WORK PLAN TO PERFORM A DYE TRACER STUDY TO EVALUATE TRANSPORT AND MIXING IN THE HYPOLIMNION OF ONONDAGA LAKE

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WORK PLAN TO PERFORM A DYE TRACER STUDY TO EVALUATE TRANSPORT AND MIXING IN THE HYPOLIMNION OF ONONDAGA LAKE

1.0 INTRODUCTION

The bottom of Onondaga Lake is a subsite of the Onondaga Lake Superfund site. The remedy for the lake bottom is described in a 2005 Record of Decision prepared by the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (USEPA). The remedy for the lake bottom includes performance of a pilot study to evaluate methods to prevent the formation of methylmercury in the deep water areas of the lake, called Sediment Management Unit (SMU) 8. Before an effective pilot study can be conducted, more information is needed about deep water circulation that is ongoing within the lake. The primary objective of this study is to quantify horizontal dispersion in the hypolimnion of Onondaga Lake in order to guide the design of a system for electron acceptor (oxygen and/or nitrate) addition. The measured horizontal dispersion coefficient will likely be used in a hydrodynamic/transport model to assess sizing and configuration options for an electron acceptor addition system.

This document describes a plan for work to be conducted by the Upstate Freshwater Institute (UFI) for Honeywell during 2008 to directly measure horizontal mass transport and mixing in the hypolimnion of Onondaga Lake. The deep water sediments of Onondaga Lake release methylmercury to the water column under conditions of low oxygen and nitrate concentrations in the overlying hypolimnetic waters. Water column measurements suggest that accumulation of methylmercury in the hypolimnion during summer stratification could be substantially reduced or eliminated through maintenance of adequate electron acceptor (nitrate and/or oxygen) levels above the sediment-water interface (UFI and Syracuse University (SU) 2007a). Under contemporary lake conditions, an engineered system may be required to maintain adequate electron acceptor concentrations in the hypolimnion. Quantification of horizontal dispersion in the hypolimnion is necessary for the design of an electron acceptor addition system. Direct measurements of the horizontal dispersion will be obtained by conducting a hypolimnetic dye tracer study during the period of thermal stratification in 2008.

During summer stratification, hypolimnetic pools of oxygen and nitrate are consumed in the oxidation of organic matter and reduced chemical species. These redox reactions occur largely at the sediment water interface, but also occur to some extent in the water column. Effective operation of an engineered system for electron acceptor addition requires that (1) a minimum electron acceptor concentration be maintained at the sediment-water interface; (2) electron acceptor concentrations in the hypolimnion are lower than in the epilimnion; and (3) a relatively uniform distribution of electron acceptor be maintained.

The dye tracer will be placed directly into the lower waters of the Onondaga Lake. During different tests within this dye tracer study, the dye tracer will be placed at more than one location. The major bathymetric features of Onondaga Lake are the North Basin and the South Basin separated by a relatively shallow “saddle”. Because of its relative shallowness, the saddle could act as a physical barrier to transport of the additive chemical from one basin to another.

Horizontal dispersion in the hypolimnion of a stratified lake is a transport process that has received relatively little attention in either scientific or engineering studies. As a result, there are few direct measurements in other lakes. Peeters et al. (1996) conducted dye tracer studies in the hypolimnion of four Swiss lakes and reported horizontal diffusivities between 0.02 and 0.3 m^2/s. Like all transport processes in surface waters, the magnitude of dispersion in the hypolimnion of lakes is likely to be quite system-specific, so that applying measurements from one lake to another would be accompanied by significant uncertainty. Results from this dye tracer work will be compared with measurements of horizontal dispersion reported in the literature.

Horizontal dispersion is not a constant property, but rather varies in time in response to wind, lake inflow and outflow, and thermal stratification, with wind being the most important of these influences (Wüest et al. 2000). Horizontal dispersion also varies spatially within stratified lakes, with higher turbulence levels in the surface and benthic boundary layers and much weaker turbulence in stratified interior layers (Wüest and Lorke 2003). With the goal of maintaining relatively uniform concentrations of nitrate and/or dissolved oxygen in the hypolimnion, the critical conditions would be low-wind, relatively quiescent conditions. Under these conditions, horizontal dispersion will be relatively small, leading to the greatest amount of non-uniformity in hypolimnetic oxygen or nitrate concentrations. As a result, this project will specifically target low wind/mixing conditions in the lake. In addition, at least one dye tracer test will be conducted during a period of active wind-driven turbulence. It is planned that the dye tracer work will provide measurements of horizontal dispersion on at least four days during the summer. This dye tracer work will provide direct measurements of the horizontal dispersion coefficient, a key parameter that would be used in the design of an electron acceptor release system.

2.0 MATERIALS AND METHODS

A large number of fluorescent dyes are commercially available, but relatively few are suitable for water tracer studies (Wilson et al. 1986). Dyes that have been used in tracer studies include fluorescein, lissamine FF, rhodamine B, and rhodamine WT. The properties of rhodamine WT are well-suited to most studies and this is the dye most commonly used as a water tracer (Martin and McCutcheon 1999). Wilson et al. (1986) outlined the following desirable properties of rhodamine WT for tracer studies: (1) high solubility in water; (2) high fluorescence – easily detectable; (3) fluorescent in a part of the visible spectrum not common to materials generally found in water, thereby reducing the problem of background fluorescence; (4) harmless in low concentrations; (5) inexpensive; and (6) reasonably stable in a normal water environment. Additional properties of rhodamine WT are presented in Table 1.

Table 1 Properties of Rhodamine WT (after Martin and McCutcheon 1999)

Property	Rhodamine WT
Available form	21.3 percent solution and powder
Specific gravity	1.11 to 1.13
Wavelength of excitation (nm)	558
Maximum emission wavelength (nm)	582
Minimum detection limit (µg/L)	0.013
Temperature correction coefficient (°C^{-1})	-0.027
Tendency to sorb to:	
Inorganic solids	Moderate
Organic solids	Moderate
Photochemical decay rate constant (d^{-1})	Less than 0.0001 to 0.002

Health and safety are primary considerations in the application of dye tracers, including potential toxic effects on lake biota and effects on human health. Concentrations of dye known to affect biota are generally much higher than those required for tracer studies (Martin and McCutcheon 1999). In the presence of high nitrite concentrations (more than 1 mg/L) rhodamine WT has been found to form the carcinogen diethylnitrosamine (DENA). The potential for DENA formation is low in Onondaga Lake and other surface water bodies because of relatively low nitrite concentrations. The maximum nitrite concentration measured in Onondaga Lake in 2007 was 0.311 mg/L, and 97 percent of the measurements were less than 0.2 mg/L. The USEPA and the US Geological Survey have adopted a policy that prohibits the injection of fluorescent dyes in quantities that would result in dye concentrations greater than 10 µg/L at drinking water intakes.

A Material Safety Data Sheet (MSDS) for rhodamine WT is provided in Appendix B. Hazardous Materials Identification System^{R} ratings are presented in the MSDS for health (moderate hazard), flammability (slight hazard), and reactivity (slight hazard). The MSDS lists lethal concentrations for 50 percent of the sample organisms of greater than 320 mg/L and 170 mg/L for rainbow trout and *Daphnia magna*, respectively. According the to Environmental and Water Quality Operational Studies by the U.S. Army Corps of Engineers (see Appendix B), "Rhodamine WT has been chosen as the dye most suitable for use in inflow studies ..." and "poses no known environmental or health hazards when used in unpolluted waters. " Rhodamine WT has been selected for use in the study described herein, based on the characteristics listed above and experience using this dye in similar tracer studies.

