The *Oncor* Geodatabase for the Columbia Estuary Ecosystem Restoration Program: Handbook of Data Reduction Procedures, Workbooks, and Exchange Templates

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May 2014

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Contents

1.0 Introduction

In 2012, the U.S. Army Corps of Engineers (USACE) Portland District initiated development of a web-accessible geoscientific database (called *Oncor*) for analysis and synthesis of action effectiveness and related data from monitoring and research efforts for the Columbia Estuary Ecosystem Restoration Program (CEERP). Pacific Northwest National Laboratory (PNNL) researchers are developing this estuary-wide data management and information discovery/retrieval system to provide an intuitive user environment and the necessary resources and tools to standardize and upload/download data (see the 2012 annual report by Coleman et al. 2013). The intent is for *Oncor* to enable synthesis and evaluation of data generated by multiple entities, the results of which can then be applied in subsequent CEERP adaptive management and decision-making processes. The database is called *Oncor* after the genus *Oncorhynchus*, which includes Pacific salmon and steelhead, the focus of CEERP estuarine and tidal freshwater habitat restoration efforts in the lower Columbia River and estuary (LCRE).

Action-effectiveness monitoring and research (AEMR[1]) and other relevant data are being collected at CEERP restoration and reference marshes, shrub-dominated wetlands, forested wetlands, and other habitats and AEMR study sites (Figure 1.1). Where applicable, data are collected using protocols developed by Roegner et al. (2009), called the *Data Collection Protocols*. Many regional entities are involved in this data collection, including the following organizations: Columbia Land Trust, Columbia River Estuary Study Taskforce, Cowlitz Tribe, Lower Columbia Estuary Partnership, National Oceanic and Atmospheric Administration, Oregon Department of Fish and Wildlife, PNNL, USACE, and the Washington Department of Fish and Wildlife. The CEERP prioritizes AEMR measurements and metrics pertaining to juvenile salmon and their habitats, because the focus of CEERP is on ecosystem improvements to support juvenile salmon emigrating from the Columbia River basin (BPA/USACE 2013; Thom et al. 2013). In addition, CEERP prioritizes select habitat data important for the assessment and adaptive management of ecosystem restoration, such as plant communities, channel cross sections, photo points, sediment accretion/erosion rate, water-surface elevation, water temperature, and inundation. But, while there are standard protocols for data collection, none exist for the next phase of the scientific process for reducing and uploading these data to a regional database in support of CEERP.

Figure 1.1. From left: tidal freshwater marsh, beaver dam in shrub-dominated wetland, riparian forest, and Sitka spruce swamp.

[1] Action-effectiveness *monitoring* involves spatially extensive sampling of basic restoration indicators, whereas action-effectiveness *research* involves locally intensive sampling at restoration and reference sites to characterize ecosystem structures, processes, and functions.

1.1 Purpose of This Handbook

The purpose of this handbook is to provide the regional partners that are collecting AEMR and other data supporting CEERP with the procedures and tools to reduce and upload their field-collected data into *Oncor* (Figure 1.2; Table 1.1). The data categories included in this handbook include physical and biological characteristics. Not all data categories covered by the *Data Collection Protocols* are covered herein and, likewise, not all data categories covered herein were included in the *Data Collection Protocols.*

Figure 1.2. Data flow for AEMR and other data intended to support CEERP. The red boxes signify material that is covered in this handbook.

Table 1.1. Data categories covered in the *Data Collection Protocols* and the *Handbook of Data Reduction Procedures, Workbooks, and Exchange Templates.* Green shading signifies the data category is covered to some degree.

Data Category	Collection Protocols	Reduction Handbook
Water-surface elevation	covered; referred to as Hydrology	covered
Water quality	water temperature and salinity	water temperature; included within the data reduction procedure for water surface elevation
Elevation	elevation survey methods	covered as related to sediment accretion
Sediment accretion	covered	covered as a distinct data category
Channel cross section	covered	covered as a distinct data category (under construction)
Landscape features	aerial photography and photo points	photo points
Plant communities	herbaceous vegetation	covered for herbaceous wetland vegetation cover (plant community composition and percent cover)
	forested wetlands	covered for tree plots and site summaries (tree densities)
	shrub/scrub vegetation communities	shrub/scrub vegetation densities
Vegetation plantings	pertained to planting success	not covered
Fish catch	variety of gear types covered to sample species composition, size distribution, catch per unit effort (CPUE)	covered for beach seine methods only
Fish density	expressed as CPUE	covered as a distinct data category pertaining to beach seine collections
Fish size	included under fish community	ibid
Chinook salmon genetics	not covered	ibid
Fish diet	not covered	ibid
Fish prey	not covered	covered as a distinct data category

The handbook presents a set of data reduction[2] procedures (DRPs) that data generators can follow to process raw data collected in the field, for the purposes of analysis and reporting and standardization for uploading to *Oncor*. In association with the DRP documentation in this handbook, we created Microsoft Excel workbooks for actual data reduction for specific data categories (Table 1.1). These workbooks are termed data reduction workbooks (DRWs), and the most current versions are available for download on the *Oncor* website: http://oncor.pnnl.gov/ (link for external, non-PNNL users). A subset of the sheets in each workbook constitutes a data exchange template (DET), which provides a standard mechanism for importing data into *Oncor*. The selected subset is customized for each data category, e.g., fish density. Guidance to support data quality and management efforts is also incorporated in the DRPs. To summarize, the DRPs, DRWs, and DETs provided in this handbook and accompanying Excel files help ensure *Oncor* data integrity while maximizing ease of data reduction, quality control, and uploading. The ultimate intent is to have a web-accessible, comprehensive geodatabase of AEMR and other data to facilitate synthesis and evaluation of the collective effectiveness CEERP restoration actions.

1.2 Organization of This Handbook

The next section of this handbook contains basic material that apply to all data categories covered in the handbook. After the basic material, detailed DRPs for select data categories are presented (Table 1.1). Each DRP has an associated Excel workbook, the DRW. Because there may be multiple definitions of the same term and that the terminology involved in the entire data flow process can be confusing, there is a glossary of the terms in Appendix A. Other appendices include technical information about *Oncor* such as data workflow (Appendix B) and data standardization (Appendix C). Appendix D demonstrates outcomes from data analysis to answer analysis questions with specific temporal or spatial parameters (e.g., seasonal temperatures and fish densities), and how monitored indicators from different data categories can be combined to answer analysis questions (e.g., topography and plant species presence).

1.3 How to Use This Handbook

For a given data category, complete the following steps:

- Visit the *Oncor* website and download the latest version of the *Handbook of Data Reduction Procedures, Workbooks, and Exchange Templates*. Open the handbook PDF.
- Download the latest version of the DRW for the data category(s) of interest, save it to a local computer, and open it. Having a split screen of the handbook PDF and the DRW Excel workbook will facilitate the work.
- Study the basic material on general procedures and requirements.
- Go to the appropriate data category in the handbook and read the section completely before working with data.
- Familiarize oneself with the content and structure of the particular DRW.
- Create a trial data set, enter the data in the DRW, perform the data reduction procedure, and inspect the results for the desired outcome.
- Use the Help button on the *Oncor* website to request assistance.

