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Overview

The Service Water and Impoundment Monitoring (SWIM) database was developed for the purposed of maintaining water level and water quality (salinity) data for areas managed by the U.S. Fish and Wildlife Service (USFWS). There are two versions of SWIM. SWIM1 is a Microsoft Access relational database intended for use by field stations not desiring to store their location data in a GIS format. A "geodatabase" version (SWIM2) is also available for field stations that would like to capture and maintain their location data using a GIS format.

SWIM was NOT designed to record water management actions! Other Service databases such as the Refuges Land Geographic Information System (RLGIS) and the Refuge Management Action Database (RMAD) are available to maintain this information. However, if properly used, SWIM1 data tables can be linked to data residing in RLGIS or with data exported from RMAD.

A user acceptance team (UAT) comprised of the following individuals were involved in the design and development of SWIM:

Todd Sutherland – Region 3/5
Kevin Holcomb - Region 5
Wendy Stanton – Region 4
Mary Balogh – Region 3
Tom Penn – Region 5
Doug Brewer – Region 3
Steve Earsom – Region 4
John Gallegos – Region 5
Jorge Coppen – Region 5

The following individual contributed significantly by designing and developing the Visual Basic application H20 which is used by SWIM for graphing purposes:

Tim Fox - USGS

The following individuals contributed by providing guidance, assistance, and/or suggestions:

Hal Laskowski – Region 5
Patrick Donnelly – Region 2
Chuck Loesch – Region 6
Dan Craver – Region 1
Ron Huffman – Region 3

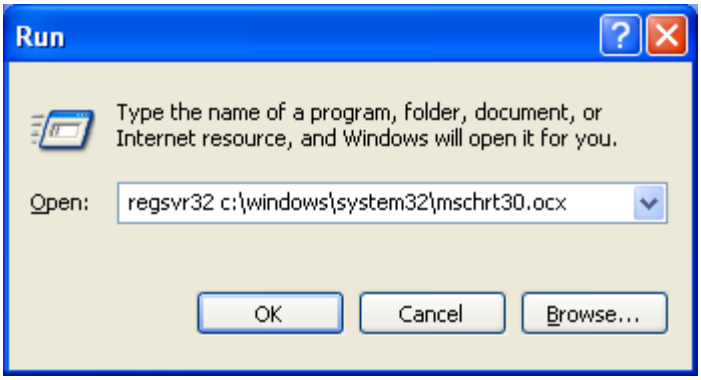
Installation

1. Unzip the *SWIM1.zip* file to any drive/folder on your PC or network drive.

2. NOTE: This step is only required if the computer you are using does not have ArcGIS 9.2 service pack 4 or higher installed. If not, you will need to register an OCX file that is used by the graphing application. You need ADMIN rights on your computer to register and OCX file.

   Copy the *mschrt20.ocx* file located in *\SWIM1\VB* folder and paste into *c:\windows\system32* folder. If asked to overwrite the file, say NO and do not continue with this step. If not asked to overwrite this file, you will need to register this OCX file. From the **Start** menu, choose **Run** and type or paste the following text into the OPEN section:

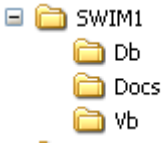
   regsvr32 c:\windows\system32\mschrt20.ocx



   Click **OK** and you will be notified that the file has been registered.

SWIM Folder Structure

Once the SWIM1 application files have been unzipped, you will have the following directory structure underneath the folder you specified during installation:



Do not move or rename any files underneath the SWIM1 folder structure!

The main application file is located immediately underneath the SWIM 1folder and is named *watermon_main.mdb*. This is the file you open to enter data and

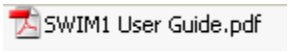
generate reports. It contains the code to run the SWIM1 user interface. This file does NOT store any of your data.

Under the **DB** folder, there are 2 Access database files (MDBs).

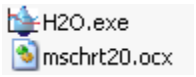
The *Water_Monitoring.mdb* file is the file that stores all of your station's water monitoring data. The *Water_Monitoring.mdb* file is the most important file and a copy or backup should be made periodically.

The *watermon_lookup.mdb* file stores the lookup tables used by the SWIM1 application.

The **DOCS** folder contains the "SWIM1 USER GUIDE".

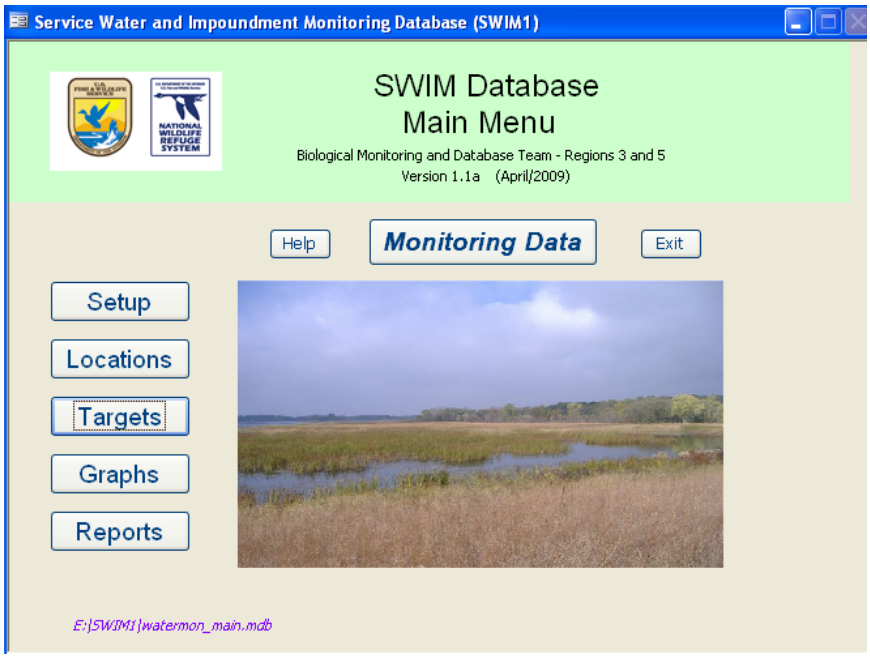


The **VB** folder contains the executable for the H20 charting application and a required OCX file that needs to be registered in order to use the graphing application (see Installation Step 2 above).



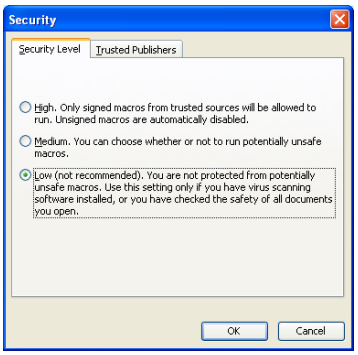
Getting Started

1. Double click on the *watermon_main.mdb* file to launch the *Main Menu*.



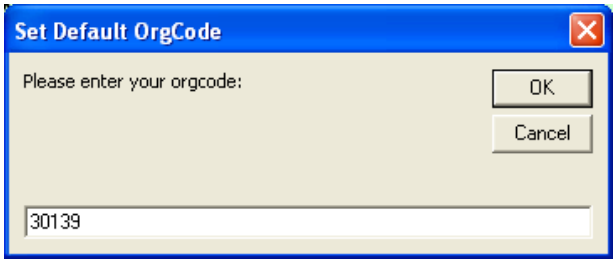
NOTE: If a security warning message appears, click NO and then choose OPEN in the next dialog that appears.

TIP: To avoid this security warning, change your MACRO SECURITY settings in Access. Simply go to **Tools**…**Macro**…**Security** and then check *LOW*.



2. Click on the **Setup** button. Enter your 5 digit organizational code. If you manage only one site, you just have to use the setup function once. If you manage more than one site, use the setup function prior to entering data for a site that uses a different organizational code.

NOTE: The **Initial Setup** button also checks and establishes links to required tables and other system files. You are warned if you have moved, deleted or renamed any required files. Therefore, after installing SWIM1, you must run **Setup** to ensure links to the required data tables and files are established. If you ever move the SWIM 1 folder after installation, you must run Setup again to establish table links!

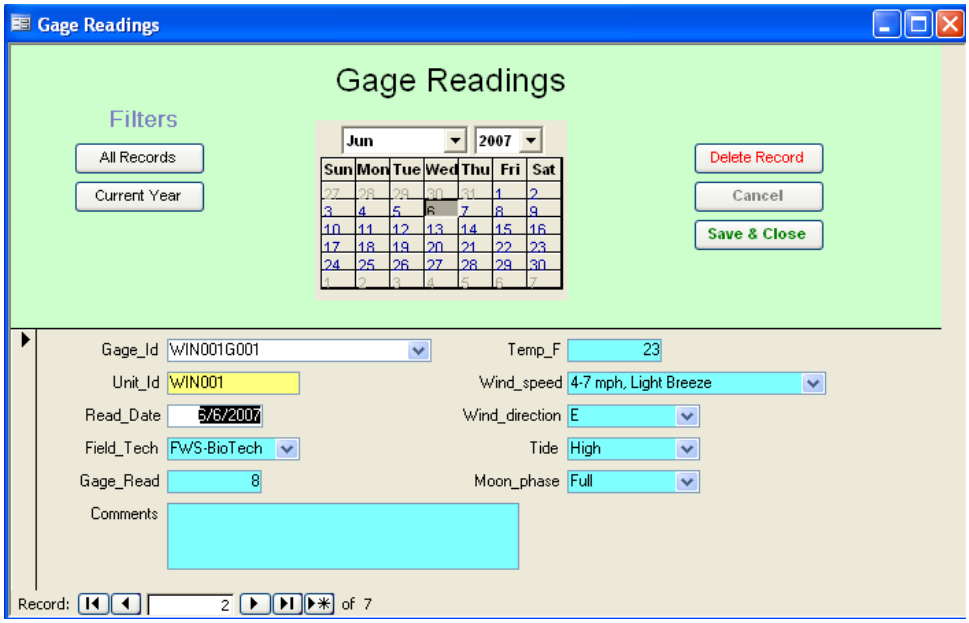


3. You are now ready to begin using SWIM1!

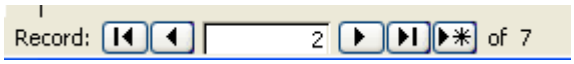
Data Entry Basics

Data entry for SWIM is primarily performed through the use of forms. All forms can be accessed through the *Main Menu*. The *Gage Readings* form is provided below as an example.

All **required** fields have a white background.
All **auto-populated** fields have a yellow background.
And, fields that are **optional** have a blue background.



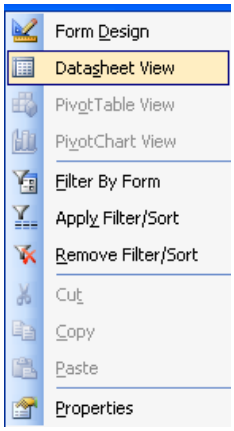
The lower left portion of the form has the navigation buttons for moving between records.

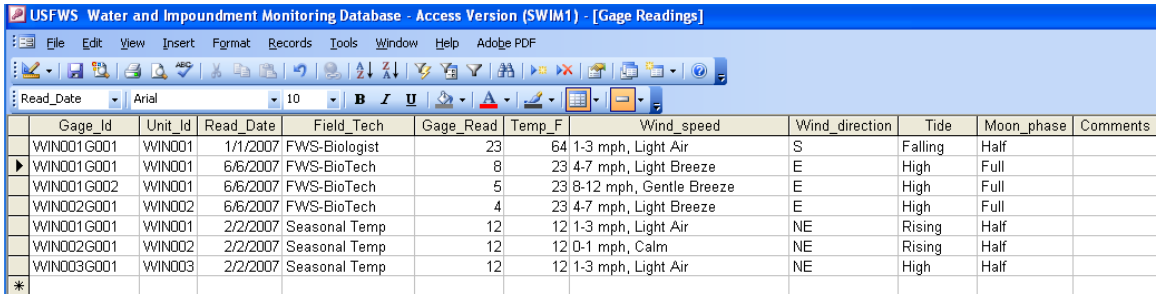


Move to the first record….
Previous record……..
Next record……
Move to last record……
Create new record…….

You may also choose to use datasheet view to enter records in a tabular format.

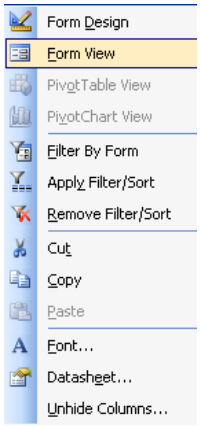
To switch to the datasheet view, simply right click on any empty space from the current form and choose *Datasheet View*.





Gage_Id	Unit_Id	Read_Date	Field_Tech	Gage_Read	Temp_F	Wind_speed	Wind_direction	Tide	Moon_phase	Comments
WIN001G001	WIN001	1/1/2007	FWS-Biologist	23	64	1-3 mph, Light Air	S	Falling	Half	
WIN001G001	WIN001	6/6/2007	FWS-BioTech	8	23	4-7 mph, Light Breeze	E	High	Full	
WIN001G002	WIN001	6/6/2007	FWS-BioTech	5	23	8-12 mph, Gentle Breeze	E	High	Full	
WIN002G001	WIN002	6/6/2007	FWS-BioTech	4	23	4-7 mph, Light Breeze	E	High	Full	
WIN001G001	WIN001	2/2/2007	Seasonal Temp	12	12	1-3 mph, Light Air	NE	Rising	Half	
WIN002G001	WIN002	2/2/2007	Seasonal Temp	12	12	0-1 mph, Calm	NE	Rising	Half	
WIN003G001	WIN003	2/2/2007	Seasonal Temp	12	12	1-3 mph, Light Air	NE	High	Half	

To switch back to the form, simply right click on the datasheet view window heading and choose “Form View”.



Some forms have filters which allow you to subset the data by the current year. You can also subset by specific gage or sampling site using a custom date range on forms related to target values.

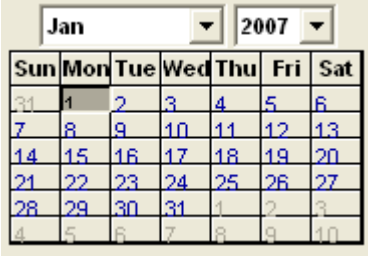
Delete Record – Deletes the existing record.
Cancel – Cancels any changes made to the existing record and closes the form.
Save & Close – Saves the existing record and closes the form.

NOTE: If you click the X in the upper right of the form, this will also save the existing record and close the form.

Records are also saved when you move to the next record. You will be warned if any required fields are missing or if there are duplicate values in a primary key field.

Some records cannot be deleted due to referential integrity. For example, if you have any records related to an existing gage (targets or readings), you will not be able to delete this gage unless you delete the associated records.

On several forms, date fields can be entered manually using any acceptable DATE format or by choosing a date from the calendar.



Use the TAB key on your keyboard to move to the next field on the form or datasheet.

The *Unit_Id*, *Gage_Id*, *Site_Id* fields automatically convert letters to uppercase.

The *Unit_Name*, *Gage_Name* and *Site_Name* fields automatically convert the first letter of each word to upper case.

Locations

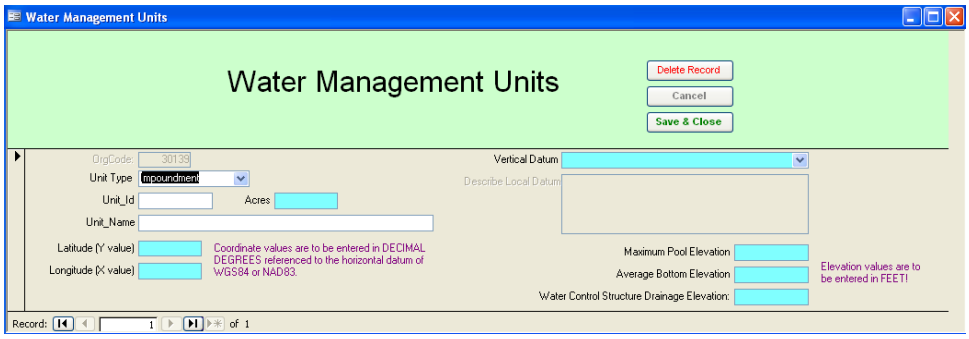
The locations button on the main menu launches the *Locations Menu*. This menu provides access to three data entry forms:

Water Management Units
Gages
Sampling Sites

Water Management Units

Water Management Units must be entered before any other data can be entered.

