APPENDIX B

TRIP REPORT

Project 2: Environmental Remediation Science & Technology

In-Situ Data Collection and Water Quality Sampling in Tims Branch, Savannah River Site, Aiken, SC

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Introduction

In situ data collection refers to the acquisition of data and samples in their natural context. Depending on the type of research and specific study requirements actual field samples and data may be required from the study site. Development of hydrological models where there is either insufficient or unreliable data is an example where collection of field data can provide important information to improve model accuracy and performance with respect to predictive capability. In many cases, required model input parameters are unavailable due to site characteristics, for example if the area is remote and has not been well studied. A hydrological model of the Tims Branch watershed which passes through the U.S. Department of Energy's (DOE's) Savannah River Site (SRS) in Aiken, SC, is being developed by the Applied Research Center (ARC) at Florida International University (FIU). Site sampling and data collection was necessary to support development of the hydrology and transport model for Tims Branch watershed/stream to quantify model parameters and was performed by ARC researchers and students at SRS in August 2016 in collaboration with the Savannah River Ecology Laboratory (SREL) and under full supervision of SREL staff and scientists. This fieldwork provided a great opportunity for FIU undergraduate and graduate STEM students (DOE fellows) to gain hands-on experience and technical training on the use of in-situ measurement equipment. The data derived from their fieldwork will be implemented into the hydrology model as initial and boundary conditions.

Study Area and Sampling Locations

SRS lies in the sand-hills region of South Carolina and covers approximately 800 km2. It encompasses parts of Aiken, Barnwell and Allendale counties and is bordered on the west by the Savannah River and the State of Georgia (Figure 1). SRS includes facilities such as reactors, laboratories, waste disposal sites, cooling towers, incinerators, etc.

