TITLE 47
LEGISLATIVE RULE
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES

SERIES 60
MONITORING WELL DESIGN STANDARDS

§47-60-1. General.

1.1. Scope and Purpose. -- This rule establishes minimum acceptable documentation and standards for the design, installation, construction, and abandonment of monitoring wells and for the abandonment of all boreholes.

1.2. Authority. -- W. Va. Code § 22-12-5(d).

1.3. Filing Date. --

1.4. Effective Date. --

§47-60-2. Applicability.

This rule applies to any person who either owns, operates, constructs, installs or abandons monitoring wells and boreholes. All monitoring wells and boreholes shall be abandoned according to section 19 of this rule. This rule does not apply to monitoring wells and boreholes installed prior to the effective date of this rule, except as provided for in section 19 of this rule.

§47-60-3. Definitions.

3.1. "Abandonment" means the sealing of a monitoring well or borehole in accordance with section 19 of this rule in order to restore original hydrogeologic conditions and/or to prevent contamination.

3.2. "Air rotary drilling" means a drilling method whereby the borehole is advanced using a circular rotating action applied to a string of drilling rods that have a diffused discharge bit attached to the bottom of the rods. Pressurized air is forced through the drilling rods that cools the drilling tools and removes the cuttings from the borehole.

3.3. "Annular space" (Annulus) means the space between two well casings or between the casing and the borehole sidewall.

3.4. "Annular space seal" means the following:

3.4.a. For wells constructed with filter packs, it is the material placed above the top of the filter pack or the filter pack seal up to the surface seal and between the well casing and the adjacent formation; or

3.4.b. For wells constructed into bedrock formations and without well screens, it is the material placed from the bottom of the enlarged borehole up to the surface seal, between the well casing and the adjacent formation.

3.5. "Appropriate groundwater regulatory agency" means the groundwater regulatory agency that has primary regulatory oversight of a particular facility or activity. Where primary regulatory oversight is unassigned or shared, the Secretary shall determine which groundwater regulatory agency is to be the appropriate groundwater regulatory agency.

3.6. "Aquifer test well" means a monitoring well installed to provide information on the hydraulic conductivity, transmissivity, storage coefficient, capture zone, specific capacity, radius of influence or other physical parameters of an aquifer, defined geologic unit, or water bearing formation.

3.7. "ASTM" means American Society for Testing and Materials.

3.8. "Bedrock" means the continuous solid rock underlying any loose surface material such as soil, alluvium or boulders. Bedrock includes, but is not limited to, limestone, dolomite, sandstone, shale, coal, igneous, and metamorphic rock.

3.9. "Bentonite" means a clay consisting of at least eighty-five percent (85%) montmorillonite. Bentonite is available in the following forms:

3.9.a. "Bentonite powder" means two hundred (200) mesh pure bentonite, without additives.

3.9.b. "Bentonite granules" means eight (8) mesh pure bentonite, without additives.

3.9.c. "Bentonite pellets" means commercially manufactured tablets made by compressing pure bentonite, without additives, into forms greater than one-quarter inch (1/4") in size.

3.9.d. "Bentonite chips" means commercially processed angular fragments of pure bentonite, without additives.

3.10. "Bentonite-cement grout" means a mixture with the ratio not to exceed five (5) pounds of bentonite with ninety-four (94) pounds of Portland cement and approximately eight and six-tenths (8.6) gallons of water from an uncontaminated source.

3.11. "Bentonite-fine sand slurry" means a mixture with the minimum ratio of fifty (50) pounds of bentonite with one hundred (100) gallons of water from an uncontaminated source and ten to twenty-five percent (10-25%) sand by volume for a mud weight of eleven (11) pounds per gallon.

3.12. "Bentonite granular slurry" means a thoroughly blended mixture of up to thirty (30) pounds of untreated bentonite powder added to one hundred (100) gallons of water from an uncontaminated source with a minimum of one hundred (100) pounds of untreated bentonite granules mixed together by a Venturi hopper mud mixer or other equivalent high shear mixer.

3.13. "Bentonite high-solids grout" means a thoroughly blended mixture of water from an uncontaminated source with untreated bentonite, without additives. The mixture by weight shall contain a minimum of twenty percent (20%) bentonite solids.

3.14. "Borehole" means a circular hole, deeper than it is wide, constructed in earth material for the purpose of obtaining geologic or groundwater related data. Boreholes are also referred to as drill holes.

3.15. "Certified monitoring well driller" means an individual granted a written certificate by the Secretary to drill, construct, alter or abandon monitoring wells or boreholes, except those defined as low-risk

in subdivision 19.2.a below, and who meets the requirements of 47 CSR 59, "Monitoring Well Regulations."

3.16. "Clay" means a fine grained inorganic soil with a grain size less than seventy-five micrometers (75 μm) and having a plasticity index equal to or greater than four (4).

3.17. "Clustered monitoring wells" means individual monitoring wells situated close together, but not in the same borehole. Clustered wells are most often used for monitoring ground water conditions at various depths in roughly the same area.

3.18. "Coarse sand" means a well sorted sand with a predominant grain size between four and seventy-six hundredths millimeters (4.76 mm) and two millimeters (2.0 mm) as established by the unified soil classification system.

3.19. "Concrete" means a slurry mixture with a ratio of ninety-four (94) pounds of cement, equal volumes of dry sand and gravel, and five (5) to six (6) gallons of water from an uncontaminated source. The ratio of sand and gravel to cement may not exceed three (3) parts to one (1).

3.20. "Contaminant" means any material in a solid, liquid or gaseous state that has the potential to cause contamination.

3.21. "Contamination" means any manmade or man-induced alteration of the chemical, physical or biological integrity of the groundwater resulting from activities regulated under the West Virginia Groundwater Protection Act in excess of existing groundwater quality, unless that site has been granted a deviation or variance from existing quality as provided for in the West Virginia Groundwater Protection Act, or is subject to an order, permit, or other regulatory action that requires restoration or maintenance of groundwater quality at a different concentration or level.

