1.0 Purpose and Scope

This procedure prescribes the Sandia National Laboratories (SNL) Waste Isolation Pilot Plant (WIPP) process for the collection of water-level data from WIPP groundwater monitoring wells. Measurements include depth-to-water (DTW) using a water-level meter, pressure head and barometric pressure using pressure transducers, and conveyance of collected data through telemetry system monitoring. The objective of this procedure is to describe how water-level and pressure data are collected for use in the hydrology characterization of the WIPP vicinity. In addition, this procedure aims to establish a method for accurate measurement of depth-to-water (DTW) in wells and to describe the field check process for electric sounders (aka electric water level meters).

This Activity/Project Specific Procedure (SP) is intended to direct SNL technical personnel in the procedures needed to obtain high-quality data that meet SNL Quality Assurance (QA) standards. All activities will be documented in the appropriate Scientific Notebook (SN) according to NP 20-2, “Scientific Notebooks”. This SP is in support of activities described in WIPP Test Plans TP 06-01, “Monitoring Water Levels in WIPP Wells” and TP 03-01, “Test Plan for Testing of Wells at the WIPP Site”.

Acronyms and definitions for terms used in this procedure may be found in the Glossary located on the Sandia National Laboratories (SNL) WIPP Online Documents web site.

2.0 Implementation Actions

2.1 Responsibility

The SNL Manager Designee(s) (SMD) is/are responsible for implementing the requirements of this procedure.

The Technical Staff are responsible for performing the measurements following the requirements of this procedure, documenting all required information described in this SP, and assuring the latest revision of this document is followed.
If the procedure cannot be worked as written, the user has the responsibility to stop work and resolve all concerns with the SNL Manager or SMD prior to proceeding with the work.

2.2 Safety

The activities described in this SP shall conform to SNL Environmental Safety and Health programs (ES&H). All activities described in this SP are also subject to ES&H requirements governed by the WIPP Industrial Safety Program and the WIPP Industrial Hygiene Program when work is conducted within the WIPP site land withdrawal boundary. The operations in this procedure are performed on location and in field conditions. Biological and environmental hazards associated with field work are addressed in the ES&H documents for the hydrology group.

2.3 Equipment

Water-Level Sounder
Depth to water level measurements in wells are completed using an electric water-level sounder according to the procedure herein.

A typical electric sounder (or water level meter) consists of a graduated plastic-coated tape with two wire leads, a DTW probe at the downhole end of the tape, batteries, and a signal light and buzzer mounted on a surface reel. When the DTW probe enters the water, the water closes the electric circuit on the probe, activating the surface light and buzzer.

Water level meters must be field checked at least annually to verify they are within measurement tolerance of +/- 0.20 inches per 100 feet of tape. If the water level meter cannot meet this tolerance, it shall be removed from service in the WIPP program. Do not use a water level meter to measure DTWs if it has been more than one year since the meter has undergone a field check. The field check process is described in Section 2.4.

Pressure-Head Gauges
Pressure-head measurements are collected on a continuous basis, for both hydraulic tests and long-term monitoring purposes using pressure transducer gauges (PTs). PTs typically consist of a temperature sensor, a pressure transducer, and a programmable data logger housed in a sealed instrument body. The data logger is accessed from ground surface via a communication cable, allowing the data logger to be programmed and accumulated data to be downloaded to a laptop or handheld computer/personal digital assistant (PDA). Prior to the Monitoring Run (MR), the laptop or PDA’s clock shall be synced with the SNL Hydrology Group’s data storage server/PC clock, which is always set to Arizona Standard Time and does not incorporate daylight savings time.

PTs monitor the temperature of the water [in degrees Celsius (C) or Fahrenheit (F)] and the pressure-head response to changes in water level [in pounds per square inch (psi) or kilopascals kPa]. Pressure transducers have maximum pressure ranges from 15 to 500 psi and are absolute and the units should be recorded as pounds per square inch absolute (psia). Absolute PTs do not compensate for atmospheric pressure, which is ~13.100 psi in the vicinity of WIPP, thus barometric pressure must be manually subtracted to determine true pressure-head measurements.