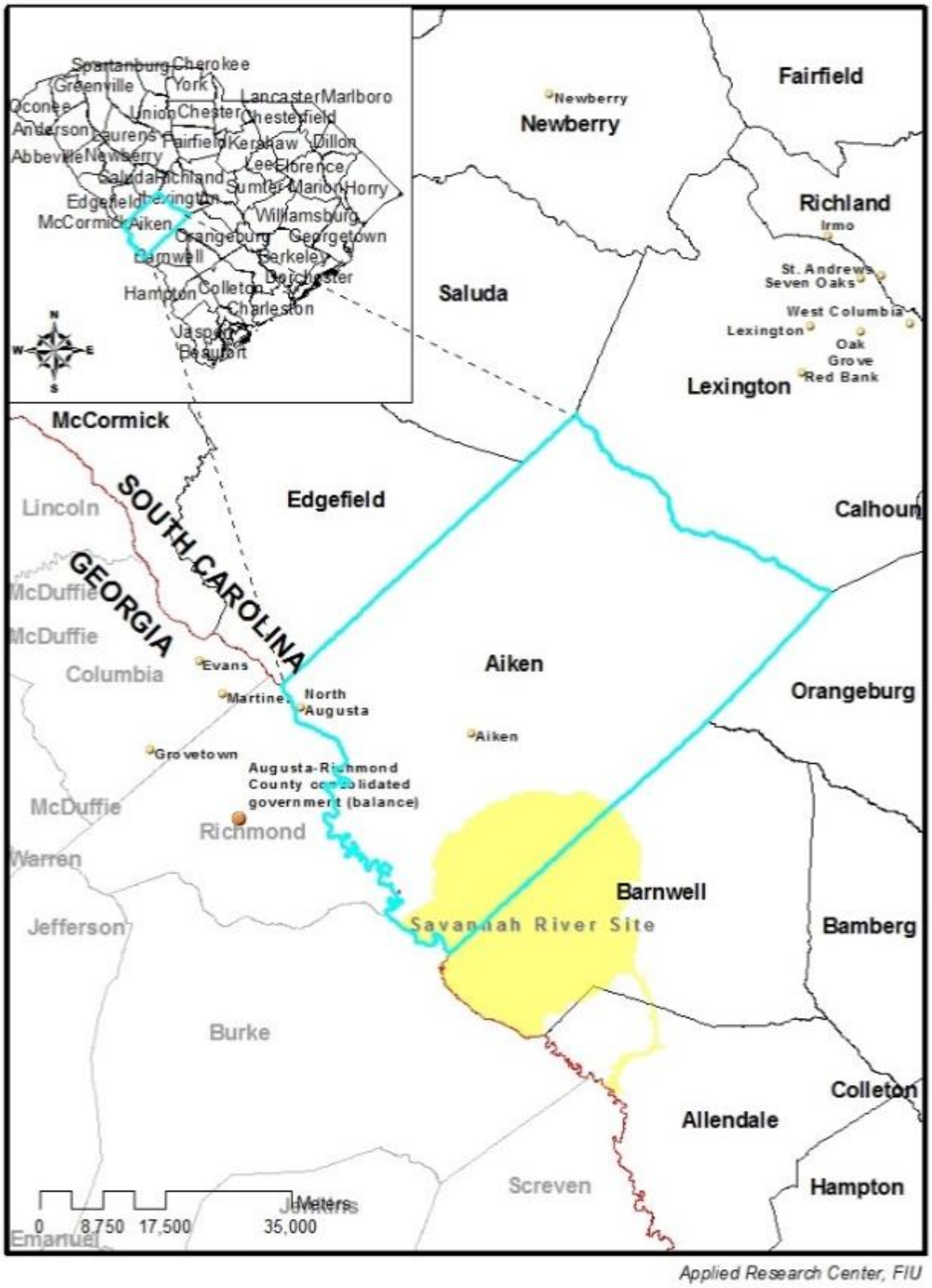

Figure 1: Location of Savannah River Site (SRS), SC.

The Tims Branch watershed (TBW) is located within SRS and is contained within the larger Upper Three Runs watershed, which is a sub-basin of the Lower Savannah River Basin. Tims Branch stream is a small braided, marshy, second-order stream that starts at the northern portion of SRS and passes through Beaver Ponds 1-5 and Steed Pond, and eventually discharges into Upper Three Runs (Figure 2). Its drainage area is nearly 16 km2 (Batson et al., 1996). The average width of the stream varies between 2 to 3 m. Two major tributaries of Tims Branch are A-014 and A-011 outfalls which are approximately 230 m apart. They combine with the main stream of Tims Branch 1,400 m from the A-014 outfall (Hayes, 1984). Flow in Tims Branch is strongly influenced by groundwater discharge (Mast and Turk, 1999). Because of the water table elevation and Tims Branch bed elevation, it is considered to be a losing stream (surface water discharges into the groundwater) near the A/M outfalls and a gaining stream (groundwater discharges into the stream) further south toward the confluence with Upper Three Runs (Looney et al., 2010; Varlik, 2013).

