computer simulation models for pipe discharges. These provide incomplete insight to ballast water discharge dispersion problems. Why, then, was it necessary to conduct full-scale testing?

Within the scope of this report, these results provide:

1) Support for an envisioned ballast water biocide test, not part of this study, on vessels of similar characteristics. Data are provided here that allow pretrial predictions regarding the maximum concentration of the discharged ballast water within 54 feet of the overboard, as well as general predictions of the plume behavior.

Beyond the scope of this report, but valuable for the community, these results provide:

2) Benchmark data and observations that can be used to develop computer simulations of the same event. This model could then be used to introduce additional variables within bounds similar to the field test.

3) Basis for field and model study of significantly different ballast configurations including: below-waterline discharge pipe, seachest discharge, lower flow rates common in container and car carriers, and various hull form characteristics.

4) Basis for comparison with results from various shipboard waste water discharge field tests. Combined with this extensive body of wastewater information, the general understanding of vessel contributions to water quality can be increased.

III. TEST VARIABLES

This section details variables that affect the geometry and concentration characteristics of the ballast water discharge, in both near and far field. Near field is that which is affected by the jet trajectory of the effluent. Far field is that which is affected primarily by ambient environmental conditions. This section does not attempt to differentiate between near- and far-field variables.

Test variables were selected and controlled such that if follow-on testing efforts are conducted under similar discharge conditions and similar or rougher environmental conditions, then follow-on testing would expect similar or lower concentrations of ballast water in the discharge plume, a *worst-case scenario*. In this test we limited the *worst-case* to conditions which did not deviate from standard vessel practice and avoided environmental or waterway conditions that are either atypical or difficult to analyze, such as shallow drafts or pilings in way of the overboard.

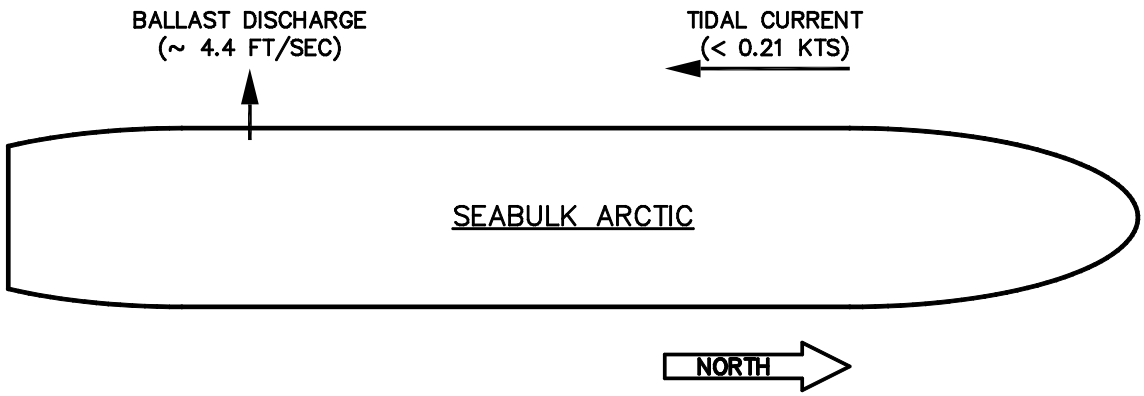
A. Discharge Kinetics

- The relative density of the ballast water to the **harbor** (body of water the ballast is discharged into) influences the tendency of the plume to rise or fall, and maintain itself as a cohesive body. This relationship is affected by temperature and specific gravity (salinity) of the water. It was intended that the test be performed in nearly neutrally buoyant conditions, by means of loading the ballast into the vessel from the harbor just prior to conducting the test. However, the adjacent heated cargo tanks raised the temperature of the ballast water, reducing its relative density. Observations indicate that this reduced dispersion. **Prediction limit**: A greater density difference could make the ballast plume more cohesive, further reducing dispersion.
- Volume flow rate and discharge velocity influence dispersion, determining distance from the hull in which jet properties will dominate. These two variables work together and are interdependent. The vessel discharged through its pumps and overboard at a maximum 'normal' flow rate (7,365 barrels/hour, 4.4 feet/second at the pipe) in order to decrease the time required for the ballast to reach the 54-foot radial measurement distance. **Prediction limits**: Rates should not be significantly higher than those studied. Ballast should be discharged through the overboard (a pipe in the vessel side shell) and not the seachest (box shaped opening at the bilge turn). A seachest discharge was not studied.

B. Environmental Conditions

- Current speed and direction can influence a plume by entrainment in the direction of the current. The figure below shows the current and discharge

vectors during the test. Visual observations indicated that a 0.21 knot current did not dominate plume characteristics until nearly 100 feet from the ballast overboard. Greater currents while the vessel is at anchor could cause the plume and its dispersion pattern to shift downstream. **Prediction limit**: A docked vessel could have a current vector perpendicular to the vessel's centerline (that is, opposite to the overboard flow), possibly causing local recirculation of discharged ballast and limiting dispersion.



Current and Discharge Vectors

- Wind/wave force and direction can disperse a plume which reaches the surface of the harbor. Testing conditions ranged from dead calm to 9 knots of wind, flat to light ripples of waves. These are very calm conditions for Puget Sound, and did little to disperse a plume, allowing study of a near to worst-case condition. **Prediction limit**: none.
- Vessel relative heading will influence plume shape if allowed to interfere with the vessel hull. It is possible that wind and a large vessel sail area could push a vessel broadly against a light current. In this case the plume could be driven against the vessel hull. This was the case in this test, allowing study of a near to worst-case scenario with the vessel hull following the plume.

C. Vessel and Load Configuration

- Overboard configuration and orientation can influence the direction of the plume, and determine the discharge kinetics. The discharge conducted was typical for this vessel, above the waterline. **Prediction limit**: Ballast should be discharged through the overboard and not the seachest, as a seachest discharge was not studied.

- Vessel draft at discharge will affect whether the discharge is above the waterline, or whether the plume will reach the surface of the harbor. The discharge for this vessel was above the waterline by approximately six feet throughout the test effort. The vessel was at near maximum draft for this test. A lighter draft, with a higher overboard position relative to the harbor, would increase the energy of the falling ballast water, likely increasing the

immediate dispersion taking place on contact with the harbor. **Prediction limit**: none.

D. Waterway Geometry

- Depth and width of the waterway and obstructions may be affected by the plume, causing changes to the dispersion. A narrow width may cause the plume to concentrate if it recirculates back toward the overboard. The plume could be broken up by pilings. To define the baseline variables, the testing was conducted in an open waterway of adequate depth (108 feet) and surrounding free distance. **Prediction limit**: A docked vessel could have a current vector perpendicular to the vessel's centerline, opposite to the overboard flow, possibly causing local recirculation of discharged ballast and limiting dispersion.
- Tidal recirculation can recirculate a plume back to the overboard location. In this way the discharging ballast enters into harbor water with a background concentration of ballast from previously discharged ballast which recirculated with the harbor water. The test was conducted under conditions relatively close to the "worst case" scenario of slack water. Additionally, to define the baseline variables, the testing duration was short enough to lower the significance of this recirculation effect. **Prediction limit**: The test discharge duration was 4 hours, in which time the plume did mature with some recirculation noted. It is possible that a significantly longer test could result in more recirculation and higher ballast concentrations in the discharge plume.

IV. EVENT LOG/TEST PROTOCOL /CONDITIONS

The Event Log and Test Protocol are included in Appendix A and Appendix B respectively. The field test effort followed the protocol closely, with particulars as detailed in the event log. Dosing of the tanks went smoothly, with an adjustment of concentration within the first 30 minutes to match the desired concentration of 160 ug/L of rhodamine. Ballast discharge resulted in gaining two sets of discharge data. However, a launch (40 foot power boat) ran through and idled in our discharge plume halfway through the first data set. The plume did visually reset, allowing that data set to be completed, and most of a second data set to be gained.

Throughout the test environmental conditions were relatively calm. Wind conditions were never more than 9 knots. The vessel swung on its anchor keeping the slow current, never more than 0.21 knots, to the vessel's bow. This was observed to have little effect on the plume within the measured 54 feet from the overboard. Beyond 54 feet, the current swept the plume towards the vessel stern and away.

V. DATA, OBSERVATIONS AND ANALYSIS

The data and observations collected in the field test and analyzed here support the objective of this test: Measure the near-field dispersion of the vessel's ballast water discharge. Near-field measurements were made radially within 54 feet from the end-

of-pipe. In addition, video and still photos were taken throughout the event to support visual observations.

The term used in this report to characterize the dispersion of the ballast water is ***dispersion ratio***, which equals ***(parts of dyed ballast water) : (parts of harbor water)***. For example a ratio of 1:10 indicates that one ton of ballast water is dispersed in ten tons of harbor water. It could also be said that there is ten percent (10%) concentration ballast water at the measurement point.

Detailed data and analysis are provided in Appendix A. This section provides a general summary of each.

A. Start Concentration:

Dye was metered into the ballast tanks during a ballast uptake event. Appendix A provides a predicted dye concentration in the tanks based on this metering. This was compared to actual measurements of the dyed water in the ballast tanks. A conservative approach indicates an initial concentration of 146 ug/L of rhodamine WT dye. This approach takes the average tank reading rather than the tank reading corresponding to the highest plume concentration reading. For example, a conservative dispersion ratio of 1:15 would read 1:16 if the higher start concentration of 157 ug/L was used.

B. Visual Observations

Photographs and video documented visual observations of the discharge plume. Appendix A provides a key plan of photos, each of which highlights a specific characteristic of the plume. Key observations include:

- Within the 54-foot radial transect line there is significant turbulence in the plume, which may be the cause for variances in collected data. The dye appeared to separate into channels in the harbor water as it moved away from the discharge. This finger effect was perhaps induced by the pipe bend just prior to the overboard.

- Observed color and intensity are greatest just outside the turbulent area, on 54-foot radial transect line at the +1 and +2 positions. This observation indicates that measured readings at these positions are maximums within the plume.

- Observed color and intensity decrease gradually from the 54-foot to the 100-foot lines, with maximums similar to the 54-foot -1, -2 and -3 positions. This observation indicates that readings near the 100-foot line are less than those at the 54-foot -1, -2 and -3 positions, corresponding to measured readings giving dispersion ratios of 1:44.

- Beyond the 100-foot line, color and intensity are significantly decreased, and current moves the plume downstream. This indicates these readings were

greater than 1:44, (for example 1:45 and more). Beyond 250 feet, color and intensity become difficult to detect.

C. Field Data Visual Analysis

Measured dye concentrations in the ballast plume were hand logged to correspond with radial transect positions, depths and time. These transects were effectively five tight nets bounded by the hull forward and aft of the overboard, nearly to the waterway bottom up through two feet from the surface. **The highest concentration measured in this net indicates a minimum dispersion ratio of 1:20.**

These readings were entered into a visual analysis tool allowing ready identification of high concentration areas. This process is detailed in Appendix A. Both runs one and two indicate the highest concentrations in the +1 and +2 positions nearest the harbor surface, matching visual observations. It is notable that these positions are upstream of the current flow, indicating that near-field jet trajectory is the principle dispersion motive within the measured 54 feet. The asymmetrical dispersion pattern running counter to harbor current may be due to a ninety degree bend in the pipe just prior to the overboard, imparting rotation in the jet trajectory.

The visual analysis indicates the highest concentrations at two feet of harbor depth. The field test did not take hand logged readings at depths to the harbor surface. The effort to extrapolate data to the surface is detailed in the Surface Extrapolation section. It is likely that this concentration at the surface was due to a combination of the temperature of the discharged ballast water being three degrees Fahrenheit higher than the harbor, and the visual observation of the ballast appearing to partially deflect off the surface of the harbor water (almost as if a bucket of water was poured on concrete).

The mass concentrations over area for the various radial transects do not balance. The total mass at the 54-foot transects is significantly more than that of the inner transects. The total masses measured for run one indicates a trend of about a third more mass with each radial transect. The trend of this missing mass may be a result of increasing difficulty in measuring dye concentrations with increasing turbulence as the overboard is approached. Another consideration may be a need for an even tighter grid closer to the discharge to detect smaller higher dye concentration areas closest to the discharge. Considerations of boundary layers near the surface have been previously discussed.

D. Surface Extrapolation

As indicated in the field data visual analysis section, an effort was made to extrapolate measured readings from 70 through 2 feet of harbor depth, up to the harbor surface. This effort is detailed in Appendix A.

It is important to note that complex boundary interactions can not be accounted for by extrapolating data. Visual observations indicate turbulence inside the 54-foot radial transect data. This lessens confidence that accurate extrapolations can be made in

these areas. Significantly reduced turbulence and a strong trend line through data points indicate accuracy of the extrapolations at the 54-foot radial transects.

Extrapolations were performed in locations of highest concentration readings. **The highest concentration measured at this point indicates a minimum dispersion ratio of 1:18.**

E. Data Logger Maximum Value

A field test limitation was not having an automatic logger which correlated geographic and depth positions to dye concentrations. This required the use of a hand log to connect this data to space. The fluorometric probe used (detailed in Appendix B) in the hand logging exercise was, however, set-up to automatically record dye concentration, temperature, conductivity and time every ten seconds. This resulted in 1,031 readings over 205 minutes. **The highest concentration measured in this net indicates a minimum dispersion ratio of 1:17.**

VI. RESULTS/APPLICATION

The three analysis methods employed in this effort indicate that at all depths at 54 feet radially from the overboard, concentrations were at most 1:17, 1:18 and 1:20 parts dyed ballast water to parts harbor water (dispersion ratio). Visual observations indicate that dispersion ratios will approach 1:44 at a radial distance of 100 feet from the overboard and continue to disperse until difficult to detect visually at a 250 foot distance. Inside the 54-foot radius, indicated concentrations were variable, probably due to turbulent flows.

Results Summary

Method/Description	Radial Distance (feet)	Dispersion Ratio
Visual Observations	100	1:44
	100 to 250	> 1:44
	250 plus	>> 1:44
Visual Analysis	14 to 54	not known
	54 plus	1:20
Surface Extrapolations	14 to 54	not known
	54 plus	1:18
Data Logger	14 to 54	1:17

These results can be applied with confidence to the *MT Seabulk Arctic* or any of its sister vessels under similar conditions. The below list includes environmental and operating conditions which are normal for a sheltered anchorage and would assure that the ballast concentrations indicated here will not be exceeded. This guidance, provided to support future testing efforts, does not, however, mean that ballast

concentration will be higher, just that we can't predict them with the information in hand.

- Ballast should be discharged through the overboard (a pipe in the vessel side shell) and not the seachest (box shaped opening at the bilge turn). A seachest discharge was not studied.

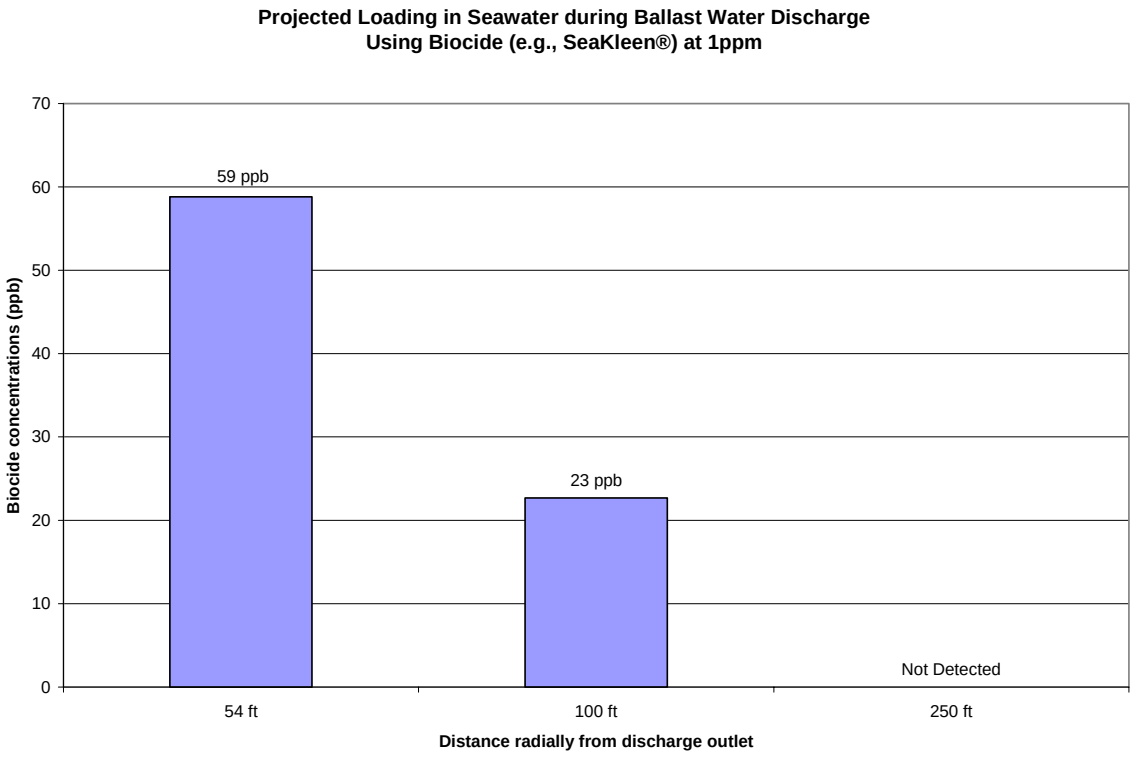
- Density difference between ballast and harbor water should not be significantly more than test parameters. In the test the ballast water was less dense than the harbor by 0.0006 lb-sec^2/ft^4. A greater density difference could make the ballast plume more cohesive.

- The current vector perpendicular to the vessel's centerline, opposite to the overboard flow should be low in order to avoid significant local recirculation of discharged ballast. A vessel at anchor will tend to keep its centerline parallel to the current vector. (Note: Visual observations indicated that a 0.21 knot current did not dominate plume characteristics until nearly 100 feet from the ballast overboard.)

- There should be no obstruction to the discharge for about 500 feet. In other words, discharges into pilings or on the land side of a dock could interfere with the ballast dispersion.

VII. PROJECTIONS

Assuming that the biocide is evenly dispersed throughout the tank at discharge, and assuming that the addition of the biocide to the ballast water does not significantly alter its specific gravity, it is possible to project worst case dispersal concentrations of a biocide like SeaKleen® for a known initial concentration based on the dispersion ratios calculated and observed in this test. The figure below shows the results for an initial concentration of 1ppm, using the conservative figure of 1:17 from the data logger at 54 feet and 1:44 from visual observation for 100 feet. Inside the 54-foot radius, concentrations are likely to vary considerably as they did with the dye dispersion test.



The discharged, dye-laden ballast water in this study remained close to the surface of the water, and it is reasonable to assume that biocide-laden ballast water, with a lower relative density compared to the harbor water and released under similar conditions, would also remain close to the surface of the water. Ballast water at the surface will have a greater exposure to UV radiation; other studies have indicated photo decay properties of the SeaKleen® biocide. It is outside the scope of this report to draw conclusions as to the rate of SeaKleen® breakdown, except to say that it would likely be increased by the ballast water remaining at the surface.

