STATE OF HAWAII
LANDFILL GROUNDWATER MONITORING
GUIDANCE DOCUMENT

Version 1.8 – September 2002

Department of Health

Solid and Hazardous Branch

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PREFACE

This Groundwater Guidance Document is for landfill owners, operators, and consultants to provide a clear and detailed guidance in understanding and implementing the EPA Federal Subtitle D regulations. The detection monitoring section identifies a set of indicator monitoring parameters that are more sensitive and cost effective than the Appendix I parameters. The assessment monitoring section provides a flow chart and a timeline to clarify the steps involved in assessment monitoring. The corrective action section provides a flow chart and timeline to describe the decisions involved in corrective action.

There has been a long-standing need for a comprehensive document that simplifies and brings clarity to the EPA Federal Subtitle D regulations. These regulations are complicated and a number of technologies and sciences are needed for the clear understanding of the engineering, geologic, hydrogeologic, geochemical, and statistical aspects of a quality groundwater monitoring program that meets RCRA Subtitle D requirements.

To fill this need, Joe Hernandez, of Waste Management of Hawaii, Inc. (WMHI), and Gary Siu of the State of Hawaii, Department of Health enlisted the talents of distinguished experts in this field to blend their knowledge with years of practical experience in groundwater monitoring system design and groundwater chemistry. This taskforce core group had many discussions with Jim Brown, principal author of EPA Federal Subtitle D regulations, to clarify the intent of the EPA in specific sections of the Subtitle D regulations. The result is this Groundwater Guidance Document which includes much valuable information not found in the literature but known to practitioners in different segments of the engineering and geologic professions.

A lot has been learned since 1991 about environmental monitoring at solid waste sites. Subtitle D is outdated in many regards (e.g. monitoring parameter lists (Appendix I & II) and statistics (the emphasis on ANOVA and Student's T Test)). The regulation is often convoluted in its presentation and wording. An example is the discussion on intra-well monitoring from which, it is difficult to understand that EPA's intent was to allow intra-well monitoring. Another example is the discussion on Assessment Monitoring (including statistics). Few regulated parties can comprehend the intent of EPA or how to implement Assessment Monitoring. These are some of the areas, which this guidance document seeks to clarify.

This document and its subsequent training are not designed to make people do more than is required by Subtitle D, but to implement it clearly, within the past and current intents of EPA, using recognized technical standards. The document provides guidance on how to most effectively comply with the Subtitle D regulations, while also bringing technically defensible approaches to bear. If a poll were taken of all state owners/operators/consultants, many would report that they understand and implement Subtitle D effectively and accurately. It is hoped that following a reading of this guidance document or attendance at a training workshop, these same people will discover built-in flexibility and new approaches. This guidance effort, is a means for the State of Hawaii to lead the regulated community into a better understanding of Subtitle D and the state regulations in terms of what they offer in flexibility and technical implementation. The perception that it is all about doing more is not correct. It is about doing what is necessary within the regulations without negatively impacting the environment.

The State of Hawaii Landfill Taskforce

Hawaii Landfill Groundwater Monitoring Guidance

This guidance document offers an organized collection of information or a series of options and does not recommend one specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This guidance is intended to be specific to the State of Hawaii, but is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of the many unique aspects of a project. This guidance document is not intended as a design specification nor an instruction manual for untrained persons.

This guidance document does not relieve any individuals from the responsibility of complying with applicable provisions contained in the Hawaii Revised Statutes and the Hawaii Administrative Rules on Solid Waste and any other applicable state and federal rules and regulations.

ACKNOWLEDGMENTS

This document could not have been produced without the generous help of a number of recognized experts. The Landfill Taskforce Core Group shouldered the bulk of the work and provided their unique and varied expertise to the Project. The Core Group consisted of John Baker, Director of Technology, WMI, Dave Burt, Director of Hydrogeology & GW Programs, Sanifill (now WMI), Stephen E. Joseph of Masa Fujioka & Associates, Mike McKee, Hydrogeologist, A-Mehr, Inc., Mark Verwiel, Manager, Hydrogeology Programs, Sanifill (now WMI), and Marty Sara, Principal Hydrogeologist, Arcada-Geraghty & Miller. The Core Group donated freely of their time and experience both in Hawaii and on the Mainland. The Core Group has an average of 20 years of experience per person in groundwater chemistry, hydrogeology, geology, and facility monitoring. Through an involved process of interaction and cooperation with the State of Hawaii, Department of Health (DOH), managed to bring some clarity to the Subtitle D regulations.

Gary Siu of the State DOH was the key facilitator and coordinator of the process. He initiated the guidance document and continued to coordinate and lead the project through its completion. He recognized the need for a technical guidance document as a result of the questions and issues that were raised when the State adopted the Federal Subtitle D Regulations and provided a focus and a contact point within the Department of Health for the entire Landfill Taskforce.

Jim Brown with the U.S. Environmental Protection Agency (EPA) deserves recognition for providing critical information into the intent of the Subtitle D regulations and, in some cases, providing explicit interpretation of the more complicated aspects of the federal regulations. He was a needed sounding board for the ideas of the taskforce Core Group.

Dr. Robert Gibbons with the University of Illinois, Chicago, deserves our gratitude for his insight and work on the statistical aspects of the document. He gave numerous presentations to the Task Force and DOH during the course of this effort, and his insight into statistical monitoring has been invaluable. His book, "Statistical Methods for Groundwater Monitoring", (1994, Wiley & Sons Publishers) has provided the framework for the statistical portion of the guidance document.

Joe Hernandez, Environmental Manager with WMHI and a member of the Solid Waste Association of Hawaii, provided critical coordination, financial support, scheduling, and dedication to the overall process from the start, and has been vital to the Landfill Taskforce.

Jeffrey Kaohi, Site Manager with Sanifill (now WMHI) provided initial coordination and financial support, which are greatly appreciated.

Well-deserved thanks go to all the members of the Landfill Taskforce for their patience, support, input, comment, and reviewed of the guidance document through all of its iterations.

Solid Waste Association of Hawaii

LANDFILL GROUNDWATER MONITORING GUIDANCE DOCUMENT

CHAPTER 1 INTRODUCTION

The purpose of this document is to clarify and provide guidance regarding current Federal and State regulation with respect to groundwater monitoring at solid waste facilities in the State of Hawaii. It is not intended to be part of any State specific regulation. The guidance provided herein is intended to be specific to the State of Hawaii while providing state-of-the-art technical approaches to full regulatory compliance. The development of this guidance document is the direct result of the formation of the State of Hawaii Landfill Task Force. The Task Force's purpose is to benefit both the State of Hawaii and landfill owner and operators with respect to environmental protection and compliance with State and Federal regulations.

The hydrogeologic and statistical evaluation methods and detection monitoring efforts outlined in this guidance document attempts to verify attainment of performance objectives for the site, at appropriate points of compliance, in accordance with the Code of Federal Regulations (CFR), Solid Waste Disposal Facility Criteria (and its revisions) in 40 CFR Part 258 (Subtitle D) and State of Hawaii (Title 11, Chapter 58.1, Hawaii Administrative Rules (HAR)). This guidance document includes recommendations for the following:

1) Performance of regional studies and site specific investigations for complete hydrogeologic assessment (Chapter 2),
2) Location, design, and installation of groundwater monitoring systems (Chapter 3),
3) Standards for groundwater sampling and analysis (Chapter 4),
4) Effective selection of monitoring parameters and sampling frequencies (Chapter 5),
5) Data evaluation and statistics (Chapter 6),
6) Decision standards for identifying significant changes in groundwater quality (Chapter 7), and
7) Reporting (Chapter 8).

The Environmental Protection Agency (EPA) has commended the State of Hawaii for maintaining the lead role in the implementation and enforcement of the Subtitle D regulations through approved permit programs. Adherence to additional State monitoring requirements may also be necessary for proper compliance with the various solid waste landfill regulations. Adhering to this Guidance Document will ensure compliance with state subtitle D requirements for the adequate characterization of groundwater systems and the implementation of groundwater monitoring programs. This document also outlines comprehensive monitoring program elements to meet the objectives of these regulations.

CHAPTER 2 HYDROGEOLOGIC CHARACTERIZATION

Subsurface information is always necessary during the early stages of planning and development of land disposal facilities. Sufficient understanding of such aspects as groundwater flow, aquifer hydraulic parameters, depth to the uppermost groundwater zone, preferential groundwater flow pathways, recharge and discharge relationships, geotechnical information, groundwater chemistry, subsurface stratigraphy, geologic structure, mineralogy, etc., is critical if a successful detection monitoring program is to be implemented. The following section of this Guidance Document addresses the minimum procedures necessary to conducting hydrogeologic characterization fieldwork. The ultimate goal of hydrogeologic characterization is a concise and accurate hydrogeologic model bringing all aspects into one coherent picture. Figure 2–1 Summary Groundwater Monitoring Procedures and Table 2-1 Hydrogeologic Characterization present outlines of the basic issues that need to be addressed.

Table 2 - 1

Hydrogeologic Characterization

A. Introduction
- Assess Regional Geology - Desk Study
    - Hawaii State Soil Survey
    - Regional State Geology - Volcanoes in the Sea; Geology and Ground-Water Resources of the Islands of Hawaii; Geology of the State of Hawaii
    - Regional Hydrogeologic - Aquifer Identification and Classification for (island): Strategy for Hawaii, Mink & Lau; other area or site specific hydrogeologic from USGS; and the DLNR Groundwater Index and Summary for existing wells.

B. Components of Hydrogeologic Characterization
- Desk Study
    - Site specific or local hydrogeologic reports
    - Local master's thesis or previous site reports
    - Preliminary Geologic and Hydrogeologic Model
    - Field Investigation
    - Geology
        - Surface geology
        - Subsurface geologic
    - Hydrogeologic
    - Data Analysis
- Refine Hydrogeologic Model
- Hydrogeologic Report

The surface geology should contain and evaluate detailed geologic mapping including type of rock or soil underlying the landfill, its mineralogy, and lithology. Topography and geomorphology sections should discuss landforms and areas of possible instability along with drainage and any surface water features, which might exist. Any surface geologic structures such as dikes, faults, and fractures should be included in the surface geology section. Any air photo interpretations should be included.

The subsurface geologic section should include the log of borings using the USCS classification and ASTM standards with appropriate core collection in competent rock. At least 3 borings should be completed as piezometers (wells) in a triangular pattern. More wells should be added as needed to verify the preliminary conceptual hydrogeologic model. An evaluation of the subsurface lithology, fracturing, relative weathering, and continuity of lithologies should be made. Where core recovery from a borings is poor, the boring should be logged in a manner that obtains a detailed description of the stratigraphy at that location. In such instances, it is strongly recommended that either geophysically logging or downhole video logging be conducted. Surface geophysics (e.g. seismic, electromagnetic, gravity, magnetics) should be considered where target intervals are sufficiently shallow. To depict subsurface geology, cross-sections should be prepared and correlated with borings where possible. In the cross-sections, geologic contact descriptions (i.e. gradational, sharp, weathering, etc.) should be noted.

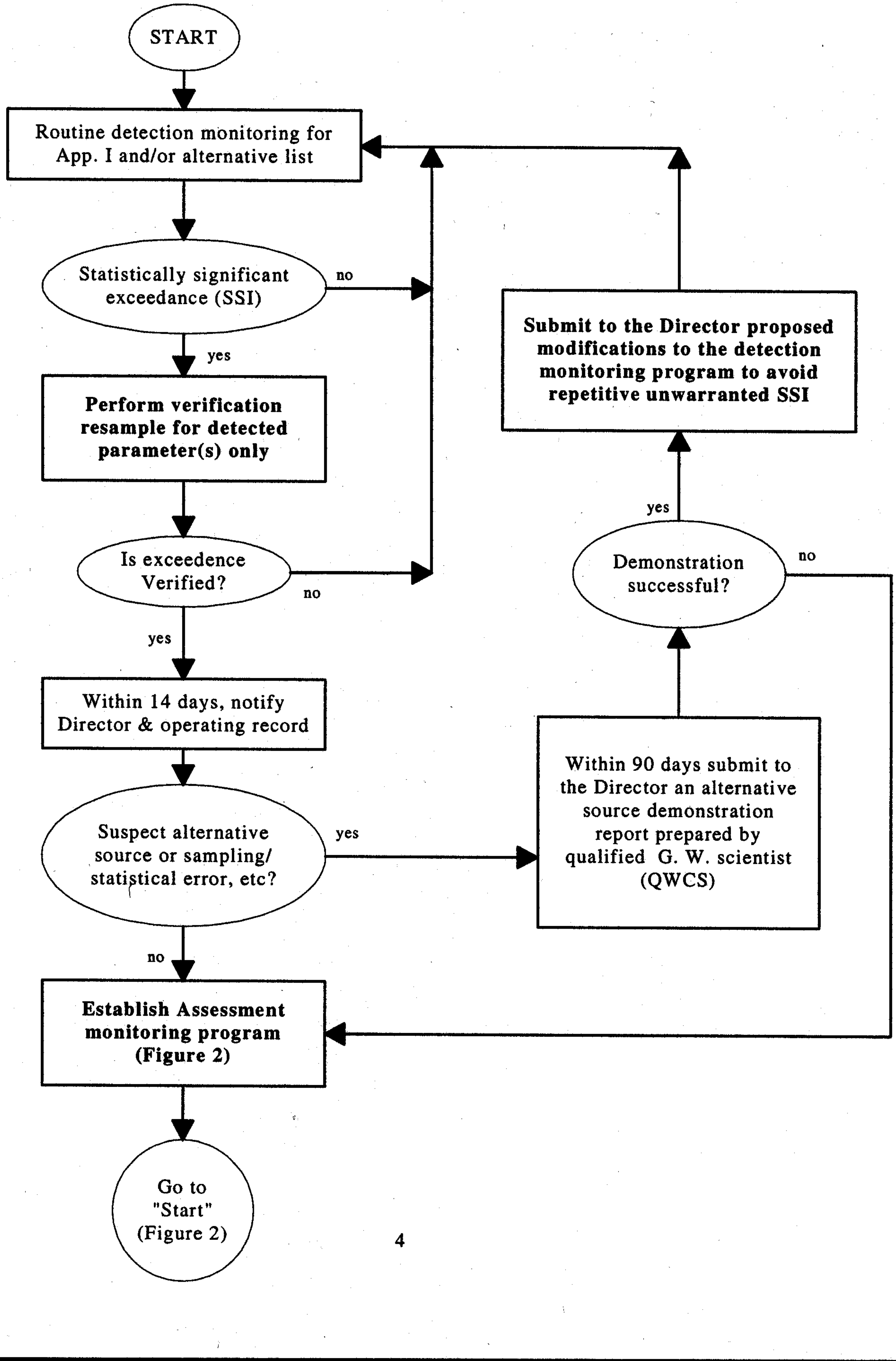
The hydrogeologic section should compare wells and piezometers in borings in each uppermost aquifer. It should also discuss all available hydrogeochemical and isotopic analysis of water samples collected from wells on the site (See chapter 3 for a list of analytes and sampling procedures). The range of hydraulic conductivity should be defined (preferential migration pathways). Groundwater depths and elevations should be noted and recharge and discharge areas defined if possible. The degree of chemical and spatial variability indicated (by a minimum of two sampling events) should be defined along with any shallow confining units (e.g., caprock or lateral extensive clay zones). Barriers to lateral flow if any should also be defined, along with any tidal influences on groundwater elevations (e.g., transducers in wells over 2 tidal cycles) or to groundwater chemistry (e.g., saltwater intrusion). Site specific groundwater chemistry should be reconciled with regional groundwater information (e.g., sample offsite wells, elevations, and chemistry).

The data analysis should include a groundwater level contour map drawn on the uppermost aquifer, pumping and slug test data for hydraulic parameters, and stiff and piper diagrams for all samples collected. From this information, groundwater flow, velocities, and time of travel can be calculated.

The hydrogeologic model can be refined by looking at the water table, lithologies, well completion logs and depths, and hydrogeologic cross-sections

A qualified groundwater scientist is an individual with five years professional experience in hydrogeologic investigations at Solid Waste Landfills.

Subtitle D Groundwater Monitoring Program Flow Chart
Figure 1: Detection Monitoring Program



CHAPTER 3 GROUNDWATER MONITORING WELL NETWORK

3.0 INTRODUCTION

This section details the guidelines for a groundwater monitoring system design at a given site, including monitor well construction and inspection details, and schedule of monitoring.

3.1 MONITORING NETWORK SYSTEM DESIGN

The groundwater monitoring network consists of a series of monitor wells and other surface water, leachate, and vadose zone monitoring points, if applicable at locations determined most likely to yield the earliest possible detection of a release. The system and its details must be developed after a comprehensive evaluation of the site hydrogeology and operational history.

The groundwater monitor well screen placement should be determined through interpretation of both site–specific investigations and regional geologic and structural trends. A summary of the procedures needed to determine the hydrogeologic characteristics of a site is presented in Chapter 2.

The downgradient (point of compliance) wells should be placed in locations to intercept potential primary migration pathways controlled by the hydrogeologic setting. Based on these features, the point of compliance wells should be positioned laterally along the downgradient margin of the facility at the downgradient edge of the waste management unit. Monitoring wells should target preferential groundwater pathways as determined most effective by a qualified groundwater scientist or hydrogeologist. Upgradient wells should be installed as appropriate to intercept primary migration pathways and to detect onsite migration of contaminants from offsite.

The targeted detection monitoring zone is defined as the hydrostratigraphic unit nearest to the natural ground surface that provides the earliest possible detection of a potential release from the facility. The groundwater monitoring network at each landfill should therefore be placed in the zone that satisfies these criteria.

