WATER QUALITY PROGRAMS DIVISION

Standard Operating Procedure for the Recording of Physical/Chemical Parameters using a Remotely Deployed Continuously Recording Multiparameter Instrument in Streams

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STANDARD OPERATING PROCEDURE FOR THE RECORDING OF PHYSICAL/CHEMICAL PARAMETERS USING A REMOTELY DEPLOYED CONTINOUSLY RECORDING MULTIPARAMETER INSTRUMENT IN STREAMS

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1.0 General Information

A multiparameter instrument may be remotely deployed to collect and store information for some of the physical/chemical parameters of the stream being studied. Parameters measured by these instruments include water temperature, dissolved oxygen (D.O.), dissolved oxygen % saturation, pH, specific conductivity, salinity, depth, total dissolved solids, and turbidity. Some instructions on operating the YSI® are provided in this document but specific training on the operation of each instrument will be provided by the supervising F.T.E. The important thing to remember is to always use the same type of multiparameter instrument (even the same serial number instrument, when possible) throughout a particular study so that data collected is comparable.

2.0 Definitions/Terms

- Team Leader—crew member of team who provides support, expertise, and opinions; gives instruction and has final say on how work will be done
- Team Member—crew member of team who provides support, expertise, and opinions; follows the instructions of the team leader
- Field Multiparameter (FM) instrument—instrument not deployed in the field but maintained in the office and used to check the remotely deployed instruments
- Continuous Multiparameter (CM) instrument—instrument remotely deployed in the field for collection of continuously measured data *in-situ*
- Continuously Measured Data—data collected *in-situ* by a remotely deployed instrument with measurements made on set time interval (e.g., every 15 minutes)
- Service Interval—time period between instrument servicing including calibration and cleaning. The service interval is project specific.

3.0 Safety

Upon reaching the sampling location, site safety determinations should be made before proceeding. These will be different for wadeable and bridge sites. Please refer to the OWRB safety manual for instructions on how to sample both kinds of sites. When regulating the flow of traffic is necessary, please refer to the portion of the safety manual outlining “Traffic Safety Protocols”.

4.0 Quality of the Measurement

Principle investigators for the OWRB are required to have degrees and/or experience with biological or other applicable sciences. Principle investigators are defined as Team Leaders, and this designation may be made upon the leader of a multi- or a one-person

crew. Training is required for all SOPs dealing with water quality and quantity collections and measurements as well as habitat assessments and biological collections. In-house training will be conducted for the use of all meters and digital titrators used for water quality or quantity measurements. Investigators must be familiar with OWRB SOP document and all training will follow the methods outlined in that document. Extra training will be provided when new SOPs are developed. Training of field crews will be done through dry run exercises in the laboratory to familiarize field crews with sample collection, sample preservation, instrument operation, calibration, and maintenance. In addition, when new personnel are hired or new methods developed, qualified staff will train on sample collection, measurement, and field analysis methods through side-by-side field trips. These trips will familiarize staff with SOP requirements. When training is considered adequate, a qualified staff member will check field staff for adherence to SOPs.

When sampling for all programs, Quality Assurance/Quality Control (QA/QC) samples will be routinely collected to assure that environmental samples meet the Data Quality Objectives (DQO's) that are outlined in the controlling Quality Assurance Project Plan (QAPP). QA/QC sampling is designed to control each step of the sampling process. Known standards for each parameter should be routinely measured. Protocols for these calibrations are listed in Section 5.12 of this document.

4.1 Primacy of Standard Operating Procedures

The United States Geological Survey TM1-D3 document (Wagner et al., 2006) is the industry standard and governing document for real-time monitoring. This OWRB SOP is meant to be an informal reiteration of the document to guide OWRB work flow and projects, but is not meant to usurp the intent or technical underpinning of TM1-D3. Therefore, this SOP will be used in concert with TM1-D3, with TM1-D3 followed when any discrepancies occur. It is encouraged that the tables and graphics in TM1-D3 be utilized and that all investigators become familiar with both documents.