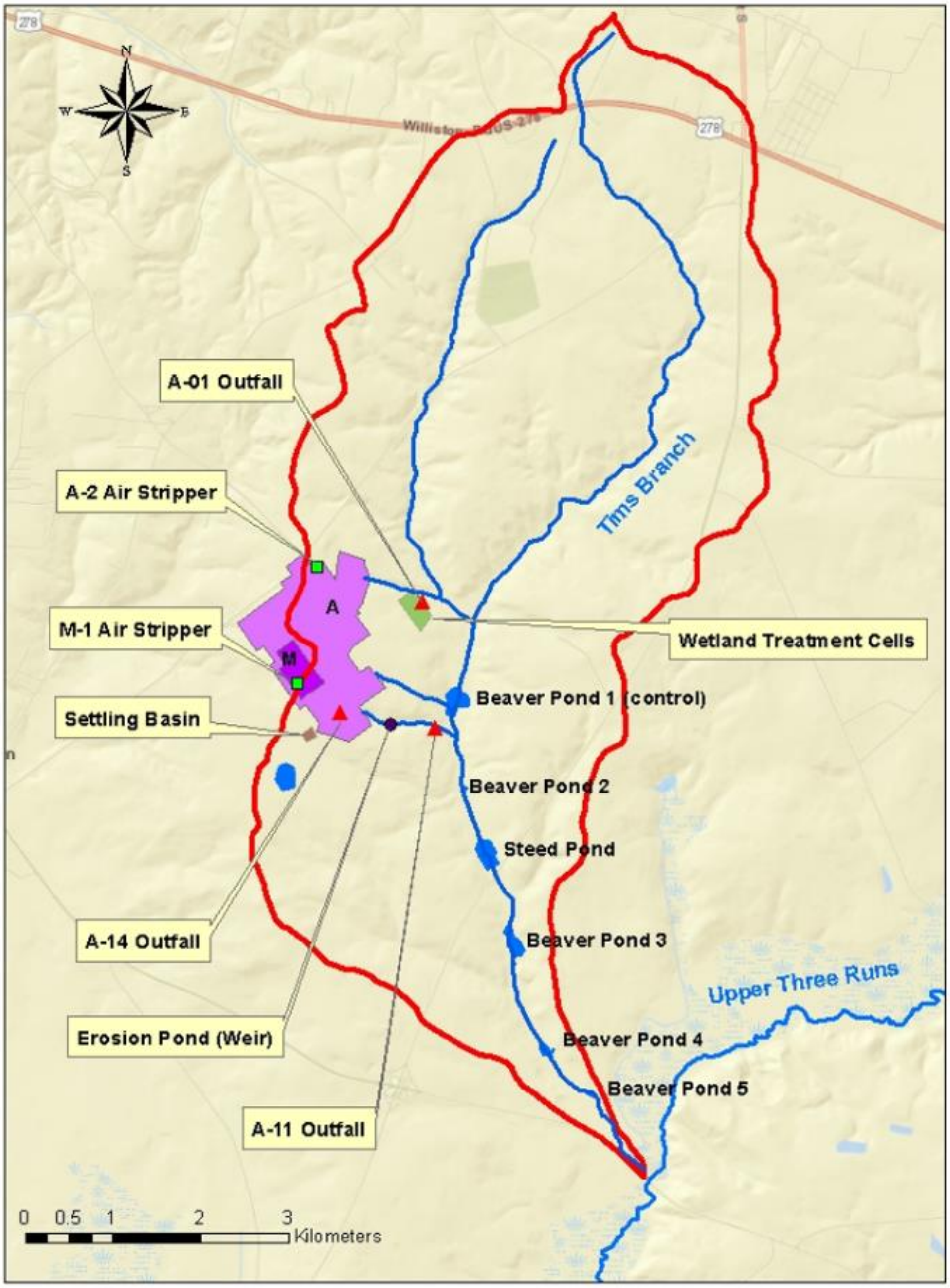

Figure 2: Tims Branch location.

Figure 3 shows the locations along A-014, A-011, and Tims Branch where cross section measurements and samples were taken. Other water quality parameters were also measured at these same locations.

Figure 3: Sampling locations along A-014 and A-011 outfall tributaries.

Methodology

Several types of equipment were used during this data collection exercise, including:

- Flow Meter with FP101-FP201 Global Flow Probe
- Range Finder
- Handheld GPS
- YSI Water Quality Field Meter

Discharge (Flow) Measurement

Discharge (flow) plays a major role in developing a surface water hydrological model. In particular, when developing a transport model, it is important to use real-time discharge data in the calibration and validation processes. The 2016 trip to SRS involved flow measurements using a flow meter with FP101 probe at various locations along Tims Branch, Steed Pond, and the A-014 and A-011 outfall tributaries. Measurements were taken at more than 18 locations to estimate the stream velocity. Three flow velocity readings were taken at each sample location and the average reported. The flow meter was calibrated prior to each reading and the display was reset to zero. The method employed involved orientation of the propeller (the bottom part of the flow meter) directly into the flow using the arrow indicator aimed downstream and moving it in a smooth vertical motion to attain the average velocity in the water column, which was recorded in the SI units of meters per second (m/s).

Figure 4: Measuring flow velocity using a flow meter.

Figure 5: Propeller inside the flow meter.

Figure 6: The reading panel of the flow meter.

Cross Section Profiling

Stream cross section is one of the most important inputs to in developing a stream flow model. Having an accurate representation of the stream cross sections is a crucial step in modeling since the most important equations in open-channel flow, such as Manning's equation, are governed by parameters such as area, wetted perimeter, and hydraulic radius. Accurate cross section profiles will increase the model certainty and minimize the error factors related to stream bathymetry and bank topography. In situ field data was necessary to profile the cross sections of the Tims Branch stream, particularly in locations where the stream width was smaller than the mesh/grid cell size of the topographical data being used for model development. In this field work, cross sections were profiled in Steed Pond as well as two major tributaries of Tims Branch which receive discharge from the A-014 and A-011 outfalls. The approximate lengths of the A-014 and A-011 branches are 1 km and 0.5 km respectively. The equipment used to measure the cross sections included:

- TruPulse 200X Laser Rangefinder
- eTrex HC series GPS
- Tripod
- Measuring tape
- Measuring rod

Cross section profiles were generated in two steps: first, the channel width and the banks were measured by a rangefinder, and then the stream geometry was measured manually using a measuring rod. To create the stream bed geometry, measurement of the water depth was required. Each cross section was segmented and flagged prior to taking water depth measurement (Figure 8). Water depth was measured by using a measuring rod. The coordinates of each location was obtained by a handheld GPS unit. The stream side bank elevation was obtained by the rangefinder using a 2-point shooting method (specified in the equipment manual). This method is particularly useful when measuring distances having one of the points as reference. This method also requires a clear line of sight for both shots. After the rangefinder was properly set up, the person taking the measurement was required to point at one side of the stream for the first shot and then aim at the other side of the stream for the second shot (Figure 7 and Figure 9). In locations where there was no clear line of sight for both shots, the stream width was measured manually using a measuring tape (Figure 10). Cross section geometry was manually measured by placing the measuring rod at each flag and recording the water depth and the flag's distance from the reference point (one side of the stream).

