Picnic Rocks, Current Meter

MET 431 Project Summary

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Scott McLain

Fall 2009-2010
# Table of Contents

**Design Report**

- Project Background ............................................................................................. 2
  - History .................................................................................................................... 2
  - Currents ................................................................................................................ 2

- Project Objective’s .............................................................................................. 3

- Measurement Methods .......................................................................................... 3
  - Turbine Measurements ....................................................................................... 3
  - Doppler Measurement ....................................................................................... 4

- Telemetry System .................................................................................................. 5
  - WIMAX .................................................................................................................. 5
  - Cellular ................................................................................................................ 5
  - 900 MHz Radio ..................................................................................................... 5

- Measuring Devices ................................................................................................ 6
  - Sontek Current Meter’s ...................................................................................... 6
  - Argonaut-XR Current Profiler ......................................................................... 6
  - Argonaut-SL Current Meter .............................................................................. 7
  - Nortek Current Meter’s .................................................................................... 7
  - Aquadopp Current Meter ................................................................................... 7

- Mooring Equipment ............................................................................................... 7

- Power Supply ......................................................................................................... 8

- Computing Options ............................................................................................... 8

- Microcontroller LED Warning Systems ................................................................ 8

- Funding .................................................................................................................. 8

- Permit Requirements .............................................................................................. 9

- Budget ................................................................................................................... 9

- Implementation and Timeline ................................................................................ 10
  - Project Proposal ................................................................................................. 10
  - Project Meeting ................................................................................................. 10
  - City Approvals ................................................................................................. 10
  - Bid Approvals, and Permits ............................................................................ 10
  - Implementation Plan ......................................................................................... 11

- Conclusion ............................................................................................................. 11

**Appendixes**

- Appendix Section A: Budget
- Appendix Section B: Project Timeline
- Appendix Section C: Meeting Summaries
  - 10/6 Project Introduction
  - 10/19 Project Outline
  - 10/26 WIMAX Discussion
11/9 Project Update Meeting
12/3 Final Project Planning

Appendix Section D: Required Equipment and Descriptions
Cellular Telemetry System Quote, Fondriest Environmental
Radio Telemetry System Quote, Fondriest Environmental
Argonaut-XR Specifications, Sontek
Cellular Telemetry Account Set up, NexSens
Data Buoy Specifications, Sontek
Meter Platform Specifications, Approtek
Data Logger Specifications, NexSens
Current Meter System Drawing’s, Fondriest Environmental

Revisions
Acknowledgements
The following document describes the reasoning and development of the MET 431 Rip Current Project. A brief description of the project history is included. This is supplemented with details about the project path’s considerations and the decision making process. There are multiple options that may be used for the Picnic Rocks current meter; once a final path including computing needs and signal transfer is chosen, this report may be used to rationalize all decisions made during the development of this project.
Project Background

HISTORY

The channel located between Marquette’s Picnic Rock beach, and the offshore rocks has produced dangerous currents that have attributed to numerous drowning accidents. Since the 1960’s there have been an exceptional number of deaths related to this current. In recent years drowning deaths have caused a heightened awareness, and increased need for safety measures; recent deaths have left a feeling of ill preparedness for such events. Since then, the city of Marquette has gone to extreme measures to ensure that when the strong current events happen, the park goers will not be left at the mercy of uncontrollable Lake Superior.

CURRENTS

Water currents in Marquette began to develop shortly after the addition of the two local piers. This increased the amount of water that moves along the Picnic Rocks Park. The currents are explained as a long shore current. Water picks up speed during periods of East winds; when the water travels through the shallow region located between the beach and the rocks, the water velocity increases and cause dangerous swimming conditions.

The slightest increase in water speed can create a swimming hazard. One mile per hour is considered to be a moderate level for the casual swimmer. As the currents increase above two or three miles per hour the conditions in the water become increasingly dangerous. The fastest Olympian swimmer can only swim the hundred meter sprint at 5.05 mph; this was trained professional in an ideal swimming environment. Swimming in mild currents and frigid waters
for even a short time causes muscles to tire, and swimmers are quickly pulled into deeper and colder water.

The Marquette city has developed a water rescue team to increase preparedness for dangerous currents. The rescue team is to be notified when conditions become dangerous and swimmers put themselves at risk by disregarding the beach warnings to swim to the offshore rocks. One very important piece of this project is the development of a warning system that can be used to notify the Marquette Fire Department, City Offices, National Oceanic and Atmospheric Association (NOAA), and possibly the public in Marquette when swimming conditions are dangerous.

**Project Objective**

The objective of the 2009-2010 senior projects Rip Current team is to develop a system that can be used to notify the appropriate parties when swimming conditions are dangerous. Data from this system may also be logged and used to help NOAA increase their knowledge of when long shore currents occur and develop a system to increase awareness and preparedness. This will ultimately allow lives to be saved both in the local Marquette Community and in many other cities by increasing the knowledge of how Lake Superior’s water movements work.

The water current recording system is to be deployed on the shallow area between Marquette’s beach and the offshore rocks. It will be placed in the water in the early spring or summer to ensure that it is active during the popular swimming season; it will be removed from the water each year prior to the lake freezing to ensure that the harsh lake conditions do not damage the system during the winter months. Few swimmers are at risk during this season as the local temperatures do not promote beach activity.

During meter deployment it is essential that the data that is recorded by the measurement equipment can be forwarded to the appropriate parties as readings are taken. This will allow an increased preparedness during the most dangerous swimming conditions. The system used to transmit data and house the measurement device may be mounted to underwater mooring’s, and located on a surface buoy. It will be battery powered and a long lifetime with minimal maintenance is very important for this project. The possible outcome of a system failure may result in death; this requires that all systems are designed with the highest caution for awareness of failure.