Barometric Pressure Gauges
Barometric pressure measurements are typically collected on a continuous basis, using a PT that is able to log data or will be coupled with a data logger. These data are collected for the primary purpose of correcting pressure-head data for fluctuations in barometric pressure.
Pressure Transducer (PT) Cables
The data logger is typically housed in the PT body and is accessed from ground surface via a communication cable, which allows the data logger to be programmed and accumulated data to be downloaded. Communication cables are also used to suspend a PT in a well at a fixed depth. In order to constrain the depth at which a PT is suspended, the cables must be measured in a consistent manner and under tension. Cables should be measured using a graduated tape and marked at 100 foot (ft) increments until the last 100 ft of cable, which shall be marked at 25 ft increments.

Note: Almost every cable is longer than the actual reported length and any excess (“pigtail”) will be noted as part of the total cable length (i.e., connector to connector), which will be annotated at the top of each cable. The communication cable serial number, manufacturer length, and measured total length will be documented in the appropriate SN.

Telemetry System
A telemetry system has been deployed at WIPP wells in order to record and transmit data collected from PTs and other field data collection devices (i.e. rain gauges, borehole tilt meter, etc). Each telemetry station includes a locked enclosure containing a Campbell Scientific datalogger (CR300 or CR1000), a Campbell Scientific RF451 radio and a 12v sealed lead acid (SLA) rechargeable battery. An example of the enclosure is provided in Appendix F. This enclosure is attached to a mast/tower of appropriate height (dependent upon well profile and line of sight to the data collection tower). A telemetry station’s main power supply comes from a solar panel attached to the mast/tower and secondary power is supplied by the 12v SLA rechargeable battery. The SLA rechargeable battery is recharged via the solar panel. The datalogger is attached by a short cable to the cable deployed in the well with the pressure transducer for continuous monitoring. The data logger communicates with the transducers using SDI-12 serial protocol and stores data in the CR300/CR1000 data logger memory until retrieved via radio network or direct connection. The data is recorded on the external datalogger every 15 minutes and scheduled for collection once daily at the SNL Carlsbad office. Most telemetry stations are outfitted with a Yagi antenna (6db or 9db) which transmits/receives data in a single direction. Additionally, some sites will have an Omnidirectional antenna, which can capture signal from all directions that allows those stations to operate as repeater stations. Repeater stations capture signal from stations that do not have adequate line of sight to the relay tower then transfer the captured signals to a Yagi antenna which repeats the transmission to the relay tower. The relay tower can transmit and receive data from each telemetry station and the central location at the SNL Carlsbad office, where the data can be monitored, downloaded and processed remotely.

2.4 Depth to Water Level Measurement Procedure

Setup
- Unlock the wellhead cover. Caution: When unlocking and opening the wellhead, be aware of biting/stinging insects.
- Secure the meter so the sensor can be easily deployed into the well casing without causing personal injury or damage to the measuring tape or other equipment.
- Turn the volume control knob to the ON position and then test the probe by pressing the small black test button located near the red light. The meter should beep. Use the volume (i.e., sensitivity) control knob to adjust the level of sound emission so that it is easy to hear.
- The DTW should be read directly in ft off of the graduated plastic tape referenced against below the top of the casing (BTOC), below the top of environmental casing (BTEC), or below the top of tubing (BTOT), depending on type of well completion.

Measurement
- Review previous water-level measurements at the location to establish a general understanding of where to expect the water. Release the brake and lower the probe into the well until the meter
beeps and the light indicates water is reached. The meter will indicate this by simultaneously emitting a tone and lighting up the light as the electric circuit is completed (when the probe touches water).

- When the beep is emitted, raise the tape upward a small amount until the beeping stops and then lower the probe slowly down until the meter beeps. **Note:** This should be done more than once to insure an accurate reading. If the probe becomes coated with residue in the water (i.e. complete submergence of the probe), beeping may not cease. In this case, it might be necessary to adjust the sensitivity level of the probe or shake the tape and probe gently up and down until the beeping stops. If the beeping does not stop, rewind the tape, rinse the probe with fresh water and dry it with a clean towel or canned air. Determine DTW to the nearest 1/100\(^{th}\) of a foot by placing the graduated tape on the north side of casing/tubing and reading the tape directly where it meets the top edge of the casing/tubing. Record the DTW and time of the measurement in the appropriate SN.