The number of wells required for a given facility will vary based on the physical setting, groundwater flow pathways, facility geometry, number of leachate sumps, etc. The specific number and location of wells should be determined by a qualified groundwater scientist or hydrogeologist. Once the minimum site wells are in place and targeted properly, a qualified groundwater scientist or hydrogeologist must make the fundamental determination of whether intrawell (downgradient wells compared to their own history) or interwell (up to downgradient well comparisons) monitoring is appropriate for the site. For additional information concerning intra-well versus inter-well comparisons the reading is directed to ASTM Standard PS-64-96. If intrawell monitoring is proposed at an existing site, a test for potentially masking impacts should be performed. This determination should be based on an evaluation of the site hydrogeology, as well as groundwater and leachate chemistry.

Intrawell monitoring does not require background monitoring at upgradient wells because the water chemistry of a well is compared to itself over time. However, upgradient well(s) are useful for detecting any potential offsite influences on the monitoring network. Intrawell monitoring is generally preferable to interwell monitoring because it eliminates the spatial component of natural groundwater chemistry variability and is statistically more powerful. This spatial component comprises a significant portion of the total variability that must be accounted for by the statistical methodology (See Chapter 6).

3.2 MONITORING WELL CONSTRUCTION

Well construction techniques are designed to maintain the integrity of the borehole, minimize introduction of extraneous materials, provide representative groundwater samples from the monitored groundwater interval, minimize maintenance, and prevent entry of surface water into the annular space of the well.

All new monitor wells should be installed in accordance with the Monitoring Well and Piezometer Standard. This standard follows industry guidelines and ASTM standards (ASTM D 5092 & etc.), and is appropriate for use at sites in the State of Hawaii. Well permits are required from DLNR and Well and Pump Installation permits will need to be obtained from DLNR before installation can begin.

This Guidance presents the minimum requirements for the installation of monitor wells at Hawaii landfill sites. Typical monitor wells should be constructed of 2 or 4-inch diameter, schedule 40, polyvinyl chloride (PVC) casing. This guideline may be supplemented based on site-specific conditions that preclude strict adherence to the standards as described herein. Any variation from this guidance should be approved by a qualified hydrogeologist and the Solid Waste Division of the Department of Health, State of Hawaii. Possible reasons for variation from this Guidance include, but are not limited to, unusual site hydrogeologic conditions, deep monitor wells that may require a thicker schedule (i.e., PVC Schedule 80 casing), shallow groundwater zones or other site specific constraints.

The owner or operator is ultimately responsible for the proper construction of monitor wells and piezometers. The oversight consultant should be familiar with this Guidance prior to the design of each monitor well or piezometer. The consultant or drilling subcontractor should be responsible for procuring well permits and registering all monitoring wells as required by State or local regulations. Supporting documentation required for these purposes (e.g., aerial photographs, maps, groundwater gradients, etc.) should be obtained by the oversight consultant or drilling subcontractor.

It is the Landfill Task Force's goal to provide more consistent approaches to groundwater-related work, which should result in more consistent hydrogeology and groundwater quality data.

3.2.1 Well Construction Materials

Well construction materials that are described in this Guidance include well screen, riser pipe, well head protection, grout mix, gravel pack, filter pack, and bentonite seal. All materials should be new and free from defects. Well screen and riser casing materials should be individually wrapped and factory-certified to be free of contaminants.

Presently, the State will allow the use of 2 or 4-inch diameter, Schedule 40 PVC material for wells or piezometers installed to depths up to 250 feet below ground surface (bgs). Wells installed to depths between 250 and 300 feet bgs may be 2-inch or 4-inch (depending on site specific conditions), Schedule 80 PVC. Wells installed below 300 feet bgs must be constructed of 4-inch diameter, Schedule 80 PVC. Piezometers may be constructed of 2-inch diameter casing to any depth, following the PVC Schedule requirements listed above. Regardless of the casing materials used, the casing should be kept under tension during installation (i.e., the weight of the casing must not be supported by the bottom of the borehole).

It is Landfill Task Force policy not to allow the introduction of drilling fluids of any kind except for air during well or piezometer drilling and construction unless absolutely necessary. In some situations, fluids other than air may be more effective in drilling. In such cases, the approval of a qualified hydrogeologist or groundwater scientist should be obtained in writing. In these cases, provisions should be made to ensure that fluids of a known chemistry are utilized during drilling activities.

3.2.2 Well Screen

The typical well screen should be new, machine-slotted or continuous wrapped 2-inch diameter, schedule 40 PVC, and should conform to an appropriate standard such as ANSI-ASTM F480-81. Diameter and Schedule rating of the PVC may vary for deep wells or piezometers as discussed in the above Section on Well Construction Materials of this Guidance. The screen should be designed with a bottom plug or end cap made of the same material as the well screen. The typical screen slot size is 0.010-inch or 0.020-inch unless the formation and or the gravel pack require a different slot size (i.e., in general, the gradation of the gravel pack should have a grain size between the screen slot size and the mean grain size of the water-bearing zone). The consultant or drilling subcontractor should make the screen selection based on knowledge of the formation materials or site-specific field sieves. Use of screen slot size other than the above should be documented, justified, and approved by a qualified Hydrogeologist prior to installation.

The well screen and riser pipe should be furnished in minimum 5-foot, flush joint, threaded sections. Longer sections can be used when appropriate, but the well casing should be assembled in the borehole. The well screen should withstand all installation, well development, and sampling pressures without becoming dislodged or damaged. The use of glue should be prohibited.

3.2.3 Riser Pipe

The riser pipe is that portion of the well casing extending from the screen interval to the ground surface. Riser pipe should be new, flush joint threaded, and will typically be constructed of 2-inch diameter Schedule 40 PVC meeting appropriate specifications (e.g., ASTM D 1785 and D 5092). Schedule 80 PVC may be used for deep wells in accordance with procedures described in the above Well Construction Materials Section of this Guidance. All joints should be hand-tightened. Glued joints and rivet joints should not be permitted. The riser pipe should be fitted with a watertight top cap constructed of the same material (i.e., PVC). The diameter of the borehole should be designed to ensure proper placement of annular materials as discussed below.

3.2.4 Well-Head Protection

Well-head protection for wells and piezometers should be provided by installing a steel or aluminum outer casing, protected from vehicle traffic and vandalism, around the upper portion of the well or piezometer. This protection should either be installed flush with the ground surface, or with a stick-up (i.e., the vertical length of the portion of the protective casing, which extends above the ground surface) above ground surface. The protector casing should be installed during well construction and immobilized in concrete placed around the outside of the protector casing. The protective casing should typically be about 8- to 10-inches in diameter, and must be four inches larger in diameter than the well casing. All casing should be new and free of interior coatings. No paint should ever be used. The well protector should be watertight, with a locking lid to prevent unauthorized well access. The protective casing should provide about 10-inches of space between the top of the well casing and the locking protective-casing lid to facilitate sampling equipment. Sampling equipment at monitoring wells should consist of either QED® type dedicated bladder pumps or similar dedicated pumps or clean and dedicated bailers and accessories. The well casing should be centrally positioned within the protective casing.

3.2.5 Stick-Up

All wells with a designed stick-up (i.e., the vertical length of the portion of the protective casing, which extends above the ground surface) should be provided surface protection from tampering or accidental breakage. The well casing should extend approximately three to four feet above ground surface, and about ten inches below the top of the protective casing. The preferred protection material is anodized aluminum, although steel casing may be used if justified by site-specific criteria (no paint should ever be used). The protective casing should be no less than six feet, and securely seated into the borehole grout material. The depth that the protective casing extends downward into the borehole will depend upon site specific conditions (e.g., temperature fluctuations, geology, etc.), but should be more than two feet. The base of the protective casing should be surrounded by the borehole grout material, which should extend into the annulus of the protective casing at least 2.5 feet (nominal). It should be the responsibility of the well installation contractor to ensure that the protective casing is properly secured.

A 1/4-inch diameter weep hole should be provided in the casing about six inches above the ground surface to permit water to drain out of the annular space. Dry bentonite pellets, granules, or chips should be placed in the annular space from the level of the weep hole to below ground level within the protective casing. A ten to twelve inch (minimum) coarse sand or pea gravel (or both) interval should be placed in the annular portion of the protective casing above the dry bentonite pellets and above the weep hole to help prevent entry of insects.

A formed, slightly mounded, 4-inch-thick by three-feet-diameter (nominal) or three-feet-square concrete pad should be constructed around the base of each stick-up monitor well. The pad should be designed to slope away from the well in all directions to facilitate drainage. The specifications of the concrete material should account for possible temperature fluctuations and other factors which might produce cracking or otherwise reduce the quality of the surface seal. The pad should contain sufficient reinforcing steel (mesh or bar) to provide structural integrity.

Where vehicle traffic presents a threat to the well head, protective posts should be provided around the well. The posts should be made of steel or equivalent-strength material, and should be designed appropriately to provide protection from the specific traffic type of concern. A minimum of three posts, each with a minimum stick-up of three feet, should be used for this purpose. The installation contractor should ensure that the posts are sized and installed properly.

3.2.6 Flush-Mounted

This detail type should generally be avoided but site specific conditions may necessitate the installation of flush-mounted well head protection. The well casing should be cut two to three inches below the surface grade and a locking, water tight lid consisting of an aluminum (or stronger equivalent) valve box (i.e., vault or manhole) assembly should be installed. The lid assembly should be centered in a formed, slightly mounded 4-inch thick by nominal three-foot diameter or three-feet-square concrete pad to slope away from the well in all directions. The pad should contain sufficient reinforcing steel (mesh or bar) to provide structural integrity. In cases where the well must be located in a roadway, the flush-mounted box must be traffic rated.

An internal cap should be fitted on top of the riser within the vault or manhole. The cap should be leak-proof so that if the vault or manhole fills with water, the water will not enter the well casing. If dedicated sampling equipment is to be fitted in the well, adequate space should be provided within the vault.

3.2.7 Grout Mix

The cement should be Portland Cement® Type 1 in accordance with ASTM C150, Type 1 or API-10A, Class A. The use of any other cements should be approved by a qualified Hydrogeologist prior to its use. Water should be obtained from an approved source as designated by the qualified hydrogeologist based on recommendations by the consultant or drilling subcontractor, if necessary. Hydrated lime should be ASTM C207, Type S and should not contain air entrainment additives. Bentonite should be powdered sodium bentonite without additives.

The cement should be mixed with water in the proportion of five to six gallons of water per sack of cement (i.e., about 94 pounds). Hydrated lime may be substituted for cement up to 10% by volume. Between two and four pounds of bentonite powder should be added to the mix for each sack of cement used. Grout should be thoroughly mixed until lumps are eliminated. All grouting lines (i.e., hoses, pipes, drill rods, etc.) should have an inside diameter of at least 0.50 inches.

Grout should be injected under pressure using a tremie pipe (or equivalent) to displace water and cuttings from the seal above the screened zone to the top of the borehole. Grout should be deflected to the sides at the base of the tremie, and continued until clean grout flows from the top of the well hole. The well (and protective casing) should not be disturbed for a period of at least 24 hours after grouting to allow the grout to set and gain strength.

3.2.8 Gravel Pack

The gravel pack (or sand pack) is the material placed around the well screen. This material should be uniformly graded sand and gravel, washed and screened with a particle size at least four times the d-15 size of the formation (i.e., 15 percent of the adjacent, *in situ* soil is finer than the d-15) and no more than four times the d-85 size of the formation. A sand filter of 20-40 gradation should be used. A qualified hydrogeologist should ensure that the proper sand pack is used, based on the site specific hydrogeology and screen opening size.

3.2.9 Filter Pack (Optional)

The filter pack is the layer of material placed in the annular space between the gravel pack and the bentonite seal. The purpose of this interval is to prevent an excessive amount of overlying grout material from penetrating the gravel pack. The filter pack material should be a uniformly graded sand with 100 percent by weight passing the No. 30 sieve, and less than 2 percent by weight passing the 200 sieve. The decision to use a filter pack interval should be based on site and well specific criteria, including the depth bgs to the gravel pack, adjacent geology, State regulations, etc. It should be the responsibility of the installation contractor to prevent grout from entering the gravel pack portion of the well.

3.2.10 Bentonite Seal

The bentonite that is used for the seal should be pelletized or chipped sodium montmorillonite furnished in sacks or buckets from a commercial source and free of impurities. The diameter of the pellets should be less than one-fifth the width of the annular space into which they are to be placed to reduce the potential for bridging. This interval is emplaced over the gravel filter pack interval of the annular space.

3.2.11 Construction Water

Construction water used in the drilling process, to prepare grout mixtures, and to decontaminate the well screen, riser, and annular sealant injection equipment should be obtained from a source of known chemistry that does not contain constituents which could compromise the integrity of the well installation. All water (or any other fluid) that is used in the down-hole construction process should be sampled and analyzed for VOCs and other parameters sensitive to the site monitoring program. It should be the responsibility of the installation contractor to ensure that nothing enters the well during well construction that could affect the results of subsequent groundwater monitoring.

3.3 WELL INSTALLATION

A stable borehole that was properly logged and visually inspected by a qualified hydrogeologist or geologist should be constructed prior to attempting the installation of well screen and riser materials. If the borehole is caving, the drilling subcontractor, at the direction of the qualified hydrogeologist, should take steps to stabilize the borehole before attempting installation of the well casing. These steps will often include installing the well materials through driven drill casings or hollow-stem auger flights. Boreholes that are not plumb or are partially obstructed should be corrected prior to the installation of the well materials. Jetting (i.e., inducing pressurized water flow within the well casing) or driving the well screen should not be permitted.

3.3.1 Well Screen

Personnel handling the well screen and riser should wear new cotton or surgical gloves during installation. To prevent kinking of the threads, no more than 15 feet of screen or riser pipe should be assembled above ground. Joints should be tightened by hand. Decontaminated pipe or chain wrenches should not be used, unless absolutely necessary.

Typically, well screens should be a minimum of 20 feet in length unless site-specific hydrogeologic or regulatory constraints exist. The well should be screened a minimum of 5 feet above the projected highest annual groundwater level as determined by a qualified hydrogeologist or groundwater scientist familiar with the hydrogeologic conditions at the site. Similarly, the well should be screened 15 feet below the projected lowest annual groundwater level. If projected annual groundwater level fluctuations are significant, well screen lengths will necessarily vary to facilitate long-term water table monitoring. It should be the responsibility of the installation contractor to ensure that adequate screen lengths are provided. Screen casing section lengths should be no less than five feet and threaded unless groundwater conditions preclude this.

3.3.2 Riser Pipe

The riser should be slowly lowered into the borehole (or pushed into the water in the borehole) by hand or using steam-cleaned drill rig apparatus, as necessary, as additional sections of riser are added to the string. If required, the well screen and riser should be ballasted to counteract the tendency of the well screen to float in the borehole. Water should be used only if necessary and only from an approved source from which a sample can be obtained.

Centralizers should be used at appropriate spacings to keep the riser pipe centered in the borehole. Centering disks and seal tamper can be used to center the well screen and riser pipe in the borehole where centering cannot be assured otherwise. Keeping the well screen and riser pipe centered in the borehole will help to ensure that the gravel pack is emplaced properly and is of consistent thickness. The riser should extend above grade a minimum of 3 feet where stick-up is required and trimmed to its proper length after the grout is in place. The protective casing (or flush-mounted vault) should be positioned properly once the well has been grouted to the surface.

The riser pipe and protective casing should not be disturbed until a minimum of 24 hours after grouting is complete except for water level measurements made using an electronic water level indicator. Trimming should not be attempted during the interim period unless required by site-specific considerations. Precautions should be made to prevent pipe cuttings from entering the riser.

3.3.3 Placement of the Gravel Pack

The volume of gravel pack that is required to fill the annular space should be computed and carefully measured out. Computed gravel pack volumes and volumes actually used should be documented in field notes. The gravel pack should extend a minimum of about three feet above the screen, or a distance of about 20% of the length of the well screen, whichever is greater (ASTM D 5092). The preferred method of placement of the gravel pack into the annular space is via a tremie pipe (side discharges), unless consistent and proper placement can be assured using other methods. The method of gravel pack emplacement and verification of proper placement should be fully documented on field information forms. As the gravel pack is placed into the annular space, the tremie pipe (if used) should be raised accordingly to keep the mouth of the tremie slightly above the upper gravel pack. Periodic measurements using a weighted tape should be made to the top of the gravel pack to ensure that bridging does not occur during placement.

If the well casing is emplaced through drill casing or hollow-stem auger, the temporary casing or hollow stem augers should be withdrawn during annular material emplacement. The well installation contractor must periodically verify that the gravel pack and seal materials have not bridged. Additional annular materials may need to be added after auger withdrawal from each portion of the borehole.

3.3.4 Placement of the Filter Pack

When used, the filter pack should extend a minimum distance of 2 feet within the annular space from the top of the gravel pack. Where appropriate, the filter pack should be tremied or poured into the annular space to ensure complete and proper emplacement. The State of Hawaii preferred method of emplacement is via tremie pipe. The filter pack may be eliminated where conditions warrant with the approval of a qualified hydrogeologist or groundwater scientist. Factors important to the use of a filter pack include the gradation of the gravel pack and the potential for grout intrusion into the gravel pack.