**Measurement Methods**

**TURBINE MEASUREMENT**

The initial measurement method considered was to implement the use of a turbine system. These systems measure rotations of a turbine and output water current. If a device were to be made by the senior project team, it would utilize this type of design. These designs are simple, low cost, and accurate. The most important consideration of this project is that the device must be long term reliable along with consistent accuracy. Turbine current measuring devices are currently manufactured by many companies for forestry applications. These are referred to
as flow probes and typically are intended for single reading use. A system that is intended to remain submerged for months at a time without displaying signs of corrosion or wear is required to reduce the risk of failure and provide enough data for the cities effort to implement.

In the consideration of developing a handmade system that could be made to measure water current the same issues were discussed. Electronic sensor equipment is required to remain submerged for months at a time. Corrosion resistance is very important for submerged use; water can corrode metallic wiring systems. A plastic turbine blade would best suit the application to ensure that corrosion would not be an issue. 316 Stainless Steel could be used for the meter housing. It could also be used to contain all of the appropriate seals for the electrical equipment as it has exceptional corrosive resistance for a reasonable cost of about fifty dollars for a six foot length of tubing.

DOPPLAR MEASUREMNT

Doppler current meters and profilers were the next system considered for the use of this project. Known as Hydrostatic Technology, a transducer outputs an acoustic pulse; as this pulse impacts particles in the water it is scattered. The velocity of these particles affects the frequency recorded. As the signal is deflected away from the sensor the pitch is decreased allowing the relative velocity of the fluid to be measured. The change in frequency is known as the Doppler shift. This shift is very similar to the affect of a vehicle horn. As a fast moving vehicle or siren passes a large change in pitch is heard. The relative velocity can be calculated using the Doppler formula. This method can be explained by the following equation used in many common applications:

\[
\Delta f = \frac{V_{sr}}{c} f_o
\]

\(\Delta f\) = Recorded Change in Frequency

\(V_{sr}\) = Relative Velocity of source to receiver (Water Particles)

\(c\) = Wave Speed

\(f_o\) = Frequency Observed by the Sensor

Doppler current meters and profilers are used for a variety of applications. They are commonly mounted on sailing vessels to monitor water currents during race events; they are also used to monitor things such as wastewater flow. If water velocity at multiple water depths is measured for this project, a current profiler may be used. The current profiler devices considered can measure water current at up to ten different water depths. A current meter could be used to measure water speed in a single plane. These would be mounted to the bottom of a buoy and measure velocity at a depth of about three feet.
The use of Hydrostatic technology to measure water current is very accurate and many devices are designed for extended periods of use. These devices are enclosed, and because there are no or few mechanical parts there very reliable. The average cost of the current meters considered with this type of application is about ten thousand dollars. With these meters an increased amount of hardware is required to transmit data to an onshore site where it may be viewed by the appropriate parties.

**Telemetry Systems**

The objective of the water current measurement system is to have the ability to transmit the data recorded to all appropriate parties as the data is recorded. To have this ability there were many signal transfer methods considered. Mounting a colored light to the buoy was an initial consideration, but this will not supply the necessary information to the National Weather Service, and provide any real information for further current research. Because the sensor will be mounted close to the shore, a buried cable was a considered option. Due to the constant movement of the water, this cable may consistently be worn and buried in the sand. This could become a failure mode for long term use. The ability to transmit real time data to the appropriate parties through space was decided as the required method for this project.

**WIMAX**

The use of the newly developed WiMAX system located in Marquette was the consideration for the transmission of data to a computer for further deployment. Data can be transmitted long distances and easily read with this type of system. This is still relatively new technology and would require a computer processer to be deployed with the buoy and measuring device, increasing the power draw and decreasing the reliability of the project.

**CELLULAR**

A cellular transmitter located on a data buoy is a common method used for real time data transmission. These systems have been developed and provide a reliable signal in other oceanographic applications. Data can be transferred anywhere there is cellular coverage for a relatively small cost of approximately forty dollars per month. These systems have a low enough power draw to be used for this application. Common cellular suppliers such as Verizon or Sprint may be selected to set up the cellular system. The data that is measured will be sent through a cellular signal and output to an IP address. From that address it can be displayed on the appropriate computer software for further evaluation.

**900 MHz RADIO**

Radio signal transfer was the last method considered. Signals can be sent approximately one mile with very low power draw. A 902-928 MHz radio transmitter would be used to send a signal to the local water treatment center, or Pine Ridge apartments located on Pine Street in Marquette. The computing software may be located at the site of the radio base stations. From here the data may be displayed at a web address. If the computing software is located at a location other than the radio base station, the signal will be sent through a radio to Ethernet.
converter. From there it will be transferred to an IP address and displayed on the base computer.

**Measuring Device**

The objective of the senior project rip current meter team was to develop a system that could be implanted by the local Marquette community at Picnic Rocks Park once per year to measure water currents and provide warnings to the local officials when conditions are dangerous. To do this multiple tasks were required such as scheduling an implementation plan; acquiring project funding and environmental permits are also required. The risk of implementing a system of this size is that it is expected to be reliable for multiple seasons and provide accurate data when required.

Due to these strict requirements multiple project paths were considered. A current meter system could be developed from the ground up and the probability of deploying it in under a year with minimal reliability concerns was very unlikely. To ensure the safety of the population that may put their lives at risk based on the output of a sensor extensive testing would be required to verify reliability. With the hope of still providing a system that meets all of the community’s requirements, outside suppliers were sought to determine what the best solution would be.

After speaking with system suppliers, it was determined that developing a system that can be deployed in the coming summer is a possibility. Many companies such as Nortek Inc. and Sontek Inc. have developed very reliable Doppler current meters that can be deployed for long periods of time with minimal power draw. Accurate waterproof radio and cellular transmitters and power supply systems are also available for offshore deployment applications.