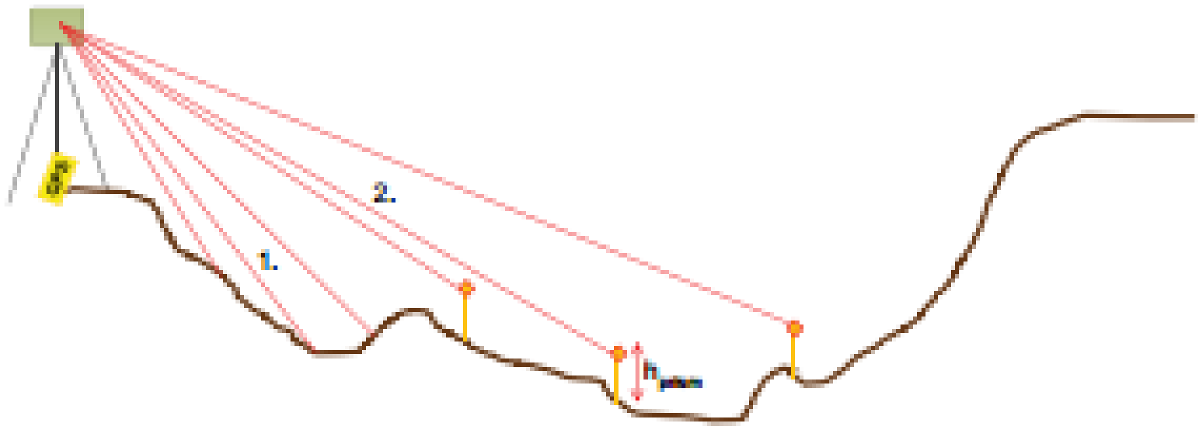

Figure 7: Schematic of how the rangefinder works.

Figure 8: Flagging the segment across the stream cross section.

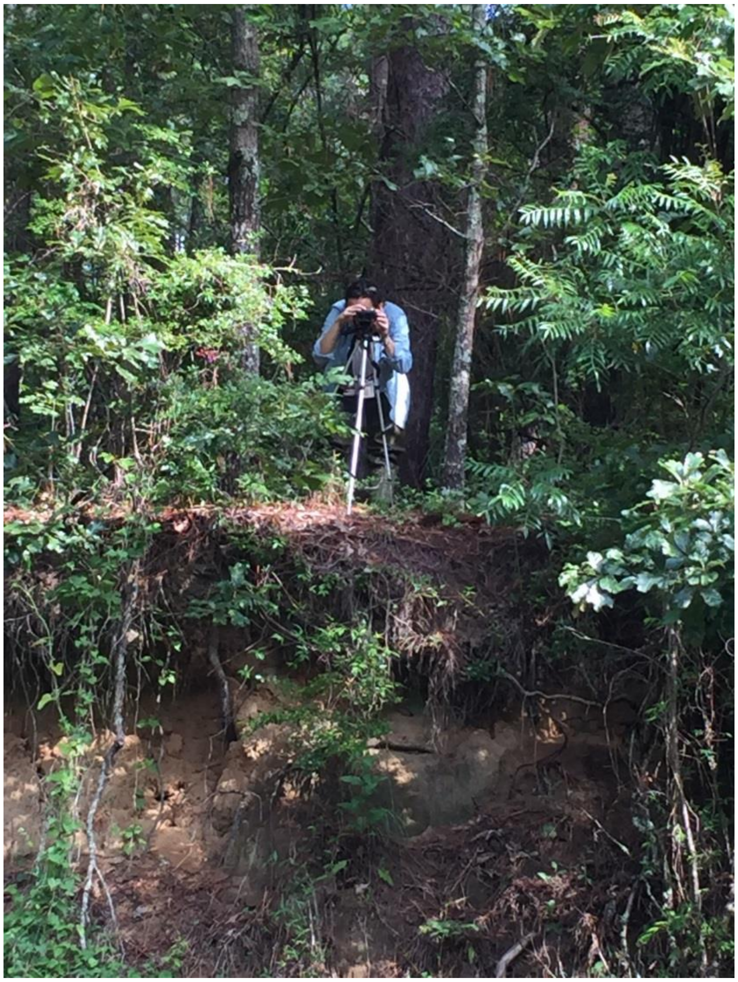

Figure 9: Aiming at each side of the stream with the rangefinder.