VIII. APPENDICES

Appendix A – Testing Data and Results

1. Event Log
2. Start Concentration
3. Visual Observations
4. Visual Analysis
5. Surface Extrapolation
6. Data Logger Maximum Value

Appendix B – Test Protocol

Appendix C – Environmental Regulations

1. General Description
2. Letter from Randall Marshall, WET Coordinator, Dept. of Ecology to Kevin Reynolds, The Glosten Associates, dated March 2, 2004
3. Letter from Randall Marshall, WET Coordinator, Dept. of Ecology to Kevin Reynolds, The Glosten Associates, dated June 28, 2004
4. Email from Randall Marshall, WET Coordinator, Dept. of Ecology to Kevin Reynolds, The Glosten Associates, dated September 17, 2004
5. Dye Test Particulars (15 September 2004 Revision)
6. Letter from D. Ellis, United States Coast Guard, dated June 7, 2004
7. Email from Joan Cabreza, EPA Region 10 to Mac McCarthy, The Glosten Associates, dated June 8, 2004

Appendix D – Source Data, *Available Upon Request*

1. Event Hand Log
2. Protocol Datasheets Hand Log
3. Zero and Offset Correction Tables
4. Auto Logger Data Sets

Appendix A – Testing Data and Results

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1. Event Log
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Appendix A1 – Event Log, 11 October 2004

- Staging and Setup:
  - Prior weeks. Gear prepared for deployment.
  - 0100 (24 hour time = 1 am). Gear and personnel collected by launch.
  - 0230. All aboard MT Seabulk Pride. Meeting with Chief Mate.
  - 0400. Discharge sampling test run complete. Crew on board for rest.
  - 0400. Dye dosing equipment set-up complete. Ready to take ballast on board.
- Ballast uptake:
  - 0430. Ballast pump recirculating between seachest and overboard. Dye dosing begins in order to flush lines and gain steady state dye concentration in ballast water.
  - 0449. Begin filling ballast tanks 4P and 4S (port and starboard) by opening their root valves, and closing the overboard. Dye dosing continues in steady state.
  - 0517. Ballast tank 4P – 2822 bbl (barrels), 4S – 2240 bbl
  - 0544. Ballast tank 4P – 5155 bbl, 4S – 4490 bbl
  - 0712. Complete filling 4P and 4S, switch discharge to 2P and 2S. This allows flushing of dosing and ballast lines to ensure clean water to discharge upon discharging 4P and 4S.
  - 0718. Final level in ballast tank 4P – 12350 bbl, 4S – 12350 bbl.
  - 0800. Flushing of ballast lines and dosing lines complete. Dosing gear secured and cleanup commence.
- Discharge discharge:
  - 0800. Begin discharge of 0 ppb, setting of discharge pattern
  - 0826. Discharge now at 152 ppb, setting of dye pattern
  - 0826 through 0850 average rate 8,000 barrels per hour (bph)
  - 0844 through 0909 Arctic 01:50 Readings (First Run at 54 foot radial transect)
  - 0850 through 0930 average rate 7,365 bph
  - 0914 through 0933 Arctic 01:35 Readings
  - 0930 through 1020 average rate 6,852 bph
  - 0935 through 0945 Arctic 01:25 Readings (partial only, positions +4, +3, +2, +1, 0, -1)
  - 0950. Plume Disturbed by Launch vessel

- 1013 through 1015 Arctic 01:25 Readings (partial only, position -2) NOT VALID AS PER LAUNCH
- 1017 through 1047 Arctic 01:20 Readings NOT VALID AS PER LAUNCH
- 1020. Launch leaves, Plume is still disturbed
- 1020 through 1120 average rate 6,060 bph
- 1050. 30 Minutes after launch departure, PLUME IS RESET AS PER VISUAL
- 1051 through 1104 Arctic 01:15 Readings
- 1107 through 1118 Arctic 01:10 Readings
- 1120 through 1145 average rate 5,736 bph
- 1126 through 1132 Arctic 02:10 Readings
- 1134 through 1138 Arctic 02:15 Readings
- 1138 through 1145 Arctic 02:20 Readings
- 1145 through 1200 average rate 5,920 bph
- 1146 through 1151 Arctic 02:25 Readings
- 1152 through 1158 Arctic 02:35 Readings
- 1200 through 1211 Arctic 02:50 Partial Readings (+4, +3, +2, +1, 0, -1) prior to tank stripping
- 1210 through 1218 stripping tanks and completed discharge
- 1212 through 1215 Arctic 02:50 Partial Readings (-2, -3, -4) NOT VALID AS STEADY STATE ON DISCHARGE NOT MAINTAINED

- Environmental Log
  - 0826. Vessel position 48° 07.915' N x 123° 24.737' W. Heading 354°. Current visual observance at 0.07 knots from North. Wind 9 knots, 300°.
  - 0910. Vessel position 48° 07.917' N x 123° 24.758' W. Heading 003°. Wind 7 knots, 305°.
  - 1029. Vessel position 48° 08.015' N x 123° 24.882' W. Heading 89°. Wind none. **Note: vessel swing on anchor was about 900 feet over 80 minutes as heading shifted with current.**
  - 1140. Vessel position 48° 08.026' N x 123° 24.876' W. Heading 96°. Current visual observance at 0.20 knots from West. Wind 2 knots, 350°.
  - 1220. Vessel position 48° 08.023' N x 123° 24.858' W. Heading 94°. Wind 2 knots, 310°.

- 1223 through 1251. Set drogue to measure current, start position 48° 08.054' N x 123° 24.677' W, stop position 48° 08.051' N x 123° 24.532' W. Calculated current as 0.21 knots, from West.

- Demobilization:
  - 1218. Ballast discharge operations secured.
  - 1240. Launch along side to begin transfer of gear and personnel.

Appendix A2 – Start Concentration

The first data sheet indicates a series of dilution steps to create a standard for calibrating the meter, then for determining the concentration of a second dye lot to be used during the testing.

The second data sheet first predicts what the ballast dye concentration would be based on the total amount of dye concentrate added to the ballast tank and the concentration determined in the first data sheet. This projected concentration is gained by comparing to the total volume of water added to the ballast tanks upon uptake.

The second data sheet also indicates the measured dye concentrations in the ballast tank at various times through the test. Based on the highest readings in the discharge plume being near 0900, it is most likely that the ballast being discharged was higher than the average calculated in this section. As such, it was determined to be conservative to use the average in determining ballast dispersion ratios.

STEP 1, MAKE RHODAMINE WT 100 AND 200 ug/L STANDARDS
STEP 2, CALIBRATION YSI 6130 FLUROMETRIC PROBE

METER CALIBRATION

Date/Signature	Test Performed	Notes
KJR 9 / OCT 2004	Serial Dilution	From known 5% rodamine WT solution
	Concentrations	0, 100, 200 ug/L rhodamine WT
KJR 9 / OCT 2004	3 Point Rhodamine WT	0, 100, 200 ug/L rhodamine WT
	2 Point Conductivity	0, 10,000 microsiemens standard

STEP 3, DETERMINE DYE LOT CONCENTRATION

-performed serial dilution as detailed below
-used YSI 6130 flurometric probe to measure Second Dilution, Result (86.2 ug/L)
-calculation to determine to determine First Dilution, Concentrate (0.695%)

DYE INITIAL CONCENTRATION TEST

Dilution Step	Concentrate				Diluent		Result		
	mL	%	uG/L	Sp.Gr	mL	Sp.Gr.	mL	Sp.Gr.	uG/L
First Dilution	5	**0.695**	6.98E+06	1.005	1000	1.000	1005	3.48E+04	1.000
Second Dilution	2.5	-	3.48E+04	1.000	1000	1.000	1002.5	**8.67E+01**	1.000

Notes:

Performed at UW Fisheries Lab, 9 October 2004, Jake Perrins, Kevin Reynolds.

Calculations based on Wilson, J. F., Jr. Fluorometric Procedures for Dye Tracing, Techniques for Water Resources Investigations of the U.S. Geological Survey, Book 3, Applications of Hydraulics, Chapter A12: VIII, U.S. Government Printing Office, Washington, D.C. (1968).

Dosing Pump Log/Calculations

Target Concentration uG/L **1.80E+02**

Time		Remaining		Added			Total		Dosing				
			Conc	Water	Dye				Rate	time	micrograms dye		
Clock	Min	Gal	ug/L	Gal	Gal	ug/L	Gal	ug/L	gal/hr	min	Waste	Tank	Note
4:08	0	0.00	0.00E+00	5.00	0.00	6.95E+06	5.00	0.00E+00	20	15	0.00E+00		Ballast to Overboard
4:23	15	0.00	0.00E+00	10.00	5.00	6.95E+06	15.00	2.32E+06	20	2	5.85E+06		
4:25	17	14.33	2.32E+06	5.00	2.50	6.95E+06	21.83	2.32E+06	20	24	7.01E+07		
4:49	41	13.83	2.32E+06				13.83	2.32E+06	20	7		2.05E+07	Ballast to 4P and 4S
4:56	48	11.50	2.32E+06	5.00	2.50	6.95E+06	19.00	2.32E+06	20	27		7.89E+07	
5:23	75	10.00	2.32E+06	3.67	5.00	6.95E+06	18.67	3.10E+06	20	23		9.00E+07	
5:46	98	11.00	3.10E+06	5.00	5.00	6.95E+06	21.00	3.28E+06	20	32		1.32E+08	
6:18	130	10.34	3.28E+06	2.50	2.50	6.95E+06	15.34	3.34E+06	20	25		1.05E+08	
6:43	155	7.00	3.34E+06	2.50	2.50	6.95E+06	12.00	3.40E+06	20	29		1.24E+08	
7:12	184	2.34	3.40E+06				2.34	3.40E+06	20	3	1.29E+07		Ballast to 2P and 2S
7:15	187	1.34	3.40E+06	14.00			15.34	2.96E+05	20	45	1.68E+07		Flushing
8:00	232	0.34	3.40E+06						20				End Operations
									Totals		**1.06E+08**	**5.52E+08**	

Added Dye Concentration from measurement of dye lot 6.95E+06 ug/L

Ballast Uptake Totals

Tank	bbl	litres
4P	12350	1963486.98
4S	12350	1963486.98

Measured by vessel gaging system

Projected Concentration (micrograms of dye/ total ballast uptake)

Ballast uptake	3.93E+06	litres
Added dye	5.52E+08	ug
Concentration	1.40E+02	ug/L

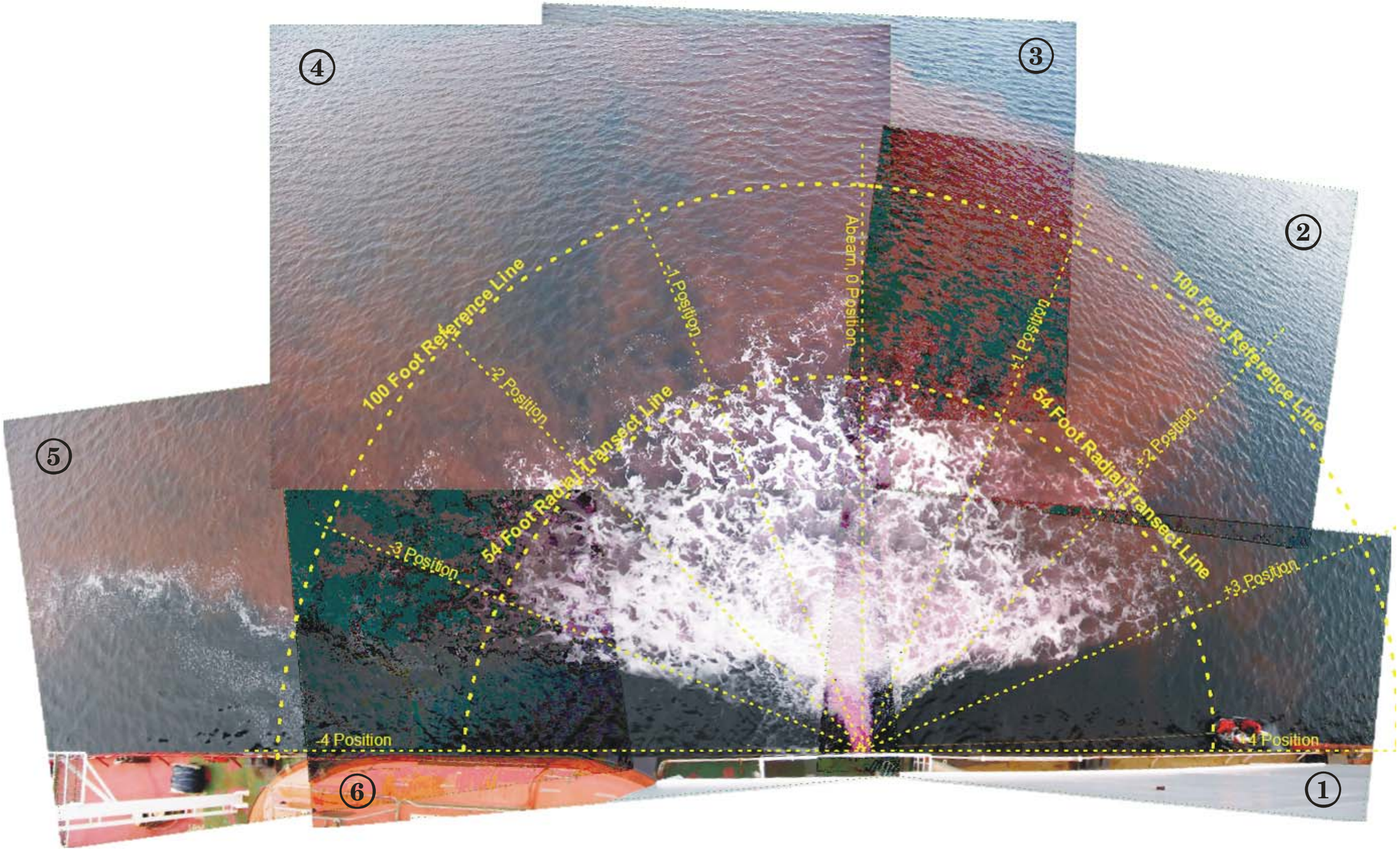
Dye Concentrations, Measured

Location	Time	ug/L
4P - Btm	0815	153
4P - Btm	0940	154
4P - Top	0619	142
4P - Top	0840	139
4S - Btm	0815	163
4S - Btm	0930	131
4S - Top	0615	142
4S - Top	0800	-
Total average		1.46E+02

Start Concentration Error Review

Highest Discharge Concentrations Measurements were made at 0853
This most closely corresponds to Btm (Bottom) tank measurements
An average of Btm tank measurements indicates 150 ug/L, without\
4S - Btm 0930 reading (appears low), average is 157 ug/L.
Projected concentration used only as a guide, accuracy in dosing
not intended to match meter, note 140 ug/L projection within 4%
of measured reading.

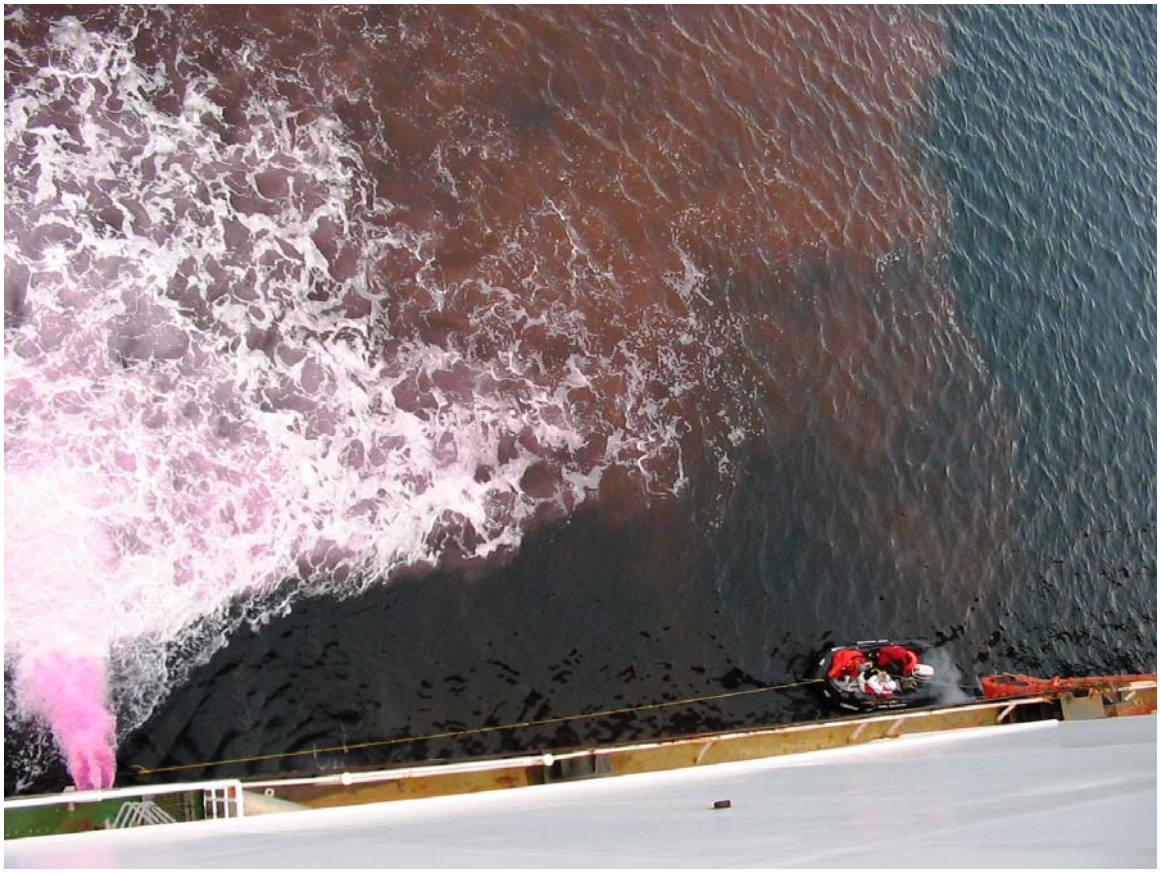
Conclusion, 146 ug/L start concentration is conservative.



Visual Observations, Key Plan

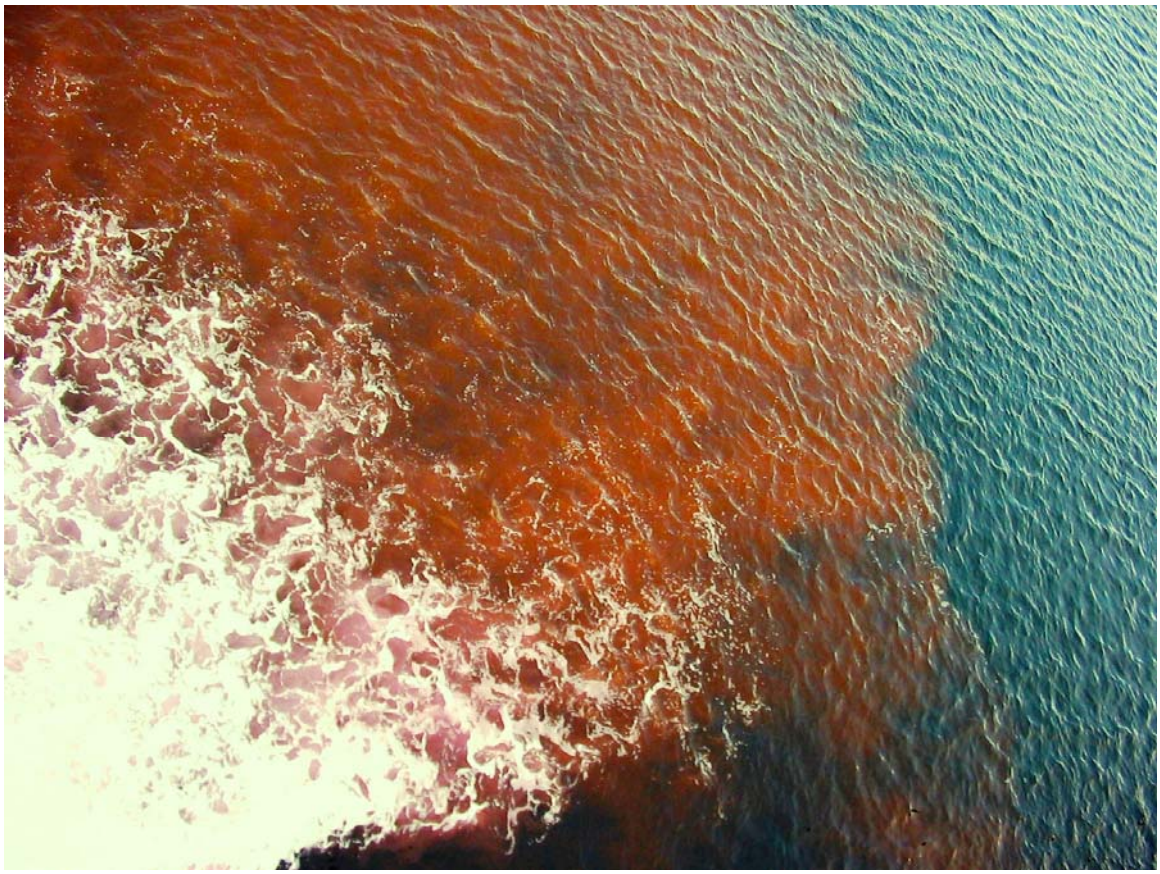
Appendix A3 – Visual Observations

Photographs and video documented visual observations of the discharge plume. Each of following photos is numbered from the Key Plan, previous page, and highlights a specific characteristic of the plume.



Picture 1

Within the 54 foot radial transect line there is significant turbulence in the plume, which may be the cause for variances in collected data points. A significant finger effect was observed, perhaps induced by the pipe bend just prior to the overboard.

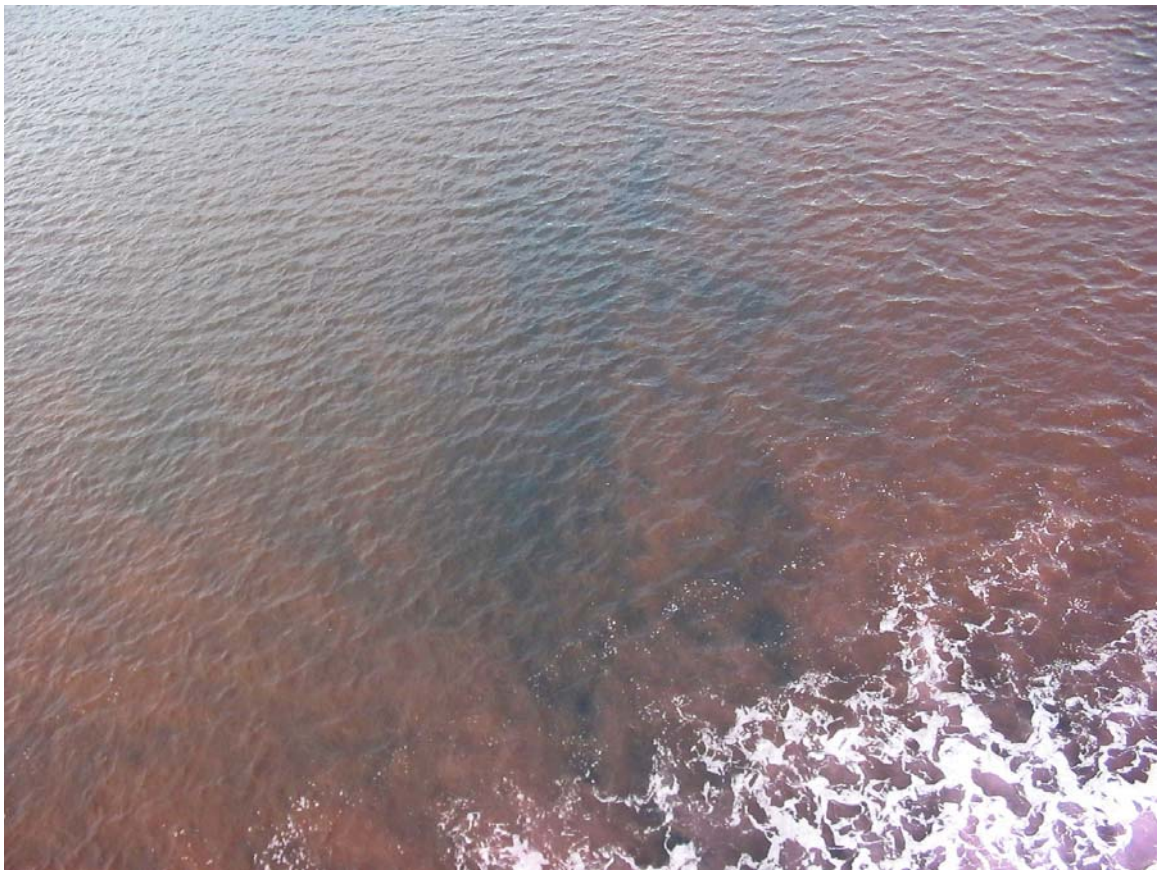


Picture 2

Observed color and intensity is greatest just outside the turbulent area, on 54 foot radial transect line at the +1 and +2 positions. This observation indicates that measured readings at these positions are maximums within the plume. (Color in photo is overexposed to show contrast.)