3.22. "Driven-point well" means a well constructed by joining a drive point with lengths of pipe and driving the assembly into the ground with percussion equipment or by hand, without first removing material below the ten (10) foot depth.

3.23. "Excavated well" means any monitoring well that is constructed by backfilling appropriately sized unconsolidated material around the well screen. Excavated wells will be installed in accordance with sections 6, 7, and 8, subdivision 11.4.c, and subsection 11.5 of this rule. Excavated wells include, but are not limited to, any tank pit observation well.

3.24. "Filter pack" means the sand, gravel or both placed in direct contact with the well screen.

3.25. "Filter pack seal" means the sealing material placed in the annular space above the filter pack and below the annular space seal to prevent the migration of annular space sealant into the filter pack.

3.26. "Fine sand" means a well sorted sand with a predominant grain size between 0.42 mm and 0.074 mm, as established by the Unified Soil Classification System.

3.27. "Gravel" means an unconsolidated material with the predominant grain size being between 76.2 mm and 4.76 mm, as established by the Unified Soil Classification System.

3.28. "Groundwater" means the water occurring in the zone of saturation beneath the seasonal high water table, or any perched water zones.

3.29. "Groundwater observation well" means any monitoring well in which the screened interval intersects the water table.

3.30. "Groundwater Regulatory Agency" means the Department of Environmental Protection, the Bureau for Public Health, the Department of Agriculture, or any other political subdivision that has received approval from the Secretary to regulate facilities or activities for groundwater protection.

3.31. "Hollow stem auger drilling" means a drilling method where continuous flighting is welded to a hollow stem pipe. The flighting carries drill cuttings to the surface as the flighting is rotated and pushed down into the earth.

3.32. "Inside diameter" means the horizontal distance between the inner walls of a well casing, hollow stem auger or tremie pipe.

3.33. "Medium sand" means a well sorted sand with a predominant grain size between 2.0 mm and 0.42 mm, as established by the Unified Soil Classification System.

3.34. "Monitoring well" means any cased excavation or opening into the ground made by digging, boring, drilling, driving, jetting, or other methods for the purpose of determining the physical, chemical, biological, or radiological properties of groundwater. The term "monitoring well" includes piezometers and observation wells that are installed for purposes other than those listed above, but does not include wells whose primary purpose is to provide a supply of potable water.

3.35. "Montmorillonite" means a group of expanding lattice clay minerals of the general formula: $R_{0.33}Al_2Si_4O_{10}(OH)2.H_2O$, where R means one or more cations of sodium, potassium, magnesium or calcium and where Al means aluminum, Si means silicon, O means oxygen and H means hydrogen.

3.36. "Mud rotary drilling" means a drilling method whereby a borehole is advanced by using a circular rotating action applied to a string of drilling rods that have a diffused discharge bit attached to the bottom of the string. A bentonite and water mud slurry is used to provide borehole stability, to cool the bit and to carry cuttings to the ground surface.

3.37. "Neat cement grout" means a slurry mixture with a ratio of ninety-four (94) pounds of Portland cement mixed with five (5) to six (6) gallons of water from an uncontaminated source.

3.38. "Nested monitoring wells" means two (2) or more casing strings within the same borehole. The screened interval of each casing string is designed to monitor water from different zones.

3.39. "Percussion drilling" means a drilling method using a cable tool drilling machine or a drilling method whereby the permanent or temporary well casing is driven, or is set into a borehole and then driven.

3.40. "Permanent monitoring well" means any monitoring well in place for sixty (60) days or longer.

3.41. "Person" means any industrial user, public or private corporation, institution, association, firm or company organized or existing under the laws of this or any other state or country; state of West Virginia; governmental agency, including federal facilities; political subdivision; county commission; municipal corporation; industry; sanitary district; public service district; soil conservation district; watershed improvement district; partnership; trust; estate; person or individual; group of persons or individuals acting individually or as a group; or any legal entity whatever.

3.42. “Piezometer” means a monitoring well sealed below the water table that is installed for the specific purpose of determining the potentiometric surface or the physical, chemical, biological, or radiological properties of groundwater, or both.

3.43. “Potentiometric surface” or “piezometric surface” means an imaginary surface representing the total head of groundwater and is the level to which water will rise in a well.

3.44. “PSI” means pounds per square inch.

3.45. “Purge” means an action that removes water from the well, commonly accomplished by using a pump or bailer.

3.46. “Recovery well” means a well intended and designed to capture and remove contaminants from the subsurface.

3.47. “Rotary wash drilling” means a drilling method whereby metal temporary casing is advanced into the borehole by driving. At selected intervals, the temporary casing is cleaned out using rotary drilling tools by pumping clean water through the rod to flush out accumulated cuttings. This drilling method is also known as wash bore or wash down drilling.

3.48. “Sand-cement grout” means a mixture of cement, sand and water in the proportion of ninety-four (94) pounds of Portland cement, one (1) cubic foot of dry sand, and five (5) to (6) gallons of water from an uncontaminated source.

3.49. “Secretary” means the Secretary of the Department of Environmental Protection or his or her authorized designee.

3.50. “Sediment” means any unconsolidated material including, but not limited to, clay, silt, sand, gravel, and rock particles.

3.51. “Solid stem auger drilling” means a drilling method where continuous flighting is welded onto a solid stem pipe. The flighting carries drill cuttings to the surface as the flighting is rotated and pushed down into the earth. The borehole is created by a cutting bit located at the tip of the lead auger.

3.52. “Specific gravity” means the weight of a particular volume of substance compared to the weight of an equal volume of water at a reference temperature.