Figure 10: Manual measurement of stream width.

Water Quality Parameters

Water quality parameters provide important information about the health of a water body. These parameters are used to find out if the quality of water is safe for drinking, recreation, irrigation, and aquatic life. Monitoring water quality is essential in assessing environmental impact and can help to determine human impact on the ecosystem. Water quality parameters can be physical such as temperature (T) and turbidity; chemical such as pH and dissolved oxygen (DO); or biological (algae, phytoplankton). In this sampling exercise, DO, T, pH, conductivity, and total dissolved solids (TDS) were measured along A-014, A-011, and Tims Branch, by using a handheld Multi Probe System (MPS) YSI (Yellow Springs Instrument, Inc.), Model 556.

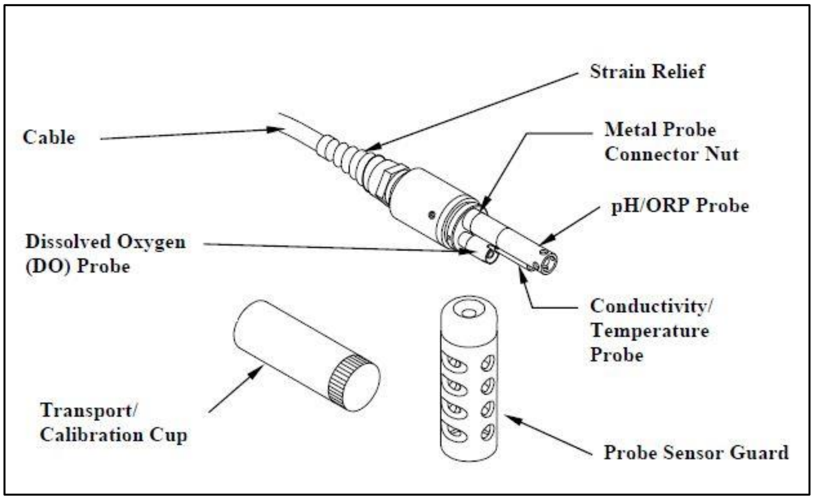

Figure 11: YSI sensor probe/calibration equipment.

Water quality was measured by lowering the YSI multi-parameter probe into the water at each cross section location (Figure 12). Water quality parameters included T, pH, salinity, conductivity, and TDS.

Figure 12: Water quality testing in Tims Branch using YSI multi-parameter meter.

The geographic coordinates of each testing location were recorded by using a GPS device. Elevation was also recorded at each sample point. The YSI was calibrated prior to each use by filling the calibration cup with 200 mL water at each location. Results were both manually recorded as well as electronically by the YSI data storage application.

Water samples were taken, acidified and kept in a cooler to preserve and prevent from possible degradation. Samples were filtered and then analyzed by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) using a NexlON 300x mass spectrometer (Perkin Elmer, Inc.) following EPA protocol for quality control and quality assurance (USEPA 2007).

Figure 13: ICP-MS at Savannah River Ecology Lab (SREL).

Figure 14: Preparation for laboratory testing at SREL: vacuum filtering of samples.

Results and Discussion

Discharge (Flow) Measurement

The flow measurements have been recorded in more than 18 locations along the Tims Branch watershed and several graphs have been created based on the recorded data to understand the behavior of the flow. Figure 15 illustrates the graph of flow velocity measured along Tims Branch, A-011, and A-014. As it shows on the graph, average flow velocity in Tims Branch, A-011, and A-014 are approximately 2.0 cm/s, 7.0 cm/s, and 17.0 cm/s respectively. Flow velocity was higher at the culvert in A-014. In general, the results show that flow velocity is higher in A-014 than in A-011 and Tims Branch. The highest flow velocity was registered at the culvert location in A-014. Because the water level was too low in Steed Pond, no flow was registered in Steed Pond locations downstream Tims Branch. It should be taken into consideration that data collection was limited by time and location. The intention is to use the recorded measurements as preliminary input values required for the model development, however, further data collection may be required to validate this data.