Picture 3

Observed color and intensity decrease gradually from the 54 foot to the 100 foot lines, with maximums similar to the 54 foot -1, -2 and -3 positions. This observation indicates that readings near the 100 foot line are less than those at the 54 foot -1, -2 and -3 positions.

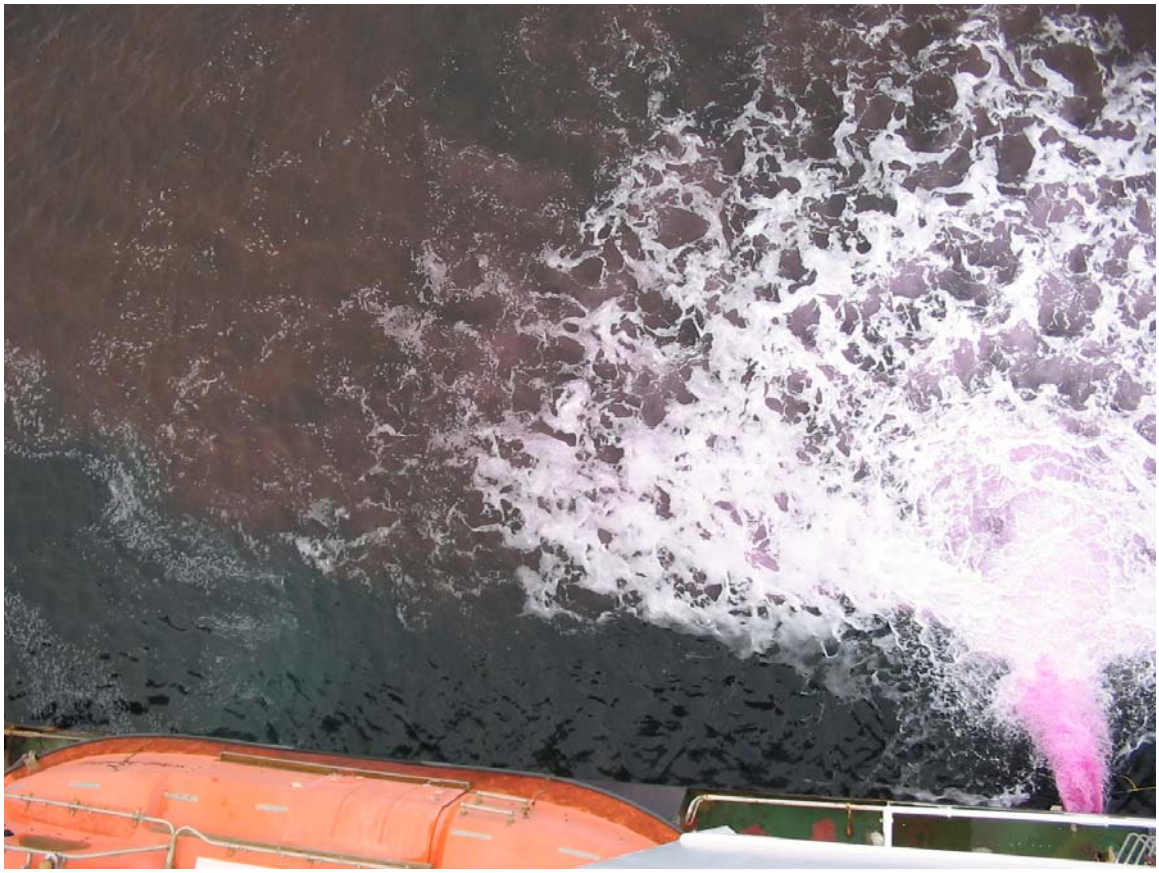


Picture 4

Beyond the 100 foot line, color and intensity is significantly decreased, and current moves the plume downstream. Beyond 250 feet color and intensity becomes difficult to detect.

Picture 5

Warm water from an engine cooling overboard is about 70 feet aft of the ballast overboard. The boundary between the two effluents is distinct.



Picture 6

This photo indicates the rotation of the jet as it leaves the overboard. This perhaps influences the finger-like pattern observed in the upper left of this photo. The turbulence in the plume within the 54 foot radius is also apparent.

Appendix A4 – Field Data Visual Analysis

1. Collected Data

We collected two sets of Rhodamine concentration data along radial transects within the discharge area as was described in the Dye Test Protocol section of this report. The first set of radial transects, called Run 1, was conducted during the first half of ballast tank discharge. The second set of radial transects, called Run 2, was conducted during the latter half of tank discharge. Each of these runs comprised several radial transects of the area at increasing distances from the ballast tank discharge location. Transects were conducted at radii of 14, 19, 24, 29 39 and 54 feet. Several vertical profiles of concentration data were collected along each radial transect to depths up to 70 feet.

2. Data Processing

2.1 Discarded Data

A supply launch interrupted data collection during Run 1. Because the launch disturbed the dye plume during part of Run 1, we discarded the entire 24-foot radial transect collected during this run. We also discarded the data from the profile at the -2 position (-45°) from the 29-foot radial transect.

2.2 Data Correction Functions

We applied a 2-point linear correction function to the data for calibration purposes. For Run 1, the lower concentration in the correction function was 0 μg/L, which corresponded to a meter reading of -0.7, the lowest reading obtained during the first run. The upper concentration in the correction function was 200 μg/L, which corresponded to a meter reading of 200. Thus the correction function for Run 1 takes the form:

$$C_C = \left(C_M + 0.7\right) 200 / 200.7 , \tag{0.1}$$

where C_M is the measured value and C_C is the corrected concentration. For Run 2, the lower concentration was also 0 μg/L, which corresponded to a meter reading of –2.4, the lowest reading obtained during a subsequent calibration test in clean water. The upper point on the correction function was the same as for Run 1. Thus the correction function for Run 2 takes the form:

$$C_C = \left(C_M + 2.4\right) 200 / 202.4 . \tag{0.2}$$

2.3 Gridding

We gridded the data from each radial transect separately, each on a vertically oriented cylindrical mesh surface defined by the transect radius. The over-sample grid had approximately ten times the spatial resolution in both the *x*- and *z*-directions. We used a cubic spline interpolation scheme based on a Delaunay triangulation to fit the mesh surface to the data. The gridded surface goes directly through all measured values. The gridded surface is smooth, with no discontinuities in the first or zeroth derivative. Gridded data points were only defined within the region bounded by the extent of the Delaunay triangulation.

3. Results

3.1 2-D Contour Plots

Contours of the gridded surfaces for Run 1 are shown in Figures 1-5. The contour plots show each radial transect "rolled out", not projected on to a plane. The vertical axis is exaggerated by a factor of 1.5. Contours are drawn at 0.5 μg/L intervals. The maximum, minimum and mean concentration values for each transect are listed in the table, along with the corresponding dispersion ratio. Each figure shows a region of relatively high concentration near the surface, between about 40° and 70° forward of the ballast overboard. The concentration values within this plume increase away from the discharge point. There is also a secondary, less robust plume near the surface between the vessel side shell and about –70°.

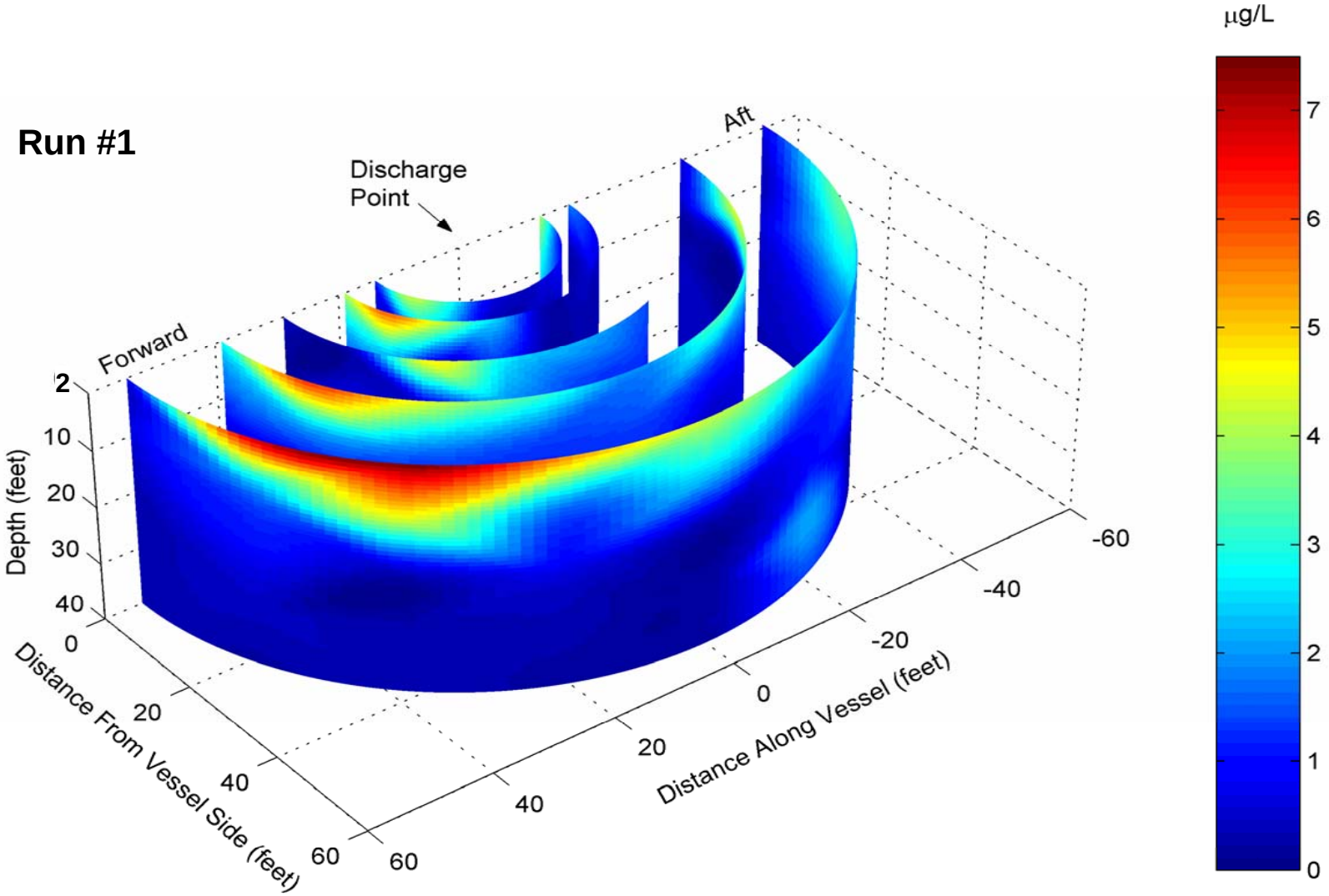
Contours of the gridded surfaces for Run 2 are shown in Figures 6-11. During this run, a relatively robust plume was observed near the vessel side shell forward of the discharge point. A weaker plume was observed near the side shell aft of the discharge point, and another area of relatively high concentrations was observed at about 45° in the 54-foot radius transect. Generally, the Rhodamine concentrations observed during this run were slightly higher, extended slightly deeper, and were more dispersed than in Run 1.

3.3 3-D Filled Contour Plots

To better visualize the nature of the measured signals, the gridded surfaces for each run were plotted as a nested set of filled color contours in three-dimensional Cartesian space. Figures 12 and 13 show these filled contour plots. In these plots, which show an oblique view of the nested set of filled contours (or shells), the ship would be situated with its port side next to the open side of the shells. The location of the ballast discharge is marked with an arrow. The colorbar on the right-hand side of each of these figures shows the relationship of the plotted colors to measured Rhodamine concentrations.

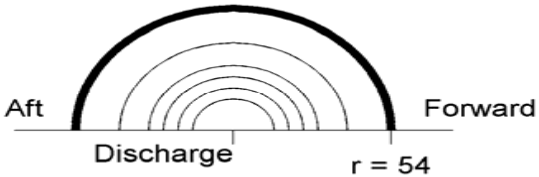
In Run 1, the relatively cohesive plume extending from the discharge point outward at an angle of approximately 40°-70° can be clearly identified. In Run 2, the dye plume has evolved somewhat, with the strongest plume abutting the vessel side shell forward. There are a few other areas of relatively high concentration, and the concentrations everywhere are slightly elevated with respect to Run 1.

Run #1



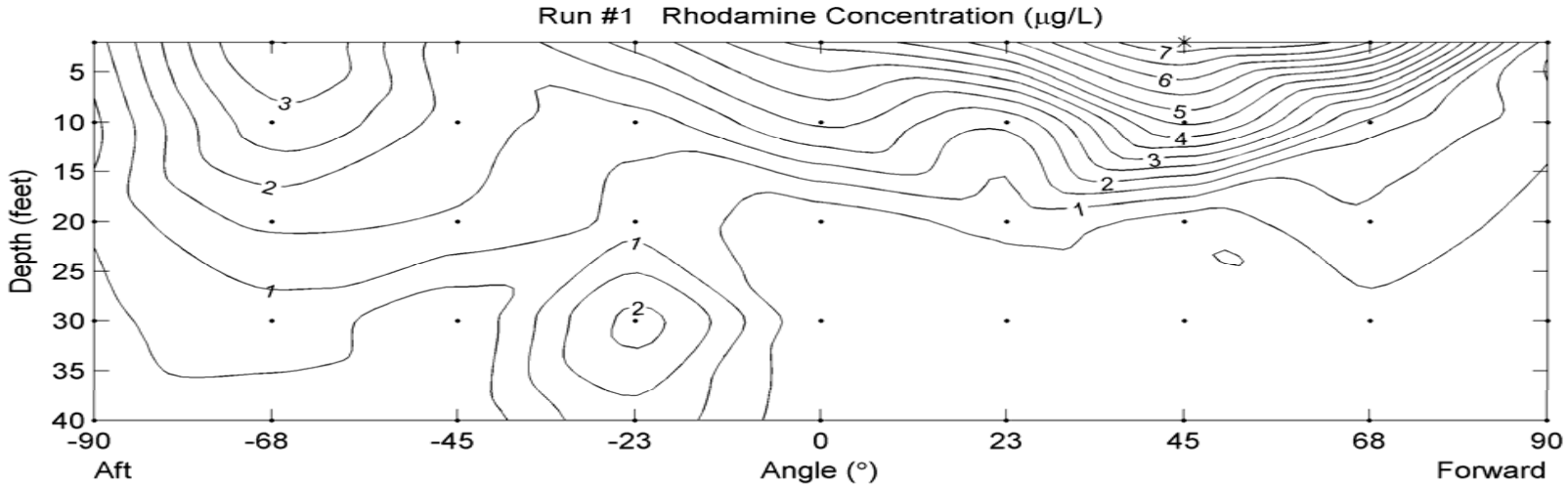
Notes:

1) No vertical exaggeration



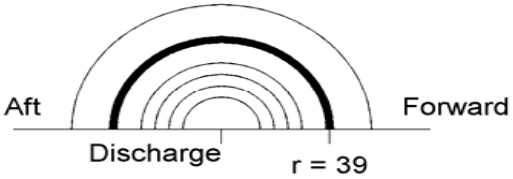
Run #1 Radius = 54 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	7.4	1:20	2 ft	45°
Min	146	0	n/a	50 ft	-45°
Mean	146	1.0	1:146	n/a	n/a



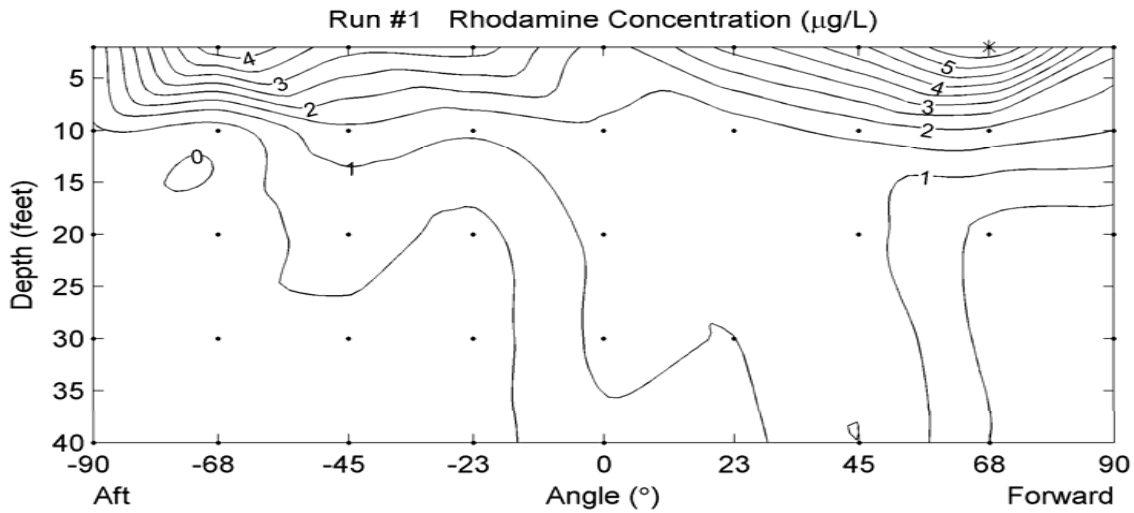
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



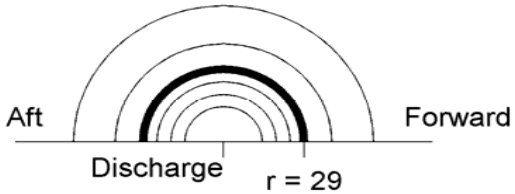
Run #1 Radius = 39 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	6.0	1:24	2 ft	68°
Min	146	0.2	1:730	multiple	multiple
Mean	146	1.0	1:146	n/a	n/a



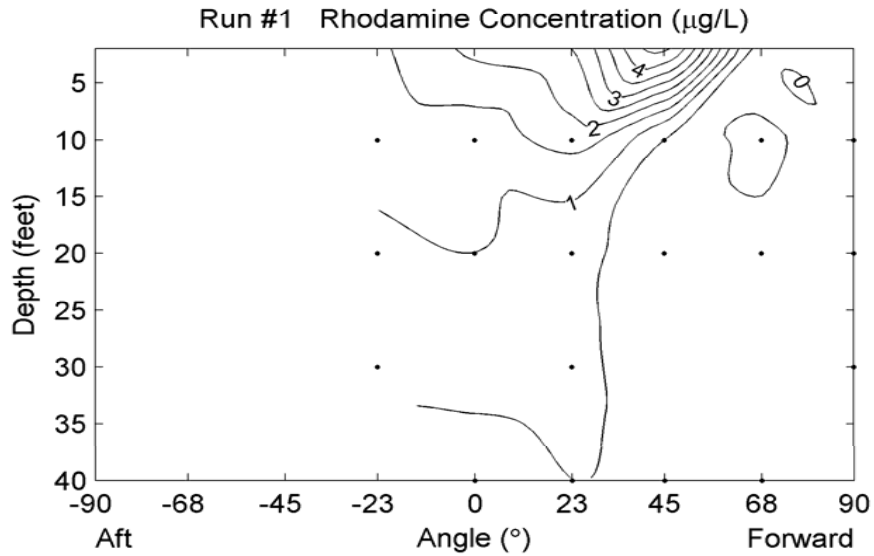
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



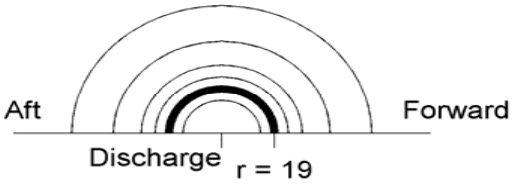
Run #1 Radius = 29 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	4.6	1:32	2 ft	45°
Min	146	0.1	1:1460	10 ft	90°
Mean	146	0.9	1:162	n/a	n/a



