FIELD DATA COLLECTION ACTIVITIES FOR WATER-DISTRIBUTION SYSTEMS SERVING MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Preliminary Test and Tracer Study of the Hadnot Point Water-Distribution System

DRAFT WORK PLAN

Developed in cooperation with:

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FOREWORD

The Agency for Toxic Substances and Disease Registry (ATSDR) is conducting an epidemiologic study to determine if there is an association or potential link between exposure to contaminated drinking water and birth defects for women who were pregnant during the period 1968–1985. More than 12,000 women of childbearing age may have been exposed to well water contaminated with volatile organic compounds (VOCs) that was used for the potable water source and distributed through the water-distribution systems at Marine Corps Base, Camp Lejeune, North Carolina.

To quantify historical exposures needed by the epidemiologic study, ATSDR is using water-distribution system modeling to estimate the spatial and temporal distributions of contaminants in the historical water-distribution systems. To understand the historical water-distribution system characteristics, information based on the operation of the present-day water-distribution systems will be used in the process of historical reconstruction. The purpose of this work plan is to describe the general procedures that will be used to obtain hydraulic and water-quality data during an approximately three-day test of the Hadnot Point water-distribution system. These data will be used to assist in calibrating a present-day water-distribution model of the Hadnot Point water-distribution system.

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DRAFT WORK PLAN

By M.L. Maslia, J.B. Sautner, C. Valenzuela, F.J. Bove, and M.M. Aral

BACKGROUND

Camp Lejeune is a military base adjacent to and southeast of Jacksonville, Onslow County, North Carolina (Figure 1). It covers approximately 164 square miles and consists of six Marine Corps commands and two Navy commands. The population of the base includes active military personnel and their dependents (43,000 and 52,000, respectively). Base housing for enlisted personnel, officers, and their families are located in 15 different areas on the base (ATSDR 1998). More than 100 groundwater wells have been drilled to supply water for base activities. Almost all of the wells withdraw water from the permeable Castle Hayne aquifer which is composed of 60 to 90 percent sand and limestone (Harned et al. 1989, Cardinell et al. 1993).

Volatile organic compound (VOC) contamination of drinking water was first detected at Camp Lejeune in 1982. The start of contamination, however, is unknown. It is believed that the source of the contamination may have originated from a dry cleaning business located off base. The contaminated wells were not capped until 1985.

EPIDEMIOLOGIC STUDY

The Agency for Toxic Substances and Disease Registry (ATSDR) is conducting an epidemiologic study to determine if there is an association or potential link between exposure to contaminated water and birth defects for women who were pregnant during the period 1968–1985. More than 12,000 women of childbearing age who may have been exposed to the contaminated well water have been interviewed to date. As part of the epidemiologic study, the frequency, duration, and spatial distribution of human exposure to contaminated potable water need to be assessed and quantified. Water-distribution system modeling is being used by engineers and environmental health scientists at ATSDR as part of the process of quantifying historical exposures.

WATER-DISTRIBUTION SYSTEM MODELING

Owing to the paucity of historical, contaminant-specific, water-quality data at points of exposure, water-distribution system modeling is being used by ATSDR to synthesize temporal and spatial distributions of contaminants throughout the water-distribution systems serving populations that resided at Camp Lejeune from 1968–1985. To understand the historical water-distribution system characteristics, information based on the operation of the present-day water-

distribution systems will be used in the process of historical reconstruction (Maslia et al. 2001). To model present-day and historical water-distribution systems, an extended period simulation water-quality model (EPANET 2 [Rossman 2000]) must be calibrated against present-day field data. The purpose of this work plan is to describe the general procedures that will be used to obtain hydraulic (pressure and hydraulic head) and water-quality data (fluoride and chloride concentrations and conductivity) during an approximately three-day preliminary test of the water-distribution system serving Camp Lejeune.

Rational for Conducting Preliminary Test

For purposes of the epidemiologic study, the two water-distribution systems of interest at Camp Lejeune are Hadnot Point (HP) and Holcomb Boulevard (HB). Each is presently serviced by a water treatment plant known by the same name (Figure 2). Spatial and temporal distributions of parameter data (such as pressure, hydraulic head, pipe roughness coefficients, flows, and fluoride concentration) do not exist for the HP and HB water-distribution systems. Additionally, water-distribution system models have not been developed for the present-day or the historical systems. Thus, a preliminary test can be used to gather data solely from the Hadnot Point water-distribution system and will last for a limited duration of time (2–3 days). This approach is best suited for establishing initial water-distribution system parameters needed for more comprehensive field tests and model calibration. For purposes of conducting a preliminary field test, ATSDR staff, in cooperation with Camp Lejeune civilian staff and military personnel, decided that testing a single system rather than the combined HP and HB water-distribution system would be more manageable in terms of data gathering, personnel, and analyses. The HP water-distribution system was chosen to conduct the preliminary field test for the following reasons:

- The HP water-distribution system serviced the area that is now serviced by the HB water-distribution system prior to 1972, a period of interest for the epidemiologic study;
- The HP water-distribution system is operated manually, and therefore, can be more readily controlled during a field test; and
- At present (and for much of the historical period) the HP water-distribution system is (was) operated separately from the HB water-distribution system (by use of shut-off valves), thereby allowing investigators an opportunity to observe and measure water-quality parameters by conducting a tracer test without interference from the operation of the HB water-distribution system.

A detailed description of procedures developed to collect hydraulic data (pressure and hydraulic head) during extensive field tests is provided in Maslia et al. (2000a, b). Similar techniques will be used to obtain hydraulic data for the HP water-distribution system. However, based on preliminary field measurements at 9 selected hydrants, pressures ranged between 58 and 65 pounds per square inch (psi) with a mean value of 60 psi (Table 1). Considering the nearly flat terrain at Camp Lejeune, the resulting hydraulic gradient is extremely small. Attempting to calibrate a water-distribution system model solely based on pressure or hydraulic head data may prove infeasible, yield non-unique results, and result in a poorly calibrated water-quality network model. To address this situation, water-quality parameter data (fluoride and chloride concentrations and conductivity) will also be collected by conducting a tracer study of

the HP water-distribution system. In this manner, results from the tracer study can be used as a calibration tool (Grayman 2001).

Conducting a Tracer Study

A tracer study is a method for observing and measuring the movement of water within a water-distribution system. In this type of study a conservative substance, such as calcium chloride, can be injected into the water supply and the resulting concentration can be measured in terms of its spatial and temporal distribution as it moves through the distribution system. Alternatively, if a water-distribution system contains a compound at a known concentration, such as fluoride, the source of the compound can be abruptly shut off, and the decay of the compound (in this case, fluoride) can also be measured in terms of its spatial and temporal distribution as it decays throughout the distribution system. Details pertaining to the background and procedures of conducting a tracer study are described in Clark et al. (2004) and will not be repeated here.

The choice of the type of tracer that should be used to conduct a tracer study should be predicated on the following criteria: (1) regulatory requirements, (2) analytical methods for measuring tracer concentration, (3) injection and operational requirements, (4) chemical composition of the finished or treated water, (5) cost of the tracer, and (6) public perception. Four commonly used tracers in distribution systems are fluoride, calcium chloride, sodium chloride, and lithium chloride. The advantages and disadvantages of using each compound as a tracer for analysis of water-distribution systems are discussed in Clark et al. (2004). For testing the HP water-distribution system, fluoride and calcium chloride will be used. The reasons are:

- The HP water-distribution system currently uses fluoride (sodium fluoride crystals) to fluoridate the treated water so that a delivered water concentration of approximately 1 milligram per liter (mg/L) is achieved (TH Burton, MCB Camp Lejeune, written communication, October 15, 2003). Thus, delivered water contains fluoride that can be shutoff and re-injected for a tracer study;
- Calcium chloride requires only one secondary maximum contaminant level (MCL) standard to be met—chloride at 250 mg/L. HP water contains low chloride concentrations—raw water at 0.14 mg/L (BT Ashton, MCB Camp Lejeune, written communication, April 6, 2004) and treated water at 20 mg/L (BT Ashton, MCB Camp Lejeune, written communication, March 31, 2004). Therefore, the injection concentration for calcium chloride can be kept low so that the chloride concentration is well below the 250 mg/L MCL while still producing a measurable effect for the tracer study; and
- The cost of food grade liquid calcium chloride (35% by weight) is inexpensive at approximately $4.00 per gallon (gal) and can be delivered in convenient 55-gal drums (J. Weyenth, Benbow Chemical Packaging, Inc., written communication, April 1, 2004).

A tracer study is conceptually very simple, although successfully executing the study requires careful planning, coordination with water-utility personnel, regulatory agencies, and fire and safety officials, and judicious implementation to achieve useful results. The discussion in the section below on “Test Procedures” addresses these issues.

TEST PROCEDURES

Data Collection

Data to be collected during the preliminary field test are: distribution system pressures, hydraulic heads in elevated storage tanks, pumpage from groundwater supply wells, flows from raw-water pumps and treated water booster pumps, system operation procedures (on/off cycling of wells and pumps), fluoride[1] and chloride concentrations, and conductivity[2]. A description of types of data and the means by which they will be collected are listed in Table 2.

Tracer Injection

Careful planning must be used to insure that tracers injected into the treated water do not exceed state or federal standards for protecting the environment and public health while conducting the tracer study. Therefore, a review of expected tracer concentrations is presented below (refer to the section on "Time Schedule" for occurrence of specific activities relative to tracer injections). All tracer injections will take place at an injection port that is located on the treated water side of the HP water-treatment plant. Figure 3 shows a schematic of the HP water treatment plant and the location of the tracer injection point referenced to the water treatment plant. Figure 4 shows photographs of the point of injection with a generalized schematic of the tracer injection apparatus. Both Figures 3 and 4 clearly show that injection will occur on the delivered water side of the HP water-treatment plant.

Calcium chloride concentration. The calcium chloride ($CaCl_2$) solution that will be used for the tracer study is delivered in 55-gal drums and is 35% $CaCl_2$ by weight (Figure 5). As previously discussed, the resulting chloride concentration from the mixture of treated (delivered) water and $CaCl_2$ must not exceed the secondary standard MCL of 250 mg/L. To assure the public's health and safety, an upper limit concentration for the tracer study using $CaCl_2$ is set at 200 mg/L. To estimate the concentration that will be achieved by injecting the $CaCl_2$ solution, chemical mass balance computations were conducted using the average flow for May 2002 of 3 million gallons per day (MGD) or 125,000 gallons per hour (gph), 35% $CaCl_2$ solution by weight, a background chloride concentration of HP water of 20 mg/L (BT Ashton, MCB Camp Lejeune, written communication, March 31, 2004), and a 4- to 6-hour injection time using a 60 gph flow-paced injection pump[3]. Based on these data, and the assumption of complete mixing a very short distance away from the injection point, the maximum chloride concentration is computed to be 164 mg/L which is well below the allowable MCL of 250 mg/L (Appendix A). The material safety data sheet (MSDS) for calcium chloride is provided in Appendix B.

Fluoride concentration. To collect appropriate fluoride data that will be useful in understanding the fate and transport of constituents in the distribution system, the injection of fluoride at the water treatment plant will be shut off prior to the start of the test so that approximate equilibrium concentration conditions can be achieved at fluoride sampling locations (Plate 1). For the HP water-distribution system, this will occur when fluoride concentrations approach 0.2 mg/L

[1] At present, treated water at the HP water-treatment plant (WTP) is fluoridated so that a concentration of approximately 1 mg/L is maintained throughout the distribution system.

[2] Chloride concentration in mg/L and conductivity in microsiemens per centimeter (μS/cm) will be collected as a result of injecting a calcium chloride solution into treated water at the HP WTP.

[3] A flow-paced pump will assure that as the flow rate of delivered water changes based on demand, $CaCl_2$ injection rate will also change to maintain a near-constant concentration of the mixed $CaCl_2$ and treated water.

because this is the concentration of fluoride in the raw (or untreated) water (BT Ashton, MCB Camp Lejeune, written communication, April 6, 2004). Fluoride will then be re-introduced into the distribution system to achieve a maximum distribution-system concentration of 2 mg/L. The location of the fluoride injection will be at the same location used for the calcium chloride injection (Figures 3 and 4).

The source of the fluoride for tracer injection will be sodium fluoride (NaF) crystals used at the HP water treatment plant. To assure the public's health and safety, an upper limit fluoride concentration for the tracer study using NaF is set at 2 mg/L. To estimate the concentration that will be achieved by injecting the NaF solution, chemical mass balance computations were conducted using the average flow for May 2002 of 3 million gallons per day (MGD) or 125,000 gallons per hour (gph), a maximum background fluoride concentration of HP water of 0.2 mg/L (BT Ashton, MCB Camp Lejeune, written communication, April 6, 2004), and a 4- to 6-hour injection time using a 60 gph flow-paced injection pump. Based on these data, and the assumption of complete mixing a very short distance away from the injection point, it is estimated that about 36 pounds of NaF crystals will be required (when mixed 500 gallons of water) to achieve a maximum fluoride concentration of 2 mg/L in the delivered water (Appendix C). The material safety data sheet (MSDS) for the sodium fluoride that is used at the HP water treatment plant is provided in Appendix D.

An alternative approach to injecting the fluoride solution (by mixing NaF crystals with 500 gallons of water in a storage tank) is to use a chemical feed pump and a saturator kit (e.g., LMI fluoride saturator kit, part number 28850). With this approach, a 50-pound bag of NaF crystals is placed in the bottom of the saturator and water is added so that the saturator maintains a solution of 4% fluoride. With a background concentration of 0.2 mg/L (BT Ashton, MCB Camp Lejeune, written communication, April 6, 2004), and a maximum allowable concentration (for the tracer test) after injecting the fluoride of 2 mg/L, an additional 1.8 mg/L of fluoride need to be injected from the saturator. The 4% fluoride solution that is maintained by the saturator is equivalent to 40,000 mg/L. Therefore, the required dilution of the 4% solution is 22,222:1 (40,000 mg/L divided by 1.8 mg/L). With an average flow rate of 3 MGD (125,000 gph), 5.6 gph of the 4% fluoride solution would be added at the injection port from the fluoride saturator kit. For a 4- to 6-hour tracer test, 22 to 34 gallons of 4% fluoride solution would be required to be injected. This is within the volumetric capacity of the saturator kit which holds 50 gallons of solution. A summary of these calculations is provided in Appendix E. Using the saturator kit approach avoids having to manually or mechanically mix the NaF crystals with water in the 500 gallon tank as previously discussed. Therefore, this approach and equipment (saturator kit) will be used to inject fluoride for the tracer test of the HP water-distribution system.

Sampling Locations

Twenty seven sampling locations will be used for the preliminary test to gather data on pressure, fluoride, chloride, and conductivity (Plate 1; Appendix F, Table F-1). Nine hydrant locations will be equipped with continuous-recording pressure loggers (Dixon PR300; Table 1), nine locations will be equipped with continuous-recording loggers that will monitor fluoride, chloride, and conductivity (HORIBA W-23XD, Table 1), and the remaining nine locations will be equipped with continuous-recording conductivity loggers (HORIBA W-21XD, Table 1). On Plate 1, the pressure monitoring hydrants are designated with the letter "P", the combined fluoride, chloride, and conductivity monitoring hydrants are designated with the letter "F", and

the conductivity monitoring hydrants are designated with the letter "C." Appendix F (Table F-1) provides a comprehensive description of sampling locations. Test hydrants are marked with five-foot red and white fiberglass poles that have a red plastic flag at the top of the pole with the designated sampling hydrant identification (Figure 6).

Quality assurance and quality control (QA/QC) procedures for continuous-recording loggers will be instituted by having members of the ATSDR tracer study team make rounds at each of the loggers to check data that is being recorded at the monitoring locations. Team members will record pressures and water-quality parameters on data-entry log sheets as well as obtain grab samples of water for analysis of fluoride and chloride concentrations and conductivity. The analysis will be conducted at a temporary water-quality laboratory set up within the confines of the HP water-treatment plant. Examples of data-entry log sheets that will be used during the tracer study are provided in Appendix G.

Time Scheduling for Preliminary Test Activities

The scheduling of activities prior to and during the preliminary test is listed in Table 3. Installation of equipment is scheduled to begin on Monday, May 17, 2004. While tracer injection equipment (tank and flow-paced pump) are being installed, ATSDR staff will begin installing and calibrating continuous-recording data loggers. The loggers will be activated so that background data on pressure, fluoride and chloride concentrations, and conductivity can be gathered prior to the start of the test. After all loggers are installed, the HP water treatment plant fluoride system will be shut off and the decay of fluoride concentration throughout the distribution system will be closely monitored by use of the continuous-recording data loggers (Plate 1). Based on preliminary water-quality model simulation, it is estimated that within 48 hours the fluoride concentration throughout the HP water-distribution system will have attained a concentration of 0.2 mg/L[4].

The test will begin on Monday, May 24, 2004, at 0800 hours when the $CaCl_2$ solution injection will begin. Specific duties and responsibilities of ATSDR test staff are listed in Table 4. The injection will last 4 to 6 hours, depending on the actual flow rate of delivered water at the time of the test and results of monitoring and grab-sample data analyses during the day. Fluoride injection will begin at 0800 hours on Tuesday, May 25, 2004 and will also last 4 to 6 hours, depending on the actual flow rate of delivered water at the time of the test and results of monitoring and grab-sample data analyses during the day. Based on monitoring and grab-sample data after the fluoride injection is discontinued, it is anticipated that on Wednesday, May 19, normal WTP operations at HP can resume by turning on the HP fluoride injection system. During the tracer study test (May 24–26), ATSDR staff will be assigned different tasks as listed in Table 4. There will always be test staff at the HP water treatment plant to continuously monitor injection pumps and resulting concentrations of both $CaCl_2$ and fluoride and discuss any operational changes required from this plan with water utility staff (Table 3). It should be noted, however, that activities and task times listed in Tables 3 and 4 are approximate and may be

[4] Because of the manner in which the HP water-distribution system is operated, only the French Creek elevated storage tank water level is allowed to fluctuate. Therefore, the remaining elevated storage tanks will still contain water that has a fluoride concentration of approximately 1 mg/L. This water will not significantly affect the tracer study result should any of the water be released into the distribution system during the tracer study test.

modified during the progression of the test in response to test conditions and communications between Camp Lejeune water utility staff and ATSDR test staff.

