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16/02/2015

Installation Report – Automated Weather Station (Telemetered)

Project Overview

Element Hydrographic Solutions (Element) were contracted MWCC Group (on behalf of Novo Resources) in November 2014 for the supply and installation of an Automated Weather Station at Nullagine, Western Australia. The data collected from this site is to be used for a variety of reasons as the exploration and mining projects develop, including:

- To gain an improved understanding of Hydrology in the area - including catchment run-off characteristics, rainfall distribution across the lease area.
- For daily operational needs such as assessment of road conditions.
- To provide an early flood warning system through analysis of not only daily rainfall totals, but also extremes in rainfall event intensity.

System Overview

The Nullagine Automated Weather Station (AWS) is located 3km north of the Nullagine Township within the Beatons Creek gold exploration area (Novo Resources) in the Pilbara Region of Western Australia. The site is located approximately 200km north of Newman, and approximately 1,375 km north of Perth by road.

The instrumentation and sensors selected for this project are all high quality for mining and hydrological assessment purposes, and selected to meet Bureau of Meteorology standards. In addition to rainfall, the site also records Air Temperature, Relative Humidity, Solar Radiation, Barometric Pressure Wind Speed and Wind Direction.

Please refer to Table 1 for a summary of accuracy and measurement ranges of each of the AWS sensors.

Wind parameters are recorded at 10-meters above surrounding ground level, as per Bureau of Meteorology guidelines for exposure and siting. To enable sensor servicing and routine maintenance, a 10-metere break-back (seesaw) style mast was installed to mount all weather sensors and enclosures.

Below is an overview on the key components of the Nullagine AWS:

Air Temperature & Relative Humidity Sensor – HC2S3:

- Manufactured by ROTRONIC in Switzerland, distributed by MEA Pty Ltd in South Australia.
- Utilises IN1 capacitive sensor to measure RH and a 100 ohm PRT to measure temperature long-term stability in harsh monitoring conditions.
- Weather-proof enclosure (IP66 Rated), with protective radiation screen.
- Data logged every 5-minutes by the Neon Remote Terminal (Next G).

