U.S. Army Corps of Engineers –
Baltimore District

Final

Remedial Action Work Plan

Oasis Fuel Point Site
Wheeler-Sack Airfield
Fort Drum, New York

September 2015

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Contract No.: W912DR-12-D-0007
Delivery Order No.: 0003

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Fort Drum, New York

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CERTIFICATION

I, Cullen Flanders, PE, certify that I am currently a NYS registered professional engineer as defined in 6 NYCRR Part 375 and that this Remedial Action Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

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Table of Contents

Figures

Tables

Appendices

1. Introduction

The Fort Drum Military Installation (Fort Drum), which encompasses approximately 168 square miles, is located approximately 10 miles northeast of Watertown, 80 miles north of Syracuse, and 25 miles southeast of the United States and Canadian border (Figure 1-1). Fort Drum occupies a large portion of northeastern Jefferson County, a portion of western Lewis County, and abuts the southern edge of St. Lawrence County.

The Oasis Fuel Point (Oasis) site is a refueling area for helicopters located at Fort Drum Wheeler-Sack Army Airfield. In May 2006, during a routine inspection of the Oasis refueling system, JP-8 fuel was discovered in the service sump pit located at the northern end of the system pipeline. The spill resulted in a light non-aqueous phase liquid (LNAPL) plume that covers approximately 3.6 acres at Oasis, as well as an associated dissolved–phase plume of volatile organic compounds (VOCs) that emanates from the Oasis site and extends approximately 2,800 feet to the east.

1.1 Purpose

On 28 January 2011, a Consent Decree listing the State of New York and the New York State Department of Environmental Conservation (NYSDEC) as the plaintiffs and the United States of America as the defendant was filed (Case 7:10-CV-1495). The Consent Decree specifies compliance obligations, including milestones for remediation at the Oasis Site. In accordance with Section IV.A of Consent Decree, the Army is required to restore the Oasis Site to pre-discharge conditions, to the extent technically feasible, through the preparation and implementation (upon approval by the NYSDEC) of a Remedial Action Work Plan (RAWP) based on the following documents.

1. NYSDEC Final Technical Guidance for Site Investigation and Remediation (DER-10), dated May 2010 (NYSDEC 2010).
2. Final Remedial Action Selection Report - Oasis Fuel Point Site (RAS), dated April 2014 (PIKA-MP 2014).
3. Final Remedial Action Design Report – Oasis Fuel Point Site (RADR), dated February 2014 (PIKA-MP 2015).

The RADR documents the design specifications of the groundwater recirculation (GWRC) system, dual phase extraction (DPE) system, ozone sparge system and bioventing technology selected for operation at the Site in accordance with the recommended remedial alternative presented in the RAS. This RAWP documents the requirements, strategy, metrics, and evaluation of the selected remedial alternative.

1.1.1 Objectives

The objectives of this RAWP are as follows:

1. Define the requirements, schedule, and metrics for remedial system performance.
2. Present the locations, methods, schedule, and metrics for remedial system and site-wide performance monitoring.
3. Establish remedial endpoints and the strategy for achieving site closure.

2. Background

The Oasis Fuel Point Spill Site (Oasis Site) (Figure 2-1) consists of the area encompassing the original JP-8 fuel release, including the resultant LNAPL source area and down-gradient dissolved-phase groundwater plume. This area extends from the northeastern portion of the Oasis Fuel Point pad easterly beneath the North Aircraft Staging Pad (North Pad) to the easternmost extent of the dissolved-phase contaminant plume east of the aircraft hangars, approximately 2,800 feet east of Oasis (Figure 2-2).

An LNAPL plume formed at the water table interface beneath the site as a result of the JP-8 fuel release. Subsurface vadose zone soil has been impacted by residual JP-8 in the area immediately around and beneath the release extending to, and spreading out along, the water table. The LNAPL plume acts as the source area for a plume of dissolved-phase JP-8 constituents.

2.1 Contaminants of Concern

The primary contaminants of concern (COCs) include:

- Volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) associated with JP-8 jet fuel;
- Methyl-tert butyl ether (MTBE) (assumed to be from impurities in the JP-8 fuel);
- Acetone (a degradation byproduct of a Surfactant Enhanced Aquifer Remediation (SEAR) interim remedial measure (IRM)); and
- Residual surfactant from the SEAR IRM.

2.2 LNAPL

Fuel leaking from Service Pit #6 entered the subsurface at a depth of approximately 16 feet bgs and migrated vertically until intercepting the water table (at 40-45 feet bgs). Upon reaching the water table, the fuel spread radially in the direction of groundwater flow (east-northeast) directly beneath the release point, and depending on the amount and rate of fuel infiltration, LNAPL may have displaced groundwater several feet below the water table, in addition to spreading out along the water table. The maximum extent of the LNAPL plume was approximately 3.6 acres - extending from the vicinity of Service Pit No. 6 northeast toward the North Ramp. However, the most recent full gauging events in 2015 have shown that the measureable LNAPL plume area has been reduced in size to less than1.6 acres as a result of several IRMs (see Section 2.4, below).

Due to seasonal fluctuations in the water table at Oasis, an LNAPL smear zone developed, which extends up to five to eight feet above the current water table level, based on current

(2013) water levels. Lowering of the water table due to decreases in seasonal precipitation, resulting in decreased infiltration and aquifer recharge, have contributed to an increase in the thickness of the smear zone over time in some areas. Based on the results of various field investigations, the area with the thickest interval of petroleum impacted soil at the water table interface (approximately eight feet) is beneath the point of the original release at Service Pit No. 6. The interval of petroleum impacted soil throughout the majority of the LNAPL plume appears to be between four and five feet, decreasing to two feet at the margins.

Based on initial LNAPL thickness measurements, soil characteristics at the site, fluid characteristics of JP-8, a range of approximate LNAPL volumes were estimated. The amount of recoverable LNAPL (via hydraulic means) was estimated using the leading-edge DPE system recovery data as a surrogate for the remaining areas of the LNAPL plume. This data was compared to recovery data for the larger seasonal DPE system as a means to predict both the size of the original release and the point at which LNAPL recovery would no longer be practicable over the entire site. Based on this estimate, the total LNAPL collected to date, and a general industry guideline that a maximum of approximately 50 percent of the original released volume is recoverable by hydraulic means, the volume of the original JP-8 release is estimated to be between 500,000 and 550,000 gallons.

2.3 Groundwater

The Oasis site is located southeast of a shallow groundwater divide and overlies a deltaic sand, silt, and gravel deposit with observed zones of varying hydraulic conductivity which may locally affect groundwater flow (and contaminant transport). A groundwater plume comprised of dissolved-phase petroleum compounds extends approximately 2,800 ft eastward in the direction of groundwater flow from the upgradient boundary of the LNAPL plume. Groundwater sampling of the site-wide monitoring network has been conducted quarterly since May 2009. The magnitude and extent of the plume have decreased during that time, likely as a result of the IRMs conducted to date (see below). The current (December 2014) extent of the groundwater plume is presented on Figure 2-2.

2.4 Summary of Interim Remedial Measures

Several IRMs have been conducted at the OASIS site since 2007. The majority of the IRMs have targeted the LNAPL source area. The IRMs are discussed in detail in the RAS. These IRMs have included:

- LNAPL Skimming Systems and Vacuum-Ehanced Skimming (VES);
- SEAR treatment;

- Dual-Phase Extraction (DPE);
- Groundwater Recirculation (GWRC); and
- Ozone Sparging.

The locations of the various IRMs are shown on Figure 2-3. To date, the IRMs implemented at the OASIS site have resulted in the physical recovery 238,825 gallons of LNAPL. In addition, it is estimated that an equivalent volume of approximately 23,000 gallons of JP-8 have been removed from the subsurface in the dissolved and vapor phases.

2.4.1 Skimming

An IRM consisting of the installation of LNAPL skimmer systems, was implemented in January 2007. LNAPL skimmer systems were installed in five extraction wells/piezometers and recovered a total of approximately 32,000 gallons of LNAPL through May 2008. An upgrade to the LNAPL skimming IRM was implemented in July 2008 using VES to increase LNAPL recovery. The IRM upgrade included installation of 10 additional recovery wells and a vacuum blower to recover LNAPL from up to 15 locations.

2.4.2 SEAR

A SEAR pilot study was subsequently performed at the Oasis from August to November 2009 in a 100 foot by 50 foot area along the western hydraulically upgradient edge of the LNAPL boundary. Based on the results of the pilot study, implementation of full-scale SEAR as an IRM was initiated in an upgradient portion of the LNAPL plume from September to November 2010. Although the SEAR IRM resulted in the recovery of more than 23,000 gallons of LNAPL, a large percentage of the injected surfactant was not recovered and remained in the subsurface after the completion of the IRM. While the remaining surfactant mixture has substantially degraded over time, the degradation has resulted in the generation of acetone in the groundwater in, and downgradient from, the area where the SEAR IRM was implemented.

2.4.3 DPE

In lieu of additional SEAR implementation, two DPE systems were installed in 2011 – a plume-wide DPE system that runs seasonally from April through November, and a Leading Edge DPE system designed for full-time, year round operation. Operation of both systems continues. The DPE system operations were optimized by operational changes in 2012, and in 2014 with the installation of new blowers and infrastructure to enhance LNAPL recovery.

2.4.4 GWRC

A GWRC pilot system was constructed in 2013 and began operation in January 2014. The primary goal of the GWRC pilot system is to evaluate enhanced biodegradation of the dissolved-phase contaminants, including petroleum compounds and acetone, beneath portions of the LNAPL source area. GWRC was selected for enhanced biodegradation over other remedial strategies (e.g., air sparging) for two primary reasons: higher oxygen concentrations (up to 11 milligrams per liter) can be efficiently delivered and maintained within the mobile groundwater pathways where the dissolved-phase mass flux is greatest; and hydraulic control of the groundwater containing organic compounds is inherent in the application of groundwater recirculation. To maintain hydraulic control of the plume while delivering oxygen, the GWRC pilot system operates at an unbalanced re-injection rate such that more groundwater is extracted than is re-injected (currently 60% re-injection).

2.4.5 Ozone Sparging

As discussed in Section 2.3, a groundwater plume comprised of dissolved-phase petroleum compounds extends approximately 2,800 ft eastward from the LNAPL source area. Since the plume contains MTBE, which is generally recalcitrant to degradation using just air sparging, chemical oxidation using ozone was selected for an IRM. An ozone sparging pilot test was conducted at the Oasis Site between October 2011 and January 2012 to evaluate groundwater plume treatment and assess whether in situ chemical oxidation (ISCO) via ozone injection is a viable remedial alternative to address the dissolved-phase groundwater plume at the Site. The location selected for ozone pilot testing was approximately 1,000 feet east (downgradient) of the LNAPL plume edge and directly upgradient from the MW-16 well cluster. Based on the results of the Ozone Sparging Pilot Study, a full-scale ozone sparging system was installed in the area of the pilot test. The design, installation and startup of the full-scale ozone sparge system were completed between August 2012 and April 2013. The objective of the ozone-sparging system is to prevent further down gradient migration of Oasis-related dissolved contaminants in the groundwater while concurrent remedial actions are being implemented to remove LNAPL source material.

To date, the IRM efforts have resulted in the removal of over 200,000 gallons of JP-8 LNAPL from the subsurface. In addition, it is estimated that the groundwater IRMs have removed approximately 70,000 gallons of JP-8 equivalent. Last, monitoring data indicates that the GWRC IRM has successfully cut-off the dissolved phase source area from the downgradient groundwater plume while, at the same time, the ozone sparging IRM has prevented further migration of the downgradient portion of the dissolved phase plume However, LNAPL remains at thicknesses ranging from less than one to three feet throughout a 170,000 square foot LNAPL plume area. In particular, areas of recalcitrant LNAPL remain in the central and southern portions of the historic LNAPL plume area.

3. Proposed Remedial Action

The RAS presents the analysis of the various remedial alternatives as they relate to the Oasis Site. The design details of the selected alternative are presented in the RADR. The elements of the selected remedial alternative are summarized below.

3.1 Groundwater and Smear Zone

RAS Alternative 3b was selected as the preferred remedial alternative for the OASIS Site. Alternative 3b utilizes the treatment components currently existing at the site as part of on-going IRMs, or slated to be installed. These include: DPE, bioventing, GWRC, and downgradient ozone/air sparging.

3.1.1 DPE

Dual phase extraction is currently utilized at the site for LNAPL source zone remediation. System operation is continually monitored and optimized to maximize recovery of LNAPL. Operation of the DPE systems will continue as part of the site remedy. Details of the DPE systems operation and planned optimization strategies are presented in the RADR and will include:

1. Continued operation of the DPE systems until achievement of shut-down criteria (see Sections 4 and 5).

2. Installation and operation of additional DPE wells to focus treatment on areas of recalcitrant LNAPL presence.

3. Injection of treated (and aerated) water from the DPE groundwater treatment system back into existing DPE wells during seasonal system operational periods to promote and accelerate the natural attenuation of the shallow dissolved-phase petroleum contamination in and immediately below the smear zone.

4. Utilization of pulsing and targeted higher vacuum operation to optimize recovery of recalcitrant LNAPL.

The current and expanded layout of the DPE systems is presented on Figure 3-1.

3.1.2 Bioventing

The bioventing system will target the portion of the smear zone above the water table in four treatment areas, which will eventually encompass the entire LNAPL footprint after DPE is completed (approximately four acres). Bioventing has already been initiated in the western portion of the LNAPL source area as a field-scale pilot, and will be implemented in the remainder of the LNAPL areas after the DPE systems have been shut-down in accordance with the criteria presented in Sections 4 and 5.

3.1.3 GWRC

Groundwater recirculation is currently utilized at the site to enhance biodegradation of dissolved-phase hydrocarbons in groundwater beneath the source mass and to provide for hydraulic control of the dissolved phase plume beneath the historical LNAPL source zone. As discussed in the RADR, the GWRC will be expanded and optimized as part of the site rememdy. The configuration of the current and expanded GWRC system is presented on Figure 3-2.

In accordance with NYSDEC Division of Water Technical and Operational Guidance Series (TOGS) 2.1.2, maintenance of both hydraulic control and a net hydraulic deficit between extraction and re-injection are also requirements for GWRC operations. Details of the GWRC system design and operation are included in the RADR. As discussed in the RADR, the existing generalized three-dimensional numerical flow model of the Oasis Site was used to evaluate the ability of the expanded DPE and GWRC systems to maintain hydraulic control of the dissolved-phase plume beneath the LNAPL source area. The flow regime predicted by the model will be verified through empirical testing and operational monitoring (see Sections 4 and 5).

3.1.4 Downgradient Ozone/Air Sparging

Ozone sparging is currently utilized at the Site to chemically oxidize Oasis-related dissolved contaminants in the groundwater and prevent their further migration down gradient. As shown on Figure 3-3, the sparging system is located east of the airfield tarmac and is positioned perpendicular to the direction of groundwater flow. Details of the ozone-sparging system design and operation are presented in the RADR. Operation of the ozone sparging system will continue until the criteria are met for transition to air sparging and/or system shut-down (see Sections 4 and 5).

3.2 Unsaturated Soil

For unsaturated soil, the RAS recommended Alternative S2 as the preferred remedy. This alternative utilizes the treatment components currently existing at the Oasis Site to treat unsaturated soil in the service pit area, which was the original source of the Oasis spill, by bioventing. Source area (service pit area) bioventing treatment would be conducted concurrently with smear zone bioventing treatment.

4. Remedial Action Criteria

4.1 Remedial Action Objectives and Performance Metrics

The site-specific remedial action objectives for the OASIS site were presented in Section 4 of the RAS and are summarized below.

- **Unsaturated Soil**: Prevent migration of contaminants that would result in groundwater contamination.
- **Groundwater and Smear Zone**:
  - Remove LNAPL from the subsurface to the extent practicable.
  - Prevent further migration of groundwater containing petroleum constituents from the airfield area, thus eliminating the potential drinking water exposure pathway.
  - Achieve groundwater quality standards.

The success of the remedial actions in meeting the RAOs will be measured and evaluated using criteria specific to each remedial activity and the associated impacted media. These criteria have been developed based on performance of the interim remedial systems to date; between the Army, USACE, and NYSDEC; and industry standards as presented in the following documents.

- ASTM. 2006. Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface (E 2531-06). American Society for Testing and Materials, West Conshohocken, PA.
- ITRC. 2009. Evaluating Natural Source Zone Depletion at Sites with LNAPL (LNAPL-1). Interstate Technology & Regulatory Council, Washington, DC.
- USEPA. 1995. Manual – Bioventing Principles and Practice, Volume II: Bioventing Design (EPA 625-XXX-01). United States Environmental Protection Agency Office of Research and Development.
- USEPA. 2005. A Decision-Making Framework for Cleanup of Site Impacted with Light Non-Aqueous Phase Liquids (EPA 542-R-04-011). United States Environmental Protection Agency Office of Solid Waste and Emergency Response.

The procedures and schedule for groundwater monitoring in support of the performance criteria are presented in the Remedial Action Monitoring Plan (Appendix A).

4.2 LNAPL Source Zone

4.2.1 Performance Metrics

The goals and metrics for LNAPL source zone remedial activities are summarized in Table 4-1 (below).

Table 4-1 – LNAPL Source Zone Remedial Goals and Metrics

Remedial Goal	Remedial Technology	Metric
Remove LNAPL from the subsurface to the extent practicable and eliminate LNAPL migration potential.	Physical extraction of LNAPL through DPE.	• Physical LNAPL recovery trends • Petroleum mass recovery trends • LNAPL plume stability in the absence of active remediation
Mitigate further impacts to groundwater from remaining LNAPL by reducing LNAPL solubility potential.	In-situ bioremediation of residual LNAPL in the unsaturated smear zone through bioventing.	• Subsurface CO_2 and O_2 concentration trends. • Respiration rates
	In-situ bioremediation of remaining LNAPL in the saturated smear zone through treated water re-injection.	• Petroleum mass recovery trends from water table extraction wells. • VOC concentrations in water table monitoring wells in the treatment area.
Treat, and prevent further migration of, groundwater containing petroleum constituents from the airfield area.	In-situ bioremediation treatment of groundwater contamination and hydraulic containment through GWRC.	• LNAPL source area groundwater contaminant concentrations • Groundwater elevations
Attain groundwater standards	All of the above combined with monitored natural attenuation (MNA).	• Groundwater sampling results

4.2.2 Remedial Action Criteria

4.2.2.1 LNAPL Removal

Typical mass recovery observed with a DPE system declines over time as LNAPL saturation approaches residual saturation and VOCs are removed from the residual LNAPL. Therefore, the remedial action criterion for the DPE system is asymptotic conditions of mass recovery. As stated in EPA 2005, “after LNAPL removal is implemented, recovery rates will asymptotically approach zero. Further attempts at removal will become more costly; further removal may be impractical”. The proposed metrics for are listed below. These metrics, once achieved, will be used to demonstrate that physical recovery of LNAPL is no longer an effective remedial technology for the site, and that resources should be shifted to other technologies (such as bioventing and groundwater recirculation) that are better suited for the remediation of the remaining petroleum impacts and achieving site closure.

1. **LNAPL Recovery**: Asymptotic LNAPL recovery/recovery practicability will be demonstrated through the following lines of evidence:
    a. When the daily total LNAPL recovery is less than 0.1% of the cumulative total LNAPL recovery, indicating that future recovery will be insignificant compared to the mass recovered to date (ASTM, 2006).
    b. Decline curve analysis: Total daily recovery rates vs. total cumulative recovery rates will be plotted to demonstrate that limits of recoverable LNAPL have been reached.
2. **Petroleum Mass Recovery**: Diminishing returns for petroleum mass recovery will be evidenced when total petroleum mass recovery (LNAPL, groundwater, and vapor) is less than five times the natural degradation (Natural Source Zone Depletion [NSZD]) rate, which, based on guidance and empirical data, is approximately 1,000 gallons/acre/year for a typical petroleum site (ASTM, 2006; ITRC, 2009). Total mass recovery will be calculated based on the results of the monthly DPE effluent sampling.
3. **LNAPL Plume Stability**: LNAPL plume stability will be demonstrated as follows:
    a. Plume Definition: The LNAPL plume is currently considered to be defined since there is no ongoing release of LNAPL and measurable LNAPL in monitoring wells and the associated dissolved-phase plume are delineated by the existing monitoring well network.
    b. Plume Stability: The following criteria will be used to demonstrate LNAPL plume stability:
        i. Stable or decreasing thickness of measurable LNAPL in monitoring wells
        ii. Stable or decreasing area of LNAPL plume

4.2.2.2 Mitigate Groundwater Impacts

Impacts to groundwater in the LNAPL source area will be mitigated through treatment of residual LNAPL in the smear zone through bioventing and smear zone oxygenated water injection. These technologies will operate in tandem so that both the unsaturated and saturated portions of the smear zone will be treated regardless of the water table elevation at the time of treatment. The metrics for operation of these systems will be as follows.

1. **Bioventing**: Operation of the bioventing systems will continue until monitoring data shows:
    a. Asymptotic and/or declining carbon dioxide production (relative to atmospheric levels) indicating that petroleum mass has been degraded to levels where natural processes are capable of treating residuals in the absence of bioventing.
    b. Respiration testing results that show that the addition of oxygen through bioventing is no longer necessary to maintain natural degradation processes.
2. **Smear Zone Oxygenated Water Re-Injection**: Details of the operation of the Smear Zone Injection System are presented in Appendix B. As shown in Appendix B, smear zone re-injection will be accompanied by groundwater extraction from water table extraction wells to meet the requirements of TOGS 2.1.2. Operation of smear zone injection systems will be based on the following criteria:
    a. Petroleum mass recovery from water table extraction wells (former DPE extraction wells[1]) and VOC concentrations in source area water table monitoring points, as presented in Section 4.2.2.1 (above).

4.2.2.3 Groundwater Source Area Active Treatment

Groundwater treatment and containment in the LNAPL source area will be accomplished through GWRC. The metrics for operation and shutdown of the GWRC system are as follows:

1. **Hydraulic Control**: The GWRC system will maintain hydraulic capture of the groundwater beneath the LNAPL source area. This will be demonstrated by:
    a. Comparison of groundwater elevations in groundwater monitoring wells to modeled groundwater elevations (as presented in the RADR).
    b. Utilization of measured groundwater elevations in additional groundwater modeling to demonstrate the groundwater particle tracks are intercepted by the extraction well network.

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[1] For the purposes of this document, a DPE well refers to a location where groundwater is extracted while vacuum is being applied. Water table extraction well refers to groundwater extraction in the absence of vacuum from wells that screen the water table.

   c. Potentiometric surface contouring using measured groundwater elevations.

2. **Attainment of Groundwater Standards**: Attainment of NYSDEC Class GA groundwater standards in, and immediately downgradient from, the LNAPL source area will be demonstrated using a staged "outside-in" approach as follows (see Figures 4-1 and 4-2):

   a. Source Area Downgradient:

      i. Attainment of groundwater standards in the area immediately downgradient of the LNAPL source zone will be measured at MW-11, MW-24, MW-26, MW-35, UFA-MW-4, PMW-B-01, MW-12 and PMW-B-02. Data from the MW-13 cluster will also be utilized for decision-making.

      ii. Upon attainment of groundwater standards at the Source Area Downgradient wells for a period of one year (as demonstrated through quarterly groundwater monitoring), the GWRC Area B system will be shut down and rebound monitoring will be conducted at the GWRC Area B Performance Monitoring Well clusters listed above.

      iii. If groundwater standards have also been met at the GWRC Area A Performance Monitoring Wells (MW-9, PMW-A-01, PMW-A-02, PMW-A-03 – see below), then the GWRC Area A system will also be shut down (if it has not been shut down previously per the criteria below).

      iv. The GWRC Area B system will remain off unless rebound monitoring shows non-attainment of groundwater standards at the performance monitoring well clusters.

   b. Source Area:

      i. Attainment of groundwater standards in the LNAPL source zone will be measured at the following locations:

         1. Monitoring Well Clusters: MW-9

         2. GWRC Area A Performance Monitoring Wells Clusters: PMW-A-01, PMW-A-02, PMW-A-03

      ii. Upon attainment of groundwater standards at the Source Area wells for a period of one year (as demonstrated through quarterly monitoring), the GWRC Area A system will be shut down and plume-wide rebound monitoring will be conducted in accordance with the Remedial Action Completion and Site Closure criteria presented in Section 5.

4.3 Downgradient Groundwater Plume

As discussed in Section 3, migration of the downgradient groundwater plume is currently being mitigated through the operation of the Downgradient Ozone Sparging System. The metrics for operation and shutdown of the Downgradient Ozone Sparging System are as follows:

1. **Ozone Sparging**: Ozone is being utilized to prevent further migration of MTBE present in the groundwater at concentrations greater than the NYSDEC Class GA groundwater standard of 10 ug/L. The criteria for continued use of ozone will be attainment of the Class GA standard upgradient of the sparging system, as measured monitoring well cluster MW-28. Ozone sparging will be discontinued after one year of monitoring shows no detections of MTBE greater than the Class GA standard at the MW-28 cluster. MTBE concentrations in monitoring wells upgradient of the MW-28 cluster will also be considered when evaluating the discontinuation of ozone sparging.
2. **Air Sparging**: Air sparging will continue until one year of monitoring shows no detections of regulated petroleum constituents at concentrations greater NYSDEC Class GA standards at well cluster MW-28 after one year of monitoring. Plume-wide rebound monitoring will be conducted after shutdown of the air sparging system in accordance with the Remedial Action Completion and Site Closure criteria presented in Section 5.

4.4 Remedial Action Sequencing Limitations

The following limitations will be applied to the remedial action criteria presented above.

1. Re-injection of aerated water into the smear zone will only be conducted when both the GWRC system and water table extraction wells are being operated to maintain hydraulic control of the re-injected water in accordance with TOGS 2.1.2.
2. Upon shutdown of GWRC Area B, GWRC Area A will be operated such that hydraulic control of the re-injected water is maintained in accordance with TOGS 2.1.2. This will be demonstrated through empirical data (including potentiometric contour evaluation) and groundwater particle track modeling. If GWRC Area A achieves the shutdown criteria before GWRC Area B, then GWRC Area B will be operated accordingly to meet the conditions of TOGS 2.1.2 until the shutdown criteria are met.

5. Remedial Action Completion and Site Closure

5.1 Remedial Action Completion (RAC)

As discussed in the RAS, it is anticipated that RAC for the various components of the remedial action will be achieved in the following order (from soonest to latest):

1. DPE Systems
2. Ozone Sparging
3. Bioventing Systems
4. Air Sparging
5. GWRC

The conditions for RAC for each of the components of the remedial action are presented below. These conditions reflect the requirements of DER-10 Section 6.4.

5.1.1 DPE Systems

The DPE remedial action will be considered complete when the following conditions are met:

1. The performance criteria for LNAPL Recovery, Petroleum Mass Recovery, and Plume Stability are achieved.
2. Water table extraction (through the former DPE wells) is no longer needed for hydraulic control of re-injected water for smear zone treatment.

Upon achievement of the RAC conditions, the DPE systems will be permanently decommissioned. This will include removal of all DPE piping and blowers, and removal/abandonment of the DPE wells in accordance with NYSDEC Commissioner's Policy (CP) 43: Groundwater Monitoring Well Decommissioning Policy (November 3, 2009) (CP-43).

5.1.2 Bioventing Systems

The bioventing remedial action will be considered complete when the performance metrics listed in Section 4 for bioventing operations are achieved. Upon achievement of the RAC conditions, the bioventing systems will be permanently decommissioned. This will include removal of all bioventing piping and blowers, and removal/abandonment of the bioventing wells in accordance with CP-43.

5.1.3 Downgradient Ozone/Air Sparging Systems

The downgradient ozone/air sparging remedial action will be considered complete when the performance metrics for air sparging operations listed in Section 4 are achieved. Upon achievement of the RAC conditions, the sparging system will be permanently decommissioned. This will include removal of all sparging equipment and piping, and removal/abandonment of the sparging wells in accordance with CP-43.

5.1.4 GWRC

The GWRC remedial action will be considered complete when the following conditions are met:

1. The performance metrics for GWRC Areas A and B presented in Section 4 are achieved.
2. Plume-wide rebound monitoring, as presented in Appendix A, shows that groundwater standards are being achieved at monitoring well cluster MW-13 for a period of four years (equivalent to approximately twice the travel time from the center of the LNAPL source area to the listed monitoring wells).

Upon achievement of the RAC conditions, the GWRC systems will be permanently decommissioned. This will include removal of all GWRC equipment and piping, and removal/abandonment of the GWRC injection, extraction, and performance monitoring wells in accordance with CP-43.

5.2 Site Closure

Site closure will be achieved upon concurrence that the RAC conditions for GWRC have been achieved and that any remaining groundwater impacts in the LNAPL source area are stable or decreasing in accordance with DER-10 Section 6.4 (c).

6. Reporting

The following reports will be prepared and submitted to the NYSDEC to document the remedial action. Operations and Maintenance (O&M) plans for each of the remedial systems were included as appendices to the RADR. The monitoring plan for the remedial action is included in Appendix A of this RAWP.

6.1 Final Engineering Report

In accordance with the requirements of the Consent Decree, a Final Engineering Report (FER) will be submitted within 45 days after the completion of the full-scale bioventing system installation, which will complete the remedial construction activities at the OASIS site.

6.2 Operations, Maintenance, and Monitoring (OM&M) Plan

An OM&M Plan will be submitted within 30 days of approval of the FER. The OM&M Plan will provided for reporting of remedial activities as listed below.

6.2.1 Progress Reports

6.2.1.1 Annual Operations Reports

Annual Operations Reports will be prepared and submitted to the NYSDEC no later than January 31 of each year during the course of the remedial action. The annual reports will summarize the operations of the various remedial actions and document the progress toward meeting the remedial action criteria.

The annual reports will also include requests for remedial system shutdown and/or decommissioning when remedial performance criteria for each of the five elements of the Remedial Action (DPE, Bioventing, Ozone Sparging, Air Sparging, GWRC) are met in accordance with the remedial action metrics and conditions presented herein. The final request for site closure will also be submitted in an annual operations report.

6.2.1.2 Quarterly Progress Reports

Quarterly Progress Reports (QPRs) will continue to be submitted no later than January 10, April 10, July 10, and October 10 in accordance with the Consent Decree. Notable remedial system results that have a bearing on operational decisions will also be reported in the QPRs.

6.3 Groundwater Monitoring Reports

6.3.1 Semi Annual Monitoring Reports

Semi-annual groundwater reports will be submitted after completion of the March and September semi-annual monitoring events in accordance with the Remedial Action Monitoring Plan in Appendix A.

6.3.2 Quarterly Technical Memoranda

A technical memorandum that includes a summary of the analytical data will be submitted upon the completion of the June and December quarterly monitoring events.

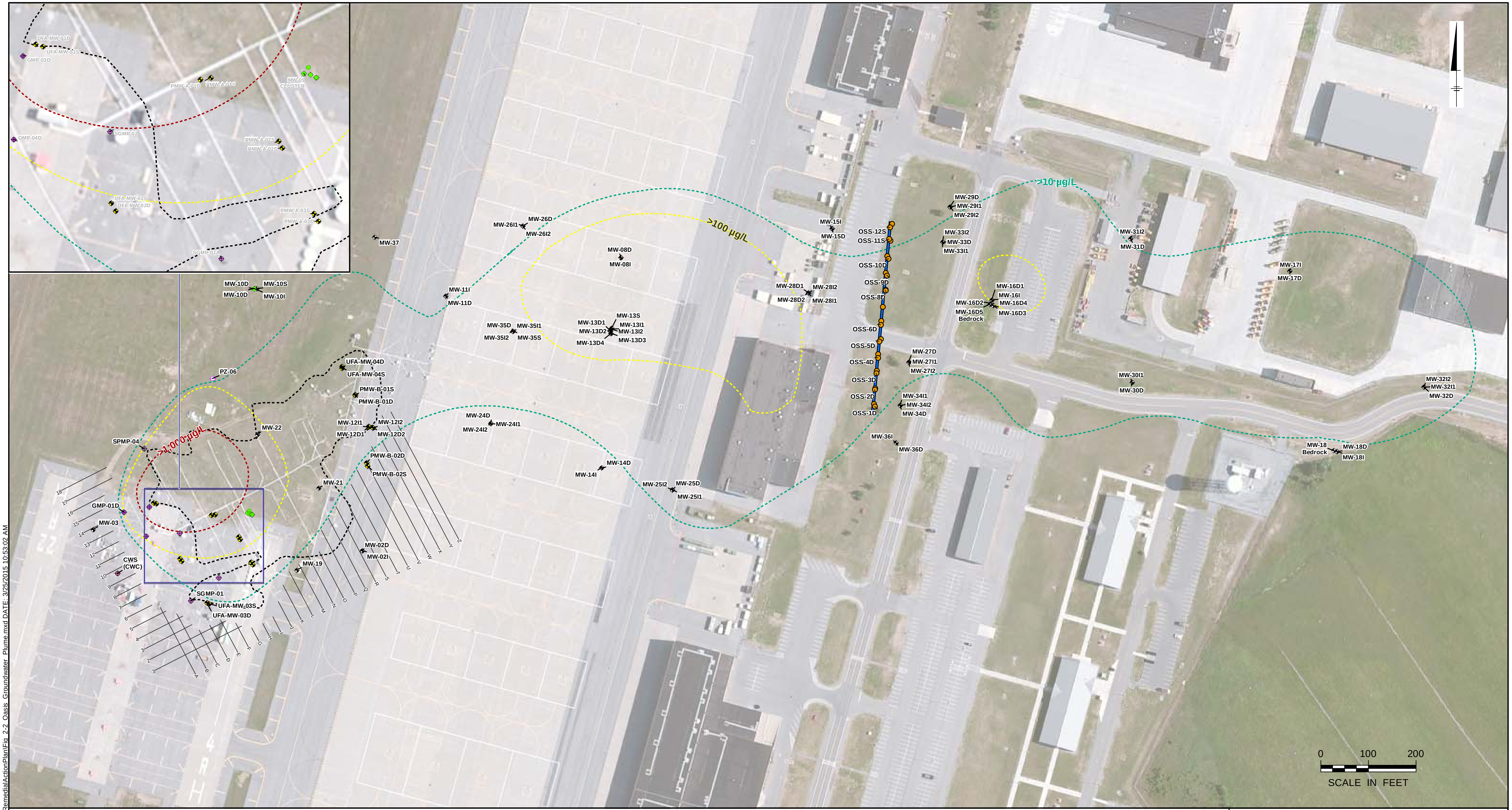
OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

Remedial Action Work Plan

Site Location

PIKA ARCADIS

2-1
FIGURE



LEGEND

- ● Ozone Sparge Well
- ◆ GWRC Performance Monitoring Well
- ◆ Monitoring Well
- ⊖ Piezometer
- ● Observation
- ◆ SEAR Pilot Groundwater Monitoring Point
- ◆ SEAR Groundwater Monitoring Point
- ◆ SEAR Process Monitoring Point
- ◆ SEAR Water Supply Well
- ━ Ozone Sparge Wall
- ─ Wellfield Grid

Approximate VOC Extent (Dec-2014)

- ⬚ >10 µg/L
- ⬚ >100 µg/L
- ⬚ >1,000 µg/L
- ⬚ LNAPL Extent (Approximate)

DRAFT

OASIS FUEL POINT
WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

OASIS GROUNDWATER PLUME

PIKA
ARCADIS
A JOINT VENTURE

FIGURE
2-2

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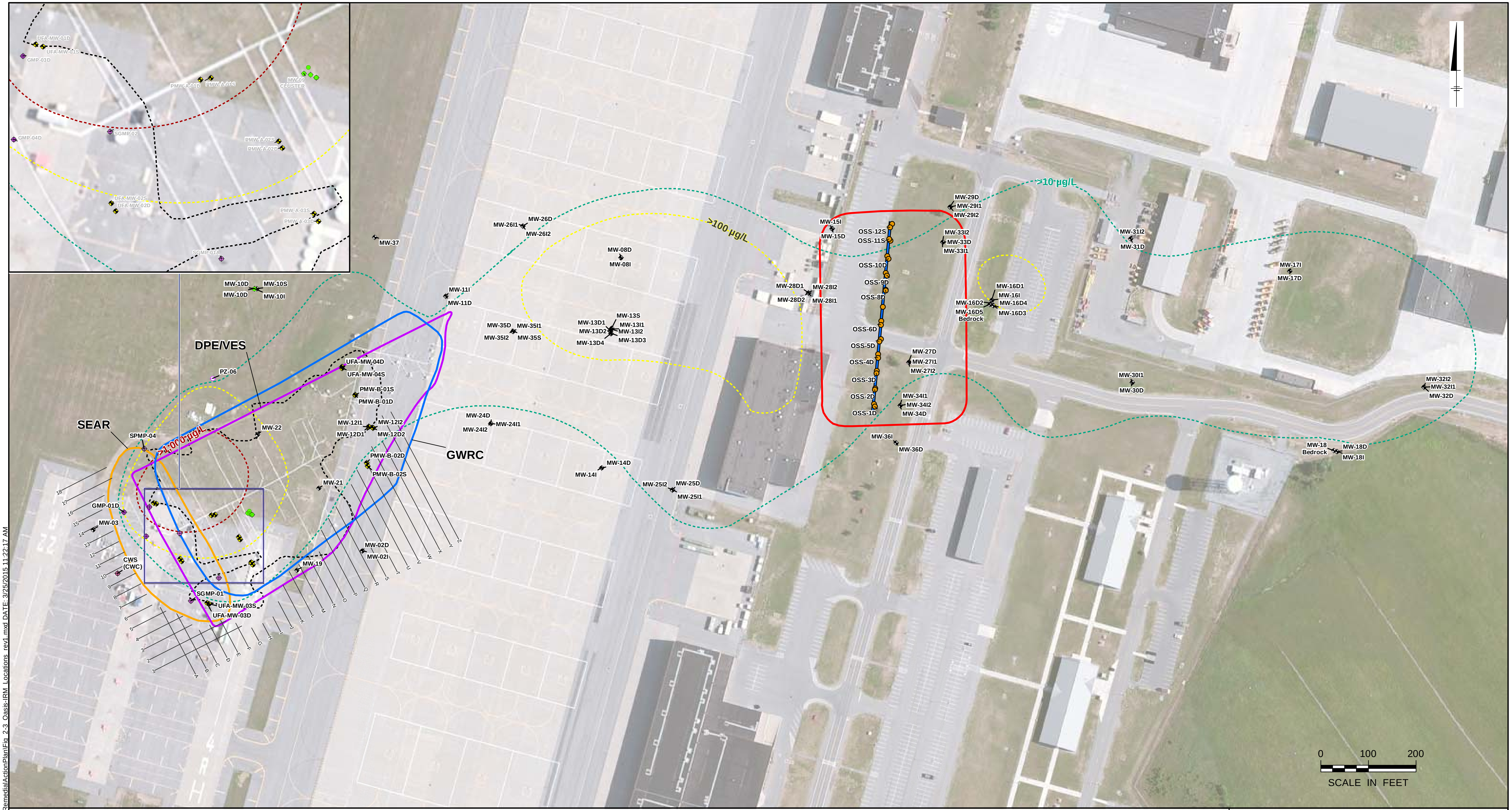

LEGEND

- ● Ozone Sparge Well
- ◆ GWRC Performance Monitoring Well
- ◆ Monitoring Well
- ⊖ Piezometer
- ● Observation
- ◆ SEAR Pilot Groundwater Monitoring Point
- ◆ SEAR Groundwater Monitoring Point
- ◆ SEAR Process Monitoring Point
- ◆ SEAR Water Supply Well
- ▬ Ozone Sparge Wall
- — Wellfield Grid

Approximate VOC Extent (Dec-2014)

- ▭ >10 µg/L
- ▭ >100 µg/L
- ▭ >1,000 µg/L
- ▭ LNAPL Extent (Approximate)

Interim Remedial Measures

- ▭ SEAR
- ▭ DEP/VES
- ▭ GWRC
- ▭ OZONE SPARGE

DRAFT

OASIS FUEL POINT
WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

IRM LOCATIONS

PIKA ARCADIS
A JOINT VENTURE

FIGURE
2-3

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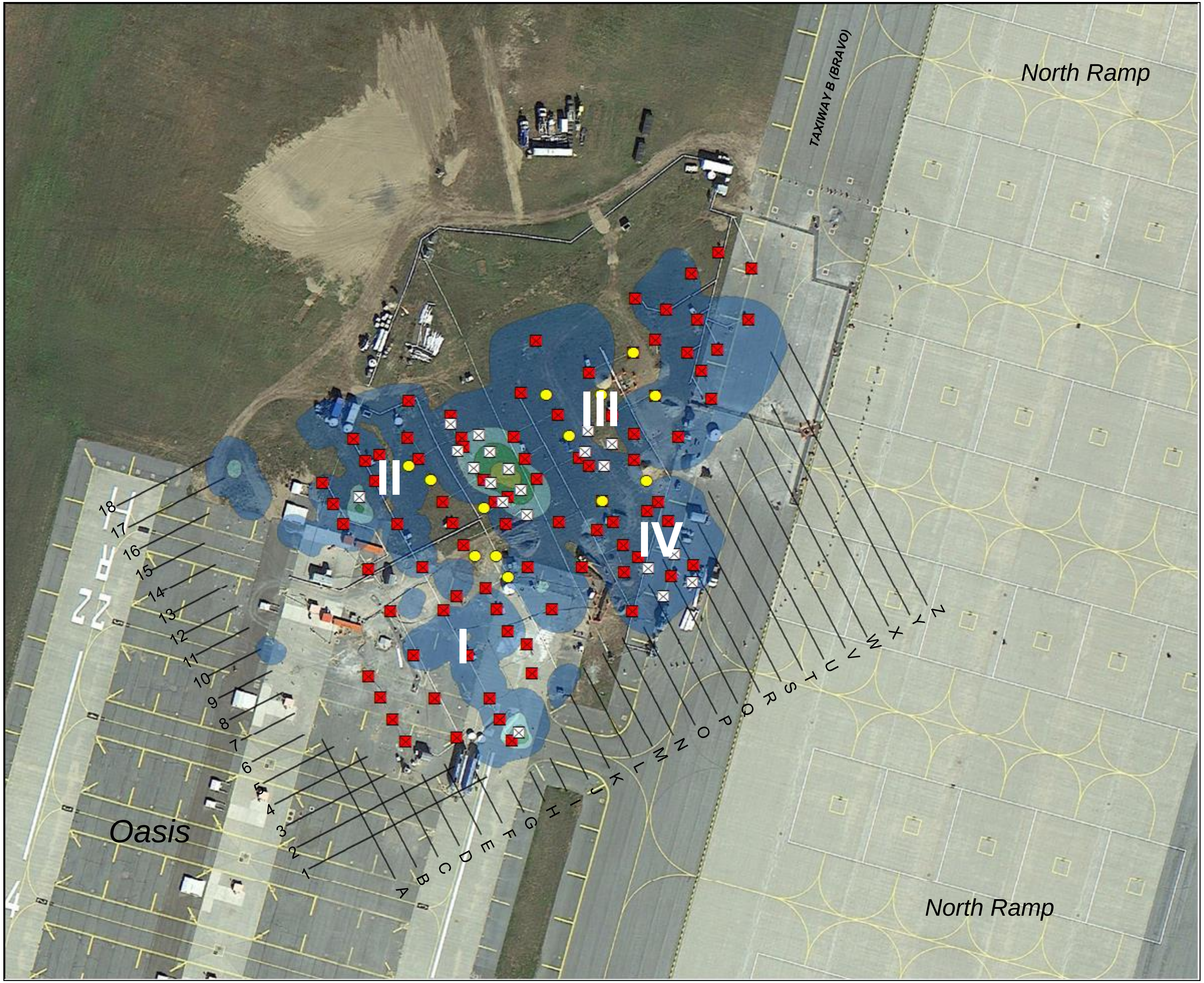


LEGEND

●	SMEAR ZONE INJECTION WELL
🟥	EXISTING DPE EXTRACTION WELL
☒	PROPOSED DPE EXTRACTION WELL
IV	DPE SUB-AREA

OCTOBER 2014 LNAPL Thickness (Feet)

🟧	2.5 – 3.0
🟨	2.0 – 2.5
🟩	1.5 – 2.0
🟩	1.0 – 1.5
🟦	0.5 – 1.0
🟦	0.01 – 0.5

N

0 50 100 200 300

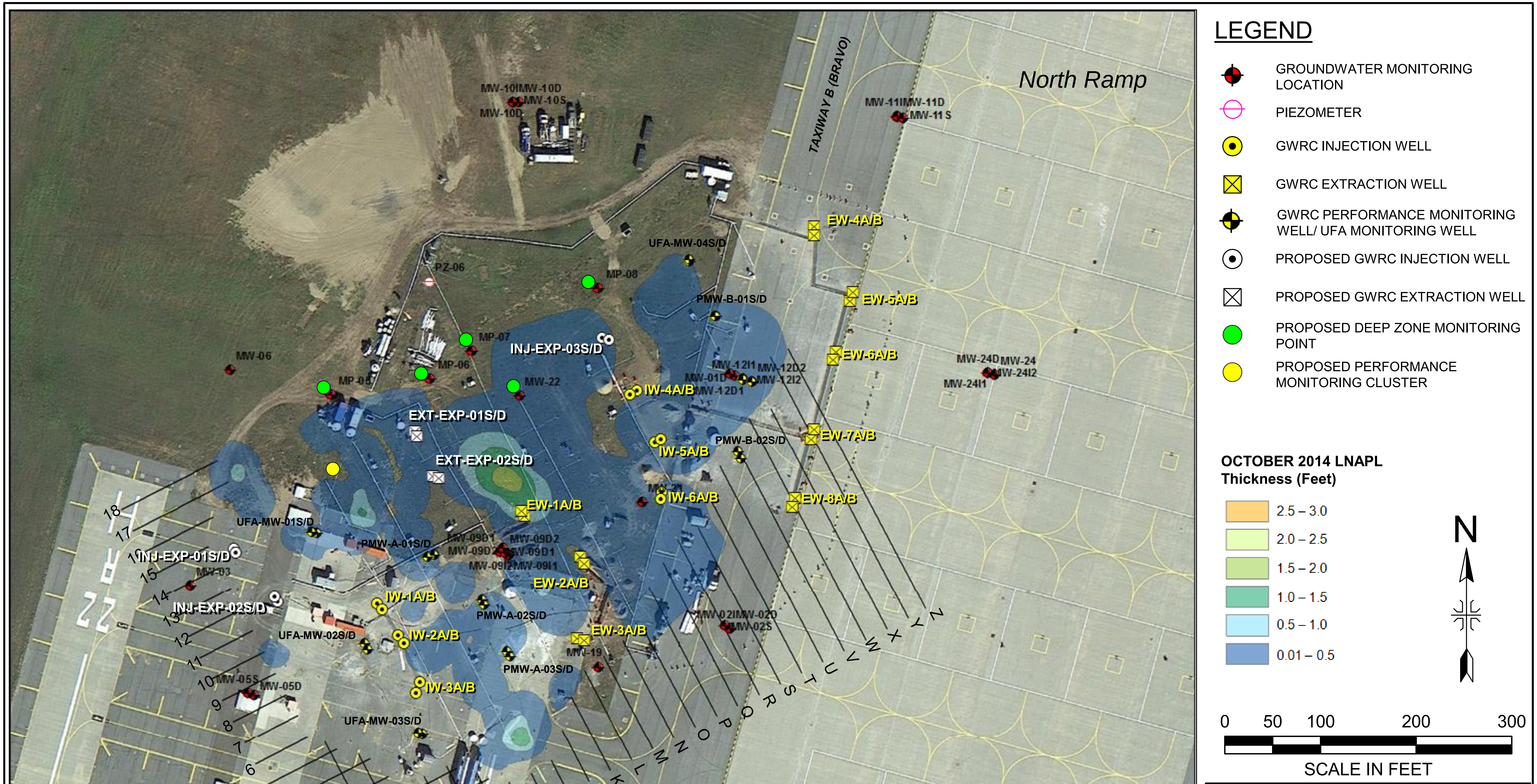
SCALE IN FEET

OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

Current and Expanded Dual-Phase Extraction System

PIKA ARCADIS

3-1
FIGURE



OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

Current and Expanded Groundwater Recirculation System

PIKA ARCADIS

3-2
FIGURE

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND:

- ● OZONE SPARGE LCOATION
- ⊕ OZONE MONITORING POINT
- ⊕ MONITORING WELL
- ▪ SUPPLY LINE PULL ENCLOSURE
- ☐ ELECTRIC METER/PANEL BOX
- ■ OZONE SYSTEM TRAILER
- ▬ TRENCH FOR POWER CONNECTION
- ▬ OZONE SUPPLY TRENCH
- —FO FIBER OPTIC
- — CABLE
- —G GAS
- — STORM SEWER
- —WW WASTEWATER
- —W WATER
- — ELECTRIC
- ▮ ELECTRICAL JUNCTION

OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

OZONE SPARGING SYSTEM

PIKA
ARCADIS

DRAWING
3-3

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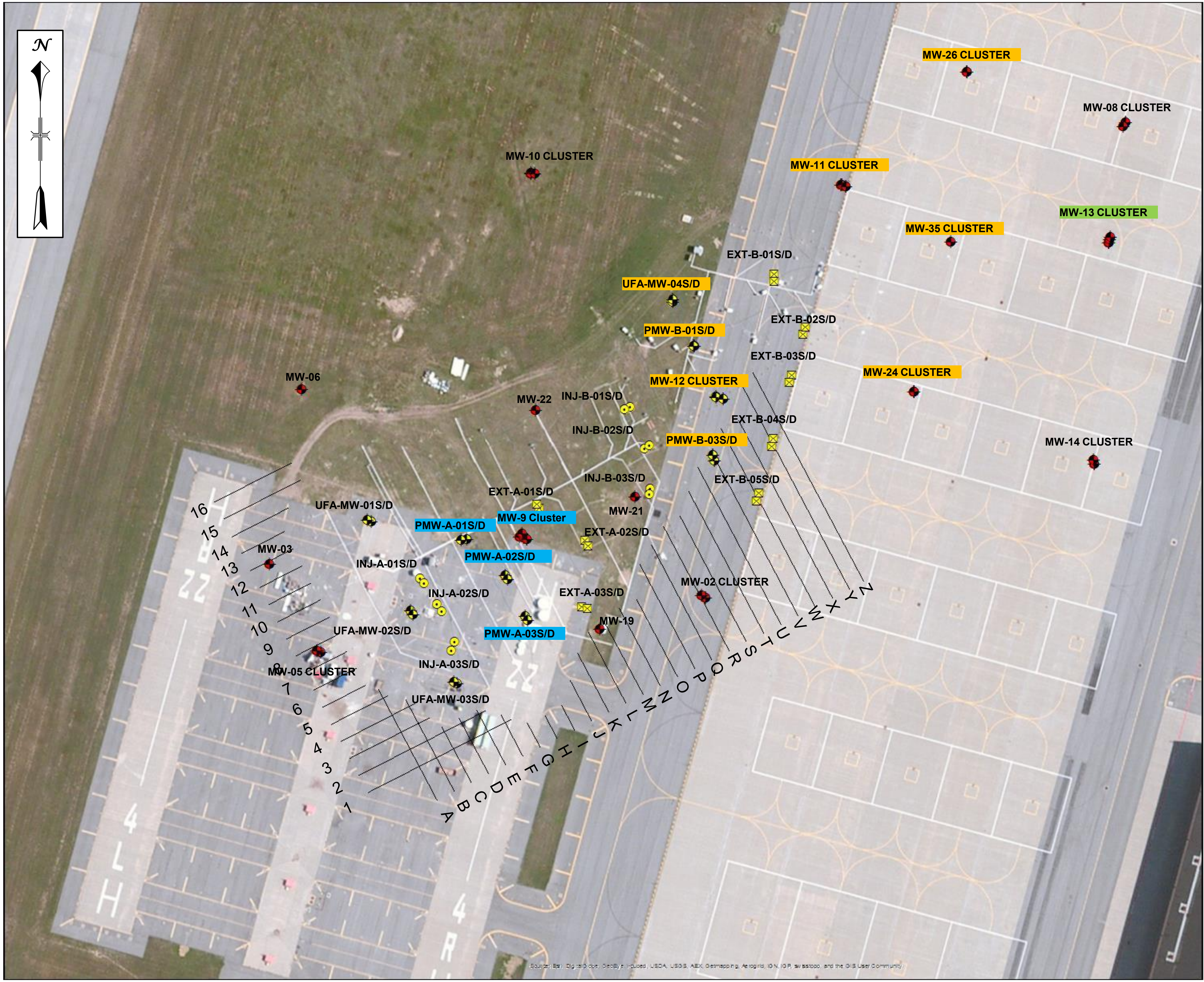


Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

⌖ MW-26D	GROUNDWATER MONITORING WELL/ CLUSTER
⊙	GWRC INJECTION WELL CLUSTER
☒	GWRC EXTRACTION WELL CLUSTER
⊕	GWRC PERFORMANCE MONITORING WELL CLUSTER LOCATION
MW-24 CLUSTER	SOURCE AREA DOWNGRADIENT PERFORMANCE MONITORING LOCATION
MW-9 CLUSTER	SOURCE AREA PERFORMANCE MONITORING LOCATION
MW-13 CLUSTER	GWRC REMEDY PERFORMANCE MONITORING LOCATION

0 50 100 200 300

SCALE IN FEET

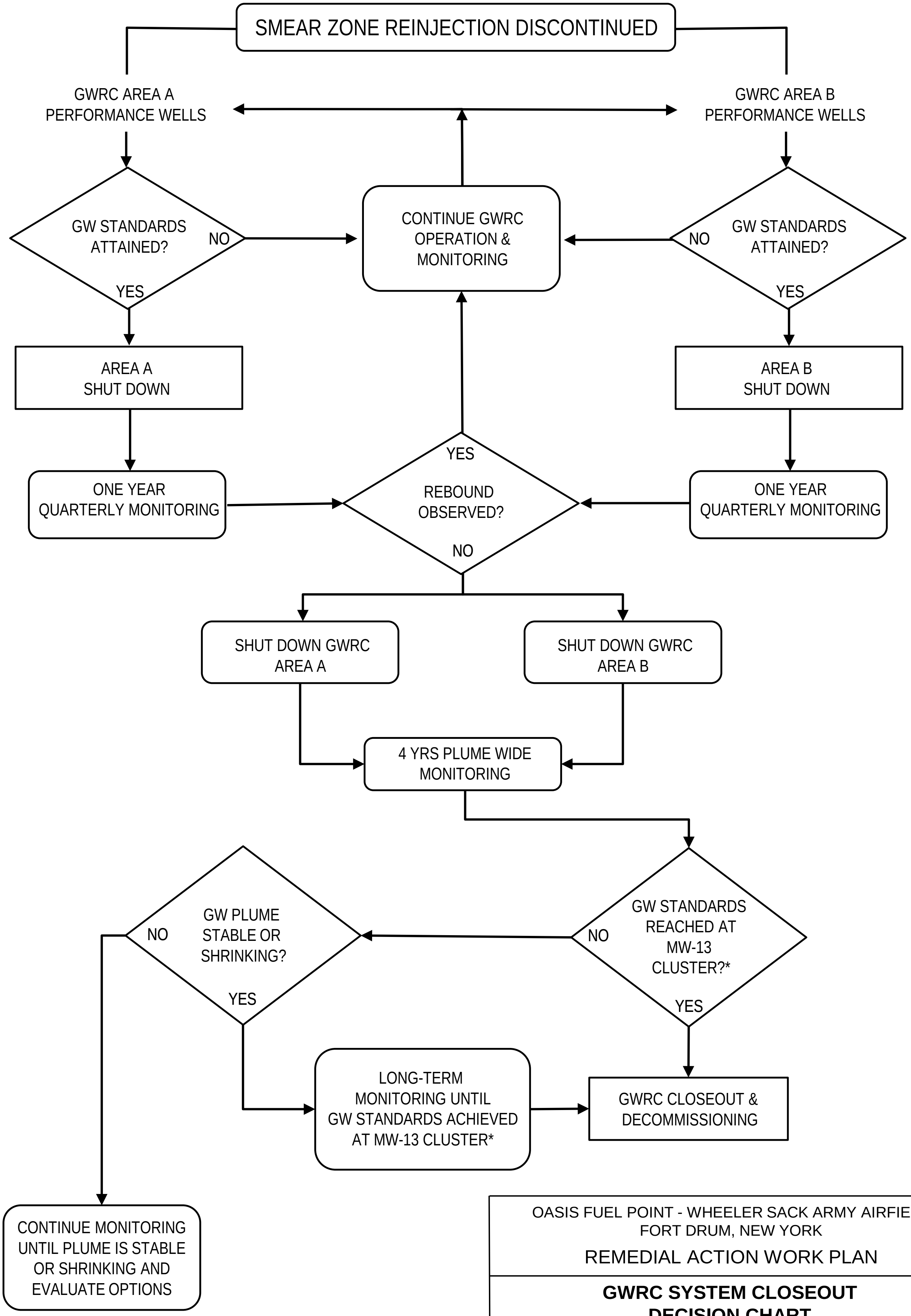
OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

Remedial Action Work Plan

GWRC Performance Monitoring Locations

PIKA ARCADIS

4-1
FIGURE



*TO BE EVALUATED ON A SEMI-ANNUAL BASIS

OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK
REMEDIAL ACTION WORK PLAN

GWRC SYSTEM CLOSEOUT DECISION CHART

PIKA
ARCADIS

Figure
4-2

Appendix A

Remedial Action Monitoring Plan

US Army Corps
of Engineers

Final Remedial Action Monitoring Plan

Oasis Fuel Point Site
Wheeler Sack Army Air Field
Fort Drum, New York

September 2015

Contract No.: W912DR-12-D-0007

Delivery Order No.: 3

Prepared For:

U.S. ARMY CORPS OF ENGINEERS BALTIMORE DISTRICT
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PIKA
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A JOINT VENTURE

Andrew R. Vitolins, PG
Project Manager

Final Remedial Action Monitoring Plan

Oasis Fuel Point Site
Wheeler Sack Army Air Field
Fort Drum, New York

Prepared for:

United States Army Corps of Engineers
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Our Ref.:

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Date:

September 22, 2015

Tables

Figures

Appendices

Acronyms and Abbreviations

AMSL	Above Mean Sea Level
ASL	Airfield Sanitary Landfill
bgs	Below Ground Surface
cm/sec	Centimeters per Second
DO	Dissolved Oxygen
DOD	Department of Defense
DPW	Directorate of Public Works (Fort Drum)
DPE	Dual-phase Extraction
DRO	Diesel-range Organic Compounds
ENV	Environmental Division (Fort Drum)
ELAP	Environmental Laboratory Accreditation Program
ft	Feet
ft3/sec	Cubic Feet per Second
ft3/day	Cubic Feet per Day
GAC	Granular Activated Carbon
GIS	Geographic Information Systems
gpd	Gallons per Day
gpm	Gallons per Minute
GRO	Gasoline-range Organic Compounds
GWRC	Groundwater Recirculation
HDPE	High Density Polyethylene
in	Inches

ISCO	In Situ Chemical Oxidation
IRM	Interim Remedial Measure
LNAPL	Light Non-aqueous Phase Liquid
MP	Measurement Point
NAVD88	North American Vertical Datum (1988)
NTU	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
ORP	Oxidation/Reduction Potential
OWS	Oil/Water Separator
O3	Ozone
PVC	Poly-vinyl Chloride
PWS	Performance Work Statement
ROI	Radius of Influence
SEAR	Surfactant Enhanced Aquifer Remediation
SP	State Plane
SVOCs	Semi-volatile Organic Compounds
TOC	Top of Casing
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VES	Vacuum Enhanced Skimming
VOCs	Volatile Organic Compounds
WSAAF	Wheeler Sack Army Air Field

1. Introduction

This *Remedial Action Monitoring Plan* (RAMP) documents the field sampling and analytical requirements for groundwater quality monitoring for the selected remedial actions at the Oasis Fuel Point Site. This RAMP also specifies the field documentation and quality assurance/ quality control (QA/QC) requirements for the groundwater monitoring program.

This RAMP is provided as Appendix A to the *Remedial Action Work Plan* (RAWP), which documents the methods by which the Oasis Fuel Point (Oasis) Site will be restored to pre-discharge conditions, to the extent feasible.

1.1 Background and Objectives

The Oasis is a refueling area for helicopters located at Fort Drum Wheeler-Sack Army Airfield (WSAAF). In May 2006, during a routine inspection of the Oasis refueling system, JP-8 fuel was discovered in the service sump pit located at the northern end of the system pipeline. The spill resulted in a light non-aqueous phase liquid (LNAPL) plume that covered approximately 3.6 acres at Oasis, as well as an associated dissolved–phase plume of volatile organic compounds (VOCs) that emanates from the source area and extended up to approximately 2,800 feet to the east.

On 28 January 2011, a Consent Decree was filed, listing the State of New York and the New York State Department of Environmental Conservation (NYSDEC) as the plaintiffs and the United States of America as the defendant. The consent decree specifies compliance obligations, including milestones for remediation, at the Oasis Site and states that the overall goal of the remediation efforts is the restoration of the site to pre-release conditions to the extent practicable. As a condition of the Consent Decree, Fort Drum is required to develop a remedial strategy to address remediation of contamination not addressed by the Interim Remedial Measures (IRMs) approved by the NYSDEC. This includes development of remedial strategies to address impacts to groundwater below the LNAPL source area and areas immediately downgradient of the LNAPL plume.

1.2 Report Organization

The remainder of this RAMP is organized as follows:

- **Section 2** provides an overview of the purpose and goals of the RAMP.

- **Section 3** details procedures for field sampling, field documentation, and sampling QA/QC.
- **Section 4** provides the references cited in this RAMP.

2. Remedial Action Monitoring Plan

This section summarizes the purpose of the RAMP, associated measurable metrics and general implementation. Specific field procedures and protocols are provided in Section 3.

2.1 Purpose

This RAMP is being implemented to monitor the performance of the selected remedies presented in Section 4 of the Final Remedial Action Selection Report (RAS) for the OASIS site, dated April 2014, and summarized in the RAWP. The Remedial Action Objectives (RAOs) for groundwater and the smear zone at the Oasis are to:

- Remove LNAPL from the subsurface to the extent practicable;
- Prevent further migration of groundwater containing petroleum constituents from the airfield area, thus eliminating the potential drinking water exposure pathway; and,
- Achieve groundwater quality standards.

The monitoring locations included in this RAMP have been selected to document conditions across the source- and dissolved plume-areas of the site (remedial effectiveness monitoring) and to allow for tracking of contaminant response to the remedial technologies implemented (remedial performance monitoring). The criteria for well selection and monitoring frequency are based on the Long Term Groundwater Monitoring Optimization (USACE 2014) report, as amended by the NYSDEC via email on 20 February 2015. This RAMP will be modified to reflect optimized monitoring conditions and regulatory requirements as the remedial actions progress. Optimization recommendations will be presented in the semi-annual reports.

2.2 Monitoring Data

2.2.1 Water Level Measurements and LNAPL Gauging

Water levels and LNAPL thickness (if present) will be measured prior to each sampling event in those wells listed in Table 1.

During each groundwater monitoring event, water levels in each monitored well will be measured manually using an electronic water level probe. Water level measurement procedures are summarized in Section 3.2.1.

2.2.2 Groundwater Sampling and Analysis

Groundwater analytical data will be evaluated to assess the efficacy of the remedial strategies.

During each sampling event, wells scheduled for sampling (Table 1 and Figure 1) are sampled for the following parameters:

- Field parameters, including dissolved oxygen (DO), pH, oxidation/reduction potential (ORP), salinity, and turbidity
- VOCs using USEPA Method 8260B + MTBE

Analyses of VOCs will be performed by an NYSDOH ELAP-approved analytical laboratory. Field parameters are measured during sampling using a multi-parameter water quality instrument. Field sampling procedures are described in Section 3.

