ER-GUIDE-20005, R.1

Groundwater Monitoring Well Dual-Screen Sampling System Installation and Testing

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ER-ES	Environmental Protection
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Name (print)	Z#	Signature	Date
Billy Turney	/112765	//s/ Billy Turney	/2/17/16

Responsible Manager, Division and Title

Name (print)	Z#	Signature	Date
Alan MacGregor	/ 112808	//s/ Alan MacGregor	/2/22/16

Revision History

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EP-DIV-SOP-20005,R0	6/21/11	New document.	T/E
EP-DIV-SOP-20005,R0 IPC-1	12/1/11	Changes to Attachment 6: updated references in Section 1.2.C4 & 1.2C5; and changed maximum Rockwell hardness in Section 2.2.	T
ER-GUIDE-20005, R0	1/7/16	Additional clarification and instructions regarding removal of dual screen pumping systems for maintenance purposes provided. Incorporated IPC-1 and superseded EP-DIV-SOP-20005 with new number per organizational changes. Revised as a guide instead of procedure.	T/E
ER-GUIDE-20005, R1	2/24/16	Added two equations back into Attachment 7 that had been removed in previous revisions.	T/E

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Attachments

1. PURPOSE

This guide states the responsibilities and describes the process for installing and testing Baski-style single and dual pump systems in dual-screen groundwater monitoring wells for the Los Alamos National Laboratory (LANL) Environmental Programs (EP) Directorate.

2. SCOPE

This guide applies to all LANL EP Directorate personnel and contractor personnel who are authorized to install or maintain dedicated dual-screen pumping systems or assist with these tasks.

3. BACKGROUND

3.1 Basic Design

Dedicated pumping systems are required to purge monitoring wells for the purpose of sample collection. Dual-screen wells require unique pumping systems that are capable of actively purging each screened interval discretely. Two types of pumping systems are typically specified for LANL dual-screen monitoring wells: dual access port valve (APV) systems that share a single submersible pump and two-pump systems using a submersible pump and a pneumatic piston-type pump. Factors that may impact the choice of system include, but are not limited to, well screen separation length and well screen specific capacities. All dual-screen systems include at least one inflatable packer to isolate each screened interval from the other.

LANL has designated dual-screen sampling systems procurement ML-3.

- Dual APV systems use pneumatically operated valves to purge water from the desired screened interval. These systems share a single submersible pump.
- Two-pump systems use a single pump in each screened interval. Pump operation and discharge are independent from one another. The most common two-pump system includes a submersible pump for the lower-screened interval and a pneumatic piston-type pump for the upper-screened interval.

This guide is based on the assumption that the end user has made appropriate pumping system selection. This guide is not intended as a guide for system selection or system design.

3.2 Pre-Installation Requirements

Dual-screen systems are more complicated than typical single pump installations found in single-screen wells. Plumbing components and combinations of components may be elaborate. Precautions to be considered include, but are not limited to, the following:

- Perform a complete and thorough well inspection to include total depth, static composite water level, physical dimensions of the well casing and screen(s), and aquifer-pumping tests (one per screen), or review of aquifer test data to determine well screen specific capacities. If aquifer-pumping tests are required, discrete static water levels of the respective well screen intervals must be collected. If well screen depths are uncertain or if the well is old, perform video inspection.
- System components should be preassembled at the supplier's point of origin to the degree possible. Preassembled "modules" save time and reduce possible sources of error and contamination in the field. Examples of modules include submersible pumps preloaded into pump shrouds and preassembling inflatable packers and liquid inflation chambers (LICs).
- If pumping systems are to be stored for any length of time, general precautions should be taken for storage. Components susceptible to ultraviolet light (e.g., packers, polyvinyl chloride (PVC) pipe, and electrical cable) should be covered or stored indoors. Freeze prevention is not necessary because no liquids are contained within the system before installation. Store all equipment, parts, etc., at a controlled location.
- Dual-screen pumping systems must be inspected and inventoried before starting installation activities. All components of the system must be accounted for, verified, and present onsite.
- Installation crew must take the time to familiarize themselves with system components and installation requirements. All parties (crew, field team leader, and any additional oversight personnel) must be in agreement on order and arrangement of system components before starting installation task.
- Individuals participating in dual-screen well-pumping system installations shall be trained to the requirements listed by functional assignment.

4. REFERENCES

Swagelok Tube Fitter's Manual

EP-ERSS-SOP-5061 *Field Decontamination of Equipment*

CAP-WELLS-SPEC-40 0511, Compression Fittings on Stainless Steel Tubing

5. DEFINITIOND AND ACRONYMS

5.1 Definitions

Minimum Pressure – Pressure required to swell packer element at any given position and achieve sealing

Action Pressure – Pressure required to actuate APV piston

Target Pressure – Pressure at which a packer is set and maintained

Maximum Pressure – Pressure that should not be exceeded that may result in failure and/or destruction

5.2 Acronyms

APV	access port valve
EP	Environmental Programs (directorate)
ID	inside diameter
IWD	Integrated Work Document
LANL	Los Alamos National Laboratory
LIC	liquid inflation chamber
ML	Management level
NM PE	New Mexico Professional Engineer
OD	outside diameter
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RIR	Receipt Inspection Report
SOP	standard operating procedure
STR	subcontract technical representative

6. TOOLS AND EQUIPMENT

- Well construction diagram
- Sampling system engineering design drawings released for construction
- Pump hoist capable of lifting pumping system outfitted with typical pump-set equipment and tooling
- Entire pumping system (receipt inspected, inventoried, and independently checked by two parties for completeness)
- Engineer’s measuring tape (measuring in tenths/hundredths of a foot)
- Water-level meter of sufficient length to measure water levels and total depth of well.
- Compressed nitrogen cylinder(s)
- Pressure safety manifold (LANL provided)
- Digital pressure gauge(s) capable of measuring in single units of millibars

7. STEP-BY-STEP PROCESS DESCRIPTION

This guide uses the terms “nitrogen line” and “control line” in reference to any hard- or soft-walled tube that has a pneumatic operational function. All pneumatic operations shall use nitrogen as the compressed gas. These lines use fittings for the purpose of splicing and/or terminating. The terms “drop pipe” and “pump column” may be used interchangeably. Both terms reference the column of static, hard-walled pipe in which the water discharge travels to the surface.