Figure 1 – General site lay-out

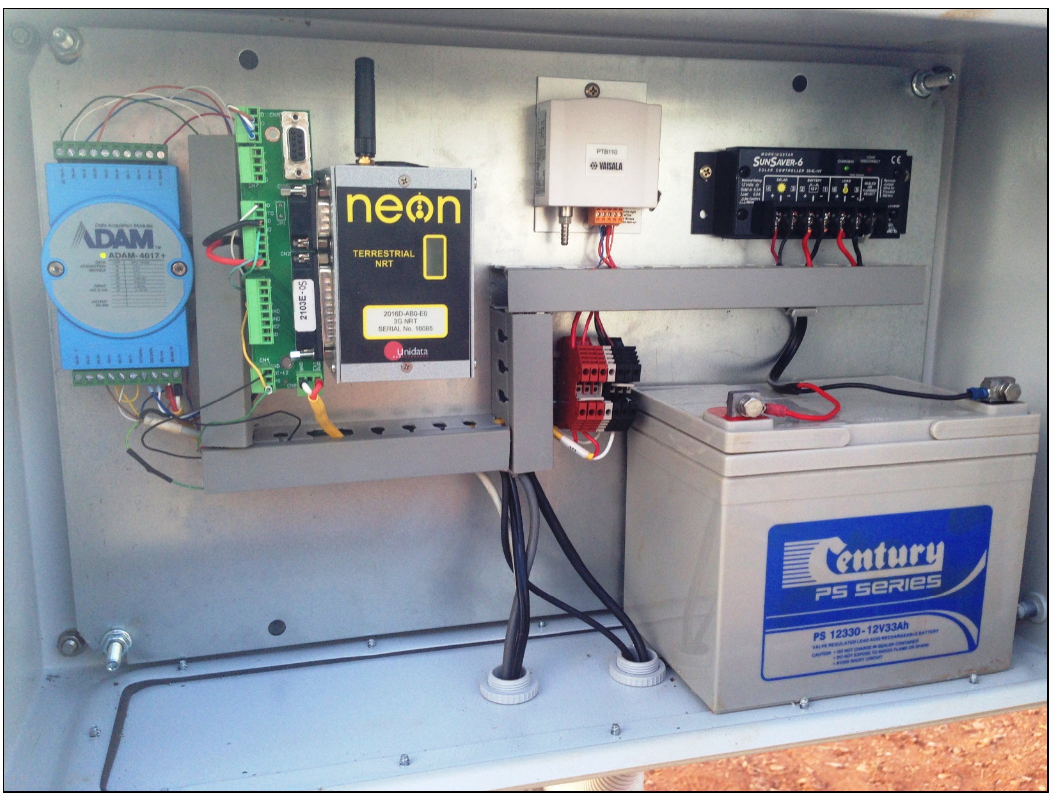

Figure 2 – Internal layout of instrumentation cabinet

Solar Radiation Sensor – LP02:

- Manufactured by Hukseflux in the Netherlands, distributed by MEA Pty Ltd in South Australia.
- Pyranometer with passive state operation, output signal via internal amplifier.
- Weather-proof enclosure (IP66 Rated).
- Data logged every 5-minutes by the Neon Remote Satellite Module.
- Mounted on extension arm designed by Element to provide uninterrupted 180º sunlight exposure.

Wind Speed and Direction Sensor – WMS301:

- Manufactured by Vaisala, distributed by MEA Pty Ltd in South Australia.
- Conical cup wind vane for linear response to wind speed and angular velocity of the cup wheel.
- Data logged every 5-minutes by the Neon Remote Satellite Module.
- Mounted on top of 10-metere break-back mast for ease of servicing.

Neon Remote Terminal (Next G) – 2016D:

- Manufactured in Western Australia by Unidata Pty Ltd:
- Data Logger (8MB Memory) with in-built Telstra Next G Modem.
- Capable of recording data from up to 4 Analogue sensors, 3 Counter Inputs, and SDI-12 sensors (additional 8 analogue channels with ADAM Modbus Module).
- Externally powered with internal lithium cell back-up.

Tipping Bucket Rain Gauge (TBRG) – TB3:

- Manufactured in New South Wales by Hydrological Services Pty Ltd
- Records Rainfall in 0.2mm increments, logged every 5-minutes by the data logger.
- TBRG Catch level at 1-metere above surrounding ground level – reducing the effects of dust and grass seed build-up in siphon.
- Adjustable levelling and serviceable leaf guard.
- Long-term stability in harsh environmental conditions.

Barometric Pressure Sensor – PTB110:

- Manufactured by Vaisala, distributed by MEA Pty Ltd in South Australia.
- Measurement made using a silicon capacitive absolute pressure sensor (BAROCAP®) developed by Vaisala, logged every 5-minutes by the data logger.
- Long-term stability in harsh environmental conditions.

Solar-recharged Power Supply:

- 12-Volt / 10-Watt Solar Panel mounted at optimum angle for solar recharge (75^0)
- 12-Volt / 6-Amp Solar Regulator.
- 12-Volt / 33Ah Sealed VRLA Battery.

Sensor	Model	Manufacturer	Power Supply	Unit of Measurement	Measurement Range	Accuracy at Typical Range
Tipping Bucket Rain Gauge (TBRG)	TB3	Hydrological Services	1-Volt Counter Only	mm	0.2mm Increments 0 to 700mm/hr	±2%
Air Temperature	HC2S3	Rotronics	12-Volt DC	Degrees C	-40º to +60º C	±0.1º C
Relative Humidity	HC2S3	Rotronics	12-Volt DC	%	0 to 100%	±0.8%
Solar Radiation	LP02	Hukseflux	N/A (passive)	Watts / m^2	0 to 2000 W/m^2	±2.5%
Wind Speed	WMS301	Vaisala	12-Volt DC	Metres / sec	0.5 to 60m/s	±0.3m/s (≤10m/s) ±2% (>10m/s)
Wind Direction	WMS301	Vaisala	12-Volt DC	Degrees	0 to 355º	±0.3º

Table 1 - Summary of Sensor Accuracy and Measurement Range

Pre-installation Testing

The instrumentation, power supply and data logging systems were set-up and tested at Element's office prior to on-site installation and commissioning. Each system was tested for 3-weeks, with all sensors being tested simultaneously for comparison.

System testing includes monitoring of all site components such as the solar-recharge power supply, Next G communications, and sensor responses.