2.3 Measurable Goals and Metrics

2.3.1 LNAPL Source Zone

LNAPL source zone remedial goals and metrics are defined in Table 4-1 of the RAWP. To evaluate attainment of LNAPL removal goals, LNAPL and petroleum mass recovery, and LNAPL plume stability, will be measured against the Remedial Action Criteria defined in Section 4.2.2.1 of the RAWP.

Impacts to groundwater in the LNAPL source area will be mitigated through treatment of residual LNAPL in the smear zone through bioventing and smear zone oxygenated water injection. The metrics for these successful implementation of these remedies are described in Section 4.2.2.2 of the RAWP.

Groundwater treatment and containment in the LNAPL source area will be accomplished through operation of the groundwater recirculation (GWRC) system. The metrics for operation and shutdown of the GWRC system are described in Section 4.2.2.3 of the RAWP.

2.3.2 Downgradient Groundwater Plume

Migration of the downgradient groundwater plume is being mitigated through the operation of the Downgradient Ozone Sparging System. The metrics for operation and shutdown of the Downgradient Ozone Sparging System are described in Section 4.3 of the RAWP.

2.4 Monitored Data Review

Data collected during implementation of this RAMP will be reviewed annually to observe trends in the reduction/presence of LNAPL in the source zone as well as concentrations of petroleum constituents in groundwater in and downgradient of the source area. The resulting data will be compared to the Remedial Action Completion (RAC) conditions defined in Section 5.1 of the RAWP. Upon achievement of the RAC conditions for each remedial action, the corresponding system(s) will be permanently decommissioned.

2.5 Schedule

Remedial action monitoring events will be completed on the following schedule:

- **Quarterly events**: During the third month (March, June, September, December) of each calendar quarter.
- **Semi-Annual events**: In tandem with the March and September quarterly monitoring events.
- **Annual events**: In tandem with the September quarterly/semi-annual monitoring event.

2.6 Reporting

2.6.1 Semi-Annual Reports

Remedial Action Monitoring Reports (RAMRs) will be generated semi-annually for submission to NYSDEC after the receipt of analytical data from the March and December sampling events. Each semi-annual report will include monitoring data captured from the respective semi-annual monitoring event as well as data from any quarterly or annual sampling events completed during that semi-annual period.

2.6.2 Quarterly Technical Memoranda

A technical memorandum that includes a summary of the analytical data will be submitted upon the completion of the June and December quarterly monitoring events.

3. Field Sampling Procedures

This section summarizes the field procedures for environmental media sampling performed as part of RAMP operations at Oasis:

- Field quality control samples
- Field measurements
- Sample equipment decontamination
- Groundwater sampling
- Storage and disposal of investigation derived waste
- Field documentation

To the extent allowable by airfield operational schedules, groundwater sampling will be proceed in order of least contaminated wells to the most contaminated wells based on previous groundwater sampling results. Sampling procedure reference documents are provided in **Appendix A**. Field equipment operation manuals are provided in **Appendix B**. Examples of field forms and other documentation are provided in **Appendix C**.

3.1 Field Quality Control Samples

Quality control procedures will be employed to ensure that sampling, transportation and laboratory activities do not bias sample analytical quality. Trip blanks, field blanks, and duplicate samples will provide a quantitative basis for validating the analytical data.

3.1.1 Trip Blanks

The trip blanks will be prepared by the laboratory by filling 40 ml vials with a Teflon-lined septum with deionized, analyte-free water. The trip blank will accompany the day’s sample containers at all times. One trip blank will be returned to the laboratory with each cooler containing aqueous samples for volatile organic compound (VOC) analysis. The trip blank will be analyzed for VOCs to detect possible contamination during shipment. Trip blanks will remain in the shipping cooler from the time of packing, in the laboratory, to arrival back at the laboratory.

3.1.2 Field Blanks

A field blank sample may be collected for laboratory analysis at a rate of one sample per 20 groundwater samples. A field blank consists of an empty set of laboratory-cleaned sample containers. At the field location, deionized, analyte-free water is passed through decontaminated sampling equipment and placed in the empty set of sample containers for analysis of the same parameters as the samples collected with the sampling equipment.

The analytical results of field blank sample will be evaluated to verify the effectiveness of equipment decontamination procedures.

3.1.3 Field Duplicates

A field duplicate sample will be collected for the analytical laboratory at a rate of one sample per 20 groundwater samples. The duplicate sample is collected at the same location as the parent groundwater sample. The identity of the field duplicate is not revealed to the laboratory.

The analytical results of the environmental sample will be compared to the field duplicate sample to evaluate field sampling precision.

3.2 Field Measurements

Tasks requiring recording of field measurements include field screening of well headspaces, evaluating the progress of monitoring well development (if necessary) and monitoring well sample collection. A summary of field measurements is provided below. Specific procedures for inspection and calibration of the related field equipment are provided in **Appendix B**.

3.2.1 Water Level Measurements

3.2.1.1 Measurement Equipment

The following equipment will be used for the measurement of water levels:

- Electronic water level indicator and/or interface probe
- Field logbook and pen
- Photoionization Detector

- Deionized Water
- Low Phosphate Detergent

3.2.1.2 Measurement Procedure

The monitoring well expansion cap will be removed and the well head space and breathing zone's air quality will be monitored with a PID. If air quality readings in the breathing space around the well exceed action levels set in the site-specific Accident Prevention Plan (APP), appropriate measures will be taken as listed in the APP.

The battery of the electric water level indicator will be checked by pushing the battery check button, and waiting for the audible signal to sound or the instrument light to come on. The water level indicator will be decontaminated before collecting a measurement in each monitoring well by using a low phosphate detergent wash (Alconox™ or equivalent) and deionized water rinse. The instrument will then be turned on and the probe will be slowly lowered into the monitoring well until the audible signal is heard or the instrument light goes on, indicating that the sensor in the probe has made contact with the water surface in the monitoring well.

In the presence of LNAPL, an interface probe, which can indicate and differentiate between the contact surfaces of LNAPL and water, will be used in the place of an electric water level indicator. The probe is checked, decontaminated, and used in the same manner as an electric water level indicator. When the sensor probe makes contact with the LNAPL or water surfaces in a monitoring well, an audible signal will be heard. In order to distinguish between LNAPL and water surfaces, a different audible signal is used for each medium (i.e., constant signal for LNAPL, intermittent signal for water).

The depth to water will be recorded to the nearest one-hundredth of a foot, from the reference point at top of the well casing. The date, time, monitoring well number, depth to water and depth to LNAPL, if present, will be recorded in the field book.

3.2.2 Water Quality Parameters

Water quality parameters, including pH, conductivity, dissolved oxygen, temperature and turbidity are measured during monitoring well development and groundwater and surface water sampling tasks. The parameters are typically measured using a multi-parameter water quality instrument equipped with a flow-through cell (e.g., Horiba U-22 or equivalent). At a minimum, the multi-parameter water quality instrument will measure the following field parameters:

- Dissolved oxygen (DO)
- pH
- Oxidation/Reduction Potential (ORP)
- Conductivity
- Turbidity
- Temperature

3.2.2.1 Instrument Operation

A thermistor is used by the instrument to measure temperature. The thermistor also measures the change in electrical resistance accompanying changes in temperature. The instrument uses the temperature data in conductivity temperature conversions, DO temperature compensation and pH temperature compensation. The unit of measurement for temperature is degrees Celsius (ºC).

The conductivity of water is determined by measuring the resistance of ion flow in between charged plates because conductivity is inversely proportional to resistance. The instrument reports conductivity as milliSiemens per centimeter (mS/cm).

The instrument uses the membrane-electrode method for DO. A reduction reaction in the cathode is caused by oxygen diffusing through the membrane of the sensor to create a current. This current is proportional to the concentration of oxygen dissolved in water. DO is reported as milligrams DO per Liter (mg DO/L).

The instrument uses a glass-electrode method to determine pH. The known pH of a reference solution is determined by using two electrodes, a glass electrode and a reference electrode, and measuring the voltage (difference in potential) generated between the two electrodes. The difference in pH between solutions inside and outside the thin glass membrane creates electromotive force in proportion to this difference in pH. The reporting unit is the standard unit of pH (for example, 7.00 pH units).

The instrument measures turbidity using the light-transmission scattering method. The unit for turbidity is Nephelometric Turbidity Unit (NTU).

3.2.2.2 Water Quality Measurement Procedures

Procedures for measuring water quality parameters are provided in the USEPA Low-flow Groundwater Sampling procedure provided in **Appendix A**, and summarized below. A Horiba U-22 water quality instrument (or equivalent) will be used for water quality parameter measurements. The U-22 is utilized with a water flow-through cell during groundwater sampling, resulting in greater DO measurement accuracy. Field personnel will follow all procedures outlined for calibration and operation of the Horiba U-22 or equivalent instrument when collecting field parameter measurements, as provided in the U-22 operation manual provided in **Appendix B**.

The U-22 will be decontaminated (Section 3.4) and re-calibrated prior to sampling in each well. After calibration has been documented, the flow-through cell will be attached in-line with the sampling pump outlet at the wellhead, to allow flow of discharged water through the cell. Measurements will not be recorded until the cell is completely full.

3.3 Groundwater Sampling

3.3.1 Sampling Equipment

The following equipment may be required for groundwater sampling:

- Electric water level indicator and/or interface probe
- Polyethylene or Teflon®-lined polyethylene tubing
- Silicone tubing
- Temperature, pH, DO, ORP, specific conductivity, and turbidity meters
- Photoionization detector
- Field logbook and field data sheets
- Laboratory prepared sample containers
- Decontamination equipment (see Section 3.4)
- Disposable latex or nitrile gloves
- Pump controller/ air compressor
- Bladder pump
- Replacement bladders
- Air compressor power source (12 volt battery)

Operating and maintenance manuals for the pumps and operating manuals for the controllers are provided in **Appendix B**. Refer to the instructions in **Appendix B** for details on proper operation and maintenance.

3.3.2 Sampling Procedures (Monitoring Wells)

Groundwater sampling will typically be conducted in accordance with the USEPA Low-Flow Sampling Protocol (USEPA 1998). The specific procedure is provided in the low-flow groundwater sampling guidance provided in **Appendix A** (USEPA 1998). General low-flow sampling procedures are summarized below.

Prior to sampling each monitoring well, the well cap will be removed and the head space and breathing zone's air quality will be monitored with a PID (see the Oasis APP).

Field parameters consisting of pH, specific conductance, temperature, DO, ORP, and turbidity will be measured in each sample collected from each monitoring well prior to sampling, using a multi-parameter water quality instrument equipped with a flow-through cell (see Section 3.2.2, above, and **Appendix B**). The instrument will be decontaminated and calibrated as per the manufacturer instructions before use at each well and following completion of sampling activities at the end of each day.

The volume of water removed from each monitoring well will be dependent upon the amount of time required for stabilization of the field parameters. In general, the well will be considered stabilized for sample collection when field parameters have stabilized for three consecutive readings as follows:

■ pH:	+/- 0.1 standard units
■ Specific Conductance:	+/- 3%
■ Oxidation-Reduction Potential:	+/- 10 millivolts
■ Dissolved Oxygen:	+/- 10%
■ Turbidity:	< 50 NTUs (when achievable) < 100 NTUs (maximum allowable)

When the field parameters have stabilized, the volume of water purged will be recorded, and the monitoring point will be sampled in the same manner as was used to purge the well.

After recording field measurements, the field sample will be collected.

The VOC sample vials will be pre-preserved by the laboratory. The sample vials/ bottles will be immediately placed in a cooler held at 4°C. Disposable latex or nitrile gloves will be worn by the sampling personnel and changed between sampling points. Data to be recorded in the field purge log will include purging and sampling methods, depth to water, volume of water removed during purging, pH, temperature, ORP, DO, turbidity, and specific conductivity values, and PID readings.

Groundwater that is purged from monitoring wells will be contained in 5-gallon buckets, and disposed of in the on-site DPE system oil/water separator or the GWRC extraction well equalization tank (see Section 3.5). Following cessation of DPE and GWRC systems operation, purge water will be containerized and shipped offsite to an appropriately permitted facility for disposal.

3.4 Sampling Equipment Decontamination

Cross contamination of samples from any source is to be avoided. As discussed previously, groundwater sampling will be proceed in order of least contaminated wells to the most contaminated wells based on previous groundwater sampling results to the extent allowable by airfield operational schedules. All sampling equipment must be clean and free from the residue of any previous samples. All non-dedicated sampling equipment must be cleaned initially and prior to being re-used. The following procedure for decontamination does not apply to heavy equipment or drilling equipment, with the exception of split spoons or equivalent samplers.

3.4.1 Equipment and Supplies

The following equipment may be needed to decontaminate equipment and tools used to collect water samples:

- Tap water for initial cleaning and rinsing of equipment
- Distilled water for final rinsing of equipment after tap water or solvent rinse
- Non-phosphate detergent (e.g., Alconox™) for cleaning equipment.
- Dishwashing detergent to remove oily or organic residue
- Personnel protective equipment (PPE) - including disposable gloves (Nitrile preferred), first aid kit, and waterproof outerwear (if necessary)
- Re-sealable buckets approved for waste collection

- Squirt bottles
- Brushes for cleaning equipment
- Field notebooks, pens, pencils, and digital camera to document decontamination procedures

3.4.2 Decontamination Guidelines

- Non-dedicated water sampling and processing equipment should be decontaminated between locations.
- All decontamination water must be captured and disposed of in appropriate, labeled, aqueous waste containers. All instruments that come into contact with the sample water must be cleaned in the same manner as the sampling device.
- Liquids collected into the aqueous waste container must be discarded in an appropriate waste stream.
- Staff performing decontamination procedures are required to wear appropriate PPE, gloves (e.g., Nitrile) and eye protection.
- Care should be taken during cleaning to prevent cleaning solution contact with clothing. If circumstances dictate that contact will occur (e.g., high wind), waterproof outer clothing (e.g., foul weather gear or rain gear) and face shields must be worn.

3.4.3 Decontamination Procedure

The following procedures will be followed for decontamination:

a) Disassemble item(s) (if necessary).
b) Rinse each item with tap water.
c) Thoroughly scrub the item with a brush and soapy water, using non-phosphate detergent such as Alconox™ for non-oily residue, or a detergent for items with oily or other sticky organic residue.
d) During the scrubbing process, be sure to bleed Alconox™ solution or equivalent through small passageways/nozzles/vents, etc.
e) Rinse the item with tap water to remove all residual soap. Be sure to bleed tap water through small passageways/nozzles/vents, etc.
f) Rinse the item with de-ionized or analyte-free water and allow to air dry. Be sure to bleed de-ionized or analyte-free water through small passageways, nozzles, vents, etc.
g) Re-assemble item(s) (if necessary).

h) Wrap the item(s) in aluminum foil or plastic bag to protect it until it is used.

Equipment used for sampling water from monitoring wells such as pneumatic bladder pumps will be decontaminated by thoroughly washing all internal and external surfaces with soapy water and rinsing with deionized water prior to use. All tubing must be dedicated to individual monitoring wells (i.e., tubing cannot be reused). Field instrumentation will be cleaned per manufacturer's instructions (Appendix A). Probes, such as those used in pH and conductivity meters, and thermometers will be rinsed prior to and after each use with deionized water.

3.5 Storage and Disposal of Investigation Derived Waste

Investigation derived waste generated during remedial action monitoring events will be limited to purge water extracted from the monitoring wells, decontamination water and spent PPE. Purge/decontamination water will be managed as follows:

- During sampling, purged monitoring well water will be containerized in 5-gallon pails prior to disposal.
- During decontamination procedures, decontamination water will be containerized in 5-gallon pails prior to disposal.
- After sampling is complete, the purge/decontamination water will be disposed of in an on-site DPE system oil/water separator or an onsite GWRC extraction well equalization tank at Oasis. Following cessation of DPE and GWRC systems operation, purge/decontamination water will properly containerized for shipping and will be shipped offsite for disposal at an appropriately-licensed facility.
- Spent PPE will be disposed of as municipal waste.

3.6 Field Documentation

Documentation of an investigative team's field activities often provides the basis for technical site evaluations and other such related written reports. All records and notes generated in the field will be considered controlled evidentiary documents and may be subject to scrutiny in litigation.

Personnel designated as being responsible for documenting field activities must be aware that all notes may provide the basis for preparing responses for legal interrogatories. Field documentation must provide sufficient information and data to enable reconstruction of field activities. Numerically serialized field logbooks provide the basic means for documenting field activities. The following information must be provided on the inside front cover of each field logbook:

- Project Name – Oasis Remedial Action Monitoring
- Site Location – Oasis Fuel Point, Wheeler Sack Army Air Field, Fort Drum, NY
- Field Team/ Task Leader
- Date of Issue

Control and maintenance of field logbooks is the responsibility of the Field Team Leader.

3.6.1 Sample Designation

A sample numbering system will be used to identify each sample. This system will provide a tracking procedure to allow retrieval of information about a particular sample, and will assure that each sample is uniquely numbered. The sample identification will consist of at least two components as described below.

Project Identification: The first component consists of a two- or three-letter designation, which identifies the project site.

Sample Location: The second component identifies the sample location using the appropriate alphanumeric well name.

Quality Assurance/Quality Control Samples: The samples will be labeled with the following suffixes:

- TB – Trip Blank
- FB – Field Blank
- DUP – Duplicate

Duplicate samples will be numbered uniquely as if they were samples. A record of identification for duplicate samples will be maintained.

3.6.2 Documentation of Field Activities

Field logbook entries must be legibly written and provide an unbiased, concise, detailed picture of all field activities. Use of preformatted data reporting forms must be identifiable and referenced to field notebook entries.

Step-by-step instructions and procedures for documenting field activities are provided below and in following sub-sections. Instruction and procedures relating to the format and technique in which field logbook entries are made are as follows:

- Leave the first two pages blank. They will provide space for a table of contents to be added when the field logbook is complete.
- The first written page for each day identifies the date, time, site name, location, PIKA-ARCADIS personnel and their responsibilities, other non-personnel and observed weather conditions. Additionally, during the course of site activities, deviations from the RAMP must be documented.
- All photos taken must be traceable to field logbook entries. It is recommended to reference photo locations on the site sketch or map.
- All entries must be made in ink. Waterproof ink is recommended.
- All entries must be accompanied by the appropriate 24-hour time (such as 1530 instead of 3:30).
- Errors must be lined through and initialed. No erroneous notes are to be made illegible.
- The person documenting must sign and date each page as it is completed.
- Isolated logbook entries made by a team member other than the team member designated responsible for field documentation, must be signed and dated by the person making the entry.
- Additions, clarifications, or corrections made after completion of field activities must be dated and signed.

3.6.3 General Site Information

General site characteristics must be recorded. Information may include:

- Type of access into facility (locked gates, etc.).
- Anything that is unexpected on Site (e.g., appearance of drums that have not been previously recorded).

- Information obtained from interview with access or responsible party personnel (if applicable), or other interested party contact on-site.
- Names of any community contacts on-site.
- A site map or sketch may be provided. It can be sketched into the logbook or attached to the book.

2.7.4. Sample Activities

A chronological record of each sampling activity must be kept that includes:

- Explanation of sampling at the location identified in the RAMP
- Observed changes in conditions at sampling locations (e.g., discolored soil, stressed vegetation).
- Exact sample location, using permanent recognizable landmarks and reproducible measurements.
- Sample matrix.
- Sample descriptions, i.e., color, odor and any other important distinguishing features.
- Decontamination procedures.

As part of chain-of-custody procedures, recorded on-site sampling information must include sample number, date, time, sampling personnel, sample type, designation of sample as a grab or composite and any preservative used. Sample locations should be referenced by sample number on the site sketch or map. The offer and/or act of providing sample splits to a thirty party (e.g., the responsible party representative; state, county, or municipal, environmental and/or health agency, etc.) must be documented.

3.7 Sample Handling

The analytical laboratory will provide the sample containers necessary for all groundwater and quality assurance/quality control samples. Container closures for all samples will be screw-on type and made of inert materials. Sample containers will be cleaned and prepared by the laboratory prior to transportation to the site. Trip blanks will be used to check for false positives due to laboratory cleaning procedures or cross contamination during sample shipment.

All samples collected will be identified with a sample label. A label will be attached to each bottle and each sample will be identified with a unique sample number.

Immediately following sample collection, each sample container will be marked with the following information:

1) Sample Identification
2) Project Number
3) Date/Time
4) Sample Type
5) Requested Analysis
6) Preservative, if used
7) Sampler's Initials

After all sample identification information has been recorded, each sample label will be covered with waterproof clear plastic tape to preserve its integrity. All samples will be recorded and tracked under strict chain-of-custody protocols. In the field, each sample will be checked for proper labeling. The samples will then be packed into coolers with ice and shipped to the laboratory, if applicable.

A chain-of-custody form will be completed for each cooler. The form will be signed and dated by the person who collected the samples, the person the samples were relinquished to for transport to the laboratory, and the laboratory sample controller/custodian who receives the samples.

3.7.1 Chain-of-Custody Record

A chain-of-custody record is a printed form that accompanies a sample or group of samples as custody is transferred from person to person. A sample chain-of-custody form is included in **Appendix C**. It documents custody transfer from person to person and sample information recorded on bottle labels. A chain-of-custody record is a controlled document.

As soon as practicable after sample collection, preferably after decontamination, the following information must be entered on the chain-of-custody form. All information is to be recorded in ink:

1) Project name. Enter site name.
2) Project location. Enter the city and state of site.

3) Samplers. Sign the name(s) of the sampler(s).
4) Sample Identification. Enter the sample identification for each sample in the shipment. This appears on the sample identification label.
5) Date. Enter an eight-digit number, indicating the day, month, and year of sample collection (DD/MM/YYYY); for example, 06/01/2014.
6) Time. Enter a four-digit number indicating the 24-hour format time of collection; for example, 1354.
7) Composite or grab. Indicate the type of sample.
8) Number of containers. For each sample number, enter the number of sample bottles that are contained in the shipment.
9) Remarks. Enter any appropriate remarks.

3.7.2 Transferring to Laboratory Courier

Instructions for PIKA-ARCADIS, transferring custody of samples to a laboratory courier are as follows:

1) Sign, date, and enter time under "Relinquished by" entry.
2) Enter name of courier under "Received by."
3) Enter bill-of-lading number under "Remarks", if applicable.
4) Place the original of the chain-of-custody form in the appropriate sample shipping package. Retain a copy with field records.
5) Sign and date the custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field.
6) Wrap the seal across filament tape that has been wrapped around the package at least twice.
7) Fold the custody seal over on itself so that it sticks together.
8) Complete other courier-required shipping papers.

In some cases, couriers will not accept responsibility for handling chain-of-custody forms; this necessitates packing the record in the sample package.

4. Site Restoration

Monitoring wells will be abandoned in accordance with NYSDEC Commissioner's Policy (CP) 43: Groundwater Monitoring Well Decommissioning Policy (November 3, 2009) (CP-43) upon confirmation from the NYSDEC that monitoring is no longer required.

5. References

PIKA-ARCADIS, 2015.”Remedial Action Work Plan”. ARCADIS U.S., Inc. (PIKA/ARCADIS JV), Clifton Park, NY. March 2015.

USACE, 2014. “Long-Term Groundwater Monitoring Optimization”. United States Army Corps of Engineers, Environmental and Munitions Center of Expertise, September 2014.

USEPA, 2008. “Guide for Assessing Biodegradation and Source Identification of Organic Ground Water Contaminants using Compound Specific Isotope Analysis (CSIA)”; EPA 600/R-08/148. United States Environmental Protection Agency Office of Research and Development, National Risk Management Research Laboratory, December 2008.

Tables

Table 1 - Remedial Action Monitoring Locations
OASIS Fuel Point Site
Wheeler-Sack Army Airfield, Fort Drum, New York

Well Name	Sampling Frequency
GMP-03D	Quarterly
GMP-04D	Quarterly
MW-09D1	Quarterly
MW-09I1	Quarterly
MW-09I2	Quarterly
MW-13D1	Quarterly
MW-16D1	Quarterly
MW-16D2	Quarterly
MW-16D3	Quarterly
MW-16I	Quarterly
MW-21	Quarterly
MW-22	Quarterly
MW-27I1	Quarterly
MW-27I2	Quarterly
MW-28D1	Quarterly
MW-28D2	Quarterly
MW-28I1	Quarterly
MW-28I2	Quarterly
MW-33I1	Quarterly
MW-33I2	Quarterly
SGMP-01	Quarterly
SGMP-01A	Quarterly
SGMP-02	Quarterly
SPMP-04	Quarterly
PMW-A-01S	Quarterly*
PMW-A-01D	Quarterly*
PMW-A-02S	Quarterly*
PMW-A-02D	Quarterly*
PMW-A-03S	Quarterly*
PMW-A-03D	Quarterly*
PMW-B-01S	Quarterly*
PMW-B-01D	Quarterly*
MW-12I1	Quarterly*
MW-12I2	Quarterly*
MW-12D1	Quarterly*
MW-12D2	Quarterly*
PMW-B-02S	Quarterly*
PMW-B-02D	Quarterly*
PMW-C-01S	Quarterly*
PMW-C-01D	Quarterly*
MP-05D	Semi-Annual
MP-06D	Semi-Annual
MP-07D	Semi-Annual
MP-08D	Semi-Annual
GMP-01D	Semi-Annual
MW-08D	Semi-Annual
MW-08I	Semi-Annual
MW-11D	Semi-Annual
MW-11I	Semi-Annual
MW-13S	Semi-Annual
MW-13D2	Semi-Annual
MW-13I1	Semi-Annual
MW-13I2	Semi-Annual
MW-15D	Semi-Annual
MW-15I	Semi-Annual
MW-17D	Semi-Annual
MW-17I	Semi-Annual
MW-24D	Semi-Annual
MW-24I1	Semi-Annual
MW-24I2	Semi-Annual
MW-25D	Semi-Annual
MW-25I1	Semi-Annual
MW-25I2	Semi-Annual
MW-27D	Semi-Annual
MW-29D	Semi-Annual
MW-29I1	Semi-Annual
MW-29I2	Semi-Annual
MW-30I1	Semi-Annual
MW-31D	Semi-Annual
MW-31I2	Semi-Annual
MW-34D	Semi-Annual
MW-34I1	Semi-Annual
MW-34I2	Semi-Annual
MW-35D	Semi-Annual
MW-35I1	Semi-Annual
MW-35I2	Semi-Annual
MW-35S	Semi-Annual
UFA-MW-01S	Semi-Annual
UFA-MW-01D	Semi-Annual
UFA-MW-02S	Semi-Annual
UFA-MW-02D	Semi-Annual
UFA-MW-03S	Semi-Annual
UFA-MW-03D	Semi-Annual
UFA-MW-04S	Semi-Annual
UFA-MW-04D	Semi-Annual
MW-02D	Semi-Annual
MW-02I	Semi-Annual
MW-09D2	Semi-Annual
MW-09D3	Semi-Annual
MW-19	Semi-Annual
MW-33D	Semi-Annual
CWS (CWC)	Annual
MW-03	Annual
MW-10D	Annual
MW-10I	Annual
MW-10S	Annual
MW-13D3	Annual
MW-13D4	Annual
MW-14D	Annual
MW-14I	Annual
MW-16D4**	Annual
MW-16D5 Bedrock**	Annual
MW-18 Bedrock	Annual
MW-18D	Annual
MW-18I	Annual
MW-26D	Annual
MW-26I1	Annual
MW-26I2	Annual
MW-30D	Annual
MW-32D	Annual
MW-32I1	Annual
MW-32I2	Annual
MW-36D	Annual
MW-36I	Annual
MW-37	Annual
PZ-06	Annual

Notes:

* GWRC system performance monitoring wells. Sampling frequency to remain quarterly for at least two years.

** Monitoring schedule will revert to semi-annual if contaminants are detected at concentrations greater than water quality standards.A1

The following shallow wells proposed for exclusion based on lack of data should be retained for water level monitoring and potential water quality sampling under higher water table conditions due to position with respect to the source area and/or dissolved phase plume: MW-11S, MW-14S, MW-15S, MW-24S and MW-25S.

Figures

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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LEGEND

- 🟩 Annual Monitoring
- 🟦 Quarterly Monitoring
- 🟦 Quarterly Monitoring* (GWRC system performance monitoring wells. Sampling frequency to remain quarterly for at least two years).
- 🟥 Semi-Annual Monitoring

- GWRC Performance Monitoring Well
- Monitoring Well
- Monitoring Point
- Piezometer
- Observation

- SEAR Pilot Groundwater Monitoring Point
- SEAR Groundwater Monitoring Point
- SEAR Process Monitoring Point
- SEAR Water Supply Well

- Ozone Sparge Wall
- Wellfield Grid
- LNAPL Extent (Approximate)

Approximate VOC Extent (Dec-2014)

- >10 µg/L
- >100 µg/L
- >1,000 µg/L

DRAFT

OASIS FUEL POINT
WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

REMEDIAL ACTION MONITORING PLAN

PIKA
ARCADIS
A JOINT VENTURE

FIGURE
1

Appendix A

Low-flow Groundwater Sampling Procedure (USEPA)

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

Quality Assurance Unit
U.S. Environmental Protection Agency – Region 1
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Prepared by: Charles Porfert 1/19/10
(Charles Porfert, Quality Assurance Unit) Date

Approved by: Gerard Sotolongo 1-19-10
(Gerard Sotolongo, Quality Assurance Unit) Date

Revision Page

Date	Rev #	Summary of changes	Sections
7/30/96	2	Finalized	
01/19/10	3	Updated	All sections

TABLE OF CONTENTS

USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Poteniometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. <u>All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.</u>

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convention cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic “tape”, pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level “tape” at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

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APPENDIX A
PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

Turbidity (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

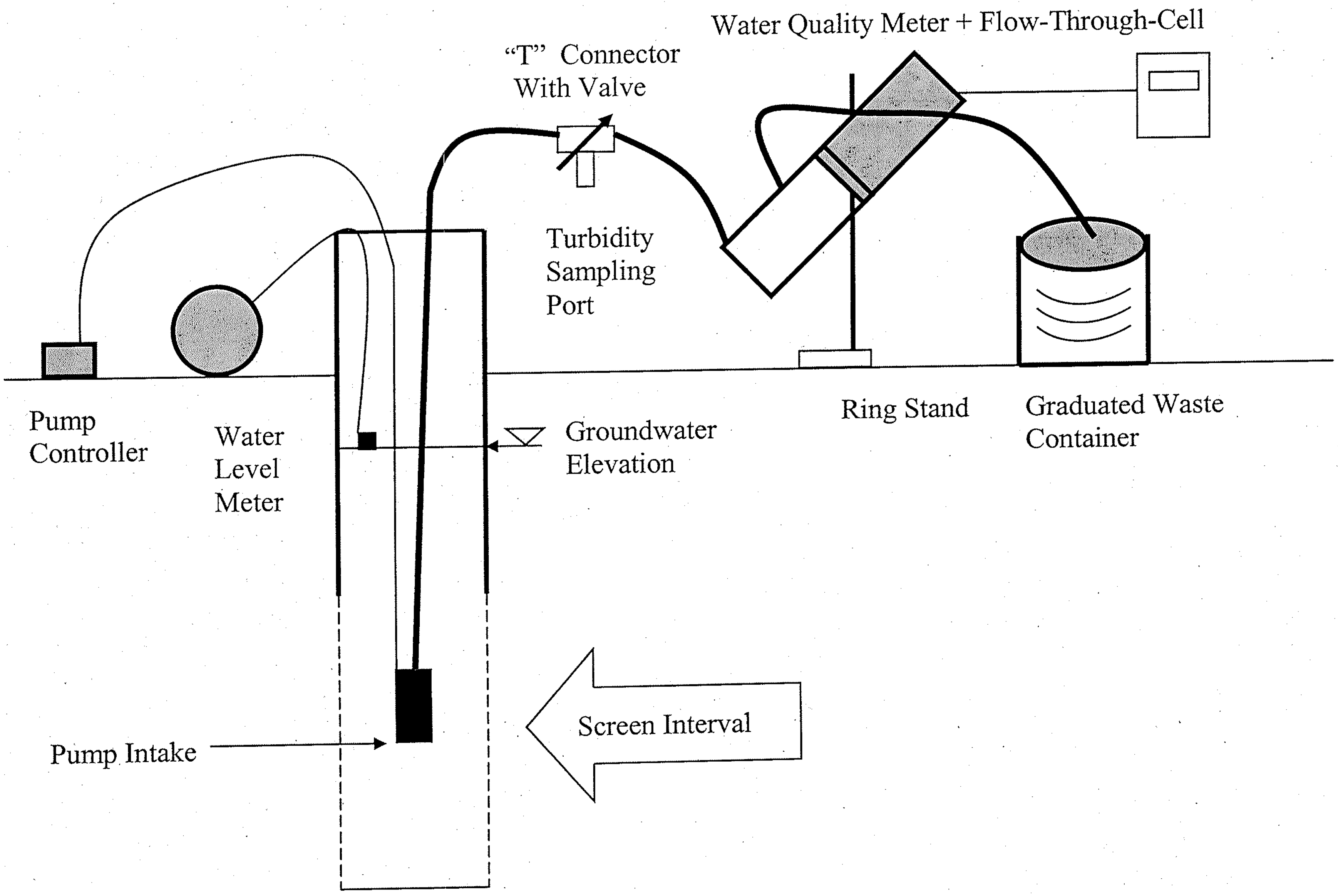
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C
EXAMPLE (Minimum Requirements)
WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)____________________
Well Number________________Date______________
Field Personnel____________________
Sampling Organization____________________
Identify MP____________________

Depth to _______/________ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)__________
Purging Device; (pump type)__________
Total Volume Purged __________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

Appendix B

Field Equipment Operating Manuals

MICRO PURGE®
basics
▼QED

MODEL MP10
CONTROLLER

PATENT PENDING

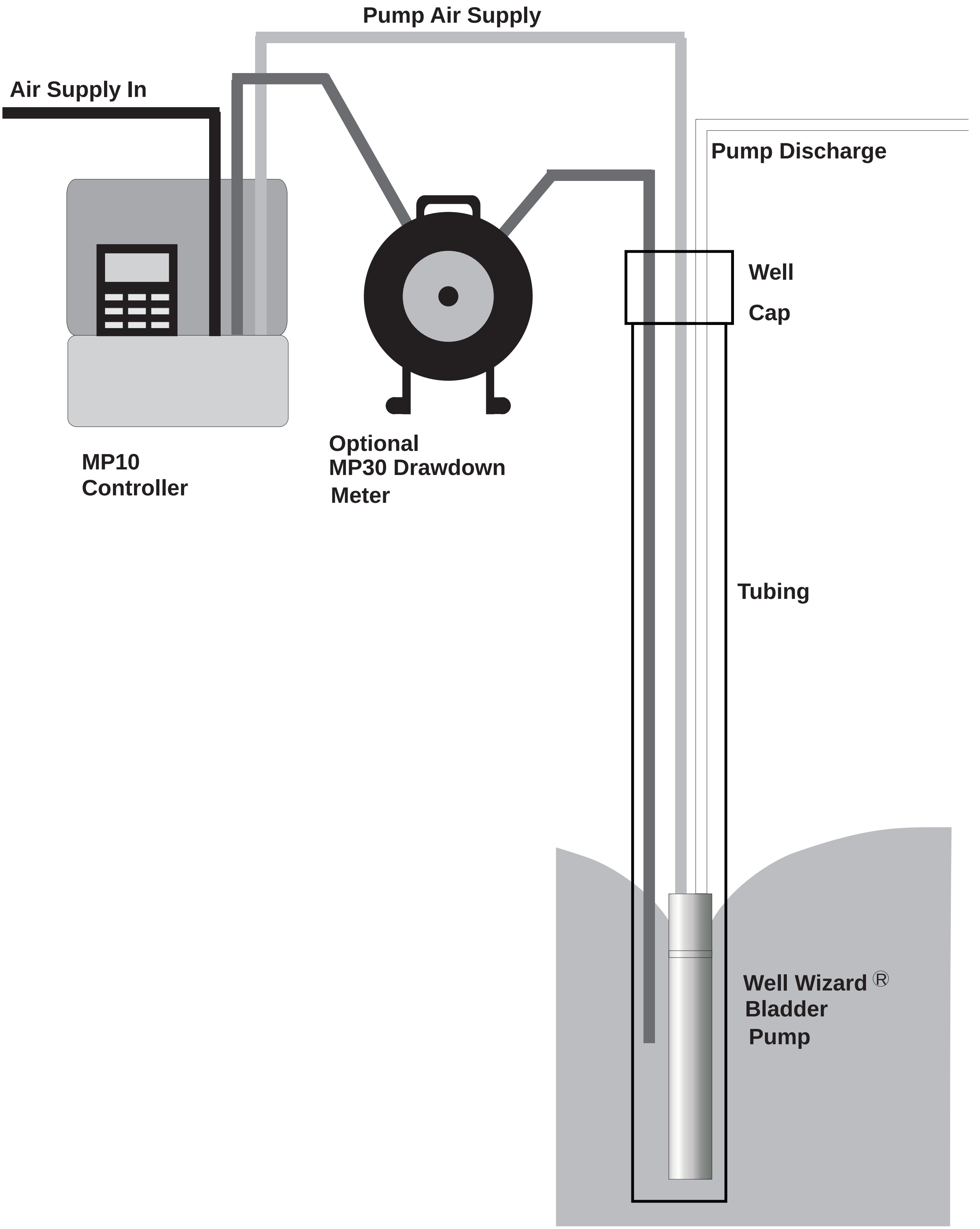
Instruction Manual

Part No. 95177 9-23-07

▼QED
Environmental Systems

P.O. Box 3726 Ann Arbor, MI 48106-3726 USA
1-800-624-2026 Fax (734) 995-1170
info@qedenv.com www.qedenv.com

MP10 Basic Setup



Topic

Page

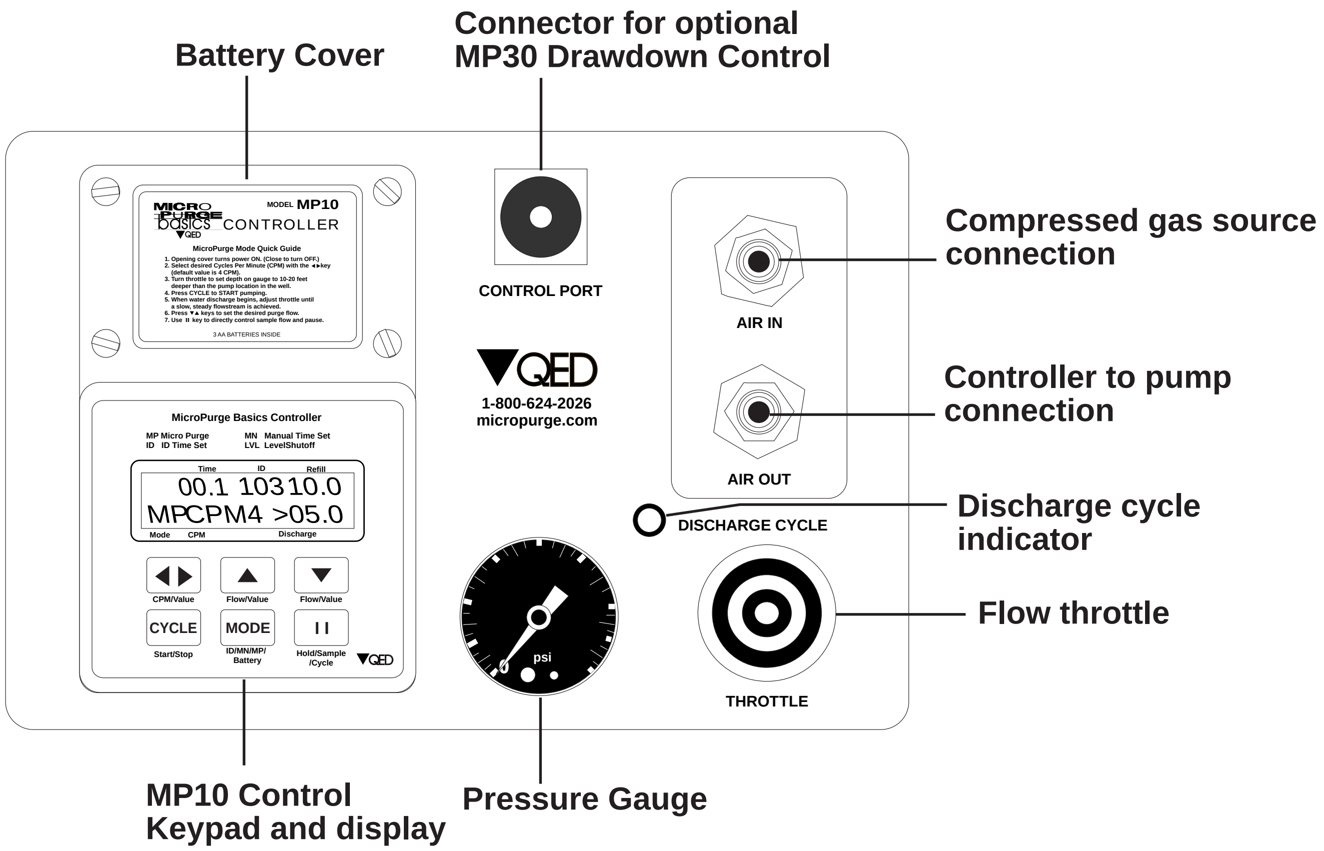
Safety warnings

Compressed air - Use caution when working with compressed air or gas. Compressed gas cylinders are under extreme pressure and can cause unrestrained hoses to whip about dangerously. Do not over pressurize your controller. Failure to operate the controller within the pressure limits could result in failure. Read all operating instructions before operating the MP10 controller.

Warning - Do not disassemble the pneumatic pump while it is connected to a compressed gas source. Dangerous pressures could cause injury.

Diagrams and Conventions used in the Text

MP10 Panel Layout:

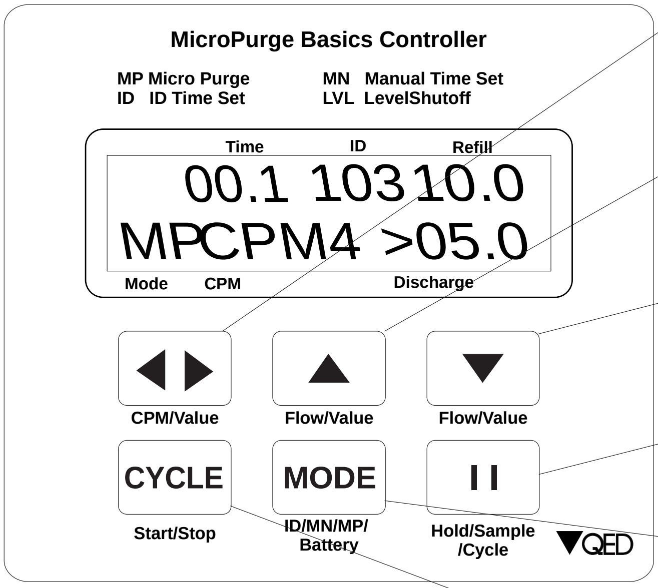


MicroPurge Mode Quick Guide

1. Opening cover turns power ON. (Close to turn OFF.)
2. Select desired Cycles Per Minute (CPM) with the ◄► key (default value is 4 CPM).
3. Turn throttle to set depth on gauge to 10-20 feet deeper than the pump location in the well.
4. Press CYCLE to START pumping.
5. When water discharge begins, adjust throttle until a slow, steady flowstream is achieved.
6. Press ▼▲ keys to set the desired purge flow.
7. Use II key to directly control sample flow and pause.

Diagrams and Conventions used in the Text (cont.)

MP10 Control Keys:

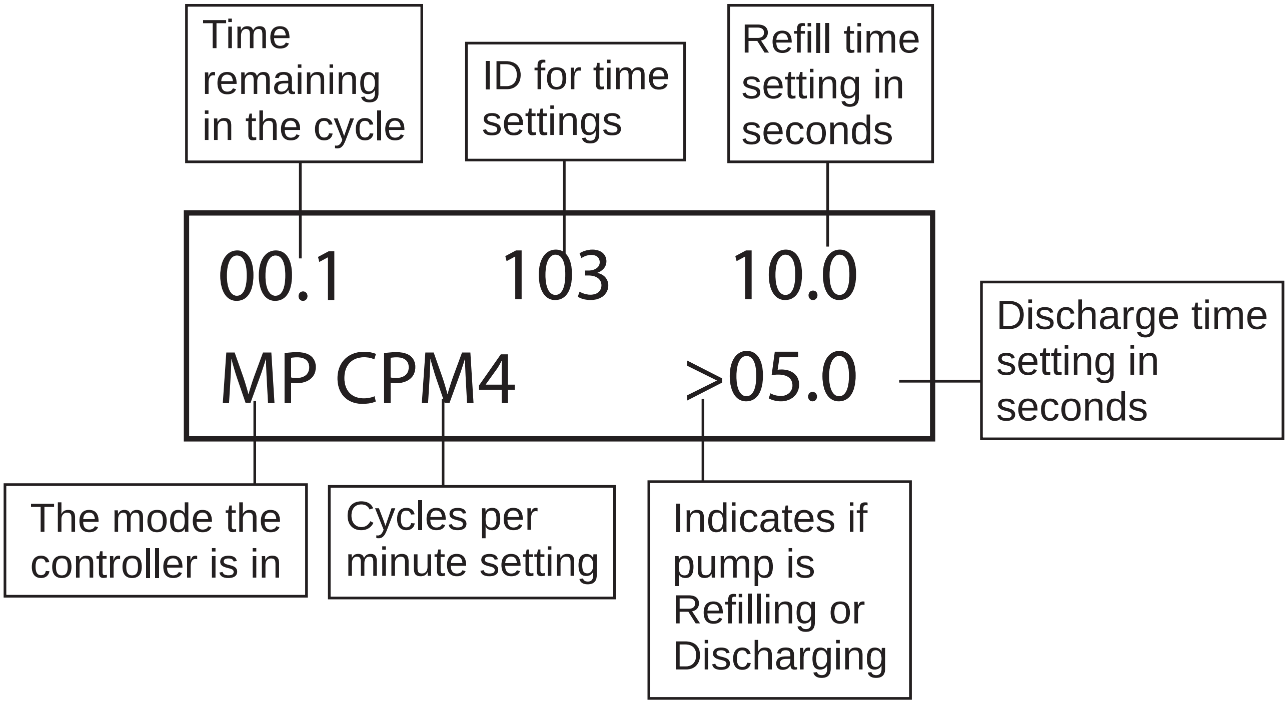


In MP Mode	In Other Modes
Cycle Per Minute key - Changes cycle per minute	Scrolls cursor
Faster key - Speeds up flow	Changes a value at the cursor location
Slower key - Slows down flow	Changes a value at the cursor location
Pause key - Pauses flow for sampling	
Mode key -Selects the operation mode. Also battery check	
Cycle key -Selects Start and Stop of pump cycling	

◀ ▶	CPM Button (also scroll for item selects)	CYCLE	CYCLE Button
▲	UP Button, faster pumping (also increase item)	MODE	MODE Button (also battery check)
▼	DOWN Button, slower pumping (also decrease item)	I I	PAUSE Button (also manual sample)

Diagrams and Conventions used in the Text (cont.)

MP10 Display:



Abbreviations:

CPM	Cycles Per Minute
MP	MicroPurge Mode
ID	ID Time Set Mode
HELD	Held In A Cycle
MN	Manual Time Set Mode
BAT	Battery
LVL	Level Pause
>	Indicates Refill Or Discharge Cycle

Introduction / Quick start

Introduction: The MP10 Micro Purge Basics Controller is used to operate QED Well Wizard bladder sampling pumps to purge and sample ground water. The MP10 has specific design features to make MicroPurge ™ sampling easier. These features include:

- **MicroPurge Mode Operation** Simple Increase / Decrease keys allow you to easily set the flow rate you need for each well.
- **ID Time Set Mode Operation** Quickly recalls pre-determined settings for each well by specifying a 3-digit ID.
- **Level Delay Interface** The controller plugs into the optional MP30 MicroPurge Drawdown / Water Level Meter to provide direct feedback of well drawdown and to pause pump operation until the level recovers.

The optional MP30 MicroPurge Drawdown / Water Level Meter plugs into the MP10 to provide water level feedback. The MP30 uses a standard conductivity probe to detect the ground water surface and a marked tape allowing the user to measure the depth. When the meter is set in MicroPurge mode, the probe is lowered a specific distance below the static water level and fixed in this position. During well sampling if the water level drops below the user-set probe position, the MP10 is paused which prevents further drawdown by the pump. Once the level recovers the MP10 begins pump operation again, starting in the pump refill cycle. Use of the MP10 with the MP30 is detailed later in this manual.

Insert Batteries: Remove the battery cover on the top of the MP10. Insert 3, AA alkaline batteries into the battery holder and carefully replace the holder in the carrier. Replace the battery cover and tighten the 4 screws. Batteries should last for about 6-8 weeks of typical full-timefield use. If the MP10 will be stored longer than about 3 months, the alkaline batteries should be removed to prevent leakage.

Quick Start: Connect the light blue coiled pump hose to the fitting labeled AIR OUT on the MP10. Connect the red (or black, depending on your air source) air supply hose to a compressed air or gas source and connect it to the fitting labeled AIR IN on the MP10. Supply up to 125 psi compressed air or gas to the controller. Turn the controller throttle until the gauge reads the approximate depth of the sample pump (See Page 6) Follow instructions on the battery panel:

Opening the MP10 case turns power ON.
Note: It may take up to 20 seconds for the unit to power up.

Select desired Cycles Per Minute (CPM) with ◀▶ (default value is 4 CPM, lower CPM for deeper wells, higher CPM possible with shallow wells-See Page 6).

Turn throttle to set depth on gauge to 10-20 feet deeper than the pump location in the well.

Press Cycle to START pumping.

When water discharge begins, adjust throttle until a slow, steady flowstream is achieved.

Press ▼ ▲ keys to set the desired purge flow rate.

To collect samples, continue purge flow, or use II key to directly control sample flow and pause.

Bladder Pump Operation in Low-Submergence Applications

Pump submergence is defined as the height of the static water column above the top of the pump. In wells in which this water column height is 5 feet or less, the pump is considered to be in a low-submergence application.

QED sampling bladder pumps fill by hydrostatic pressure. As the inside of the pump's bladder fills with water, the bladder expands. This filling and expanding of the bladder is referred to as the "refill" half of the pump cycle. When air pressure is applied to the outside of the bladder, the bladder is squeezed, forcing the water up the discharge tubing. This is referred to as the "discharge" half of the pump cycle. In low-submergence applications, there is less water pressure available to expand the bladder during the refill.

This can result in a smaller volume of water being pumped with each pump cycle because the bladder may not fully expand.

As a result of the lower volume per cycle, more time will be required to bring the water to the surface. An easy way to verify that the pump is working, prior to the water reaching the surface, is to submerge the pump's discharge tubing in a beaker of water. Each time the pump goes into discharge, air in the discharge tubing, which is displaced as the water level in the tubing rises, can be seen as air bubbles coming from the end of the tubing. To optimize the pumping rate, the refill time should be set long enough to achieve the maximum volume of air bubbles on each pump cycle, and the discharge time should be set long enough to ensure that the air has stopped bubbling out of the tube before the pump controller switches back into refill.

In low submergence wells, ***it is critical that the air pressure driving the pump not be more than 10-15psi higher than the minimum requirement of 0.42psi per foot of pump depth.*** Higher pressures than this can cause the bladder to be squeezed too tightly during discharge, a condition which can prevent the bladder from expanding during refill. To avoid this condition in deeper wells, it is suggested that the air pressure applied to the pump be gradually increased as the water level in the pump's discharge tubing rises. It is recommended that the air pressure be set at 15 psi initially, and slowly increased in increments of 10 psi as needed until the water reaches the surface. Submerging the end of the discharge tubing under water as described above will verify whether the air pressure is set high enough.

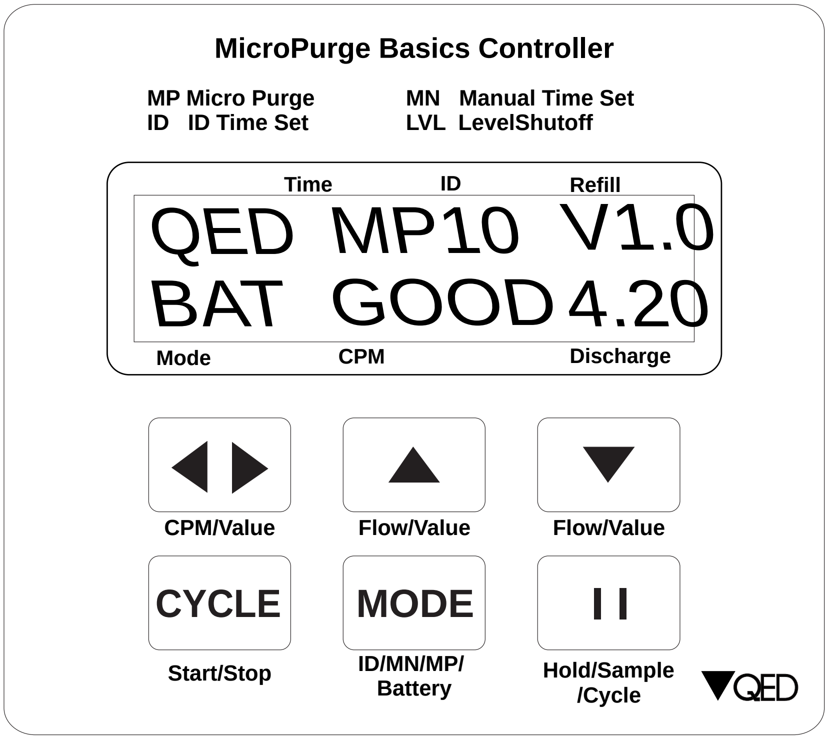
Operation

Turning the MP10 Display On - The MP10 is powered on auto-matically by opening the lid. The MP10 displays an opening screen for 5 seconds, after which it displays the default MicroPurge screen. At this point the MP10 is in MicroPurge mode (MP) but not cycling the pump. This initial state allows the user to adjust time and throttle settings before the pump starts to operate. Pressing the Cycle key begins pump cycling. Times and modes may be adjusted while the pump is cycling or before. Pressing the Cycle key a second time will stop pump cycling.

Note: *all user-entered time settings are lost when the MP10 is turned off. Also, the MP10 automatically powers down when the lid is closed, so make sure the MP10 is stored with its lid closed.*

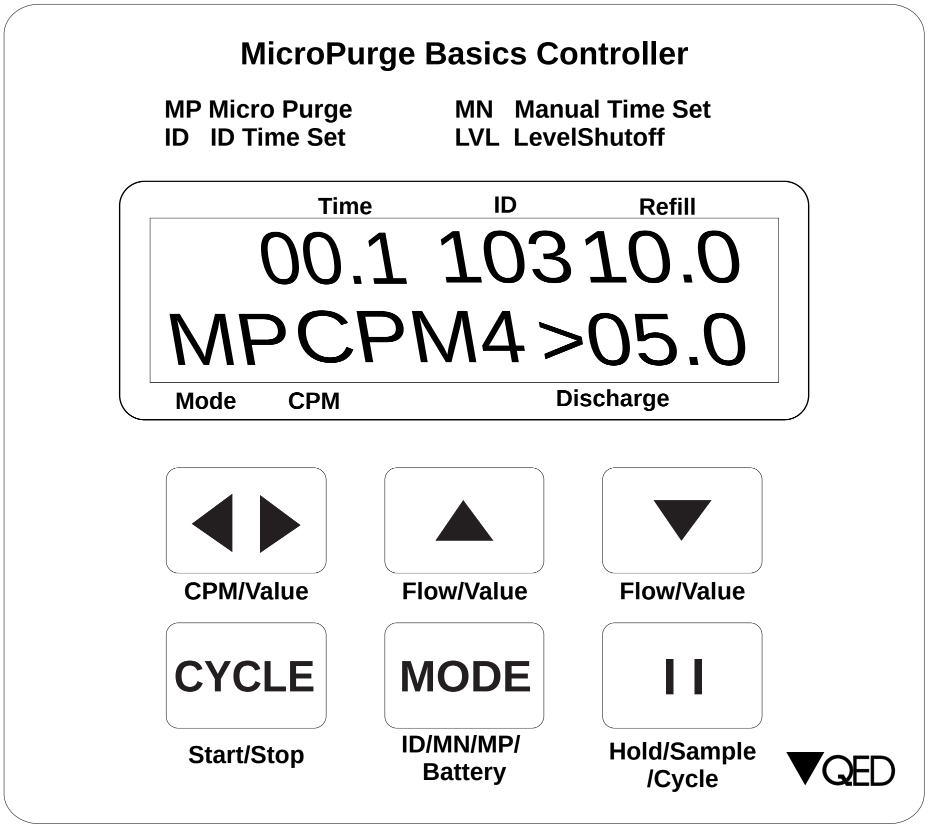
Opening Display - The opening display is shown for 5 seconds and displays the controller name, the version number and the battery voltage, as shown in Figure 1. Figure 1 shows that the battery is GOOD, that the battery voltage is 4.20 volts and that the software version in the cont-roller is 1.0. Battery voltage must be greater than 3.6 volts for the unit to operate. If the unit fails to cycle replace the 3-AA batteries with fresh cells. The opening screen is displayed for 5 seconds, if you wish to by pass the opening screen, hitting any key, such as the CPM key will bring you to the default MP display.

Figure 1 Opening Screen



MicroPurge Mode Most MP10 users will leave the controller in the default MicroPurge (MP) mode. See Figure 2 for an example of the MP10 in MP mode. MP mode lets you to use the UP and DOWN keys to directly increase and decrease pump flow rates. The MP10 has a broad range of other CPM settings to ensure the availability of a time setting that will match your specific conditions. MP mode also displays an ID, with a value of 1 to 165 that matches the flow settings (CPM and refill and discharge times you have set). This ID should be noted alongside the well identification (QED provides custom weatherproof ID badges for purchasers of our MP series of well caps) for quick setting of the optimal controller settings on the next visit by using the MP10 in ID mode.

Figure 2 MP10 MicroPurge Mode



Using CPM The MP10 introduces a revolutionary, simpler way to control bladder pump flow rate and achieve the low-flow method used by experts. Up/down arrow keys are used to adjust pump flow even at verylow rates, with excellent control and repeatability.

With previous bladder pump controllers, a leading low-flow technique called for selecting the number of pump cycles per minute, then adjust-ing the bladder pump discharge and refill times to achieve the desired volume per cycle. These adjustments were inter-related, complex, and varied by operator. The new MicroPurge Mode (MP) of the MP10 builds in a "cycles per minute", or CPM, method of flow control.

With this method, the number of complete pump cycles per minute is fixed, within a range of 1 to 6; 4 CPM is the default value which appears at startup. Each time the up/down arrow keys are pressed, the pump refill and discharge times are both automatically adjusted to maintain the selected CPM value. Each adjustment increases or decreases the volume pumped per cycle, and the per-minute flow rate is the volume per cycle X the CPM value.

For example, with a 4 CPM setting, 60 ml volume per cycle equates to 4 X 60 = 240 ml/min flow rate. A single press of the Flow up arrow key could change the volume per cycle to 80 ml, for example, resulting in a new, increased flow rate of 4 X 80 = 320 ml/min. And the MP10 assigns a unique identification value to each setting, the ID value, which can be directly set during later sampling events.

"MP" displayed in the lower left corner of the display indicates MicroPurge mode. The default CPM setting of 4 cycles per minute is a good starting point for wells with depths from 25-100 ft. MicroPurge mode starts at a time setting of 10 seconds refill and 5 seconds discharge, close to optimal for many wells. This startup settings corresponds to a 4 cycles per minute setting (CPM4) and an ID setting of 103.

Using the CPM key will change the CPM setting on the controller. The range of CPM settings is CPM1 through CPM6. CPM changes like this each time you hit the CPM key: 4 5 6 1 2 3 4 5, etc. The UP and DOWN keys change the flow rate directly, by altering the refill and discharge times *within* a CPM setting.

Note: *changes in settings that are entered while the controller is cycling are reflected on the next cycle change (so a long refill time of 15 seconds will time out before a new refill time becomes valid).*

Here is an example of the use of the UP (faster) key:

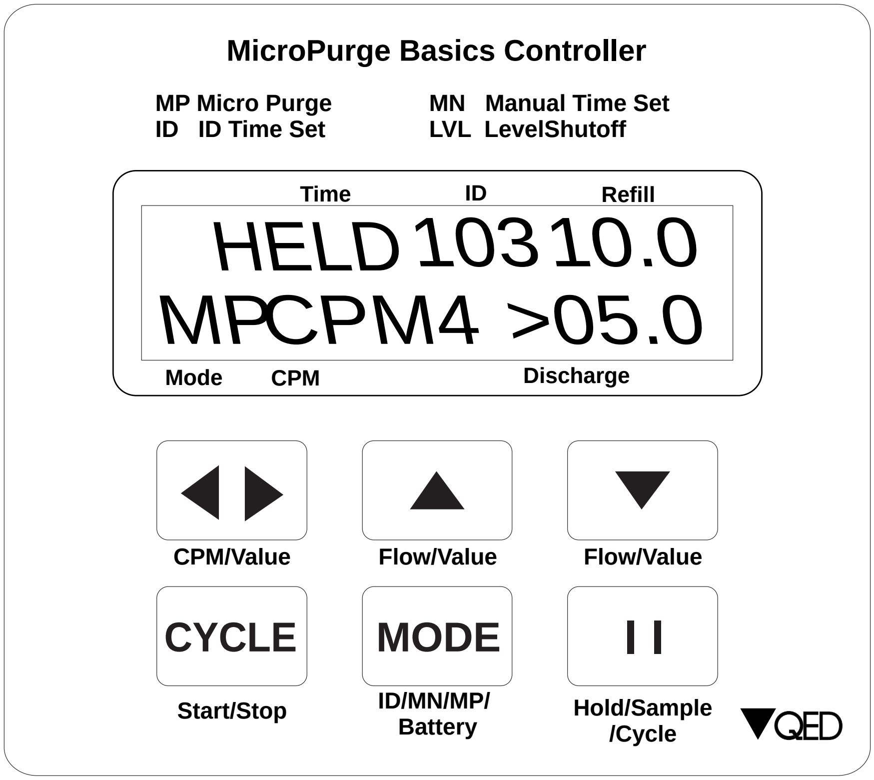
Key Press	Refill (sec)	Discharge (sec)	ID
---	10.0	5.0	103
1	9.5	5.5	104
2	9.0	6.0	105
3	8.5	6.5	106

Each of the 165 possible ID settings corresponds to a unique ID that is associated with CPM, refill and discharge time values. For typical usage, only the UP/DOWN arrow keys are required to set flow, and the ID number is provided for easy, direct return to past settings. Appendix 1 lists all possible ID settings and the default refill and discharge time settings for each CPM. Appendix 1 also shows how the refill and dis-charge time will change within a CPM setting as you press the UP or DOWN keys.

Sample Collection The PAUSE key (II) is used to freeze the controller action to allow the user time to collect a sample or carry out other steps that might be difficult if the controller continued to automatically cycle and cause the pump to produce water. While the controller is cycling, pressing the PAUSE key causes the controller to immediately enter the Hold state. Drive air is vented from the pump (this is the pump refill cycle) and the pump fills and waits. Pressing the PAUSE key a second time causes the controller to immediately enter the Sample state. Drive air is directed to the pump causing the pump to discharge its volume of liquid. Bladder pumps typically hold 400-500 ml of liquid, so use of the Hold and Sample states allow the full volume of the pump to be discharged into a sample container. Pressing PAUSE once again returns the MP10 to its normal Automatic Cycling state. During Hold and Sample a HELD is displayed to remind you that the controller is in a paused state. Figure 3 shows an example of the MP10 in MP mode, but HELD in the Sample state.