[2] Data reduction is simply the process of transforming raw data by statistical or mathematical functions into a structured format.

2.0 Basic Material on DRPs, DRWs, and DETs Relevant to All Data Categories

Data undergo a series of steps from collection to uploading into *Oncor* (Figure 2.1). The collective term for data reduction and uploading to *Oncor* is "data processing." In research and monitoring, the measurements made by scientists in the field or laboratory are colloquially referred to as "raw data." This section describes the effort by the *Oncor* development team to provide detailed and efficient methods for those collecting raw data for the CEERP ("data generators") to reduce data as needed to meet typical reporting requirements and upload data into *Oncor* (Figure 2.1). We understand and recognize that there is not a single best way to accomplish this goal. However, it is important to standardize the process to enable data to be integrated for estuary-wide analysis. The procedures apply to existing data (both *Oncor*-formatted and custom-formatted) and new data. Once data are in the *Oncor* database, they will be available for *Oncor* users to analyze across data collection sites, times, and monitoring programs in the LCRE and answer specific CEERP analysis questions.

This section includes the relationship between this handbook and the data collection protocols, key terminology, quality assurance and quality control procedures, and detailed information about data reduction workbooks. The section culminates with the DET uploading procedure.

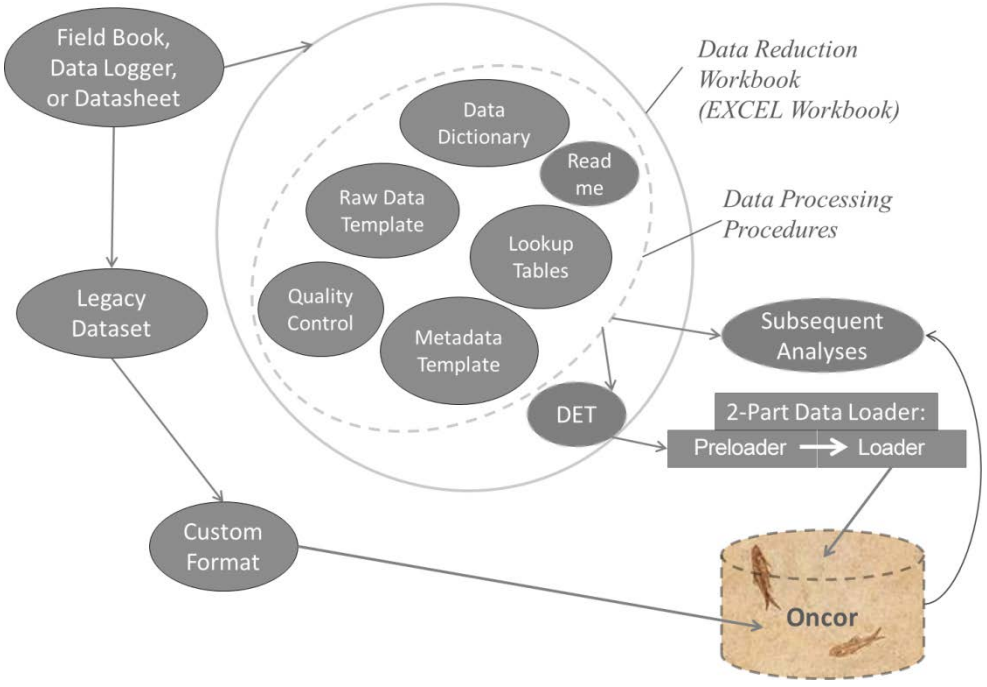


Figure 2.1. Schematic of data flow from field data to *Oncor*. Data flow includes data reduction and entry into a Data Exchange Template (DET) by the data generator, prior to uploading to the *Oncor* database. The data reduction workbook also includes spatial data.

2.1 Relationship to Standard Data Collection Protocols

In the LCRE, many people who monitor restoration and reference sites use the *Data Collection Protocols* described by Roegner et al. (2009), a document developed by the USACE's Cumulative Effects study (study code EST-P-04-04). The *Data Collection Protocols* were developed to support the CEERP and are available at www.nwfsc.noaa.gov/publications/. The individual methods presented by Roegner et al. (2009)—e.g., hydrology, vegetation—are also available for selection at www.monitoringmethods.org, where according to the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) terminology, they are termed "methods" not "protocols."

In the 2013 geographic review of the Bonneville Power Administration (BPA)/Northwest Power and Conservation Council's Fish and Wildlife Program by the Independent Scientific Review Panel, proposals for five "umbrella projects" implementing CEERP restoration actions—Columbia Land Trust, Cowlitz Indian Tribe, Columbia River Estuary Study Taskforce, Lower Columbia Estuary Partnership, and Washington Estuary Habitat Memorandum of Agreement (Washington-Action Agencies 2009)—state that the *Data Collection Protocols* by Roegner et al. (2009) will be the basis of monitoring in 2014.

The *Data Collection Protocols* focused on field data collection with few references to the procedures required for data reduction, analysis, and reporting. Not surprisingly, questions have arisen about how to ensure data quality and standardization to provide comparable results across the CEERP (see for example Borde et al. 2012). In addition, several metrics that are frequently calculated for salmon today, including density, genetics stock identification, and diet, were not detailed in the protocols (Table 1.1). To address these needs, the *Oncor* development team created this *Handbook of Data Reduction Procedures, Workbooks, and Exchange Templates* and associated Excel workbooks providing detailed instructions and demonstration examples to help users efficiently transform raw data collected with these methods into measurements, metrics, and indicators in formats for uploading to *Oncor*.

2.2 Terminology

This section contains frequently used terms that users of the handbook must understand. These and additional terms are defined in the glossary (Appendix A).

As a matter of principle, *Oncor* adopts whenever possible the relevant PNAMP terminology, which is available from www.monitoringmethods.org/Glossary/Definition/, including the following three terms:

- *Measurement*: A value resulting from a data collection event at a specific site and temporal unit.
- *Metric*: A value resulting from the reduction or processing of measurements taken at a site and temporal unit at one or more times during the study period based on the procedures defined by the response design. Metrics can be used to estimate an indicator using an inference design. Note that a variety of metrics can be derived from original measurements.
- *Indicator*: A value resulting from the data reduction of metrics across sites and/or temporal periods based on applying the procedures in the inference design. A reported value used to indicate the status, condition, or trend of a resource or ecological process; intended to answer questions posed by the objectives of the protocol. According to the inference design, metrics are combined or reduced to produce indicators.

Other terms that are essential to understand warrant definitions here because they are used throughout this handbook.

