

**SUBCHAPTER J: GROUNDWATER MONITORING AND CORRECTIVE ACTION**  
**§§330.401, 330.403, 330.405, 330.407, 330.409, 330.411, 330.413,**  
**330.415, 330.417, 330.419, 330.421**  
**Effective March 27, 2006**

**§330.401. Applicability.**

(a) Facilities that have closed in accordance with §§330.453, 330.455, or 330.457 of this title (relating to Closure Requirements for Municipal Solid Waste Landfill Units that Stopped Receiving Waste Prior to October 9, 1991, Type IV Landfills, and Municipal Solid Waste Sites; Closure Requirements for Municipal Solid Waste Landfill Units that Received Waste on or after October 9, 1991, but Stopped Receiving Waste Prior to October 9, 1993; or Closure Requirements for Municipal Solid Waste Landfill Units that Receive Waste on or after October 9, 1993) prior to the effective date of the comprehensive rule revisions in this chapter as adopted in 2006 (2006 Revisions) may continue to monitor groundwater using the well location requirements contained in previously issued authorizations, as allowed by §330.1(a)(1) of this title (relating to Purpose and Applicability).

(b) Owners and operators of landfill units shall comply with the 2006 Revisions to this subchapter by applying for a permit modification with public notice in accordance with §305.70(l) of this title (relating to Municipal Solid Waste Permit and Registration Modifications) to revise any inconsistent permit provisions within two years from the effective date of the 2006 Revisions. If an approved groundwater sampling and analysis plan allows for filtering groundwater samples, owners or operators may continue to sample and analyze groundwater in accordance with their approved groundwater sampling and analysis plan while also collecting and analyzing unfiltered groundwater samples to reestablish background groundwater constituent concentrations. The requirements in this subchapter apply to all municipal solid waste landfill units, except for Type IAE and Type IVAE landfills as provided in §330.5(b) of this title (relating to Classification of Municipal Solid Waste Facilities) and except as provided in §330.417 of this title (relating to Groundwater Monitoring at Type IV Landfills). Additionally, the executive director may establish groundwater monitoring requirements for solid waste management units other than Type I or Type IV landfills where site-specific conditions and operations have the potential for groundwater contamination.

(c) Composting operations that require a permit are subject to the groundwater monitoring requirements of §332.47(6)(C)(ii) of this title (relating to Permit Application Preparation).

(d) Groundwater monitoring requirements under §330.403 of this title (relating to Groundwater Monitoring Systems), §330.405 of this title (relating to Groundwater Sampling and Analysis Requirements), §330.407 of this title (relating to Detection Monitoring Program for Type I Landfills), and §330.409 of this title (relating to Assessment Monitoring Program) may be suspended by the executive director for a solid waste management unit if the owner or operator can demonstrate that there is no potential for migration of hazardous constituents from that solid waste management unit to the uppermost aquifer as defined in §330.3 of this title (relating to Definitions) during the active life and the closure and post-closure care period of the unit. This demonstration shall be certified by a qualified groundwater scientist and approved by the executive director, and must be based upon:

(1) site-specific field-collected measurements, sampling, and analysis of physical, chemical, and biological processes affecting contaminant fate and transport; and

(2) contaminant fate and transport predictions that maximize contaminant migration and consider impacts on human health and the environment.

(e) Owners or operators of new solid waste management units must submit to the executive director a documented certification signed by a qualified groundwater scientist that the facility is in compliance with the groundwater monitoring requirements specified in §§330.403, 330.405, 330.407, and 330.409 of this title before waste can be placed in the unit.

(f) Once established at a solid waste management unit, groundwater monitoring must be conducted throughout the active life and any required post-closure care period of that solid waste management unit as specified in §330.463 of this title (relating to Post-Closure Care Requirements).

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### **§330.403. Groundwater Monitoring Systems.**

(a) A groundwater monitoring system must be installed that consists of a sufficient number of monitoring wells, installed at appropriate locations and depths, to yield representative groundwater samples from the uppermost aquifer as defined in §330.3 of this title (relating to Definitions).

(1) Background monitoring wells shall be installed to allow determination of the quality of background groundwater that has not been affected by leakage from a unit. Background monitoring wells may be placed in locations that are not hydraulically upgradient of the waste management area if hydrogeologic conditions do not allow the owner or operator to determine which wells are hydraulically upgradient or if sampling at other wells will provide a better indication of background groundwater quality than is possible from upgradient wells.

(2) The point of compliance monitoring system must include monitoring wells installed to allow determination of the quality of groundwater passing the point of compliance as defined in §330.3 of this title and to ensure the detection of groundwater contamination in the uppermost aquifer. Monitoring well spacing for a municipal solid waste landfill unit shall not exceed 600 feet without an applicable site-specific technical demonstration that may be supplemented with a multi-dimensional fate and transport numerical flow model as set forth in subsection (e) of this section. The owner or operator of a municipal solid waste landfill unit must install a groundwater monitoring system at the point of compliance, as required by 40 Code of Federal Regulations §258.51(a)(2). When physical obstacles preclude installation of the groundwater monitoring wells at existing units, the wells may be installed at the closest practicable distance to the point of compliance as defined in §330.3 of this title that will ensure detection of groundwater contamination of the uppermost aquifer.

(b) The executive director may approve a multi-unit groundwater monitoring system instead of separate groundwater monitoring systems for each municipal solid waste management unit when the facility has several units, provided the multi-unit system meets the requirement of subsection (a) of this

section and will be as protective of human health and the environment as individual monitoring systems for each unit, based on the following factors:

(1) number, spacing, and orientation of the solid waste management units within an overall waste management area;

(2) hydrogeologic setting;

(3) site history;

(4) engineering design of the units; and

(5) type of waste accepted at the units.

(c) The executive director may approve an alternative design for a groundwater monitoring system that uses other means in conjunction with monitoring wells to ensure detection of groundwater contamination in the uppermost aquifer from a solid waste management unit. The alternative design shall be at least as protective of human health and the environment as a monitoring-well system as specified in §330.403(a) of this title (relating to Groundwater Monitoring Systems).

(d) All parts of a groundwater monitoring system shall be operated and maintained so that they perform at least to design specifications through the life of the groundwater monitoring program.

(e) A groundwater monitoring system, including the number, spacing, and depths of monitoring wells or other sampling points, shall be designed and certified by a qualified groundwater scientist. Within 14 days of the certification, the owner or operator shall submit the certification to the executive director and place a copy of the certification in the operating record. The plan for the monitoring system and all supporting data must be submitted to the executive director for review and approval prior to construction.