4.2 Service Interval

Service intervals for real-time instrumentation are the time period between maintenance and calibration events. A service interval begins after calibration and ends when an instrument is pulled for maintenance and cleaning. To ensure that service intervals are complete and that corrections related to fouling and calibration drift can be made to data collection periods, routine visits to instrumentation should include both maintenance and calibration activities.

The time between service intervals is not static, but varies depending on site conditions, project, and unforeseen, unique events (e.g., flooding or intense productivity). It is important to remember that the majority of data correction between service intervals is a 2-point interpolation. Therefore, intervening events or extending service intervals beyond a reasonable time could bias data. When beginning a project, it is recommended that service intervals be set as narrow as possible (1-2 weeks), until site conditions are well-documented, and effect on data are understood. Service intervals

may increase or decrease depending on season, intervening events, and data issues, among other things. If data are not telemetered for review remotely, service intervals should be narrowed to ensure data are not lost. Also, regular service intervals help to ensure that only 2-point interpolations are necessary for drift corrections. Lastly, manufacturer recommendations for service intervals should be considered only anecdotally and not as a primary source of information.

Several items may decrease drift related to fouling or lengthen periods between needed calibrations. Subsequently, service intervals are increased. These include:

- optical probes
- instrument or probe wiping systems
- copper coatings and taping
- stainless steel standpipes
- HDPE drag tubes
- areas with adequate flow of water

5.0 Personnel and Equipment

In most instances, the collection of water quality samples requires only one field person. However, depending on the safety requirements of a particular station, additional crewmembers may be necessary to ensure a safe work zone.

5.1 Data Collection Platform

Data collection platforms (DCP) are essential to the operation of remotely deployed instruments. The DCPs generally consist of power supply (batteries and solar panels), datalogger, telemetry equipment (satellite goes radio, broad spectrum radio, beacon for satellite units, and antennae), cabling, etc. It is important that these units be regularly inspected and maintained. Senior personnel will train each new staff member on the basic installation, operation, and maintenance of the platforms.

5.2 Field Multiparameter (FM) Instrument

The FM instrument is maintained in the office and is used to check the calibration of remotely deployed instruments. Check calibration and maintenance logs before leaving office to ensure that the pre-trip calibration has occurred. If calibration has not occurred, perform the pre-trip calibrations (a supervising F.T.E. will demonstrate calibration techniques and the unit's operations manual can be consulted for calibration techniques). **ALL CALIBRATIONS AND MAINTENANCE MUST BE RECORDED IN THE UNIT'S LOGBOOK.**

5.3 Maintenance

When not in use, the FM should be in kept in its carrying case. The instrument should be kept dry and clean both inside and out. After each measurement, the probes should be rinsed twice with tap water and stored in the storage cap in tap water. The instrument should never be stored in temperatures below freezing in extremely hot temperatures. Surveyor stored data should be recorded and deleted on a weekly

schedule. Failure to do so may result in shortening the life of the internal lithium battery and/or the loss of valuable field data.

Specific pre-trip and in field maintenance should occur for the multiparameter instrument as follows

- **Multiparameter instrument casing**—Check the instrument casing periodically for cracks or looseness of connections. Connections may need to be tightened or re-siliconed periodically (only after the approval of a supervisor or senior staff member).
- **Bulkhead**— Periodically check the bulkhead connection for bent pins or looseness.
- **Temperature Probe**— Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water.
- **Dissolved Oxygen Probe**—Check the probe ROX membrane for any cracks or other abnormalities, and change membrane if necessary.
- **pH Probe**—Check the probe bulb for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
- **Specific Conductance (SpC) Probe**—Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
- **Turbidity Probe**—Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
- **Chlorophyll A Probe**—Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
- **Blue-Green Algae Probe**—Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
- **Wiper**—Change foam wiper pads on probes as necessary.
- **Central Cleaning System**— Periodically check the wiping brush and clean out embedded sediment.