- Rewind the tape onto the reel taking care to keep the tape untangled and clean. If necessary, use a clean rag to wipe any residue on the tape while rewinding. Rinse the probe with fresh water and turn the probe power off. Secure and relock the wellhead before departing the location.

**Water-Level Sounder Field Check**

- The field check shall be completed at least annually or as determined by the SMD. The purpose of the field check is to compare the water level meter graduated tape with a known distance (i.e. distance between certified marks) which will quantify the accuracy of the tape. The certified distance will be established using a Leica laser meter, certified by the Sandia Primary Standards laboratory or a qualified supplier. Measurement readings are recorded onto a spreadsheet.

**Field Check Setup**

- Establish two fixed reference points approximately 100 feet (+/- 0.5 ft) apart. This distance will be established and measured using the Leica laser distance meter. The exact distance between the two measurement points as displayed on the Leica will be noted on the Field Check spreadsheet. In this procedure, one point will be referred to as the 0 ft mark and the other point will be referred to as the 100 ft mark.

- Place the tensioning device at approximately the -1 to -5 ft position (i.e. 1 to 5 ft before the 0 ft survey mark) and the tape is threaded through the wheel assembly as shown in the diagram of Appendix A.

- Place the meter probe at the 100 ft mark, aligning the meter's measurement pin directly over the mark as shown in Appendix B.

- Make sure the tape is not twisted or slack then attach the 11-pound weight from the tape at the tensioning device. This method will apply a constant tension to the tape for all measurements. Refer to the diagram in Appendix C for additional detail.

- Take a measurement reading at the 0 ft survey mark and record. Move the tape slightly (without removing the tensioning weight), reposition the measurement pin directly over the 100 ft survey mark again, and take another measurement reading, at the 0 ft survey mark, and record.

- **Repeat the above procedure in 100 ft increments, placing the hundred-foot marks of the tape on the 100 ft survey mark and reading the tape value at the 0 ft survey mark until the last 100 ft segment of the tape is reached.** For the last segment of tape to be measured the tape must be reversed, because the tape reel is too close to the tensioning rig. The last segment of tape is measured by placing the final mark of the tape (1000 ft) on the 100 ft survey mark and reading the tape value at the 0 ft survey mark, in duplicate. Because the tape is reversed for this measurement, the resultant reading will be the opposite of the other measurements (i.e. instead of reading 1000.001 ft the reading would be 899.999 ft). In order to correct for this, the last measurement is reversed, so that it corresponds to the previous measurements, using the
following formula:

\[
\text{Field Check Measured Value (FCMV)} = \text{Starting Value of the Measured Range – Actual Reading + Ending Value of the Measured Range}
\]

**Example:** FCMV = (900.000 ft – 899.999 ft) + 1000.000 ft = 1000.001.

- To demonstrate the reproducibility of the field check measurements, repeat the measurements on the segment (0 to 100 ft), in duplicate, and record onto the spreadsheet.
- At the conclusion of the Field Check, use the Leica laser distance meter to again verify the distance between the 0 and 100 ft marks. Record the measured distance onto the Field Check spreadsheet. If the distance between the initial Leica reading recorded and this closing Leica reading varies by more than +/- .05 inches, the Field Check will be repeated.

**Field Check Documentation**

After the field check is successfully completed and the results are reviewed by the SMD, a calibration sticker will be placed on the meter. Submit the spreadsheet that documents the Field Check results to the SNL WIPP Records Center per NP 17-1 “Records”.

**2.5 Pressure Transducer (PT) Maintenance**

Per manufacturer and SNL recommendations, PT gauges are calibrated annually or as directed by the SMD. PTs are typically battery operated and must be monitored for battery capacity (volt (V) or percent (%)) to prevent data loss. There are typically two types of batteries utilized in PT gauges including:

- Replaceable alkaline or lithium batteries that last approximately one year under normal SNL monitoring conditions. At the time of PT installation in the well, batteries should be at 3.5 V capacity, and while the PT is operational in the well, batteries should be changed before capacity drops below 3.1 V.