**SONTEK CURRENT MEASUREMENT SYSTEMS**

Argonaut-XR Current Profiler

The Argonaut-XR is a three cell programmable current profiler that has the ability to measure water velocity at ten different water depths, (thirty locations) which may be useful for further analysis of the local water currents. This device is supplied with appropriate mooring hardware for a bottom mount application. Data measured from the device can be transferred via cable to a data logger located on a surface buoy and transmitted by antenna to shore. This device requires many components due to its bottom mount technology and multiple depth reading abilities.
Argonaut-SL Current Meter

The Argonaut-SL Side Looking current meter can be mounted to a vessel, or the underside of a data buoy. This sensor has the ability to measure a two dimensional water velocity at up to one hundred and twenty meters. It is also programmable to record up to ten profiles of water at different distances from the mounting point. This system can be used to eliminate the mooring hardware that’s required for the data sensor to be located at the bottom of the channel. Velocity will be measured at about one meter below the water surface; this depth is the biggest concern for swimming safety.

NORTEK MEASUREMENT SYSTEM

Aquadopp Current Meter

The Aquadopp Current Meter is a sensor that can be used for many different applications. The sensor has optional 3D profiling or 2D measuring. They can be mooring line mounted, or mounted to a rigid fixture in the water. A system that includes this device would include similar technology to the Argonaut-SL current meter. The sensor would be interfaced with a buoy and radio or cellular transmitter. Information recorded would be transferred to an onshore computer for further evaluation.

Mooring Equipment

Two mooring lines will be included to fix the Buoy. Each will be mounted on opposite sides of the data buoy. Marker buoys will be used to locate the system. Any rigid mooring object may be used to fix the system to the channel. For this system two mushroom anchors weighing at least one hundred and twenty five pounds will be obtained.

The current meter will be mounted on a removable mooring base constructed of either 316 SST, or marine grade aluminum. The 316 SST meter mount is ideal for this application. It’s heavier, and has superior corrosion resistance to 6063,
and 5052 aluminum which would be used to manufacture an aluminum mounting bracket. Fabricating a meter mount is a possibility for the project, but would require that the sensor is shipped well before the system is to be implemented so the design and build process can be completed.

**Power Supply**

To power the whole system, three solar packs will be used. These solar packages are capable of supplying five watts of power each, for a total of fifteen watts. These will be used to charge the system’s twelve and a half Amp-Hour capacity battery bank. The total system will use about 1.67 Amp-Hours a day. This solar charging system and battery bank can supply power to the system for five days and possibly a little longer without any light to charge the batteries. With this type of power supply and charging system, power the module should not be an issue. Data from the power module will be output by the radio or cellular transmitter and displayed on a base computer.

**Computing Options**

There are three software packages that may be used to display the data recorded from a Sontek measuring device. Each package displays similar data and allows a different group of users to do a variety of tasks with the information. It is required that the iChart user license is purchased for one computer. This onetime fee software allows the settings of the measurement system to be adjusted. The system may be programmed to turn off at night and only record data during the day. An email list may also be generated by this program, and daily reports of the recorded data can be transmitted to the appropriate parties. The iChart viewer software is also purchased as a onetime fee. It displays the same data that can be displayed by the main iChart computer; the user will not have the option to change any of the system settings. This will allow multiple computers and locations to display the current conditions in the channel without the yearly cost of a public display. The WQData hosting package allows the information to be displayed on a webpage. These webpage’s are very presentable and can be set up for public view or password protected. This display is included with the system cost for a one year free trial. Following the first year trial, the site address will cost nine-hundred dollars a year to maintain.

**Microcontroller LED Warning System**

A microcontroller was considered to be used as an onboard warning system to display a warning light that is located on the buoy. This would be achieved by utilizing the optional analog output package for the Argonaut-SL sensor. The microcontroller would use the analog output signal from the Argonaut, which would be a 0-5 V signal. The microcontroller would take this signal and convert it to display a warning light if the water velocity is above a predetermined velocity of 1-1.5 mph. The Argonaut sensor will send out a voltage signal when every reading takes place. If the voltage that it sends out is at the voltage level that corresponds to a 1-1.5 mph velocity, the microcontroller will turn on a warning light on the buoy. This light will warn people at the beach that a mildly dangerous current is passing through the area, and
deter swimmers from entering the channel. The light will be on until the velocity drops back down to a slower velocity under 1 mph.

**Funding**

Following the cities approvals in mid February, the process of accumulating the appropriate funds for the system will begin. There is not a specific grant that will be looked to for funding the project. One recommended grant will be a cumulative grant application for a Coastal Management Grant. Support will be sought from Northern Michigan University, the City of Marquette and NOAA. Gaining the approval from all parties that wish to be included will be the responsibility of the Rip Current senior project team. When the appropriate funds have been achieved the equipment procurement process will begin, and the project will be implemented.

**Permit Requirements**

As with the grant application, the permit requirement has not been finalized. A joint effort for the project permit will also be sought, and it will be the responsibility of the senior project team to acquire assistance for the application process. A bottomlands permit may be required by the Michigan Department of Environmental Quality. This permit is required for any project that may affect the bottomlands of the Great Lakes. This system will be removable and is intended for yearly deployment during the summer and fall swimming season in Marquette Michigan.

**Budget**

There are four current meter options that would suit the application for the Picnic Rocks system. The Argonaut-XR Current Profiler is the best meter for the application. Radio or Cellular Telemetry may be used to transmit the data to an onshore site. Cellular Telemetry may be the most reliable option for this system, and can transmit data an unlimited distance to an IP address. The advantage of this system is the removal of the radio base station. An average cost of about $2,500 can be saved with use of cellular Telemetry. Other projects that use this type of signal transfer were studied in the decision making process and it was found that the power supply will be adequate for either system.

To utilize the 316 Stainless Steel meter mount the total cost will increase by about $500. This cost is well justified, as the stainless steel option displays much higher corrosion resistance. The aluminum mount is designed for salt water use where the steel mount may not withstand the corrosiveness of the oceans water.