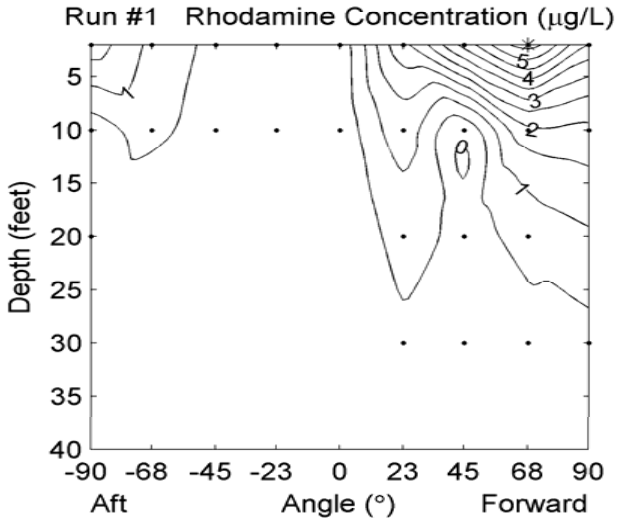
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



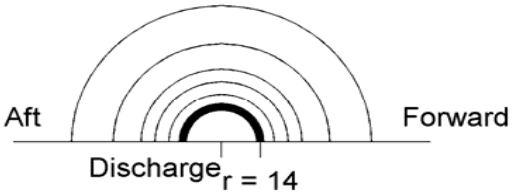
Run #1 Radius = 19 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	5.7	1:26	2 ft	68°
Min	146	0.2	1:730	multiple	mulitple
Mean	146	1.2	1:122	n/a	n/a



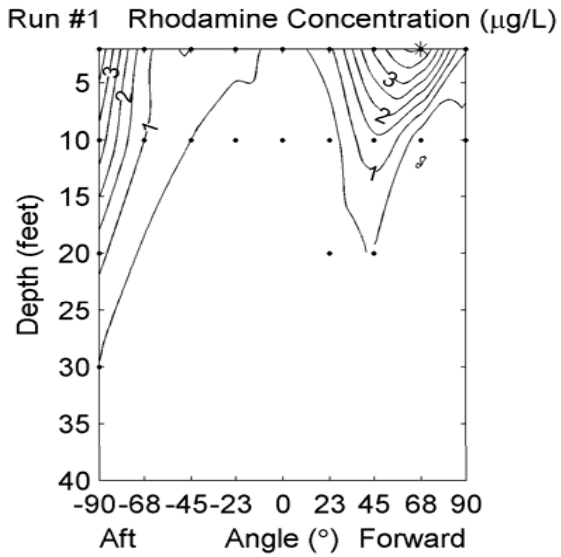
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



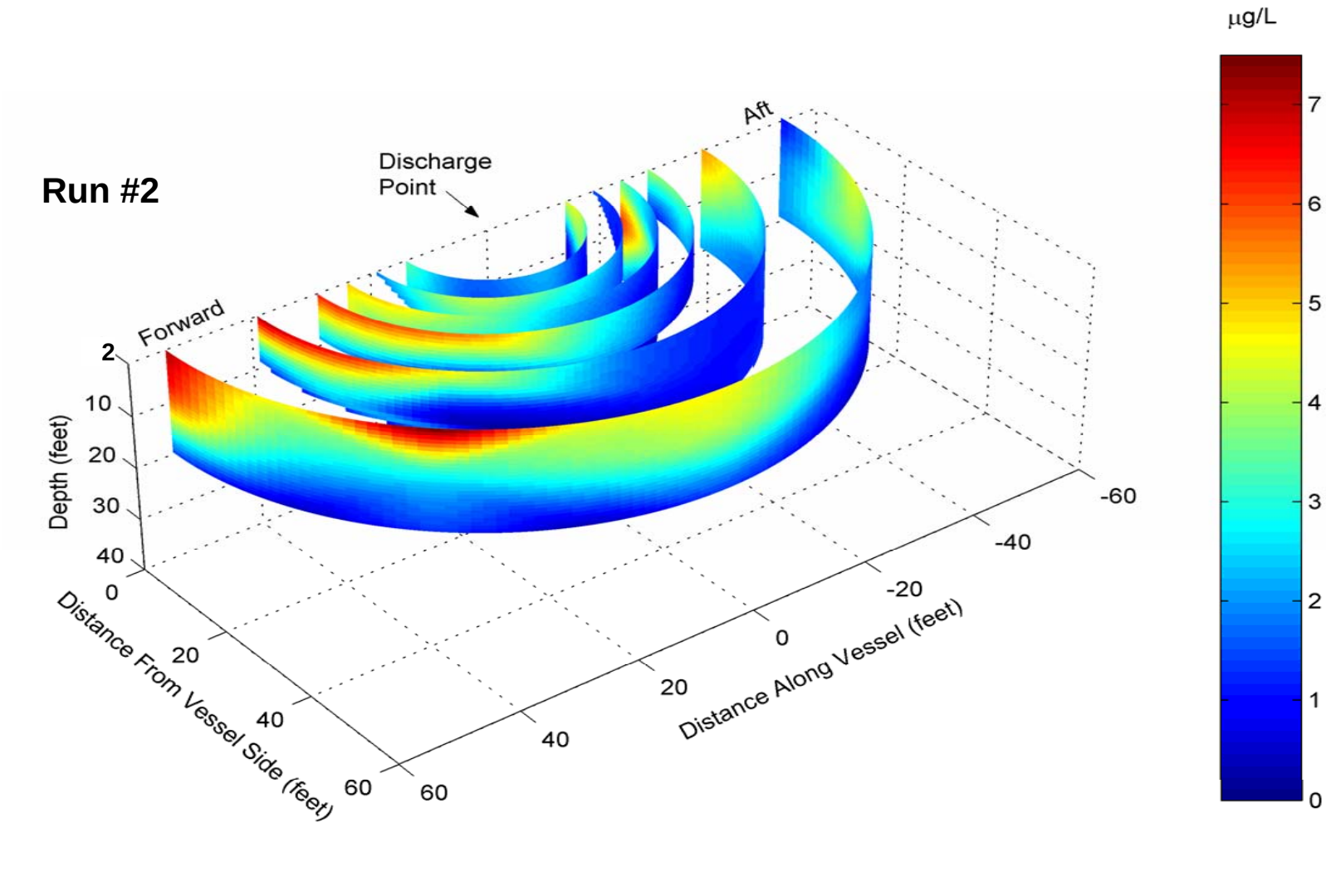
Run #1 Radius = 14 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	4.0	1:37	2 ft	68°
Min	146	0.2	1:730	multiple	multiple
Mean	146	1.2	1:122	n/a	n/a



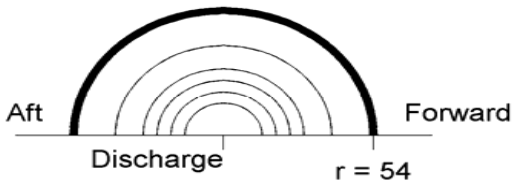
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



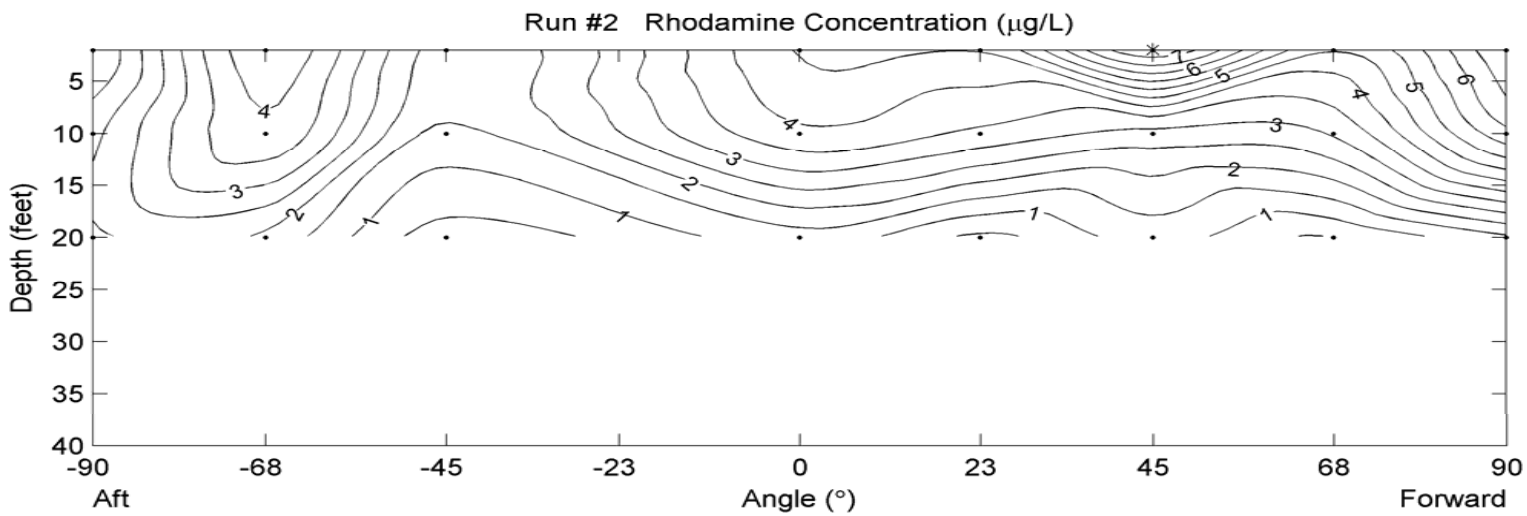
Notes:

1) No vertical exaggeration



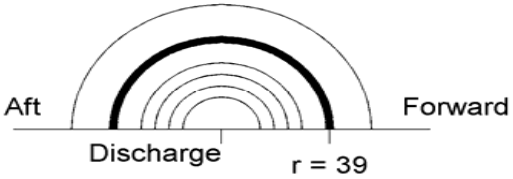
Run #2 Radius = 54 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	7.4	1:20	2 ft	45°
Min	146	0.3	1:487	20 ft	-45°
Mean	146	2.9	1:50	n/a	n/a



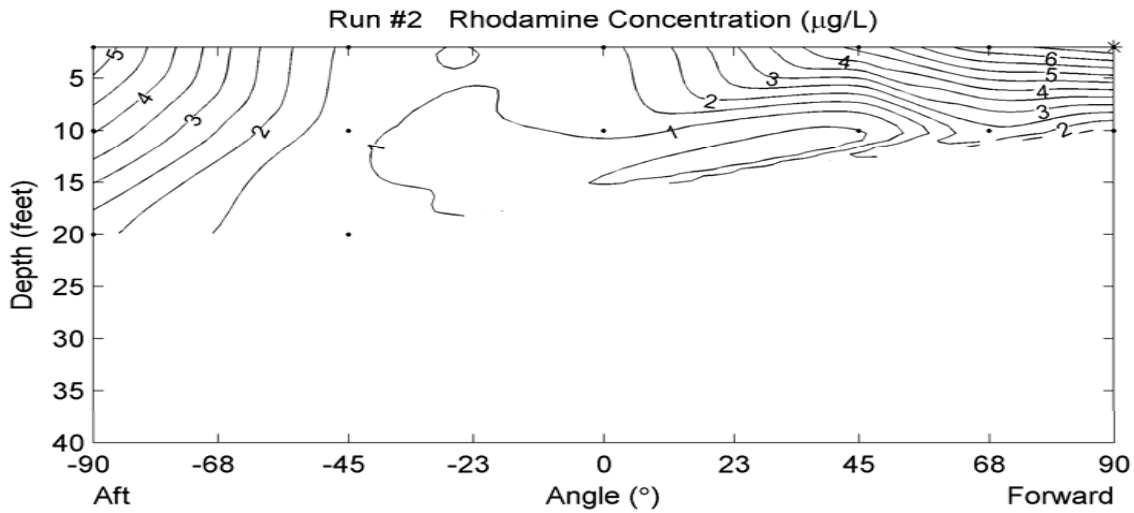
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



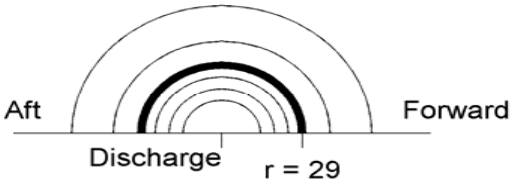
Run #2 Radius = 39 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	6.9	1:21	2 ft	90°
Min	146	0.5	1:292	10 ft	45°
Mean	146	2.9	1:50	n/a	n/a



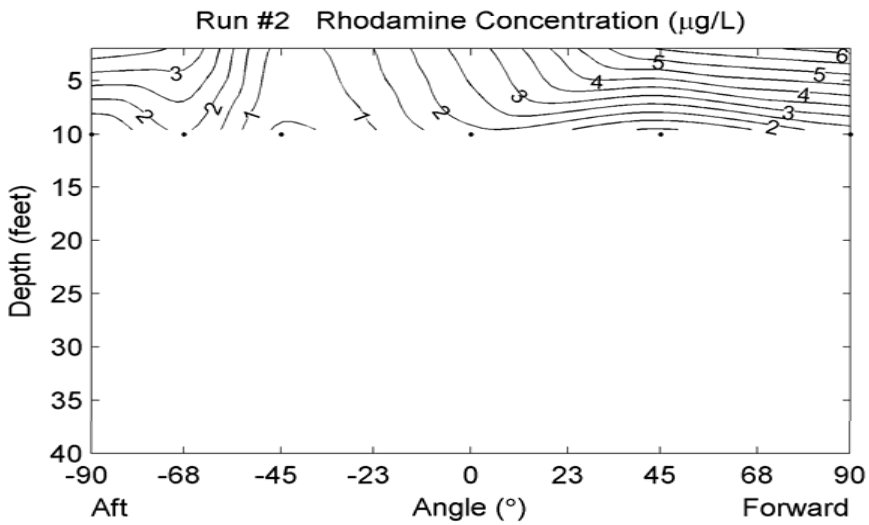
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



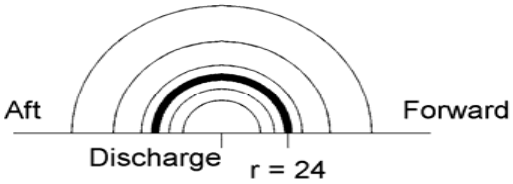
Run #2 Radius = 29 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	6.2	1:24	2 ft	90°
Min	146	0.4	1:365	10 ft	-45°
Mean	146	2.5	1:58	n/a	n/a



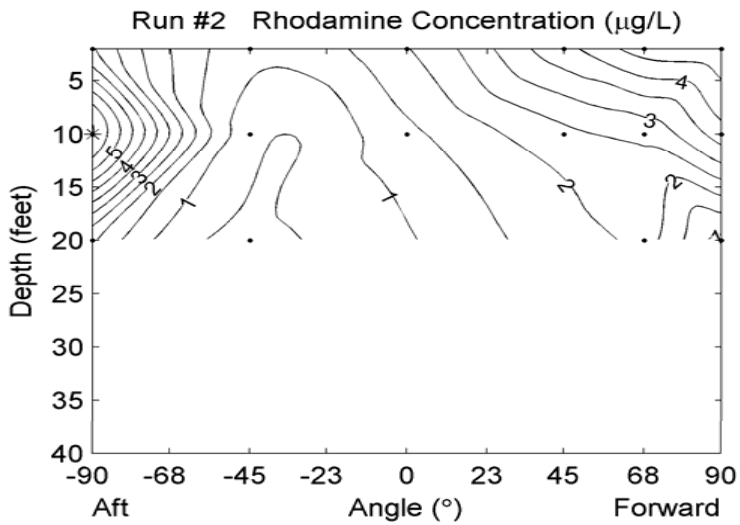
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



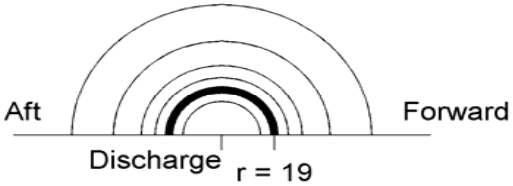
Run #2 Radius = 24 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	6.0	1:24	10 ft	-90°
Min	146	0.4	1:365	20 ft	-45°
Mean	146	2.7	1:54	n/a	n/a



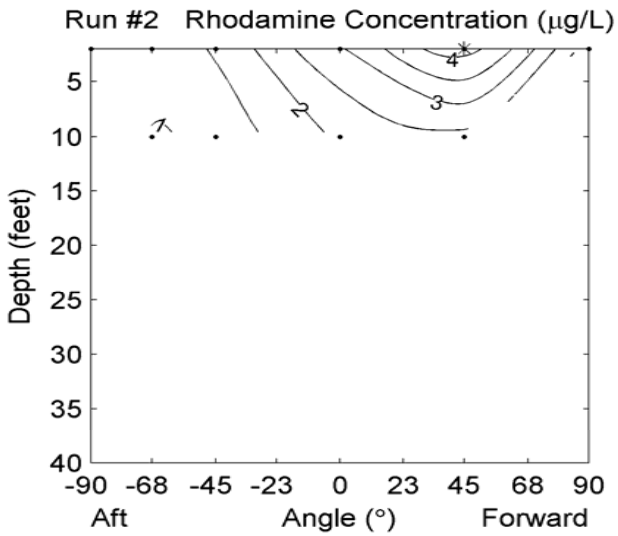
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest concentration
4) Contour interval is 0.5 μg/L



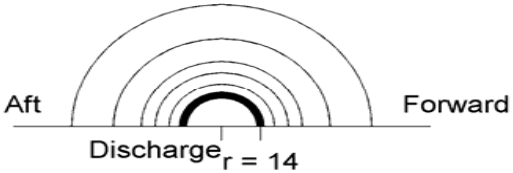
Run #2 Radius = 19 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	4.2	1:35	2 ft	45°
Min	146	1.0	1:146	10 ft	-68°
Mean	146	2.0	1:73	n/a	n/a



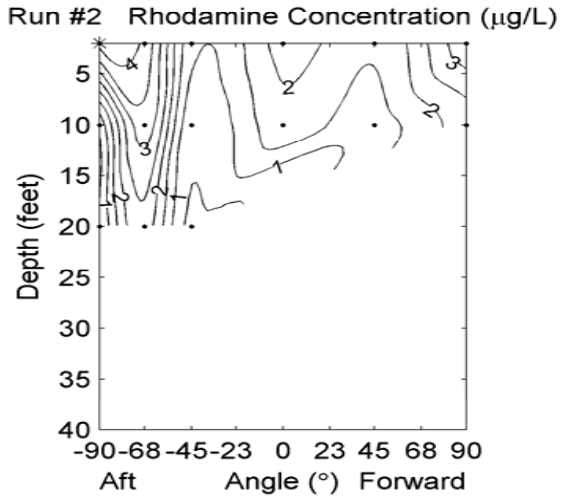
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L



Run #2 Radius = 14 ft

	Discharge Concentration	Measured Concentration	Dispersion Ratio	Depth	Position
Max	146	4.2	1:35	2 ft	-90°
Min	146	0.4	1:365	20 ft	-45°
Mean	146	2.0	1:73	n/a	n/a



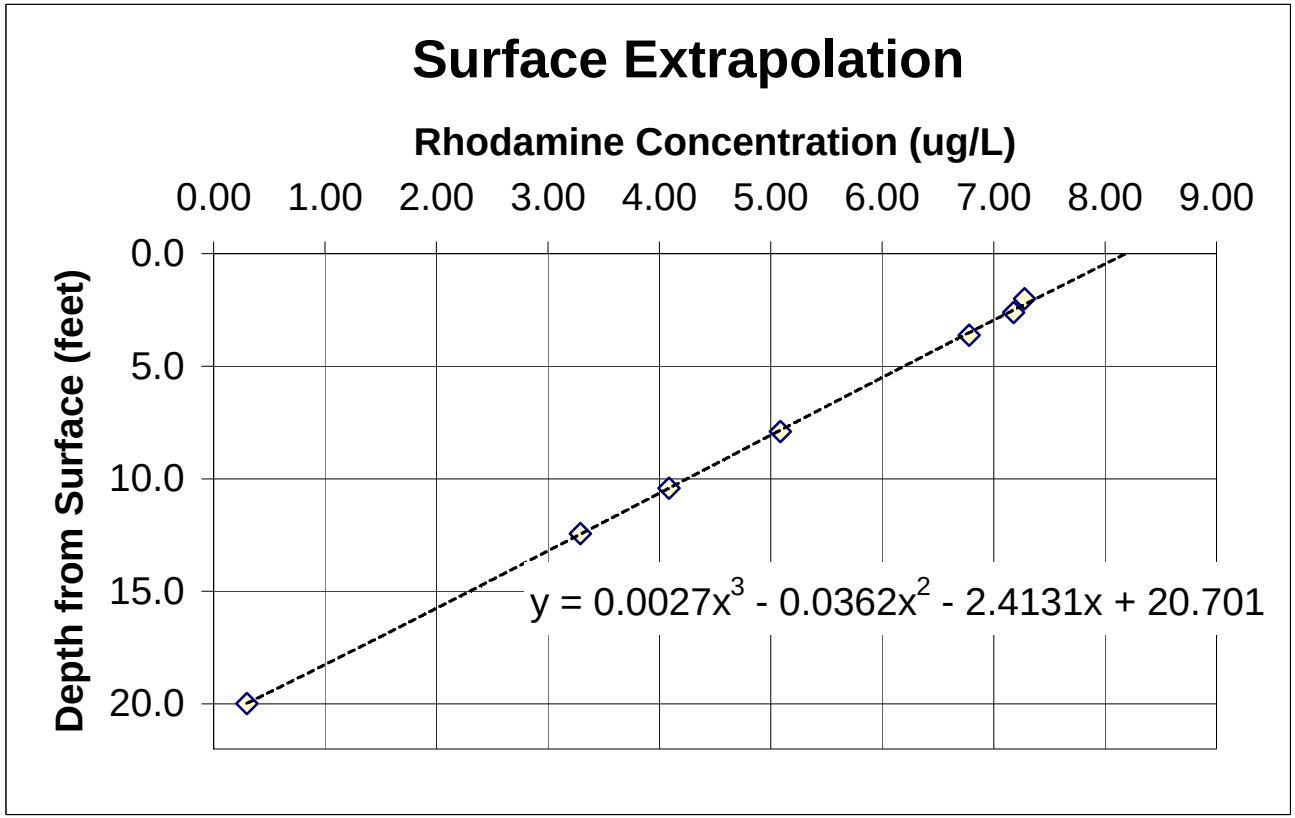
Notes:

1) Vertical axis exaggerated 1.5x
2) Black dots denote measurement locations
3) Red asterisk denotes location of highest reading
4) Contour interval is 0.5 μg/L

Appendix A5 – Surface Extrapolations

The following tables and graphs extrapolate measured readings from 70 through 2 feet of harbor depth, up through the harbor surface. The selected points were noted as having high concentrations and steep gradients, indicating a high surface concentration.