A completed installation checklist (Attachment 4) shall be used to document the installation procedure and submitted to the subcontract technical representative (STR).

7.1 Performing Inventory and Receipt Inspections

Dual-screen pumping systems are generally outfitted with equipment from more than one manufacturer. Once all shipments have been received, the equipment must be accounted for and verified using invoice receipts and/or packing slips and verified using the design drawings and documented in a receipt inspection report. (Attachment 5). Completed receipt inspection report shall be submitted to the STR.

7.2 Site Set-Up

Site set-up involves positioning the pump hoist, associated equipment and tools, and the area where the drop pipe will be laid down in a logical and safe fashion. Upon leveling the pump hoist and raising the derrick, the hoist will need to be approved for work by a LANL rig inspection.

7.3 Decontamination of Dual-Screen Pumping Systems

1. All components of the pumping system (i.e., pump shroud, pump(s), liquid inflation chamber, packer, APVs, drop pipe, tube bundle(s), PVC pipe, and fittings) must be decontaminated before installation.

   For decontamination procedures, follow procedures consistent with Field Decontamination of Equipment, EP-ERSS-SOP-5061.

7.3 Decontamination of Dual-Screen Pumping Systems (continued)

New PVC manufactured for supply to the environmental sector is delivered factory cleaned and wrapped in plastic. High-quality stainless-steel fittings may also be delivered in a similar fashion. The origin of parts and those parts' degree of cleanliness must be verified with the manufacturer or supplier to meet decontamination requirements.

2. If fittings or nitrogen tubing are pre-attached to the pumping components, the open fittings and/or the ends of the tubes must be plugged with compatible pipe plugs to prevent water from entering into the fittings/tubes while decontaminating components.

3. Project-specific requirements for Quality Assurance/Quality Control (QA/QC) samples that may be collected (rinsate) from decontaminated permanent pumping hardware can differ. Consult project-specific technical guidance documents (e.g., Drilling Plan, Exhibit D, Statement of Work, etc.) for sample collection requirements. Any QA/QC sample collection must take place after decontamination and before starting assembly.

4. Before/after decontamination, the main pumping system components must be measured to the hundredth of a foot, and the arrangement of system components must be agreed upon before installation.

7.4 Installation of Dual-Screen Pumping Systems

The installation of a dual-screen pumping system involves wiring pump motor to pump cable; threading stainless-steel drop pipe and components to one another per pump system design; threading PVC pipe together; banding PVC pipe, nitrogen tubing, and pump cable to stainless-steel drop pipe; pressure testing nitrogen lines after plumbing into fittings; and landing the pump system on top of the stainless-steel well casing. Assembly and testing occur while the system is lowered into the well with the pump hoist.

The nitrogen lines that operate the pneumatic components of these sampling systems, or are a part of the systems themselves, typically require splicing and insertion into a variety of fittings because they routinely are not continuous lines from top to bottom. Typically, the fittings are stainless-steel Swagelok brand fittings.

7.4 Installation of Dual-Screen Pumping Systems (continued)

Splicing stainless-steel nitrogen lines involves cutting the tubing, deburring the tubing, placing a nut and ferrules onto the tubing, inserting the tubing into the stainless-steel fitting, and tightening the nut and ferrules onto the fitting body. The most recent revision of the attached specification, CAP-WELLS-SPEC-40 0511, must be reviewed before making tubing cuts, bends, or fittings. The specification and this procedure can be combined in the field during installation to make successful fitting-to-tubing connections.

Tube cutting shall be conducted in accordance with CAP-WELLS-SPEC-40 0511. Rushing this procedure will result in poor cuts and excessive cutter wheel wear. Tube cutters do not remove material but push material aside and down. The duller the cutter wheel, the more material raised at the tube end, increasing tube OD. This raised material can prevent the tubing from resting firmly on the shoulder of the fitting body, which may cause the fitting to leak. Therefore, sharp cutting wheels should be used at all times.

Both Swagelok and Baski provide procedures for insertion of tubing into stainless-steel fittings and tightening the nut and ferrule onto the fitting body, and retightening instructions for tubing fittings with preset ferrules. Both procedures are incorporated into CAP-WELLS-SPEC-40 0511.

According to the Swagelok Tube Fitter’s Manual, connections can be disconnected and retightened many times, with the reliable, leak proof seal obtained every time the connection is remade; however, this technique has not been successful in practice. Most commonly, fittings are observed to leak. Leaky fittings may be attributable to faulty fittings, nuts, or ferrules; tubing and fittings that may have been exposed to dirt, dust, sand, or other particles; tubing that was not cut precisely; or tubing that was not appropriately deburred. Field crews are tasked with identifying which part(s) of the fitting component is leaking (i.e., nut, ferrule, fitting, or tubing) and needs to be replaced. Therefore, it is necessary for field crews to have extra fitting components and tubing available onsite to replace leaky fittings.

7.4.1 Dual APV System

The following describes dual APV systems installed at LANL. The main components of the system include (from first component installed to last component installed, excluding drop pipe details) the following:

- Bull nose plug
- Lower APV
- Inflatable packer
- Liquid inflation chamber (LIC)
- Upper APV
- Pump shroud with pre-loaded pump and motor
- Upper and lower water-level PVC gauge tubes
- Drop pipe with weep valve
- Wellhead body

1. The bull nose plug terminates the bottom of the typical dual APV system.

2. The lower APV is threaded to the bull nose plug.

   The lower APV open control line (when pressurized, the APV screen is “open” and water from that zone is pumped) is connected to the APV open fitting and passes through the packer and LIC, around the upper APV, and through the pump shroud. The lower APV open control line is continuous above the pump shroud up to the bottom of the wellhead body.