1. To enter water management units, from the *Main Menu* click on **Locations**. From the *Location Menu*, choose **Water Management Units**.



2. Begin entering data to define your water management unit. The *OrgCode*, *Unit_Type*, *Unit_ID* and *Unit_Name* fields are required. See *Appendix A* for field definitions and suggested naming conventions.

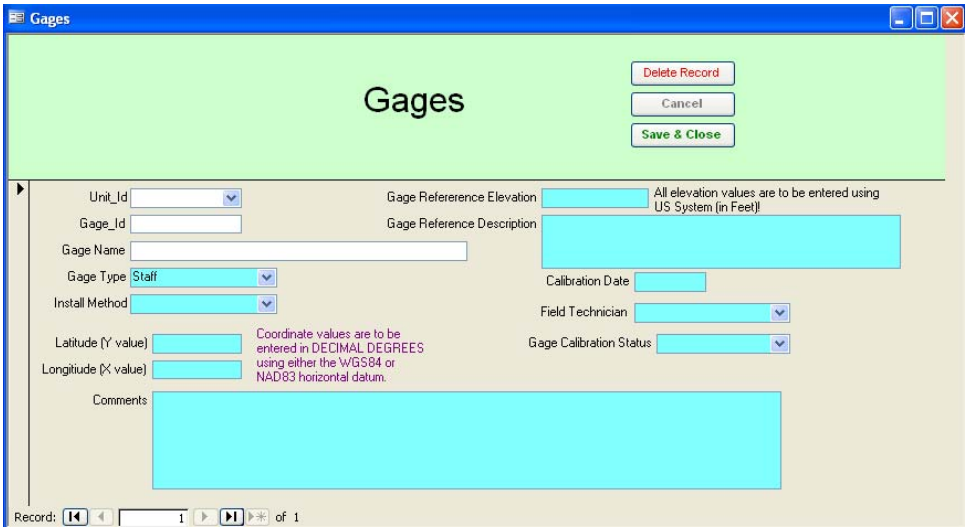
TIP: If you already have your water management units in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

TIP: Here is a URL to convert from UTM coordinates to decimal degrees:

http://home.hiwaay.net/~taylorc/toolbox/geography/geoutm.html

Gages

1. To enter gages, from the *Main Menu* click on **Locations**. From the *Location Menu*, choose **Gages**.



2. Begin entering data to define your gage. The *Unit_Type*, *Unit_ID* and *Gage Name* fields are required. See *Appendix A* for field definitions and suggested naming conventions.

   NOTE: The *Gage_Id* field will be auto-populated with a concatenation of the *Unit_Id* plus the letter *G* plus *001* to conform to suggested naming conventions. However, you can change this field if you are employing your own naming convention for the *Gage_Id*.

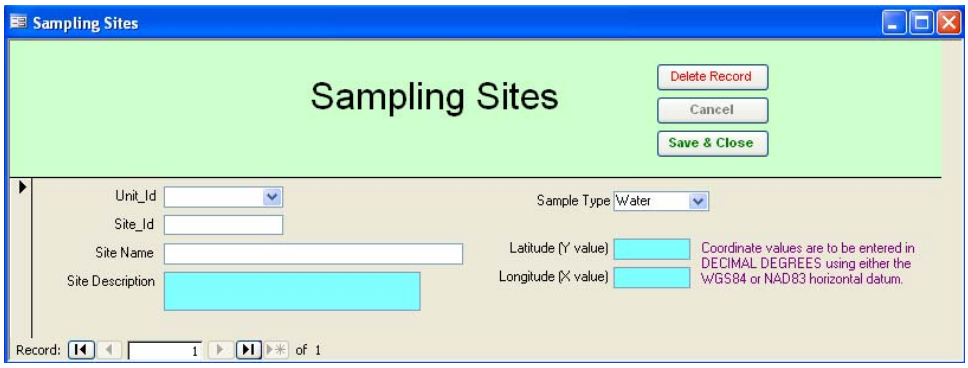
   TIP: If you already have your gages in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

   TIP: Here is a URL to convert from UTM coordinates to decimal degrees:

   http://home.hiwaay.net/~taylorc/toolbox/geography/geoutm.html

Sampling Sites

1. To enter sampling sites, from the *Main Menu* click on **Locations**. From the *Location Menu*, choose **Sampling Sites**.



2. Begin entering data to define your sampling site. The *Unit_Type*, *Unit_ID* and *Name* fields are required. See *Appendix A* for field definitions and suggested naming conventions.

   NOTE: The *Site_Id* field will be auto-populated with a concatenation of the *Unit_Id* plus the letter *S* plus *001* to conform to suggested naming conventions. However, you can change this field if you are employing your own naming convention for the *Site_Id*.

   TIP: If you already have your sampling sites in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

   TIP: Here is a URL to convert from UTM coordinates to decimal degrees:

   http://home.hiwaay.net/~taylorc/toolbox/geography/geoutm.html

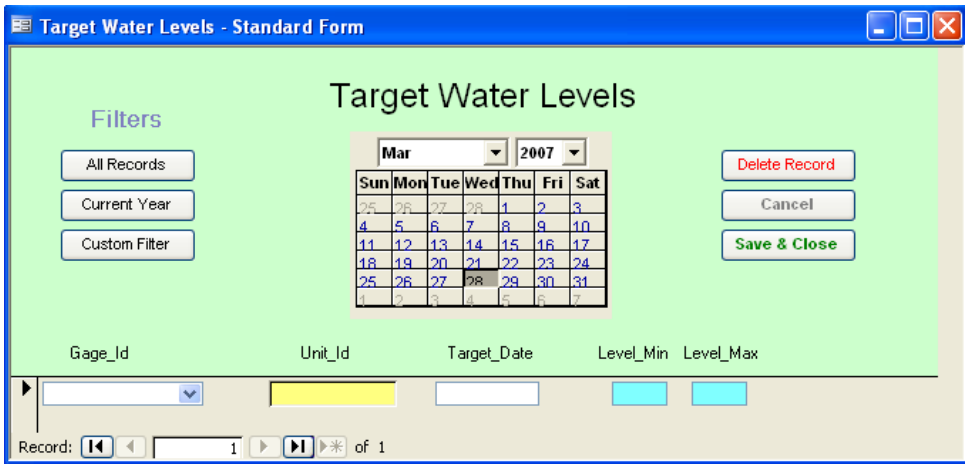
Targets

Target water levels for your gages and target salinity values for your sampling sites can be entered using two different forms. The "custom" form allows you to enter targets for an entire year using the 1st and 15th of each month as the target date. You cannot edit records using the "custom" form. The "custom" form is simply used for data entry. The "standard" form allows you to enter target records individually. The "standard" form also allows you to edit and filter records.

Water Levels – Standard

The standard form can be used when you want to enter target levels for a specific date, make minor edits or if you simply want to peruse your existing records. This form also provides the ability to filter records by the current year or by a specific gage and date range. Individual records can be deleted using this standard form as well.

1. Click **Targets**. A *Specify Targets Menu* appears. Now click on **Water Levels – Standard**.



2. Begin entering data to define a target water level or range for a particular gage. If you wish to have target water levels defined as a range, change the *Level_Max* value. If not, leave the *Level_Max* field the same as the *Level_Min* field. The *Gage_Id*, *Unit_Id* and *Target_Date* fields are required. See *Appendix A* for field definitions.

   TIP: If you already have your target water levels in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

Water Levels – Custom

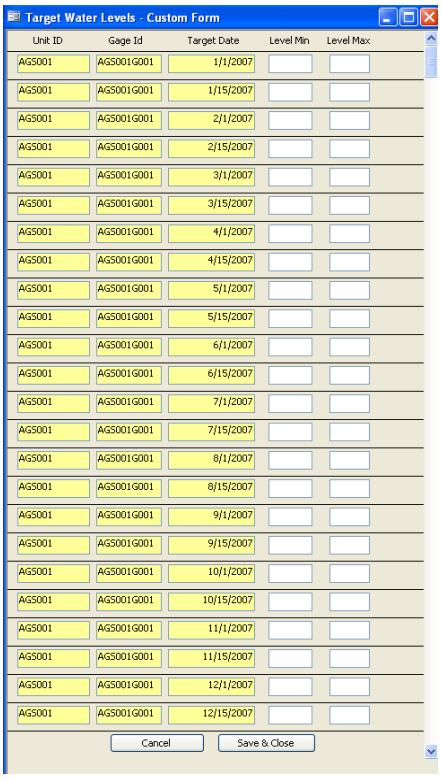
The custom form is used when you want to enter bi-monthly target levels for the entire year. This form allows you to enter target gage levels for the 1st and 15th of each month for an entire year.

1. Click **Targets**. A *Specify Targets Menu* appears. Click on **Water Levels – Custom**.

2. Choose the *Gage ID* for which you wish to establish target water levels. Enter the desired year and click **OK**.

3. Maximize the form window to see all 24 records. Begin entering minimum water levels. The *Level_Max* field is auto-populated with the *Level_Min* value. If you wish to have target water levels defined as a range, change the *Level_Max* value. If not, leave the *Level_Max* field the same as the *Level_Min* field.

   TIP: Use the TAB key to move to the next *Level_Min* record.



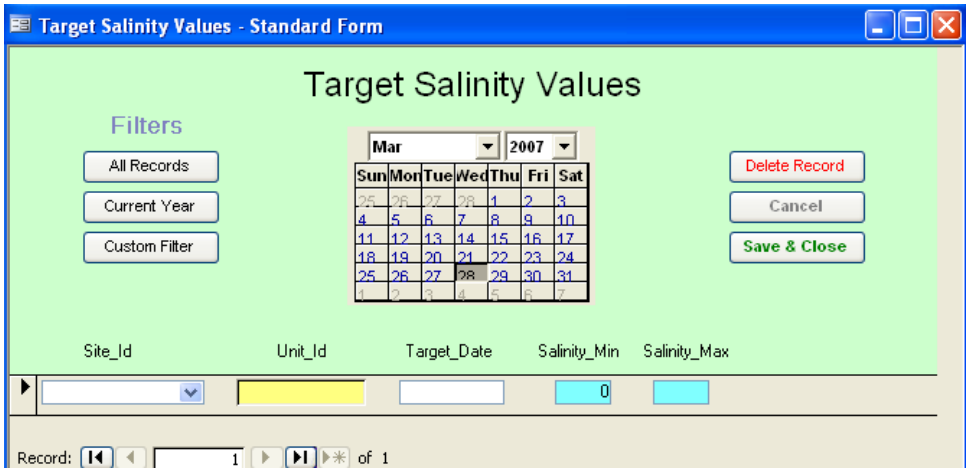
4. Click **Save & Close** when finished.

   WARNING: If any record with the same UNIT_ID, GAGE_ ID and DATE already exists in the master gage targets table (*tbl_TargetsLevel*), it will be overwritten with the information on this form. No warning is given! However, any records with an empty (null) *Level_Min* value do not overwrite an existing record.

Salinity – Standard

The standard form can be used when you want to enter target values for a specific date, make minor edits to your data or if you simply want to peruse your existing records. This form also provides the ability to filter records by current year or by a specific date range and sampling site. Individual records can be deleted using this standard form as well.

1. Click **Targets**. A *Specify Targets Menu* appears. Now click on **Salinity – Standard**.



2. Begin entering data to define a target salinity value or range for a particular sampling site. If you wish to have target salinity levels defined as a range, enter the appropriate values in the *Salinity_Min* and *Salinity_Max* fields. If you do not want to specify a range, enter the same value in both the *Salinity_Min* and the *Salinity_Max* field. The *Site_Id*, *Unit_Id* and *Target_Date* fields are required. See *Appendix A* for field definitions.

   TIP: If you already have your target water levels in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

Salinity – Custom

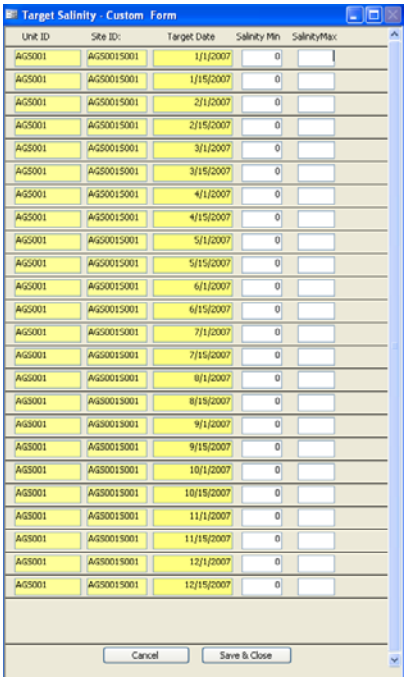
The custom form is used when you want to enter bi-monthly target values for the entire year. This form allows you to enter target salinity values for the 1st and 15th of each month for an entire year.

1. Click **Targets**. A *Specify Targets Menu* appears. Click on **Salinity – Custom**.

2. Choose the *Site ID* for which you wish to establish target salinity values. Enter the desired year and click **OK**.

3. Maximize the form window to see all 24 records. Begin entering data to define a target salinity value or range for a particular sampling site. If you wish to have target salinity levels defined as a range, enter the appropriate values in the *Salinity_Min* and *Salinity_Max* fields. If you do not want to specify a range, enter the same value in both the *Salinity_Min* and the *Salinity_Max* field.

   TIP: Use the TAB key to move to the next *Salinity_Max* record.



4. Click **Save & Close** when finished.

WARNING: If any record with the same UNIT_ID, SITE_ ID and DATE already exists in the master salinity targets table (*tbl_TargetsSalinity*), it will be overwritten with the information on this form. No warning is given! However, any records with an empty (null) *Salinity_Max* value do not overwrite an existing record.

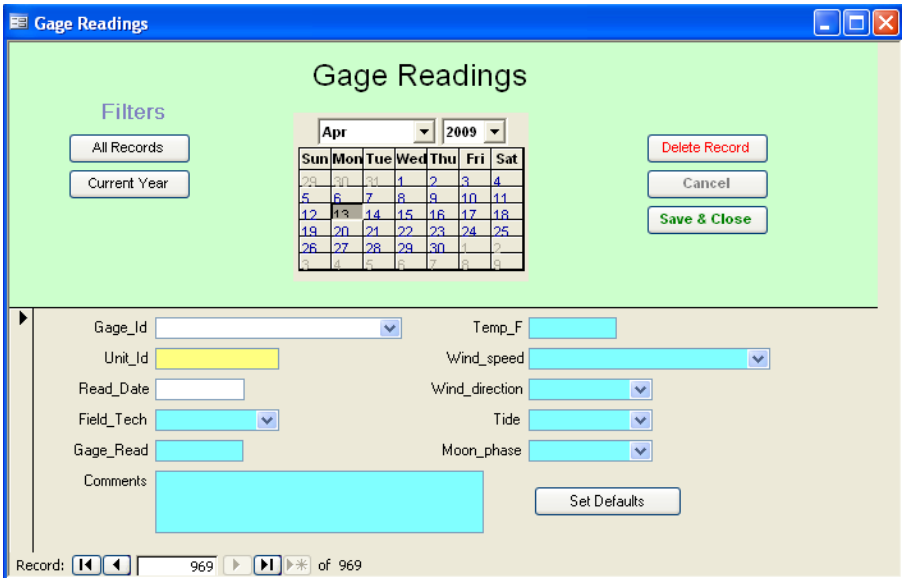
Monitoring Data

Monitoring data for gages and sampling sites can be entered using two different forms. The "standard" forms allow you to enter gage readings or salinity sampling measurements individually. These forms also allow you to edit and filter records. The "mass data entry" form allows you to enter data for all of your station's gage and/or sampling sites on one form. The monitoring event details such as date and weather conditions only needs to be entered once when using the "mass data entry" form. This form is the most efficient way to enter several monitoring data records that were obtained on the same day.