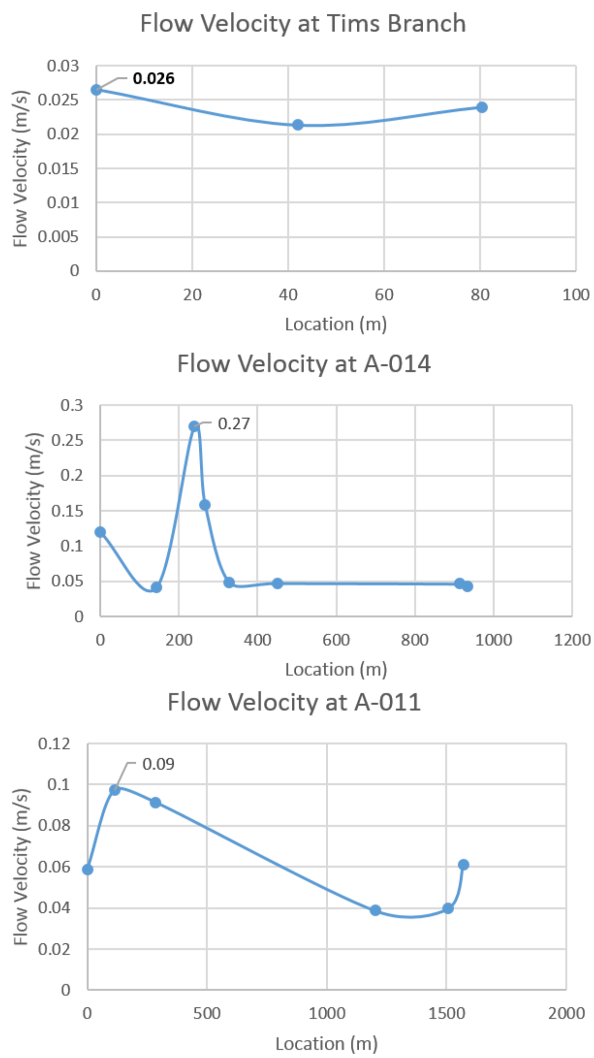

Figure 15: Flow velocity measured at the sites. The distance is relative to the dowstream start point where the original measurement has been taken.

Cross Section Profiling

After all the cross section measurements were taken, the data was processed using a combination of ArcGIS and MIKE 11 tools. The first step was to create a GIS file with the exact location of each of the cross sections. This file was then imported into MIKE 11 when setting up the network (Figure 16).

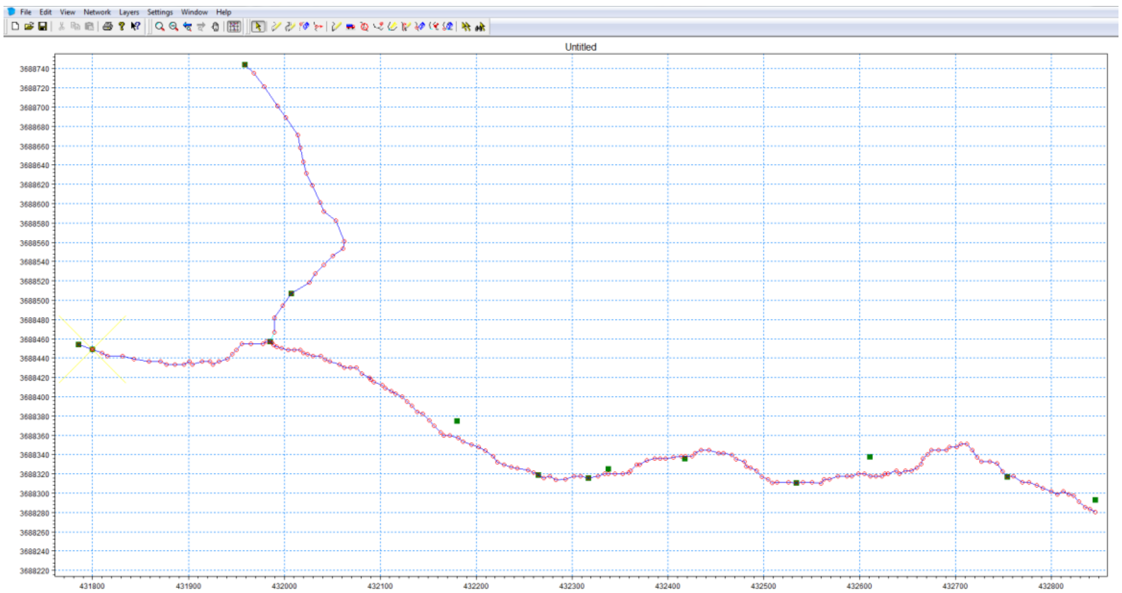

Figure 16: Network setup in MIKE 11.