3.3.5 Placement of the Bentonite Seal

A two to five feet thick bentonite seal should be emplaced above the gravel pack in the annular space. The specific thickness of the seal should be based upon well-specific criteria or State regulatory requirements. (Well-specific criteria include the depth to the seal, geology adjacent to the well, depth to groundwater, etc.) The bentonite pellets (or chips) should be carefully measured out and poured into the annular space for hydration. If the bentonite seal is being constructed above the water level in the well hole, five gallons of deionized (or otherwise decontaminated) water shall be poured into the annular space. Alternatively, a neat and lean bentonite slurry may be carefully tremied into the annular space to construct the required seal. If a bentonite slurry seal is used, then at least 2 feet of fine sand filter pack should be used at the top of the filter pack to prevent invasion of the slurry into the gravel pack.

3.3.6 Grouting the Annular Space

The grout should be injected via a tremie pipe (side discharging) and pumped through the pipe until it flows at the surface. The opening of the tremie should be maintained near the top of the bentonite seal to prevent a large free-fall of grout onto the seal. The temporary casing or augers (if used) should be removed immediately after the grout has been injected or carefully removed as the grout is emplaced. Concurrent casing removal and injection must ensure that the top of the column of grout is maintained at least several feet above the bottom of the casing to prevent caving. If casing removal does not commence until grout injection is completed, then additional grout should be poured slowly into the annular space to maintain a continuous column of grout to the ground surface. The well installation contractor should ensure that the grout is emplaced properly and that the integrity of the underlying annular materials is maintained.

3.3.7 Well-Head Protector

Well-head protection must be provided for all monitor wells and piezometers. The preferred construction technique is to provide a three-foot well casing stick-up and associated protection. However, there may be site-specific conditions that may require the use of flush-mounted surface completion. Specifications on the materials of construction are described in the above Well Construction Materials Section.

3.3.7.1 Above Grade

An anodized aluminum (preferred, although steel may be used as an alternative) well protector should be set in neat cement and placed in the plumb position extending a minimum of three feet above the ground surface. A minimum clearance between the top of the riser and the well protector of about ten inches should be maintained to accommodate dedicated sampling equipment. It is the well installation contractor's responsibility to ensure that adequate sampling equipment space at the well head exists. Grout, which has overflowed the well hole, should be removed. A 1/4-inch diameter weep hole in the well protector, 6-inches above the ground surface should be provided to permit water to drain out of the annular space. Dry bentonite pellets should be placed in the annular space below the level of the weep hole. Coarse sand or pea gravel (or both) should be placed in the annular space above the dry bentonite pellets and hole to prevent insects from entering through the weep hole. A formed, slightly mounded, 4-inch thick by 3-feet diameter concrete pad should be constructed around the monitor well to slope away from the well in all directions. The protective casing should be a minimum of six feet in length, and extend into the concrete a minimum of 2.5-feet (nominal) bgs. It is the responsibility of the well installation contractor to ensure that the protective casing is properly installed.

3.3.7.2 Flush-Mounted Well

If site specific conditions warrant, the well may be completed flush with the land surface. The well casing should be cut two to three inches below the surface grade, or to a depth that will allow the installation of dedicated sampling equipment. A water tight, locking aluminum vault assembly should house the well head. Aluminum is preferred, although other materials may be used if conditions warrant. The lid assembly should be centered in a formed, slightly mounded, 4-inch thick by appropriate diameter concrete pad to slope away from the well in all directions. The proper installation of the flush mounted vault should be the responsibility of the well installation contractor.

An internal cap should be fitted on top of the riser within the vault or manhole. The cap should be leak-proof so that if the vault or manhole fills with water, the water will not enter the well casing. Space in the well head should be provided for sampling equipment and should be the responsibility of the installer. The vault or manhole assembly must be traffic-rated if installed in or near a roadway.

3.4 SURVEYING

The location of the well should be surveyed to the nearest 0.5 feet. The ground surface elevation and top of well casing should also be surveyed to the nearest 0.1 feet and 0.01 feet, respectively, relative to mean sea level. Surveying should be performed by a State-licensed or otherwise State-approved surveyor.

3.5 WELL COMPLETION RECORDS

Well completion records for a monitor well should include the information required on the DLNR Well Completion Form along with the following information:

- Date and time of construction;
- Well designation and map location;
- Drilling method and fluids used, if any;
- Name of drilling contractor;
- Name of geologist or hydrogeologist who logged the borehole;
- Sampling protocol and analytical results of any fluids introduced to the well;
- Well location to nearest 0.5 feet;
- Borehole diameter;
- Well depth to nearest 0.1 feet;
- Drilling and lithologic logs;
- Depth to all encountered saturated zones;
- Depth to targeted groundwater zone;
- Casing materials;
- Screen materials, slot size, length, and depth to the nearest 0.1 feet;
- Casing and screen joint type;
- Depth to first encountered groundwater;
- Filter pack material and gradation;
- Sealant materials;
- Surface seal;
- Type of protective well cap;
- Ground surface elevation to nearest 0.1 feet msl;
- Type of protective well casing;
- Top of casing elevation to nearest 0.01 feet msl;
- Final well annulus construction specifications (e.g., thickness of gravel pack, seal, etc.);
- Groundwater field parameter results (e.g., specific conductance, pH, temperature, dissolved oxygen, alkalinity, etc.).

Figures 3-1 and 3-2 present typical well completion diagrams that satisfy the conditions set forth in this guidance. This information should be included in the final report submitted to DOH.

CHAPTER 4 SAMPLING AND ANALYTICAL PROCEDURES

4.0 INTRODUCTION

This section details sampling and analytical procedures for groundwater and leachate.

4.1 MONITOR POINT INSPECTION PROGRAM

Well inspections should be performed at a minimum during routine detection monitoring events. The conditions of the well and its surrounding area should be observed and recorded on a well inspection form by the groundwater sampling team. Information should be documented as part of each well inspection, which includes the following:

1) Condition of well identification plate or sign;

2) Evidence that well was recently painted;

3) Inspection of locking mechanism to confirm the well is locked and the key works;

4) The integrity of well construction and sampling equipment including:
   a) physical surroundings (high weeds, standing water, cleanliness, activities nearby);
   b) condition of dedicated pumps;
   c) condition of protective casing;
   d) obstructions or kinks in well casing;
   e) condition of concrete footing (i.e., cracked, raised; water in annular space);
   f) grease around top of well on threaded caps; and
   g) fit of cap.

5) Weather conditions during observations including:
   a) wind direction for volatiles; and
   b) note if sampling was performed downwind.

6) Evidence of contamination by animal or insect parts in well, etc.

7) Well "guard–post" condition (if applicable)

8) Evidence of vandalism

4.2 LEACHATE MONITORING

Leachate monitoring should be considered at all sites. The following section describes the leachate collection, monitoring and analysis program approved for the State of Hawaii. Leachate monitoring is not specifically required by Subtitle D or State regulation however, the DOH recommends that leachate samples be routinely collected for information to assemble a database of potential source information and to evaluate the suitability of site monitoring parameters.

4.2.1 Leachate Collection/Monitoring System

Leachate from leachate monitoring points and collection sumps should be sampled and analyzed to provide an accurate characterization of potential source chemistry. The inflow at a treatment system (if applicable), the new leachate well(s) (if applicable), and the cells leachate collection point (if applicable) should constitute the leachate monitoring system. The system should be sampled according to the schedule discussed in the Leachate Monitoring Schedule.

4.2.2 Leachate Analytes

The leachate wells should be fitted with dedicated sampling equipment and monitored for the sample analytes listed in Table 4–1. These leachate data should be compared to groundwater monitoring data on at least a bi-yearly basis. If chemical parameters, which meet certain detection monitoring criteria (as outlined in Chapter 5, Section, Approach to Selecting Sample Analytes) are detected in the leachate, those parameters should be proposed for addition to the detection monitoring program. Conversely, as the leachate database becomes more fully developed, parameters that are not found in the site leachate should be proposed for removal from the monitoring program.

4.2.3 Leachate Monitoring Schedule

Leachate monitoring should occur at least once during the first year of availability (preferably twice if sufficient leachate is available for sampling) during groundwater background sampling to establish a source characterization database for the parameters listed in Table 4–1. Leachate monitoring should occur at least annually thereafter (if possible) for the analytes used in the routine detection monitoring program (i.e., the Section, Detection Monitoring Parameters). Then every two years, leachate should be analyzed (if sufficient leachate is available) for the parameters listed in Table 4–1.

4.3 GROUNDWATER AND LEACHATE SAMPLING PROCEDURES

The objective of the detection monitoring program is to determine whether the waste facility has impacted the environment. It is recognized that sampling is a critical step for an effective monitoring program. All activities related to monitoring at each site should be continually reviewed and scrutinized for completeness and integrity.

Proper sampling procedures are the most important and fundamental aspect in an effective monitoring program. All environmental quality sampling at each site should be accomplished by personnel trained in proper sampling protocol, in accordance with these standards and guidelines. Information specifically included in this document as well as the following standards for sample preservation, sampling bottles, sampling labels, calibration of field instruments, recording of field parameters, bottle filling techniques, and etc. should be followed:

ASTM Standard D1129-90, (1990) *"Terminology Related to Water*
ASTM Standard D4448-85A, (1992) *"Guide for Sampling Groundwater Monitor Wells"*
ASTM Standard D3370-82, (1989) *"Standard Practices for Sampling Water"*
ASTM Standard D4840-88, (1993) *"Practice for Sampling Chain of Custody Procedures"*
ASTM Standard D3694-93, (1993) *"Practices for Preparation of Sample Containers and for Preservation of Organic Constituents:*
ASTM Standard D5088-90, (1993) *"Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites"*.

The Groundwater and Leachate Sampling Procedures section details the methodologies to be utilized for purging, sample handling, maintaining sample point integrity, and obtaining field measurements.

4.3.1 Groundwater

Upon arrival at the well location, the condition of the well and its surroundings should be observed and recorded on a Field Information Form. Information that is noted on this form includes the condition of the well's identification sign, the condition of the locking cap and key, the condition of the well cement footing, casing and surface seal, and evidence of any surface contamination (see Section, Monitor Point Inspection Program). Weather conditions should also be noted.

Table 4–1

Leachate Monitoring Parameters*

Initial Leachate Characterization, Plus Every Two Years

Subtitle D Appendix II parameters
Major cations and anions – (Mg, Na, Ca, K, Cl, CO_3, SO_4, HCO_3)
Major leachate indicators – (TDS, TOC, Total Alkalinity, Nitrogen–Ammonia, Cl, Fe)
Field measurements – (electrical conductance, pH, temperature, and turbidity)

* Notes:
1) Leachate samples are not field filtered.
2) Routine leachate monitoring will occur at least annually if a sufficient sample volume exists, for those parameters selected for routine groundwater detection monitoring.

Prior to groundwater purging and sample withdrawal, an accurate water level measurement should be taken with a portable electronic sounder, fiberglass tape, or a pneumatic probe. The water level measurement should be recorded on the Field Information Form.

It is strongly recommended that all monitoring wells be fitted with dedicated purge and sampling equipment to reduce the potential for false-positive monitoring results due to cross-contamination of monitoring wells. Experience has shown that the use of dedicated purge and sampling equipment in long-term monitoring programs can reduce overall monitoring costs.

Well purging procedures consist of removing the equivalent of three standing water volumes (measured from the depth to water to the bottom of the well) from the well prior to sampling or a volume sufficient to produce constants values of pH, temperature, turbidity, and specific conductivity (i.e., measurements should be within 10% of the previous measurement). Purge water should be subsequently discharged onto the ground away from the well for a normal sampling event, and discharged into a container if sampling is being performed at a suspected area of contamination. For suspected contamination, the purge water should be disposed of according to state and federal regulations if sample analysis indicated contamination.

If a monitor well does not recharge sufficiently for sampling within a reasonable time period (24 hours, or 72 hours for slow recharging wells) the well should be considered "dry" for the sampling event. Groundwater specific conductance, pH, turbidity, and temperature measurements should be taken during and after the well purging. Calibration and testing depend on the type of field instrument used. All results should be recorded on the Field Information Form. Calibration results should be maintained in a field log book or equipment calibration log book.

Once a well has been sampled, all sampling disposables should be removed from the area. Final notes should be made on the Field Information Forms indicating the time and date that sampling was completed, any changes in weather conditions that occurred during sampling, and any other unusual occurrences that may have produced an impact on the sample results.

4.3.1.1 Micro–Purge Techniques

Growing research demonstrates that the use of low–flow sampling devices, left in place or dedicated to each monitor well, can greatly reduce the volume of water that must be purged from a well before representative samples can be collected. This principle is based on the premise that water flowing through the well screen results in sufficient exchange of water to provide representative samples without removing overlying standing water (Robin and Gillham 1987; Kearl et al. 1992; Powell and Puls, 1993). The practice of low–rate or low–volume purging is referred to as Micro–Purge sampling.

Although the traditional well purging technique may be adequate for sampling, Micro–Purge sampling (i.e., low–flow sampling) is also an excellent method for the collection of groundwater. The following discussion summarizes the Micro–Purge approach, advantages of the technique, and requirements for its use.

Sampling groundwater from monitor wells has traditionally involved purging the well to remove stagnant water that may not be representative of water quality in the water–bearing zone surrounding the well screen. Most current regulatory guidance requires the removal of a fixed volume of water from the well, usually 3 – 5 times the volume of water "stored" in the well casing and screen.

Conventional fixed–volume purging often results in the removal of hundreds of gallons of purge water from a single monitor well. To remove these large volumes efficiently, many practitioners resort to high pumping rates for purging, which typically exceeds the capabilities of pumps designed to deliver high–quality samples. This practice has led to the use of conventional high–flow pumps to perform the purging operation, with separate sampling devices used to collect accurate samples.

While fixed–volume purging at higher pumping rates can result in removal of overlying standing water from a well and thus allow for the collection of representative samples in most cases. The Hawaii Landfill Task Force recommends low-flow purging and sampling as a more accurate means of collecting representative groundwater samples.

To accomplish Micro–Purge sampling, three requirements must be met:

1) The sampling pumps must be dedicated to eliminate disturbance of the upper water column caused by insertion and removal of the pump.

2) Flow rates must be low enough to achieve no net drawdown of the water level to prevent mixing within the well (usually a pumping rate of less than 1.0 liter/minute is required).

3. Intake of the sampling pump must be located within the well screen.

Micro–Purging can only be accomplished through the use of dedicated low–flow sampling devices. Bailers and portable pumps can not be used because they cause mixing of the standing water column within the well (Robin and Gillham, 1987). This mixing action requires the removal of the traditional large purge volumes before sampling. Introducing any device into the well causes a surging effect that increases turbidity dramatically and interferes with the normal flow of water through the well screen. This disturbance usually remains in effect for as long as 24 to 48 hours (Kearl et al, 1992).

Water quality parameters pH, temperature, turbidity, and conductivity are monitored during low–rate purging. The stabilization of these parameters (i.e., each measurement is within 10% to 15% of previous measurements) indicates the discharge water is representative of formation water and samples can be collected for analysis. Dedicated sampling equipment should be installed at all detection monitor wells.

The choice of which pumping method to use depends on the site-specific conditions and should be determined by a qualified hydrogeologist or groundwater scientist **and approved by the Department of Health based on a site specific demonstration**. We recommend that micro-purging be used, if a qualified groundwater scientist demonstrates the method appropriate for the site specific conditions. Acceptable sampling devices include bailers, positive displacement bladder pumps or Grundfos® type electric submersible low-flow rate sampling pumps. Gas contact, or air lift, and high-flow turbine or submersible pumps are not acceptable for sampling monitoring wells.

This means that a facility must propose to use micro-purging and make a demonstration to the OSWM (Office of Solid Waste Management). The OSWM will review the proposal and view a site-specific demonstration proof prior to making a determination of acceptance of that method at a specific facility under a specific qualified hydrogeologist or groundwater scientist.

4.3.2 Leachate (Where Applicable)

Upon arrival at the leachate sample location, the general condition of the sample location and its surroundings should be recorded on a Field Information Form. In addition, general well/access point integrity, weather conditions, visible contamination, odors, and unusual surface conditions should be observed. Field recordings of specific conductance, pH, temperature, and general appearance of liquids should also be made. Once the sample has been collected, the sample point should be secured, and all sampling disposables should be removed from the area and properly disposed of.

Final notes should be made on the Field Information Forms indicating the time and date that sampling was completed, as well as any changes in weather conditions or other unusual factors that occurred during the sampling event.

4.4 SAMPLE COLLECTION

The sampling system should consist of dedicated or disposable purging and sampling equipment for each well, thus preventing potential cross–contamination between groundwater monitor wells and leachate monitoring points, as may occur in conventional sampling practices.

There is current debate focusing on the issue of field filtering and colloidal transport of constituents. Samples requiring filtration (e.g., dissolved metals, TDS, etc.), may be field filtered through a 0.45 micron membrane pressure filter. Filter membranes should be properly disposed of after use.

Filtering is necessary to determine the ions and compounds that are dissolved in solution in the groundwater (rather than those that are present as particulates). Monitor wells are not as fully developed as drinking water wells and often contain silts and sediment that must be removed by filtration. If the water is not filtered, ions and compounds naturally present in, or adsorbed to, the suspended particles may be released when samples are preserved and analyzed. This release can result in much higher concentration levels than are actually present as dissolved constituents in the groundwater. Filtering equipment should be dedicated for groundwater only; any filtering apparatus that is used for other procedures such as TCLP should be dedicated for those purposes. Surface water, private wells, and leachate samples should never be filtered unless specifically required by the permit.