Note: *Pressing the Cycle key also freezes controller cycling. However, using the Cycle key rather than the Pause key causes the startup screen to be displayed upon restart. Use of the Pause key is recommended for typical operation.*

Figure 3 MP10 Held State (MP mode)



***Warning:** in the HELD SAMPLE state the pump, tubing and hoses are all under pressure. **DO NOT** attempt to disconnect or disassemble any part of the system when it is under pressure. The system is under pressure if the pressure gauge shows a value greater than 0 and the RED Discharge Cycle Indicator is showing.*

Flow Throttle Use The flow throttle is used during sampling to regulate the pressure applied to the pump. Turning the throttle clockwise increases the pressure and counterclockwise decreases the pressure. The pressure gauge shows the approximate pressure applied to the pump and reads in units of Feet - H^2O. This allows easy adjustment of the throttle giving pressures that will produce gentle, non-turbulent flow (normally 10-20 Feet - H^2O deeper than pump depth). For traditional, high volume purging pressure may be increased with the throttle to maximize pump flow during well purging.

Use with the MP30 Automatic Drawdown Control The MP10 may optionally be used with the MP30 MicroPurge Drawdown / Water Level Meter. See Figure 4 for an example of the MP10 in MP mode with the controller in a level paused state enacted by an MP30 meter.

Figure 4 MP10 Level Paused State (MP mode)

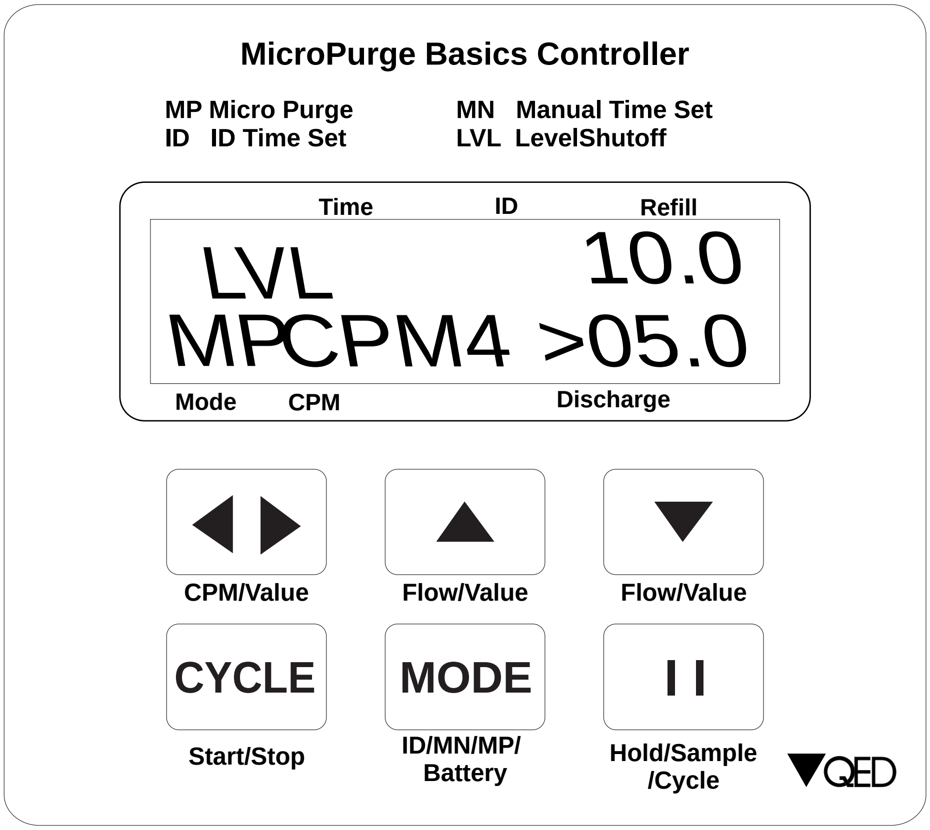


Figure 5 MP10 MP30 Use

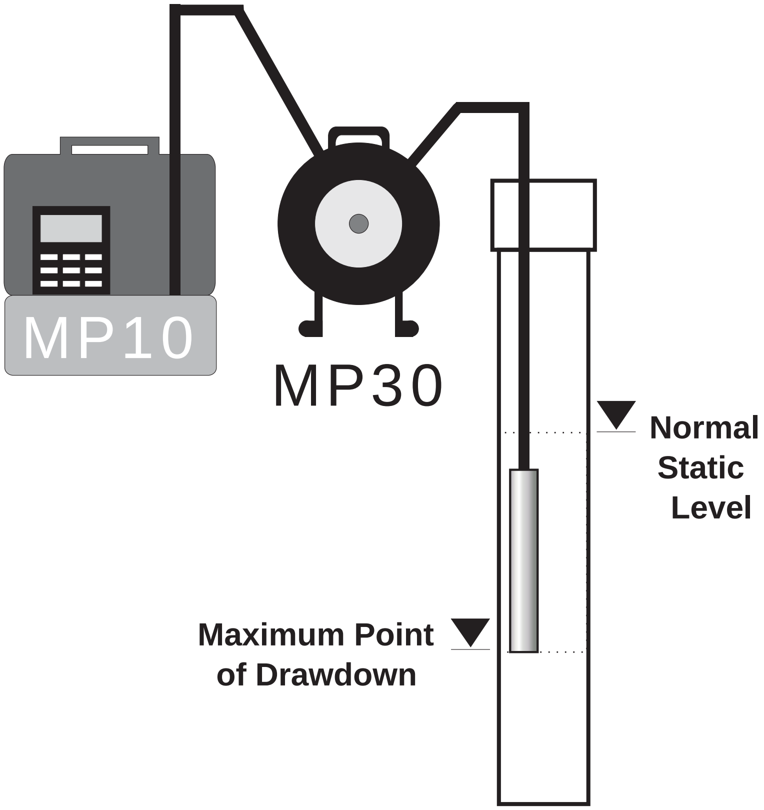
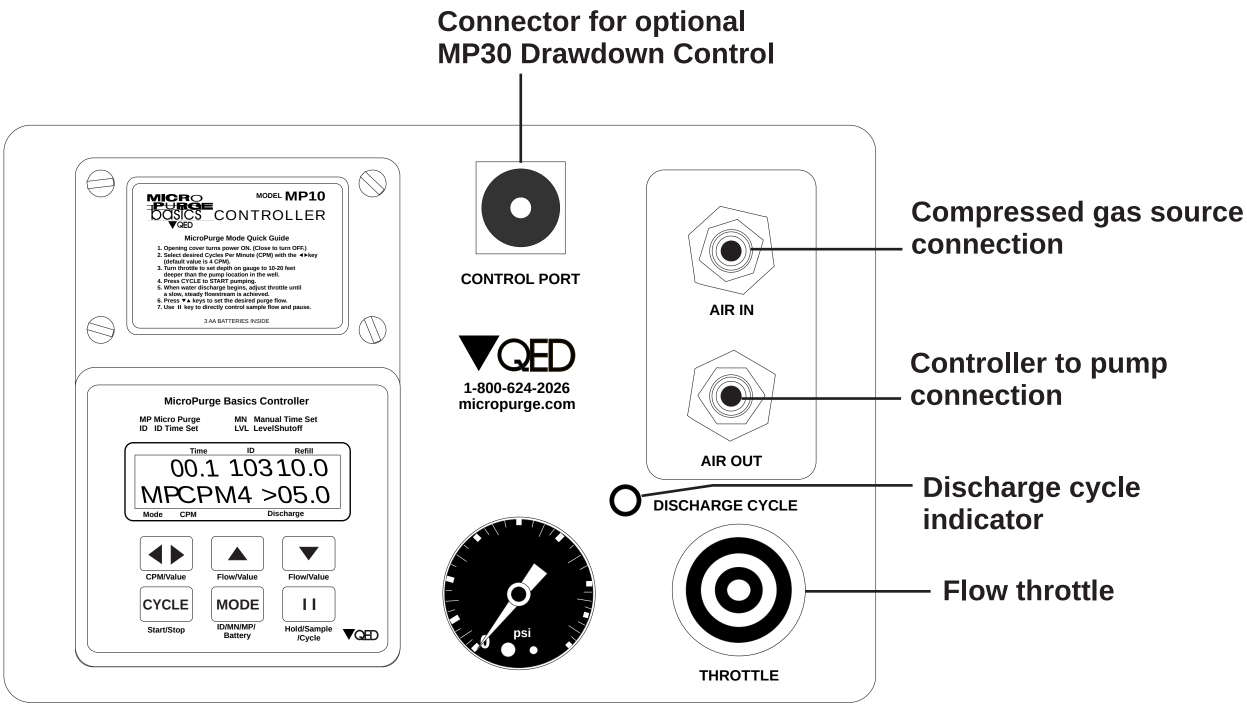


Figure 6 MP10 MP30 Use



The MP10 and MP30 are connected with a cable (see Figures 5 and 6). The MP30 is switched into mode and the water level probe is lowered to the desired maximum drawdown level. Limiting the maximum drawdown depth limits the differential head driving flow into the well and the velocity of the water flowing into the well from the surrounding formation important in Micro-Purge sampling. The MP10 and MP30 work together to automatically adjust the pump operation so as to maintain drawdown at the set level. When the water level drops below the probe, the MP30 sends a signal to the MP10 to pause pumping. Both the MP10 and the MP30 give visual signals (and the MP30 emits an audio signal) that pump operation has stopped because of too much drawdown. Once the level recovers, the MP30 signals the MP10 to resume pump operation. The MP10 resumes by starting in the refill leg of the pump cycle. "DRAWDOWN CONTROL"

The normal operating mode for using the MP30 with the MP10 is:

1. Use the MP30 in standard WLM mode to determine the static water level in the well
2. Decide what the maximum drawdown for that well is during sampling
3. Lower the probe to the maximum drawdown level
4. Switch the MP30 into Drawdown Control mode
5. Begin pumping with the MP10
6. Observe the interactions between the two devices, if the MP30 is frequently pausing the MP10, it may be appropriate to slow the flow down (using the DOWN key in MP mode) to better match pump flow to well recharge.

When switched into mode, the MP30 has a flashing red light and an optional (can be switched off by the user) audio alarm to indicate when the probe is in the dry state. A submerged probe in all modes is indicated by a solid green light. When the MP10 is paused by the MP30 the MP 10 display indicates this as shown in Figure 4 "DRAWDOWN CONTROL"

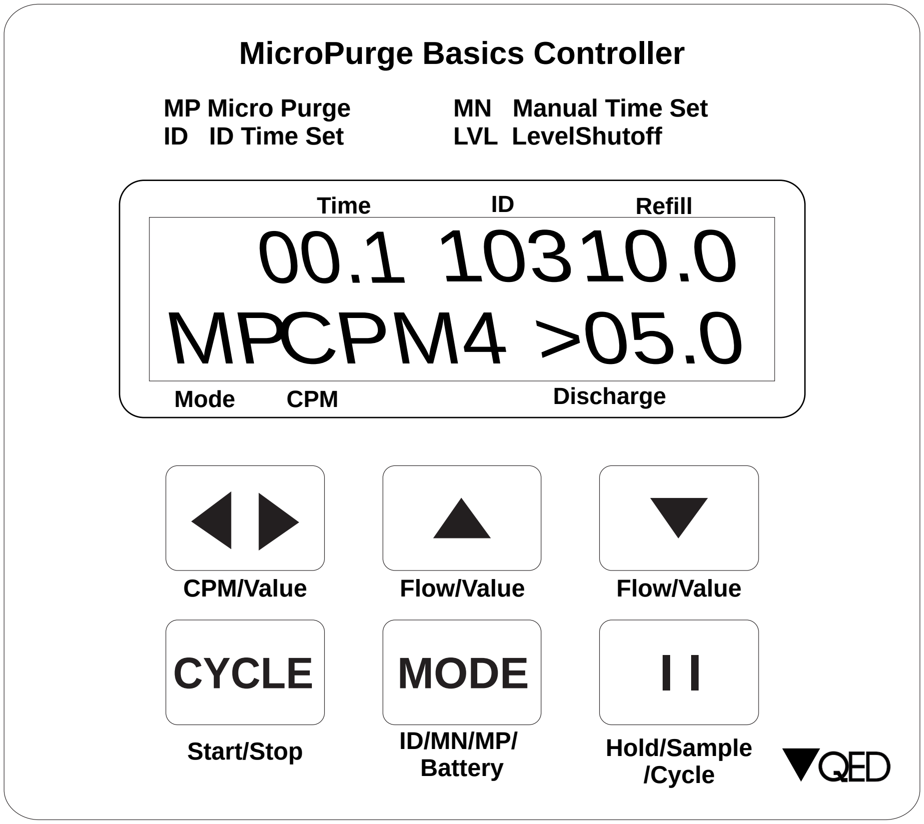
If the MP30 is signaling the MP10 too frequently, the operator can slow down the pump flow rate by using the DOWN key (effectively increasing the pump refill time period). MP30 probe position may also be varied to provide a buffer zone for your drawdown limit and gauge rate of pumping effect on water level in the well.

If the selected maximum drawdown level is being reached even with the lowest desirable pump flow rate more drawdown may be required to attain equilibration, or a passive sampling approach may be required. In passive sampling, used where well recovery is extremely slow, samples are taken after just a few pump strokes sufficient to purge the pump and tubing volumes.

Additional information on the MP30 is given in the MP30 O&M manual

ID Mode Figure 6 shows an example of the MP10 in ID time set mode. Once you've used the MP10 in MP mode and found proper settings for your wells, subsequent sampling events are speeded along by using the controller in ID mode. Once the controller is turned on, a single press of the MODE key places the controller in ID time set mode (the default initial mode is MP mode). This mode allows the user to enter a 3-digit ID, which then is translated into the correct flow settings (CPM and refill / discharge time settings) for that well.

Figure 7 MP10 ID Set Mode



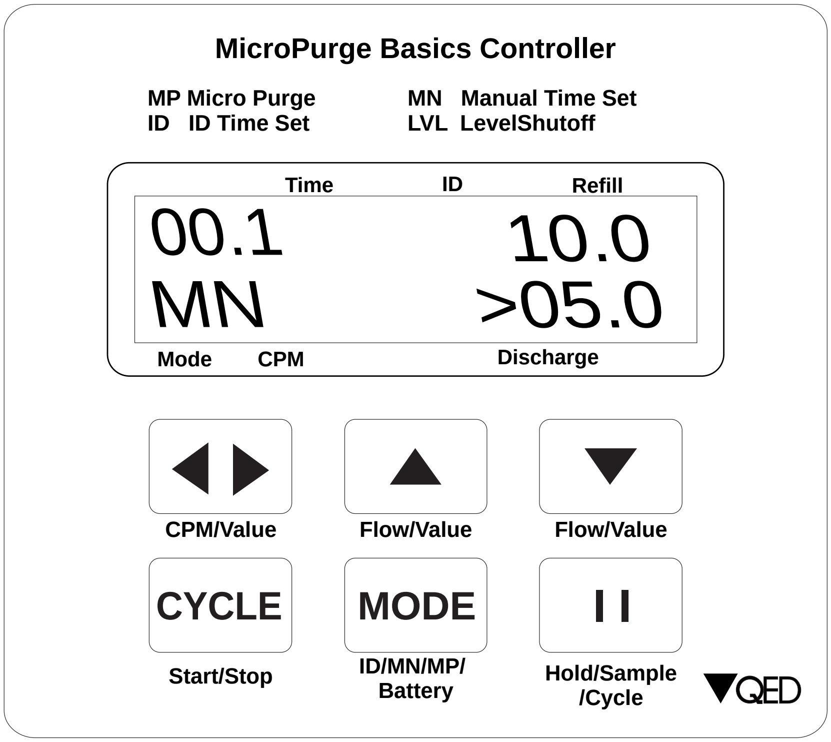
In this mode the CPM and UP, DOWN keys function differently. The CPM key becomes a key used to scroll between the one's and the ten's digits of the ID. The UP and DOWN keys are used to change the ID number (the MP10 has IDs that range from 1-165) up or down in value. Sampling in ID mode is the same as explained, above, for MP mode.

Appendix 1 lists all possible ID settings and the default refill and discharge time settings for each CPM. Appendix 1 also shows how the refill and discharge time will change within a CPM setting as you press the UP or DOWN keys. As you change IDs you will see the CPM change and the refill and discharge time setting change.

Note: *changes in time settings that are entered while the controller is cycling are reflected on the next cycle change (so a long refill time of 15 seconds will time out before a new refill time becomes valid).*

User Set Mode A final controller mode, User Set mode (MN on the display), is useful for manually setting refill and discharge times on the controller as in traditional controllers (like previous model QED pump controllers). An example of the MP10 in User Set mode is shown in Figure 8. User set mode is also used when the wells being sampled are at extreme depths or there are other conditions where one of the 165 possible preset times of ID and MP modes will not match your needs. MN mode is entered when the MODE key is pressed twice from the default MP mode. As shown in Figure 8, the display indicates MN mode in the lower left corner and CPM and ID are not displayed.

Figure 8 MP10 User Set Mode (MN mode)



In User Set mode the CPM and UP, DOWN keys function differently than MP mode. The CPM key becomes a key used to select the digits of the refill and discharge time settings found at the rightmost positions on the display. The UP and DOWN keys are used to adjust the digit value up or down. By selecting and adjusting digits up and down a user can quickly set any time from 00.1 seconds to 99.9 seconds. Sampling in User Set mode is the same as explained, above, for MP mode.

The MP10 does not attempt to translate a user set time into a corresponding ID or CPM. Also, any settings you have entered in MP or ID modes are lost once you press the MODE key to enter MN mode.

Note: *changes in time settings that are entered while the controller is cycling are reflected on the next cycle change (so a long refill time of 15 seconds will time out before a new refill time becomes valid).*

MP10 Battery - The MP10 features sophisticated power-supply circuitry that optimizes battery life. A fresh set of AA batteries will provide more than 100 hours of controller operation at normal operating temperatures. As ambient temperatures drop below 15-20˚F (-9˚C to -6˚C), the ability of the alkaline batteries to deliver energy is affected. Continuous operation may be difficult in extremely cold conditions. Once the batteries and MP10 warm, additional cycle capacity will be regained from a set of batteries.

Replace alkaline batteries by removing the 4 thumbscrews located on the battery cover and inserting 3 fresh **cells**. The MP10 battery holder includes space for ***3 spare AA cells*** so you should never be without power in the field. Properly dispose of the spent alkaline cells.

Note: *If you are storing the MP10 for more than 3 months, remove the AA batteries to prevent leakage. The MP10 power supply is automatically shut off by closing the lid. Make sure the lid is closed during storage.*

Troubleshooting

Use the following troubleshooting table to assist in troubleshooting the MP10:

Symptom	Possible Cause	Action / Fix
Display not showing	Low or dead batteries Batteries installed wrong	Check battery voltage on opening display (>3.6 volts required) Replace batteries Check battery connection
Controller not cycling	Low or dead batteries	See, above
	Lid not open	Open lid
	Temperature below 10F	Warm controller
	MP10 not STARTED with CYCLE key MP10 in HELD mode	Operate CYCLE and/or PAUSE key to return MP10 to cycling state
	MP10 in LEVEL hold	Make sure MP30 probe is submerged when in MP mode
Air not cycling through controller	Throttle turned too low	Turn throttle clock-wise to produce pressure
	Air source not delivering air	Verify air source
Pump not pumping	Throttle turned too low	Turn throttle clock-wise to produce pressure
	Time settings not correct	Try different CPM settings (lower CPM for deeper wells) and/or different refill and discharge time settings
	Air source pressure too low	Verify air source pressure
Battery life too short	Controller left on while strored	Turn MP10 off before storing and remove batteries when storing more than 1 month
	Temperature below 10F	Warm controller

MP10 Specifications

Temperature Range:	Operating range of -20º F to +150º F
Humidity:	Circuitry sealed to provide operation to 100% humidity
Protection:	Circuitry protected against transient surges introduced from improper battery installation or switch connections.
Display:	LCD display, 32-character (2 lines, 16 characters, each)
Window:	Non-glare, double hardened optical acrylic
Battery type:	3 user replaceable AA alkaline cells
Drain:	Unit off: 2mA, Unit on: 4mA, Valve Cycle: 6mA
Reserve:	100 hours operating time (1sec/1sec cycles) with fresh AA alkaline cells At 65º F (approx.)
Emergency battery:	3 AA cells stored within battery compartment

For additional assistance contact QED Service at:

Phone:	1-800-624-2026 1-734-995-2547
Fax:	1-734-995-1170
E-mail:	service@qedenv.com
24-Hour Service Hot Line:	1-800-272-9559

QED Monitoring System WARRANTY

QED ENVIRONMENTAL SYSTEMS, INC. ("QED") warrants to the original purchaser of its products that, subject to the limitations and conditions provided below, the products, materials and/or workmanship shall reasonably conform to descriptions of the products and shall be free of defects in materials and workmanship. Any failure of the products to conform to this warranty will be remedied by QED in the manner provided herein.

This warranty shall be limited to the duration and the conditions set forth below. Warranty duration is calculated from the original date of purchase.

1. **Dedicated-Use System Products**-10-year warranty on dedicated bladder pumps equipped with QED inlet screens, and purge pumps used in periodic, non-continuous groundwater sampling (up to 52 samples events per year.) All other components, equipment and accessories are warranted for one year.

2. **Portable-Use Systems -** Controllers and Water Level Meters are warranted for one year. Hose reels, pumps and caps are warranted for ninety (90) days. Tubing and Purge Mizers are covered by a ninety-(90) days material and workmanship warranty. There will be no warranty for application on tubing and Purge Mizers when used as part of a Portable System.

3. **Separately Sold Parts and Spare Parts Kits -** Separately sold parts and spare parts are warranted for ninety (90) days. Repairs performed by QED are warranted for ninety (90) days from date of repair or for the full term of the original warranty, whichever is longer.

Buyers' exclusive remedy for breach of said warranty shall be as follows: if, and only if, QED is notified in writing within the applicable warranty period of the existence of any such defect in the said products, and QED upon examination of any such defects, shall find the same to be within the term of and covered by the warranty running from QED to Buyer, QED will, at its option, as soon as reasonably possible, replace or repair any such product, without charge to Buyer. If QED for any reason, cannot repair a product covered hereby within four (4) weeks after receipt of the original Purchaser's/Buyer's notification of a warranty claim, then QED's sole responsibility shall be, at its option, either to replace the defective product with a comparable new unit at no charge to the Buyer, or to refund the full purchase price. In no event shall such allegedly defective products be returned to QED without its consent, and QED's obligations of repair, replacement or refund are conditioned upon the Buyer's return of the defective product to QED.

IN NO EVENT SHALL QED ENVIRONMENTAL SYSTEMS, INC. BE LIABLE FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES FOR BREACH OF SAID WARRANTY.

The foregoing warranty does not apply to major sub-assemblies and other equipment, accessories, and parts manufactured by others, and such other parts, accessories, and equipment are subject only to the warranties, if any, supplied by the respective manufacturers. QED makes no warranty concerning products or accessories not manufactured by QED. In the event of failure of any such product accessory, QED will give reasonable assistance to Buyer in obtaining from the respective manufacturer whatever adjustments is reasonable in light of the manufacturer's own warranty.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY (INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE). WHICH OTHER WARRANTIES ARE EXPRESSLY EXCLUDED HEREBY, and of any other obligations or liabilities on the part of QED, and QED neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with the said products, materials and/or workmanship.

It is understood and agreed that QED shall in no event be liable for incidental or consequential damages resulting from its breach of any of the terms of this agreement, not for special damages, nor for improper selection of any product described or referred to for a particular application.

This warranty will be void in the event of unauthorized disassembly of component assemblies. Defects in any equipment that result from abuse, operation in any manner outside the recommended procedures, use and applications other than for intended use, or exposure to chemical or physical environmental beyond the designated limits of materials and construction will also void this warranty. QED shall be released from all obligations under all warranties if any product covered hereby is repaired or modified by persons other than QED's service personnel unless such repair by others is made with the written consent of QED.

This warranty will be void in the event of unauthorized disassembly of component assemblies. Defects in any equipment that result from abuse, operation in any manner outside the recommended procedures, use and applications other than for intended use, or exposure to chemical or physical environmental beyond the designated limits of materials and construction will also void this warranty. QED shall be released from all obligations under all warranties if any product covered hereby is repaired or modified by persons other than QED's service personnel unless such repair by others is made with the written consent of QED.

If any product covered hereby is actually defective within the terms of this warranty, Purchaser must contact QED for determination of warranty coverage. If the return of a component is determined to be necessary, QED will authorize the return of the component, at owner's expense. If the product proves not be defective within the terms of this warranty, then all costs and expenses in connection with the processing of the Purchaser's \ claim and all costs for repair, parts and labor as authorized by owner hereunder shall be borne by the Purchaser.

RESPONSIBILITY OF THE PURCHASER

The original Purchaser's sole responsibility in the instance of a warranty claim shall be to notify QED of the defect, malfunction, or other manner in which the terms of this warranty are believed to be violated. You may secure performance of obligations hereunder by contacting the Customer Service Department of QED and:

1. Identifying the product involved (by model or serial number or other sufficient description that will allow QED to determine which product is defective).

2. Specifying where, when, and from whom the product was purchased.

3. Describing the nature of the defect or malfunction covered by this warranty.

4. Sending the malfunction component, after authorization by QED to :

QED Environmental Systems Inc.
6155 Jackson Road
Ann Arbor, MI 48103
(800) 624-2026
(734) 995-2547
www.qedenv.com
info@qedenv.com

Appendix 1 ID Data Table

NOTE: Bold Shaded values are default for that CPM

CYCLES / min (CPM)																	
1 / min			2 / min			3 / min			4 / min			5 / min			6 / min		
ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)
1	1	59	41	1	29	66	1	19	95	1	14	114	1	11	145	1	9
2	2	58	42	2	28	67	1.5	18.5	96	1.5	13.5	115	1.2	10.8	146	1.2	8.8
3	3	57	43	3	27	68	2	18	97	2	13	116	1.4	10.6	147	1.4	8.6
4	4	56	44	4	26	69	2.5	17.5	98	2.5	12.5	117	1.6	10.4	148	1.6	8.4
5	5	55	45	5	25	70	3	17	99	3	12	118	1.8	10.2	149	1.8	8.2
6	6	54	46	6	24	71	3.5	16.5	100	3.5	11.5	119	2	10	150	2	8
7	7	53	47	7	23	72	4	16	101	4	11	120	2.2	9.8	151	2.2	7.8
8	8	52	48	8	22	73	4.5	15.5	102	4.5	10.5	121	2.4	9.6	152	2.4	7.6
9	9	52	49	9	21	74	5	15	**103**	**5**	**10**	122	2.6	9.4	153	2.6	7.4
10	10	50	**50**	**10**	**20**	75	5.5	14.5	104	5.5	9.5	123	2.8	9.2	154	2.8	7.2
11	11	49	51	11	19	76	6	14	105	6	9	124	3	9	**155**	**3**	**7**
12	12	48	52	12	18	77	6.5	13.5	106	6.5	8.5	125	3.2	8.8	156	3.2	6.8
13	13	47	53	13	17	78	7	13	107	7	8	126	3.4	8.6	157	3.4	6.6
14	14	46	54	14	16	79	7.5	12.5	108	7.5	7.5	127	3.6	8.4	158	3.6	6.4
15	15	45	55	15	15	80	8	12	109	8	7	128	3.8	8.2	159	3.8	6.2
16	16	44	56	16	14	81	8.5	11.5	110	8.5	6.5	**129**	**4**	**8**	160	4	6
17	17	43	57	17	13	**82**	**9**	**11**	111	9	6	130	4.2	7.8	161	4.2	5.8
18	18	42	58	18	12	83	9.5	10.5	112	9.5	5.5	131	4.4	7.6	162	4.4	5.6
19	19	41	59	19	11	84	10	10	113	10	5	132	4.6	7.4	163	4.6	5.4
20	**20**	**40**	60	20	10	85	10.5	9.5				133	4.8	7.2	164	4.8	5.2
21	21	39	61	21	9	86	11	9				134	5	7	165	5	5
22	22	38	62	22	8	87	11.5	8.5				135	5.2	6.8			
23	23	37	63	23	7	88	12	8				136	5.4	6.6			
24	24	36	64	24	6	89	12.5	7.5				137	5.6	6.4			
25	25	35	65	25	5	90	13	7				138	5.8	6.2			
26	26	34				91	13.5	6.5				139	6	6			
27	27	33				92	14	6				140	6.2	5.8			
28	28	32				93	14.5	5.5				141	6.4	5.6			
29	29	31				94	15	5				142	6.6	5.4			
30	30	30										143	6.8	5.2			
31	31	29										144	7	5			
32	32	28															
33	33	27															
34	34	26															
35	35	25															
36	36	24															
37	37	23															
38	38	22															
39	39	21															
40	40	20															

QED
Environmental Systems

P.O. Box 3726 Ann Arbor, MI 48106-3726 USA
1-800-624-2026 Fax (734) 995-1170
info@qedenv.com www.qedenv.com

MODEL 3020 DRIVER COMPRESSOR INSTRUCTIONS

NOTICE

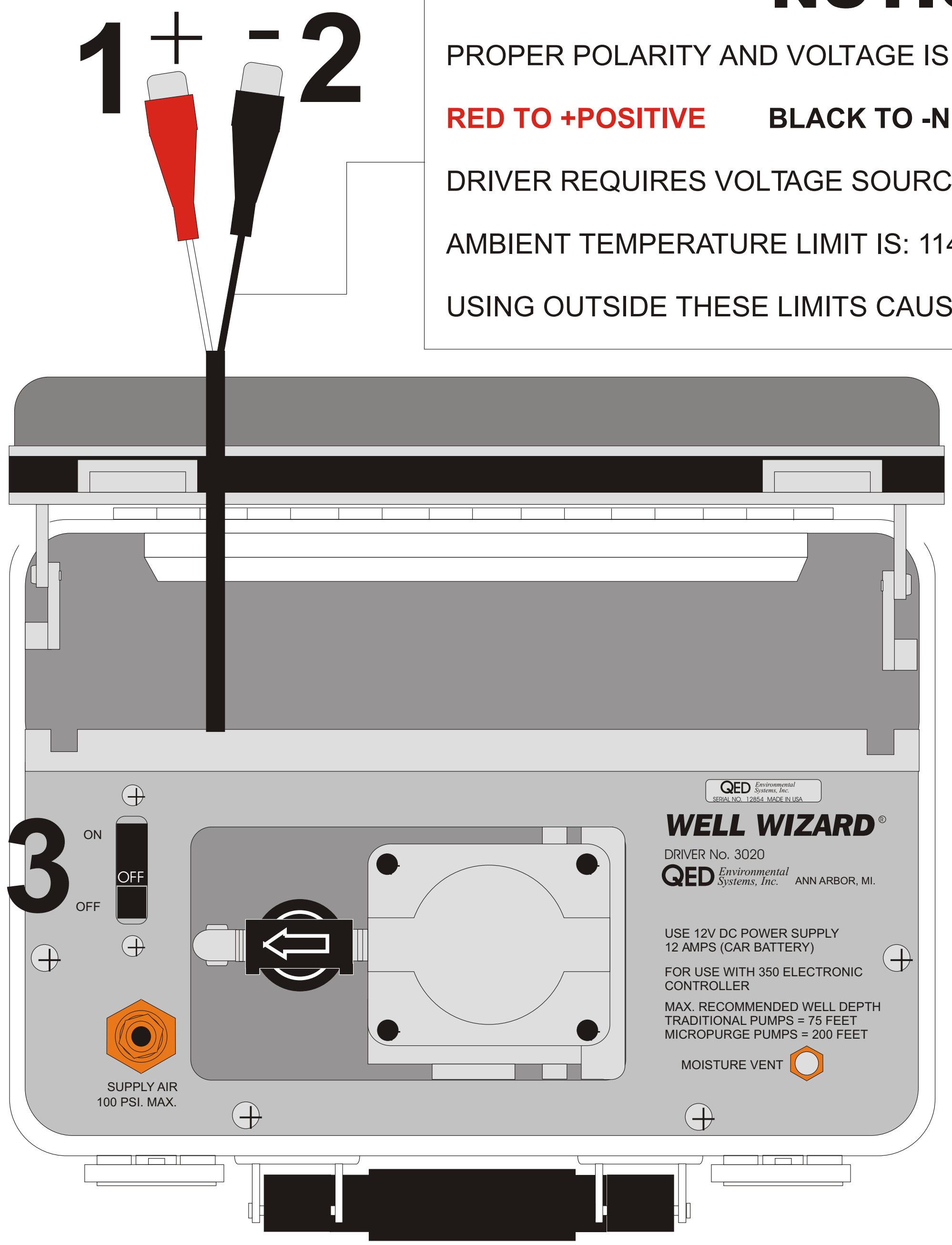
PROPER POLARITY AND VOLTAGE IS CRITICAL FOR OPERATION.

RED TO +POSITIVE **BLACK TO -NEGATIVE**

DRIVER REQUIRES VOLTAGE SOURCE OF: 11-12VDC.

AMBIENT TEMPERATURE LIMIT IS: 114°F

USING OUTSIDE THESE LIMITS CAUSES OVERHEAT / SHUTDOWN.



1. **Attach Red Positive (+) cable clamp to the Positive (+) terminal of battery.**
2. **Attach Black Negative (-) cable clamp to the Negative (-) terminal of battery.**
3. **Turn the On/Off switch on the Model 3020 to the "On" position.**

MiniRAE 3000
User's Guide

RAE SYSTEMS

Rev. C
August 2010
P/N 059-4020-000

FCC Information

Contains FCC ID: PI4411B

The enclosed device complies with part 15 of the FCC rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

Contents

Read Before Operating

This manual must be carefully read by all individuals who have or will have the responsibility of using, maintaining, or servicing this product. The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions. The user should understand how to set the correct parameters and interpret the obtained results.

CAUTION!

To reduce the risk of electric shock, turn the power off before removing the instrument cover. Disconnect the battery before removing sensor module for service. Never operate the instrument when the cover is removed. Remove instrument cover and sensor module only in an area known to be non-hazardous.

Special Notes

⚠ When the instrument is taken out of the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the instrument. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

⚠ The battery of the instrument discharges slowly even if it is turned off. If the instrument has not been charged for 5 to 7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the instrument before using it. It is also recommended to fully charge the instrument for *at least 10 hours* before first use. Refer to this User Guide's section on battery charging for more information on battery charging and replacement.

WARNINGS

STATIC HAZARD: Clean only with damp cloth.

For safety reasons, this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part numbers 059-3051-000, 059-3052-000, and 059-3054-000. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

Do not mix old and new batteries or batteries from different manufacturers.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

For maximum safety, the accuracy of the instrument should be checked by exposing it to a known concentration calibration gas before each day's use.

Do not use USB/PC communication in hazardous locations.

AVERTISSEMENT

DANGER RISQUE D'ORIGINE ELECTROSTATIQUE: Nettoyer uniquement avec un chiffon humide.

Pour des raisons de sécurité, cet équipment doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Utiliser seulement l'ensemble de batterie RAE Systems, la reference 059-3051-000 au 059-3052-000 au 059-3054-000. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsique. Ne charger les batteries que dans emplacements désignés non-dangereuse.

Ne pas melanger les anciennes et les nouvelles batteries, ou bien encore les batteries de differents fabriquants.

La calibration de toute instruments de RAE Systems doivent être testé en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant de mettre en service l'instrument pour la première fois.

Pour une securite maximale, la sensibilité du l'instrument doit être verifier en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant chaque utilisation journalière.

Ne pas utiliser de connection USB/PC en zone dangereuse.

Standard Contents

Instrument
Calibration Kit
Charging Cradle
AC/DC Adapter
Alkaline Battery Adapter
Data Cable
CD-ROM With User's Guide, Quick Start Guide, and related materials

General Information

The compact instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a photoionization detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas-discharge lamp. Features are:

Lightweight and Compact

- Compact, lightweight, rugged design
- Built-in sample draw pump

Dependable and Accurate

- Up to 16 hours of continuous monitoring with rechargeable battery pack
- Designed to continuously monitor VOC vapor at parts-per-million (ppm) levels

User-friendly

- Preset alarm thresholds for STEL, TWA, low- and high-level peak values.
- Audio buzzer and flashing LED display are activated when the limits are exceeded.

Datalogging Capabilities

- 260,000-point datalogging storage capacity for data download to PC

The instrument consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged case with a backlit LCD and 3 keys to provide easy user interface. It also has a built-in flashlight for operational ease in dark locations.

Physical Description

The main components of the portable VOC monitoring instrument include:

- Three keys for user to interact with the instrument: 3 operation/programming keys for normal operation or programming
- LCD display with back light for direct readout and calculated measurements
- Built-in flashlight for illuminating testing points in dark environments
- Buzzer and red LEDs for alarm signaling whenever exposures exceed preset limits
- Charge contacts for plugging directly to its charging station
- Gas entry and exit ports
- USB communication port for PC interface
- Protective rubber cover

Specifications

Size:	9.25" L x 3.6" W x 2.9" H
Weight:	28 oz with battery pack
Detector:	Photoionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 3.7V rechargeable Lithium-Ion battery pack (snap in, field replaceable, at non-hazardous location only) Alkaline battery holder (for 4 AA batteries)
Battery Charging:	Less than 8 hours to full charge
Operating Hours:	Up to16 hours continuous operation
Display:	Large dot matrix screen with backlight

Measurement range & resolution

Lamp	Range	Resolution
10.6 eV	0.1 ppm to 15,000 ppm	0.1 ppm
9.8 eV	0.1 ppm to 5,000 ppm	0.1 ppm
11.7 eV	0.1 ppm to 2,000 ppm	0.1 ppm

Response time (T_{90}):	2 seconds
Accuracy (Isobutylene):	10 to 2000 ppm: ±3% at calibration point.
PID Detector:	Easy access to lamp and sensor for cleaning and replacement
Correction Factors:	Over 200 VOC gases built in (based on RAE Systems Technical Note TN-106)
Calibration:	Two-point field calibration of zero and standard reference gases
Calibration Reference:	Store up to 8 sets of calibration data, alarm limits and span values
Inlet Probe:	Flexible 5" tubing
Radio module:	Bluetooth (2.4GHz), RF module (433MHz, 868MHz , 915MHz, or 2.4GHz)
Keypad:	1 operation key and 2 programming keys; 1 flashlight switch
Direct Readout:	Instantaneous, average, STEL, TWA and peak value, and battery voltage
Intrinsic Safety:	US and Canada: Class I, Division 1, Groups A, B, C D Europe: ATEX (0575 Ex II 2G Ex ia IIC/IIB T4 Gb) KEMA 07 ATEX 0127 Complies with EN60079-0:2009, EN60079-11:2007

	IECEx CSA 10.0005 Ex ia IIC/IIB T4 Gb Complies with IEC 60079-0:2007, IEC 60079-11:2006 (IIC: 059-3051-000 Li-ion bat pack or 059-3054-000 NiMH bat pack; IIB: 059-3052-000 alkaline bat pack)
EM Interference:	Highly resistant to EMI/RFI. Compliant with EMC R&TTE (RF Modules)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Hygiene or Search mode
Alarm:	Buzzer 95dB at 30cm and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure
Alarm Type:	Latching or automatic reset
Real-time Clock:	Automatic date and time stamps on datalogged information
Datalogging:	260,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC via USB on charging station.
Sampling Pump:	Internally integrated. Flow rate: 450 to 550 cc/min.
Temperature:	-20º C to 50º C (-4º to 122º F)
Humidity:	0% to 95% relative humidity (non-condensing)
Housing (including rubber boot):	Polycarbonate, splashproof and dustproof Battery can be changed without removing rubber boot.

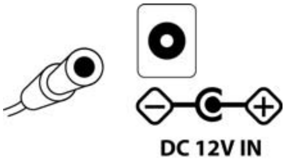
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle's contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter's barrel connector into the instrument's cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glow

The instrument begins charging automatically. The "Primary" LED in the cradle blinks green to indicate charging. During charging, the diagonal lines in the battery icon on the instrument's display are animated and you see the message "Charging..."

When the instrument's battery is fully charged, the battery icon is no longer animated and shows a full battery. The message "Fully charged!" is shown. The cradle's LED glows continuously green.

Note: If you see the "Battery Charging Error" icon (a battery outline with an exclamation mark inside), check that the instrument or rechargeable battery has been set into the cradle properly. If you still receive the message, check the Troubleshooting section of this guide.

Note: If the instrument or battery has been in the cradle for more than 10 hours and you see the "Battery Charging Error" icon and a message that says, "Charging Too Long," this indicates that the battery is not reaching a full charge. Try changing the battery and make sure the contacts between the instrument (or battery) are meeting the cradle. If the message is still shown, consult your distributor or RAE Systems Technical Services.

Charging A Spare Rechargeable Battery

A rechargeable Li-ion battery can be charged when it is not inside the monitor. The charging cradle is designed to accommodate both types of charging. Contacts on the bottom of the battery meet the contacts on the cradle, transferring power without other connections, and a spring-loaded capture holds the battery in place during charging.

1. Plug the AC/DC adapter into the monitor's cradle.
2. Place the battery into the cradle, with the gold-plated contacts on top of the six matching charging pins.
3. Plug the AC/DC adapter into the wall outlet.

The battery begins charging automatically. During charging, the Secondary LED in the cradle blinks green. When charging is complete, it glows steady green.

Release the battery from the cradle by pulling it back toward the rear of the cradle and tilting it out of its slot.

Note: If you need to replace the Li-ion battery pack, replacements are available from RAE Systems. The part number is 059-3051-000.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. Remove and replace batteries only in areas known to be non-hazardous.

Low Voltage Warning

When the battery’s charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the “empty battery” icon blinks on and off once per second. You should turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Clock Battery

An internal clock battery is mounted on one of the instrument’s printed circuit boards. This long-life battery keeps settings in memory from being lost whenever the Li-ion battery or alkaline batteries are removed. This backup battery should last approximately five years, and must be replaced by an authorized RAE Systems service technician. It is not user-replaceable.

Data Protection While Power Is Off

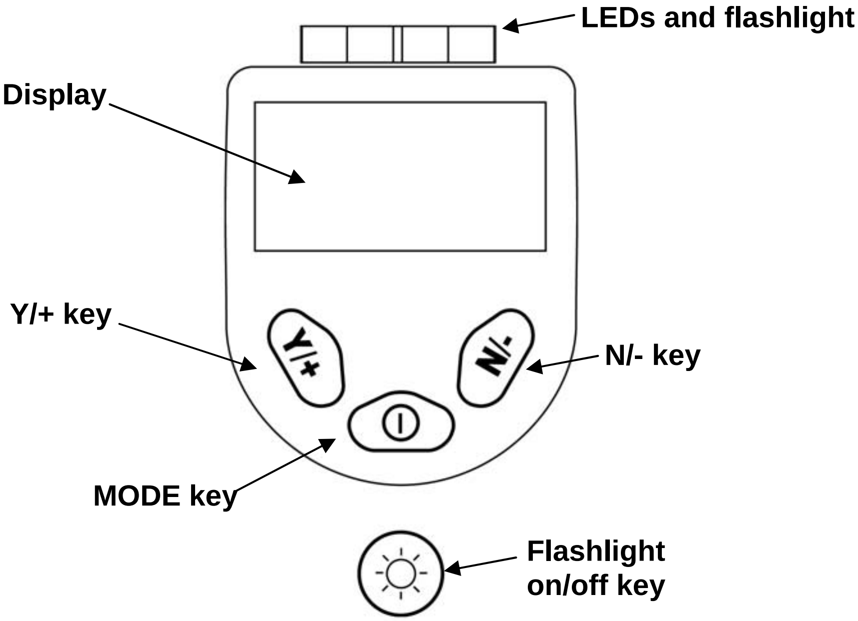
When the instrument is turned off, all the current real-time data including last measured values are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost.

User Interface

The instrument's user interface consists of the display, LEDs, an alarm transducer, and four keys. The keys are:

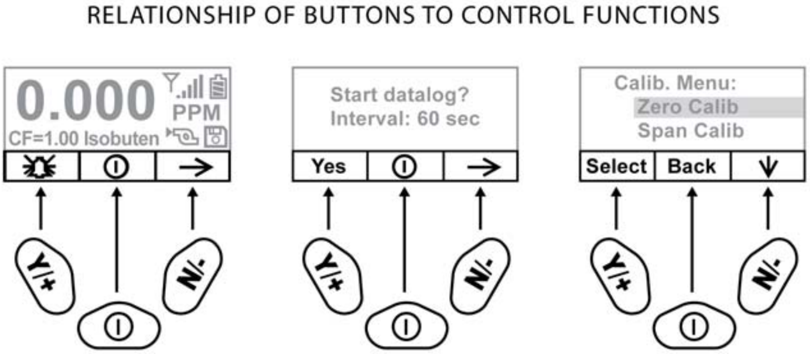
Y/+
MODE
N/-
Flashlight on/off

The LCD display provides visual feedback that includes the reading, time, battery condition, and other functions.



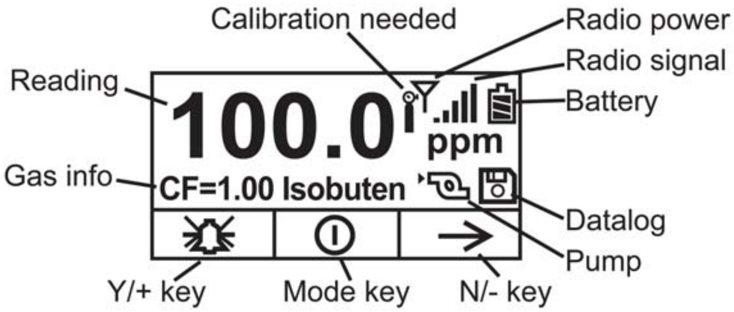
In addition to their labeled functions, the keys labeled Y/+, MODE, and N/- act as "soft keys" that control different parameters and make different selections within the instrument's menus. From menu to menu, each key controls a different parameter or makes a different selection.

Three panes along the bottom of the display are "mapped" to the keys. These change as menus change, but at all times the left pane corresponds to the [Y/+] key, the center pane corresponds to the [MODE] key, and the right pane corresponds to the [N/-] key. Here are three examples of different menus with the relationships of the keys clearly shown:



Display

The display shows the following information:



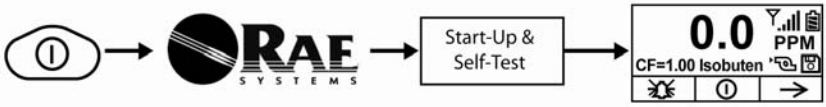
Graph	Graphic representation of concentration plotted over time
Gas info	Tells the Correction Factor and type of calibration gas
Reading	Concentration of gas as measured by the instrument
Calibration needed	Indicates that calibration should be performed
Radio power	Indicates whether radio connection is on or off
Radio signal	Indicates signal strength in 5-bar bargraph
Battery	Indicates battery level in 3 bars
Pump	Indicates that pump is working
Datalog	Indicates whether datalog is on or off
Y/+	Y/+ key's function for this screen
MODE	MODE key's function for this screen
N/-	N/- key's function for this screen

Operating The Instrument

The instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real-time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment, the instrument is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, you should test the instrument and verify the calibration before the first use. After the instrument is fully charged and calibrated, it is ready for immediate operation.

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.



The RAE Systems logo should appear first. (If the logo does not appear, there is likely a problem and you should contact your distributor or RAE Systems Technical Support.) The instrument is now operating and performs self tests. If any tests (including sensor and memory tests fail), refer to the Troubleshooting section of this guide.

Once the startup procedure is complete, the instrument shows a numerical reading screen with icons. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. Once the countdown stops, the instrument is off. Release the Mode key.
3. When you see “Unit off...” release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Operating The Built-In Flashlight

The instrument has a built-in flashlight that helps you point the probe in dark places. Press the flashlight key to turn it on. Press it again to turn it off.

Note: Using the flashlight for extended periods shortens the battery’s operating time before it needs recharging.

Pump Status

IMPORTANT!

During operation, make sure the probe inlet and the gas outlet are free of obstructions. Obstructions can cause premature wear on the pump, false readings, or pump stalling. During normal operation, the pump icon alternately shows inflow and outflow as shown here:

During duty cycling (PID lamp cleaning), the display shows these icons in alternation:

If there is a pump failure or obstruction that disrupts the pump, you will see this icon blinking on and off:

If you see this blinking icon, consult the Troubleshooting section of this guide.

Calibration Status

The instrument displays this icon if it requires calibration:

Calibration is required (and indicated by this icon) if:

- The lamp type has been changed (for example, from 10.6 eV to 9.8 eV).
- The sensor has been replaced.
- It has been 30 days or more since the instrument was last calibrated.
- If you have changed the calibration gas type without recalibrating the instrument.

Operating Modes

Your instrument operates in different modes, depending on the model and its factory default settings. In some cases, you can change modes using a password and using the instrument's navigation. In other cases, you must use ProRAE Studio software.

The default setting for your instrument is:

User Mode: Basic
Operation Mode: Hygiene

This is outlined in detail on page 74.

The other options, covered later in this guide, are:

User Mode: Advanced (page 78)
Operation Mode: Hygiene

User Mode: Advanced (page 82)
Operation Mode: Search

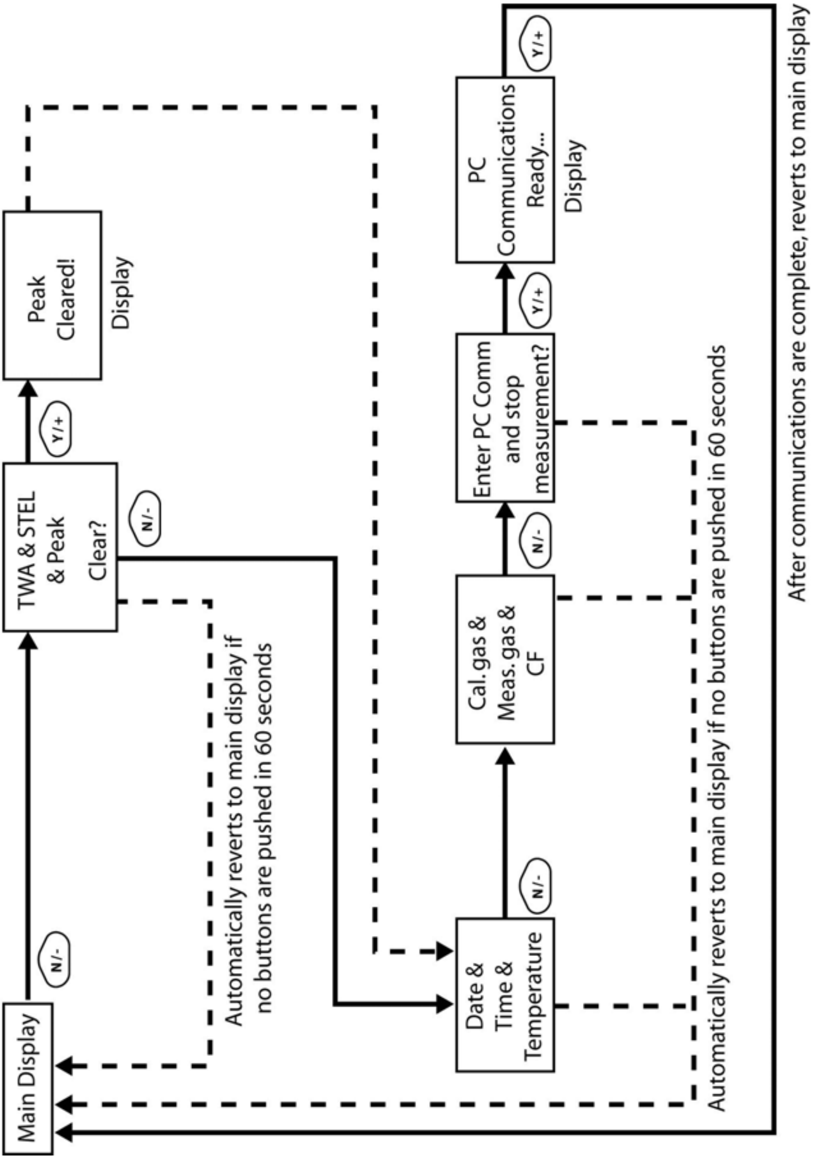
Using ProRAE Studio allows access to other options. In addition, Diagnostic Mode (page 83) is available for service technicians.

Basic User Level/Hygiene Mode (Default Settings)

The instrument is programmed to operate in Basic User Level/Hygiene Mode as its default. This gives you the most commonly needed features while requiring the fewest parameter adjustments.

Pressing [N/-] steps you from one screen to the next, and eventually return to the main display. If you do not press a key within 60 seconds after entering a display, the instrument reverts to its main display.

Note: While viewing any of these screens, you can shut off your instrument by pressing [MODE].



Note: Dashed line indicates automatic progression.

After the instrument is turned on, it runs through the start-up menu. Then the message "**Please apply zero gas…**" is displayed.

At this point, you can perform a zero air (fresh air) calibration. If the ambient air is clean, you can use that. Otherwise, use a cylinder of zero air. Refer to Zero Calibration on page 37 for a more detailed description of zero calibration.

Start zero calibration by pressing Start. You see the message "Zeroing…" followed by a 30-second countdown.

Note: You can press [MODE] to quit, bypassing the zero air calibration.

When zero calibration is complete, you see the message:

Zeroing is done!

Reading = 0.0 ppm

The instrument is now sampling and collecting data.

Note: At the Average & Peak, Date & Time & Temperature, Calibration Gas & Measurement Gas & Correction Factor, and PC Communications screens, the instrument automatically goes to the main display after 60 seconds if you do not push a key to make a selection.

Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn you of the alarm condition.

In addition, the instrument alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, or pump stall.

Alarm Signal Summary

Message	**Condition**	**Alarm Signal**
HIGH	Gas exceeds "High Alarm" limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second*
MAX	Gas exceeds electronics' maximum range	3 beeps/flashes per second*
LOW	Gas exceeds "Low Alarm" limit	2 beeps/flashes per second*
TWA	Gas exceeds "TWA" limit	1 Beep/flash per second*
STEL	Gas exceeds "STEL" limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus "Lamp" message on display
Battery icon flashes	Low battery	1 flash, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

* Hygiene mode only. In Search mode, the number of beeps per second (1 to 7) depends upon the concentration of the sampled gas. Faster rates indicate higher concentrations.

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	Cal Span	unit	Low	High	TWA	STEL
MiniRAE 3000	100	ppm	50	100	10	25

Testing The Alarm

You can test the alarm whenever the main (Reading) display is shown. Press [Y/+], and the audible and visible alarms are tested.

Integrated Sampling Pump

The instrument includes an integrated sampling pump. This diaphragm-type pump that provides a 450 to 550 cc per minute flow rate. Connecting a Teflon or metal tubing with 1/8" inside diameter to the gas inlet port of the instrument, this pump can pull in air samples from 100' (30 m) away horizontally or vertically.

Note: In Search Mode, the pump turns on when a sample measurement is started, and turns off when the sample is manually stopped.

If liquid or other objects are pulled into the inlet port filter, the instrument detects the obstruction and immediately shuts down the pump. The alarm is activated and a flashing pump icon is displayed.

You should acknowledge the pump shutoff condition by clearing the obstruction and pressing the [Y/+] key while in the main reading display to restart the pump.

Backlight

The LCD display is equipped with an LED backlight to assist in reading the display under poor lighting conditions.

Datalogging

During datalogging, the instrument displays a disk icon to indicate that datalogging is enabled. The instrument stores the measured gas concentration at the end of every sample period (when data logging is enabled). In addition, the following information is stored: user ID, site ID, serial number, last calibration date, and alarm limits. All data are retained (even after the unit is turned off) in non-volatile memory so that it can be down- loaded at a later time to a PC.

Datalogging event

When Datalogging is enabled, measurement readings are being saved. These data are stored in “groups” or “events.” A new event is created and stored each time the instrument is turned on and is set to automatic datalogging, or a configuration parameter is changed, or datalogging is interrupted. The maximum time for one event is 24 hours or 28,800 points. If an event exceeds 24 hours, a new event is automatically created. Information, such as start time, user ID, site ID, gas name, serial number, last calibration date, and alarm limits are recorded.

Datalogging sample

After an event is recorded, the unit records a shorter form of the data. When transferred to a PC running ProRAE Studio, this data is arranged with a sample number, time, date, gas concentration, and other related information.

Auto/Manual/Snapshot Datalogging

The instrument has three datalog types:

Auto	Default mode. Collects datalog information when the instrument is sampling.
Manual	Datalogging occurs only when the instrument’s datalogging is manually started (see page 63 for details).
Snapshot	Datalogs only during snapshot (single-event capture, initiated by pressing [MODE]) sampling. See page 65 for details.

Note: You can only choose one datalog type to be active at a time.

Accessories

The following accessories are included with the instrument:

- An AC Adapter (Battery Charger)
- Alkaline battery adapter
- External Filter
- Organic Vapor Zeroing kit

Hard-case kits also include these accessories:

- Calibration adapter
- Calibration regulator and Flow controller

Standard Kit & Accessories

AC Adapter (Battery Charger)

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

Ne charger les batteries que dans emplacements designés non-dangereuses.

A battery charging circuit is built into the instrument cradle. It only needs a regular AC to 12 VDC adapter (wall-mount transformer, part number 500-0114-000) to charge the instrument.

To charge the battery inside the instrument:

1. Power off the instrument.
2. Connect the AC adapter to the DC jack on the instrument's cradle. If the instrument is off, it automatically turns on.
3. While charging, the display message shows "Charging." The Primary LED on the cradle flashes green when charging.
4. When the battery is fully charged, the LED changes to glowing green continuously, and the message "Fully charged" appears on the

display. If there is a charging error, the LED glows red continuously.

A completely discharged instrument can be charged to full capacity within 8 hours. Batteries drain slowly even if an instrument is off. Therefore, if the instrument has been in storage or has not been charged for several days or longer, check the charge before using it.

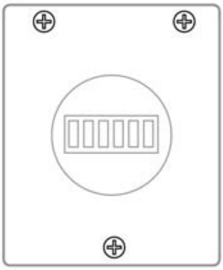
The factory-supplied battery is designed to last for 16 hours of normal operation (no alarm), for a new battery under the optimum circumstances. As the battery becomes older or is subject to adverse conditions (such as cold ambient temperature), its capacity will be significantly reduced.

Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500) and provides approximately 12 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

To insert batteries into the adapter:

1. Remove the three Philips-head screws to open the compartment in the adapter.
2. Insert four fresh AA batteries as indicated by the polarity (+/-) markings.
3. Replace the cover. Replace the three screws.



To install the adapter in the instrument:

1. Remove the Li-ion battery pack from the instrument by sliding the tab and tilting out the battery.
2. Replace it with the alkaline battery adapter
3. Slide the tab back into place to secure the battery adapter.

IMPORTANT!

Alkaline batteries cannot be recharged. The instrument's internal circuit detects alkaline batteries and will not allow recharging. If you place the instrument in its cradle, the alkaline battery will not be recharged. The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the instrument. If you try to charge an alkaline batteries installed in the instrument, the instrument's display will say, "Alkaline Battery," indicating that it will not charge the alkaline batteries.

Note: When replacing alkaline batteries, dispose of old ones properly.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge the battery only in areas known to be non-hazardous. Remove and replace the battery only in areas known to be non-hazardous.

External Filter

The external filter is made of PTFE (Teflon®) membrane with a 0.45 micron pore size to prevent dust or other particles from being sucked into the sensor manifold, which would cause extensive damage to the instrument. It prolongs the operating life of the sensor. To install the external filter, simply connect it to the instrument's inlet tube.

Optional Accessories

Calibration Adapter

The calibration adapter for the instrument is a simple 6-inch Tygon tubing with a metal adapter on one end. During calibration, simply insert the metal adapter into the regular gas inlet probe of the instrument and the tubing to the gas regulator on the gas bottle.

Calibration Regulator

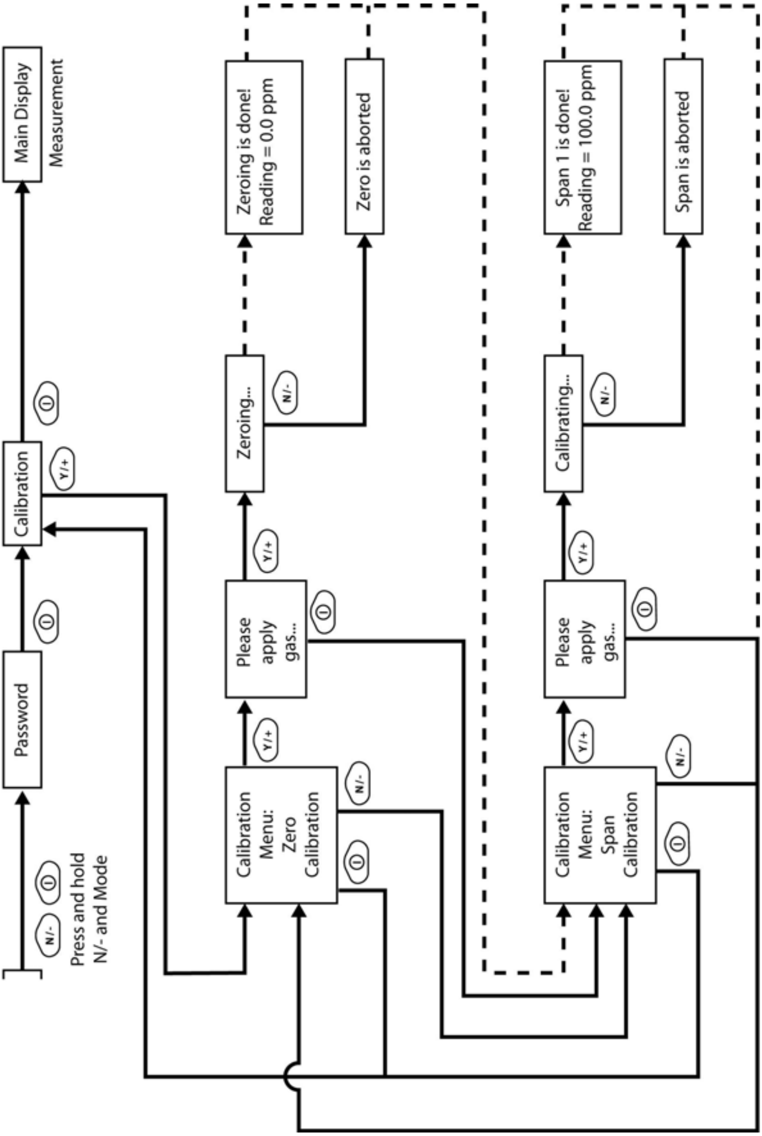
The Calibration Regulator is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the instrument during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a demand-flow regulator or a Tedlar gas bag may be used to match the pump flow precisely.

Organic Vapor Zeroing Kit

The Organic Vapor Zeroing Kit is used for filtering organic air contaminants that may affect the zero calibration reading. To use the Organic Vapor Zeroing Kit, simply connect the filter to the inlet port of the instrument.

Standard Two-Point Calibration (Zero & Span)

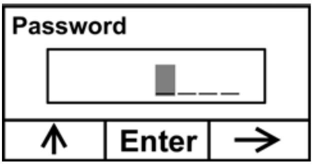
The following diagram shows the instrument's calibrations in Basic/Hygiene mode.



Note: Dashed line indicates automatic progression.

Entering Calibration

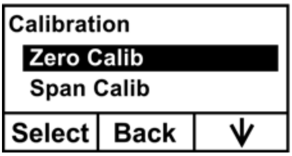
1. Press and hold [MODE] and [N/-] until you see the Password screen.



2. In Basic User Level, you do not need a password to perform calibrations. Instead of inputting a password, enter calibration by pressing [MODE].

   Note: If you inadvertently press [Y/+] and change any of the numbers, simply press [MODE] and you will be directed to the calibration menu.

The Calibration screen is now visible with Zero Calibration highlighted.



These are your options:

- Press [Y/+] to select the highlighted calibration (Zero Calib or Span Calib).
- Press [MODE] to exit calibration and return to the main display and resume measurement.
- Press [N/-] to toggle the highlighted calibration type.