To prepare for this dye tracer study, the following activities will take place:

1. Equipment will be tested. This equipment includes a GPS sensor, YSI 6130 rhodamine WT sensor (fluorometer) connected to a YSI multiprobe for measurement of dye concentration, temperature, and depth, and a portable computer. Specifications for the YSI 6130 are listed in Table 2 below, and a manufacturer’s brochure for this sensor is provided as Appendix C.

Table 2 YSI 6130 Rhodamine WT Sensor Specifications

Detection Limit	0.5 µg/L
Range	0 to 200 µg/L as true dye; 1,000 µg/L as dye tracer
Accuracy	Plus or minus 1.0 µg/L or plus or minus 5 percent of reading
Depth	61 meters

2. An initial supply of rhodamine WT dye will be purchased.

3. Software will be developed to allow reliable recording and display of field measurements on the on-board computer to be used during a test. Because the dye cloud will not be visible from the boat, the ability to compare the current position of the boat relative to the position of the dye cloud as identified from earlier measurements will be invaluable.

4. A pre-test will be conducted in Onondaga Lake in late June or early July before the first dye tracer test is conducted. A small amount of dye (approximately 1 liter) will be released and tracked for a period of hours. The amount of dye will be too small to allow the dispersion coefficient to be determined, but the pre-test will allow testing of the individual sensors (GPS, fluorescence, depth, temperature), the recording of measurements on the on-board computer, the software to be used to display these measurements, and the general protocol of the test to be assessed onsite. Using the range of horizontal diffusivities reported by Peeters et al. (1996) we estimate that after 8 hours the dye cloud will have an area between 576 and 8640 m^2 and an average dye concentration between 4 and 58 µg/L. It will require between 3 and 48 hours for concentrations to fall below the drinking water limit of 10 µg/L.

5. The following protocol has been established by Honeywell for notifying NYSDEC, USEPA, and Onondaga County about the upcoming dye tracer tests.

    a. Items included in notification:

        i. Scope and purpose of work - Add safe dye to bottom waters to measure natural dispersion within the deepest portions of the lake in the South and North Basins.

        ii. Lake activity - One or two boats will be moving slowly in a portion of either the South Basin or the North Basin for 2 to 3 days.

        iii. Frequency of dye application - The first effort is scheduled for the week of June 23. The other four efforts will take place intermittently between mid-July and early October. Specific timeframes for the other four efforts have not yet been determined. Follow up notifications will be provided once the additional tracer study timeframes are established.

        iv. Effects of dye - The dye will not be visible given it is being released in small quantities into deep, stratified lake waters. The dye (Rhodamine WT) is commonly used for tracing work in sewers and has no effects on human health or the environment particularly at the low concentrations being applied. Use of this dye is acceptable to NYSDEC who has reviewed the work scope.

    b. Contacts notified by Honeywell:

        i. Joe Mastriano (OCDWEP), and Bob Geraci (Onondaga County Parks)

        ii. Tim Larson (NYSDEC project manager) and Tom Biel (NYSDEC Region 7 rep) who in turn can notify others at NYSDEC and at other state agencies as warranted.

        iii. Bob Nunes (USEPA Region 2 project manager) who can notify other federal contacts as warranted.

        iv. Field team leaders including Neil Ringer at SUNY-ESF.

3.0 PROTOCOLS FOR DYE TRACER TEST STUDY

The goal is to conduct four successful dye tracer tests over the course of the summer to early fall 2008 time period. UFI has conducted such dye tracer tests before in rivers and in the surface waters of reservoirs. However, a review of the literature indicates that very few groups in the world have done this for lower waters of a stratified body of water. As a result, it is likely that unanticipated situations and/or circumstances will occur.

The intent is to conduct the first dye tracer test in mid-to-late July following the pre-test. The first dye tracer test will involve some testing of the detailed protocol to be used over the course of the study Other tests will take place over the course of the summer and early fall, separated in time by at least one week. A preliminary schedule for dye tracer tests is presented in Table 3. This schedule provides a general framework for the dye tracer study and is subject to change as a result of weather conditions and the outcomes of earlier tests. The objective of the dye tracer tests is to measure dispersion under a range of lake conditions, with a focus on weak to moderate mixing conditions. As a result, most of the tests will begin during days following major wind or major runoff events. At least one mid-summer period, where calm winds have persisted for two to three days, will be targeted. At least one dye tracer test is also planned to be conducted during a period of active wind-driven turbulence. In addition, a period in the interval between mid-September and early October, ideally during a period of calm winds, will be targeted. Any major public events occurring on the lake, such as the fishing derby, will be avoided. "Blackout" dates during the summer of 2008 established to date in consultation with Honeywell, the SMU 8 Technical Work Group, and with the Onondaga County Department of Water Environment Protection are June 28-29 (free fishing), July 12-13 (Hydrofest in Willow Bay), and July 19, 2008 (fishing tournament).   Effort will continue throughout the summer and early fall to identify other "blackout" dates that may be identified in the future.

Table 3 Preliminary Schedule for Dye Tracer Tests in Onondaga Lake During 2008

Test	Timing	Location
Pre-test	Late June to early July	South Basin
1	Mid-to-late July	North Basin
2	Mid-August	South Basin
3	Early September	North Basin
4	Mid-September to early October	South Basin

Every reasonable effort will be made to give NYSDEC at least one weeks notice of dye tracer tests when possible. Because of the weather-dependent nature of this work it is likely that one week advance notice may not be possible for every test. Every reasonable effort will also be made to notify NYSDEC in a timely manner of any changes to the schedule outlined in Table 3 and also to specify test start dates once they are identified. In order to mobilize equipment and supplies, and to provide reasonable notification, the decision about a date during which to conduct a dye tracer test will be made in conjunction with Honeywell and NYSDEC by noon on the day before dye is to be released. This decision would be based on weather conditions over the previous days and on the weather forecast.

Individual dye tracer tests will be separated by intervals of time of at least one week, so that any lingering amounts of dye that remain in the lake from the previous test will be dispersed or otherwise undetectable when a new test is initiated. To confirm this, on the day before a dye test is to begin, dye concentrations will be measured over the entire basin (north or south) where the release is to occur. If measurable concentrations are found, the test would be delayed. The goal is to ensure that dye concentrations are at undetectable concentrations prior to the beginning of a new test.

The intent is to commence dye tracer tests on Tuesdays or Wednesdays, thus providing five to six days of dilution prior to the baseline water column/zooplankton sampling that is conducted on Mondays. Release of the dye will occur shortly after sunrise to allow as much time as possible for dye tracking over the course of the day. The dye will be released from a boat into the lake below the lake thermocline at a water depth in the range of 15 to 18 meters (i.e., 49 to 59 ft). The release will be made through a small diffuser that is designed to induce a small amount of mixing with the ambient lake water (e.g., Peeters et al. 1996 and Goudsmit et al. 1997). The dye will be diluted with ambient lake water, taken from the lake at the depth of release. The objective of this initial dilution is to adjust the density of the resulting dye solution so that it matches as closely as possible the density of the ambient lake water at the depth of release (e.g., Peeters et al. 1996 and Goudsmit et al. 1997). Thus, the released dye will be neutrally-buoyant and will not, by itself, tend to rise or sink in the water column due to density effects. The dye release will occur over a relatively short period of time, likely 5 to 10 minutes. A buoy will be deployed to mark the location of the dye release. In terms of position on the lake surface, the release point will be at either of the two deep points, in the vicinity of either north deep or south deep. It is a goal to conduct at least one successful dye tracer test in each of the two basins of the lake.