(1) The design of a monitoring system shall be based on site-specific technical information that must include a thorough characterization of: aquifer thickness; groundwater flow rate; groundwater flow direction, including seasonal and temporal fluctuations in flow; effect of site construction and operations on groundwater flow direction and rates; and thickness, stratigraphy, lithology, and hydraulic characteristics of saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials of the uppermost aquifer, and materials of the lower confining unit of the uppermost aquifer. A geologic unit is any distinct or definable native rock or soil stratum.

(2) The owner or operator may use an applicable multi-dimensional fate and transport numerical flow model to supplement the determination of the spacing of monitoring wells or other sampling points and shall consider site-specific characteristics of groundwater flow as well as dispersion and diffusion of possible contaminants in the materials of the uppermost aquifer. Any model used shall:

(A) have supporting documentation that establishes its ability to represent groundwater flow and contaminant transport, as needed;

- (B) have a sound set of equations based on accepted theory representing groundwater movement and contaminant transport;
- (C) have numerical solution methods that are based on sound mathematical principles and supported by verification and checking techniques;
- (D) be calibrated against site-specific field data;
- (E) have a sensitivity analysis to measure its response to changes in the values of major parameters, error tolerances, and other parameters;
- (F) show mass-balance calculations, where necessary; and
- (G) be based on actual field or laboratory measurements, or equivalent methods, that document the validity of chosen parameter values.

(3) The owner or operator shall promptly notify the executive director, and any local pollution agency with jurisdiction that has requested to be notified, in writing of changes in facility construction or operation or changes in adjacent property that affect or are likely to affect the direction and rate of groundwater flow and the potential for detecting groundwater contamination from a solid waste management unit and that may require the installation of additional monitoring wells or sampling points. Such additional wells or sampling points require a modification of the site development plan.

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**§330.405. Groundwater Sampling and Analysis Requirements.**

(a) The groundwater monitoring program shall include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide an accurate representation of groundwater quality at the background and point of compliance wells, or other monitoring system, installed in compliance with §330.403(a) - (c) of this title (relating to Groundwater Monitoring Systems).

(b) The owner or operator shall submit a groundwater sampling and analysis plan to the executive director for review and approval prior to commencement of sampling and shall maintain a current copy in the operating record. The groundwater sampling and analysis plan shall:

(1) include procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, chain of custody controls, and quality assurance and quality control;

(2) provide for measurement of groundwater elevations at each sampling point prior to bailing or purging; measurement at an event shall be accomplished over a period of time short enough to avoid temporal variations in water levels; sampling at each event shall proceed from the point with the highest water-level elevation to those with successively lower elevations unless contamination is known to be present, in which case wells not likely to be contaminated shall be sampled prior to those that are known to be contaminated unless an alternative procedure is approved by the executive director; and

(3) include sampling and analytical methods that are appropriate for groundwater sampling and that accurately measure hazardous constituents and other monitoring parameters in groundwater samples.

(A) For Type I landfills, the owner or operator shall collect an appropriate number of samples necessary to establish groundwater quality data consistent with the appropriate statistical procedures determined in accordance with subsection (f) of this section. The sampling procedures for Type I landfills shall be those specified under §330.407(a) of this title (relating to Detection Monitoring Program for Type I Landfills) for detection monitoring, §330.409(b) - (f) of this title (relating to Assessment Monitoring Program) for assessment monitoring, and §330.411(b) of this title (relating to Assessment of Corrective Measures) for corrective action.

(B) For Type IV landfills, the owner or operator shall sample the groundwater monitoring parameters at the frequency specified in §330.417 of this title (relating to Groundwater Monitoring at Type IV Landfills).

(C) For other solid waste management units that will have a groundwater monitoring program in accordance with §330.401(b), of this title (relating to Applicability) the executive director will specify groundwater monitoring parameters and frequencies appropriate to the facility conditions.

(c) Groundwater samples shall not be field-filtered prior to laboratory analysis.

(d) The owner or operator shall establish background groundwater quality that has not been affected by leakage from a solid waste management unit in hydraulically upgradient wells or in background wells for each of the monitoring parameters or constituents required in the groundwater monitoring program for a solid waste management unit, as determined under §330.419 of this title (relating to Constituents for Detection Monitoring). A determination of background quality may include sampling of wells that are not hydraulically upgradient of the waste management area if hydrogeologic conditions do not allow the owner or operator to determine which wells are hydraulically upgradient or if sampling at other wells will provide a better indication of background groundwater quality than is possible from upgradient wells. Point of compliance groundwater data shall not be adjusted by subtracting background groundwater data.

(e) The owner or operator shall specify in the groundwater sampling and analysis plan one or more of the following statistical methods to be used in evaluating groundwater monitoring data for each parameter or constituent analyzed as required under §330.407 of this title and §330.409 of this title. The statistical test(s) chosen shall be conducted separately for each tested constituent in each well or sampling point:

(1) a parametric analysis of variance followed by multiple-comparisons procedures to identify statistically significant evidence of contamination. The method shall include estimation and testing of the contrasts between each point of compliance well's mean and the background mean levels for each constituent;

(2) an analysis of variance based on ranks followed by multiple-comparisons procedures to identify statistically significant evidence of contamination. The method shall include estimation and testing of the contrasts between each point of compliance well's median and the background median levels for each constituent;

(3) a tolerance or prediction interval procedure in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each point of compliance well is compared to the upper tolerance or prediction limit;

(4) a control-chart approach that gives control limits for each constituent; and

(5) another statistical test method that meets the performance standards of subsection (f) of this section. The owner or operator shall submit to the executive director satisfactory justification for this alternative test.

(f) Any statistical method chosen under subsection (e) of this section shall comply with the following performance standards, as appropriate.

(1) The statistical method used to evaluate groundwater monitoring data shall be appropriate for the distribution of tested constituents. If the distribution of a tested constituent is shown by the owner or operator to be inappropriate for a normal theory test, then the data should be transformed or a distribution-free theory test should be used. If the distributions for the constituents differ, more than one statistical method may be needed.

(2) If an individual well (or sampling point) comparison procedure is used to compare an individual compliance well constituent concentration with background constituent concentrations or a groundwater protection standard, the test shall be done at a Type I error level no less than 0.01 for each testing period. If a multiple-comparisons procedure is used, each testing period shall be no less than 0.05, but the Type I error of no less than 0.01 for individual well comparisons shall be maintained. This performance standard does not apply to tolerance intervals, prediction interval, or control charts.

(3) If a control-chart approach is used to evaluate groundwater monitoring data, the specific type of control chart and its associated parameter values shall be protective of human health and the environment. These parameters shall be determined after considering the number of samples in the background database, the data distribution, and the range of the concentration values for each constituent of concern.