Water Levels

This standard form is used when you want to enter a gage reading for a specific gage and date, make minor edits to your data or if you simply want to peruse your existing records. This form also provides the ability to filter records by current year. Individual records can be deleted using this standard form as well.

1. Click **Monitoring Data**. An *Enter Monitoring Data Menu* appears. Click on **Water Levels**.



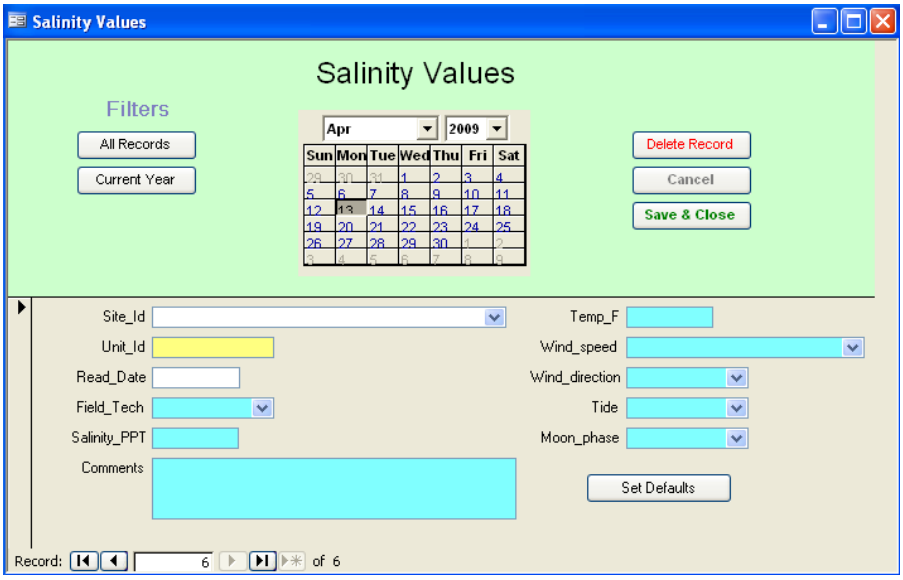
2. Begin entering gage readings data See *Appendix A* for field definitions. Use "Set Defaults" to streamline data entry when entering multiple readings.

   TIP: If you already have gage reading data in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

Salinity

This standard form is used when you want to enter a salinity values for a specific sampling site and date, make minor edits to your data or if you simply want to peruse your existing records. This form also provides the ability to filter records by current year. Individual records can be deleted using this standard form as well.

1. Click **Monitoring Data**. An *Enter Monitoring Data Menu* appears. Click on **Salinity**.



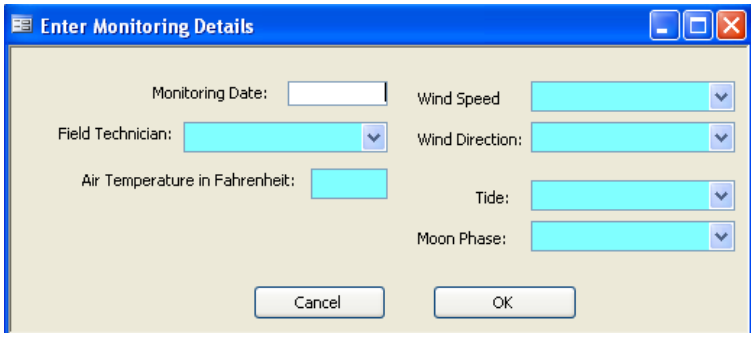
2. Begin entering salinity values data. See *Appendix A* for field definitions. Use “Set Defaults” to streamline data entry when entering multiple readings.

TIP: If you already have salinity values data in a spreadsheet or other database, see *Appendix B* for instructions on importing existing data into SWIM1.

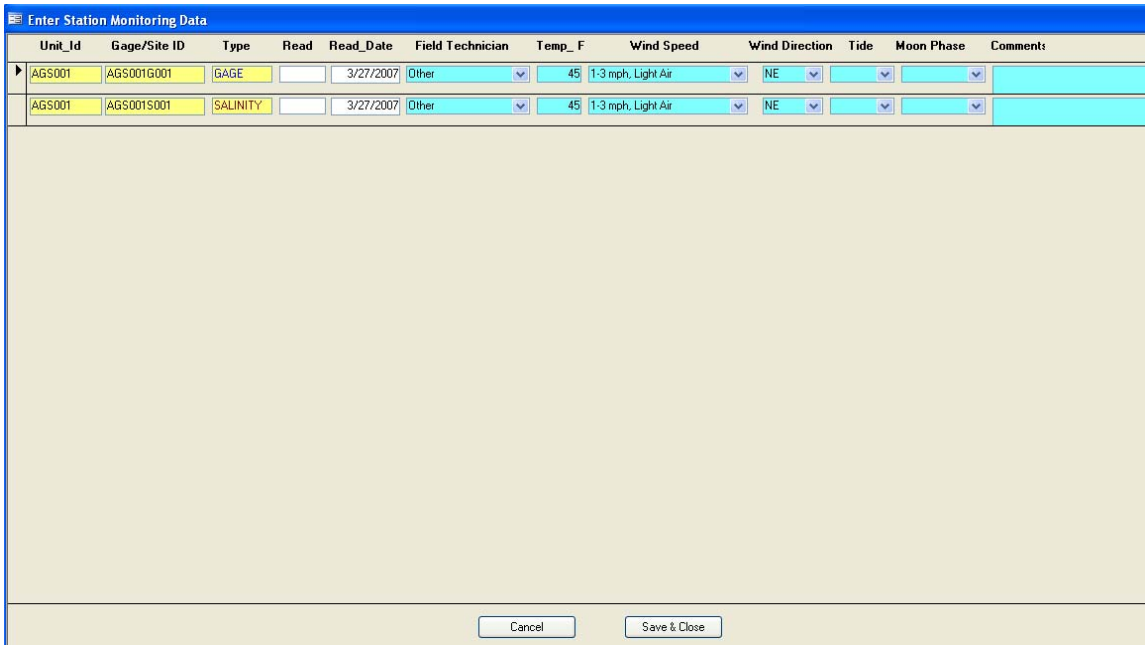
Mass Data Entry

The “mass data entry” form allows you to enter data for all of your station’s gage and/or sampling sites on one form. The monitoring event details such as date and weather conditions only needs to be entered once when using the “mass data entry” form. This form is the most efficient way to enter several monitoring data records that were obtained on the same day.

1. Click **Monitoring Data**. An *Enter Monitoring Data Menu* appears. Click on **Mass Data Entry**.



3. Enter your monitoring details. See *Appendix A* for field definitions. Click **OK** when finished. A new form opens up showing all of your gages and sampling sites on one form.



4. Enter your “read” for each gage and sampling site. Change additional parameters if necessary. Click **Save & Close** when finished.

   WARNING: If records with the same UNIT_ID, LOC_ ID and DATE already exist in the master tables (*tbl_Gage_Reads*, *tbl_Quality_Reads*), they will be automatically overwritten with the new data you have entered on this form. No warning is given! If you did not obtain a “read” value for one of the gages or sampling sites on this particular date, delete the record before clicking on **Save & Close**. But, if this is a legitimate null value (you actually went to the site on this date but couldn’t perform a reading because of ice or some other reason), then do not delete the record so it can be recorded as a null value (essentially recording the fact that you actually physically monitored this gage or site, but could not obtain a value). If you do not delete gage and site records that were not physically monitored on this date, these records will appear in the master database with null values in the *Gage_Read or Salinity_PPT* field.

   TIP: To delete a record on this form, click on the left side of the record you wish to delete to **select the record**. Next, right click and select **Cut**. Click **OK** to delete the record from the form.

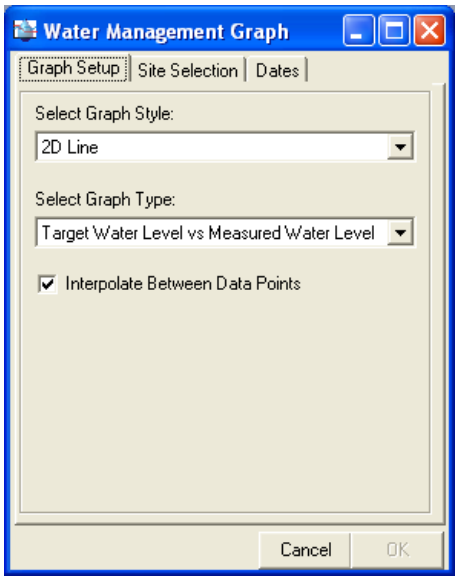
Graphs

After you have successfully entered your data into SWIM, you can easily start producing graphical reports. A separate Visual Basic application called H20, allows you to generate graphs using the SWIM database. Click **Graphs**.

1. Ensure the GRAPH SETUP tab is selected. Select your *Graph Style* and *Graph Type*. There are two types of graphs that can be generated:

   Target Water Level vs. Measure Water Level
   Target Salinity vs. Measured Salinity

   Specify whether you want interpolation between the data points. By default, interpolation is selected.



3. Now click the SITE SELECTION tab. Specify the water management unit. A list of all gages or sampling sites appear depending on you graph type selection. Choose the appropriate gage or sampling site that you want to use.

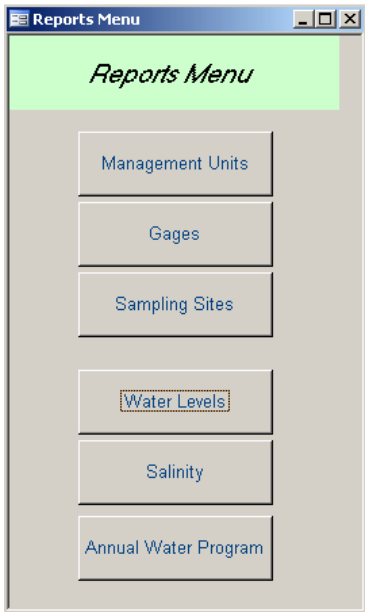
5. Now click on the DATES tab. Choose the *Graphing Interval*. The total number of records that meet your gage/site and date parameters are displayed in red.

6. Click **OK**. The *H20 Chart* window appears. You can modify the graph using the CAPTIONS, LEGEND, AXES or SERIES tabs. There is also functionality to save and export your graphs in a vector format.

7. If you want to change your data parameters, close the *H20 Chart* window and the *Water Management Graph* dialog will appear again. Now simply change your parameters and hit **OK** to view your changes.

Reports

There are six summary reports that can be generated from SWIM data.



Management Units - Summary report of all water management units in the SWIM database.

Gages - Summary report of all gages in the SWIM database.

Sampling Sites - Summary report of all sampling sites in the SWIM database.

Water Levels – Summary report for a specific gage and date range.

Salinity – Summary report for a specific sampling site and date range.

Annual Water Program – Summary report for annual water program. This report interpolates data to report dates of the 1st and 15th of the month. All read dates between the 23rd and the 7th are interpolated to the 1st. All read dates between the 8th and the 22nd are interpolated to the 15th. If more than one read date occurs within these periods, the closest to the report date is used.

TIP: For reports requesting start/end dates, simply double click in the *Enter Start Date* field to auto-populate with January 1st of current year. Double click in the *Enter End Date* field to auto-populate with December 31st of current year.

APPENDIX A – Table & Field Descriptions

LOCATIONS

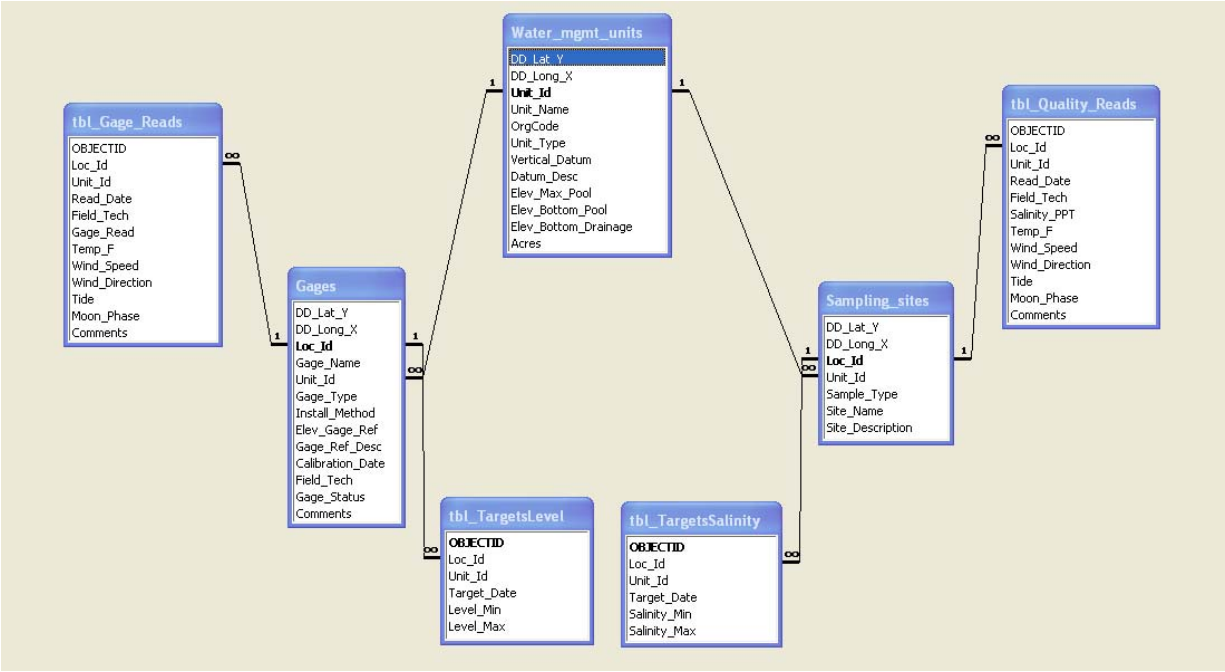
Water Management Units data are stored in the *Water_mgmt_units* table.
Gages data are stored in the *Gages* table.
Sampling Sites data are stored in the *Sampling_sites* table.

TARGETS

Water Level Targets data are stored in the *tbl_TargetsLevel* table.
Salinity Targets data are stored in the *tbl_TargetsSalinity* table.

MONITORING DATA

Water Levels data are stored in the *tbl_Gage_Reads* table.
Salinity data are stored in the *tbl_Quality_Reads* table.



Water Management Units

Water management units (WMUs) are areas located within or outside NWRS boundaries that are managed or monitored by FWS staff. These units can be natural occurring or artificial impoundments.

WMUs must be entered into SWIM1 before anything else can be entered. WMUs have "gages" and "sampling sites". WMUs may have zero, one or many "gages". WMUs may have zero, one or many "sampling sites".

Data records for WMUs are stored in the ***Water_mgmt_units*** table.

There are four required fields in the ***Water_mgmt_units*** table: *Unit_Id*, *Unit_Name*, *OrgCode* and *Unit_Type*.

The primary key for the ***Water_mgmt_units*** table is the *Unit_Id* field. Since this field is the primary key, all records in this field must be unique. The *Unit_Id* field contains a unique identifier for each WMU.

You may use an existing naming convention for the *Unit_Id* field. However, the naming convention must conform to this field's data type and length. The *Unit_Id* field is a "text" field with a length of 6. If your existing naming convention doesn't meet these requirements, a suggested naming convention is provided below. You may also choose to develop your own naming convention.

The "suggested" naming convention is as follow:

Station literal **+** *sequential numbering starting at 001*

A list of all FWS station literals(lit) is found here:
http://www.fws.gov/stand/standards/IFWS_LIT_LRS_012406.txt

NWR Example: WMUs located on Agassiz NWR would have the following Unit_Ids:

AGS001, AGS002, AGS003…….AGS999

WMD Example: WMUs located in Jackson County Minnesota maintained by the Windom WMD would have the following Unit_IDs:

WJC001, WJC002, WJC003…….WJC999

This suggested naming convention allows for a maximum of 999 water management units for each NWR or 999 WMUs for each county within a WMD. This naming convention is highly recommended for field stations that may want

to combine monitoring data at a later point in order to conduct regional statistical analysis.