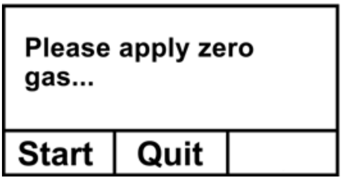
Zero (Fresh Air) Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the instrument to a “fresh” air source such as from a cylinder or Tedlar bag (optional accessory). The “fresh” air is clean, dry air without organic impurities and an oxygen value of 20.9%. If such an air cylinder is not available, any clean ambient air without detectable contaminants or a charcoal filter can be used.

At the Zero Calibration menu, you can proceed to perform a Zero calibration or bypass Zero calibration and perform a Span calibration. You may also go back to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to start calibration.
- Press [MODE] to quit and return to the main calibration display.

If you have pressed [Y/+] to enter Zero calibration, then you will see this message:



Please apply zero gas...

1. Turn on your Zero calibration gas.
2. Press [Y/+] to start calibration.

   Note: At this point, you may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu, highlighted for Span calibration.

3. Zero calibration starts a 30-second countdown and displays this message:

   Zeroing...

During the zeroing process, the instrument performs the Zero calibration automatically and does not require any action on your part.

Note: To abort the zeroing process at any time and proceed to Span calibration, press [N/-] at any time while zeroing is being performed. You will see a confirmation message that says "Zero aborted!" and then the Span calibration menu appears.

When Zero calibration is complete, you see this message:

Zeroing is done!
Reading = 0.0 ppm

The instrument will then show the Calibration menu on its display, with Span Calib highlighted.

Span Calibration

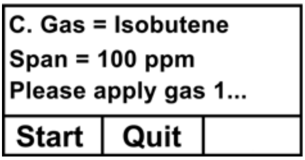
This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:



C. Gas = Isobutene
Span = 100 ppm
Please apply gas 1...

1. Turn on your span calibration gas.
2. Press [Y/+] to initiate calibration.

Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will abort the span calibration and take you directly to the Calibration menu for Zero calibration.

3. Span calibration starts and displays this message:

Calibrating...

During the Span calibration process, there is a 30-second countdown and the instrument performs the Span calibration automatically. It requires no actions on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says "Span is aborted!" and then the Zero calibration menu appears. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you see a message similar to this (the value is an example only):

Span 1 is done!
Reading = 100.0 ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Two-Point Calibration In Basic User Level

When you are done performing calibrations, press [MODE], which corresponds with “Back” on the display. You will see the following message:

Updating settings…

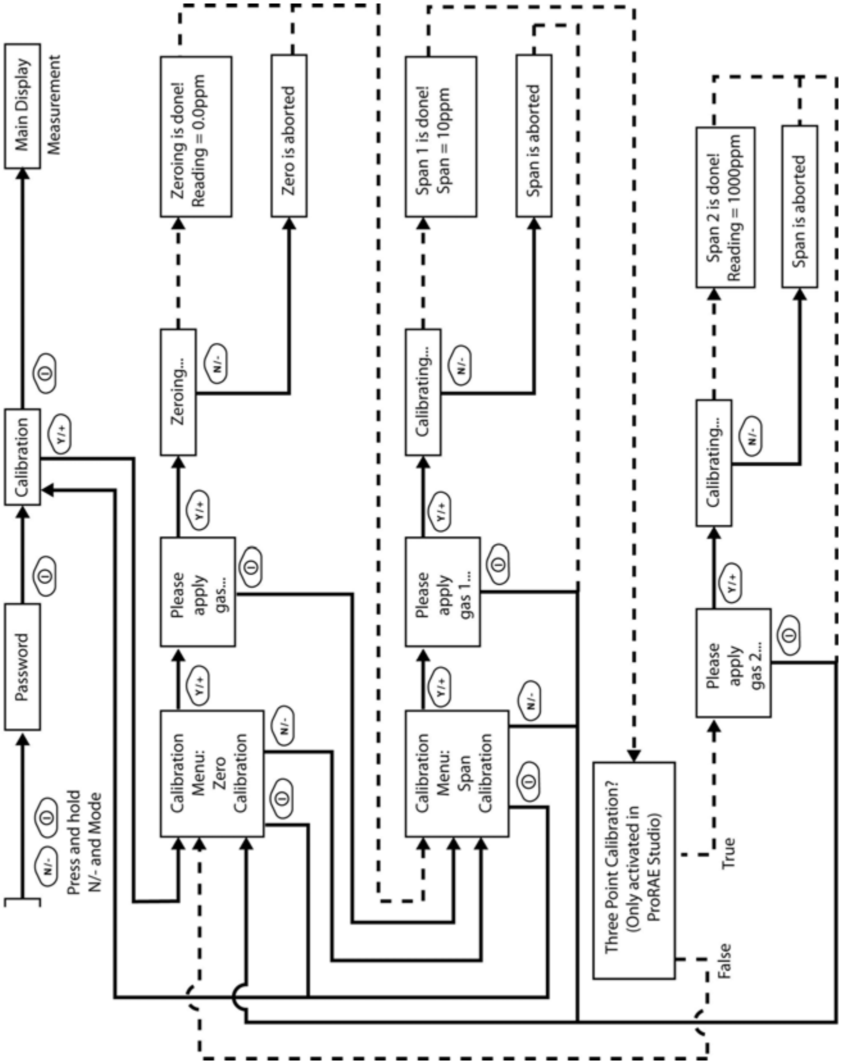
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Three-Point Calibration

For enhanced accuracy, it is possible to perform a second Span calibration in addition to the Zero and Span calibrations outlined in the previous section. Your instrument first must be set to allow this third calibration. This requires using ProRAE Studio software and a PC, as well as a higher concentration of calibration gas.

Note: Once the third calibration is set, you do not need to use ProRAE Studio to allow future 3-point calibrations. Also, you can only disable 3-point calibration capability by using ProRAE Studio again.

Perform the Zero and Span calibrations. After the first Span calibration (Span 1) is completed, the display a second Span calibration (Span 2) can be performed. The process is identical to the first calibration. As in the Span 1 calibration, you may exit and return to the Zero calibration screen if you choose not to perform this calibration or to abort it.



Note: Dashed line indicates automatic progression.

Span 2 Calibration

A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure.

Note: This gas should be of a higher concentration than the gas used for Span 1 calibration.

Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span 2 calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:

Please apply gas...

4. Turn on your span calibration gas.
5. Press [Y/+] to initiate calibration.

Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu for Zero calibration.

6. Span calibration starts a 30-second countdown and displays this message:

Calibrating...

During the Span calibration process, the instrument performs the Span calibration automatically and does not require any action on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says "Span is aborted!" and then the Zero calibration menu will appear. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you will see a message similar to this (the value shown here is for example only):

Span 2 is done!
Reading = 1000 ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Three-Point Calibration

When you are done performing calibrations, press [MODE], which corresponds with "Back" on the display. You will see the following message:

Updating settings…

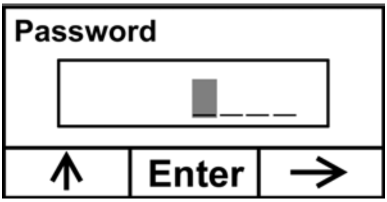
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Programming Mode

Programming Mode can be entered from either Hygiene Mode or Search Mode. If the current user mode is Basic, you must provide a 4-digit password to enter.

Entering Programming Mode

1. Press and hold [MODE] and [N/-] until you see the Password screen.



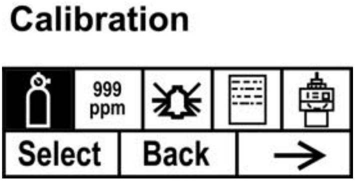
2. Input the 4-digit password:

- Increase the number from 0 through 9 by pressing [Y/+].
- Step from digit to digit using [N/-].
- Press [MODE] when you are done.

If you make a mistake, you can cycle through the digits by pressing [N/-] and then using [Y/+] to change the number in each position.

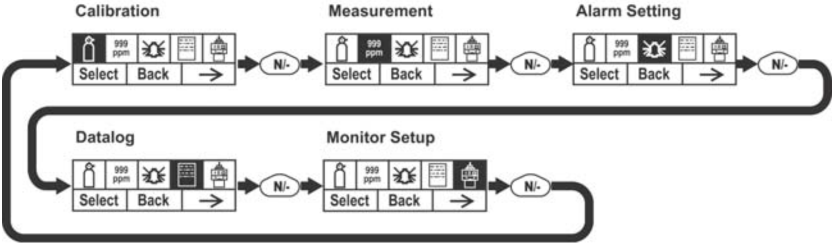
Note: The default password is 0000.

When you have successfully entered Programming Mode, you see this screen:



Note: The password can only be changed by connecting the instrument to a PC running ProRAE Studio software. Follow the instructions in ProRAE Studio to change it.

The Calibration label is shown and its icon is highlighted, but you can press [N/-] to step from one programming menu to the next, with the name of the menu shown at the top of the display and the corresponding icon highlighted. As you repeatedly press [N/-], the selection moves from left to right, and you see these screens:



Note: When you reach Monitor Setup and press [N/-], the menu cycles back to Calibration.

Programming Mode Menus

The Programming Mode allows anyone with the password to change the instrument's settings, calibrate the instrument, modify the sensor configuration, enter user information, etc. Programming Mode has five menus. Each menu includes several sub-menus to perform additional programming functions.

This table shows the menus and sub-menus:

	999 ppm			
Calibration	**Measurement**	**Alarm Setting**	**Datalog**	**Monitor Setup**
Zero Calibration	Meas. Gas	High Alarm	Clear Datalog	Op Mode
Span Calibration	Meas. Unit	Low Alarm	Interval	Site ID
		STEL Alarm	Data Selection	User ID
		TWA Alarm	Datalog Type	User Mode
		Alarm Type		Date
		Buzzer & Light		Time
				Pump Duty Cycle
				Pump Speed
				Temperature Unit
				Language
				Radio Power
				Real Time Protocol
				Power On Zero
				Unit ID
				LCD Contrast

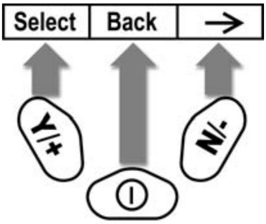
Once you enter Programming Mode, the LCD displays the first menu, Calibration. Each subsequent menu is accessed by pressing [N/-] repeatedly until the desired menu is displayed. To enter a sub-menu of a menu, press [Y/+].

Exiting Programming Mode

To exit Programming Mode and return to normal operation, press [MODE] once at any of the programming menu displays. You will see "Updating Settings…" as changes are registered and the mode changes.

Navigating Programming Mode Menus

Navigating through the Programming Mode menus is easy and consistent, using a single interface format of "Select," "Back" and "Next" at the top level. The three control buttons correspond to these choices as shown:



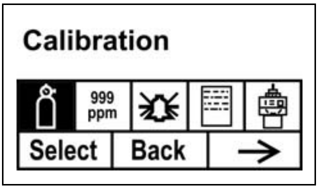
Note: Pressing [MODE] in the Programming Mode's top level causes the instrument to exit Programming Mode and return to monitoring.

The three keys perform the following functions in Programming Mode:

Key	Function in Programming Mode
[MODE]:	Exit menu when pressed momentarily or exit data entry mode
[Y/+]:	Increase alphanumerical value for data entry or confirm (yes) for a question
[N/-]:	Provides a "no" response to a question

Calibration

Two types of calibration are available: Zero (fresh air) and Span.



Select Zero or Span Calibration by pressing [N/+]. Once your choice is highlighted, press [Y/+].

Zero Calibration

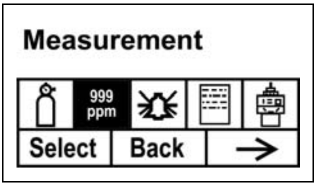
The procedure for performing a zero calibration is covered on page 35.

Span Calibration

The procedure for performing a basic span calibration is covered on page 35.

Measurement

The sub-menus for Measurement are Measurement Gas and Measurement Unit.



Meas. Gas

Measurement gases are organized in four lists:

- My List is a customized list of gases that you create. It contains a maximum of 10 gases and can only be built in ProRAE Studio on a PC and transferred to the instrument. **Note:** The first gas in the list is always isobutylene (it cannot be removed from the list).
- Last Ten is a list of the last ten gases used by your instrument. The list is built automatically and is only updated if the gas selected from Custom Gases or Library is not already in the Last Ten. This ensures that there is no repetition.
- Gas Library is a library that consists of all the gases found in RAE Systems' Technical Note TN-106 (available online at www.raesystems.com).
- Custom Gases are gases with user-modified parameters. Using ProRAE Studio, all parameters defining a gas can be modified, including the name, span value(s), correction factor, and default alarm limits.

1. Scroll through each list by pressing [N/-].
2. Press [Y/+] to select one (My List, Last Ten, Gas Library, or Custom Gases).

3. Once you are in one of the categories, press [N/-] to scroll through its list of options and [Y/+] to select one. (If you press [MODE], you exit to the next submenu.)
4. Press [Y/+] to save your choice or [N/-] to undo your selection.

Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

Meas. Unit

Standard available measurement units include:

Abbreviation	**Unit**	**MiniRAE 3000**
ppm	parts per million	Yes
ppb	parts per billion	
mg/m3	milligrams per cubic meter	Yes
ug/m3	micrograms per cubic meter	

- Scroll through the list by pressing [N/-].
- Select by pressing [Y/+].
- Save your selection by pressing [Y/+] or undo your selection by pressing [N/-].

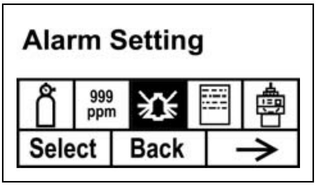
Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

Alarm Setting

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings: Low, High, TWA and STEL). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn of the alarm condition.

An alarm signal summary is shown on page 27.

In this menu, you can change the High and Low alarm limits, the STEL limit, and the TWA. Press [Y/+] to to enter the Alarm Setting menu. **Note:** All settings are shown in ppb (parts per billion), or µg/m^3 (micrograms per cubic meter), depending on your setting.



1. Scroll through the Alarm Limit sub-menu using the [N/-] key until the display shows the desired limit to be changed (High Alarm, Low Alarm, STEL Alarm, and TWA Alarm)
2. Press [Y/+] to select one of the alarm types. The display shows a flashing cursor on the left-most digit of the previously stored alarm limit.
3. Press [Y/+] to increase each digit's value.
4. Press [N/-] to advance to the next digit.
5. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

Press [MODE] when you are done.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

When all alarm types have been changed or bypassed, press [MODE] to exit to the Programming Menu.

High Alarm

You can change the High Alarm limit value. The value is typically set by the instrument to match the value for the current calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the High Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.
When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

Press [Y/+] to save the changes.
Press [N/-] to undo the changes and revert to the previous settings.

Low Alarm

You can change the Low Alarm limit value. The value is typically set by the instrument to match the value for the current calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the Low Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

STEL Alarm

You can change the STEL Alarm limit value. The value is typically set by the instrument to match the value for the calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the STEL Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

TWA Alarm

You can change the TWA (time-weighted average) Alarm limit value. The value is typically set by the instrument to match the value for the calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the TWA Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices:

- Save
- Undo

You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Alarm Type

There are two selectable alarm types:

Latched	When the alarm is triggered, you can manually stop the alarm. The latched setting only controls alarms for High Alarm, Low Alarm, STEL Alarm, and TWA alarm. **Note:** To clear an alarm when the instrument is set to “Latched,” press [Y/+] when the main (Reading) display is shown.
Automatic Reset	When the alarm condition is no longer present, the alarm stops and resets itself.

1. Press **[N/-]** to step from one alarm type to the other.
2. Press **[Y/+]** to select an alarm type.

When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Buzzer & Light

The buzzer and light alarms can be programmed to be on or off individually or in combination. Your choices are:

- Both on
- Light only
- Buzzer only
- Both off

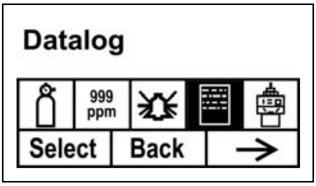
1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates your selection).
3. When you have completed your selections, press [MODE].

   You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Datalog

The instrument calculates and stores the concentration and ID of each sample taken. In the datalog sub-menu, a user can perform the tasks and functions shown below.



1. Scroll through the Datalog sub-menu using the [N/-] key until the display shows the desired parameter to be changed:

   Clear Datalog
   Interval
   Data Selection
   Datalog Type

2. Press [Y/+] to make your selection. Exit by pressing [MODE] for Back.

Clear Datalog

This erases all the data stored in the datalog.

Note: Once the datalog is cleared, the data cannot be recovered.

Press [Y/+] to clear the datalog. The display asks, "Are you sure?"

- Press [Y/+] if you want to clear the datalog. When it has been cleared, the display shows "Datalog Cleared!"
- Press [N/-] if you do not want to clear the datalog.

The display changes, and you are taken to the next sub-menu, Interval.

Interval

Intervals are shown in seconds. The default value is 60 seconds. The maximum interval is 3600 seconds.

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Data Selection

Data Selection allows you to select which types of data are stored and made available when you offload your datalog to a computer via ProRAE Studio software.

You can choose any or all of three types of data (you must choose at least one):

- Average
- Maximum
- Minimum

1. Press [N/-] to step from one option to the next. The highlighter indicates your choice.
2. Press [Y/+] to toggle your selection on or off (the check box indicates "on" with an "X").
3. When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Datalog Type

The instrument has three datalog types:

Auto	Default mode. Collects datalog information when the instrument is sampling.
Manual	Datalogging occurs only when the instrument's datalogging is manually started (see below for details).
Snapshot	Datalogs only during single-event capture sampling.

Note: You can only choose one datalog type to be active at a time.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.

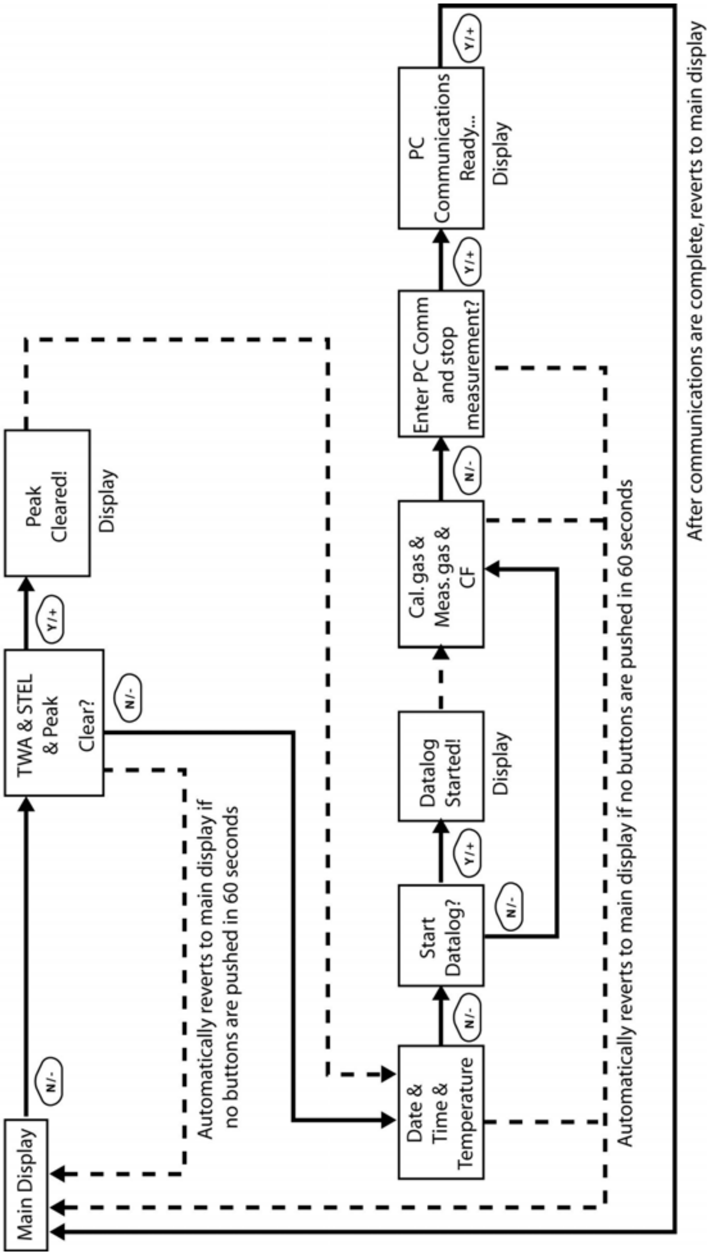
Press [N/-] to undo the changes and revert to the previous settings.

Manual Datalog

When the instrument is set to Manual Datalog, you turn datalogging on and off by stepping through the displays from the Main Display, and then pressing the keys to select datalog on/off functions.

- When you reach the screen that says "Start Datalog?" press [Y/+] to start it. You see "Datalog Started," confirming that datalogging is now on.

When you reach the screen that says "Stop Datalog?" press [Y/+] to stop it. You see "Datalog Stopped," confirming that datalogging is now off.



Note: Dashed line indicates automatic progression.

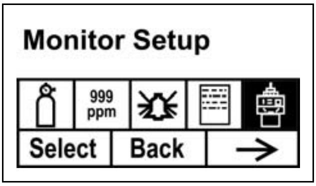
Snapshot Datalog

When the instrument is in Snapshot datalogging mode, it captures a single "snapshot" of the data at the moment of your choosing. Whenever the instrument is on and it is set to Snapshot, all you have to do is press [MODE] each time you want to capture a snapshot of the data at that instant.

When you send the data to a computer using ProRAE Studio, the data snapshots are uniquely identified by time and other parameters.

Monitor Setup

Many settings can be accessed in this menu, including setting the date and time and adjusting the pump's on/off duty cycle.



Op Mode

Under Monitor Setup is "Op Mode."

Press [Y/+] to select.

You see two options (one is highlighted):

Hygiene
Search

The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-]. The highlighting changes from one to the other each time you press [N/-].
2. Press [Y/+] to select that mode for the instrument.
3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

Site ID

Enter an 8-digit alphanumeric/character Site ID in the programming mode. This Site ID is included in the datalog report.

1. Press [Y/+] and the display shows the current site ID. Example: "RAE00001." Note that the left-most digit flashes to indicate it is the selected one.
2. Press [Y/+] to step through all 26 letters (A to Z) and 10 numerals (0 to 9).
   Note: The last four digits must be numerals.
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all eight digits of the new site ID are entered.

Press [MODE] to exit.

If there is any change to the existing site ID, the display shows "Save?" Press [Y/+] to accept the new site ID. Press [N/-] to discard the change and move to the next sub-menu.

User ID

Enter an 8-digit alphanumeric User ID in the programming mode. This User ID is included in the datalog report.

1. Press [Y/+] and the display shows the current User ID. Example: "RAE00001." Note that the left-most digit flashes to indicate it is the selected one.
2. Press [Y/+] to step through all 26 letters (A to Z) and 10 numerals (0 to 9).
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

Repeat this process until all eight digits of the new User ID are entered.

Press [MODE] to exit.

If there is any change to the existing User ID, the display shows "Save" Press [Y/+] to accept the new site ID. Press [N/-] to discard (undo) the change and move to the next sub-menu.

User Mode

The instrument has two user modes:

Basic Basic users can only see and use a basic set of functions.
Advanced Advanced users can see all screens and perform all available functions.

Note: The default value for User Mode is Basic.

To change the User Mode:

1. Press [N/-] to step from one option to the next. The highlighting changes each time you press [N/-].
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
4. Press [Y/+] to accept the new User Mode. Press [N/-] to discard the change and move to the next sub-menu.

Date

The Date is expressed as Month/Day/Year, with two digits for each.

1. Press [Y/+] and the display shows the current date. Note that the left-most digit flashes to indicate it is selected.
2. Press [Y/+] to step through all 10 numerals (0 to 9).
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

Repeat this process until all six digits of the new date are entered.

Press [MODE] to exit.

- Press [Y/+] to save the new date.
- Press [N/-] to undo the change and move to the next sub-menu.

Time

The Time is expressed as Hours/Minutes/Seconds, with two digits for each. The time is in 24-hour (military) format.

1. Press [Y/+] and the display shows the current time. Note that the left-most digit flashes to indicate it is selected.
2. Press [Y/+] to step through all 10 numerals (0 to 9).

3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all six digits of the new time are entered.

Press [MODE] to exit.

- Press [Y/+] to save the new date.
- Press [N/-] to undo the change and move to the next sub-menu.

Duty Cycle

The pump's duty cycle is the ratio of its on time to off time. The duty cycle ranges from 50% to 100% (always on), and the period is 10 seconds. Therefore, a duty cycle of 60% means that the pump is on for 6 seconds and off for four seconds. Duty cycling is employed by the instrument to clean the PID. A lower duty cycle has a greater effect on keeping the PID clean than a higher duty cycle.

Important! Pump duty cycling is interrupted when the instrument senses a gas. The pump's duty cycle is disabled when the measurement is greater than the 2ppm threshold and is re-enabled when the reading falls below 90% of the threshold (1.8 ppm).

1. Press [Y/+] to increase the value.
2. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new duty cycle value.
   - Press [N/-] to undo the change and move to the next sub-menu.

Temperature Unit

The temperature display can be switched between Fahrenheit and Celsius units.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
    - Press [Y/+] to save the new temperature unit.
    - Press [N/-] to undo the change and move to the next sub-menu.

Pump Speed

The pump can operate at two speeds, high and low. Running at low speed is quieter and conserves a small amount of power. There is almost no difference in sampling accuracy.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
    - Press [Y/+] to save the new temperature unit.
    - Press [N/-] to undo the change and move to the next sub-menu.

Language

English is the default language, but other languages can be selected for the instrument.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
    - Press [Y/+] to save your new language choice.
    - Press [N/-] to undo it and return to the previous language selection.

Radio Power

The radio connection can be turned on or off.

1. Press [N/-] to step from one option to the next (on or off).
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates that the option is selected).
3. When you have completed your selection, press [MODE].

    - Press [Y/+] to accept the new radio setting (on or off).
    - Press [N/-] to discard the change and move to the next sub-menu.

Real Time Protocol

Real Time Protocol is the setting for data transmission.

The choices are:

P2M (cable)	Point to multipoint. Data is transferred from the instrument to multiple locations using a wired connection. Default data rate: 19200 bps.
P2P (cable)	Point to point. Data is transferred only between the instrument and one other location, such as a computer. Default data rate: 9600 bps.
P2M (wireless)	Point to multipoint, wireless. Data is transferred wirelessly and can be received by multiple receivers.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new real-time communications protocol.
   - Press [N/-] to undo the change and move to the next sub-menu.

Power On Zero

When Power On Zero is on, the instrument performs a zero calibration when it is turned on.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates your selection).
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the change.
   - Press [N/-] to discard the change and move to the next sub-menu.

Unit ID

This three-digit number keeps data separated by instrument when more than one instrument is used in a network. If multiple sensing units are attempting to communicate with the same Host, then the units must all have a different Unit ID.

1. Press [Y/+] to step through all 10 numerals (0 to 9). If you pass the numeral you want, keep pressing [Y/+]. After it counts up to 9, it starts counting up from 0 again.
2. Press [N/-] to advance to the next digit. The next digit to the right flashes.

Repeat this process until all three digits of the Unit ID are entered.

3. Press [MODE] when you are done.
   - Press [Y/+] to save the change.
   - Press [N/-] to discard the change and move to the next sub-menu.

LCD Contrast

The display's contrast can be increased or decreased from its default setting. You may not need to ever change the default setting, but sometimes you can optimize the display to suit extreme temperature and ambient brightness/darkness conditions.

- The minimum value is 20.
- The maximum value is 60.

1. Press [Y/+] to increase the value or [N/-] to decrease the value.
2. Press [MODE] to save your selection.
   - Press [Y/+] to save your new contrast value.
   - Press [N/-] to undo it and return to the previous value.

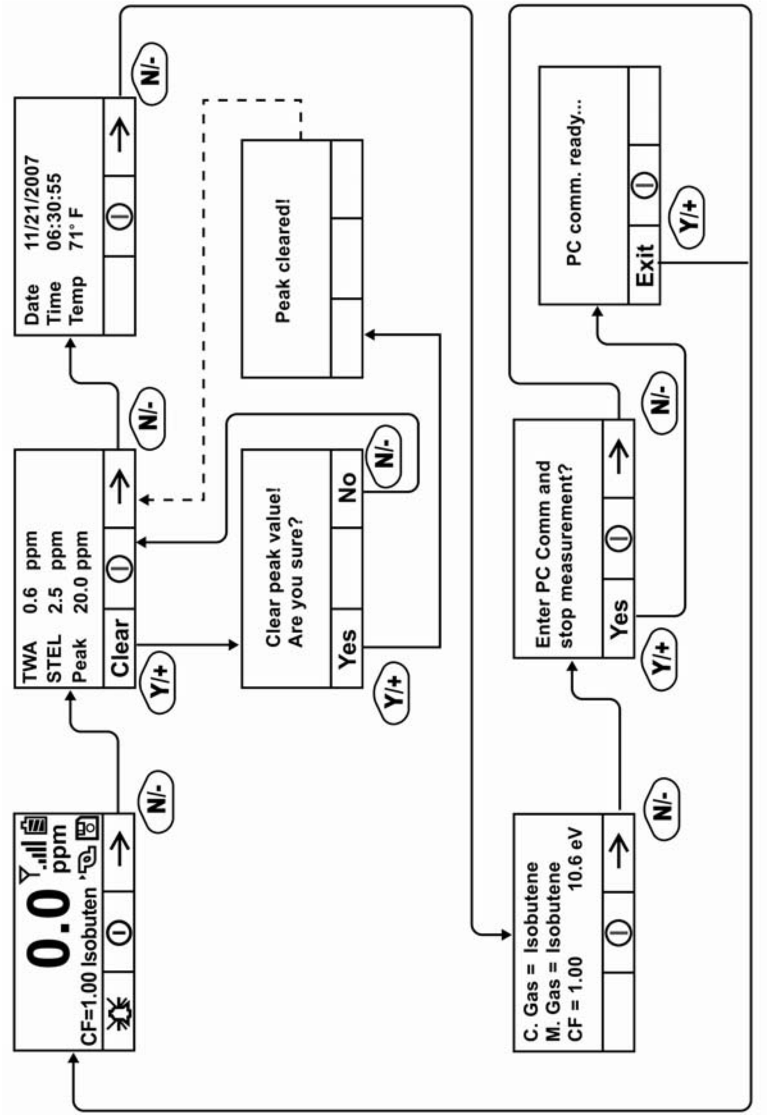
Hygiene Mode

The instrument usually operates in Hygiene Mode, which provides basic functionality. However, it is possible to operate it in a second mode called Search Mode. Here are the primary differences:

Hygiene Mode:	Automatic measurements, continuously running and datalogging, and calculates additional exposure values.
Search Mode:	Manual start/stop of measurements and display of certain exposure values.

Basic User Level & Hygiene Mode

The default setting is navigated in the following way:



Note: Dashed line indicates automatic progression.

Pressing [N/-] steps you from screen to screen. Options include clearing the Peak value and turning on the instrument’s PC Communications for data transfer to a PC.

Entering Search Mode From Hygiene Mode

In order to change the instrument's operational mode from Hygiene Mode to Search Mode, you must enter the password-protected Programming Mode:

1. Hold [MODE] and [N/-] until you see the password screen.
2. Use [Y/+] to increment to the number you want for the first digit. (If you pass by the desired number, press [Y/+] until it cycles through to 0 again. Then press [Y/+] until you reach the desired number.)
3. Press [N/-] to advance to the next digit.
4. Again press [Y/+] to increment the number.
5. Press [N/-] to advance to the next digit.

Continue the process until all four numbers of the password have been input. Then press [MODE] to proceed.

The screen changes to icons with the label "Calibration."

1. Press [N/-] to advance to "Monitor Setup."
2. Press [Y/+] to select Monitor Setup.

Under Monitor Setup, you will see "Op Mode."

Press [Y/+] to select.

You will see:

Hygiene
Search

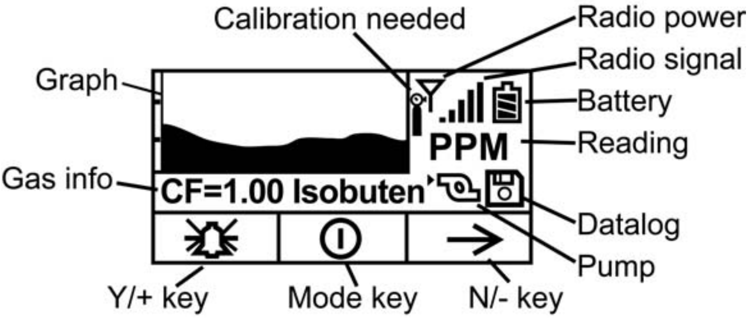
The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-].
2. Press [Y/+] to place the instrument into the selected mode.

3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

Optional Graphic Screen In Search Mode

Using ProRAE Studio, you can set your instrument to show a graphic display instead of a numeric display of ongoing data. Consult your ProRAE Studio disc for information.



During sampling, the display's readings are shown numerically, plus the graph tracks the highest readings over time. The numeric reading alternates between the value and the measurement units, as well:

Advanced User Level (Hygiene Mode Or Search Mode)

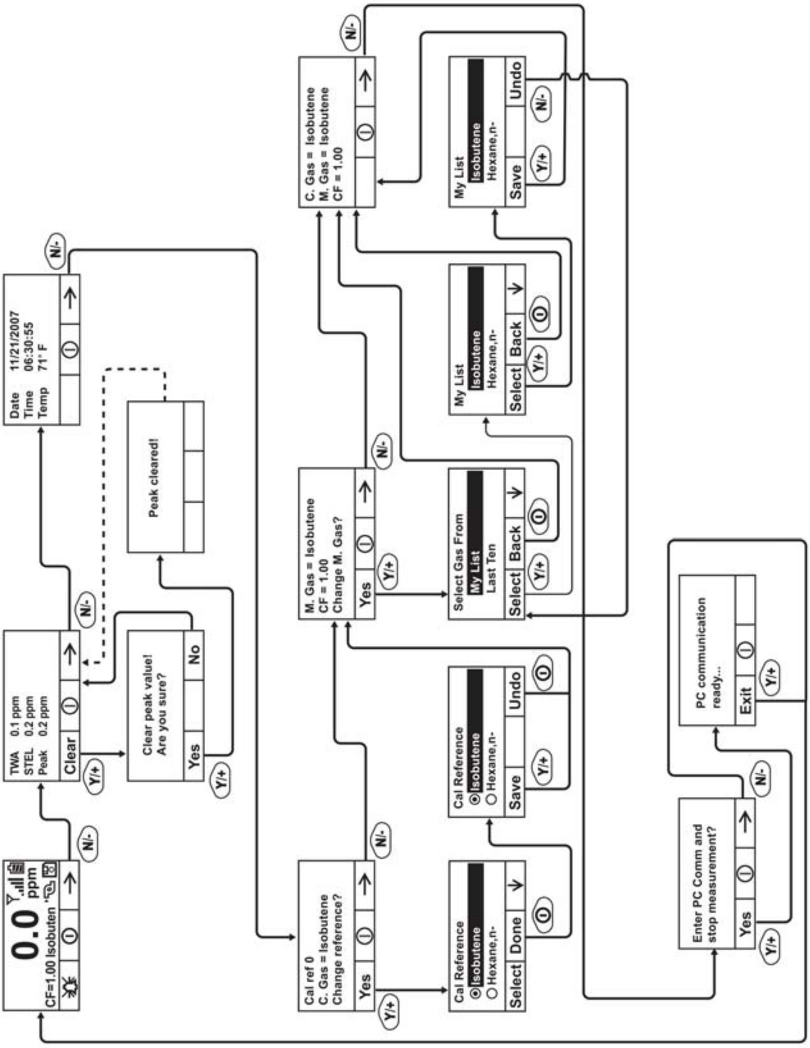
The User Mode called Advanced User Level allows a greater number of parameters to be changed than Basic User Level. It can be used with either of the Operation Modes, Hygiene Mode or Search Mode.

Advanced User Level & Hygiene Mode

With the instrument in Operation Mode: Hygiene Mode, enter User Mode: Advanced User Level (refer to the section called Monitor Mode for instructions).

Once you are in Advanced User Level and Hygiene Mode together, you can change the calibration reference and measurement gas, in addition to performing normal monitoring functions.

Pressing [N/-] progresses through the screens, while pressing [Y/+] selects options. Pressing [MODE] makes menu choices when it is shown for “Done” or “Back.” Pressing and holding [Mode] whenever the circle with a vertical line in the middle is shown activates the countdown to shutoff.

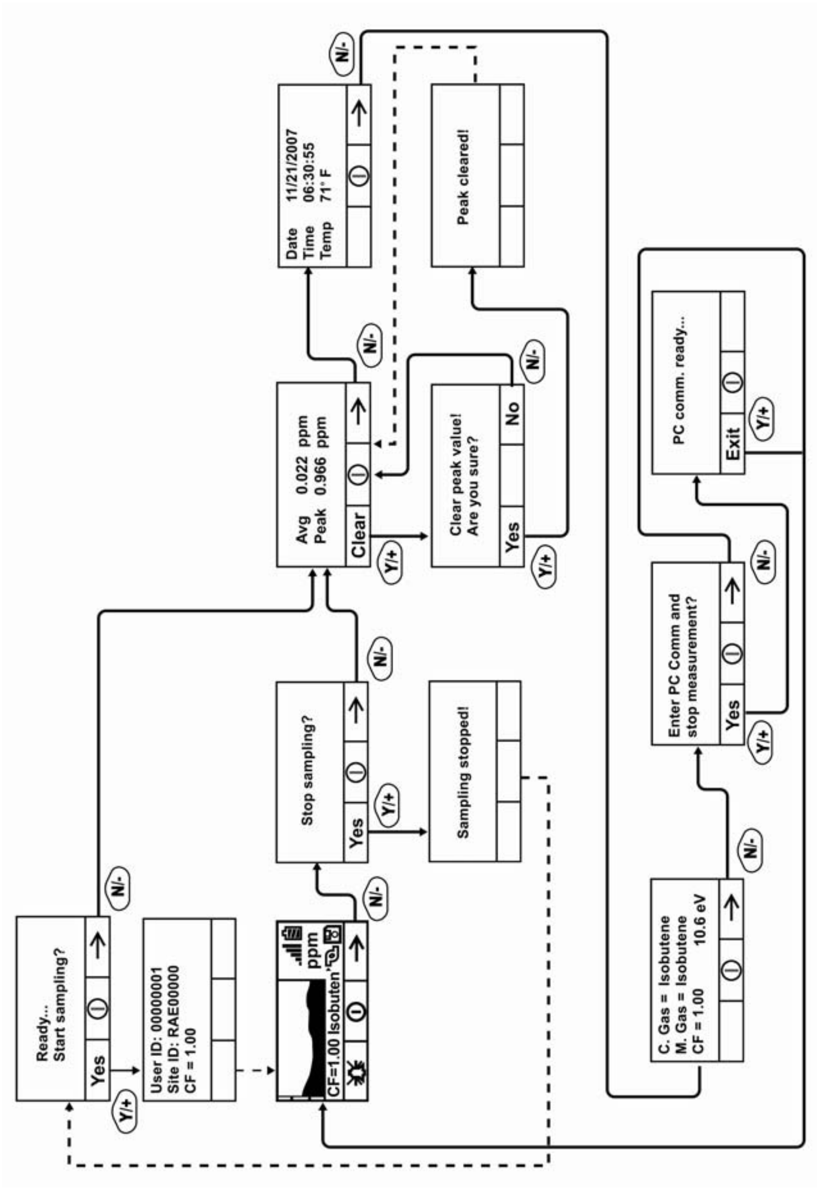


Note: Dashed line indicates automatic progression.

Basic User Level & Search Mode

With the instrument in Operation Mode: Search Mode, enter User Mode and select Basic User Level (refer to the section called User Mode for instructions).

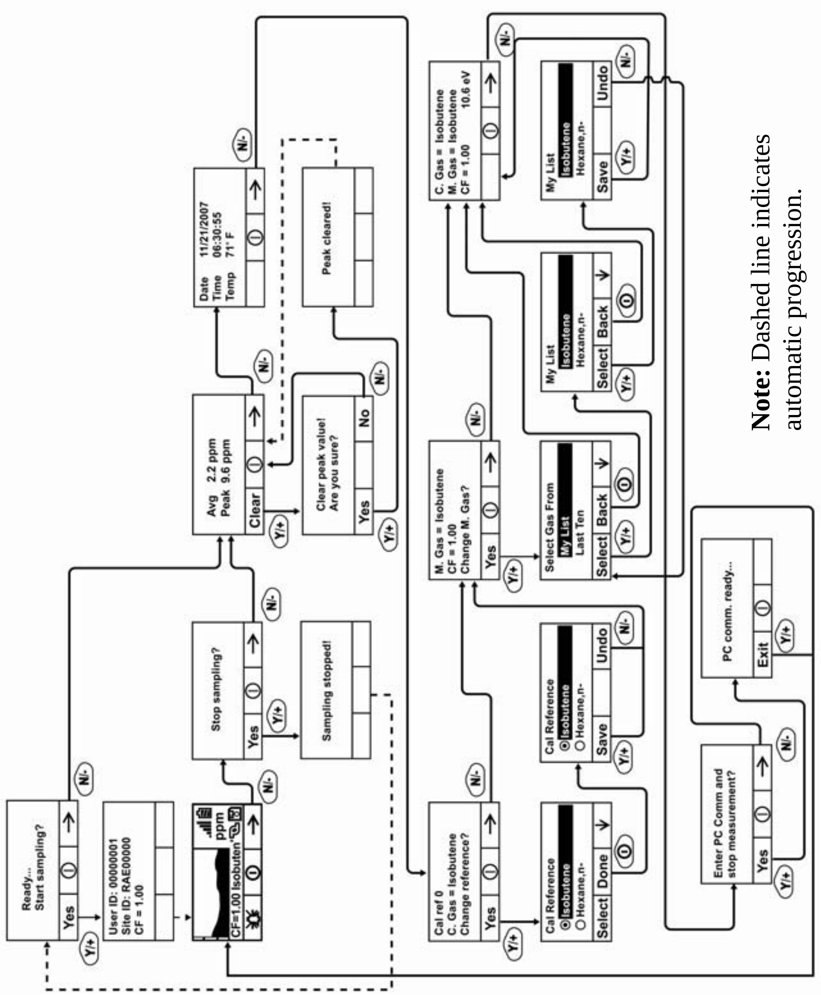
When the instrument is in Search Mode, it only samples when you activate sampling. When you see the display that says, "Ready…Start sampling?" press [Y/+] to start. The pump turns on and the instrument begins collecting data. To stop sampling, press [N/-] while the main display is showing. You will see a new screen that says, "Stop sampling?" Press [Y/+] to stop sampling. Press [N/-] if you want sampling to continue.



Note: Dashed line indicates automatic progression.

Advanced User Level & Search Mode

With the instrument in Operation Mode: Search Mode, enter User Mode and select Advanced User Level (refer to the section called Monitor Mode for instructions). Operation is similar to Basic User Level & Sampling Mode, but now allows you to change calibration and measurement reference gases. Refer to the section on measurement gases on page 52 for more details.



Note: Dashed line indicates automatic progression.

Diagnostic Mode

IMPORTANT! Diagnostic Mode is designed for servicing and manufacturing, and therefore is not intended for everyday use, even by advanced users. It provides raw data from sensors and about settings, but only allows adjustment of pump stall parameters, which should only be changed by qualified personnel.

Note: If the instrument is turned on in Diagnostic Mode and you switch to User Mode, datalog data remains in raw count form. To change to standard readings, you must restart the instrument.

Entering Diagnostic Mode

Note: To enter Diagnostic Mode, you must begin with the instrument turned off.

Press and hold [Y/+] and [MODE] until the instrument starts.

The instrument goes through a brief startup, and then displays raw data for the PID sensor. These numbers are raw sensor readings without calibration. The instrument is now in Diagnostic Mode.

Note: In Diagnostic Mode, the pump and lamp are normally on.

You can enter Programming Mode and calibrate the instrument as usual by pressing both [MODE] and [N/-] for three seconds.

You can enter Monitoring Mode by pressing [MODE] and [Y/+] together for three seconds.

Once the instrument is started up in Diagnostic Mode, you can switch between Diagnostic Mode and Monitoring Mode by pressing and holding [MODE] and [Y/+] simultaneously for two seconds.

In Diagnostic mode, you can step through parameter screens by pressing [MODE].

Adjusting The Pump Stall Threshold

If the gas inlet is blocked but the pump does not shut down, or the pump shuts down too easily with a slight blockage, the pump stall threshold value may be set too high or too low.

Use the following steps to adjust the pump stall threshold:

Pump High

In Diagnostic Mode, press the [MODE] key until "Pump High" is displayed. The display shows the maximum, minimum, and stall values for the pump at its high speed. Write down the "Max" reading.

Block the gas inlet and watch the pump current reading (labeled "I") increase. Write down its blocked reading. **Note:** If the pump current reading does not increase significantly (less than 10 counts), then there may be a leak in the gas inlet or the pump is weak or defective.

Add the two readings you wrote down. This is the average of the maximum block count and the maximum idle count. Divide that number by 2. Use the [Y/+] or [N/-] key to increase or decrease the stall value to equal that number.

Press the [MODE] key to exit this display.

Pump Low

In Diagnostic Mode, press the [MODE] key until "Pump Low" is displayed. The display shows the maximum, minimum, and stall values for the pump at its low speed. Write down the "Max" reading.

Block the gas inlet and watch the pump current reading (labeled "I") increase. Write down its blocked reading. **Note:** If the pump current reading does not increase significantly (less than 10 counts), then there may be a leak in the gas inlet or the pump is weak or defective.

Add the two readings you wrote down. This is the average of the maximum block count and the maximum idle count. Divide that number by 2. Use the [Y/+] or [N/-] key to increase or decrease the stall value to equal that number.

Press the [MODE] key to exit this display.

Exiting Diagnostic Mode

You can exit Diagnostic Mode and go directly to Programming Mode or Monitor Mode as outlined above, or you can exit Diagnostic Mode completely.

To exit Diagnostic Mode so that it cannot be re-entered without a restart:

Shut down the instrument. When it is off, restart it by holding the [MODE] key. Diagnostic Mode cannot be entered until the instrument is restarted as outlined in "Entering Diagnostic Mode."

Transferring Data To & From A Computer

Once you have connected your instrument cradle to the PC, you can can transfer data, including a download of the datalog to the computer and updates of firmware to the instrument (should this ever be necessary).

Downloading The Datalog To A PC

1. Connect the data cable to the PC and the cradle.
2. Place the instrument into its cradle. The charging LED should be illuminated.
3. Start ProRAE Studio on your PC.
4. From ProRAE Studio, select "Operation" and select Setup Connection.
5. Select the COM port to establish a communication link between the PC and the instrument.
6. To receive the datalog in the PC, select "Downlog Datalog."
7. When you see "Unit Information," click OK.

During the data transfer, the display shows a progress bar.

When the transfer is done, you will see a screen with the datalog information. You can now export this datalog for other use or printing.

Uploading Firmware To The instrument From A PC

Uploading new firmware to your instrument requires connecting the instrument and PC. Follow these steps to make the connection:

1. Connect the data cable to the PC and the cradle.
2. Place the instrument into its cradle. The charging LED should be illuminated.
3. Start RAEProgrammer 7000 on your PC.
4. From RAEProgrammer 7000, select "Operation" and select Setup Connection.
5. Select the COM port to establish a communication link between the PC and the instrument.
6. Select Operation → Download Firmware.

Once communication is established, follow the instructions that accompany RAEProgrammer 7000 and the firmware to upload the new firmware to your instrument.

Note: Check for the latest updates to ProRAEProgrammer 7000 at www.raesystems.com.

Maintenance

The major maintenance items of the instrument are:

- Battery pack
- Sensor module
- PID lamp
- Sampling pump
- Inlet connectors and filters

Note: Maintenance should be performed by qualified personnel only.

NOTE: The printed circuit board of the instrument is connected to the battery pack even if the power is turned off. Therefore, it is very important to disconnect the battery pack before servicing or replacing any components inside the instrument. Severe damage to the printed circuit board or battery may occur if the battery pack is not disconnected before servicing the unit.

Battery Charging & Replacement

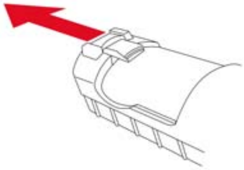
When the display shows a flashing empty battery icon, the battery requires recharging. It is recommended to recharge the instrument upon returning from fieldwork. A fully charged battery runs a instrument for 16 hours continuously. The charging time is less than 8 hours for a fully discharged battery. The battery may be replaced in the field (in areas known to be non-hazardous), if required.

WARNING!

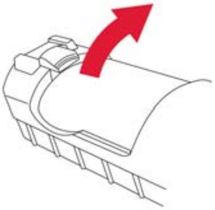
To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in areas known to be non-hazardous.

Replacing The Li-ion Battery

1. Turn off the instrument.
2. Located on the rear of the instrument is a battery tab. Slide it down to unlock the battery.



3. Remove the battery pack from the battery compartment by tilting it out.



4. Replace a fully charged spare battery pack inside the battery compartment. Make sure the battery pack is oriented properly inside the compartment.
5. Slide the capture tab back up to its locked position.

Replacing The Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500) and provides approximately 12 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

To insert batteries into the adapter:

1. Remove the three Philips-head screws to open the compartment.
2. Insert four fresh AA batteries as indicated by the polarity (+/-) markings.
3. Replace the cover. Replace the three screws.

To install the adapter in the instrument:

1. Remove the Li-ion battery pack from the battery compartment by sliding the tab and tilting out the battery.
2. Replace it with the alkaline battery adapter
3. Slide the tab back into place to secure the battery adapter.

IMPORTANT!

Alkaline batteries cannot be recharged. The instrument's internal circuit detects alkaline batteries and will not allow recharging. If you place the instrument in its cradle, the alkaline battery will not be recharged. The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the instrument.

Note: When replacing alkaline batteries, dispose of old ones properly.

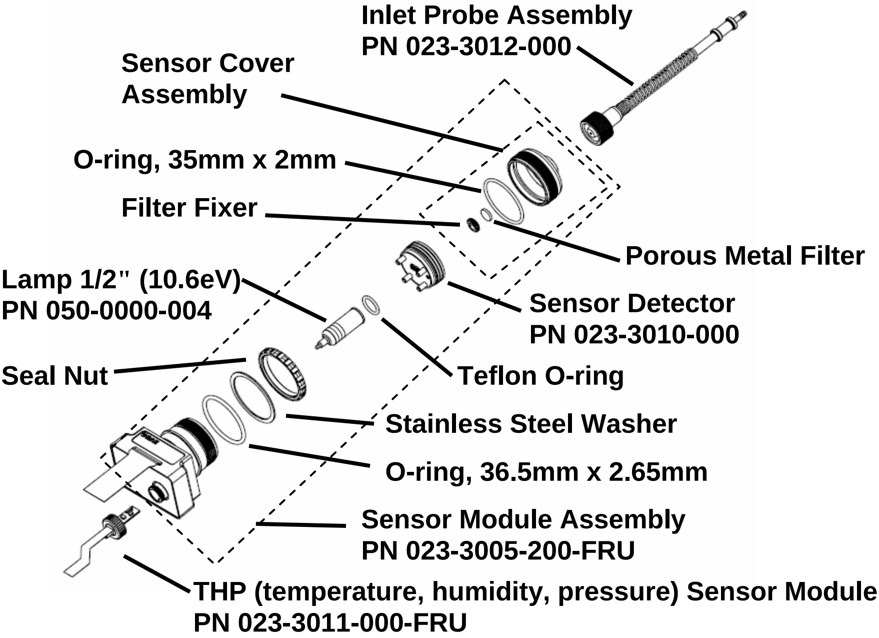
WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge the battery only in areas known to be non-hazardous. Remove and replace the battery only in areas known to be non-hazardous.

Note: The internal charging circuit is designed to prevent charging to alkaline batteries.

PID Sensor & Lamp Cleaning/Replacement

The sensor module is made of several components and is attached to the lamp-housing unit as shown below.



Sensor Components

Note: The cleaning procedure is not normally needed. Clean the PID sensor module, the lamp and the lamp housing only if:

1. The reading is inaccurate even after calibration.
2. The reading is very sensitive to air moisture.
3. A liquid has been sucked into the unit and damaged the unit.

Use of the external filter helps to prevent contamination of the sensor.

To access the sensor components and lamp, gently unscrew the lamp-housing cap, remove the sensor adapter with the gas inlet probe and the metal filter all together. Then hold the PID sensor and pull it straight out. A slight, gentle rocking motion helps release the sensor.

Cleaning The PID Sensor

Place the entire PID sensor module into GC grade methanol. It is highly recommended that an ultrasound bath to be used to clean the sensor for at least 15 minutes. Then dry the sensor thoroughly. Never touch the electrodes of the sensor by hand.
Also use a methanol-soaked cotton swab to wipe off the lamp housing where it contacts the sensor when the sensor is installed.

Turn over the sensor so that the pins point up and the sensor cavity is visible. Examine the sensor electrodes for any corrosion, damage, or bending out of alignment. The metal sensor electrode "fingers" should be flat and straight. If necessary, carefully bend the sensor fingers to ensure that they do not touch the Teflon portions and that they are parallel to each other. Make sure that the nuts on the sensor pins are snug but not overtight. If the sensor is corroded or otherwise damaged, it should be replaced.

Cleaning The Lamp Housing Or Changing The Lamp

If the lamp does not turn on, the instrument will display an error message to indicate replacement of the lamp may be required.

1. If the lamp is operational, clean the lamp window surface and the lamp housing by wiping it with GC grade methanol using a cotton swab using moderate pressure. After cleaning, hold the lamp up to the light at an angle to detect any remaining film. Repeat the process until the lamp window is clean. Never use water solutions to clean the lamp. Dry the lamp and the lamp housing thoroughly after cleaning.

   CAUTION: Never touch the window surface with the fingers or anything else that may leave a film. Never use acetone or aqueous solutions.

2. If the lamp does not turn on, remove the lamp from the lamp housing. Place the lamp O-ring onto the new lamp. Insert the new lamp, avoiding contact with the flat window surface.
3. Reinstall the PID sensor module.
4. Tighten the Lamp Housing Cap.

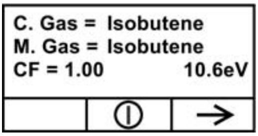
Determining The Lamp Type

The monitor can accommodate three lamp values: 10.6eV (standard), 9.8eV, and 11.7eV. The monitor automatically reads a marking on the side of the lamp to set the proper Correction Factor. There are two ways to determine the lamp type:

Remove the lamp and look for markings (bars) on the side:

- No bars: 10.6eV
- 1 bar: 11.7eV
- 2 bars: 9.8eV

Also, when the monitor is running, the lamp type is shown along with the calibration and measurement gas and Correction Factor:



C. Gas = Isobutene
M. Gas = Isobutene
CF = 1.00 10.6eV

Note: This screen can be accessed from the reading screen by pressing [N/-] four times.

Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

If the pump is not working properly, refer the instrument to qualified service personnel for further testing and, if necessary, pump repair or replacement.

Cleaning The Instrument

Occasional cleaning with a soft cloth is recommended. Do not use detergents or chemicals.

Visually inspect the contacts at the base of the instrument, on the battery, and on the charging cradle to make sure they are clean. If they are not, wipe them with a soft, dry cloth. Never use solvents or cleaners.

Ordering Replacement Parts

If you need replacement parts, contact your local RAE Systems distributor. A list is available online:

http://www.raesystems.com

In the U.S., you can order sensors, replacement batteries, and other accessories online at:

http://istore.raesystems.com/

Special Servicing Note

If the instrument needs to be serviced, contact either:

1. The RAE Systems distributor from whom the instrument was purchased; they will return the instrument on your behalf.

   or

2. The RAE Systems Technical Service Department. Before returning the instrument for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the instrument is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

Troubleshooting

Problem	Possible Reasons & Solutions	
Cannot turn on power after charging the battery	**Reasons:**	Discharged battery. Defective battery.
	Solutions:	Charge or replace battery.
Lost password	**Solutions:**	Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
Reading abnormally High	**Reasons:**	Dirty filter. Dirty sensor module. Excessive moisture and water condensation. Incorrect calibration.
	Solutions:	Replace filter. Blow-dry the sensor module. Calibrate the unit.
Reading abnormally Low	**Reasons:**	Dirty filter. Dirty sensor module. Weak or dirty lamp. Incorrect calibration.
	Solutions:	Replace filter. Remove Calibration Adapter. Calibrate the unit. Check for air leakage.
Buzzer Inoperative	**Reasons:**	Bad buzzer.
	Solutions:	Check that buzzer is not turned off. Call authorized service center.

Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
"Lamp" message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on. Replace UV lamp

Technical Support

To contact RAE Systems Technical Support Team:

Monday through Friday, 7:00AM to 5:00PM Pacific (US) Time
Phone (toll-free): +1 888-723-4800
Phone: +1 408-952-8461
Email: tech@raesystems.com

Life-critical after-hours support is available:

+1 408-952-8200 select option 8

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Web Site: www.raesystems.com

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Kyungki-Do, Korea
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Fax: 82-32-328-7127
Email: krsales@raesystems.com

Controlled Part of Manual

Intrinsic Safety:
US and Canada: Class I, Division 1, Groups A,B,C,D T4

Europe: ATEX (0575 Ex II 2G Ex ia IIC/IIB T4 Gb)
KEMA 07 ATEX 0127
Complies with EN60079-0:2009, EN60079-11:2007
IECEx CSA 10.0005 Ex ia IIC/IIB T4 Gb
Complies with IEC 60079-0:2007, IEC 60079-11:2006

Temperature:	-20º C to 50º C (-4º to 122º F)
Humidity:	0% to 95% relative humidity (non-condensing)

Basic Operation

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.

The instrument is now operating and performs self tests. Once the self tests are complete, the display shows a graph or numerical gas reading. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. When you see "Unit off..." release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn you of the alarm condition.

In addition, the instrument alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, pump stall, or when the datalog memory is full.

Alarm Signal Summary

Message	Condition	Alarm Signal
HIGH	Gas exceeds "High Alarm" limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second*
MAX	Gas exceeds electronics' maximum range	3 beeps/flashes per second*
LOW	Gas exceeds "Low Alarm" limit	2 beeps/flashes per second*
TWA	Gas exceeds "TWA" limit	1 Beep/flash per second*
STEL	Gas exceeds "STEL" limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus "Lamp" message on display

Battery icon flashes	Low battery	1 flash, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	**Cal Span**	**unit**	**Low**	**High**	**TWA**	**STEL**
ppbRAE 3000	10	ppm	10	25	10	25
MiniRAE 3000	100	ppm	50	100	10	25
MiniRAE Lite	100	ppm	50	100	10	25
UltraRAE 3000	100	ppm	50	100	10	25

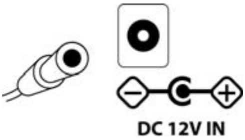
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion/NiMH battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle's contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter's barrel connector into the instrument's cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glows.

Note: To release the instrument, press down and tilt the top out of the cradle and lift up.

The instrument begins charging automatically. The LED on the front of the cradle marked "Primary" blinks during charging. During charging, the diagonal lines in the battery icon on the instrument's display are animated and you see the message "Charging..."

When the instrument's battery is fully charged, the battery icon is no longer animated and shows a full battery. The message "Fully charged!" is shown and the Primary LED on the cradle glows continuously green.

Note: A spare Li-ion battery (059-3051-000) or NiMH(059-3054-000) can be charged by placing it directly in the charging port on the back of the cradle. It can be charged at the same time as the instrument. Press the battery in place, sliding it slightly toward the front of the cradle. This locks it in the cradle. To release the battery, slide it forward again and tilt it up.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. **Remove and replace batteries only in areas known to be non-hazardous.**

Low Voltage Warning

When the battery's charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the battery icon blinks once per second. You should turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Clock Battery

An internal clock battery is mounted on one of the instrument's printed circuit boards. This long-life battery keeps settings in memory from being lost whenever the Li-ion, NiMH, or alkaline batteries are removed. This backup battery should last approximately five years, and must be replaced by an authorized RAE Systems service technician. It is not user-replaceable.

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in an area known to be non-hazardous.

Replacing Rechargeable Li-Ion or NiMH Battery

Caution: Turn off the instrument before removing or replacing the battery.

Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500).

Do not mix old and new batteries or different type batteries.

Troubleshooting

Problem	Possible Reasons & Solutions	
Cannot turn on power after charging the battery	**Reasons:**	Discharged battery. Defective battery.
	Solutions:	Charge or replace battery.
Lost password	**Solutions:**	Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
Reading abnormally High	**Reasons:**	Dirty filter. Dirty sensor module. Excessive moisture and water condensation. Incorrect calibration.
	Solutions:	Replace filter. Blow-dry the sensor module. Calibrate the unit.
Reading abnormally Low	**Reasons:**	Dirty filter. Dirty sensor module. Weak or dirty lamp. Incorrect calibration.
	Solutions:	Replace filter. Remove Calibration Adapter. Calibrate the unit. Check for air leakage.
Buzzer Inoperative	**Reasons:**	Bad buzzer.
	Solutions:	Check that buzzer is not turned off. Call authorized service center.

Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
"Lamp" message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on. Replace UV lamp

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Rev. C
August 2010
P/N 059-4020-000

Multi Water Quality Checker
U-50 Series

Instruction Manual

CODE:GZ0000144342C

Preface

This manual describes the operation of the Multi Water Quality Checker, U-50 Series.
Be sure to read this manual before using the product to ensure proper and safe operation of the instrument. Also safely store the manual so it is readily available whenever necessary.

Product specifications and appearance, as well as the contents of this manual are subject to change without notice.

■ Warranty and Responsibility

HORIBA warrants that the Product shall be free from defects in material and workmanship and agrees to repair or replace free of charge, at HORIBA's option, any malfunctioned or damaged Product attributable to HORIBA's responsibility for a period of one (1) year from the delivery unless otherwise agreed with a written agreement. In any one of the following cases, none of the warranties set forth herein shall be extended;

- Any malfunction or damage attributable to improper operation
- Any malfunction attributable to repair or modification by any person not authorized by HORIBA
- Any malfunction or damage attributable to the use in an environment not specified in this manual
- Any malfunction or damage attributable to violation of the instructions in this manual or operations in the manner not specified in this manual
- Any malfunction or damage attributable to any cause or causes beyond the reasonable control of HORIBA such as natural disasters
- Any deterioration in appearance attributable to corrosion, rust, and so on
- Replacement of consumables

HORIBA SHALL NOT BE LIABLE FOR ANY DAMAGES RESULTING FROM ANY MALFUNCTIONS OF THE PRODUCT, ANY ERASURE OF DATA, OR ANY OTHER USES OF THE PRODUCT.

■ Trademarks

Generally, company names and brand names are either registered trademarks or trademarks of the respective companies.

Conformable Directive

This equipment conforms to the following directives and standards:

Directives: the EMC Directive 2004/108/EC

Standards: [the EMC Directive]
EN61326-1:2006 Class B, Portable test and measurement equipment

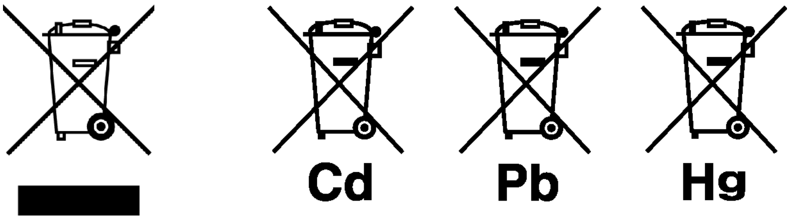
Information on Disposal of Electrical and Electronic Equipment and Disposal of Batteries and Accumulators

The crossed out wheeled bin symbol with underbar shown on the product or accompanying documents indicates the product requires appropriate treatment, collection and recycle for waste electrical and electronic equipment (WEEE) under the Directive 2002/96/EC, and/or waste batteries and accumulators under the Directive 2006/66/EC in the European Union.