- *Alias:* A user-specific name for a standard value in *Oncor*. For example, more than one project or organization may collect data at the same site. A standard name (value) for that site will exist in a lookup table in *Oncor*. Users (data generators) may also enter an alias, or more typically used name, for that value, for their convenience. This may also apply to instruments, organizations, etc.
- *Data category*: A set of data collected under a particular field-data collection method. Each data category has a corresponding data reduction workbook. For example, all data associated with water-surface elevation monitoring using data loggers would constitute a single category. This includes data about the instrumentation used and the time-series measurements. Multiple data categories may be combined to answer analysis questions. A data category may include multiple metrics and indicators, e.g., mean accretion as well as annual sediment accretion rates.
- *Data custodian*. An *Oncor* administrator responsible for ensuring data standards are met and that data are uploaded into the database correctly.
- *Data generator*: The person, or agency/organization, providing data to *Oncor*.
- *Data exchange template (DET)*: The Excel file format used to transfer data from a data generator to *Oncor*. The DET is a subset (one or more worksheets) within the DRW.
- *Data reduction*: The process of transforming raw data by statistical or mathematical functions into a more usable format.
- *Data reduction procedure (DRP):* A data-category−specific stepwise description of how to reduce data for *Oncor*.
- *Data reduction workbook (DRW)*: The Excel workbook, corresponding to the DRP, which contains informational, data reduction, and data loading worksheets documenting the data reduction process for a specific data set.
- *Original data*: Measurements made by scientists or technicians in the field or laboratory. Data that are not quality control checked, reduced, or mathematically transformed. Also called “raw data.”
- *Standard value*: A frequently referenced person, place, or thing, that has been assigned a single term in the database. This standardized set of values is managed by the data custodian. Examples include people who collected the data, sampling locations, and instruments. For example, Jane Doe may be the standard value and the initials JAD may be an alias used by a data generator.
- *Worksheet*: The same as a single worksheet/tab in an Excel workbook. Also “datasheet” or “spreadsheet.”

2.3 Quality Assurance and Quality Control

The steps in the data reduction process include electronic data entry, subsequent calculations, and quality control to reduce the data into a usable format. (Additional details are provided in Appendix C, Data Quality.) Data reduction can be as simple as changing the unit—a common example being changing survey feet to meters. Typically, a series of reduction steps needs to be performed on AEMR and other data, with quality control (QC) checks at each step to ensure that the original values are correctly reduced.

Final data used for reporting or uploading into *Oncor* should be traceable from raw data through all processing steps that were performed. Ultimately, data reduction should produce documentation sufficient to permit an independent data auditor to determine whether data are accurate, complete, traceable, and meet specifications. These types of procedures also help to ensure that data are not lost when staff members change at a data-generating organization.

For the purposes of *Oncor*, the focus of QC is on *data verification*. In general, data verification is the process used to determine if data are accurate, complete, traceable, and meet specified performance criteria or control limits. In the metadata for a given data category DRW, the user is requested to indicate whether QC was done to the level described in this section.

A review of logbooks and other data collected and recorded in the field should occur as soon as practically possible after the data are collected. In fact, completing this process in the field helps to ensure that any missing, unclear, or incomplete data can be corrected without making additional field trips. The design and use of datasheets and logbooks should ensure maximum legibility, accuracy, traceability, validity, and clarity of meaning. While the use of pencil in the field is standard, scanned or printed backup copies should be made in the office and archived separately from the raw datasheets as soon as possible upon return from the field. Datasheets and logbooks require the date of collection, time of collection if appropriate to the indicator, the initials of the recorder(s), and in most cases, the place of collection (e.g., the site, plot, global positioning system [GPS] point, etc.). These data are typically included in *Oncor*. Because *Oncor* is a geospatial database and all data are organized based on place of collection, the most accurate measurement of location that can be made in the field should be made. The indicator-specific procedures specify whether points, lines, or polygons are the standard.

For *Oncor* data, we recommend that independent verification of the data in the reduction process comprise the following, at a minimum:

- 100% check of data transcription (data entry)
- 10% check of calculations, with a 100% check required when errors are found to determine the extent of the problem and correct it.

Data verification must be independent. That is, it can be completed by a peer reviewer or quality assurance staff member, if available, but it should not be completed by the scientist or technician who conducted the data entry or the calculations that are being verified. To make the QC process traceable, all activities must be recorded, and therefore it is customary to conduct checks on paper copies in ink. For example, one standard method for documenting the process involves 1) denoting all transcribed data that have been checked with a mark made in ink; 2) crossing out incorrect values and writing the correct ones instead; and 3) on each page, noting the level of data review performed (e.g., 100%, 10%) and the initials and date of the checker. Once this level of check has been performed, the data in the electronic file must be corrected; when correction is completed, the initials and date of the person who has done so are also noted in ink on the QC record sheet. Ideally, a final copy is printed and verified for 100% correctness. While the QC process is typically conducted using paper copies of datasheets, an alternative approach is to perform data checks and documentation of errors using electronic files. Data generators should ultimately select an approach that is most suitable for project needs and programmatic requirements.

2.4 Data Access Control: Permissions and Security in *Oncor*

For a variety of reasons, owners of data in the *Oncor* database may not wish to share parts of their data sets with other users or the public. Data could be provisional and not ready to be publicly disseminated or results could be of a type that might be easily misinterpreted. To address this anticipated need, *Oncor* includes a mechanism that allows data generators to control access to data they have uploaded.

Data access control is implemented using a permission-based system. Every measurement record in the database is associated with a data owner and an access group. The DB_Access column in each DET is where the user can define the level of access for the individual measurements, metrics, or indicators in the data set. Every *Oncor* user will have a list of access groups to which they have owner-permitted access. To access a record, the user must have permission from the owner of the data for the access group associated with the record.

When data are uploaded via a DET, *Oncor* stores the metadata supplied for that DET with the data set. Two metadata fields will be used for establishing the accessibility of the data: DET_Owner and Access_Group. The DET_Owner field represents the person who owns the data in the DET. This person is referred to here as the data owner. The Access_Group field is a column in each of the DET worksheets of the DRW workbook that allows the data owner to assign each table row to a group for the purpose of restricting access. An access group is a collection of owned records that have similar access properties. Access groups are specified with a positive integer, with the group 0 representing the default publicly accessible group. A blank value in the Access_Group field will assign the record to the 0 access group.

To view data beyond the standard *Oncor* base data, users must have an account on the system. Part of the information associated with *Oncor* user accounts is a table of group permissions. The table lists owner and access-group pairs to which the user has access. The absence of a permission record for a data owner is equivalent to having access only to his/her public (access group 0) records. Data owners will have access to all their data without an explicit entry in the permission table.

2.5 Standard Values

To ensure proper integration of all data in *Oncor*, the maintenance of a single set of data standards is critical. Prior to entering data into DRWs, users must first provide standard values via the StandardValues_v0.4.xlsm file which is structured according to the following topic areas:

- **Agency.** Organizations associated with lower Columbia and estuary (LCRE) data (e.g., Lower Columbia River and Estuary Partnership, Columbia Land Trust, etc.).
- **Person.** Full name and affiliation of people associated with LCRE projects.
- **Program.** Highest organizational level guiding a data collection effort; missions, research questions, and protocols are defined at this level (e.g., Columbia Estuary Ecosystem Restoration Program; CEERP)
- **Project.** Specific research activity that supports one or more of the research questions of the Program (e.g., Reference Site Study).

- **Document.** Reference document citation provided as supportive material for methods that may be referenced in various DRWs.
- **Instrument.** Specifications for equipment used to collect data (e.g., data logger, fish net, etc.).
- **Method.** Data collection method.
- **Species.** Specific information for a plant or animal (e.g., scientific name, species code, common name, etc.).
- **Unit.** Measurement units reported.