   The lower APV closed control line (when pressurized, the APV screen is “closed” and water from that zone cannot be pumped) is connected to the APV closed fitting. The lower APV closed control line passes through the packer and LIC and is fitted to a Y-block. The Y-block has two fittings in the bottom: one connected to the lower APV closed control line and one connected to the packer inflation line.

   The lower APV is function (pressure) tested before being advanced into the well.

3. Depending on well-specific depths, drop pipe may be threaded together between the lower APV and the packer/LIC assembly.

7.4.1 Dual APV System (continued)

4. For the purposes of this guide, the packer and the LIC are considered to be one functional unit. The packer is below the LIC, or first, in order of assembly. The packer inflation line is connected from the top of the packer and fitted to the bottom of the LIC. The LIC is an assembly containing a 4.75-in. outside diameter (OD) liquid chamber that is filled with distilled water before installation (when pressurized, the packer inflates with water via nitrogen pressure supplied to the LIC). The packer inflation line continues from the top of the LIC and is connected to the bottom of the Y-block fitting. See fitting guidance (Section 7.4, Installation of Dual-Screen Pumping Systems). The nitrogen line from the top of the Y-block passes around the upper APV and is fitted to the bottom of a second Y-block located above the upper APV.

5. The packer/LIC is pressure tested before being advanced into the well.

6. Depending on well-specific depths, drop pipe will be threaded together between the packer/LIC assembly and the upper APV.

7. The upper APV open control line is connected to the APV open fitting and passes through the pump shroud. The upper APV open control line is continuous above the pump shroud to the bottom of the wellhead body.

8. The upper APV closed control line (when pressurized, the APV screen is closed, and water from that zone cannot be pumped) is connected to the APV closed fitting. The upper APV closed control line is connected to the bottom of the second Y-block located above the upper APV. The nitrogen line fitted to the top of the Y-block passes through the pump shroud. Above the pump shroud, the nitrogen line is one continuous line up to the bottom of the landing plate.

9. The upper APV is function (pressure) tested before being advanced into the well.

10. Depending on well-specific depths, drop pipe will be threaded together between the upper APV and the shrouded pump.

7.4.1 Dual APV System (continued)

11. A stainless-steel water-level line with a screened fitting extends below the packer. A stainless-steel faucet screen with a U.S. mesh size between 25 (0.028-in.) and 80 (0.007-in.) is sandwiched between a male tube connector and a coupling. The terminus of the water-level line must be screened to prevent debris from plugging the line and rendering it useless. The water-level line passes through the packer and LIC, around the upper APV, and through the pump shroud. The water-level line is fitted into the end cap of the lower transducer PVC gauge tube. This tube provides lower-screen water-level measurements. The lower transducer PVC gauge tube is generally placed above the pump shroud. The upper transducer PVC gauge tube, with a slotted screen section and end cap, is placed beside the lower transducer PVC gauge tube above the pump shroud. This tube provides upper-screen water-level measurements.

12. The PVC gauge tube columns extend to the wellhead body. Both of these columns comprise 10-foot-long sections of PVC pipe and are assembled by hand (hand-tight) as the system is assembled and advanced into the well.

13. An air-vent line extends from the top of the pump shroud to the bottom of the wellhead body. This line is nylon because it is not pressurized and serves only as a vent to prevent vapor locking of the pump.

14. Electrical service to the pump motor is provided by the pump cable. The wire gauge of the pump cable is selected based on the requirements for the size (horsepower) of the pump motor and the set depth of the pump. Typically, submersible pumps installed with dual-screen sampling systems at LANL have three-phase motors. Three-phase motors require pump cable with four leads. Submersible pump cable is almost always double-jacketed; that is, each lead is insulated, and the insulated leads are bound together in an all-inclusive outer layer of insulation.

15. The pump cable, PVC pipes, stainless-steel nitrogen pressure lines, and nylon vent lines are banded to the stainless-steel pump column. The pump column and all associated hardware running to the surface are assembled one piece at a time as the assembly is lowered into the well. Stainless-steel banding and buckles are used to bind all of the hardware together. It is recommended that one band be used per each 10-foot piece of PVC (i.e., every 10 feet on the drop pipe). Tape of any sort is never to be used because of long-term durability and environmental sample quality issues. The PVC gauge tubes, stainless-steel pump column, and pump cable are inserted into the wellhead body, and the nitrogen lines and air vent line are fitted into the bottom of the wellhead body.

7.4.1 Dual APV System (continued)

16. Near the end (top) of the pump column (i.e., the wellhead body), a riser pipe with a weep valve must be installed. The weep valve is located 3-ft bgs at a minimum. The weep valve allows water in the pump column to drain out after pumping has stopped.

17. The wellhead body is the top piece of the pumping system seen at the top of the well casing. It is also the terminating point for all of the various lines and pipes extending to the surface. The wellhead body is commonly referred to as a “landing plate,” although landing plates are much simpler by comparison. The wellhead bodies typically supplied for LANL dual-screen pumping systems are custom-made units that are very nearly well specific. The central feature of the wellhead body is the discharge port. The pump column threads into the bottom of the discharge port and a sampling “tree” threads into the top of the discharge port. On either side of the discharge port are holes for the PVC water-level gauge tube columns. The PVC gauge tube columns slide through these holes and are cut off nearly flush with the top of the wellhead body. No mechanical connection exists between the wellhead body and the PVC gauge tubes. Surrounding these three central access holes or ports are smaller, ¼-in. female national pipe thread (NPT) ports for the ¼-in. control lines described above. Typically, the wellhead body is supplied with six of these ¼-in. ports. In the system outlined above, three control lines and one vent line extend to the surface and would occupy four of the six ports. The other two ports are plugged with compatible pipe plugs. The “finishing” of the wellhead body is accomplished with the installation of a pressure gauge for the packer control line, the installation of the fittings for the APV control lines, the installation of any plugs for any potentially vacant access ports, and the installation of the permanent transducers into the PVC gauge tubes. See Attachments 1 and 2 for typical wellhead body detail.