TEST EQUIPMENT

Equipment utilized for the test will enable continuous gathering of data for system pressures, fluoride and chloride concentrations, and conductivity. Additionally, injection pump equipment and 525-gallon storage tanks will be used to conduct the tracer study. Descriptions of the monitoring equipment and methods by which they will be attached to the test hydrants (Plate 1) are described below.

Pressure Loggers

Pressure data will be gathered using the Dixon PR300 continuous pressure data logger (Figure 7) at sampling locations P01–P09 (Plate 1). It will be attached to a hydrant using a Dixon A7983 hydrant adapter kit and a Dixon R022 filter kit (1/4 NPT x 1/4 NPTF). During the test, real-time pressure can be viewed by connecting a nine-pin cable to a standard computer port (COM1 or COM2 port), as shown in Figure 8. This is also the means by which all recorded data is retrieved. For QA/QC purposes, pressures will be measured during installation and during removal of the continuous-recording pressure logger by using a Class 1 hand-held pressure gage that can be attached to the Dixon A7983 hydrant adapter kit as shown in Figure 9.

Dual Probe Fluoride and Chloride Ion and Conductivity Loggers

To record fluoride and chloride concentration and conductivity data simultaneously (sampling locations F01–F09, Plate 1, Table F-1), the HORIBA W-23XD dual probe, multi-parameter water-quality monitoring system will be used. This system consists of dual probe ion detector, (fluoride and chloride ion sensors and conductivity sensor, Figure 10), and a flow cell that fits the double probe W-23XD (Figure 11). The probe and flow cell will be housed in a plastic protective container which is a standard 5-gallon water jug (Figure 12). Water will pass through the flow cell by attaching a Dixon A7893 hydrant adapter kit to the sampling location hydrant. The adapter kit will be configured with a 1/4 NPT brass “T” and two 1/4-inch ball valves on each side of the brass “T” (Figure 13). One valve will be used to control flow into the flow cell and the other valve will be used to turn water on and off when obtaining grab samples from the hydrant (Figure 14). The complete configuration consisting of the HORIBA W-23XD probe, flow cell, and 5-gallon plastic protective water jug will be secured to the hydrant by means of a chain and lock as shown in Figure 14. There will be a continuous discharge of water coming from the flow cell and plastic protective container (approximately 1–2 gallons per minute). To monitor and download fluoride and chloride concentration and conductivity data, the HORIBA water-quality control unit is attached to the sensor probe using a cable (Figure 15). With the configuration described above, the data logger continues to record data while real-time data values can be viewed using the HORIBA water-quality control unit and grab samples can be obtained for QA/QC analyses.

Single Probe Conductivity Loggers

Because of the cost of the dual probe loggers described above, and the need to have additional sampling stations, a single probe continuous recording logger will be used to record conductivity at hydrant sampling stations C01–C09 (Plate 1, Table F-1). By measuring

conductivity, chloride concentration can be determined from a conductivity versus chloride calibration curve that is determined in the laboratory using HP water. The water-quality monitoring system that will be used at the conductivity sampling hydrants C01–C09 is the HORIBA 21XD single-probe water-quality measurement logger (Figure 16). The singe-probe unit will be attached to the sampling hydrant in the same manner as discussed above for the dual-probe unit (Figure 14). To monitor and download conductivity data, the HORIBA water-quality control unit is attached to the sensor probe using a cable as previously described and shown in Figure 16.

Calcium Chloride Injection System

As describe in the section on "Calcium chloride concentration," about 8 drums of 35% by weight $CaCl_2$ solution (55-gallons per drum) will be pumped into a holding tank and then injected into the delivered water (Figures 3 and 4). The holding tank has a volume of 525 gallons and a picture of the tank and a schematic are shown in Figure 17. To pump the $CaCl_2$ solution from the 525-gallon tank into the injection port (Figure 4) a Tuthill TX-series pump will be used. The pump is driven by a Baldor ½-horespower, 1,725 revolutions per minute (RPM) inverter drive motor with controls that can pick up a 4-20 miliamp signal from a discharge venturi meter. The pump is capable of delivering approximately 120 gph (2 gallons per minute) at 100 psi. A schematic of the pump is shown in Figure 18 and photographs of the pump and motor controls are shown in Figure 19.

Sodium Fluoride Injection System

As discussed in the section on "Fluoride concentration," there are two approaches that are considered for injecting fluoride into the distribution system. The first approach requires 36 pounds of NaF crystals to be mixed with about 500 gallons of water in the holding tank described above (Figure 17). Then the mixture is pumped into the delivered water through the injection port (Figure 4) using the pump and motor mechanism described above (Figures 18 and 19).

The second approach uses a fluoride saturator mechanism and a chemical feed pump. The saturator mixes the NaF crystals with inflowing water and assures a consistent fluoride saturation of 4% (40,000 mg/L). The advantage of this approach is that for the tracer test being planned, only one bag (50 pounds) of NaF crystals needs to be placed at the bottom of the saturator and no additional manual or mechanical mixing is required by the tracer study staff. Additionally, the chemical feed pump will assure that a consistent amount of fluoride solution is injected into the delivered water stream based on the delivered water flow rate[5]. For the fluoride injection, the saturator kit and chemical feed pump will be used. Therefore, the fluoride injection system will consist of a 525-gallon tank (Figure 17) to hold treated water where the fluoride concentration has decayed to 0.2 mg/L (refer to section on "Fluoride concentration" and Table 3). The LMI 50-gallon saturator kit and chemical feed pump with flow controller for picking up a 4-20 miliamp signal from the delivered water venturi meter are show in Figure 20.

[5] It should be noted, however, that based on computations provided in Appendices C and E, both approaches will result in delivered fluoride concentration of 2 mg/L or less.

TRAINING

A day-long training session was held at ATSDR, in Atlanta, Georgia, on April 21, 2004. The purpose of the training session was to introduce tracer test team members to the installation, calibration, and use of the HORIBA W-23XD water-quality monitoring system. Representatives from the manufacturer and vendor of the water-quality monitoring system were present to provide instruction and guidance on calibrating and using the instruments as well as to answer any questions. Furthermore, instruction on laboratory techniques with respect to calibrating the instruments and conducting QA/QC on the instrument was also provided to team members. Figure 21 shows team members and instructional staff during the training session. A sample of the training agenda is presented in Appendix H.

During the week of May 17–19, when loggers and injection pump equipment will be installed (Table 3), training on the use of the chemical feed and injection pumps will also be conducted. The training will be attended by the three ATSDR tracer study team members on site during the week (Table 3) and Camp Lejeune water-utility operations staff that will be operating the HP water-distribution system during the tracer test study period. The purpose of this training will be to review the calibration procedures and operations of the chemical injection pump equipment to assure that during the tracer injection (May 24 and 25, Table 3) the required amount of $CaCl_2$ solution and fluoride will be injected into the distribution system.

COMMUNICATIONS AND CONTINGINCIES

All sampling hydrants will be marked with signage providing information to those on base as to the purpose of the tracer test and who they should contact with any questions. A copy of the signage that will be used is provided in Appendix I. Figure 14 shows how the signage will be displayed at all sampling hydrant locations.

The ATSDR project officer will be the “person-in-charge” for the ATSDR tracer study team. Any modifications of test procedures or activities as described herein—required as a result of actual field conditions—will involve decisions made in consultation with the ATSDR project officer. The ATSDR project officer will be the liaison between the tracer study team and the Camp Lejeune water utility staff and military personnel. The project officer will be the agency’s representative who communicates work plan changes to the tracer study team and to Camp Lejeune water-utility staff and military personnel.

The ATSDR tracer study team will have in their possession at all times during the tracer study a minimum four cellular telephones or two-way radio communication devices. The telephones or two-way radios will be located at the HP water-treatment plant and with tracer study staff conducting QA/QC at pressure sampling hydrants (P01–P09; Plate 1), fluoride and chloride sampling hydrants (F01–F09), and conductivity sampling hydrants (C01–C09). ATSDR tracer study team members (including the project officer) will have in their possession at all times a complete list of all cellular telephone numbers and radio frequencies.

Of paramount importance are the health and safety of the public (military and civilian) that will be using water from the HP water-distribution system during the tracer study. For the Camp

Lejeune water utility staff, the shift foreman shall be present during the 4-6 hour period of chemical injection ($CaCl_2$ and NaF). For ATSDR, two tracer study team members will always be present at the HP water treatment plant to closely monitor the injection of tracer solution and the resulting concentration in delivered water (at sampling hydrant F03 which is located next to the HP water treatment plant) during the tracer injection (Table 4).

The ATSDR tracer study team will frequently monitor the fluoride and chloride levels at the sampling hydrant locations (F01–F09 and C01–C09; Plate 1) to assure that chloride concentrations are below 200 mg/L and fluoride concentrations are below 2 mg/L. Should concentrations at the sampling hydrants exceed these levels—based on data obtained from either the continuous recording loggers (Figures 10 and 16) or the QA/QC grab samples—then: (1) The ATSDR project officer will immediately be notified as to the resulting concentration, the sampling hydrant identification, and whether the exceeding concentration was observed from a continuous recording logger or a grab sample, and (2) The ATSDR project officer will communicate these findings to the Camp Lejeune water-utility shift foreman. Based on the concentration of the specific tracer constituent (Cl or F), the following procedures will be followed:

(1) Chloride concentration exceeding 200 mg/L and less than 250 mg/L,
   a. More frequent monitoring of continuous recording loggers will begin and additional QA/QC grab samples will be obtained from sampling hydrants to more closely assess if there is a trend to the increasing chloride concentrations;
   b. Verification grab samples shall be taken at the sampling hydrant that indicated the exceeding concentration and immediately brought back to the water-quality lab at the HP water-treatment plant for analysis; and
   c. If the additional QA/QC grab samples indicate concentrations within acceptable limits (200 mg/L or less), the QA/QC sampling frequency may be reduced after consultation between the ATSDR project officer and the water utility shift foreman.

(2) Chloride concentration exceeds 250 mg/L,
   a. The $CaCl_2$ chemical feed equipment (Figure 20) will be shut off;
   b. Verification grab samples shall be taken at the sampling hydrant that indicated the exceeding concentration and immediately brought back to the water-quality lab at the HP water treatment plant for analysis;
   c. If the additional QA/QC grab samples indicate concentrations of less than 250 mg/L, the injection equipment may be turned back on and the tracer injection resumed after consultations between the ATSDR project officer and the Camp Lejeune water utility shift foreman; and
   d. Should the additional QA/QC grab samples confirm a concentration exceeding 250 mg/L, then North Carolina Department of Environment and Natural Resources will be contacted by Camp Lejeune water utility staff.

(3) Fluoride concentration exceeding 2 mg/L and less than 4 mg/L,
   a. The NaF chemical feed equipment (Figure 19) will be shut off;
   b. Verification grab samples shall be taken at the sampling hydrant that indicated the exceeding concentration and immediately brought back to the water-quality lab at the HP water treatment plant for analysis;

c. If the additional QA/QC grab samples indicate concentrations of less than 2 mg/L, the injection equipment may be turned back on and the tracer injection resumed after consultations between the ATSDR project officer and the Camp Lejeune water utility shift foreman; and
d. Should the additional QA/QC grab samples confirm a concentration exceeding 2 mg/L, then North Carolina Department of Environment and Natural Resources will be contacted by Camp Lejeune water utility staff.

(4) Fluoride concentration exceeds 4 mg/L,

a. The NaF chemical feed equipment (Figures 19) will be shut off;
b. The entire HP water-distribution system will be flushed until fluoride residuals reach acceptable levels (less than 2 mg/L);
c. If flushing is initiated, the hydrants will essentially flush elevated storage tanks, S-5, S-29, S-1000, and SFC-314;
d. High lift pumps will be secured and water levels in storage tanks will be allowed to decline several feet while flushing the hydrants; and
e. Pumps will be turned back on and Camp Lejeune water utility personnel will continue to flush the distribution system with water from the reservoir.

HEALTH AND SAFETY ISSUES

All traffic regulations, procedures, and laws will be strictly observed by ATSDR tracer study team members when driving vehicles on site at Camp Lejeune. This includes, obeying all posted vehicle speed regulations. Each vehicle occupant must wear a seat belt and assure that it is securely buckled at all times when the vehicle is moving.

Each vehicle that will be used by the ATSDR tracer study team will be equipped with a 25-unit first aid kit. Additionally, tracer test members stationed at the HP water treatment plant will also have the first aid kit available to them. Figure 22 shows a photograph of a typical first aid kit that will be available on site. Because of the duration of time that ATSDR tracer study team members may be out in the sun conducting QA/QC on the sampling hydrant locations, team members will also be provided with sun block cream (SPF 30 or higher) to protect their skin from the possibility of long exposure to the sun. Additionally, fire ants, other stinging insects, and rash-causing vegetation such as poison ivy are found on-site as Camp Lejeune. Therefore, each tracer study team member will be supplied with an outdoor skin protection kit, shown in Figure 23.

Because of security issues at Camp Lejeune, all ATSDR tracer study team members must have on their possession at all times proper identification. This can be either a valid driver's license or a government employee identification card. Team members will wear T-shirts that contain the ATSDR agency name so that team members can be identified while on base at camp Lejeune by both military personnel and civilians.

ATSDR tracer study team members will be supplied with an orange fluorescent traffic safety vest. The vest will be worn at all times when team members are conducting activities at the

sampling hydrant locations. Figure 24 is a photograph of a typical traffic safety vest that will be worn by team members.

SUMMARY

ATSDR is conducting an epidemiologic study to determine if there is an association or potential link between exposure to contaminated drinking water at Camp Lejeune, North Carolina, and birth defects for women who were pregnant during the period 1968–1985. To understand the historical water-distribution system characteristics, information based on the operation of the present-day water-distribution system will be used in the process of historical reconstruction. To obtain present-day data and information, a tracer study test of the HP water-distribution system is planned for May 24-16, 2004. This work plan describes the general procedures, water-quality monitoring equipment, and tracer injection equipment that will be used to obtain hydraulic and water-quality data during an approximately three-day tracer study test of the HP water-distribution system.

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Table 1. Pressure measurements for selected test hydrants, Hadnot Point water-distribution system, April 19, 2004 (see Plate 1 for hydrant locations). [psi, pounds per square inch]

Hydrant Identification	Time (hours)	Pressure (psi)
P01	13:45	60
P02	14:23	60
P03	15:15	60
P04	15:30	65
P05	15:47	60
P06	16:15	60
P07	16:48	59
P08	17:48	59
P09	17:55	58

Table 2. Water-distribution system data collection methods, Hadnot Point water-distribution system, Marine Corps Base, Camp Lejeune, North Carolina.
[QA/QC, quality assurance and quality control; SCADA, supervisory control and data acquisition]

Parameter	Collection Method	Notes
Pressure	Continuous recording data logger; 15-minute interval	Dixon PR300 pressure logger; 9 locations– refer to Plate 1 and Appendix F for locations; QA/QC using hand gauge
Hydraulic head	SCADA system records for water-level in storage tanks during test; 15-minute interval	If SCADA unavailable, manual recording of water-level in elevated storage tanks by ATSDR staff in control rooms
Groundwater well supply	SCADA system records for groundwater supply well pumpage during test; 15-minute interval	If SCADA unavailable, manual recording of groundwater well pumpage by ATSDR staff in control rooms
Flow from raw water pumps and treated water booster pumps	SCADA system records for pump flows during test; 15-minute interval	If SCADA unavailable, manual recording of pump flows by ATSDR staff in control rooms
System operation procedures (on/off cycling of wells and pumps)	Operator system records for on/off cycling events;	Manual recording on/off cycling events by ATSDR staff in control room
Fluoride concentration	Continuous recording data logger; 15-minute interval	HORIBA W-23XD dual ion probe logger, 9 locations– Plate 1 and Appendix F for locations; QA/QC using grab samples
Chloride concentration	Continuous recording data logger; 15-minute interval	HORIBA W-23XD dual ion probe logger, 9 locations– Plate 1 and Appendix F for locations; QA/QC using grab samples
Conductivity	Continuous recording data logger; 15-minute interval	HORIBA W-23XD dual ion probe logger, 9 locations; HORIBA W-21XD single probe logger; 9 locations– Plate 1 and Appendix F for locations; QA/QC using grab sample

Table 3. Schedule of preliminary test activities, Hadnot Point water-distribution system, Marine Corps Base, Camp Lejeune, North Carolina, May 17–27, 2004.
[ATSDR, Agency for Toxic Substances and Disease Registry; CL, Camp Lejeune water-utility staff; HP, Hadnot Point, WTP, water treatment plant; QA/QC, quality assurance and quality control]

Date	Time (Hours)	Activity	Responsible Staff
May 17	0800	Setup and installation of injection pumps on grounds of HP WTP	CL; ATSDR[1]
	0800–1600	Install pressure and water-quality monitoring equipment on all test hydrants (refer to Plate 1 for locations)	ATSDR
	1600	Shut off fluoride feed at HP WTP	CL
May 18	0800–1600	Calibrate injection pumps to delivered water flow rate	CL; ATSDR
	0800–1600	QA/QC pressure and water-quality monitoring equipment (refer to Plate 1 for locations)	ATSDR
May 19	0800–1200	QA/QC injection pumps	CL; ATSDR
	0800-1200	QA/QC pressure and water-quality monitoring equipment (refer to Plate 1 for locations)	ATSDR
May 24	0800	Begin calcium chloride injection	ATSDR[2]
	0800–2200	QA/QC pressure and water-quality monitoring equipment (refer to Plate 1 for locations); lab analysis of grab samples	ATSDR
	1400	Shut off calcium chloride injection	ATSDR
May 25	0800	Begin fluoride injection	ATSDR
	0800–2200	QA/QC pressure and water-quality monitoring equipment (refer to Plate 1 for locations); lab analysis of grab samples	ATSDR
	1400	Shut off fluoride injection	ATSDR
May 26	0800–2200	QA/QC pressure and water-quality monitoring equipment (refer to Plate 1 for locations); lab analysis of grab samples	ATSDR
May 27	0800	Disassemble injection pump equipment	CL
	0800–1400	Remove data loggers from hydrants and retrieve data from loggers	ATSDR
	1400–1600	HP tracer study concludes; post-test discussions with Camp Lejeune staff	CL; ATSDR

[1] Only 3 ATSDR staff required, May 17–19.
[2] Nine ATSDR staff require for test, refer to Table 4 for specific duties and responsibilities of ATSDR staff.