Appendix C provides additional background information as well as an expansion on the purpose of standard values. During the beta testing phase, users should populate each of worksheets within the StandardValues_v0.4.xlsm file, to the extent possible. Ultimately, the standard value file will be linked to the metadata and other relevant locations within each of the individual DRWs. In the future, coupling the standard values file with the DRW will facilitate a more automated process for data entry while assuring proper integration of data into *Oncor*.

2.6 Data Reduction Workbooks and Data Exchange Templates

This section describes the DRWs, data dictionary, metadata, entering data into DRWs, validation mechanisms, and key fields.

2.6.1 Description of DRW

We are calling the activities that occur after data collection and before *Oncor* data loading "data reduction" (Figure 2.2), which includes implementing DRPs and preparing DRWs and DETs (Figure 2.1). As noted above, we provide as a companion to this handbook example data reduction workbooks in Excel corresponding to key data categories: water-surface elevation and temperature, sediment accretion rate, photo points, channel cross sections,[3] herbaceous wetland vegetation cover, tree plots and site summaries, fish catch and density, fish size, fish diet, fish prey, and Chinook salmon genetic stock identification.

The DRWs (Figure 2.2) are available on the *Oncor* website to data generators and may be adopted at will, but are not required because many data generators may have preferred data reduction workbooks already in use. As depicted in Figure 2.1, *Oncor* can also accept "custom-format" data given appropriate coordination between the data generator and *Oncor* data custodian. Data generators should follow the stepwise process outlined in the DRPs to ensure data are formatted according to the DET, which is a subset of worksheets in the DRW workbook containing final data for upload into *Oncor* (see Figure 2.2, red boxes). The DETs will be required for all data uploaded to *Oncor* in the future. The DETs contain fields that represent data collection in the LCRE that have been identified as a priority by the CEERP managers. DETs include fields for each measurement, metric, and indicator that will be entered into the *Oncor* database.

[3] Under construction.

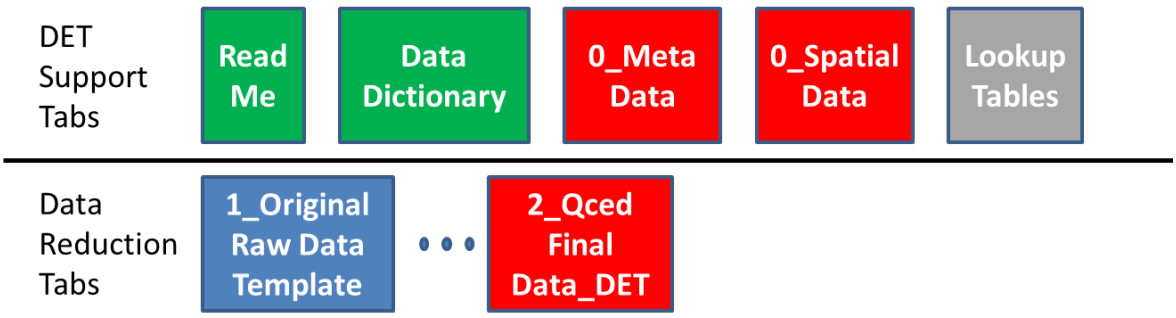


Figure 2.2. Generic Data Reduction Workbook structure including the Data Exchange Template (in red). The three-part general processing sequence is represented by 0, 1, and 2. Each box represents a worksheet tab in the workbook. Green tabs are informational. Blue tabs consist of a template with column headers for the entry of raw data. The ellipsis represents the data reduction process, e.g., QC checks. Grey tabs provide standardized naming conventions. Red tabs are quality-control and data-reduction end points and constitute the Data Exchange Template. The red tabs are required for uploading information into *Oncor*. Only quality-control-checked data may be uploaded into *Oncor*.

When ready to reduce the field data, data generators will download blank DRWs from the *Oncor* web site. The DRWs will not only be specific to the data category requested, they will also contain the latest standard-value lookup lists with alias values associated with the requesting user. To access *Oncor* for upload, data generators will need to identify themselves so that pre-loaded information specific to them can be incorporated with the upload, e.g., name and agency. Data generators will be presented with a choice of DRW data category(s) to download. By accessing DRW/DETs through the web interface, format updates will be easily disseminated. After a DRW/DET modification, the loader would remain backward compatible for some set period of time to allow data generators to complete old DETs that they may have already started.

Data reduction space (Figure 2.1) includes data processing procedures (e.g., mathematical transformations and QC checks), as well as several key elements that can be stored in Excel data reduction workbooks (Figure 2.2). The DRW contains a set of worksheet tabs, which are described as follows:

- **Read Me.** Contains general information about the DRW, including a list of the names of each worksheet tab that describes its purpose, contents, and use.
- **Data Dictionary.** Defines each field (i.e., each column header) found in subsequent sheets; information includes a description of what goes in the field, the data type, whether the field is required, what automatic validation occurs, any applicable standards, and whether it is a calculated field.
- **0_Metadata.** Lists associated metadata (e.g., data owner, contact, instrumentation, etc.); contains the same columns for all data categories, which must be filled in by the data generator.
- **0_SpatialData.** Two tabs for entering spatial data. One tab can be used to enter coordinates for points the other can be used for to enter information for an uploaded shapefile with points, polylines, or polygons.
- **Raw Data Template.** One or more tabs containing an empty table into which the data generator enters or copies data.

- **DET Tabs.** One or more tabs into which the data generator copies quality-control−checked and reduced data; for some data categories, the DET tabs may be automatically populated using formulas and/or macros.
- **Lookup Tables.** Tabs that, through the use of lookup lists, are used to help populate standard-value fields (e.g., species, instruments, organizations, sites, etc.) to ensure compliance with *Oncor* data standards; lookup tables may be viewed and edited by pressing the Standard Values button available on most tabs.

Each DRW includes as many datasheets as necessary to accommodate associated measurements, metrics, and indicators, and data generators can add sheets for their own purposes as needed, which will not be delivered to *Oncor*. The data generator may choose to perform QC checks within sheets in the DRW, on a printed copy, or in another electronic file as preferred. Raw data are not delivered to *Oncor*. Only the DET, a subset of the DRW, is delivered to *Oncor*.

2.6.2 Data Dictionary

The data dictionary in each DRW contains the following information about each worksheet in the DRW:

- **Sheet**. Name of worksheet where the field appears.
- **Col_Num.** (hidden column) Column to help sort the fields.
- **Column**. Letter identifying a column in the worksheet.
- **Field Name**. Name in the column header cell.
- **Description**. Description of what the field is used for.
- **Data Type**. Storage category of the field in the database (text, integer, Boolean, etc.).
- **Key Field**. Yes, if the field is required to uniquely identify the record.
- **Required**. Yes, if the field must be nonblank.
- **Std Value**. If nonblank, the standard value must be used to populate the field.
- **Validation**. Description of the automatic validation performed by the workbook.
- **Conventions**. Data standards applicable to the field (e.g., units),
- ***Oncor* Attribute Name**. Name of *Oncor* attribute to which field will be mapped.
- **Formula**. Excel formula for calculation of a value in a worksheet cell.