7.4.2 Two-Pump System

The following describes the two-pump system. The main components of the system include (from first component installed to last component installed, excluding drop pipe details) the following:

- Submersible pump
- Packer
- LIC
- Pneumatic piston-type pump
- Riser pipe with weep valve
- Wellhead body

7.4.2 Two-Pump System (continued)

The lower water-level line and PVC gauge tube columns are fashioned in a similar way as described above for dual APV systems, although the PVC gauge tube would be placed above the largest diameter component (i.e., LIC). The main difference in these systems compared with dual APV systems is the type and location of pumps, discharge lines, and nitrogen lines. There are two discharge lines for the two pumps. The submersible pump will discharge through a stainless-steel pipe column, and the pneumatic piston-type pump will be equipped with a tube bundle containing a flexible discharge line. The tube bundle will also be equipped with nitrogen lines for actuation and exhaust.

1. Because the submersible pump is used only to purge one zone and is typically the terminus for the system on the bottom end, only the pump cable and lower water-level line pass through the packer and LIC. The submersible pump may or may not be housed in a pump shroud. If no shroud is used, no air vent will be included in the assembly.

2. Depending on well-specific depths, drop pipe will be threaded together between the submersible pump and the packer/LIC assembly.

3. For the purposes of this guide, the packer and the LIC are considered to be one functional unit. The packer is below the LIC, or first, in order of assembly. The submersible pump is located below the packer and LIC with the pump cable, lower water-level tube, and air-vent line (if equipped) passing through the packer and LIC. The packer inflation line is connected from the top of the packer and fitted to the bottom of the LIC. The LIC is an assembly containing a 4.75-in. OD liquid chamber that is filled with distilled water before installation (when pressurized, the packer inflates with water via nitrogen pressure supplied to the LIC). The packer inflation line continues from the top of the LIC and extends to the wellhead body.

   The packer/LIC is pressure tested before being advanced into the well.

4. Depending on well-specific depths, drop pipe will be threaded together between the packer/LIC assembly and the upper interval’s pump.

7.4.2 Two-Pump System (continued)

5. The upper zone will be purged and sampled with a pneumatic piston-type pump. The placement of this pump must be accommodated during the design phase. A pump "holder" must be fashioned. The holder must attach the piston pump to the lower zone's pump column and securely hold it in place. By no means shall the upper zone's pump be lowered into place after the lower zone's pump has been set or suspended in the well without attachment to the pumping apparatus in the lower zone.

   The piston pump will have a tubing bundle that will contain a Teflon water discharge line and nitrogen supply and exhaust lines. The tubing bundle is connected to the pump before lowering the pump into the well.

   The pneumatic pump is function (pressure) tested before being advanced into the well.

6. The pump cable, PVC pipe, nitrogen pressure lines, and tubing bundle are banded to the stainless-steel pump column.

7. Near the end of the pump column, a riser pipe with a weep valve is installed. The pump cable, PVC pipe, nitrogen pressure lines, and tube bundle are banded to the stainless-steel pump column. The pump column and all associated hardware extending to the surface are assembled one piece at a time as the assembly is lowered into the well. Stainless-steel banding and buckles are used to bind all of the hardware together. It is recommended that one band be used per each 10-ft piece of PVC (i.e., every 10 feet on the drop pipe).

8. The PVC gauge tubes, stainless-steel pump column, pump cable, nitrogen lines, and air vent line are inserted into the bottom of the wellhead body. The finishing of the wellhead body is accomplished with the installation of a pressure gauge for the packer control line, the installation of any plugs for any potentially vacant access ports, and the installation of the permanent transducers into the PVC gauge tubes.

7.4.3 General Installation Considerations

1. Wiring pump motor to the pump cable must be performed and tested by qualified individuals (Attachment 4).

2. When making threaded connections, an approved pipe dope (e.g., Jet-Lube V-2) must be used. Threads must be compatible. When threading PVC pipe to one another, O-rings must be present. As a further precaution, threads on the submerged sections of the PVC tube for the lower screen zone may be Teflon taped.

3. Stainless-steel banding and buckles must be used to attach PVC pipe, nitrogen tubing, vent tubing, and pump cable to the pump column. It is recommended that each piece of PVC is attached to the pump column (i.e., one band every 10 feet of drop pipe length). Caution must be used so as not to pinch tubing/cables.

4. Pressure testing shall be performed after plumbing nitrogen tubes into any fitting or group of fittings. Pressure testing includes the following:

   The ends of nitrogen lines that are being inserted into fittings must have a small application of pipe dope on the end before insertion.

   Nitrogen pressure must be exerted on the tubing equal to the operating pressure of the component to which it is attached.

   The amount of time the pressure test is conducted usually depends on the component that is being pressure tested. For example, in the dual APV system, the APV closed sides and packer inflation lines are generally tested at longer intervals than the APV open sides because of the sampling method during which the APVs will have constant supplied pressure via a nitrogen tank during the sampling event.

   Pressure monitoring can be performed by observing the regulator pressure on the nitrogen supply. When the nitrogen tank is closed, leaks can be detected by reading the gauge on the regulator that is still open to the system.

   If a leak (e.g., audible hissing, bubbles observed when soapy water is applied to the fitting, measured pressure loss above ambient temperature-induced fluctuations) is detected, the tubing must be cut and inserted into a new ferrule and/or fitting. Pressure testing must be re-performed.

7.4.3 General Installation Considerations (continued)

Changes in ambient air temperature will affect the pressure-gauge readings during pressure-testing activities. Therefore, weather/temperature conditions must be observed, noted, and incorporated into the interpretation of the pressure-testing results to assess whether leaks in the system are present.

The nitrogen tank(s) and nitrogen tubing coil(s) connected to the system components being tested must be kept out of temperature extremes to avoid overheating or cooling the tubing and causing fluctuations in gauge pressure during pressure-testing activities. Tarps or insulating blankets may be used for this purpose.

Pressure tests are typically conducted at pressures within the range expected to be applied to the system during operation, which requires documenting anticipated packer and APV pressure requirements as presented in Attachment 7.