4.4.1 Groundwater

Laboratory–supplied bottles should be filled from the discharge tube of the sample pump or dedicated bailer. A physical description of the sample should be recorded on the Field Information Form, including the sample color, odor, clarity, foaming, and any other physical characteristics. If the field values obtained are not within the expected ranges, the qualified hydrogeologist should be notified immediately, as it may be necessary to resample. The initial sample should not be discarded. Additional samples may be requested by the qualified hydrogeologist to ascertain the cause of the erratic field measurements.

Special care should be taken to assure that the sample bottles for VOCs are completely filled, leaving no headspace at the top of the bottle. This is accomplished by inverting the full, capped bottle and tapping it to detect whether any air bubbles rise in the bottle. If bubbles are present, the bottle should be re–filled with a fresh sample, and the procedure should be repeated.

If the well becomes dry prior to completion of the sampling event, the sampling team should return to the well no more than 24 hours later. Upon return, the sampling team should measure the depth of water in the well and calculate the volume of water present in the well casing. If this volume is sufficient, the team should complete the sampling. If the volume of water in the well casing is not sufficient, the team should not complete sampling and should send the samples already taken to the laboratory. Whether or not the sampling team is able to complete the sampling, all occurrences and conditions should be recorded on a Field Information Form.

4.4.2 Leachate (Where Applicable)

Single-use (disposable) bailers are recommended for leachate and groundwater sampling because of the possibility of carry over and cross-contamination. If a permanent bailer is used before sampling, the leachate bailer should be thoroughly cleaned and rinsed with deionized or laboratory quality water before and after field use and between uses at different sampling locations. This procedure will maintain sample integrity at each sample location. Otherwise, dedicated sampling equipment should be used.

Leachate level measurements should be obtained and recorded on the Field Information Form. During sampling, the samples should be observed and a description of the color, odor (if any), and any layers or phases present in the sample should be recorded on the Field Information Form. The pH, temperature, and specific conductance of the leachate should be recorded in the field after the sample is collected. Leachate samples should not be filtered.

Special care should be taken when preserving leachate samples with acid since a violent reaction may occur. Acid should be added slowly and carefully to the leachate samples to avoid a violent reaction.

Once the sampling event is completed, all non–dedicated equipment should be gathered and disposed of properly, or stored in a separate area. When a sampling device (e.g., bailer) is not stored in the well or riser, it should be stored in a new, clean plastic bag and identified with the well or riser ID. All equipment dedicated for leachate sampling should be marked for leachate sampling only.

4.4.3 Preservation And Shipment

Samples should be preserved immediately after filtering or immediately after sample collection (if samples are not filtered). Volatile organic samples cannot have headspace (no air bubbles trapped in the sample). These sample containers may have preservatives included in the sample bottle as discussed below. When filling bottles containing preservative, the bottles should not be allowed to overflow any more than is necessary to eliminate headspace.

Pre–measured amounts of preservative reagents are usually supplied with the sample bottles by the laboratory. Analysis methods should determine which samples require preservation, identify the specific preservative, and specify how much preservative is required. For samples that do not contain preservatives, but require preservation, the preservatives should be added to the sample bottle after it has been filled. Bottles should not be overfilled, and should be inverted (once capped) to mix the preservative with the sample. Bottle lids should not be placed on the ground or interchanged among sample bottles.

Subsequent to sample collection, samples should be immediately placed in insulated containers chilled to 4 degrees C, and "locked" with a security seal. Ice packs used in containers should be frozen prior to use. The sampling team should record sample designations on Field Chain–of–Custody Records and Field Information Forms. Both forms should be reviewed to ensure completeness, and all paperwork (with the exception of carbon copies that are held for documentation purposes) should be placed in a plastic bag, sealed, and placed inside the container.

The containers and packing materials provided by the laboratory should be designed to prevent breakage and spillage during shipping. Shock–resistant bottle holders or other material are provided for this purpose. Volatile organic vials must be arranged so that they are never in direct contact with the ice packs.

The filled, sealed containers should be sent to the laboratory. All arrivals should be scheduled for next day delivery. A member of the sampling team should be appointed to arrange sample pickup and transportation to the laboratory. The laboratory should accept sample deliveries within three days. Friday shipment of samples to subcontract laboratories should be avoided, when possible, to ensure that holding times are not exceeded over a weekend.

To comply with packaging regulations and to take practical measures to prevent damage to expensive samples, the sampling personnel should follow packaging and shipping instructions supplied by the certified testing laboratory.

In the event that materials to be shipped are considered hazardous, or if their nature is uncertain, the samples should be appropriately labeled and transported by sampling personnel directly to the analytical facility. The other alternative is to ship by a carrier licensed to transport hazardous materials. However, in most instances, the concentration and type of compounds present in sample media are considered non–hazardous by the U.S. Department of Transportation (DOT) and can be shipped as described above.

4.4.4 Field Chain–Of–Custody Record

To help maintain the integrity of the samples, strict chain–of–custody procedures should be utilized. An example of a Field Chain–of–Custody Record form is provided in (Appendix A). These procedures ensure that the bottles and samples will be recorded from the time the sample bottles leave the laboratory to the issuance of the analytical laboratory results.

In order to maintain the chain–of–custody, the samples should be either in sight of the assigned custodian, locked in a tamper–proof location, or sealed with a tamper–proof seal. A record of sample bottle possession and any transfers of samples must be maintained and documented on the Field Chain–of–Custody Record.

The Field Chain–of–Custody Record must be signed with each date and time that the container's seal is broken. When the shipment container is initially opened for inspection of its contents, the seal number (if any) should be noted. The signature of the responsible party, time, and date should be recorded each time the sample container is transferred to the custody of another person, and immediately before sealing the container for transport to the laboratory.

In addition, the sample point designation, source code, date, and time of sampling should be recorded on the form. Each sampling location should be provided with a corresponding analytical method or description of the analytes for which testing is to be performed. Use of pre–filtration bottles and any problems with the sample should be noted on the form. Upon receipt of the sample container by the laboratory, the seal should be broken, and the condition of the samples, temperature, date, and time be recorded on the Field Chain–of–Custody Record by the log–in personnel receiving the sample shipment.

The Field Chain–of–Custody Record should indicate by bottle and analysis group whether samples are to be preserved. If actual preservation and filtration procedures vary from the instructions provided in these spaces, the chain–of–custody instructions should be so modified by a member of the sampling team and initialed in the appropriate locations provided on the Field Chain–of– Custody Record or on the accompanying Field Information Form.

4.4.5 Field Information Forms

The quality control of field activities should be administered by a qualified hydrogeologist or delegate and the field sampling personnel by documenting field tasks using Field Information Forms. The various Field Information Forms should be thoroughly completed by the individuals performing field sampling and physical parameter monitoring activities. The specific information that is required for documentation is both listed on the form and described in previous Sections of this Guidance Document. All Field Information Forms should be signed by the appropriate individual(s) performing the field task and copies filed in the site records. The forms should be used to help generate the routine monitoring reports for the site. Copies of all the Field Information Forms should be included in each monitoring report. The original forms should be filed by responsible persons at the facility and regional office, respectively. These forms should be retained for a minimum of three years.

4.4.6 Filtration

Field filtering should be conducted at all applicable sites unless the site is otherwise prohibited by local or State regulation. All appropriate samples, including Total Metals, should be filtered through a 0.45-micron membrane pressure filter, unless site-specific regulatory requirements specify otherwise. A list of analytical target compounds that do not require filtering is presented below. The technical and regulatory purposes of field filtering include the following:

- Field filtering was discussed in 1997 between members of the Task Force Core Group and EPA. This group consisted of Dave Burt, Mark Verwiel, Steve Joseph, John Baker, and Mike McKee of the core group and Jim Brown of EPA headquarters in Washington DC. Jim Brown of EPA acknowledged that changes were needed to clarify Subtitle D, especially in the areas of field filtering, micro purging, intra-well monitoring, monitoring parameter lists, and statistics.
- Particulate material larger than 0.45 micron is not part of the groundwater flow and would cause a positive skewing of the sampling results for Total Metals. Particulate material from well drilling and development can remain in the monitoring well for long periods of time. If this material is not filtered prior to preservation, adhered metals can be stripped from the particular material causing falsely elevated concentrations of target compounds.

Samples Not Requiring Filtration

The following samples do not require field filtering:

Alkalinity, Turbidity, Total Suspended Solids (TSS), Total Solids, Semi Volatile Organics, Volatile Organics (VOA), Total Organic Halides (TOX), Coliform, pH, Specific conductivity, Oil and grease.

It should be noted that some samples require field filtration even when a "total" analysis is requested. Examples include total organic carbon and total hardness analyses. This is required because if small amounts of detritus or other organic particulate material get into the sample, which is acidified in the field, it would bias the sampling results. The same is true for total hardness, where a small amount of detritus or coral would bias (Ca, Mg) the end result, because the groundwater sample is acidified in the field. The laboratory performing the analyses should be consulted for assistance on this issue for all parameters that are not specifically listed above.

Regulatory and permit requirements will generally specify whether to analyze, for example, for "Total" metals as opposed to "Dissolved" metals. DOH's landfill groundwater policy is to filter all heavy metals samples collected from monitoring wells unless otherwise specifically prohibited. The requirements should be noted on the filed Chain-of-Custody Records.

Filtration and preservation of groundwater samples is an integral part of the monitoring program. Improper techniques during this process can destroy the integrity of the sample. All possible precautions should therefore be taken to ensure that no contamination sources are introduced during filtration or preservation.

Filtering should be performed immediately after or during sample collection with inline filters and should be done in the field. Filtering equipment must be dedicated for groundwater only, and must be disposable. Do not use any filtering apparatus that has been used for other procedures such as EP-TOX or TCLP. Surface water, private wells, and leachate samples are never filtered unless specifically required by permit. Prefiltration bottles are not to be reused. The material and use of prefiltration bottles should be noted on the Filed Chain-of-Custody Record.

4.4.7 In-Line Filtration

All samples requiring filtration should be filtered using an inline filtration system, if possible. Enough water should be allowed to pass through the filter to thoroughly wet it before obtaining a sample. These filters should only be used for filtering inorganic parameters unless otherwise specifically prohibited.

4.4.8 Filling Sample Bottles

Sample bottles should be filled directly from the bailer or pump with a minimal amount of air contact. Volatile organics (VOA) and TOX bottles should be headspace-free (i.e., no air bubbles in the sample bottle). All samples must be filtered in accordance with Filtration section of this document unless specifically required to do otherwise. Where in-line filtration is not available, prefiltration bottles may be used to collect the samples. This collection method is to ensure that no sediment will be introduced into the filtered sample, which could cause possible analytical errors. [Prefiltration bottles must be obtained from the laboratory with the sample coolers]. All bottles or containers must be kept in a clean and locked storage area.

When filling the sample bottles, the following procedures and precautions are essential:

1. Bottle caps should be removed carefully so that the inside of the cap is not touched. Caps should never be put on the ground. Caps for VOA vials contain Teflon lined septum. The Teflon side of the septum must be facing the sample to prevent contamination of the sample through the septum.

2. Sampling Team should wear appropriate gloves.

3. Sample coolers should have ice packs in them before taking them into the field to aid in the cooling process for samples.

CHAPTER 5 DETECTION MONITORING PARAMETERS AND SCHEDULE

5.0 INTRODUCTION

Section 11-58.1 (1) of Hawaii's Solid Waste Management Regulations requires that MSWLFs routinely monitor groundwater for the 15 heavy metals and 47 volatile organic compounds (VOC) listed in Appendix I to Section 11-58. This is the same generic list of monitoring parameters contained in the Federal Subtitle D regulations (40 CFR Part 258, Appendix I) and in addition to containing an excessively large number of parameters, also contains several parameters (i.e., the 15 heavy metals) which are generally ineffective monitoring parameters because of their limited mobility in most subsurface environments. Fortunately, the EPA intended the Appendix I analytes only as default parameters for use in those states which have not yet obtained Subtitle D authorization and through 40 CFR Part 258.54 (a)(1) and (2) has provided authorized states, such as Hawaii, the flexibility to approve alternative lists of site-specific monitoring parameters. This flexibility is specifically outlined in subsections 11-58.1 (1)(A) and (B) of Hawaii's Solid Waste Management Regulations. It is recommended by DOH that an appropriate alternative list of sampling parameters be developed for each site.

This section describes the recommended approach for selecting an alternative list of site-specific groundwater monitoring parameters for use during detection monitoring programs. It first describes several fundamental concepts associated with the selection process and then illustrates how the collection and evaluation of site-specific information regarding background groundwater quality, leachate characteristics, and waste composition can be used to maximize the efficiency of the monitoring program while at the same time controlling costs.

The specific parameters for which analysis will be performed in the detection monitoring program should be based on background groundwater sampling results and constituent physical and chemical properties (e.g., persistence, detectability, mobility) that make them generally good indicators of contaminant migration. As stated above, VOCs (as a class) are detected more frequently than any other class of organic compounds in Municipal Solid Waste (MSW) landfill leachate. However, other Subtitle D, Appendix I compounds are not often found in landfill leachates. Additional research by Dr. Gibbons and others indicate that, in addition to VOCs, certain leachate indicators (e.g., total dissolved solids, chloride, alkalinity) and metals (e.g., magnesium, calcium, potassium) not found in Subtitle D, Appendix I have greater detection frequencies in leachate than other constituents in their compound class (personal communication, Dr. Robert Gibbons, 1993). An examination of landfill leachate databases supports these conclusions.

Considering these factors, a detection monitoring program based solely on the extensive list of Subtitle D Appendix I (or State equivalent) parameters is not effective on its own. Establishing background groundwater and leachate concentrations for the monitoring parameters as well as considering the migration potential of detected constituents is the basis for developing an effective site–specific detection monitoring parameters list. The characterization of background groundwater and leachate quality becomes more and more accurate as detection monitoring continues at the site. Therefore, the list of detection monitoring parameters may ultimately include less, more, or different parameters than those listed in Subtitle D, Appendix I or this Plan.

5.1 FUNDAMENTAL CONCEPTS

Incorporating the minimum number of effective monitoring parameters into the detection monitoring program is always the most effective approach over utilization of a very long list of monitoring parameters, such as that in Appendix I. This is true because of the direct relationship between the number of statistical comparisons performed during each sampling event and the resulting false positive error rates. For example, if a given detection monitoring program consists of 5 wells each of which is sampled for 20 parameters (i.e., 100 statistical decisions per monitoring event), even using a very low error rate (e.g., 0.01, or 1%), would yield one false positive result every sampling event. The larger the number of statistical decisions that are performed each sampling event, the higher (i.e., less conservative) the associated statistical limit must be to avoid excessively high false positive results.

A combination of VOCs plus select general water quality indicators will typically provide the most reliable monitoring parameters for most MSWLFs. Although commonly present in MSW landfill leachate, semi-volatile organic compounds, as a group, are significantly less mobile than VOCs in most subsurface environments and do not typically provide for substantial additional monitoring benefits. Likewise, heavy metals, because of their limited mobility in most subsurface environments, also generally make for ineffective monitoring parameters. In almost all cases, a short list of general water quality parameters, when carefully selected, will provide substantially better monitoring performance than the 15 Appendix I heavy metals.

The selection of alternative monitoring parameters should, to the greatest extent possible, be based on actual site conditions and involve a detailed evaluation of available site-specific data concerning leachate composition, groundwater geochemistry, and waste composition, as well as, any anticipated changes in leachate geochemistry within the unsaturated and saturated zones beneath the landfill. If possible, the alternative list of inorganic monitoring parameters should include only those parameters that exhibit a sufficiently high (i.e., 5 times or greater in leachate) concentration contrast between the facility's leachate and groundwater. VOCs utilized as monitoring parameters should routinely be detected at sufficiently high concentrations in the facility's leachate or likely transformation products associated with those VOCs detected in leachate.

The effectiveness of a facility's proposed alternative monitoring parameters will depend primarily on the amount and quality of site-specific groundwater and leachate data available for use during the selection process. Because the characterization of leachate and groundwater geochemistry becomes increasingly accurate as monitoring continues at the facility. For this reason, Monitoring Parameter lists should be re-evaluated periodically and modified appropriately, based on changes in groundwater or leachate conditions.

5.2 THE SELECTION PROCESS

The selection of an appropriate "short-list" of monitoring parameters is one of the most critical steps in the development of an effective detection monitoring program. When performed correctly, this selection can maximize the owner or operator's ability to detect leachate impacts at the earliest possible time. An appropriate short-list can also decrease the number of false-positive results while at the same time reducing overall monitoring costs and regulatory interface. The following subsections describe how the fundamental concepts described in the preceding sections can be used to select an appropriate short list subset of VOCs and general water quality parameters for use during detection monitoring programs.

5.3 VOLATILE ORGANIC COMPOUNDS (VOCs)

VOCs as a group are typically the most effective indicators of landfill leachate from MSW landfills. Their effectiveness is due primarily to their common abundance in MSW landfill leachate as well as their high mobility in most subsurface environments. As with inorganic monitoring parameters, the list of VOCs used for detection monitoring should be relatively short, and should be limited primarily to those compounds which are known or expected to be routinely present in the facility's leachate at relatively high concentrations.

An appropriate short-list of VOCs is typically developed by starting with the Appendix I parameters and then removing compounds from consideration which are not routinely present in the facility's leachate. The facility should avoid removing compounds that are common transformation products of VOCs, which are present in the facility's leachate. In general, the facility should also consider removing common laboratory contaminants such as methylene chloride and bis(2-ethylhexyl) phthalate, unless these compounds are present in the facility's leachate at very high levels.

For lined facilities in which a substantial amount of leachate data is available, a list consisting of ten to twenty carefully selected VOCs will be sufficient for detection monitoring. For unlined sites with no leachate data, a significantly longer list of VOCs should be considered in order to ensure proper coverage.