5.31 Pre-trip Calibration

Specific weekly pre-trip calibrations should occur for the field instrument as follows:

- **Temperature Probe**—Place instrument and an independent lab grade thermistor/thermometer into water and compare the readings. If the difference is greater than 0.4 mg/l the probe should be replaced or the instrument needs to be repaired (only after the approval of a supervisor or senior staff member).
- **Dissolved Oxygen Percent Saturation**—Perform an “air” calibration with tap water using the barometric pressure (BP) of the laboratory. The lab and field barometers give BP in units of “inHg”, and the unit can only accept BP in units of “mmHg”. A conversion chart is provided in the laboratory and in each field

notebook (the conversion is 'inHg x 25.4 = mmHg'). The unit should then be placed in a zero-DO solution to ensure the instruments ability to read extremely low DO values. If the instrument does not read <0.4 mg/l while in this solution the ROX membrane needs to be cleaned and inspected. If instrument will still not read <0.4 mg/l the ROX membrane should be replaced.

- **pH Probe**—Determine the expected range of pH by consulting the station data, and perform a two-point calibration based on the pH values. For example, if the pH ranges on the trip are from 7.5 to 8.1, perform a 7-10 pH calibration, or if the pH ranges are from 6.6 to 7.1, perform a 7-4 pH calibration. If values vary from station to station, always calibrate to the first station on the trip.
- **Specific Conductance (SpC) Probe**—Determine the expected range of SpC by consulting the station data, and perform a two-point calibration based on the SpC values. For example, if the ranges on the trip are low range (< 700), perform a 0-500 SpC calibration, or if the ranges are high range (> 700), perform a 0-1413 SpC calibration. If values vary from station to station, always calibrate to the first station on the trip.
- **Turbidity—**Perform a calibration at all ranges of measurement including 0-10 NTU's, 10-100 NTU's, 100-1000 NTU's according to manufacturer specifications and using manufacturer approved turbidity standards. If values vary from station to station, always calibrate to the first station on the trip.

5.32 Site Specific Calibrations or Checks

The following in-field calibrations and checks should occur as follows:

- **Depth—**Depth (meters) should be calibrated to 0.1 at each station.
- **Dissolved Oxygen Percent Saturation (D.O.)—**At each station, check the probe membrane for any cracks, or other abnormalities, and change membrane if necessary. Dissolved oxygen percent saturation should also be calibrated when BP change is greater than 0.5 inHg in comparison to the previous calibration, when the reading is below the screening, or when the reading is outside the norm for a particular station (refer to the description of lab calibration). Local BP can be obtained from the YSI 650 handheld display or a SHERPA® weather watch or a comparable instrument (an FTE will demonstrate appropriate use and calibration of the watch).
- **pH—**At each station, check the probe bulb for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only change probe after consulting with supervisor). Clean with warm soapy water and Q-tip. Determine the expected range of pH by consulting the station data. Refer to the description of lab calibration. If the initial reading at a site is outside the range of current calibration, the instrument needs to be calibrated to the correct two-point calibration. If the reading is outside the OWQS standard of 6.5 - 9.0 pH, then the instrument needs to be calibrated at the appropriate range to ensure that the reading is accurate.
- **Specific Conductance (SpC)—**Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only change probe after consulting with supervisor). Clean with warm soapy water and Q-tip. Determine the expected range of SpC by consulting the station data. Refer to the

description of lab calibration. If the initial reading at a site is outside the range of current calibration, the instrument needs to be calibrated to the correct two-point calibration.

- **Turbidity—**Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only change probe after consulting with supervisor). Clean with warm soapy water and Q-tip. Determine the expected range of turbidity by consulting the station data. Refer to the description of lab calibration. If the initial reading at a site is outside the range of current calibration, the instrument needs to be calibrated to the correct calibration range (0-10 NTU's, 10-100 NTU's, and 100-1000 NTU's).