(4) If a tolerance interval or a prediction interval is used to evaluate groundwater monitoring data, the levels of confidence, and for tolerance intervals the percentage of the population that the interval must contain, shall be protective of human health and the environment. These parameters shall be determined after considering the number of samples in the background data base, the data distribution, and the range of the concentration values for each constituent of concern.

(5) The statistical method shall account for data below the limit of detection with one or more statistical procedures that are protective of human health and the environment. Any practical quantitation limit that is used in the statistical method shall be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility.

(6) If necessary, the statistical method shall include procedures to control or correct for seasonal and spatial variability as well as temporal correlation in the data.

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**§330.407. Detection Monitoring Program for Type I Landfills.**

(a) The monitoring frequency for all constituents listed in §330.419 of this title (relating to Constituents for Detection Monitoring) shall be at least semiannual during the active life of the facility and the closure and post-closure care period.

(1) A minimum of four statistically independent samples from each background and each point of compliance well shall be collected and analyzed for the constituents listed in §330.419 of this title to establish background groundwater quality. Initial background sampling for a well shall be completed on a quarterly basis, unless an alternative schedule is approved by the executive director. Background data sets may be updated once every two years with semiannual detection monitoring results that are demonstrated to be representative of background groundwater quality. Upon completion of background monitoring and during background updates, the owner or operator shall evaluate the background data to ensure that the data are representative of background groundwater constituent concentrations unaffected by waste management activities or other sources of contamination. The evaluation shall be documented in a report and submitted to the executive director before the next subsequent groundwater monitoring event following the updated background period. At least one sample from each background and point of compliance well shall be collected and analyzed during each subsequent semiannual sampling event.

(2) The executive director may specify an appropriate alternative frequency for repeated sampling and analysis of the constituents listed in §330.419 of this title during the active life and the closure and post-closure care period. The alternative frequency shall be no less than annual and shall be based on factors such as lithology and hydraulic conductivity of the aquifer and unsaturated zone, groundwater flow rates, minimum distance of travel from waste to monitoring wells, and resource value of the uppermost aquifer.

(3) For the purpose of establishing background groundwater quality, the executive director may agree to consider analytical data acquired prior to the effective date of this chapter in addition to the data required in this subsection and in §330.409(b) of this title (relating to Assessment Monitoring Program).

(b) Not later than 60 days after each sampling event, the owner or operator shall determine whether there has been a statistically significant increase over background of any tested constituent at any monitoring well. If there has been a statistically significant increase, the owner or operator shall notify the executive director, and any local pollution agency with jurisdiction that has requested to be notified, in writing within 14 days of this determination.

(1) If a statistically significant increase over background of any tested constituent at any monitoring well has occurred, the owner or operator shall immediately place a notice in the operating record describing the increase and shall establish an assessment monitoring program meeting the requirements of §330.409 of this title within 90 days of the date of the notice to the executive director required under this subsection, except as provided for in paragraphs (2) and (3) of this subsection.

(2) If a statistically significant increase over background of any tested constituent at any monitoring well has occurred, the owner or operator may submit the results of resampling as appropriate for the statistical method being used within 60 days of determining the statistically significant increase. The resample data may be used to statistically confirm or disprove the determination made in this subsection.

(3) If a statistically significant increase over background of any tested constituent at any monitoring well has occurred and the owner or operator has reasonable cause to think that a source other than a landfill unit caused the contamination or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality, then the owner or operator may submit a report providing documentation to this effect. In making a demonstration under this paragraph, the owner or operator must:

(A) notify the executive director, and any local pollution agency with jurisdiction that has requested to be notified, in writing within 14 days of determining a statistically significant increase over background at the compliance point that the owner or operator intends to make a demonstration under this paragraph;

(B) within 90 days of determining a statistically significant increase, submit a report to the executive director, and any local pollution agency with jurisdiction that has requested to be notified, that demonstrates that a source other than a monitored landfill unit caused the contamination or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The report must be prepared and certified by a qualified groundwater scientist;

(C) not filter the groundwater sample for constituents addressed by the demonstration prior to laboratory analysis. The executive director may also require the owner or operator to provide analyses of the landfill leachate to support the demonstration; and

(D) continue to monitor in accordance with the detection monitoring program established under this section.

(4) If the owner or operator does not make a demonstration satisfactory to the executive director within 90 days after the date of the notice to the executive director required under this subsection, the owner or operator shall initiate an assessment monitoring program as required in paragraph (1) of this subsection. The executive director may require the owner or operator to install additional wells at the point of compliance to further characterize the release.

(c) The owner or operator shall submit an annual detection monitoring report within 90 days after the facility's last groundwater monitoring event in a calendar year that must include the following information determined since the previously submitted annual report:

(1) a statement regarding whether a statistically significant increase has occurred over background values in any well during the previous calendar year period and the status of any statistically significant increase events;

(2) the results of all groundwater monitoring, testing, and analytical work obtained or prepared under the requirements of this permit, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;

(3) the groundwater flow rate and direction in the uppermost aquifer. The groundwater flow rate and direction of groundwater flow shall be established using the data collected during the preceding calendar year's sampling events from the monitoring wells of the detection monitoring program. The owner or operator shall also include in the report all documentation used to determine the groundwater flow rate and direction of groundwater flow;

(4) a contour map of piezometric water levels in the uppermost aquifer based at a minimum upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map should be included in the report;

(5) recommendation for any changes; and

(6) any other items requested by the executive director.

(d) If the owner or operator determines that the detection monitoring program no longer satisfies the requirements of this section, the owner or operator must, within 90 days of this determination, submit an application for a permit amendment or modification to make any appropriate changes to the program.

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**§330.409. Assessment Monitoring Program.**

(a) Assessment monitoring is required whenever the owner or operator determines there has been a statistically significant increase over background for one or more of the constituents listed in §330.419 of this title (relating to Constituents for Detection Monitoring).

(b) Within 90 days of determining that a statistically significant increase has occurred in accordance with §330.407(b) of this title (relating to Detection Monitoring Program for Type I Landfills), and not less than annually thereafter, the owner or operator shall sample and analyze the groundwater monitoring system for the full set of constituents listed in Appendix II to 40 Code of Federal Regulations (CFR) Part 258, effective July 14, 2005, is adopted by reference. A minimum of one sample shall be collected from each point of compliance well and analyzed for the 40 CFR Part 258, Appendix II constituents during each sampling event. For any new constituent(s) detected in the point of compliance wells as a result of the complete Appendix II analysis, a minimum of four statistically independent samples from each background well shall be collected and analyzed to establish background levels for the additional constituent(s). After sampling all point of compliance wells for Appendix II constituents, the executive director may specify an appropriate subset of wells to be sampled and analyzed for the Appendix II constituents during assessment monitoring and may delete any of the Appendix II constituents for a municipal solid waste management unit if the owner or operator can document that the removed constituents are not reasonably expected to be in or derived from the waste contained in the unit.