3.53. “Surge” means an action causing water to move rapidly in and out of the well screen, thereby removing fine material from the surrounding aquifer.

3.54. “Tank pit observation well” means any vapor observation well or groundwater observation well or both installed in an underground storage tank excavation for release detection purposes.

3.55. “Temporary monitoring well” means any monitoring well in place for less than sixty (60) days.

3.56. “Top of bedrock” or “top of firm rock” means at least seventy percent (70%) of the drill cuttings being either:

3.56.a. Angular rock fragments, as in the case of crystalline rock; or

3.56. b. Rock fragments composed of individual grains or rock particles that are cemented together to form an aggregate, as opposed to a single sediment particle.

3.57. "Tremie pipe" means a pipe or hose used to install well construction materials in an annular space or a borehole.

3.58. "Unconsolidated material" means that material found above bedrock, composed of single sediment particles, individual grains or rock fragments. Unconsolidated material includes but is not limited to clay, silt, sand, gravel, loess, peat and organic soil.

3.59. "Unified Soil Classification System" means the soil designation system based on the physical properties of the soil developed from the airfield classification system in 1952 and adopted by the American Society for Testing and Materials in standard test method D2487-83.

Note: A copy of this publication is available from the American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428.

3.60. "Vapor observation well" means any excavated well in which the screened interval intersects the backfill or unconsolidated material that is sufficiently porous to readily allow diffusion of vapors into the well.

3.61. "Water table" means the surface of unconfined groundwater where the water pressure is equal to atmospheric pressure.

3.62. "Water table observation well" means any monitoring well in which the screen or open borehole intersects a water table that is installed for the specific purpose of determining either the elevation of the water table or the physical, chemical, biological or radiological properties of groundwater, or both.

3.63. "Well" means any borehole or other excavation or opening in the ground, deeper than it is wide, constructed for the purpose of obtaining or monitoring the surrounding media, including groundwater. This definition does not include water wells whose sole purpose is to provide: a supply of water, for exploration of water, for dewatering, or for functioning as heat pump wells.

3.64. "Well depth" means the distance from the ground surface to the bottom of the well screen or to the bottom of the open hole when a well screen is not used.

3.65. "Well riser" means the impervious portion of pipe extending from the top of the well screen or open borehole to the top of the monitoring well. The well riser prevents undesirable fluids and materials from entering the monitoring well and provides access to the zone or the interval being monitored.

3.66. "Well screen" means the filtering device that allows groundwater to flow freely into a monitoring well from an adjacent formation.

3.67. "Well volume" means the volume of water contained in the well casing and the filter pack.

§47-60-4. Conflicting Provisions.

Where, in certain instances, existing rules impose requirements that are more or less restrictive than the requirements of this rule, and in the event that this rule conflicts with another applicable rule, the Secretary shall determine which rule or section(s) thereof best complies with the intent of the Groundwater Protection

Act, West Virginia Code § 22-12-1 et seq., and require adherence to said rule or section(s) thereof. The Secretary may, at his or her discretion, begin the formal regulatory process to remove the conflict between the rules.

§47-60-5. Borehole Protection.

Protective measures shall be taken to prevent a borehole from acting as a conduit for contamination or becoming a safety hazard until abandonment in accordance with section 19 of this rule.

§47-60-6. Monitoring Well Location And Reporting Requirements.

6.1. Where prior groundwater regulatory agency approval is required, monitoring wells shall be installed at the locations indicated on the approved plans and specifications.

6.2. Following installation of a monitoring well, each certified monitoring well driller shall report to the Secretary, on forms provided by the Secretary, the following information within sixty (60) days after completion of the well installation.

6.2.a. The name and address of the person for whom the wells were installed;

6.2.b. The date the wells were installed; and

6.2.c. The latitude and longitude coordinates in degrees, minutes, and seconds to the nearest second, and the method used to determine such coordinates for each well installed.

6.3. The certified monitoring well driller shall assign each monitoring well a registration number using the following system:

6.3.a. The first group of numbers will be the certified monitoring well driller's certification number followed by a dash (-).

6.3.b. The second group of numbers will represent the number of the monitoring well(s) installed by the driller for the calendar year followed by a dash (-).

6.3.c. The third group of numbers will represent the calendar year in which the well was installed.

Example: The first well drilled by a certified monitoring well driller with certification number 0123 in calendar year 1996 would be: 0123-0001-96.

6.4. The certified monitoring well driller shall permanently affix the registration number onto each well installed.

6.5. Failure to comply with any part of section 6 of this rule may result in enforcement action taken pursuant to 47CSR59 §7.

§47-60-7. Well Riser.

7.1. The well riser for wells constructed in a floodplain or floodway shall terminate a minimum of two (2) feet above ground level and be provided with a watertight cap, unless it can be demonstrated that inundation will not occur, except as provided for in subsection 11.6 of this rule.

7.2. Specifications - The riser must consist of materials that will not alter the quality of water samples for the constituents of concern and that are appropriate for the monitoring environment. The riser should have adequate wall thickness and coupling strength to withstand installation and development stresses. Each section of riser should be uncontaminated prior to installation. The minimum nominal internal diameter of the riser should be chosen based on the particular application. However, in most instances, a minimum of two (2) inches (50.8 mm) is needed to accommodate sampling devices.

Note: Risers are generally constructed of PVC, stainless steel, fiberglass, or fluoropolymer materials.

7.3. Assembly and Installation - Where the well is to be used for organic water quality monitoring, all riser couplings shall use a coupling method that is watertight and that does not introduce organic compounds to the well. Wells that will not be monitored for organic compounds may use any industry accepted watertight coupling method.

7.4. Inspection - Prior to use, the casings, couplings and other components shall be inspected for cuts, deformities, gouges, deep scratches, damaged ends, and other imperfections that could compromise the integrity of the well. Any casing, coupling or component having such a defect may not be used.