- Non-replaceable lithium batteries, which can last up to five years under normal monitoring conditions (though this may be shorter due to the usage variation discussed above). Lithium batteries cannot typically be replaced; therefore, an external battery pack may be attached either directly to the gauge or to the top of the communication cable. The battery pack is attached when the internal lithium battery capacity of the gauge reads between approximately 40-50%, or as directed by the SMD. External battery packs are replaced when capacity reaches approximately 10%, in order to preserve the internal battery as an emergency backup.

**2.6 Procedure for Monitoring Tests**

As part of the SNL WIPP mission, a groundwater monitoring program has been established to acquire detailed records of changes in water-level and pressure head in the WIPP vicinity. TP 06-01, “Monitoring Water Levels in WIPP Wells” outlines the strategies and philosophy of this program. As part of the monitoring program, certain QA records must be produced. To this end, all quality-affecting data collected under this SP will need to be documented in the appropriate SN, including serial numbers for measuring and testing equipment (per NP 20-2, Scientific Notebooks). Examples of the information that should be included in data entries are provided as Appendix D and Appendix E.

**Pressure Transducer (PT) Installation and Test Setup**

PTs are installed and monitoring tests are setup as follows:

- Collect a DTW measurement. Select a communication cable of appropriate length to reach the desired depth, typically the middle of the geologic formation being observed and within tolerance of the PT. To avoid over-pressuring a PT, the gauges are rated to allow a limited number of feet of water above the gauge and this needs to be taken into account when choosing and installing PTs.
• Perform an operational check to determine if the PT is functioning properly, by establishing communication with the PT, checking to see if the battery is within acceptable levels, and synchronizing the internal gauge clock with the PDA or laptop device.

• Perform a surface check unless one has been done within the last month. A surface check consists of taking pressure and temperature measurements of ambient conditions, and the surface pressure on ambient (psia) PTs should read within 13 ± 0.50 psia. If the pressure readings exceed the guidelines, the SMD should be contacted for a decision to be made as to whether or not a different gauge should be used. The surface check guideline is intended to consider the effects that ambient barometric pressure variations can have on background measurements.

• Denote the installation depth (ideally mid-formation of the unit to be monitored) on the cable to the nearest 1/10th of a foot, including all hardware attached to the cable. The PT depth reference point should be noted as feet BTOC/BTEC/BTOT, as applicable. Secure the cable to the wellhead and lower/install the PT and cable to the desired depth. Take care as the PT nears the air-water interface in order to avoid a “waterhammer” effect, which can damage the transducer.

• For routine monitoring purposes, once the PT is at depth, a monitoring test is setup using a PDA/laptop. The test setup is determined by the SMD. The actual test setup will be clearly documented in the SN. Tests are scheduled to begin at the nearest hour (unless this will occur within the next 15 minutes, in which case, the test is started on the next hour).

• For testing purposes, a hydraulic test is setup per the SMD’s direction, which includes the type, trigger value, trigger threshold value, scan rate, and default sample frequency.

• After completing and scheduling a pressure transducer test, the input parameter interface will close. Once this occurs, check the scheduled test to confirm the indicator symbol shows that the test will start at the desired time (i.e., the clock icon in Aqua4Plus).

• After the PT has been installed, for new installations or when verification of the depth is needed, the PT is moved approximately 2 ft up while the pressure reading is monitored to ensure that the pressure is changing when the PT is moved. This check shall be completed to verify that the PT is not obstructed downhole or sitting on the bottom of the well and is actually at the intended depth.

• To verify that the telemetry system is functioning properly and that the CR300/CR1000 is communicating with the Pressure Gauge/Pressure Transducer connect the pressure transducer cable to the short cable that runs from the telemetry enclosure into the well casing. This cable is equipped with a twist-lock and it should be verified that the connection is locked into place. Connect a USB cable (attached to a laptop) directly to the datalogger and open the LoggerNet software from a laptop computer. Once you have connected, verify that the data logger is returning PSI and Temp values from the Pressure Gauge/Pressure Transducer. If it is not, you may need to perform additional troubleshooting steps (i.e. check wiring, check fuses, check connections, etc.). Proceed to download the collected data from the PT and disconnect from the site, then disconnect the USB from the datalogger. You will leave the short cable connected to the pressure transducer cable.