(c) The executive director may specify an appropriate alternative frequency for repeated sampling and analysis for the full set of 40 CFR Part 258, Appendix II constituents required by subsection (b) of this section during the active life and the closure and post-closure care period of the unit considering the following factors:

- (1) lithology and hydraulic conductivity of the aquifer and unsaturated zone;
- (2) groundwater flow rates;
- (3) minimum distance of travel from the waste nearest to any point of compliance monitoring well;
- (4) resource value of the uppermost aquifer; and
- (5) nature (fate and transport) of any constituents detected in response to this section.

(d) Not later than 60 days after each sampling event, the owner or operator shall submit to the executive director the results from the initial and subsequent sampling events required in subsection (b) of this section and also place them in the operating record. The owner or operator shall also:

(1) within 90 days of submittal of the results from a sampling event and on at least a semiannual basis thereafter, resample all wells specified by §330.403(a) of this title (relating to Groundwater Monitoring Systems) and conduct analyses for all constituents in §330.419 of this title and for those additional constituents in 40 CFR Part 258, Appendix II that are detected in response to subsection (b) of this section. The results must be submitted to the executive director not later than 60 days after the sampling event and shall also be placed in the operating record. At least one sample must be collected and analyzed from each background and point of compliance well at each sampling event. The executive director may specify an alternative monitoring frequency during the active life and the closure and post-closure care period for the constituents referred to in this paragraph. The alternative frequency during the active life and the closure and post-closure care period shall be not less than annual. The alternative frequency shall be based on consideration of the factors described in subsection (c) of this section;

(2) establish background concentrations for any additional Appendix II constituents detected in accordance with subsection (b) of this section or paragraph (1) of this subsection; and

(3) establish groundwater protection standards for all constituents in point of compliance wells detected in accordance with subsection (b) of this section or paragraph (1) of this subsection. The groundwater protection standards shall be established in accordance with subsection (h) or (i) of this section.

(e) If the concentrations of all 40 CFR Part 258, Appendix II constituents are shown to be at or below background values, using the statistical procedures in §330.405(f) of this title (relating to Groundwater Sampling and Analysis Requirements) for two consecutive sampling events, the owner or operator must notify the executive director in writing and return to detection monitoring if approved.

(f) If the concentrations of any 40 CFR Part 258, Appendix II constituents are above background values, but all concentrations are below the groundwater protection standard established under subsection (h) or (i) of this section, using the statistical procedures in §330.405(f) of this title, the owner or operator shall continue assessment monitoring in accordance with this section.

(g) Not later than 60 days after each sampling event, the owner or operator shall determine whether any 40 CFR Part 258, Appendix II constituents were detected at statistically significant levels above the groundwater protection standard established under subsection (h) or (i) of this section in any sampling event. If the groundwater protection standard has been exceeded, the owner or operator shall notify the executive director and appropriate local government officials in writing within seven days of this determination.

(1) The owner or operator shall also:

(A) characterize the nature and extent of the release by installing additional monitoring wells as necessary;

(B) install at least one additional monitoring well between the monitoring well with the statistically significant level and the next adjacent wells along the point of compliance before the next sampling event and sample these wells in accordance with subsection(d)(1) of this section;

(C) notify in writing all persons that own or occupy the land that directly overlies any part of the plume of contamination if contaminants have migrated off-site as indicated by sampling of wells in accordance with subsection (d)(1) of this section; and

(D) initiate an assessment of corrective measures as required by §330.411 of this title (relating to Assessment of Corrective Measures) all within 90 days of the notice to the executive director.

(2) The owner or operator may demonstrate that a source other than the monitored solid waste management unit caused the contamination or that the statistically significant level resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. In making a demonstration under this paragraph, the owner or operator must:

(A) notify the executive director in writing within 14 days of determining a statistically significant level above the groundwater protection standard at the point of compliance that the owner or operator intends to make a demonstration under this paragraph;

(B) within 90 days of determining a statistically significant level above the groundwater protection standard, submit a report to the executive director that demonstrates that a source other than the monitored solid waste management unit caused the contamination or that the statistically significant level resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The report shall be prepared and certified by a qualified groundwater scientist;

(C) not filter the groundwater samples for constituents addressed by the demonstration prior to laboratory analysis. The executive director may also require the owner or operator to provide analysis of landfill leachate to support the demonstration; and

(D) continue to monitor in accordance with the assessment monitoring program established under this section.

(3) If a successful demonstration is made, the owner or operator shall continue monitoring in accordance with the assessment monitoring program required by this section and may return to detection monitoring if the 40 CFR Part 258, Appendix II constituents are at or below background as specified in subsection (e) of this section. Until a successful demonstration is made, the owner or operator shall comply with paragraph (1) of this subsection, including initiating an assessment of corrective measures.

(4) If the owner or operator determines that the assessment monitoring program no longer satisfies the requirements of this section, the owner or operator must, within 90 days, submit an application for a permit amendment or modification to make any appropriate changes to the program.

(h) The owner or operator shall establish a groundwater protection standard for each 40 CFR Part 258, Appendix II constituent detected in the point of compliance monitoring wells. The groundwater protection standard must be:

(1) for constituents for which a maximum contaminant level (MCL) has been promulgated under 40 CFR Part 141, Safe Drinking Water Act (codified), §1412, the MCL for that constituent;

(2) for constituents for which MCLs have not been promulgated, the background concentration for the constituent established from wells in accordance with §330.405(d) of this title; or

(3) for constituents for which the background level is higher than the MCL identified under paragraph (1) of this subsection or health-based levels identified under subsection (i) of this section, the background concentration.

(i) The executive director may establish an alternative groundwater protection standard for 40 CFR Part 258, Appendix II constituents for which MCLs have not been established. These groundwater protection standards shall be appropriate health-based levels that satisfy either the criteria of paragraphs (1) - (4) of this subsection, inclusive or comply with paragraph (5) of this subsection:

(1) the level is derived in a manner consistent with United States Environmental Protection Agency guidelines for assessing the health risks of environmental pollutants (51 FR 33992, 34006, 34014, 34028, September 24, 1986);

(2) the level is based on scientifically valid studies conducted in accordance with the Toxic Substances Control Act Good Laboratory Practice Standards (40 CFR Part 792) or equivalent;

(3) for carcinogens, the level represents a concentration associated with an excess lifetime cancer risk level (due to continuous lifetime exposure) with the  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  range; and

(4) for systemic toxicants, the level represents a concentration to which the human population (including sensitive subgroups) could be exposed to on a daily basis that is likely to be without appreciable risk of deleterious effects during a lifetime. For purposes of this subchapter, systemic toxicants include toxic chemicals that cause effects other than cancer or mutation; or

(5) the level is developed in accordance with Chapter 350 of this title (relating to Texas Risk Reduction Program).