The reference elevation at each location was obtained from a digital elevation model (DEM) using ArcGIS (Figure 17). From this base elevation, the measured water stream geometry was subtracted using a MS Excel file (Figure 18). This processed cross section data was then imported into MIKE 11 to create each of the cross sections (Figure 19).

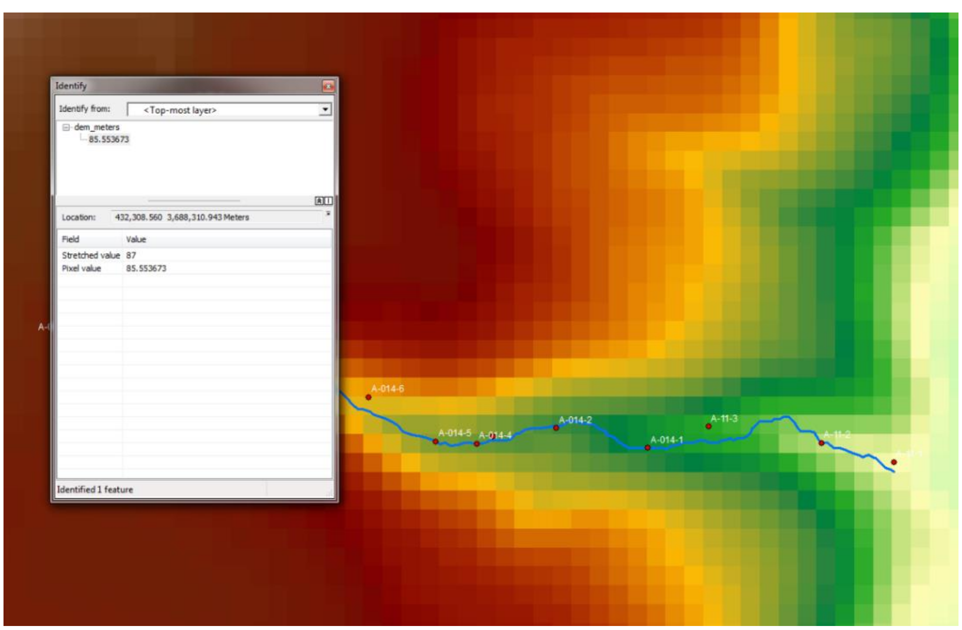

Figure 17: Obtaining base elevation from DEM.

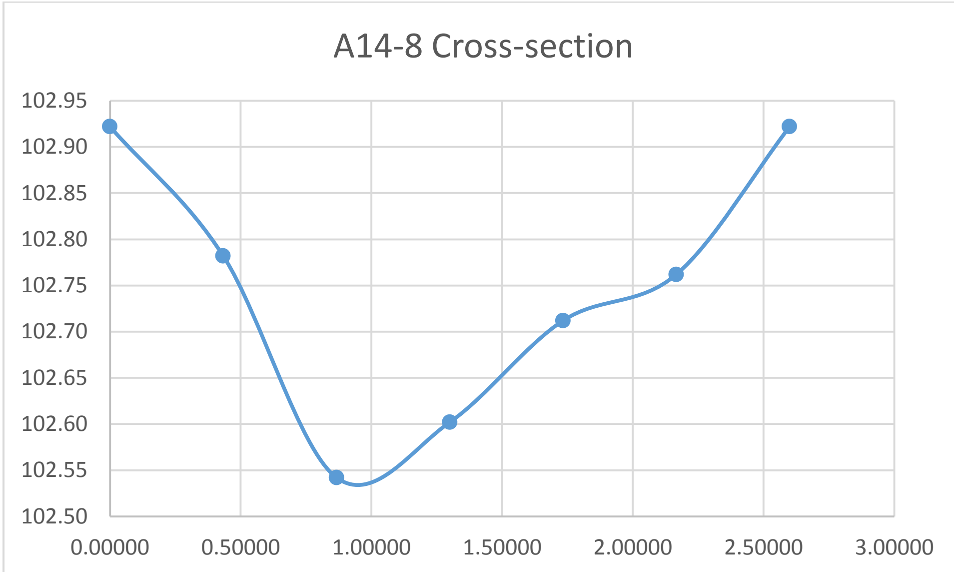

Figure 18: Cross section profile shown in Excel spreadsheet.