2.6.3 Validation Mechanisms

The data-entry worksheets in the DRW incorporate automated validation mechanisms to help assure data integrity. The types of validation performed include assuring that standard-value fields only contain values in appropriate lookup lists, checking that data in certain numeric fields fall within an appropriate value range, and verifying compliance with other rules. See Appendix C - - Data Quality and Format: Standards and Enforcement for more details about data validation and standards. Specific validation rules for each field are given in the Data Dictionary.

Data-entry validation is initiated by clicking on a custom button titled “Validate” that is located on the last worksheet where data are manually loaded. This button is powered by underlying Visual Basic for Applications (VBA) code. Because the DRW must include VBA code, the filename extension of the DRW file is .xlsm, to indicate the presence of macros. In addition to data validation, the integrity of the DRW file is protected by selective locking of cells to prevent inadvertent changes to the sheets.

The spatial data in a DRW is validated by checking all fields that require the entry of a location against a set of allowable values. The validation process searches three places in the DRW to determine whether a specified location is valid. First, it looks at a list in a hidden tab called LU-Location, which contains all currently existing locations in *Oncor*. Next, it looks at the Alias_Name field of any records in the tab 0_SpatialData_Coordinates. Finally, it looks at the FileRelate_Field attribute of any shapefiles specified in the tab 0_SpatialData_Shapefile.

2.6.4 Key Fields

Most data-entry worksheets contain key fields, which are indicated in the data dictionary. The presence of key fields ensures that individual records can be distinguished from each other. Every combination of key-field values must be unique in the data-entry table. For example, if a data set such as water-surface elevation consists of a location, measurement date/time, and measurement value, the key fields include both location and measurement date/time. This ensures that records can be distinguished from each other in the database. Compliance with the key-field rule is checked when the Validation button is pressed.

2.6.5 Entering Data into DRWs

The data-entry sheets of the DRWs are designed to make entry of data as easy as possible, while ensuring data integrity and completeness. Data are first entered into the worksheet called “0_Metadata” (Figure 2.2). (See the following subsection for more details on metadata.)

Next, raw data are entered into the tab or tabs that have the suffix “_Template.” If field data are collected electronically, most data entry should be able to be accomplished with a small number of copy-and-paste operations. For manually recorded data, the Excel data-table structure should mirror the form of the field notes. The number, format, and content of DRW data-entry sheets will differ for each data category.

The raw data in the template worksheets are then processed according to the specific DRP, each step documented under the appropriately numbered tab, until, at the end, one or more red-tabbed DET worksheets is populated. The red-tabbed DET worksheets initially contain gray-shaded example records to assist with understanding the expected contents of the fields. These example records must be deleted before submitting the DET for uploading to *Oncor*.

The data dictionary will provide guidance on whether a particular field in a DRW must be populated. Examples of required fields include site name and sample date. However, it is plausible that not all fields will always contain data. For example, while water temperature is a routine measurement that occurs in conjunction with fish sampling, data may not be available if there the meter malfunctions. In lieu of blank cells, missing data should be indicated using one of two approaches. The code ‘ND’, meaning ‘no data’

can be used when the data type associated with a given field is TEXT. Missing data in fields whose data type is defined as INTEGER or DOUBLE should be populated using '-9999'.

2.6.6 Metadata

Every DRW includes a data-entry sheet with the name "0_Metadata" for the purpose of entering metadata about the DET. Currently, required information includes the following:

- **DET_Type**. Standard value for the data category (read only).
- **DET_Version**. Version number of the DET electronic file (read only).
- **DET_Creation_Date**. The date the data generator created the DRW/DET (read only).
- **DET_Generator.** Name of person generating (creating) the DET.
- **DET_POC**. Standard value for the name of the contact person for the data.
- **DET_File_Name**. Name of the DET file.
- **DB_Alias_Owner**. Standard value for the name of the person associated with Alias_Groups included in this DRW (read only).
- **Sponsor_ProjectID.** Project identifier used by project sponsor.
- **Generator_ProjectID.** Project identifier used by data generator.
- **Project_Name**. Standard value for the name of the project that generated the data.
- **Method.** Method used to collect the data.
- **QC_Procedure.** Note percentage of data transcription and percentage of data calculations quality-control checked (e.g., 100% transcription, 10% calculations).
- **Instrumentation**. If applicable to a given data category, the metadata sheet in the DRW will also identify instrumentation.
- **Vert_Datum.** If any elevation data is included apart from that in the Spatial Data tabs then the vertical datum should be specified here (e.g., North American Vertical Datum of 1988, NAVD88)
- **Units.** If applicable, units for the data reported in the DET should be specified here (e.g., water surface elevation data is in meters or feet).

2.6.7 Spatial Data

Spatial data, the information that describes the geographic location of a feature, is an essential component of the *Oncor* database. Because *Oncor* is a geodatabase, all measurements, metrics, and indicators in the DRWs must be associated with a location on the ground. *Oncor* recognizes three types of geographic features: points, lines, and polygons. A point is defined by a single pair of horizontal coordinates, such as latitude and longitude or easting and northing. A line is defined by a set of two, or more, points that form an open shape, and a polygon is defined by a set of three, or more, points that form a closed shape. To define a location, one must specify the feature type, the point coordinates, and the geographic coordinate system used.

Oncor manages locations as standard values. This means that locations referenced in new data are validated against a list of standard, locations maintained in the database to ensure consistency. The procedure for data entry differs from that for other standard values, because users can specify new location data in two ways, by providing either explicit coordinates (point locations only) or a reference to external GIS shapefile.

Users may define new point locations by explicitly providing coordinates into the table located on a tab called 0_SpatialData_Coordinates, which is available in every DRW. New locations defined this way must include information in the following fields:

- **PointID.** The name of the point. The point name needs to be the same as the names in the DET that identify a spatially distinct data record (e.g., a point ID field or a Site ID field).
- **SiteID.** If the location of a specific point is not available then the site location can be used instead. The name of the site is then identified in the SiteID field.
- **Alias_Group.** Grouping category for Standard-Value Name alias (see Appendix C - Data Standardization for more on Alias Names).
- **Easting and Northing.** The fields associated with the x (e.g., easting or longitude) and the y (e.g., northing or latitude) coordinates.
- **Horiz_Coord_System.** Horizontal coordinate system associated with Easting and Northing values.
-

These fields are further described in the Data Dictionary of the DRW. The user may optionally provide a vertical elevation (Elev), including the referenced vertical datum (Vert_Datum).

While the point-entry method described above provides a way to load point data for those without access to a GIS, the preferred method for defining new locations is through the use of an ESRI shapefile[4]. This method is preferred because it is versatile, allowing the user to upload points, lines, and polygons into *Oncor*; compact, needing only one record for a shapefile that may contain many individual locations; and extendible, allowing the user to include additional attributes about each location.

Users specify a shapefile as the spatial data source in the tab called 0_SpatialData_Shapefile, which is available in every DRW. Every new shapefile definition record must contain values for the following fields:

- **File_Path.** File path to File_Name on user hard drive; this is needed for the validation step described in Validation Mechanisms above.
- **File_Name.** Name of zipped file containing ArcGIS shapefile-format files with GIS data.
- **Alias_Group.** Grouping category for Standard-Value Name alias (see Appendix C - Data Quality for more on Alias Names).

