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Sensor Recommendations for Long Term Monitoring of the F-Area Seepage Basins

T. L. Danielson

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PREFACE OR ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

In mid-2018, a new paradigm for long-term monitoring was developed after of decade of applied research projects funded by the Department of Energy's office of Environmental Management Technology Development program. The program at SRNL was focused on transitioning complex environmental waste sites from active to passive remediations strategies. A key result of these studies was that the use of enhanced attenuation approaches at radiologically contaminated sites will result in the creation of secondary source areas in the subsurface that will require monitoring for decades. Alternative monitoring approaches are being developed and tested at the Savannah River Site's F-Area Hazardous Waste Management Facility, the new paradigm provides innovative solutions that will significantly lower costs of monitoring through the coupling of data collection, machine learning and deterministic groundwater modeling. The foundation of this approach is a well-optimized network of sensors for measuring hydrogeochemical master variables that control, and therefore act as indicators of groundwater contaminant transport. By monitoring changes in the controlling master variables over time arising from geological and environmental shifts, predictive modelling can assist with identifying new strategies for ensuring regulatory requirements are met if trends toward conditions for potential remobilization of attenuated contaminants are detected. In this report, we evaluated commercially available single parameter sensor platforms (e.g., temperature/depth) and configurable multi-parameter sensor platforms (e.g., pH, oxidation-reduction potential, temperature, depth, dissolved oxygen, and conductivity). Each was scored using an optimization function based on how well the system supports the proposed long-term monitoring paradigm, in general, and the site-specific conditions at F-Area, in particular. Several viable sensor systems were identified. Of these, a combined platform including the In-Situ Aqua TROLL 500 multi-parameter sensor platform and the In-Situ temperature/depth sensor had the highest rating and was identified as the most suitable candidate for installation and monitoring of the master variables and potentiometric surface that control groundwater contaminant plumes emanating from the F-Area Seepage Basins. The discussion of recommended potential deployment locations builds upon recommendations made by Denham et al (2019).

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LIST OF ABBREVIATIONS

CDOM/FDOM	Colored Dissolved Organic Matter/Fluorescent Dissolved Organic Matter
DOE-EM	Department of Energy Office of Environmental Management
DO	Dissolved Oxygen
nLF	Non-linear Function Conductivity
ORP	Oxidation-Reduction Potential
PAR	Photosynthetic Active Radiation
SRNL	Savannah River National Laboratory
SSG	Seawater Specific Gravity
TDG	Total Dissolved Gas
TDS	Total Dissolved Solids

1.0 Introduction

In mid-2018, the Department of Energy's Office of Environmental Management (DOE-EM) Technology Development program funded the assembly of a technical assistance team to document a site specific innovative long-term monitoring strategy for waste units contaminated with metals and radionuclides (Denham, 2019). The Savannah River Site's F-Area Hazardous Waste Management Facility, or F-Area Seepage Basins, was the chosen test bed for the development work as it is approaching the latter stages of active remediation and has complex geochemistry with a data-rich environment provided by historical and ongoing monitoring programs. From 1955 to 1988, the three unlined basins received approximately 7 billion liters of acidic, low-level radioactive waste solutions containing tritium, nitrate, uranium, strontium-90, iodine-129, and technetium-99 as waste-byproducts from reprocessing of irradiated uranium. The fate of contaminant species transported in groundwater plumes emanating from the basins is surface discharge at Four Mile Branch and its associated wetlands. To ensure regulatory compliance, several mitigation and in situ attenuation strategies have been implemented over the years, including: the placement of a low-permeability cap over the basins to minimize infiltration (1991); a pump-and-treat system to minimize discharge to surface waters (1997 – 2004); and a subsurface funnel-and-gate system with periodic base injections installed perpendicular to preferential flow paths (2004 to present). While multiple regulatory milestones have been completed at the time of this report, several additional milestones are scheduled for completion over the course of the next decade (subject to changes from regulatory re-negotiations), including:

- Reducing uranium and Sr-90 concentrations discharged from the F-Area plume to the surface water at the Four Mile Branch seepline to less than the groundwater protection standard before July 31 of 2020.
- Reducing I-129 concentration in Fourmile Branch to levels that are below groundwater protection standards before October 31 of 2025.
- Reducing discharge of I-129 from the F-Area plume to the surface water at the seepline to concentrations that are less than groundwater protection standards as measured at various Wetland Seepline Surface Water Sampling Locations (FAS-91, FAS-92, FAS-92, FAS-96, and FAS-103) by October 30 of 2030.