5.4 GENERAL WATER QUALITY PARAMETERS

The approach to selecting an appropriate short list of general water quality parameters is generally similar to that used for VOCs. The first step is typically to identify those inorganic parameters whose concentration in leachate is significantly higher than in groundwater. In general, effective inorganic monitoring parameters should have concentrations in leachate which are at least 2 times higher than in groundwater. The resulting list of potential monitoring parameters should then be reduced further by identifying and removing parameters that provide substantially redundant coverage (e.g., monitoring for both electrical conductivity and total dissolved solids).

From the remaining parameters, the facility should then select the group of parameters, which would be expected to provide the earliest and most reliable indication of a release. In making this determination, the facility should consider the relative mobility of the constituents, the detectability of each parameter using existing analytical methods, the likelihood of false positive results associated with each analyte, as well as any changes in the parameter that might be expected during its migration through the unsaturated and saturated zones beneath the facility (e.g., due to changes in pH or Eh).

For facilities with sufficient leachate data, a carefully selected short list containing between 3 and 7 inorganic parameters utilized in conjunction with the short list of VOCs will typically provide adequate monitoring coverage while still controlling the site-wide false positive rate at an acceptable rate. For unlined facilities for which no leachate data is available the alternative monitoring parameters list may need to be substantially longer to ensure proper coverage.

5.5 BACKGROUND SAMPLING OBJECTIVES

The purpose of obtaining adequate background groundwater data is to approximate the true range of ambient concentrations of targeted compounds in the groundwater system being monitored. In other words, background groundwater data should eliminate, to the extent possible, all potential causes of statistically significant changes in groundwater chemistry not attributable to the monitored facility. True background data is obtained by monitoring a sufficient number of wells upgradient of the facility (for inter–well comparisons), or wells downgradient of the facility not previously impacted by the waste management unit (for intra–well comparisons).

Three major components must be met to successfully achieve the goals of obtaining adequate background samples:

1) Collecting the minimum number of samples that satisfy the requirements of the statistical methods that are used (i.e., that result in adequate statistical power);

2) Incorporating seasonal or temporal variability into the background dataset; and;

3) Incorporating the spatial component of variability into the background dataset (i.e., the variability that comes with obtaining samples from different locations within the same groundwater zone.

This last source of variability constitutes a large percentage of the overall variability with environmental statistical approaches (up to 50% to 66%). Eliminating the spatial component of variability (through the use of intra–well comparisons), or adequately incorporating it into the background dataset (through the use of multiple upgradient wells in inter–well comparisons) is extremely important in developing an effective detection monitoring program.

The parameters that should be analyzed to establish the background groundwater database are presented in Table 5–1.

5.6 FREQUENCY FOR BACKGROUND SAMPLING

The schedule for background monitoring at each site is dictated by the statistical methodology proposed and by performance criteria for the statistical methodology detailed in 40 CFR 258 (Subtitle D – see Section, Data Evaluation). If an upgradient–to–downgradient monitoring program is used at the site, background sampling should consist of a minimum of eight samples collected from upgradient wells in a period of no less than one year. This background monitoring effort should occur prior to the application of any statistical comparisons. Quarterly sampling for a period of two years is preferable in order to more fully incorporate seasonal variability into the background database.

This background sampling approach is proposed to ensure that the samples satisfy the requirements of the statistical methods being used (see Groundwater Monitoring Network). These requirements include accounting for seasonal or temporal variability and for the spatial component of variability.

For sites that utilize intra–well, monitoring should provide for eight sampling events per well (but no less than six) prior to the implementation of statistics. Each well should have eight samples to increase the sensitivity of the statistical method(s) being used, and to account for seasonal or other causes of temporal variability. Upgradient wells maybe sampled on a less frequent basis; even with intrawell monitoring, they are used to detect off-site migration to the point of compliance.

5.7 DETECTION MONITORING PARAMETERS

If existing leachate is present, the site–specific detection monitoring parameters for the facility should be based on this site leachate and groundwater data and the above criteria outlined in Section 5.4, General Water Quality Parameters, including the following:

If leachate is available for sampling, but insufficient data exist to amend the standard monitoring parameter list, then the initial detection monitoring parameter list for the facility should be the constituents listed in Table 5–1, with the exception of the major anions and cations. No statistics are ever applied to the field measurements. However, once adequate leachate data are collected and evaluated pursuant to the Section 5.4, General Water Quality Parameters, the list of detection monitoring parameters may be amended, if appropriate. Parameters should be added or deleted from the list based on occurrence and sampling results in the site leachate, concentration contrast with surrounding groundwater chemistry, mobility, persistence, and detectability. The final site–specific monitoring parameter list for the site should be proposed and submitted to DOH for approval at that time.

If no leachate is available for sampling or if leachate sampling was otherwise not performed, the proposed routine detection monitoring parameters for the facility should be those constituents listed in Table 5–1, with the exception of the major anions and cations. Statistics are normally not applied to field parameters (e.g., pH and EC) due to the excessively high false positive rates commonly associated with these parameters. However, should site leachate have sufficient quantity in the future, the leachate data should be evaluated pursuant to the Section 5.4, General Water Quality Parameters, and the list of detection monitoring parameters may be amended accordingly. Parameters should be added or deleted from the list based on occurrence in the site leachate, concentration contrast with surrounding groundwater chemistry, mobility, persistence, and detectability. The final site–specific monitoring parameter list for the site should then be proposed and submitted to DOH for approval.

5.8 FREQUENCY OF DETECTION MONITORING

Detection monitoring (40 CFR Part 258.54) should be conducted semi–annually at detection monitoring locations at each site once background sampling has been completed at each monitoring point. Each sampling event should include the collection and analysis of one sample at each of the monitor wells included in the detection program. The monitoring requirement continues throughout the active life of the landfill and the post–closure care period. Less frequent sampling may be considered if warranted by site hydrogeologic characteristics, and proposed by a qualified groundwater scientist or hydrogeologist.

Table 5–1

Background Groundwater Monitoring Parameters

1) Subtitle D Appendix I constituents. Samples analyzed for metals should be filtered and unfiltered at least once, otherwise samples should be filtered.

2) Major cations and anions (i.e., Mg, Na, Ca, K, Cl, CO_3, SO_4, and HCO_3),

3) Major "leachate indicators" (i.e., TDS, TOC, Total Alkalinity, Nitrogen–Ammonia, Cl, and Fe), and

4) Field measurements (i.e., electrical conductance, pH, temperature, turbidity, and groundwater surface elevation) - no statistics will be performed on these parameters.

CHAPTER 6 DATA EVALUATION

6.0 INTRODUCTION

The following subsections describe the criteria by which data should be evaluated at a site. These criteria represent a conservative approach to groundwater analysis and incorporate state–of–the–art statistical and other evaluation methodologies. For additional statistical evaluation for waste disposal ASTM standard PS-64-96 should be consulted along with U.S. EPA *Interim Final Guidance Document - Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* (1989) and the addendum to that guidance (EPA 1992). It is suggested that the regulated community obtain the services of a professional, either through use of a landfill monitoring program compliance software package, or by retaining a qualified statistical consultant.

6.1 QUALITATIVE AND OUTLIER GROUNDWATER DATA EVALUATION

This section outlines the evaluation methodology that should be used for detection of a release from the facility using PQLs as the concentration limits for VOCs, the Shewart– CUSUM control chart for intra–well comparisons; and Prediction Limits for up– to downgradient statistical comparisons.

Prior to the evaluation of any inorganic parameters, it is necessary to examine the historical database for outliers, anomalies, and trends that might confound the evaluation procedure. Outliers and anomalies are inconsistently large or small values that can occur due to sampling, laboratory, transportation or transcription errors, or even by chance alone. Significant trends indicate a source of systematic error, or an actual contamination occurrence, that must be evaluated and corrected before the detection monitoring program can be implemented. The inclusion of such values in the historical database would result in an artificial increase in the magnitude of statistical limits, which could result in an increase in the false negative rate (i.e., a decrease in the sensitivity of the statistical procedure).

Once the background database has been developed, it is necessary to examine the database for outliers, anomalies and trends that might confound evaluation methodologies. Outliers and anomalies are inconsistently large or small values that can occur due to sampling, laboratory, transportation or transcription errors, or even by chance alone. Significant trends indicate a source of systematic error, or an actual contamination occurrence, that must be evaluated and corrected before the detection monitoring program can be implemented. The inclusion of such values in the historical database could cause mis–interpretation of the data set, which could result in high false positive (i.e., an indication of a release when none exists) and/or false negative (i.e., falsely concluding there is no release in the presence of an actual release) conclusions.

To remove the possibility of this type of systematic error, outliers should be removed from consideration during the establishment of background. The outlier detection procedure should be performed for those wells that have at least 4 measurements for a given constituent using time vs. Concentration graphs. Parameter concentrations that appear anomalous (i.e., that are 5 times or greater than the previous results) should be verified during the next sample collection event or after a reasonable period of time to ensure sample independence (e.g., six months). If the potential outlier result is not verified, the anomalous sample result should be removed from the database. Any detected systematic trends in the background database should be evaluated and reported to OSWM within 90 days.

Detection monitoring parameters should be evaluated based on time vs. concentration plots for each constituent for each well. Should a significant trend of a constituent, an unexpected geochemical signature at a well as indicated on a piper or stiff diagram, or an anomalously high result (i.e., greater than 5 times average background concentration) be verified after results have been checked for QA/QC, OSWM should be notified within 90 days. Potential outlier data should have an associated Data Quality Report (DQR) prepared by the laboratory to determine the quality and integrity of the data in question. Information provided in the DQR will be important in evaluating the significance of the analysis result(s) and determining whether a result represents an outlier, a cross–contaminated value, or other laboratory error.

In addition, the characterization of leachate should be performed as soon as leachate can be sampled to potentially amend the list of detection monitoring parameters. Source characterization is an effective technique in reducing false positive and false negative detections because groundwater concentrations of a parameter must be correlatable with source concentrations (i.e., source concentrations must be greater and in appropriate contrast with groundwater concentrations). Therefore, if a parameter is detected in groundwater at a concentration of concern but that parameter is either not in leachate, or in leachate at a much lower concentration, it can be concluded that the source of the parameter is not site leachate. If after this evaluation leachate is still suspected as the source of the parameter, verification resampling should be conducted.

6.1.1 Historical Data Analysis

To remove the possibility of historical outliers and trends creating false statistical limits, the historical data for each well and each constituent should be tested for the existence of outliers (Gibbons, 1994). Gibbons presents a detailed approach to the evaluation of the database for the proposed list of wells and parameters. Outliers will be removed from consideration during the establishment of all statistical limits. Once the background database is established, the outlier procedure described above should be applied and appropriate statistical limits set in accordance with the section on Statistical Methodology 6.2.

6.2 STATISTICAL METHODOLOGY

The development of a groundwater statistical monitoring plan for detection monitoring involves the proper collection of background samples. It must be determined if wells are placed (i.e., screened) in different water–bearing zones and if the zones are geochemically distinct. Furthermore, these zones must be represented in both upgradient and downgradient locations.

Based on these and other criteria, the landfill should utilize either intra–well or inter–well monitoring to provide effective indication of a release from the facility.

Intra–well monitoring is always the preferred approach because it eliminates the spatial component of chemistry variability from the statistical evaluation. However, intra–well comparisons are appropriate only if it can be demonstrated that the well(s) have not been impacted by the site. Additionally, intra–well monitoring is the preferred monitoring strategy when there is 1) no definable groundwater gradient; 2) no pre–existing contamination; 3) too few upgradient wells; 4) radial groundwater flow patterns; or 5) low groundwater flow rate (e.g., 50 feet/year. For intra–well comparisons, a minimum of eight background samples (i.e., from each well in the monitoring program) are required for parametric tests and 13 background samples for nonparametric tests. Additional discussion of intra-well monitoring can be found in Gibbons (1987a, 1987b, 1990, and 1994).

The statistical plan developed for a site should include an effective verification resampling plan, the proper selection of constituents and appropriate statistical methods (e.g., parametric and nonparametric prediction limits or control charts for intra–well comparisons) that detect constituents when present and do not falsely conclude the presence of constituents. The statistical plan should be developed through the interaction of a qualified statistician, hydrogeologist, or groundwater scientist.

6.2.1 Volatile Organic Compounds

Practical Quantitation Limits (PQLs) assure that the quantitative value of the analyte is close to the measured value. Method detection limits (MDLs), on the other hand, indicate that the analyte is present in the sample with a specified degree of confidence (Gibbons et al., 1991). For analytes with estimated concentrations greater than the MDL but not the PQL, it can only be concluded that the true concentration is greater than zero; the actual concentration can not be determined. The actual concentration of an analysis result between the PQL and the MDL may actually be less than the MDL. Comparison of a detected concentration to a maximum contaminant level (MCL), or any other concentration limit, is not meaningful unless the concentration is greater than the PQL.

It is generally accepted that when a landfill facility actually produces a release to groundwater, multiple constituents contained in the leachate are associated with the source fluids and are subsequently detected by the groundwater monitoring program. A single constituent at very low concentration (i.e. below the PQL) typically is not the signature that is produced from an actual release.

Volatile organic compounds (VOCs) represent very effective indicators of a release from a solid waste unit. Because these compounds are rarely detected in background groundwater samples, establishing monitor well–specific limits for VOCs is generally not an option. Therefore, detection decision rules based on laboratory–specific practical quantitation limits (PQL) should be used. If laboratory–specific PQLs are not available at the start of the detection monitoring program, PQL values as defined in USEPA SW–846 should be used. The computation of laboratory–specific PQLs is described in Chapter 7.

The use of a PQL in the absence of a measurable background value is supported by 40 CFR 258.53(h)(5), which states that any PQL, used in a statistical analysis:

> ...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.

In addition, Regional Water Boards in California and Texas have supported the use of PQLs. Gibbons, et al., (1992) have developed a statistical method for computing PQLs that are more rigorous than the generic PQLs listed in SW 846.

The PQLs computed by Gibbons, et al. (1992) are derived from laboratory–specific calibration data for each analyte. The method achieves results consistent with the traditional 10% relative standard deviation (rsd) definition of the PQL that has been used most often over the past 25 years. The PQLs proposed as the constituent concentration limits should be determined on a compound specific basis at the selected laboratory using the algorithm defined by Gibbons, et al., (1992).

The calculation of laboratory–specific PQLs (Gibbons, et al., 1992) already incorporates a measure of the statistical uncertainty that is associated with the measurement process. Therefore, any VOC detected and verified at a concentration above the PQL would be statistically significant, and would therefore trigger assessment monitoring. These decision rules only apply in cases where the constituent has rarely, or never, been detected in background.

6.2.2 Inorganic Constituents

A detailed description of the statistical methodology proposed for a site should be included in a monitoring plan. The following text provides a brief summary of the preferred method in Hawaii.

6.2.2.1 For Inter–Well Comparisons

Wells and constituents that show similar variability in upgradient and downgradient monitoring zones should be compared by computing limits based on historical upgradient data. These limits should be used to compare new downgradient monitoring measurements to determine whether a statistically significant event has occurred. The decision factors for determining the most appropriate statistical methodology for use at the site are based on detection frequency and distributional form of the upgradient data, as discussed below.
Three cases can be assessed using the multiple group version of the Shapiro–Wilk test (Wilk and Shapiro, 1968). These cases are: 1) compounds quantified in all background samples, 2) compounds quantified in at least 50% of all background samples, and 3) compounds quantified

in less than 50% of all background samples. This approach allows for the calculation of normal, lognormal, nonparametric, and Poisson prediction limits depending on the detection frequency and distribution of the data. At least four quarters of background samples in at least two upgradient wells are required for the parametric tests and at least 20 to 30 background measurements are needed if nonparametric limits are used. Inter-well prediction limits are normally updated following each sampling event. The specific calculations are summarized in Gibbons and Discerning Systems (April 1994).

6.2.2.2 For Intra–Well Comparisons

The preferred statistical analysis methodology (Gibbons, 1992; Gibbons 1994; Appendix B) for inorganic parameters, when justified, should be based on the combined Shewart–cumulative sum (CUSUM) control chart that is capable of detecting both sudden and gradual changes in groundwater chemistry. Combined Shewart–CUSUM control charts should be constructed for each well where intra-well monitoring is performed to provide a statistical and visual tool for detecting trends and abrupt changes in inorganic groundwater chemistry.

The combined Shewart–CUSUM procedure assumes that the data are independent and normally distributed. The most important assumption is independence (Gibbons, 1994). Therefore, care should be taken to never sample wells more frequently than sample independence can be demonstrated based on site–specific hydrogeological factors, as determined by a qualified hydrogeologist or groundwater scientist.

The assumption of normality is somewhat less of a concern because the data can usually be adequately transformed for most applications. Nondetects (NDs) can be replaced by one–half of the MDL without serious consequence, although this procedure should be applied only to constituents that are detected in at least 25% of all samples. If one or more of the monitoring parameters can not be evaluated using control charts, the Task Force recommends that a combination approach be used, whereby control charts are used for the majority of parameters and an appropriate prediction limit is used for each of the remaining parameters.

The combined Shewart–CUSUM procedure requires a minimum of eight historical independent samples (i.e., background data) to provide a reliable estimate of the mean and standard deviation of each constituent in each well. Once these background data are obtained from each detection monitor well, subsequent sample results are statistically compared to the estimated control limit both in terms of their absolute magnitude and cumulative sum. The specific calculations are summarized in Intra–Well Statistical Methods for Groundwater Monitoring at Waste Disposal Facilities.