[4] The shapefile format (see http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf) is a commonly used GIS file format that consists of several individual files and, while native to ESRI products, can be generated using a variety of GIS software

- **File_RelateField.** The name of the field (attribute) in the shapefile that contains the feature name. The feature name needs to be the same as the names in the DET that identify a spatially distinct data record (e.g., a point ID field).

These are further described in the Data Dictionary of the DRW. The shapefile may contain additional attributes that can be associated with each feature. If elevation data is part of the shapefile, the name of the elevation attribute is specified in the field File_ElevField. The attribute with that name is thereby mapped to the *Oncor* attribute Elev (elevation). Similarly, if the shapefile contains an attribute identifying the site, then File_SiteField is specified.

2.7 DRW/DET Uploading Procedure

Users of this document must access the *Oncor* website to verify that they have the most recent version of the DRW and therefore the DET. This will ensure compatibility with the latest *Oncor* data loaders. Data generators will submit completed DET files via the *Oncor* web interface. Initially, this will be in the form of electronic mail, but ultimately there will be a data upload button for automated uploading. Only QC-checked data may be uploaded into *Oncor*. The data generator is responsible for assembling, verifying, and formatting the data, uploading the file to *Oncor*, and following up with the data custodian as necessary. A detailed explanation of the current plan for DET uploading procedure is presented in Appendix B.

3.0 Data Reduction Procedure Overview

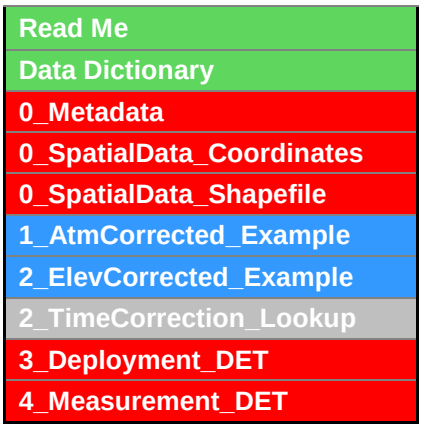
The DRP for a given data category is intended to provide stand-alone guidance for the data generator. Each DRP includes guidance for data QC, stepwise data reduction, and formatting for the DET. As a reminder, there are common features in the process across data categories. For example, there is a DRW in Excel to lead users through data processing that is specific to each DRP. Data generators are responsible for the quality assurance (QA)/QC of their data. It is suggested that the workbooks be saved separately in a file structure to aid in the tracing of data processing steps. The uploading of the final data (DETs, coded in the red-tabbed sheets) is completed through the *Oncor* website (http://oncor.pnnl.gov), where the entire DRW or independently saved DET Excel files can be uploaded along with any associated spatial data sets saved in the Shapefile format (*.shp).

4.0 Water-Surface Elevation and Temperature DRP[5]

The *Data Collection Protocols* identify hydrology, and specifically, measures in the variation of water-surface elevation (WSE) as part of the "Core Monitored Metrics" (see Section 2.2.1 – Hydrology of Roegner et al. 2009). Using pressure transducers with automated hourly logging is the recommended approach for capturing the variability in water levels. Section 4.1 – Hydrology (Protocol 1) of Roegner et al. (2009) provides the field deployment and general calculation and analysis methodology. The procedure presented below covers processing data collected with a data-logging pressure transducer (hereafter water-level logger), methods for calculating WSE, QC measures, and final data formatting for entry into the *Oncor* database.

4.1 DRW Structure

This procedure refers to the DRW_WSE_v0.X.xlsm Excel workbook, which has the following tab colors and structure:



> The **green** tabs are information only, the **blue** tabs provide examples from the data processing steps, the **gray** tab provides lookup information for the time correction step, and the **red** tabs provide the format for the DET that will be used for uploading data to *Oncor*.

Cell Color Codes. Within the DRW, gray highlighting is used for cells containing example data. When gray is seen in cells with blue-highlighted tabs, it is example data that the data generator may view but does not need to delete. When gray is seen in cells with red-highlighted tabs, the data generator must delete those data before entering final data into the DET.

Tab Numbering. Tab numbers convey the steps used to complete the DRW. When two tabs have the same number, they are paired for one step in the process. The data generator copies raw data into the

[5] Prepared by Amy Borde, Shon Zimmerman, Andre Coleman, and Ron Kaufmann. For more information, please contact Amy Borde (360-681-3663; amy.borde@pnnl.gov).

template. The example in the DET is for the data generator to review for guidance. The examples may also contain formulas, where applicable. These may be copied into the templates as needed.

Definitions. The column headers or "fields" of each tab in the DRW are defined in the data dictionary.

The metadata and spatial data entry steps are described in the section on basic material of this handbook. The process converting field collected water depth data to water surface elevation is described below.

An organized file structure is important for keeping track of the various files created throughout the data correction process for WSE. A suggested file structure includes the following files and folders:

- Sensor Log file (see example in DRW)

Folders:

- 1_Original Files (downloaded from the sensor)
- 2a_AtmCorrected_Files
- 2b_ElevCorrected_Files
- 3_QAQC_Files
- 4_Final_Files

Note: a specific directory structure for WSE data files is prescribed because of the typically large amount of data and the complexity of the data reduction steps for WSE. The numbers in front of the folder names keep them in an organized order when working in Windows. Suggested filenames and locations in the file structure are provided in the sections below, with the following "2a_AtmCorrection". Example filenames are also provided in the steps below in the following format:

[SITE]_elev_correct_[*mmddyyii*].xlsx

where, [SITE] refers to a user defined site name or code and [*mmddyyii*] refers to the six digit date in month, day, year format, with two-letter initials at the end for the person who conducted the correction, QA/QC, or finalization step.

4.2 Data Reduction Steps

The steps taken to process the WSE data are described below.

Step 1. Save and read the Sensor Log.

The Sensor Log is a way of tracking and organizing the information collected as part of the field deployment and retrieval of water-level loggers. The Sensor Log usually contains information such as the following:

- serial number of each sensor for data tracking
- deployment and retrieval date and time

- initials of personnel conducting deployment/retrieval
- water depth above the sensor at the time of deployment and retrieval. This information is used to verify that the sensor is measuring correctly.
- distance from the sensor to the top of deployment post (or some way of marking the position of the sensor) at deployment and retrieval. This information is critical to determining the sensor elevation if elevation is surveyed at the top of the deployment post. This distance is also useful for determining if the sensor moved during the deployment period.
- distance from the sediment to the top of the post. This measurement is not needed for the processing, but indicates whether conditions surrounding the sensor changed during the deployment (e.g., erosion, deposition) or if the post moved.
- elevation of the top of the deployment post and/or elevation of the sensor
- notes about the deployment or retrieval.

See the Sensor Log template and example tabs in the DRW (1_SensorLog_Template and 1_SensorLog_Example).

Step 2. Perform the atmospheric pressure correction.