7.5. Risers shall be centered in the borehole, using centralizers if necessary, except in the case of nested monitoring wells.

7.6. A protective cap on the well riser may be necessary during the installation of the annular space seal, the filter pack, the filter pack seal and the ground surface seal to prevent any of these materials from entering the monitoring well.

§47-60-8. Well Screen.

8.1. Specifications - The well screen must consist of materials that will not alter the quality of water samples for the constituents of concern and that are appropriate for the monitoring environment. The well screen should have adequate wall thickness and coupling strength to withstand installation and development stresses. Each section of well screen should be uncontaminated prior to installation. The minimum nominal internal diameter of the well screen should be chosen based on the particular application.

8.2. All monitoring well screens shall be constructed of material that is nonreactive with the constituents in soils and groundwater at the monitoring location. The well screen slot size shall be sized to retain at least ninety percent (90%) of the grain size of the collapsed formation where such is used as filter pack material, or at least ninety percent (90%) of the grain size of the filter pack if material other than collapsed formation is used. In lieu of a sieve analysis, or where other well design considerations require a different slot size, a number ten (10) slot screen size may be used, as a maximum, to retain at least ninety percent (90%) of the filter pack material. Well screen interval lengths should be chosen to adequately monitor the water-bearing zone of interest and to comply with section 13 of this rule. Well screens on piezometers installed for the purpose of determining the elevation of the potentiometric surface may not exceed five (5) feet in length, except where potentiometric surfaces may fluctuate over greater intervals.

Note: Well screens for wells other than the water table observation wells and piezometers identified above may vary in length.

8.3. Assembly and Installation. All well screens shall be joined to the well riser by methods described in subsection 7.3 of this rule. All joints shall be watertight. Monitoring wells installed in bedrock using an open

borehole may be constructed without a well screen.

8.4. Well screens shall be centered in the borehole, using centralizers if necessary, except in the case of nested monitoring wells.

8.5. The bottom portion of each well screen or well must be plugged or capped to prevent oversized material from entering the well.

§47-60-9. Tremie Pipes and Sealing Procedures.

9.1. Materials - The tremie pipe used for the placement of sealant materials shall be one of the following materials and shall exhibit pressure ratings adequate for the pumping pressures to be used:

9.1.a. Metal pipe,

9.1.b. Rubber-covered hose reinforced with braided fiber or steel,

9.1.c. Thermoplastic pipe including but not limited to:

9.1.c.1. Polyvinyl chloride (PVC)

9.1.c.2. Chlorinated polyvinyl chloride (CPVC),

9.1.c.3. Polyethylene (PE),

9.1.c.4. Polybutylene (PB), or

9.1.c.5. Acrylonitrite butadiene styrene (ABS).

9.2. Procedures - This subsection describes groundwater regulatory agency approved sealant placement methods when a tremie pipe is used.

Note: These procedures apply to the use of grout or slurry sealant.

9.2.a. The sealant material shall be placed in such a manner as to not disturb the integrity of the filter pack and seal, and to not threaten the integrity of the riser.

9.2.b. When a tremie pipe is used for placement of fluid sealants, the bottom end shall be kept submerged in the sealant material throughout the sealing process.

9.2.c. The sealant material shall be brought up to the ground surface seal. Any settling of the sealant material shall be topped off.

9.2.d. Tremie pipe – gravity. Sealing material may flow by gravity through a funnel or hopper connected to a tremie pipe. The tremie pipe shall be lowered to the bottom of the annular space or borehole to be sealed and the sealing material placed from the bottom up.

9.2.e. Tremie pipe – pumped. Sealing material shall be placed by a pump through a tremie pipe into the annular space or borehole. Tremie pipes used for the placing of pumped slurry or grout should be fitted with a J-hook end or a closed end with side discharge.

Note: The J-hook end or closed end with side discharge of the tremie pipe will direct the flow of the materials to the side or upward.

§47-60-10. Filter Packs.

10.1. All permanent monitoring wells installed in unconsolidated material and used for the collection of water quality samples shall be constructed with filter packs, except as provided in subsection 10.4 of this rule. Permanent monitoring wells installed in bedrock may be constructed with filter packs. When used, the filter pack shall be the only material in contact with the well screen. All commercially prepared filter packs installed in permanent monitoring wells shall meet the requirements in subsection 10.2 of this rule. All other filter packs shall meet the requirements in subsection 10.4 of this rule.

10.2. Specifications - The filter pack shall be a silica based sand or gravel. The sand or gravel used for filter packs shall be hard and durable and shall have an average specific gravity of not less than 2.50. The sand and gravel shall be visibly free of clay, dust and micaceous and organic matter. Not more than five percent (5%) of the sand or gravel shall be soluble in a ten percent (10%) hydrochloric acid solution. Uniformity coefficients for filter pack material shall range from one (1) to three (3). All filter pack material should be purchased from a reputable supplier who has properly cleaned and bagged the material. In lieu of a sieve analysis, for unconsolidated material that is predominately silt and clay, the filter pack shall be a fine sand. In bedrock, the filter pack shall be a medium or coarse sand or gravel, except in karst or highly fractured bedrock formations where fine sand filter packs may be used. Crushed limestone, dolomite or any material containing clay or any other material that will adversely impact on the performance of the monitoring well may not be used as filter pack.

Note: When installing a monitoring well in karst or highly fractured bedrock, a pre-packed or double sleeved screen may be necessary to hold the filter pack material in place.