When a final system has been defined a total listed cost can be calculated in the Appendix Section A. The computing requirements will also be included in the final cost of this project. With an estimated five percent increase in cost for next year, the total system will be roughly $30,000. Page three of the Budget can be used to calculate final costs.
Implementation and Timeline

PROJECT PROPOSAL

The final proposal for the city’s Parks and Recreation board is to be completed by January fifteenth. This proposal will include a summary report of the project intentions, and requirements. It must also include a rationalization for the equipment recommended for the project. Attached with the summary report must be a project budget and timeline.

PROJECT MEETING

Upon the completion of the project proposal, an official document that describes all of the project requirements and costs will be distributed to the appropriate parties. These organizations will then be gathered to discuss the project plans. The requirements of this meeting include:

- The approval to continue the current meter project for the city of Marquette
- Computing Requirements
- Finalized Project Budget
- Finalized Project Timeline
- Long Term Maintenance and Cost Responsibilities

Other subjects may include:

- Public Warning Responsibilities
- Cumulative Grant Applications
- Cumulative Permit Applications
- Meter Location

CITY APPROVALS

The project will hopefully be included in the February Parks and Recreation meeting. Gaining approval will result in a project presentation for the Marquette City Commission. If permission to move forward is granted the grant application process will occur.

BID APPROVALS, AND PERMITS

If project funding is received, permits for the current meter system may be filed. In parallel with this process, the equipment procurement process will begin. This includes finalizing purchasing plans. Another City approval will be required for the project purchase.
IMPLEMENTATION

Upon the reception of the final system, the project will be implemented into the channel of water at the decided location by the end of the 2010 summer. This will be implemented in time for the popular swimming season. The first deployment period will give all users an attempt to test their ability to operate the equipment, and fine tune the system for years to come.

A Gantt chart for this project can be reviewed in the Appendix Section B.

Conclusion

The objective of the Senior Project Rip Current team is to develop and implement a system that may be used to notify the appropriate parties when swimming conditions are dangerous at Picnic Rocks Park. This information may be measured with a variety of methods. The method selected for this project includes the use of a Doppler Current Profiler. This device along with all other devices was chosen to provide the most accurate and reliable data to the city and NOAA possible in a one year development period. The risk of failure due to a lack of testing was the driving factor in this decision. A current warning system will allow authorities to prepare for water related incidents, and allow the beachgoers of Marquette to enjoy the Picnic Rocks Park with a heightened awareness for the water movements; this system is intended to save lives, and hopefully provide information for future research opportunities.
Appendix

CONTENTS

Section A: Project Budget
Section B: Gantt Chart
Section C: Meeting Summaries
Section D: Required Equipment and Descriptions
This is an accumulative table containing all of the required costs for each current meter system discussed. The final page can be used to display the system totals and calculate the project costs.
## Picnic Rocks, Current Meter
### Appendix Section A: Budget

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Description</th>
<th>Price</th>
<th>Qty.</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>5200-iSIC</td>
<td>Nexsens</td>
<td>Radio to Ethernet data logger</td>
<td>$2,995.00</td>
<td>1</td>
<td>$2,995.00</td>
</tr>
<tr>
<td>SCP-M150</td>
<td>Jamestown Distributors</td>
<td>150 lb Mushroom Anchor</td>
<td>$215.00</td>
<td>2</td>
<td>$430.00</td>
</tr>
</tbody>
</table>

**Consumables**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Description</th>
<th>Price</th>
<th>Qty.</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>8.5 A-Hr. Batteries</td>
<td>$35.00</td>
<td>3</td>
<td>$105.00</td>
</tr>
</tbody>
</table>

### Final Project Cost

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Telemetry System (Aluminum Meter Mount)</td>
<td>$26,604.55</td>
</tr>
<tr>
<td>Radio Telemetry System (316 SST Meter Mount)</td>
<td>$27,104.55</td>
</tr>
<tr>
<td>Cellular Telemetry System (Aluminum Meter Mount)</td>
<td>$23,759.70</td>
</tr>
<tr>
<td>Cellular Telemetry System (316 SST Meter Mount)</td>
<td>$24,259.70</td>
</tr>
<tr>
<td>Cellular Telemetry System (Approximate Monthly Fee)</td>
<td>$40.00</td>
</tr>
<tr>
<td>iChart Software, (1 Computer)</td>
<td>$895.00</td>
</tr>
<tr>
<td>WQData Package (Yearly Fee after First Year)</td>
<td>$900.00</td>
</tr>
<tr>
<td>iChart Viewer Software, (1 Computer)</td>
<td>$695.00</td>
</tr>
</tbody>
</table>

Include One Telemetry System plus the required computing costs.
WQ Data Package, $900.00 yearly fee after first year of use.
3 - 8.5 A-Hr batteries will be required every 2-3 years.

Total Cost: ______________________________
Displayed in the following pages are the project timelines. These may be updated as the project implementation occurs to display the current deadlines. Outdated timelines shall be marked as obsolete and remain in this folder.
This is a short summary of the project meetings that have taken place in the development of the current meter system. Each summary displays a brief description of the meeting objectives and items discussed.
Objective:
To determine the objective of the Picnic Rocks Rip Current meter project. The project was proposed by Dave Guenther, Meteorologist/Forecaster from the National Oceanic and Atmospheric Association (NOAA) for a meter to be placed at Marquette Michigan’s Picnic Rocks Park that can be used to study the cause of the alongshore currents in Marquette. This data can be used to display warning systems and increase the public safety on Marquette’s beaches.