Water-level loggers record absolute pressure, which is converted to water depth by processing software that uses atmospheric pressure. Absolute pressure includes atmospheric pressure and water pressure. Atmospheric pressure is nominally 100 kPa (14.5 psi) at sea level and must be separated from the water pressure to determine water depth. However, atmospheric data fluctuate with weather and altitude; left uncompensated, barometric variations could result in errors of 0.6 m (2 ft) or more.

To compensate for barometric pressure changes, hourly atmospheric pressure data need to be acquired from either a local meteorological station (i.e., from the nearest station listed under the National Oceanic and Atmospheric Administration's [NOAA's] National Climatic Data Center [NCDC]) or from another pressure sensor that is deployed near the site and out of the water, specifically to collect atmospheric pressure. In either case, the time period during which atmospheric pressure data were collected needs to span the same time period the water level logger was deployed and, ideally, should have the same temporal resolution (i.e., hourly). Some software allows for the direct input of atmospheric data when they are collected with the same kind of data logger. If this is the case, follow the manufacturer's instructions for the correction process. If atmospheric are needed they can be downloaded from the NCDC at: at http://www.ncdc.noaa.gov/data-access/land-based-station-data. There are search tools for finding a specific station or a mapping tool to allow the user to search for the closest station with climate data.Once the atmospheric data is downloaded, format the data file according to the sensor software's specifications for using an imported atmospheric data file. For example, Onset Computer HOBOware® software requires a tab-delimited text file with only three columns: "Date", "Time (in same time zone as data was collected)", and "Sea level pressure (SLP) (mbar)", with the data in the following format: mm/dd/yyyy, hh:mm:ss, and the SLP should have one decimal place visible. Formatting can be done in Excel or any other worksheet.

Follow the manufacturer's software instructions for converting pressure data to water depth using the atmospheric data file and specifying the water density. Water density is determined based on salinity

and/or the water temperature if freshwater. After the water depth is calculated, export the data for further manipulations in a worksheet.

Example filename: [*SITE*]_atm_correct_[*mmddyyii*].xlsx
Located in: \2a_ Atm_Corrected_Files

The file exported from the water depth processing software will look something like the tab provided in the DRW titled: 2_AtmCorrected_example.

Step 3. Perform the elevation correction.

Water-surface elevation is determined by the sum of the sensor depth below the water-level surface and the surveyed elevation of the water-level logger (see Roegner et al. 2009, Section 4.1 Hydrology). The WSE will be relative to the datum in which the elevation was collected and can be converted into different data if desired.

For the following steps, please also refer to the "3_ElevCorrected_Example" tab in the DRW.

1. Save the file "atm_correct" as "elev_correct".

   Example filename: [*SITE*]_elev_correct_[*mmddyyii*].xlsx
   Located in: \2b_ElevCorrected_Files

   Remove unnecessary data columns, insert a new column at column A, and populate it with the site code. Ensure that the first row of the worksheet contains the column headers, with no extra rows above it. The only needed columns are as follows:

   "Site Code"
   "Date time"
   "Temp, °C"
   "Sensor Depth, meters"

   If the atmospheric pressure and the absolute pressure do not occur at the same logging interval, blank cells will occur in the Sensor Depth column and need to be removed.

2. Often the data are collected in the time zone in which the sensor is launched (e.g., daylight savings time, which is Greenwich Mean Time [GMT]-7 hours in the Pacific time zone). If the deployment period spans a time change, the data can be converted to"local" time, which will switch between daylight savings and standard time on the correct date.
   a. If converting to local time then the following steps can be followed:
      i. From the data reduction workbook, copy the 3_TimeCorrection_Lookup worksheet from its original workbook to the WSE workbook you are currently editing.
      ii. Insert two columns for "Date Time, GMT+00:00 and "Date Time, local".
      iii. The time must first be standardized to GMT+00:00 by populating the first new column with the sum of the GMT-7 date/time and 7hrs/24hrs (0.292) for converting from Pacific Daylight Time or 8hrs/24hrs (0.333) for converting from Pacific Standard Time.

iv. Copy the formula found in cell C3 from the example worksheet 3_ElevCorrected_Example in the DRW.

v. Paste the copied formula into the first blank cell in your second new column below the Date Time, local header. Populate the rest of the column with the formula.

3. Remove the data with time stamps that are outside the deployment period (i.e., times when the logger is recording, but has not been put in the water) by referring to the deployment/retrieval times in the Sensor Log. Be sure time zones are the same in the Sensor Log and in the data file.

4. In the sensor depth column, if the sensor was out of the water at any time the values will be negative. These negatives need to be changed to 9999 so they are easily identifiable during later processing.

5. Insert the following columns as shown in 3_ElevCorrected_Example

   "Temp Sensor Exposed"

   "ElevCorrection_*unit*"

   "Water_Surface_Elevation_*unit_datum*"

6. To calculate the WSE, get the sensor elevation value from the Sensor Log and sum the sensor elevation value and the values from the "Sensor Depth, meters" column. The resultant value is the WSE relative to the vertical datum, NAVD88 (North American Vertical Datum of 1988; assuming that was the datum used to collect the sensor elevation).

7. An optional step is to convert the WSE from NAVD88 to the Columbia River Datum (CRD), a low-water datum developed by the USACE. The conversion varies with location in the river and has been calculated by the USACE for each river mile. The conversions are available in NOAA Technical Memorandum NOS CS 22 (Xu et al. 2010).

Step 4. Quality control check.

This step is necessary to ensure the data was collected accurately and that the corrections and data processing steps were conducted properly. See QA/QC of Water Surface Elevation Data below for details.

Step 5. Finalize the WSE data.

This step completes the preparation of the WSE data for use in analysis or by others.

1. If uncorrectable errors are found then the QA/QC version of the file should not be finalized. If there are no errors or any detected errors are corrected then save the file in the Final folder.

   Example filename: [*SITE*]_FINAL_[*mmddyyii*].xlsx
   Located in: 4_Final_Files

2. Copy all data and paste as values so there are no formulas in the cells.

3. Delete unnecessary data:

    a. Delete the elevation conversion values.
    b. Delete any of the date/time columns except the desired time zone.

A time-series of WSE values is the final output from the procedure. The time-series data show plainly the hydrologic patterns at the site over time. Also, derived data such as the sum exceedance value and area-time inundation index use these WSE data.

Step 5. Enter the data into the DRW and prepare the DET.

The finalized WSE and temperature data will be uploaded into the *Oncor* database. Data can be copied and pasted into the pre-formatted red DET example tabs provided in the DRW or the Final data file created in the previous step can be formatted to be identical to the Measurements_DET example (i.e., with the necessary columns added). The three tabs required for uploading data to *Oncor* are as follows:

0_Metadata. This tab is where information about the DET is entered: the data point of contact, the filename, the program and project under which the data were collected, and the method used for data collection are input here.

Note: All data must be entered using the dropdown arrows at the right of the cell. If the needed option is not available, it can be added by clicking on the Standard Values button at the top of the page.