10.3. Installation - The filter pack shall generally extend from six (6) inches beneath the bottom of the well to between two (2) and five (5) feet above the top of the well screen. For water table observation wells constructed in areas where the depth to water table is less than seven (7) feet or where discrete monitoring is desired, the required filter pack height above the top of the well screen may be reduced to six (6) inches to allow for the required amount of annular space sealant to be placed. To ensure that the filter pack is installed evenly surrounding the well screen and casing over the proper depth interval, a tape measure, measuring rod or similar device shall be used to measure the height of the filter pack. The tape measure, measuring rod or similar device shall be carefully raised and lowered while the filter pack is being installed to identify bridging. If bridging occurs, the filter pack material shall be tamped into place surrounding the well screen and riser, using a measuring rod or similar device. Pre-packed screens may be used if necessary

10.4. Collapsed Formation - Collapsed formation may be used as filter pack material, if the collapsed formation will limit the passage of formation fines into the well screen and either an artificial filter pack cannot be installed or the formation grain size is greater than or equal to fine sand sized grains. The grain size distribution of the collapsed formation shall be such that at least ninety percent (90%) of the formation will be retained by the well screen.

§47-60-11. Sealing Requirements.

11.1. All materials and procedures used in the installation of seals for permanent monitoring wells shall meet the requirements of this section.

11.2. Installation of the Filter Pack Seal - A bentonite chip, pellet or a slurry seal shall be placed in the annulus between the borehole and the riser pipe on top of the secondary or primary filter pack. This seal will retard the movement of cement-based grout backfill into the primary or secondary filter packs. To be effective, the filter pack seal should extend above the filter packs approximately three (3) feet or more, but may be less depending on site-specific conditions, where discrete sampling is desired or where physical conditions prohibit a longer seal depending on local conditions. The filter pack seal should be installed using a tremie pipe lowered to the top of the filter pack and slowly raised as the bentonite pellets or the slurry fill the annular space. Bentonite pellets may bridge and block the tremie pipe in deep wells. In these cases, pellets may be allowed to free fall into the borehole. As a bentonite pellet seal is poured into the tremie pipe or allowed to free fall into the borehole, a tamper or weighted line may be necessary to tamp pellets into place. If the seal is installed above the water level, water from an uncontaminated source shall be added to allow proper hydration of the annular seal. The tremie pipe or a weighted line inserted through the tremie pipe shall be used to measure the top of the filter pack seal as the work progresses. Sufficient time should be allowed for the bentonite pellet seal to hydrate or the slurry annular seal to expand prior to grouting the remaining annulus. The volume and elevation of the filter pack seal material should be measured and recorded on the well construction diagram.

11.3. Annular Space Seal Specifications - All permanent monitoring wells shall be installed with an annular space seal designed to achieve a permeability of 10^{-5} centimeters per second or less. For permanent monitoring wells constructed with filter packs, the annular space seal shall extend from the filter pack seal to the ground surface seal and should be at least two (2) feet in length. For monitoring wells constructed into bedrock formations and without well screens, the annular space seal shall extend from the bottom of the outer casing to the ground surface seal.

11.4. Annular Space Seal Installation - Bentonite chips, pellets or granules with a diameter of three-eighths inches (3/8”) or less shall either be poured freely down the borehole or added through a tremie pipe to seal the annular space. When a tremie pipe is used to place the annular space sealant, the procedures in subsections 9.2.a and 9.2.b of this rule shall be followed.

11.4.a. When grouts or slurries are used to seal the annular space, the material shall be poured freely down a tremie pipe or pumped down a borehole with the use of a tremie pipe. When a tremie pipe is used to place the annular space sealant, the procedures of subsection 9.2 of this rule shall be followed.

11.4.b. When any slurry or grout is used, there shall be a twelve (12) hour period between the time the annular space seal is installed and the time the protective ground surface seal is installed. Any settling in the annular space seal shall be topped off before the ground surface seal is installed.

11.4.c. The top of the well casing shall be covered with a protective cap.

11.5. Excavated Wells - For excavated wells, the seal between the protective cover and the riser pipe acts as both the filter pack seal and the annular space seal.

11.6. Ground Surface Seal and Protective Cover Pipe.

11.6.a. Ground surface seal - All permanent monitoring wells shall be constructed with a bentonite cement grout, neat cement grout, or concrete ground surface seal. The ground surface seal shall extend to a minimum of thirty (30) inches below the land surface, and the top shall be sloped away from the well casing. If the monitoring well depth is such that both a minimum two (2) foot annular space seal and a minimum two and one-half (2.5) foot ground surface seal cannot both be placed, the ground surface seal may be shortened.

11.6.b. Protective cover pipe - The protective cover pipe shall consist of a casing at least two (2) inches larger in diameter than the well riser and have a locking cap. The protective cover pipe shall extend from the bottom of the ground surface seal to a minimum of twenty-four (24) inches above the ground surface, except as provided in subsection 11.5 of this rule. The protective cover pipe shall always extend above the top of the well riser. For water table observation wells constructed in areas where the depth to the water table is less than seven (7) feet, the required length (depth) of protective cover shall be reduced and may not extend into the filter pack.

11.7. Ground Surface Seal and Flush Mounted Protective Cover.

11.7.a. Ground surface seal - All permanent monitoring wells with a flush mounted protective cover shall be constructed with a concrete ground surface seal. The ground surface seal shall extend to, but not beyond, the total depth of the flush mounted protective cover. The ground surface seal shall be installed around the flush mounted protective cover and may not be placed between the flush mounted protective cover and the well casing.

11.7.b. Flush mounted protective cover - The flush mounted protective cover shall not be installed in areas subject to ponding or flooding. The flush mounted protective cover lid(s) shall indicate on its outer surface that it is a type of monitoring well as defined in section 3.35 of this rule. A black equilateral triangle inset in a white background is also an acceptable label. If an impervious surface does not exist, an apron shall be created that will support the weight of the traffic in the area. The flush mounted protective cover shall consist of a watertight metal casing with an inside diameter at least two (2) inches greater than the inside diameter of the monitoring well riser. The flush mounted protective cover shall be one continuous metal piece or two metal pieces that are joined with a continuous weld. The flush mount protective cover shall be a minimum of twelve (12) inches in length. There may be no more than eight (8) inches between the top of the monitoring well riser and the top of the flush mounted protective cover after installation. The flush mounted protective cover shall have an exterior flange or lugs. The flush mounted protective cover or the monitoring well shall have a locking mechanism. The monitoring well installed within any flush mounted protective cover shall have a watertight cap.