Table 4. Duties and responsibilities of ATSDR staff during tracer study test, Hadnot Point water-distribution system, Marine Corps Base, Camp Lejeune, North Carolina, May 24–27, 2004.

Date	Time	Test Activity and ATSDR Test Staff Assignments[1]					
		Control Room	Injection Pumps	Water-Quality Analyses	Pressure Loggers	Fluoride Loggers	Conductivity Loggers
May 24	0800–1400	#5	#5	#3, #6	#6	#1, #2, #4	#7, #8, #9
	1400–2200	#5	Pump off	#1, #6	#6	#2, #3, #4	#7, #8, #9
	2200–2400	#6	Pump off				
May 25	0800–1400	#2	#2	#9, #6	#6	#1, #3, #4	#5, #7, #8
	1400–2200	#2	Pump off	#1, #6	#6	#3, #4, #9	#5, #7, #8
	2200–2400	#6	Pump off				
May 26	0800–1200	#5		#3, #6	#6	#1, #2, #4	#5, #7, #8
	1200–1600	#6		#2, #9	#6	#2, #3, #4	#5, #7, #8
	1600–2400	#2					
May 27	0800–1400[2]		#5, #6		#2, #4, #8	#2, #4, #8	#2, #4 , #8

[1] Not all ATSDR test staff are employed by ATSDR, but for the purpose of this document and the test, they will be referred to as ATSDR staff. Test staff and their affiliations are as follows: #1: M. Cienek, U.S. Geological Survey, Raleigh, North Carolina; #2: R.E. Faye, Eastern Research Group, Boston, Massachusetts; #3: A.B. Funk, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia; #4: G.C. Mayer, U.S. Geological Survey, Norcross, Georgia; #5: M. Martinson, ATSDR, Atlanta, Georgia; #6: M.L. Maslia, ATSDR, Atlanta, Georgia; #7: C. Pfeifle, U.S. Geological Survey, Raleigh, North Carolina; #8: J.B. Sautner, ATSDR, Atlanta, Georgia; #9: C. Valenzuela, Georgia Institute of Technology, Atlanta, Georgia.

[2] Injection equipment disassembled, loggers are removed from hydrants, and data retrieved from loggers, refer to Table 3.

Water-Distribution System Tracer Test
Hadnot Point Water Treatment Plant Sampling Locations

MCB, Camp Lejeune, North Carolina
May 2004

EXPLANATION

- Fire Hydrant
- ATSDR test hydrant
  - P - pressure
  - F - fluoride-chloride
  - C - condcutivity
- Storage Tank
  - Elevated
  - Ground - Treated Water
  - Ground - Raw Water
  - Ground - Treated (TT)
- Water pipeline
  - Raw water
  - Delivered water
- Street
- Camp Lejeune

N

500 0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 Feet

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

F01 P01 C01 C02 F02 P02 C03 P03 F03 C04 P04 F04 P05 F05 C05 C06 F06 P06 P07 F07 C08 P08 F08 C09 P09 F09

Julian C Smith
Holcomb Boulevard
Hadnot Point WTP
Michael Road
Luis Street
McHugh Boulevard
Sneads Ferry Road
Gonzalez Boulevard

New River

Plate 1. Locations of pressure, fluoride-chloride, and conductivity loggers for conducting preliminary test of the Hadnot Point water-distribution system.

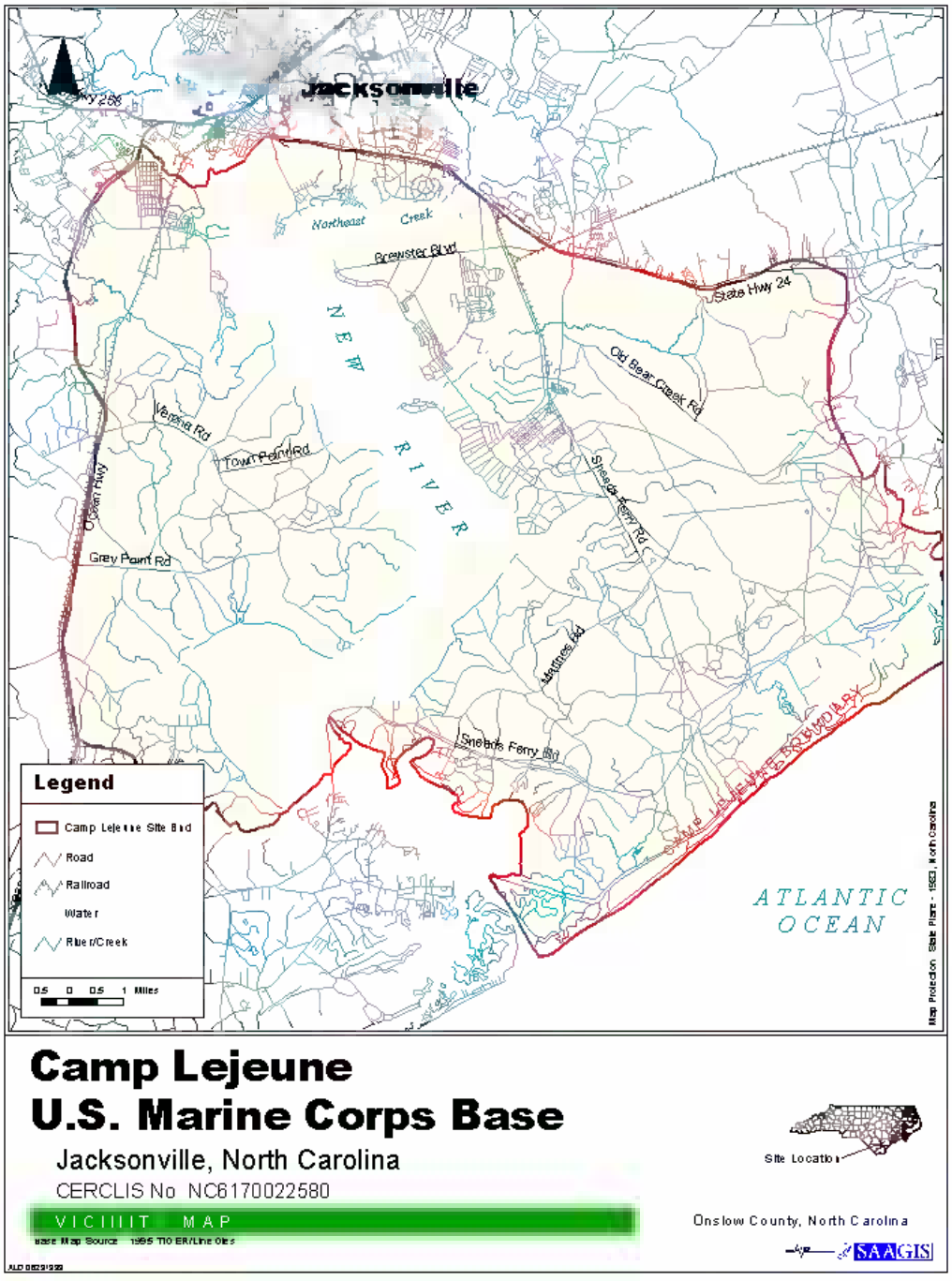

Figure 1. Location of study area

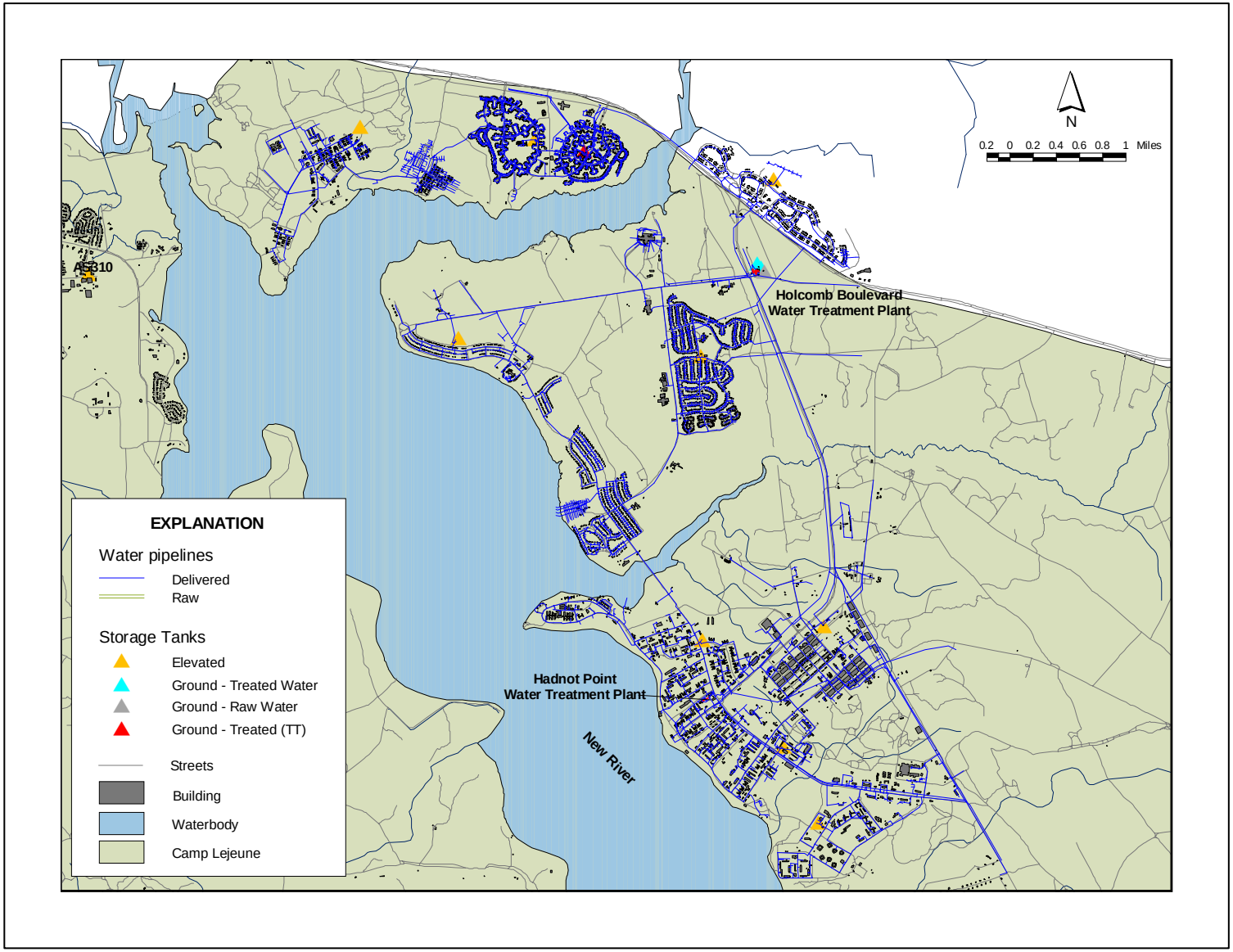

Figure 2. Location of Hadnot Point and Holcomb Boulevard water-distribution systems.

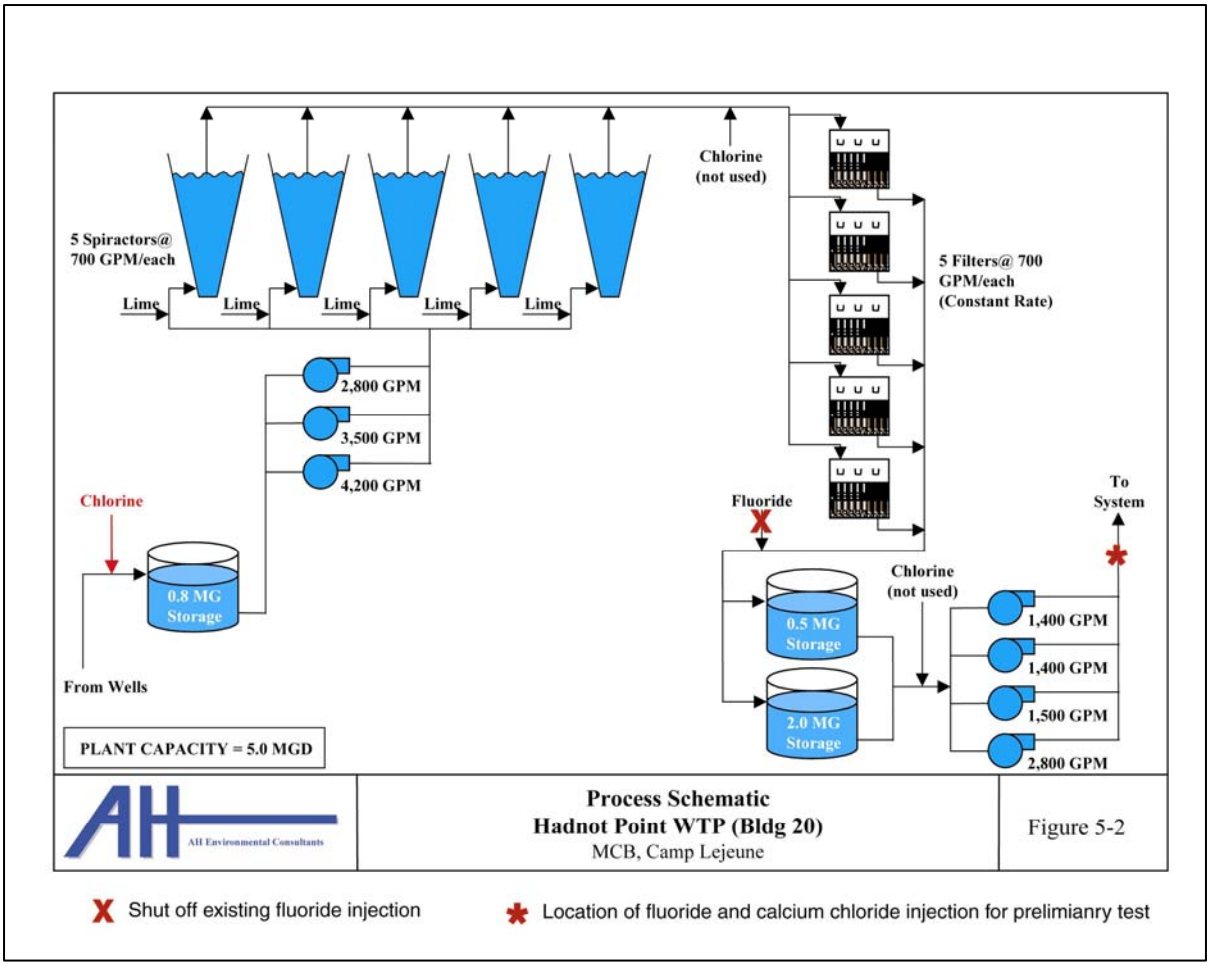

Figure 3. Location of fluoride and calcium chloride injection at the Hadnot Point water treatment plant for preliminary test.