The main purposes of the testing regime were to identify:

- Sensor accuracy and resolution.
- Repeatability of rainfall calibration results
- Sensor response times to changing meteorological conditions.

Temperature and relative Humidity accuracy was assessed against reference checks from a Vaisala HM34 handheld meter. TBRG calibration was checked using a Hydrological Services FCD (field calibration device) – refer to Figure 3 as an example of the FCD in use following site installation and commissioning.

Following the intensive system checking process, all instrumentation was dismantled and re-packaged for freight to site in a secure timber shipping crate – freighting provided by Norwest Freight Services

Site Installation & Commissioning

The installation of the AWS was undertaken in two stages due to the requirement of a 10-metre break-back mast for mounting the Wind Speed and Direction sensor.

The mast installation works were completed by Bill Edwards (Edwards Transport & Earthmoving) in January 2015. These works included the excavation of hole for the pre-fabricated mast footing cage, and pouring of approximately $2m^3$ of concrete to form the footing. Upon setting of the concrete footing, the mast required a vertical lift into position and securing onto the mast locating bolt assembly.

The final stage of the installation was completed by Element on 12th February 2015 – including the fit-out of the monitoring instrumentation. This phase included the mounting of the wind sensors on top of the mast, followed by mounting the Temperature and Relative Humidity sensor, and Solar Radiation sensor were onto the northern face of the mast with a specially designed mounting arm. The sensor mounting arm's design and northerly location on the mast at 2-metres above surrounding ground level allows for correct all year round measurement of each parameter - refer to Figure 5.

The TBRG was installed as per the Rainfall Stations, requiring a hole measuring approximately 40cm (D)* 20cm (W) * 20cm (L) to be dug by hand to locate the TBRG mounting post. The post was securely stabilised using rapid set cement mixed in the hole. The cable between the TBRG and the data logging cabinet has been run in 25m PVC conduit to reduce the chance of damage by vermin.

The data logging and power supply enclosure was mounted against the break-back mast at 1.5-metres below surrounding ground level. This position on the northern face of the mast allows for the full tilting action of the mast during Wind Instrument servicing and provides the best exposure for solar-recharging.

Figure 3 – Tipping Bucket Rain Gauge during field calibration

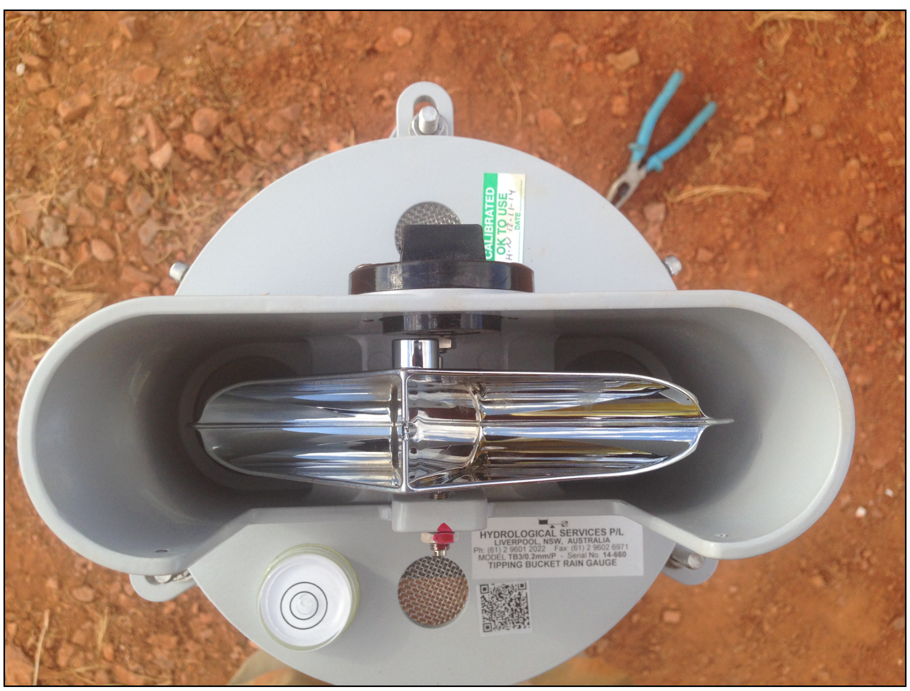

Figure 4 – Tipping Bucket Rain Gauge with catch removed during installation

Site Selection Criteria

Key to the collection of reliable quality meteorological data is correct site location and instrument selection. The final location was selected by project personnel with reference to the Bureau of Meteorology (BoM) Observation Specification No.2012.1 document – “Guidelines for the Siting and Exposure of Meteorological Instruments and Observing Facilities”.