5. The wellhead body must be manufactured to allow access to all pump system pipe and tubing. For dual APV systems, pipe and tubing that may be part of the pump system include stainless-steel drop pipe, PVC pipe, packer inflation line, air-vent line, lower APV open control line, and upper APV open control line. For two-pump systems, pipe and tubing that may be part of the pump system include stainless-steel drop pipe, PVC pipe, packer inflation line, air-vent line, and piston pump discharge and nitrogen lines. The landing plate/wellhead body must be equipped with pipe joints, fittings, and valves compatible with the function of the pipe or tubing (i.e., sampling trees, quickly-connect fittings, etc.).

6. Once the system is landed at its final depth, the packer must be inflated. Each packer has a minimum pressure needed to function properly, and a maximum pressure above which it may be permanently damaged. The minimum pressure is calculated using equations provided by the packer manufacturer. Likewise, the maximum inflation pressure is provided by the manufacturer. The “target pressure,” which is the desired pressure for the packer to operate, is set at halfway between the minimum and maximum pressures. The “action pressure,” is the pressure below which the packer should not be allowed to drop, has been set at halfway between the minimum and target pressures.

7.4.3 General Installation Considerations (continued)

7. Once the packer is inflated to the target pressure, final system pressure tests must be conducted. Dual APV system components that must be tested include packer inflation line/lower and upper APV closed control line and lower and upper APV open control lines. Two-pump system components that must be tested include packer inflation line and piston pump nitrogen lines.

8. The PVC gauge tube(s) must be measured to compare with manual measurements.

7.5 <u>Testing and Monitoring Dual-Screen Pumping Systems</u>

7.5.1 Testing and Monitoring for Systems after Final Pressure Tests

1. After the pump system is landed and final pressure tests have been performed, the pumping system must be tested. Testing involves installing transducers, inflating/deflating the packer, monitoring water levels, pumping, etc., until the pumping system is observed to be operating to its specifications. Prior to performing these tests, a LANL-qualified electrician shall make final hook-ups between pump cable and pump control panel.

2. Manually measure water levels in each 1-inch PVC using a clean, calibrated water-level probe to determine the depth to water for each screen zone.

3. Measure the bottom depth of each PVC tube as a QC check on the documented installation depths. Install transducers to begin monitoring water levels electronically.

4. Monitor the water-level trend in each zone, and adjust for the transient water-level offset between the time the level was measured manually and the time that electronic monitoring began. Use this information to convert water depths to actual groundwater elevations.

5. Using the above information, determine the current head difference between the two screen zones.

6. Program both upper and lower transducers for temporary dense data collection (10-second intervals) to monitor transient water-level response and set up in-situ software for real-time water-level monitoring during system checkout.

7.5.1 Testing and Monitoring for Systems after Final Pressure Tests (continued)

7. Sequentially open and close each APV while monitoring water levels in both zones. Look for any water-level anomalies, such as a water-level response in one or both zones when opening the lower APV, which can indicate a hydraulic leak in the pump shroud. Initial valve actuation can trigger anomalous water-level responses. If an anomalous water-level response is observed, sequentially open and close each valve to see if the anomaly is repeated or absent. If the anomaly persists, document condition and notify the STR.

8. Using well component installation details, water levels, and well geometry, compute the purge volume associated with each screen zone. The purge volume for the upper screen is $\pi r^2 h$ where π=3.14, r is the inside radius of the well casing, and h is the column of water standing above the packer. The purge volume for the lower screen is $\pi r^2 h$ where $\pi = 3.14$, r is the inside radius of the well casing, and h is the column of water from the bottom of the packer to the bottom of the well sump.

9. Pump each screen zone. Open the appropriate APV and wait for stable water-level conditions. Start the pump to begin the testing process. Note the time it takes for water to reach the surface. Measure the discharge rate several times using a bucket and stopwatch.

10. Pump a minimum of three purge volumes for the zone being tested, unless otherwise directed by an STR. (This process will simulate a sampling event.)

11. Once a sufficient volume has been pumped, shut off the pump, and begin observing recovery data. After several minutes, the APV may be closed as recovery continues.

12. NOTE: Monitor the water level in the drop pipe to see if it is dropping. This practice provides a check on the frost-protection weep valve, allowing a determination of whether the valve is working (letting water drain). In this regard, examine pumping water-level data to verify that the valve did not leak during testing. If the data suggest a possible leak, operate the pump again while applying artificial backpressure to the discharge to seat the check ball. Retest the zone to see if the valve has seated and no longer leaks while pumping.

13. Using the observed drawdown data, determine the specific capacity of the screen zone. Combine this information with data from the original extended aquifer test to extrapolate the estimated specific capacity applicable to extended cross flow that would have occurred during the sampling system installation.

7.5.1 Testing and Monitoring for Systems after Final Pressure Tests (continued)

14. Once data are available from both zones, use the collected information (zone-specific capacities and head difference) to determine the cross flow rate and total cross flow volume associated with the sampling system installation. Provide this information to LANL so decisions can be made regarding purging the appropriate water volume. See Attachment 8 for cross-flow calculation.

15. Following completion of the testing procedures, download the transducer data files and reprogram the transducers to the standard data collection protocol (1-hour intervals).

7.5.2 Testing and Monitoring for Systems Removed and Reinstalled

1. Pumping systems may need to be removed from monitoring wells for maintenance or other purposes. If a dual screen pumping system has been removed and reinstalled in the same order and arrangement as it was found, the testing of the system may be curtailed from the above description. Some, if not all, of the parameters discussed above (e.g.,. cross flow rate) will have already been established. Other general operational details may also necessitate alternative testing procedures for a system that has been removed and reinstalled. A testing plan should be developed accordingly, agreed upon by the LANL technical team and STR, and implemented. The steps identified in Section 7.5.1 should be used as a starting point to guide development of the testing plan.

7.5.3 Post Installation 24-hour and 7-day Tests (including acceptance criteria)

1. After the pump system is landed, final pressure tests have been performed, and the system has been tested, the packer pressures shall be monitored for 8 days. Acceptable pressure drops are less than 5 psi in the first 24 hours and less than 5 psi during the 7 days following the 24-hour period. During the 7-day period, the pressure will be checked daily.