After allowing for some initial spreading of the dye cloud, monitoring of dye concentration will begin (see the standard operating procedure presented as Appendix D). During monitoring, position of the boat will be determined using the GPS sensor and recorded on the on-board computer at a regular interval. The sensors on the YSI Sonde will be interrogated at the same time interval recorded on the onboard computer. The general approach will be to “sweep” across the dye cloud in both longitudinal and lateral directions, where each sweep will begin outside the dye cloud, continue through the cloud, and end where the edge of the cloud on the opposite side will be identified (e.g., Peeters et al. 1996). The depth of the sensors will be adjusted to identify the extent of dye tracer movement in the vertical direction.

The fluorometer apparatus will induce some mixing as it is towed through the dye cloud. However this mixing will be: (a) weak because the towing will be as slow as reasonably possible (approximately 2 knots); (b) of a small scale because the fluorometer probe that will be towed is small (approximately 30 centimeters (12 inches) in size; and (c) sustained over a period of perhaps 10 to 20 seconds at any position as the apparatus is towed. The field objective is to measure sustained, large-scale mixing over tens to hundreds of meters, which will not be affected in any significant manner by the towing of instruments. The sampling approach also provides flexibility to measure various dye shapes in an implementable manner.

This type of dye tracer study is based on the dye being released and remaining at a significant water depth, so visual identification of the dye cloud from the boat will not be possible. Multiple buoys may be deployed and moved over the course of the day to mark the location of the edge of the dye cloud as it spreads. In addition, software will display the following graphical information on the on-board computer screen: (1) a map of the lake; (2) current position of the boat (from the GPS sensor); and (3) the location of and concentrations within the dye cloud as determined from measurements made up to that point in time. The YSI multiprobe has a weighted protective guard intended to keep it vertical and additional weight can be added. The field team will determine during the pre-test if additional weight is needed. The YSI also has a depth sensor, so depth will be recorded along with dye concentration. In addition, the depth of the YSI will be tracked with a depth finder. It will be important to keep the YSI nearly vertical so that the GPS coordinates are representative of the actual location of the sensor. An additional sampling rig (boat, crew, fluorometer, CTD sensor) will be used if it is found that two boats are required to track the dye cloud.

Dye tracking will continue over the entire course of the day until detectable concentrations are no longer found. The quantity of dye to be released will be estimated so that detectable concentrations will remain for the daylight period. However, the time period over which detectable dye concentrations will persist will be strongly dependent on the magnitude of mixing that occurs during each test. If a test is conducted under quiescent conditions, detectable concentrations may remain during the day after the dye release. If this is the case, then monitoring will continue the following day.

Experience indicates that the protocol described above will lead to successful tests. However, unanticipated or unforeseen circumstances or conditions may occur. As a result, this protocol may be modified over the course of the summer. Within a week after the completion of each test, Parsons/Honeywell and NYSDEC will be briefed on how the test proceeded, discuss any problems that occurred, and present recommendations as to how future tests could be modified to maximize effectiveness.

4.0 HEALTH AND SAFETY

Health and safety is the highest priority. The UFI Safety Plan (Appendix C of UFI and SU 2007b) prepared for previous Onondaga Lake field activities will be used for this investigation and will be strictly followed by all personnel. Any task outside of the current scope defined in the Safety Plan, such as dye deployment and dye measurement, will have new job safety analyses completed as warranted before the task begins. Copies of the UFI Safety Plan will be maintained at the support zone and on the boat.

5.0 DATA MANAGEMENT AND REPORTING

Processing of the dye measurements will lead to quantifying the dispersion coefficient over the course of each test. It is possible that the measurements will indicate that the dispersion in the hypolimnion is anisotropic, meaning that dispersion in the longitudinal (along the long axis of the basin) is different from lateral or transverse mixing. In addition, it may be found that the dispersion is scale-dependent, meaning that the rate of increase of the size of the dye cloud (i.e. the dispersion coefficient) becomes larger as the size of the cloud itself increases.

A detailed analysis of the data from each of the dye tracer tests will be provided in a final report to Honeywell and discussed with the SMU 8 Technical Work Group as input to the design of the nitrate application field trial planned for 2009. Output from this dye tracer study will also be applied to the comparison of boat-based and pipe-based delivery of nitrate and/or oxygen to the lake's hypolimnion. Results from the dye tracer work will be provided by January 2009. As indicated in the Remedial Design Work Plan, the draft SMU 8 dye tracer report is due to NYSDEC by July 22, 2009.

6.0 REFERENCES

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APPENDIX A
CALCULATION OF DISPERSION COEFFICIENT

The following is an illustration of how dye data would be used to compute the dispersion coefficient, which could be used directly in a 3-dimensional hydrodynamic transport model (e.g., EFDC) to simulate the performance of various designs for the delivery of nitrate and/or oxygen to the hypolimnion of Onondaga Lake. If we make the very idealistic assumption that the dye spreads horizontally as a circular cloud, the dispersion coefficient *E* can be computed from the rate of increase of the diameter *D* of the cloud as:

$$E = \frac{1}{2}\frac{d}{dt}(D^2)$$

In practice, the derivative in this equation is approximated by a finite difference. Assume that the field data indicates that the diameter of the dye cloud is 50 meters 3 hours after the release, and 150 meters 6 hours after the release. The dispersion coefficient over this period is then:

$$\begin{aligned} E &\approx \frac{1}{2}\frac{(D_2)^2 - (D_1)^2}{t_2 - t_1} = \frac{1}{2}\frac{(150)^2 - (50)^2}{6-3} \\ &= 3300\,\text{meter}^2/\text{hr} \\ &= 0.93\,\text{meter}^2/\text{sec} \end{aligned}$$

In practice, the dye cloud will likely have an irregular shape. In addition, the longitudinal dispersion coefficient (along the long axis of the lake basin, roughly northwest-southeast) will likely be different from the lateral dispersion coefficient (across the width of the basin, roughly southwest-northeast). In this case, more complete and complicated equations are used to compute the both the longitudinal and lateral components of the dispersion coefficient (Fischer et al. 1979).

APPENDIX B

MSDS FOR RHODAMINE WT

KEYSTONE ANILINE CORPORATION
2501 WEST FULTON STREET
CHICAGO, ILLINOIS 60612
CORPORATE OFFICE: 312.666.2015
HEALTH & SAFETY FAX 312.666.8530

TRADE NAME RHODAMINE WT LIQUID
PRODUCT ID 703-010-27
PREPARED FOR
EMERGENCY PHONE Call CHEMTEL 800.255.3924
HEALTH & SAFETY TEL: 312.666.2015

MATERIAL SAFETY DATA SHEET

!!!!!!! !!!

NOTE: DO NOT DETACH THIS GUIDANCE COVER SHEET FROM THE REST OF THIS DOCUMENT. This page indicates the Keystone Trade Name and Product ID. This identifying information must be referenced when ordering products or making inquiries.

!!

A) YOUR CERTIFICATION OF COMPLIANCE UNDER FEDERAL AND STATE REGULATIONS

IMPORTANT NOTE: THIS DOCUMENT IS YOUR OFFICIAL CERTIFICATION OF COMPLIANCE as stated in each applicable section. It is compiled in accordance with OSHA's Hazard Communication standard (29 CFR 1910.1200), and other federal and state regulations. NOTE: NO ADDITIONAL COMPANY CERTIFICATION OF COMPLIANCE IS REQUIRED WHEN COMPLIANCE IS INDICATED IN THE APPROPRIATE SECTION OF THIS DOCUMENT. To avoid use of outdated information, please completely destroy ALL previously dated MSDS' that are on file.