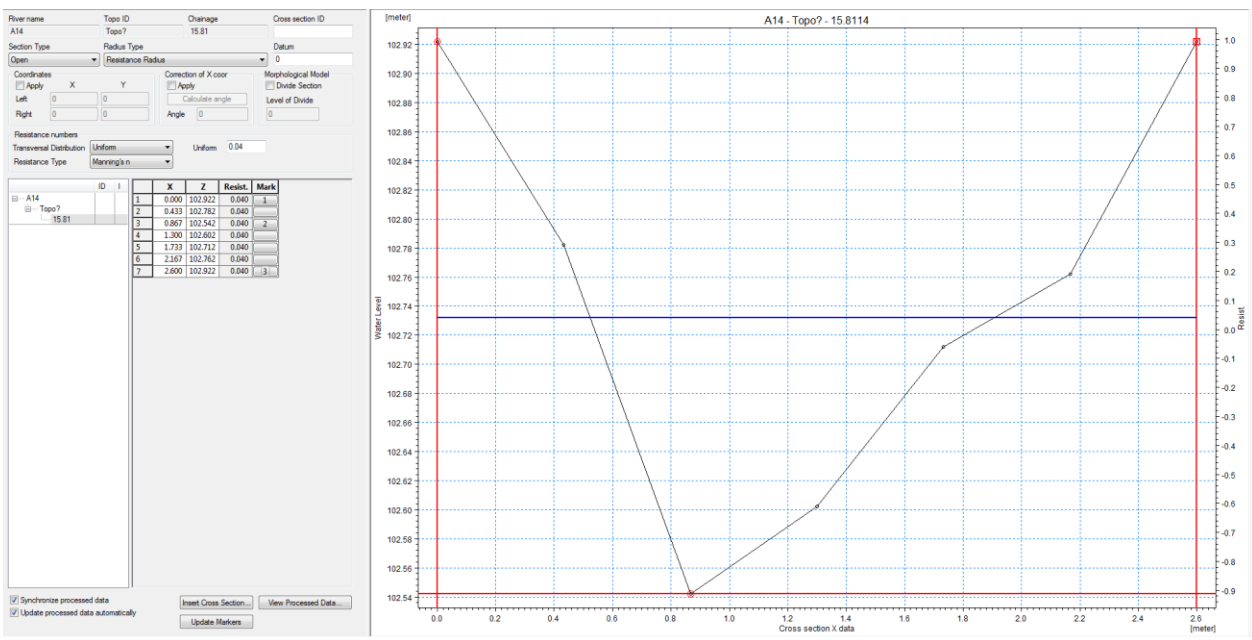

Figure 19: Processing cross section in MIKE 11.

When creating cross sections in MIKE 11, it is necessary to input certain parameters that are characteristic of the stream such as resistance type and associated Manning's number. Currently, a Manning's number of 0.04 has been assigned to all of the cross sections. This number is recommended for these types of stream characteristics. Boundary conditions and hydrodynamic parameters will be added to the model after processing of all the cross section data is completed.

Water Quality Parameters

Table 1 shows the recorded averages of the triplicate YSI measurements of the water quality parameters. As indicated, Tims Branch has lower temperature but higher conductivity, salinity, and total dissolved solids relative to A-011, and A-014.

Table 1: Average Values of Water Quality Measured by YSI

Sample Location	Temperature (°C)	Conductivity (ms/cm)	Total Dissolved Solids (mg/L)	Salinity (ppt)	Dissolved Oxygen (mg/L)	pH
Tims Branch	21.7	0.07	45	0.03	19.9	7.0
Steed Pond	26.7	0.04	14	0.02	4.5	7.3
A-014	23.2	0.04	26	0.02	10.8	6.4
A-011	23.6	0.04	26	0.02	6.9	6.8
Upper Three Runs	23.4	0.03	17	0.02	5.7	7.0

Conclusion

Real-time data provided during in situ data collection and sampling is crucial in hydrological model development. It provides initial data and parameters required when setting up the model. The field data collected during the trip to SRS will be used as initial input parameters for simulation of the Tims Branch watershed hydrology. A secondary benefit was the facilitation of FIU undergraduate and graduate STEM students with hands-on fieldwork experience that has provided a platform for them to enhance their understanding of watershed hydrology and water quality.

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