Additionally, publications released by the EPA (USA) and the World Meteorological Organisation (WMO) have been referenced for best practices as relevant to the sites selected.

Key siting criteria included:

- Sites to be located on relatively flat terrain, away from significant topographical features and heavy vegetation.
- Sites to be installed away from main roads to reduce dust accretion caused by Heavy Vehicles.
- Rainfall measuring gauges should have 1:4 exposure from obstacles (e.g. an 11-metre high tree must be 44-metres from the TBRG).
- TBRG Mounted at 1-metere above surrounding ground level – reducing the effects of dust and grass seed build-up in siphon.
- For reliable Wind Speed and Direction, the instrument is located 10-metres above ground level to reduce turbulence.
- Temperature and Relative Humidity sensor mounted at 2-metres above surrounding ground level.
- Temperature and Relative Humidity Sensor mounted within a radiation screen housing – reducing the effects of direct sun but maintaining sensor ventilation.
- Solar Radiation sensor to be mounted with full expose to sun across 180º during all times of the year.
- Site to be located away from flood-prone land and areas proposed for mining and roads.

Figure 5 – Temperature, RH and Solar Radiation sensor mounting at Nullagine AWS

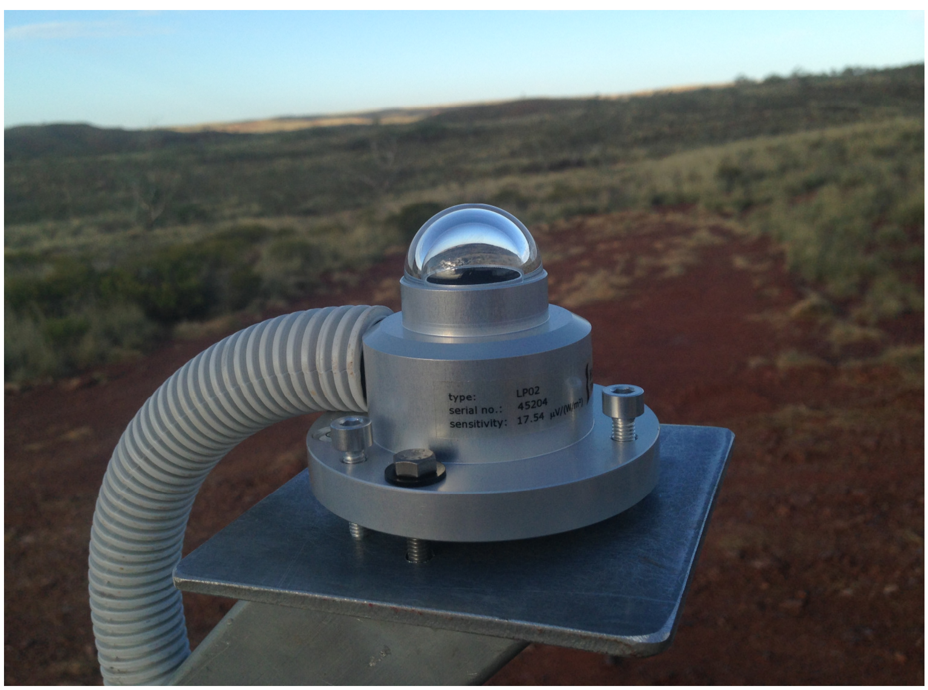

Figure 6 – Hukseflux Solar Radiation Sensor (pyranometer)

Servicing and Maintenance Requirements

As with all environmental monitoring systems, regular site servicing is essential for accurate measurement and the longevity of instruments in the field.

Due to the extreme nature of the site location including the high temperatures and dust, Element recommends site operation and maintenance visits be undertaken on a minimum quarterly basis.