B) ABOUT THE FORMAT OF THIS MATERIAL SAFETY DATA SHEET

New and updated MSDS' are presented in the ANSI Z400.1 Sixteen-section format All available information is included in systematic updates.

C) ABOUT THE PURPOSE AND AVAILABILITY OF THIS DOCUMENT

Under the federal OSHA Hazard Communication Standard and some State Right to Know laws, employers using this product in their operation must make this MSDS available to all employees handling this product in any manner. The MSDS must be readily available for review by all persons concerned.

This MSDS is designed to effectively communicate Health and Physical Hazards to the material handler and all other responsible persons concerned with Health and Environmental protection and regulatory compliance. Distributors receiving this MSDS are obligated to readily provide a copy to their customers, affiliates, and agents.

D) THE PRODUCT USER RESPONSIBILITY NOTICE

This type of document cannot cover all possible unique situations. It is the product user's responsibility to provide a safe workplace, and to pass on all Health, Safety and Environmental information to all employees and customers that may handle this product. Under 29 CFR 1910.1200, all product users and handlers must be informed of U.S. OSHA requirements, and the need to be familiar with them.

E) ABOUT CUSTOMER INQUIRIES

This MSDS includes all technical and Regulatory information available on the Effective Date. Please Fax technical questions directly to the appropriate laboratory. Chicago Lab Fax: 312-666-8530, or Los Angeles Lab Fax: 562-921-3461. Fax all health, safety & environmental questions to the Chicago office at 312-666-2015. Note: Product information requests will be expedited by providing: 1) The eight digit Keystone Product ID Number, 2) The complete Keystone Trade Name and 3) Detailed comments explaining the nature of our client's request or problem.

<<<<<<<<<< MATERIAL SAFETY DATA SHEET >>>>>>>>>>

EFFECTIVE DATE	SUPERSEDES
06-18-01	11-24-99

SECTION 1 CHEMICAL IDENTIFICATION

C.I. NAME : ACID RED 388
CAS NUMBER : PROPRIETARY
CHEMICAL FAMILY : XANTHENE DYE
PHYSICAL FORM : LIQUID

SECTION 2 INGREDIENTS HAZARDOUS UNDER OSHA 29 CFR PART 1910.1200 APPENDIX A & B

COMPONENT NAME	CAS NUMBER	PEL	TLV	%
TRIMELLITIC ACID*	528-44-9	NE	NE	2.6

*READ & UNDERSTAND SECTIONS 3, 8 & 11 FOR HEALTH & SAFETY INFORMATION. WEAR ALL PROTECTIVE EQUIPMENT AND CLOTHING AS DESCRIBED IN SECTION 8.

SECTION 3 HAZARD IDENTIFICATION AND EMERGENCY OVERVIEW

HMIS RATINGS

HEALTH	2
FLAMMABILITY	1
REACTIVITY	1
PROTECTION	H, O, Q

EMERGENCY OVERVIEW:

POSSIBLE EXPOSURES: EYES, SKIN, BREATHING VAPORS/MIST, ACCIDENTAL SWALLOWING

POSSIBLE HEALTH EFFECTS:
EYE CONTACT: CAUSES IRRITATION.* 1
SKIN CONTACT: CAN CAUSE IRRITATION.* 1
BREATHING VAPOR OR MIST: NE. TAKE PRECAUTIONS. 1
SWALLOWING: NE. WASH HANDS AFTER HANDLING & BEFORE EATING & DRINKING

* EXPECTATIONS BASED ON PRODUCT COMPONENT

SENSITIZATION: NK
TARGET ORGANS: EYES SKIN 1

CANCER INFORMATION:
PRODUCT AND COMPONENTS NOT KNOWN TO US TO BE CARCINOGENS
NTP: NK
IARC: NK
OSHA: NR

1 PRECAUTIONS:
TO HELP PROTECT YOURSELF AGAINST ANY UNFORSEEN IRRITATION OR ALLERGIC REACTIONS, AS PRECAUTIONS WORKERS SHOULD ALWAYS BE SURE TO WEAR ALL THE PROPERLY SELECTED PROTECTIVE EQUIPMENT AND CLOTHING AS INSTRUCTED IN SECTION 8 OF THIS MATERIAL SAFETY DATA SHEET. AS PRECAUTIONS, WASH YOUR HANDS AND FACE AFTER HANDLING AND BEFORE EATING, DRINKING, SMOKING OR USING RESTROOM FACILITIES. AFTER EACH SHIFT, CLEAN ALL PROTECTIVE EQUIPMENT, WASH ALL WORK CLOTHES, AND SHOWER. CHECK SECTION 11 FOR TOXICOLOGY INFORMATION.

UNUSUAL HAZARDS NK

SECTION 4 FIRST AID INSTRUCTIONS

EYE CONTACT: IMMEDIATELY RINSE WITH PLENTY OF CLEAN FLOWING WATER FOR AT LEAST 20 MINUTES, HOLDING EYELIDS OPEN TO RINSE COMPLETELY. CALL A DOCTOR AND GET MEDICAL HELP QUICKLY, AS A PRECAUTION.

SKIN CONTACT: REMOVE AFFECTED CLOTHING. WASH AFFECTED SKIN AREA WITH PLENTY OF SOAP AND WATER. RINSE WITH PLENTY OF WATER. WASH ALL WORK CLOTHES BEFORE WEARING AGAIN. IF ANY REDNESS, SWELLING, ITCHING, OR PAIN OF THE SKIN STARTS, SEE A DOCTOR QUICKLY, AS A PRECAUTION.

BREATHING PRODUCT VAPOR/MIST: MOVE PERSON TO FRESH AIR. IF PERSON IS HAVING DIFFICULTY BREATHING, GIVE OXYGEN. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. GET EMERGENCY MEDICAL HELP QUICKLY. CALL 911 IF AVAILABLE

IN YOUR AREA, OR OTHER MEDICAL EMERGENCY NUMBER.

SWALLOWING OF PRODUCT: IF SWALLOWED, GIVE PERSON SEVERAL GLASSES OF WATER AND FORCE VOMITING. NEVER GIVE ANY FLUIDS OR FORCE VOMITING IF THE PERSON IS UNCONSCIOUS, OR IS HAVING CONVULSIONS, OR HAS NO GAG REFLEX. CONTACT A DOCTOR QUICKLY TO GET MEDICAL HELP, CALL 911, OR OTHER MEDICAL EMERGENCY SERVICES AVAILABLE IN YOUR AREA.

SECTION 5 FIRE FIGHTING INSTRUCTIONS

FLASH POINT : NA
TYPES OF EXTINGUISHERS : CO2, DRY CHEMICAL, WATER FOG
FIREFIGHTING DIRECTIONS: WEAR SELF-CONTAINED BREATHING APPARATUS TO PROTECT AGAINST POSSIBLY TOXIC FUMES. WEAR FULL FIRE-PROTECTIVE CLOTHING.

SECTION 6 ACCIDENTAL SPILLS OR RELEASES

WEAR A NIOSH APPROVED VAPOR/MIST RESPIRATOR, WITH ALL PROTECTIVE CLOTHING & EQUIPMENT AS DIRECTED IN SECTION 8 OF THIS MSDS.