Gages

Gages are located within WMUs and used to measure water levels.

You must create and attribute "gages" before you can specify “targets” or enter “gage readings”.

A “gage” is owned by one and only one WMU. There can be many “gages” within one WMU.

Data records for gages are stored in the ***Gages*** table.

There are three required fields in the ***Gages*** table: *Gage_Id**, *Gage_Name* and *Unit_Id*.

*Field alias, this field is actually named *Loc_Id* in the master table.

The primary key for the ***Gages*** table is the *Gage_Id* field. Since this field is the primary key, all records in this field must be unique. The *Gage_Id* field contains a unique identifier for each gage.

A foreign key in the **Gages** table is the *Unit_Id* field. This field allows gages to be related back to the **Water_mgmt_units** table.

You may use an existing naming convention for the *Gage_Id* field. However, the naming convention must conform to this field’s data type and length. The *Gage_Id* field is a “text” field with a length of 10. If your existing naming convention doesn’t meet these requirements, a suggested naming convention is provided below. You may also choose to develop your own naming convention.

<u>The “suggested” naming convention is as follow:</u>

Unit_Id **+** *G* **+** *sequential numbering starting at 001*

NWR Example: A gage located on an Agassiz NWR impoundment with a *Unit_Id* of AGS001 would have the following *Gage_Id*:

AGS001G001

WMD Example: A gage located on a Jackson County impoundment with a *Unit_Id* of WJC001 would have the following *Gage_Id*:

WJC001G001

This suggested naming convention allows for a maximum of 999 gages for each WMU. This naming convention is highly recommended for field stations that may want to combine monitoring data at a later point in order to conduct regional statistical analysis.

Sampling Sites

Sampling sites are the point locations within WMUs where salinity measurements are taken.

You must create and attribute "sampling sites" before you can specify “targets” or enter “salinity readings”.

A “sampling site” is owned by one and only one WMU. There can be many “sampling sites” within one WMU.

Data records for sampling sites are stored in the ***Sampling_sites*** table.

There are four required fields in the ***Sampling Sites*** table: *Site_Id**, *Site_Name*, *Unit_Id* and *Sample_Type*.

*Field alias, this field is actually named *Loc_Id* in the master table.

The primary key for the ***Sampling_sites*** table is the *Site_Id* field. Since this field is the primary key, all records in this field must be unique. The *Site_Id* field contains a unique identifier for each sampling site.

A foreign key in the **Sampling_sites** table is the *Unit_Id* field. This field allows sampling sites to be related back to the **Water_mgmt_units** table.

You may use an existing naming convention for the *Site_Id* field. However, the naming convention must conform to this field’s data type and length. The *Site_Id* field is a “text” field with a length of 10. If your existing naming convention doesn’t meet these requirements, a suggested naming convention is provided below. You may also choose to develop your own naming convention.

<u>The “suggested” naming convention is as follow:</u>

Unit_Id **+** *S* **+** *sequential numbering starting at 001*

NWR Example: A sampling site located on a Back Bay NWR impoundment with a *Unit_Id* of BKB001 would have the following *Site_Id*:

BKB001S001

This suggested naming convention allows for a maximum of 999 sampling sites for each WMU. This naming convention is highly recommended for field stations that may want to combine monitoring data at a later point in order to conduct regional statistical analysis.

Water Level Targets

Water level targets are the proposed or desired target levels for a particular gage.

A target value is owned by one and only one gage. A gage may have zero, one or many target values.

Data records for water level targets are stored in the ***tbl_TargetsLevel*** table.

There are four required fields in the ***tbl_TargetsLevel*** table: OBJECTID, *Gage_Id*, Unit_Id and Target_Date*.

*Field alias, this field is actually named *Loc_Id* in the master table.

The primary key for the ***tbl_TargetsLevel*** table is the *OBJECTID* field. This field is automatically maintained by MS Access.

A foreign key in the ***tbl_TargetsLevel*** table is the *Gage_Id* field. This field allows water level targets to be related back to the **Gages** table.

Salinity Targets

Salinity targets are the proposed or desired salinity values for a particular sample site.

A target value is owned by one and only one sampling site. A sampling site may have zero, one or many target values.

Data records for salinity targets are stored in the ***tbl_TargetsSalinity*** table.

There are four required fields in the ***tbl_TargetsSalinty*** table: OBJECTID, *Site_Id*, Unit_Id and Target_Date*.

*Field alias, this field is actually named *Loc_Id* in the master table.

The primary key for the ***tbl_TargetsSalinity*** table is the *OBJECTID* field. This field is automatically maintained by MS Access.

A foreign key in the ***tbl_TargetsSalinity*** table is the *Site_Id* field. This field allows salinity targets to be related back to the **Sampling_sites** table.

Water Levels

Water levels are the values obtained when readings gages.

A water level is owned by one and only one gage. A gage may have zero, one or many water level readings associated to it.

Data records for water levels are stored in the **tbl_Gage_Reads** table.

There are four required fields in the **tbl_Gage_Reads** table: OJBECTID, *Gage_Id*, Unit_Id and Read_Date*.

*Field alias, this field is actually named *Loc_Id* in the master table.

The primary key for the **tbl_Gage_Reads** table is the *OBJECTID* field. This field is automatically maintained by MS Access.

A foreign key in the **tbl_Gage_Reads** table is the *Gage_Id* field. This field allows water levels to be related back to the **Gages** table.

Salinity

Salinity is the measurement obtained at a sampling site.

A salinity reading is owned by one and only one sample site. A sample site may have zero, one or many salinity readings associated to it.

Data records for salinity are stored in the **tbl_Quality_Reads** table.

There are four required fields in the **tbl_Quality_Reads** table: OBJECTID, *Site_Id*, Unit_Id and Read_Date*.

*Field alias, this field is actually named *Loc_Id* in the master table.

The primary key for the **tbl_Quality_Reads** table is the *OBJECTID* field. This field is automatically maintained by MS Access.

A foreign key in the **tbl_Quality_Reads** table is the *Site_Id* field. This field allows water levels to be related back to the **Sampling_sites** table.

Field descriptions for **Water_mgmt_units** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
DD_Lat_Y	Latitude (Y value)	Double	n/a		Latitude in decimal degrees	-90 to 90	Coordinate values must be referenced to the horizontal datum of WGS84 or NAD83.
DD_Long_X	Longitude (X value)	Double	n/a		Longitude in decimal degrees	-180 to 180	Coordinate values must be referenced to the horizontal datum of WGS84 or NAD83.
Unit_Id	None	Text	6	x	Unique identifier for water management unit	Any valid text	Primary key, must be unique
Unit_Name	None	Text	50	x	Common name of water management unit	Any valid text	Use the same water management unit name as used in RLGIS/RMADs so SWIM data can be linked to these databases
OrgCode	None	Long Integer	n/a	x	Organizational Code	Any valid 5 digit integer	This field is auto-populated. Setup must be run to set your orgcode.
Unit_Type	None	Integer	n/a	x	Type of water management unit	1= Impoundment 2 = Natural	Lookup values obtained from *tlu_UnitType* table. The default value is 1.
Vertical_Datum	None	Text	20		Vertical Datum used for all elevation values related to this water management unit	Local = Local Datum MSL = Mean Sea Level NGVD 29 = Sea Level Datum of 1929 NGVD 88 = North American Vertical Datum of 1988	Lookup values obtained from *tlu_VerticalDatum* table.
Datum_Desc	Describe Local Datum	Text	255		Description of "LOCAL" datum used.	Any valid text	Only available on form if LOCAL is selected.
Elev_Max_Pool	Maximum Pool Elevation	Double	n/a		Elevation value when the water management unit is at its maximum pool level	Any valid number	
Elev_Bottom_Pool	Average Bottom Elevation	Double	n/a		Average bottom elevation value of water management unit	Any valid number	
Elev_Bottom_Drainage	Water Control Structure Drainage Elevation	Double	n/a		Lowest elevation value at which water can be drained using existing water control structure	Any valid number	
Acres	None	Double	n/a		Total area in acres for the water management unit.	Any valid number	

Field descriptions for **Gages** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
DD_Lat_Y	Latitude (Y value)	Double	n/a		Latitude in decimal degrees.	-90 to 90	Coordinate values must be referenced to the horizontal datum of WGS84 or NAD83.
DD_Long_X	Longitude (X value)	Double	n/a		Longitude in decimal degrees.	-180 to 180	Coordinate values must be referenced to the horizontal datum of WGS84 or NAD83.
Loc_Id	Gage_Id	Text	10	x	Unique identifier for gage	Any valid text	Primary key, must be unique
Gage_Name	Gage Name	Text	50	x	Common name of gage.	Any valid text	
Unit_ID	None	Text	6	x	Unit_ID of the water management unit this gage is located within.	Any existing *Unit_Id* found in the **water_mgmt_units** table.	This field is auto-populated on all forms. Foreign key, allows linking back to **water_mgmt_units** table.
Gage_Type	None	Integer	n/a		Type of gage	1= Staff 2 = Other	Lookup values obtained from *tlu_GageType* table. The default value is 1.
Install_method	None	Integer	n/a		The type of gage installation method.	1 = Vertical 2 = Inclined	Lookup values obtained from *tlu_GageInstall* table.
Elev_Gage_Ref	Gage Reference Elevation	Double	n/a		Elevation value used to calibrate or reset gage if disturbed.	Any valid number	Use same vertical datum as specified by the water management unit in which this gage is located
Gage_Ref_Desc	Gage Reference Description	Text	255		Brief description of how to calibrate or reset gage if disturbed.	Any valid text	
Calibration_Date	None	Date/Time	n/a		Date gage was last calibrated or reset.	Any valid date	Leave blank if unknown
Field_Tech	None	Double	n/a		Position/title of field technician who last calibrated or reset gage.	1 = FWS- Biologist 2 = FWS-BioTech 3 = FWS-OTHER 4 = Seasonal Temp. 5 = Volunteer 6 = Other	Lookup values obtained from *tlu_FieldTech* table.
Gage_Status	None	Double	n/a		Status of gage calibration.	1 = OK 2 = Needs to be reset 3 = Needs to be checked	Lookup values obtained from *tlu_GageStatus* table.
Comments	None	Text	255		Additional comments.	Any valid text	

Field descriptions for **Sampling_sites** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
DD_Lat_Y	Latitude (Y value)	Double	n/a		Latitude in decimal degrees.	-90 to 90	Coordinate values must be referenced to the horizontal datum of WGS84 or NAD83.
DD_Long_X	Longitude (X value)	Double	n/a		Longitude in decimal degrees	-180 to 180	Coordinate values must be referenced to the horizontal datum of WGS84 or NAD83.
Loc_Id	Site_Id	Text	10	x	Unique identifier for gage	Any valid text	Primary key, must be unique
Unit_ID	None	Text	6	x	Unit_ID of the water management unit this site is located within.	Any existing *Unit_Id* found in the **water_mgmt_units** table.	This field is auto-populated on all forms. Foreign key, allows linking back to **water_mgmt_units** table.
Sample_Type	None	Integer	n/a	x	Type of salinity sample.	1= Water 2 = Soil	Lookup values obtained from *tlu_SampleType* table. The default value is 1(Water).
Site_Name	Site Name	Text	50	x	Common name of sampling site.	Any valid text	
Site_Description	Site Description	Text	50		Brief description of site where sample is taken.	Any valid text	

Field descriptions for **tbl_TargetsLevel** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
OBJECTID	None	AutoNumber	n/a	x	Unique system generated number		Primary key maintained by MSAccess.
Loc_Id	Gage_Id	Text	10	x	Gage ID for which this target water level value is associated with	Any valid *Gage_Id* found in the **Gages** table.	Foreign key, used as link to **Gages** table.
Unit_ID	None	Text	6	x	Water management unit ID for which this target water level value is associated with	Any existing *Unit_Id* found in the **water_mgmt_units** table.	This field is auto-populated on all forms.
Target_Date	None	Date/Time	n/a	x	Target date	Any valid date	
Level_Min	None	Double	n/a		Minimum target water level	Any valid number	
Level_Max	None	Double	n/a		Maximum target water level	Any valid number greater than Level_Min	Defaults to Level_Min value. Change only if target "range" is desired. Otherwise, leave same as Level_Min.

Field descriptions for **tbl_TargetsSalinity** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
OBJECTID	None	AutoNumber	n/a	x	Unique system generated number		Primary key maintained by MSAccess.
Loc_Id	Site_Id	Text	10	x	Site ID for which this target salinity value is associated with	Any valid *Gage_Id* found in the **Gages** table.	Foreign key, used as link to **Sampling_sites** table.
Unit_ID	None	Text	6	x	Water management unit ID for which this target salinity value is associated with	Any existing *Unit_Id* found in the **water_mgmt_units** table.	This field is auto-populated on all forms.
Target_Date	None	Date/Time	n/a	x	Target date	Any valid date	
Salinity_Min	None	Double	n/a		Minimum target salinity value	Any valid number	Defaults to 0.
Salinity_Max	None	Double	n/a		Maximum target salinity value	Any valid number greater than Level_Min	

Field descriptions for **tbl_Gage_Reads** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
OBJECTID	None	AutoNumber	n/a	x	Unique system generated number		Primary key maintained by MSAccess.
Loc_Id	Gage_Id	Text	10	x	Gage ID for which this gage reading is associated with	Any valid text	Foreign key, used as link to **Gages** table.
Unit_Id	None	Text	6	x	Water management unit ID for which this gage reading is associated with	Any valid text	This field is auto-populated on all forms.
Read_Date	None	Date/Time	n/a	x	Date gage was read	Any valid date	
Field_Tech	None	Double	n/a		Position/title of field technician who read the gage.	1 = FWS- Biologist 2 = FWS-BioTech 3 = FWS-OTHER 4 = Seasonal Temp. 5 = Volunteer 6 = Other	Lookup values obtained from *tlu_FieldTech* table.
Gage_Read	None	Double	20		The water level gage reading	Any valid number	Usually in tenths of a foot.
Temp_F	None	Double	n/a		Air temperature at the time of the monitoring activity in Fahrenheit degrees	Any valid number	
Wind_Speed	None	Integer	n/a		Estimated wind speed at the time of the monitoring activity using the Beaufort wind scale.	0 = 0-1 mph, Calm 1= 1-3 mph, Light Air 2 = 4-7 mph, Light Breeze 3 = 8-12 mph, Gentle Breeze 4 = 13-18 mph, Moderate Breeze 5 = 19-24 mph, Fresh Breeze 6 = 25-31 mph, Strong Breeze 7 = 32-38 mph, Near Gale 8 = 39-46 mph, Gale 9 = 47-54 mph, Severe Gale	
Wind_Direction	None	Text	3		Estimated wind direction at the time of the monitoring activity	E = east N = north NE = northeast NW = northwest SE = southeast SW = southwest VRB = variable wind direction W = west	Lookup values obtained from *tlu_WindDirection* table.
Tide	None	Text	8		Tide status at the time of the monitoring activity	Low Falling High Rising	Lookup values obtained from *tlu_Tides* table.
Moon_Phase	None	Text	8		Moon phase at the time of the monitoring activity	Full Half New Quarter	Lookup values obtained from *tlu_MoonPhase* table.
Comments	None	Text	255		Additional comments.		