(j) In establishing groundwater protection standards under subsection (i) of this section, the executive director may consider multiple contaminants in the groundwater, exposure threats to sensitive environmental receptors, and other site-specific exposure or potential exposure to groundwater.

(k) The owner or operator shall submit an annual assessment monitoring report within 60 days after the facility's second semiannual groundwater monitoring event that includes the following information determined since the previously submitted report:

(1) a statement whether an statistically significant level above a groundwater protection standard established in subsection (h) or (i) of this section has occurred in any well during the previous calendar year period and the status of any statistically significant level events;

(2) the results of all groundwater monitoring, testing, and analytical work obtained or prepared in accordance with the requirements of this chapter, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;

(3) the groundwater flow rate and direction in the uppermost aquifer. The groundwater flow rate and direction of groundwater flow shall be established using the data collected during the preceding calendar year's sampling events from the monitoring wells of the Assessment Monitoring Program. The owner or operator shall also include in the report all documentation used to determine the groundwater flow rate and direction of groundwater flow;

(4) a contour map of piezometric water levels in the uppermost aquifer based, at a minimum, upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map should be included in the report;

(5) recommendation for any changes; and

(6) any other items requested by the executive director.

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**§330.411. Assessment of Corrective Measures.**

(a) Within 90 days of finding that any of the 40 Code of Federal Regulations Part 258, Appendix II constituents have been detected at a statistically significant level above the groundwater protection standards defined under §330.409(h), (i), or (j) of this title (relating to Assessment Monitoring Program), the owner or operator shall initiate an assessment of corrective measures. Such an assessment shall be completed within 180 days of initiating the assessment.

(b) The owner or operator shall continue to monitor in accordance with the assessment monitoring program as specified in §330.409 of this title.

(c) The assessment shall include an analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of the remedy as described under §330.413 of this title (relating to Selection of Remedy), addressing at least the following:

(1) performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) time required to begin and complete the remedy;

(3) costs of remedy implementation; and

(4) institutional requirements such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy or remedies.

(d) The owner or operator shall discuss the results of the corrective measures assessment, prior to the selection of a remedy, in a public meeting with interested and affected parties. The owner or operator shall arrange for the meeting and provide notice in accordance with the provisions of §39.501(e)(3) of this title (relating to Application for Municipal Solid Waste Permit).

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**§330.413. Selection of Remedy.**

(a) Based on the results of the corrective measures assessment conducted under §330.411 of this title (relating to Assessment of Corrective Measures), the owner or operator shall select a remedy that, at a minimum, meets the standards listed in subsection (b) of this section and is in accordance with rules of the commission. Within 30 days of completing the assessment of corrective measures described in §330.411 of this title, the owner or operator shall submit a report to the executive director for review and approval and place it in the operating record. The report shall describe the remedy or remedies proposed for selection and the way it or they meet the standards in subsection (b) of this section.

(b) Remedies shall:

(1) be protective of human health and the environment;

(2) attain the groundwater protection standard as specified in accordance with §330.409(h), (i), or (j) of this title (relating to Assessment Monitoring Program);

(3) control the source(s) of releases so as to reduce or eliminate, to the maximum extent practicable, further releases of 40 Code of Federal Regulations Part 258, Appendix II constituents into the environment that may pose a threat to human health or the environment; and

(4) comply with standards for management of wastes as specified in §330.415(d) of this title (relating to Implementation of the Corrective Action Program).

(c) In selecting a remedy that meets the standards of subsection (b) of this section, the owner or operator shall consider the following evaluation factors:

(1) long- and short-term effectiveness and protectiveness of the potential remedy, along with the degree of certainty that the remedy will prove successful based on consideration of:

(A) magnitude of reduction of existing risks;

(B) magnitude of residual risks in terms of likelihood of further releases due to waste remaining following implementation of a remedy;

(C) type and degree of long-term management required, including monitoring, operation, and maintenance;

(D) short-term risks that might be posed to the community, workers, or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, redisposal, or containment;

(E) time until full protection is achieved;

(F) potential for exposure of humans and environmental receptors to remaining wastes, considering potential threats to human health and the environment associated with excavation, transportation, redisposal, or containment;

(G) long-term reliability of the engineering and institutional controls; and

(H) potential need for replacement of the remedy;

(2) effectiveness of the remedy in controlling the source to reduce further releases based on the extent to which containment practices will reduce further releases and the extent to which treatment technologies may be used;

(3) ease or difficulty of implementing a potential remedy based on consideration of:

(A) degree of difficulty associated with constructing the technology;

(B) expected operational reliability of the technologies;

(C) need to coordinate with and obtain necessary approvals and permits from other agencies and regulatory bodies;

(D) availability of necessary equipment and specialists; and

(E) available capacity and location of needed treatment, storage, and disposal services;

(4) practicable capability of the owner or operator, including a consideration of the technical and economic capability; and

(5) degree to which community concerns are addressed by a potential remedy.

(d) The owner or operator shall specify as part of the selected remedy a schedule for initiating and completing remedial activities. The schedule shall require the initiation of remedial activities within a reasonable time approved by the executive director, taking into consideration the following factors:

- (1) extent and nature of contamination;
- (2) practical capabilities of remedial technologies in achieving compliance with groundwater protection standards established under §330.409(h), (i), or (j) of this title and other objectives of the remedy;
- (3) availability of treatment or disposal capacity for wastes managed during implementation of the remedy;
- (4) desirability of utilizing technologies that are not currently available but that may offer significant advantages over available technologies in terms of effectiveness, reliability, safety, or ability to achieve remedial objectives;
- (5) potential risks to human health and the environment from exposure to contamination prior to completion of the remedy;
- (6) resource value of the aquifer, including current and future uses; proximity and withdrawal rate of users; groundwater quantity and quality; potential damage to wildlife, crops, vegetation, and physical structures from exposure to waste constituents; hydrogeologic characteristics of the facility and adjacent land; groundwater removal and treatment costs; and cost and availability of alternative water supplies;
- (7) practicable capability of the owner or operator; and
- (8) other relevant factors.

(e) The executive director may determine that remediation of a release of a 40 Code of Federal Regulations Part 258, Appendix II constituent from a solid waste management unit is not necessary if the owner or operator demonstrates to the satisfaction of the executive director that:

- (1) the groundwater is additionally contaminated by substances that have originated from a source other than a solid waste management unit and those substances are present in concentrations such that cleanup of the release from the solid waste management unit would provide no significant reduction in risk to actual or potential receptors; or
- (2) the constituent is present in groundwater that is not currently or reasonably expected to be a source of drinking water and is not hydraulically connected with waters to which the constituent is migrating or is likely to migrate in a concentration that would exceed the groundwater protection standards established under §330.409(h), (i), or (j) of this title; or
- (3) remediation of the release is technically impracticable; or

(4) remediation of the release results in unacceptable cross-media impacts.