The symbol might be put with one of the chemical symbols below. In this case, it satisfies the requirements of the Directive 2006/66/EC for the object chemical.

This product should not be disposed of as unsorted household waste.
Your correct disposal of WEEE, waste batteries and accumulators will contribute to reducing wasteful consumption of natural resources, and protecting human health and the environment from potential negative effects caused by hazardous substance in products.

Contact your supplier for information on applicable disposal methods.



FCC Rules

Any changes or modifications not expressly approved by the party responsible for compliance shall void the user's authority to operate the equipment.

WARNING

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

For your safety

Warning messages are described in the following manner. Read the messages and follow the instructions carefully.

● Meaning of warning messages

⚠ DANGER	This indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.
⚠ WARNING	This indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	This indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices. Without safety alert indication of hazardous situation which, if not avoided, could result in property damage.

● Symbols

❗	Description of what should be done, or what should be followed
🛇	Description of what should never be done, or what is prohibited

■ Safety Precautions

This section provides precautions to enable you to use the product safely and correctly and to prevent injury and damage. The terms of DANGER, WARNING, and CAUTION indicate the degree of imminency and hazardous situation. Read the precautions carefully as it contains important safety messages.

⚠	**WARNING**
🛇	Do not disassemble or modify the meter. May cause overheating or fire, resulting in accidents.

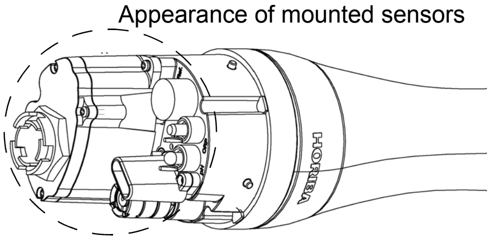
⚠	**CAUTION**
❗	The pH and ORP sensors are made of glass. Handle them carefully to avoid breakage.
❗	Do not ingest the DO, pH or ORP standard solutions. If it comes into contact with the eyes, rinse thoroughly with water. If swallowed, consult a physician.
🛇	Keep away from water when using USB communication. Improper use may result in fire or damage.

Points of concern

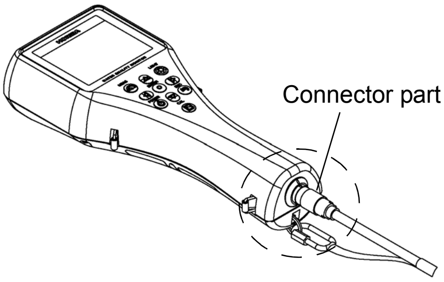
Use of the equipment in a manner not specified by the manufacturer may impair the protection provided by the equipment. It may also reduce equipment performance.

Sensor probe

- Do not immerse the sensor probe in seawater or other samples with high salinity. Doing so may erode metallic parts. After use, promptly wash the sensor probe thoroughly in water.
- Do not immerse the sensor probe in alcohol, organic solvent, strong acid, strong alkaline, and other similar solutions.
- Do not subject to strong shocks.
- Do not perform measurement in environments of magnetic fields. Measurement errors may result.
- The sensor probe is no longer waterproof when the sensors are not mounted.

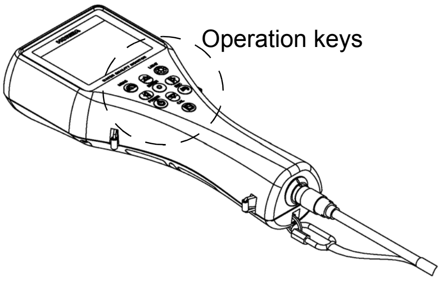


- Does not support measurement of samples containing fluorine.
- To disconnect the sensor cable or interface cable, pull them out with holding the connector part. Do not pull the cable part; it may cause breakage.



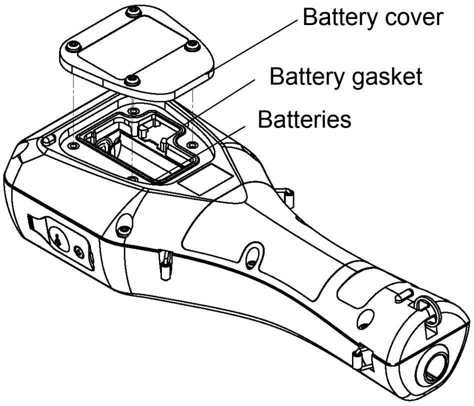
Control unit

- Do not subject to strong shocks.
- The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.



- The control unit is no longer waterproof when the USB cable is connected.
- When operating the control unit only, protect the connector with the connector cap provided.

- Remove the batteries when not using the control unit for an extended period of time. Battery fluid leakage may cause equipment failure.
- Do not wipe the control unit with organic solvents or powder polish. The surface may deteriorate or its printing may disappear. If the display becomes dirty, wipe the dirt off with a soft cloth soaked in neutral detergent.
- Do not turn the power OFF or disconnect the cable during calibration or setting. Memory data may be erased.
- To perform measurement, connect the sensor probe cable before turning the power ON.
- Do not remove the battery gasket or twist it.
- When opening the battery case, make sure that no foreign matter is attached to the battery gasket.
- Do not use any unspecified batteries; it may cause breakage.



Measurement

- Do not pull the cable when lowering the sensor probe into the sample during measurement. Lower the sensor probe into the sample on a chain or string.
- Before lowering the sensor probe into the sample, do not connect the hook on the unit to a human body.
- The correct values are not displayed if the sensor is not mounted when the measurement display is activated.
- Perform DO measurement with no air bubbles in the internal solution.
- Do not reuse a membrane cap of DO sensor.
- Use the spanner for DO sensor provided to attach or remove the DO sensor.
- Avoid both U-53 and U-53G turbidity measurement in air, since the rubber wiper will quickly become damaged.
- Avoid turbidity measurement in direct sunlight, since the readout may be affected.

Calibration

During atmosphere calibration for the DO electrode with DO salinity compensation set to automatic, values are compensated based on electrical conductivity, but calibration is performed normally.

Location of use and storage

- Storage temperature: –10°C to 60°C
- Relative humidity: Under 80% and free from condensation

Store the meter in locations void of dust, strong vibrations, direct sunlight, corrosive gases, near air conditioners or windy areas.

Disposal of the product

When disposing of the product, follow the related laws and/or regulations of your country for disposal of the product.

Description in this manual

Note

This interprets the necessary points for correct operation and notifies the important points for handling the unit.

Reference

This indicates where to refer for information.

Tip

This indicates reference information.

Contents

1 About this Unit

The U-50 Series Multi Water Quality Checker features an integrated control unit and sensors. It is capable of making a maximum of eleven simultaneous measurements for various parameters, and is perfect for use in the field. The U-50 Series is designed with on-site ease-of-use in mind, provides a wide variety of functions, and can be used for water quality measurements and inspections of river water, groundwater, and waste water.

2 Device Information

2.1 Measurement parameters

Parameters	Model				
	U-51	U-52	U-52G	U-53	U-53G
pH (pH)	✓	✓	✓	✓	✓
pH (mV)	✓	✓	✓	✓	✓
Oxidation reduction potential (ORP)	✓	✓	✓	✓	✓
Dissolved oxygen (DO)	✓	✓	✓	✓	✓
Electrical conductivity (COND)	✓	✓	✓	✓	✓
Salinity (SAL) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Total dissolved solids (TDS) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Seawater specific gravity (SG) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Water temperature (TEMP)	✓	✓	✓	✓	✓
Turbidity (TURB) [LED transmission/front 30° scattering method]	–	✓	✓	–	–
Turbidity (TURB) [tungsten lamp 90° transmission/scattering method] with wiper	–	–	–	✓	✓
Water depth (DEP)	–	–	✓	✓	✓
GPS	–	–	✓	–	✓

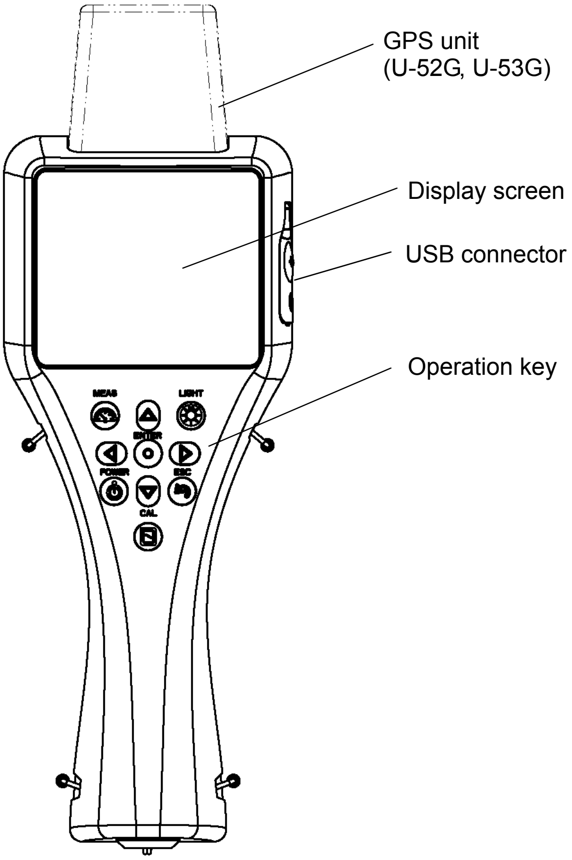
"✓" indicates a measurable parameter.

2.2 Packing list

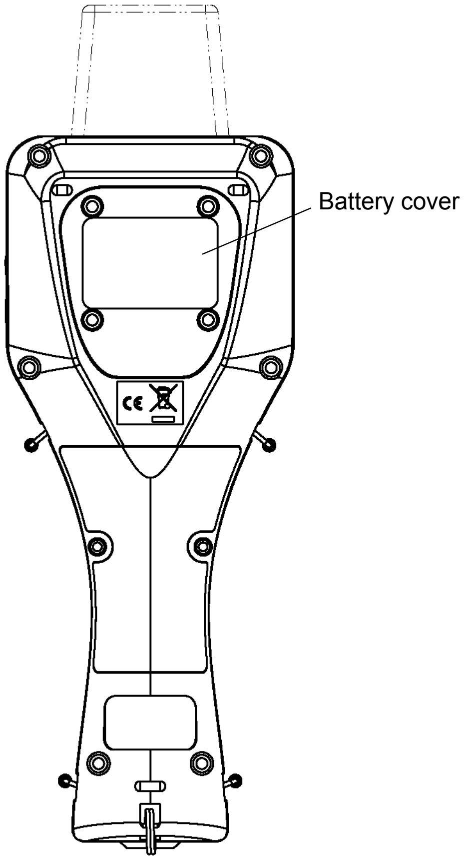
Parts Name	Quantity	Note
Control unit	1	
Sensor probe	1	
pH sensor (#7112)	1	
ORP sensor (#7313)	1	
Reference electrode (#7210)	1	
DO sensor (#7543)	1	
Turbidity sensor (#7800)	1	With U-52/U-52G only. Attached to the sensor probe.
Turbidity sensor (#7801)	1	With U-53/U-53G only. Attached to the sensor probe.
pH 4 standard solution (#100-4)	1	500 mL
pH reference internal solution (#330)	1	250 mL
DO sensor internal solution set (#306)	1	Internal solution (50 mL), Sandpaper (#8000, #600), Syringe
DO Membrane spare parts set	1	
Spanner for DO sensor	1	
Cleaning brush	1	
calibration cup	1	transparent calibration cup, black calibration cup
Back pack	1	
Strap	1	
Alkaline batteries	4	LR14
Silicon grease	1	
Instruction manual	1	

2.3 Parts name and functions

● Display

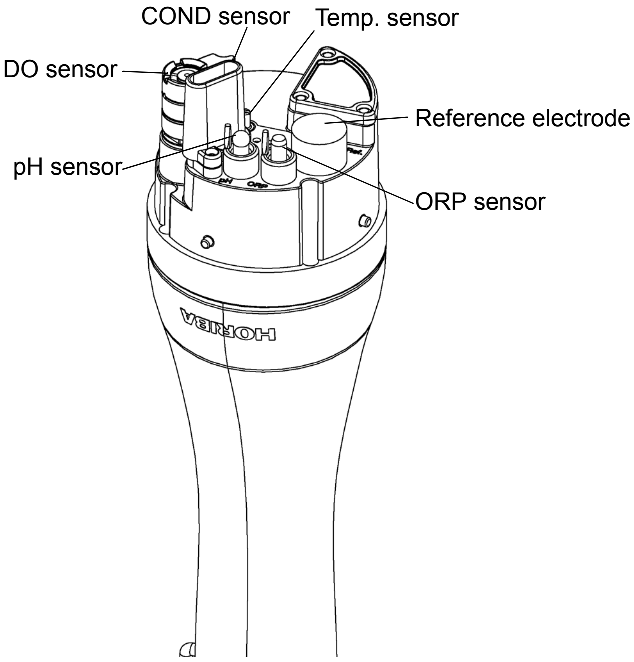


Front view

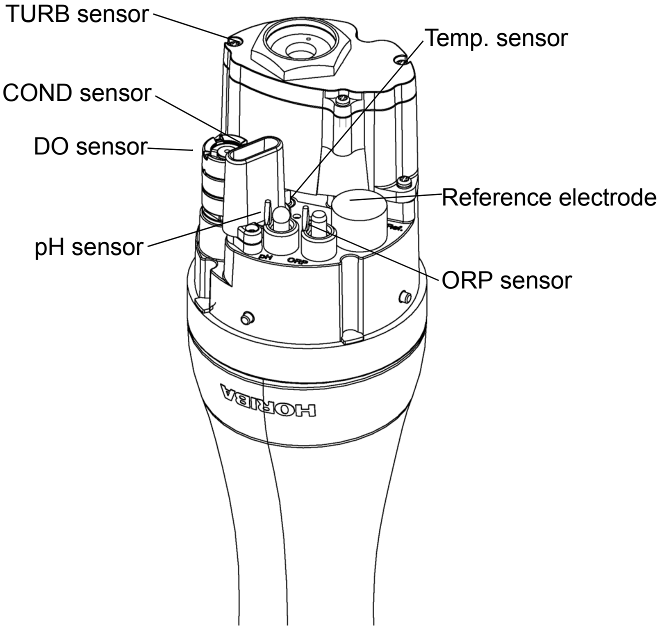


Back view

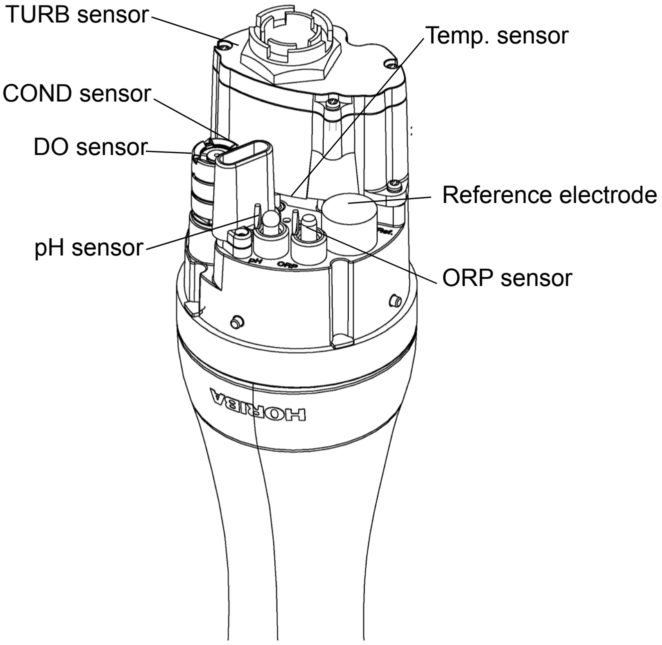
● Sensor probe (U-51)



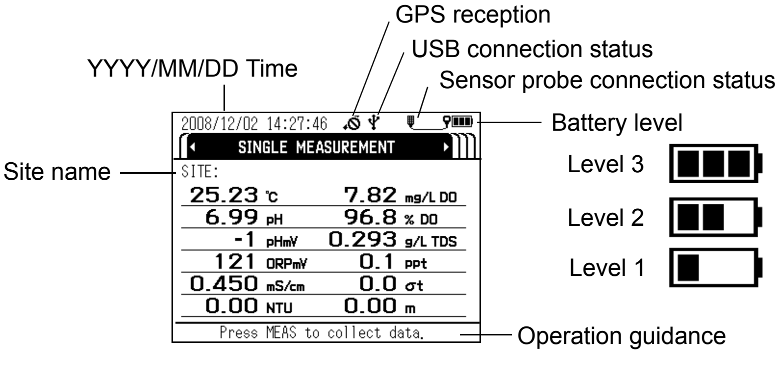
Sensor probe (U-52)



Sensor probe (U-53)



Display screen



```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
25.23 ℃          7.82 mg/L DO
 6.99 pH         96.8 % DO
   -1 pHmV      0.293 g/L TDS
  121 ORPmV       0.1 ppt
0.450 mS/cm       0.0 σt
 0.00 NTU        0.00 m
Press MEAS to collect data.
```

Level 3	▮▮▮	Sufficient power remaining
Level 2	▮▮	Remaining power does not affect operation
Level 1	▮	Batteries need replacing

● Operation key

	Key name	description
POWER	POWER key	Turns the system’s power ON/OFF. The initial screen appears immediately after turning the power ON. Press and hold down the POWER key for about 3 seconds to turn the power ON and OFF.
MEAS	MEAS key	When pressed in the measurement screen, used to set the measurement values of all the measurement parameters. Measurement values flash until the data stabilizes.
		When pressed in the setting, calibration or data operation screen, returns to the measurement screen.
ENTER	ENTER key	Used to execute functions, set entered values or store data in memory.
CAL	CAL key	Switches to the calibration screen.
ESC	ESC key	Returns to the immediately preceding operation.
LIGHT	LIGHT key	Turns the backlight ON/OFF. ● Using the backlight shortens battery life. ● The backlight does not light for about 3 seconds after power ON. ● When the sensor probe is connected while the display's backlight is lit, the backlight goes out for about 3 seconds.
◁	Left key	Moves the cursor to the left.
▷	Right key	Moves the cursor to the right.
△	Up key	Moves the cursor up.
▽	Down key	Moves the cursor down.

2.4 Setting menu items

- Measurement
  - Single measurement
  - Interval measurement
  - “ 3.2.1 Setting measurement methods ” (page 18)
- Site
  - Select site
  - Create new site
  - Delete site
  - “ 3.2.2 Setting sites ” (page 20)
- Unit for report
  - TEMP (temperature)
  - TURB (turbidity)
  - DO (dissolved oxygen)
  - COND (electrical conductivity)
  - SG (seawater specific gravity)
  - Depth (water depth)
  - SALT (salinity)
  - “ 3.2.3 Unit for report ” (page 23)
- Sensor selection
  - TEMP (temperature)
  - pH
  - pH mV
  - ORP
  - COND (electrical conductivity)
  - TURB (turbidity)
  - DO (dissolved oxygen)
  - TDS (total dissolved solids)
  - SALT (salinity)
  - SG (seawater specific gravity)
  - DEPTH (water depth)
  - “ 3.2.4 Sensor selection ” (page 25)
- Compensation
  - DO salinity compensation
  - DO atmospheric pressure compensation
  - Electrical conductivity temperature coefficient
  - TDS
  - “ 3.2.5 Compensation ” (page 26)
- System
  - Language
  - Version
  - Date/time
  - Auto power OFF
  - Display contrast
  - Initialize
  - GPS locate*
  - GPS locating accuracy*
  - “ 3.2.6 System settings ” (page 32)

*Only on models with a GPS unit.

2.5 Calibration menu items

- Auto calibration
  - pH
  - COND (electrical conductivity)
  - TURB (turbidity)
  - DO (dissolved oxygen)
  - DEPTH (water depth)
  - “ 3.3.1 Auto calibration ” (page 39)
- Manual calibration
  - TEMP (temperature)
  - pH
  - ORP
  - COND (electrical conductivity)
  - TURB (turbidity)
  - DO (dissolved oxygen)
  - DEPTH (water depth)
  - “ 3.3.2 Manual calibration ” (page 42)

2.6 Data operation menu items

- Data operation
  - View data
  - Delete data
  - Check data memory
  - Calibration record
  - GPS information*
  - “ 3.5 Data operations ” (page 64)

*Only on models with a GPS unit.

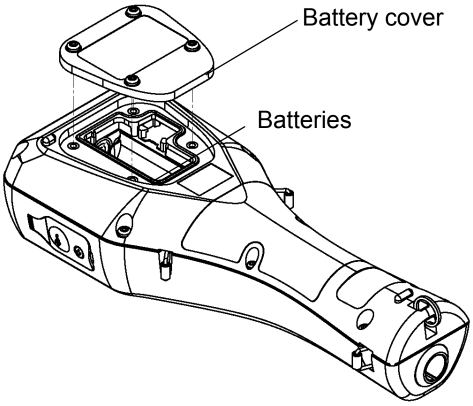
3 Basic Operation

3.1 System setup

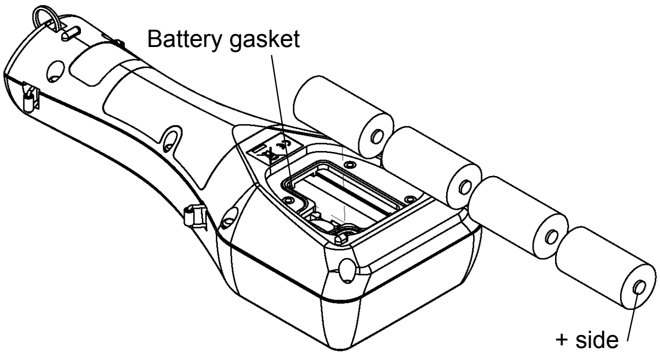
3.1.1 Inserting and replacing the batteries

The control unit is shipped without batteries. Follow the steps below to insert the batteries when using the system for the first time or replacing old batteries.

1. **Loosen the 4 screws on the battery cover by using No. 2 Phillips head screwdriver and remove the cover.**



2. **If replacing the batteries, discard the old batteries.**
3. **Insert new batteries in the control unit.**
   Check that the battery gasket is not dirty or twisted.



4. **Replace the battery cover and fasten it with the 4 screws.**
   Tighten the screws to less than 0.5 N·m.

Note

- **Data and settings will not be lost when the batteries are replaced.**
- **If dirty or twisted, the battery gasket will fail to keep the batteries dry. Check its condition before closing the cover.**
- **To ensure long service life, replacing the battery gasket periodically (once a year) is recommended.**

Precautions when using dry cell batteries

- **Batteries to use: LR14 alkaline dry cell batteries (C-size dry cell batteries) or rechargeable nickel-metal hydride dry cell batteries (C-size)**
  Do not use manganese batteries.
- **Dry cell batteries used incorrectly may leak or burst. Always observe the following**
  - Orient the batteries correctly (positive and negative ends in correct positions).
  - Do not combine new and used batteries, or batteries of different types.
  - Remove the batteries when not using the system for a prolonged period.
  - If batteries leak, have the system inspected at your nearest Horiba service station.

● Battery life

- The battery life for continuous operation when using C-size alkaline dry cell batteries is about 70 hours.
- Using the backlight consumes a proportionate amount of battery power, shortening battery life.
- Searching position information using the GPS unit consumes a proportionate amount of battery power, shortening battery life.
- Nickel-metal hydride secondary batteries can be used, but the battery life is not guaranteed since it will vary according to usage (number of times data is saved, number of charges and amount of each charge). In general, secondary batteries have one-half to one-third the life of C-size alkaline batteries.
- The 70-hour battery life figure applies to a control unit operating temperature of 20°C or more. The battery characteristics shorten the battery life at operating temperatures lower than 20°C, so check the remaining battery level, and replace the batteries before it reaches Level 1.
- The batteries packed with the system at the time of shipment are for checking operation. Their life is not guaranteed.
- The 70-hour battery life figure is the amount of operating time the batteries can provide until the system stops operating. The system may fail during operation if the remaining battery level is low, so it is a good idea to check the remaining battery level and replace the batteries with new ones well before the batteries run out completely.

U-51/52

Battery life: 70 hours (backlight off)

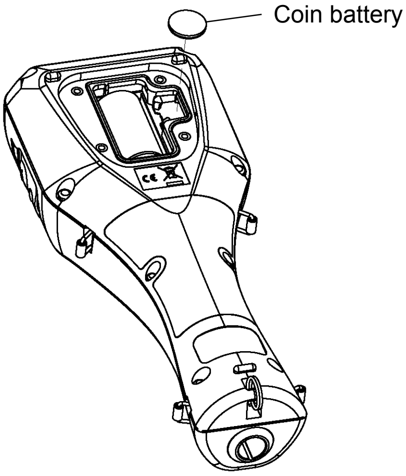
U-53

Battery life: 500 measurements (backlight off)

- Since U-53 is designed for turbidity measurement with wiper, its battery life is estimated in terms of the number of turbidity measurement sequences performed.
- Battery power is also consumed by measurement operations other than turbidity measurement.
- The battery life when turbidity measurement is not performed is about 70 hours.

3.1.2 Replacing the coin battery

- Coin battery to use: CR-2032
- The coin battery is only for the clock. It will provide problem-free operation for three years, but when using the clock continuously, it should be replaced every two years as a precaution.
- When replacing the coin battery for the clock, leave the control unit ON. If the coin battery is replaced when the control unit is turned OFF, the clock will be reset to the default settings.



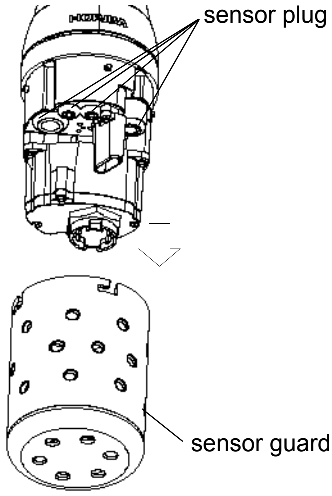
3.1.3 Attaching sensors

Note

- **When attaching or replacing a sensor, wipe any moisture off the sensor probe and sensor.**
- **Be sure to keep water out of sensor connectors. If moisture comes in contact with a sensor connector, blow-dry it with dry air.**
- **The sensor probe is not waterproof when the sensor is not mounted.**
- **Take care not to tighten the sensor too much.**

● Attaching the pH sensor

1. **Remove the sensor guard.**

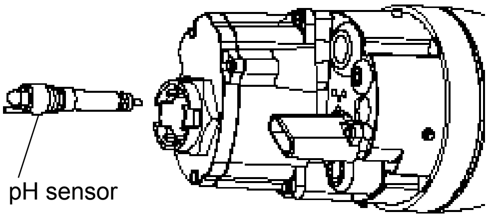


2. **Remove the sensor plug.**
3. **Coat the pH sensor O-ring with a thin layer of silicon grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "pH").**
5. **Fasten the pH sensor securely by hand.**



6. **Clean the sensor with an alcohol-soaked cloth.**

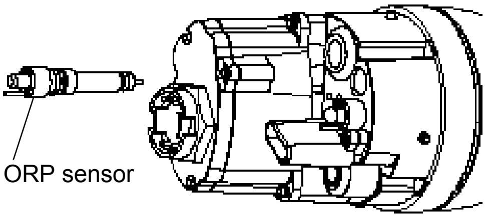
- **Attaching the ORP sensor**

  1. **Remove the sensor guard.**
  2. **Remove the sensor plug.**
  3. **Coat the ORP sensor O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe’s sensor connector (marked "ORP").**
5. **Fasten the ORP sensor securely by hand.**



6. **Clean the sensor with an alcohol-soaked cloth.**

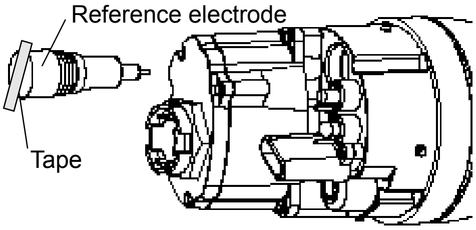
- **Attaching the reference electrode**

  1. **Remove the sensor guard.**
  2. **Remove the sensor plug.**
  3. **Coat the reference electrode O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe’s sensor connector (marked "REF").**
5. **Fasten the reference electrode securely by hand.**
6. **Remove the tape from the liquid junction part of the reference electrode.**



● Attaching the dissolved oxygen (DO) sensor

1. **Remove the membrane cap mounted on the DO sensor beforehand, and replace it with the new membrane cap provided. Replace the internal solution with fresh solution. The main component of the internal solution is potassium chloride (KCl), so the old solution can be disposed of down a sink or other drain.**

Reference

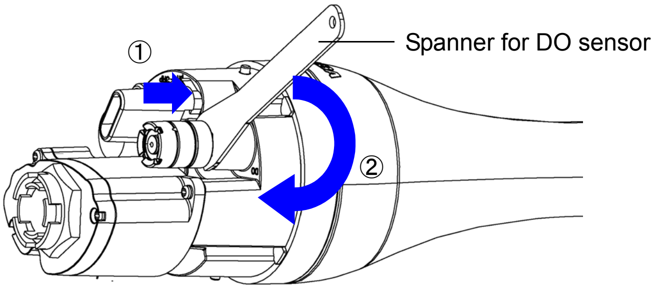
“ 4.5 Replacing the membrane cap ” (page 87)

2. **Screw in the DO sensor to attach it, allowing the internal solution to overflow slightly.**
3. **Use a soft cloth to wipe off the internal solution that overflowed onto the DO sensor.**
4. **Remove the sensor guard.**
5. **Remove the sensor plug.**
6. **Coat the DO sensor O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

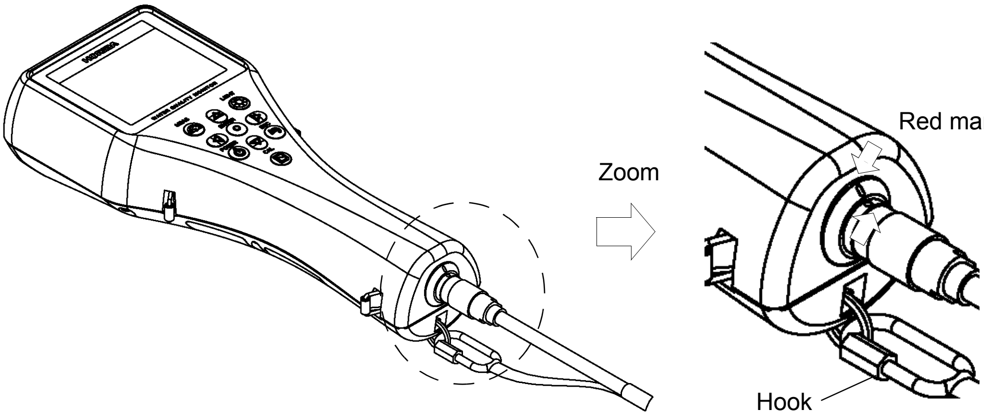
7. **Make sure there is no moisture on the sensor probe’s sensor connector (marked "DO").**
8. **Fasten the DO sensor securely using the spanner for DO sensor.**
   - Hold the DO sensor with the provided spanner for DO sensor and push the sensor down. (Step 1 in figure below)
   - Screw the DO sensor in place. (Step 2 in figure below)



3.1.4 Connecting the control unit and sensor probe

Note

Connect the control unit with its power OFF.

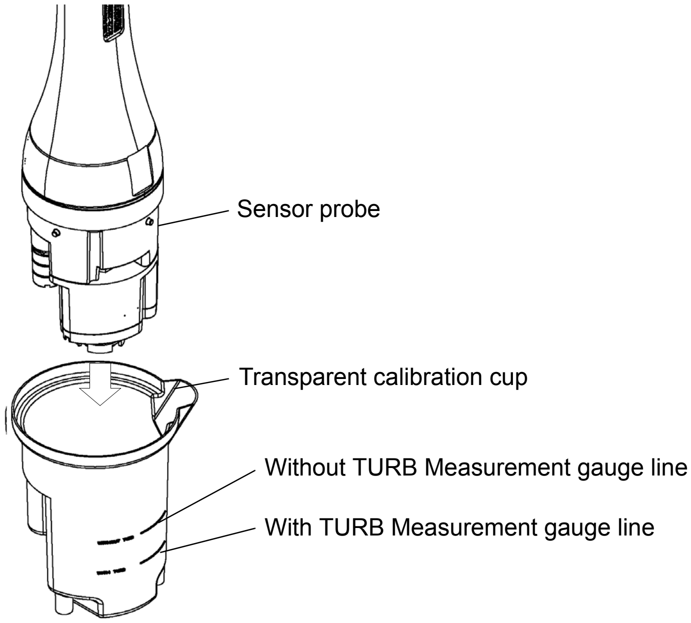


1. **Align the red mark on the connector, and press the connector in until you hear it click.**
2. **Connect the cable's hook to the display.**

3.1.5 Conditioning

Carry out the steps below when using the unit for the first time or when the system has not been used for 3 months or longer.

1. **Fill the transparent calibration cup to the line with pH 4 standard solution.**
   The transparent calibration cup has With TURB Measurement and Without TURB Measurement gauge lines.
2. **Insert the sensor probe in the transparent calibration cup.**



Note

Check that all sensors are attached.

3. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON. Leave the unit for at least 20 minutes to condition the sensors.**

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

Tip

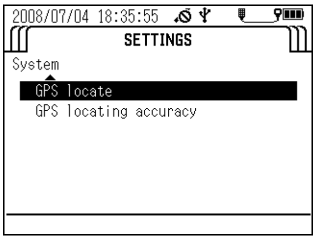
- **The procedure for immersing the sensor probe in the pH standard solution is the same as that described in " 3.3.1 Auto calibration " (page 39).**
  Auto calibration can be performed using the same pH 4 standard solution that was used in the conditioning procedure.
- **Immersing the sensor in the standard solution is generally required for sensor conditioning, but a voltage supply is required for DO sensor conditioning. Turning ON the power of the control unit is necessary during sensor conditioning.**

3.1.6 GPS (U-52G, U-53G)

The GPS position measurement precision is proportional to the GPS position measurement time. When the position measurement precision increases, the position measurement time also increases. See " ● GPS locating accuracy" (page 17) for how to set the position measurement precision. See " ● GPS locate" (page 15) below for how to check acquired GPS data.

● GPS locate

1. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
2. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**
3. **Press the down (▽) key to move the cursor to "GPS locate", then press the ENTER key.**



2008/07/04 18:35:55

SETTINGS

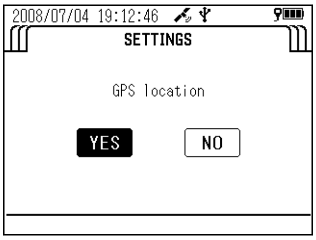
System

GPS locate

GPS locating accuracy

4. **The message "Press ENT key to start position measurement." appears. Press the ENTER key.**

5. **The message "Execute GPS position measurement?" appears. Move the cursor to "YES", then press the ENTER key.**

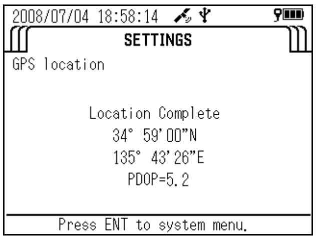


2008/07/04 19:12:46

SETTINGS

GPS location

6. **The message "Warming up. Please wait." appears. Wait until the system has finished warming up (about 10 seconds).**
   - Position measurement starts automatically when warmup has finished. Position measurement is performed up to 10 times.
   - The GPS location complete screen appears after successful position measurement.



2008/07/04 18:58:14

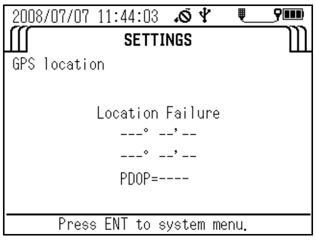
SETTINGS

GPS location

Location Complete
34° 59' 00"N
135° 43' 26"E
PDOP=5.2

Press ENT to system menu.

   - The GPS location failure screen appears after position measurement has failed. Redo the measurement in a location free from obstacles, or wait for the meteorological conditions to improve before redoing the measurement.



2008/07/07 11:44:03

SETTINGS

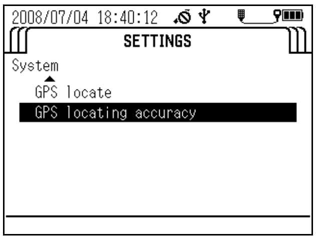
GPS location

Location Failure
---° --' --
---° --' --
PDOP=----

Press ENT to system menu.

● GPS locating accuracy

1. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
2. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**
3. **Press the down (▽) key to move the cursor to "GPS locating accuracy", then press the ENTER key.**



2008/07/04 18:40:12

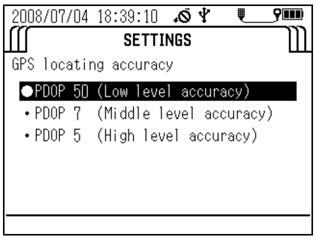
SETTINGS

System

GPS locate

GPS locating accuracy

4. **The screen below appears. Move the cursor to the locating accuracy, then press the ENTER key. The black circle (●) indicates the currently set precision.**



2008/07/04 18:39:10

SETTINGS

GPS locating accuracy

●PDOP 50 (Low level accuracy)

• PDOP 7 (Middle level accuracy)

• PDOP 5 (High level accuracy)

3.2 Settings

3.2.1 Setting measurement methods

This section describes how to set the measurement method.

● Measurement methods

● U-51/U-52

Single measurement	Pressing the MEAS key acquires the 5-second average for the selected measurement parameter.
Interval measurement	Pressing the MEAS key acquires and saves the 5-second average for the selected measurement parameter in the set interval. The measurement interval can be set to any value between 10 seconds and 24 hours.

● U-53

The U-53 turbidity sensor uses a tungsten lamp. The lamp lights for about 10 seconds, and the average measurement value acquired during this interval is displayed.

Single measurement	Pressing the MEAS key acquires the 5-second average for the selected measurement parameter after wiper operation. The 10-second average is acquired when measuring turbidity.
Interval measurement	Pressing the MEAS key acquires and saves the 5-second average for the selected measurement parameter in the set interval. The 10-second average is acquired when measuring turbidity. The measurement interval can be set to any value between 10 seconds (final check of this value required; 30 seconds may be better for U-52) and 24 hour.

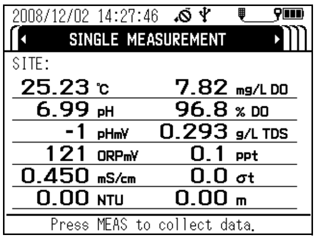
Reference

“ 3.4 Measurement ” (page 61)

● Operation method

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.



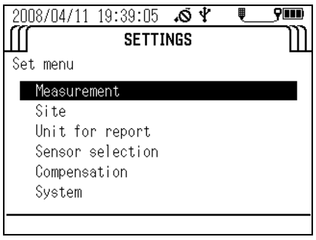
```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
  25.23 ℃         7.82 mg/L DO
   6.99 pH        96.8 % DO
     -1 pHmV     0.293 g/L TDS
    121 ORPmV      0.1 ppt
  0.450 mS/cm      0.0 σt
   0.00 NTU       0.00 m
Press MEAS to collect data.
```

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

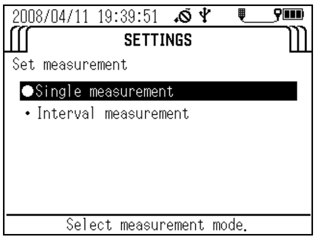
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Measurement", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to the desired measurement mode. Press the ENTER key to save the setting.**

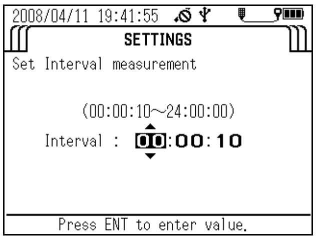
   The black circle (●) indicates the currently selected measurement mode.



Select measurement mode.

5. **If you selected "Interval measurement", the display switches to the screen used to set the measurement interval. Press the up (△) and down (▽) keys to set the measurement interval.**

   The measurement interval can be set to any value between 10 seconds and 24 hours in the case of the U-51 and U-52, or between 30 seconds and 24 hours in the case of the U-53.



Interval : 00:00:10

Press ENT to enter value.

3.2.2 Setting sites

The site function allows position data to be connected to corresponding measurement data. Sites have the following specifications and features:

Site names:	Text data consisting of up to 20 one-byte alphanumeric characters, spaces, etc. Site names can be used for control unit searches and as labels for computer processing. Site names allow measurement data to be saved with a name corresponding to the actual location where it was measured.

You can use site information as a search key when viewing data uploaded by a PC or data saved in the control unit (see “ 3.5 Data operations ” (page 64)).

● Selecting sites

You can select previously created sites. The black circle (●) indicates the name of the currently selected site. No sites are created at new purchasing or after initialization. Select a site after first creating one from the "Create new site" menu.

● Creating new sites

You can create and save new sites. Up to 20 site names can be registered.

● Deleting sites

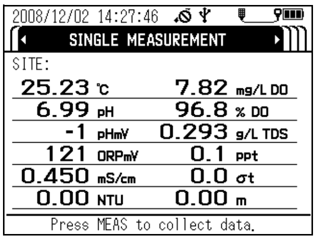
You can select a previously created site and delete it.

● Operation methods

● Selecting a site

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

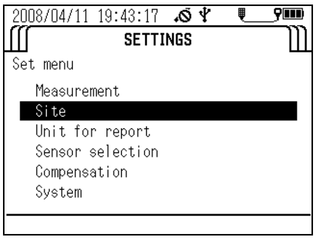
25.23	℃	7.82	mg/L DO
6.99	pH	96.8	% DO
-1	pHmV	0.293	g/L TDS
121	ORPmV	0.1	ppt
0.450	mS/cm	0.0	σt
0.00	NTU	0.00	m

Press MEAS to collect data.

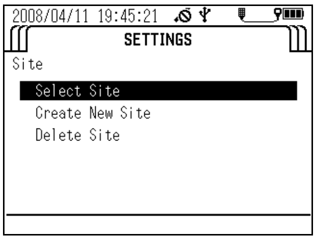
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

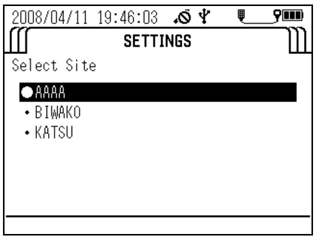
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**



4. Press the down (▽) key to move the cursor to "Select Site", then press the ENTER key to display the names of the currently saved sites.



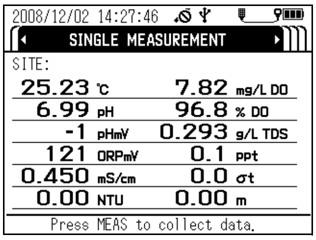
The black circle (●) indicates the currently selected site.



● Creating a new site

1. Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.

The "MEASUREMENT" screen appears after about 10 seconds.



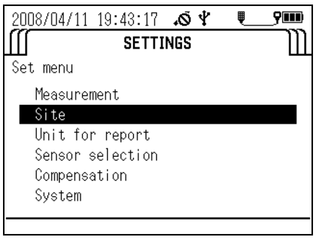
```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
25.23 ℃        7.82 mg/L DO
 6.99 pH       96.8 % DO
   -1 pHmV    0.293 g/L TDS
  121 ORPmV     0.1 ppt
0.450 mS/cm     0.0 σt
 0.00 NTU      0.00 m
Press MEAS to collect data.
```

Note

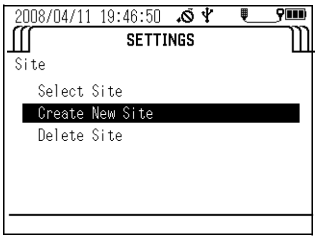
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. Press the right (▷) key to switch the display to the "SETTINGS" screen.

3. Press the down (▽) key to move the cursor to "Site", then press the ENTER key.

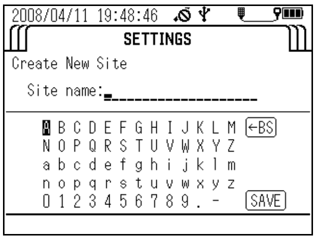


4. **Press the down (▽) key to move the cursor to "Create New Site", then press the ENTER key.**
   Enter the desired site name (up to 20 alphanumeric non-Asian width characters).



2008/04/11 19:46:50
SETTINGS
Site
Select Site
Create New Site
Delete Site

5. **Press the up (△), down (▽), right (▷), and left (◁) keys to move the cursor to each letter or number to use in the name, then press the ENTER key to confirm the entered characters. To delete incorrectly entered characters, move the cursor to "BS" and press the ENTER key to start deleting from the last character. When you have finished entering the name, save it by moving the cursor to "SAVE" and pressing the ENTER key.**

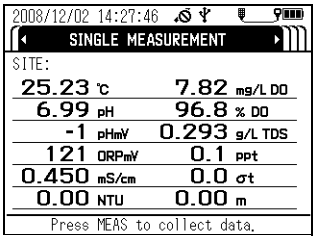


2008/04/11 19:48:46
SETTINGS
Create New Site
Site name:_

A B C D E F G H I J K L M ←BS
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m
n o p q r s t u v w x y z
0 1 2 3 4 5 6 7 8 9 . - SAVE

● Deleting a site

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:

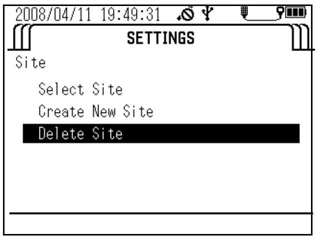
25.23	℃	7.82	mg/L DO
6.99	pH	96.8	% DO
-1	pHmV	0.293	g/L TDS
121	ORPmV	0.1	ppt
0.450	mS/cm	0.0	σt
0.00	NTU	0.00	m

Press MEAS to collect data.

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

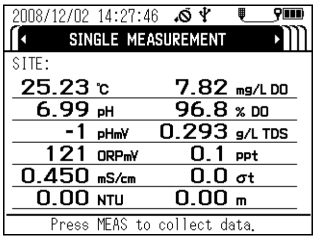


2008/04/11 19:49:31
SETTINGS
Site
Select Site
Create New Site
Delete Site

3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**

4. **Press the down (▽) key to move the cursor to "Delete Site", then press the ENTER key.**

   A list of the currently saved sites appears. The black circle (●) indicates the currently selected site.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

25.23 ℃ 7.82 mg/L DO

6.99 pH 96.8 % DO

-1 pHmV 0.293 g/L TDS

121 ORPmV 0.1 ppt

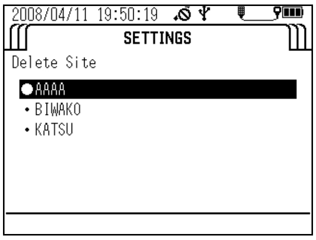
0.450 mS/cm 0.0 σt

0.00 NTU 0.00 m

Press MEAS to collect data.

5. **Press the down (▽) key to move the cursor to the site to delete, then press the ENTER key to delete it.**

   The currently selected site can be deleted after a different site has been selected from the site selection menu or after all unselected sites have been deleted. The same site name cannot be registered more than once.



2008/04/11 19:50:19

SETTINGS

Delete Site

- ●AAAA
- • BIWAKO
- • KATSU

3.2.3 Unit for report

Note

Units can only be selected when the sensor probe is connected.

Follow the steps below to set the measurement units of measurement parameters. No units are displayed if a measurement parameter has not been selected in the measurement parameter selection screen (see “ 3.2.4 Sensor selection ” (page 25)).

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.

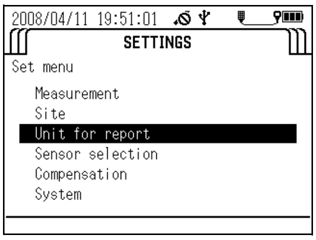
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Unit for report", then press the ENTER key.**

A list of the currently selected measurement parameters and their units appears. Note that measurement parameters not selected (in the measurement parameter selection screen) are not displayed.



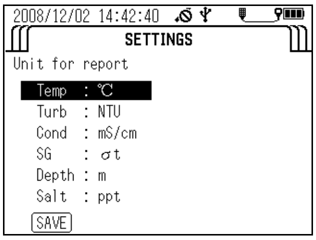
2008/04/11 19:51:01

SETTINGS

Set menu

Measurement
Site
Unit for report
Sensor selection
Compensation
System

4. **Press the up (△) and down (▽) keys to move the cursor to the item to change, then press the ENTER key.**



2008/12/02 14:42:40

SETTINGS

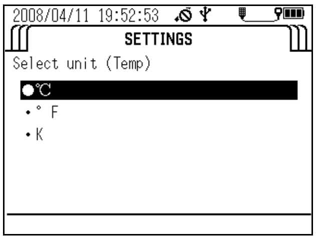
Unit for report

Temp : ℃
Turb : NTU
Cond : mS/cm
SG : σt
Depth : m
Salt : ppt

SAVE

5. **A list of the units that can be selected appears. The black circle (●) indicates the currently selected unit. Press the up (△) and down (▽) keys to move the cursor to the desired unit, then press the ENTER key.**

Fix S/m: Fixes S/m with no auxiliary units for any measurement range.

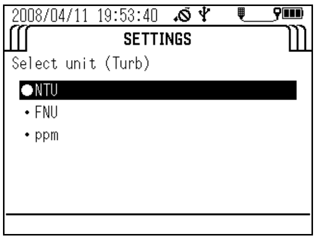


2008/04/11 19:52:53

SETTINGS

Select unit (Temp)

●℃
• ° F
• K

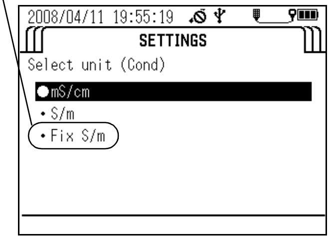


2008/04/11 19:53:40

SETTINGS

Select unit (Turb)

●NTU
• FNU
• ppm

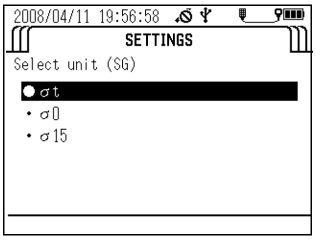


2008/04/11 19:55:19

SETTINGS

Select unit (Cond)

●mS/cm
• S/m
• Fix S/m

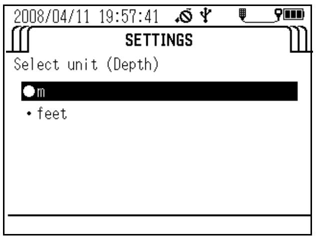


2008/04/11 19:56:58

SETTINGS

Select unit (SG)

●σt
• σ0
• σ15

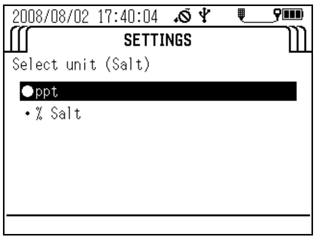


2008/04/11 19:57:41

SETTINGS

Select unit (Depth)

●m
• feet



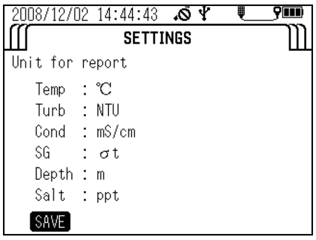
2008/08/02 17:40:04

SETTINGS

Select unit (Salt)

●ppt
• % Salt

6. **To save the changes, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you do not want to save the changes, press the ESC key.**



2008/12/02 14:44:43

SETTINGS

Unit for report

Temp : ℃
Turb : NTU
Cond : mS/cm
SG : σt
Depth : m
Salt : ppt

SAVE

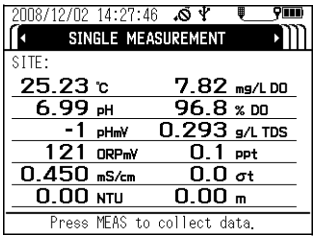
3.2.4 Sensor selection

Note

Measurement parameters can only be selected when the sensor probe is connected.

You can set between 1 and 11 measurement parameters to display in the control unit screen. Follow the steps below to select the desired measurement parameters.

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

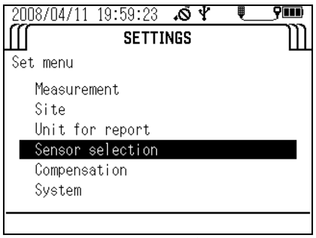


```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
 25.23 ℃          7.82 mg/L DO
  6.99 pH         96.8 % DO
    -1 pHmV      0.293 g/L TDS
   121 ORPmV       0.1 ppt
 0.450 mS/cm       0.0 σt
  0.00 NTU        0.00 m
Press MEAS to collect data.
```

Note

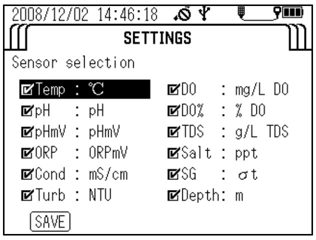
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Sensor selection", then press the ENTER key.**
   A list of the measurement parameters that can be set and the currently set units are displayed.



```
2008/04/11 19:59:23
SETTINGS
Set menu
  Measurement
  Site
  Unit for report
  Sensor selection
  Compensation
  System
```

4. **Move the cursor to each measurement parameter to change, then press the ENTER key.**
   A check in the check box of a measurement parameter indicates it will be displayed.
5. **To save the changes, press the up (△), down (▽), left (◁) and right (▷) keys to move the cursor to SAVE, then press the ENTER key. If you don’t want to save the changes, press the ESC key.**



```
2008/12/02 14:46:18
SETTINGS
Sensor selection
 ☑Temp : ℃         ☑DO   : mg/L DO
 ☑pH   : pH        ☑DO%  : % DO
 ☑pHmV : pHmV      ☑TDS  : g/L TDS
 ☑ORP  : ORPmV     ☑Salt : ppt
 ☑Cond : mS/cm     ☑SG   : σt
 ☑Turb : NTU       ☑Depth: m
  SAVE
```

Note

Available measurement parameters differ according to product specifications.

3.2.5 Compensation

Note

Compensation settings can only be made when the sensor probe is connected.

U-50 series have following functions of compensation.

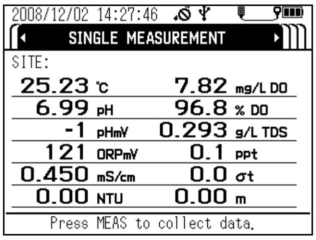
- Salinity compensation and atmospheric pressure compensation for dissolved oxygen (DO)
- Temperature compensation for conductivity (COND)
- Setting total dissolved solid (TDS) coefficient for TDS

● Salinity compensation (DO)

The dissolved oxygen (DO) value is presented higher than actual value if salinity compensation is not added, because the increase of salinity gives higher DO value. To obtain correct value salinity compensation is needed. The following modes are available for calculation of salinity compensation.

AUTO:	Salinity compensation is performed automatically with salinity converted from conductivity.
Value input:	Press the up (△) and down (▽) keys to enter a setting value when the salinity is known.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

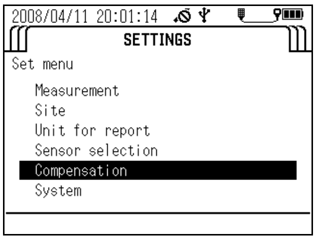
25.23 ℃	7.82 mg/L DO
6.99 pH	96.8 % DO
-1 pHmV	0.293 g/L TDS
121 ORPmV	0.1 ppt
0.450 mS/cm	0.0 σt
0.00 NTU	0.00 m

Press MEAS to collect data.

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



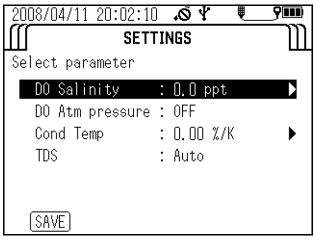
2008/04/11 20:01:14

SETTINGS

Set menu

- Measurement
- Site
- Unit for report
- Sensor selection
- Compensation
- System

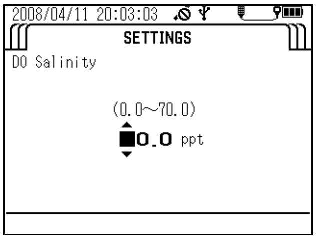
4. **Press the down (▽) key to move the cursor to "DO Salinity", then press the ENTER key to toggle the setting between "Auto" and "Input mode".**
   Default: Auto



```
2008/04/11 20:02:10
SETTINGS
Select parameter
  DO Salinity     : 0.0 ppt      ▶
  DO Atm pressure : OFF
  Cond Temp       : 0.00 %/K     ▶
  TDS             : Auto

SAVE
```

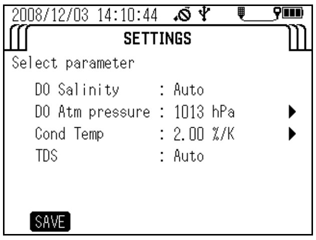
5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



```
2008/04/11 20:03:03
SETTINGS
DO Salinity

        (0.0~70.0)
         0.0 ppt
```

6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



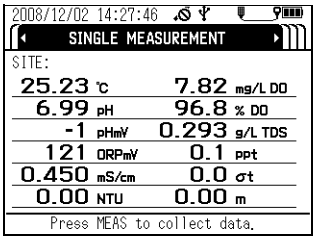
```
2008/12/03 14:10:44
SETTINGS
Select parameter
  DO Salinity     : Auto
  DO Atm pressure : 1013 hPa     ▶
  Cond Temp       : 2.00 %/K     ▶
  TDS             : Auto

SAVE
```

- **Atmospheric pressure compensation (DO)**

Differences in the atmospheric pressure of the measurement location influence the Dissolved Oxygen (DO) measurement. By setting (input) the actual atmospheric pressure of the measurement location into the control unit, it is possible to standardize the measured Dissolved Oxygen (DO) value to a value at the standard atmospheric pressure (1013 hPa).

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



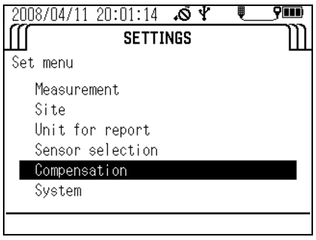
```
2008/12/02 14:27:46
◀ SINGLE MEASUREMENT ▶
SITE:
 25.23 ℃        7.82 mg/L DO
  6.99 pH       96.8 % DO
    -1 pHmV    0.293 g/L TDS
   121 ORPmV     0.1 ppt
 0.450 mS/cm     0.0 σt
  0.00 NTU      0.00 m
   Press MEAS to collect data.
```

Note

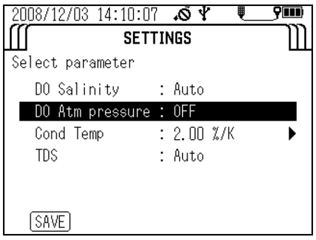
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

---

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Cond Temp", then press the ENTER key to toggle the setting between "OFF" and "Input mode".**
   Default: OFF



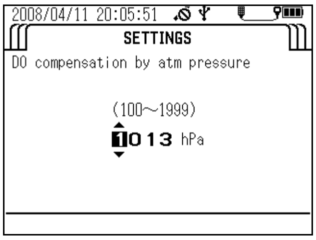
2008/12/03 14:10:07

SETTINGS

Select parameter

DO Salinity : Auto
DO Atm pressure : OFF
Cond Temp : 2.00 %/K ▶
TDS : Auto

5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



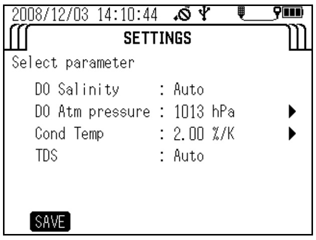
2008/04/11 20:05:51

SETTINGS

DO compensation by atm pressure

(100~1999)
1013 hPa

6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



2008/12/03 14:10:44

SETTINGS

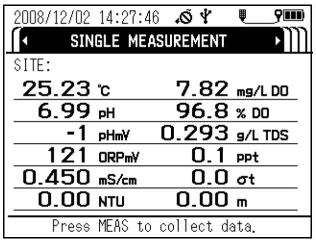
Select parameter

DO Salinity : Auto
DO Atm pressure : 1013 hPa ▶
Cond Temp : 2.00 %/K ▶
TDS : Auto

Temperature compensation for conductivity (COND)

Sample conductivity (COND) varies with temperature, and this control unit uses a temperature compensation coefficient to automatically standardize the conductivity (COND) at 25°C. The initial setting coefficient is 2%/K, which is the generally used.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

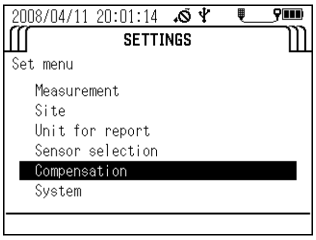


```
SITE:
 25.23 ℃          7.82 mg/L DO
  6.99 pH         96.8 % DO
    -1 pHmV      0.293 g/L TDS
   121 ORPmV       0.1 ppt
 0.450 mS/cm       0.0 σt
  0.00 NTU        0.00 m
      Press MEAS to collect data.
```

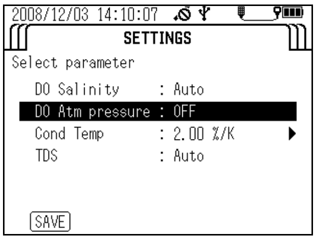
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



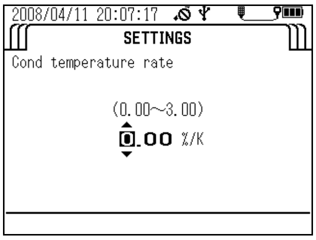
4. **Press the down (▽) key to move the cursor to "Cond Temp", then press the ENTER key to toggle the setting between "OFF" and "Input mode".**
   Default: 2.00%/K



DO Salinity : Auto
DO Atm pressure : OFF
Cond Temp : 2.00 %/K
TDS : Auto

---

5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



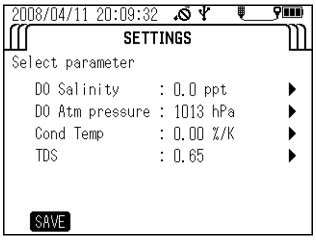
2008/04/11 20:07:17

Cond temperature rate

(0.00~3.00)

0.00 %/K

6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key.**
   If you don’t want to save the change, press the ESC key.



2008/04/11 20:09:32

Select parameter

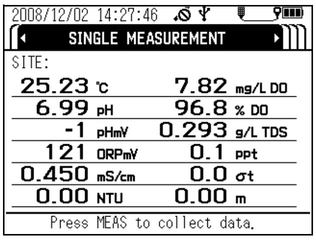
DO Salinity : 0.0 ppt
DO Atm pressure : 1013 hPa
Cond Temp : 0.00 %/K
TDS : 0.65

● Setting a total dissolved solid (TDS) coefficient

The total dissolved solid amount (TDS) is a converted value obtained by multiplying the conductivity (COND) by a known coefficient. The coefficient initially set for the control unit is based on a conversion for KCl and $CaCO_3$ solutions and it depends on the conductivity (COND) value as shown below.