ENVIRONMENTAL PROTECTION: PREVENT LIQUID FROM ENTERING FLOOR DRAINS. FOR LARGE SPILLS, DIKE AND CONTAIN WITH ABSORBENT MATERIAL OR SPILL BARRIERS. DO NOT RELEASE TO SEWERS OR ANY BODIES OF WATER WITHOUT PROPER PERMISSION FROM ALL GOVERNMENTAL AUTHORITIES WITH JURISDICTION IN YOUR LOCALITY.

CONTAIN AND CLEAN UP SPILL IMMEDIATELY. SOAK UP & SOLIDIFY SPILLS USING A SUITABLE ABSORBENT SUCH AS "OIL DRY", "FULLER'S EARTH", SAND OR OTHER APPROPRIATE MATERIAL. SCOOP SOLIDIFIED MATERIAL & ABSORBENT INTO PROPER WASTE DISPOSAL CONTAINER AND SEAL. DISPOSE OF ACCORDING TO ALL APPLICABLE CITY. COUNTY, STATE, AND FEDERAL REGULATIONS. CONTACT APPROPRIATE AGENCIES FOR GUIDANCE ON HOW TO PROCEED. CONSIDER ALTERNATIVES AS SHOWN IN SECTION 13, DISPOSAL CONSIDERATIONS/ENVIRONMENTAL PROTECTION PROCEDURES. ALSO, SEE SECTION 13 FOR ANY ADDITIONAL DIRECTIONS PROVIDED.

RCRA STATUS CHECK REGULATORY INFORMATION, SECTION 15

SECTION 7 HANDLING AND STORAGE

STORE PRODUCT IN THE ORIGINAL OR IN EQUIVALENT WATER-PROOF CONTAINERS. RESEAL CONTAINERS TIGHTLY AFTER EACH USE. KEEP IN A COOL, DRY AREA AWAY FROM EXCESSIVE HEAT. DO NOT STORE IN DIRECT SUNLIGHT.

SHELF LIFE UP TO ONE YEAR WHEN STORED CAREFULLY AS INSTRUCTED ABOVE.

SECTION 8 EXPOSURE CONTROLS AND PERSONAL PROTECTION

NOTE: WHEN SELECTING PERSONAL PROTECTIVE EQUIPMENT AND CLOTHING, FOLLOW ALL OF THE MANUFACTURERS SPECIFICATIONS AND RECOMMENDATIONS THAT APPLY TO YOUR SPECIFIC OPERATIONS AND PROCESSING CONDITIONS. TAKE INTO CONSIDERATION ALL CONDITIONS AND ALL CHEMICALS TO BE HANDLED OR PROCESSED

EYE PROTECTION: WEAR SPLASH-PROOF CHEMICAL SAFETY GOGGLES CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH CHEMICALS.

SKIN PROTECTION: WEAR CHEMICALLY RESISTANT RUBBER GLOVES, SELECTED WITH YOUR SPECIFIC PROCESSING CONDITIONS IN MIND. WEAR AN APRON WHEN USING. WEAR COVERALLS AND BOOTS TO MINIMIZE SKIN CONTACT. AS PRECAUTIONS, WASH HANDS & FACE WITH MILD SOAP & WATER BEFORE EATING, DRINKING, SMOKING, OR USING RESTROOM. AFTER EACH SHIFT, CLEAN ALL PROTECTIVE EQUIPMENT, WASH WORK CLOTHES, AND SHOWER.

LUNG, THROAT & NASAL PROTECTION: WEAR NIOSH APPROVED ORGANIC VAPOR/MIST RESPIRATOR FOR YOUR PARTICULAR OPERATION AND MATERIALS BEING HANDLED.

OTHER PROTECTION: EYE WASH FOUNTAINS & DRENCH SHOWERS SHOULD BE LOCATED WITHIN 100 FEET OR A 10 SECOND WALK OF THE WORK AREA PER ANSI Z358.1-1990

VENTILATION: LOCAL EXHAUST IS RECOMMENDED

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION : RED LIQUID; NO ODOR
BOILING POINT : NE
MOLECULAR WEIGHT : 509
WATER SOLUBILITY : MISCIBLE
PH @ 1.0% : 10.5
VAPOR DENSITY : IS HEAVIER THAN AIR

EVAPORATION RATE : IS SLOWER THAN BUTYL ACETATE
% TOTAL VOC : NE (BY WGT.)
% NON-VOLATILES : NE (BY VOL.)
SPECIFIC GRAVITY : 1.13
DENSITY : 9.41 (LBS. PER GAL.)
% WATER CONTENT : NE (BY WGT.)

SECTION 10 STABILITY AND REACTIVITY

STABILITY : STABLE
CONDITIONS TO AVOID : NK
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR
INCOMPATIBLE MATERIALS : NK
HAZARDOUS DECOMPOSITION PRODUCTS: BURNING CAN PRODUCE OXIDES OF CARBON NITROGEN AND/OR SULFUR.

SECTION 11 TOXICOLOGY INFORMATION

ORAL LD50 (RAT): NE
DERMAL LD50 (RAT): NE
INHALATION LC50 (RAT): NE

EYE EFFECTS (RABBIT): NE. TAKE PRECAUTIONS. 1
SKIN EFFECTS (RABBIT): NE. TAKE PRECAUTIONS. 1
BREATHING EFFECTS: NE. TAKE PRECAUTIONS. 1

1) NO ANIMAL TOXICITY DATA IS CURRENTLY AVAILABLE FOR 100% PRODUCT. AS A PRECAUTION IT IS RECOMMENDED THAT ALL WORKERS WEAR ALL OF THE PROTECTIVE CLOTHING & EQUIPMENT DESCRIBED IN SECTION 8. READ SECTION 8.

GENERAL PRECAUTIONS: ALWAYS PRACTICE GOOD INDUSTRIAL HYGIENE, HANDLE WITH CARE, AVOID PERSONAL CONTACT. DO NOT GET INTO EYES OR ON SKIN, DO NOT BREATHE VAPOR OR MISTS OF PRODUCT, DO NOT SWALLOW. BE SURE TO WASH HANDS WITH SOAP & WATER AND RINSE WELL AFTER HANDLING PRODUCT AND BEFORE EATING DRINKING, SMOKING, OR USING RESTROOM FACILITIES. BE SURE TO SHOWER AFTER EACH SHIFT, WASH ALL WORK CLOTHING, AND COMPLETELY CLEAN ALL PROTECTIVE EQUIPMENT AFTER EACH SHIFT. SEE SECTION 2.

MUTAGENICITY: RHODAMINE WT WAS POSITIVE IN A SALMONELLA/MAMMALIAN MICROSOME ASSAY (NESTMANN AND KOWBEL, 1979). G. DOUGLAS, AS REFERENCED, STATED THAT IMPURITIES IN THE DYE MAY HAVE CAUSED THE MUTAGENIC EFFECTS SEEN OR ALTERNATIVELY THE DYE CAN BE A POINT MUTAGEN. DOUGLAS FURTHER REPORTED THAT TAKING THE DATA ALTOGETHER FROM HIS STUDY, "...RHODAMINE WT APPEARS NOT TO REPRESENT A MAJOR GENOTOXIC HAZARD".