   In addition to the above testing, any system modifications that would involve de-pressurization and disassembly (without removal) must also be monitored for tightness as described in the previous paragraph.

7.6 Reporting

7.6.1 Sampling System Test Report

After testing, a sampling system test report with the following shall be prepared and submitted:

- Summary of testing conducted
- Brief summary of well completion details and packer information
- Pressure requirements for operating the system
- Groundwater-level data, including:
  - Baseline groundwater-level data collected before system testing
  - Groundwater-level data collected during system testing
- APV operation, including actuation pressures and response times
- Cross-flow information during installation, including:
  - Estimated cross-flow during system installation
  - Parameters used to calculate cross-flow volumes
  - Summary of pumping operations to remove calculated cross-flow volume
- Summary of purge volume requirements
- Identification of any water-level response anomalies that may have been observed
- New Mexico Professional Engineer (NM PE) stamped as-built drawings
- Receipt inspection report, including pump column material test report and retrofitted submersible pump documentation
- Installation checklist
- Results of post installation 24-hour and 7-day tests

7.6.2 Well Construction and Sampling System Information

A Well Construction and Sampling System Information sheet shall be prepared following sampling system installation and testing. The sheet shall be a standalone document that will provide the following information:

- Summary of the well location and well completion type, including description of screen locations
- Special instructions, including pumping rate limitations for each screen
- Table showing well construction information
- Table showing estimated purge volumes for each screen
- Table showing pressure requirements for operation of the system, including minimum, action, target, and maximum pressure requirements for the packer, and pressure requirements for the APVs
- Performance curve for the installed pump(s)
- Labeled photograph and/or sketch of the top of the wellhead body

7.7 Long-Term Monitoring

For monitoring the system after installation, follow procedures outlined in, ER-SOP-20006, *Pressure Monitoring of Packer Systems in Monitoring Wells*.

7.8 Records Management

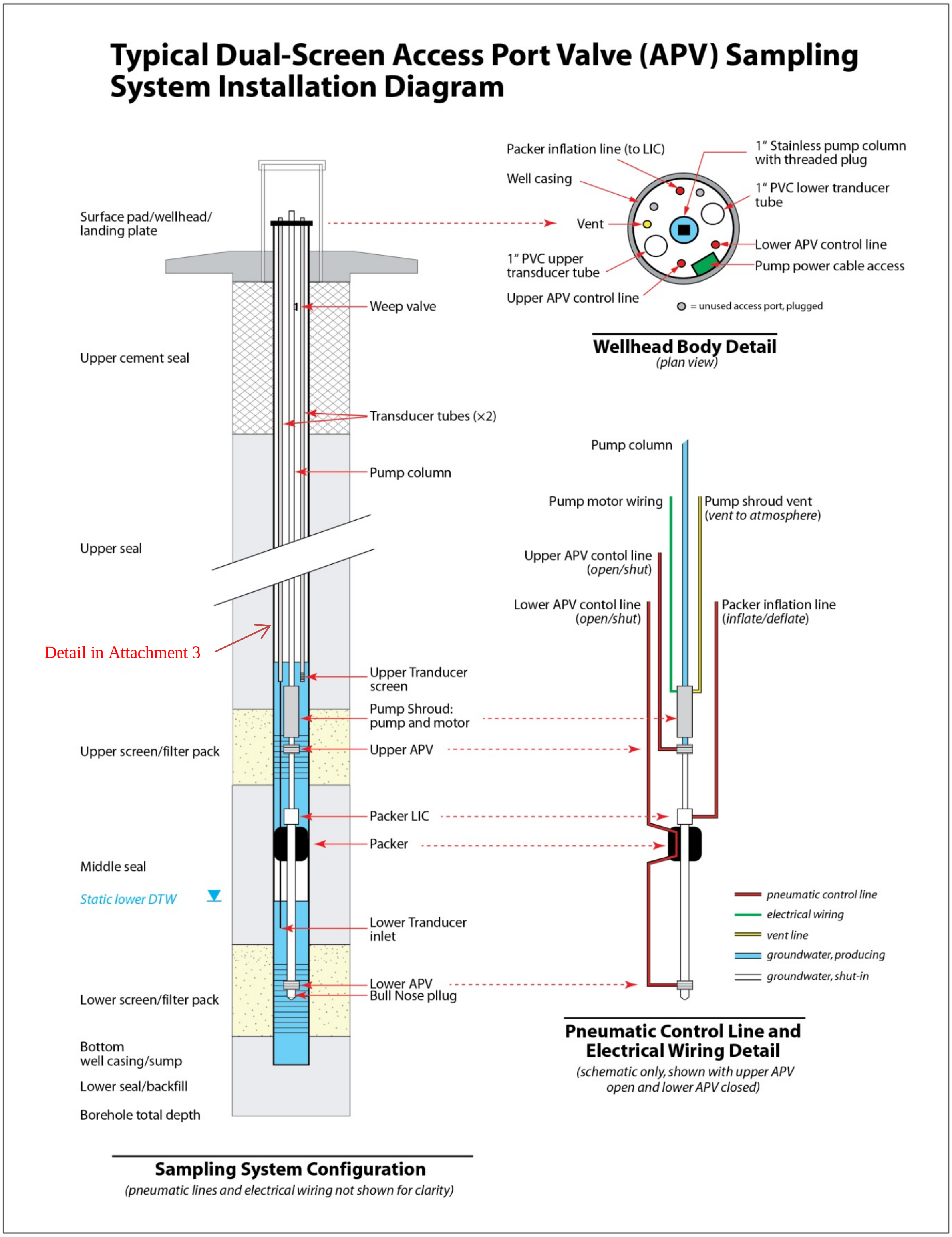
Maintain and submit records and/or documents generated to the Records Processing Facility according to EP-AP-10003, *Records Management*.

- Sampling system receipt inspection report
- Sampling system test report
- Well construction and sampling system information sheet
- Installation Checklist
- As-built drawings, NM PE stamped including electronic files in native format (e.g., dwg for Autocad)
- Field logs, logbooks, field reports, etc.