Note: After removing the watertight cap and prior to taking a head level measurement, a waiting period is recommended to enable the water level to stabilize.

§47-60-12. Drilling Methods and Fluids.

Drilling shall be conducted in a manner so as to minimize the introduction of foreign material into the borehole, produce the least possible disturbance to the formation, and permit the proper construction and development of the required diameter well. Only air, water free of bacterial and chemical contamination, or bentonite drilling mud mixed with water from an uncontaminated source may be used as drilling fluids. The water used for drilling shall be stored in such a manner as to prevent contamination of the clean water. If air is used as a drilling fluid, the air shall be filtered by an oil-air filter or oil trap to reduce or remove the oil content discharged from the compressor. If water is used, the source of the water shall be reported.

§47-60-13. Cross Contamination.

In areas where contamination is suspected to exist, precautions shall be taken to prevent cross contamination of groundwater bearing zones or uncontaminated zones.

§47-60-14. Disposal and Decontamination.

14.1. In areas where contamination is known to occur, all drill cuttings and fluids and surge and wash waters from borehole and monitoring well construction and development shall be disposed of in a manner that is protective of the waters of the State.

14.2. All borehole and monitoring well construction and development equipment shall be decontaminated as needed to prevent contamination or cross-contamination of boreholes or monitoring wells.

§47-60-15. Borehole Diameter.

15.1. Boreholes in unconsolidated geologic formations - For all permanent monitoring wells in unconsolidated geologic formations, the borehole diameter shall meet the following requirements:

15.1.a. If hollow stem augers are used, their inside working diameter shall be at least two (2) inches greater than the inside diameter of the permanent well casing.

15.1.b. If solid stem augers are used, their outside diameter shall be at least four (4) inches greater than the inside diameter of the permanent well casing.

15.1.c. If an air or mud rotary method is used, the borehole diameter shall be at least four (4) inches greater than the inside diameter of the permanent well casing. If a temporary outer casing is used, the inside diameter of the temporary outer well casing shall be at least four (4) inches greater than the inside diameter of the permanent well casing. The temporary outer casing shall be pulled immediately before or as the annular space is sealed, depending on site specific geology.

Note: The dual-tube or triple-tube reverse rotary systems are rotary methods.

15.1.d. If percussion methods, including the rotary wash, wash down, and wash bore methods are used with a temporary outer casing in unconsolidated geologic formations, the inside diameter of the temporary outer casing shall be at least four (4) inches greater than the inside diameter of the permanent well casing. The temporary outer casing shall be removed during the sealing of the annular space.

15.2. Boreholes in bedrock geologic formations - For all permanent monitoring wells installed deeper than two (2) feet past the top of the bedrock, the borehole diameter shall meet the following requirements:

15.2.a. If an air or mud rotary method is used to construct the monitoring well, the requirements of subdivision 15.1.c of this rule shall be followed.

15.2.b. If percussion methods are used to construct the monitoring well, the requirements of subdivision 15.1.d of this rule shall be followed.

§47-60-16. Recovery Wells.

Groundwater quality data from recovery wells may not be acceptable, as some recovery wells may not meet the minimum design standards required for monitoring wells. Recovery wells shall be subject to the reporting requirements in section 6 of this rule, documentation requirements in section 18 of this rule, and the abandonment requirements in section 19 of this rule.

§47-60-17. Well Development, Redevelopment and Reconditioning.

All permanent monitoring wells shall be developed according to the requirements of this section, except

for excavated wells and wells that are installed for the sole purpose of determining the level of groundwater or the potentiometric surface. Wells sealed with grout or slurry shall be developed after a minimum waiting period of twelve (12) hours after installation is completed. Development, redevelopment and/or reconditioning operations shall be performed with care, so as to prevent damage to the well and any strata surrounding the well. Care is necessary to prevent the spread of contaminants, particularly when the well is situated in known or suspected areas of contamination. The goal of well development is to produce water free of sediment and all drill cuttings and drilling fluids. Appropriate methods of well development vary with the type and use of a monitoring well. Development methods that may be acceptable under certain circumstances include:

17.1. Methods for wells that cannot be purged dry - All permanent monitoring wells that cannot be purged dry shall be developed until a minimum of ten (10) well volumes of water are removed or until the well produces sediment free water. Well volumes shall be calculated in the manner prescribed in Table 1 of this rule. One or more of the following methods shall be used to develop a well under this section:

17.1.a. Surge and Purge Method - The surge and purge cycle shall consist of several minutes of surging followed by several minutes of purging to remove the material collecting in the bottom of the well. The surging shall move formation water in and out of the well screen. The surging shall be accomplished by using a bailer, surge block or by pumping the well sufficiently to cause a drawdown and then allowing the well to recover and repeating the process. Plungers, bailers, surge blocks, and other surging devices must incorporate safety valves or vents to prevent excessive pressure differentials that could damage casing, screen, or the formation. The positive and negative pressures exerted shall not force contaminants from or into the well bore, cause mechanical damage to the well components, draw annular space or filter pack sealant into the filter pack, bridge the filter pack with excessive sediments, or collapse the formation.

17.1.b. Over Pumping (Pump Surging Method) - The monitoring well shall be pumped at a rate considerably higher than it would be during normal operation to dislodge fine-grain materials from the filter pack and surrounding strata. This method also requires mechanical surging in order to delete the negative influences associated with one directional movement of water. This method may not be suitable for wells producing large amounts of sediment that could jam or clog a pump. Over pumping can also create a cone of depression in the water table that can draw contaminants to the well.