Field note information uses its correlation between dye concentration and depth to assign a trend to the multiple data logger points captured within the same time period. This expanded data series is then corrected for offset and zero and plotted as points on the graph. A second order polynomial curve was selected to extrapolate all curves to the surface.



Start concentration	**146**
Extrapolation	**8.2**
Ratio	**18**

Run 1, Radius 54 feet, Position +45 degrees

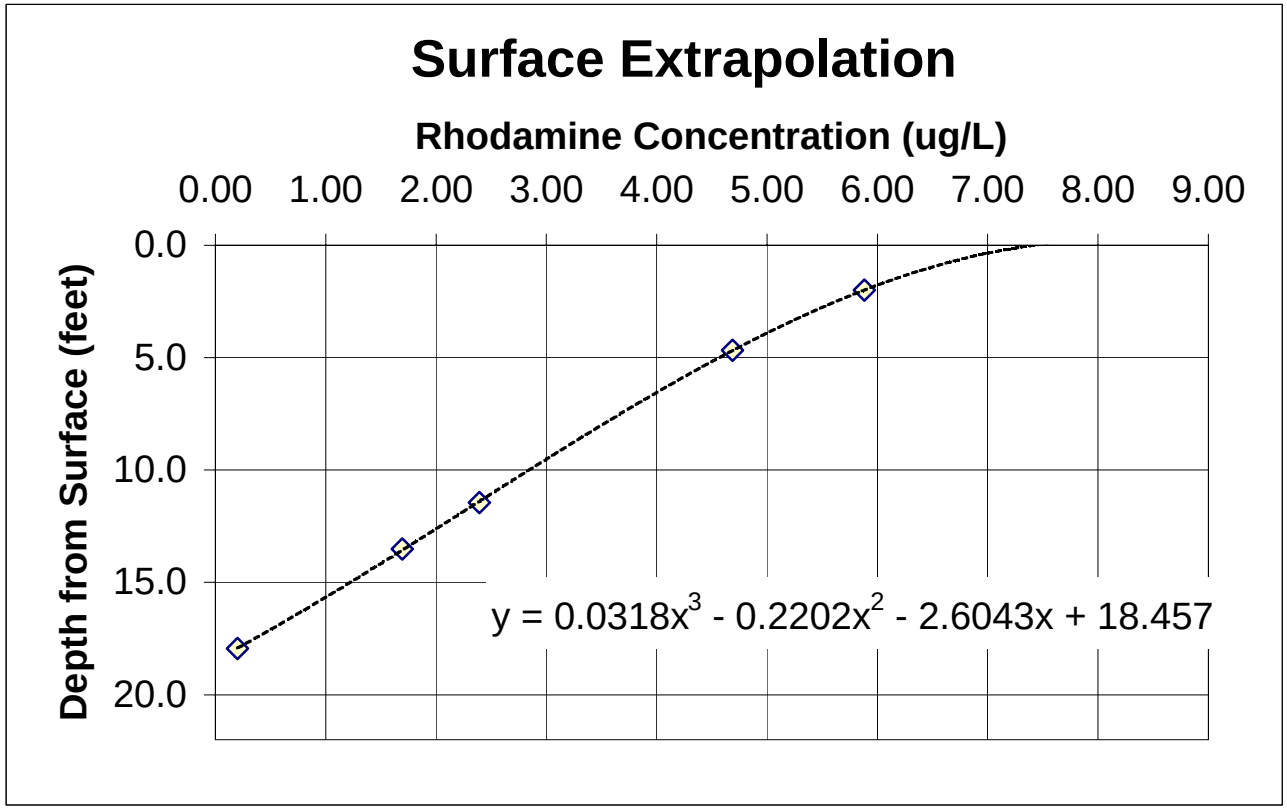
Field Note Trend Data		
Time (hh:mm)	Depth (feet)	Rodamine (ug/L)
x	20.0	-0.40
x	10.0	3.90
8:53	2.0	6.70

Zero and Offset, Rhodamine (ug/L)		
	Raw	Corrected
Zero	-0.6	0.0
Offset	200.0	200.0

**Surface extrapolation performed as field data range is between 2 and 70 feet.
(1) Field data from hand log with corresponding depth, used to establish depth trend to logger data.
(2) Field and logger data zero and offset corrections

Derived Data (1) (2)		
Time (hh:mm:ss)	Depth (feet)	Rodamine (ug/L)
8:52:32	-0.7	8.47
8:52:42	20.0	0.30
8:52:52	12.4	3.29
8:53:02	10.4	4.09
8:53:12	7.9	5.08
8:53:22	3.6	6.78
8:53:32	2.6	7.18
8:53:42	2.0	7.28

Logger Raw Data		
Time (hh:mm:ss)	Sp. Cond. (mS/cm)	Rodamine (ug/L)
8:52:32	50.412	7.90
8:52:42	50.385	-0.30
8:52:52	50.386	2.70
8:53:02	50.345	3.50
8:53:12	50.373	4.50
8:53:22	50.305	6.20
8:53:32	50.291	6.60
8:53:42	50.319	6.70



Start concentration	**146**
Extrapolation	**7.4**
Ratio	**20**

Derived Data (1) (2)		
Time (hh:mm:ss)	Depth (feet)	Rodamine (ug/L)
9:32:03	17.9	0.20
9:32:13	13.5	1.69
9:32:23	11.5	2.39
9:32:33	4.7	4.69
9:32:43	2.0	5.88

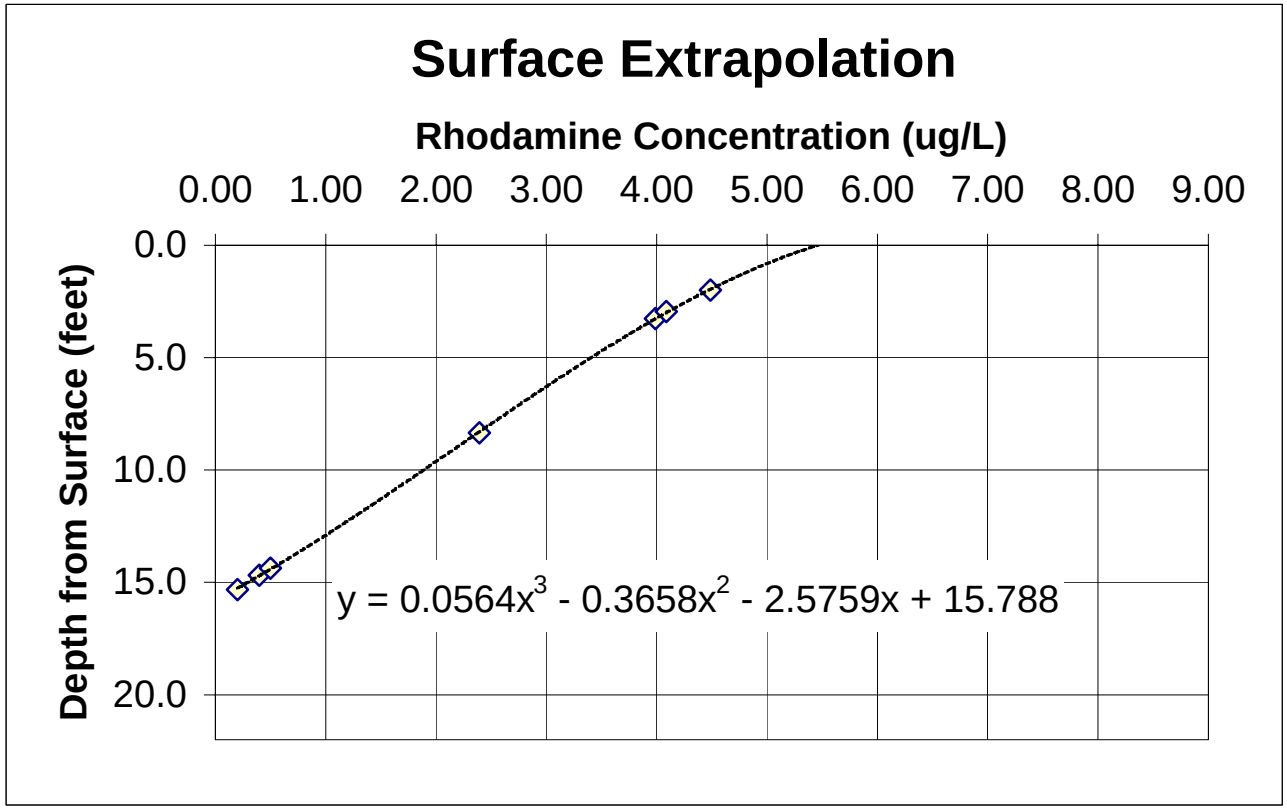
Run 1, Radius 39 feet, Position +68 degrees

Field Note Trend Data		
Time (hh:mm)	Depth (feet)	Rodamine (ug/L)
x	20.0	-0.30
x	10.0	1.20
9:32	2.0	5.30

Zero and Offset, Rhodamine (ug/L)		
	Raw	Corrected
Zero	-0.6	0.0
Offset	200.0	200.0

Logger Raw Data		
Time (hh:mm:ss)	Sp. Cond. (mS/cm)	Rodamine (ug/L)
9:32:03	50.178	-0.4
9:32:13	50.247	1.1
9:32:23	50.234	1.8
9:32:33	50.221	4.1
9:32:43	50.139	5.3

**Surface extrapolation performed as field data range is between 2 and 70 feet.
(1) Field data from hand log with corresponding depth, used to establish depth trend to logger data.
(2) Field and logger data zero and offset corrections



Start concentration	**146**
Extrapolation	**5.5**
Ratio	**27**

Derived Data (1) (2)		
Time (hh:mm:ss)	Depth (feet)	Rodamine (ug/L)
9:39:57	15.3	0.20
9:40:07	14.7	0.40
9:40:17	14.4	0.50
9:40:27	8.3	2.39
9:40:37	3.3	3.99
9:40:47	2.9	4.09
x	2.0	4.49

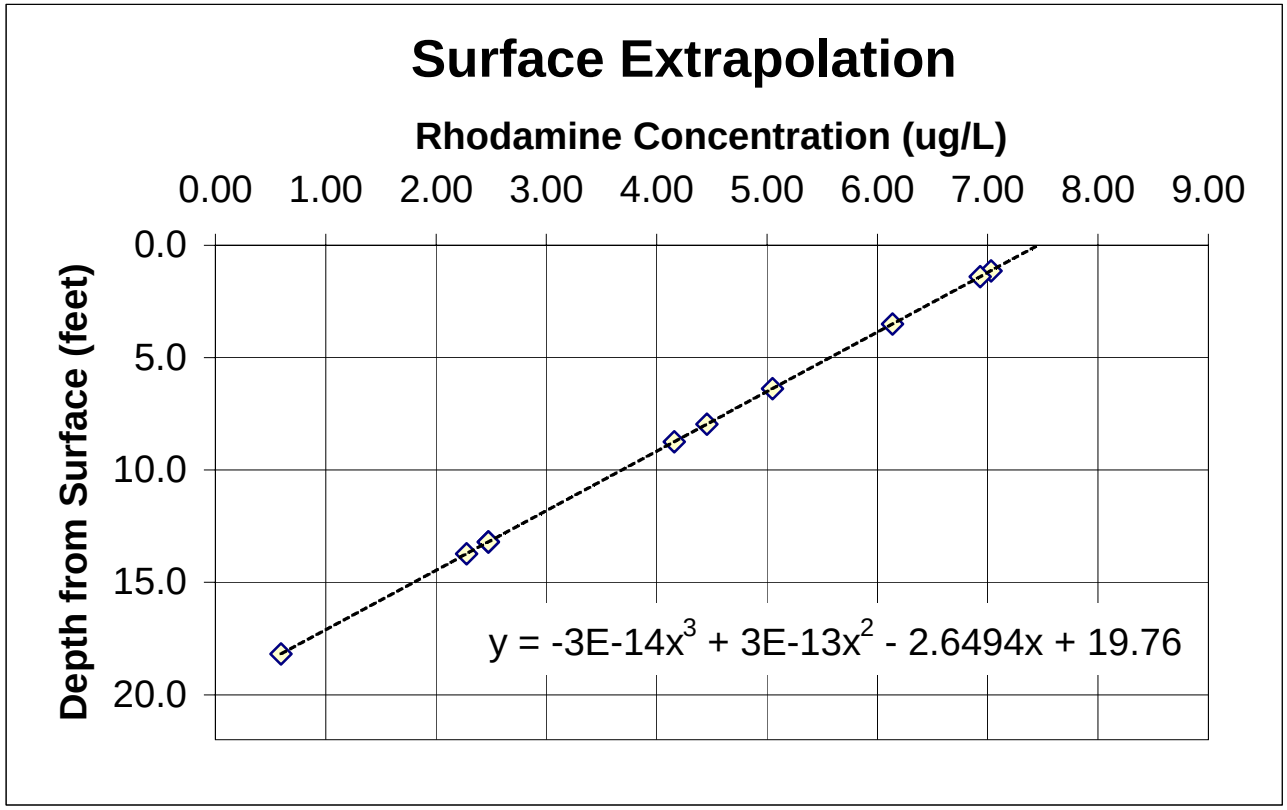
Run 1, Radius 29 feet, Position +45 degrees

Field Note Trend Data		
Time (hh:mm)	Depth (feet)	Rodamine (ug/L)
x	20.0	-0.50
x	10.0	-0.20
9:40	2.0	3.90

Zero and Offset, Rhodamine (ug/L)		
	Raw	Corrected
Zero	-0.6	0.0
Offset	200.0	200.0

Logger Raw Data		
Time (hh:mm:ss)	Sp. Cond. (mS/cm)	Rodamine (ug/L)
9:39:57	50.384	-0.4
9:40:07	50.357	-0.2
9:40:17	50.358	-0.1
9:40:27	50.234	1.8
9:40:37	50.055	3.4
9:40:47	49.904	3.5

**Surface extrapolation performed as field data range is between 2 and 70 feet.
(1) Field data from hand log with corresponding depth, used to establish depth trend to logger data.
(2) Field and logger data zero and offset corrections



Start concentration	**146**
Extrapolation	**7.5**
Ratio	**19**

Derived Data (1) (2)		
Time (hh:mm:ss)	Depth (feet)	Rodamine (ug/L)
12:03:47	1.1	7.03
12:03:57	1.4	6.93
12:04:07	3.5	6.14
12:04:17	8.0	4.46
12:04:27	6.4	5.05
12:04:37	8.7	4.16
12:04:47	13.2	2.48
12:04:57	13.2	2.48
12:05:07	13.7	2.28
12:05:17	18.2	0.59

Run 2, Radius 54 feet, Position +45 degrees

Field Note Trend Data		
Time (hh:mm)	Depth (feet)	Rodamine (ug/L)
x	20.0	-1.20
x	10.0	0.50
12:05	2.0	5.10

Zero and Offset, Rhodamine (ug/L)		
	Raw	Corrected
Zero	-2.0	0.0
Offset	200.0	200.0

Logger Raw Data		
Time (hh:mm:ss)	Sp. Cond. (mS/cm)	Rodamine (ug/L)
12:03:47	50.507	5.1
12:03:57	50.52	5
12:04:07	50.506	4.2
12:04:17	50.49	2.5
12:04:27	50.518	3.1
12:04:37	50.476	2.2
12:04:47	50.516	0.5
12:04:57	50.571	0.5
12:05:07	50.517	0.3
12:05:17	50.529	-1.4

**Surface extrapolation performed as field data range is between 2 and 70 feet.
(1) Field data from hand log with corresponding depth, used to establish depth trend to logger data.
(2) Field and logger data zero and offset corrections

Appendix A6 – Data Logger Maximum Value

The flurometric probe used was set-up to automatically record dye concentration, temperature, conductivity and time every ten seconds. This resulted in 1,031 readings over 205 minutes.
The following table is a digest of this data, showing the highest 20 readings for run one and run two. This is then compared to the start concentration to indicate a dispersion ratio.

Run One

Date Time (M/D/Y hh:mm:ss)	Temp (F)	Cond. (mS/cm)	Rhod. (ug/L)
10/11/2004 9:33:03	51.04	50.071	7.9
10/11/2004 9:32:53	51.03	50.125	7
10/11/2004 8:53:42	51.04	50.319	6.7
10/11/2004 8:53:32	51.04	50.291	6.6
10/11/2004 11:01:55	50.97	48.01	6.6
10/11/2004 9:33:13	51.04	49.988	6.5
10/11/2004 8:53:22	51.04	50.305	6.2
10/11/2004 8:54:32	51.04	50.195	5.7
10/11/2004 11:01:45	50.9	49.07	5.6
10/11/2004 11:02:05	50.97	47.871	5.5
10/11/2004 8:54:22	51.03	50.222	5.4
10/11/2004 8:54:02	51.04	50.236	5.3
10/11/2004 9:32:43	51.03	50.139	5.3
10/11/2004 8:54:12	51.03	50.236	5.2
10/11/2004 10:26:12	51.01	48.288	4.8
10/11/2004 8:48:52	50.88	50.148	4.7
10/11/2004 8:53:52	51.04	50.291	4.7
10/11/2004 10:26:22	50.97	48.548	4.7
10/11/2004 8:48:32	50.88	50.12	4.6
10/11/2004 8:53:12	50.99	50.373	4.5

742 Logger readings sorted on rhodamine conc.
over 156 minutes
Highest uncorrected reading 7.9 ug/L
Corrected for zero and offset 8.4 ug/L

Highest Reading	**8.4**
Start Concentration	**146**
Ratio	**17**

Run Two

Date Time (M/D/Y hh:mm:ss)	Temp (F)	Cond. (mS/cm)	Rhod. (ug/L)
10/11/2004 11:46:17	50.95	50.22	6
10/11/2004 11:46:07	50.88	50.148	5.9
10/11/2004 11:45:57	50.86	50.383	5.5
10/11/2004 12:03:47	50.85	50.507	5.1
10/11/2004 12:03:57	50.83	50.52	5
10/11/2004 12:03:37	50.85	50.521	4.9
10/11/2004 12:00:27	50.83	50.506	4.8
10/11/2004 11:59:00	50.83	50.506	4.7
10/11/2004 11:58:50	50.83	50.506	4.6
10/11/2004 11:59:10	50.85	50.493	4.6
10/11/2004 11:59:20	50.85	50.479	4.6
10/11/2004 11:46:27	50.88	50.369	4.5
10/11/2004 11:59:27	50.85	50.479	4.5
10/11/2004 11:59:37	50.85	50.465	4.5
10/11/2004 12:00:17	50.81	50.492	4.3
10/11/2004 12:00:37	50.85	50.493	4.3
10/11/2004 12:03:27	50.83	50.534	4.3
10/11/2004 12:04:07	50.83	50.506	4.2
10/11/2004 12:03:07	50.81	50.575	4
10/11/2004 12:03:17	50.83	50.506	4

289 Logger readings sorted on rhodamine conc.
over 49 minutes
Highest uncorrected reading 6.0 ug/L
Corrected for zero and offset 7.9 ug/L

Highest Reading	**7.9**
Start Concentration	**146**
Ratio	**18**

Appendix B – Test Protocol

SHIP'S BALLAST DISCHARGE DISPERSION
BENCHMARK TRACER TEST

ATTACHMENT 1
DYE TEST PARTICULARS (15 September 2004 Revision)

Vessel Names:		*MT Seabulk Pride, MT Seabulk Artic*
		(Sister vessels, Test to be conducted on one)
	Owner:	Seabulk Tankers, Inc.
	Particulars:	Crude and Product Oil Carrier, Double Hull, US Flag
		46,069 tonnes deadweight
		183.0 meters length overall
		342,040 barrel cargo capacity
Location:		Washington State, Puget Sound
	Primary:	Port of Port Angeles, Anchorage
	Secondary:	Anacortes, March's Point, Refinery Docks
Testing Date:		One test in October or November
Investigator:		The Glosten Associates, Inc., Seattle, Washington
	Primary:	Kevin J. Reynolds
	Secondary:	Maurice W. McCarthy
Dye,	Generic Name:	Rhodamine WT
	Trade Name:	Intracid Rhodamine WT Liquid, A34517L100 Tracer Dye
	Transport/Injection:	1-1/4% concentration, premixed for testing event
		0-0.31% concentration, prior to entrainment into ballast stream
	Vessel Discharge:	200 uG/L (parts per billion), entrained in ballast stream, end-of-pipe value, maximum concentration
		2,000 metric tons per hour, maximum rate
		10,000 metric tons, maximum volume
		1.8 grams, maximum dye discharge

15 September 2004 Revision Notes:

1. Vessel information was US Shipping Owned ITB Groton, of similar dimensions and capacities.
2. Testing was for 3 tests between February and June 2004.
3. Removed note 1, regarding reference to *ST Tonsina* discharge values. Vessel discharge values shown here have not changed, and are accurate for subject vessel.
4. Removed note 2, regarding definition of end-of-pipe.