Field descriptions for **tbl_Quality_Reads** table:

Field Name	Alias	Type	Length	Required	Description	Valid Values	Notes/Tips
OBJECTID	None	AutoNumber	n/a	x	Unique system generated number		Primary key maintained by MSAccess.
Loc_Id	Site_Id	Text	10	x	Site ID for which this salinity reading is associated with	Any valid text	Foreign key, used as link to **Sampling_sites** table.
Unit_Id	None	Text	6	x	Water management unit ID for which this salinity reading is associated with	Any valid text	This field is auto-populated on all forms.
Read_Date	None	Date/Time	n/a	x	Date salinity was measured or read	Any valid date	
Field_Tech	None	Double	n/a		Position/title of field technician who took the salinity reading	1 = FWS- Biologist 2 = FWS-BioTech 3 = FWS-OTHER 4 = Seasonal Temp. 5 = Volunteer 6 = Other	Lookup values obtained from *tlu_FieldTech* table.
Salinity_PPT	None	Double	20		The salinity value in parts per thousand	Any valid number	
Temp_F	None	Double	n/a		Air temperature at the time of the monitoring activity in Fahrenheit degrees	Any valid number	
Wind_Speed	None	Integer	n/a		Estimated wind speed at the time of the monitoring activity using the Beaufort wind scale.	0 = 0-1 mph, Calm 1= 1-3 mph, Light Air 2 = 4-7 mph, Light Breeze 3 = 8-12 mph, Gentle Breeze 4 = 13-18 mph, Moderate Breeze 5 = 19-24 mph, Fresh Breeze 6 = 25-31 mph, Strong Breeze 7 = 32-38 mph, Near Gale 8 = 39-46 mph, Gale 9 = 47-54 mph, Severe Gale	
Wind_Direction	None	Text	3		Estimated wind direction at the time of the monitoring activity	E = east N = north NE = northeast NW = northwest SE = southeast SW = southwest VRB = variable wind direction W = west	Lookup values obtained from *tlu_WindDirection* table.
Tide	None	Text	8		Tide status at the time of the monitoring activity	Low Falling High Rising	Lookup values obtained from *tlu_Tides* table.
Moon_Phase	None	Text	8		Moon phase at the time of the monitoring activity	Full Half New Quarter	Lookup values obtained from *tlu_MoonPhase* table.
Comments	None	Text	255		Additional comments.		

Appendix B – Importing Existing Data

Importing existing data into SWIM1 requires some knowledge of Microsoft Access and familiarity with the data structure of the SWIM database (*see Appendix A*). Depending on the volume of data you wish to import, it may be easier to simply re-enter the data using SWIM forms.

If you wish to import existing data, you should initiate this process at the very beginning (with an empty database) instead of waiting until new data is entered using SWIM1.

<u>The correct sequence for importing your data is shown below:</u>

Water Management Units
Gages
Target Water Levels
Water Levels
Sampling Sites
Target Salinity Values
Salinity Values

Here are the general steps that need to be performed in order to successfully import existing data into SWIM1.

1. Familiarize yourself with the data structure of the appropriate SWIM1 table using *Appendix A – Table & Field Descriptions*.

2. Ensure your existing data structure and values are compatible with the structure and values of the appropriate SWIM1 table. If not, create a duplicate copy of your table or spreadsheet and modify your field structure and/or records to match the format of the appropriate SWIM1 table that you wish to import your data into. You must ensure that all required fields exist in your table or spreadsheet and they conform to the SWIM data field's type and length. Also, no primary keys can have duplicate values!

3. Open up a new blank Access database.

4. From the **File** menu, choose **Get External Data**….**Import**. Navigate to the spreadsheet or table you wish to import. Ensure you bring the data into MS Access as a new table.

5. Using the new table you just imported, go into *Table Design* mode and double check to ensure the field data types match the data types used by the appropriate SWIM1 table. If not, edit as necessary.

6. Select **Query,** choose **New,** select **Design View** and click **OK**. Add the new table you just imported.

7. From the **Query** menu, choose **Append Query**. Specify the *Water_Monitoring.MDB* database and choose the name of the appropriate SWIM table you wish to append to. Click **OK**.

8. In the *Field* row, choose the fields you from the existing table that you wish to export and in the *Append* To row choose the appropriate field from the SWIM table that will receive this data.

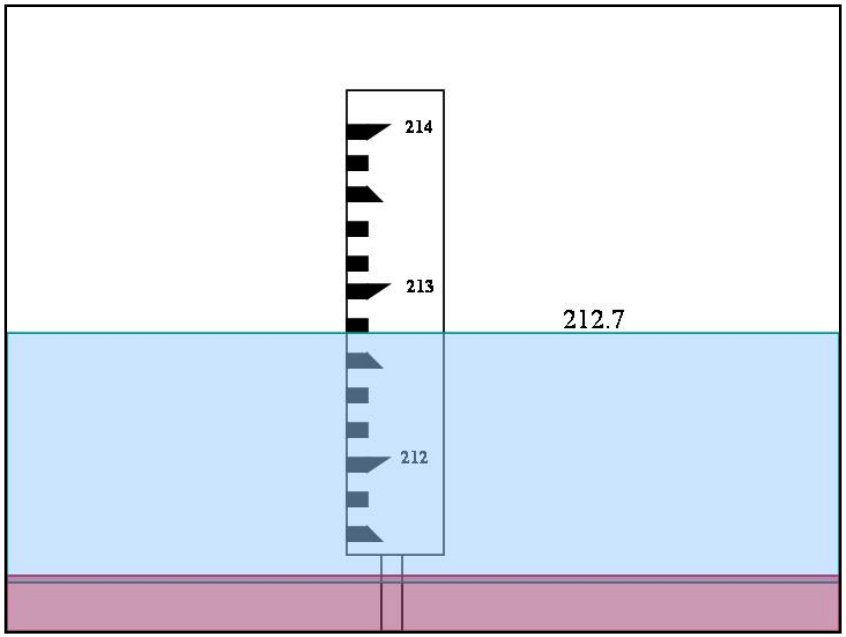
9. Run the query. If you did not receive any errors, all of your data was successfully imported into the SWIM database.

10. Repeat as necessary for the remaining SWIM data tables.

Water Gauges:

Checking to Determine if a Water Gauge Has Changed Elevation From One Date to Another.

Hal Laskowski October 13, 2005



Why Check the Gauge?

- Water gauges are used to measure, evaluate, and plan annual hydrology within a managed wetland.
  - Water gauge readings are used as a surrogate to determine what type of habitat (water depth) is being provided within a wetland. Water gauge readings are also used to measure rates of drawdown or flood-up.
  - New refuge staff who might be unfamiliar with specific habitat conditions within an impoundment, might rely heavily upon previous water gauge readings at specific dates, to duplicate previously provided habitat conditions within an impoundment.
  - Refuge staff often have previous knowledge that providing specific drawdowns or water levels at certain times of year, will result in desirable vegetation communities or habitat conditions to meet objectives. Thus for planning purposes, refuge staff frequently base upcoming water manipulations on previous water gauge readings.

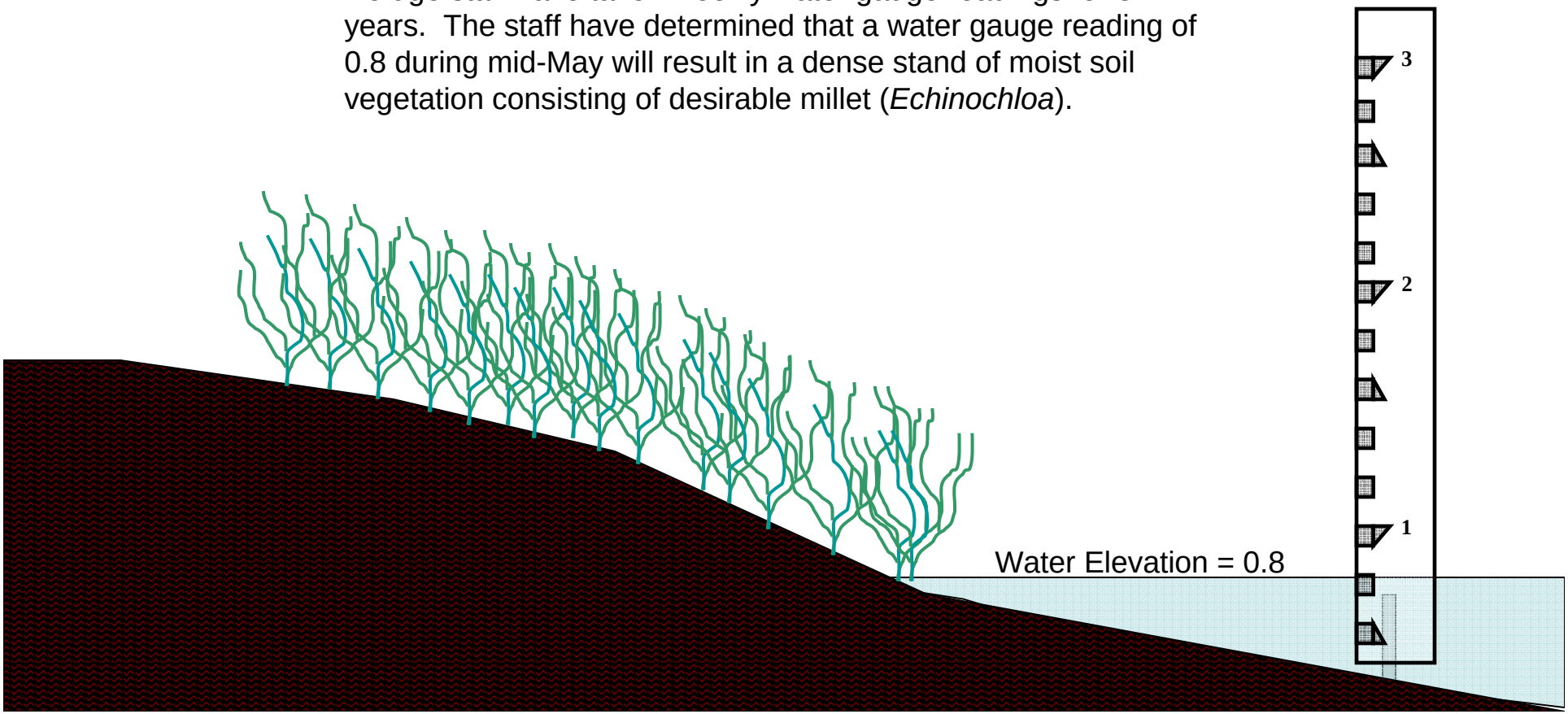
- If a water gauge changes elevation as a result of ice, wind, or other factor, without refuge staff knowledge, then previously collected data can not validly be compared to current data, or used in making any management decisions. Previously collected data can continue to be used however, if the amount of error (change in gauge level) can be determined.

Example of the Problem:

The below water gauge was simply attached to a post in the water. There is no relationship between the water gauge readings and any known vertical datum.

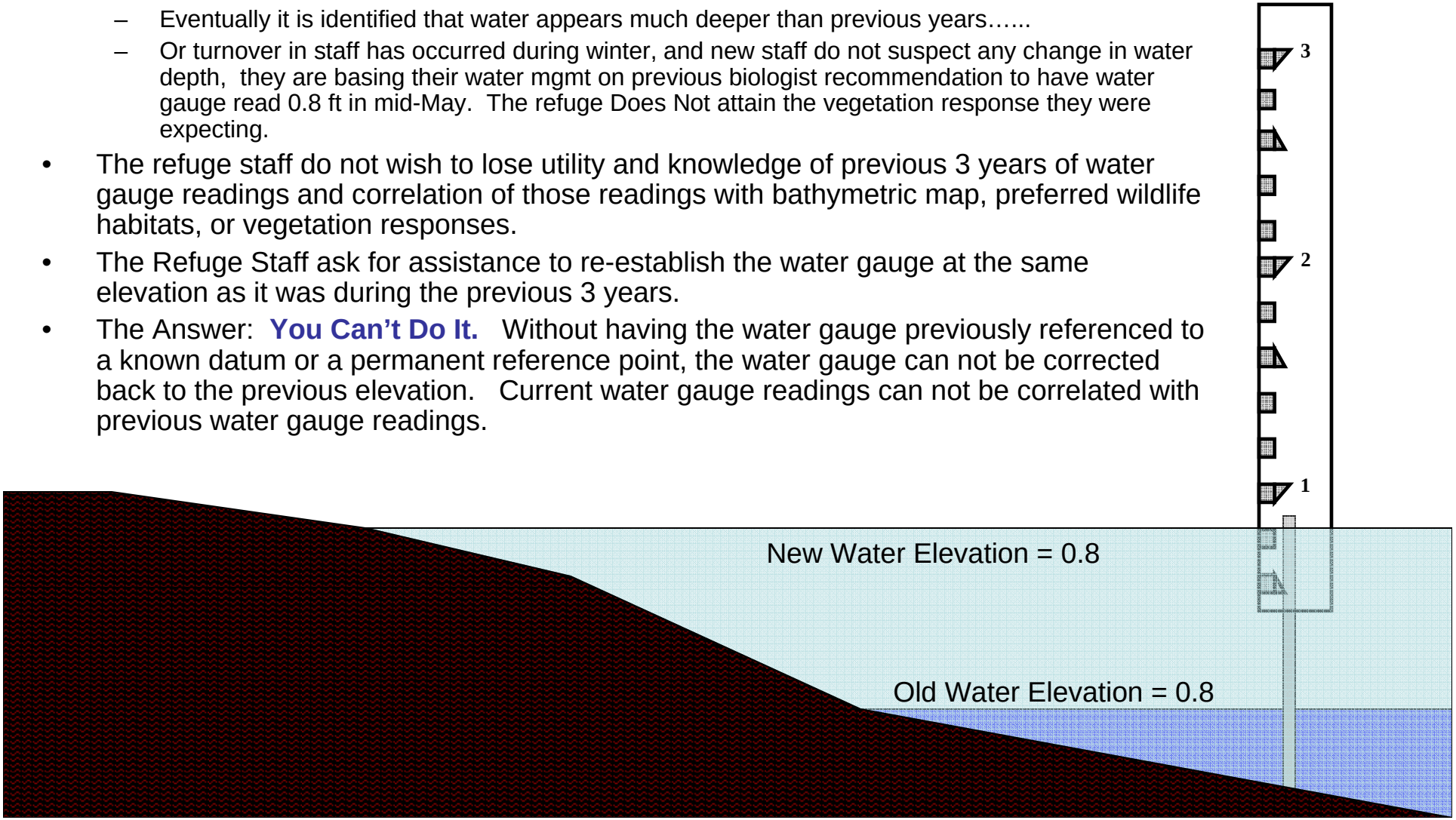
Alternatively, there is no known relationship between the water gauge (a temporary object) and a permanent object such as top of WCS Headwall, or some other permanent reference point.

Refuge staff have taken weekly water gauge readings for 3 years. The staff have determined that a water gauge reading of 0.8 during mid-May will result in a dense stand of moist soil vegetation consisting of desirable millet (*Echinochloa*).

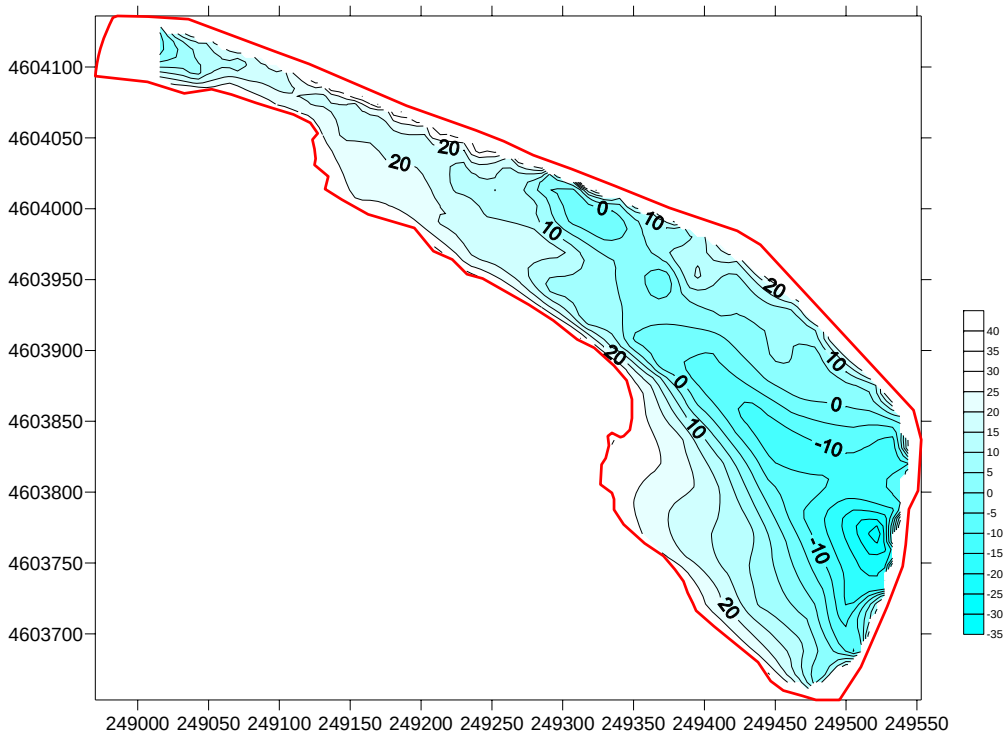


Example of the Problem:

- During the winter, ice and a flood lift the water gauge on its post.
  - Refuge staff are unaware this has occurred.
  - The water gauge is not checked and is assumed to be at same elevation as the previous 3 years.
  - Refuge staff complete an Annual Habitat Mgmt Plan and identify a spring drawdown with water gauge readings leading to elevation of 0.8 ft in mid-May to promote a stand of millet.
  - Eventually it is identified that water appears much deeper than previous years……
  - Or turnover in staff has occurred during winter, and new staff do not suspect any change in water depth, they are basing their water mgmt on previous biologist recommendation to have water gauge read 0.8 ft in mid-May. The refuge Does Not attain the vegetation response they were expecting.
- The refuge staff do not wish to lose utility and knowledge of previous 3 years of water gauge readings and correlation of those readings with bathymetric map, preferred wildlife habitats, or vegetation responses.
- The Refuge Staff ask for assistance to re-establish the water gauge at the same elevation as it was during the previous 3 years.
- The Answer: **You Can't Do It.** Without having the water gauge previously referenced to a known datum or a permanent reference point, the water gauge can not be corrected back to the previous elevation. Current water gauge readings can not be correlated with previous water gauge readings.