Summary:
- A quick summary of the alongshore currents in Marquette and the weather conditions that causes currents was discussed.
- Water builds and moves along local piers and increases in velocity when crossing the narrow channel between the rocks and beach.
- System can be introduced to the water every summer and removed during non-swimming seasons. It is intended for safety warnings and data is not necessary during non-swimming months.
- The most ideal location for the current meter is directly between the offshore rocks and beach where swimmers are often swept from the beach.
- A meter that can display real-time water velocity will be best suited for this project; it can be used to notify appropriate parties when swimming conditions are dangerous.
- Information found will be helpful for NOAA to determine the magnitude of affects of the causes for alongshore current’s. This information can be used to provide more accurate warnings on Marquette’s beach, and better understand the currents located in other regions with large bodies of water.
- A meeting is to be scheduled with the Marquette Board of Parks and Recreation to determine their objectives and what will be necessary to have the project implemented.
Date: 10/19/09  
Location: Lakeview Arena Parks and Recreation Office  
Attendee’s: Karl Zueger – Asst. City Manager, City of Marquette  
            Doug Smith – Asst. Parks and Rec. Director, City of Marquette  
            Scott McLain  
            Craig Wiseman

Objective:
To discuss the city of Marquette’s interest in seeing a current meter implemented into the local beach, and to determine what is necessary for this project to be completed. A scope for the financial objectives of the project is necessary in determining the measuring equipment that is to be used. A brief discussion of the sensor equipment that will be necessary was also to be included in this discussion.

Summary:
- The city of Marquette is interested in seeing a current meter deployed in the lake near picnic rocks to be used to provide adequate warnings and allow the water rescue teams to better prepare for emergencies.
- Project concerns discussed included:
  - Power Supply
  - Signal Transfer
  - Output Method
  - Reliability
- Each of these items was discussed briefly in discussion about project design.
- It was discussed in the 10/6 meeting with Dave Guenther, that NOAA buoy’s include the use of solar and battery power to proved for measurement devices. The same method is to be researched for this project.
- The use of Marquette’s Wi-Max network was discussed. An internet signal can be used to display the information on an IP address and then a computer. A meeting is to be scheduled to further discuss this option.
- Multiple sensor types were discussed for reliability. The use of a Doppler sonar device was mentioned with an estimated cost of $8,000 for the measurement device. This cost is an acceptable amount for the scope of this project.
- Turbine sensors were briefly discussed. This measurement method may not be intended for long term (5-10 year) deployment and was not discussed as a group beyond this meeting.
- A list of milestones and project requirements is to be completed by Scott McLain and Craig Wiseman following this meeting and submitted to Karl Zueger. This list includes the issues to be resolved and project deadlines with responsibilities.
Date: 10/26
Location: Marquette City Hall
Attendee’s: Al Hawker – Information Technology, City of Marquette
Scott McLain
Craig Wiseman

Objective:
To discuss the requirements and use of the City’s local Wi-Max network to transmit data from a buoy to an onshore computer.

Summary:
- The use of a Wi-Max radio will require a computer processor to be located on the data buoy. This will also require constant power to the device rendering it an unrealistic device for this system.
- The option of using a cellular signal was discussed.
  - This signal has a much lower power draw and can be used to send signals an unlimited distance.

Following this meeting a phone call was made to Paul Nieberding of Fondriest environmental. In this conversation the available methods of measuring signals and transmitting data to an onshore warning system were discussed. A bottom mount current meter with radio or cellular telemetry would best fit this application. This method was further researched for the duration of the semester to determine the most reliable equipment for the Cities Current Meter Project.
Date: 11/9
Location: Lakeview Arena Parks and Recreation Office
Attendee’s: Karl Zueger – Asst. City Manager, *City of Marquette*
             Tom Belt – Marquette Fire Chief, *City of Marquette*
             Scott McLain
             Craig Wiseman

Objective:
To discuss the questions of reliability, and signal transfer. Further details were to be determined such as signal rate and project cost.

Summary:
- **Signal Transfer**
  - The inability to utilize a form of internet signal was initially discussed.
  - The use of the radio and cellular signal would both be applicable for this project.
    - 900MHz Radio is a free line of sight signal.
    - Cellular has an unlimited distance, and small monthly free (Approx. $40)
  - A radio antenna can be placed near the Marquette Water Treatment facility, or the elevated water tower.
  - The use of a radio signal was heavily considered following this meeting.
- Signals measured for five minutes every 15 minutes will be sufficient for increasing the swimming safety.
- An estimated budget of about $25,000 dollars will be required to provide the use of a Doppler current meter with a radio telemetry base station. This system will provide data in real time to one computer for the values to be evaluated.
- System also includes a one-year free trial of an internet display of the current meter measurements. This is available for the public to view on the web from their home computers. A similar web page may be viewed at: [http://v4.wqdata.com/webdblink/trec.php?tab2=overview&t=classic_web](http://v4.wqdata.com/webdblink/trec.php?tab2=overview&t=classic_web)
- A final quote is to be obtained for the project following this meeting and the evaluation of the project goals.
- When final budget is completed a cooperative meeting is to be held for all parties involved to discuss their inclusion in the current meter project.
Date: 12/3
Location: Lakeview Arena Parks and Recreation Office
Attendee's: Karl Zueger – Asst. City Manager, City of Marquette
         Tom Belt – Marquette Fire Chief, City of Marquette
         Craig Wiseman

Objective:
To discuss the final budget and determine a task list that must be completed for project implementation. The appropriate grants and permits were to be discussed for inclusion in the MET 431 presentation.

Summary:
- The use of a pole mount system that measures a 2D water velocity was initially discussed. This item would be used to decrease the overall cost of the system. Initially it was expected that the meter could be mounted to the underside of a buoy. Due to the turbulence of the water this mounting system would not provide adequate support for accurate readings. A bottom mount Argonaut XR sensor was decided on for the project.
- An increased mooring weight of 125 lbs is to be researched for the final budget.
- Data can be sent through a 900 MHz signal to the Water Treatment center and broadcast through the internet to the appropriate parties. The cost of this device is approximately $3,000.
- A brief discussion was included about the parties that wish to have involvement in the project and how the data is to be transmitted to them. Upon completion of the project budget and proposal a project meeting (Project Meeting 1 as shown in the timeline) is to be held with all appropriate parties to discuss funding, signal reading, and maintenance.
- An overall life expectancy of 5-10 years is a good estimate for this system. It is intended for long term deployment. Consumables include (3) 8.5 A-Hr Batteries, Approximately $35 a piece. It is recommended that these are replaced once every 2-3 years.