Note:
Now Appendix B, Revision B

Appendix A – Test Protocol

Ship's Ballast Discharge Dispersion Benchmark Dye Tracer Test

Revision B

Prepared for

Vitamar, LLC
Germantown, Tenneesse

KEVIN J. REYNOLDS
STATE OF WASHINGTON
36584
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 10/14/2004

William L. Hurley, P.E.
Principal-in-Charge

Kevin J. Reynolds, P.E.
Project Engineer

File No. 03104
5 May 2004

GLOSTEN
The Glosten Associates, Incorporated

Consulting Engineers Serving The Marine Community

600 Mutual Life Building • 605 First Avenue
Seattle Washington 98104-2224
Phone: (206) 624-7850 • Fax: (206) 682-9117
E-mail: email@glosten.com

DOCUMENT REVISION LOG			
REV	DESCRIPTION	BY	DATE
A	Appendix A Protocol: Title was 'Ships Ballast Discharge Mixing Zone, Benchmark Dye Tracer Test.' Removed all other references to Mixing Zone.	MWM	05 March 2004
A	Appendix A Protocol, Added: documentation of the regulatory notification procedure.	MWM	11 March 2004
A	Appendix A Protocol, Added: establishment of an instrument "zero".	MWM	05 March 2004
A	Appendix A Protocol, Added: evaluation procedure for presence of photochemical decay.	MWM	05 March 2004
A	Appendix A Protocol, Added: evaluation procedure for presence of sorption.	MWM	05 March 2004
A	Appendix A Protocol Attachment 2, Added: QA/QC Verification Supporting Data log sheet.	MWM	05 March 2004
A	Appendix A Protocol Attachment 3 – Regulatory Contact List, Added: additional agencies to the test notification list.	MWM	05 March 2004
A	Appendix A Protocol, Added: Attachment 4 - Regulatory Notification Fax	MWM	09 March 2004
A	Appendix A Protocol, Added Attachment 5 - Department of Ecology's Protocol Approval Letter	MWM	11 March 2004
A	Appendix A Protocol: Added Attachment 6 – Selected Bibliography	MWM	09 March 2004
B	Revision B changes are made as a result of executional refinements developed in the 29 April 2004 field practice exercise.		
B	Appendix A Protocol Body, Page A-5: added synchronization of participant clocks.	MWM	05 May 2004
B	Appendix A Protocol Body, Page A-5: added reference to measurement of Sea State.	MWM	05 May 2004
B	Appendix A Protocol Body, Page A-6: directed Photochemical Decay and Sorption QA/QC samples to be submerged alongside host vessel.	MWM	05 May 2004
B	Appendix A Protocol Body, Page A-6: added reference to pre-measured control line.	MWM	05 May 2004
B	Appendix A Protocol Body, Page A-6: redefined Methodical Sweep.	MWM	05 May 2004
B	Appendix A Protocol Body, Page A-6: deleted Tracking Run.	MWM	05 May 2004
B	Appendix A Protocol Attachment 2: deleted Tracking Run log sheet.	MWM	05 May 2004
B	Appendix A Protocol Attachment 2, Sheet 5/8: modified Radial Transect log sheet.	MWM	05 May 2004
B	Appendix A Protocol Attachment 2, Sheet 7/8: added Communications Plan.	MWM	05 May 2004
B	Appendix A Protocol Attachment 2, Sheet 7/8: added Synchronization to Ship's Time.	MWM	05 May 2004
B	Appendix A Protocol Attachment 2, Sheet 7/8: modified Verification Appendix A Protocol Attachment 2, Sheet 7/8: of "Instrument Zero".	MWM	05 May 2004
B	Appendix A Protocol Attachment 2, Sheet 7/8: added Verification of Camera Position.	MWM	05 May 2004
B	Appendix A Protocol Attachment 2, Sheet 8/8: added Time Sequenced Data Collection Task Guide.	MWM	05 May 2004

Note: Now Appendix B, Revision B

APPENDIX A – TEST PROTOCOL

SHIP'S BALLAST DISCHARGE DISPERSION BENCHMARK DYE TRACER TEST

Note: Now Appendix B, Revision B

This test protocol has been prepared for use by the vessel crew and the testing team in the field, and submittal to regulatory agencies. This protocol is a stand alone document, and is Appendix A of the testing report.

A. Dye Test Particulars (Attachment 1)

Attachment 1 provides details of the planned test. Included are details on the vessel, locations, testing dates, dye and investigators.

B. Testing Equipment Overview

1) Dye Concentration Measurement Instrumentation

Instrumentation of the discharge is to be made with YSI Incorporated instruments. A 650 multiparameter display system logger is used to drive the 600 optical monitoring system sonde. The sonde is outfitted with conductivity, temperature and rhodamine WT probes. This is attached to a 75 foot extension cable. The logger is waterproof, rated to IP-67. The sonde is suitable for depths to 200 feet. See *Vessel Prearrival* for information on hazardous zone considerations.

The sonde provides a range of 0 – 200 parts per billion (ug/L) of rhodamine. It has an accuracy of +/-5% of reading, or +/-1 ug/L which ever is greater. It has a resolution of 0.1 ug/L.

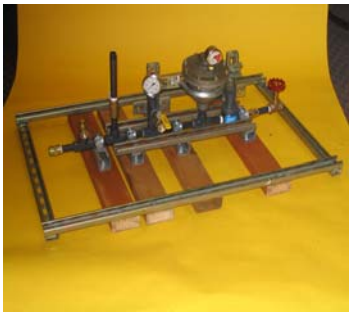
YSI 650 Multiparameter Display System, YSI 600 Optical Monitoring System sonde, and the YSI 6130 rhodamine sensor.

2) Dye Injection Equipment

The dye injection equipment consists of mobile, skid mounted assemblies, suitable for rapid deployment on board a vessel. All equipment meets the hazardous zone requirements of the US

Coast Guard, specifically Class 1, Division 1, hazardous locations as defined by National Electric Code Article 504. This equipment is capable of metering between 0.5 and 20 gallons per hour of tracer dye into the ballast main. A backpressure valve maintains constant system pressure to ensure even metering through system fluctuations. An adjustable relief valve on the discharge of the pump protects the ballast piping from over pressurization. All connections are rated to 300 pounds per square inch, maximum setting of the relief valve. The components are shown below.

Note: Now Appendix B, Revision B



Dosing tank and tracer dye transport container, Discharge manifold with pulsation dampener, Calibration tube and suction manifold.

Pump assembly with explosion-proof disconnect, 200 foot armored cable (one of two) with explosion-proof connector.

C. Dye Preparation:

To support rapid deployment on board the vessel, the dye batch should be mixed prior to team arrival on-site. A single final dilution of the dye should be made on board the vessel with seawater. This will assure near neutrally buoyant tracer dye entrainment into the ballast system. **Attachment 2 (Sheet 1/8)** details the tracer dye dilution process.

The dye concentration measuring instrumentation is to be calibrated for both rhodamine WT, and conductivity within 24 hours of deployment as per YSI instructions. **Attachment 2 (Sheet 1/8)** provides a calibration log.

D. Vessel Prearrival

The Washington Department of Ecology has approved this test protocol, their letter has been reproduced in **Attachment 5**. In compliance with the approval conditions, Glosten will fax notification to the pertinent regulatory agencies 24-hours in advance of our intention to conduct this test. **Attachment 3** lists agencies with a potential interest in advance notification of this test. **Attachment 4** details the information to be relayed to those agencies requiring notification. On the day of test execution, the agencies with required notification status will also receive a courtesy telephone call from one of the investigators.

The vessel should arrive under the following conditions:

- Ballast tank status. <u>One pair of ballast tanks should be empty</u>. These tanks should be of a capacity such that the ballast system can be regulated to discharge these tanks when full in not less than 2 hours. The vessel should be loaded/ballasted in such a manner that this tank pair can be filled and then discharged without significant counter ballasting or other operations required.

- Ballast tank access. Each of the two ballast tanks should have two separate access locations to verify the dosing concentration. Each of these accesses should provide a means of 'sounding' the tanks through substantially their full height, with a 2" diameter probe. Suitable means such as hatches or manhole covers should be removed prior to testing day.

- Ballast system. There should be a <u>single fitting (1/4" or larger)</u> available for injecting dye into the suction main (preferred) or discharge main. This connection will be plumbed with gear brought aboard for this testing, and injected with dye at a rate of less than 20 gallons per hour, while the ballast tanks are being filled.

- Electrical, dosing equipment. The testing equipment runs on <u>120 Vac, 1 phase, 60 Hertz</u>, with a full load draw of 5.8 amps. A <u>standard three prong outlet supplied by at least a 15 amp breaker</u> in a safe location is needed to support this equipment. The test equipment is also outfitted for a 3 prong explosion proof outlet suitable for connection to a mating connection in a hazardous zone. The testing equipment has 2 x 200 feet of armored cable. All electrical dosing gear is manufactured and assembled suitable for Class 1, Division 1 locations.

- Electrical, testing equipment. A battery powered probe and logger is used to verify the dye concentration of the ballast water after dosing. This unit has not been tested for use in Class 1, Division 1 locations. However, we have used this probe and logger in Class 1, Division 1 locations on vessels where a Class 3 hot work permit has been issued. <u>We need to know if we can use the probe and logger in way of the ballast tank access.</u> If not, other less advantageous arrangements can be made. To assist this decision, please consider the following:

    - The National Electric Code Article 504, referred to by Code of Federal Regulations, allows use of certain equipment of low power generation in Class 1,

Note: Now Appendix B, Revision B

Division 1 locations without being listed as suitable for these locations. The criteria for this states "… does not generate more than 1.5 volts, 100 milliamps, and 25 milliwatts …"

- The logger, YSI model 650 MDS, runs on 50.5 milliamps, and is powered at 6 volts. The logger has an IP67 enclosure (Dust proof, protected from temporary immersion in water 1 meter deep for 30 minutes).

- The probe, YSI model 600 OMS-0, is powered by the logger, and is rated to 90 meters immersion in water.

- Information. The following information is requested to assist equipment set-up and analysis of results:

  - Ballast tank pair capacity,

  - Ballast system expected flow rate at test conditions,

  - Ballast overboard, detailed construction drawing (size, orientation, schedule),

  - Ballast overboard position relative to vessel hull, and relative to expected waterline at test conditions,

  - Ballast connection position in system, size, and fitting type (i.e. 1-1/4" NPT female coupling).

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E. Dosing Tanks (5 – 6 Hours):

Dosing of the tanks is achieved by metering in dye while an initially empty pair of tanks are being filled. This may be conducted at any time before the discharge monitoring event. This pair need be filled only until there is at least two hours of discharge available.

- Set-up (90 minutes): Place four equipment pallets on board. Connect dye feed tank, suction and discharge manifolds, discharge connection to ballast system. Make electrical connection. Discuss plan with vessel operators.

- Dose tank pair (depends on system, estimate 3 hours): Tank pair is to be filled as per standard vessel practice, allowing only the filling of this tank pair. No other tanks may be filled at this time. It is acceptable to stop filling this tank pair, perform other ballast operations, and then resume filling tank pair. While the tank pair is being filled, the dosing system will meter dye into the ballast main on a continuous basis, specifically matching the ballasting rate. Tank pair only need be filled enough to allow a minimum of two hours of discharge. The metering rates and log sheets are given in **Attachment 2 (Sheets 2/8 and 3/8)**.

  - It is important that the injection piping is purged with the tracer dye prior to starting filling the tank pair. **Attachment 2 (Sheet 2/8)** provides guidance on volumes to be displaced. Additionally, it is important that the ballast main is purged with traced dye water prior to filling. As such, it is desirable that the ballast system be aligned to take suction from the sea, and discharge to the sea during this purging period.

- Verify dye concentration/dosing system breakdown (90 minutes): These two operations will take place at the same time. Once the tank pair is full with dyed ballast water, they need to be sampled with the electrical testing gear through the ballast tank accesses. Following completion of the "instrument zero" verification detailed in **Attachment 2 (Sheet 7/8, page 1)**, two vertical profiles will be taken. Readings of each profile are to be recorded in the log every ten feet, detailed in **Attachment 2 (Sheet 4/8)**. The first objective is to assure that there is an even distribution of the dye through the tank. The second objective is to identify the start concentration of the ballast water. This start concentration, when compared to concentrations upon discharge will determine the dilution ratios. Four equipment pallets to be taken off board.

Note: Now Appendix B, Revision B

F. Discharge Monitoring (3 – 4 Hours):

Discharge monitoring is the process of measuring dye concentrations in the sea as ballast water is discharged overboard. At the overboard, a three person team in a dingy will trace a radial pattern measuring dye concentrations in the sea. On board the vessel, a single team member will provide communications with the dingy. The following outlines this process:

- Coordination of placing team member aboard, establishing vessel communications, and synchronizing participant clocks. Log sheets for these activities are provided in **Attachment 2 (Sheet7/8, page 1)**.
- Set-up (performed during dosing tanks event – 60 minutes): Measurement of start event current, wind, and sea state. Establishment of an instrument "zero" by taking fluormetric background measurements of the sea surrounding the vessel. Log sheets for these respective activities are provided in **Attachment 2 (Sheets 6/8 and 7/8, page 1)** .
- Place magnets on vessel hull for measurement of radial tracing pattern. Mark hull in way of overboard, and 50 feet forward and aft with non-permanent paint or chalk. Subject to the Master's approval, additional markings may be made to assist the skiff operator align position. Place a calibrated digital VCR camera at deck location above overboard discharge. Record camera position in **Attachment 2 (Sheet 7/8, pg 2)**. Coordinate discharge event start.
- QA/QC verification of photochemical decay and adsorption of organic solids.
    - For photochemical decay: transfer a solution of dyed sea water into a clear sample bottle. Record dye concentration before and after study period. Keep sample submerged, below the water's surface alongside host vessel, for the duration of the discharge period. A log sheet for this exercise is provided in **Attachment 2 (Sheet 7/8, page 2)**.
    - For adsorption of organic solids: transfer a solution of dyed sea water into a dark sample bottle. Record dye concentration before and after study period. Keep sample submerged, below the water's surface alongside host vessel, for the duration of the discharge period. A log sheet for this exercise is provided in **Attachment 2 (Sheet 7/8, page 2)**.
- Check that, prior to the start of the discharge event, all Enviromental Data, Tank Dye Concentration Reading, and QA/QC verification has been completed. To assist the team in consequtively managing these tasks, a time sequence checklist has been included **Attachment 2 (Sheet 8/8)**.

- Discharge sampling (depends on system, minimum 2 hours, estimate 3 hours): While vessel is discharging, team will use a pre-measured control line attached to vessel by means of a magnet to trace a radial pattern around the vessel ballast overboard. Log sheets for this exercise are provided in **Attachment 2 (Sheet 5/8)**.
    - It is not known how long it will take for the discharge plume to reach steady state. Twenty minutes after the discharge has started, the team will assume steady state and begin readings, starting at the point furthest from the end-of-pipe.
    - It is not known if the plume will be a cohesive jet, a diffusing flow, or both within the 50 feet area from the end-of-pipe. As such, the test strategy will rely on a series of methodical sweeps with full vertical profiles taken at 9 radial locations within each sweep sortie:
        - A **methodical sweep** of the area will canvas the 50 foot radial area. The first sweep at 50 feet will be made by performing a single vertical profile at Position 0 located directly outboard of the discharge. Adjacency to the overboard and all subsequent other positions will be documented through use of the calibrated digital VCR camera that has been secured to the vessel's rail. The dingy will then be maneuvered to vertically profile Position +1, approximately 22.5° forward relative to the overboard discharge. This process will then be repeated by maneuvering the dingy forward through Positions +2 (45°), +3 (67.5°), and +4 (90°) and then maneuving aft to Positions –1 through –4.To minimize time and reading instability, the sonde will remain submerged at its last depth when transiting between positions. The sonde will be allowed 5-seconds to stabilize at each depth before readings will be recorded on the log sheet. Subsequent sweeps are to be made at 35, 25, 20, 15, and 10 feet.
        - A second completed series of radial data sweeps will be attempted prior to stripping the dyed ballast tanks.
    - Visual reviews of wider dispersion will be made from the vessel bridge. These will be followed up with testing of concentrations of visual sites by the dingy.

Note: Now Appendix B, Revision B

Note:
Now Appendix B, Revision B

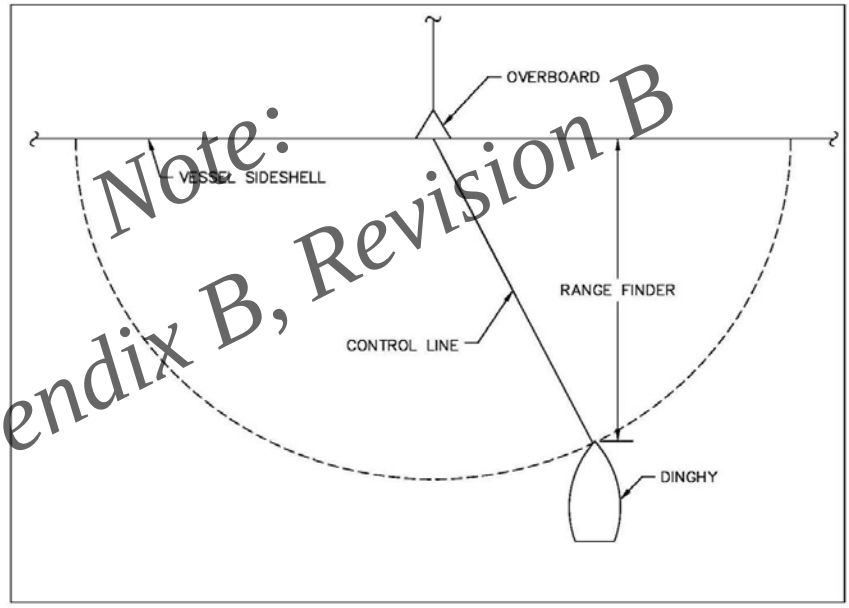

Diagram showing use of control line to set radial distance from end-of-pipe.

Control line use in field, Dosing equipment deployed on product carrier.

- In the event of a failure of the rhodamine WT probe, NISKIN bottle samples will be drawn. A string of three ½ liter bottles will be used to gain samples. At 10, 30 and 50 foot depth intervals, samples will be drawn at outboard, 45 degree forward, and 45 degree aft positions from the overboard, at 50, 30, 20, and 10 feet from the overboard.
- Environmental data will be gained by the setting of a current drogue by the dingy team before and after the discharge event. In addition, environmental data will be gained from the vessel navigation suite and crew. See **Attachment 2 (Sheet 6/8)**.
- Sampling breakdown (vessel interaction – 30 minutes, after vessel departs – 30 minutes): Pick-up person on board the vessel. Measurement of end event current and wind.

Note: Now Appendix B, Revision B

ATTACHMENT 1
DYE TEST PARTICULARS

Vessel	Name:	Groton
	Owner:	United States Shipping, LLC
	Particulars:	Oil Tank Barge, Single Hull, US Flag
		48,067 long ton deadweight
		691'-02" length overall
		375,145 barrel cargo capacity
Location:		Washington State, Puget Sound
	Primary:	Port of Port Angeles, Anchorage
	Secondary:	Anacortes, March's Point, Refinery Docks
Testing Date:		Three tests maximum between February and June 2004, data below is for one test.
Investigator:		The Glosten Associates, Inc., Seattle, Washington
	Primary:	Kevin J. Reynolds
	Secondary:	Maurice W. McCarthy
Dye,	Generic Name:	Rhodamine WT
	Trade Name:	Intracid Rhodamine WT Liquid, A34517L100 Tracer Dye
	Transport/Injection:	1-1/4% concentration, premixed for testing event
		0-0.31% concentration, prior to entrainment into ballast stream
	Vessel Discharge:	200 uG/L (parts per billion), entrained in ballast stream, end-of-pipe value, maximum concentration 1, 2
		2,000 metric tons per hour, maximum rate 1
		10,000 metric tons, maximum volume 1
		1.8 grams, maximum dye discharge 1

Note 1: Rate, volume, and dye discharge are based on Steam Tanker Tonsina particulars, and are listed here as maximums. Groton values may be less.

Note 2: Maximum concentration is end-of-pipe value, which does not consider dilution due to mixing upon discharge.