Example of Problem



- Refuge has constructed a bathymetric map of water depths for an impoundment based upon the existing water gauge.
- The map is used to determine area of impoundment within different depth categories at specified water gauge readings.
- Map also, identifies germination conditions for different vegetation zones by correlating water gauge readings (in spring of year) with vegetation sample plots at time of germination.
- If the water gauge is destroyed and can not be re-established at the same elevation due to lack of reference to permanent object, then the map loses its usefulness, as it will not be referenced to the new water gauge.

Accuracy of Water Gauges.

- Accuracy of a water gauge
  - Is determined by how close the water gauge is established to a known datum. Thus, if mean sea level is the datum and the actual impoundment water level is determined to be 97.6 ft above sea level using an established benchmark, and at the same time the water gauge reads 97.5 ft, then the water gauge is inaccurate by 0.1 ft.
  - At some refuges, the water gauge is not established relative to any known datum, but rather the gauge is simply installed at an unknown elevation. This is an ASSUMED datum. This is fine, as long as the water gauge is referenced to an immovable object which can be used to re-establish the water gauge at the same ASSUMED elevation.

When to Check Gauge for Accuracy

- Water gauges are most often damaged or destroyed during winter. Ice and lifting action of flood, floating logs, high wind, or vandalism, may all influence accuracy of the gauge from one season to the next.
- We recommend that each water gauge be checked for accuracy once in Fall season prior to ice-up, and again in Spring season after any severe flooding. Additionally, check the water gauge after any significant event where the suspicion exists that the gauge may have been altered.
- Records of how to check for accuracy and results, should be maintained in Refuge Files. Each time a water gauge is checked for precision, the date, gauge location, and results of the check should be recorded.

Procedure to Check Water Gauge:

- Several methods are identified to check a water gauge for accuracy, depending upon equipment available and the location of the gauge.
  - When checking the water gauge, we assume the gauge is established at the correct elevation to begin with. Thus, in lieu of beginning the process at a known Benchmark elevation, we will start the process in reverse at the water gauge itself and determine a reference elevation relative to the water gauge onto a permanent inmovable object (i.e., headwall of a water control structure (wcs)).
  - It is acknowledged that some refuge staff have the appropriate equipment and expertise to both check the accuracy and precision of a water gauge beginning at a known benchmark. For those refuge staff's with this ability, this is strongly encouraged.

Checking Your Water Gauge for Accuracy.

Depending Upon How and Where Your Gauge is Mounted, You Might Use One of the Following Lists of Equipment

1. Straight 1 x4 x L Board and 4 ft Carpenters Level.
2. Ruler that measures in tenths of feet.
3. Inexpensive Laser Level purchased at Home Depot, and ruler that measures in tenths of feet.
4. Engineer’s Level, tripod and surveyors rod.
5. Engineer’s Laser Level, tripod and surveyors rod.

Water Gauge Attached to WCS.

Top of WCS Headwall

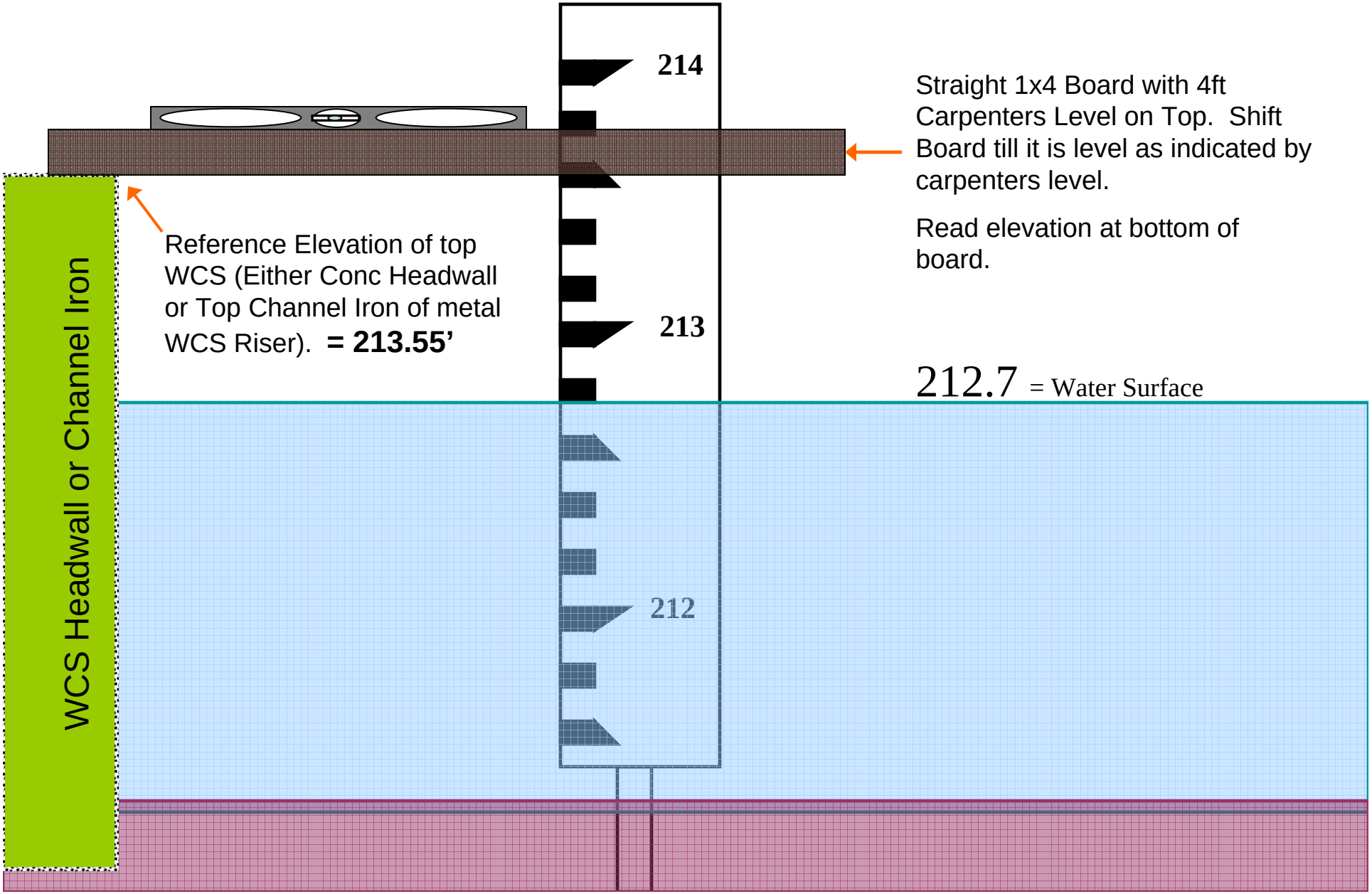
Top of water gauge

Simply measure distance from top of gauge to top of headwall. Add distance to top of gauge reading to provide elevation of top of headwall. Record date and headwall elevation in refuge files.

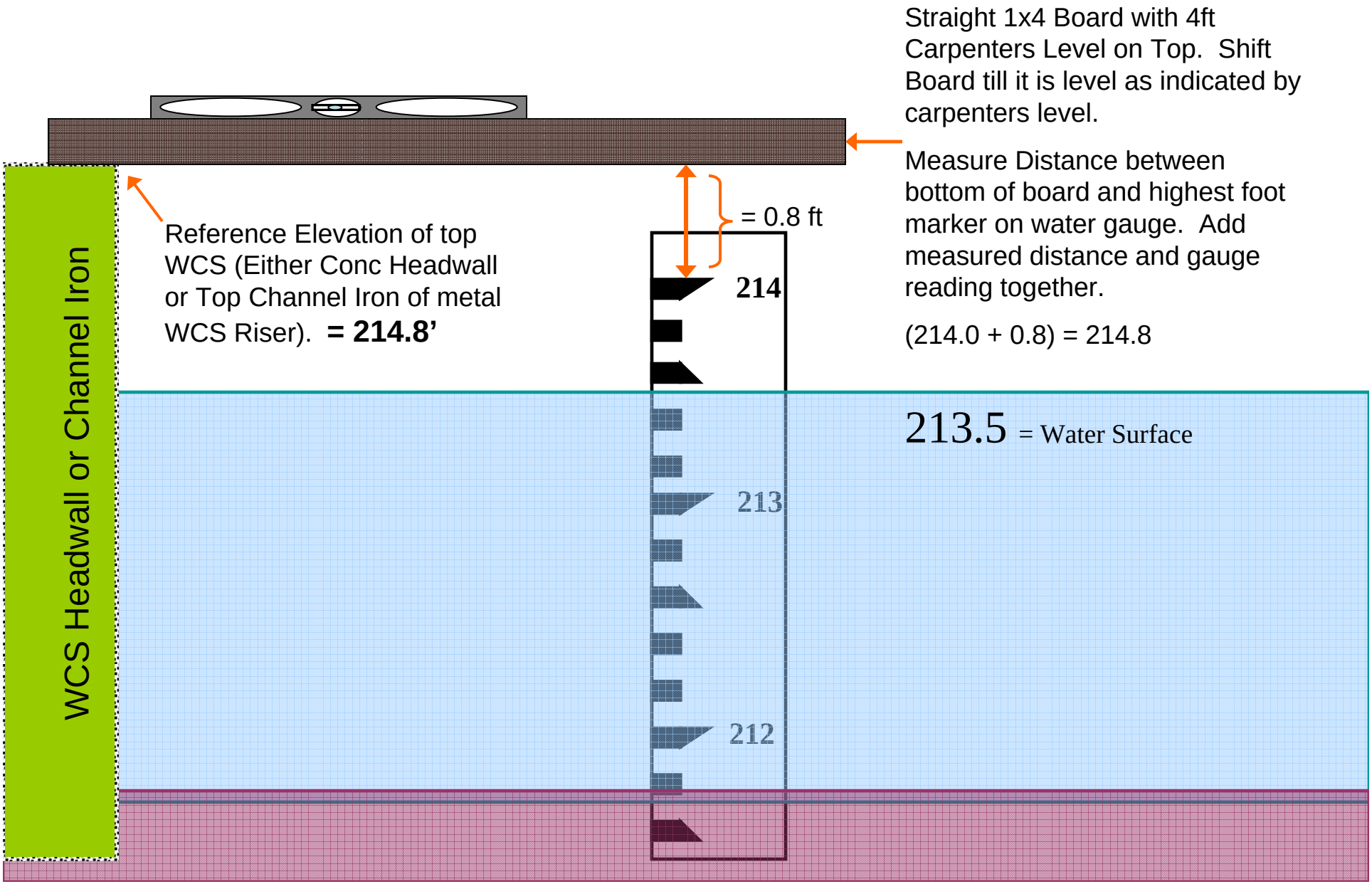
Water Gauge extends above headwall. Simply read top of headwall elevation from water gauge. Record date and headwall elevation in Refuge Files.

Water Gauge Mounted on Post in Front of WCS.

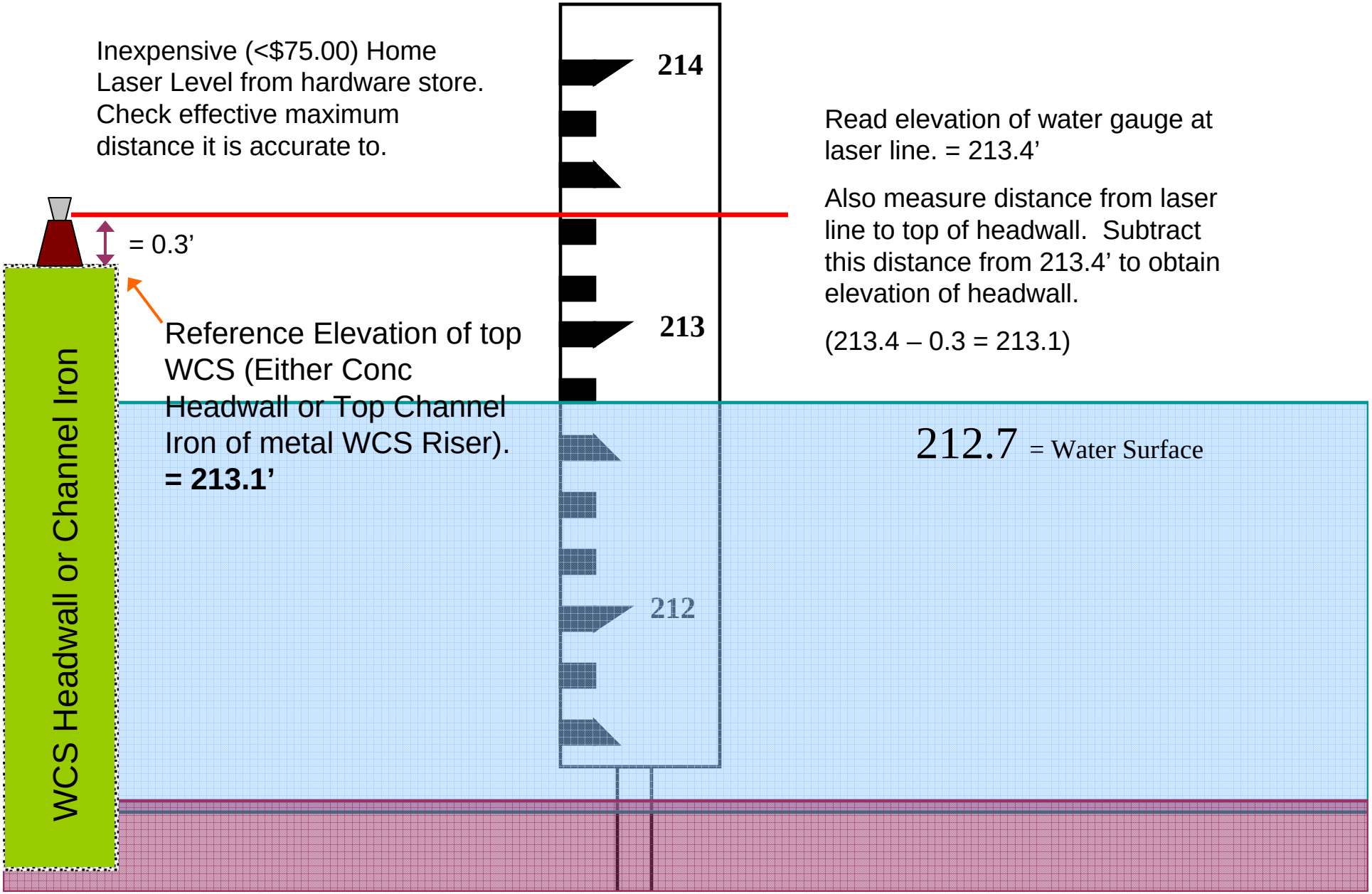
Water Gauge Above WCS and < 14’ from WCS