- Project Timeline includes
  - Budget – 12/11
  - Proposal Draft – 12/24
  - Final Proposal – 1/15
  - Project Meeting – 1/18
  - Parks and Recreation Approval – 2/3
  - City Commission Approval – Not Available
  - Grant Application – 4/1
  - Grant Acceptance – 5/1
  - File Permits – Not Available
  - Equipment Procurement – 5/25
  - Bid Approvals – Not Available
  - Purchase Equipment and implement project – Completed by early September
This is a short summary of the required equipment for the Current Meter Project. Including two complete quotes. The first for the Argonaut XR System with Radio Telemetry and internet display, second with Cellular Telemetry and internet display. Data sheets were attached for the items included in the quotes.
NexSens Technology
Real-Time Environmental Data

Data logging and telemetry systems for environmental monitoring

Detailed Price Quotation
Additional Services

Craig Wiseman
Northern Michigan University

888-426-2151
About Us

Located near Dayton Ohio, Fondriest Environmental is a consulting, sales, service, and support provider for a wide variety of environmental monitoring equipment and systems in the Great Lakes region. The company specializes in designing and implementing real-time environmental monitoring systems with data transmission via cellular, radio, land-line, satellite, and SMS messaging. The company is led by President and Chief Executive Officer, Steve Fondriest, who was himself a member of the senior management team at YSI Incorporated, leading their research and development efforts for 15 years.

Training & Support

Rely on our detailed product knowledge and experience to get you over the hurdles. To ensure our customers can begin using their equipment as quickly and efficiently as possible, our application engineers are available for training and technical support, both by phone and in person. Our company offers both extensive field experience and a wide array of deployment hardware to facilitate the implementation of your project, no matter how complex. Our close proximity to many customers also provides us with the unique opportunity to offer personalized, on-site training, and our commitment enables us to establish long-lasting relationships for on-going product support.

Real-Time Network Design & Data Collection

Save valuable time and money by eliminating the need to manually retrieve field data. Fondriest Environmental combines cutting edge technology and advanced software to produce seamless networks of environmental sensors that provide real-time data from remote locations. Contact us to find out how simple and cost-effective it is to have 24-hour access to your data, automatically generate reports, receive instant notifications, and easily share data with colleagues around the world. Fondriest Environmental can even perform the field monitoring and data collection, so you can concentrate on the system analysis and modeling.

Factory-Authorized Repair & Maintenance

Fondriest Environmental is a factory-authorized repair and service center for many environmental instrument manufacturers. To ensure the continuity of your sampling program and accuracy of your data, we offer excellent turn-around times and low service costs on instrument repair and annual maintenance services. Send your instrument to us, and you can be assured it will be returned to you meeting factory specifications in a timely and cost-effective manner.

Our Commitment

Fondriest’s commitment to customers and their projects ensure continued product support, resulting in long-lasting, value-added business relationships.
The PRACTICAL SOLUTION to CURRENT and WAVE MEASUREMENT

The Argonaut-XR offers exceptional value for current profiling applications. Its small size, rugged build quality, and flexible system architecture make the Argonaut-XR very attractive for both real-time operation as well as autonomous deployments.

SonTek’s exclusive MultiCell feature allows you to preprogram 10 fixed velocity cells wherever you want, then an 11th dynamic cell can be set to automatically change its position as the water level changes.

The basic autonomous system includes batteries, internal recorder, compass/tilt sensor, pressure and temperature sensors. Adding options such as the SonWave package, or a SeaBird MicroCAT CT sensor, make the Argonaut-XR the centerpiece of a complete oceanographic system.

### FEATURES
- 10 cell current profiling
- AutoTide - Additional velocity cell that dynamically adjusts with changing water level
- Pressure
- Temperature
- Internal recorder
- Non-corrosive housing

### OPTIONS
- Waves (height, period, spectra)
- Battery power
- Integrated CTD

---

The additional dynamic cell adjusts with changing water level.

The Argonaut-XR measures water velocities at each of the profiling cells.
Argonaut-XR

Select the Argonaut-XR frequency that meets your range and resolution requirements:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Maximum Range*</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 MHz</td>
<td>6.0 m (20.0 ft)</td>
<td>0.2 m (0.6 ft)</td>
</tr>
<tr>
<td>1.5 MHz</td>
<td>20.0 m (66.0 ft)</td>
<td>0.4 m (1.2 ft)</td>
</tr>
<tr>
<td>0.75 MHz</td>
<td>40.0 m (131.0 ft)</td>
<td>0.8 m (2.5 ft)</td>
</tr>
</tbody>
</table>

* Maximum range may vary depending on environmental conditions.

Water Velocity
- Range: ±6m/s (0.003 ft/s)
- Resolution: 0.1 cm/s
- Accuracy: (0.016 ft/s) ±1% of measured velocity, ±0.5 cm/s

Standard Features
- MultiCell feature (10 water velocity cells plus an eleventh automatically adjusting cell)
- Three-beam transducer for measuring 3D water velocity
- Integrated piezoresistive pressure sensor 0.1% accuracy
- Reflected echo intensity output
- SDI-12 (with a limited set of output parameters)
- Mounting plate for easy installation
- RS 232 communication protocol
- ViewArgonaut Windows software for real time data collection, data retrieval, deployment, diagnostics and processing
- Flexible sampling strategies for reduced duty cycle operation and extended deployments of over 1 year
- Internal memory (stores over 20,000 samples)
- Compass/two-axis tilt sensor
- Temperature sensor on exposed titanium pin for fast response

Optional Features
- External battery pack for autonomous operation
- RS422 or RS485 output
- RPT Pressure sensor
- Integrated SeaBird CTD

SonWave real-time non-directional wave spectra package
YSI 6820

Temperature Sensor
- Resolution: 0.01°C
- Accuracy: ±0.1°C

Compass/Tilt Sensor
- Resolution: Heading, Pitch, Roll 0.1°
- Accuracy: Heading ±0.5°
- Accuracy: Pitch, Roll ±1°
- Built-in calibration procedure to compensate for ambient magnetic fields