6.3 DETECTION VERIFICATION PROCEDURE

Once groundwater analysis results have been collected, checked for QA/QC consistency (Chapter 8) and determined to be above the appropriate statistical level, the results should be verified in accordance with the objectives of 40 CFR Part 258.53 and Section 11-58.1 of

Hawaii's Solid Waste Management Regulations. Verification resampling is an integral part of the statistical methodology described by EPA's Addendum to Interim Final Guidance Document – Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (July 1992). Without verification resampling, much larger statistical limits would be required to achieve site–wide false positive rates of 5% or less. Furthermore, the resulting false negative rate would be greatly increased. The following procedure should be performed for each compound determined to initially be above its statistical limit. Only those compounds that initially exceed their statistical limit should be sampled for verification purposes.

6.3.1 Volatile Organic Compounds

If one or more VOCs is detected above their statistical limit (i.e., PQL), one immediate resample and analysis should be conducted. A statistical exceedance should be recorded and assessment monitoring initiated if any single VOC is measured above the PQL in the verification resample.

6.3.2 Inorganic Constituents

If one or more of the inorganic parameters are detected above their statistical limit (i.e., Shewart–CUSUM control chart computation value for intra-well or prediction limit for intra-well), one verification resample should be collected at the next scheduled sampling event. A statistical exceedance should be recorded and assessment monitoring initiated if verification of an elevated parameter is confirmed for one discrete verification resample.

6.4 ASSESSMENT MONITORING

Assessment monitoring should be conducted in accordance with Section 11-58.1 of Hawaii's Solid Waste Management Regulations if during detection monitoring a statistically significant increase over background has been detected and verified for one or more of the constituents identified in Chapter 5.

CHAPTER 7 LABORATORY ANALYSIS PLAN

7.0 INTRODUCTION

This section describes the procedures for completing successful laboratory analyses of the samples that are collected from the site.

7.1 PROGRAM QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Trip blanks, equipment blanks, and field blanks provide quality assurance and quality control measures for the monitoring program.

7.1.1 Trip Blanks

Trip blanks are a required part of the field sampling Quality Assurance/ Quality Control (QA/QC) program. They are used to detect contamination that may be introduced in the field (either atmospheric or from sampling equipment), in transit (to or from the sampling site), or in the bottle preparation, sample log– in, or sample storage stages at the laboratory. Laboratory method blanks are used during the analytical process to detect any laboratory introduced contamination that may occur during analysis.

Trip blanks are samples of organic–free water (e.g., deionized) prepared at the laboratory. They remain with the sample bottles while in transit to the site, during sampling, and during the return trip to the laboratory. Trip blank sample bottles must not be opened at any time during this process. Upon return to the laboratory, trip blanks should be analyzed using the same procedures and methods that are used for the collected field samples.

Trip blank results should be reported in the laboratory results as separate samples, using the designations TB–(well#) as their sample point designation.

7.1.2 Field Blanks

Field blanks are a highly recommended part of the field sampling QA/QC program. The purpose of the field blank is to detect any contamination, which might be introduced into the groundwater samples through the air. For sites with sampling programs involving VOCs, at least one field blank should be analyzed for the first 20 samples or less. At least one field blank sample should be collected for each day of sampling, and for each subsequent 20 samples, whichever is greater. For programs that do not involve volatile organics analyses, a duplicate well sample should take the place of the field blank.

Field blanks must be prepared in the field (at the sampling site) using laboratory–supplied bottles and deionized or laboratory reagent–quality water. Each field blank is prepared by pouring the deionized water into the sample bottles at the location of one of the wells in the sampling program. The well at which the field blank is prepared must be identified on a Field Information Form, along with any observations that may help explain anomalous results (e.g., prevailing wind direction, up–wind potential sources of contamination, etc.). Once a field blank is collected, it is handled and shipped in the same manner as the rest of the samples.

For dedicated or disposable equipment requiring no filtration, or in–line filtration, the deionized or laboratory reagent–quality water is exposed to the air, transferred to the field blank bottles, and the proper preservative added as required. If the required filtration is not done in–line, the deionized or laboratory reagent–quality water is exposed to the air, poured into pre–filtration bottles, filtered (as required), placed in the field blank bottles, and the proper preservative is added as required.

Field blank results should be reported in the laboratory results as separate samples, using the designations FB–(well #) as their sample point designation.

7.1.3 Equipment Blanks

For non–dedicated equipment, decontamination procedures consist of rinsing the equipment once with deionized or laboratory reagent–quality water, brushing the equipment with a laboratory–quality soap, and triple rinsing the equipment with deionized or laboratory reagent quality water. Deionized or laboratory reagent–quality water is poured into the sampling device (e.g., the bailer) prior to sampling.

If the analytes for the equipment blank would normally be filtered, this water should be placed into a pre–filtration bottle and subsequently filtered. Whether or not it is filtered, this water is placed into the field blank bottles, and the proper preservative added as required.

Equipment blank results should be reported in the laboratory results as separate samples, using the designations EB–(well#) as their sample point designation.

7.2 LABORATORY QUALITY CONTROL PROCEDURES

The quality assurance program for the laboratory is described in their Quality Assurance Program Plan (QAPP), which should be available from the laboratory upon request. The QAPP describes mechanisms the laboratory employs to ensure that all data reported meets or exceeds all applicable EPA and State requirements. It describes the laboratory's experience, its organizational structure, and procedures in place to ensure quality of the analytical data. The QAPP outlines the sampling, analysis, and reporting procedures used by the laboratory. The laboratory is responsible for the implementation of and adherence to the quality assurance and quality control requirements outlined in the QAPP.

Audits are an important component of the quality assurance program at the laboratory. Audits are conducted by the laboratory. Internal system and performance audits should be conducted periodically to ensure adherence by all laboratory departments to the QAPP.

Data Quality Reviews (DQR), or equivalent, are requests submitted to the laboratory to formally review results that differ from historical results, or that exceed certain permit requirements or quality control criteria. The laboratory should prepare a formal written response to each DQR explaining the discrepancy. The DQR is the first line of investigation following any anomalous result.

7.3 PRACTICAL QUANTITATION LIMITS (PQLS)

Laboratory–specific PQLs should be used as the reporting limits of applicable low– detection analytes (especially organics). The EPA developed the concept of the PQL to address the issue of analytical variability. The PQL concept was developed for compliance with the Safe Drinking Water Act (50FR46906, Nov. 13, 1985) where it is defined: "The PQL thus represents the lowest level achievable by good laboratories within specified limits during routine laboratory operating conditions." The EPA states in 52FR25699 (July 8, 1987):

> The Agency developed the PQL concept to define a measurement concentration that is time and laboratory independent for regulatory purposes. Method Detection Limits, although useful to individual laboratories, [do] not provide a uniform measurement concentration that can be used to set standards.

The EPA's defined MDL, as published in 40CFR136, has limited application. The Agency acknowledges that "MDLs are not necessarily reproducible over time in a given laboratory, even when the same analytical procedures, instrumentation and sample matrix are used" (50FR46906, Nov. 13, 1985). As indicated in 52FR25699 (July 8, 1987), the MDLs have had a tendency to be misunderstood by regulatory agencies developing policies for how low– concentration standards (in this case, "detection of a contaminant") can be established. Use of MDL's may result in false positives since EPA admits it is an ideal limit that cannot be reliably measured by even the best laboratories. Therefore, in its regulatory programs, EPA has determined that the PQL is a more appropriate measure for compliance purposes.

While EPA has defined PQLs, these limits are often based on consensus rather than operational definitions and experimental evidence. The actual PQL limit that may be achieved in a specific laboratory for a specific compound may be higher or lower than the PQLs listed in SW–846.

In contrast to the PQL, which is a measure of analytical precision, the MDL is a hypothesis test that leads to the binary decision of whether or not an analyte is present or absent in a sample. The MDL is defined by the EPA as the "minimum concentration of a substance that can be measured and reported with 99 percent confidence that the true value is greater than zero" (50FR46906, Nov. 13, 1985).

Recently developed estimators (Gibbons, et al., 1991) have overcome many of the limitations associated with traditional detection limit estimators by:

1) Providing a test of the null hypothesis that the concentration in the solution is zero with fixed Type I and Type II error rates, and

2) Incorporating uncertainty in the slope and intercept of the calibration function.

This estimator is still limited, however, by the assumption of constant variance across the calibration line and by the application of the estimator to only the next single detection decision. Transformation of the peak area ratio and concentration may bring about constant variance while maintaining linearity of the calibration function, but it is not always sufficient (Gibbons, 1994).

For constituents such as VOCs, which are analyzed by gas chromatography/mass spectrometry (GCMS) and that utilize the internal standard calibration methodology, the computation of PQLs can be derived from the calibration function. In the simplest case of spiked calibration samples in distilled water, these values can be computed directly from calibration samples routinely performed by the laboratory. PQLs obtained in this manner empirically model:

1) The relationship between variability and concentration,

2) The effects of multiple instruments and analysts,

3) The effects of groundwater matrices,

4) A balance of false positive and false negative rates at nominal levels,

5) The effects of background instrument response levels,

6) The effects of recovery bias, and

7) The uncertainty in the calibration line.

A statistical method for computing laboratory–specific PQLs has been developed (Gibbons, et al., 1992). The PQL is operationally defined as the concentration at which the instrument response signal is 10 times its standard deviation. The response signal is defined as the ratio of analyte to internal standard peak areas Ninety–five percent confidence limits for a PQL are also derived. The PQL is estimated directly from calibration data, and uncertainty in parameters of the calibration function are incorporated. The non–constant variance problem is dealt with using a variance stabilizing transformation. Results of these analyses suggest that EPA estimates of PQLs are reasonably consistent with the 10% rsd definition.

PQLs for each VOC to be monitored should be supplied when they are determined at the laboratory. Until these laboratory–specific PQLs are established, the values listed in SW–846 should be utilized.

7.4 ANALYTICAL METHODOLOGIES

Table 7–1 presents the analytical methodologies to be used by the laboratory for all of the parameters required in the monitoring program. All methods are EPA approved and are fully described in the laboratory method and standard operating procedure documents.

Table 7–1

Analytical Methods

Parameter	Method Description	Reference Method
Alkalinity	Total, Methyl Orange	(A) 310.2
Chloride	Ion Chromatography	(A) 300.0
Chemical Oxygen Demand	Colorimetric	(A) 410.4
Dissolved Metals	ICP/ICP–MS	(A) 200.7/200.8
Nitrogen–Ammonia	Colorimetric, Automated Phenate	(A) 350.1
Sulfate	Ion Chromatography	(A) 300.0
Total Dissolved Solids	Gravimetric	(A) 160.1
Total Organic Carbon	Combustion or oxidation	(A) 415.1
Volatile Organic Compounds	Purge & Trap GC/MS equivalent	(B) 8260 or
Semi–VOCs	GC/MS with Solid–phase Extraction	(B) 8270 or equivalent
Total Organic Halides	Microcoulometric Titration, Automated	(B) 9020 or equivalent

References:

(A): Methods for Chemical Analysis of Water and Wastes, EPA 600/4–79–020, EMSL, Cincinnati, OH (Revision March 1983).

(B): Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW–846, 3rd Edition, Update 0.

CHAPTER 8 DATA QUALITY REVIEW, REPORTING, AND RECORD KEEPING

8.0 INTRODUCTION

Prior to the submittal of a monitoring report to DOH, OSWM, several data evaluation, reporting, and record keeping tasks should be implemented. The following sections describe the evaluation, reporting and record keeping procedures that should be followed upon receipt of an analytical report.

8.1 DATA QUALITY REVIEW

Each analytical report received from the laboratory should undergo two levels of quality assessment. These quality assessment procedures are described below.

8.1.1 Initial QA/QC Checks

Before the data are subjected to statistical analysis, a qualified hydrogeologist should evaluate the data by examining the quality control information accompanying the data report from the laboratory. Relevant quality control data include measures of accuracy (percent recovery), precision (relative percent difference, RPD), and sample contamination (blank determinations). Data that fail any of these checks should be flagged for closer evaluation and a DQR. Results of the DQR should be submitted with the analytical data in the routine monitoring report (see Section Laboratory Quality Control Procedures, for a description of DQR). A brief summary of these relevant quality control data follows. A more complete description should be contained in the laboratory Quality Assurance Program Plan.

Accuracy defines the relationship between the laboratory's measurement of a sample's concentration and the "true", but unknown concentration of the sample. Because the "true" concentration is unknown, accuracy must be measured indirectly by determining the percent recovery of a sample called the matrix spike (MS). The MS is analyzed under the same conditions as the groundwater sample and its concentration is determined. Because the MS has a known concentration its percent recovery can be calculated. It is assumed that the groundwater sample behaves exactly like the MS and thus the "true" concentration of the submitted groundwater sample can be back–calculated. Control criteria for percent recovery are taken from regulatory method requirements.

Precision is the assessment of the variability that can be expected in data resulting from the analytical procedures employed. It provides a measure of the reproducibility, which is estimated through duplicate measurements of a matrix spike. Two matrix spike samples are prepared as described above, an MS and a matrix spike duplicate (MSD). Both spikes are analyzed along with the unknown sample and the "relative percent difference" (RPD) between the two spikes is determined. Control criteria for RPD are taken from regulatory method requirements.

The potential for sample contamination is assessed by measurements of "blank" samples. Blanks are samples of ultra–pure laboratory water that are not spiked with any analytes and are carried through the field sampling and laboratory environments. These samples are known as "field," "lab," and "equipment" blanks. It is assumed that any analytes that occur in the field or laboratory, which might add to the concentration of the analyte in the sample, will be picked up by the blank samples and measured. If any of the analytes of interest are found in the blank samples, it is an indication of potential contamination of the unknown sample.

8.1.2 Qualitative Data Evaluation

Following the initial QA/QC checks, all data should undergo a second level of review by graphing historical trends and comparing new results with these historical trends to flag visual outliers or other anomalous data. If a clearly anomalous result is found, a DQR should be initiated with the laboratory to ascertain if laboratory error is involved. In addition, field information should be checked for anomalous occurrences or observations that might help to explain an outlier result.

8.2 DATA RECORD KEEPING REQUIREMENTS

The laboratory maintains all analytical data indefinitely. The laboratory ensures that, at each stage of a process where a permanent data record is required, security measures are in place to guarantee the integrity of the data. Standard Operating Procedures are in place for computer security, computer data storage and back–up.

8.3 DATA REPORTING REQUIREMENTS

Monitoring data should be submitted in reports that summarize all detection monitoring activities that took place during the preceding time period in accordance with State and Federal regulations. An annual report should be submitted after the fourth quarter of each year summarizing monitoring activities for the preceding year. This year–end report will include graphs of all analytical data from each monitoring point and background monitoring point, as required, except for those constituents for which no new data were collected since the previous graph submittal.

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APPENDICES

Appendix A –

Example Chain–of–Custody Form
Monitor Well/Piezometer Standard

Appendix B –

PQL Reference Papers
DUMPStat Reference Paper (Inter–Well and Intra–Well Comparisons)

HAWAII LANDFILL GROUNDWATER MONITORING GUIDANCE DOCUMENT MODULE II:

Assessment Monitoring

Preamble

(Triggered by verified statistical significant increase (SSI) over background in Detection Monitoring program)

1. Evaluate if alternate source
    a) Does an alternate explanation of exceedance potentially exist at site (natural change or spacial variability, upgradient source, manmade cause, etc.)? If not, go to Assessment Monitoring or as otherwise stipulated in Section I, Assessment Monitoring, below. If so, proceed with the following:
    b) Sample upgradient wells
    c) Sample leachate (if possible)
    d) Sample regional wells
    e) Fingerprint groundwater and potential sources (isotopes, Stiff diagrams, Piper diagrams, etc.)
    f) Develop alternate monitoring scheme that incorporates different source(s) by qualified groundwater scientist - e.g., incorporate new data into background if alternate source, or eliminate parameter(s) from routine Detection Monitoring program.
    g) Perform other related tasks as appropriate.

2. If source is verified not to be the landfill, amend Detection Monitoring program to avoid repetitive SSI.

3. If source is verified to be the landfill, move to Assessment Monitoring.

Assessment Monitoring

1. Follow regulation requirements for notification (see Attachment A)

2. Initial Assessment Monitoring → If approval has already been obtained or can be obtained within the required time frame from the Director of an approved state:

    a) Within 90 days of triggering Assessment Monitoring sample only the well(s) that triggered Assessment for Appendix II parameters (i.e., alternate assessment wells [AAW]).
    b) If approval from the Director has not or cannot be obtained within the specified time frame (i.e., 90 days from trigger), sample all of the wells in the approved network for Appendix II parameters.

(Note: The preferred approach is to sample only the well(s) that triggered Assessment, since by definition these are the only wells that are possibly indicative of a release at the facility, and the regulations support this preferred approach (see EPA's guidance document: Solid Waste Disposal Criteria, Technical Manual, 1993, page 286). However, approval from the State Director must be obtained to use a subset of the approved Detection Monitoring network prior to this approach being implemented)

c) If approval cannot be obtained prior to the initial Appendix II sampling, submit a formal request as soon as possible to the State Director to allow the site to address only the well(s) that have triggered a statistically significant increase (SSI) during future Assessment Monitoring.

3. In this manner, only those wells exhibiting impacts are in Assessment Monitoring, while the rest of the site remains in Detection Monitoring (258.55(b)&(d)(2)).

4. Verify any Appendix II parameters that were detected above the relevant laboratory reporting limit or previously established statistical limit and that were not previously verified in Detection Monitoring with a resample as soon as sample independence is achieved. The verification resample should be for the parameter(s) that failed only.