5.33 Post-Trip Checks

All units should undergo a post-trip check. After each trip (normally before pre-trip calibration for the following week), the unit should be checked against known standards to ensure that probes are reading correctly. If a probe is not reading correctly, the information should be recorded in the logbook and on the field sheet of comments of the previous trip.

5.34 Continuous Multiparameter (CM) Instrument

The CM is continuously deployed in the field and is used to measure various *in-situ* parameters. Check calibration and maintenance logs at the site to determine if any special conditions or situations exist for the instrument. If previous calibrations are incomplete or have occurred to far in the past, please note on the "notes" sheet for the site visit (refer to section 7). **ALL CALIBRATIONS AND MAINTENANCE MUST BE RECORDED IN THE UNIT'S LOGBOOK.**

5.35 Generalized 5-step Operation and Maintenance Process

Step 1 (Deployment of Field Probe): A site-calibrated field probe is set to log on 2-min. intervals and deployed immediately adjacent to the drag tube. These data are later used in the calculation of continuous probe fouling drift.

Step 2 (Cleaning, Fouling Drift and Maintenance): Prior to any disturbance, an initial reading is recorded from the continuous probe, and a pre-clean value is recorded for all available parameters. The continuous probe is pulled from the tube and thoroughly cleaned. The probe is thoroughly inspected and required maintenance is performed (wiper pad replacement, batteries, etc.). The continuous probe is redeployed and allowed to stabilize. A post-clean value is recorded.

Step 3 (Calibration Drift and Re-calibration): The continuous probe is removed again from the tube, and a calibration check is performed. First, a pre-calibration value is recorded and compared to an expected value. If the pre-calibration value varies greater than 3% from the expected value, a calibration is performed. When calibration is successfully completed, a post-calibration value is recorded.

Step 4 (Zero DO Check) (DO probes only): The continuous probe is placed in zero DO solution to determine if it is accurately measuring very low dissolved oxygen levels. When stabilized, the measured value is recorded. If an unacceptable reading is recorded, further maintenance or probe replacement is required.

Step 5 (Redeployment): When the probes are successfully calibrated and maintained, it is redeployed. When the readings are again stabilized, final measurements for all available parameters are recorded. The field probe is removed and data are backed up for later use.

Optional Step (Annual or Needed Maintenance): All continuous instruments are removed annually, or as needed, for intensive maintenance at the OWRB Oklahoma City office. Service includes an internal data retrieval, thorough cleaning of the sonde housing, and replacement of anti-fouling measures, ROX DO membrane, and battery. Steps 1-5 are always completed prior to removal for annual maintenance, and the probes are rotated for annual service in such a way that data loss is minimal.

5.36 Maintenance

Before maintenance is performed a pre-clean reading should be recorded for both the FM and CM instrument, and then recorded on the "Continuous Water-Quality Monitor Field Form". After maintenance is performed a post- clean reading should be recorded for both instruments. Specific in field maintenance should occur for the multiparameter instrument as follows

1. **Multiparameter instrument casing—**Check the instrument casing periodically for cracks or looseness of connections. Connections may need to be tightened or re-siliconed periodically (only after the approval of a supervisor or senior staff member). Clean instrument casing thoroughly with a mild cleaning solution.
2. **Bulkhead—**Check the bulkhead connection for bent pins or looseness.
3. **Temperature Probe—** Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water.
4. **Dissolved Oxygen Probe—**Check the probe for any cracks, or other abnormalities. Change membrane as necessary. Clean probe thoroughly with a mild cleaning solution.
5. **pH Probe—**Check the probe bulb for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
6. **Specific Conductance (SpC) Probe—**Check the probe bulb for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
7. **Turbidity Probe—**Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.