(f) A determination by the executive director in accordance with subsection (e) of this section shall not affect the authority of the state to require the owner or operator to undertake source-control measures or other measures that may be necessary to eliminate or minimize further releases to the groundwater, to prevent exposure to the groundwater, or to remediate the groundwater to concentrations that are technically practicable and that significantly reduce threats to human health or the environment.

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**§330.415. Implementation of the Corrective Action Program.**

(a) Based on the schedule established under §330.413(d) of this title (relating to Selection of Remedy) for initiation and completion of remedial activities, the owner or operator shall:

(1) establish and implement a corrective action groundwater monitoring program that:

(A) at least meets the requirements of an assessment monitoring program under §330.409 of this title (relating to Assessment Monitoring Program);

(B) indicates the effectiveness of the corrective action remedy; and

(C) demonstrates compliance with groundwater protection standards under subsection (f) of this section;

(2) implement the corrective action remedy selected under §330.413 of this title; and

(3) take any interim measures necessary to ensure the protection of human health and the environment. Interim measures should, to the greatest extent practicable, be consistent with the objectives of and contribute to the performance of any remedy that may be required under §330.413 of this title. The following factors shall be considered by an owner or operator in determining if interim measures are necessary:

(A) time required to develop and implement a final remedy;

(B) actual or potential exposure of nearby populations or environmental receptors to hazardous constituents;

(C) actual or potential contamination of drinking water supplies or sensitive ecosystems;

(D) further degradation of the groundwater that may occur if remedial action is not initiated expeditiously;

(E) weather conditions that may cause hazardous constituents to migrate or be released;

(F) risks of fire or explosion, or potential for exposure to hazardous constituents as a result of an accident or failure of a container or handling system; and

(G) other situations that may pose threats to human health and the environment.

(b) An owner or operator may determine, based on information developed after implementation of the remedy has begun or other information, that compliance with requirements of §330.413(b) of this title are not being achieved through the remedy selected. In such cases, the owner or operator shall, with approval of the executive director, implement other methods or techniques that could practicably achieve compliance with the requirements unless the owner or operator makes the determination under subsection (c) of this section and if it is approved by the executive director. Failure to obtain approval from the executive director for the other methods and techniques does not relieve the owner or operator of the burden to implement an acceptable remedy.

(c) If the owner or operator determines that compliance with requirements under §330.413(b) of this title cannot be practically achieved with any currently available methods, the owner or operator shall:

(1) present to the executive director certification by a qualified groundwater scientist that compliance with requirements under §330.413(b) of this title cannot be practically achieved with any currently available methods;

(2) implement alternative measures, with the approval of the executive director, to control exposure of humans or the environment to residual contamination, as necessary to protect human health and the environment;

(3) implement alternative measures, with the approval of the executive director, for control of the sources of contamination, or for removal or decontamination of equipment, units, devices, or structures that are technically practicable and consistent with the overall objective of the remedy; and

(4) place a copy of all approved alternative measures in the operating record.

(d) All solid wastes that are managed in accordance with a remedy required under §330.413 of this title, or an interim measure required under subsection (a)(3) of this section, shall be managed in a manner that is protective of human health and the environment and that complies with applicable Resource Conservation and Recovery Act requirements.

(e) Upon implementation of a corrective action program, the owner or operator shall submit an annual corrective action report by March 1st every year that includes the following information determined since the previously submitted report:

(1) a statement regarding whether a statistically significant level above a groundwater protection standard established in §330.409(h), (i), or (j) of this title in any well during the previous calendar year period has occurred and the status of any statistically significant level events;

(2) the results of all groundwater monitoring, testing, and analytical work obtained or prepared in accordance with the requirements of this chapter, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;

(3) the groundwater flow rate and direction in the uppermost aquifer. The groundwater flow rate and direction of groundwater flow shall be established using the data collected during the preceding calendar year's sampling events from the monitoring wells of the Corrective Action Program. The owner or operator shall also include in the report all documentation used to determine the groundwater flow rate and direction of groundwater flow;

(4) a contour map of piezometric water levels in the uppermost aquifer based at a minimum upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map should be included in the report;

(5) recommendation for any changes; and

(6) any other items requested by the executive director.

(f) Remedies selected under §330.413 of this title shall be considered complete when:

(1) the owner or operator complies with the groundwater protection standards established under §330.409(h), (i), or (j) of this title at all points within the plume of contamination that lies beyond the groundwater monitoring system established under §330.403 of this title (relating to Groundwater Monitoring Systems);

(2) compliance with the groundwater protection standards established under §330.409(h), (i), or (j) of this title has been achieved by demonstrating that concentrations of 40 Code of Federal Regulations Part 258, Appendix II constituents have not exceeded the groundwater protection standards for a period of three consecutive years, using the statistical procedures in §330.405(e) and (f) of this title (relating to Groundwater Sampling and Analysis Requirements) and performance standards in §330.409(h), (i), or (j) of this title. The executive director may specify an alternative length of time during which the owner or operator shall demonstrate that concentrations of 40 Code of Federal Regulations Part 258, Appendix II constituents have not exceeded the groundwater protection standards. The alternative length of time shall be based on:

(A) extent and concentration of the release;

(B) behavior characteristics of the hazardous constituents in the groundwater;

(C) accuracy of monitoring or modeling techniques, including any seasonal, meteorological, or other environmental variabilities that may affect the accuracy; and

(D) characteristics of the groundwater; and

(3) all actions required to complete the remedy have been satisfied.

(g) Within 15 days of completion of the remedy, the owner or operator shall submit to the executive director and also place in the operating record a certification by a qualified groundwater scientist that the remedy has been completed in compliance with the requirements of subsection (a) of this section.

(h) Upon submittal of satisfactory certification of the completion of the corrective action remedy, the executive director may release the owner or operator from the requirements for financial assurance for corrective action under §330.509 of this title (relating to Corrective Action Cost Estimates for Landfills).

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**§330.417. Groundwater Monitoring at Type IV Landfills.**

(a) The requirements in this section apply to Type IV landfills, as defined in §330.5(a)(2) of this title (relating to Classification of Municipal Solid Waste Facilities), except as provided in §330.5(b) of this title, and in subsection (b) of this section.

(b) At the discretion of the executive director, the owner or operator of a Type IV landfill may be required to install groundwater monitoring systems and to monitor on a regular basis the quality of groundwater at the point of compliance.