Technical Note: Sample **independence** is controlled by site groundwater flow conditions, and is achieved when sufficient time has passed such that the radius of influence (ROI) from one sample event is substantially beyond the ROI caused by the subsequent sample event. For relatively high permeability groundwater zones (e.g., $>10^{-3}$ cm/sec hydraulic conductivity) sample independence may be obtained within a matter of days. Lower permeability groundwater zones take progressively longer. However, verification resampling should always be performed within three months of determination of SSI.

5. If no Appendix II parameters are detected above the relevant laboratory reporting limit or previously established statistical limit (i.e., background), obtain another independent sample and analyze again for Appendix II. If no Appendix II parameters are detected above background for two consecutive sample events, return to Detection Monitoring and notify state per regulations (see Attachment A & 258.55(e)).

Technical Note: Return **to Detection Monitoring -** Pursuant to 258.55(e), any time during assessment monitoring that Appendix II parameters statistically return to background levels (i.e., Detection Monitoring background levels or background as defined in Assessment Monitoring [see I.7, below]) for two consecutive sample events, the site may return to Detection Monitoring upon notification of the State Director.

6. If an alternate Detection Monitoring parameter (e.g., chloride, ammonia-N, iron, etc.) caused the initial SSI, and no Appendix II parameters are detected in the Assessment Monitoring, perform an alternate source evaluation as described in the Preamble to this guidance document.

a) If it cannot be determined that the landfill is not the source of the alternate parameter SSI(s) (i.e., the landfill could be the source of the SSI), site returns to Detection Monitoring (258.55(e)), however Appendix II sampling occurs at the SSI well(s) once every two years instead of once every five years (as stipulated in normal Detection Monitoring) until the alternate parameters remain below the statistical limit(s) for two consecutive samples. These alternate SSI parameters remain in the monitoring program, but are not used as formal Detection Monitoring parameters until the concentrations return to below SSI levels, or until an alternate source not associated with the landfill is determined to be the cause of the SSI(s).

b) If alternate source analysis performed in I.6., above, determines that the landfill is not the source of the SSI, place results in the operating record and either incorporate the new data into background to recalculate the statistical limits, eliminate the SSI parameters from the monitoring program, or revise the statistical methodology pursuant to ASTM Standard PS-64 96.

7. Develop Background - Develop background for all newly detected and verified Appendix II parameters (see I.4, above) that could be derived from a release at the landfill (see Attachment A), pursuant to the following:

a) Inorganic Appendix II parameter for which background has not previously been established → background should include a minimum of eight independent samples recommend over at least a one year period. Samples should be collected at locations that are appropriate to obtain an accurate representation of background groundwater chemistry in the effected aquifer as determined by a qualified groundwater scientist (all background and downgradient wells must be sampled in the absence of State Director approval).

b) Independent of the background development process for the detected Appendix II parameter(s), obtain a minimum of four independent samples from the SSI well(s) and analyze for the detected Appendix II parameter(s). These data will be necessary to establish a statistical base for ultimate comparison with the Groundwater Protection Standard (see I.12, below). In addition, leachate and groundwater should be sampled for major anions and cations and general leachate indicators (if sufficient data do not already exist) to aid potential future source characterization (see Module I of the Guidance Document for specific parameters). Should the original SSI parameter(s) return to pre-Assessment background levels at any time, analyze two independent samples for full Appendix II list. If two consecutive events verify non-exceedances of pre-Assessment background, notify the State Director and return to Detection Monitoring (258.55(e)).

c) Organic parameters not suspected to previously be in the groundwater system, and inorganic Appendix II parameters for which background has previously been established → collect four independent samples to comply with the regulations (258.55(b)) from appropriate wells and to allow more confident statistical comparison to MCLs or other established and relevent Groundwater Protection Standards). At a minimum, obtain four independent samples from the SSI well(s) and analyze for the detected Appendix II parameter(s). These data will be necessary to establish a statistical base for ultimate comparison with the Groundwater Protection Standard (see I.12, below).

d) Establish background → establish background concentrations for any constituents detected pursuant to I.4, above (258.55(d)(3))).

8. Groundwater Protection Standards (GWPS) → Establish GWPS for all detected Appendix II constituents based on background concentrations if the background concentrations are greater than any published MCL or if no MCL exists for a given parameter. Use the statistical methodologies as outlined in ASTM (e.g., PS-64 96) to determine GWPS using background (if >MCL or no MCL), or the other no-MCL health-based methodology specified in 258.55(i). In all other cases, the MCL should be used if possible.

9. Routine Assessment Monitoring → Recommended procedure: routine Assessment Monitoring should only be performed at the well(s) that exhibited the SSI. All other wells in the approved network should remain in Detection Monitoring. The Director of an approved state must be approached with a proposal allowing this use of a subset of wells in accordance with Section 258.55(b) & (d)(2). Routine Assessment Monitoring should consist of sampling the SSI well(s) 90 days from the verified Appendix II sample date (see I.4, above), and semiannually thereafter, for the routine Detection Monitoring parameters and the detected Appendix II parameter(s) from I.4, above. The full Appendix II parameter list should be monitored at the SSI well(s) every five years (with the approval of the state Director). Semi-volatiles should be monitored at the SSI wells every two years (with the approval of the state Director).

Technical Note: Default **requirements** - in the absence of Director approval as outlined above, the site must monitor all wells in the approved network semiannually and 90 days following the verified detection of Appendix II parameter(s) for detected Appendix II parameters (I.4, above) and routine Detection Monitoring parameters. In addition, annual monitoring must be conducted at all downgradient wells for the full list of Appendix II parameters. Since the regulation allows a less stringent course of action (258.55(b) & (d)(2)), approval from the state Director is strongly recommended to limit the Assessment activities to only the well(s) at which there is evidence of a release from the landfill.

10. If the results of the routine Assessment Monitoring program reveal concentrations less than or equal to background (as determined either in Detection Monitoring or pursuant to I.7, above) for two consecutive sampling events, notify State Director & return to Detection Monitoring.

11. If the results of the Assessment Monitoring program show concentrations greater than background but less than the GWPS, continue Assessment Monitoring (see flow chart in Attachment A).

12. See the attachment by Dr. R.D. Gibbons entitled Statistical Methods for Assessment Monitoring and Corrective Action Programs, 1997, for guidance on determining whether a statistically significant increase over GWPS has occurred.

a) If an SSI over the GWPS is confirmed, notify appropriate parties in accordance with the regulations (258.55(g)), characterize nature & extent of release by installing additional wells as necessary using such methods as geophysics, geochemistry, hydropunch, etc., to define locations of wells and plume characteristics. At least one additional well within the flow path of contaminant migration at the property boundary is required by the regulation. Screen intervals should intercept the preferential groundwater migration pathways. In addition, appropriate landfill operational actions should be implemented to minimize or eliminate the release, if possible.

--- Or ---

b) Perform an alternate source demonstration by a qualified groundwater scientist, if appropriate, and submit the report to the State Director. Until a successful demonstration is made (i.e., approved), comply with I.13a, above, and I.15, below. If the report is approved by the State Director, place in the Operating Record for the site. Continue Assessment Monitoring until all Appendix II parameters are below background levels established incorporating the alternate source concentrations, or eliminate the exceedance parameters from the comparison (with State Director approval), for two consecutive sample events; then return to Detection Monitoring.

13 Obtain approval from the State Director to delete those Appendix II parameters shown to be from an alternate source (i.e., not the landfill) from the routine Detection Monitoring program. The state Director should comply with this request since the parameters would by definition not be effective at detecting a future release from the landfill.

Technical Note: Statistically **significant increase (SSI) over GWPS** - - Additional details on comparing groundwater data to a regulatory limit (e.g., GWPS) is provided in Gibbons, 1994, Statistical Methods for Groundwater Monitoring; John Wiley & Sons.

14 Initiate Assessment of Corrective Measures within 90 days of the verified exceedance of the GWPS (i.e., I.13a, above) if no alternate source evaluation was conducted, if it failed, or if awaiting approval (258.55(g)(2)). There is no formal requirement for state notification in the Federal regulation, although specific state regulations may provide such requirement. This corrective measures assessment must be complete within a “reasonable period of time” (258.56(a)). Results must be presented in a public hearing prior to the selection of the remedy (258.56(d)).

HAWAII LANDFILL GROUNDWATER MONITORING GUIDANCE DOCUMENTMODULE III:

Corrective Action

Assessment of Corrective Measures

1. Assessment of corrective measures must be complete within a reasonable period of time (258.56(a)).
2. Continue to monitor in accordance with the Assessment Monitoring regulations (258.56(b)). Make use of the flexibility identified in this guidance document.
3. Determine and characterize the source within the landfill unit and/or the landfill property boundary (e.g., landfill gas migration, leachate release, condensate release, etc.) - Module II Guidance Document will provide detail on the approaches.
4. Implement any appropriate interim source control measures (i.e., readily repairable engineering condition including unlined leachate storage ponds, gas migration near a certain area of the landfill, failed cover system, leaky leachate force mains, previous leachate sump or stormwater overflows, etc.).
5. If the source is landfill gas, evaluate gas collection control/upgrades in refuse and/or out of refuse ;

a. Consider passive vs. active; bioventing of vadose zone; air sparging of vadose zone;

6. If the source is leachate from landfill leakage, determine if more detailed information is needed on geology, hydrogeology, vadose zone, stormwater/new construction effects on hydrogeology;
   a. determine if additional plume delineation is required, especially horizontal/vertical extent, additional wells/piezometers in area of concern, concerns on more complex areas than originally defined
   b. Consider groundwater modeling if the following is desired:
      i. influences of pumping rates/locations of public/private wells
      ii. prediction of contaminant concentration at exposure points
      iii. evaluation of source control options on groundwater quality
      iv. effects of advection, dispersion, retardation, adsorption, and other attenuating processes (EPA,1989b)

Note: It is critical that all data elements for fully evaluating each potential remedial scenario be collected prior *to selection of the potential remedial options and/or final remedy.*

7. Evaluate risks to existing and future off-site receptors and potential impacts on sensitive receptors
8. If no threats to receptors, (e.g., groundwater is in UIC area), evaluate remediation by natural attenuation (RNA) as follows:
    a. Evaluate plume status:
        i. Wells near source
        ii. Wells downgradient on flowline
        iii. Edge of plume within 10-20 ppb
        iv. Four or more sampling events at each well
    b. If plume is not stable, shrinking, or if the status is unknown, collect additional data/parameters in order to evaluate plume dimensions further, and/or to provide evidence that biodegradation is or is not occurring. In addition, more sophisticated data may be required such as isotope geochemistry and bacterial investigation & counts (see RBCA Guidance Document)
    c. If plume is stable or shrinking, compare estimated or modeled RNA performance to remediation goals:
        i. If RNA meets goals, compare to source controls, active groundwater pump and treatment, and other active remediation;
        ii. If RNA is more cost-effective and timely, then select RNA, if not, then consider a combination of active groundwater treatment, (e.g., in-situ bioremediation)
9. If there are potential risks to off-site receptors, consider source controls, containment, and interim measures;
    a. Landfill surface water infiltration controls
    b. Leachate collection and removal
    c. Leachate recirculation
    d. Liner repair/localized source removal
    e. Slurry wall
    f. Pump and treat groundwater for hydraulic control
    g. In-situ treatment by chemicals, permeable treatment walls, air sparging, enhanced bioremediation

Technical Note: The risk of the release to human health and the environment should be evaluated to help in the selection of the appropriate remedial alternative. Interim measures may need to be taken during the corrective measures assessment if there is high risk to human health and the environment. A risk assessment as the sole remedial alternative is not permitted in the regulation. ((((((((See USEPA's guidance document: Solid Waste Disposal Criteria, Technical Manual, 1993, pages 300-308.

10. Analyze above potential corrective measures - list options, address at least the following:
    a. The performance, reliability, ease of implementation, and potential impacts (e.g., safety, cross media effects, etc.) (258.56(c)).
    b. The time required to begin and complete the remedy (258.56(c)(2)).
    c. The costs of implementation (258.56(c)(3)).
    d. Permit requirements prior to selection of the remedy (258.56(c)(4)).
11. Present the results in a public hearing with interested and affected parties prior to selection of the remedy (258.56(d)).

Technical Note: Module III Guidance Document will address corrective measures recommended for waste disposal facilities in Hawaii. UIC issue will also be addressed (i.e., conditions that corrective action may be necessary outside the UIC, etc.).

Selection of Remedy

1. Select list of possible remedy(ies) based on the results of the corrective measures assessment (258.56).
2. The Director of an approved state may determine that remediation is not necessary (258.57(e)) if it can be demonstrated that:
    a. Contaminants are adequately shown to be derived solely or additionally from an alternate source such that remediating the landfill contribution (if any) produces no significant reduction in risk to receptors; or
    b. Contaminants are not currently or reasonably expected to be in groundwater used as a source of drinking water, and are not
        i. Laterally or vertically hydraulically connected[*1] to other drinkable groundwater units; or
        ii. migrating to other connected units[*1]; or
        iii. migrating at concentrations that will exceed the GWPS at the drinkable connected unit (i.e., attenuation factors[*1] will keep the contaminants below the GWPS);

        or,

    c. Remediation of the release is technically impracticable, or
    d. Remediation results in unacceptable cross-media impacts (e.g., excessive groundwater-to-air transfer of VOCs, adverse discharge to surface water, or impact to connected groundwater zone(s) from pumping or other remediation efforts).

→ If such a determination is made, obtain approval from the State Director, and return to routine assessment monitoring.

[*1]Technical Note: A lack of **hydraulic connection** to the affected groundwater zone is defined as groundwater that is naturally geochemically distinct and/or that acts independently when appropriately stressed by pumping, and that is separated by a lower hydraulic conductivity intervening stratigraphic or lithologic interval (e.g., a transmissivity of about 0.1 ft^2/day of the intervening unit should be sufficient. Nominally, a 20- to 30-year migration time is considered adequate). It can be concluded that contaminants do not have the potential to **migrate toward other hydraulically connected units** if the affected groundwater zone is hydraulically downgradient of the connected groundwater unit. The hydraulic relationship is determined by installing appropriately placed well nest(s) screened in the impacted and potentially connected groundwater zone. If the impacted groundwater is hydraulically downgradient of the potentially connected zone, it may be concluded that migration will not occur. **Attenuation factors** include retardation, dispersion/dilution, adsorption, biodegradation, etc., as determined by a qualified groundwater scientist. An exemption from remedial action may be sought if it can be demonstrated that attenuation, advection/dispersion or other processes can remove the threat to interconnected aquifers. This exemption can only be sought if the contaminated zone is not a source of drinking water. If it can be shown that attenuation factors will reduce the concentrations of the contaminants to below-GWPS levels prior to arrival at the connected groundwater zone, this portion of the criteria for non-remediation has been met.

→ Otherwise:

3. Proceed with the final remedy(ies) decision procedure as outlined below.
4. The final remedy(ies) must meet the following standards (258.57(b)):
    a. Be protective of human health & environment;
    b. Must attain GWPS everywhere within the plume;

c. Control the source(s) of releases to reduce or eliminate additional releases;
d. Comply with standards for management of wastes (e.g., determination of solid waste, no hazardous waste generation, etc.).

5. The selected remedy must be evaluated using factors as specified in Section 258.57(c)(1)-(5). See the attached flow chart for step-by-step decision procedure. When applying the evaluation factors to the remedy selection process, a scoring should be maintained to allow selection of the best possible remediation scenario(s). It is likely that none of the remedies under consideration in any release scenario will satisfy all of the evaluation factor criteria completely.
   a. The following discussion of the evaluation factors is provided for clarification and ease of implementation:
      i. The final remedy(ies) should reduce the existing risks (258.57(c)(1)(i)) → the greater the reduction, the higher the scoring should be. Any remedy(ies) that does not significantly reduce exiting risks should be eliminated or modified;
      ii. The final remedy(ies) should reduce risk of ongoing or future releases (258.57(c)(1)(ii)) → the greater the reduction of future releases, the higher the scoring. Any remedy(ies) that does not significantly reduce risk of further releases should be eliminated or modified;
      iii. If the final remedy requires excessive long term management (monitoring, operation & maintenance) (258.57(c)(1)(iii)) → reduce the score, eliminate from further consideration, or modify appropriately;
      iv. If the final remedy(ies) pose a significant risk to human health or the environment due to excavation, transportation, or other operational/implementational impacts (258.57(c)(1)(iv)) → reduce the score, eliminate from further consideration, or modify appropriately;
      v. The longer a given remedy(ies) will take to achieve final remediation, the lower the score should be (258.57(c)(1)(v)) → options that require excessive lengths of time for completion should be eliminated from consideration or modified appropriately;
      vi. If the final remedy(ies) result in a high potential for exposure of humans and environmental receptors to the residual wastes (258.57(c)(1)(vi)) → reduce the score, eliminate from further consideration, or modify appropriately. The additional threat of removing the waste to humans and environmental receptors should be considered when evaluating this factor.
      vii. The long-term reliability of the remedy(ies) should be evaluated and considered (258.57(c)(1)(vii)) → if the institutional or engineering controls of the remedy under consideration is not reliable in the long-term, reduce the score eliminate from further consideration, and/or alter appropriately.
      viii. If there is a high potential that the remedy(ies) will have to be replaced in the future (258.57(c)(1)(viii)) → reduce the score, eliminate from further consideration, or modify appropriately.

ix. Evaluate the potential remedy(ies) regarding its ability to control the source to reduce potential future releases (258.57(c)(2)(i)&(ii)) → the less a given remedy will control the source, the lower the score should be or the remedy should be eliminated or altered. This factor incorporates primarily containment and treatment options of the waste, if any.

b. The ease or difficulty of implementing the remedy(ies) should then be evaluated (258.57(c)(3)). The criteria for evaluating this factor include:

i. Degree of difficulty associated with constructing the technology (258.57(c)(3)(i))→ the greater the difficulty in construction, the lower the score should be for this factor. Excessively difficult options should be eliminated or altered appropriately.

ii. Expected operational reliability of the option(s) (258.57(c)(3)(ii)) → the less reliable a given remedy is expected to be (i.e., expected level of upkeep and maintenance), the lower the score should be for this factor. Excessively unreliable options should be eliminated or altered appropriately.

iii. Need to coordinate and obtain approvals/permits from other agencies (258.57(c)(3)(iii)) → This factor affects primarily the timing and expediency of implementing a given remedy. Score this factor based on the ease of full implementation of the remedy, and eliminate or alter any options requiring excessive coordination with other regulatory bodies.

iv. Availability of necessary equipment or specialists (258.57(c)(3)(vi)) → If a given remedy requires technology that is difficult to obtain, or is such that very few qualified specialists capable of designing, implementing, and maintaining the given remedy are available, lower the score or eliminate/alter the option.

v. Available capacity and location of needed treatment, storage, or disposal services (258.57(c)(3)(v)) → If the remedy incorporates the need for TSD services (e.g., pump & treat effluent disposal, soil excavation and/or source removal, ex-situ soil treatment and disposal, etc.), evaluate the availability, cost, capacity, and proximity of the TSD service. Lower the score or eliminate the option if the service is not adequate for the given remedy.

c. The practicable capability of the owner or operator to implement and maintain a given remedy should then be evaluated (258.57(c)(4)) → this factor takes into consideration the economic and technical capability of the owner/operator. The final remedy should not exceed the capability of the owner/operator, while still achieving the cleanup goals of the corrective action program (258.58).

d. Finally, the degree to which the given remedy(ies) address the concerns identified based on the public meeting held in 258.56 should be evaluated. The given remedy(ies) should be given a greater score if it addresses these concerns to a greater degree.