• Lock and secure the wellhead after all well activities described in this SP are completed, except for under certain circumstances which will be documented in the SN.

Routine Monitoring and Downloads
As part of the SNL WIPP hydrology monitoring activities, MRs are conducted typically monthly, during which data are downloaded from the PTs (in conjunction with a DTW measurement), and maintenance will be performed as necessary. The reasons for the MR are twofold, to check the status of the PT (i.e. battery capacity and operability) and to have the most up-to-date pressure data available.
There are multiple reasons to end a PT test including: the need to move a gauge either within the well or to a new well, well test monitoring setup, calibration interval is due, PT failure, Maintenance and Operations Contractor (MOC) well activities, etc. If the PDA/laptop cannot establish communication with the PT, the following steps are completed and documented in the appropriate SN:

- Remove the PT from the well and attempt to establish connection with the PT. Whenever a PT is removed from a well and the gauge is operable, a surface check shall be conducted and documented in the SN.
- If communication cannot be established, an as found calibration is attempted.
- If at any time communication is re-established with the PT, it must be further evaluated prior to re-installation.

The installation of telemetry stations on the WIPP monitoring wells will allow the collection and viewing of PT data in near real-time via the Real Time Monitoring and Control Software (RTMC Pro), an application within the LoggerNet software. This application allows for a graphical display of data, remote control of dataloggers, or creation of various types of alarm events to alert in off-normal conditions.

2.7 Procedure for Pressure Transducer (PT) Use During Hydraulic Tests

Hydraulic tests are overseen by the SMD. The SMD determines PT installation and setup parameters for the test well. Details of these protocols are outlined in TP 03-01, “Test Plan for Testing of Wells at the WIPP Site”. All quality-affecting data generated during hydraulic testing activities are documented in the appropriate SN.

Hydraulic Test PT Setup and Initiation

PT setup and initiation for hydraulic tests can be quite different from monitoring tests. Because of this, the SMD will determine how PTs are installed and set up. Ideally, the following information associated with PT setup and installation is documented:

- A DTW is taken prior to installation of any equipment (i.e. pump) used for the hydraulic test.
- Conduct an operational check and surface check (if necessary) and install PTs, either with or after the pump is installed.
- Setup the hydraulic tests per the SMD’s direction regarding type, trigger value, trigger threshold value, scan rate, and default sample frequency.

Hydraulic tests are terminated at the discretion of the SMD. In most instances, a monitoring test will be set up soon after the hydraulic test is complete. However, the test parameters will be determined by the SMD. If a PT fails to communicate with the PDA/laptop, the steps outlined in Section Routine Monitoring and Downloads are completed.

2.8 Procedure for Barometric Pressure Tests

As part of the SNL WIPP hydraulic testing and groundwater monitoring activities, barometric pressure fluctuations in the WIPP vicinity are measured. A description of the importance of these data is provided in TP 03-01, “Test Plan for Testing of Wells at the WIPP Site”. All quality-affecting information generated by the following barometric monitoring test procedure are documented in the appropriate SN. Barometric tests are setup and maintained as follows:

- PTs are installed near ground level and in such a way as to avoid direct sunlight.
- Conduct an operational check and conduct a surface check if necessary (>1 month since last surface check).
- Barometric monitoring tests are typically defined as linear tests with a scan rate of 15 minutes (unless altered by the SMD).
- Barometric monitoring tests are downloaded as part of the MR, which includes checking the battery capacity.

2.9 Pressure Transducer (PT) Data Storage

All data (monitoring, testing, barometric) downloaded from PTs are uploaded from the laptop/PDA to a directory on the SNL Hydrology Group's data storage server/PC. This directory is in turn backed up onto the SNL Hydrology Group's directory on the SNL SRN.