The attenuation-based remedies that have been put in place are intended to leave metal and radionuclide contamination in a non-bioavailable state within the sub-surface. However, over the long term, environmental and climatological shifts can lead to changes in the complex hydrogeochemical environment and transport dynamics of contaminant species and in some cases, re-mobilization. Therefore, the multi-laboratory technical assistance team set out to implement a new paradigm for long-term monitoring that would promote proactive decision making and reduce life-cycle costs compared to the traditional strategy, which consists of the periodic collection and analysis of samples from more than 100 groundwater and surface water monitoring stations located in F-Area. The newly proposed approach leverages the coupling of predictive groundwater contaminant transport modeling and data analytics that de-emphasize the use of point measurements of contaminant concentrations in favor of measuring master variables that control, and therefore act as indicators, of the evolving contaminant transport dynamics.

The success of this new paradigm hinges on the proper selection and installation of a network of reliable sensors for in situ measurement of master variables that control the transport of contaminant species. To address the former, this report documents a matrix of commercially available sensors and an "optimization function" used for objectively selecting and recommending sensors from the commercial market for use in long-term monitoring of contaminants emanating from the F-Area Seepage Basins. To address the latter, recommendations are made, based on the "zones of vulnerability" identified by Denham et al (2019), regarding the locations in which each class of sensor should be installed. Lessons learned from installation of three long term monitoring sensors at the F-Area Field Research Site (Amidon and Millings, 2015) will be considered in the proposed recommendations.

2.0 Evaluation of Commercially Available Sensors

Three broad categories of sensor configurations are to be evaluated for use. First, and most widely to-be-installed, are single-location temperature and water table depth sensors for measuring the lateral heterogeneity of the F-Area hydrogeology. Next, single-location multi-parameter probes will be evaluated for applicability in accurately measuring geochemical master variables such as conductivity, dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, and water-level/depth. This class of sensors will be installed in several (e.g., 6 to 8) key locations to provide evolutionary hydrogeological insights to machine learning models. Finally, one to two depth-discrete/vertical-profiling multi-parameter sensors will be installed in locations where accurate vertical resolution of contaminant plumes is desired. For depth-discrete measurements, linking several multi-parameter probes (e.g., by “daisy chaining”) has been identified as the preferred methodology as mobile vertical profilers may cause mixing within the well which could lead to measurement artifacts in the data. In the selection of sensors, it is desirable to have brand uniformity and/or seamless integration between each sensor class, which will simplify communications and data logging and ensure greater reliability and data access in the overall sensor network. Here, the second class of sensor, single-location multi-parameter probes will be used as the basis for identifying the best commercial option. Implicit to this selection methodology is that the multi-parameter probe has an accompanying single-location depth/temperature probe and a means to obtain depth discrete readings e.g., by “daisy chaining” some number of multi-parameter probes together.

In the following subsections, a set of objective selection criteria will be outlined, a matrix of commercially available sensors will be presented, and an optimization function will be used to rate each sensor and select the best commercially available platform.

2.1 Sensor Selection Criteria and Optimization Function

To more objectively select the best commercially available sensor platform, several selection criteria (outlined in Table 2-1) have been combined to create an optimization function, where a sensor’s rating is given on a 0 to 10 scale by:

$$Sensor\ Rating = A \times D \times (0.5F + 0.4L + 0.05S + 0.05P)$$

Note that “Available Sensors” has a binary rating scale and is included only for completeness. In other words, if the multi-parameter sensor platform is not capable of measuring the required master variables, it is not included for consideration as a viable platform. Similarly, “Dimensions” has a ternary scale, where if the sensor will not fit in a 2-inch well, but will fit in a 4-inch well, its rating is cut in half. If it does not fit in either a 2-inch or 4-inch well, it is eliminated as a candidate and not included in this report. The other four selection criteria are scored on a 1 to 10 rating scale and are weighted based on the importance, where “Required Calibration Frequency” is defined as the single most important criteria, followed by “Data Logging and Communications” and finally, “Detection Sensitivity” and “Price”. The justification for these weights is two-fold. First, the new paradigm for long-term monitoring that is outlined by Denham et al (2019), among other things, seeks to lower costs primarily through a reduction in time spent on sensor re-calibration and field measurement of contaminant concentrations (estimated to cost $3,000 per sample location). In addition, the lessons learned reported by Amidon and Millings (2015) described unexpected and cumbersome re-calibration requirements, along with communications and data logging issues associated with attempted simultaneous connections to the server and incoherent data-point time stamps. On the other hand, while marginal differences may exist in the detection sensitivity (e.g., range, accuracy, and resolution) offered by each of the sensor platforms, it is not expected that marginal gains or losses in any variable’s measurement will inhibit the applicability of any sensor under consideration – if this is the case, the sensor is removed from consideration. Likewise, while it is important that the price of a sensor platform fits within allocated budgets, only substantial differences in price (i.e., such that a given sensor is entirely cost-prohibitive and vice-versa) should positively or negatively impact the sensor's overall rating.