17.1.c. Air Lift Pumping Method - An air lift pump shall be operated by cycling the air pressure on and off for short periods of time to provide a surging action that will dislodge fine-grained materials from the filter pack and surrounding strata. A steady, low pressure shall be applied to remove the fines that have been drawn into the well by the surging action. Efforts should be made (through the use of a foot valve) to avoid pumping air into the filter pack and adjacent hydrologic unit because the air may lodge there and inhibit future sampling efforts and may also alter ambient water chemistry. Furthermore, application of high air pressures should be avoided to prevent damage to PVC risers, screens, and filter packs. The use of an eductor pipe is recommended. Operational air must be free of oil or other contaminants through use of a coalescing filter.

17.1.d. Well Jetting Method - The well screen area shall be jetted with water using sufficient pressure to achieve the desired effect but limiting force to prevent damage to the well components and surrounding formation. Water added during this development procedure will alter the natural, ambient water quality and may be difficult to remove. Therefore, the water added should be obtained from an uncontaminated source. Water from the monitoring well being developed may also be used if the suspended sediments are first removed.

17.2. Methods for Wells that Can Be Purged Dry. All permanent monitoring wells that can be purged

dry shall be developed in a manner that limits agitation by slowly purging the well dry. Any water added for development shall be from an uncontaminated source, and an equal volume of water shall be purged upon completion of development.

§47-60-18. Monitoring Well Construction Documentation.

18.1. All permanent monitoring well construction details shall be reported to the person for whom the wells were installed using forms and instructions provided by the Secretary within sixty (60) days after the well has been installed. These forms are to be retained by the person for whom the well was installed for five (5) years beyond the abandonment of the well. These forms are transferable with notification to the proper groundwater regulatory agency. At a minimum, the completed report shall include the following information:

18.1.a. Well location, as determined by subdivision 6.2.c of this rule;

18.1.b. Well casing material and installation procedures;

18.1.c. Well screen materials and installation procedures;

18.1.d. Filter pack materials, installation procedures, and depth to bottom and top of filter pack;

18.1.e. Sealing materials, installation procedures, and depth to bottom and top of seal (i.e. filter pack, annular space, etc,);

18.1.f. Drilling methods and fluids used for installation;

18.1.g. Borehole diameter;

18.1.h. Well development procedures;

18.1.i. Length of screen;

18.1.j. Screen slot size;

18.1.k. Depth of bottom of screen;

18.1.l. Well depth;

18.1.m. Total drilled depth of the borehole;

18.1.n. Well registration number;

18.1.o. Certified driller's name and company name(s), address(es), and telephone number(s); and

18.1.p. Driller's certification number,

18.2. The certified monitoring well driller shall report any and all decontamination procedures for each borehole to the person for whom the wells were installed.

§47-60-19. Abandonment Requirements.

The following requirements apply to the abandonment of all monitoring wells and all boreholes. The appropriate groundwater regulatory agency may require, by order or other appropriate means, that any borehole or monitoring well be abandoned. The appropriate groundwater regulatory agency shall consider the following factors in determining whether a borehole or monitoring well should be abandoned: purpose, location, groundwater quality, age and condition of the well or borehole, potential for groundwater contamination, and well or borehole construction.

19.1. Timelines for Abandonment.

19.1.a. A borehole shall be abandoned within three (3) working days after its use has been discontinued.

19.1.b. Any permanent monitoring well no longer being used to gather information on geologic or groundwater properties shall be abandoned within sixty (60) days after its use has been discontinued.

19.1.c. Any monitoring well or borehole found by the appropriate groundwater regulatory agency to be acting as a conduit for groundwater contamination shall be abandoned within fifteen (15) working days after written notification by the appropriate groundwater regulatory agency.

19.1.d. Any monitoring well constructed after the effective date of this rule not meeting the requirements of this rule shall be abated, abandoned or replaced with a monitoring well meeting the requirements of this rule within sixty (60) days after written notification by the appropriate groundwater regulatory agency that the well is noncompliant, unless approved by the appropriate groundwater regulatory agency in accordance with section 22 of this rule.

19.2. Abandonment Procedures.

19.2.a. Boreholes are determined to be low risk or high risk. High risk boreholes are those boreholes on sites containing or formerly containing solid or hazardous waste, hazardous materials or their by-products, or that may be affected by solid or hazardous waste, hazardous materials or their by-products in the future; or at sites of known or suspected contamination unless otherwise determined to be innocuous; or in situations where water quality in one water bearing zone may be detrimental to another water bearing zone. All other boreholes are low risk. Low risk boreholes may be abandoned by complete filling from bottom to top with drill cuttings, tailings or native materials to restore the borehole to its original geologic setting, such that the natural migration of groundwater is not significantly influenced and the borehole has no adverse influence on the environment. High risk boreholes shall be abandoned in accordance with subsection 19.3 of this rule.

19.2.b. Monitoring wells with impermeable annular space seals - Monitoring wells known to be constructed with an impermeable annular space seal shall be abandoned according to the requirements of subsection 19.3 of this rule after the protective cover pipe or the flush mounted protective cover and the ground surface seal have been removed and the well riser cut off at least thirty (30) inches below the ground surface. The well riser may be completely removed during abandonment by pulling the well riser, over-drilling around the riser and then pulling the well riser out of the ground, or by drilling out the well riser completely. If the well riser is to be removed, the well should be sealed as the riser is removed pursuant to subsection 19.3 of this rule.