Conductivity (COND) (S/m)	Conversion coefficient
< 0.05	0.65
0.05 to 0.5	0.64
0.5 to 1	0.63
1 to 3	0.62
3 to 5	0.61
> 5	0.60

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

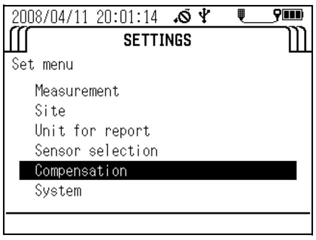


```
SITE:
 25.23 ℃        7.82 mg/L DO
  6.99 pH       96.8 % DO
    -1 pHmV    0.293 g/L TDS
   121 ORPmV     0.1 ppt
 0.450 mS/cm     0.0 σt
  0.00 NTU      0.00 m
Press MEAS to collect data.
```

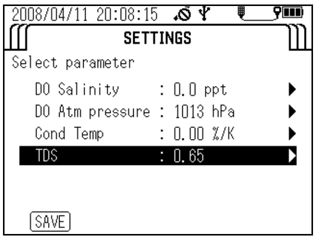
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**

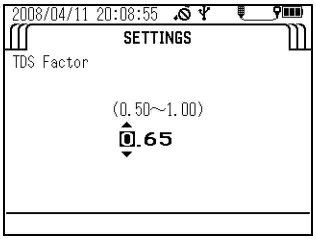


4. **Press the down (▽) key to move the cursor to "TDS", then press the ENTER key to toggle the setting between "AUTO" and "Input mode".**
   Default: Auto



```
DO Salinity     : 0.0 ppt
DO Atm pressure : 1013 hPa
Cond Temp       : 0.00 %/K
TDS             : 0.65
```

5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



2008/04/11 20:08:55

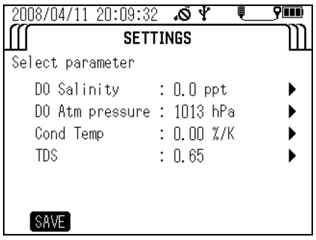
SETTINGS

TDS Factor

(0.50~1.00)

0.65

6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



2008/04/11 20:09:32

SETTINGS

Select parameter

DO Salinity : 0.0 ppt
DO Atm pressure : 1013 hPa
Cond Temp : 0.00 %/K
TDS : 0.65

SAVE

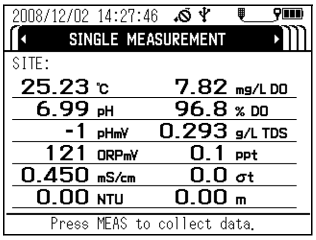
3.2.6 System settings

The system settings let you change the display language, check the system software version, set the date/time, set the auto power OFF time, set the display contrast, and initialize the settings.

● Display language

Follow the steps below to select either English or Japanese as the display language.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

25.23 ℃	7.82 mg/L DO
6.99 pH	96.8 % DO
-1 pHmV	0.293 g/L TDS
121 ORPmV	0.1 ppt
0.450 mS/cm	0.0 σt
0.00 NTU	0.00 m

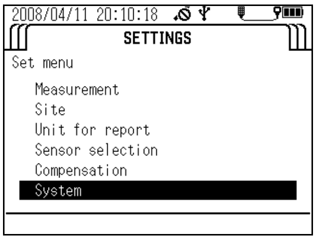
Press MEAS to collect data.

Note

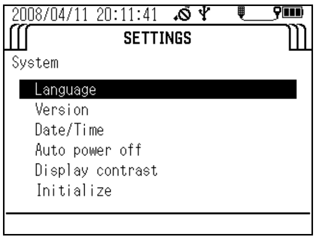
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**

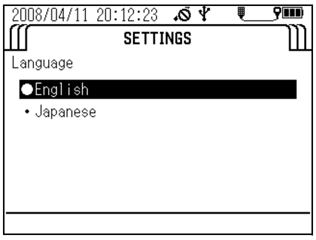


4. **Press the down (▽) key to move the cursor to "Language", then press the ENTER key.**



5. **A list of the supported display languages appears. Press the up (△) and down (▽) keys to move the cursor to the desired language, then press the ENTER key.**

   The black circle (●) indicates the currently selected display language.



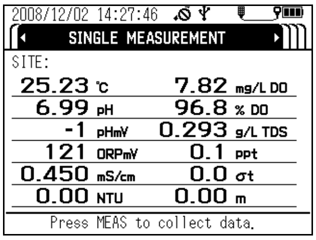
● Version

Follow the steps below to display the program No. and version of the control unit and sensor probe software.

The program No. and version of the sensor probe software will not be displayed if the sensor probe is not connected.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.



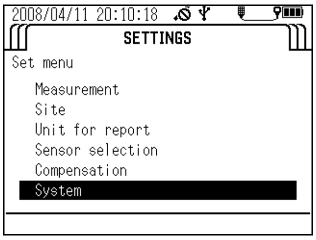
25.23 ℃	7.82 mg/L DO
6.99 pH	96.8 % DO
-1 pHmV	0.293 g/L TDS
121 ORPmV	0.1 ppt
0.450 mS/cm	0.0 σt
0.00 NTU	0.00 m

Note

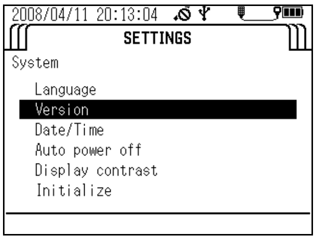
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



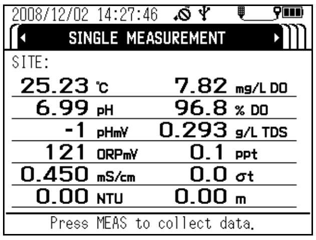
4. **Press the down (▽) key to move the cursor to "Version", then press the ENTER key.**
   The program No. of the control unit and sensor probe software appears.



Setting the date/time

Follow the steps below to set the date and time.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

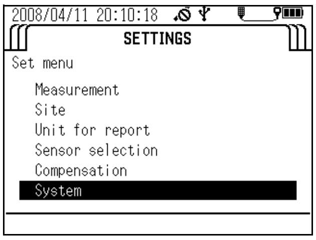


```
25.23 ℃        7.82 mg/L DO
 6.99 pH       96.8 % DO
   -1 pHmV    0.293 g/L TDS
  121 ORPmV     0.1 ppt
0.450 mS/cm     0.0 σt
 0.00 NTU      0.00 m
Press MEAS to collect data.
```

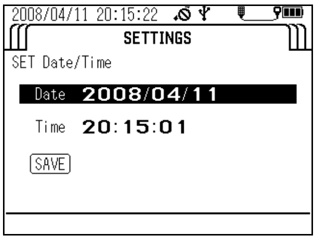
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Date/time", then press the ENTER key.**



2008/04/11 20:15:22

SETTINGS

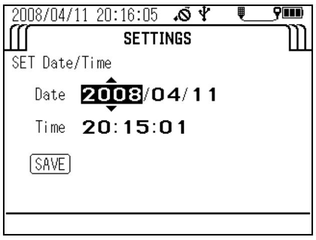
SET Date/Time

Date 2008/04/11

Time 20:15:01

SAVE

5. **Move the cursor to the date, then press the ENTER key.**
6. **Press the right (▷) key to move the cursor to the year, month, day, hour, minute and second, and press the up (△) and down (▽) keys to enter each value.**



2008/04/11 20:16:05

SETTINGS

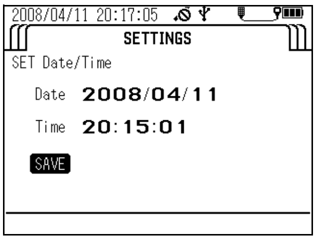
SET Date/Time

Date 2008/04/11

Time 20:15:01

SAVE

7. **When finished entering settings, press the ENTER key to move the cursor to SAVE, then press the ENTER key again to save the settings.**



2008/04/11 20:17:05

SETTINGS

SET Date/Time

Date 2008/04/11

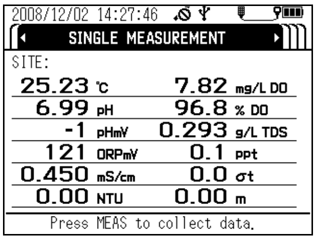
Time 20:15:01

SAVE

- **Setting the auto power OFF time**

Follow the steps below to set the time for the auto power OFF function (which turns the power OFF automatically when no operation is performed for the preset amount of time).

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

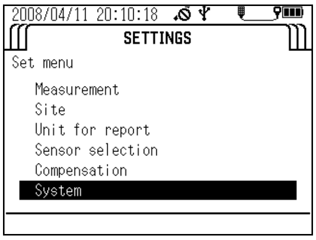
25.23	℃	7.82	mg/L DO
6.99	pH	96.8	% DO
-1	pHmV	0.293	g/L TDS
121	ORPmV	0.1	ppt
0.450	mS/cm	0.0	σt
0.00	NTU	0.00	m

Press MEAS to collect data.

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



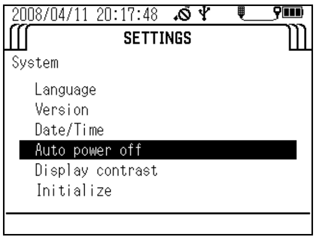
2008/04/11 20:10:18

SETTINGS

Set menu

Measurement
Site
Unit for report
Sensor selection
Compensation
System

4. **Press the down (▽) key to move the cursor to "Auto power off", then press the ENTER key.**



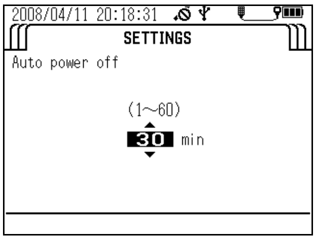
2008/04/11 20:17:48

SETTINGS

System

Language
Version
Date/Time
Auto power off
Display contrast
Initialize

5. **Press the up (△) and down (▽) keys to select the desired time setting, then press the ENTER key.**
   You can select OFF, or settings of 1, 2, 5, 10, 20, 30 or 60 minutes.
   Default: 30 minutes



2008/04/11 20:18:31

SETTINGS

Auto power off

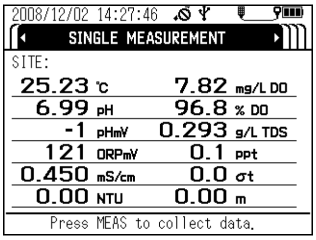
(1~60)

30 min

● Display contrast

Follow the steps below to adjust the display's contrast.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

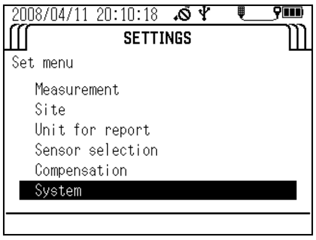
25.23	℃	7.82	mg/L DO
6.99	pH	96.8	% DO
-1	pHmV	0.293	g/L TDS
121	ORPmV	0.1	ppt
0.450	mS/cm	0.0	σt
0.00	NTU	0.00	m

Press MEAS to collect data.

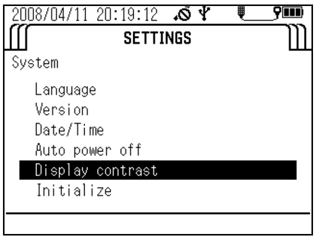
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

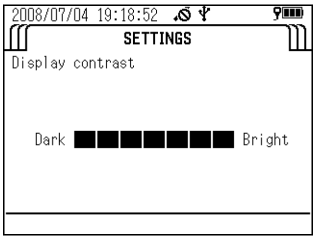
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Display contrast", then press the ENTER key.**



5. **Press the left (◁) and right (▷) keys to adjust the contrast.**
   Adjustment can be made in 26 steps.

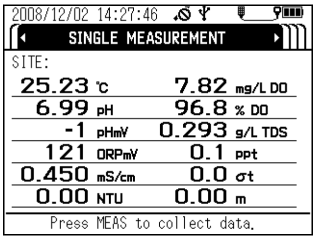


6. **Press the ENTER key.**

● Initialization

Follow the steps below to restore all the settings except date/time to their factory defaults. Factory default calibration data for the electrical conductivity and turbidity sensors will also be deleted at the same time.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



25.23 ℃ 7.82 mg/L DO
6.99 pH 96.8 % DO
-1 pHmV 0.293 g/L TDS
121 ORPmV 0.1 ppt
0.450 mS/cm 0.0 σt
0.00 NTU 0.00 m

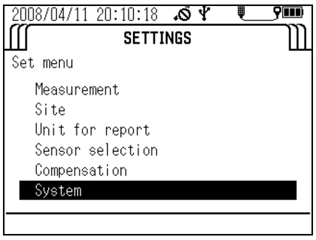
Press MEAS to collect data.

Note

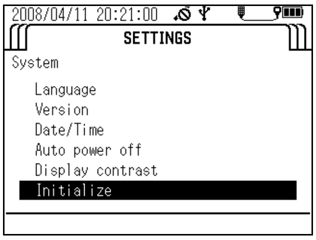
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

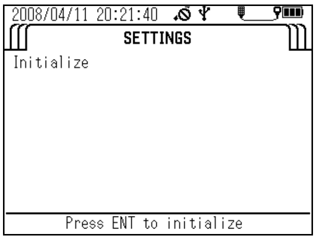
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Initialize", then press the ENTER key.**



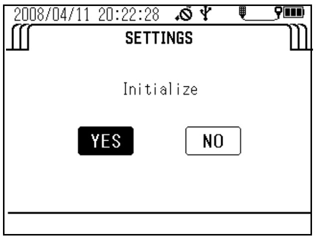
5. **Press the ENTER key again.**



Press ENT to initialize

6. **A confirmation message appears asking whether to execute initialization. Press the left (◁) key to move the cursor to YES, then press the ENTER key.**

The message "Initialize Complete" appears to indicate the process has finished.



3.3 Calibration

To obtain correct measurement values, the sensors need to be calibrated using standard solution before measurement. You can select simultaneous auto calibration of the pH, COND and TURB sensors in pH4 standard solution and DO and DEP sensors simultaneously in air, or manual calibration of individual measurement parameters. You can check the result of the previous calibration using the procedure on “ 3.5.4 Checking the calibration record ” (page 70).

Note

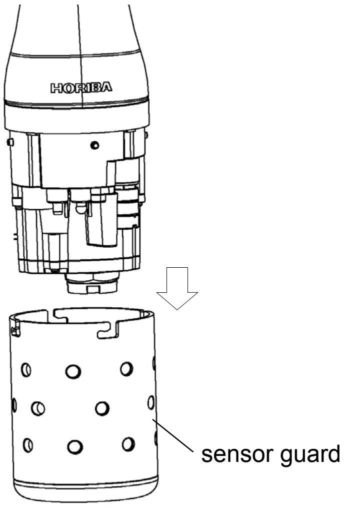
- **Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.**
- **Make the DO and COND compensation settings before calibration since these settings are applied during calibration.**
- **You can select only the desired parameters for calibration and calibrate just those parameters (see “ 3.2.4 Sensor selection ” (page 25)).**
- **Use about 200 mL of standard solution in the calibration cup.**
- **Calibration data is stored in the sensor probe.**

3.3.1 Auto calibration

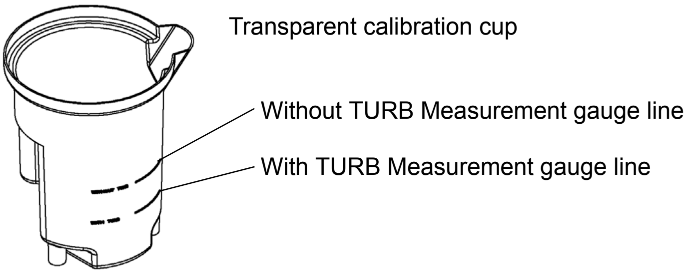
Tip

- **The following parameters are calibrated (at 25°C):**
  pH: Set to 4.01 (zero-point calibration); the span is adjusted to the factory default value.
  COND: 0.449 S/m (4.49 mS/cm, span calibration); the zero point is adjusted to the factory default value.
  TURB: 0 NTU (zero-point calibration); the span is adjusted to the factory default value.
  DO: 8.92 mg/L (span calibration); the zero point is adjusted to the factory default value.
  DEP: 0 m (zero-point calibration); the zero point is adjusted to the factory default value.
- **If the air temperature changes, the readout value may not be stable. Ensure that the ambient air temperature is the same temperature as the calibration solution, because the internal probe temperature sensor and external temperature sensor (in the calibration solution) are used for the auto calibration. Allow the probe and standard solution to equilibrate for 1 hour if a thermometer is not available to verify that these temperatures are the same.**
- **Do not hold the probe while performing the auto calibration. Body temperature may elevate the internal temperature sensor measurement creating DO calibration error.**

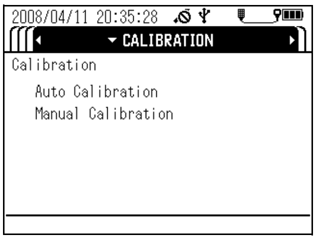
1. **Remove the sensor guard and wash the sensor probe 2 or 3 times with deionized water.**



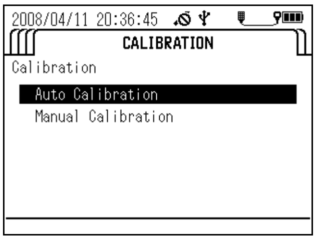
2. **Remove the transparent calibration cup.**
3. **Fill the transparent calibration cup to the line with pH 4 standard solution.**
   The transparent calibration cup has With TURB Measurement and Without TURB Measurement gauge lines.



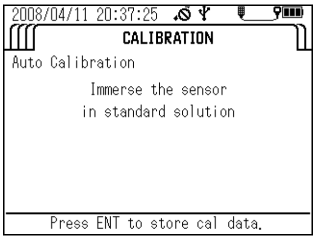
4. **Press the control unit's CAL key to set the calibration mode.**



5. **Press the down (▽) key to move the cursor to "Auto Calibration", then press the ENTER key.**



6. **Immerse the sensor probe in the transparent calibration cup.
Check that the pH sensor, ORP sensor, reference electrode, COND sensor, TURB sensor and temperature sensor are submerged in the pH 4 standard solution and check that there are no air bubbles on the sensor.**



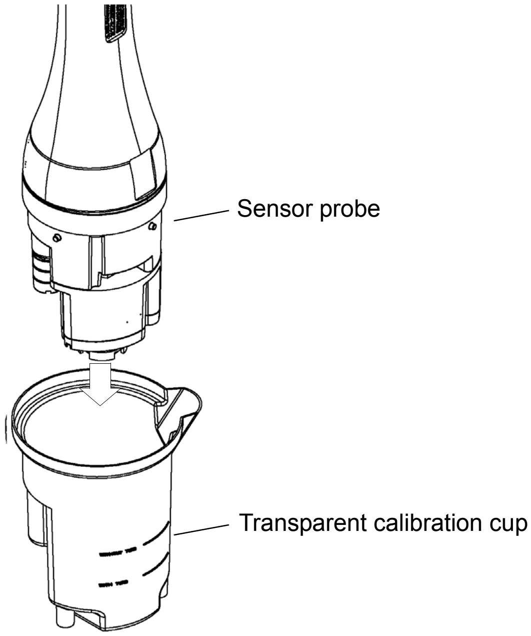
2008/04/11 20:37:25

CALIBRATION

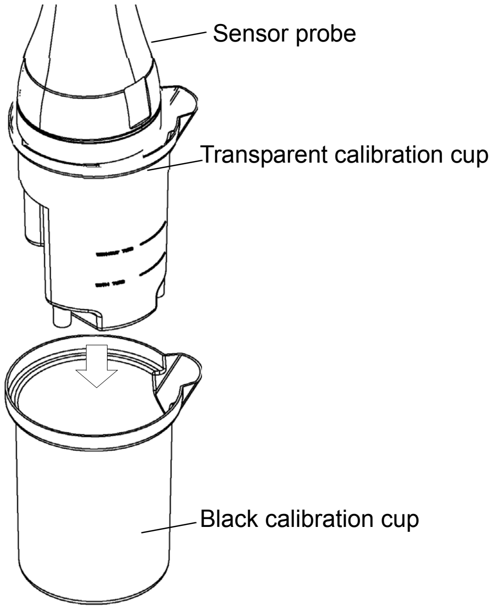
Auto Calibration

Immerse the sensor
in standard solution

Press ENT to store cal data.



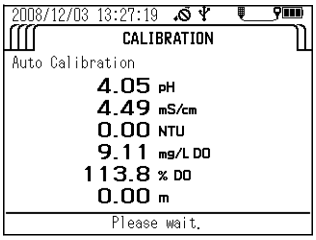
7. **With the sensor probe still in the transparent calibration cup, place the transparent calibration cup into the black calibration cup.**



8. **When all the sensor values have stabilized, press the ENTER key to start calibration.**

Note

Do not remove the sensor probe from the calibration solution. U-53 turbidity data will display "----" until the calibration is completed.



2008/12/03 13:27:19

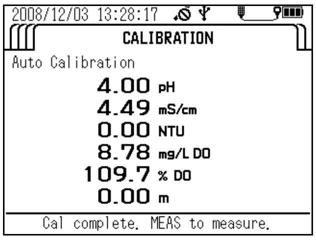
CALIBRATION

Auto Calibration

4.05 pH
4.49 mS/cm
0.00 NTU
9.11 mg/L DO
113.8 % DO
0.00 m

Please wait.

Calibration is finished when the message "Cal complete. MEAS to measure." appears. Press the MEAS key to set the measurement screen, then start measurement.



2008/12/03 13:28:17

CALIBRATION

Auto Calibration

4.00 pH
4.49 mS/cm
0.00 NTU
8.78 mg/L DO
109.7 % DO
0.00 m

Cal complete. MEAS to measure.

If a calibration error occurs, start calibration after first resolving the issue according to the instructions in " 4.6 Troubleshooting " (page 89).

3.3.2 Manual calibration

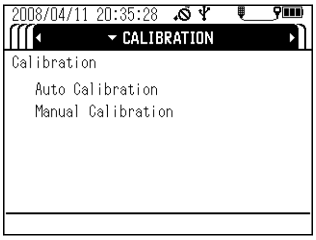
The procedures below describe how to calibrate each sensor individually.

Note

The displayed units are the units set by selecting "Unit for report" in the "SETTINGS" screen.

● Temperature (TEMP) calibration

1. **Fill a bucket or similar container with water of a known temperature, and insert the sensor probe in it.**
   Wait 5 minutes before starting calibration to allow the sensor probe temperature to stabilize.
2. **Press the control unit's CAL key to set the calibration mode.**
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**

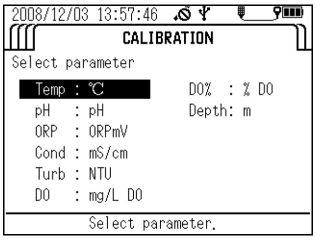


2008/04/11 20:35:28

CALIBRATION

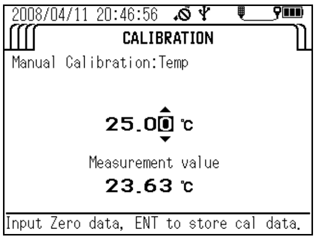
Calibration
Auto Calibration
Manual Calibration

4. **In the parameter selection screen, move the cursor to “Temp”, then press the ENTER key.**



```
2008/12/03 13:57:46
CALIBRATION
Select parameter
  Temp : ℃          DO%  : % DO
  pH   : pH         Depth: m
  ORP  : ORPmV
  Cond : mS/cm
  Turb : NTU
  DO   : mg/L DO
Select parameter.
```

5. **Press the up (△) and down (▽) keys to set the calibration value - the temperature of the water containing the submerged sensor probe.**



```
2008/04/11 20:46:56
CALIBRATION
Manual Calibration:Temp

25.00 ℃

Measurement value
23.63 ℃
Input Zero data, ENT to store cal data.
```

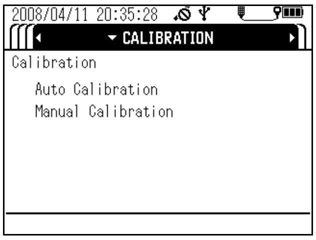
6. **Check that “Measurement value” has stabilized, then press the ENTER key to start calibration.**
   Calibration is finished when the message “Cal complete. CNT to measure.” appears.

● pH calibration

Note

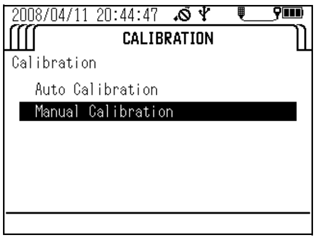
You can select one calibration point (zero-point calibration) or two calibration points (zero-point calibration and span calibration). Carry out two calibration procedures to ensure good measurement precision throughout all measurement ranges.

1. **Calibrate the zero point. Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with pH 7 standard solution.**
2. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
3. **Press the control unit’s CAL key to set the calibration mode.**



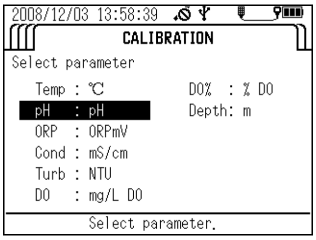
```
2008/04/11 20:35:28
CALIBRATION
Calibration
  Auto Calibration
  Manual Calibration
```

4. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



```
2008/04/11 20:44:47
CALIBRATION
Calibration
  Auto Calibration
  Manual Calibration
```

5. **In the parameter selection screen, move the cursor to "pH", then press the ENTER key.**



2008/12/03 13:58:39

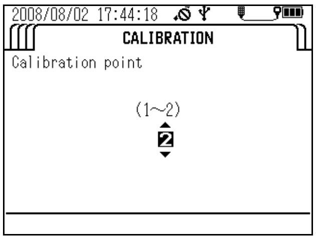
CALIBRATION

Select parameter

Temp : ℃
pH : pH
ORP : ORPmV
Cond : mS/cm
Turb : NTU
DO : mg/L DO
DO% : % DO
Depth: m

Select parameter.

6. **Set the number of calibration points, then press the ENTER key.**



2008/08/02 17:44:18

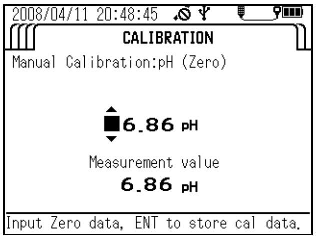
CALIBRATION

Calibration point

(1~2)

2

7. **Press the up (△) and down (▽) keys to set the pH value of the pH 7 standard solution containing the submerged sensor probe at the measurement temperature**



2008/04/11 20:48:45

CALIBRATION

Manual Calibration:pH (Zero)

6.86 pH

Measurement value

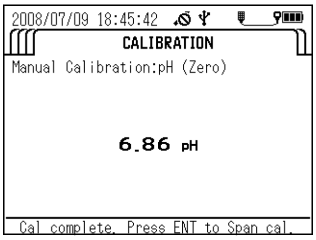
6.86 pH

Input Zero data, ENT to store cal data.

Temp. (°C)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

9. **Press the ENTER key to start the span calibration procedure when the message "Cal complete. Press ENT to Span cal." appears.**



2008/07/09 18:45:42

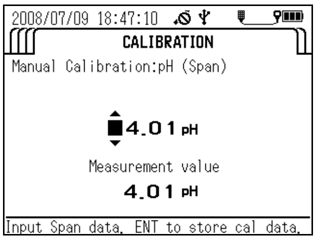
CALIBRATION

Manual Calibration:pH (Zero)

6.86 pH

Cal complete. Press ENT to Span cal.

10. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with pH 4 or pH 9 standard solution.**
11. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
12. **Press the up (△) and down (▽) keys to set the pH value of the pH 4 or pH 9 standard solution containing the submerged sensor probe at the measurement temperature.**



2008/07/09 18:47:10

CALIBRATION

Manual Calibration:pH (Span)

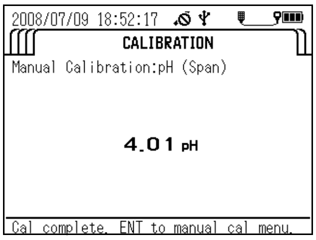
4.01 pH

Measurement value

4.01 pH

Input Span data. ENT to store cal data.

13. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
14. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter**



2008/07/09 18:52:17

CALIBRATION

Manual Calibration:pH (Span)

4.01 pH

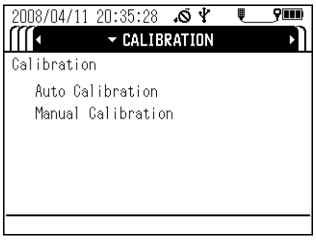
Cal complete. ENT to manual cal menu.

ORP calibration

Note

- **If the prepared ORP standard solution is left in open air for one hour or more, the solution may be transformed. For this reason ORP standard solution cannot be stored.**
  Calibrate within one hour of preparing the solution.
- **When measuring sample with low concentrations of oxidants and reductants after conducting an operational check using a standard substance, the measured values may not stabilize or the results of measurement might not be repeatable. If this is the case, start the measurement after immersing the sensors in the sample water sufficiently.**
- **Note that when measuring the ORP of solution with extremely low concentrations of oxidants and reductants, such as tap water, well water, or water treated with purifying equipment, there may be less responsiveness, repeatability, and stability, in general.**
- **When alkaline ion water is left for 5 minutes, its ORP undergoes changes significantly. Always measure alkaline ion water promptly.**

1. **Fill a clean beaker with one bag of ORP standard powder No. 160-22 or No. 160-51. Add 250 mL of deionized water and agitate the solution thoroughly (there will be some excess quinhydrone (a black powder) that floats on the surface when agitating the solution). Fill the transparent calibration cup to the reference line with this standard solution.**
2. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
3. **Press the control unit's CAL key to set the calibration mode.**
4. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**


2008/04/11 20:35:28

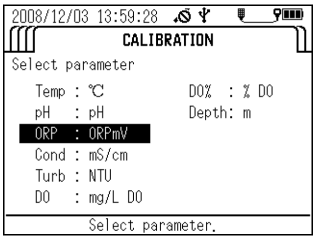
CALIBRATION

Calibration

Auto Calibration

Manual Calibration

5. **In the parameter selection screen, move the cursor to ORP, then press the ENTER key.**


2008/12/03 13:59:28

CALIBRATION

Select parameter

Temp : ℃

pH : pH

ORP : ORPmV

Cond : mS/cm

Turb : NTU

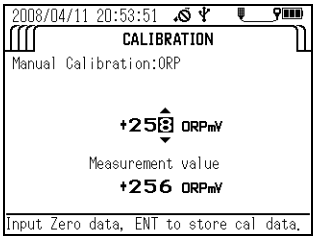
DO : mg/L DO

DO% : % DO

Depth: m

Select parameter.

6. **Press the up (△) and down (▽) keys to set the mV value of the ORP standard solution containing the submerged sensor probe at the measurement temperature.**


2008/04/11 20:53:51

CALIBRATION

Manual Calibration:ORP

+258 ORPmV

Measurement value

+256 ORPmV

Input Zero data, ENT to store cal data.

Table 1 Indicated value of ORP standard solution at various temperatures (mV)

Temperature	160-22	16051
5	+274	+112
10	+271	+107
15	+267	+101
20	+263	+95
25	+258	+89
30	+254	+83
35	+249	+76
40	+244	+69

7. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
8. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**

● Conductivity (COND) calibration

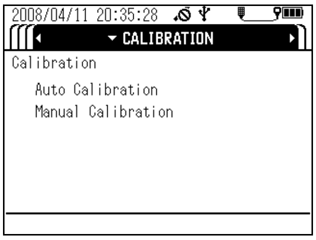
Note

- **To support a wide range of sample concentrations, electrical conductivity is divided into three measurement ranges: 0.0 mS/m to 99.9 mS/m, 0.090 S/m to 0.999 S/m, and 0.9 S/m to 9.99 S/m.**
- **When manually calibrating conductivity, you can select two calibration points (one zero-point calibration point and a span calibration point for one of the three measurement ranges) or four calibration points (one zero-point calibration point and span calibration points for all three measurement ranges). Carry out the four calibration points to ensure good measurement precision throughout all measurement ranges.**
- **Make the compensation setting before calibration since this setting is applied during calibration. (Refer to “ 6.5.3 Temperature coefficient ” (page 104)).**

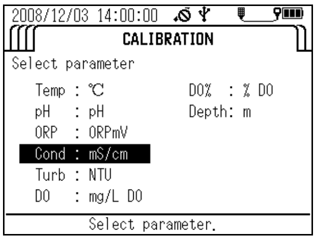
1. **Prepare the standard solution. Dry Potassium chloride (KCl) powder (high-grade commercially available) at 105°C for two hours, and leave it to cool in a desiccator.**
2. **Consult the following table and weigh potassium chloride (KCl), then prepare three standard potassium chloride (KCl) solutions following the procedure below.**

Potassium chloride (KCl) standard solution	Conductivity (COND) value	Potassium chloride (KCl) mass (g) at solution temperature of 25 °C	Calibration range
0.005 mol/L	71.8 mS/m (0.718 mS/cm)	0.373	0.0 mS/m to 99.9 mS/m (0.00 mS/cm to 0.999 mS/cm)
0.050 mol/L	0.667 S/m (6.67 mS/cm)	3.73	0.090 S/m to 0.999 S/m (1.00 mS/cm to 9.99 mS/cm)
0.500 mol/L	5.87 S/m (58.7 mS/cm)	37.2	0.9 S/m to 9.99 S/m (10.0 mS/cm to 99.9 mS/cm)

3. **Dissolve the weighed Potassium Chloride (KCl) in deionized water.**
4. **Put the dissolved Potassium Chloride (KCl) into a 1 L measuring flask, and fill to the 1 L mark with deionized water.**
5. **Calibrate the zero point. Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then remove all moisture from the sensor probe (it will be calibrated in air).**
6. **Press the control unit’s CAL key to set the calibration mode.**
7. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



8. **In the parameter selection screen, move the cursor to “Cond”, then press the ENTER key.**



2008/12/03 14:00:00

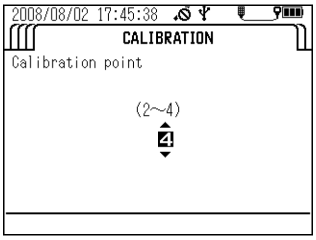
CALIBRATION

Select parameter

Temp : ℃ DO% : % DO
pH : pH Depth: m
ORP : ORPmV
Cond : mS/cm
Turb : NTU
DO : mg/L DO

Select parameter.

9. **Set the number of calibration points, then press the ENTER key.**



2008/08/02 17:45:38

CALIBRATION

Calibration point

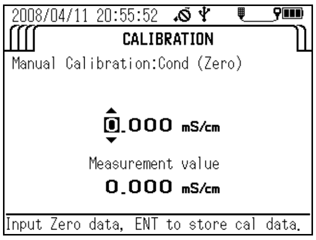
(2~4)

4

The instructions below assume that four calibration points have been set.

10. **Press the up (△) and down (▽) keys to set the "Cond" value to 0.0 mS/m (0.000 mS/cm).**

11. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



2008/04/11 20:55:52

CALIBRATION

Manual Calibration:Cond (Zero)

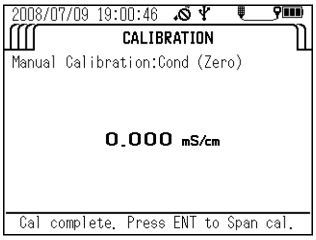
0.000 mS/cm

Measurement value

0.000 mS/cm

Input Zero data, ENT to store cal data.

12. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the first span calibration procedure.**



2008/07/09 19:00:46

CALIBRATION

Manual Calibration:Cond (Zero)

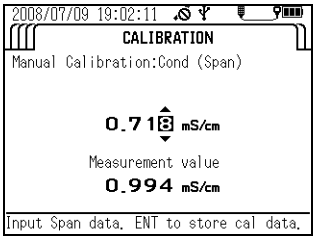
0.000 mS/cm

Cal complete. Press ENT to Span cal.

13. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 71.8 mS/m (0.718 mS/cm) standard solution.**

14. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

15. **Press the up (△) and down (▽) keys to set the "Cond" value to 71.8 mS/m (0.718 mS/cm).**
Calibration range = 0 mS/m to 99.9 mS/m (0 mS/cm to 0.999 mS/cm)



2008/07/09 19:02:11

CALIBRATION

Manual Calibration:Cond (Span)

0.718 mS/cm

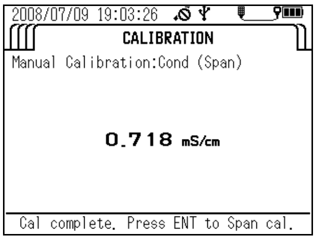
Measurement value

0.994 mS/cm

Input Span data. ENT to store cal data.

16. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

17. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



2008/07/09 19:03:26

CALIBRATION

Manual Calibration:Cond (Span)

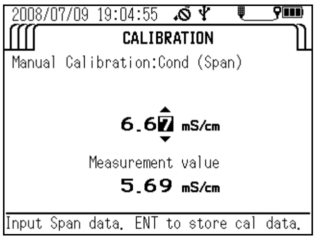
0.718 mS/cm

Cal complete. Press ENT to Span cal.

18. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 0.667 S/m (6.67 mS/cm) standard solution.**

19. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

20. **Press the up (△) and down (▽) keys to set the "Cond" value to 0.667 S/m (6.67 mS/cm).**
Calibration range = 0.100 S/m to 0.999 S/m (1.00 mS/cm to 9.99 mS/cm)



2008/07/09 19:04:55

CALIBRATION

Manual Calibration:Cond (Span)

6.67 mS/cm

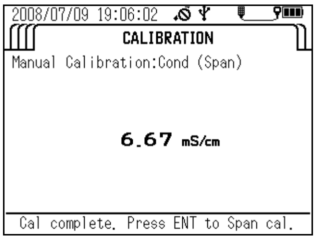
Measurement value

5.69 mS/cm

Input Span data. ENT to store cal data.

21. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

22. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



2008/07/09 19:06:02

CALIBRATION

Manual Calibration:Cond (Span)

6.67 mS/cm

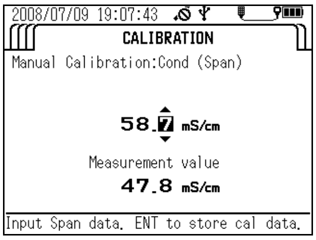
Cal complete. Press ENT to Span cal.

23. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 5.87 S/m (58.7 mS/cm) standard solution.**

24. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

25. **Press the up (△) and down (▽) keys to set the "Cond" value to 5.87 S/m (58.7 mS/cm).**

Calibration range = 1.00 S/m to 10.00 S/m(10.0 mS/cm to 100.0 mS/cm)



2008/07/09 19:07:43

CALIBRATION

Manual Calibration:Cond (Span)

58.7 mS/cm

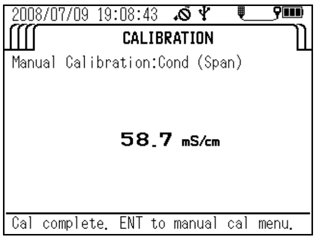
Measurement value

47.8 mS/cm

Input Span data. ENT to store cal data.

26. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

27. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



2008/07/09 19:08:43

CALIBRATION

Manual Calibration:Cond (Span)

58.7 mS/cm

Cal complete. ENT to manual cal menu.

Turbidity (TURB) calibration

Note

- **To support a wide range of sample concentrations, turbidity is divided into three measurement ranges: 0.0 to 9.9 NTU, 10 to 100 NTU, and over 100 NTU.**
- **When manually calibrating turbidity, you can select two calibration procedures (one zero-point calibration procedure and a span calibration procedure for one of the three measurement ranges), three calibration procedures (one zero-point calibration procedure and a span calibration procedure for two of the three measurement ranges) or four calibration procedures (one zero-point calibration procedure and span calibration procedures for all three measurement ranges). Carry out the four calibration procedures to ensure good measurement precision throughout all measurement ranges.**
- **Always use the calibration cup provided. Using other containers can create effects from ambient light that cause incorrect calibration.**

Preparing the standard solutions

1. **Weigh out 5.0 g of hydrazine sulfate (commercial special grade or above), and dissolve it in 400 mL of deionized water. Dissolve 50 g of hexamethylene tetramine (commercial special grade or above) in 400 mL of deionized water in anther flask.**
2. **Mix the two solutions and add deionized water until the total solution volume is 1000 mL, and mix well. Store this solution at a temperature of 25°C ±3°C for 48 hours.**
   The turbidity value (TURB) of this solution is equivalent to 4000 NTU.
3. **Dilute 4000 NTU-solution 5 times (use a pipette to measure 50 mL of the 4000 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 800 NTU.
4. **Dilute 800 NTU solution 10 times (use a pipette to measure 25 mL of the 800 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 80 NTU.
5. **Dilute 80 NTU solution 10 times (use a pipette to measure 25 mL of the 80 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 8 NTU.

Note

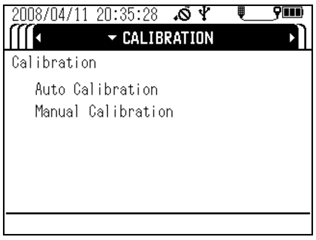
Instead of the standard solutions above, you can use other standard solutions of known concentration measured with other standard instruments.

U-52, U-53 turbidity calibration

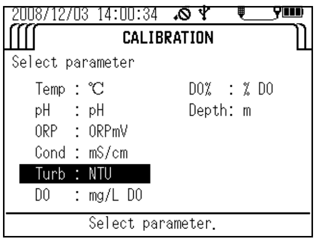
Set the number of calibration points.

You can set between 2 and 4 points.

1. **Press the control unit's CAL key to set the calibration mode.**
2. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**

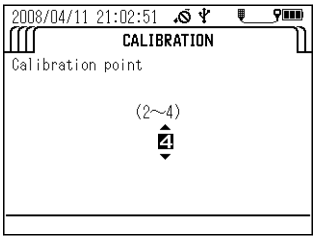


3. **In the parameter selection screen, move the cursor to "Turb", then press the ENTER key.**



```
2008/12/03 14:00:34
CALIBRATION
Select parameter
   Temp : ℃           DO%  : % DO
   pH   : pH          Depth: m
   ORP  : ORPmV
   Cond : mS/cm
   Turb : NTU
   DO   : mg/L DO
Select parameter.
```

4. **Press the up (△) and down (▽) keys to set the number of calibration points, then press the ENTER key.**



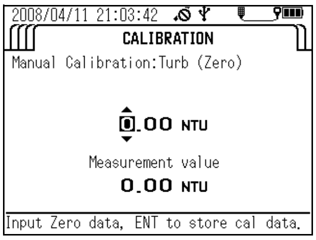
```
2008/04/11 21:02:51
CALIBRATION
Calibration point
          (2~4)
            4
```

The instructions below assume that four calibration points have been set.

5. **Calibrate the zero point. Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with deionized water.**

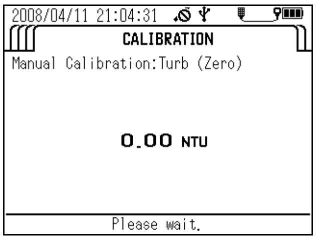
6. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

7. **Press the up (△) and down (▽) keys to set the "Turb" value to 0.0 NTU.**



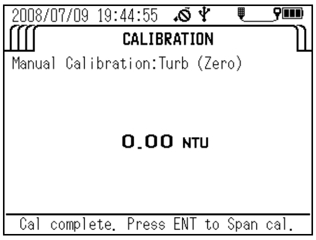
```
2008/04/11 21:03:42
CALIBRATION
Manual Calibration:Turb (Zero)
          0.00 NTU
     Measurement value
          0.00 NTU
Input Zero data, ENT to store cal data.
```

8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



```
2008/04/11 21:04:31
CALIBRATION
Manual Calibration:Turb (Zero)
          0.00 NTU
Please wait.
```

9. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the first span calibration procedure.**



2008/07/09 19:44:55

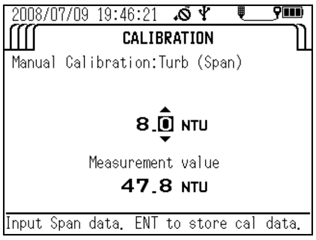
CALIBRATION

Manual Calibration:Turb (Zero)

0.00 NTU

Cal complete. Press ENT to Span cal.

10. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 8 NTU standard solution, or a standard solution of known concentration between 0.1 and 10 NTU.**
11. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
12. **Press the up (△) and down (▽) keys to set the "TURB" value to 8 NTU, or to the known concentration of the standard solution between 0.1 and 10 NTU. (Input range = 0 NTU to 9.9 NTU (U-51) or 0 NTU to 9.99 NTU (U-52))**



2008/07/09 19:46:21

CALIBRATION

Manual Calibration:Turb (Span)

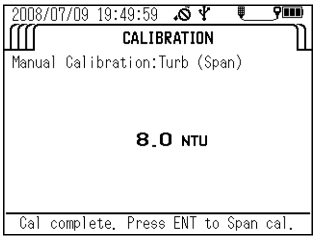
8.0 NTU

Measurement value

47.8 NTU

Input Span data. ENT to store cal data.

13. **Check that "Current measurement value" has stabilized, then press the ENTER key to start calibration.**
14. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



2008/07/09 19:49:59

CALIBRATION

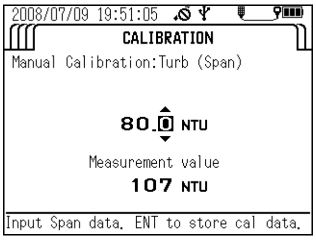
Manual Calibration:Turb (Span)

8.0 NTU

Cal complete. Press ENT to Span cal.

15. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 80 NTU standard solution, or a standard solution of known concentration between 10 and 100 NTU.**
16. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

17. **Press the up (△) and down (▽) keys to set the "Turb" value to 80 NTU, or to the known concentration of the standard solution between 10 and 100 NTU. (Input range = 10.0 NTU to 99.9 NTU)**



2008/07/09 19:51:05

CALIBRATION

Manual Calibration:Turb (Span)

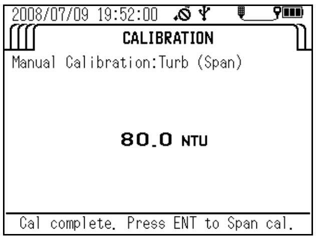
80.0 NTU

Measurement value

107 NTU

Input Span data. ENT to store cal data.

18. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
19. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



2008/07/09 19:52:00

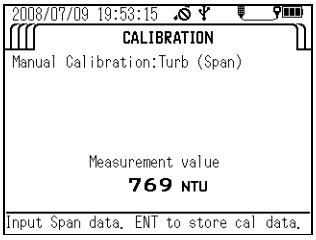
CALIBRATION

Manual Calibration:Turb (Span)

80.0 NTU

Cal complete. Press ENT to Span cal.

20. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 800 NTU standard solution, or a standard solution of known concentration 100 NTU above.**
21. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
22. **Press the up (△) and down (▽) keys to set the "TURB" value to 800 NTU, or to the known concentration of the standard solution 100 NTU above.**
    (Input range = 100 NTU to 800 NTU (U-51), 100 NTU to 1000 NTU (U-52))



2008/07/09 19:53:15

CALIBRATION

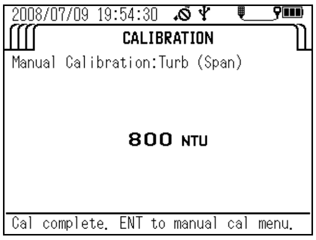
Manual Calibration:Turb (Span)

Measurement value

769 NTU

Input Span data. ENT to store cal data.

23. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
24. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



2008/07/09 19:54:30

CALIBRATION

Manual Calibration:Turb (Span)

800 NTU

Cal complete. ENT to manual cal menu.

Dissolved oxygen (DO) calibration

Note

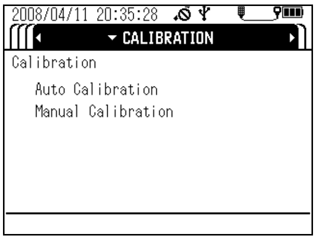
- **You can select one calibration procedure (span calibration) or two calibration procedures (zero-point calibration and span calibration). Carry out the two calibration procedures to ensure good measurement precision throughout all measurement ranges.**
- **It is necessary to prepare new solution before calibration of the Dissolved Oxygen (DO) sensor.**
- **The calibration cup (included) cannot be used to manually calibrate the DO sensor. Use a suitable bottle in which the DO sensor and the temperature sensor can be immersed.**
- **Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.**
- **Make the compensation setting before calibration since the setting is applied during calibration.**
- **The DO sensor is affected by flow. When performing span calibration with saturated dissolved oxygen water, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) or agitate the saturated dissolved oxygen water.**

1. **Prepare the standard solution.**

- Add about 50 g of sodium sulfite to 1000 mL of water (either deionized water or tap water) and stir the mixture to dissolve the sodium sulfite in it.
- Pour 1 to 2 liters of water into a suitable flask (either deionized water or tap water). Using a air pump, feed air into the water and aerate the solution until oxygen is saturated.

2. **First, calibrate the zero point. Press the control unit's CAL key to set the calibration mode.**

3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



2008/04/11 20:35:28

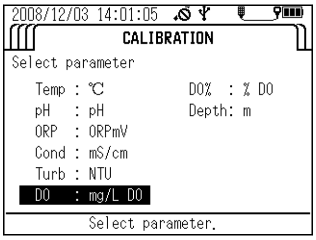
CALIBRATION

Calibration

Auto Calibration

Manual Calibration

4. **In the parameter selection screen, move the cursor to DO or DO%, then press the ENTER key.**



2008/12/03 14:01:05

CALIBRATION

Select parameter

Temp : ℃ DO% : % DO

pH : pH Depth: m

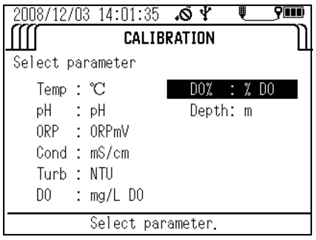
ORP : ORPmV

Cond : mS/cm

Turb : NTU

DO : mg/L DO

Select parameter.



2008/12/03 14:01:35

CALIBRATION

Select parameter

Temp : ℃ DO% : % DO

pH : pH Depth: m

ORP : ORPmV

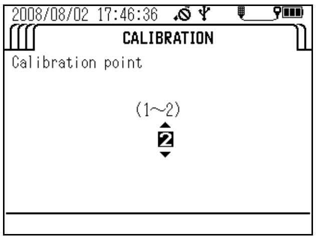
Cond : mS/cm

Turb : NTU

DO : mg/L DO

Select parameter.

5. **Set the number of calibration procedures, then press the ENTER key.**



2008/08/02 17:46:36

CALIBRATION

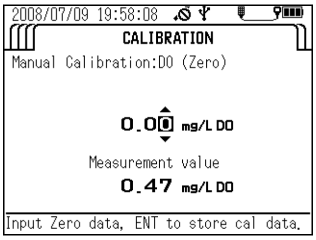
Calibration point

(1~2)

2

The instructions below assume that two calibration points have been set.

6. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the bottle.**
7. **Press the up (△) and down (▽) keys to set the DO value to 0.00 mg/L or 0.0%.**


2008/07/09 19:58:08

CALIBRATION

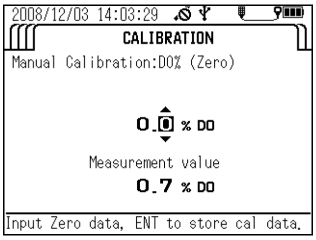
Manual Calibration:DO (Zero)

0.00 mg/L DO

Measurement value

0.47 mg/L DO

Input Zero data, ENT to store cal data.


2008/12/03 14:03:29

CALIBRATION

Manual Calibration:DO% (Zero)

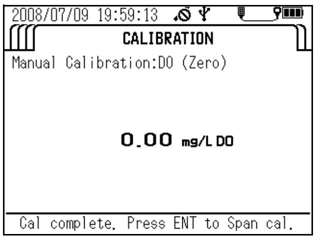
0.0 % DO

Measurement value

0.7 % DO

Input Zero data, ENT to store cal data.

8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
9. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the span calibration procedure.**

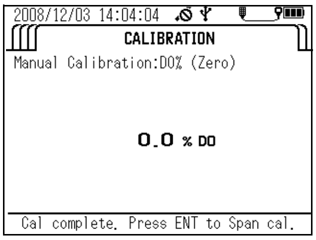

2008/07/09 19:59:13

CALIBRATION

Manual Calibration:DO (Zero)

0.00 mg/L DO

Cal complete. Press ENT to Span cal.


2008/12/03 14:04:04

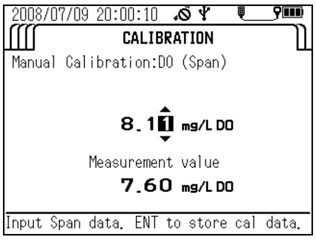
CALIBRATION

Manual Calibration:DO% (Zero)

0.0 % DO

Cal complete. Press ENT to Span cal.

10. **Wash the sensor probe 2 or 3 times with deionized water to remove any dirt, then submerge the sensor probe in the container filled with the span solution.**
11. **Press the up (△) and down (▽) keys to set the DO value to the saturated dissolved oxygen value (mg/L) of the water at that temperature or the dissolved oxygen saturation ratio.**


2008/07/09 20:00:10

CALIBRATION

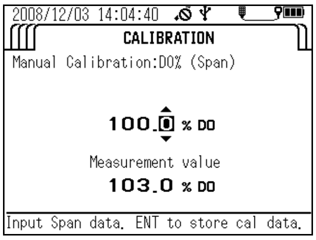
Manual Calibration:DO (Span)

8.11 mg/L DO

Measurement value

7.60 mg/L DO

Input Span data. ENT to store cal data.


2008/12/03 14:04:40

CALIBRATION

Manual Calibration:DO% (Span)

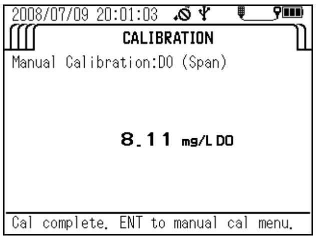
100.0 % DO

Measurement value

103.0 % DO

Input Span data. ENT to store cal data.

12. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
13. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**

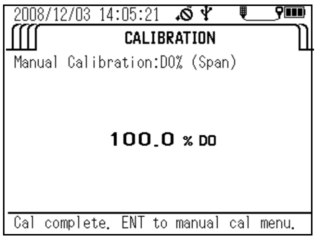

2008/07/09 20:01:03

CALIBRATION

Manual Calibration:DO (Span)

8.11 mg/L DO

Cal complete. ENT to manual cal menu.


2008/12/03 14:05:21

CALIBRATION

Manual Calibration:DO% (Span)

100.0 % DO

Cal complete. ENT to manual cal menu.

Amounts of saturated dissolved oxygen in water at various temperatures (salinity=0.0%)

JIS K0101

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.16						
1	13.77	11	10.67	21	8.68	31	7.42
2	13.40	12	10.43	22	8.53	32	7.32
3	13.04	13	10.20	23	8.39	33	7.22
4	12.70	14	9.97	24	8.25	34	7.13
5	12.37	15	9.76	25	8.11	35	7.04
6	12.06	16	9.56	26	7.99	36	6.94
7	11.75	17	9.37	27	7.87	37	6.86
8	11.47	18	9.18	28	7.75	38	6.76
9	11.19	19	9.01	29	7.64	39	6.68
10	10.92	20	8.84	30	7.53	40	6.59

ISO5814

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.62				
1	14.22	11	11.03	21	8.91
2	13.83	12	10.78	22	8.74
3	13.46	13	10.54	23	8.58
4	13.11	14	10.31	24	8.42
5	12.77	15	10.08	25	8.26
6	12.45	16	9.87	26	8.11
7	12.14	17	9.66	27	7.97
8	11.84	18	9.47	28	7.83
9	11.56	19	9.28	29	7.69
10	11.29	20	9.09	30	7.56

● Span setting values for calibration in air

The software should display these values when auto calibration is performed.

Use this table to input values for manual span calibrations in air.

Tip

The DO measurement value of “air-saturated water” and air are different.

Due to the pressure difference against the membrane in air versus the membrane in water, the measurement value in air is about 10% higher than the value of air-saturated water on average.

Amounts of saturated dissolved oxygen in air at various temperatures

Following tables are applicable only to the air calibration of the U-50 DO sensor. Do not use them for other purpose.

Air calibration value in adopting evaluation based on JIS K0101

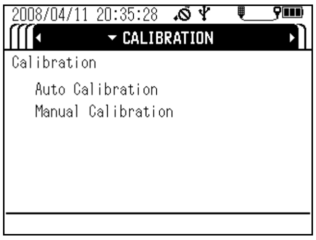
Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	15.58						
1	15.15	11	11.74	21	9.55	31	8.16
2	14.74	12	11.47	22	9.38	32	8.05
3	14.34	13	11.22	23	9.23	33	7.94
4	13.97	14	10.97	24	9.08	34	7.84
5	13.61	15	10.74	25	8.92	35	7.74
6	13.27	16	10.52	26	8.79	36	7.63
7	12.93	17	10.31	27	8.66	37	7.55
8	12.62	18	10.10	28	8.53	38	7.44
9	12.31	19	9.91	29	8.40	39	7.35
10	12.01	20	9.72	30	8.28	40	7.25

Air calibration value in adopting evaluation based on ISO5814

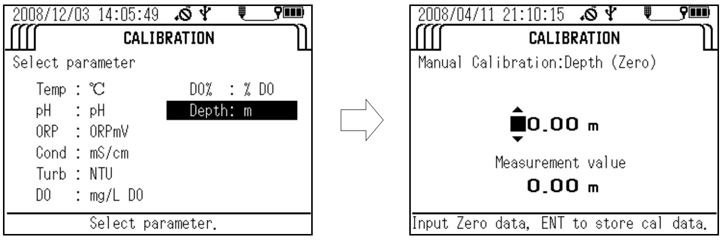
Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	16.08				
1	15.64	11	12.13	21	9.80
2	15.21	12	11.86	22	9.61
3	14.81	13	11.59	23	9.44
4	14.42	14	11.34	24	9.26
5	14.05	15	11.09	25	9.09
6	13.70	16	10.86	26	8.92
7	13.35	17	10.63	27	8.77
8	13.02	18	10.42	28	8.61
9	12.72	19	10.21	29	8.46
10	12.42	20	10.00	30	8.32

● Water depth (DEPTH) calibration

1. **Calibrate the zero point. Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then remove all moisture from the sensor probe (it will be calibrated in air).**
2. **Press the control unit's CAL key to set the calibration mode.**
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**

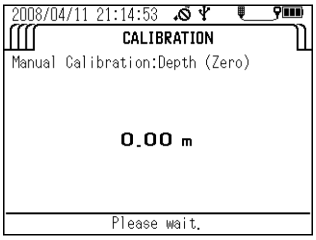

2008/04/11 20:35:28
CALIBRATION
Calibration
Auto Calibration
Manual Calibration

4. **In the parameter selection screen, move the cursor to "Depth", then press the ENTER key.**

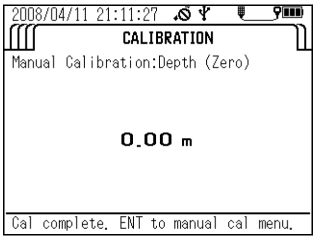

2008/12/03 14:05:49
CALIBRATION
Select parameter
Temp : ℃
pH : pH
ORP : ORPmV
Cond : mS/cm
Turb : NTU
DO : mg/L DO
DO% : % DO
Depth: m
Select parameter.

2008/04/11 21:10:15
CALIBRATION
Manual Calibration:Depth (Zero)
0.00 m
Measurement value
0.00 m
Input Zero data, ENT to store cal data.

5. **Press the up (△) and down (▽) keys to set the "Depth" value to 0.00 m.**
6. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**


2008/04/11 21:14:53
CALIBRATION
Manual Calibration:Depth (Zero)
0.00 m
Please wait.

7. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**


2008/04/11 21:11:27
CALIBRATION
Manual Calibration:Depth (Zero)
0.00 m
Cal complete. ENT to manual cal menu.

3.4 Measurement

You can perform measurement by either of the methods below.

- Storing data in memory manually with reference to the measurement value (single measurement)
- Having data stored in memory automatically and continuously
  U-51/U-52: Interval measurement (minimum memory interval of 10 seconds)
  U-53: Interval measurement (minimum memory interval of 30 seconds)

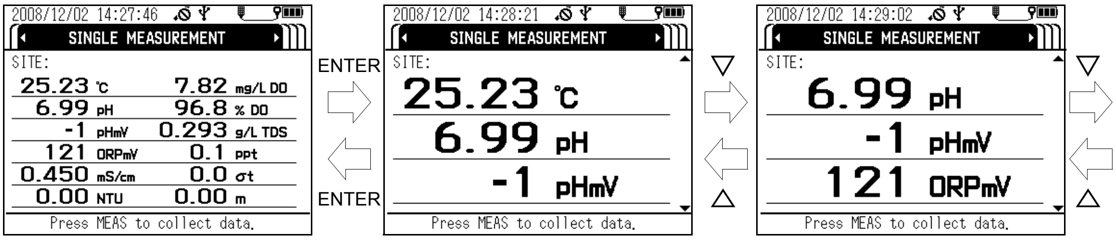
Select the measurement method that meets your requirements.

Note

- **Lower sensor probe slowly when submerging them in samples.**
- **Sensors may break if sensor probe are dropped from a height of 1 meter or more.**
- **Do not submerge sensor probe in water depths of over 30 meters. Sensor probe are only resistant to water pressure of up to 30 meters.**
- **After turning the power ON, check that the DO readout value has stabilized before starting measurement (takes around 20 minutes).**

Tip

- **When on the measurement screen, pressing the ENTER key enlarges the display and shows three measured values at a time.**
- **Pressing the up (△) and down (▽) keys scrolls through the measured values one item at a time.**
- **Pressing the ENTER key again reverts to the normal measurement screen display.**



```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
25.23 ℃      7.82 mg/L DO
 6.99 pH     96.8 % DO
   -1 pHmV  0.293 g/L TDS
  121 ORPmV   0.1 ppt
0.450 mS/cm   0.0 σt
 0.00 NTU    0.00 m
Press MEAS to collect data.
```

```
2008/12/02 14:28:21
SINGLE MEASUREMENT
SITE:
25.23 ℃
 6.99 pH
   -1 pHmV
Press MEAS to collect data.
```

```
2008/12/02 14:29:02
SINGLE MEASUREMENT
SITE:
 6.99 pH
   -1 pHmV
  121 ORPmV
Press MEAS to collect data.
```

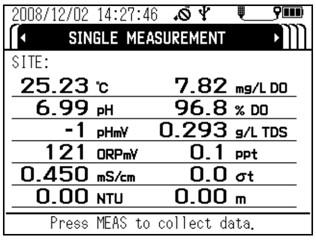
Measurement screen Normal Enlarged

3.4.1 Storing data in memory manually

Follow the steps below to manually store data in memory while referring to the measurement value to check the readout value is stable.