Physical & Environmental
- Depth rating: 200m
- Dimensions: 15.2 cm (6.0 in.) diameter by 18.0 cm (7.1 in.) height
- Weight in air: 2.5 kg (5.5 lb.)
- Weight in water: -0.3 kg (-0.7 lb.)
- Operating Temperature: -5° to 40°C
- Storage Temperature: -10° to 50°C

Power
- Input power: 7-15 V DC
- Typical power consumption: 0.2 to 0.3 W (continuous operation); 0.01W (stand-by)
- Battery capacity (alkaline): 400 W-hr

GLOBAL HEADQUARTERS
SonTek/YSI Inc.
9940 Summers Ridge Road
San Diego, CA 92121
Tel: (1) 858-546-8327
Fax: (1) 858-546-8150
inquiry@sontek.com
www.sontek.com

The Argonaut-XR on mounting plate with optional battery pack.

Display multi-cell velocities using SonTek’s ViewArgonaut software.

SonTek and Argonaut are registered trademarks of SonTek/YSI, Inc, San Diego CA, USA. Specifications subject to change without notice. SonTek/YSI is an employee-owned company. Argonaut-XR V4, 9/04
Setting Up A Cellular Data Account
This guide will help you set up a cellular account for a 3100 or 3200-iSIC data logger.

Overview
In order for a NexSens cellular telemetry system to function properly, there are details that need to be specified to the cellular service provider during account setup.

General Account Requirements
1. Unrestricted. An unrestricted account allows the device general internet access.
2. Static Public IP Address. This provides quick and reliable access to the data logger when the system is reset or when the cellular modem is reconnected.
3. Mobile-Terminated. A Mobile-Terminated account allows connections to be made from iChart software to the iSIC cellular data logger.

Cellular Coverage
The chosen service provider must offer good coverage in the area of deployment. Use these links to check coverage areas.

1. Verizon/Alltel:
   www.verizonwireless.com/b2c/CoverageLocatorController
2. Sprint:
   http://coverage.sprintpcs.com

Alltel Specific Requirements
1. Contact NexSens to obtain the cellular modem ESN number.
2. Contact Alltel and request a new account with the three general requirements. Supply the ESN number and modem type (Airlink Raven XT) to the service provider upon request.

Verizon Specific Requirements
1. Contact NexSens to obtain the cellular modem ESN number.
2. Contact Verizon and request a new account with the three general requirements. Supply the ESN number and modem type (Airlink Raven XT) to the service provider upon request.
3. Contact NexSens with the information so factory-activation and configuration can be completed.

Sprint Specific Requirements
1. Contact NexSens to obtain the cellular modem ESN number.
2. Contact Sprint and request a new account with the three general requirements. Supply the ESN number and modem type (Airlink Raven XT) to the service provider upon request.
3. Contact NexSens to confirm the account is setup and the modem is ready for factory-activation and configuration.

Note: If initial account activation is unsuccessful, the MDN and MIN/MSID numbers may be required.

NOTE: All cellular iSIC data loggers should be activated, configured, and tested by NexSens to ensure quick startup in the field. After following the appropriate steps outlined above, keep in contact with NexSens about account updates and/or issues so as to guarantee prompt shipment or delivery.

Users may choose to activate, configure and test the cellular modem without assistance if desired.

For more information see the online manual
The NexSens Data Buoys are perfect for offshore water monitoring systems. The floating platform supports various equipment mountings, both above and below the surface. Temperature strings, multi-parameter sondes, weather stations, and other monitoring instruments can be quickly deployed in reservoirs, lakes, rivers, streams, and protected coastal waters. Aluminum above the water and stainless steel below provide a structurally sound platform for mounting instrumentation.

The buoys are constructed of an inner core of cross-linked polyethylene foam with a tough polymer skin. A single, 6-inch diameter pipe passes through the center of the buoy for housing instrumentation. The topside cylindrical aluminum tower features a locking hinge mount, allowing quick access to the instrumentation for calibration and maintenance. Three topside power compartments house NexSens SP5 solar power packs, which include an upward-looking 5-watt solar panel and 8.5 amp-hour battery housed in a watertight compartment. Top and bottom-mounted stainless steel eye-nuts support mooring lines and lifting rigs.

The MB-300 and MB-500 buoys are designed to accommodate NexSens SDL500 submersible data loggers. The SDL500 Submersible Data Logger is configured with five sensor ports for connection to industry-standard digital and analog interfaces, including RS-485, SDI-12, 1-wire temp string, 0-2.5V, pulse count, and more. Each sensor port offers a UW receptacle with double o-ring seal for a reliable waterproof connection. SDL500 data loggers are available with built-in spread spectrum radio or cellular telemetry for data transmission to shore. Contact our application engineering team for assistance on configuring a monitoring buoy for your next project.
PMD Series Trawl resistant Sea Floor Platform for Acoustic Doppler Current Meter instruments.

- Trawl resistant design
- Constructed out of Marine Grade Aluminum or Type 316 Stainless Steel
- Easy underwater instrument retrieval on some models
- Multiple hoist points
- Field tested design
- Approximate weight in Marine Grade Aluminum: 30-40 kg.
- Approximate weight in Type 316 Stainless Steel: 60-80 kg.
- Additional weight rods can be fitted inside.
- Optional Gimbal stabilizer.

Sea Floor Trawl resistant platform for Sontek® Argonaut XR™ With integrated pvc weight container attachment.
Sea Floor Trawl resistant platforms
Pictured with Sontek® Argonaut™ series, battery and weight attachment.