Table 2-1. Sensor selection criteria.

Selection Criteria	Optimization Function Variable	Scale	Qualification
Available Sensors	*A*	Binary (0 or 1)	Does the sensor platform allow measurement of the desired master variables?
Dimensions	*D*	Ternary (0, 0.5, or 1)	Will the sensor fit in a 2" or 4" well? (0 if OD > 4", 0.5 if OD <= 4" and OD > 2", 1 if OD <=2"
Required Calibration Frequency	*F*	1 to 10	Recommended re-calibration frequency
Data Logging and Communications	*L*	1 to 10	Logging frequency, tailoring data reading frequency, data upload/access method, setup and installation, reliability of power sources, and connectivity to servers
Detection Sensitivity	*S*	1 to 10	Sensor measurement specifications compared to other products
Price	*P*	1 to 10	Cost of sensor relative to other sensors

2.2 Matrix of Commercially Available Multi-Parameter Platforms

In the current section, an exploration of commercially available multi-parameter sensors has been performed. In an initial down-selection process, each vendor has been contacted and provided a high-level description of the proposed sensor network and a technical sales representative has provided a response for their most suitable platform.

Several commercial offerings exist within the class of single location multi-parameter sensors. The time-dependent master variables logged by these sensors will be used by both deterministic groundwater models and machine learning algorithms to identify and quantify changes in contaminant plume characteristics that may arise from environmental factors such as a change in groundwater recharge or changes to the geochemical environment that may promote re-mobilization. As mentioned in Section 2.0, only probes that have available sensors for temperature, depth, conductivity, ORP, DO, and pH are included. Additionally, only probes that offer optical variants of sensors (for the applicable sensor types) are included, as these are proven to be most resistant to fouling and are inert and therefore will not leach contaminants to the environment. The matrix of available sensors is listed in Table 2-2. The cost estimates that are provided include the cost for the multi-parameter sensor platform that includes each of the required sensors, all connecting cables, wireless telemetry, multi-researcher access to a data analysis platform (e.g., web based), and external power sources (e.g., solar panels). Itemized quotes are provided Danielson (2020). No internal data logging or internal power source is required but both are available for most of the platforms presented.

Table 2-2. Matrix of commercially available multi-parameter sensors.

Parent Company	Multi-Parameter Probe	Parameters Measured	Dimensions	Re-Calibration Frequency	Quoted Price ($)	URL
In-Situ	Aqua TROLL 500	**DO**, **Actual and Specific Conductivity**, **pH**, **ORP**, Salinity, TDS, Resistivity, Density, Turbidity, **Temperature and Pressure**, Ion Selective Electrodes, Fluorometers	4.7 cm OD x 46 cm	2-3 times per year	~7700.00	https://in-situ.com/us/aqua-troll-500-multiparameter-sonde
YSI	EXO1 Multiparameter Sonde	**Conductivity**, **Temperature**, **DO**, fDOM, Ammonium, Chloride, Nitrate, **pH**, **ORP**, Rhodamine, Total Algae, Turbidity, Absolute Pressure, Ammonia, **Depth**, DO% Local, Gauge Pressure, nLF Conductivity, PAR, Resistivity, Salinity, Specific Conductivity, TDS, Total Suspended Solids, Water Density	4.7 cm OD x 64.77 cm	Every 1 to 2 months	~16,000.00	https://www.ysi.com/EXO1
Seametrics	Multi-Parameter	**pH**, **ORP**, **Temperature**, **Conductivity**, Salinity, TDS, **Pressure**, **DO**, Turbidity	Fits in 2” well	Every 3 to 6 months	~11,250.00	https://www.seametrics.com/wp-content/uploads/LT-14413r7-20190215-Multi-Parameter-Spec.pdf
OTT HydroMet	Hydrolab HL4	**Temperature**, **Conductivity**, **Depth**, **pH**, **DO**, Turbidity, **ORP**, Blue-Green Algae, Chlorophyll a, Ammonium, Rhodamine, Nitrate, Chloride	4.4 cm OD x 77.8 cm (max)	Every 1 to 3 months (no longer than 90 days)	~13,500.00	https://www.ott.com/en-us/products/water-quality-2/hydrolab-hl4-multiparameter-sonde-54/
Aquaread Water Monitoring Instruments	AP-2000	**DO**, **Conductivity**, **pH**, **ORP**, TDS, Resistivity, Salinity, SSG, **Temperature**, **Depth**, Ammonium, Ammonia, Chloride, Fluoride, Nitrate, Calcium, Turbidity, Chlorophyll, Phycocyanin, Phycoerythrin, Rhodamine, Fluorescein, Refined Oil, CDOM/FDOM	4.2 cm OD x 29 cm	Every 3 weeks	~20,000.00	https://www.aquaread.com/portofolio/ap-2000/
RS Hydro	Manta + Water Quality Sonde	**Temperature**, **DO**, **Conductivity**, Salinity, TDS, Turbidity, **ORP**, **pH**, **Depth**, **Level**, Ammonium, Nitrate, Chloride, TDG, Chlorophyll a, Rhodamine, Blue Green Algae	1.93 in OD x 19 in (Each additional connection requires an additional quarter inch of diameter)	Every 1 to 2 months	~8,100.00	https://www.rshydro.co.uk/water-quality-monitoring-equipment/water-quality-testing-equipment/multiparameter-water-quality-sonde/manta-2-multi-parameter-water-quality-sonde/