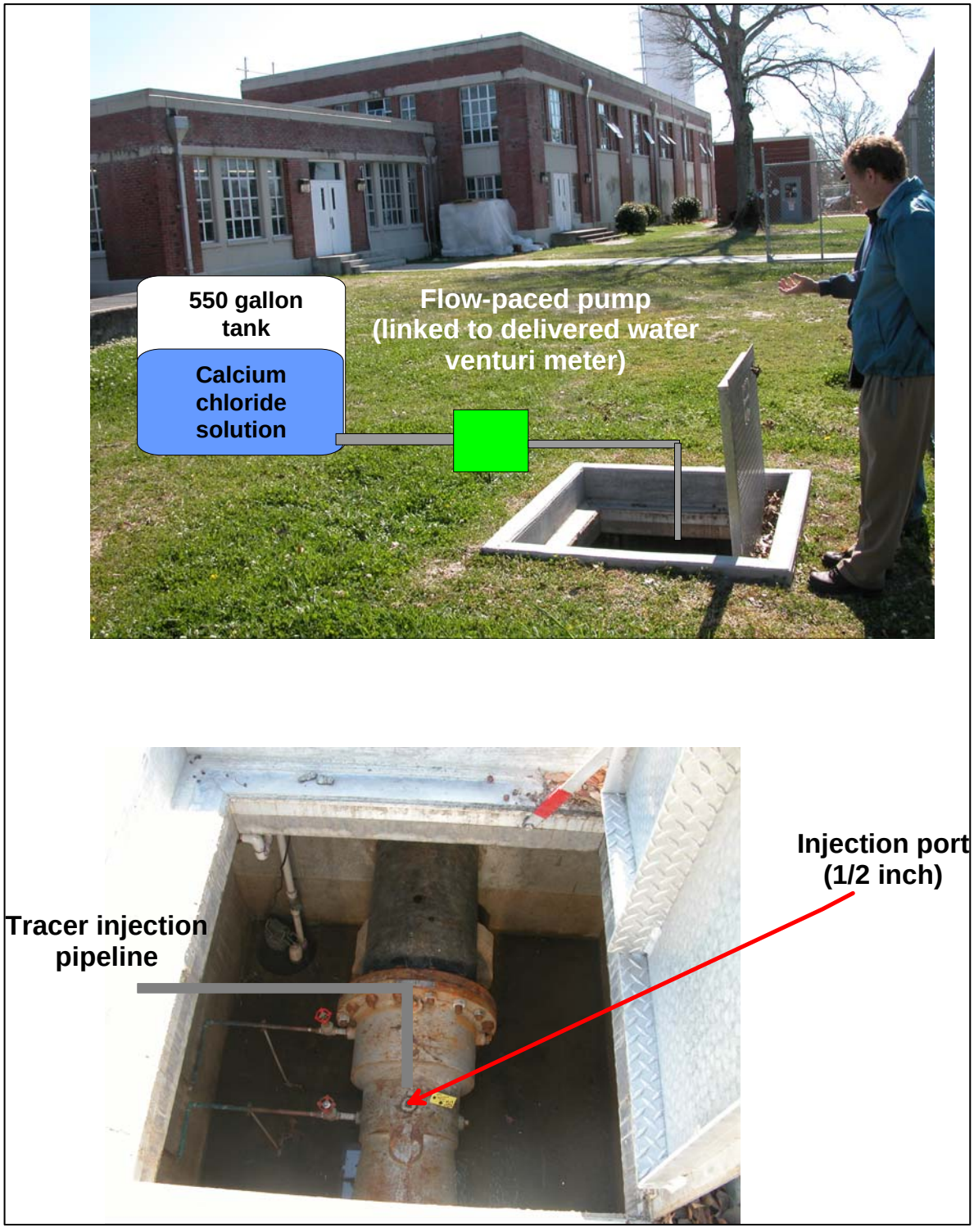

Figure 4. Photographs showing location of tracer injection and generalized schematic of injection apparatus for tracer study of Hadnot Point water-distribution system.

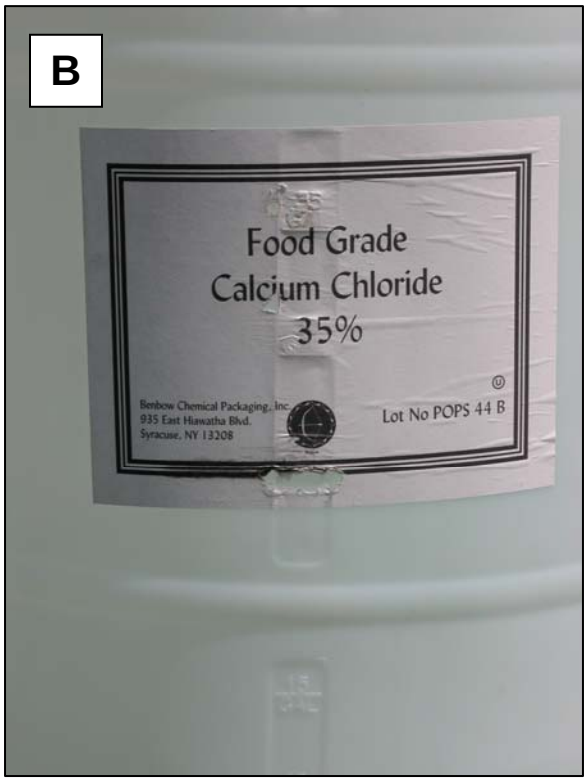

Figure 5. Photographs showing calcium chloride solution to be used for tracer study of the Hadnot Point water-distribution system: (A) 55-gal drums, and (B) label showing 35% by weight.

Figure 6. Photograph showing sampling hydrant F03 marker flag mounted on 5-foot fiberglass pole (refer to Plate 1 and Appendix F for hydrant location).

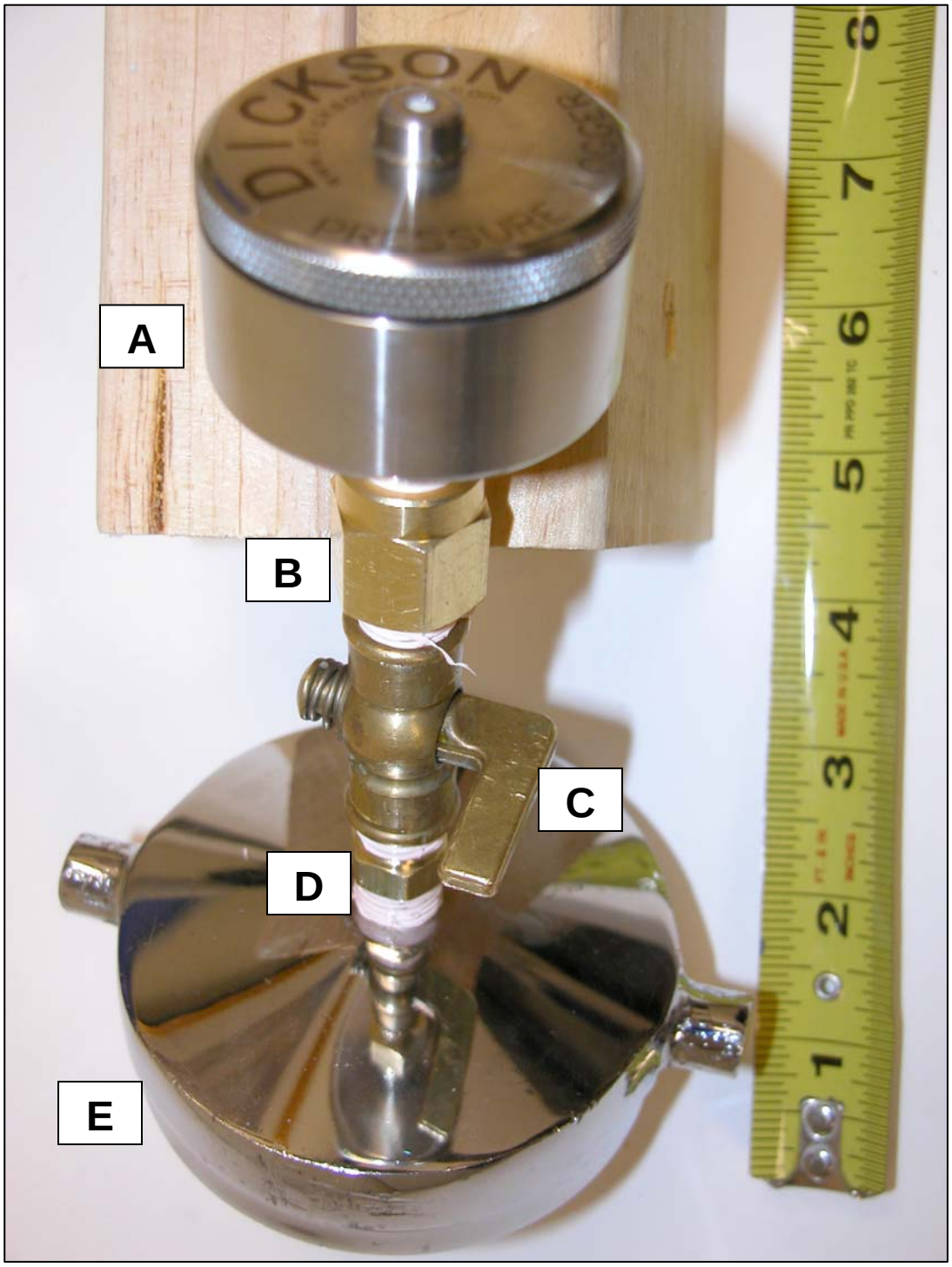

Figure 7. Photograph showing: (A) Dixon PR300 continuous recording pressure data logger, (B) Dixon R022 filter kit (1/4 NPT x 1/4 NPTF), (C) Dixon brass lever handle shut-off valve (1/4 NPTF x 1/4 NPTF) in off position, (D) Hofmann brass nipple (1/4 NPT x 1/4 NPT), and (E) Dixon A7983 hydrant adapter kit**.**

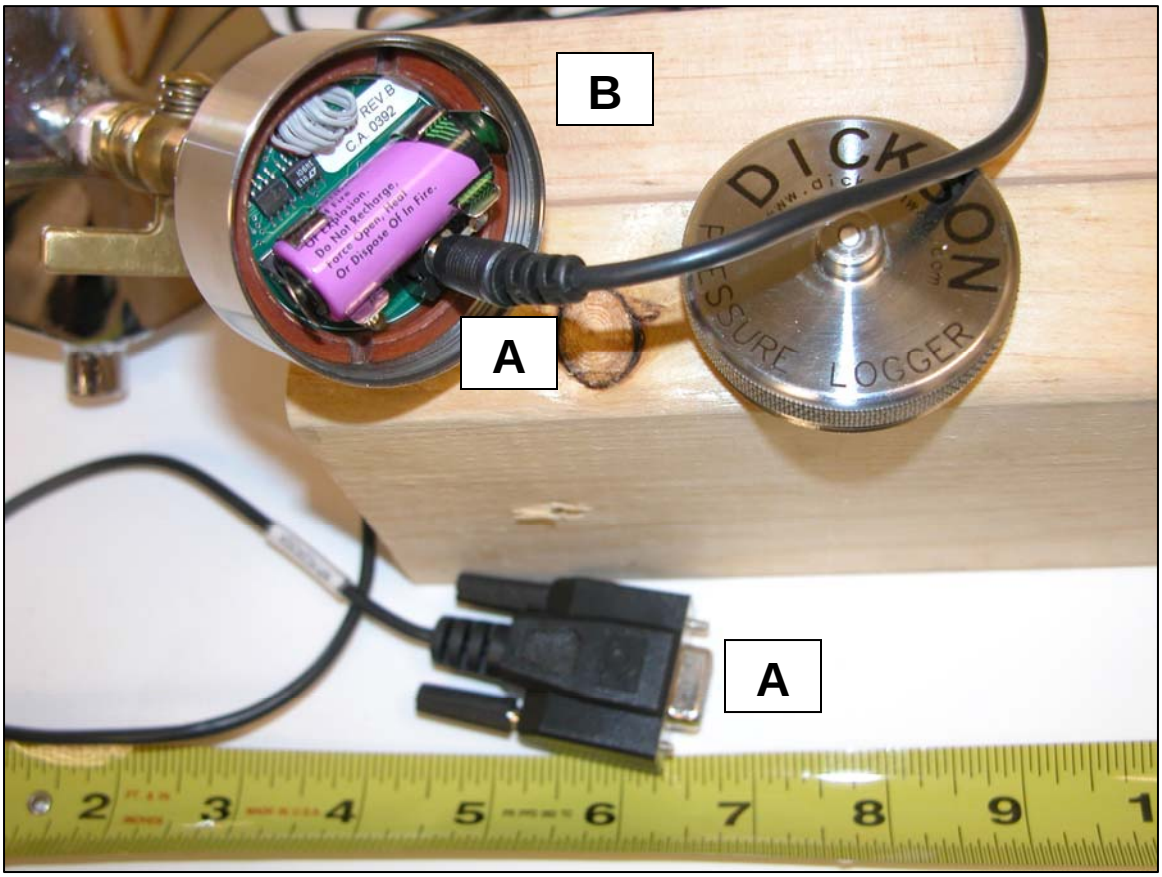

Figure 8. Photograph showing: (A) nine-pin standard computer cable, and (B) Dixon PR300 continuous recording pressure gauge.

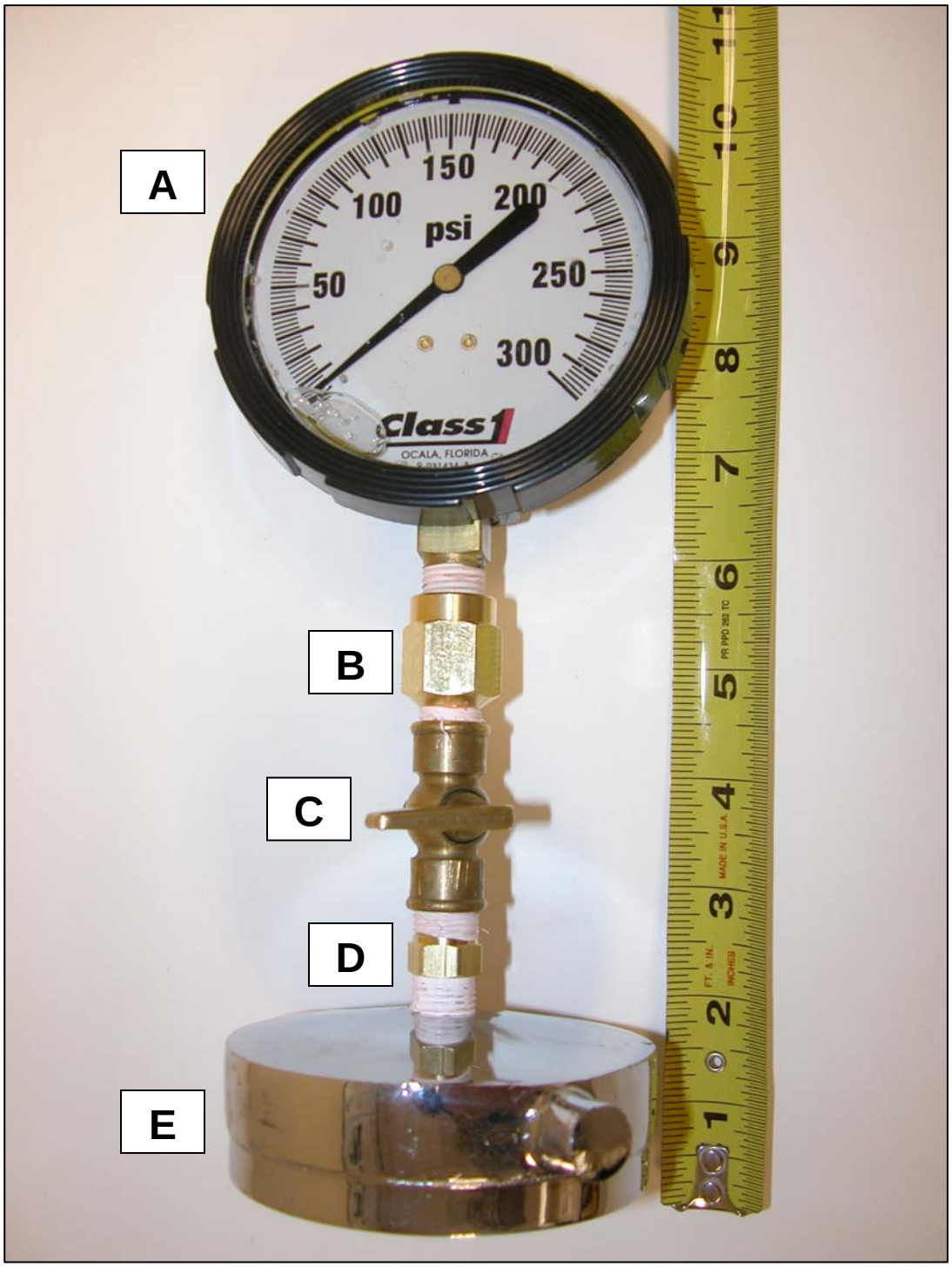

Figure 9. Photograph showing: (A) Class 1 hand-held pressure gauge, (B) Dixon R022 filter kit (1/4 NPT x 1/4 NPTF), (C) Dixon brass lever handle shut-off valve (1/4 NPTF x 1/4 NPTF) in off position, (D) Hofmann brass nipple (1/4 NPT x 1/4 NPT), and (E) Dixon A7983 hydrant adapter kit.

Figure 10. Photograph showing HORIBA W-23XD dual probe ion detector with: (A) fluoride and chloride sensors, and (B) pH, temperature, and conductivity sensors (located inside metal housing).