8. **Chlorophyll A Probe—**Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
9. **Blue-Green Algae Probe—**Check the probe for cracks, dirt, scum, or other abnormalities, and change or clean probe if necessary (only after the approval of a supervisor or senior staff member). Clean with warm soapy water and Q-tip.
10. **Wiper—**check foam wiper pad and replace as needed.
11. **Central Cleaning System—**Check the wiping brush for proper operation and clean out embedded sediment.

5.37 Calibration

Before calibration is performed a pre-cal reading should be recorded for both the FM and CM instrument, and then recorded on the "Continuous Water-Quality Monitor Field Form". After calibration is performed a post-cal reading should be recorded for both instruments. During each visit, specific calibrations and checks should occur for instrument as follows:

1. **Depth—**Depth (meters) should be calibrated to 0.1.
2. **Temperature Probe—**Place instrument and an independent lab grade thermistor/thermometer into water and compare the readings. If the difference is greater than 0.4 mg/l the probe should be replaced or the instrument needs to be repaired (only after the approval of a supervisor or senior staff member).
3. **Dissolved Oxygen Percent Saturation—**Perform an "air" calibration with tap water using the local uncorrected barometric pressure (BP). The lab and field barometers give BP in units of "inHg", and the unit can only accept BP in units of "mmHg". A conversion chart is provided in the laboratory and in each field notebook (the conversion is 'inHg x 25.4 = mmHg'). The unit should then be placed in a zero-DO solution to ensure the instrument accuracy. If the instrument does not read <0.4 mg/l while in this solution the ROX membrane needs to be cleaned and inspected. If instrument will still not read <0.4 mg/l the ROX membrane should be replaced. The zero-DO check value should be recorded on the "Continuous Water-Quality Monitor Field Form".
4. **pH Probe—**Determine the expected range of pH by consulting the station data, and perform a two-point calibration based on the pH values. For example, if the ranges on the trip are from 7.5 to 8.1, perform a 7-10 pH calibration, or if the ranges are from 6.6 to 7.1, perform a 7-4 pH calibration. Pre and post calibration, compare the instrument reading to known standards.
5. **Specific Conductance (SpC) Probe—**Determine the expected range of SpC by consulting the station data, and perform a two-point calibration based on the SpC values. For example, if the ranges on the trip are low range (< 700), perform a 0-500 SpC calibration, or if the ranges are high range (> 700), perform a 0-1413 SpC calibration. Pre and post calibration, compare the instrument reading to known standards.
6. **Turbidity—**Perform a calibration at all ranges of measurement including 0-10 NTU's, 10-100 NTU's, 100-1000 NTU's according to manufacturer specifications

and using manufacturer approved turbidity standards. Pre and post calibration, compare the instrument reading to known standards.

7. **Blue-Green Algae and Chlorophyll A Probes-** Perform calibration is De-ionized water. Make sure that there is zero contamination from the instrument itself in the calibration cup. Calibrate both parameters to zero. When doing a field calibration of a continuous meter a sample of the native water must be taken and analyzed for both parameters. The results of the analysis id then compared back to the instruments readings and the data from the probe is adjusted accordingly.

5.38 Final Reading

After calibration is performed the CM instrument should be redeployed and allowed to stabilize before a final reading is recorded for both the field and continuous instrument on the "Continuous Water-Quality Monitor Field Form".

6 Measurement of *in-situ* Parameters Using Multiparameter Instruments

6.1 Calibrating Grab Sample

Take measurement according to the referenced document "Standard Operating Procedure for the Recording of Physical/Chemical Parameters Using a Multiparameter Instrument in Streams".