2.3 Evaluation of Commercially Available Multi-Parameter Platforms

The sensors listed in Table 2-2 have been assigned a rating based on the optimization function that was presented in Section 2.1. The sensor ratings are presented in Table 2-3, where the In-Situ Aqua Troll 500 has received a maximum 10.0 rating, thereby rendering it the strongest candidate sensor for installation in the F-Area long-term monitoring project. Additional comments for the categorical ratings are provided in Table 2-4. The Aqua TROLL 500's selection is based on its low re-calibration frequency and the relative ease with which recalibration can be performed in the field, the single-step setup procedure subsequent to installation, which essentially involves the push of a button, its user friendly data logging and analysis platform, and its comparatively low price. The itemized quote showing the necessary equipment for the multi-parameter probe is shown in Appendix A of Danielson (2020) and includes:

- Aqua TROLL 500 vented platform
- Wiper port plug
- Temperature/conductivity sensor
- pH/ORP sensor
- DO optical sensor
- Port plug (i.e., where an additional sensor from Table 2-2 could be added in the future)
- Necessary cables
- Cellular telemetry, communications antenna, and subscription to web-based data analysis software
- All necessary calibration tools
- 3 year extended warranty

A depth/temperature sensor from In-Situ pairs with telemetry systems and was quoted at $1,195.00 for a vented and $795.00 for a non-vented system (vendor-recommended), where the non-vented platform paired with telemetry will provide barometric correction without the use of desiccant. Substituting the cost of the non-vented depth/temperature sensor for the multiparameter probe gives an estimated cost of $1,900.00 for each monitoring station in this configuration.

Depth profiling can be performed by connecting any number of Aqua TROLL 500 probes via splitter cable, which costs $295.00. Therefore, the total cost for the depth discrete vertical profiling setup can be obtained by using the quote from Appendix A of Danielson (2020) and including the location-specific number of multi-parameter probes and associated splitter cables. For example, a depth discrete monitoring configuration with three multi-parameter In-Situ probes would be estimated to cost approximately $17,000.00.

Table 2-3. Rating of multi-parameter sensor platforms using the optimization function.

Sensor	Dimensions	Re-Calibration Frequency	Data Logging and Communications	Detection Sensitivity	Price	Overall Rating
In-Situ Aqua TROLL 500	1	10	10	10	10	10.0
YSI EXO1	1	6	9	10	6	7.4
Seametrics Multiparameter	1	9	8	10	8	8.6
OTT HydroMet HL4	1	7	9	10	7	8.0
Aquaread AP-2000	1	4	8	10	5	6.0
RS Hydro Manta+	0.5	6	8	10	9	3.6

Table 2-4. Categorical comments used for calculating sensor ratings.