Water Gauge Below WCS and < 14’ from WCS

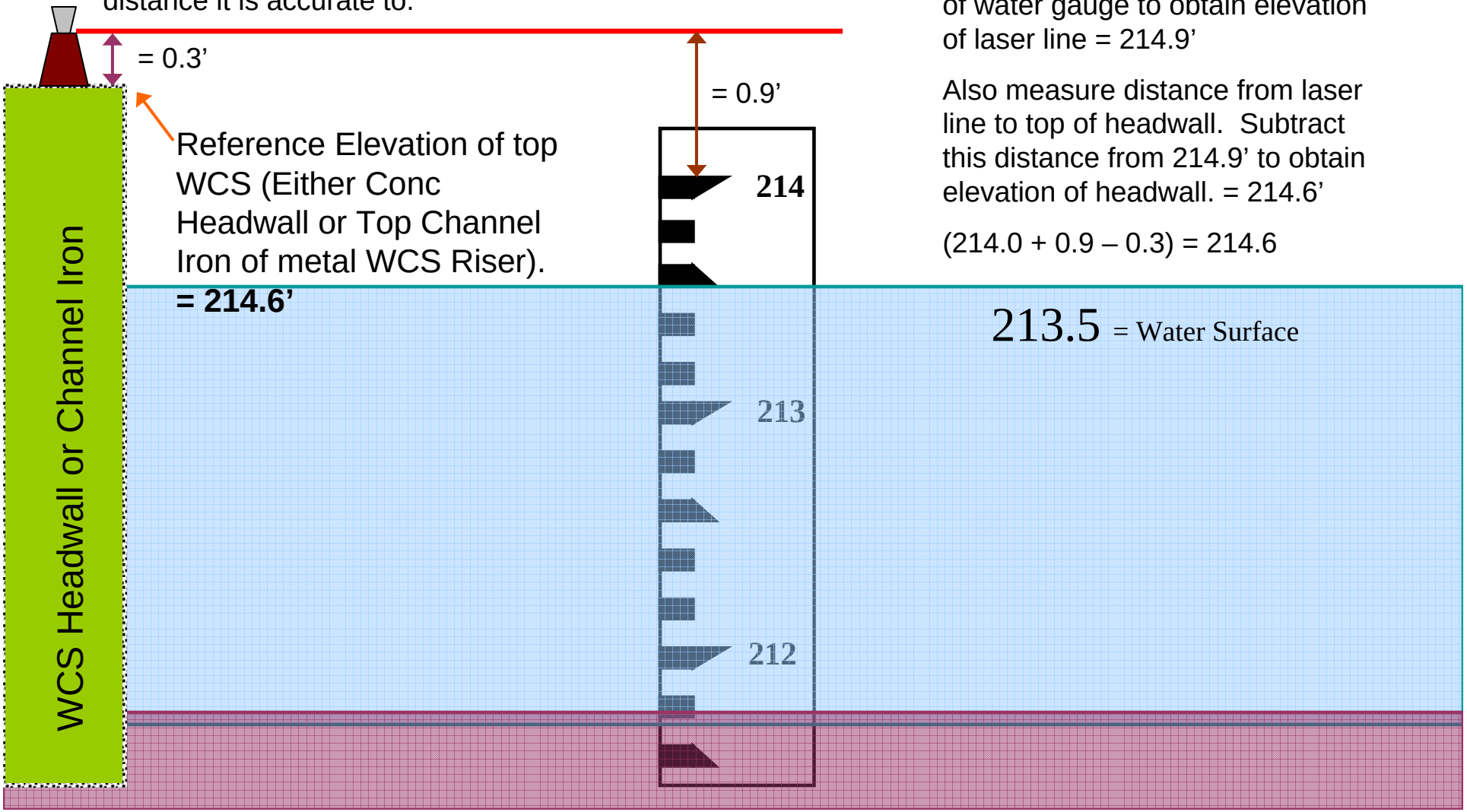


Water Gauge Above WCS and Beyond Distance Where You can Use Straight Board.



Water Gauge Below WCS Using Homeowner's Laser Level.

Inexpensive (<$75.00) Home Laser Level from hardware store. Check effective maximum distance it is accurate to.



Measure from laser line down to foot marker on water gauge.

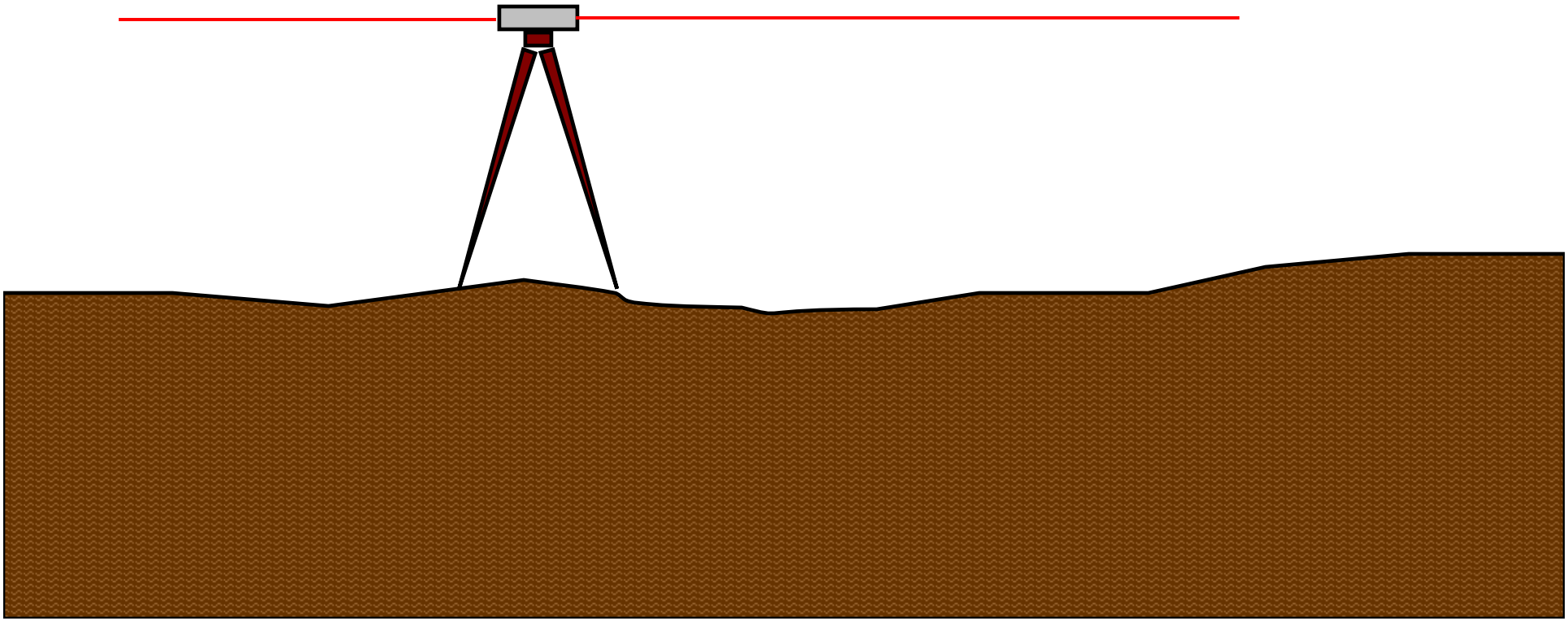
Add measurement to foot marker of water gauge to obtain elevation of laser line = 214.9'

Also measure distance from laser line to top of headwall. Subtract this distance from 214.9' to obtain elevation of headwall. = 214.6'

(214.0 + 0.9 – 0.3) = 214.6

Check Water Gauge Using Engineers Level or Laser Level

Utilize exact same process as outlined for the homeowner's laser level, except that instead of having the laser level sitting directly atop the wcs, the level will be set-up on a tripod a short distance away on dry ground.



Water Gauge Precision Data

Date	Water Gauge Name/Location	Describe Location Reference Elevation	Reference Elevation	Difference in Elevation between last check.	Observer
10/17/2005	Pool 1 water gauge at 24” wcs.	Top of northeast channel iron of WCS.	245.60	-	HPL
10/21/2005	Mallard Pool water gauge at twin 48” wcs	Top of east headwall of WCS.	231.8	-	HPL
04/14/2006	Pool 1 water gauge at 24” wcs.	Top of northeast channel iron of WCS.	245.65	- 0.05[A]	HPL

Note[A] : The top of the water control structure is permanent. Thus, the top elevation of the WCS remains at 245.60, what has actually occurred is the water gauge has settled (lowered) by 0.05 ft.

What To Do if the Gauge is Found to Have Moved Up or Down?

- If water gauge is found to be in error > 0.1 ft.
- Simply reverse the procedure you used to establish a reference elevation on the WCS headwall.
- Using the WCS Headwall elevation, and:
  - board and carpenters level,
  - laser level, etc.
    - Determine known elevation of board or laser line and move new water gauge up or down on post until it reads at the correct elevation.
    - Or more simply, from top of headwall reference elevation, determine current water elevation and establish new water gauge to correctly read water level at that elevation.

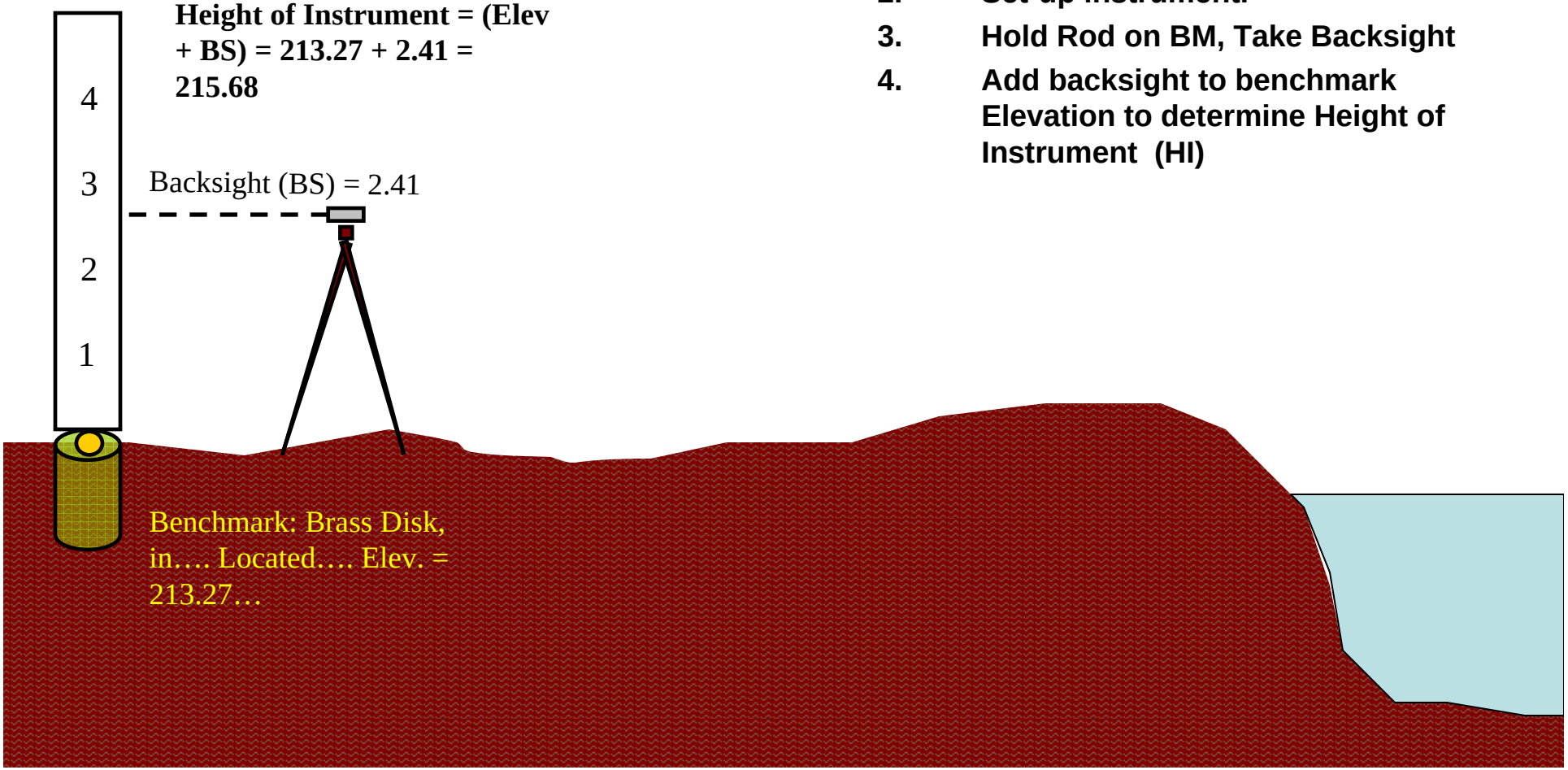
Following is Separate Process to Reference a Water Gauge to a Known Datum.

Establishing a New Water Gauge or Converting a Water Gauge Established at an Assumed Datum to a Known Datum
(i.e.,Mean Sea Level)

- What is Required:
  - Engineers Level, Tripod, Rod.
  - Expertise in use of level.
  - Location of a nearby Benchmark
    - Benchmarks throughout the U.S. may be located at: http://www.ngs.noaa.gov/cgi-bin/datasheet.prl
- Note:
  - Establishing water gauges referenced to a known datum is preferred. In this manner water levels may be correlated with topographic maps of the refuge, or water levels of other nearby impoundments.