6.2 Remotely Deployed Instrument

6.21 Installation

Installation of remotely deployed instruments can be done in one of several ways including a stainless steel standpipe, a polypropylene drag tube, or a stainless steel bank pipe. No matter the method to be used, the portion of the pipe where the instrument will be located should be perforated. The method used will be outlined in the station installation plan. The following general factors should be considered when selecting an installation method:

- **Safety of the Instrument—**This is perhaps the most significant factor to consider. These instruments are costly to replace, and although they are ruggedized, they cannot take a significant beating. Instrument should be deployed so that it does not hang so loosely in the pipe that it takes significant beatings during high flows. Instrument and instrument pipe should also be securely fastened to prevent removal by man or nature. This includes attaching the instrument by bail to tethered steel cable and locking the lower portion of the instrument.
- **Quality of the Measurement—**The instrument should be deployed in a location within the stream channel that will take the most representative measurement.
- **Accessibility—**Deployment should be in a place that is accessible for both maintenance and calibration of the instrument.

6.12 Measuring and Recording Readings

- Measurements will be made on a set schedule (e.g., every 15 minutes).
- Unit should be set so that probes are wiped before each reading.
- Before data is recorded probes should be given adequate time to equilibrate.
- Data may be stored internally within the instrument and downloaded at each site visit. If this is done, batteries should be changed on a regular basis.
- Data may be recorded using a data recorder by attaching the instrument via an SDI cable. When this is done, a calibration tail should be attached at the junction of the wet and dry cables. When data are recorded in this fashion, it is often telemetered and is the desired form of data acquisition.

6.13 Short-Term Deployments

- These type deployments are used to gather shorter periods of data such as weekly to month long data. The calibration and set up procedures are explained in much greater detail in the preceding sections. The instrument should be setup and calibrated before any deployment to ensure proper operation. This calibration is performed with known standards. Upon retrieval of instrument from study area, a post calibration check is performed. This is to determine any fouling or drift associated with the data and calibration
- The multi-parameter instrument is most often used to collect, and store the data from the study area. To ensure complete datasets, each unit should be equipped with a new set of batteries, previous logged files are downloaded then deleted, and that adequate memory is available to handle the new logged file. To determine log file size and memory availability, consult the operation manual of the instrument.
- These instruments are deployed in a less obtrusive manner than the long term deployments. The common method is to house the sonde in a large perforated HDPE / PVC tube that is connected by heavy weight chain to the barrier wall of a bridge or similar structure. The attachment point should be accessible at all stages of the river. For security purposes, the tube should be locked or constructed in a manner to prevent un-authorized access and or tampering. Additionally, each tube and sonde shall be prominently marked to aid in recovery of the instrument in the event of loss.

7 Forms

For each visit to a station, a “Continuous Water-Quality Monitor Field Form” sheet is completed. This sheet will include the pre and post calibration results, maintenance performed, and results of other instrument checks. The sheet should also included notes about the condition of the installation and the instrument. Whether data are downloaded is also recorded on the sheet. Remember, the notes recorded are data and should be treated as such. Therefore, they should be written, legible, and complete. To avoid confusion and loss of data, a new sheet should be used at each project site. Field notes should be initialed and dated by the collecting personnel and data entry personnel. Both multiparameter instrument and recorded serial numbers should be recorded on the field notes. For guidance on proper procedure to complete the field notes, refer to your supervisor and or FTE. Field notes can be found at S:\Monitoring\STREAMS\forms\Field Notes.doc.

8 Data Storage

All completed paper copies of “notes” sheets should be maintained with the appropriate station notebook. The data from the field notes and laboratory data sheets should be either entered into or uploaded to the Water Quality Database. Each sample should be maintained electronically in the database under a unique sample number. Data will also be stored on the telemetry website. However, these data are not fully checked and censored and should not be considered final.

9 References

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A. 2006. *Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting.* U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments. *http://pubs.water.usgs.gov/tm1d3*.

YSI Incorporated, 2010 Revision F. *Environmental Monitoring Systems Operations Manual, 6-Series Multiparameter Water Quality Sondes. https://www.ysi.com/media/pdfs/069300-YSI-6-Series-Manual-RevF.pdf*