(1) The factors to be considered by the executive director in determining the need for groundwater monitoring shall include: relationship of the facility to drinking water intakes (both surface and subsurface); hydrogeology of the shallow water-bearing zones in the facility area; use of shallow groundwater in the facility area; type of waste being or to be taken; types of liner; likelihood of leakage of contaminants from the facility; and protection of human health and the environment.

(2) A groundwater monitoring system shall be installed in accordance with §330.403 of this title (relating to Groundwater Monitoring Systems) except for the point of compliance monitoring well spacing requirement of §330.403(a)(2) of this title.

(3) Groundwater sampling and analysis requirements shall be in accordance with §330.405(a) - (d) of this title (relating to Groundwater Sampling and Analysis Requirements).

(4) Each monitoring well or other sampling point shall be sampled and analyzed annually, or on some other schedule but not less frequently than annually as determined by the executive director, for the following constituents: chloride, iron, manganese, cadmium, zinc, total dissolved solids, specific conductance (field and laboratory measurements), pH (field and laboratory measurements), and non-purgeable organic compounds.

(5) Not later than 60 days after each sampling event, the owner or operator shall determine whether the landfill has released contaminants to the uppermost aquifer. The owner or operator shall provide an annual detection monitoring report within 60 days after the facility's annual groundwater monitoring event that includes the following information determined since the previously submitted report:

(A) the results of all monitoring, testing, and analytical work obtained or prepared in accordance with the requirements of this permit, including a summary of background groundwater quality values, groundwater monitoring analyses, any statistical calculations, graphs, and drawings;

(B) the groundwater flow rate and direction in the uppermost aquifer. The groundwater flow rate and direction of groundwater flow shall be established using the data collected during the preceding calendar year's sampling events from the monitoring wells of the Detection Monitoring Program. The owner or operator shall also include in the report all documentation used to determine the groundwater flow rate and direction of groundwater flow;

(C) a contour map of piezometric water levels in the uppermost aquifer based at a minimum upon concurrent measurement in all monitoring wells. All data or documentation used to establish the contour map should be included in the report;

(D) recommendation for any changes; and

(E) any other items requested by the executive director.

(6) The executive director may require additional sampling, analyses of additional constituents, installation of additional monitoring wells or other sampling points, and/or other hydrogeological investigations if the facility appears to be contaminating the uppermost aquifer.

(7) If the owner or operator finds the facility to have contaminated or be contaminating the uppermost aquifer, the executive director may order corrective action appropriate to protect human health and the environment up to and including that in §§330.411, 330.413, and 330.415 of this title (relating to Assessment of Corrective Measures; Selection of Remedy; and Implementation of the Corrective Action Program).

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**§330.419. Constituents for Detection Monitoring.**

(a) The owner or operator shall sample and analyze the groundwater monitoring system for the constituents listed in 40 Code of Federal Regulations (CFR) Part 258, Appendix I, effective July 14, 2005, herein adopted by reference.

(b) The executive director may delete any of the constituents listed in 40 CFR Part 258, Appendix I for a municipal solid waste management unit if it can be documented that the removed constituents are not reasonably expected to be in or derived from the waste contained in the unit.

(c) The executive director may establish an alternative list of inorganic indicator constituents for a municipal solid waste management unit in lieu of some or all of the heavy metals (constituents (1) - (15) in the table located in 40 CFR Part 258, Appendix I) if the alternative constituents provide a reliable indication of inorganic releases from the municipal solid waste management unit to the groundwater. The executive director may also add inorganic or organic constituents to those to be tested if they are reasonably expected to be in or derived from the waste contained in the unit or if they are likely to provide a useful indication of releases from the municipal solid waste management unit to the groundwater. In determining alternative or additional constituents, the executive director shall consider the following factors:

(1) the types, concentrations, quantities, and persistence of waste constituents in wastes at the municipal solid waste management unit;

(2) the mobility, stability, and persistence of waste constituents or their reaction products in the unsaturated and saturated zones adjacent to or beneath the municipal solid waste management unit;

(3) the detectability of indicator constituents, waste constituents, and reaction products in the groundwater; and

(4) the concentrations and coefficients of variation of monitoring parameters or constituents in the groundwater background.

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**§330.421. Monitor Well Construction Specifications.**

(a) Monitoring well construction. Monitoring well construction shall provide for maintenance of the integrity of the bore hole, collection of representative groundwater samples from the water-bearing zone(s) of concern, and prevention of migration of groundwater and surface water within the bore hole. The following specifications must be used for the installation of groundwater monitoring wells at municipal solid waste landfills. Equivalent alternatives to these specifications may be used if prior written approval is obtained in advance from the executive director.

(1) Drilling.

(A) Monitoring wells must be drilled by a Texas-licensed driller who is qualified to drill and install monitoring wells. The installation and development shall be supervised by a licensed professional geoscientist or engineer who is familiar with the geology of the area.

(B) The well shall be drilled by a method that will allow installation of the casing, screen, etc., and that will not introduce contaminants into the borehole or casing. Drilling techniques used for boring shall take into account the materials to be drilled, depth to groundwater, total depth of the hole, adequate soil sampling, and other such factors that affect the selection of the drilling method. If any fluids are necessary in drilling or installation, then clean, treated city water shall be used; other fluids must be approved in writing by the executive director before use. If city water is used, a current chemical analysis of the city water shall be provided with the monitor-well report.

(C) The diameter of the boring shall be at least four inches larger than the diameter of the casing. When the boring is in hard rock, a smaller annulus may be approved by the executive director.

(D) A log of the boring shall be made by or under the supervision of a licensed professional geoscientist or engineer who is familiar with the geology of the area, and shall be sealed, signed, and dated by the licensed professional.

(2) Casing, screen, filter pack, and seals.

(A) The well casing shall be: two to four inches in diameter; National Science Foundation-certified polyvinyl chloride (PVC) Schedule 40 or 80 pipe, flush-thread, screw joint (no glue or solvents); polytetrafluorethylene (PTFE, such as Teflon) tape or O-rings in the joints; no collar couplings. The top of the casing shall be at least two feet above ground level. Where high levels of volatile organic compounds or corrosive compounds are anticipated, stainless steel or PTFE casing and screen may be used, subject to approval by the executive director. Four-inch diameter casing is recommended because it allows larger volume samples to be obtained and provides easier access for development, pumps, and repairs. The casing shall be cleaned and packaged at the place of manufacture; the packaging shall include a PVC wrapping on each section of casing to keep it from being contaminated prior to installation. The casing shall be free of ink, labels, or other markings. The casing (and screen) shall be centered in the hole to allow installation of a good filter pack and annular seal. Centralizers are recommended on wells over six meters (20 feet) in length, but may not be needed if the wells are installed through hollow-stem augers. The top of the casing shall be protected by a threaded or slip-on top cap or by a sealing cap or screw-plug seal inserted into the top of the casing. The cap shall be vented to prevent buildup of methane or other gases and shall be designed to prevent moisture from entering the well.