19.2.c. Monitoring wells with permeable annular space seals and wells in waste areas - A monitoring well not known to be constructed with an impermeable annular space seal or located in an existing or planned future waste disposal or treatment area shall be abandoned by removing the protective cover pipe or the flush mounted protective cover and the ground surface seal and then completely removing the well riser. The well

riser may be completely removed during abandonment by pulling the well riser, overdrilling around the riser and then pulling the well riser out of the ground, or by drilling out the well riser completely. The well riser shall be removed from the well and should be sealed as the riser is removed, pursuant to subsection 19.3 of this rule.

19.3. Sealing requirements - Boreholes and monitoring wells shall be abandoned by complete filling with neat cement grout, bentonite-cement grout, bentonite high-solids grout, concrete, bentonite-sand slurry or sand-cement grout. When a tremie pipe is used to place the sealing material, the procedures of subsection 9.2 of this rule shall be followed. A tremie pipe shall be used to abandon monitoring wells and boreholes greater than thirty (30) feet in depth or with standing water. Monitoring wells and boreholes greater than one hundred (100) feet in depth shall be sealed with a tremie pipe-pumped method. A J-hook end or closed end with side discharge is recommended, but not required, when placing sealant materials for the abandonment of a borehole. Bentonite may be used as a sealing material without the use of a tremie pipe under the following conditions:

19.3.a. Bentonite or bentonite mixed sand consisting of eighty percent (80%) silica sand and twenty percent (20%) bentonite by volume may be used for abandonment of boreholes and monitoring wells less than thirty (30) feet deep where there is no standing water.

19.3.b. Bentonite chips or bentonite pellets may be used for abandonment of boreholes and monitoring wells less than fifty (50) feet deep and where the depth of standing water is less than thirty (30) feet, provided that the pellets or chips are smaller than one-fifth (1/5) the diameter of the hole or the annular space.

19.3.c. Bentonite chips or bentonite pellets may be used for abandonment of boreholes and monitoring wells that are greater than four (4) inches in diameter and less than two hundred fifty (250) feet deep and where the depth of standing water is less than one hundred fifty (150) feet, provided that the pellets or chips are smaller than one-fifth (1/5) the diameter of the hole or the annular space.

19.4. Sealant Settlement - Any settling of the sealant material shall be topped off. Sealing material may be terminated thirty (30) inches below the ground surface in agricultural areas to avoid interference with agricultural activities. A native soil plug shall be placed on top of the settled sealing material in such cases.

19.5. Abandonment Documentation - ~~All borehole~~ High risk borehole and permanent monitoring well abandonments shall be reported to the appropriate groundwater regulatory agency within sixty (60) days of the abandonment on forms supplied by the appropriate groundwater regulatory agency. In addition to the information required on the form, the person performing the abandonment shall report any decontamination procedures used between borehole and well abandonments.

§47-60-20. Driven-Point Wells.

Driven-point wells with contaminant compatible drive pipes and well screens may be used as permanent monitoring wells if prior groundwater regulatory agency approval is obtained. Prior approval is not necessary for driven-point wells installed in the backfill surrounding underground storage tanks used solely to determine the water table elevation in the tank pit for tank tightness testing purposes. Written documentation shall be supplied to the appropriate groundwater regulatory agency prior to installation indicating:

20.1. That the well is to be used only for water table elevation measurements or to monitor for parameters for which the well casing and screen material will not interfere with the analytical results;

20.2. That the well will not provide a conduit for contaminants to enter the groundwater; and

20.3. That information on subsurface stratigraphy is not needed. In situations where subsurface geologic information is needed, a separate borehole shall be constructed to collect the required data.

§47-60-21. Temporary Monitoring Wells.

Temporary monitoring wells may be installed according to alternate standards than specified for permanent monitoring wells. Any temporary monitoring well construction shall be approved by the appropriate groundwater regulatory agency prior to its installation. All temporary monitoring wells shall be abandoned in accordance with section 19 of this rule within one hundred twenty (120) days after their installation unless an exception is allowed under section 22 of this rule.

§47-60-22. Special Circumstances and Exceptions.

22.1. The appropriate groundwater regulatory agency may require or approve more restrictive or alternative well material, assembly, installation, development or abandonment procedures if the contaminant concentrations or geologic setting require alternative construction. Prior written approval is required before any alternative materials are used in monitoring well installation.

22.2. Exceptions to the requirements of this rule may be approved by the appropriate groundwater regulatory agency prior to installation or abandonment. An exception request shall state the reasons why compliance with the rule requirements is infeasible or unnecessary. The appropriate groundwater regulatory agency may conditionally approve an exception by requiring materials or procedures that safeguard against contamination and result in monitoring well construction that is substantially equivalent to the requirements of this rule. Failure to comply with the conditions of an exception voids the appropriate groundwater regulatory agency's approval of the exception.

§47-60-23. Enforcement.

23.1. Any person who violates this rule shall be subject to civil administrative penalties, civil or criminal penalties, enforcement orders, and procedures as set forth in W. Va. Code § 22-12-10 and 47 CSR 59 "Monitoring Well Regulations."

23.2. The appeal and review procedures set forth in W. Va. Code § 22-12-11 shall be applicable to actions arising under this rule.

TABLE 1

WELL VOLUME CALCULATIONS

$V_1 + V_2$ = well volume

Where:

V_1 = volume of water in well casing = $3.1416 \times (D_1/2)^2 H_1$
V_2 = volume of water in filter pack = $N \times 3.1416 \times H_2 [(D_3/2)^2 - (D_2/2)^2]$
N = porosity of filter pack
D_1 = inside diameter of well casing
D_2 = outside diameter of well casing
D_3 = diameter of borehole
H_1 = height of water column

-- (Use appropriate H_2) --

H_2 = length of sand used in filter pack and fine sand filter pack seal or the height of the water column in water table observation wells.

-- or --

H_2 = length of filter pack or the height of the water column in water table observation wells.
Note: There are 7.48 gallons per cubic foot.