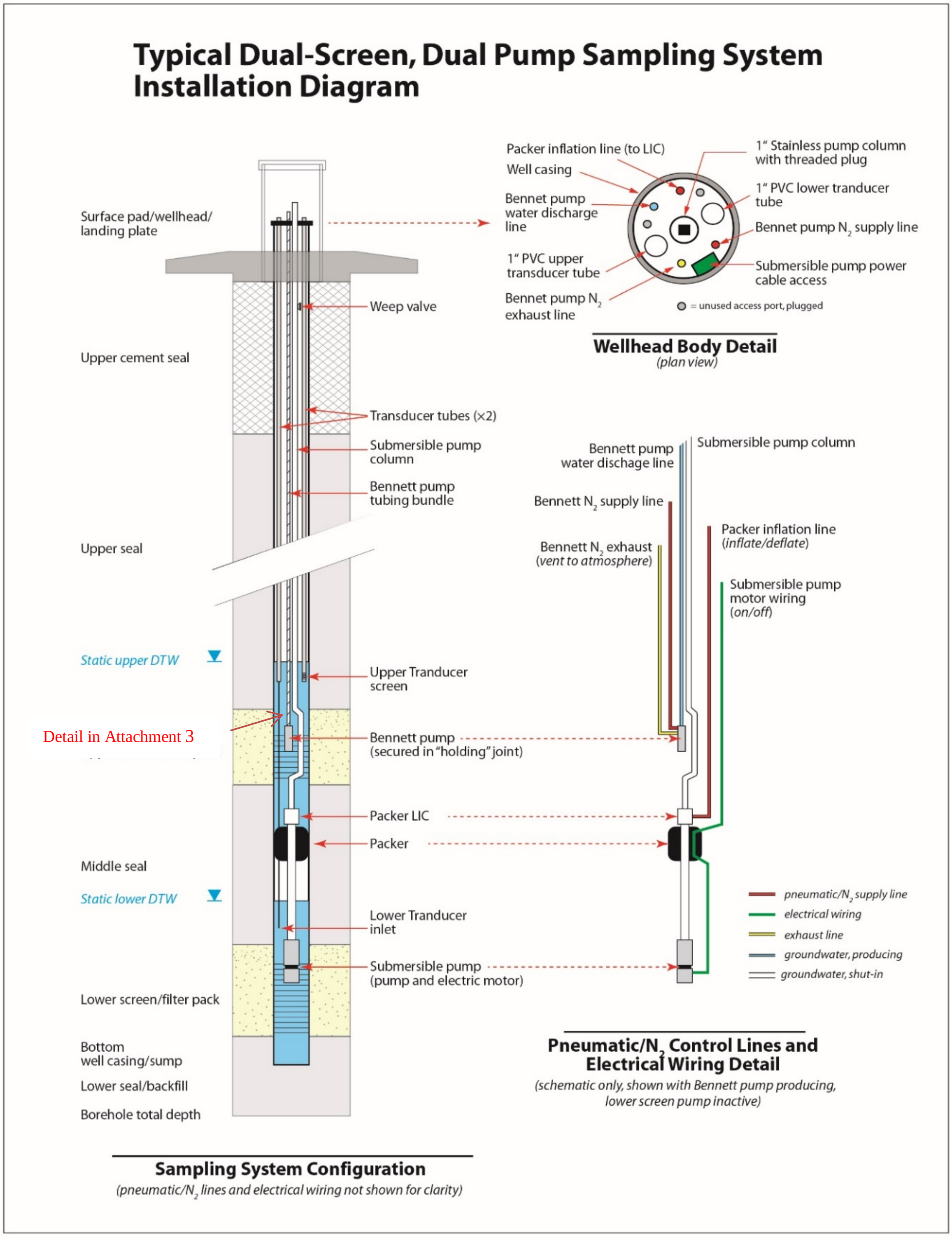
8. ATTACHMENTS

Attachment 1, Sampling System Installation Diagram
Attachment 2, Dual Pump Sampling System Installation Diagram
Attachment 3, Lower Transducer Bottom Assembly
Attachment 4, Training Requirements
Attachment 5, Installation Checklist
Attachment 6, Receipt Inspection Report
Attachment 7, Packer and APV Pressure Requirements
Attachment 8, Cross Flow Calculation

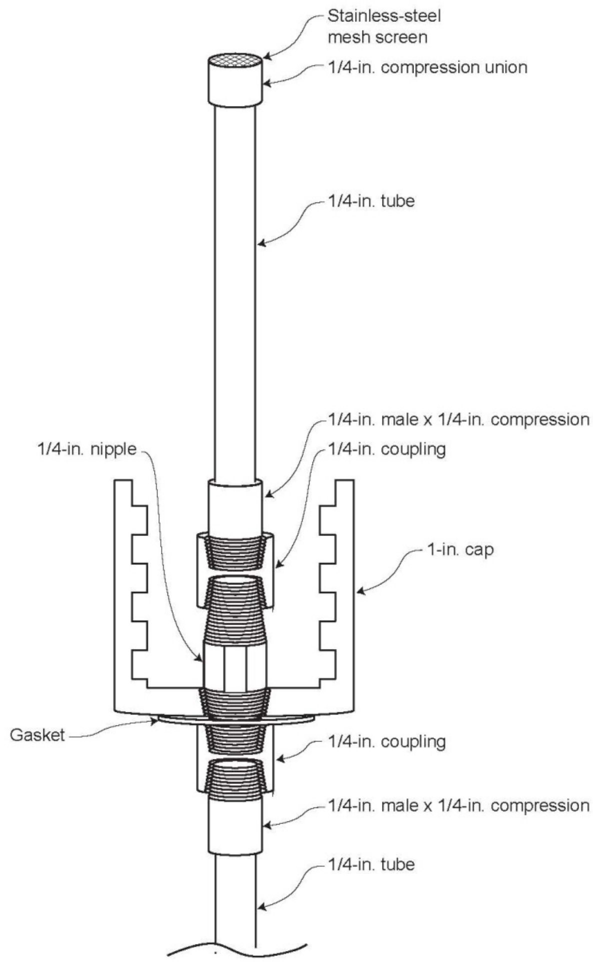
ATTACHMENT 1
Page 1 of 1
Sampling System Installation Diagram