ADDITIONAL INFORMATION: RHODAMINE WT WAS TESTED IN A BATTERY OF IN VITRO AND IN VIVO MAMMALIAN ASSAYS RESULTING IN NEGLIGIBLE, LOW LEVELS OF GENOTOXIC ACTIVITY EVEN AT VERY HIGH CONCENTRATIONS. NO EVIDENCE OF IN VIVO GENETIC ACTIVITY WAS OBSERVED EITHER IN TERMS OF BONE MARROW MICRONUCLEI OR SPERM ABNORMALITIES. (G.R. DOUGLAS ET AL, "COMPARATIVE MAMMALIAN IN VITRO AND IN VIVO STUDIES ON THE MUTAGENIC ACTIVITY OF RHODAMINE WT", MUTATION RESEARCH, 118, 1983, 117-125).

TERATOGENICITY: THIS PRODUCT IS NOT KNOWN TO CONTAIN ANY MATERIAL THAT HAS BEEN IDENTIFIED AS A TERATOGEN.

MEDICAL CONDITIONS WORSENED BY EXPOSURE: PERSONS WITH BREATHING AND LUNG PROBLEMS CAN BE AFFECTED BY BREATHING IN ANY TYPE OF VAPORS OR MISTS. AS A PRECAUTION TO PROTECT HEALTH AND MINIMIZE POSSIBLE OR UNEXPECTED REACTIONS, ANY PERSONS WITH ASTHMA, ALLERGIES, OR OTHER BREATHING-RELATED PROBLEMS SHOULD NOT HANDLE, NOR BE EXPOSED TO ANY PRODUCTS OR CONDITIONS WHERE VAPORS OR MISTS OF ANY CHEMICAL PRODUCTS MAY BE PRESENT.

REFERENCES:
1) EPA LETTER, 8/2/88, RECOMMENDED GUIDELINES, EFFECTIVE THROUGH 4/7/90
2) GRADIENT CORPORATION LETTER, 11/20/89, RISK ASSESSMENT.

SECTION 12 ECOLOGICAL DATA

BOD 5: NE
COD: NE
FISH TOXICITY: LC50 >320 MG/L RAINBOW TROUT (96 HR);
LC50 170 MG/L DAPHNIA MAGNA
SEED TOXICITY: NE
CWA TOXIC POLLUTANTS: NK
ADDITIONAL INFORMATION: NO DEVELOPMENTAL ABNORMALITIES OR TOXICITY TO OYSTER LARVAE AT 100 MG/L.

SECTION 13 DISPOSAL CONSIDERATIONS/ENVIRONMENTAL PROTECTION PROCEDURES

DISPOSAL METHODS

IT IS RECOMMENDED THAT YOU SELECT AN ALTERNATIVE BELOW ACCORDING TO THE FOLLOWING ORDER OF PREFERENCE, DEPENDING ON ENVIRONMENTAL IMPACT:

1) RECYCLE OR REWORK MATERIAL IF AT ALL POSSIBLE
2) INCINERATE MATERIAL AT AN APPROVED FACILITY
3) TREAT AT AN ACCEPTABLE WASTE TREATMENT FACILITY, OR MUNICIPAL WASTE TREATMENT PLANT AFTER PROPER TESTING & APPROVAL WASTE SAMPLES.

IF DISPOSED OF IN IT'S ORIGINAL UNUSED FORM, THIS MATERIAL SHOULD BE TREATED, AND DISPOSED OF AT AN APPROVED SITE OR FACILITY, IN COMPLIANCE WITH ALL APPLICABLE FEDERAL, STATE & LOCAL ENVIRONMENTAL REGULATIONS. YOU MUST CONTACT THE PROPER GOVERNMENT AGENCIES FOR ADDITIONAL DIRECTIONS. ALL WASTE MATERIAL & WASTE WATER SHOULD BE DISPOSED OF CORRECTLY, UNDER ALL FEDERAL, STATE , CITY & COUNTY LAWS.

RCRA STATUS: SEE SECTION 15, REGULATORY INFORMATION

DO NOT RELEASE ANY CHEMICALS, DYES, OR DYE SOLUTIONS INTO ANY WATERWAYS OR SEWER SYSTEMS WITHOUT PROPER GOVERNMENT PERMISSION AT ALL LEVELS.

CONTAINER REUSE: AN "EMPTY" CONTAINER CAN CONTAIN PRODUCT RESIDUE, AND SHOULD NOT BE REUSED. IF NOT PROFESSIONALLY CLEANED & RECONDITIONED, CRUSHING OR OTHER MEANS IS RECOMMENDED TO PREVENT UNAUTHORIZED REUSE.

SECTION 14 TRANSPORT INFORMATION

DOT STATUS (HIGHWAY AND RAIL) NR

IATA STATUS (AIR): NR

SECTION 15 REGULATORY INFORMATION

AICS (AUSTRALIA): NOT LISTED
CAL. PROP. 65: CADMIUM (<1), TOTAL CHROMIUM (8), LEAD (1.5), COBALT (1), NICKEL (2). HEXAVALENT CHROMIUM IS A LISTED SUBSTANCE. MINUTE TRACES MAY BE PRESENT IN THE TOTAL PPM CHROMIUM. NOTE: PPM QUANTITIES APPLY TO 100% PRODUCT. FOR COLOR USED AT A FEW PERCENT ORE LESS, WHEN MAKING CAL. PROP. 65 DETERMINATION FOR END-PRODUCTS, CALCULATE ACTUAL SUBSTANCE PRESENT. EXAMPLE: WITH 3% COLOR USED IN END PRODUCT, AND CHROMIUM PRESENT AT <10 PPM IN 100% DYE, ACTUAL AMOUNT PRESENT FROM COLOR = 0.30 PPM = 0.00005%.
CERCLA: NH
CLEAN AIR ACT:
TITLE III (HAPS): NK
TITLE V (VOCS): SEE SECTION 9
TITLE VI (ODCS): NOT MANUFACTURED WITH NOR CONTAINING CLASS I OR II ODCS
CONEG-TYPICAL METALS PRESENT IN PPM:

CADMIUM	<1.0
CHROMIUM	8.0 (TOTAL INCLUDING HEXAVALENT CR+6)
LEAD	1.5
MERCURY	NE

DSL (CANADA): COMPONENTS LISTED. THE COMPONENTS OF THIS PRDUCT ARE INCLUDED ON THE CANADIAN DOMESTIC SUBSTANCE LIST. THIS PRODUCT DOES CONTAIN TRIMELITIC ACID WHICH IS NOT ON THE DSL BUT WHICH IS PRESENT ONLY AS AN IMPURITY-BYPRODUCT AND THUS NOT SUBJECT TO THE DSL LISTING REQUIREMENT.
ECL (KOREA): NOT LISTED
EINECS (EUROPE): COMPONENTS LISTED
ENCS (JAPAN): NOT LISTED
FDA STATUS: NL
NSF INTERNATIONAL: RHODAMINE WT LIQUID HAS BEEN CERTIFIED BY THE NATIONAL SANITATION FOUNDATION INTERNATIONAL (NSF) TO THE REQUIREMENTS OF ANSI/NSF STANDARD 60: DRINKING WATER TREATMENT CHEMICALS - HEALTH EFFECTS, FOR USE IN TRACING DRINKING WATER UNDER THE FOLLOWING CONDITION:

"CONCENTRATIONS OF RHODAMINE WT LIQUID IN DRINKING WATER ARE NOT TO EXCEED 0.1PPB (PARTS PER BILLION) AND THE EXPOSURE (END USE) IS TO BE INFREQUENT" ACCORDING TO THE ENVIRONMENTAL AND WATER QUALITY OPERATIONAL STUDIES BY THE U.S. ARMY CORPS OF ENGINEERS, "RHODAMINE WT HAS BEEN CHOSEN AS THE DYE MOST SUITABLE FOR USE IN INFLOW STUDIES..." AND "POSES NO KNOWN ENVIRONMENTAL OR HEALTH HAZARDS WHEN USED IN UNPOLLUTED WATERS."