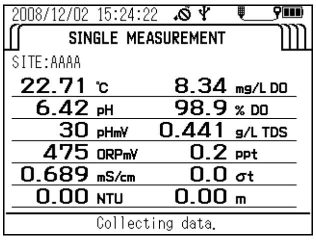
- **U-51/U-52**

1. **Check that each sensor and sensor guard is mounted.**
2. **Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.**



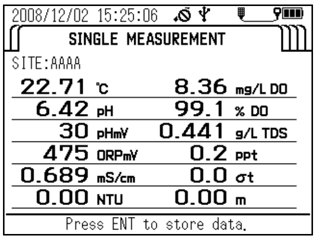
```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
25.23 ℃      7.82 mg/L DO
 6.99 pH     96.8 % DO
   -1 pHmV  0.293 g/L TDS
  121 ORPmV   0.1 ppt
0.450 mS/cm   0.0 σt
 0.00 NTU    0.00 m
Press MEAS to collect data.
```

3. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.
4. **When the measurement values are stable, press the MEAS key to acquire the 5-second average.**

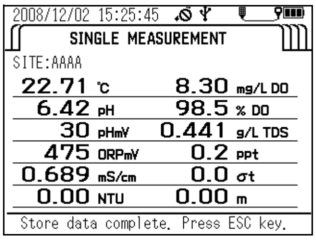


```
2008/12/02 15:24:22
SINGLE MEASUREMENT
SITE:AAAA
 22.71 ℃        8.34 mg/L DO
  6.42 pH       98.9 % DO
    30 pHmV    0.441 g/L TDS
   475 ORPmV     0.2 ppt
 0.689 mS/cm     0.0 σt
  0.00 NTU      0.00 m
Collecting data.
```

5. **Press the ENTER key to save the held measurement values, or press the ESC key to cancel the operation.**



```
2008/12/02 15:25:06
SINGLE MEASUREMENT
SITE:AAAA
 22.71 ℃        8.36 mg/L DO
  6.42 pH       99.1 % DO
    30 pHmV    0.441 g/L TDS
   475 ORPmV     0.2 ppt
 0.689 mS/cm     0.0 σt
  0.00 NTU      0.00 m
Press ENT to store data.
```



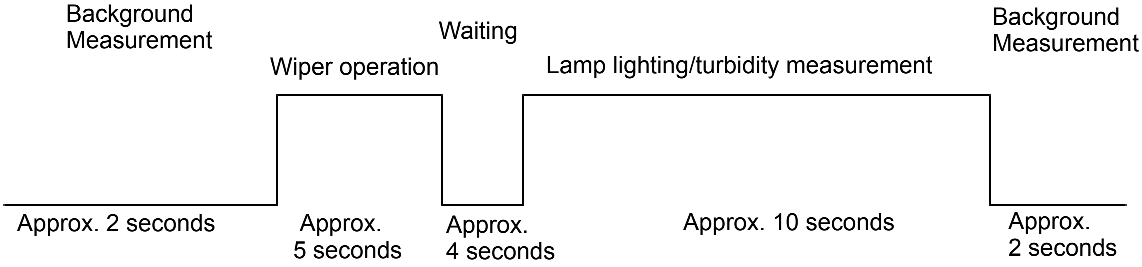
```
2008/12/02 15:25:45
SINGLE MEASUREMENT
SITE:AAAA
 22.71 ℃        8.30 mg/L DO
  6.42 pH       98.5 % DO
    30 pHmV    0.441 g/L TDS
   475 ORPmV     0.2 ppt
 0.689 mS/cm     0.0 σt
  0.00 NTU      0.00 m
Store data complete. Press ESC key.
```

● U-53

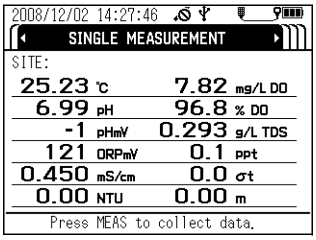
Note

Do not perform turbidity measurement in air as it may damage the wiper.

U-53 turbidity measurement follows the sequence below. The measurement values are held after each sequence.



1. **Check that each sensor and sensor guard is mounted.**
2. **Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.**

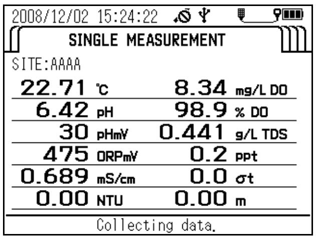


```
2008/12/02 14:27:46
◂ SINGLE MEASUREMENT ▸
SITE:
 25.23 ℃        7.82 mg/L DO
  6.99 pH       96.8 % DO
    -1 pHmV    0.293 g/L TDS
   121 ORPmV     0.1 ppt
 0.450 mS/cm     0.0 σt
  0.00 NTU      0.00 m
Press MEAS to collect data.
```

3. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**

   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.

4. **When the non-turbidity meter measurement values are stable, press the MEAS key to start the sequence above.**



2008/12/02 15:24:22

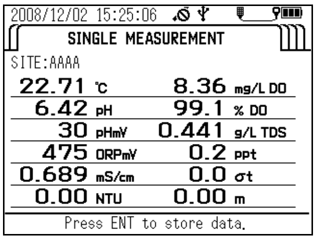
SINGLE MEASUREMENT

SITE:AAAA

22.71 ℃ 8.34 mg/L DO
6.42 pH 98.9 % DO
30 pHmV 0.441 g/L TDS
475 ORPmV 0.2 ppt
0.689 mS/cm 0.0 σt
0.00 NTU 0.00 m

Collecting data.

5. **When the sequence has finished, hold the measurement values. Press the ENTER key to store the held measurement values, or press the ESC key to cancel the operation.**



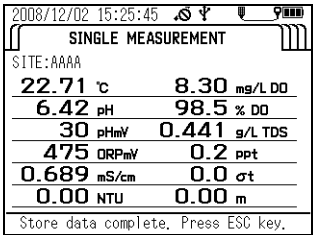
2008/12/02 15:25:06

SINGLE MEASUREMENT

SITE:AAAA

22.71 ℃ 8.36 mg/L DO
6.42 pH 99.1 % DO
30 pHmV 0.441 g/L TDS
475 ORPmV 0.2 ppt
0.689 mS/cm 0.0 σt
0.00 NTU 0.00 m

Press ENT to store data.



2008/12/02 15:25:45

SINGLE MEASUREMENT

SITE:AAAA

22.71 ℃ 8.30 mg/L DO
6.42 pH 98.5 % DO
30 pHmV 0.441 g/L TDS
475 ORPmV 0.2 ppt
0.689 mS/cm 0.0 σt
0.00 NTU 0.00 m

Store data complete. Press ESC key.

3.4.2 Automatic, continuous measurement

● Interval measurement

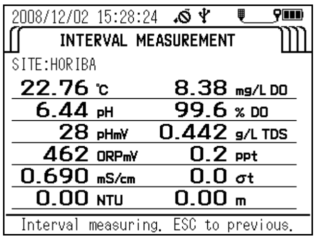
1. **Select the "Interval measurement" measurement setting (see " 3.2.1 Setting measurement methods " (page 18)).**
2. **Press the up (△) and down (▽) keys to set the interval value to the desired value (U-51/U-52: minimum interval: 10 seconds, U-53: minimum interval: 30 seconds), then press the ENTER key.**

   The measurement screen appears automatically, and the system becomes ready for measurement.

3. **Check that each sensor and sensor guard is mounted.**
4. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**

   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.

5. **Press the ENTER key to start measurement.**



2008/12/02 15:28:24

INTERVAL MEASUREMENT

SITE:HORIBA

22.76 ℃ 8.38 mg/L DO
6.44 pH 99.6 % DO
28 pHmV 0.442 g/L TDS
462 ORPmV 0.2 ppt
0.690 mS/cm 0.0 σt
0.00 NTU 0.00 m

Interval measuring. ESC to previous.

3.5 Data operations

Use the procedures below to retrieve data stored in memory, delete all the data, check the remaining data memory capacity, and check the calibration record.

3.5.1 Displaying data

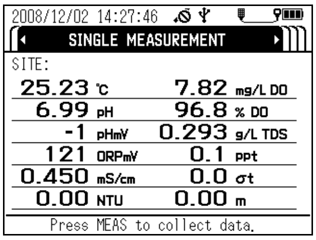
For maximum efficiency, there are 3 methods of displaying data.

- Displaying the data for a specified site
- Displaying the data for a specified date/time
- Displaying all the data

Use the method that best suits your requirements.

● Displaying the data for a specified site

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

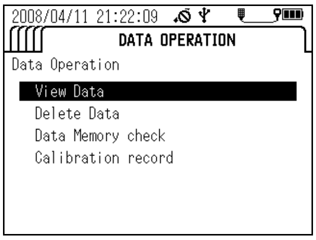


SITE:
25.23 ℃ 7.82 mg/L DO
6.99 pH 96.8 % DO
-1 pHmV 0.293 g/L TDS
121 ORPmV 0.1 ppt
0.450 mS/cm 0.0 σt
0.00 NTU 0.00 m
Press MEAS to collect data.

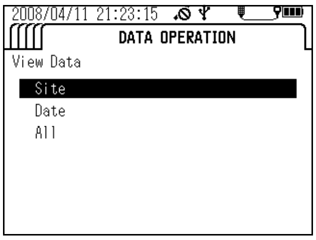
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**

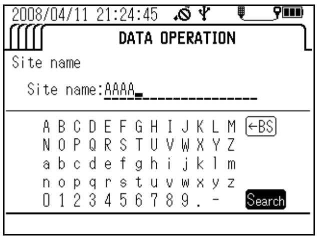


4. **Move the cursor to "Site", then press the ENTER key.**



5. **Press the up (△), down (▽), left (◁) and right (▷) keys to enter the site to retrieve.**

6. **Move the cursor to "Search", then press the ENTER key.**



2008/04/11 21:24:45

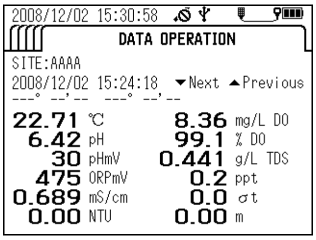
DATA OPERATION

Site name

Site name:AAAA_

All site names that begin with the entered text are displayed.
The most recently measured data for the entered site is displayed.

7. **Press the up (△) and down (▽) keys to display earlier data.**



2008/12/02 15:30:58

DATA OPERATION

SITE:AAAA

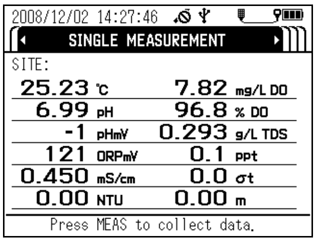
2008/12/02 15:24:18 ▼Next ▲Previous

---° --'-- ---° --'--

22.71	℃	8.36	mg/L DO
6.42	pH	99.1	% DO
30	pHmV	0.441	g/L TDS
475	ORPmV	0.2	ppt
0.689	mS/cm	0.0	σt
0.00	NTU	0.00	m

● **Displaying the data for a specified date/time**

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

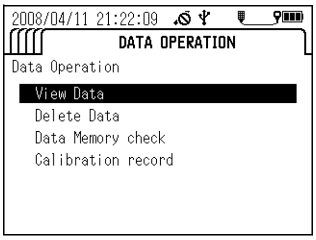
25.23	℃	7.82	mg/L DO
6.99	pH	96.8	% DO
-1	pHmV	0.293	g/L TDS
121	ORPmV	0.1	ppt
0.450	mS/cm	0.0	σt
0.00	NTU	0.00	m

Press MEAS to collect data.

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**



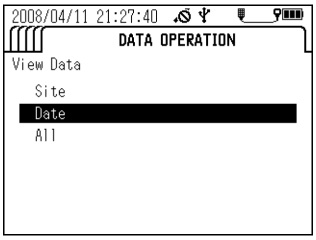
2008/04/11 21:22:09

DATA OPERATION

Data Operation

4. **Move the cursor to "Date", then press the ENTER key.**

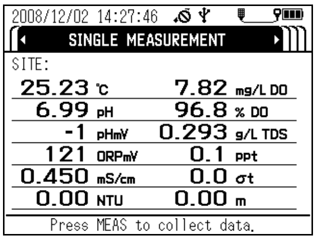
5. **With the cursor on the Date, press the ENTER key.**



6. **Press the up (△), down (▽), left (◁) and right (▷) keys to enter the desired date/time, then press the ENTER key to apply the setting.**
7. **The cursor moves to "Search". Press the ENTER key to start the search.**
8. **Press the up (△) and down (▽) keys to display earlier data.**

● Displaying all the data

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

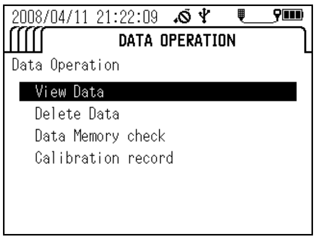


```
SITE:
 25.23 ℃        7.82 mg/L DO
  6.99 pH       96.8 % DO
    -1 pHmV    0.293 g/L TDS
   121 ORPmV     0.1 ppt
 0.450 mS/cm     0.0 σt
  0.00 NTU      0.00 m
    Press MEAS to collect data.
```

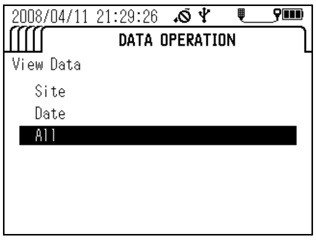
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**



4. **Move the cursor to "All", then press the ENTER key.**
The most recently measured data is displayed.



2008/04/11 21:29:26

DATA OPERATION

View Data

Site

Date

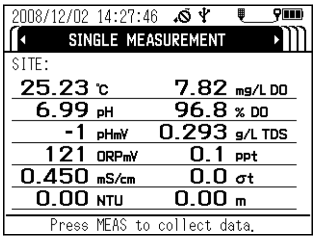
All

5. **Press the up (△) and down (▽) keys to display earlier data.**

3.5.2 Deleting data

Follow the steps below to delete all the data stored in memory.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



2008/12/02 14:27:46

SINGLE MEASUREMENT

SITE:

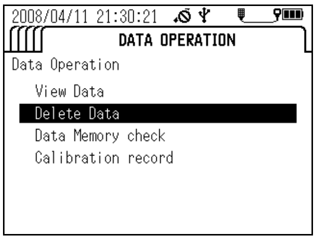
25.23 ℃ 7.82 mg/L DO
6.99 pH 96.8 % DO
-1 pHmV 0.293 g/L TDS
121 ORPmV 0.1 ppt
0.450 mS/cm 0.0 σt
0.00 NTU 0.00 m

Press MEAS to collect data.

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Delete Data", then press the ENTER key.**



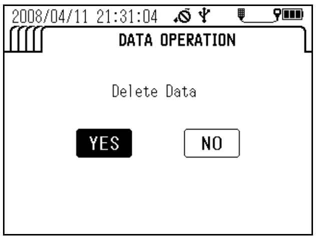
2008/04/11 21:30:21

DATA OPERATION

Data Operation

View Data
Delete Data
Data Memory check
Calibration record

4. **Press the left (◁) key to move the cursor to YES, then press the ENTER key.**
   All the data has been deleted when the indicator appears along with the message "No data exists".



2008/04/11 21:31:04

DATA OPERATION

Delete Data

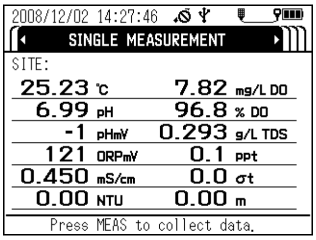
YES NO

3.5.3 Checking the data memory

You can check the used data capacity and the remaining data capacity.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.

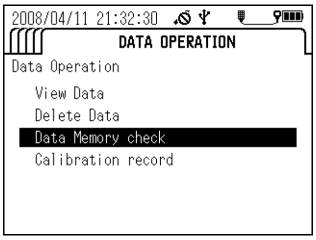


```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
25.23 ℃          7.82 mg/L DO
 6.99 pH         96.8 % DO
   -1 pHmV      0.293 g/L TDS
  121 ORPmV       0.1 ppt
0.450 mS/cm       0.0 σt
 0.00 NTU        0.00 m
Press MEAS to collect data.
```

— **Note** —

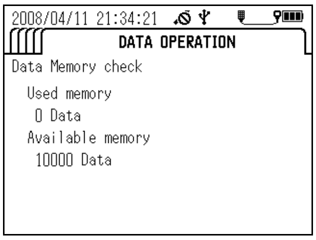
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Data Memory Check", then press the ENTER key.**



```
2008/04/11 21:32:30
DATA OPERATION
Data Operation
  View Data
  Delete Data
  Data Memory check
  Calibration record
```

The amount of memory in use and amount of available memory are displayed.



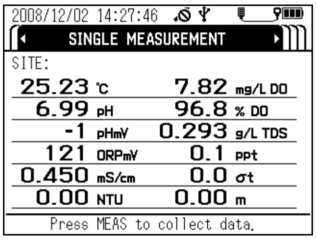
```
2008/04/11 21:34:21
DATA OPERATION
Data Memory check
  Used memory
   0 Data
  Available memory
   10000 Data
```

3.5.4 Checking the calibration record

Follow the steps below to check the latest calibration history.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.



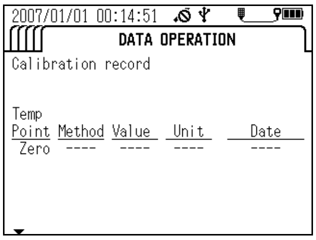
```
2008/12/02 14:27:46
SINGLE MEASUREMENT
SITE:
25.23 ℃          7.82 mg/L DO
 6.99 pH         96.8 % DO
   -1 pHmV      0.293 g/L TDS
  121 ORPmV       0.1 ppt
0.450 mS/cm       0.0 σt
 0.00 NTU        0.00 m
Press MEAS to collect data.
```

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Calibration record", then press the ENTER key.**

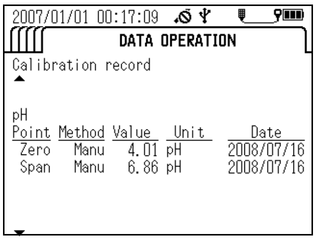
   The latest calibration record is displayed.



```
2007/01/01 00:14:51
DATA OPERATION
Calibration record

Temp
Point Method Value  Unit    Date
 Zero  ----   ----  ----    ----
```

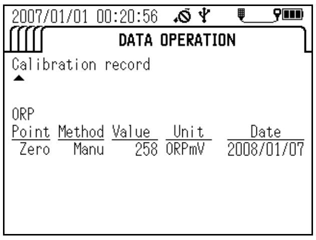
▽



```
2007/01/01 00:17:09
DATA OPERATION
Calibration record

pH
Point Method Value  Unit     Date
 Zero  Manu   4.01  pH    2008/07/16
 Span  Manu   6.86  pH    2008/07/16
```

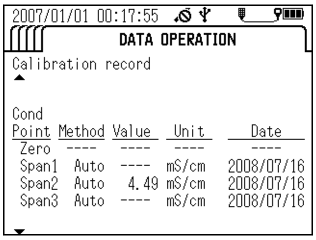
▽



```
2007/01/01 00:20:56
DATA OPERATION
Calibration record

ORP
Point Method Value  Unit     Date
 Zero  Manu    258 ORPmV  2008/01/07
```

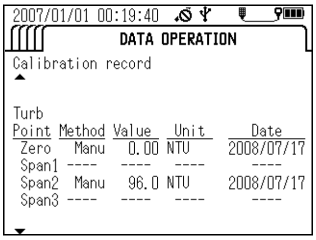
▽



```
2007/01/01 00:17:55
DATA OPERATION
Calibration record

Cond
Point Method Value  Unit     Date
 Zero  ----   ----  ----     ----
 Span1 Auto   ----  mS/cm 2008/07/16
 Span2 Auto   4.49  mS/cm 2008/07/16
 Span3 Auto   ----  mS/cm 2008/07/16
```

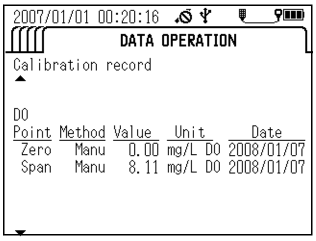
▽



```
2007/01/01 00:19:40
DATA OPERATION
Calibration record

Turb
Point Method Value  Unit     Date
 Zero  Manu   0.00  NTU   2008/07/17
 Span1 ----   ----  ----     ----
 Span2 Manu   96.0  NTU   2008/07/17
 Span3 ----   ----  ----     ----
```

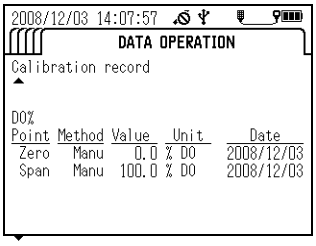
▽



```
2007/01/01 00:20:16
DATA OPERATION
Calibration record

DO
Point Method Value  Unit       Date
 Zero  Manu   0.00 mg/L DO 2008/01/07
 Span  Manu   8.11 mg/L DO 2008/01/07
```

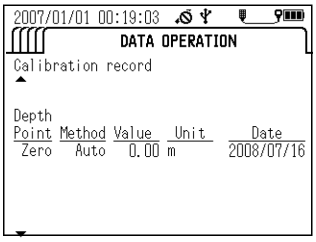
▽



```
2008/12/03 14:07:57
DATA OPERATION
Calibration record

DO%
Point Method Value  Unit     Date
 Zero  Manu    0.0 % DO   2008/12/03
 Span  Manu  100.0 % DO   2008/12/03
```

▽



```
2007/01/01 00:19:03
DATA OPERATION
Calibration record

Depth
Point Method Value  Unit     Date
 Zero  Auto   0.00  m     2008/07/16
```

3.5.5 GPS data operations

The menu for GPS data operations appears on the display to which the GPS unit is mounted.

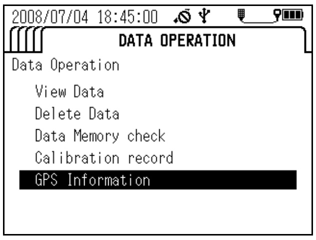
● GPS information

Follow the steps below to display acquired GPS information.

Note

Turning the power OFF erases the GPS information.

1. **Press the right (▷) key to switch the display to the "DATA OPERATION" screen.**
2. **the down (▽) key to move the cursor to "GPS Information", then press the ENTER key.**



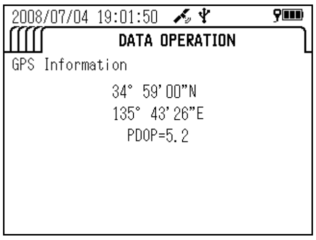
2008/07/04 18:45:00

DATA OPERATION

Data Operation

The last GPS information acquired is displayed.

- When received data exists



2008/07/04 19:01:50

DATA OPERATION

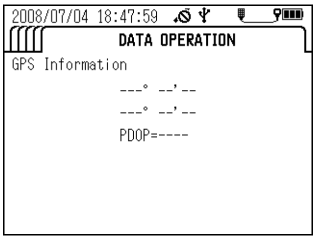
GPS Information

34° 59’00”N

135° 43’26”E

PDOP=5.2

- When no received data exists



2008/07/04 18:47:59

DATA OPERATION

GPS Information

---° --’--

---° --’--

PDOP=----

3.6 Sensor information

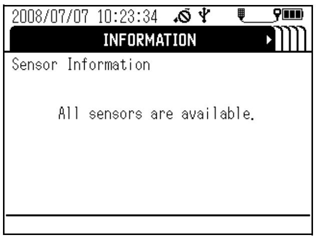
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.

2. **Press the left (◁) key once to display the "INFORMATION" screen.**

   The "Sensor Information" screen displays the sensor probe's status.

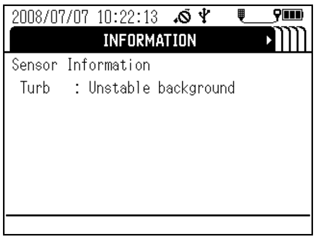
   - When the sensor probe is normal, the display below appears.



Sensor Information

All sensors are available.

   - When there is a sensor probe problem, individual measurement parameters generate messages such as the one shown below. Follow the troubleshooting information to remove the problem before continuing to operate the system.



Sensor Information

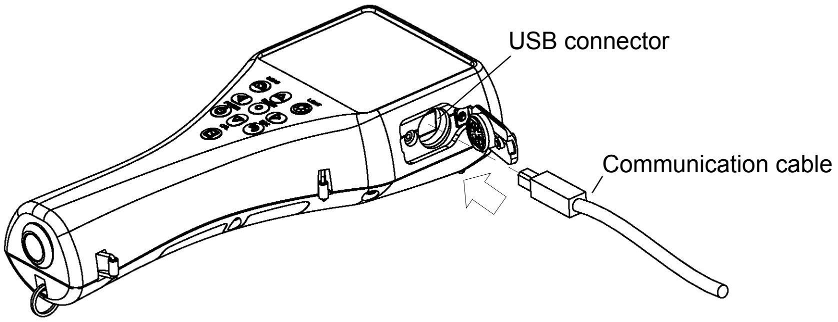
Turb : Unstable background

3.7 USB communication

The separately-sold, dedicated PC connection cable comes with data collection software. This software allows data to be downloaded from the control unit in CSV format.

This section contains instructions for communication commands used for USB communication.

● Connecting the cable



Dedicated cable

Part name: Communication cable (with data collection software)

Part no.: 3200174823

● Cautions when using USB communication

Take care to observe the following when using USB communication.

- Use the dedicated cable (with data collection software) or a commercially-available USB cable (A-B type) to connect to a PC.
- Be sure to match the transmission format on the control unit and the computer.
  The control unit uses the following transmission format:

Baud rate:	19200 bps
Number of stop bits:	1 bit
Data bit length:	8 bits
Parity:	None
Flow control:	None

Tip

If the transmission formats do not match, a communication error occurs and USB communication will not function normally. After changing the transmission format, restart the control unit and the computer.

- If received data is not sent back or an error occurs after a data request has been sent, adjust the program configuration so that it allows a little waiting time before a data request is sent again. This will enable more stable communication.
- The unit does not use DCD, CTS, or DSR signals. Take care of this when creating programs.

3.7.1 Communication settings

Baud rate:	19200 bps
Number of stop bits:	1 bit
Data bit length:	8 bits
Parity:	None
Flow control:	None

3.7.2 Commands

● Instant data requests

● Request command format

#	RD	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character	1 character
4	Frame check sequence (FCS)	2 characters

The two ASCII-code characters created by converting the 8 bits of data created by successively combining the value of each character from # through @ in an exclusive OR (XOR) operation with the value of the next character.

Example: #RD@

(1)	0	XOR	35	(ASCII code of # symbol)	⇒	35
(2)	35	XOR	82	(ASCII code of R)	⇒	113
(3)	113	XOR	68	(ASCII code of D)	⇒	53
(4)	53	XOR	64	(ASCII code of @ symbol)	⇒	117 (decimal)
						↓
						75 (hex)
						↓
						Sets "75".

Example: 35 XOR 82 operation

35 in binary	⇒	0	0	1	0	0	0	1	1		
82 in binary	⇒	0	1	0	1	0	0	1	0		
XOR result		0	1	1	1	0	0	0	1	⇒	113 (decimal)

Note: Set "XX" if you do not want to test for communication frame errors with FCS.

● Response format

#	RD	AAAAAAAAAAAAAAAAAAAA	X	X	XXXX	XX	X	X	XXXXX	X
1	2	3	4	5	6	7	8	9	10	11

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56

```
XX   X   X   XXXXX X   XX   X   X   XXXXX  X   XX   X   X   XXXXX  X
57   58  59  60    61  62   63  64  65     66  67   68  69  70     71

XX  XX  XX  XX  XX  XX  XX  XX  XX  X   X   XXX  XX  XX  X   X   @   XX  [CR] [LF]
72  73  74  75  76  77  78  79  80  81  82  83   84  85  86  87  88  89
```

1	Header		1 character
2	Command		2 characters
3	Site name	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
4	Probe status	(3) Status code	1 character
5	Probe error	(4) Status error code	1 character
6	Unused		4 characters
7	Parameter 1 code	(1) Parameter code	2 characters
8	Parameter 1 status	(5) Parameter status code	1 character
9	Parameter 1 error	(6) Parameter error code	1 character
10	Parameter 1 data	5 characters including decimal point, right-justified with blanks filled	5 characters
11	Parameter 1 unit	(2) Unit code	1 character
12	Parameter 2 code	(1) Parameter code	2 characters
13	Parameter 2 status	(5) Parameter status code	1 character
14	Parameter 2 error	(6) Parameter error code	1 character
15	Parameter 2 data	5 characters including decimal point, right-justified with blanks filled	5 characters
16	Parameter 2 unit	(2) Unit code	1 character
17	Parameter 3 code	(1) Parameter code	2 characters
18	Parameter 3 status	(5) Parameter status code	1 character
19	Parameter 3 error	(6) Parameter error code	1 character
20	Parameter 3 data	5 characters including decimal point, right-justified with blanks filled	5 characters
21	Parameter 3 unit	(2) Unit code	1 character
22	Parameter 4 code	(1) Parameter code	2 characters
23	Parameter 4 status	(5) Parameter status code	1 character
24	Parameter 4 error	(6) Parameter error code	1 character
25	Parameter 4 data	5 characters including decimal point, right-justified with blanks filled	5 characters
26	Parameter 4 unit	(2) Unit code	1 character
27	Parameter 5 code	(1) Parameter code	2 characters
28	Parameter 5 status	(5) Parameter status code	1 character
29	Parameter 5 error	(6) Parameter error code	1 character
30	Parameter 5 data	5 characters including decimal point, right-justified with blanks filled	5 characters
31	Parameter 5 unit	(2) Unit code	1 character
32	Parameter 6 code	(1) Parameter code	2 characters
33	Parameter 6 status	(5) Parameter status code	1 character
34	Parameter 6 error	(6) Parameter error code	1 character

35	Parameter 6 data	5 characters including decimal point, right-justified with blanks filled	5 characters
36	Parameter 6 unit	(2) Unit code	1 character
37	Parameter 7 code	(1) Parameter code	2 characters
38	Parameter 7 status	(5) Parameter status code	1 character
39	Parameter 7 error	(6) Parameter error code	1 character
40	Parameter 7 data	5 characters including decimal point, right-justified with blanks filled	5 characters
41	Parameter 7 unit	(2) Unit code	1 character
42	Parameter 8 code	(1) Parameter code	2 characters
43	Parameter 8 status	(5) Parameter status code	1 character
44	Parameter 8 error	(6) Parameter error code	1 character
45	Parameter 8 data	5 characters including decimal point, right-justified with blanks filled	5 characters
46	Parameter 8 unit	(2) Unit code	1 character
47	Parameter 9 code	(1) Parameter code	2 characters
48	Parameter 9 status	(5) Parameter status code	1 character
49	Parameter 9 error	(6) Parameter error code	1 character
50	Parameter 9 data	5 characters including decimal point, right-justified with blanks filled	5 characters
51	Parameter 9 unit	(2) Unit code	1 character
52	Parameter 10 code	(1) Parameter code	2 characters
53	Parameter 10 status	(5) Parameter status code	1 character
54	Parameter 10 error	(6) Parameter error code	1 character
55	Parameter 10 data	5 characters including decimal point, right-justified with blanks filled	5 characters
56	Parameter 10 unit	(2) Unit code	1 character
57	Parameter 11 code	(1) Parameter code	2 characters
58	Parameter 11 status	(5) Parameter status code	1 character
59	Parameter 11 error	(6) Parameter error code	1 character
60	Parameter 11 data	5 characters including decimal point, right-justified with blanks filled	5 characters
61	Parameter 11 unit	(2) Unit code	1 character
62	Parameter 12 code	(1) Parameter code	2 characters
63	Parameter 12 status	(5) Parameter status code	1 character
64	Parameter 12 error	(6) Parameter error code	1 character
65	Parameter 12 data	5 characters including decimal point, right-justified with blanks filled	5 characters
66	Parameter 12 unit	(2) Unit code (6) Parameter error code	1 character
67	Parameter 13 code	(1) Parameter code	2 characters
68	Parameter 13 status	(5) Parameter status code	1 character
69	Parameter 13 error	(6) Parameter error code	1 character
70	Parameter 13 data	5 characters including decimal point, right-justified with blanks filled	5 characters
71	Parameter 13 unit	(2) Unit code	1 character
72	Year	00 to 99	2 characters

73	Month	01 to 12	2 characters
74	Day	01 to 31	2 characters
75	Hour	00 to 23	2 characters
76	Minute	00 to 59	2 characters
77	Second	00 to 59	2 characters
78	Longitude (degrees)	00 to 90 or "--" (no GPS data)	2 characters
79	Longitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
80	Longitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
81	Unused	1 character	1 character
82	North latitude/South latitude	N: North; S: South	1 character
83	Latitude (degrees)	000 to 180 or "---" (no GPS data)	3 characters
84	Latitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
85	Latitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
86	Unused		1 character
87	East longitude/West longitude	E: East; W: West	1 character
88	Delimiter character		1 character
89	Frame check sequence (FCS)		2 characters

● Memory data requests

● Request command format

#	RM	X	X	AAAAAAAAAAAAAAAAAAAA	XX	XX	XX	@	XX	[CR]	[LF]
1	2	3	4	5	6	7	8	9	10		

1	Header		1 character
2	Command		2 characters
3	Data specification*1	0: Start search; 1: Next data item; 2: Previous data item; 3: Request same data again	1 character
4	Search method specification	0: All data; 1: Site search; 2: Date search	1 character
5	Search site*2	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
6	Search year*3	00 to 99	2 characters
7	Search month*3	01 to 12	2 characters
8	Search day*3	01 to 31	2 characters
9	Delimiter character		1 character
10	Frame check sequence (FCS)		2 characters

*1: When sending the RM command, first send 0 [Start search], then 1 [Next data item], 2 [Previous data item] or 3 [Request same data again].

*2: [Search site] is only needed when [Site search] is specified as the search method. If another search method is specified, fill this field with spaces.

*3: [Search year], [Search month] and [Search day] are only needed when [Date search] is specified as the search method. If another search method is specified, fill this field with spaces.

- **Response format**

(when data exists)

```
#   RM  AAAAAAAAAAAAAAAAAAAA    XX  X   X   XXXXX  X
1   2   3                       4   5   6   7      8

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
9   10  11  12     13  14  15  16  17     18  19  20  21  22     23

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
24  25  26  27     28  29  30  31  32     33  34  35  36  37     38

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
39  40  41  42     43  44  45  46  47     48  49  50  51  52     53

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
54  55  56  57     58  59  60  61  62     63  64  65  66  67     68

XX  XX  XX  XX  XX  XX  XX  XX  XX  X   X   XXX  XX  XX  X   X   @   XX  [CR] [LF]
69  70  71  72  73  74  75  76  77  78  79  80   81  82  83  84  85  86
```

1	Header		1 character
2	Command		2 characters
3	Site name	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
4	Parameter 1 code	(1) Parameter code	2 characters
5	Parameter 1 selection	0: No selection; 1: Selection made	1 character
6	Parameter 1 error	(6) Parameter error code	1 character
7	Parameter 1 data	5 characters including decimal point, right-justified with blanks filled	5 characters
8	Parameter 1 unit	(2) Unit code	1 character
9	Parameter 2 code	(1) Parameter code	2 characters
10	Parameter 2 selection	0: No selection; 1: Selection made	1 character
11	Parameter 2 error	(6) Parameter error code	1 character
12	Parameter 2 data	5 characters including decimal point, right-justified with blanks filled	5 characters
13	Parameter 2 unit	(2) Unit code	1 character
14	Parameter 3 code	(1) Parameter code	2 characters
15	Parameter 3 selection	0: No selection; 1: Selection made	1 character
16	Parameter 3 error	(6) Parameter error code	1 character
17	Parameter 3 data	5 characters including decimal point, right-justified with blanks filled	5 characters
18	Parameter 3 unit	(2) Unit code	1 character
19	Parameter 4 code	(1) Parameter code	2 characters
20	Parameter 4 selection	0: No selection; 1: Selection made	1 character

21	Parameter 4 error	(6) Parameter error code	1 character
22	Parameter 4 data	5 characters including decimal point, right-justified with blanks filled	5 characters
23	Parameter 4 unit	(2) Unit code	1 character
24	Parameter 5 code	(1) Parameter code	2 characters
25	Parameter 5 selection	0: No selection; 1: Selection made	1 character
26	Parameter 5 error	(6) Parameter error code	1 character
27	Parameter 5 data	5 characters including decimal point, right-justified with blanks filled	5 characters
28	Parameter 5 unit	(2) Unit code	1 character
29	Parameter 6 code	(1) Parameter code	2 characters
30	Parameter 6 selection	0: No selection; 1: Selection made	1 character
31	Parameter 6 error	(6) Parameter error code	1 character
32	Parameter 6 data	5 characters including decimal point, right-justified with blanks filled	5 characters
33	Parameter 6 unit	(2) Unit code	1 character
34	Parameter 7 code	(1) Parameter code	2 characters
35	Parameter 7 selection	0: No selection; 1: Selection made	1 character
36	Parameter 7 error	(6) Parameter error code	1 character
37	Parameter 7 data	5 characters including decimal point, right-justified with blanks filled	5 characters
38	Parameter 7 unit	(2) Unit code	1 character
39	Parameter 8 code	(1) Parameter code	2 characters
40	Parameter 8 selection	0: No selection; 1: Selection made	1 character
41	Parameter 8 error	(6) Parameter error code	1 character
42	Parameter 8 data	5 characters including decimal point, right-justified with blanks filled	5 characters
43	Parameter 8 unit	(2) Unit code	1 character
44	Parameter 9 code	(1) Parameter code	2 characters
45	Parameter 9 selection	0: No selection; 1: Selection made	1 character
46	Parameter 9 error	(6) Parameter error code	1 character
47	Parameter 9 data	5 characters including decimal point, right-justified with blanks filled	5 characters
48	Parameter 9 unit	(2) Unit code	1 character
49	Parameter 10 code	(1) Parameter code	2 characters
50	Parameter 10 selection	0: No selection; 1: Selection made	1 character
51	Parameter 10 error	(6) Parameter error code	1 character
52	Parameter 10 data	5 characters including decimal point, right-justified with blanks filled	5 characters
53	Parameter 10 unit	(2) Unit code	1 character
54	Parameter 11 code	(1) Parameter code	2 characters
55	Parameter 11 selection	0: No selection; 1: Selection made	1 character
56	Parameter 11 error	(6) Parameter error code	1 character
57	Parameter 11 data	5 characters including decimal point, right-justified with blanks filled	5 characters
58	Parameter 11 unit	(2) Unit code	1 character
59	Parameter 12 code	(1) Parameter code	2 characters

60	Parameter 12 selection	0: No selection; 1: Selection made	1 character
61	Parameter 12 error	(6) Parameter error code	1 character
62	Parameter 12 data	5 characters including decimal point, right-justified with blanks filled	5 characters
63	Parameter 12 unit	(2) Unit code	1 character
64	Parameter 13 code	(1) Parameter code	2 characters
65	Parameter 13 selection	0: No selection; 1: Selection made	1 character
66	Parameter 13 error	(6) Parameter error code	1 character
67	Parameter 13 data	5 characters including decimal point, right-justified with blanks filled	5 characters
68	Parameter 13 unit	(2) Unit code	1 character
69	Year	00 to 99	2 characters
70	Month	01 to 12	2 characters
71	Day	01 to 31	2 characters
72	Hour	00 to 23	2 characters
73	Minute	00 to 59	2 characters
74	Second	00 to 5	2 characters
75	Longitude (degrees)	00 to 90 or "--" (no GPS data)	2 characters
76	Longitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
77	Longitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
78	Unused		1 character
79	North latitude/South latitude	N: North; S: South	1 character
80	Latitude (degrees)	000 to 180 or "---" (no GPS data)	3 characters
81	Latitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
82	Latitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
83	Unused		1 character
84	East longitude/West longitude	E: East; W: West	1 character
85	Delimiter character		1 character
86	Frame check sequence (FCS)		2 characters

When no data exists, or memory is at capacity)

#	RM	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character\	1 character
4	Frame check sequence (FCS)	2 characters

Memory data count request

Request command format

#	RN	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character\	1 character
4	Frame check sequence (FCS)	2 characters

Response format

#	RN	XXXXX	@	XX	[CR]	[LF]
1	2	3	4	5		

1	Header		1 character
2	Command		2 characters
3	Total data count	0 to 10000	5 characters
4	Delimiter character\		1 character
5	Frame check sequence (FCS)		2 characters

Command parse failure response

#	??	X	XX	X	@	XX	[CR]	[LF]
1	2	3	4	5	6	7		

1	Header	1 character
2	Command	2 characters
3	Command parse failure reason*4	1 character
4	Received command*5	2 characters
5	(3) Status code for probe status*5	1 character
6	Delimiter character	1 character
7	Frame check sequence (FCS)	2 characters

*4: List of command parse failure reasons

1: Frame length error
2: FCS mismatch
3: Undefined command
4: Data error
5: Data out of range
6: No "@" delimiter character
7: No "#" header character
8: No [Carriage return] + [Line feed] footer
9: Cannot accept command in this timing.

*5: Only set for command parse failure reason 9, [Cannot accept command in this timing]. Otherwise this field is filled with spaces.

4 Maintenance

Tip

HORIBA recommends regular manufacturer maintenance checks in order to ensure a long product life.

4.1 Routine care

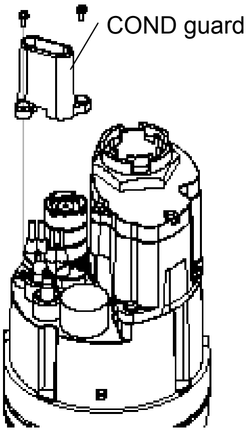
● After measurement

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power OFF.**

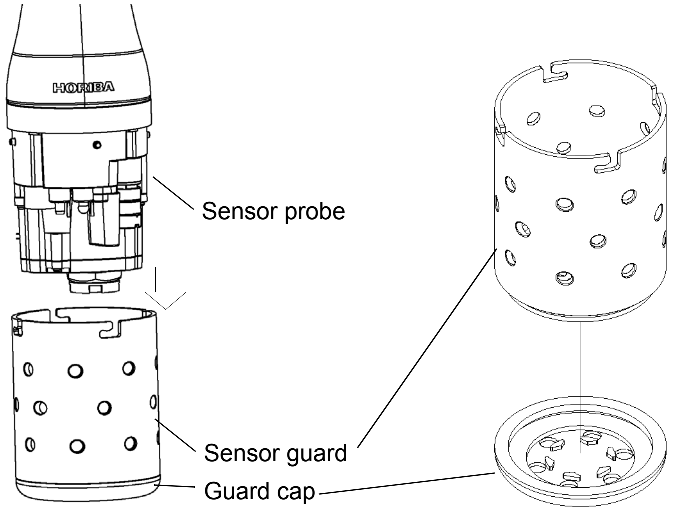
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Remove the sensor guard, and clean the sensor with tap water.**
3. **Clean the turbidity sensor with the cleaning brush provided.**
4. **Remove the two screws securing the COND guard, and the COND guard itself, and use a test tube brush to gently remove any dirt from the electrical conductivity electrode.**



5. **Wipe off any dirt with a soft cloth. If parts are very dirty, clean them with neutral detergent, then rinse them. If parts are contaminated by oil, wipe it off with a soft cloth soaked in alcohol.**
6. **Put the COND guard back in place.**
7. **Remove the sensor guard's guard cap, wash off any dirt with tap water, then put the guard cap back in place.**



4.2 Every 2 months maintenance

● Dissolved oxygen (DO) sensor

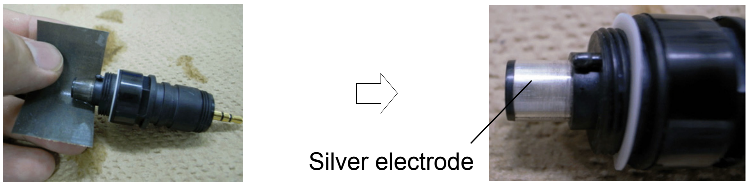
Note

- **The DO sensor's internal solution is potassium chloride (KCl). Although KCl is harmless, protective equipment such as gloves and goggles should be worn when working with it.**
- **Internal solution can be disposed of down a sink.**

- Replace the membrane cap.
- Polish the gold and silver electrodes when replacing the membrane cap.
  The gold electrode does not need to be polished if it is not dirty.

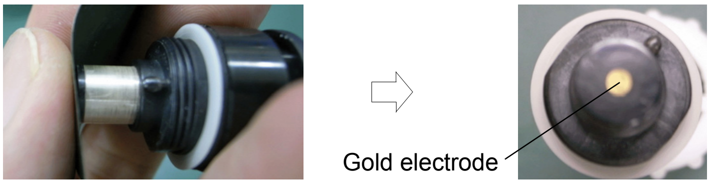
● **Silver electrode**

Polish a silver electrode part with sandpaper (#500) and then wash metal electrode parts with water.



● **Gold electrode**

Polish a gold electrode part with sandpaper (#8000) and then wash metal electrode parts with water.



Replace a membrane cap after clean metal electrodes parts.
Refer to " 4.5 Replacing the membrane cap " (page 87).

● **Reference electrode**

Note

- **The pH reference internal solution is potassium chloride (KCl). Although KCl is harmless, protective equipment such as gloves and goggles should be worn when working with it.**
- **Internal solution can be disposed of down a sink.**

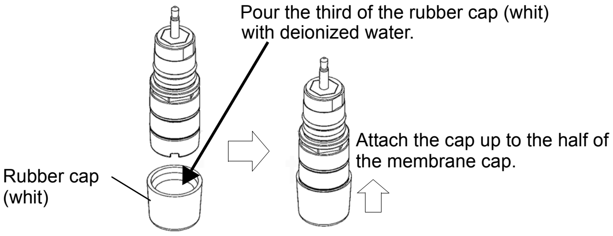
1. **Remove the rubber liquid junction plug from the reference electrode and dispose of the internal solution.**
2. **To prevent air entering, fill the reference electrode to the brim with its internal solution (No. 330).**
3. **Put the rubber liquid junction plug back in place.**

   If the rubber liquid junction plug is dirty, replace the liquid junctions (set of two; No. 9037005100). The reference electrode's internal solution will spill when replacing the liquid junctions. Rinse parts with tap water and dry them with a soft cloth.

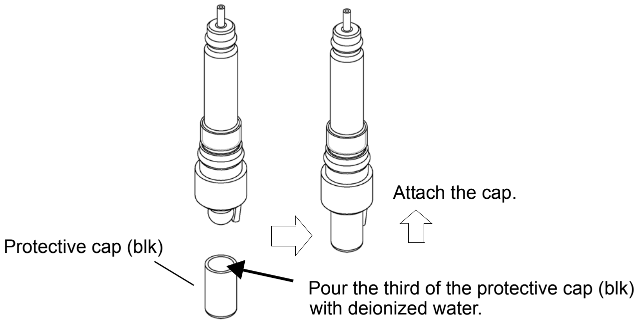
4.3 Storage

● Short-term (under 2 months) storage

- Before storing the DO sensor, pour the third of the rubber cap (whit) provided with deionized water and cover the DO sensor with them.



- Before storing the pH sensor, pour the third of the protective cap (blk) provided with deionized water and cover the pH sensor with them.



Note

Before measuerment, remove the rubber cap (whit) and the protective cap (blk).

● Long-term (2 months or more) storage

- Remove a membrane cap from DO sensor, and wash the gold electrode and silver electrode parts with water. Wipe off the moisture before storing DO sensor in the pack.
- Prevent internal solution seeping out of the reference chip by taping over the point of seepage with electrical tape.
- Before storing the system, remove the control unit's batteries to prevent battery leakage.

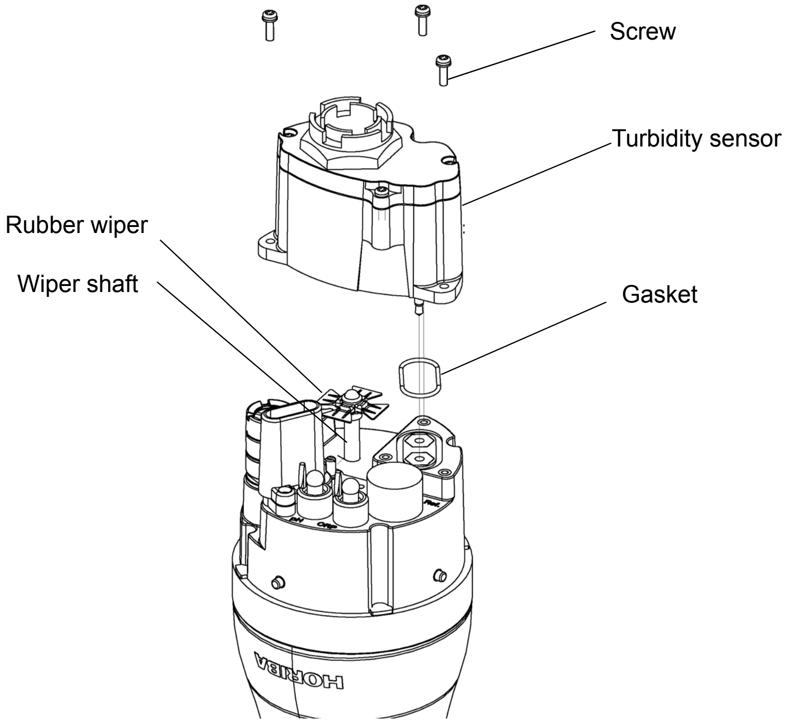
4.4 Replacing the turbidity sensor

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power OFF.**

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Remove the sensor guard, and clean the sensor probe with tap water.**
3. **Use dry air to blow away and dry off any moisture.**
4. **Remove the three screws holding the turbidity sensor by using No. 2 Phillips head screwdriver.**
5. **Pull out the turbidity sensor horizontally.**
6. **Remove the rubber wiper and gasket, and use a soft cloth to wipe off any dirt from the wiper shaft and turbidity sensor attachment. If parts are very dirty, use a soft cloth soaked in neutral detergent or alcohol.**
7. **Replace the rubber wiper and gasket with new ones. Coat the gasket with a thin layer of grease (No. 3014017718).**
8. **Attach the new turbidity sensor and fasten it in place with the three screws.**
9. **Perform four-point calibration before using the sensor.**



4.5 Replacing the membrane cap

● Replacement procedure

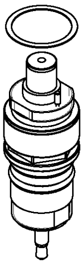
1. **Prepare the DO sensor.**
   - Take a DO sensor out of pack (newly purchasing).
   - Remove a DO sensor from the sensor probe (after use).

Newly purchasing

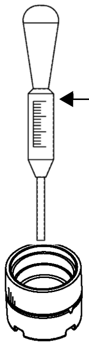
Undo a DO sensor from the sensor probe

   - Twist a membrane cap from DO sensor.
   - Wash the gold electrode and silver electrode parts with water.

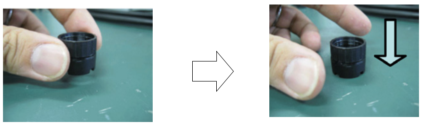
2. **Replace the silicone gasket with a new one.**



3. **Pour internal solution into a membrane cap with a dropper.**

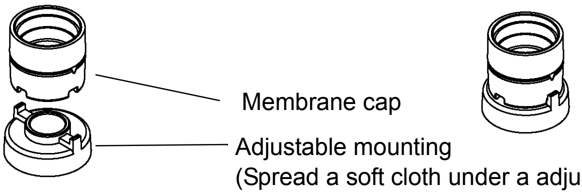


   - Check air bubbles in a membrane cap.



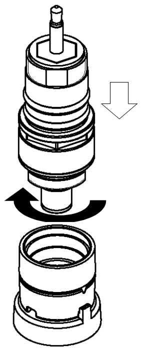
Pick a Cap up and drop it down, if there is air bubbles in internal solution of it.

4. **Set up a membrane cap on a adjustable mounting.**



(Spread a soft cloth under a adjustable mounting)

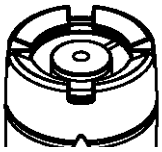
5. Attach a membrane cap to DO sensor



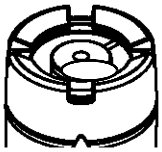
Twist a DO sensor
with holding a membrane cap tight.

6. Check for membrane surface

Check air bubbles in a membrane cap.



Good: Limited air bubbles



NG: Air bubbles of more than 5 mm in diameter

- ● NG → Replace a membrane cap again.
- ● Check that span calibration can be performed.

If the membrane cap is not attached correctly, sensitivity may be lost or response speed may decrease.

4.6 Troubleshooting

Note

If the sensor probe is removed while the control unit is indicating an error, errors cannot be canceled by using the ESC key. Either reconnect the sensor probe or restart the control unit.

4.6.1 Error displays

Error	Cause	Solution
Probe ADC error	Internal IC failure	Contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error/Factory	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error/User	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.
Turbidity sensor light source error	Turbidity sensor light source failure	Turn the power OFF, wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor.
Turbidity sensor wiper motor error	The turbidity sensor wiper is not operating.	Press the ESC key. Check there are no obstacles near the wiper, then perform the measurement again. If the error persists, the motor will need to be replaced. Contact your nearest sales outlet to have the sensor probe repaired.
Probe capacitor error	Low battery voltage or internal IC failure	Turn the power OFF. Replace the display's batteries. If the error persists, contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error	Internal IC failure	Press the ESC key, then redo the operation. If the error persists, turn the power OFF, then restart the system (the current data will not be saved). If the error still persists, contact your nearest sales outlet to have the display repaired.
Probe board error	Probe board failure	Turn the power OFF. Contact your nearest sales outlet to have the sensor probe repaired.

Error	Cause	Solution
Zero-point calibration error	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. There is moisture on the sensor. 2. The sensor is dirty. 3. The COND sensor is broken.	COND sensor 1. Blow-dry the moisture off the sensor. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. There are air bubbles in the internal solution. 2. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the DO sensor.
	Water depth sensor 1. The water depth sensor is dirty. 2. The water depth sensor has failed.	Water depth sensor 1. Clean the water depth sensor. 2. Contact your nearest sales outlet.

Error	Cause	Solution
Span calibration error	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	ORP sensor 1. The ORP standard solution is contaminated. 2. The ORP electrode is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The ORP electrode has failed.	ORP sensor 1. Replace the standard solution with new solution. 2. Clean the ORP electrode. 3. Refil the reference electrode's internal solution. 4. Replace the ORP electrode.
	COND sensor 1. The calibration solution is not correct. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Use the correct calibration solution for calibration. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. The diaphragm is torn. 2. There are air bubbles in the internal solution. 3. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 3. Replace the DO sensor.
	Temperature sensor The temperature sensor has failed.	Temperature sensor Contact your nearest sales outlet.
Calibration stability error	The calibration value of an individual parameter is not stable. 1. The sensor is dirty. 2. The sensor has not adjusted to the standard solution. 3. The temperature was unstable during calibration.	1. Clean the sensor. 2. Fill the transparent calibration cup with pH 4 standard solution, and wait for at least 20 minutes of conditioning before starting calibration. 3. Start calibration after the temperature has stabilized.
Turbidity calibration error	Error in turbidity measurement sequence	Turbidity calibration failed. Redo calibration after removing the displayed error.
Wet check	The cable connector is submerged.	Turn the power OFF and disconnect the cable connector. Wipe or blow-dry off all the water droplets on the probe. If the error persists, contact your nearest sales outlet to have the display and sensor probe repaired.
Power voltage error	The display's power board has failed.	This error could also be caused by poor cable contact. Turn the power OFF and disconnect the cable connector. Reconnect the connector and turn the power ON. If the error persists, contact your nearest sales outlet to have the display and sensor probe repaired.
Turbidity lamp power voltage error	The remaining battery level is low.	Turn the power OFF and replace the display's batteries with new ones.

Error	Cause	Solution
Display RTC error	The time display is incorrect.	Replace the coin battery.
Display FROM error	Internal IC failure	Contact your nearest sales outlet to have the control unit repaired.
Display EEPROM error	Internal IC failure	Contact your nearest sales outlet to have the control unit repaired.
Display save error	Insufficient memory space	Move data from the display, use the data operations screen to delete data, then redo the measurement.
Measurement sequence error	● When the measurement item is turbidity 1. The battery power is low. 2. The wiper is not operating normally. 3. The light source lamp is not lit. ● If items other than turbidity are also displayed 4. Board failure	1. Replace the batteries with new ones. 2. Check there are no obstacles near the wiper, then redo the measurement. If the error persists, the motor will need to be replaced. Contact your nearest sales outlet to have the sensor probe repaired. 3. Wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor. 4. Contact your nearest sales outlet to have the sensor probe repaired.
Out of measurement range	The attempted measurement is outside the measurement range supported for that item.	The system must be used within its supported measurement ranges.
Last zero-point calibration invalid	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. There is moisture on the sensor. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Blow-dry the moisture off the sensor. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. There are air bubbles in the internal solution. 2. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the DO sensor.
	Water depth sensor 1. The water depth sensor is dirty. 2. The water depth sensor has failed.	Water depth sensor 1. Clean the water depth sensor. 2. Contact your nearest sales outlet.
Out of measurement range	[See above.]	[See above.]
Last zero-point calibration invalid		

Error	Cause	Solution
Last span calibration invalid	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	ORP sensor 1. The ORP standard solution is contaminated. 2. The ORP electrode is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The ORP sensor glass is broken.	ORP sensor 1. Replace the standard solution with new solution. 2. Clean the ORP electrode. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. The calibration solution is not correct. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Use the correct calibration solution for calibration. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. The diaphragm is torn. 2. There are air bubbles in the internal solution. 3. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 3. Replace the DO sensor.
	Temperature sensor ● The temperature sensor has failed.	Temperature sensor ● Contact your nearest sales outlet.
Out of measurement range	[See above.]	[See above.]
Last zero-point calibration invalid		
Last span calibration invalid	The calibration value of an individual parameter is not stable. 1. The sensor is dirty. 2. The sensor has not adjusted to the standard solution. 3. The temperature was unstable during calibration.	1. Clean the sensors. 2. Fill the transparent calibration cup with pH 4 standard solution, and wait for at least 20 minutes of conditioning before starting calibration. 3. Start calibration after the temperature has stabilized.
Out of measurement range	[See above.]	[See above.]
Last zero-point calibration invalid		
Calibration value is factory default value.	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.

Error	Cause	Solution
Sample is unstable.	1. The concentration of the sample is unstable. 2. External light disturbance has affected the sensor. 3. Water has entered the turbidity sensor's connector.	1. Use a stirrer to agitate the sample during measurement. 2. Perform measurement away from direct sunlight. 3. Turn the power OFF, wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor.

4.6.2 Error displays in sensor information

Error display	Cause	Solution
Measurement sequence error	Measurement sequence error	Turn the power OFF, then restart the system. If the error persists, have the probe repaired.
Out of measurement range	The measurement value is outside the measurement range.	Samples for measurement must be within the measurement range.
Last calibration invalid	The last calibration failed.	Redo calibration.
Calibration invalid	The calibration value is the factory default value.	Redo calibration.
Background unstable	The U-53 turbidity sensor is exposed to direct light.	Mount the guard cap and sensor guard and perform measurement away from direct sunlight.
	The turbidity value changed rapidly during measurement.	Measure a sample that has stable turbidity.

5 Specifications

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
Sensor probe	Measurement temperature range	−10°C to 55°C	✓	✓	✓	✓	✓
	Maximum sensor outer diameter	Approx. 96 mm					
	Sensor length	Approx. 340 mm					
	Cable length	2 m (standard) 10 m/30 m (options)					
	Mass	Approx. 1800 g					
	Auto calibration function	Uses pH 4 standard solution.					
	Measurement depth	30 m max.	✓	✓	✓	✓	✓
	Wet-part materials[*3]	PPS, glass, SUS316L, SUS304, FKM, PEEK, Q, titanium, FEP membrane, POM					
	Waterproofing standard	IP-68					
Control unit	Outer dimensions (W × D × H)	115 × 66 × 283 mm	✓	✓	—	✓	—
		115 × 66 × 335 mm	—	—	✓	—	✓
	Mass	Approx. 800 g	✓	✓	✓	✓	✓
	LCD	320 × 240 mm graphic LCD (monochrome) with backlight	✓	✓	✓	✓	✓
	Memory data items	10000	✓	✓	✓	✓	✓
	Communication interface	USB peripheral	✓	✓	✓	✓	✓
	Batteries	C-size dry cells (×4)	✓	✓	✓	✓	✓
	Waterproofing standard	IP-67	✓	✓	✓	✓	✓
	GPS unit	● Reception method (12 channel parallel) ● Measurement precision [With PDOP (high precision): 30 m or less (2 drms)]	—	—	✓	—	✓
	Estimated battery life[*1]	—	70 hours (no backlight)			500 measurements (no backlight)	
	Storage temperature range	−10°C to 60°C	✓	✓	✓	✓	✓
	Ambient temperature range	−5°C to 45°C					

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
pH measurement Two calibration	Measurement method	Glass electrode method	✓	✓	✓	✓	✓
	Range	pH 0 to 14					
	Resolution	0.01 pH					
	Precision[*2]	±0.1 pH					
Dissolved oxygen measurement ● Salinity conversion (0 to 70 PPT, automatic) ● Automatic temperature compensation	Measurement method	Polarographic method	✓	✓	✓	✓	✓
	Film thickness	25 µm					
	Range	0 mg/L to 50.0 mg/L					
	Resolution	0.01 mg/L					
	Precision[*2]	0 mg/L to 20 mg/L: ±0.2 mg/L 20 mg/L to 50 mg/L: ±0.5 mg/L					
Electrical conductivity measurement ● Auto range ● Automatic temperature conversion (25°C)	Measurement method	Four-AC-electrode method	✓	✓	✓	✓	✓
	Range	0 S/m to 10 S/m (0 mS/cm to 100 mS/cm)					
	Resolution	0.000 mS/cm to 0.999 mS/cm: 0.001 1.00 mS/cm to 9.99 mS/cm: 0.01 10.0 mS/cm to 99.9 mS/cm: 0.1 0.0 mS/m to 99.9 mS/m: 0.1 0.100 S/m to 0.999 S/m: 0.001 1.00 S/m to 9.99 S/m: 0.01					
	Precision[*2]	1% of full-scale (midpoint of two calibration points)					
Salinity measurement	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 PPT to 70 PPT (parts per thousand)					
	Resolution	0.1 PPT					
	Precision	±3 PPT					
TDS (total dissolved solid) measurement ● Conversion coefficient setting	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 g/L to 100 g/L					
	Resolution	0.1% of full-scale					
	Repeatability	±2 g/L					
	Precision	±5 g/L					
Seawater specific gravity measurement ● σt, σ0, σ15 display	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 σt to 50 σt					
	Resolution	0.1 σt					
	Precision	±5 σt					

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
Temperature measurement	Measurement method	Platinum temperature sensor	✓	✓	✓	✓	✓
	Range	−10°C to 55°C					
	Resolution	0.01°C					
	Sensor	Platinum temperature sensor, JIS Class B (0.3 + 0.005 |t|)					
Turbidity measurement	Measurement method		–	LED forward 30° transmission/ scattering method		Tungsten lamp 90° transmission scattering method	
	Range			0 NTU to 800 NTU		0 NTU to 1000 NTU	
	Resolution			0.1 NTU		0.01 NTU	
	Precision[*2]			±5%of readout or ±1 NTU, whichever is larger		● ±0.5NTU (for 0 NTU to 10 NTU measurement range) ● 3% of readout or 1 NTU, whichever is larger (for 10 NTU to 1000 NTU measurement range)	
	Turbidity sensor wiper			–		✓	
Water depth measurement	Measurement method	Pressure method	–	–	✓	✓	✓
	Range	0 m to 30 m					
	Resolution	0.05 m					
	Precision[*2]	±0.3 m					
ORP (oxidation reduction potential) measurement	Measurement method	Platinum electrode method	✓	✓	✓	✓	✓
	Range	−2000 ～ +2000 mV					
	Resolution	1 mV					
	Precision[*2]	±15 mV					

*1: Battery life is estimated under following conditions.
- Continuous operation
- Using batteries: C-size alkaline dry cells
- Ambient temperature of the control unit: 20°C or more
- Backlight off

*2: The precision is defined by measuring the standard solution in the following cases.
- Turbidity and conductivity: after four point calibration
- pH and DO: after two point calibration
- Water depth and ORP: after one point calibration

*3: Metallic parts are made of stainless steel. Immersing in seawater may erode metallic parts.

6 Reference

6.1 Consumable parts

● Sensor

Name	Model	No.	Description
pH sensor	#7112	3014057312	Standard type pH sensor
pH sensor ToupH	#7113	3200170923	Tough glass type pH sensor
ORP sensor	#7313	3200170920	
DO sensor	#7543	3200170924	
Reference electrode	#7210	3200043582	
R bush unit	—	3200043587	Reference electrode liquid junction
TURB cell U-52	#7800	3200172803	For U-52/U-52G
TURB cell U-53	#7801	3200172800	For U-53/U-53G
Membrane cap	—	3200170194	For DO sensor

● Standard solution and inner solution

Name	Model	No.	Description
pH 4 (For automatic calibration) 500 mL	#100-4	3200043638	Standard solution for auto calibration. Also used for manual pH span calibration.
pH 4 (For automatic calibration) 4 L	#140-4	3200174430	
pH 7 500 mL	#100-7	3200043637	Standard solution for pH zero-point calibration.
pH 9 500 mL	#100-9	3200043636	Standard solution for pH manual span calibration.
Powder for ORP standard solution 10 packs	#160-51	3200043618	For ORP calibration.
Powder for ORP standard solution 10 packs	#160-22	3200043617	
Inner solution for DO sensor, 50 mL	#306	3200170938	Internal solution for DO sensor.
Internal solution for pH, 250 mL	#330	3200043641	Supplementary internal solution for pH reference electrode.