ATTACHMENT 2
LOG SHEETS

Note:
Now Appendix B, Revision B

1. **Dye Dilution Prep Worksheet/ Meter Calibration Check**
2. **Dosing Pump Set Point Chart/ Total Rhodamine Wt Added**
3. **Dosing Pump Log Record**
4. **Tank Dye Concentration Readings**
5. **Radial Transect Log**
6. **Environmental Data Log**
7. **QA/QC Verification Supporting Data**
8. **Time Sequenced Task Guide**

Now Appendix B, Re

DYE DILUTION PREP WORKSHEET

Dilution Step	Initial			Diluent		Working			
	Gal.	Sp.Gr.	uG/L	Gal.	Sp.Gr.	Gal.	uG/L	%	Sp.Gr
Intracid 20%	5	1.150	2.30E+08	0	0.000	5	2.30E+08	20	1.150
First Dilution	1	1.150	2.30E+08	3	1.000	4	5.75E+07	5	1.038
Second Dilution	4	1.038	5.75E+07	12	1.000	16	1.44E+07	1.25	1.009
---Final dilution with seawater, prior to injection									
Final Dilution	5	1.009	1.44E+07	15	1.025	20	3.59E+06	0.3125	1.021

* Fill out only highlighted cells in worksheet
** Gal. is Gallons
*** Entered data is ideal for dosing systems with 750 tons/hour capacity, and suitable up to 1,500 tons/hr.

Conversions

1 Gallon = x liters	*3.78541*	
1 Barrel = x liters	*158.987*	
1 metric ton = x liters	*1000*	*volumetric (sea and fresh)*

METER CALIBRATION CHECK

Date/Signature	Test Performed	Notes
	2 Point Rhodamine WT	
	2 Point Conductivity	

* Calibration should be less than 24 hours prior to testing.

Now Appendix B, Re

DOSING PUMP SET POINT CHART

Target Concentration (uG/L) **1.80E+02**
Tracer Solution (uG/L) **3.59E+06**

Ballast Pump Rate			Dose Pump Rate	
Ton/hr	Bbl/hr	Gal/min	Gal/hr	Gal/min
200	1,258	881	2.6	0.04
300	1,887	1,321	4.0	0.07
400	2,516	1,761	5.3	0.09
500	3,145	2,201	6.6	0.11
600	3,774	2,642	7.9	0.13
700	4,403	3,082	9.3	0.15
800	5,032	3,522	10.6	0.18
900	5,661	3,963	11.9	0.20
1,000	6,290	4,403	13.2	0.22
1,100	6,919	4,843	14.6	0.24
1,200	7,548	5,283	15.9	0.26
1,300	8,177	5,724	17.2	0.29
1,400	8,806	6,164	18.5	0.31
1,500	9,435	6,604	19.8	0.33

Purge Volumes				
diameter	0.25	0.50	1.00	inch
area	0.20	0.39	0.79	inch^2
length	100.00	100.00	100.00	feet
volume	235.50	471.00	942.00	inch^3
	1.02	2.04	4.08	gallons

TOTAL RHODAMINE WT ADDED

Target Concentration (uG/L) **1.80E+02**

Ballast Tank Capacity				Added
Tons	Bbls	Gallons	Liters	Grams
100	629	26,417	1.00E+05	-
200	1,258	52,834	2.00E+05	-
300	1,887	79,252	3.00E+05	-
400	2,516	105,669	4.00E+05	-
500	3,145	132,086	5.00E+05	-
600	3,774	158,503	6.00E+05	-
700	4,403	184,920	7.00E+05	-
800	5,032	211,338	8.00E+05	-
900	5,661	237,755	9.00E+05	-
1000	6,290	264,172	1.00E+06	-
1500	9,435	396,258	1.50E+06	-
2000	12,580	528,344	2.00E+06	-
2500	15,725	660,430	2.50E+06	-
3000	18,869	792,516	3.00E+06	-
3500	22,014	924,602	3.50E+06	-
4000	25,159	1,056,688	4.00E+06	-
4500	28,304	1,188,774	4.50E+06	-
5000	31,449	1,320,861	5.00E+06	-
5500	34,594	1,452,947	5.50E+06	-
6000	37,739	1,585,033	6.00E+06	-
7000	44,029	1,849,205	7.00E+06	-
8000	50,319	2,113,377	8.00E+06	-
9000	56,608	2,377,549	9.00E+06	-
10000	62,898	2,641,721	1.00E+07	-

Now Appendix B, Re

DOSING PUMP LOG RECORD

Target Concentration (uG/L) **1.80E+02** **Test Date:**

Tracer Solution (uG/L) **3.59E+06**

Time	Tanks Dosing	Ballast Pump Rate			Dose Pump Rate		Notes (Track dye quantities)
		Ton/hr	Bbl/hr	Gal/min	Gal/hr	Gal/min	

Now Appendix B, Re

Tank Dye Concentration Readings

***Take two soundings for each tank after dosing ballast water. Readings at least every ten feet.**

Tank 1 ( ) Location 1 ( )		Tank 1 ( ) Location 2 ( )		Tank 2 ( ) Location 1 ( )		Tank 2 ( ) Location 2 ( )	
Level	**uG/L**	**Gallons**	**Liters**	**Level**	**uG/L**	**Gallons**	**Liters**
Average		Average		Average		Average	

Now Appendix B, Re

Radial Transect Log (circle one) 50, 35, 25, 20, 15, 10 Foot

Position	Aft - 4	- 3	- 2	-1	Abeam 0	+ 1	+ 2	+ 3	Fwd + 4
Start Time									
GPS Way Point									
2 Ft Conductivity (uS/cm)									
Rhodamine WT (uG/L)									
2 FT									
10 FT									
20 FT									
30 FT									
40 FT									
50 FT									
60 FT									
70 FT									
Stop Time									
70 Ft Conductivity (uS/cm)									
Notes:									

Now Appendix B, Re

Environmental Data Log

Date:

Navigation Bridge Data	Time	Vessel		Current		Sea State	Wind Heading	Wave Heading
		Position	Heading	Direction	Heading			
Filling Start								
Filling Complete								
Discharge Start								
Plus 1 Hour								
Plus 2 Hours								
Plus 3 Hours								
Discharge Complete								

Testing Crew Data
20 Minute Test Prior to Discharge Event

Drogue Height	
Set Drogue Time	
Set Drogue Position	
Retrieve Drogue Time	
Retrieve Drogue Position	

Testing Crew Data
20 Minute Test Following Discharge Event

Drogue Height	
Set Drogue Time	
Set Drogue Position	
Retrieve Drogue Time	
Retrieve Drogue Position	

Now Appendix B, Re

QA / QC Verification
Supporting Data

SECTION 1 - COMMUNICATIONS PLAN

Comm Type	Vessel	Skiff	Investigator (Deck)
VHF Channel			
2-Way *Talkabout* Radio Channel			
Cell Phone	**Prohibited**		**Prohibited**

SECTION 2 - SYNCHRONIZATION TO SHIP'S TIME

Time Piece	Time	Initials
Ship's Time		
Investigators' Time		
Data Logger Time		
Sonde Time		

SECTION 3 - VERIFICATION OF "INSTRUMENT ZERO"

Radial Sweep 1	Time:		Distance from pipe:			
Depth	Position -3 Aft		Position 0		Position +3 Fwd	
2'		ug/L		ug/L		ug/L
10'						
20'						
30'						
40'						
50'						
60'						
70'						

Radial Sweep 2	Time:		Distance from pipe:			
Depth	Position -3 Aft		Position 0		Position +3 Fwd	
2'		ug/L		ug/L		ug/L
10'						
20'						
30'						
40'						
50'						
60'						
70'						

Now Appendix B, Re

SECTION 4 - EVALUATION OF PHOTOCHEMICAL DECAY

Light Bottle Procedure	
Finish Time: _____	Rhodamine Concentration: _____ ug/L
Start Time: _____	Rhodamine Concentration: _____ ug/L
Elapsed Time: _____	

SECTION 5 - EVALUATION OF SORPTION

Dark Bottle Procedure	
Finish Time: _____	Rhodamine Concentration: _____ ug/L
Start Time: _____	Rhodamine Concentration: _____ ug/L
Elapsed Time: _____	

SECTION 6 - VERIFICATION OF CAMERA POSITION

Camera Position	
Finish Time: _____	Height of Camera Above Waterline_____
Start Time: _____	Position of Camera Relative to Control Line Magnets_____
Elapsed Time: _____	

Now Appendix B, Re

Time Sequenced
Data Collection Task Guide

Task No.	Log Sheet No.	Description	Time Completed
1	7/8	Communication Plan and Time Synchronization	
2	6/8	Opening Environmental Data	
3	7/8, Pg 1/2	Instrument Zero	
4	7/8, Pg 2/2	Log VCR Position	
5	6/8	Opening Drogue Measuremnt	
6	4/8	Tank Dye Concentrations	
7	7/8, Pg 2/2	Opening Photochemical Decay	
8	7/8, Pg 2/2	Opening Sorption	
9	5/8	Radial Transects	
10	6/8	Periodic Environmental Data	
11	6/8	Closing Drogue Measurements	
12	7/8, Pg 2/2	Closing Photochemical Decay	
13	7/8, Pg 2/2	Closing Sorption	
14	6/8	Closing Environmental Data	

Now Appendix B, Re

Dispersion Study
Regulatory Contact List

No.	Agency	Tel. No.	Fax No.	E-Mail	Comments
REQUIRED NOTIFICATION					
1	US Coast Guard, MSO Puget Sound Marine Environmental Protection Branch Lt. Tedd Hutley	206-217-6164 (DID) 206-217-6002 (24/7)	206-217-6345	thutley@pacnorwest.uscg.mil	Notify for all Puget Sound locations.
2	Washington Department of Ecology Northwest Regional Office Donna Musa	425-649-7229	425-649-7098	dmusa461@ecy.wa.gov	Notify for Skagit and Whatcom counties.
3	Washington Department of Ecology Southwest Regional Office Jeri Berube	360-407-6311	360-407-6305	jber461@ecy.wa.gov	Notify for Clallam and Pierce counties.
4	US Coast Guard Vessel Traffic - Operations	206-217-6046 206-217-6025	206-217-6058	N/A	Notify as a courtesy.
	US Coast Guard Vessel Traffic - Center	206-217-6152	206-217-6058	N/A	
5	Clallam County Sheriff	360-452-7836 x1	360-417-2498	sheriff@co.clallam.wa.us	
6	Skagit County Sheriff	360-336-9450	360-336-9455	sheriff@co.skagit.wa.us	
ADDITIONAL AGENCY CONTACTS					
7	US Coast Guard Captain of the Port	206-217-6200 x2	206-217-6345	N/A	Notification not required as undertaken by MSO-MER.
8	Port of Port Angeles	360-457-8527	360-452-3959	www.portofpa.com	
9	Clallam County Emergency Management	360-417-2525	360-417-2485	dbrennan@co.clallam.wa.us jciarlo@co.clallam.wa.us lyarnes@co.clallam.wa.us	
10	Port of Anacortes	360-293-3134	360-293-9608	www.portofanacortes.com	
11	Skagit County Emergency Management	360-428-3250	N/A	dem@co.skagit.wa.us	
12	Whatcom County Sheriff	360-676-6650	360-738-2494	sheriff@co.whatcom.wa.us	

Now Appendix B, Re

Dispersion Study
Regulatory Contact List

No.	Agency	Tel. No.	Fax No.	E-Mail	Comments
13	Whatcom County Emergency Management	360-676-6681	N/A	dem@co.whatcom.wa.us	
14	Washington Department of Emergency Management	800-258-5990	N/A		

Note:
Now Appendix B, Revision B

Appendix A
Test Protocol Attachment 4

Regulatory Notification Fax

600 Mutual Life Building
605 First Avenue
Seattle, WA 98104-2224

THE GLOSTEN ASSOCIATES

Tel. 206-624-7850
Fax 206-682-9117

[redacted]

Fax

Note:
Now Appendix B, Revision B

To:	Jeff Berube / Ecology SW Region	From:	M.W. (Mac) McCarthy
	Donna Musa / Ecology NW Region		Cell: 206-369-0206
	Lt. Tedd Hutley / MEP-MSO Puget Sound		
Fax:		Pages:	1
Phone:		Date:	5/13/2004
Re:	24-Hour Notice of Rhodamine Dye Use	CC:	

☐ Urgent X For Review ☐ Please Comment ☐ Please Reply ☐ Please Recycle

This is to provide regulatory agencies with 24-hour notice of our intention to conduct an engineering field study involving the discharge of Rhodamine WT dye. This study will be executed from a ship at anchor as specified below:

Vessel Name: _____

Anchorage Location: Port Angeles Harbor

Study Date: _____

Time: _____

Dye Color: Red Fading to Pink

Estimated Time Noticeable in Water: 3 – 4 Hours

Prior to beginning operations on the day of the fieldwork, we will also place a confirming telephone call to your office. Please call me directly on my cell phone (206-369-0206) if you require additional information.

Note: Now Appendix B, Revision B

Attachment 5

Washington State Department of Ecology,

Protocol Acceptance Letter,

2 March 2004

Randy Marshall
Reader File

FAX

FILE COPY

MAR 0 8 2004

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
TTY (711) or 800-833-6388 (For the Speech or Hearing Impaired)

FILE NO. 03104

March 2, 2004

Post-it® Fax Note 7671	Date 3/8/04	# of pages ▶ 2
To Kevin J. Reynolds	From Randall Marshall	
Co./Dept. The Glosten Assoc.	Co. Dept of Ecology	
Phone # (206) 624-7850	Phone # (360) 407-6445	
Fax # (206) 682-9117	Fax # (360) 407-6426	

Kevin J. Reynolds, P.E.
The Glosten Associates, Inc.
600 Mutual Life Building
605 First Avenue
Seattle Washington 98104-2224

Note: Appendix B, Revision B
Now

Dear Mr. Reynolds:

We have reviewed the protocol for the ballast water dispersion study and found it to be a good and well-written plan. The protocol is acceptable and may be conducted as written. However, we believe that the ideas in the following comments can be used to strengthen the study and recommend that they be considered. The use and discharge of rhodamine dye is approved as long as the concentration is kept to the minimum that is effective under the study circumstances and the notification requirements below are followed.

General comment on the study:

The dilution factors will be used in the interpretation of ballast water biocide toxicity test results. The study will be conducted in nearly neutral buoyant conditions. The discharge port will be submerged with low discharge velocity. The study will be conducted, if possible, under conditions of low wind speed and low ambient current velocity. The study location will have minimum waterway obstructions. To prevent dye buildup due to tidal reflux, the study period will be short and likely during period of slack tide.

Specific comments on the study:

1. The purpose of the study is not to support the establishment of any mixing zone for ballast water discharges. WDFW is studying many different types of ballast water treatment in order to determine which can meet their regulatory standards for removal of invasive species and be practical for the shipping industry to use. Some of these treatment technologies involve biocides and some of the biocides may need to be toxic at discharge in order to meet the WDFW standards. The task is to set an upper limit on this toxicity. In order to do that, we need to have some estimates of the immediate dilution of ballast water as it is being discharged.
2. Given the ambient and discharge conditions sought in this study, it is likely that critical condition (when the dilution is the lowest) may not be present during the study. Mixing zone models are used widely to predict dilution factors under critical conditions following calibration with dye study results. Although it is understandable that not

every discharge configuration can be modeled, some information on the use of a model should be included and justified.

3. If a model is used, what will be the limitations, e.g. can it be used for all types of discharge outlets and ambient conditions?
4. It is not clear whether the dye study results will be used only for vessels with similar discharge configuration, i.e. submerged seachest discharges. A ballast discharge from a free flowing port may not result in similar dilution.
5. Prior to commencing the dye study, background measurements should be made to establish instrument "zero".
6. Although the study period is short and any dye degradation, due to light, is likely to be insignificant, a statement to this effect should be included and justified. Alternately, a light bottle with the dyed sea water can be submerged in the sea and dye concentrations measured before and after the study period.
7. Rhodamine dye is known to be adsorbed by organic solids. Although the dye will be added to sea water and any adsorption to organic solids, if any, would likely take place in the ballast tanks, an accurate measurement can be made by placing a dark bottle containing dyed sea water in the sea for the duration of the study and measuring the dye concentration before and after the study period.
8. Actual dilution factors take in to account the background concentration of the pollutant. Ballast discharge in an area where recent historical discharge (with biocide) has occurred will reduce available dilution for the new discharge. Therefore, if discharge is to this area, background concentration of biocide should be accounted for. Some information on recommended time-period between two ballast discharges should be made. Alternately, the time for complete dissipation/degradation of the biocide (i.e. negligible ambient biocide concentration) should be estimated.

Note Appendix B Revision B

Notification of dye tests in Puget Sound:

- Notify the United States Coast Guard. In order for them to send a broadcast notice to mariners, they need to know the time, date, location, color of dye, and how long it is expected to be noticeable to the mariners.
- Notify the Captain of the Port and Vessel Traffic Service. They will notify whomever they deem appropriate.
- Notify Department of Ecology's appropriate Regional Office (either Northwest or Southwest).
- Notify the local county sheriff's office.
- Provide project contact name and phone number to all of the above agencies.

If you have any questions, please call me at 360-407-6445 or e-mail at rmar461@ecy.wa.gov. Good luck and we look forward to seeing the study report.

Sincerely,

Randall Marshall

Randall Marshall
WET Coordinator

cc: Scott Smith, WDFW Aquatic Nuisance Species Coordinator

Appendix A
Attachment 6

Selected Bibliography

Note: Now Appendix B, Revision B

1. **Smart, P.L. and Laidlaw, I.M.S. An Evaluation of Some Fluorescent Dyes for Water Tracing. *Water Resources Research*, 13(1), 15, 1976.**

2. **Turner Designs. A Practical Guide to Flow Measurements. Sunnyvale, CA.**

3. **Turner Designs. Preparation of Standards for Dye Studies Using Rhodamine WT . Sunnyvale, CA.**

4. **U.S. EPA, Study Plan for Washington Aqueduct Water Quality Studies. Cover letter, pages 5 and 6, June 24, 1999.**

5. **U.S. Geological Survey, PROGRAMS AND PLANS—Dyes for Water Tracers. *Surface Water Technical Memo No. 86.08,* , July 21, 1986.**

6. **U.S. Geological Survey, Rhodamine WT Reader: Readings on the Reactivity and Transport Characteristics of This Tracer. Revised October 7, 2002.**

7. **Wilson, J. F., Jr. Fluorometric Procedures for Dye Tracing, Techniques for Water Resources Investigations of the U.S. Geological Survey, Book 3, Applications of Hydraulics, Chapter A12: VIII, U.S. Government Printing Office, Washington, D.C. (1968).**

8. **YSI Environmental. Water Tracing, *In Situ* Dye Fluorometry and the YSI 6130 Rhodamine WT Sensor .**

Appendix C – Environmental Regulations

TABLE OF CONTENTS

1. General Description
2. Letter from Randall Marshall, WET Coordinator, Dept. of Ecology to Kevin Reynolds, The Glosten Associates, dated March 2, 2004
3. Letter from Randall Marshall, WET Coordinator, Dept. of Ecology to Kevin Reynolds, The Glosten Associates, dated June 28, 2004
4. Email from Randall Marshall, WET Coordinator, Dept. of Ecology to Kevin Reynolds, The Glosten Associates, dated September 17, 2004
5. Dye Test Particulars (15 September 2004 Revision)
6. Letter from D. Ellis, United States Coast Guard, dated June 7, 2004
7. Email from Joan Cabreza, EPA Region 10 to Mac McCarthy, The Glosten Associates, dated June 8, 2004

GENERAL DESCRIPTION

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A. Discharge of Pollutants - Overview 3

B. General Information – Rhodamine Wt Properties: 3

I. REGULATORY ENVIRONMENTAL CONSIDERATIONS

Merchant vessels, and in particular product carriers, are sensitive to environmental considerations. Discharges from these vessels are closely monitored, including bilge and ballast water, black and grey water, and circulating water. The discharge of ballast water traced with rhodamine WT required special consideration. This consideration resulted in the submittal of the protocol in this report for approval to the regulatory agencies with juristiction in the test area. These agencies are Washington State Department of Ecology (DOE), and the United States Captain of the Port, Puget Sound (COP). There approval/acknowlegdement letters are attached in the Protocol appendix.

A. Discharge of Pollutants - Overview

Discharge of pollutants are specified by Washington State Law. The below sections are the definitions of prohibited discharges and pollution:

> **RCW 90.48.080**
> **Discharge of polluting matter in waters prohibited.**
>
> *It shall be unlawful for any person to throw, drain, run, or otherwise discharge into any of the waters of this state, or to cause, permit or suffer to be thrown, run, drained, allowed to seep or otherwise discharged into such waters any organic or inorganic matter that shall cause or tend to cause pollution of such waters according to the determination of the department, as provided for in this chapter.*
>
> **RCW 90.48.020**
> **Definitions.**
>
> *Whenever the word "pollution" is used in this chapter, it shall be construed to mean such contamination, or other alteration of the physical, chemical or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.*

It is understood that a list of "approved non-pollutants" does not exist. The past history of rhodamine WT indicates that it has not previously been considered a pollutant. Glosten has received assurances from COP and DOE that this tracer dye is routinely used without incident. However, neither COP or DOE have the authority to prevent an individual or group from making a case that rhodamine WT is a pollutant.

B. General Information – Rhodamine Wt Properties:

Rhodamine WT was specifically selected for this testing due to its widespread usage, and suitability for this work. **Attachment B** provides the material safety data sheet

and the specifications for Intracid rhodamine WT used in this test. The Keystone specifications are provided for further information.