(B) The screen shall be compatible with the casing and should generally be of the same material. The screen shall not involve the use of any glues or solvents for construction. A wire-wound screen is recommended to provide maximum inflow area. Field-cut slots are not permitted for well screen. Filter cloth shall not be used. A blank-pipe sediment trap, typically one to two feet, should be installed below the screen. A bottom cap is typically placed on the bottom of the sediment trap. The sediment trap shall not extend through the lower confining layer of the water-bearing zone being tested. Screen sterilization methods are the same as those for casing. Selection of the size of the screen opening should be done by a person experienced with such work and shall include consideration of the distribution of particle sizes both in the water-bearing zone and in the filter pack surrounding the screen. The screen opening shall not be larger than the smallest fraction of the filter pack.

(C) The filter pack, placed between the screen and the well bore, shall consist of prepackaged, inert, clean silica sand or glass beads; it shall extend from one to four feet above the top of the screen. Open stockpile sources of sand or gravel are not permitted. The filter pack usually has a 30% finer grain size that is about four to ten times larger than the 30% finer grain size of the water-bearing zone; the filter pack should have a uniformity coefficient less than 2.5. The filter pack should be placed with a tremie pipe to ensure that the material completely surrounds the screen and casing without bridging. The tremie pipe shall be steam cleaned prior to the first well and before each subsequent well.

(D) The annular seal shall be placed on top of the filter pack and shall be at least two feet thick. It should be placed in the zone of saturation to maintain hydration. The seal should be composed of coarse-grain sodium bentonite, coarse-grit sodium bentonite, or bentonite grout. Special care should be taken to ensure that fine material or grout does not plug the underlying filter pack. Placement of a few inches of prepackaged clean fine sand on top of the filter pack will help to prevent migration of the annular seal material into the filter pack. The seal should be placed on top of the filter pack with a steam-cleaned tremie pipe to ensure good distribution and should be tamped with a steam-cleaned rod to determine that the seal is thick enough. The bentonite shall be hydrated with clean water prior to any further activities on the well and left to stand until hydration is complete (eight to 12 hours, depending on the grain size of the bentonite). If a bentonite-grout (without cement) casing seal is used in the well bore, then it may replace the annular seal described in this paragraph.

(E) A casing seal shall be placed on top of the annular seal to prevent fluids and contaminants from entering the borehole from the surface. The casing seal shall consist of a commercial bentonite grout or a cement-bentonite mixture. Drilling spoil, cuttings, or other native materials are not permitted for use as a casing seal. Quick-setting cements are not permitted for use because contaminants may leach from them into the groundwater. The top of the casing seal shall be between five and two feet from the surface.

(3) Concrete pad. High-quality structural-type concrete shall be placed from the top of the casing seal (two to five feet below the surface) continuously to the top of the ground to form a pad at the surface. This formed surface pad shall be at least six inches thick and not less than four (preferably six) feet square or five (preferably six) feet in diameter. The pad shall contain sufficient reinforcing steel to ensure its structural integrity in the event that soil support is lost. The top of the pad shall slope away from the well bore to the edges to prevent ponding of water around the casing or collar.

(4) Protective collar. A steel protective pipe collar shall be placed around the casing "stickup" to protect it from damage and unwanted entry. The collar shall be set at least one foot into the surface pad during its construction and should extend at least three inches above the top of the well casing (and top cap, if present). The top of the collar shall have a lockable hinged top flap or cover. A sturdy lock shall be installed, maintained in working order, and kept locked when the well is not being bailed/purged or sampled. The well number or other designation shall be marked permanently on the protective steel collar; it is useful to mark the total depth of the well and its elevation on the collar.

(5) Protective barrier. Where monitoring wells are likely to be damaged by moving equipment or are located in heavily traveled areas, a protective barrier shall be installed. A typical barrier is three or four six- to 12-inch diameter pipes set in concrete just off the protective pad. The pipes can be joined by pipes welded between them, but consideration must be given to well access for sampling and other activities. Separation of such a pipe barrier from the pad means that the barrier can be damaged without risk to the pad and well. Other types of barriers may be approved by the executive director.

(b) Unusual conditions. Where monitoring wells are installed in unusual conditions, all aspects of the installation shall be approved in writing in advance by the executive director. Such aspects include, for example, the use of cellar-type enclosures for the top-well equipment or multiple completions in a single hole.

(c) Development. After a monitoring well is installed, it shall be developed to remove artifacts of drilling (clay films, bentonite pellets in the casing, etc.) and to open the water-bearing zone for maximum flow into the well. Development should continue until all of the water used or affected during drilling activities has been removed and field measurements of pH, specific conductance, and temperature have stabilized. Failure to develop a well properly may mean that it is not properly monitoring the water-bearing zone or may not yield adequate water for sampling even though the water-bearing zone is prolific.

(d) Location and elevation. Upon completion of a monitoring well, the location of the well and all appropriate elevations associated with the top-well equipment shall be surveyed by a registered professional surveyor. The elevation shall be surveyed to the nearest 0.01 foot above mean sea level (with year of the sea-level datum shown). The point on the well casing for which the elevation was determined shall be permanently marked on the casing. The location shall be given in terms of the latitude and longitude at least to the nearest tenth of a second or shall be accurately located with respect to the landfill grid system described in §330.143(b)(5) of this title (relating to Landfill Markers and Benchmark).

(e) Reporting. Monitoring well installation and construction details must be submitted on forms available from the commission and must be completed and submitted within 60 days of well completion. A copy of the detailed geologic log of the boring, a description of development procedures, any particle size or other sample data from the well, and a site map drawn to scale showing the location of all monitoring wells and the point of compliance must be submitted to the executive director at the same time. The licensed driller should be familiar with the forms required by other agencies; a copy of those forms must also be submitted to the commission.

(f) Damaged wells. Any monitoring well that is damaged to the extent that it is no longer suitable for sampling shall be reported to the executive director, who may make a determination about whether to repair or replace the well.

(g) Plugging and abandonment. Any monitoring well that is no longer used shall be properly abandoned and plugged in accordance with 16 TAC §76.702 (relating to Responsibilities of the Licensee and Landowner--Well Drilling, Completion, Capping and Plugging) and §76.1004 (relating to Technical Requirements--Standards for Capping and Plugging of Wells and Plugging Wells that Penetrate Undesirable Water or Constituent Zones). No abandonment shall take place without prior authorization in writing by the executive director.

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