(THE SUITABILITY OF THIS DYE FOR A SPECIFIC WATER TRACING APPLICATION SHOULD BE EVALUATED BY A QUALIFIED HYDROLOGIST. A MANUFACTURER OF FLUOROMETERS, SUCH AS TURNER DESIGNS* SHOULD BE CONSULTED FOR DETAILED APPLICATION INFORMATION. FOR PRECISE SCIENTIFIC WORK, THE USER SHOULD CARRY OUT HIS OWN MEASUREMENTS ON THE STARTING MATERIAL SINCE THERE MAY BE SOME VARIATION FROM LOT TO LOT.)

*TURNER DESIGNS, 845 W. MAUDE AVENUE, SUNNYDALE, CA 94086 (408) 749-0994

OTHER TYPICAL DATA IN PPM

COBALT	1.0
COPPER	8.0
MANGANESE	1.0
NICKEL	2.0
ZINC	3.0

< = NOT FOUND AT TEST LEVEL SHOWN IF PRESENT, UNMEASURABLE TRACE IS BELOW LEVEL INDICATED.

RCRA: NOT HAZARDOUS IN IT'S PURCHASED FORM. HOWEVER, UNDER RCRA, IT IS THE PRODUCT USER'S RESPONSIBILITY TO DETERMINE AT TIME OF DISPOSAL IF ANY MATERIAL CONTAINING THE PRODUCT OR DERIVED FROM THE PRODUCT IS A HAZARDOUS WASTE.

SARA 311/312: IMMEDIATE/ACUTE HEALTH HAZARD : YES
DELAYED/CHRONIC HEALTH HAZARD : NO
FIRE HAZARD : NO
SUDDEN RELEASE OF PRESSURE HAZARD: NO
REACTIVITY HAZARD : NO
SARA 313: NR
TSCA: COMPONENTS LISTED
USDA: NL
WHMIS: D-2-B

SECTION 16 OTHER INFORMATION

REVISION DATE: 11-24-99 REVISED SECTION 15 (NATIONAL INVENTORIES)
REVISION DATE: 11-24-98 REVISED TO ADD MW TO SECTION 9
REVISION DATE: 06-18-01 GENERAL REVIEW

ACRONYM LIST

NA = NOT APPLICABLE TO THIS MATERIAL
NC = NOT CERTAIN, UNDETERMINED
ND = NO DATA IS CURRENTLY AVAILABLE
NE = NOT ESTABLISHED, NO TESTING IS PLANNED
NH = NOT HAZARDOUS UNDER CITED REGULATIONS
NK = NONE KNOWN
NL = NOT LISTED OR APPROVED UNDER THESE REGULATIONS
NR = NOT REGULATED OR REPORTABLE

PK = CALCULATED BY PROCESS KNOWLEDGE WITH FORMULATION DATA

NIOSH = NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

THE INFORMATION AND RECOMMENDATIONS CONTAINED HEREIN ARE BASED UPON DATA BELIEVED TO BE CORRECT. HOWEVER, NO GUARANTEE OR WARRANTY OF ANY KIND EXPRESSED OR IMPLIED, IS MADE WITH RESPECT TO THE INFORMATION CONTAINED HEREIN. THIS MATERIAL SAFETY DATA SHEET WAS PREPARED TO COMPLY WITH THE OSHA HAZARD COMMUNICATION STANDARD 29 CFR 1910.1200, AND SUPERSEDES ANY PREVIOUS INFORMATION. PREVIOUSLY DATED SHEETS ARE INVALID & UNAPPLICABLE

APPENDIX C

BROCHURE FOR YSI 6130 RHODAMINE WT SENSOR

YSI Environmental

NEW

YSI 6130 Rhodamine WT Sensor

In response to the need for accurate, *in situ* measurement of Rhodamine WT for water and pollutant tracing, YSI has developed the 6130 Rhodamine WT Sensor. The 6130 is a fouling-resistant, wiped sensor designed to seamlessly integrate – using no external interface hardware – with all YSI sondes that contain an optical port. The YSI 6130 provides accurate, *in situ* measurement of Rhodamine WT in fresh, brackish, and sea water, as well as in stormwater and wastewater.

The YSI 6130 Rhodamine WT Sensor rejects turbidity and chlorophyll interference. Measurement accuracy is further enhanced through correction for the effects of temperature.

The YSI 6130 sensor can be used in combination with those YSI sondes that have optical ports – 600 OMS, 6820, 6920, or 6600 – and a YSI 650 MDS handheld display-logger. Make surface as well as vertical profile measurements. In addition, the YSI 6130 in combination with one of the YSI data-logging sondes can be used for unattended continuous monitoring or integrated with data collection platforms for real-time data acquisition.

The YSI 6130 rhodamine sensor. Use with the YSI 600 OMS, 6820, 6920, 6600, 6600EDS, and ADV6600.

Pure Data for a Healthy Planet.™

Providing accurate, in situ measurement of Rhodamine WT in fresh, brackish, sea water, stormwater, and wastewater.

www.YSI.com

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To order or for more information, contact YSI Environmental.

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ISO 9001
ISO 14001

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CE

Features and Benefits

- Temperature compensation provides greater accuracy
- Turbidity and chlorophyll fluorescence rejection helps eliminate interferences
- Wiped optics: field-proven for fouling prevention
- Compatibility with all YSI optical port sondes provides system flexibility
- Handheld measurements, continuous data-logging, real-time data acquisition

Applications

- Time of travel: surface water, groundwater, wastewater
- Dispersion and mixing studies
- Circulation: lakes, reservoirs, bays, estuaries
- Spill mapping and response
- Stormwater retention
- Wastewater treatment facility: hydraulics, performance evaluation

YSI 6130 Rhodamine WT Sensor Specifications

Detection Limit	0.5 Γg/L
Range	0 - 200 Γg/L as true dye; 1,000 Γg/L as dye tracer.
Accuracy	±1.0 Γg/L or ±5% of reading
Depth	61 meters (200 feet)
Warranty	One-year

APPENDIX D

STANDARD OPERATING PROCEDURE FOR *IN SITU* WATER TRACING USING RHODAMINE WT SENSOR YSI 6130

Edited by: DAM Date:05/06/08	UPSTATE FRESHWATER INSTITUTE STANDARD OPERATING PROCEDURE	Page 1 of 5 Procedure No. SOP
Revision No: 1 Replaces:	***Rhodamine WT Sensor – YSI 6130*** *In situ* Water Tracing	Effective Date: 05/06/08 Copy No: 1

1) **Test method:**

Rhodamine WT Sensor – In-Situ Water Tracing

2) **Applicable matrix or matrices:** fresh, brackish, and sea waters, <61 m depth

3) **Detection limit:** 0.5 µg/L.

4) **Scope and application:** *In situ* measurement of rhodamine WT dye for water and pollutant tracing. This procedure is used for time of travel, dispersion, and mixing studies in surface waters.

5) **Summary of test method:** The YSI 6130 is an optical sensor that can be used in conjunction with YSI 6-Series sondes and handheld display-loggers. This arrangement allows for manual or automatic collection of rhodamine WT dye concentration and various other parameters (e.g., temperature, dissolved oxygen, specific conductance, pH, turbidity, depth, GPS location). Dyes such as rhodamine WT mimic the movement of water molecules. The concentration of a dye tracer is directly proportional to its fluorescence. Therefore, the spread of a dye plume over time is a measure of transport of water or a waterborne substance under the conditions in which the study was performed.

6) **Definitions:** none

7) **Interferences:** The following substances share excitation or emission spectra with rhodamine WT and can cause interference: algae; certain salt compounds; naturally occurring colored organic compounds; and manmade organic pollutants (i.e., dyes, petroleum distillates, detergents). Turbidity can be a significant source of physical interference through inhibition of transmitted and emitted light. Chlorine is a quenching agent of rhodamine WT. Photochemical decay is a major loss process for rhodamine WT. Rhodamine WT can also be loss through sorption processes. Dye losses by sorption, photochemical decay, and quenching are rarely large enough to impact time of travel, or dispersion measurements (YSI Environmental 2001).

8) **Safety:** Standard field safety procedures should be applied. Keep work area clean and clutter free. The submersible cable should be stowed in an organized fashion and not left in a location where it could become a tripping hazard.

9) **Equipment and supplies:** Rhodamine WT dye (20%), appropriate field sheets, GPS, connection cables, and YSI handheld display-logger.

10) **Reagents and standards:** Rhodamine WT dye (20%).

11) **Reference Solution:** Rhodamine WT dye (20%).

12) **Sample collection, preservation, shipment and storage:** No water samples collected.

13) **Quality Control:** Inspect sensor for fouling.

14) **Calibration and standardization:** The YSI 6130 rhodamine WT sensor should be calibrated within 24 hours of use in a dye tracer study. The calibration should include at least 3 standards that span the range of dye concentrations expected to be encountered in the study. The standards should be prepared from the same batch of rhodamine WT dye that will be used in the tracer study. In this case,

Rhodamine WT Liquid
Aniline Corp.
Specific gravity: 1.15 gm/mL
Active ingredient 20% by weight

The steps below describe the preparation of standards for a 3-point calibration (1, 50, 100 µg/L).

1. dilute 4.3 mL of rhodamine WT dye to 1 L
   4.3 mL rhodamine dye ×1.15 gm/mL = 4.945 gm dye
   4.945 gm dye × 20% by weight = 0.989 active dye
   0.989 gm dye × 1,000,000 µg/gm = 989,000 µg/L solution
2. 10 mL of 989,000 µg/L solution diluted to 1 L = 9890 µg/L solution
3. 10 mL of 9890 µg/L solution diluted to 1 L = 98.9 µg/L solution (used as 100 µg/L standard)
4. dilute 500 mL of the 98.9 µg/L solution to 1 L – 49.5 µg/L solution (used as 50 µg/L standard)
5. dilute 20 mL of the 49.5 µg/L solution to 1 L = 0.99 µg/L (used as 1 µg/L standard)

15) **Procedure for measuring dispersion in a lake or reservoir:**

1. Release dye into water body. The dye release should occur over a relatively short period of time, approximately 5-10 minutes. The released dye should be neutrally-buoyant and not, by itself, rise or sink in the water column due to density effects. The dye may have to be diluted to match the water density (temperature and salinity) at the target depth. A diffuser can be

used to promote mixing of the dye with the ambient water. The appropriate quantity of dye released can be estimated from equations presented in Martin and McCutcheon (1999).

2. Mark the location of the dye release with a buoy and allow some time for initial expansion of the dye cloud.
3. After allowing for some initial spreading of the dye cloud, monitoring of dye concentration will begin. During monitoring, position of the boat is determined by a GPS sensor and is recorded at a regular interval. The sensors on the YSI sonde will be recorded at the same time interval. The general approach is to "sweep" across the dye cloud in both longitudinal and lateral directions, where each sweep begins outside the dye cloud, continues through the cloud, and ends where the edge of the cloud on the opposite side is identified. The depth of the sensors will be adjusted to identify the extent of dye tracer movement in the vertical direction.
4. Dye tracking will continue over the entire course of the day until detectable concentrations are no longer found. The time period over which detectable dye concentrations will persist will be strongly dependent on the magnitude of mixing that occurs during each dye tracer study. If a study is conducted under quiescent conditions, detectable concentrations may remain during the day after the dye release. If this is the case, then monitoring will continue the following day.

16) Calculations: The following is an illustration of how dye data would be used to compute the dispersion coefficient, which could be used directly in a 3-D hydrodynamic transport model (e.g., EFDC). If we make the very idealistic assumption that the dye spreads horizontally as a circular cloud, the dispersion coefficient *E* can be computed from the rate of increase of the diameter *D* of the cloud as

$$E = \frac{1}{2}\frac{d}{dt}(D^2)$$

In practice, the derivative in this equation is approximated by a finite difference. Assume that the field data indicates that the diameter of the dye cloud is 50 meters 3 hours after the release, and 150 meters 6 hours after the release. The dispersion coefficient over this period is then

$$
\begin{aligned}
E &\approx \frac{1}{2}\frac{(D_2)^2-(D_1)^2}{t_2-t_1}=\frac{1}{2}\frac{(150)^2-(50)^2}{6-3}\\
&=3300\,\text{meter}^2/\text{hr}\\
&=0.93\,\text{meter}^2/\text{sec}
\end{aligned}
$$

In practice, the dye cloud is likely to be of irregular shape. In addition, the longitudinal dispersion coefficient (along the long axis of the lake basin, roughly northwest-southeast) is likely to be different from the lateral dispersion coefficient (across the width of the basin, roughly southwest-northeast). In this case, more complete and complicated equations are used to compute the both the longitudinal and lateral components of the dispersion coefficient (Fischer et al. 1979).

17) **Method performance:** See #3 above

18) **Pollution prevention:** Health and safety are primary considerations in the application of dye tracers, including potential toxic effects on lake biota and effects on human health. Concentrations of dye known to affect biota are generally much higher than those required for tracer studies (Martin and McCutcheon 1999). In the presence of high nitrite concentrations (>1 mg/L), rhodamine WT has been found to form the carcinogen diethylnitrosamine (DENA). The potential for DENA formation is low in most surface water bodies because of relatively low nitrite concentrations. The USEPA and USGS have adopted a policy that prohibits the injection of fluorescent dyes in quantities that would result in dye concentrations >10 µg/L at drinking water intakes.

19) **Data assessment and acceptance criteria for quality control measures**: Assessment of results is done at UFI facilities (post collection). Acceptance criteria for quality control include consideration of field notation concerning interferences and presence of data points outside parameter detection range values.

20) **Corrective actions for out-of-control or unacceptable data:** Identify data that fail QA/QC, record throughout data transfer to client. Analyze cause of unacceptable data (*i.e.*, instrument error or interferences). Return instrument to manufacturer for repair and recalibration if deemed necessary.

21) **Contingencies for handling out of control or unacceptable data:** Calibration and standardization procedures listed above (#14) ensure that data are within specification.

22) Waste management: This procedure generates no hazardous waste.

23) References:

Fischer, H. B., E. J. List, R. C. Y. Koh, J. Imberger, and N. H. Brooks. 1979. Mixing in Inland and Coastal Waters. Academic, New York.

Martin, J. L. and S. C. McCutcheon. 1999. Hydrodynamics and Transport for Water Quality Modeling. CRC Press, Boca Raton, FL. 794 p.

YSI Environmental. 2001. White paper: Water Tracing, *In Situ* Dye Fluorometry and the YSI 6130 Rhodamine WT Sensor. www.ysi.com.