ATTACHMENT 2
Page 1 of 1
Dual Pump Sampling System Installation Diagram



ATTACHMENT 3
Page 1 of 1
Lower Transducer Bottom Assembly



Not to scale

ATTACHMENT 4
Page 1 of 1
Table 1 – Training Requirements

TITLE	OJT	GUIDE	NGWA Certification	CAP-WELLS-SPEC-40 0511	Electrical Training Requirements/NEC
Installation Foreman/ Rig Operator		X	X	X	X
Foreman Helper		X		X	
Field Team Leader/Site Geologist	X	X		X	
Installation Specialist	X	X		X	

ATTACHMENT 5

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Installation Checklist

Installation Checklist			
No.	**Inspection Attribute**	**Sat**	**Unsat**
1.	Verify formal receipt inspection completed. Receipt Inspection Report (RIR) No.:		
2.	All major components of the pumping system [i.e., pump shroud, pump(s), liquid inflation chamber, packer, access port valves, drop pipe] decontaminated before installation. If fittings or nitrogen tubing are pre-attached to the pumping components, the open fittings and/or the ends of the tubes should be plugged to prevent water from entering into the fittings/tubes. Verify that pump model is the same as model specified on design drawings.		
3.	Before/after decontamination, the main pumping system components measured to the hundredth of a foot, and the arrangement of system components agreed upon before installation.		
4.	Assembled according to engineering drawing approved for construction Verify weep hole located below local frost line (at least 3 feet below ground surface). Upper screen interval PVC transducer tube equipped with a 0.010-in. slot screen with a threaded end cap at the bottom of the tube. Lower screen interval PVC transducer tube equipped with a flexible nylon tube that extends from a threaded end cap at the bottom of the PVC tube.		
5.	Wiring of pump-to-pump cable inspected and approved by qualified individuals once wiring is complete and before installation.		
6.	Stainless-steel banding and buckles used to attach PVC pipe, nitrogen tubing, and pump cable to the pump column do not pinch tubing/cables.		
7.	Pressure tests performed after plumbing nitrogen tubes into any fittings that pressurize the packer do not indicate a leak. (Pressure tests conducted at pressures within the range expected to be applied to the system during operation.)		
8.	Pump(s) tested after installation. Discharge rate calculated and pump performs to specifications.		
9.	Final APV and packer pressure tests conducted following installation.		
10.	Packer pressure maintained 24 hours after installation within 5 psi.		
11.	Packer pressure maintained 7 days after installation within 5 psi.		

ATTACHMENT 6

Page 1 of 1

Receipt Inspection Report

RECEIPT INSPECTION REPORT

Attribute	**Specific Attribute Inspected**	**Sat**	**Unsat**	**Not Observed**
1	Visually inspect all material and verify that items have not been damaged during shipment.			
2	Verify that all items received are as identified and described on the Dual-Screen Well Pumping Assembly Design Drawings.			
3	Verify that pump column is constructed of non-annealed, pickled, passivated stainless-steel pipe as certified by a Material Test Report.			
4	Verify that submersible pump is environmentally retrofitted as certified with documentation from supplier, including modified pump curve.			

Inspected by:

(Print name/signature/date inspection completed)

☐ **See attached pages**

ATTACHMENT 7
Page 1 of 2
Packer and APV Pressure Requirements

Minimum Packer Pressure Required

The formula used to determine the minimum packer inflation pressure required for proper system operation is as follows:

$$R_{\min} = 50 + M(50, 0.2h) + \frac{d_p - d_{hswl}}{2.31} \tag{1}$$

where,

R_{min} = minimum packer inflation pressure required, in psi

$M(a,b)$ = the maximum of *a* or *b*

h = head difference above and below packer, in feet

d_p = depth to packer, in feet

d_{hswl} = depth to the higher static water level of the two zones above and below the packer (usually that of the upper zone), in feet

Maximum Packer Pressure Allowable

The formula used to estimate the maximum safe packer pressure is as follows:

$$R_{\max} = 300 + \frac{M(-27, d_p - d_{lpwl})}{2.31} \tag{2}$$

where,

R_{max} = maximum allowable packer inflation pressure, in psi

$M(a,b)$ = the maximum of *a* or *b*

d_p = depth to packer, in feet

d_{lpwl} = depth to the lower pumping water level of the two zones, in feet

ATTACHMENT 7
Page 2 of 2
Packer and APV Pressure Requirements

Minimum APV Pressure Required

The access port valves are opened by overcoming frictional forces and the packer pressure that is keeping the valves closed. The following formula can be used to estimate the pressure required:

$$R_{APV} = f + \frac{1}{2.2}\left[3.2P - \frac{M\left(0, d_{APV} - d_{cv} - 27\right)}{2.31}\right] \quad (3)$$

where,

R_{APV} = minimum required APV pressure, in psi

f = estimated APV sliding friction pressure requirement, in psi

P = packer pressure, in psi

$M(a,b)$ = the maximum of a or b

d_{APV} = depth to APV in feet

d_{cv} = depth to check valve, in feet

All of the terms in Equation 3 are known exactly except the friction factor, *f*. This parameter varies from one APV to another, but 60 psi is considered a reasonable, conservative estimate.

ATTACHMENT 8
Page 1 of 1
Cross Flow Calculation

Cross Flow Calculation

When a two-screen well stands open with no packer separating the screen zones, groundwater from the higher-head zone flows into the well and out of the lower-head zone. The cross flow rate, *Q*, can be computed using the following formula:

$$Q = h\frac{c_1 c_2}{c_1 + c_2}$$

where,

Q = cross flow rate, in gpm
c_1 = specific capacity of screen 1, in gpm/ft
c_2 = specific capacity of screen 2, in gpm/ft
h = head difference between screens 1 and 2, in ft

The total cross flow volume over a time, *t*, can then be computed as the product *Qt*. Expressing *t* in minutes yields the cross flow volume in gallons.