● Others

Name	Model	No.	Description
Silicone grease	—	3014017718	Silicone grease for coating sensor O-ring.
Sponge brush unit	—	3200169531	Brush for cleaning sensor probe.
O-ring set for reference electrode	—	3200169376	O-rings for reference electrode.
O-ring set for DO sensor	—	3200169426	O-rings for DO sensor.
Rubber cap set for sensor guard	—	3200169428	Rubber caps used between sensor guard and sensor probe.
O-ring set for pH and ORP sensor	—	3200169520	O-rings for pH and ORP sensors.
Wiper unit	—	3200169789	Rubber wiper for U-53/U-53G turbidity sensors.
Protective cap (blk) for pH sensor	—	3200175019	Cap attached to tip of pH sensor for sensor probe storage.
Rubber cap (whit) for DO sensor	—	3200175020	Cap attached to tip of DO sensor for sensor probe storage.

6.2 Options sold separately

Name	Model	No.	Description
Bag	U-5030	3200174772	Storage bag for sensor probes and flow cell. Can be carried in one hand.
Flow cell assy	—	3200156570	Used when collecting measurement samples by pump.
Probe guard	—	3200167002	Used for taking measurements in locations where there is a current or where there is a thick layer of sludge.
Communication cable	—	3200174823	A PC connection cable. Comes with data collection software.

6.3 pH measurement

6.3.1 Principle of pH measurement

U-50 series use the glass electrode method for pH measurements. The glass electrode method measures a potential difference between the glass film for pH and the reference electrode. For more information, refer to “JIS Z 8802 pH measurement method”.

6.3.2 Temperature compensation

The electromotive force generated by the glass electrode changes depending on the temperature of the solution.

Temperature compensation is used to compensate for the change in electromotive force caused by temperature.

This function does not compensate the change in pH caused by the temperature of the solution. When pH is to be measured, the temperature of the solution must be recorded along with that pH value, even if a pH meter has automatic temperature compensation function. If the solution temperature is not recorded, the results of the pH measurement may be meaningless.

6.3.3 Standard solutions

When measuring pH, the pH meter must be calibrated using standard solution. There are five kinds of standard solutions specified in “JIS Z 8802 pH measurement”. For normal measurement, two of standard solutions with pH of 4, 7, and 9 are sufficient to accurately calibrate the meter.
For standard solutions, refer to “JIS Z 8802 pH measurement”.

pH 4 standard solution: (Phthalate)	0.05 mol/L potassium hydrogen phthalate aqueous solution
pH 7 standard solutio: (Neutral phosphate)	0.025 mol/L potassium dihydrogenphosphate, 0.025 mol/L disodium hydrogenphosphate aqueous solution
pH 9 standard solution: (Borate)	0.01 mol/L sodium tetraborate aqueous solution

Table 2 pH values of pH standard solutions at various temperatures settings

Temp. (℃)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

6.4 DO measurement

6.4.1 Principle of DO measurement

Dissolved oxygen (DO) refers to the amount of oxygen that is contained in water.

The concentration of dissolved oxygen is generally given as mg/L or as a percentage value (the dissolved oxygen saturation ratio).

Dissolved oxygen is essential for maintaining the self-purifying ability of rivers and seas and also for fish to live. The concentration of dissolved oxygen acts as an indicator of water quality. It is often measured when processing waste water and managing water quality. Fig. 1 provides an overview of the principles behind dissolved oxygen sensor measurement.

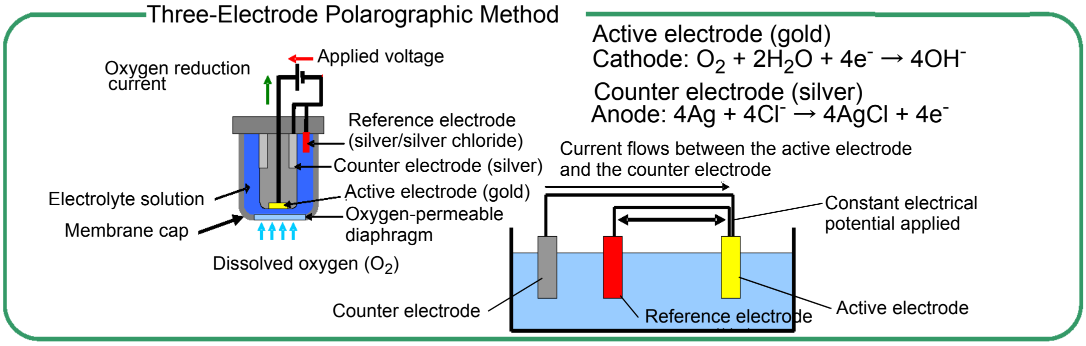


Fig. 1 Overview of principles behind dissolved oxygen sensor

The polarographic oxygen sensor is an enclosed sensor wherein voltage is applied to a cathode made of a precious metal (such as gold or platinum) and an anode also made of a precious metal (such as silver) via an external circuit, and a cap with an oxygen permeable diaphragm (membrane) is filled with electrolyte solution. As indicated in Fig. 1, the concentration of dissolved oxygen can be measured by measuring the current proportional to the amount of reduced oxygen when oxygen that has dispersed through the oxygen permeable diaphragm produces a reductive reaction on the surface of the active electrode (gold). The method of measuring dissolved oxygen based on the above principle is called the Membrane Electrode Method. Compared to the Chemical Analysis Method, which requires complicated pre-processing to alleviate the effect of reduced materials and oxidizing materials, this method allows dissolved oxygen to be measured very easily. It is also easy to remove undesired buildup from the silver electrode by polishing and cleaning if an insulator forms on it due to oxidation, making the method reusable.

6.4.2 Salinity calibration

When the solution and air come into contact and form an equilibrium (i.e. saturation), the relationship between the concentration of dissolved oxygen in the solution, C, [mol/L], and the partial pressure of oxygen in the air, Ps, [MPa/(mg/L)], can be represented by the following formula:

$C = Ps/H$

Where H [MPa/(mg/L)] is the Henry constant, a value that changes according to the composition of the solution. As H typically becomes larger as the salinity of the water increases, C becomes smaller.

The DO sensor detects the partial pressure of oxygen (Ps) in the above formula. Accordingly, if the DO sensor is immersed in deionized water saturated with air, or in an aqueous solution containing salt, the output current does not change, resulting in an erroneous measurement. For example, when salt is added to a sample, the amount of oxygen that can be dissolved in the solution decreases, but because the partial pressure of oxygen does not change, the value displayed by the control unit stays the same regardless of salt content. This concept is indicated in graph form below. (Fig. 2)

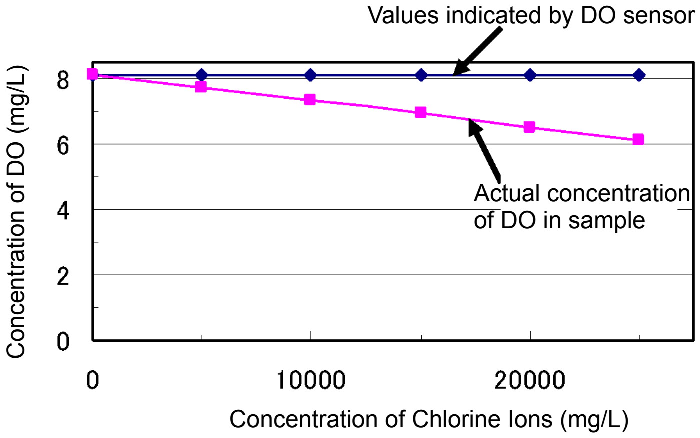


Fig. 2 Relationship between chlorine ion concentration and dissolved oxygen concentration

In samples with a high salt concentration, the solubility of oxygen is lower, but as the partial pressure of oxygen does not change, the value actually indicated on the control unit is higher than the actual value. In order to obtain a measurement of the concentration of dissolved oxygen in an aqueous solution that contains salt, it is therefore necessary to first perform salinity compensation. Conventionally, dissolved oxygen sensors have performed salinity compensation by inputting the salinity of the sample. This is fine as long as the salinity is already known. However, in most cases salinity is unknown, so even if dissolved oxygen sensors contained a salinity compensation function, it was of no practical use.

The U-50 Series can calculate and measure salinity in samples from electrical conductivity values, and can thus be used to automatically compensate for salinity.

6.5 Conductivity (COND) measurement

6.5.1 Four-AC-electrode method

Conductivity is an index of the flow of electrical current in a substance.

Salts dissolved in water are separated into cations and anions. Such solution is called electrolytic solution.

Electrolytic solution has the property of allowing the flow of current according to Ohm's law. This property is referred

to as ionic conductivity, since current flow is caused by ion movement in electrolytic solution.

Metals, on the other hand, allow the flow of current by means of electrons. This property is called electronic conductivity,

which is distinguished from ionic conductivity.

A cube with 1 m on each side, as shown in Fig. 3, is used to demonstrate an electrolytic solution. Two electrode plates are placed on opposite sides, and the cube is filled with solution. If the resistance between these two electrode plates is represented by r(Ω), the conductivity of the solution L($S \cdot m^{-1}$) is represented as L=1/r. S stands for Siemens, a unit of measurement of conductance.

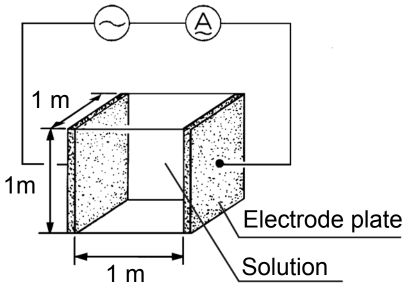


Fig. 3 Definition of conductivity

The most general method for measuring conductivity is based on the above principle, and is called the 2-electrode method.

In the 2-electrode method the influence of polarization cannot be ignored for solutions with high conductivity and conductivity cannot be measure accurately. In addition, contamination on the surface of the electrode increases apparent resistance, resulting in inaccurate measurement of conductivity.

The U-50 series has adopted the 4-electrode method to overcome these disadvantages of the the 2-electrode method.

As shown in Fig. 4, the U-50 series uses two voltage-detecting electrodes and two voltage-applying electrodes, for a total of four electrodes. The voltage-detecting electrodes are for detecting AC voltage, and the voltage-applying electrodes are for applying AC voltage.

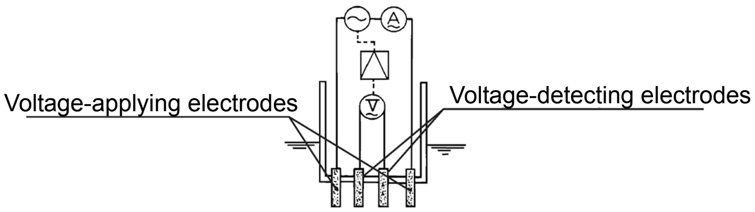


Fig. 4 Principle of the 4-electrode method

Let us assume that the current, I(A), flows in a sample of conductivity L – under automatic control of the voltage-applying electrodes – so that the voltage at the voltage-detecting-electrodes, E(V), remains constant at all times.

Then, the resistance of the sample, R(Ω), across the voltage-detecting electrodes is represented as R=E/I. The resistance, R, of the sample is inversely proportional to its conductivity, L. Accordingly, a measurement of current, Is,

of a standard solution of known conductivity, Ls, enables calculation of conductivity of a sample according to the formula L = Ls (I/Is) from the ratio L : Ls = I : Is.

Even in the 4-electrode method, polarization occurs, since AC current flows in the voltage-applying electrodes. The voltage-detecting electrodes are, however, free from the effects of polarization, since they are separated from the voltage-applying electrodes, and furthermore, current flow is negligible. Therefore, the 4-electrode method is an excellent method to enable measurement of conductivity covering a very high range.

6.5.2 SI units

New measurement units, called SI units, have been in use from 1996. Accordingly, the U-50 series also uses SI units. The following conversion table is provided for people who use the conventional kind of conductivity meter.

Note that along with the change in unit systems, the measurement values and cell counts have also changed.

	Former units	→	SI unit
Measurement value	0.1 mS/cm	→	0.01 S/m
	1 mS/cm	→	0.1 S/m
	100 mS/cm	→	10 S/m

6.5.3 Temperature coefficient

In general, the conductivity of a solution varies largely with its temperature.

The conductivity of a solution depends on the ionic conductivity, described earlier. As the temperature rises, conductivity becomes higher since the movement of the ions becomes more active.

The temperature coefficient shows the change in % of conductivity per °C, with a certain temperature taken as the reference temperature. This is expressed in units of %/°C. The temperature coefficient assumes the premise that the conductivity of a sample changes linearly according to temperature.

Strictly speaking, with actual samples, however, conductivity changes along a curve. Furthermore, the cuve varies with the type of sample. In the ranges of smaller temperature changes, however, samples are said to have the temperature coefficient of 2%/°C (at reference temperature 25°C); this holds for most samples, except in certain special cases.

(The temperature coefficients for various types of solutions are listed on the next page.)

The U-50 series uses an automatic temperature conversion function to calculate conductivity at 25°C at a temperature

coefficient of 2 %/°C based on the measured value of the temperature. Results are displayed on the readout.

The U-50 series’s temperature conversion function is based on the following formula.

$L_{25} = L_t / \{ 1 + K (t - 25) \}$

L_{25} : Conductivity of solution converted to 25°C

t : Temperature of solution at time of measurement (°C)

L_t : Conductivity of solution at t (°C)

K : Temperature coefficient (%/°C)

Conductivity and temperature coefficient for various solutions

Conductivity and related temperature coefficients of representative substances (at 25°C) are shown in the table below.

Substance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp.coef. (%/°C)	Substance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp.coef. (%/°C)
NaOH	15	5	19.69	2.01	NaCl	18	5	6.72	2.17
		10	31.24	2.17			10	12.11	2.14
		15	34.63	2.49			15	16.42	2.12
		20	32.70	2.99			20	19.57	2.16
		30	20.22	4.50			25	21.35	2.27
		40	11.64	6.48	Na_2SO_4	18	5	4.09	2.36
KOH	15	25.2	54.03	2.09			10	6.87	2.49
		29.4	54.34	2.21			15	8.86	2.56
		33.6	52.21	2.36	Na_2CO_3	18	5	4.56	2.52
		42	42.12	2.83			10	7.05	2.71
NH_3	15	0.1	0.0251	2.46			15	8.36	2.94
		1.6	0.0867	2.38	KCl	18	5	6.90	2.01
		4.01	0.1095	2.50			10	13.59	1.88
		8.03	0.1038	2.62			15	20.20	1.79
		16.15	0.0632	3.01			20	26.77	1.68
HF	18	1.5	1.98	7.20			21	28.10	1.66
		4.8	5.93	6.66	KBr	15	5	4.65	2.06
		24.5	28.32	5.83			10	9.28	1.94
HCl	18	5	39.48	1.58			20	19.07	1.77
		10	63.02	1.56	KCN	15	3.25	5.07	2.07
		20	76.15	1.54			6.5	10.26	1.93
		30	66.20	1.52			—	—	—
H_2S0_4	18	5	20.85	1.21	NH_4Cl	18	5	9.18	1.98
		10	39.15	1.28			10	17.76	1.86
		20	65.27	1.45			15	25.86	1.71
		40	68.00	1.78			20	33.65	1.61
		50	54.05	1.93			25	40.25	1.54
		60	37.26	2.13	NH_4NO_3	15	5	5.90	2.03
		80	11.05	3.49			10	11.17	1.94
		100.14	1.87	0.30			30	28.41	1.68
		—	—	—			50	36.22	1.56
HNO_3	18	6.2	31.23	1.47	$CuSO_4$	18	2.5	10.90	2.13
		12.4	54.18	1.42			5	18.90	2.16
		31	78.19	1.39			10	32.00	2.18
		49.6	63.41	1.57			15	42.10	2.31
		62	49.64	1.57	CH_3COOH	18	10	15.26	1.69
H_3PO_4	15	10	5.66	1.04			15	16.19	1.74
		20	11.29	1.14			20	16.05	1.79
		40	20.70	1.50			30	14.01	1.86
		45	20.87	1.61			40	10.81	1.96
		50	20.73	1.74			60	4.56	2.06

6.6 Salinity (SAL) conversion

The U-50 series is designed to calculate salinity as well as the other parameters.

Note that the “salinity” here is the salinity of sea water. There is a constant relation between conductivity and salinity at certain temperatures.

Therefore, if data on the conductivity and temperature are available, the corresponding salinity can be known. In other words, the salinity measurement of the U-50 series is based on the principle of calculating the salt content, making use of the measured values of conductivity and temperature.

Note therefore, that measured results of all substances whose conductivity is detected are displayed as salinity. For example, the measured result is displayed as NaCl concentration, even if in fact the sample component is, hydrochloric acid (HCl).

6.7 TDS conversion

TDS is short for Total Dissolved Solids and means the total dissolved solid amount.

The conductivity of a solution is affected by the amount of salinity, minerals, and dissolved gases. That is, conductivity is an index that shows the total amount of all substances in the solution. Of these substances, TDS indicates only the amount of dissolved solids.

TDS can be used for a comparison of the state of substances composed of a single component such as NaCl. However, the use of TDS for the comparison of solutions of different types causes serious errors.

Conductivity and TDS are expressed by the following formulas.

Conductivity in SI units (S/m) .... TDS(g/L) = L (S/m) × K × 10

TDS(g/L) = L (mS/m) × K ÷ 100

Conductivity in the old units (mS/cm) .... TDS(g/L) = L (mS/cm)× K

K = TDS coefficient

Initial settings use the values listed in the table (Page 80) that generally uses TDS coefficients.

For accurate TDS comparisons, find the TDS coefficient from measured conductivity values. Then set the value thus obtained and make measurements.

6.8 σt conversion

- **Specific gravity of seawater**

The density and specific gravity of seawater are equal numerically and generally are not distinguished strictly. Since seawater density ρ is between 1.000 and 1.031, 1 is subtracted from ρ and σ is obtained by multiplying the value by 1000.

The resultant value is used as the specific gravity of seawater.

$\sigma = (\rho - 1) \times 1000$

The density of seawater ρ is expressed by function of temperature, hydraulic pressure, and salinity. The density of seawater under the atmospheric pressure is expressed as σ_t. The density of seawater under the atmospheric pressure is determined by temperature and salinity.

The U-50 Series models make salinity measurement through temperature measurements and conductivity conversion and find σ_t through calculations.

In Japan σ_{15} at 15°C is called a standard specific gravity and widely used while in foreign countries σ_0 at 0°C is employed. σ_{15} and σ_0 are determined by the function of salinity.

In ocean surveys, in particular, these values σ_t, σ_{15}, and σ_0 are more widely used than conductivity and salinity and, in the U-50 Series models, newly added as measurement components.

6.9 Turbidity (TURB) measurement

6.9.1 Principle of turbidity measurement

U-52 and U-53 sensors measure turbidity using the Transmitting and Scattering Method shown in Fig. 5. U-52 sensors use a pulse light LED (infra-red emitting diode) as a light source, and detect scattered light from a 30° angle off center. U-53 sensors use a tungsten lamp as a light source and detect scattered light from a 90° angle. Both models display turbidity as a ratio of scattered light to transmitted light to reduce the affect of the color of the sample. The U-53 method conforms to EPA Method 180.1, and employs wipers to reduce the affect of air bubbles.

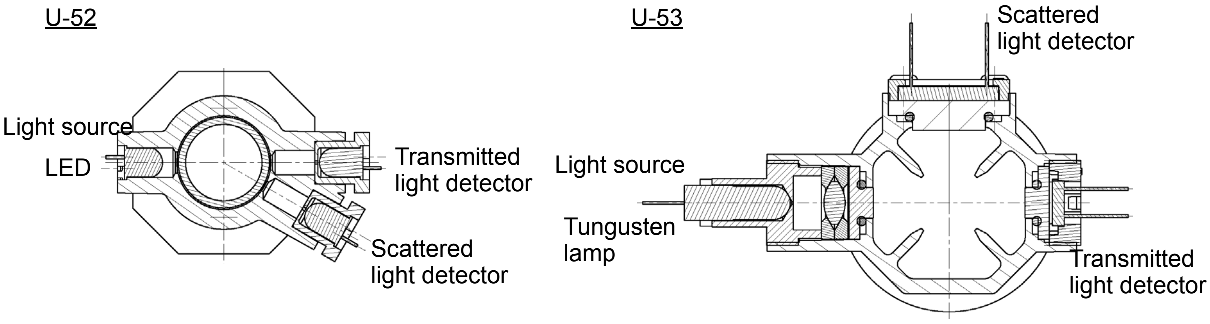


Fig. 5 Turbidity cell

6.9.2 Standard solution

U-50 series can perform calibration using formazin (NTU) or kaolin standard solutions as a turbidity standard solution. However, units for the solution used for calibration should be displayed in measurements. Do not use more than 400 mg/L of kaolin standard solution because it increases precipitation speed, resulting in measurement error.

6.10 Depth (DEPTH) measurement

6.10.1 Principle of depth measurement

For the W-22XD and W-23XD models, depth measurement can be made through use of a pressure gauge. The principle of the depth measurement uses the relation between depth and pressure.

Although the measurement with the depth sensor is affected by atmospheric pressure, the depth sensor, however, makes zero-point adjustments through the automatic calibration before measurements.

6.10.2 Influence of temperature and calibration

The depth sensor depends greatly on temperature. For a wide difference between the temperature at which the sensor has been automatically calibrated and the temperature of the measurement sample, the sensor can make depth measurements with a higher accuracy by the following method:

1. **Immerse the depth sensor of the sensor probe in the sample.**
2. **Keep the sensor immersed in the sample for about 30 minutes until the temperatures of the sensor and the sample are the same.**
3. **Then make the zero calibration of the sensor manually.**

6.11 Oxidation reduction potential (ORP) measurement

6.11.1 Principle of ORP measurement

ORP is an abbreviation for oxidation-reduction potential. ORP is the energy level (potential) determined according to the state of equilibrium between the oxidants (M^{Z+}) and reductants $M^{(Z-N)+}$ that coexist within a solution.

$$M^{Z+} + ne^{-} \Leftrightarrow M^{(Z-N)+} \qquad \cdots (1)$$

If only the solution, forming the ORP measuring system shown in Fig. 6. The difference of potential between two electrodes is generally expressed by the following equation.

$$E = E_0 - \frac{RT}{nF} \ln \frac{a_M^{(z-n)+}}{a_M^{z+}} \qquad \cdots (2)$$

E: Electric potential E_0 : Constant R: Gas constant T : Absolute temperature
n: Electron count F : Faraday constant a : Activity

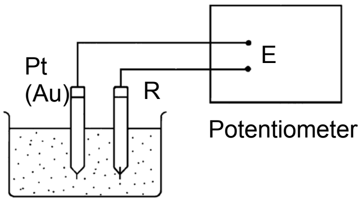


Fig. 6 Measuring mV

For example, for a solution in which trivalent iron ions coexist with bivalent iron ions, equations 1 and 2 would be as follows.

$$Fe^{3+} + e^{-} \Leftrightarrow Fe^{2+} \qquad \cdots (1)$$

$$E = E_0 - \frac{RT}{F} \ln \frac{a_{Fe}^{2+}}{a_{Fe}^{3+}} \qquad \cdots (2)$$

When only one type of state of equilibrium uniquely by equation (Fe^{3+}) and the reductant (Fe^{2+}) (using the equation a_{Fe}^{2+}/ a_{Fe}^{3+}). Actually, however many kinds of states of equilibrium exist simultaneously between various kinds of ions, in most solutions. This means that under actual circumstances, ORP cannot be expressed using the simple equation shown above and that the physical and chemical significance with respect to the solution is not very clear.

In this respect, the value of ORP must be understood to be only one indicator of the property of a solution. The measurement of ORP is widely used, however, as an important index in the analysis of solutions (potentiometric titration) and in the waste water treatment.

6.11.2 Standard electrode (reference electrode) types and ORP

The ORP is obtained comparing with corresponding reference electrode employed.

If different kinds of reference electrodes are used for measurement, the ORP value of the same solution may appear to be different. HORIBA's reference electrode uses Ag/AgCl with 3.33 mol/L KCl as inner solution. According to general technical literature, normal hydrogen electrodes (N.H.E.) are often used as the standard electrode.

The relationship between N.H.E. and the ORP that is measured using an Ag/AgCl with 3.33 mol/L KCl electrode is expressed by the following equation.

$E_{N.H.E.} = E + 206 - 0.7(t - 25)$ mV $t = 0$ - 60°C

$E_{N.H.E.}$: Measured ORP value using N.H.E. as the reference electrode

E: Measured ORP value using Ag/AgCl with 3.33 mol/L KCl as the reference electrode

Potential sign

Standard ORP is expressed in the following way, in literature related to electrochemistry and analytical chemistry.

A $Li^+ + e^- \rightarrow Li$

$E_0 = -3.024$ V VS N.H.E.

However, in some literature, the "+" and "-" signs are reversed.

B $Li \rightarrow Li^+ + e^-$

$E_0 = +3.024$ V VS N.H.E.

In expressions like B, above, the reaction is just reversed and there is no essential difference. But this kind of expression does invite confusion. The majority of the world, today, is consistent in its use of the signs as they are used in A, above.

For this reason, HORIBA, too, uses signs concerning ORP that are consistent with A, above.

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Appendix C

Field Logs

Fort Drum, Oasis; Fort Drum, NY

Month and Year **CSIA Monthly Sampling**

Site

Event

GROUNDWATER SAMPLING LOG

Sampling Personnel:

Well ID:

Client / Job Number: USACE/06261031.0000

Date:

Weather:

Time In:

Time Out:

Well Information

Depth to Water:		(feet)
Total Depth:		(feet)
Length of Water Column:		(feet)
Volume of Water in Well:		(gal)
Intake depth for tubing:		(feet)

Well Type:	Flush mount ☐	Stick-Up ☐
Well Material:	Stainless Steel ☐	PVC ☐
Well Locked:	Yes ☐	No ☐
Measuring Point Marked:	Yes ☐	No ☐
Well Diameter:	1” 2”	Other:

Purging Information

Purging Method: Bladder

Tubing/Bailer Material: Teflon

Sampling Method: Bladder

Pump Start Time:

Pump Stop Time:

Water-Quality Meter Type: Horiba U-52

Total Volume Removed: (gal)

Did well go dry:

Conversion Factors				
gal / ft. of water	1” ID	2” ID	4” ID	6” ID
	0.041	0.163	0.653	1.469
1 gal = 3.785 L =3785 ml = 0.1337 cubic feet				

Unit Stability			
pH	DO / Turb	Cond. /Temp	ORP
∀ 0.1	∀ 10%	∀ 3.0%	∀ 10 mV

Parameter:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Time									
Volume Purged (gal)									
Rate (mL/min)									
Depth to Water (ft)									
pH									
Temp. (ºC)									
Conductivity (mS/cm)									
Dissolved Oxygen (mg/L)									
ORP (mV)									
Turbidity (NTU)									
Notes:									

Sampling Information

Analyses	**#**	**n**	**Laboratory**
VOC’s 8260B + MTBE			Alpha Analytical
TPH-DRO 8015B			Alpha Analytical
Isotopes			Univ. of Oklahoma

Color:

Odor:

Appearance:

Sample ID: Sample Time:

Duplicate: Yes ☐ No ☐

Duplicate ID Dup. Time:

Chain of Custody Signed By:

Problems / Observations

Fort Drum, Oasis; Fort Drum, NY

Month and Year **CSIA Monthly Sampling**

Site

Event

GROUNDWATER SAMPLING LOG

Sampling Personnel:

Well ID:

Client / Job Number: USACE/06261031.0000

Date:

Weather:

Time In:

Time Out:

Parameter:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Time									
Volume Purged (Gal)									
Rate (mL/min)									
Depth to Water (ft.)									
pH									
Temp. (C)									
Conductivity (mS/cm)									
Dissolved Oxygen (mg/L)									
ORP (mV)									
Turbidity (NTU)									
Notes:									

Parameter:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Time									
Volume Purged (Gal)									
Rate (mL/min)									
Depth to Water (ft.)									
pH									
Temp. (C)									
Conductivity (mS/cm)									
Dissolved Oxygen (mg/L)									
ORP (mV)									
Turbidity (NTU)									
Notes:									

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Appendix B

Smear Zone Reinjection System Startup, Operation, Maintenance, and Monitoring (OM&M) Procedure

Smear Zone Reinjection System Startup, Operation, Maintenance, and Monitoring (OM&M) Procedure
Fort Drum OASIS Site

This document provides an overview of smear zone reinjection operations that will be performed at the OASIS Fuel Point Site (Site), along with procedures for startup, operation, maintenance and monitoring. The design and procedures herein are subject to change in the event that modifications are identified to optimize/improve performance during the initial Fall 2015 operating period. The system design and operational procedures will be updated as necessary to incorporate any such improvements prior to the start of the 2016 operating season.

Background/Overview

Smear zone reinjection involves reinjecting treated effluent water from the Groundwater Recirculation (GWRC) and Plume-Wide DPE Systems into existing Site wells screened across the water table and smear zone soil above. Reinjection of aerated water will enhance current site remediation operations as follows.

- Flush out residual LNAPL trapped in the smear zone pore space.
- Mitigate potential hydraulic “dead zones” and/or preferential pathways within the treatment area.
- Increase oxygen delivery to the subsurface.
- Facilitate mass transfer from the smear zone soil to the dissolved phase – where it can be captured by the water table extraction wells and/or GWRC.
- Increase dissolved oxygen (DO) levels in groundwater and stimulate aerobic biodegradation of dissolved-phase mass.

Treated effluent from the GWRC and DPE systems will be reinjected as separate streams into the following existing Site wells.

- GWRC effluent – D12-N, E14-N, MP-04, G11-N and G14-N
- DPE effluent – G4-N, G5-N, G8-N, I3-N, I5-N and K6-N

Wells that will receive effluent from the DPE System were selected to target the area of recalcitrant LNAPL in the vicinity of extraction wells H3-X through H8-X. Wells that will receive GWRC effluent, which has a higher DO concentration, were selected to target the area of highest inferred smear zone soil impacts at the center of the current dissolved-phase groundwater plume. Treated effluent water will be conveyed from the GWRC and DPE Systems to the reinjection wells via above-grade flexible reinforced rubber piping. Well locations and the approximate layout of the reinjection piping network are illustrated on Figure 1. A process flow diagram for the smear zone reinjection setup at the GWRC and DPE Systems is illustrated in Figure 2. An injection wellhead construction detail is shown on Figure 3. Groundwater modeling output showing particle tracking for the initial planned reinjection scenario is attached in Attachment A. The modeling output will be confirmed through water level measurement and evaluation during the operation of the smear zone reinjection system.

Smear zone reinjection flows will be monitored and controlled such that the total volume reinjected does not exceed 80% of the total Plume Wide DPE System groundwater recovery volume. A portion of this total will include the 40% of the total GWRC System flow that is currently being discharged to the POTW. The remainder will come from the Plume Wide DPE System. Flow calculations are explained in further detail below.

Smear Zone Reinjection System Initial/Seasonal Startup

1.) Pre-Startup Inspection

- Visually inspect valves, piping, gauges/meters, measuring ports and other system components to make sure that they are in good working condition, tight, and installed as shown on the system P&ID figure. Report any problems or discrepancies observed to the supervising engineer.
- Operate every manually operated valve through its entire stroke to make sure that there is no binding, sticking or other interference.

2.) Pre-startup Baseline Monitoring

Collect the following baseline readings from the reinjection wells and reinjection monitoring wells shown on Figure 1 prior to initial or seasonal smear zone reinjection startup.

- Smear Zone Reinjection Wells: G4-N, G5-N, G8-N, I3-N, I5-N, and K6-N
- GWRC Smear Zone Reinjection Wells: D12-N, E14-N, MP-04, G11-N, and G14-N
- Smear Zone Reinjection Monitoring Wells: E12-N, F10-X, G12-N,RW-13, RW-06, H5-N, PZ-08 and SPMP-06
- Baseline Monitoring Data
    - Depth to groundwater and LNAPL (if present) - If measuring point is above the current top of the reference point elevation on the well casing due to additional piping or fittings for reinjection connections, then provide height of measuring point above top of the measuring point.
    - Groundwater DO, pH and ORP
    - Flow totalizer and pressure readings at the wellheads
    - Flow totalizer and pressure readings at the reinjection header line

Record measurements on attached monitoring data log.

Note: If LNAPL is observed at a thickness greater than 0.1 ft in any of the smear zone reinjection wells do not inject into that well and contact the supervising engineer. An alternate injection well location will be selected based on consultation with the supervising hydrogeologist.

3.) System Startup and Shakedown Testing – GWRC System Effluent

Complete the following startup and shakedown testing procedures sequentially.

- Contact supervising engineer to obtain average POTW discharge flow rate for GWRC system.
- Prior to hooking up the GWRC recirculation well header line to the GWRC system test port, confirm that the recirculation header line ball valve is closed.
- Open all gate valves at reinjection wells halfway to avoid excess flow to the reinjection wells located closest to the header line. Open threaded gauging port on extraction well cap to allow water to discharge out in the event that groundwater should overflow the well.
- Measure and record flow rate in POTW effluent line. If significantly different (i.e., +- 5 gpm) from average flow rate provided by supervising engineer, contact supervising engineer to discuss.
- Open ball valve on GWRC reinjection header line leaving the POTW effluent line open, then slowly close the valve on the POTW effluent line to direct all of the flow to the reinjection wells.

- Measure flow rate to reinjection header line to confirm that it is the same as the flow rate in the POTW effluent line measured previously. If lower, gate valves on the reinjection wells will need to be opened more during the next step.
- Adjust gate valves on the individual reinjection wells until flows are balanced such that the flow to each well is approximately equal.
- Record the following parameters from the reinjection header and individual wells once flows are balanced.
    - Injection wells: depth to water and LNAPL (if present); pressure; instantaneous flow rate and totalizer reading
    - Injection header: pressure; instantaneous flow rate and totalizer readings
- Continue to observe the system for 30 minutes, collecting the same readings listed above approximately every 15 minutes.
  Note: if rapid water level rise, abnormally high pressures or similar abnormal conditions are observed at any of the wells, stop injecting into the well in question and contact the supervising engineer to discuss.
- After the initial 30 minute observation period, continue to monitor and record water levels in the reinjection wells until they stabilize (if not already stabilized).
- Collect one additional set of the same readings listed above approximately 3 – 4 hours after water levels stabilize.
- Complete routine performance monitoring as described below.

4.) System Startup and Shakedown Testing – DPE System Effluent

Complete the following startup and shakedown testing procedures sequentially.

- Contact supervising engineer to obtain smear zone reinjection and POTW discharge flow rates for the DPE system effluent (see below for equation) and the air stripper AS-100 reinjection flow rate.
- Prior to hooking up the reinjection well header line to the air stripper AS-100 transfer pump effluent line confirm that the ball valve is closed and the gate valve is fully open on the reinjection header line.
- Open all gate valves at reinjection wells halfway to avoid excess flow to the reinjection wells located closest to the header line. Open threaded gauging port on extraction well cap to allow water to discharge out in the event that groundwater should overflow the well.
- Record transfer pump discharge flow rate to POTW.
- Adjust butterfly valve on AS-100 effluent line until transfer pump flow rate is 150 gpm
  Note: 150 gpm is the minimum flow rate at which the transfer pump can safely operate. Operating at lower flows may risk damaging the pump.
- Open ball valve on AS-100 reinjection line and adjust until the reinjection flow rate is approximately 100 gpm, or as otherwise directed by the supervising engineer. Use the flow meter on the POTW effluent discharge line for this as there is no flow meter on the AS-100 reinjection line.
- Open valve ball valve on the reinjection header line to allow water to begin flowing to the injections wells.
- Adjust gate valves on reinjection header line and POTW discharge line to achieve the desired flows to each, as provided by the supervising engineer.
- Adjust gate valves on the individual injection wells until flows are balanced such that the flow to each well is approximately equal.
- Recheck flow rates at injection header and POTW discharge line and adjust to desired rates if needed.
- Continue flow adjustments until system is properly balanced.
- Record the following parameters from the reinjection header and individual wells once flows are balanced.

    - Injection wells: depth to water and LNAPL (if present); pressure; instantaneous flow rate and totalizer reading
    - Injection header and POTW discharge line: pressure; instantaneous flow rate and totalizer readings
- Continue to observe the system for 30 minutes, collecting the same readings listed above approximately every 15 minutes.
  Note: if rapid water level rise, abnormally high pressures or similar abnormal conditions are observed at any of the wells, stop injecting into the well in question and contact the supervising engineer to discuss.
- After the initial 30 minute observation period, continue to monitor and record water levels in the reinjection wells until they stabilize (if not already stabilized).
- Collect one additional set of the same readings listed above approximately 3 – 4 hours after water levels stabilize.
- Complete routine performance monitoring as described below.

Additional Considerations:

- The total combined effluent flow to the POTW and reinjection wells must be higher than the total Plume-Wide DPE system groundwater recovery flow (air stripper influent flow) or water will back up in the air stripper sump triggering a high high level alarm.

Smear Zone Reinjection Operational and Performance Monitoring

Once smear zone reinjection is operatingthe following performance monitoring data will be collected at the following frequency to confirm flow rates, evaluate the condition of the system components and assess system performance.

Smear Zone Reinjection Header/POTW Discharge Lines

- Readings: pressure, instantaneous flow rate and flow totalizer
- Frequency
    - Daily

  Note: frequency may be reduced by supervising engineer if data demonstrate that flow rates do not vary much over time.

Smear Zone Reinjection Wells

- Readings: pressure, instantaneous flow rate and flow totalizer, depth to water and LNAPL (if present)
- Frequency:
    - Daily for the first week following initial or season startup
    - Twice per week thereafter

Smear Zone Reinjection Monitoring Wells

- Readings: depth to water and LNAPL (if present); groundwater DO, pH and ORP
- Frequency:
    - Twice during first week following initial or season startup
    - Weekly for the next 3 weeks
    - Monthly thereafter

Note: location and number of smear zone monitoring wells may be changed by the supervising engineer based on review of performance data.

All monitoring data should be sent electronically to engineering staff on the same day that it is collected. Engineering staff will review the data, and calculate the reinjection flow rates from the flow totalizer readings to confirm that the smear zone reinjection is operating within the established flow limits, identify any operational adjustments needed.

Reinjection flows will need to be adjusted every time there is an operational change that produces as noticeable change in the groundwater recovery rates for the DPE and/or GWRC Systems.

For reference, the smear zone reinjection volumes are calculated as follows.

Total Reinjection Flow = 80%(DPE System flow)
= 40%(GWRC flow) + DPE System Effluent Component

DPE System Effluent Component = 80%(DPE System flow) – 40%(GWRC flow)

Smear Zone Reinjection System Maintenance

Since the Smear Zone Reinjection System uses mostly existing DPE and GWRC System equipment, the majority of the required routine system maintenance activities are covered under the O&M scopes for those two systems. Additional maintenance items specific to the Smear Zone Reinjection System components are identified below. A Maintenance Schedule and Checklist for the smear zone reinjection system is provided with this procedure.

Flow Meters

- The digital groundwater flow meters used on the reinjection header and lateral piping are susceptible to becoming clogged by biofouling growth or other debris present in the flow stream.
- Check for evidence of clogging after each flow reading by comparing consecutive instantaneous flow readings to confirming that they are similar and near the target flow rate.
- Flow meters should be removed from the reinjection piping assembly, inspected, and cleaned if needed on a monthly basis.

Above Grade Piping

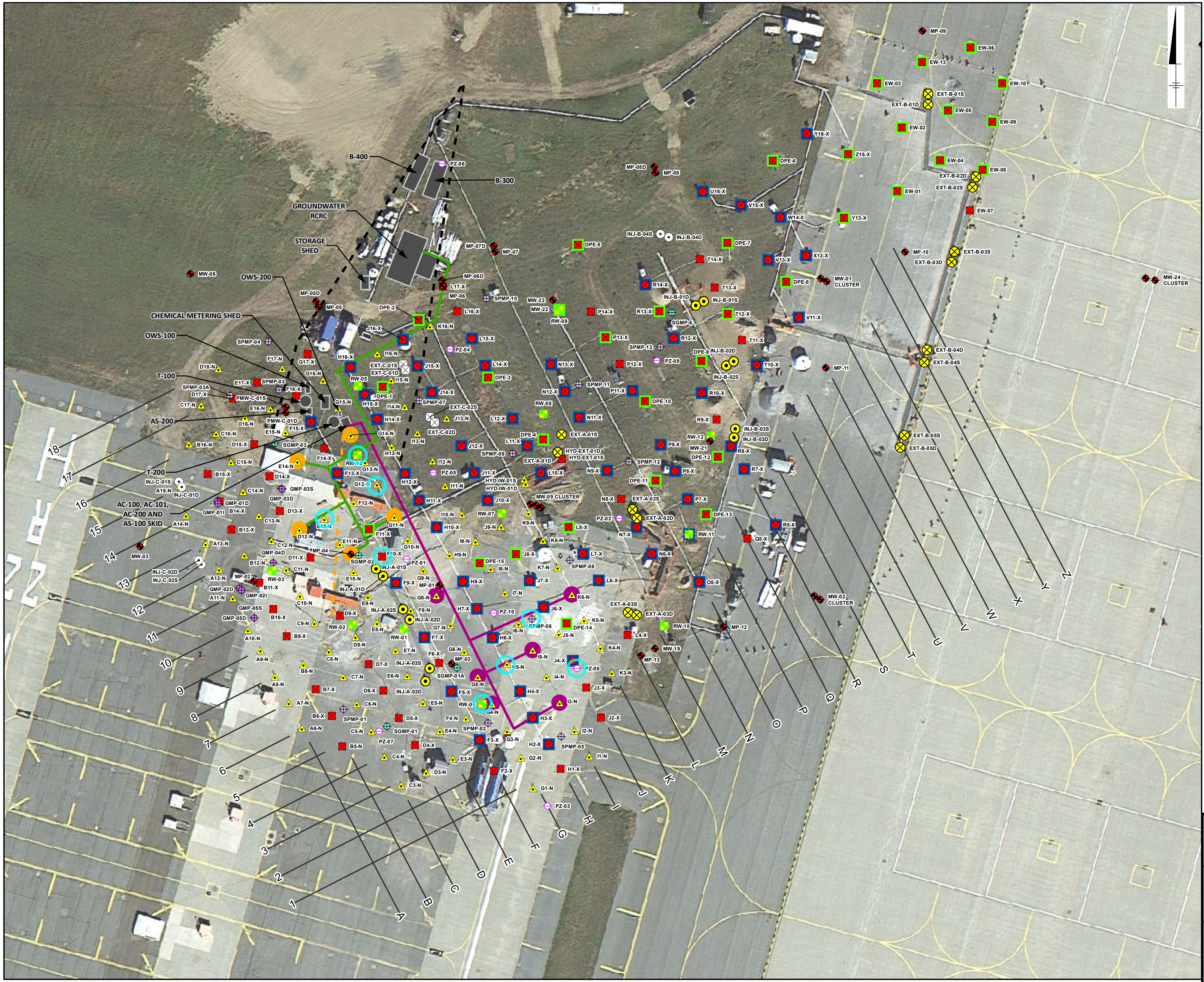
- Inspect above-grade reinjection piping, valves, and piping connections for leaks and other signs of wear while collecting performance monitoring data. Fix any issues observed.
- If large variations in pressures or flows are observed in the system, an inspection of the above grade piping should be part of the troubleshooting efforts to determine the cause of the problem.

Smear Zone Reinjection System Troubleshooting

During the operation of the smear zone reinjection system there should be minimal variation in operational data over time. Potential changes include an increase or decrease in either pressures or reinjection flows to the wells. If any of these conditions are observed, the following shall be inspected.

- Check gauge or meter in which the reading was collected to ensure proper operation
- Check for above grade piping integrity
- During sub-freezing temperature, check for ice accumulation within above grade piping

If none of the above items is the source of the problem, contact the supervising engineer to discuss and assist in further troubleshooting efforts.



LEGEND:

- 🟥 DPE Extraction
- ⊗ Existing GWRC Extraction
- ⊙ Existing GWRC-Injection
- ▲ Injection
- ⊗ Landfill Well
- ◆ Monitoring Point
- ◆ Monitoring Well
- ⊖ Piezometer
- 🟩 Recovery Well
- ⊕ SEAR Groundwater Monitoring Point
- ⊕ SEAR Pilot Groundwater Monitoring Point
- ⊕ SEAR Process Monitoring Point
- ☒ Proposed New GWRC Extraction Well
- ⊙ Proposed New GWRC Injection Well
- ● Smear Zone Recirculation Wells - Treated Effluent from DPE System
- ● Smear Zone Recirculation Wells - Treated Effluent from GWRC System
- 🟦 DPE Extraction Well With Pump (Operating)
- 🟩 DPE Extraction Well With Pump (Not Operating)
- — DPE Smear Zone Injection Piping
- — GWRC Smear Zone Injection Piping
- - - No Fly Zone Trapezoid Perimeter
- - - Treated Effluent Discharge Pipe to Oasis Manhole MH-C9
- — Wellfield Grid
- ○ Smear Zone Recirculation Monitoring Well

NOTES:
1. IMAGE SOURCE: GOOGLE EARTH PRO, OCT 2013.

0 80 160
Feet

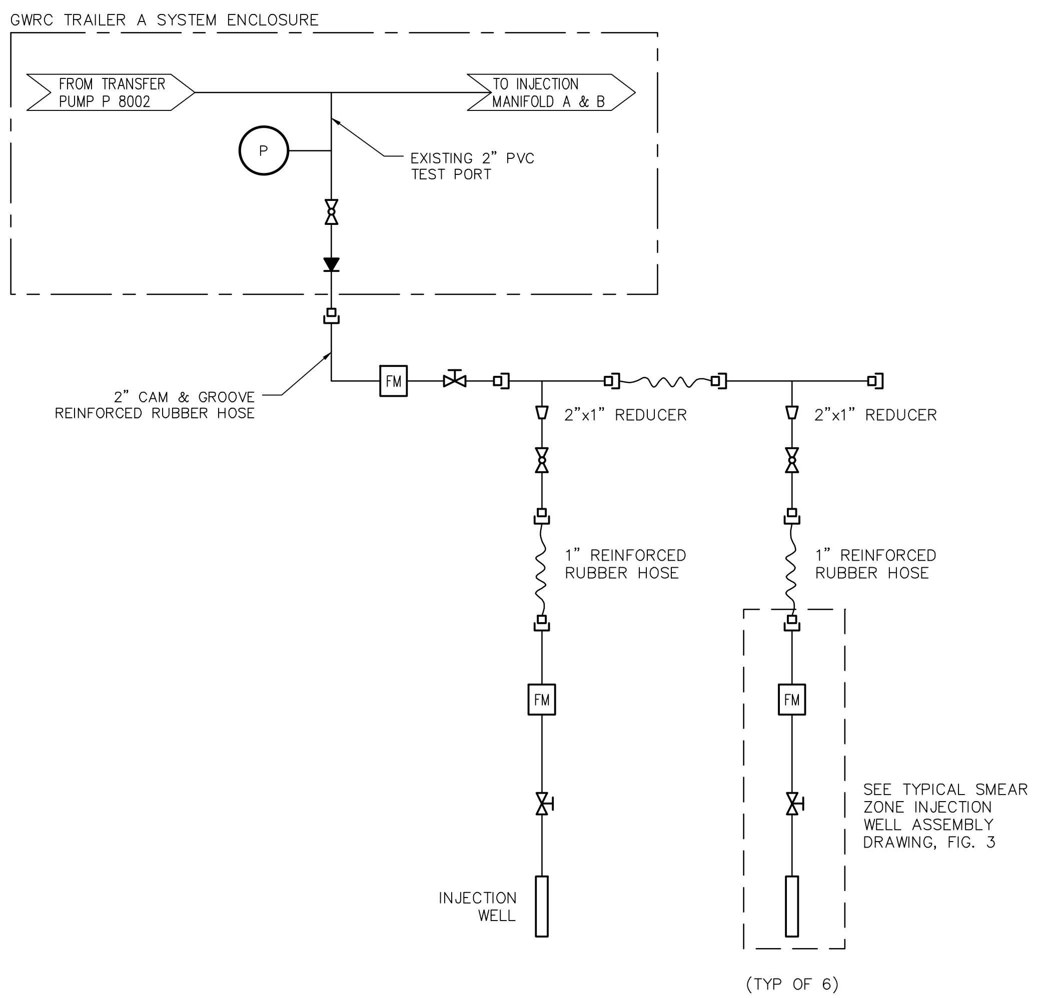
OASIS FUEL POINT
WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

2015 SMEAR ZONE RECIRCULATION PLAN

PIKA
ARCADIS
A JOINT VENTURE

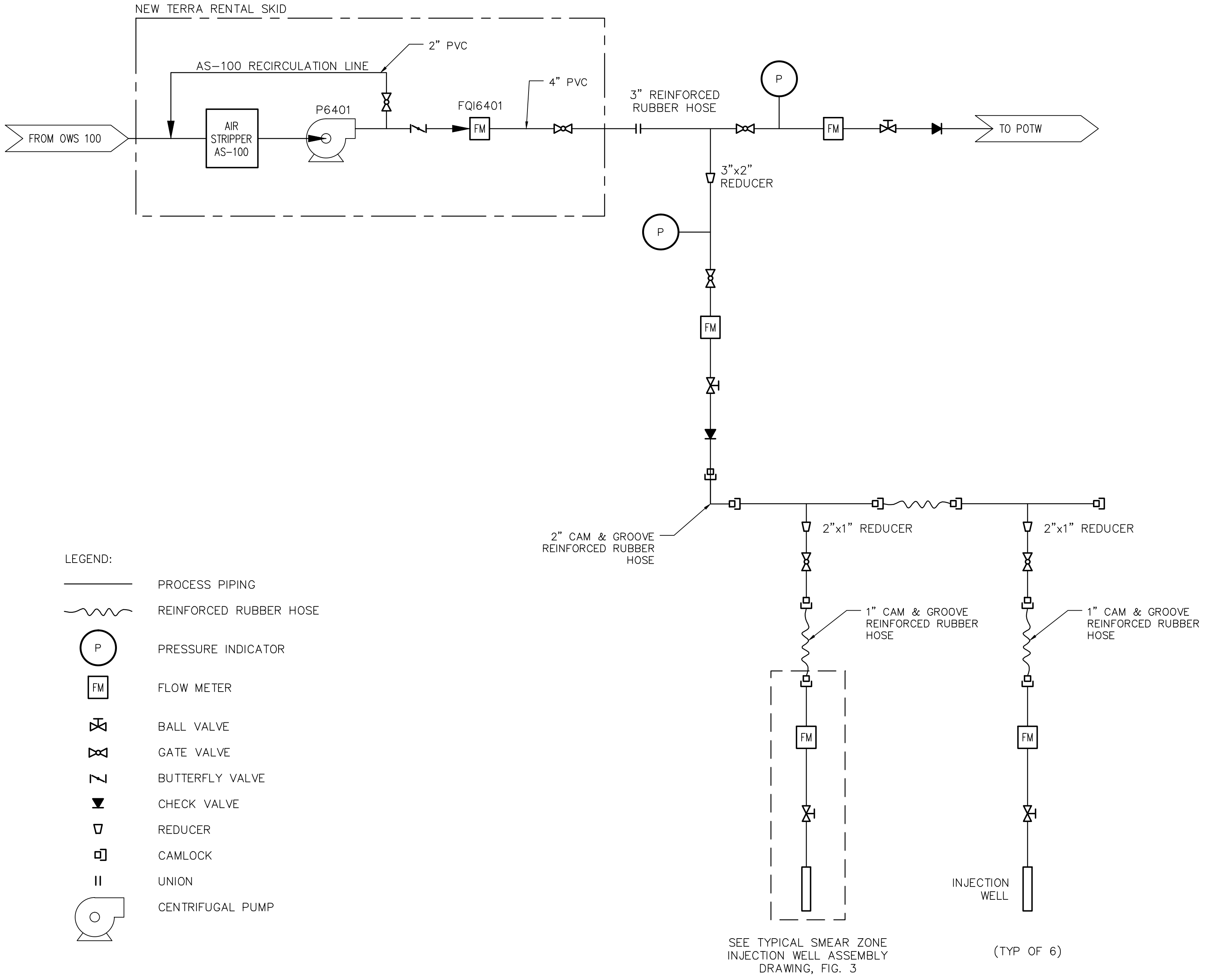
DRAWING
1

CITY:(CHARLOTTE) DIV/GROUP:(ENV/GIS) DB: S.SUTTON LD:S.SUTTON PIC: PM: TM:
PROJECT: XX000000.0000.00000 PATH: Z:\GISPROJECTS_ENVENV_FT DRUM\2015 Technical Memo\F1 SmearZonePlan.mxd



PROCESS FLOW - GWRC SYSTEM EFFLUENT

NOT TO SCALE



PROCESS FLOW - DPE SYSTEM EFFLUENT

NOT TO SCALE

LEGEND:

NOTE:

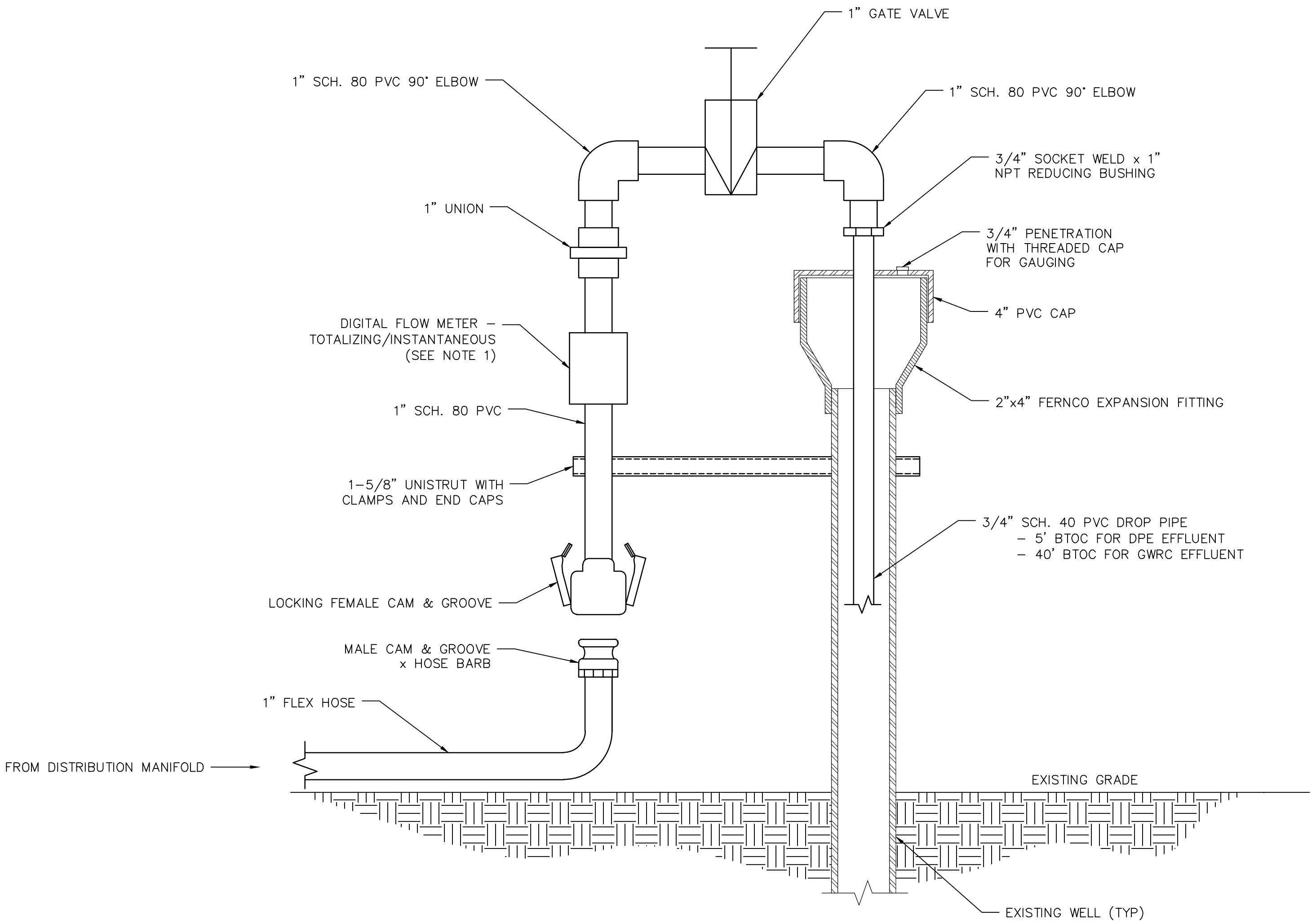
1. TO ENSURE PROPER OPERATION, ALL FLOW METERS TO BE INSTALLED A MINIMUM DISTANCE OF 10 STRAIGHT PIPE DIAMETERS DOWNSTREAM AND 5 STRAIGHT PIPE DIAMETERS UPSTREAM FROM CONTROL VALVES, ELBOWS, FITTINGS, OR SIMILAR SOURCES OF TURBULENT FLOW.

OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

SMEAR ZONE RECIRCULATION PROCESS FLOW DIAGRAM

PIKA
ARCADIS

FIGURE
2



INJECTION WELL ASSEMBLY

NOT TO SCALE

NOTE:

TO ENSURE PROPER OPERATION, ALL FLOW METERS TO BE INSTALLED A MINIMUM DISTANCE OF 10 STRAIGHT PIPE DIAMETERS DOWNSTREAM AND 5 STRAIGHT PIPE DIAMETERS UPSTREAM AND 5 STRAIGHT PIPE DIAMETERS UPSTREAM FROM CONTROL VALVES, ELBOWS, FITTINGS OR SIMILAR SOURCES OF TURBULENT FLOW.

OASIS FUEL POINT - WHEELER SACK ARMY AIRFIELD
FORT DRUM, NEW YORK

SMEAR ZONE RECIRCULATION INJECTION WELL ASSEMBLY

PIKA
ARCADIS
A JOINT VENTURE

FIGURE
3

CITY: MINNEAPOLIS, MN DIV/GROUP: ENVCAD DB: R. OBERLANDER LD: PIC: PM: TM: LYR:ON=*;OFF=*REF*
G:\ENVCAD\Minneapolis-MN\ACT\06261031\0000\0003A\DWG\FIGURE\61031C03.dwg LAYOUT: 3 SAVED: 9/3/2015 11:13 AM ACADVER: 19.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ---- PLOTTED: 9/3/2015 11:18 AM BY: OBERLANDER, ROSEANNE
XREFS: IMAGES: PROJECTNAME: ----
61031X01 PIKA_ARC-Parent_logo.jpg

ATTACHMENT A
PARTICLE TRACKING ANALYSIS

Simulation set up under existing pumping conditions as provided by Matt, using design flow rates for GWRC – expanded system not included…

Scenario 2015-01;
Simulation of smear-zone injection in 11 wells, using existing GWRC (at 60-percent recirculation) and DPE flows.

EXTRACTION SYSTEM	**FT^3/DAY**	**GPD**	**GPM**
Total GWRC Extraction:	7,700	57,596	40
Total DPE Extraction:	8,951	66,955	47
TOTAL EXTRACTION:	**16,651**	**124,551**	**87**

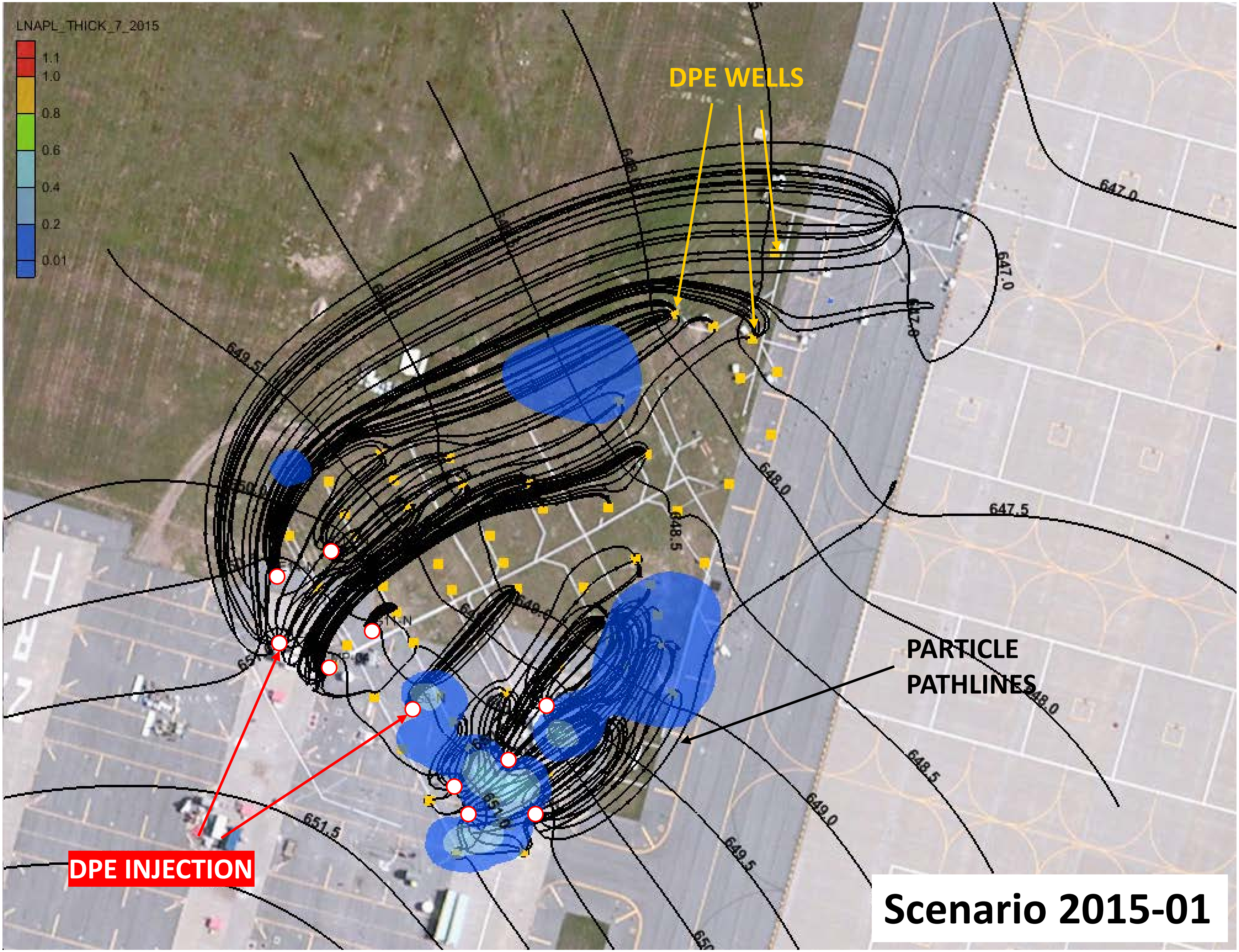
INJECTION SYSTEM	**FT^3/DAY**	**GPD**	**GPM**
Total GWRC Injection:	4,620	34,558	24
Total DPE Injection:	7,315	54,716	38
From GWRC System	3,080	23,038	16
From DPE System	4,235	31,678	22
TOTAL RE-INJECTION:	**11,935**	**89,274**	**62**

Breakdown -

GWRC Recirculation	60%
Ratio GWRC INJ/EXT	100%
Ratio DPE INJ/EXT	47%
Ratio TOTAL INJ/EXT	72%

LNAPL thickness from 28 July 2015 monitoring event…

Heads in model layer 1 – DPE zone; Pathlines released from DPE Injection Wells



Scenario 2015-01