Begin at Known Elevation, Benchmark of a Known Vertical Datum (i.e., Mean Sea Level)

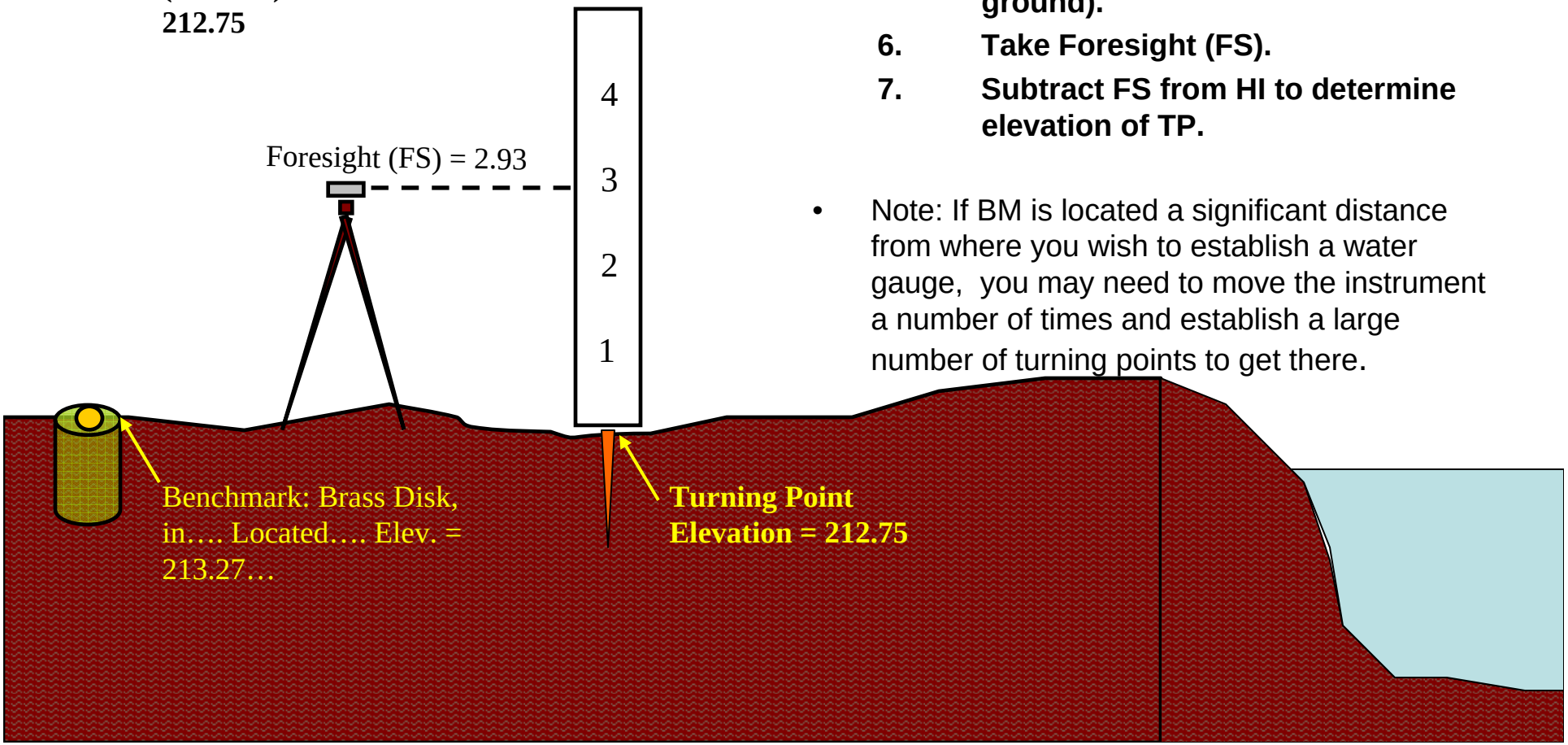
1. **Locate Benchmark (BM)**
2. **Set-up instrument.**
3. **Hold Rod on BM, Take Backsight**
4. **Add backsight to benchmark Elevation to determine Height of Instrument (HI)**



Measuring Elevation of a Turning Point:

1. Locate Benchmark (BM)
2. Set-up instrument.
3. Hold Rod on BM, Take Backsight
4. Add backsight to benchmark Elevation to determine Height of Instrument (HI)
5. **Create Turning Point (TP) (stake in ground).**
6. **Take Foresight (FS).**
7. **Subtract FS from HI to determine elevation of TP.**

Turning Point Elevation = (HI – FS) = 215.68 – 2.93 = 212.75

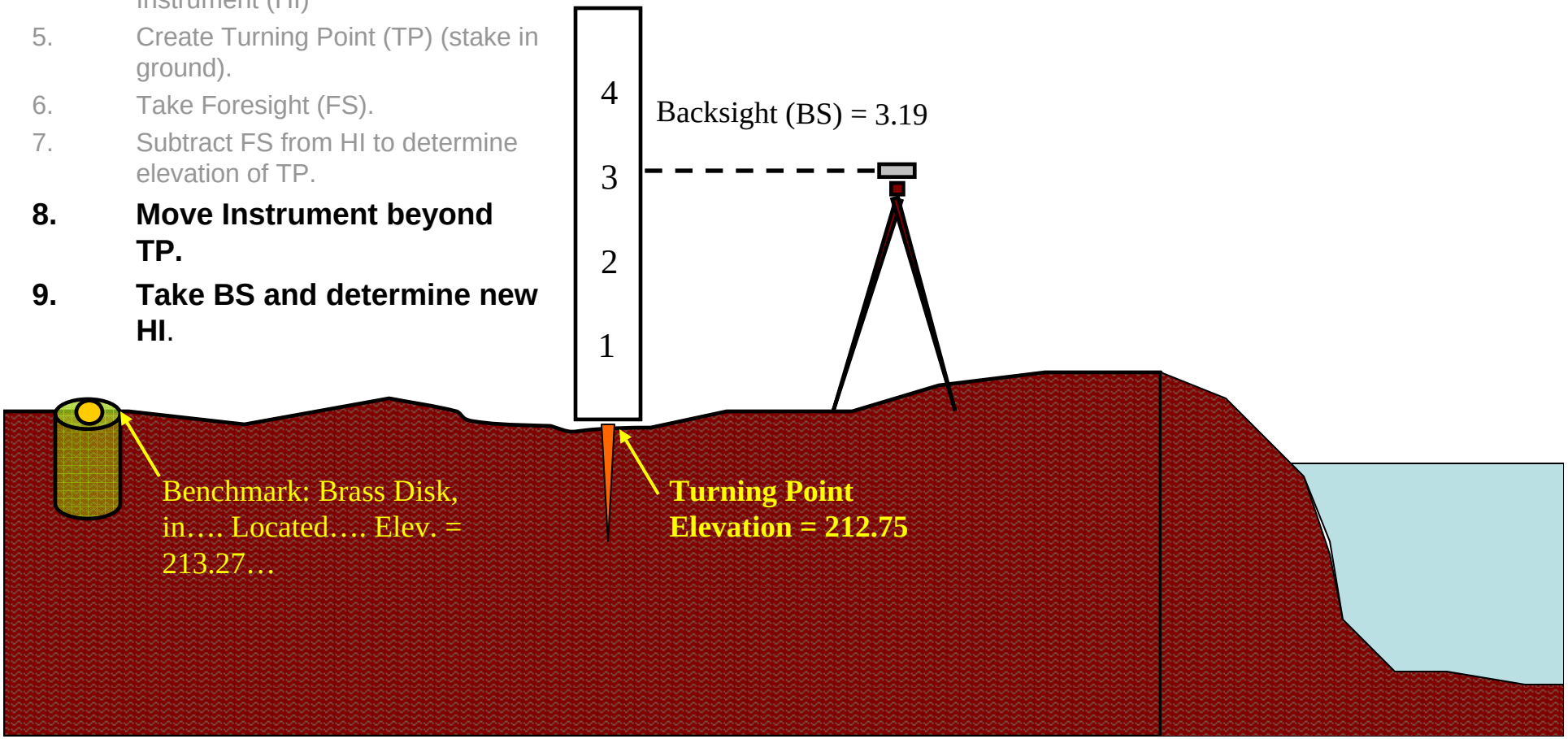


- Note: If BM is located a significant distance from where you wish to establish a water gauge, you may need to move the instrument a number of times and establish a large number of turning points to get there.

Determine New Height of Instrument from Previous Turning Point:

1. Locate Benchmark (BM)
2. Set-up instrument.
3. Hold Rod on BM, Take Backsight
4. Add backsight to benchmark Elevation to determine Height of Instrument (HI)
5. Create Turning Point (TP) (stake in ground).
6. Take Foresight (FS).
7. Subtract FS from HI to determine elevation of TP.
8. **Move Instrument beyond TP.**
9. **Take BS and determine new HI**.

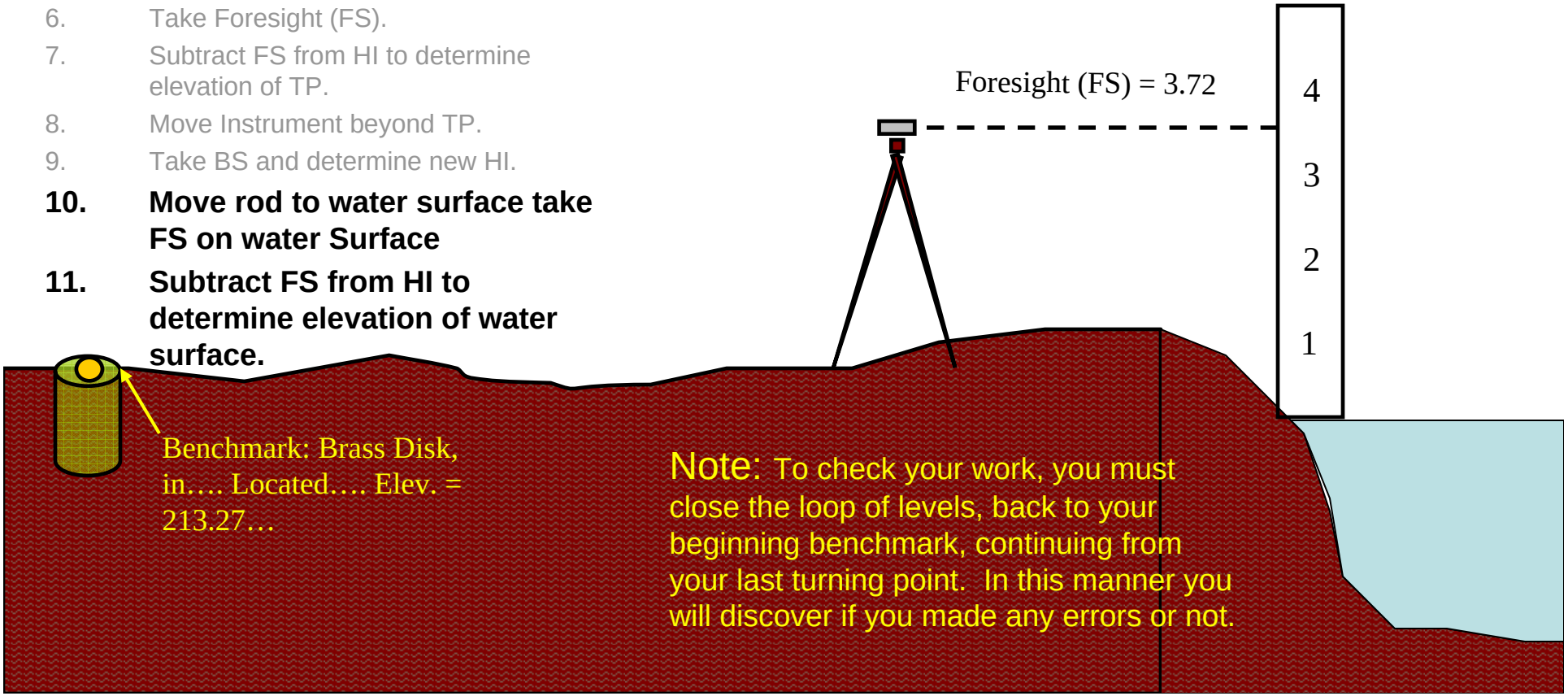
Height of Instrument = (Elev + BS) = 212.75 + 3.19 = 215.94



Measure Elevation of Water Surface:

1. Locate Benchmark (BM)
2. Set-up instrument.
3. Hold Rod on BM, Take Backsight
4. Add backsight to benchmark Elevation to determine Height of Instrument (HI)
5. Create Turning Point (TP) (stake in ground).
6. Take Foresight (FS).
7. Subtract FS from HI to determine elevation of TP.
8. Move Instrument beyond TP.
9. Take BS and determine new HI.
10. **Move rod to water surface take FS on water Surface**
11. **Subtract FS from HI to determine elevation of water surface.**

Elevation of Water Surface = (HI – FS) = 215.94 – 3.72 = 212. 22



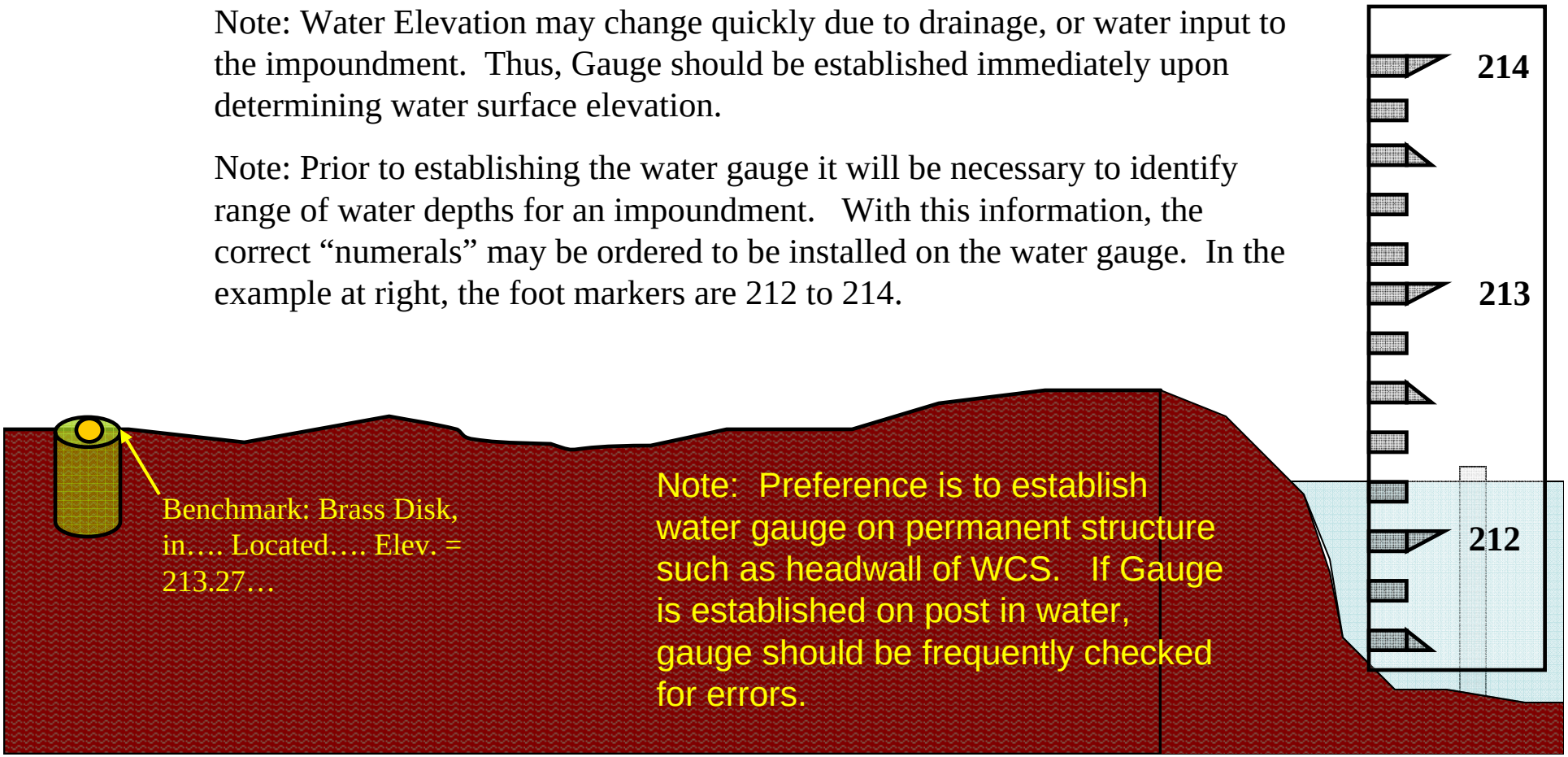
Establish Water Gauge:

Elevation of Water Surface = (HI – FS) = 215.94 – 3.72 = 212. 22

Set post or other support, place water gauge on post and move up or down until gauge reads 212.2 ft. Attach gauge permanently to post.

Note: Water Elevation may change quickly due to drainage, or water input to the impoundment. Thus, Gauge should be established immediately upon determining water surface elevation.

Note: Prior to establishing the water gauge it will be necessary to identify range of water depths for an impoundment. With this information, the correct "numerals" may be ordered to be installed on the water gauge. In the example at right, the foot markers are 212 to 214.



Sample Notes When Running a Level Loop

Note: Actual Readings from Previous Slides Used In Notes

Description	BS +	HI	FS -	Elev.
Benchmark: USGS Brass disk set in concrete on north side of Road 34 approx 50 ft east of Village Road. UTMs = ….. And …..				213.27
	2.41	215.68		
Turning Point #1			2.93	212.75
	3.19	215.94		
Surface of Water at Pintail Pool			3.72	212.22
Turning Point # 2 Top of northeast headwall of WCS #2 (Note: 2 elevations were taken from same HI. Also, this begins loop back to BM)			3.17	212.74
	2.61	215.35		
CHECK at Benchmark:Brass disk set in concrete on north side of Road 34 approx 50 ft east of Village Road. UTMs = ….. And …..			2.06	213.29 Versus 213.27

Note: When we completed loop back to BM, we determined elevation of BM to be 213.29. This represents a 0.02 error within our work. This would be an acceptable amount of error. If it were > 0.10, we would be concerned.

Note: Turning Point #2 creates a permanent reference elevation nearby the water gauge.