Sensor	Dimensions	Re-Calibration Frequency	Data Logging and Communications	Detection Sensitivity	Price	Additional Comments
In-Situ Aqua TROLL 500	Fits in 2" well	• 2-3 times per year • Less calibration solution required than industry standard • Easy field calibration	• Easy setup, install, and connection to telemetry • User friendly and customizable online data analysis platform	See Appendix A	Lowest cost option	Most straightforward calibration and setup. Sensors are least susceptible to drift.
YSI EXO1	Fits in 2" well	• Every 1-2 months • Industry standard methodology	• User friendly and customizable online data analysis platform • Full-time in-depth technical support staff for Campbell Scientific® equipment	See Appendix A	Second most expensive option	Suggested use of Campbell Scientific® data logging and software and temperature/depth sensors – integration should be seamless
Seametrics Multiparameter	Fits in 2" well	• Every 3-6 months • Industry standard methodology	• Customizable web-based data analysis platform	See Appendix A	Third lowest cost option	–
OTT HydroMet Hydrolab HL4	Fits in 2" well	• Regular maintenance required • Industry standard methodology	• User friendly and customizable online data analysis platform	See Appendix A	Third most expensive option	–
Aquaread Water Monitoring Instruments AP-2000	ts in 2" well	• Every 3-4 weeks • Industry standard methodology	• Wireless data transmission exported as Excel file to desktop • Additional software application required for processing data	See Appendix A	Most expensive option	–
RS Hydro Manta+	Base package fits in 2" well	• Every 1-2 months • Industry standard methodology	• Wireless transmission of data to Microsoft Access database • User friendly and customizable online data analysis platform at additional cost	See Appendix A	Second lowest cost option	Platform likely not feasible in a 2-inch well for vertical profiling due to an approximate 0.25-inch increase in diameter for each additional probe.

3.0 Sensor Installation Locations

Denham et al (2019) identified three specific "zones of vulnerability" within the F-Area Seepage Basins groundwater contamination system (recaptured in Table 3-1), which are primary and secondary source locations in which contaminants are primarily attenuated. The three classes of sensors that were evaluated in the previous section will be used to capture changes in water levels and master variables that are indicative of remobilization of attenuated contaminants within these "zones of vulnerability". Further, metrics such as specific conductance and nitrate have shown to be surrogates that correlate with contaminants such as tritium and are indicators of the plume footprint and migration. The precise number of wells and the optimization of the sensor network's spatial configuration is a challenging and ongoing research problem to be addressed prior to the installation of the proposed sensor platforms. In addition to supporting modeling needs, the feasibility of installing the sensor platform in any existing well will need to be evaluated against the well's current configuration. For example, several wells are used in ongoing monitoring programs and contain dedicated sampling pumps – the selection of a well should ensure that the presence of the sensor does not disrupt such existing sampling needs. Likewise, the presence of any existing equipment should not prohibit the sensor's collection of data.

Table 3-1. Summary of "zones of vulnerability" as identified in Denham et al (2019).

Zone of Vulnerability	Vulnerable Contaminants	Threat Conditions	Long-Term Monitoring Focus
Basin soils and vadose zone	All	Infiltration through cap	Cap integrity and moisture content
Treatment zones in gates	Uranium, Sr-90, I-129	Low pH (Sr-90, uranium) and reducing conditions (I-129)	pH, ORP, groundwater flow rate
Wetlands	Uranium, Sr-90, I-129	Low pH, significant change in wetland morphology, vegetation, loss of organic matter, etc.	pH, ORP, physical configuration (e.g., topography, course of Fourmile Branch, frequency of intense rain events)

Denham et al (2019) created a mapping of existing sensors and identified locations in which new sensors would be potentially useful (shown in Figure 3-1). Yellow circles (8 total) are the proposed locations where temperature/depth sensors should be installed for constructing potentiometric surfaces of the aquifer. Additional temperature/depth sensors may be of practical use to the north of the basins at locations with pink circles. Green squares are all located on the downgradient side of the seepage basins and are potential locations where multiparameter probes should be installed to monitor time-dependent changes to master variables. Vertical profiling should be performed at a location near the basin and at the location approximately two-thirds of the way between the basins and the funnel-and-gate system. Additional multi-parameter probes should be installed in each preferential flow path (i.e., at intermediate locations between the cementitious barriers) as well as near the basins as the purchasing and installation budget permits.