Dr. Joseph A. Cotruvo of the EPA sent the following letter in August 1988 to J. Warnquist, of Crompton and Knowles, a dye manufacturer:

> The Criteria and Standards Division (Office of Drinking Water) has reviewed the available data on chemistry and toxicity of Rhodamine dyes. We would not anticipate any adverse health effects resulting from the use of Rhodamine WT as a fluorescent tracer in water flow studies when used with the following guidelines.
>
> - A maximum concentration of 100 micrograms/liter Rhodamine WT is recommended for addition to raw water in hydrological studies involving surface and ground waters.
> - Dye concentration should be limited to 10 micrograms/liter in raw water when used as a tracer in or around drinking water intakes.
> - Concentration in drinking water should not exceed 0.1 micrograms/liter. Studies which result in actual human exposure to the dye via drinking water must be brief and infrequent. This level is not acceptable for chronic human exposure.
> - In all of the above cases, the actual concentration used should not exceed the amount required for reasonably certain detection of the dye as required to accomplish the intended purpose of the study.
>
> The Criteria and Standards Division recommends that Rhodamine B not be used as a tracer dye in water flow studies.
>
> This advisory supersedes all earlier advisories issued by EPA on the use of fluorescent dyes as tracers in water flow studies. This advisory is granted on a temporary basis only. EPA is terminating its voluntary additives advisory program as announced in the Federal Register (53 FR, 25586, July 7, 1988). A copy of the Federal Register Notice is enclosed for your convenience. All EPA advisory opinions issued within the framework of the additives program will expire on April 7, 1990.

It is important to note that the above advisory is in way of water which may enter the potable water supply. This testing will be conducted in a saltwater harbor or port environment. Specific to impact on aquatic organisms, the US Geological Survey publication TWI 3 – A12, Fluorometric Procedures for Dye Tracing, details an extensive list of biological studies of the effect of rhodamine WT. A summary is tabluated below:

Biota	Concentration (ug/L)	Exposure Time	Effects	Test
Pacific Oyster eggs and 12 day old larvae	1 - 10,000	Eggs to larvae formation, and larvae to survival	No abnormalities	Parker, 1973
Silver Salmon, Donaldson Trout	10,000 and 375,000	17.5 and 3.2 hours	No mortalities or other problems	Parker, 1973
Rats	Drinking-water solution of 10 ug/L	Slight loss of body weight and some effect on certain body organ-specially the liver-when the rats were given this solution for a prolonged time		D.E. Donaldson (U.S. Geological Survey, written commun. cited by Wilson, 1968b, p. 6, 2nd by Smart and Laidlaw, 1977, p. 30)
Water lea (Daphnia magna), shrimp (Gammarus zad-Ilachl], log louse (Asellus aquaticus), may fly (Cloeon dip terum), and pea mussel (species visidium)	Up to 2,000,000	Up to 1 week	No significant differences in mortality between the test and control animals were observed	J.S. Worttley and T.C. Atkinson (reported as personal commun., 1975, in Smart and Laidlaw, 1977)

Randy Marshall
Reader File

FAX

FILE COPY

MAR 0 8 2004

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
TTY 711 or 800-833-6388 (For the Speech or Hearing Impaired)

FILE NO. 03104

March 2, 2004

Post-it® Fax Note 7671	Date 3/8/04	# of pages ▶ 2
To Kevin J. Reynolds	From Randall Marshall	
Co./Dept. The Glosten Assoc.	Co. Dept of Ecology	
Phone # (206) 624-7850	Phone # (360) 407-6445	
Fax # (206) 682-9117	Fax # (360) 407-6426	

Kevin J. Reynolds, P.E.
The Glosten Associates, Inc.
600 Mutual Life Building
605 First Avenue
Seattle Washington 98104-2224

Dear Mr. Reynolds:

We have reviewed the protocol for the ballast water dispersion study and found it to be a good and well-written plan. The protocol is acceptable and may be conducted as written. However, we believe that the ideas in the following comments can be used to strengthen the study and recommend that they be considered. The use and discharge of rhodamine dye is approved as long as the concentration is kept to the minimum that is effective under the study circumstances and the notification requirements below are followed.

General comment on the study:

The dilution factors will be used in the interpretation of ballast water biocide toxicity test results. The study will be conducted in nearly neutral buoyant conditions. The discharge port will be submerged with low discharge velocity. The study will be conducted, if possible, under conditions of low wind speed and low ambient current velocity. The study location will have minimum waterway obstructions. To prevent dye buildup due to tidal reflux, the study period will be short and likely during period of slack tide.

Specific comments on the study:

1. The purpose of the study is not to support the establishment of any mixing zone for ballast water discharges. WDFW is studying many different types of ballast water treatment in order to determine which can meet their regulatory standards for removal of invasive species and be practical for the shipping industry to use. Some of these treatment technologies involve biocides and some of the biocides may need to be toxic at discharge in order to meet the WDFW standards. The task is to set an upper limit on this toxicity. In order to do that, we need to have some estimates of the immediate dilution of ballast water as it is being discharged.
2. Given the ambient and discharge conditions sought in this study, it is likely that critical condition (when the dilution is the lowest) may not be present during the study. Mixing zone models are used widely to predict dilution factors under critical conditions following calibration with dye study results. Although it is understandable that not

every discharge configuration can be modeled, some information on the use of a model should be included and justified.

3. If a model is used, what will be the limitations, e.g. can it be used for all types of discharge outlets and ambient conditions?
4. It is not clear whether the dye study results will be used only for vessels with similar discharge configuration, i.e. submerged seachest discharges. A ballast discharge from a free flowing port may not result in similar dilution.
5. Prior to commencing the dye study, background measurements should be made to establish instrument "zero".
6. Although the study period is short and any dye degradation, due to light, is likely to be insignificant, a statement to this effect should be included and justified. Alternately, a light bottle with the dyed sea water can be submerged in the sea and dye concentrations measured before and after the study period.
7. Rhodamine dye is known to be adsorbed by organic solids. Although the dye will be added to sea water and any adsorption to organic solids, if any, would likely take place in the ballast tanks, an accurate measurement can be made by placing a dark bottle containing dyed sea water in the sea for the duration of the study and measuring the dye concentration before and after the study period.
8. Actual dilution factors take in to account the background concentration of the pollutant. Ballast discharge in an area where recent historical discharge (with biocide) has occurred will reduce available dilution for the new discharge. Therefore, if discharge is to this area, background concentration of biocide should be accounted for. Some information on recommended time-period between two ballast discharges should be made. Alternately, the time for complete dissipation/degradation of the biocide (i.e. negligible ambient biocide concentration) should be estimated.

Notification of dye tests in Puget Sound:

- Notify the United States Coast Guard. In order for them to send a broadcast notice to mariners, they need to know the time, date, location, color of dye, and how long it is expected to be noticeable to the mariners.
- Notify the Captain of the Port and Vessel Traffic Service. They will notify whomever they deem appropriate.
- Notify Department of Ecology's appropriate Regional Office (either Northwest or Southwest).
- Notify the local county sheriff's office.
- Provide project contact name and phone number to all of the above agencies.

If you have any questions, please call me at 360-407-6445 or e-mail at rmar461@ecy.wa.gov. Good luck and we look forward to seeing the study report.

Sincerely,

Randall Marshall

Randall Marshall
WET Coordinator

cc: Scott Smith, WDFW Aquatic Nuisance Species Coordinator

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
TTY 711 or 800-833-6388 (For the Speech or Hearing Impaired)

June 28, 2004

RECEIVED
JUN 30 2004
THE GLOSTEN ASSOCIATES, INC

Kevin J. Reynolds, P.E.
The Glosten Associates, Inc.
1201 Western Avenue, Suite 200
Seattle WA 98101

Dear Mr. Reynolds:

I have reviewed the Ship's Ballast Discharge Dispersion Benchmark Dye Tracer Test, Revision B dated May 5, 2004 and found it to be a good plan that will not result in environmental harm if implemented as written. The list below in Table 1. summarizes the activities covered by the review and approval. A more detailed discussion of the potential for environmental harm from these activities follows Table 1. A list of persons who must be notified prior to the dye test is included in Table 3.

Table 1. List of dispersion test particulars

Vessel Name:	Groton
Owner:	United States Shipping, LLC
Vessel Particulars:	Oil Tank Barge, Single Hull, US Flag 48,067 long ton deadweight 691'-02" length overall 375,145 barrel cargo capacity
Location:	anchored in Port of Port Angeles
Testing Dates:	3 tests from June to September 2004, the data below is for 1 test, all of the
tests	will have the same data
Investigator:	The Glosten Associates, Inc., Seattle, Washington
Investigator Study Lead:	Kevin J. Reynolds
Secondary:	Maurice W. McCarthy
Dye:	Rhodamine WT (Intracid Rhodamine WT Liquid, A34517L100 Tracer Dye)
Dye Transport/Injection:	1.25% concentration, premixed for testing event 0-0.31% concentration, prior to entrainment into ballast stream
Dye Discharge Concentration:	200 ug/L (parts per billion) maximum
Ballast Discharge Rate:	2,000 metric tons per hour, maximum rate
Ballast Discharge Volume:	10,000 metric tons, maximum volume
Total Mass of Dye Discharged:	1.8 grams, maximum dye discharge

The ballast water discharge will be typical for ships at this location except for the addition of rhodamine dye to the water in the ballast tank prior to the discharge. Because the dye will be added as the ballast tanks are filled after anchoring at the Port of Port Angeles, the discharge will merely be returning the same water taken from the location plus a small amount of dye.

The maximum rhodamine dye concentration will be 200 µg/L in the discharge. Dilution in the receiving water will immediately begin reducing the rhodamine dye concentration as the ballast water disperses away from the ship. The discharge of ballast water containing rhodamine dye will continue for 3 to 5 hours. Table 2. below shows that concentrations of rhodamine dye that are orders of magnitude higher than the 200 µg/L dispersion study maximum had no effect on three species of great importance to the Pacific Northwest. These species include the Pacific oyster, which is well-established as a highly sensitive toxicity test organism. Rhodamine dye not only caused no effects at concentrations orders of magnitude above that which will be in the ballast water, but the toxicity test exposure times at these concentrations were much longer in most cases than the duration of the ballast water discharge in the dispersion study. Given the large and multiple safety margins, the environmental safety of the proposed dispersion study is not at all in doubt.

Table 2. **Rhodamine dye toxicity to important local species for comparison to the study maximum concentration of 200 ug/L in a discharge that will last a maximum of 5 hours and be continually diluted**

Common Name	*Effect*	*Duration*	*No Effect Concentration*
Coho salmon	mortality	3.2 hours	375,000 ug/L
Coho salmon	mortality	17.5 hours	10,000 ug/L
Rainbow trout	mortality	3.2 hours	375,000 ug/L
Rainbow trout	mortality	17.5 hours	10,000 ug/L
Pacific oyster	development	48 hours	10,000 ug/L
Pacific oyster	mortality	48 hours	10,000 ug/L

Reference: Parker, G.G.J. 1973. Tests of Rhodamine Wt Dye for Toxicity to Oysters and Fish. J.Res.U.S.Geol.Surv. 1(4):499.

The persons identified below in Table 3. shall be notified prior to any dye test.

Table 3. **Notification list for dye tests in Puget Sound:**

Notify the United States Coast Guard. In order for them to send a broadcast notice to mariners, they need to know the time, date, location, color of dye, and how long it is expected to be noticeable to the mariners.

- Notify the Captain of the Port and Vessel Traffic Service. They will notify whomever they deem appropriate.
- Notify Department of Ecology's appropriate Regional Office (either Northwest or Southwest)
- Notify the local county sheriff's office.
- Provide project contact name and phone number to all of the above agencies

If you have any questions, please call me at 360-407-6445 or e-mail at rmar461@ecy.wa.gov.

Sincerely,

Randall Marshall

Randall Marshall
WET Coordinator

cc: Scott Smith, WDFW Aquatic Nuisance Species Coordinator
Captain Raymond W. Marquardt, United States Shipping LLC

From: "Marshall, Randall" <rmar461@ECY.WA.GOV>
To: 'Kevin Reynolds' <kjreynolds@glosten.com>
Date: 9/17/2004 5:29:14 PM
Subject: RE: 03104 Dye Test Particulars Revision

Kevin,

Please consider my June 2004 letter to you concerning a ballast water dispersion study on the Groton to apply equally well to the MT Seabulk Pride and MT Seabulk Artic and the dispersion study to take place at the Port of Port Angeles in October 2004. Those ships have similar capacities and dimensions to the Groton. All other aspects of the dispersion study will stay the same as in the May 5, 2004 plan. Please follow the notification instructions below before conducting the dispersion study.

The ballast water discharge will be typical for ships at this location except for the addition of rhodamine dye to the water in the ballast tank prior to the discharge. Because the dye will be added as the ballast tanks are filled after anchoring at the Port of Port Angeles, the discharge will merely be returning the same water taken from the location plus a small amount of dye. The maximum rhodamine dye concentration will be 200 µg/L in the discharge. Dilution in the receiving water will immediately begin reducing the rhodamine dye concentration as the ballast water disperses away from the ship. The discharge of ballast water containing rhodamine dye will continue for 3 to 5 hours. The table below shows that concentrations of rhodamine dye that are orders of magnitude higher than the 200 µg/L dispersion study maximum had no effect on three species of great importance to the Pacific Northwest. These species include the Pacific oyster, which is well-established as a highly sensitive toxicity test organism. Rhodamine dye not only caused no effects at concentrations orders of magnitude above that which will be in the ballast water, but the toxicity test exposure times at these concentrations were much longer in most cases than the duration of the ballast water discharge in the dispersion study. Given the large and multiple safety margins, the environmental safety of the proposed dispersion study is not at all in doubt.

Rhodamine dye toxicity to important local species for comparison to the study maximum concentration of 200 ug/L in a discharge that will last a maximum of 5 hours and be continually diluted

Common Name	Effect	Duration	No Effect Concentration
Coho salmon	mortality	3.2 hours	375,000 ug/L
Coho salmon	mortality	17.5 hours	10,000 ug/L
Rainbow trout	mortality	3.2 hours	375,000 ug/L
Rainbow trout	mortality	17.5 hours	10,000 ug/L
Pacific oyster	development	48 hours	10,000 ug/L
Pacific oyster	mortality	48 hours	10,000 ug/L

Reference: Parker, G.G.J. 1973. Tests of Rhodamine Wt Dye for Toxicity to Oysters and Fish. J.Res.U.S.Geol.Surv. 1(4):499.

The persons identified below shall be notified prior to any dye test.

Notification list for dye tests in Puget Sound:

* Notify the United States Coast Guard. In order for them to send a broadcast notice to mariners, they need to know the time, date, location, color of dye, and how long it is expected to be noticeable to the mariners.
* Notify the Captain of the Port and Vessel Traffic Service. They will notify whomever they deem appropriate.
* Notify Department of Ecology's appropriate Regional Office (either Northwest or Southwest)
* Notify the local county sheriff's office.
* Provide project contact name and phone number to all of the above agencies

-----Original Message-----
From: Kevin Reynolds [mailto:kjreynolds@glosten.com]
Sent: Wednesday, September 15, 2004 2:20 PM
To: Marshall, Randall
Cc: SMITHSSS@dfw.wa.gov; Paul Smith; arctic.master@sbulk.com; patrick.unger@sbulk.com; Pride.master@sbulk.com; airish@tesoropetroleum.com
Subject: 03104 Dye Test Particulars Revision

Hello Randy,

Please find and review the attached a revision to Attachment 1 of the previously approved "Test Protocol, Ship's Ballast Discharge, Dispersion Benchmark Dye Tracer Test." There are no other changes to this protocol. We
are currently working to coordinate a test on the MT Seabulk Pride at Port Angeles Anchorage on 4 October. We have also included the Arctic in these particulars, as well as test dates through November to accommodate potential changes in this final coordination.

Please let us know if you require any further information.

Best regards,
Kevin

Kevin J. Reynolds, PE
Senior Marine Engineer
kjreynolds@glosten.com
tel. 206-624-7850

The Glosten Associates, Inc.
1201 Western Avenue, Suite 200
Seattle, Washington 98101 U.S.A.
www.glosten.com

CC: Scott Smith <smithsss@dfw.wa.gov>, "Selby, Melodie" <msel461@ECY.WA.GOV>

ATTACHMENT 1
DYE TEST PARTICULARS (15 September 2004 Revision)

Vessel Names:		*MT Seabulk Pride, MT Seabulk Artic*
		(Sister vessels, Test to be conducted on one)
	Owner:	Seabulk Tankers, Inc.
	Particulars:	Crude and Product Oil Carrier, Double Hull, US Flag
		46,069 tonnes deadweight
		183.0 meters length overall
		342,040 barrel cargo capacity
Location:		Washington State, Puget Sound
	Primary:	Port of Port Angeles, Anchorage
	Secondary:	Anacortes, March's Point, Refinery Docks
Testing Date:		One test in October or November
Investigator:		The Glosten Associates, Inc., Seattle, Washington
	Primary:	Kevin J. Reynolds
	Secondary:	Maurice W. McCarthy
Dye,	Generic Name:	Rhodamine WT
	Trade Name:	Intracid Rhodamine WT Liquid, A34517L100 Tracer Dye
	Transport/Injection:	1-1/4% concentration, premixed for testing event
		0-0.31% concentration, prior to entrainment into ballast stream
	Vessel Discharge:	200 uG/L (parts per billion), entrained in ballast stream, end-of-pipe value, maximum concentration
		2,000 metric tons per hour, maximum rate
		10,000 metric tons, maximum volume
		1.8 grams, maximum dye discharge

15 September 2004 Revision Notes:

1. Vessel information was US Shipping Owned ITB Groton, of similar dimensions and capacities.
2. Testing was for 3 tests between February and June 2004.
3. Removed note 1, regarding reference to *ST Tonsina* discharge values. Vessel discharge values shown here have not changed, and are accurate for subject vessel.
4. Removed note 2, regarding definition of end-of-pipe.

U.S. Department of Homeland Security

United States Coast Guard

Captain of the Port
United States Coast Guard
Marine Safety Office Puget Sound

1519 Alaskan Way S., Bldg 1
Seattle, WA 98134-1192
Staff Symbol: cpd
Phone: (206) 217-6180
Fax: (206) 217-6199

16600
June 7, 2004

RECEIVED
SEP 0 8 2004
THE GLOSTEN
ASSOCIATES, INC.

Mr. Kevin Reynolds, P.E.
Glosten Associates, Inc
600 Mutual Life Building
605 First Avenue
Seattle, WA 98104-2224

Dear Mr. Reynolds:

Thank you for your interest in researching and developing a ballast water treatment system to prevent the introduction and spread of aquatic non-indigenous species into the waters of the United States via ballast water. The Coast Guard appreciates you notifying us of your upcoming full-scale dye test to simulate the interactions of biocide treated ballast water discharged.

As previously provided by Lieutenant Hutley of my staff, the Coast Guard is not in a position to approve or disapprove the discharge of rhodamine dye from vessels. However, the Coast Guard, as a federal steward for marine environmental protection, is responsibility for enforcing all applicable regulations established by other federal agencies under the authorities provided, for example, in the Clean Water Act or the Ocean Dumping Act. With regard to discharges of ballast water that result from your planned test, you are advised to comply with all applicable federal, state and local laws and regulations pertaining to the discharge of a pollutant into the waters of the United States. To this end, I note that you have already received approval for your test from the State of Washington Department of Ecology (DOE letter dated March 2, 2004). I further note that you have initiated direct communications with the regional office of the U.S. Environmental Protection Agency.

The Coast Guard is charged with developing ballast water management regulations under the National Invasive Species Act. While one of the goals in establishing an effective ballast water management program is to facilitate the development of promising ballast water treatment technologies, it is the Coast Guard's intent to ensure that the development and implementation of these technologies has a minimal impact on the marine environment. Proper advance coordination with federal and state clean water regulators is imperative in order to ensure that appropriate procedures are established and any necessary permits are obtained prior to the testing taking place.

If we may be of further assistance, please do not hesitate to contact Mr. John Veentjer. (jveentjer@pacnorwest.uscg.mil) or (206) 217-6184.

Sincerely,

D. Ellis
Captain, U.S. Coast Guard
Captain of the Port Puget Sound

From: Cabreza.Joan@epamail.epa.gov
Sent: Tuesday, June 08, 2004 10:36 AM
To: mwm@macmccarthy.com
Cc: Voerman.Gary@epamail.epa.gov; Peffers.Melissa@epamail.epa.gov
Subject: Re: Rhodamine Dye Test - Updated Protocol

Hi Mac -

The Clean Water Act NPDES permitting program is the only federal environmental program I am aware of that would be implicated by your plans to use rhodamine dye in a ballast water fate and transport test. The Washington Department of Ecology is authorized to administer the NPDES program for discharges into Washington waters, and I recommend that you check with them to determine what, if any, NPDES permit they would require for this activity.

My understanding is that you intend to discharge only dye -- and no biocides -- at this time. Once biocides are involved, you will need to coordinate with the EPA Pesticides program, as ballast water treatment methods are likely to be considered "Treatment Devices" that require approval before use. It is possible that this might involve coordination with EPA headquarters, so I would suggest you start looking into this a bit now, to save time later. Karl Arne would be a good place to start (206/553-2576)

We would appreciate being notified when you plan to release the dye so that our Public Affairs Office has an explanation if they receive calls or questions from the public.

Thanks for checking with us!

Joan Cabreza
Wetland Scientist and
Regional Invasive Species Coordinator
EPA Region 10 (ECO-083)
1200 Sixth Ave, Seattle WA 98101
Phone (206) 553-7369 Fax: (206) 553-1775
cabreza.joan@epa.gov

Appendix D – Source Data

Available Upon Request

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1. Event Hand Log
2. Protocol Datasheets Hand Log
3. Zero and Offset Correction Tables
4. Auto Logger Data Sets