<table>
<thead>
<tr>
<th>mounted instrument</th>
<th>dim A</th>
<th>dim B</th>
<th>dim C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sontek® Triton®</td>
<td>1016 (40&quot;)</td>
<td>768 (30 1/4&quot;)</td>
<td>273 (10 3/4&quot;)</td>
</tr>
<tr>
<td>SonTek® Argonaut XR™ (Low profile) 3.0, 1.5 and 0.75 MHz</td>
<td>965 (38&quot;)</td>
<td>254 (10&quot;)</td>
<td>305 (12&quot;)</td>
</tr>
<tr>
<td>Sontek® Argonaut® XR 3.0, 1.5 and 0.75 MHz</td>
<td>1016 (40&quot;)</td>
<td>406 (16&quot;)</td>
<td>305 (12&quot;)</td>
</tr>
<tr>
<td>Sontek® Mini ADP® 3.0, 1.5 and 0.5 MHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sontek® ADP 1.0, 0.5 and 0.25 MHz</td>
<td>1219 (48&quot;)</td>
<td>457 (18&quot;)</td>
<td>305 (12&quot;)</td>
</tr>
</tbody>
</table>
The **SDL500** Submersible Data Logger is a rugged, self-powered remote data logging system for deploying environmental sensors in streams, rivers, wetlands, coastal waters, sewers, and culverts without fear of accidental flooding. The system is configured with five sensor ports for connection to industry-standard digital and analog interfaces including RS-485, SDI-12, 1-wire temp string, 0-2.5 VDC, and more. Each sensor port offers a UW receptacle with double O-ring seal for a reliable waterproof connection. Unlike many data loggers, the **SDL500** is truly submersible. The housing and battery compartment are completely sealed and waterproof.

When it comes to field ruggedness, the NexSens **SDL500** is in a class of its own. The housing is constructed of impact-resistant PVC and includes two elastomer bumpers for long-term deployment in close-fitting pipes and buoy ports. Internal circuit boards and communication modules are shock mounted and all access ports incorporate redundant sealing. The **SDL500** withstands extreme wave action, drops, floods, periodic & long-term deployment underwater, and more. When fitted for wireless remote communication, the radio and cellular antennas are also waterproof.

The **SDL500** can operate autonomously via eight D-cell alkaline batteries. Optional solar power kits provide long-term continuous operation and solar charging. The data logger incorporates the same analog and digital interfaces as the popular NexSens **iSIC** data loggers. Common sensor connections include multi-parameter sondes, water quality sensors, temperature strings, Doppler velocity meters, water level sensors, and weather stations. User-supplied sensor cable assemblies can also be connectorized and tested at the factory for **SDL500** integration. With this sensor interface versatility, the measurement possibilities are endless.
### Specifications

| **Analog Inputs** | (2) differential or (4) single-ended, 0-2.5V auto range, 12-bit resolution |
| **Analog Outputs** | (1) 12-bit channel, 0-2.5V |
| **Power Outputs** | (1) 12V 100 mA switch; (1) 5V 100 mA switch; (1) 12V output, fused from battery |
| **Pulse Counters** | (1) tipping bucket counter, max rate: 12 Hz |
| **Digital I/O Ports** | (1) standard generic I/O port |
| **SDI-12 Interface** | (1) SDI-12 port (10 sensors), v1.3, can be configured as master or slave |
| **RS-232 Interface** | (2) RS-232 ports |
| **RS-485 Interface** | (2) RS-485 ports, host and sensor interface |
| **NMEA 0183 Interface** | (2) RS-232 ports |
| **Modbus RTU Interface** | RS-232 or RS-485, can be configured as master or slave |
| **Internal Memory** | 2 MB Flash memory, over 500,000 data points minimum |
| **Power Requirements** | Voltage: 10.7 to 16 VDC |
| **Typical Current Draw** | 5 mA sleep, 10 mA processing, 36 mA analog measurement |
| **Battery** | (8) D-cell alkaline batteries, internal; optional 12VDC power |
| **Maximum Depth** | 200 ft. |
| **Temperature Range** | 0 to +60°C |
| **Dimensions** | 18.25” length x 5.5” diameter |
| **Weight** | 11.0 lbs without batteries; 13.8 lbs with batteries |
| **Compatible Sensors** | 4-20 mA sensors, Voltage sensors, SDI-12 sensors, RS-232 sensors, RS-485 sensors, Modbus RTU sensors, NMEA 0183 sensors, Thermistor sensors, Tipping bucket rain gauges, & sensorBUS sensors |

**Contents**

- (1) SDL500 Submersible Data Logger
- (6) SDL Port Plugs
- (1) USB Interface Cable*
- (1) USB Driver CD*
- (1) Quick Start Guide
- (8) D-Cell Alkaline Batteries
- (1) Allen Wrench
- (1) Maintenance Kit

*Only ships with SDL500 standalone data logger

### Parts List

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDL500</td>
<td>Submersible data logger</td>
</tr>
<tr>
<td>SDL500R</td>
<td>Submersible data logger with spread spectrum radio telemetry</td>
</tr>
<tr>
<td>SDL500C</td>
<td>Submersible data logger with cellular modem telemetry</td>
</tr>
<tr>
<td>A44-SDL</td>
<td>High gain antenna with UW connector, radio frequency</td>
</tr>
<tr>
<td>A49-SDL</td>
<td>High gain antenna with UW connector, cellular frequency</td>
</tr>
<tr>
<td>SP5</td>
<td>Solar power kit, 5-watt panel, regulator, 8.5 A-Hr battery</td>
</tr>
<tr>
<td>SP10</td>
<td>Solar power kit, 10-watt panel, regulator, 8.5 A-Hr battery</td>
</tr>
<tr>
<td>SP20</td>
<td>Solar power kit, 20-watt panel, regulator, 8.5 A-Hr battery</td>
</tr>
<tr>
<td>UW-FL</td>
<td>UW to flying lead cable for external power &amp; communications, 3m</td>
</tr>
<tr>
<td>UW-CON</td>
<td>UW-connectorization of user-supplied sensor cable assembly</td>
</tr>
<tr>
<td>UB500</td>
<td>Locking aluminum SDL500 utility box</td>
</tr>
<tr>
<td>1001</td>
<td>iChart Software for Windows-based computers</td>
</tr>
</tbody>
</table>