All telemetry data (monitoring, testing, barometric) is received on the base station computer (located at the SNL office in Carlsbad, NM) and collected daily. At any point in time, as needed, this data can be retrieved and uploaded onto a directory on the SNL Hydrology Group’s data storage server/PC. This directory is in turn backed up onto the SNL Hydrology Group’s directory on the SNL SRN.

3.0 Records

The following records, generated through implementation of this procedure, shall be prepared and submitted to the WIPP Records Center in accordance with NP 17-1 "Records":

- QA Record
  - Scientific Notebooks
  - Field Check Spreadsheet (printed copy)

4.0 Appendices

Appendix A: Diagram of Field Check Setup Indicating the Positioning of the Tape Tensioning Device and Survey Markers
Appendix B: Example Diagram of a Typical DTW Probe
Appendix C: Diagram of the Tape Tensioning Device
Appendix D: Examples of Data Entries Appropriate for PT Removal and Installation Activities
Appendix E: Examples of Data Entries Appropriate for PT Data Download Activities
Appendix F: Example of Telemetry System Enclosure
Appendix A
Diagram of Field Check Setup Indicating the Positioning of the Tape Tensioning Device and Survey Markers

Tensioning device must be placed between the -1 to -5 ft position.
Appendix B
Example Diagram of a Typical DTW Probe

Note: The red X indicates where the tip of the measurement pin should be held to the survey marker. The survey mark may need to be relocated depending on the configuration of the probe.
Appendix C
Diagram of the Tape Tensioning Device

Sand bags or hold down weights placed here to secure base.
Appendix D
Examples of Data Entries Appropriate for PT Removal and Installation Activities

| Document Inserted into Scientific Notebook ____________________ on page _________ |
| Well I.D. _____________________Culebra/Magenta/Other (circle one) |
| Start pulling Level Troll SN ____________________ Complete pulling |
| (time)                                                                 (time) |
| □ Surface Check                  Press.:__________psia       Temp.°F:__________ |
| Cables SN ____________________ Cable SN ____________________ |
| Total Length FT.                         Total Length FT. |

| □ Surface Check Level Troll SN__________________     Cal due date _________________________ |
| Press.:__________psia       Temp.°F:__________ |
| (time)                                                                 (time) |
| □ Begin install               □ Complete install, at depth FT. |
| □ same as before □ new depth |
| □ Sync Level Troll to PDA clock   Pressure changed when Troll was moved ~ 2 Ft. □ yes □ no |
| Test Name: SN _____________________________________________________________________ |
| Type: Event    Trigger: Pressure ΔP:__________      Scan: ___________ |
| Default: __________________________________       Schedule start:___________      ___________________ |
| (date)                            (time) |
| □ At depth check               Press.:__________psia       Temp.°F:__________ |
| (time)                                                                 (time) |
| Well Locked and Secured        Initial ___________     Date______________ |
## Appendix E
Examples of Data Entries Appropriate for PT Data Download Activities

<table>
<thead>
<tr>
<th>Document Inserted into Scientific Notebook ____________________ on page _______</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well I.D. __________________ Label added to Notebook SSW—________ on page _______</td>
</tr>
<tr>
<td>DTW: ________________ FT. BTOC  Battery (%) ________________</td>
</tr>
<tr>
<td>(time)  Stop Test / Extracted File SN ___________________________</td>
</tr>
<tr>
<td>(time)  yes ☐  no ☐  ___________________________________________</td>
</tr>
<tr>
<td>Last Point Collected ___________ Temp.°F __________  Press. ____________ psia</td>
</tr>
<tr>
<td>(date)  (time)  ________________________________________________</td>
</tr>
<tr>
<td>Well Locked and Secured  Initial __________  Date____________</td>
</tr>
</tbody>
</table>

| Well I.D. __________________ Culebra/Magenta (circle one)  Battery (%) ________________ |
|  DTW (ft.) ________________ BTOC  BTEC  BTOT  (circle one) |
|  (time)  Extracted Data File ___________________________________________ |
|  (time)  ___________________________________________________________ |
| Last Point Collected ___________ Temp.°F __________  Press. ____________ psia |
|  (date)  (time)  ________________________________________________ |
| Well Locked and Secured  Initial __________  Date____________ |
Appendix F
Example of Telemetry System Enclosure
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