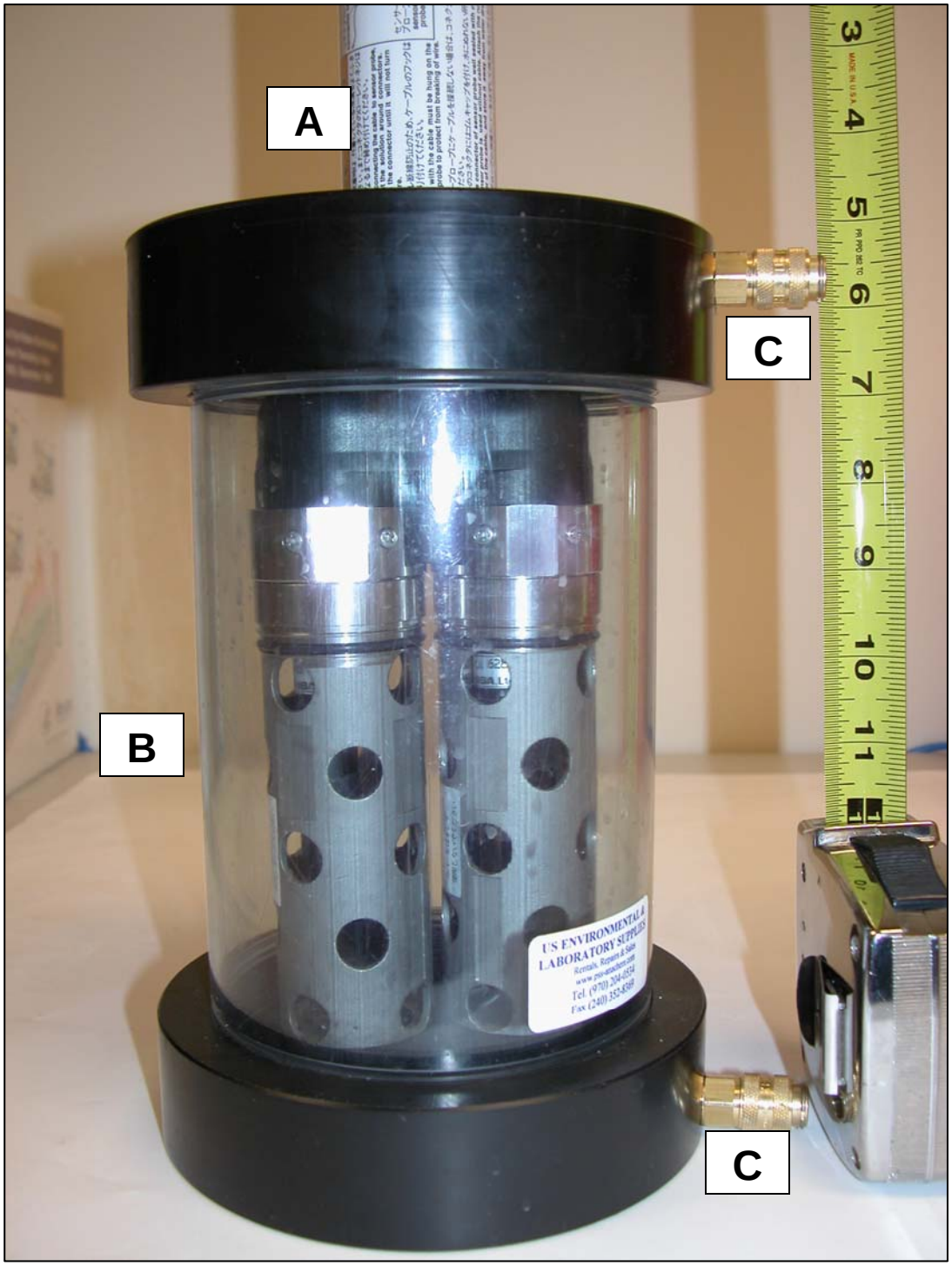

Figure 11. Photograph showing: (A) HORIBA W-23XD dual probe ion detector, (B) flow cell with (C) Rectus 21KANNMPX, 1/4 NPT brass connectors.

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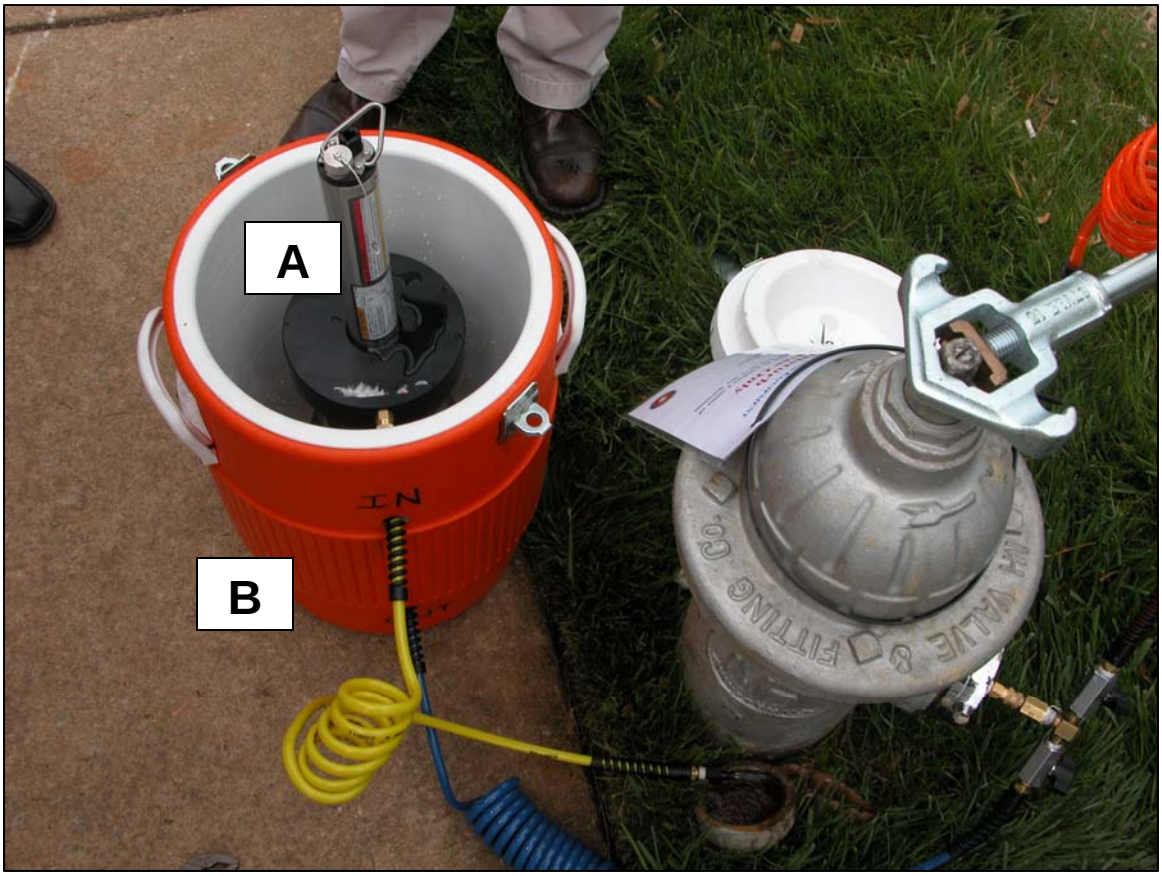


Figure 12. Photograph showing: (A) HORIBA W-23XD dual probe ion detector and flow cell housed in (B) protective 5-gallon plastic water jug.

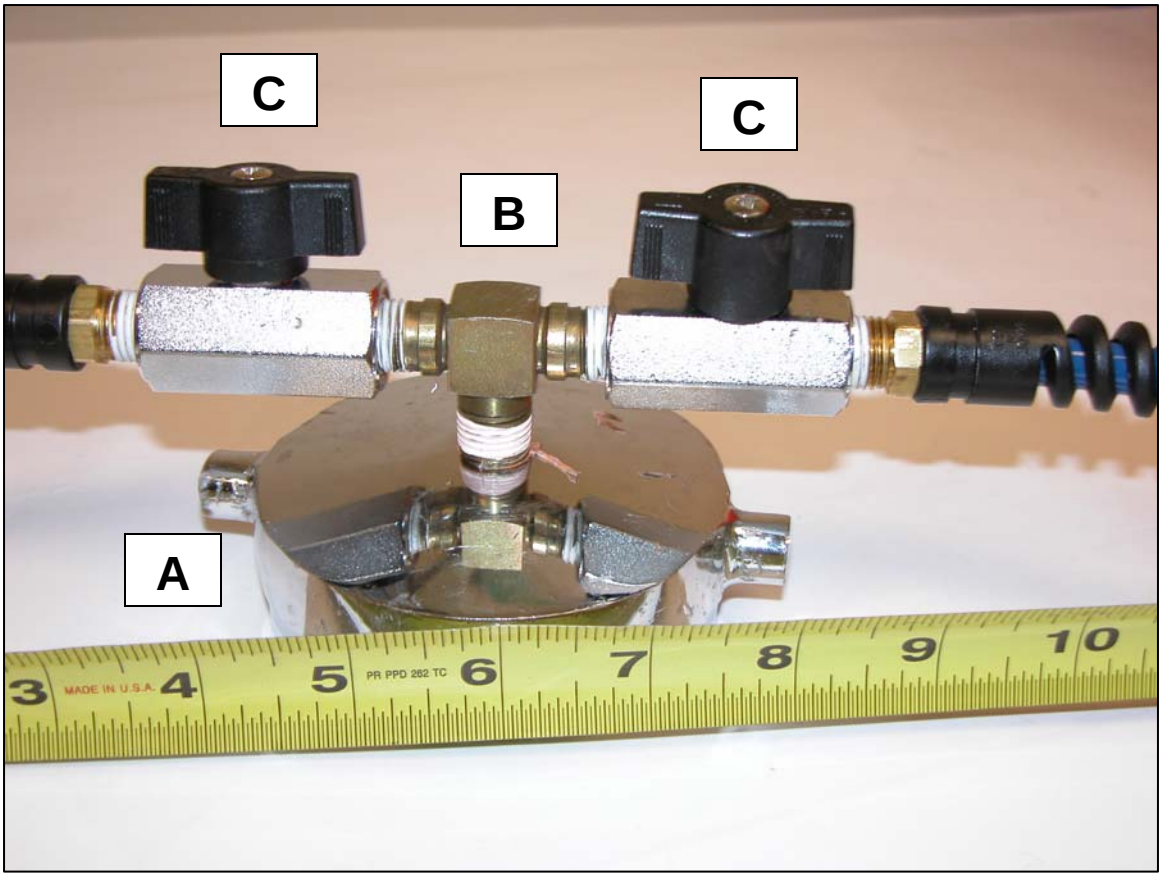


Figure 13. Photograph showing: (A) Dixon A7893 hydrant adapter kit, (B) 1/4 NPT brass "T", and (C) 1/4 NPTF ball valves.

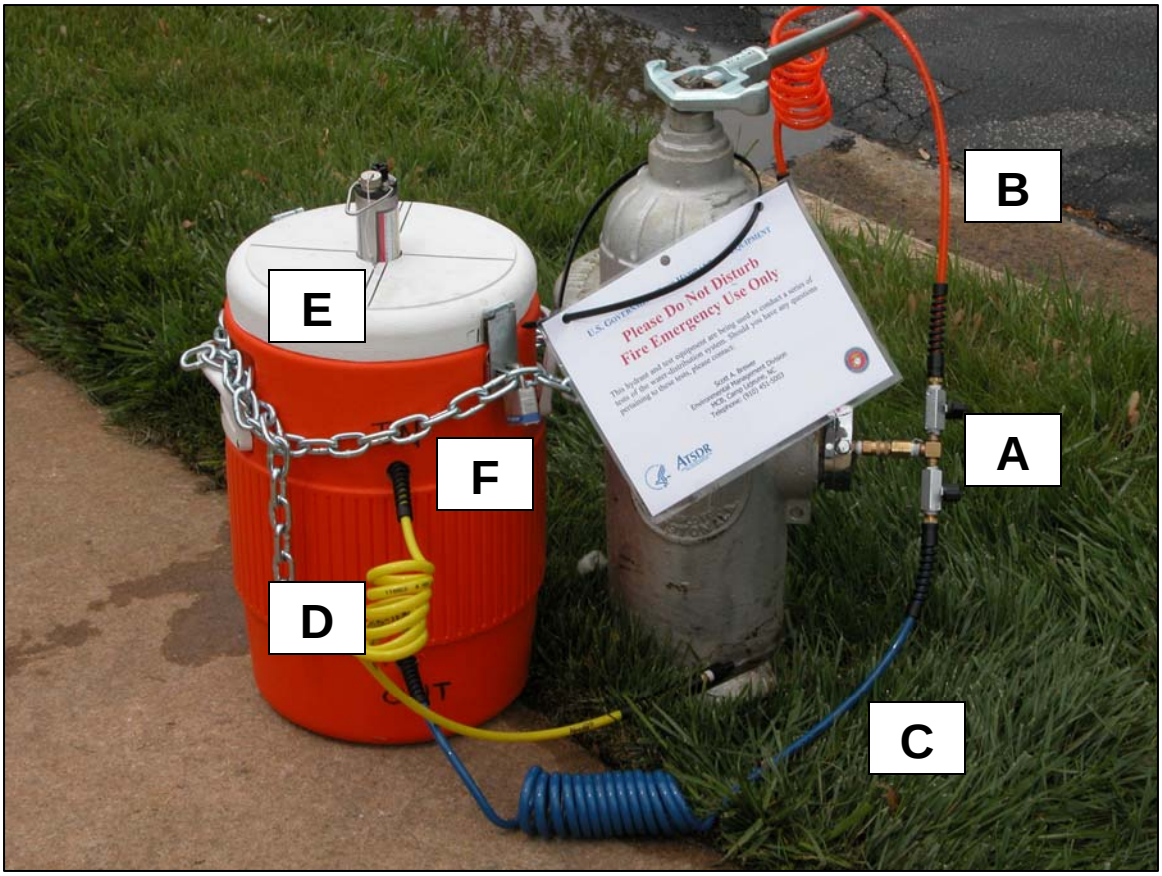


Figure 14. Photograph showing: (A) hydrant adapter kit, bass "T", and ball valve configuration, (B) Rectus PSCH0605-16, 5-foot orange hose for collecting grab sample, (C) Rectus PSCH0610-3, 10-foot blue hose for supplying flow cell with hydrant water, (D) Rectus PSCH0605-5, 5-foot yellow hose for discharging water from flow cell, (E) 5-gallon protective plastic water jug housing the HORIBA W-23XD dual-probe ion detector and flow cell, and (F) chain and lock securing equipment to hydrant.

Figure 15. Photograph showing HORIBA W-23XD water-quality control unit and cable attached to dual probe ion detector housed in a protective plastic 5-gallon water jug.

Figure 16. Photograph showing: (A) HORIBA W-21XD single probe water-quality measurement logger, (B) control unit for downloading data from logger, and (C) cable to connect control unit to probe.

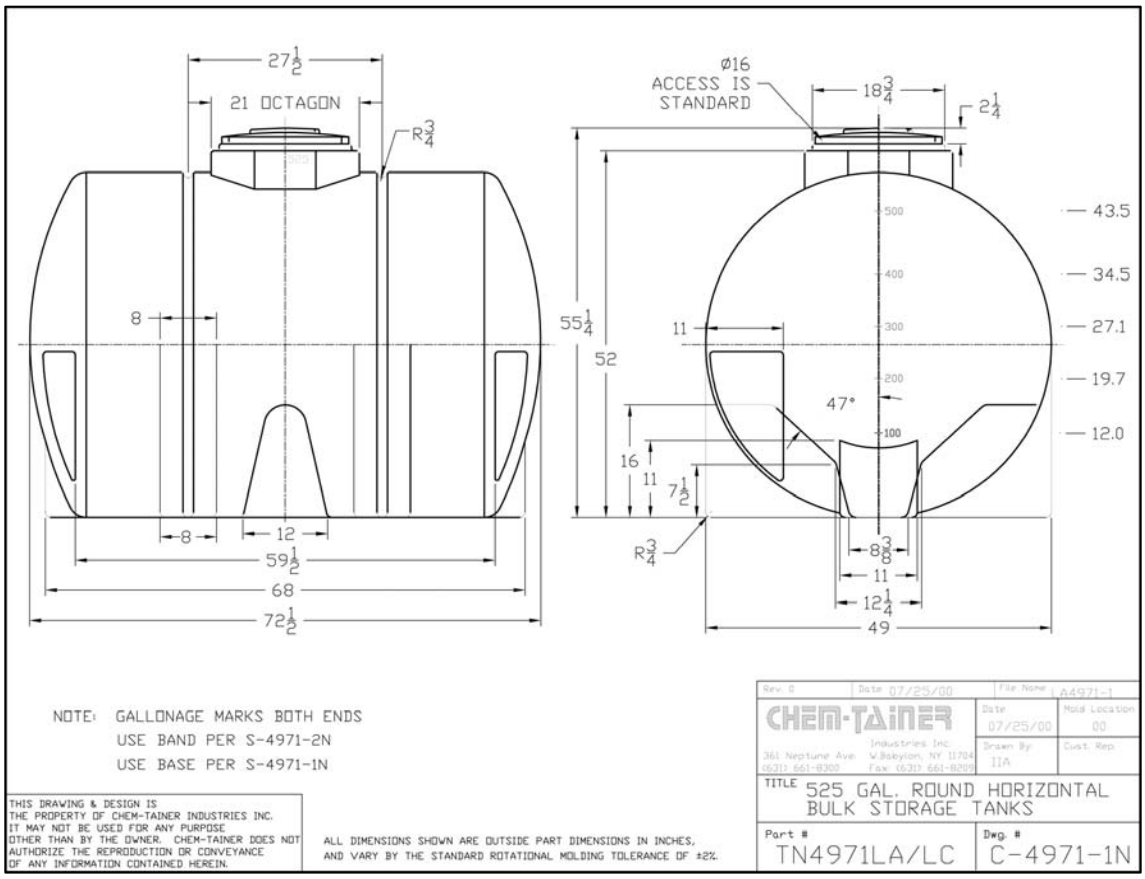


Figure 17. Picture and schematic of 525-gallon storage tank used to store calcium chloride ($CaCl_2$) solution for tracer test.