During each maintenance visit the following works should to be undertaken:

- Removal of TBRG catch for cleaning of leaf strainer, siphon and tipping buckets.
- Checking of TBRG level using in-built bubble level – adjustments can be made using tripod-style mounting bolts.
- Routine photographing and documentation of vegetation within the vicinity of the station – typically looking north, east, south and west through the TBRG.
- Power supply checks to ensure correct operation of battery, solar panel and regulator – using a good quality Multi-meter.
- Cleaning of solar panels using damp cloth.
- Connection to the Neon Remote Terminal (incorporating the data logger) to verify correct system details, data logger time and date, and Next G communications strength.
- Calibration of TBRG using a Hydrological Services FCD (field calibration device) to be undertaken at a minimum 6-monthly basis.
- Cleaning of Solar Radiation bulb using dry cloth to remove dust and other residue – wet cloth to be used for tougher build-up, but care must be taken not to leave a dirty film on the lens.
- Lowering of 10-metre mast for checking of Wind Instrument condition, operation of bearings and connections.
- Annual replacement of the anemometer bearings, the wind vane bearings, and the wind vane potentiometer if required – to be assessed by technician on site.
- Cleaning of Temperature and Relative Humidity sensor screen – with particular attention to removing dust and spider webs which will both detrimentally affect sensor operation.
- Check measurements of Temperature and Relative Humidity using a HM34 Handheld sensor.
- Wind direction checks using a compass, and Wind speed checks using handheld unit (if available).
- Factory re-calibration for many sensors are recommended by the Manufacturers to be undertaken annually. Element's experience is that this period may be extended to +2years with regular sensor maintenance, based-on routine sensor accuracy checks.
- Tools required: Allen keys, Rittal enclosure key, damp cloth, Multi-meter, digital camera, FCD, PC and communications lead.

Proposed Data Management & Reporting System

Data from the Nullagine AWS is logged on-site at 5-minute intervals, and automatically sent via NEON data transfer system (managed by Unidata) on a routine basis – this interval was set to hourly upon commissioning, typically set to every 15-minutes for sites managed by Element.

NEON allows for the data to be sent to a range of people and organisations via FTP or e-mail. The format of the data is typically in a CSV format file, a plain formatted spreadsheet where time and values are separated into columns in chronological order.

For the ongoing reporting and storage of data from real-time monitoring stations, most of our clients prefer that the data be transferred directly to Element's Hydstra Data Management System. This allows Element to configure a series of automated web-reports that can be accesses by all stakeholders via either a public access or password-secure interface – anywhere in the world with internet access.

Using various Hydstra data validation tools, the data can then be routinely validated for quality and continuity by experienced Element staff – including entry of site calibration and check information, inter-station comparisons, sensor management information, and for the recording of data validation comments.

Figure 7 below provides a basic overview of how Element proposes to manage telemetered data from the Nullagine AWS - including reporting via a custom-designed webpage within www.elemenths.com.au

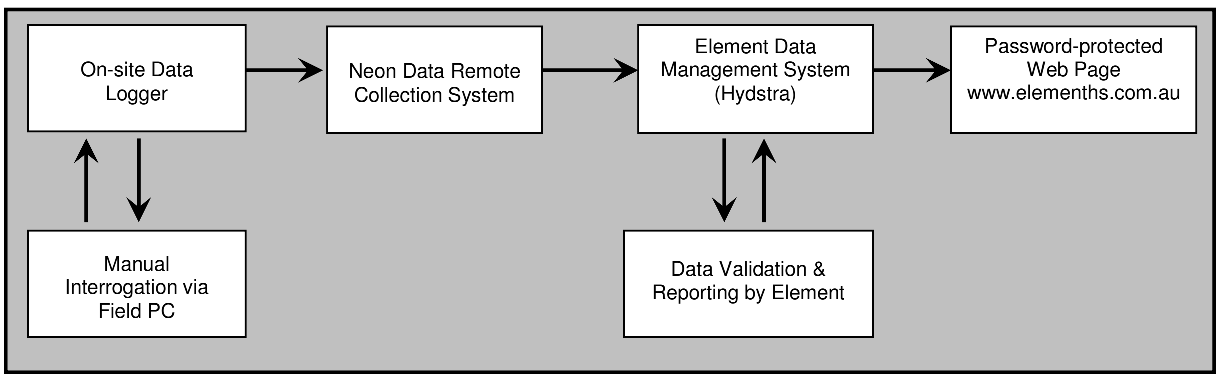

Figure 7 – Proposed Data Management Schematic

For any additional information on the Nullagine AWS, please contact:

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Figure 8 – General Station Layout