0_Spatial Data. The spatial data for each depth sensor consists of one point. This location point is required data for associating the WSE data with a place; if the location point has not been collected in the field using GPS or another survey method, it can be estimated using GIS. The elevation of the sensor can be entered with the location information. The point data associated with each depth sensor may be uploaded to *Oncor* using the DRW in one of two ways: 1) as coordinates or 2) as a shapefile. If coordinates are provided, the 0_SpatialData_Coordinates tab is used. If a shapefile is submitted, the 0_SpatialData_Shapefile tab must be completed. The spatial data must contain a column that contains a name that is the same as that in the Water_Elevation_Location field in the DET. In the 0_SpatialData_Coordinates tab this is the PointID field. In the 0_SpatialData_Shapefile tab, the File_RelateField identifies the attribute (field) in the shapefile that contains the depth sensor location ID. The names for every depth sensor must be unique from all others in the 0_SpatialData_Point tab or in the shapefile.

- 4_Deployment_DET. Each deployment period should be entered as an individual record (row). Some fields can be filled out by typing directly in the cell, while others require the use of dropdown arrows to enter a previously specified value. Again, if the needed option is not available in the drop down, it can be added by clicking on the Standard Values button at the top of the page. Descriptions of the fields can be found in the data dictionary. The Water_Elevation_Location field refers to the name of a point in the 0_SpatialData_Coordinates tab or in a GIS shapefile. The Time Zone field should include whether the data is in Greenwich Mean Time (GMT) of a specific time zone (e.g. Pacific) and the designation of Daylight Savings (e.g., PDT), Standard (e.g., PST), or if it switches between the two then both (e.g., PST/PDT). Sensor movement, any adjustments made due to the

movement, and water depth verification for each deployment should be noted in the following columns:Instrument_Movement

- Data_Corrected
- Water_Depth_Verified

Any addition information from the QA/QC procedure can be noted in the Instrument__Deployment_Notes column.

5_Measurement_DET. This tab is where the WSE and temperature data are entered, as follows:

1. In the first two columns enter the Water_Elevation_Instrument ID and Instrument_Deployment_Date from the 1_Deployment tab. These values need to be copied down the entire length of the data so that these identifying fields are associated with each individual record (row.

2. The next four columns (D−G) can be directly copied from the Final data file(s) ([*SITE*]_FINAL_[*mmddyyii*].xlsx) and pasted into the following columns in the DET:

DET Column Header	Final WSE Data Description
Water_Measurement_Date	The date/time column in "local" time
Water_Temperature	Temperature data in deg C
Temperature_Sensor_Exposed	Temperature sensor exposure flag
Water_Surface_Elevation	WSE data in meters relative to NAVD88.

3. The Instrument_Measurement_Notes column can be used to note anything that was observed about individual measurements; for example, the field water depth measurements taken at deployment and retrieval could be entered in this column.

4. The DB_Access column is where the user can define the level of access for the individual deployments in the data set.

4.3 Quality Control

The QA process and the QC steps in place for the WSE data are designed to ensure the quality of data for any ensuing tasks involving these data. The following steps should be completed by someone other than the person who conducted the data processing. In addition, all QA/QC steps should be listed in a QA/QC Log regardless of the results. Any issues found during QC should also be marked and commented on in the data file so they can be corrected for the final version. For additional details on QA/QC, see Section 2.3 and Appendix C.

1. Complete an atmospheric data correction check.

   The atmospheric correction check is designed to ensure the atmospheric data were appropriate for the site and to identify possible sensor malfunction. Pre- and post-deployment of the sensor should record a "depth" value close to 0 and not vary more than a few centimeters.

Open the [*SITE*]_atm_correct_[*mmddyy*].xlsx file from the location in:
_Atm_Corrected_Files

Using the data in the Sensor Log determine the date/times of deployment and retrieval. Check the sensor depth column before and after the dates listed for deployment and retrieval. In the QA/QC Log, record the greatest value within 2 hours prior to deployment or after retrieval.

2. Verify water depth.
Field water depth measurements are essential to confirming that the pressure sensor is measure accurately.

   Open the [*SITE*]_elev_corrected.xlsx file from the location:
   \2b_Elev_Corrected_Files

   Find the times in the Excel file closest to the times of deployment and retrieval. Compare the field water level measurement in the Sensor Log with the sensor depth measurement in the water-level file (make sure the times and time zones are the same). Note any differences in the QA/QC Log. See the tab 2_AtmCorrected_Example in the DRW and notes highlighted in blue for an example.

   If the Sensor Log has notes about potential issues with this measurement then copy the note into the QA/QC Log. If the field measurement was not taken at exactly the same time as the sensor measurement then tide tables may need to be referenced to determine whether the tide could have resulted in a difference in the measurements.

3. Perform an elevation correction check.

   Check the depth sensor elevation value in the Sensor Log to make sure the correct value was used.

   Check the equations where these values are applied to make sure that they are correctly calculated for the entire column.

4. Check for sensor movement during deployment.

   Within the Depth Sensor Log, check for differences in the measurement of the sensor to top of post ("Dist to top of post" in the log) between deployment and retrieval. Note any difference in the QA/QC Log and differences greater than 10 cm require an investigation of the water-level data to see if the time of change can be determined and corrected.

5. Check the Sensor Depth column for 9999 values.

   All negative values, which were logged when the sensor was above the water surface, should have been replaced with 9999 values. This check can easily be done using the Filter function in Excel.

6. Check the Temperature Sensor Exposed column.

   Ensure that the temperature values are flagged appropriately when the temperature sensor was exposed. Again, this can be done using the Filter function in Excel for all depth values less than 7 cm.

7. Create a hydrograph.

   The last step of the QA/QC process is the creation of the hydrograph to check for any anomalies or odd trends in the data.

   a. Create a new tab in the workbook and label it “graph”.

   b. Copy the “Time” and “WSE” columns into the new tab. Select the relevant time period to plot.

   c. In the ribbon, go to the Insert tab and select a Scatter with Smooth lines Plot type. Select the time column for the x value and select the WSE column for the dependent variable.

   Note any anomalies in the QA/QC Log. This hydrograph is also useful for looking at hydrologic patterns in the data.

If there are errors in the water-level file, make sure they are highlighted and commented on, then save the file and change the file name from “elev_correct” to QA/QC with date and initials (ii) at the end of the filename in the format mmddyyii.

Example filename: [*SITE*]_QAQC_[*mmddyyii*].xlsx
Located in: \3_QAQC_Files

4.4 Steps for Reducing Temperature Data

If temperature data were collected at the same time as the WSE data then the following procedure applies. No correction is necessary for the temperature data; however, measurements taken when the temperature sensor was out of the water should be flagged for removal prior to any analysis. The data can be either replaced by 9999, similar to the WSE data, or the data can be simply flagged so the in-air measurements are still part of the data set. The latter method allows the user to evaluate air temperature relative to water temperature, but care must be taken to ensure these measurements are not included in any water temperature analyses.

1. Determine the location of the temperature sensor relative to the pressure sensor in the sensor housing or as measured in an adjacent sensor.

2. Use the distance value between the sensors to determine when the temperature sensor is exposed. For example, with Onset HOBO data loggers, the temperature sensor is located 6 cm above the pressure sensor. Therefore, any temperature data collected when the water depth was less than 7 cm should be flagged. See the 3_ElevCorrected_Example tab in the DRW for an example of how this can be calculated.

4.5 Uploading Data to *Oncor*

Please see Section 2.6 in the basic material for a description of these procedures.