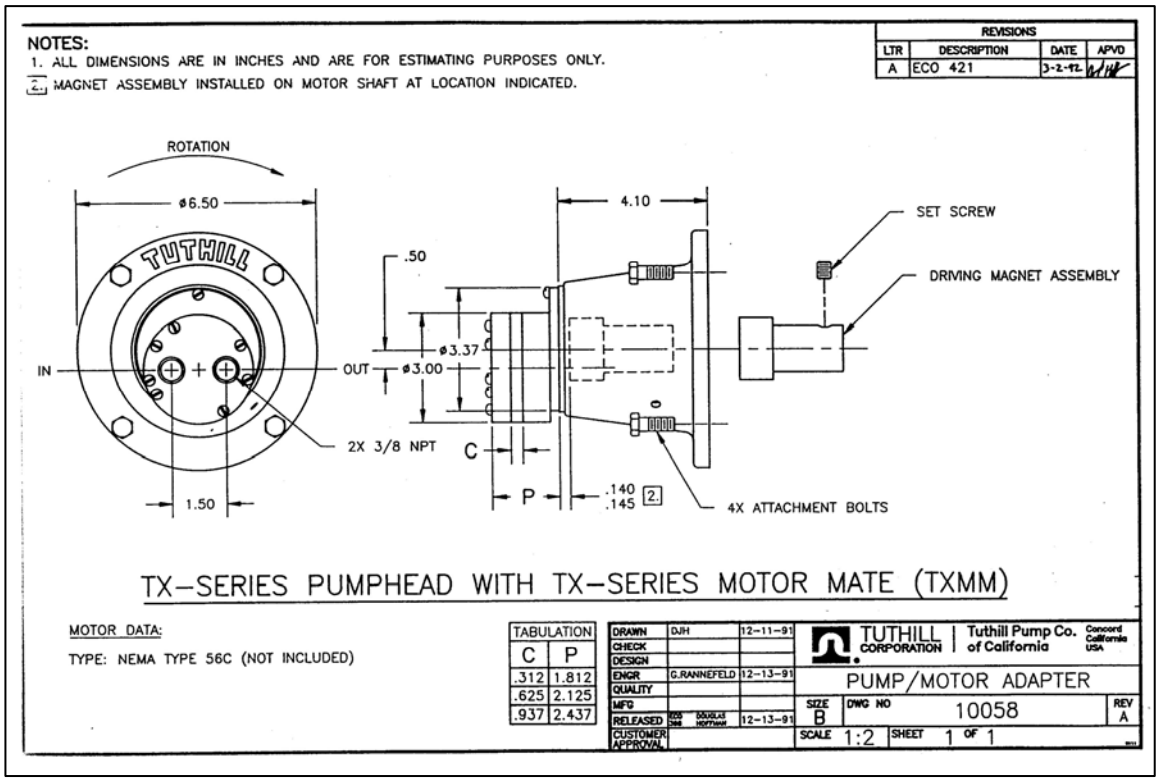


Figure 18. Schematic of Tuthill TX-series pump for calcium chloride ($CaCl_2$) solution tracer injection.

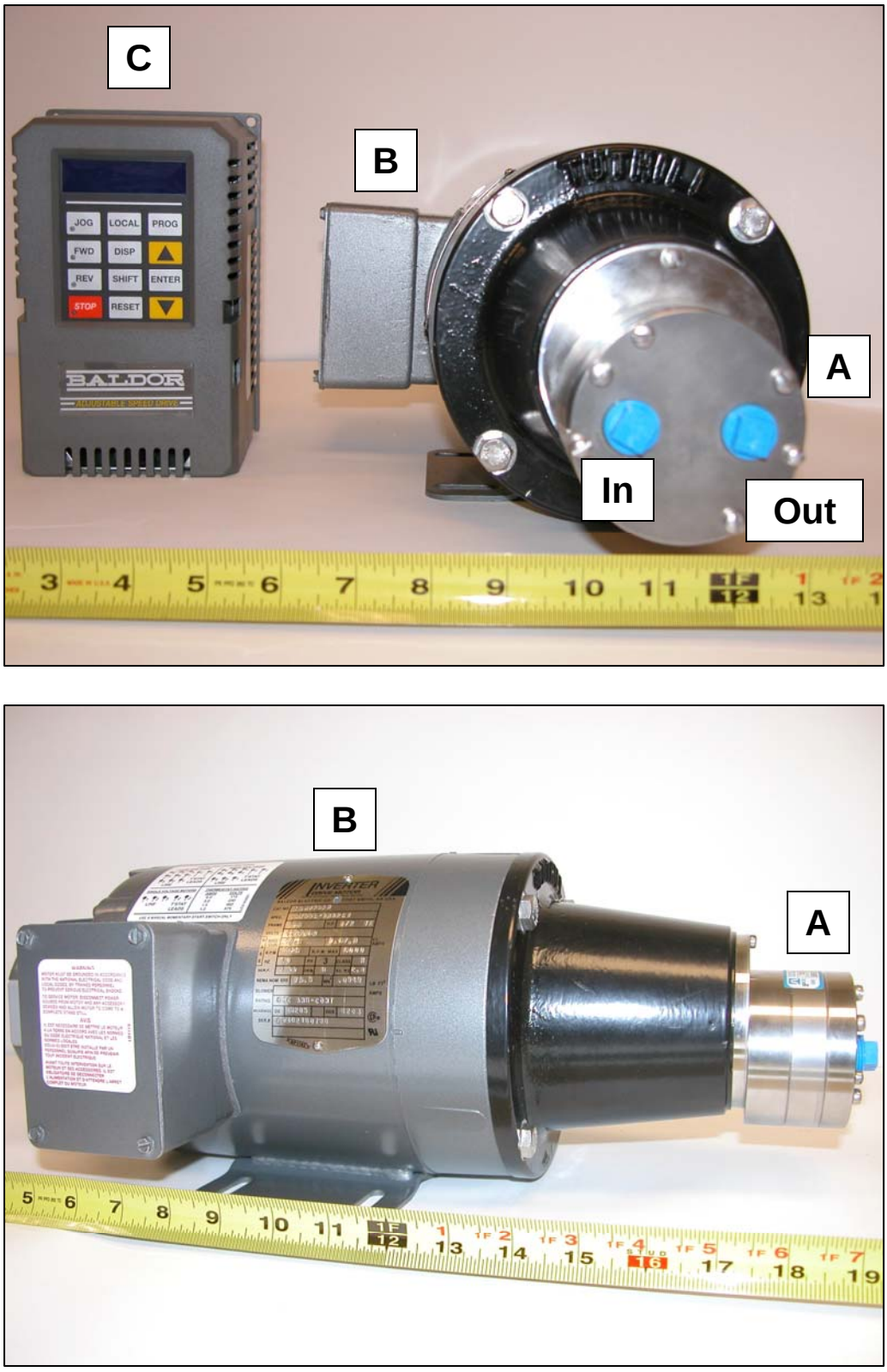
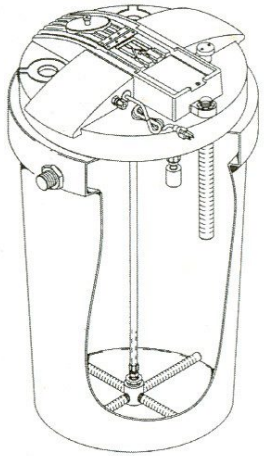


Figure 19. Photographs showing : (A) Tuthill TX-series pump, (B) Baldor ½-horsepower inverter motor, and (C) controls for picking up 4-20 miliamp signal.

(A)

LMI Fluoride Saturator

- Fluoridate water flows to 10,000 gpm
- Continuous duty, low maintenance design
- For use with sodium fluoride



The LMI fluoride saturator provides an easily maintained source of saturated sodium fluoride solution. The unit is designed for efficiency, economy, ease of installation, and minimal maintenance. The tank cover of the unit houses the saturator components, including solenoid valve, siphon breaker, and liquid level switch. A push-button light switch allows for visual inspection of fluoride bed level. The integrally mounted liquid level switch controls solenoid valve operation to maintain a proper solution level in the tank. The distributor tube assembly supplies fresh water to a bed of sodium fluoride at tank bottom. Water dispersed by the distributor tubes flows up through the sodium fluoride powder/crystals to provide a saturated (4%) solution.

The 50-gallon tank is UV light resistant, yellow polyethylene, with tapered sides, 5-gallon graduations, and installed overflow connection. LMI metering pumps can be conveniently mounted in the recess provided on the saturator cover assembly. Series 1 pumps can be used for addition of sodium fluoride with constant water flow rate applications. Series 7 or 9 pumps can be used for applications requiring pump output to change proportionally with varying water flow rate applications.

Saturator includes tank, cover assembly, distributor tube assembly and 10 feet of 3/8" O.D. polyethylene water inlet tubing. Shipping weight is 37 lbs.

(B)

External signal connectors

LMI Series A9, B9 & C9 Pumps

- LMI's most advanced pumps – flexible programming
- Accept 4-20 mA or pulse signals

LMI's Series 9 microprocessor controlled pumps feature a 4-key keypad for programming and manual control of pump speed. Speed is adjustable from 1 stroke/hour to 100 strokes/minute. In external mode, pump will accept 4-20 mA or pulse signals. The 4-20 mA response is scaleable and the pump can be programmed to respond to the 4-20 mA signal directly or inversely for maximum flexibility. Two pulse modes are available: pulse divide and pulse multiply. Pulse divide allows the pump to respond with a pre-programmed amount of strokes for every 1 to 999 incoming pulses. In pulse multiply mode, the pump can be programmed to stroke from 1 to 999 times for every incoming pulse. Stroke length is adjusted using the dial located in the center of the panel. Remote on/off and low-level shutoff inputs are standard, allowing you to shut off the pump automatically when there is no flow in the process stream or when your chemical day tank is empty. The adjustable pressure control reduces discharge pulsation and extends pump life. A rugged, totally enclosed, chemically resistant housing protects pumps in the harshest environments. Encapsulated electronics and a rigid housing and stroke bracket ensure years of precise, repeatable performance.

Pumps include 4-function discharge valve (anti-siphon, pressure relief, back pressure, priming), injection valve, suction valve, foot valve/strainer, 16' polyethylene suction and discharge tubing. Repair kits include replacement diaphragm, seals, 4 pump head screws and check valves.

Figure 20. Fluoride injection system for Handot Point tracer study: (A) LMI 50-gallon saturator kit, and (B) LMI chemical feed pump and flow controller for picking up 4-20 miliamp signal.

Figure 21. Photographs showing training session at ATSDR facilities on installation, calibration, and use of HORIBA W-23XD water-quality monitoring system, April 21, 2004.

Figure 22. Photograph showing 25-unit first aid kit.

Figure 23. Photograph showing outdoor skin protection kit .

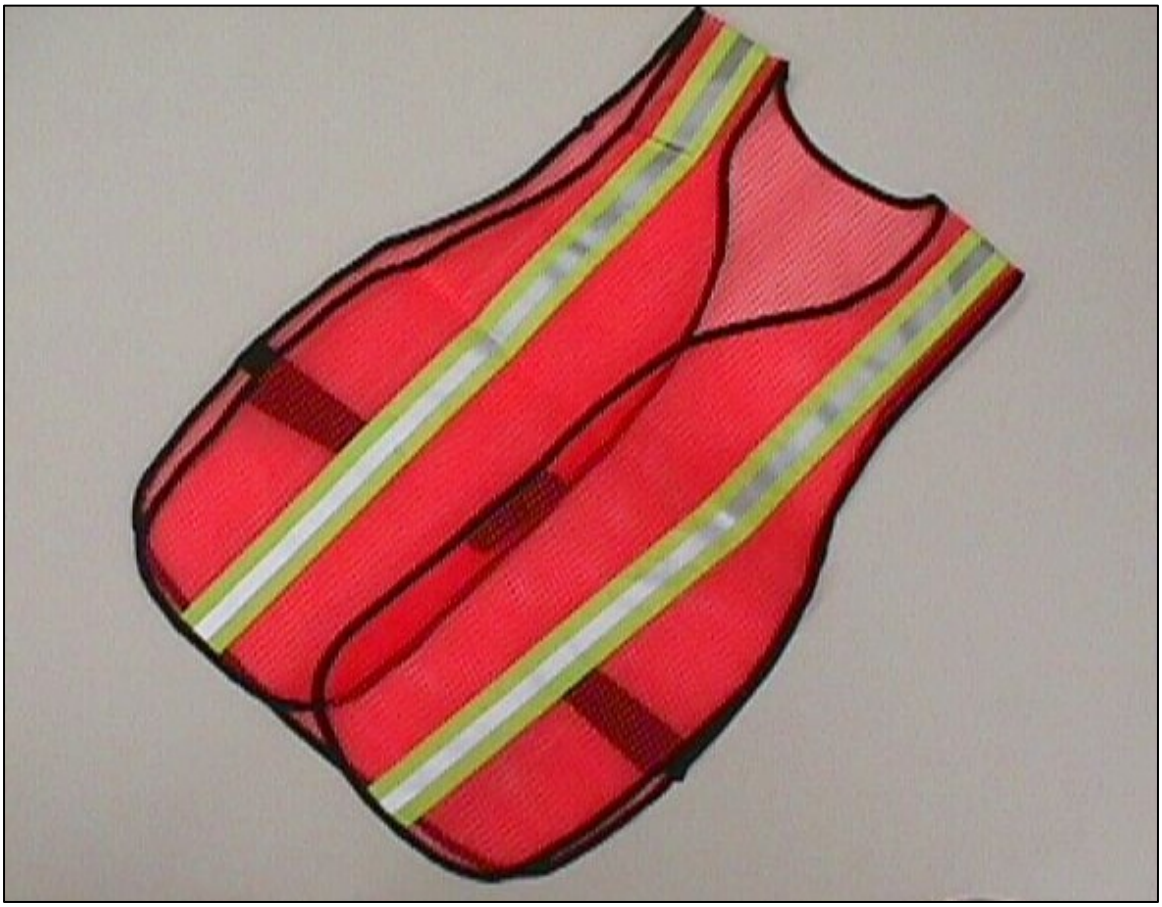


Figure 24. Photograph showing orange fluorescent safety vest to be worn by tracer study team members.

APPENDIX A

Chemical Mass Balance Computations for Calcium Chloride ($CaCl_2$) Solution

Notation

MW = molecular weight
$[CaCl_2]_i$, $[Cl]_i$ = injection concentration at the pump
ΔCl_d = *Cl* concentration increase in delivered water during test
$[Cl]_d$ = *Cl* concentration in delivered water
Q = water demand
q = injection pump flow rate

General data

$MW\ CaCl_2$ = 110.99 g/mol
$MW\ Cl$ = 35.45 g/mol
$CaCl_2$ solubility = 755 g/L (equivalent to 482 g/L of *Cl*)
$CaCl_2$ %w/w = 35%
$CaCl_2$ relative density @ 20°C = 1.3374 kg/L

***Cl* standard**

Maximum $[Cl]_d$ concentration during test (estimated) = 200 mg/L (**EPA secondary standard is 250 mg/L**)
Background *Cl* concentration = 20 mg/L (Data from Hadnot Point delivered water)
Maximum allowable *Cl* increase during test ΔCl_d = 180 mg/L

Tracer test (targeting 200 mg/L)

Demand (estimated) Q = 3 MGD = 125,000 gph
Injection pump flow rate (estimated) q = 60 gph
$CaCl_2$ concentration $[CaCl_2]_i$ = 588 g/L
Cl concentration $[Cl]_i$:

$$[Cl]_i = [CaCl_2]_i \cdot \frac{MWCl}{MWCaCl_2} \cdot \frac{2\frac{eq}{molCaCl_2}}{1\frac{eq}{molCl}} \quad (1)$$

$[Cl]_i$ = 375.6 g/L (eq. 1)

Cl concentration increase in delivered water ΔCl_d:

$$\Delta Cl_d = \frac{q[Cl]_i}{q+Q} \quad (2)$$

ΔCl_d = 180 mg/L (eq. 2)
$[Cl]_d$ = 20+180 = 200 mg/L

Tracer test (considering 35%w/w $CaCl_2$ solution)

Demand (estimated) Q = 3 MGD = 125,000 gph
Injection pump flow rate (estimated) q = 60 gph
$CaCl_2$ concentration in drums = 0.35g/g x 1.3374 kg/L x 1000 g/kg = 468.09 g/L
$CaCl_2$ concentration $[CaCl_2]_i$ = 468.09 g/L

$[Cl]_i$ = 299 g/L (eq. 1)
ΔCl_d = 144 mg/L (eq. 2)
$[Cl]_d$ = 20+144 = 164 mg/L

$CaCl_2$ Injection Time

500 gallons / 60 gph = 8.3 hours to empty the tank

Drums of $CaCl_2$ Required

Volume of $CaCl_2$ (35 %w/w) = 500 gal
Volume of drum $CaCl_2$ (35 %w/w) = 55 gal
Drums of $CaCl_2$ (35 %w/w) required = 500 gal/ 55 gal/drum $\approx$ 9 drums

APPENDIX B

Material Safety Data Sheet (MSDS) for Calcium Chloride ($CaCl_2$) Solution

Calcium Chloride Solution

This MSDS Sheet complies with the style format specified by ANSI Z400 1-1993

SECTION 1: CHEMICAL PRODUCT - COMPANY IDENTIFICATION

TETRA Technologies, Inc.
25025 I-45 North
The Woodlands, Texas 77380

(281) 367-1983
(800) 327-7817

(800) 424-9300 **CHEMTREC (24 Hour Emergency Response)**
(800) 222-1222 **POISON CONTROL**

SUBSTANCE: Calcium Chloride, Solution
TRADE NAMES/SYNONYMS: Liquid Calcium Chloride, Road Master™, Superset™, Food Grade Liquid Calcium Chloride
CHEMICAL FAMILY: Inorganic Salt
MSDS CREATION DATE: 01 MAR 94
MSDS REVISION DATE: 9 JUL 02

SECTION 2: COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENTS	CAS NUMBER	RTECS NUMBER	PERCENTAGE
Calcium Chloride	10043-52-4	EV9800000	20 – 45%
Water			55 – 80%

PROBABLE CONTAMINANTS: Calcium Carbonate, Calcium Hydroxide, Calcium Oxide, Alkali Metal Chlorides, Alkaline Earth Metal Chlorides

SECTION 3: HAZARDS IDENTIFICATION

NFPA RATINGS: (SCALE 0-4): HEALTH=1 FIRE=0 REACTIVITY=0
EMERGENCY OVERVIEW: Odorless, clear to amber liquid. May cause skin, respiratory tract, and eye irritation.
POTENTIAL HEALTH EFFECTS:
INHALATION, SKIN CONTACT, EYE CONTACT: May cause minor irritation.
INGESTION: May cause nausea.