6. Once all of the identified remedies in 258.56 have been evaluated based on the above factors, the surviving options should be ranked based on the scoring each received. Based on this ranking, and the degree to which any one remedy can achieve the goals as outlined above, one or more of the remedies should be selected for implementation.
7. Within 14 days of selecting a remedy, notify the state Director and place in the operating record of the site a report that describes the selected remedy and how it meets the standards listed in II.3, above.
8. Specify schedules for initiation and completion of remedial activities as specified in Section 258.57(d)(1)-(8). Initiation and completion must be "within a reasonable time," considering, among other factors, the following:
    a. The extent and nature of the contamination(i.e., if the plume is small and on-site, less costly source controls may be implemented prior to groundwater treatment in order to increase effectiveness);
    b. Desirability of using technologies not yet available but that may offer advantages over available technologies if the exposure risks are relatively low (i.e., the selected remedy could be delayed until the innovative technology becomes available or is proven effective);
    c. Potential risks to human health and the environment of the contamination prior to remediation;
    d. Resource value of the aquifer;
    e. If it is shown by modeling that RNA meets treatment goals before any source, containment, or ex-situ groundwater treatment option, then this should be the preferred treatment technology
    f. Practicable capability of the owner or operator, etc.

9. Approval not to actively remediate a release to groundwater does not preclude the State from requiring the owner/operator to institute source controls to reduce or eliminate the threat to human health or the environment (258.57(f)).
10. Source control should be an important part of any remedial action decision. In many cases, source controls such as those listed above (see I.4.b, above) will be sufficient to not only result in reduction of the threat to human health and the environment, but also to ultimately result in achievement of below-GWPS levels in surrounding groundwater.

Implementation of the Corrective Action Program

1. Establish & implement corrective action monitoring program (258.58(a)(1)) that:
    a. Follows the assessment monitoring program, at a minimum (see Module II);
    b. Provides an indication of the effectiveness of the corrective action remedy. Such indications would include trend and outlier identification, reduction in number of detected Appendix II parameters, capture zone radius monitoring (if applicable), downgradient migration assessment (increasing trends, detections at unimpacted wells, etc.), and other methods as determined by a qualified groundwater professional;

c. Demonstrates compliance with the GWPS (See Module II, statistical supplement) in accordance with II.7, below.

2. Implement the corrective action remedy(258.58(a)(2)).
3. Take any interim measures during the corrective action necessary to ensure protection of human health & the environment (258.58(a)(3)). Any implemented interim measures should be consistent with and contribute to the ultimate corrective action remedy. To determine whether interim measures are necessary, consider the following:
    a. Time required to develop and implement corrective measure (e.g., if rapid implementation, the need for interim measures is demented);
    b. Risk of hazardous constituents affecting human health and the environment;
    c. Risk of further degradation of the groundwater resource;
    d. Risk of catastrophic degradation of a container or handling system relating to the source of impacts or to the selected remedy.

Note: Interim measures can take many forms in dealing with potential gas or leachate exclusions from landfills. In cases where operational procedures or plant breakdowns are shown to cause the observed exceedances, interim measures may represent the main remedy for the facility.

4. If it is determined that the selected remedy is not achieving compliance with the GWPS and reduction or elimination of the source(s) in accordance with I.3 (258.57(b)), above, the owner/operator is to select an alternate remedy that can practicably achieve these results (258.58(b)), unless a determination is made that no such remedy exists, as discussed in II.5, below.
5. The requirements of the alternative measures are applicable when it becomes apparent that the remedy selected will not achieve the GWPS's or other significant objectives of the remedial program (e.g., protection of sensitive receptors). In determining that the selected corrective action approach will not achieve desired results, the owner/operator should implement alternative corrective measures to achieve the GWPS's. If it becomes evident that the clean-up goals are not technically obtainable by existing practicable technology, the owner/operator must implement actions to control exposure of humans or the environment from residual contamination and to control the sources of contamination. Prior to implementing alternative measures, the owner/operator must notify the director within 14 days that a report justifying the alternative measures has been placed in the operating record.
6. An owner/operator is required to continue the assessment monitoring program during the remedial action. Through monitoring, the short and long term success of the remedial action can be gauged against expected progress. During the remedial action, it may be necessary to install additional ground water monitoring wells, or make adjustments to the operations of the facility in order to achieve the desired results. As the remediation progresses and data are compiled, it may become evident that the remediation activities will not protect human health and the environment, meet GWPS's, control sources of contamination, or comply with waste management standards. The owner/operator should compare treatment

assumptions with existing conditions to determine if assumptions adequately depict site conditions. Implementation may be modified to improve treatment effectiveness. If the existing technology is found to be unable to meet remediation objectives, alternative approaches must be evaluated that could meet the objectives while the present remediation continued. During this reevaluation period, the owner/operator may suspend treatment only if continuation of the remedial activities clearly increases the threat to human health and the environment.

7. If the owner/operator determines that there is no currently available remedy that can practically achieve the criteria listed in I.3, above, the owner/operator must (258.58(c)):

   a. Obtain certification from a qualified groundwater scientist or approval from the State Director;
   b. Implement alternative measures as necessary to protect human health and the environment from residual contamination;
   c. Implement alternative source control, removal, or decontamination measures as technically practicable and consistent with the overall objective of the remedy.
   d. Notify the State Director within 14 days that a report justifying the alternative measures has been placed into the operating record prior to its implementation.

8. All solid wastes managed as part of the remedy or interim measure must be managed in a manner that protects human health and the environment and that complies with RCRA requirements (258.58(d)).
9. Remedies selected pursuant to I.1-9 (258.57), above, will be considered complete when the owner/operator achieves the following (258.58(e)):

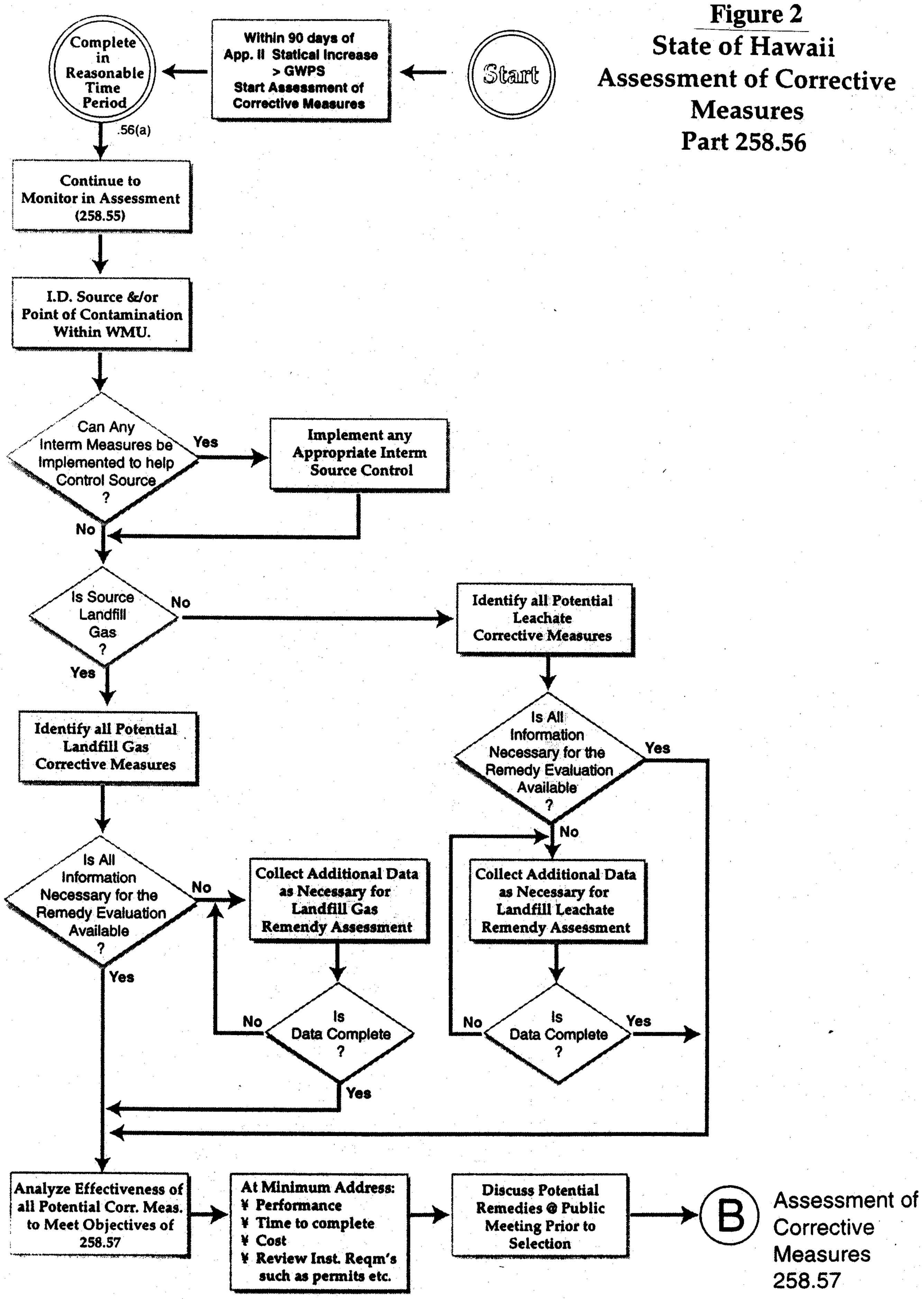
   a. Compliance with the GWPS at all points within the plume of contamination beyond the established detection monitoring network for the site – that is, beyond the point of compliance;
   b. Compliance with the GWPS is achieved when all Appendix II parameters are statistically below the GWPS using the statistical methodology identified in Attachment I, hereto, for a period of three consecutive years. The State Director may specify an alternate GWPS compliance period taking into considering the following:
   c.
      i. Extent and concentration of the release(s);
      ii. Behavior characteristics of the contaminants;
      iii. Accuracy of the monitoring or modeling techniques (factors affecting the accuracy may include seasonal, meteorological or other factors);
      iv. Characteristics of the groundwater;
      v. All actions required to complete the remedy have been satisfied.
   d. These criteria apply to facilities conducting corrective action. Remedies are considered complete when, after 3 consecutive years of monitoring (or an alternative length of time as identified by the Director), the results show statistical evidence that Appendix II constituents concentrations are below

GWPS's. Upon completion of all remedial actions, the owner/operator must certify to such, at which point the owner/operator is released from financial assurance requirements.

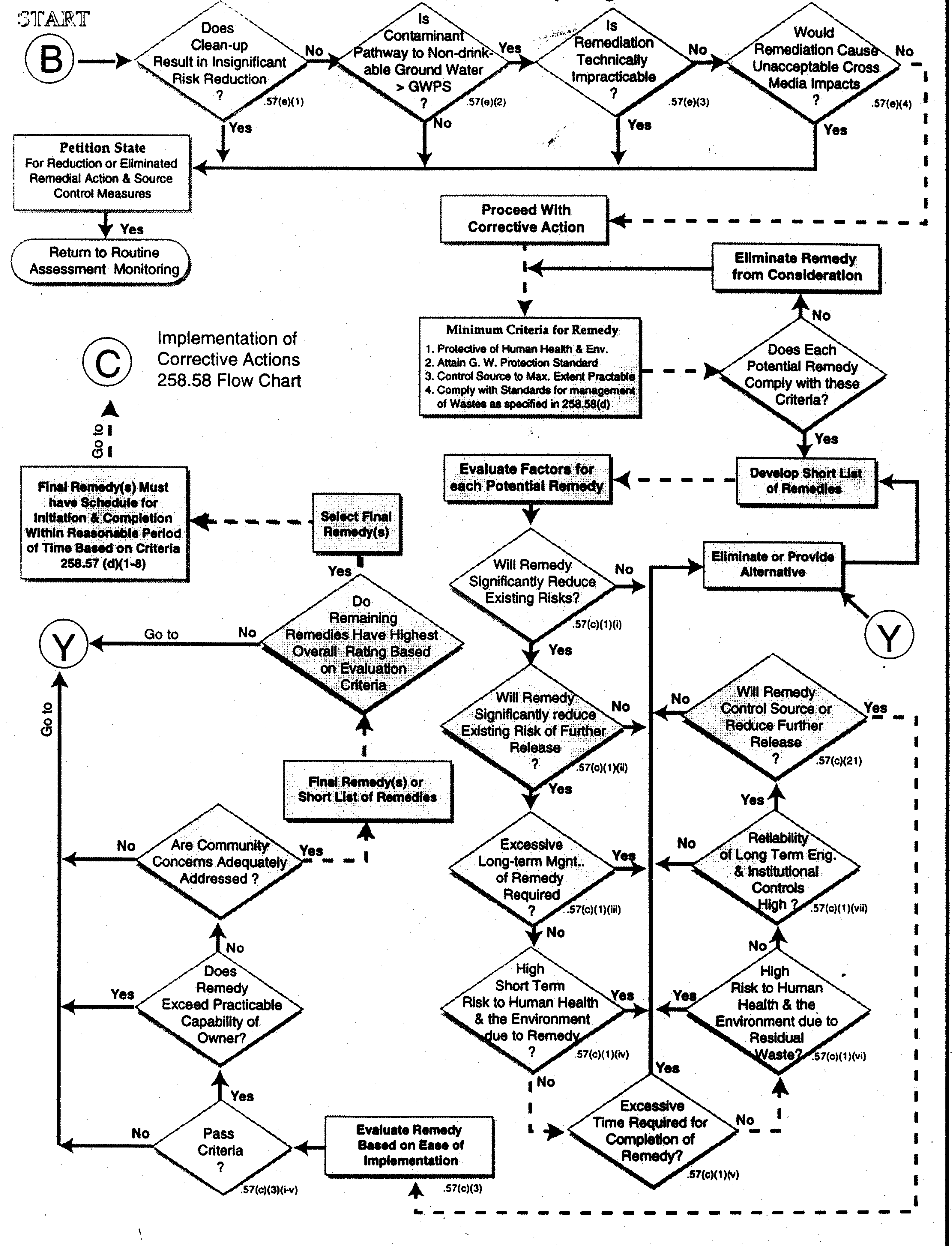
e. The regulatory period of compliance is 3 consecutive years at all points within the contaminate plume that lie beyond the ground-water monitoring system, unless the Director specifies an alternative length of time. The Director may require an alternative time period to demonstrate compliance considering the following:
   i. The extent and concentration of the release;
   ii. The behavior characteristics (fate and transport) of the hazardous constituents in the ground water (e.g., mobility, persistence, toxicity etc.);
   iii. Accuracy of monitoring or modeling techniques, including any seasonal, meteorological or other environmental variability that may affect accuracy;
   iv. The characteristics of the ground water (e.g., flow rate, pH, etc.)

10. Upon completion of the remedy, the owner/operator must notify the State Director within 14 days that a certification has been placed in the operating record stating that the criteria listed in II.7 (258.58(e)) have been met. The certification must be approved by the State Director, or signed by a qualified groundwater scientist and the owner/operator (258.58(f)).
11. Upon satisfactory completion of the corrective action in accordance with the above criteria, the owner/operator is released from the requirements for financial assurance for corrective action (258.58(g)).

Figure 2
State of Hawaii
Assessment of Corrective Measures
Part 258.56



State of Hawaii Selection of Remedy Program 258.57



State of Hawaii Implementation of Corrective Actions Program:-- 258.58

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