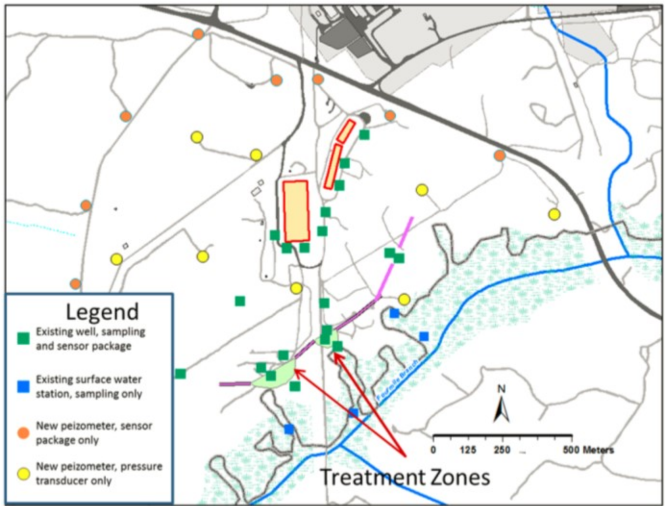

Figure 3-1. Map of a potential sensor network as envisioned by Denham et al (2019).

4.0 Conclusions

The In-Situ Aqua TROLL 500 multi-parameter sensor platform has been identified as the most suitable candidate for installation and monitoring of master variables that control groundwater contaminant plumes emanating from the F-Area Seepage Basins. In addition, the In-Situ temperature/depth sensor has been selected as the most suitable platform for measuring the lateral heterogeneity of the potentiometric surface in and around the basins. The installation of these sensors should provide a robust system that promotes success for the new paradigm of long-term monitoring proposed by Denham et al (2019).

5.0 References

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Appendix A. Sensor Measurement Specifications

	pH (pH units)			ORP (mV)			DO (mg/L)			Temperature (°C)			Conductivity (mS/cm)			Depth (m)		
	Range	*Resolution*	*Accuracy*	*Range*	*Resolution*	*Accuracy*	*Range*	*Resolution*	*Accuracy*	*Range*	*Resolution*	*Accuracy*	*Range*	*Resolution*	*Accuracy*	*Range*	*Resolution*	*Accuracy*
In Situ	0 to 14	0.01	± 0.1	±1400	0.1	± 5	0 to 60	0.01	±0.1 or ±2% of reading	-5 to 50	0.01	0.01	0 to 350	0.0001	±0.5% of reading plus 0.001 mS/ cm from 0 to 100 mS/ cm; ±1.0% of reading from 100 to 200 mS/ cm; ±2.0% of reading from 200 to 350	0 to 200	0.01%	±0.1% from -5 to 50°C
YSI	0 to 14	±0.1 within ±10˚C of calibration temp; ±0.2 for entire temp range	± 0.01	-999 to 999	± 20	± 0.1	0 to 50	0 to 20 ±0.1 mg/L or 1% of reading; 20 to 50 ±5% of reading	0.01	-5 to 35; 35 to 50	±0.01; ±0.05	0.001	0 to 100; 100 to 200	0.001 or ±0.5% of reading; ±1% of reading	0.0001 to 0.01 mS/cm (range dependent)	0 to 100	±0.04%	0.001
Seametrics	1 to 14	0.01	0.02	± 1200	0.01	0.1	0 to 25	0.01 to 0.1	0.02 or 1% of reading	-5 to 40	0.1	± 0.5	0 to 100	0.001	0.5%	0 to 70	16 bit	± 0.1%
OTT	0 to 14	0.01	± 0.2	-999 to 999	1	± 20	0 to 60	0.01	± 0.1 at <8 mg/L ± 0.2 at >8 mg/L ± 10% reading >20 mg/L	-5 to 50	0.01	± 0.10	0-100	0.001	± (0.5% of reading + 0.001 mS/cm)	0 to 25; 0 to 100; 0 to 200	± 0.05; ± 0.05; ± 0.1	0.01; 0.01; 0.1
Aquaread	0 – 14	0.01	± 0.1	± 2000	0.1	± 5	0 – 50	0.01	0 – 200%: ± 1% of reading. 200% – 500%: ± 10% of reading	-5 to 70	0.01	± 0.5	0 – 200	3 Auto-range scales: 0 – 9.999, 10.00 – 99.99, 100.0 – 200.0	± 1% of reading	0 to 60	0.01	±0.5%
RS Hydro	0 - 14	0.01	± 0.2	-999 to 999	± 20	± 1	0 to 25	0.01	1% of reading or 0.02 mg/L, whichever is greater	-5 to 50	0.01	± 0.1%	0 - 100	0.0001	1% reading ± 1 mS/cm	10; 25; 50; 100; 200	0.01	± 0.1%

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