SECTION 4: FIRST AID MEASURES

SKIN CONTACT: Remove contaminated clothing and shoes. Wash affected area with soap or mild detergent.
EYE CONTACT: Flush eyes with water or normal saline solution.
INGESTION: Get medical attention.

SECTION 5: FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD: Negligible fire hazard.
HAZARDOUS COMBUSTION PRODUCTS: Not applicable.

SECTION 6: ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL: For small spills, take up with sand or other absorbent material and place in containers for disposal. For larger spills, dike far ahead of spill for later disposal.

SECTION 7: HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this product. Store in a tightly closed container. Store away from incompatible materials.

SECTION 8: EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:	No occupational exposure limits established by OSHA/ACGIH/NIOSH.
VENTILATION:	Provide local exhaust ventilation system.
EYE PROTECTION:	Wear safety glasses with splash shields or safety goggles/shield.
CLOTHING:	Wear normal work clothing. Leather work boots and/or leather products will dehydrate with resultant shrinkage and possible destruction.
GLOVES:	Wear appropriate protective gloves.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION:	Odorless, clear to amber liquid.
MOLECULAR FORMULA:	$CaCl_2$
MOLECULAR WEIGHT:	110.99 (for pure $CaCl_2$)
BOILING POINT:	118°C (244°F) for 38% solution
SPECIFIC GRAVITY:	1.376 @ 25°C (77°F) for 38% solution
pH:	3.8 - 9.0
WATER SOLUBILITY	Miscible with water in all proportions.
SOLVENT SOLUBILITY:	Miscible in alcohol, acetic acid and acetone

SECTION 10: STABILITY AND REACTIVITY

REACTIVITY:	Stable under normal temperatures and pressures.
INCOMPATIBILITIES:	Strong oxidizing agents.
HAZARDOUS DECOMPOSITION:	None, under normal conditions.
POLYMERIZATION:	Does not occur under normal temperatures and pressures.
CONDITIONS TO AVOID:	None

SECTION 11: TOXICOLOGICAL INFORMATION

TOXICITY DATA (ANHYDROUS CALCIUM CHLORIDE):

TD_{LO}: 112g/kg, oral, 20 weeks, rat
LD_{LO}: 274 mg/kg, subcutaneous, dog
LD_{50}: 1000 mg/kg, oral, rat
LD_{50}: 264 mg/kg, intraperitoneal, rat
Mutagenic data and tumorigenic data—see Registry of Toxic Effects of Chemical Substances (RTECS) file.

CARCINOGEN STATUS:	None.
LOCAL EFFECTS:	Eye, mucous membrane and skin irritant.
ACUTE TOXICITY LEVEL:	Moderately toxic by ingestion, slightly toxic by dermal absorption.

SECTION 12: ECOLOGICAL INFORMATION

DEGRADABILITY:	Product will not biodegrade or bioaccumulate.

SECTION 13: DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

SECTION 14: TRANSPORT INFORMATION

DOT Shipping Name-ID Number: Non-regulated.

SECTION 15: REGULATORY INFORMATION

TSCA STATUS:	Yes
DSL STATUS:	Yes
EINECS STATUS:	Yes
OTHER TSCA ISSUES:	None
CALIFORNIA PROPOSITION 65:	No ingredients found on the Propositions 65 list
SARA SECTIONS 311 CLASSIFICATION:	Acute Hazard

SECTION 16: OTHER INFORMATION

Individuals handling this product should be informed of the recommended safety precautions and should have access to this information.

This information relates to the specific product designated and may not be valid for such product used in combination with any other materials or in any other processes. Such information is to the best of our knowledge and belief, accurate and reliable as of the date compiled. However, no representation, warranty or guarantee is made as to its accuracy, reliability, or completeness. It is the users' responsibility to satisfy themselves as to the suitability and completeness of such information for their own particular use. We do not accept liability for any loss or damage that may occur from the use of this information nor do we offer warranty against patent infringement.

TETRA Technologies, Inc. reserves the right to refuse shipment of this product to any consumer who fails to demonstrate the ability to consistently handle and use it safely and in compliance with all applicable laws, rules and regulations. Such demonstration may require on-site inspection of any or all storage, processing, packaging and other handling systems that come in contact with it.

Customers are responsible for compliance with local, state and federal regulations that may be pertinent in the storage, application and disposal of this product.

APPENDIX C

Chemical Mass Balance Computations for Sodium Fluoride (NaF) Solution

Notation

MW = molecular weight
$[NaF]_i$, $[F]_i$ = injection concentration at the pump
ΔF_d = F concentration increase in delivered water during test
$[F]_d$ = F concentration in delivered water
Q = water demand
q = injection pump flow rate

General data

$MW\ NaF$ = 42 g/mol
$MW\ F$ = 19 g/mol
NaF solubility = 42 g/L (equivalent to 19 g/L of F)

***F* standard**

Maximum $[F]_d$ concentration during test (estimated) = 2.0 mg/L
Background F concentration (estimated) = 0.2 mg/L (based on 7 day shut off of HP Fluoride treatment)
Maximum allowable F increase during test ΔF_d = 1.8 mg/L

Tracer test

Demand (estimated) Q = 3 MGD = 125,000 gph
Injection pump flow rate (estimated) q = 60 gph
NaF concentration $[NaF]_i$ = 8.5 g/L
F concentration $[F]_i$:

$$[F]_i = [NaF]_i \cdot \frac{MWF}{MWNaF} \quad (1)$$

$[F]_i$ = 3.8 g/L (eq. 1)

F concentration increase in delivered water ΔF_d :

$$\Delta F_d = \frac{q[F]_i}{q+Q} \quad (2)$$

ΔF_d = 1.8 mg/L (eq. 2)
$[F]_d$ = 0.2+1.8 = 2.0 mg/L

NaF required

$[NaF]_i$ = 8.5 g/L
Tank volume V = 500 gal

NaF mass required = 8.5 g/L x 3.78 L/gal x 500 gal x 1 lb/453.6 g = 35.4 lb

Number of Bags of *NaF* needed @ 50 lb/bag ≈1 bag

NaF Injection Time

500 gallons / 60 gph = 8.3 hours to empty tank

APPENDIX D

Material Safety Data Sheet (MSDS) for Sodium Fluoride (NaF)

BASF MAINTAINANCE Monday, June 30, 2003 MATERIAL SAFETY DATA SHEET HB-670 PAGE 2

02 18 CP/PHIBROCHEM TEL# (201) 914-6020
ONE PARKER PLAZA FAX# (201) 914-7911

FORT LEE NJ 07024

******* 24 HOUR EMERGENCY CONTACT: CHEMTREC (800) 424-9300 *******
******* 24 HOUR EMERGENCY CONTACT: COMPANY (803) 481-3528 *******

DATE: 10/15/00 SUPERSEDES: 3/31/99
TRADE NAME: SODIUM FLUORIDE <0218>

1 PRODUCT IDENTIFICATION

NA = NOT APPLICABLE, ND = NOT DETERMINED

********** N.F.P.A. ********** DEGREE OF HAZARD	EMERGENCY HAZARD RATING
4 = EXTREME	HEALTH < 3 >
3 = HIGH	FIRE < 0 >
2 = MODERATE	REACTIVITY < 0 >
1 = SLIGHT	SPECIFIC HAZARD < >
0 = INSIGNIFICANT	

TRADE NAME: SODIUM FLUORIDE

Distributed by:
Brenntag Southeast, Inc. - Durham
(919) 596-0681 or 1-800-849-7000

FORMULA: NAF

MOLECULAR WT.: 42.00

SYNONYMS: FLORIDINE; SODIUM MONOFLUORIDE; CHEMFLUOR; LURIDE-SF; VILLIAUMITE; FLOROCID; LIMOFLUR; OSSALIN; OSSIN; ZYMAFLUOR; KARIDIUM

2 INGREDIENTS

INGREDIENTS (CAS NO.)	WT PCT (APPROX)	PEL MG/M3	PEL PPM	TLV(TWA) MG/M3	TLV(TWA) PPM
SODIUM FLUORIDE (7681-49-4)	90-95	2.5*		2.5*	
SODIUM SILICOFLUORIDE (16893-85-9)	0-2.5	2.5*		2.5*	

* = AS FLUORIDE

THE TLV'S ARE GIVEN FOR GUIDANCE; LOCAL APPLICABLE REGULATIONS SHOULD ALWAYS BE FOLLOWED. INGREDIENTS ARE THOSE PRESENT AT 1% OR GREATER, OR AT 0.1% OR GREATER IF LISTED AS POTENTIAL CARCINOGENS BY

OSHA/IARC/NTP. PROPRIETARY INGREDIENT IDENTITIES ARE AVAILABLE IN ACCORDANCE WITH 29 CFR 1910.1200.
CARCINOGEN: NTP - NO
IARC - NO
OSHA - NO

3 PHYSICAL AND CHEMICAL CHARACTERISTICS

D = DECOMPOSES

BOILING POINT, 760 MM HG (DEG C):	1700 C (3083 F)
MELTING/FREEZING POINT (DEG C):	993 C (1819 F)
SPECIFIC GRAVITY (WATER = 1):	2.558 AT 41 C
VAPOR PRESSURE (MM HG):	1 AT 1077 C
VAPOR DENSITY (AIR = 1):	ND
WATER SOLUBILITY (% BY WT):	4 G/100 ML H20 AT 18C
VOLATILES (% BY WT):	NA
EVAPORATION RATE (BUTYL ACETATE = 1):	ND
PH OF SOLUTION:	7.4

APPEARANCE/ODOR: ODORLESS, WHITE CRYSTALS, OR POWDER. TOXIC!

4 PHYSICAL HAZARD DATA

SODIUM FLUORIDE IS NOT CONSIDERED TO BE A FIRE HAZARD. NOT COMBUSTIBLE.

FLASH POINT (DEG C):	NA
TEST METHOD:	NA
FLAMMABLE LIMITS (% BY VOL):	NA
AUTOIGNITION TEMP. (DEG C):	NA

EXTINGUISHING MEDIA: USE WATER SPRAY. REMOVE CONTAINERS FROM FIRE AREA IF IT CAN BE DONE SAFELY. COOL FIRE EXPOSED CONTAINERS WITH WATER SPRAY UNTIL WELL AFTER FIRE IS OUT. DO NOT FLUSH INTO SEWER OR STREAM.

SPECIAL FIRE FIGHTING PROCEDURES: WEAR FULL PROTECTIVE CLOTHING AND NIOSH APPROVED SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN THE PRESSURE DEMAND OR OTHER POSITIVE PRESSURE MODE.

UNUSUAL FIRE OR EXPLOSION HAZARDS: NOT CONSIDERED TO BE AN EXPLOSION HAZARD. EMITS TOXIC FUMES OF FLUORIDE AND SODIUM OXIDE WHEN HEATED TO DECOMPOSITION.

5 REACTIVITY DATA

THERMAL STABILITY: STABLE UNDER ORDINARY CONDITIONS OF USE AND STORAGE.

INCOMPATIBILITY: REACTS WITH ACIDS TO FORM HYDROGEN FLUORIDE.

CORROSIVE TO METALS ESPECIALLY TO ALUMINUM. IN SOLUTION ATTACKS GLASS.

CONDITIONS TO AVOID: EXPOSURE TO INCOMPATIBLES AND HEAT. KEEP AWAY FROM GLASS AND ALUMINUM.

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR.

HAZARDOUS DECOMPOSITION PRODUCTS: EMITS TOXIC FUMES OF FLUORIDES AND SODIUM OXIDE WHEN HEATED TO DECOMPOSITION.

6 HEALTH HAZARD INFORMATION

EFFECTS OF OVEREXPOSURE:

SYMPTOMS OF INGESTION: TOXIC! MAY CAUSE SALIVATION, NAUSEA, VOMITING, DIARRHEA, AND ABDOMINAL PAIN. SYMPTONS OF WEAKNESS, TREMORS, SHALLOW RESPIRATION, CARDOPEDAL SPASM, CONVULSIONS, AND COMA MAY FOLLOW. MAY CAUSE BRAIN AND KIDNEY DAMAGE. DEATH MAY OCCUR FROM RESPIRATORY AND CARDIAC FAILURE. LETHAL DOSE: 5-10 GRAMS.

SYMPTOMS OF INHALATION: MAY CAUSE CORROSIVE EFFECTS TO THE RESPIRATORY TRACT. SYMPTOMS MAY INCLUDE COUGHING, SORE THROAT, AND LABORED BREATHING. MAY BE ABSORBED THROUGH INHALATION OF DUST. SYMPTOMS MAY PARALLEL THOSE FROM INGESTION EXPOSURE.

SYMPTOMS OF SKIN CONTACT: MAY CAUSE IRRITATION, REDNESS, AND PAIN. SOLUTIONS ARE CORROSIVE.

SYMPTOMS OF EYE CONTACT: EYE IRRITANT! CONTACT MAY CAUSE CONJUNCTIVITIS, ULCERATION, CLOUDING OF THE CORNEA OR SEVERE EYE DAMAGE.

CHRONIC EXPOSURE: PROLONGED OR REPEATED SKIN EXPOSURE MAY CAUSE DERMATITIS. REPEATED INGESTION OF SMALL AMOUNTS MAY CAUSE MOTTLING OF TEETH AND BONE DAMAGE (OSTEOSCLEROSIS)

TOXICITY DATA:

ORAL TOXICITY:	LD50;	180	MG/KG (RAT)
	LDLO;	71	MG/KG (HUMAN)
	LDLO;	75	MG/KG (DOG)
	LD50;	200	MG/KG (RABBIT)
INTRAPERITONEAL TOXICITY:	LDLO;	50	MG/KG (DOG)
SUBCUTANEOUS TOXICITY:	LDLO;	155	MG/KG (DOG)

7 EMERGENCY AND FIRST AID PROCEDURES

EYE CONTACT: IMMEDIATELY, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE HOLDING EYELIDS APART. WASHING WITHIN ONE MINUTE IS ESSENTIAL TO ACHIEVE MAXIMUM EFFECTIVENESS. CONTINUE WASHING EYES WITH WATER FOR AT LEAST 15 MINUTES LONGER. REFER TO OPHTHALMOLOGIST AFTER FIRST AID. GET MEDICAL ATTENTION

IMMEDIATELY.

SKIN CONTACT: WASH AFFECTED AREA THOROUGHLY WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND LAUNDER BEFORE REUSE. APPLY BANDAGE SOAKED IN MILK OF MAGNESIA. GET MEDICAL ATTENTION IMMEDIATELY.

INHALATION: REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN. CONSULT A PHYSICIAN.

INGESTION: NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. DO NOT INDUCE VOMITING. IMMEDIATELY GIVE TWO TABLESPOONS OF MAGNESIUM SULFATE AND A GLASS OF WATER. REPEAT THREE TIMES. FOLLOW WITH TWO TABLESPOONS OF MILK OF MAGNESIA AND A GLASS OF WATER. REPEAT THESE DOSAGES IN TEN MINUTES. GET MEDICAL ATTENTION IMMEDIATELY.

NOTES TO PHYSICIAN: FOR PAIN, USE 2 TO 3 DROPS OF 0.5% PONTOCAIN IN EACH EYE.

8 INDUSTRIAL HYGIENE AND OCCUPATIONAL CONTROL PROCEDURES

VENTILATION: A SYSTEM OF LOCAL EXHAUST IS RECOMMENDED TO KEEP EMPLOYEE EXPOSURE BELOW THE AIRBORNE EXPOSURE LIMITS. LOCAL EXHAUST IS USUALLY PREFERRED BECAUSE IT CONTROLS THE EMISSION AT ITS SOURCE, PREVENTING DISPERSION OF IT INTO THE GENERAL WORK AREA. REFER TO THE ACGIH DOCUMENT "INDUSTRIAL VENTILATION, A MANUAL OF RECOMMENDED PRACTICES" FOR DETAILS.

RESPIRATORY PROTECTION: NIOSH/MSHA APPROVED RESPIRATOR IF EXPOSURE MAY OR DOES EXCEED OCCUPATIONAL EXPOSURE LIMITS. GENERALLY A DUST/MIST RESPIRATOR MAY BE WORN IN AREAS WHERE THE TLV IS EXCEEDED UP TO TEN TIMES. ALTERNATIVELY, A SUPPLIED AIR FULL FACEPIECE RESPIRATOR OR AIRLINED HOOD MAY BE WORN.

EYE PROTECTION: CHEMICAL SPLASH GOGGLES AND/OR FACE SHIELD. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS MATERIAL.

AN EYE WASH FOUNTAIN AND QUICK-DRENCH FACILITIES SHOULD BE MAINTAINED IN THE WORK AREA.

SKIN PROTECTION: USE RUBBER OR PLASTIC IMPERVIOUS GLOVES AND BODY-COVERING CLOTHING.

PERSONAL HYGIENE: WASH THOROUGHLY AFTER HANDLING.

9 SAFE HANDLING, STORAGE AND USE PRECAUTIONS

PRECAUTIONARY MEASURES: AVOID CONTACT WITH SKIN, EYES, AND CLOTHING. WEAR PROTECTIVE CLOTHING, GLOVES, AND SPLASH GOGGLES OR SHIELD. WASH THOROUGHLY AFTER USING. AVOID BREATHING DUST OR MIST. USE WITH ADEQUATE VENTILATION.

STORAGE AND HANDLING: KEEP IN A TIGHTLY CLOSED CONTAINER. STORE IN A COOL, DRY, WELL VENTILATED AREA. ISOLATE FROM INCOMPATIBLES.

PROTECT FROM PHYSICAL DAMAGE.

10 REGULATORY INFORMATION AND DISPOSAL PROCEDURES

SPILL/LEAK CLEAN-UP PROCEDURES: SWEEP, SCOOP, OR PICK UP SPILLED MATERIAL. AVOID DUSTING. PACKAGE FOR RECLAMATION OR RECOVERY IN DRY CONTAINERS. DO NOT FLUSH INTO SEWER OR STREAM.

DISPOSAL METHOD: DISPOSE IN ACCORDANCE WITH APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL AND REGULATORY REQUIREMENTS.

TOXIC SUBSTANCES CONTROL ACT(TSCA): CHEMICAL INGREDIENTS ARE ON THE TSCA INVENTORY.

SUPERFUND REPORTABLE QUANTITY(RQ): 1000#/2270 KG.

HAZARDOUS WASTE NO.: NOT REGULATED.

SARA TITLE III: PLEASE CHECK WITH THE APPROPRIATE AGENCIES. (SECTION 313)

CANADIAN (WHMIS) LIST: THIS PRODUCT IS SUBJECT TO REPORTING.

NEW JERSEY LIST: EMPLOYERS WHO PRODUCE, USE, OR STORE THIS PRODUCT ARE REQUIRED TO FILE AN ANNUAL SURVEY DUE ON MARCH 1 OF EACH YEAR.

FOR STATES NOT LISTED: PLEASE CHECK WITH THE APPROPRIATE AGENCIES.

WARNING: THIS PRODUCT MAY CONTAIN A CHEMICAL KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, OR BIRTH DEFECTS, AND/OR OTHER REPRODUCTIVE HARM.

11 TRANSPORTATION DATA

DOT SHIPPING NAME:	SODIUM FLUORIDE
DOT HAZARD CLASS:	6.1
HAZARD IDENTIFICATION:	SODIUM FLUORIDE
IDENTIFICATION NUMBER:	UN 1690
PACKING GROUP:	III *
LABEL:	TOXIC OR POISON

*: FOR CONTAINERS/PACKAGES EXCEEDING 1,000 LBS, RQ IS REQUIRED.

NOTE: DURING AN INCIDENT INVOLVING THIS MATERIAL, USE OF DOT EMERGENCY RESPONSE GUIDE NO. 154 IS ALSO RECOMMENDED.

ADDITIONAL WARNINGS AND INFORMATION

ALL INFORMATION PRESENTED HEREIN IS GIVEN IN GOOD FAITH AND IS BASED ON SOURCES AND TESTS CONSIDERED TO BE RELIABLE, BUT CANNOT BE GUARANTEED. IT IS THE USER'S FULL RESPONSIBILITY TO ACCEPT RISK FOR THE SAFETY, TOXICITY, HANDLING, STORAGE, AND USE OF THE PRODUCT, AS WELL AS TO DETERMINE THE SUITABILITY OF THE PRODUCT FOR A SPECIFIC PURPOSE. WE MAKE NO WARRANTY AS TO THE RESULTS TO BE OBTAINED IN USING THE PRODUCT; THEREFORE ALL RISKS MUST BE ASSUMED BY THE USER.

SCANNED
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APPENDIX E

Chemical Mass Balance Computations for Fluoride Solution Using the LMI Fluoride Saturator Kit Number 28850

Notation

MW = molecular weight
$[NaF]_i$, $[F]_i$ = injection concentration at the pump
ΔF_d = F concentration increase in delivered water during test
$[F]_d$ = F concentration in delivered water
V_F = Volume of fluoride solution
Q = water demand
q = injection pump flow rate
S = dilution

General data

MW NaF = 42 g/mol
MW F = 19 g/mol
NaF solubility = 42 g/L (equivalent to 19 g/L of *F*)

***F* standard**

Maximum $[F]_d$ concentration during test (estimated) = 2.0 mg/L
Background *F* concentration (estimated) = 0.2 mg/L (based on 7 day shut off of HP Fluoride treatment)
Maximum allowable *F* increase during test ΔF_d = 1.8 mg/L

Tracer test

Demand (estimated) Q = 3 MGD = 125,000 gph
$[F]_i$ = 4% solution = 40,000 mg/L
Required dilution (S) = 40,000 mg/L / 1.8 mg/L = 22,222:1

***Volume o f F* required**

$V_F = Q/S$ = 125,000 gph/22,222 = 5.625 gph

4 hour tracer test = 4 x 5.625 = 22.5 gallons of solution
6 hour tracer test = 6 x 5.625 = 33.75 gallons

APPENDIX F

Descriptions of Test Hydrant and Sampling Locations

Table F-1. Description of sampling locations, logger identifications, and other pertinent information that will be used to monitor water-distribution system during preliminary test at Marine Corps Base, Camp Lejeune, North Carolina (refer to Plate 1 for map showing sampling locations).

Hadnot Point: Hydrant Sampling Locations									
[1]Supply Area ID	Test ID	[2]Map ID	[3]ATSDR Logger ID	ATSDR Object ID	Camp Lejeune Hydrant ID	Longitude State Plane NAD83 (feet) (approx.)	Latitude State Plane NAD83 (feet) (approx.)	Sample Hydrant Location	Pipe Diam.
HP	T0	F6	F01	306	H-9-10	2490200.37	341642.14	S. side of Julian C. Smith Rd. (northern loop) ≈ 700 ft. W. of Cutler St.	10 in.
			P01	305	3H-8-10	2490600.17	341674.54	S. side of Julian C. Smith Rd. (southern loop) ≈ 300 ft. W. of Cutler St.	10 in.
			C01	315	3-149-8	2489539.97	340649.01	N. side of Julian C. Smith Rd. ≈ 650 ft. W. of Olive St. (in front of Bldg. H1)	10 in.
HP	T0	F7	F02	640	3-26-8	2494975.34	339146.24	S. side of C Street ≈ 950 ft. W. of McHugh Blvd.	8 in.
			P02	641	none	2494587.18	339012.54	S. side of C Street ≈ 1350 ft. W. of McHugh Blvd. (across street from Bldg. 147)	8 in.
			C02	656	none	2495447.04	340361.62	W. side of McHugh Blvd. ≈ 200 ft. S. of A Street (across street from St. Francis Church)	12 in.
HP	T0	F7	F03	1113	3-50-12	2496386.42	337528.51	S.W. corner of McHugh Blvd. and G Street intersection (in front of Hadnot Point WTP)	12 in.
			P03	1093	none	2496120.90	337467.83	N. side of G Street ≈ 300 ft. W. of McHugh Blvd. (across street from Hadnot Point WTP)	12 in.
			C03	545	3-141-8	2496964.85	337937.35	W. side of Post Ln. ≈ 500 ft. N. of Holcomb Blvd. (in front of Bldg. 27)	8 in.

[1] Supply Area ID: HP = Hadnot Point
[2] Map ID: Camp Lejeune AutoCAD referencing system
[3] ATSDR Logger ID: F = Fluoride; P = Pressure; C = Conductivity

Table F-1. Description of sampling locations, logger identifications, and other pertinent information that will be used to monitor water-distribution system during preliminary test at Marine Corps Base, Camp Lejeune, North Carolina (refer to Plate 1 for map showing sampling locations).

Hadnot Point: Hydrant Sampling Locations									
[2]Supply Area ID	Test ID	[2]Map ID	[3]ATSDR Logger ID	ATSDR Object ID	Camp Lejeune Hydrant ID	Longitude State Plane NAD83 (feet) (approx.)	Latitude State Plane NAD83 (feet) (approx.)	Sample Hydrant Location	Pipe Diam.
HP	T0	G7	F04	1065	3-72-8	2495721.79	335539.74	N. side of H Street ≈ 750 ft. E. of Julian C. Smith Rd. (in front of Bldg. 325)	8 in.
			P04	1066	3-73-8	2496025.88	335759.52	N. side of H Street ≈ 1100 ft. E. of Julian C. Smith Rd. (in front of Bldg. 319)	8 in.
			C04	1085	3-56-12	2494421.09	336126.21	S.E. corner of G Street and Julian C. Smith Rd. intersection	12 in.
HP	T0	G8	F05	608	none	2498133.32	334117.91	S. side of N Street, ≈ 350 ft. E. of M St. intersection, (in front of Bldg. HP-507)	8 in.
			P05	609	none	2497890.30	333776.65	S. side of N Street ≈ 100 ft. W. of M St. intersection (in front of Bldg. HP-509)	8 in.
			C05	1183	5-26-12	2501009.53	333623.14	N. side of McHugh Blvd. ≈ 500 ft. W. of Gonzalez Blvd. (in front of well house SFC-116)	12 in.
HP	T0	H8	F06	1147	5-197-12	2501177.60	331666.82	E. side of Gonzalez Blvd. at tank SFC314 (in front of Bldg. FC-330)	8 in.
			P06	1148	5-198-12	2501487.48	331718.60	≈ 200 ft. in front of Gymnasium (behind Bldg. FC-330)	8 in.
			C06	1132	5-179-8	2500089.95	330120.70	S. side of H.M. Smith Blvd. (Reasoner St.) ≈ 750 ft. E. of Gonzalez Blvd. (in front of Bldg. FC-500) [2nd FSG Cons. Admin. Center]	8 in.

[2] Supply Area ID: HP = Hadnot Point
[2] Map ID: Camp Lejeune AutoCAD referencing system
[3] ATSDR Logger ID: F = Fluoride; P = Pressure; C = Conductivity

Table F-1. Description of sampling locations, logger identifications, and other pertinent information that will be used to monitor water-distribution system during preliminary test at Marine Corps Base, Camp Lejeune, North Carolina (refer to Plate 1 for map showing sampling locations).

Hadnot Point: Hydrant Sampling Locations									
[3]Supply Area ID	Test ID	[2]Map ID	[3]ATSDR Logger ID	ATSDR Object ID	Camp Lejeune Hydrant ID	Longitude State Plane NAD83 (feet) (approx.)	Latitude State Plane NAD83 (feet) (approx.)	Sample Hydrant Location	Pipe Diam.
HP	T0	F8	F07	520	5-80-8	2500201.34	337626.87	N. corner of Fir St. and Michael Rd. intersection (hydrant base ≈ 12 in. above ground surface)	8 in.
			P07	521	5-87-8	2499855.45	337320.88	N. corner of Gum St. and Michael Rd. intersection	8 in.
		G9	C07	999	5-241-12	2505629.76	332767.23	N. side of McHugh Blvd. ≈ 400 ft. W. of Gonzalez Blvd. (in front of Bldg. FC-270)	12 in.
HP	T0	F8	F08	507	5-69-8	2500337.51	338780.43	S.E. corner of Dogwood St. and Gibb Rd. intersection (across street from Bldg. 1403)	8 in.
			P08	504	5-72-8	2499819.39	339364.54	E. side of Dogwood St. ≈ 100 ft. N. of West Rd.	8 in.
			C08	2257	none	2501132.53	340865.58	S. side of Holcomb Blvd. ≈ 1000 ft. E. of Birch St.	12 in.
HP	T0	F9	F09	968	5-265-12	2503964.33	338742.44	≈ 350 ft. W. of Sneeds Ferry Rd. and Lyman St. intersection (N. side of street)	12 in.
			P09	921	5-111-6	2503374.73	338823.09	≈ 500 ft S. of Louis Rd. between Franklin St. and O Street (on E. side of Bldg. 915)	6 in.
		E8	C09	2255	5-30-12	2502017.02	343158.97	E. side of Holcomb Blvd. at intersection with Sneeds Ferry Rd.	12 in.

[3] Supply Area ID: HP = Hadnot Point
[2] Map ID: Camp Lejeune AutoCAD referencing system
[3] ATSDR Logger ID: F = Fluoride; P = Pressure; C = Conductivity

APPENDIX G

Data-Entry Log Sheets

P01

ATSDR FIELD WORK
Camp Lejeune, NC – Water Distribution System
Hadnot Point Test 0, May 2004

P01

ATSDR Logger ID/Hydrant Name: P01
ATSDR Object ID: 305
Camp Lejeune Hydrant ID: 3H-8-10
Longitude (NAD83 feet): 2490600.17
Latitude (NAD83 feet): 341674.54
Location: S. side of Julian C. Smith Rd. (southern loop)
≈ 300 ft. W. of Cutler St.

Hand Gauge Pressure
Date:____/____/____ **Time:**____:____ **Initial (psi):** _____
Date:____/____/____ **Time:**____:____ **Final (psi):** _____

DICKSON PR300 Pressure Logger			
Date	Time	Pressure (psi)	Notes
5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		
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5/___/04	:		
5/___/04	:		
5/___/04	:		
5/___/04	:		

F01 ATSDR FIELD WORK F01

Camp Lejeune, NC – Water Distribution System

Hadnot Point Test 0, May 2004

ATSDR Logger ID/Hydrant Name: F01
ATSDR Object ID: 306
Camp Lejeune Hydrant ID: H-9-10
Longitude (NAD83 feet): 2490200.37
Latitude (NAD83 feet): 341642.14
Location: S. side of Julian C. Smith Rd. (northern loop)
≈ 700 ft. W. of Cutler St.

Logger Installation **Date:** _____/_____/_____
Time: _____:_____

HORIBA W-23XD Monitoring System								pHTestr 30		Notes
Sample ID	Date	Time	pH	Cond. (µS/cm)	T (°C)	Cl^- (mg/L) **ION 1**	F^- (mg/L) **ION 2**	T (°C)	pH	
	5/___/04	:								
	5/___/04	:								
	5/___/04	:								
	5/___/04	:								
	5/___/04	:								
	5/___/04	:								
	5/___/04	:								
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	5/___/04	:								
	5/___/04	:								
	5/___/04	:								
	5/___/04	:								

C01 ATSDR FIELD WORK C01

Camp Lejeune, NC – Water Distribution System

Hadnot Point Test 0, May 2004

ATSDR Logger ID/Hydrant Name: C01
ATSDR Object ID: 315
Camp Lejeune Hydrant ID: 3-149-8
Longitude (NAD83 feet): 2489539.97
Latitude (NAD83 feet): 340649.01
Location: N. side of Julian C. Smith Rd.
≈ 650 ft. W. of Olive St.
(in front of Bldg. H1)

Logger Installation **Date:** _____/_____/_____
Time: _____:_____

HORIBA W-21SDI Monitoring System					D-54	pHTestr 30		Notes
Sample ID	Date	Time	Cond. (µS/cm)	T (°C)	Cond. (µS/cm)	T (°C)	pH	
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
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	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						
	5/___/04	:						

Hadnot Point Test 0: F01

Lab Analysis											Field Measurement					
Sample ID	Date	Time	T (°C)	D-53 Cl^- (mg/L)	Time	T (°C)	D-53 F^- (mg/L)	Time	T (°C)	D-53 F^- (mg/L) TISAB II	Time	W-23XD pH	W-23XD Cond. (µS/cm)	W-23XD T (°C)	W-23XD Cl^- (mg/L) **ION 1**	W-23XD F^- (mg/L) **ION 2**
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
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	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					
	5/___/04	:			:			:			:					

Hadnot Point Test 0: C01

Lab Analysis											Field Measurement			
Sample ID	Date	Time	T (°C)	D-53 Cl^- (mg/L)	Time	T (°C)	D-53 F^- (mg/L)	Time	T (°C)	D-53 F^- (mg/L) TISAB II	Time	W-21SDI Cond. (µS/cm)	W-21SDI T (°C)	D-54 Cond. (µS/cm)
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			
	5/___/04	:			:			:			:			

APPENDIX H

Training Agenda for HORIBA Data Loggers

HORIBA W-23XD MONITORING SYSTEM TRAINING
MEETING WITH PAM MILLETT (HORIBA) AND MARIO OVES (INSTRU-MED)
April 21, 2004

Agenda and Schedule

Time	Activity
0830 hrs	Pam and Mario arrive at Century Center and check in through security 1. Photo ID required
0900 hrs	Discussions in Conference Room 1B 1. Overview of equipment setup (batteries, connect control unit, power, menu navigation, time setup) 2. Handling, maintaining, and storing probes and sensors
0930 hrs	Calibration of the W-23XD Monitoring System 1. Hands-on training using standards to calibrate
1100 hrs	Fire Hydrant Setup 1. Install equipment on fire hydrant outside Century Center 2. Allow W-23XD to monitor water quality 3. Test control unit display menu while W-23XD continuously recording
1200 hrs	Lunch
1300 hrs	Disconnect Equipment from Fire Hydrant 1. Clean and store W-23XD probe and sensors
1400 hrs	Data Recovery in Room 3B 1. Download data to laptop using extension unit connection 2. Analyze data
1500 hrs	Wrap up and Summary

Attendees
Pam Millett, Horiba
Mario Oves, Instru-Med
Bob Faye, Contractor
Amy Funk, EHH/NCEH
Morris Maslia, DHAC/ATSDR
Jason Sautner, DHAC/ATSDR
Claudia Valanezuela, ORISE, Ga. Tech

APPENDIX I

Signage for Sampling Hydrant Locations

U.S. GOVERNMENT TEST HYDRANT AND EQUIPMENT

Please Do Not Disturb
Fire Emergency Use Only

This hydrant and test equipment are being used to conduct a series of tests of the water-distribution system. Should you have any questions pertaining to these tests, please contact:

Scott A. Brewer
Environmental Management Division
MCB, Camp Lejeune, NC
Telephone: (910) 451-5003

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY