APPENDIX D

KENT HIGHLANDS LANDFILL POST-CLOSURE OPERATIONS AND MAINTENANCE MANUAL, CHAPTER 7, LANDFILL GAS COLLECTION AND TRANSMISSION

Chapter 7

Landfill Gas Collection and Transmission

The purpose of the landfill gas collection and transmission system is to extract landfill gas from the refuse and transmit it to the flare facility in order to prevent both off-site gas migration and the build-up of gas pressure, which could potentially damage the landfill cover system. Landfill gas is generated through the bacterial decomposition of refuse under anaerobic conditions (i.e., in the absence of oxygen). It is primarily composed of methane and carbon dioxide with traces of other components. Extraction of gas is accomplished by applying a vacuum from the flare facility to the landfill through the collection piping and the gas extraction wells and trenches.

The goal in operating the landfill gas collection and transmission system is to extract the same volume of gas as is generated through decomposition. If the gas is not collected or otherwise vented, pressure within the landfill can build, and landfill gas can potentially migrate laterally away from the landfill site. However, if too much vacuum is applied to the landfill, air can be drawn into the refuse. This can create the potential for other serious problems. When air is introduced into the refuse, aerobic micro-organisms begin to multiply. Decomposition under aerobic conditions occurs more rapidly and at higher temperatures than under anaerobic conditions. With the presence of sufficient oxygen, temperatures can elevate to the point where spontaneous combustion can occur, igniting the refuse. The resulting underground refuse fire can damage gas extraction wells and trenches, as well as create large areas of subsidence, damaging the cover system and surface facilities (e.g., roads and stormwater drainage facilities). For these reasons, close attention is required to maintain anaerobic conditions in operating the gas collection system while also maintaining a vacuum over the entire landfill.

7.1 Description

The landfill gas collection and transmission system for the Kent Highlands Landfill consists of two main subsystems: the interior gas extraction system and the perimeter gas migration control system. The interior gas extraction system is located within the limits of refuse and is made up of gas extraction trenches and wells, vent risers, and a manifold, hereafter referred to as the interior manifold. Gas is also extracted from leachate manholes. The perimeter gas migration control system is located outside the limits of refuse in native soil and consists of migration control wells, operational probes, and a manifold, hereafter referred to as the perimeter manifold. The vent pipes, trenches, wells, and leachate manholes are connected to a forced exhaust system, which discharges the gas to a landfill gas flare facility at the eastern end of the landfill (see Chapter 8). Two main manifold branches convey gas collected from the interior of the landfill, and a main perimeter manifold loop conveys gas collected from the perimeter wells. All the landfill gas facilities described in this chapter are shown on Map D.

The gas extraction trenches and wells were installed in the landfill during final closure construction in 1994 and 1995. A series of perimeter gas migration control wells were installed during the RI and flare facility construction. They have been placed in native soils at the landfill perimeter along its north, west and south sides. Operational probes are situated between some of the perimeter wells to provide feedback on the effectiveness of the landfill gas control system.

The interior and perimeter manifold pipes also provide for condensate collection and conveyance. The manifold piping slopes toward a low point at the east end of the landfill. Condensate drains from the manifold system through a trap located in the 18-inch header before it enters the flare facility. The condensate drainage system is described in further detail in Chapter 8, Flare Facility.

Table 7.1-1 provides a listing of all the gas extraction and migration control points. The locations of all of the landfill gas collection and transmission facilities are shown on Map D, which is included in the back of this document.

7.1.1 Gas Extraction Trenches

The gas extraction trenches are horizontal gas collectors installed within the refuse just below the base of the overlying interim cover soils. Each gas extraction trench consists of a 6-inch perforated, corrugated polyethylene (CPE) pipe placed in a gravel-filled trench that is approximately 4 feet wide by 5 feet deep. The ends of the perforated collection pipes are connected to a solid HDPE pipe, which has been brought up through the surface of the cover system, sealed with a blind flange, and covered by a protective vault to provide a gas extraction trench cleanout port. Labcock valves are installed in the flanges of these cleanout ports to permit pressure measurement and gas sampling. Figure 7.1-1 shows a typical gas collection trench riser.

There are four gas extraction trenches (approximately 1,100 feet, 1,000 feet, 400 feet, and 500 feet in length) installed in the Kent Highlands Landfill. Three are in refuse, and the fourth, a 1,000-foot-long gas extraction pipe is located in the gravel backfill for the leachate collection pipe running between manholes A and B on the leachate toe buttress collection system. The longest in-refuse trench, located at the west end of the landfill, is also the deepest. The refuse in this area was covered by as much as 28 feet of soil in places to achieve the final surface grade.

The gas extraction trenches are connected to the manifold at trench riser control valve stations that also have monitoring ports. The trench risers are constructed of 6-inch HDPE pipe. Each trench has at least one control valve station, and the longest trench has three. All control valve stations are connected to the interior manifold, except one at the south end of the longest trench, which is connected to the perimeter manifold.

7.1.2 Gas Extraction Wells

Gas extraction wells are vertical collectors drilled into the refuse. At the Kent Highlands Landfill, there are 27 gas extraction wells ranging in depth from 37 to 153 feet. Each gas extraction well consists of a 2-foot-diameter borehole into which Schedule 80 polyvinyl chloride (PVC) pipe has been placed. The area between the pipe and the borehole is backfilled with permeable drain gravel. The lower portion of the pipe, or well screen, is 8 inches in diameter, has slotted perforations and extends from approximately 5 feet above the bottom of the refuse up to approximately 21 feet below the HDPE geomembrane of the cover system. The upper portion of the well is a 6-inch-diameter Schedule 80 PVC pipe that consists of a 15-foot-long section of slotted well screen and a section of solid well casing. The well casing section extends from approximately 6 feet below the surface through the cover system and provides an above-ground, valved connection to the gas collection manifold at the control valve station. The well screen section of 6-inch-diameter schedule 80 PVC pipe is installed in the 8-inch-diameter well screen to create a telescoping joint. Slip boots in the HDPE cover along with these telescoping joints are designed to accommodate the movement that will result from the settlement of the refuse. Figure 7.1-2 shows a typical interior gas extraction well construction.

7.1.3 Vent Risers

A number of vent risers were installed in the landfill during active operations. They originally served as passive gas vents with “tiki-torch” flares attached to the top. Many of these vents were connected to perforated leachate drain pipes that were also installed during the landfill operations. Although most of these vent risers have been abandoned since the installation of the gas extraction trenches and wells, a few were left in service because they had a significant amount of gas flowing from them. There are currently 6 active vent risers. The typical vent riser is a 6-inch-diameter Schedule 40 PVC pipe fitted with a 2-inch-diameter PVC control valve station and connection to the HDPE manifold. There are no maps or records of the depths, lengths, or locations of these perforated pipes within the refuse.

7.1.4 Leachate Manholes

Gas is collected from four of the leachate manholes: MH-A (KLM-A), MH-B (KLM-B), MH-SD (KLM-SD) (spring drain), and MH-SL (KLM-SL) (south leachate). A 6-inch-diameter HDPE pipe is located within the manholes and runs to the nearest interior manifold branch. Each lateral is controlled by a butterfly valve to permit control of the extraction of gas from the manhole it serves. Because the manholes are not air tight, the operators may choose to normally leave these valves closed and open them only to purge the manhole prior to opening the covers for inspection or entry.

7.1.5 Interior Manifold

The interior manifold is the primary pipeline that transports landfill gas from the refuse area extraction points to the flare facility. It is constructed of HDPE pipe and consists of two main branches: the north interior manifold and south interior manifold. The north interior manifold is approximately 2,400 feet long and consists of 6- and 8-inch pipe. The south interior manifold is 2,800 feet long and consists of 6-, 8-, and 10-inch pipe. Lateral pipes connect the extraction trenches, wells, and vent risers to either branch of the interior manifold. Lateral pipes that connect more than one extraction trench, well, or vent riser to the manifold are fitted with butterfly valves and sampling ports for control and isolation of the entire lateral pipe.

There is a 6-inch-diameter cross-connection pipe between the north and south interior manifolds near the west end that provides a manifold connection for one extraction well (KIGW-20) and two vent risers (N49 and S-76). The connection pipe has butterfly valves at each end to allow the collected gas to flow in either direction, through the north or south branches.

There are also three cross-connections between the interior and perimeter manifolds to provide alternative gas flow paths in the event of a blockage in either system. A butterfly valve at each cross-connection isolates the two systems. These cross-connections are located at the:

- South interior manifold near vent riser X-7 and migration control well KDGW-112 on the south side of the landfill
- South interior manifold near vent riser N-59 and migration control well KSGW-102A on the west side of the landfill
- North interior manifold east of vent riser N-47 and migration control well KDGW-96 on the north side of the landfill (This cross-connection has a tie-in to the backup flare facility.)

The interior manifold is situated above ground for most of its length except for the section on the steep slopes at the eastern end of the landfill·. Just west of the upper bench on the east slope, both branches go below ground and are buried within the final cover system topsoil layer above the HDPE geomembrane. All interior manifold piping maintains a positive slope to the east to permit condensate to drain into the leachate collection system near the flare facility. Two short sections of the south interior manifold and one short section of the north interior manifold at the western end of the landfill have been fitted with adjustable pipe supports to allow a proper drainage slope to be maintained as the landfill settles.

The north and south branches of the interior manifold converge into one 12-inch HDPE pipe just before the junction of the interior and perimeter manifolds at a point approximately 40 feet from the flare facility. The interior manifold is fitted with an isolation valve and tee with blind flange prior to this junction so that gas flows in the interior manifold can be diverted to an energy recovery facility should one be built.

7.1.6 Migration Control Wells

Migration control wells have been installed in native soils around the perimeter of the landfill just outside the limits of refuse to intercept landfill gas that may have escaped from the landfill. There are 55 migration control wells. The 31 shallow wells range from 15 to 81 feet in depth; the 19 deep wells range from 75 to 157 feet in depth. Shallow wells are screened in sand and gravel units above the shallowest water-bearing zone, and deep wells are screened in sand and gravel units above deeper water-bearing zones. Because the depths of the water- bearing zones are variable, there is some overlap in the depths of the shallow and deep migration control wells. The shallow wells have 4-inch-diameter, and the deep wells have 6-inch-diameter Schedule 40 PVC well casing and screen installed in 12-inch-diameter boreholes. Permeable drain gravel fills the space between the borehole and the well screen and casing. A reducing tee is fitted to the top of each casing. These tees provide a connection to the perimeter manifold and serve as the control valve station. A typical migration control well is presented as Figure 7.1-3.

7.1.7 Gas Probes

Gas probes consist of small-diameter (1/2-inch or 3/4-inch) PVC pipes installed in 8-inch- diameter boreholes. The pipes have a slotted section open to the soil pore space, referred to as a “sampling screen,” at their bottoms. The space between the slotted sections of the pipe and the sides of the borehole are filled with pea gravel. Typically, each borehole has a cluster of up to four probe pipes installed at varying depths that correspond to gas-bearing zones in the ground. These are labeled and color coded as: S (shallow), yellow; M (middle), green; I (intermediate), orange; and D (deep), red. The vertical spaces in the boreholes between the gravel-packed zones around each of the slotted sections of pipe are filled with hydrated bentonite or grout to keep the gas sampling zones separate. Figure 7.1-4 shows the typical probe construction.

The gas probes are separated into two groups by their functions. One group (operation probes) is used to measure the vacuum in the native soil between the perimeter wells. From this information, adjustments can be made to adjacent perimeter wells to optimize the vacuum curtain effectiveness. The second group (migration control probes) is used to monitor the migration of gas from the landfill.

7.1.7.1 Operation Probes

Nineteen probes installed along the line of perimeter gas control wells are used to provide operational data on the extent of influence of the control wells. These probes were intended to serve three purposes.

- The probes were drilled before the control wells, providing stratigraphic information that allowed for the fine-tuning of the screen depths in the control wells. Probes were installed to test the region of influence of the control wells when they came online.
- The probes were used in the pump testing program that was conducted after the control wells were installed. The pump test results provided maximum well flow estimates that then served as the basis of design for the manifold piping.
- The probes can be checked periodically to ensure the system is properly balanced. Checking the pressure in these probes will show whether there is excessive or insufficient vacuum in the subsurface region around each of the control wells. Table 7.1-2 lists the operation probes and the control wells on either side of them.

7.1.7.2 Migration Control Probes

A large number of subsurface gas monitoring probes have been installed in the vicinity of the Kent Highlands Landfill during the remedial investigation and earlier investigations in order to understand the extent and nature of subsurface gas migration and the hydrogeologic conditions influencing subsurface gas migration. A total of 32 of these probes are still in existence. However, not all of them may be capable of being monitored because of water or other blockages, and not all of them show any evidence of landfill gas migration. Table 7.1-3 lists the migration control probes still in existence around the site. A subset of the migration control probes is used for landfill gas compliance monitoring (see Chapter 11).

7.1.8 Perimeter Manifold

The perimeter manifold is the primary pipeline that transports landfill gas collected by the migration control wells to the flare facility. It is constructed of HDPE pipe and forms a loop around the entire perimeter of the landfill; at the edge of the area of refuse. The continuous loop design reduces the number and severity of problems such as blockage, which can be caused by the build-up of condensate in the gas collection manifold. Both ends of the manifold terminate at the flare facility at the toe of the sloped east end of the landfill.

All the migration control wells are connected to the perimeter manifold. In addition, 3 vent risers (N-55, X-34, and X-31) and 1 gas extraction trench riser (KIGT-1), all of which are located near the edge of the refuse, are connected to the perimeter manifold because they are not located near the interior manifold.

Along most of its length, the perimeter manifold is buried approximately 3 feet below the ground surface. The manifold was designed and installed to maintain a positive slope from the northwest comer of the landfill toward the flare station at the east end. This allows condensate to drain via gravity to a single drainage point located downstream of the junction with the interior manifold just before the manifold connects to the flare facility. Along the southwest portion of the landfill, the perimeter manifold is buried up to 19 feet deep under the South Perimeter Road to maintain a downward slope to permit the drainage of condensate from the west end of the landfill. Along the southeast portion of the landfill, just east of the lower bench road, the perimeter manifold crosses over onto the area of refuse. It is buried within the final cover system topsoil layer above the HDPE geomembrane, daylighting at the junction with the interior manifold near the flare facility.

7.1.9 Manifold Valve and Cleanout Stations

Both the perimeter and interior manifolds are equipped with valve and cleanout stations, which are located at approximately 400-foot intervals. Each station contains a butterfly valve that provides manifold control and two cleanouts that provide access to the manifold pipe on either side of the valve. Manifold control valves are used to adjust the amount of vacuum applied to large portions of the system. They also permit one or more sections to be taken out of service for cleaning, inspection, or repair, while the remaining sections continue to function normally. The cleanouts are made of 6-inch-diameter PVC pipes with expanding sewer-type plugs in the open ends. Labcock valves (3/8-inch nominal size) and 1/2-inch sampling ports are provided on each cleanout pipe for gas monitoring and sampling. Different configurations are used to accommodate manifold construction around the perimeter of the landfill, within the interior of the landfill over the final cover, and within the interior of the landfill within the final cover, as shown on Figures 7.1-5, 7.1-6, and 7.1-7, respectively.

7.1.10 Control Valve Stations

Control valve stations are provided at each of the interior gas extraction points and each of the perimeter migration control wells. The control valve stations are similar in function but slightly different in construction for each type of application.

The trench risers and interior well casing pipes extend approximately 3 feet above the ground surface and are fitted with 6-inch by 6-inch by 2-inch PVC tees. Above the tee, a short nipple is installed with a 6-inch PVC cap that has been sealed with greased so that operators can access the casing without disturbing the control valve station. The PVC caps have 3/8-inch labcocks for pressure measurement and gas sampling. Stemming from the tee is a horizontal section of 2-inch Schedule 40 PVC pipe containing a gate valve for flow control and a 1/2- inch-diameter sampling port. A flexible hose connects this horizontal 2-inch PVC pipe to a vertical 2-inch HDPE pipe, which is connected to the gas collection manifold.

The vent risers have 6-inch by 2-inch reducer bushings fitted directly into the top of the riser pipes. Two-inch-diameter PVC nipples and elbows· are fitted to these bushings. Lengths of 2-inch PVC pipe connect to the elbows, and each contains a gate valve and 1/2-inch-diameter sampling port. Several of the risers on the east slope (E-4 through E-7) have 2-inch-diameter butterfly valves instead of gate valves. A flexible hose is used to connect the horizontal 2-inch PVC pipe to a vertical 2-inch-diameter HOPE pipe, which is connected to the gas collection manifold.

The control valve stations for the leachate manhole extraction points consist of a 6-inch-diameter HDPE pipe exiting the manhole horizontally to an elbow and then rising vertically through the landfill cover system. At the ground surface, there is another elbow that turns the pipe to a horizontal position. At this location, there is a butterfly valve and 1/2-inch-diameter sampling port. The 6-inch-diameter HDPE pipe connects to the top of the interior manifold through an elbow and short section of vertical pipe.

The control valve stations for the perimeter migration controls wells are similar to those on the interior wells and trenches except that the horizontal pipe is 3 inches diameter instead of 2 inches. Also, the valves are different that the ones used on the interior wells. The perimeter wells were installed in two phases. Phase I wells are fitted with 3-inch PVC gate valves, and Phase 2 wells (installed in conjunction with the flare facility construction) are fitted with 3-inch PVC butterfly valves. A flexible hose connects the end of the horizontal 3- inch PVC pipe to a vertical 3-inch HDPE pipe, which is connected to the perimeter manifold. Typical control valve station configurations for the trench risers and interior, wells, vent risers, and the perimeter wells are presented in Figure 7.1-8.

7.1.11 Condensate Trap and Drain

A condensate drain is installed on the main manifold pipe at the thrust block to collect the condensate from the manifold and route it to the condensate drain system serving the flare facility. The condensate drain pipe is a 2-inch-diarneter pipe that is tapped into the blind flange at the end of the main landfill gas manifold pipe. A rock and sediment trap is located at the bottom of the manifold pipe approximately 10 feet ahead of the drain line connection. This trap allows heavy material such as rocks, sand, sediments, and pipe shavings to drop out prior to entering the 2-inch drain line.

Figure 7.1-9 shows the configuration and components of the condensate drop-out, piping, isolation valves, and grit screen. A horizontal tee is installed in the main manifold blind flange so that the vertical leg of the tee runs in to a vault containing a grit screen with· isolation valves on either side. The valves permit the removal of the screen while the system is operating. From the vault, the pipe is routed to and connects with the condensate drain system from the flare facility. (A description of the condensate drain system is included in Chapter 8.) A clear sight tube is installed between the horizontal tee and the pipe entering the screen vault. This tube permits the operator to see if there is any liquid standing in the drain lines, which would indicate that the grit screen is clogged.

Access for cleaning and inspection of the condensate drain system is obtained through the blind flange at the end of the 2-inch tee by removing the grit screen housing and one or more of the valves in the screen vault. Also, there is a 6-inch-diameter riser pipe with blind flange on the main landfill gas manifold pipe located in a vault approximately 5 feet uphill from thrust block. Removal of this 6-inch blind flange will allow access to the rock and sediment trap. Through this access, sediment can be removed by a vactor truck. Rocks too large to be removed through the riser can be removed at the end of the manifold pipe by taking off the manifold pipe blind flange.

7.2 Operation

The landfill gas collection and transmission system should be kept under a steady vacuum to continuously collect gas from the landfill. The size of the underground area influenced by any one well, trench riser, or vent riser depends on the strength of the vacuum, the soil type, and a number of other factors. As a result, average concentrations measured at each well, trench riser, or vent riser monitoring port will vary. Therefore, the effective operation of the system also depends heavily on the operators' knowledge of the system's historical performance and familiarity with the individual components.

Because the operation of this system is closely tied to environmental compliance monitoring, decisions to make adjustments to the system should be made only after careful evaluation of all gas probe monitoring data. During normal operations, monitoring results from the landfill gas extraction wells, perimeter wells, trench risers, vent risers, and gas probes should be reviewed together. Any time the landfill gas collection system or individual control wells are off for 24 hours or more, the gas probes should be monitored for signs of gas migration.

Table 7.2-1 presents operational guidelines for the landfill gas collection and transmission system. Table 7.2-2 presents guidelines for configuring the landfill gas manifold control valves for normal operating conditions and alternative conditions when the valve configuration would be changed.

For the purpose of this operation discussion, the term "average" will refer specifically to the performance of individual gas wells and gas risers. The term "normal" will be used to refer to what is considered average for the system as a whole.

7.2.1 Gas Extraction System

Of the parameters monitored on a routine basis, the operator only has direct control of the amount of static pressure and velocity applied at each gas extraction point control valve station. The other parameters (i.e., methane, carbon dioxide, oxygen, and temperature) will respond as a result. The magnitude of any changes and the amount of time it takes for these changes to be become apparent will vary from one control valve station to another. Once the system is stable and extracting landfill gas sufficient to control migration without air intrusion, the operator will be able to determine average values for all parameters for each control valve station. The acceptable range of values for these parameters for the extraction wells, trench risers, and vent risers.

Methane	0 to 50 percent by volume
Carbon dioxide	0 to 30 percent
Oxygen	0 to 3 percent
Temperature	50°F to 120°F

If too much vacuum is applied, air can be introduced into the landfill. This can occur through breaks in the cover or through broken or cracked extraction well or trench riser casings. Permeable soils adjacent to the landfill also provide potential pathways for air intrusion into the refuse. Air can also leak directly into the gas collection manifold through damaged gas collection pipes or improper manifold control valve positioning during maintenance or repair operations. The symptoms and effects of this type of leak are most apparent at the flare facility (see Chapter 8). The consequences of such a leak are not as serious as air intrusion into the landfill but will affect the operation of the flare facility and may affect the operators' ability to apply the proper vacuum to the landfill.

When air infiltrates into refuse, the oxygen and nitrogen levels in the gas stream at any monitoring port may increase at approximately the same ratio as seen in air: 3.8 nitrogen to 1.0 oxygen. As aerobic decomposition (i.e., a composting reaction) begins, the oxygen level will decrease, but the nitrogen will not be consumed. This is referred to as residual nitrogen. Increasing levels of residual nitrogen in the gas indicate continuing composting activity. Often, increasing nitrogen is the only indication of air intrusion. When no oxygen is seen in the gas stream but there is an increase of nitrogen, the complete consumption of the oxygen portion of the air infiltrating the landfill is occurring. Often, an increase in gas temperature will also be noted. If air intrusion remains uncontrolled, the composting reaction can become hot enough to ignite the refuse causing a refuse fire. Chapter 13 provides information on how to operate the landfill gas collection and transmission system in the case of an underground refuse fire.

7.2.2 Gas Migration Control System

The purpose of the gas migration control system is to supplement the interior gas extraction system by collecting gas that escapes from the landfill. This operating strategy requires that the perimeter wells be operated at high vacuums (<30 inches· H_20), while the interior collection points are kept near equilibrium vacuums to prevent air intrusion onto the refuse.

If offsite gas migration is observed in compliance probes, the perimeter well control valves closest to the gas probe indicating possible migration should be opened to increase flow and try to draw the gas back into the collection system. Additional monitoring of the affected gas probes should be conducted, and the results carefully reviewed to determine if further adjustments are required. Increased monitoring and adjustments to the system should continue until there are no longer any indications of gas migration.

While operating the perimeter wells at high vacuums, the operator must be careful not to introduce large volumes of air from the native soil into the gas system. This could create an explosive mixture of methane and oxygen in the gas manifold. Experience has shown that a maximum of 4 percent oxygen (or a maximum ratio of CH_4 to O_2 of 8:1, whichever is lower) in the manifold gas stream at the main manifold inlet to the flare is a safe limit. The operator must also be careful not to draw so hard on the extraction wells that air is pulled into the refuse adjacent to the well, thereby creating the potential for starting a landfill fire.

7.2.3 Condensate Trap and Drain

The condensate drain is designed to operate as a passive gravity drain system. The rock and sediment trap collects the larger, heavier particles precluding the clogging of the drain line and allowing the grit screen to collect the smaller-sized materials. In normal operations, the isolation valves are open, and collected condensate flows freely into the drain system. When cleaning the grit screen, cleaning or inspecting the drain line, or obtaining condensate samples, one or both isolation valves in the screen vault will need to be closed. Once the activity is completed, the valves should be returned to the fully opened position. Operators should periodically check the sight tube. If liquid is visible within the tube, it indicates that the condensate is not draining. This may be because the grit screen is clogged, there may be another obstruction in the drain line, or there may be a severe vacuum imbalance within the condensate drain system. If after checking and cleaning the grit screen, the condensate still doesn't drain, operators should refer to Chapter 8, Flare Facility, for information and guidance on the condensate drain system operation, inspection, maintenance, and troubleshooting.

7.3 Inspection and Monitoring

There are only a few components in the landfill gas collection and transmission system that will need to be inspected periodically. Details regarding their inspection are presented in Table 7.3-1.

Monitoring is a very important task for the landfill gas collection system because the information collected is used to adjust system operations. Data should be collected at regular intervals from the main components of the gas collection and transmission system: the interior gas extraction points, perimeter wells, the gas collection manifold, operational gas probes and the compliance monitoring gas probes. Data from these components should be compiled in a database to allow operators to observe the effects of collection system adjustments on the compliance monitoring and operational probes. With this information, operators will be able to evaluate the effectiveness of gas collection and maintain controlled anaerobic conditions within the refuse.

The specific parameters to be monitored are: static pressure (inches of water column), temperature (degrees Fahrenheit), velocity (feet per minute), and fixed gas concentrations (percent by volume) for methane, carbon dioxide, and oxygen. The flow rate (cfm), water vapor, and nitrogen concentration should be calculated from these data. Appendix A contains examples of the data collection forms. Appendix C contains a copy of the database spreadsheet with documentation and a description of the calculations and their uses. Carbon monoxide should be monitored if a refuse fire is suspected. Instruments should be calibrated as per manufacturer instructions before each monitoring event. Table 7.3-2 presents specific requirements regarding the monitoring of the landfill gas collection and transmission system components. Monitoring of the compliance probes is discussed in Chapter 11.

Equipment used in monitoring the gas control system is listed in Table 7.3-3. All instruments and monitoring equipment should be calibrated prior to use following the manufacturers' instructions. Caution should be exercised during calibration because the calibration gas is explosive. It should be used only under the vent hood and away from any potential ignition sources. Although the instruments are designed to withstand the rigors of field use, they contain sensitive electronic components and some precautions are recommended. In the field, the protective cases supplied by the manufacturer should be used. Once the monitoring event is completed, the instruments should be cleaned and dried and the batteries charged.

All instruments and monitoring equipment should be maintained and repaired following the manufacturers' recommendations.

7.4 Operations and Monitoring

7.4.1 Design Philosophy

The design of the Kent Highlands Landfill gas system includes 5 basic elements:

1. An enclosed John Zinc flare is used to incinerate the landfill gas in a controlled environmental manner.
2. Collection System – includes all the piping, valves, and mechanical equipment to create a vacuum on the landfill to draw landfill gas to the flare.
3. Interior control wells are intended to extract most of the landfill gas created as waste decomposes.
4. Perimeter control wells are intended to create a vacuum curtain around the landfill that captures any landfill gas not controlled by the interior system.
5. Landfill gas compliance probes are outside of the perimeter collection and near the facility's property boundary to confirm that the system is controlling subsurface migrating landfill gas.

7.4.2 Current Operating Frequencies

- Flares are continuously monitored to ensure that the mechanical systems are operating properly. Landfill staff routinely inspect the facility 5 days a week and respond to off hour system alarms such as flame failure or temperatures out of permitted range on the enclosed flare.

- The collection system is inspected monthly.
- The interior and perimeter control wells are monitored monthly.
- Landfill gas compliance probes are monitored either monthly or quarterly depending on the compliance status of the probe.

7.4.3 Process

Seattle Public Utilities operates the Kent Highlands Landfill with an on-site 6-member team. This team includes a Manager, three (3) Associate Environmental Analysts, a Facility Maintenance Laborer, and a Senior Heavy Equipment operator. All staff have been assigned to the landfill for over 4 years, and have been thoroughly trained in gas system operation. The team conducts all the work at the landfill and can bring in other senior SPU staff, consultant, and vendor resources, as needed.

After each monthly monitoring rounds on the control wells, the manager and the environmental analysts meet to collectively discuss the current performance and trends of the extraction system, as well as, the trends and recent data from the compliance probes. This meeting covers the following:

- Ensures collection system is operating as intended.
- Ensures landfill gas migration is being controlled.
- Changes to control wells settings are discussed and confirmed.
- Determine if any non-routing or follow-up monitoring is required.
- Preventative flare facility and collection system maintenance needs.
- Overall system performance is evaluated.

Following the meeting, the system changes and maintenance needs are performed by the team. Any unanticipated conditions that are encountered trigger additional special meetings.

This team approach to system operations is used to train new staff and allow all team members to actively participate in system operation, which has been successfully practiced since 1991. Over time this process ensures that every team member collectively develops an awareness of system operation guided by the experience of the last 27 years of operation.

Figure 7.4-1 outlines the landfill gas evaluation procedure.

7.5 Maintenance

The gas collection and transmission system maintenance activities relate to the isolation and control valves and to maintaining the air-tight seals of the greased-on fittings. All of the gas collection and transmission system valves should be fully opened and closed at regular intervals. Although these valves are plastic and are relatively free of corrosion problems and, hence, the need for regular maintenance, the periodic movement of the valve components helps to prevent the valves from sticking in one position.

There are many PVC pipe fittings at the control valve stations on the interior gas extraction points and perimeter wells that have been sealed with lithium grease. These fittings should be periodically checked for leakage and resealed with new or existing grease as appropriate. It is especially important to check fittings for leakage after a positive pressure situation has been detected in the control valve stations since the pressure tends to force the grease out of the joint and affects the seal. Table 7.5-1 presents maintenance procedures for various components of the landfill gas collection and transmission system. All maintenance activities should be conducted in accordance with the specifications and record drawings.

7.6 Troubleshooting

In addition to the potential for subsurface gas migration, the primary concerns related to the landfill gas collection and transmission system are obstructions to the gas flow, leaking or broken pipes, air intrusion into the landfill, and the presence of an underground refuse fire. The first two issues need prompt attention if detected but are not as critical as a refuse fire or as significant as air intrusion into the landfill, which can produce the conditions that could result in such a fire. If evidence of an underground refuse fire is found, the suspected area should be immediately isolated from the gas collection system and expert help requested. Chapter 13 outlines procedures to be followed in case of an underground refuse fire.

Table 7.6-1 presents information necessary for troubleshooting problems that could arise as a result of catastrophic failure or through the course of regular inspection, monitoring, or maintenance procedures.

7.7 Repairs

Repairs of the gas collection and transmission system will generally be limited to the piping, valves, and flexible hose. Table 7.7-1 presents information necessary for completing repairs on the landfill gas collection and transmission system. Repairs should be made in accordance with the specifications and record drawings.

7.8 Materials

Consideration should be given to the purchase of spare valves, flexible hose, and PVC pipe and fittings so that these materials are available if the need arises. All materials should be in accordance with the specifications for the landfill gas control system and flare facility (City of Seattle, 1992) or the final closure construction (City of Seattle, 1993).

7.9 Recordkeeping and Reporting

Monitoring activities should be recorded on monitoring .data logs, samples of which are included in Appendix A. Information to be recorded on the data logs will include monitoring results, date, barometric pressure, and any pertinent comments or notes. Data gathered from the monitoring ports may also be entered directly into a hand-held monitoring instrument and downloaded directly into a computer. It is important that accurate and complete records be maintained for the landfill gas system monitoring data as this data will be reviewed and used on a regular basis to make operational decisions.

In addition, several reporting requirements must be fulfilled for the landfill gas compliance monitoring. These reporting requirements are presented in Chapter 11, Environmental Monitoring Program.

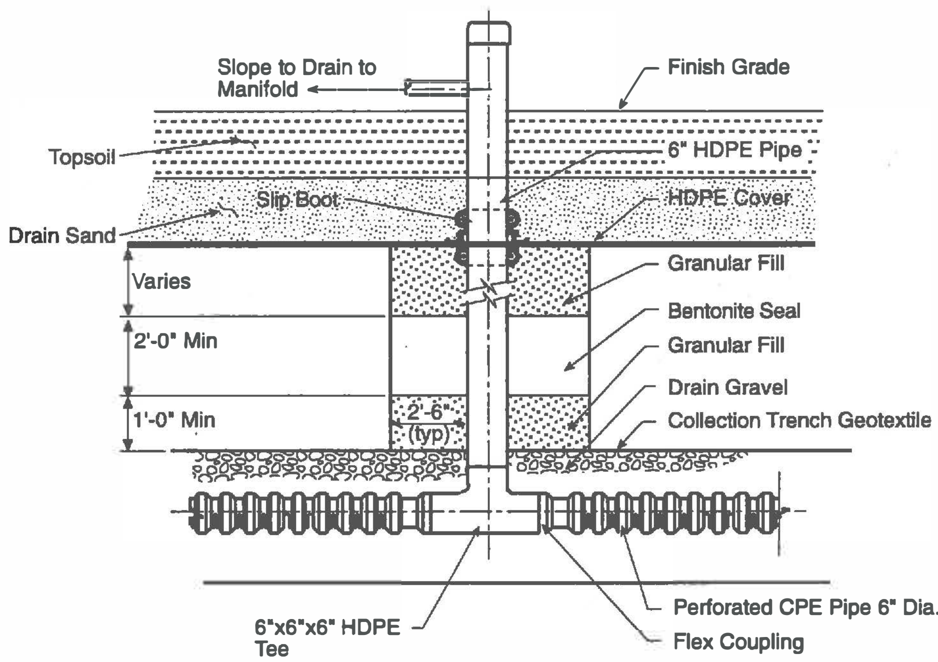


Figure 7.1-1
Typical Gas Collection Trench Riser

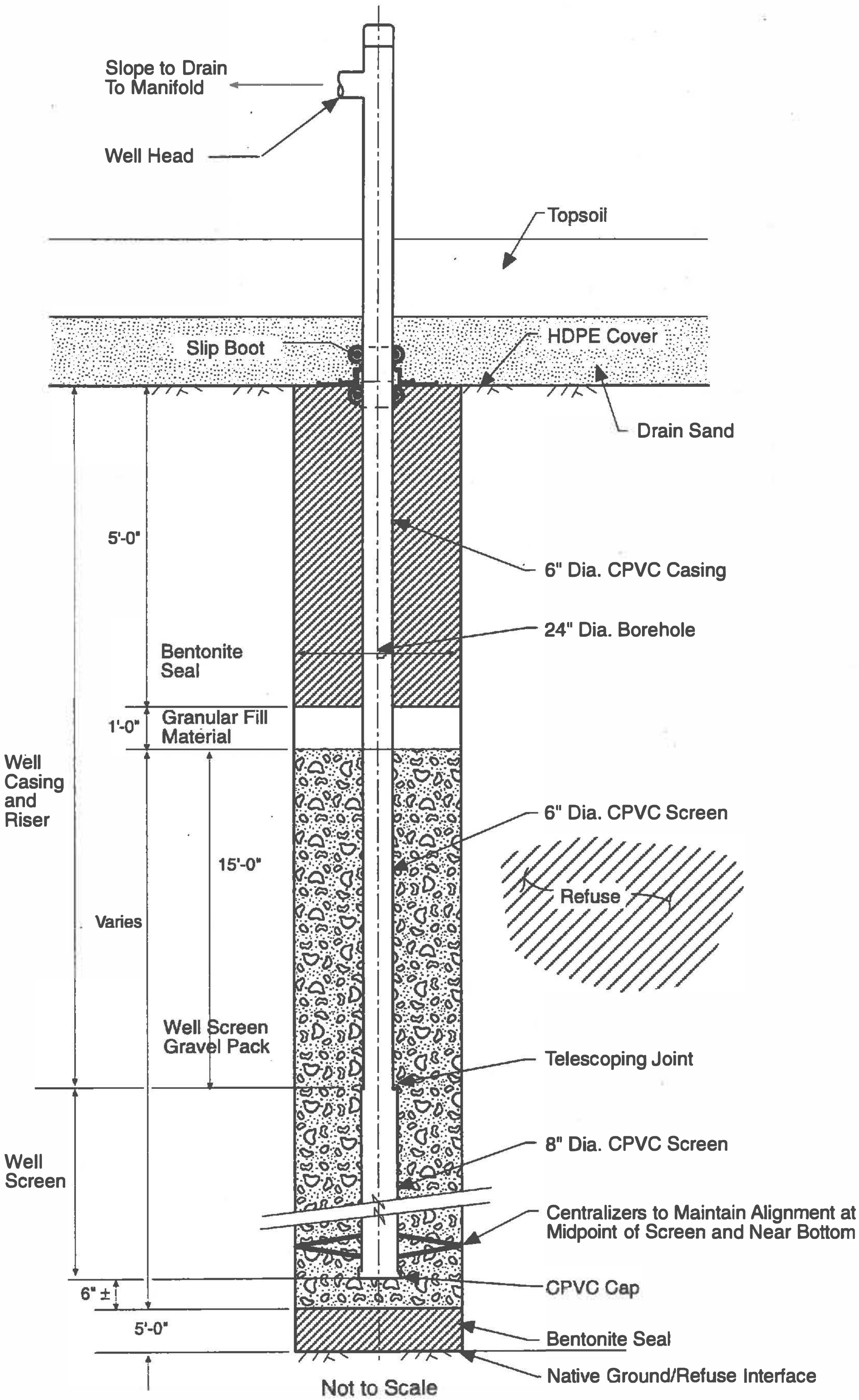


Figure 7.1-2
Typical Interior Gas Extraction Well

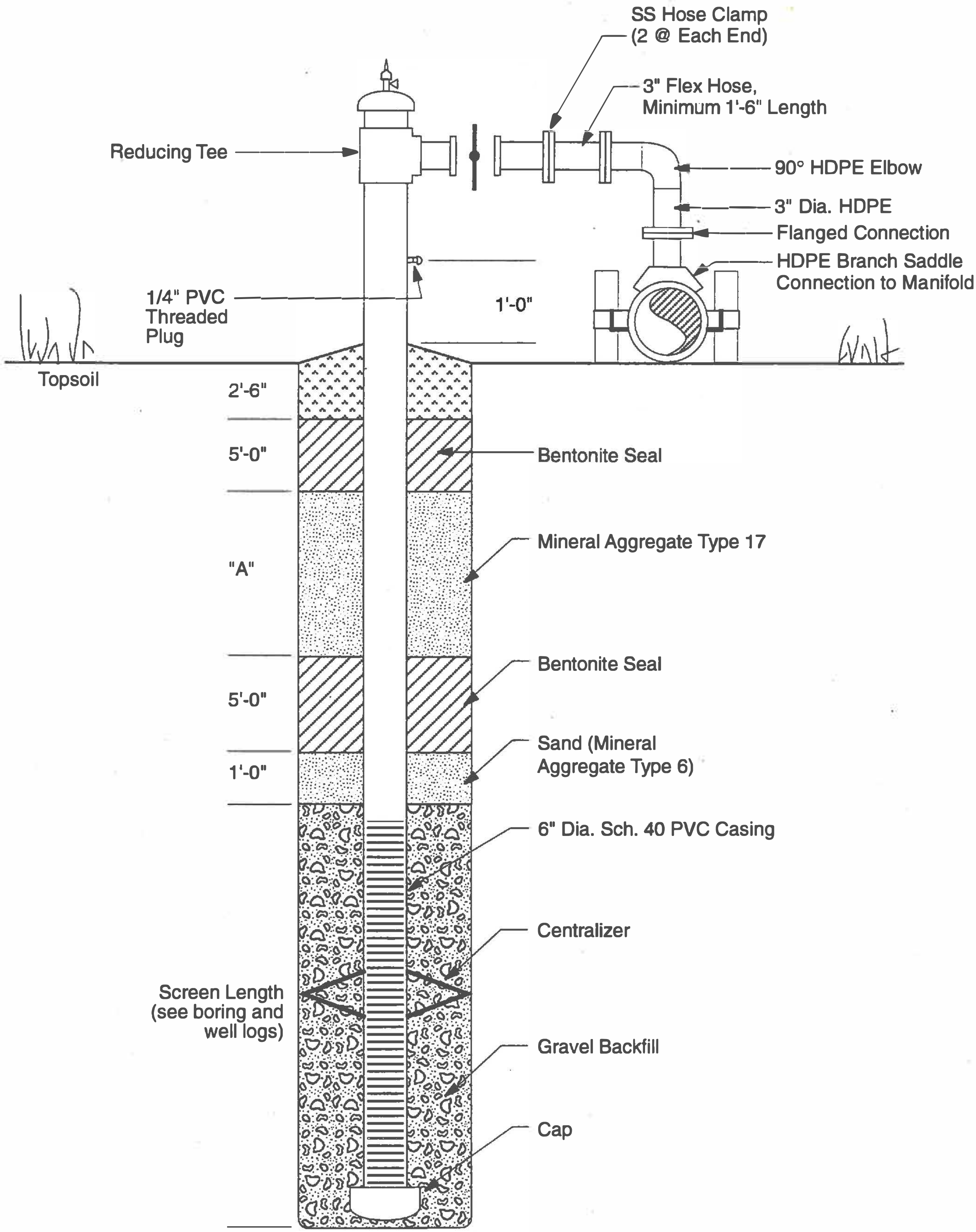
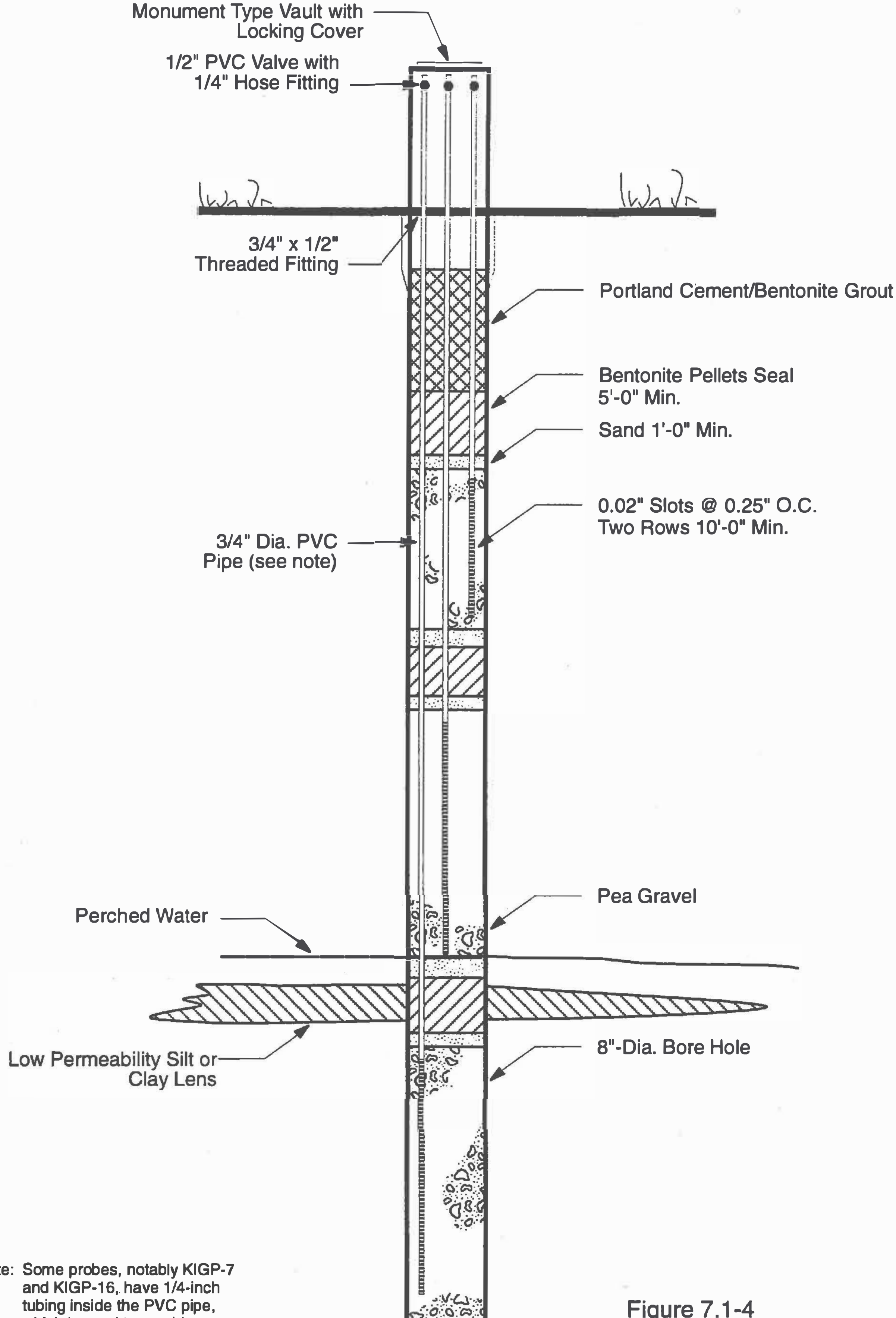
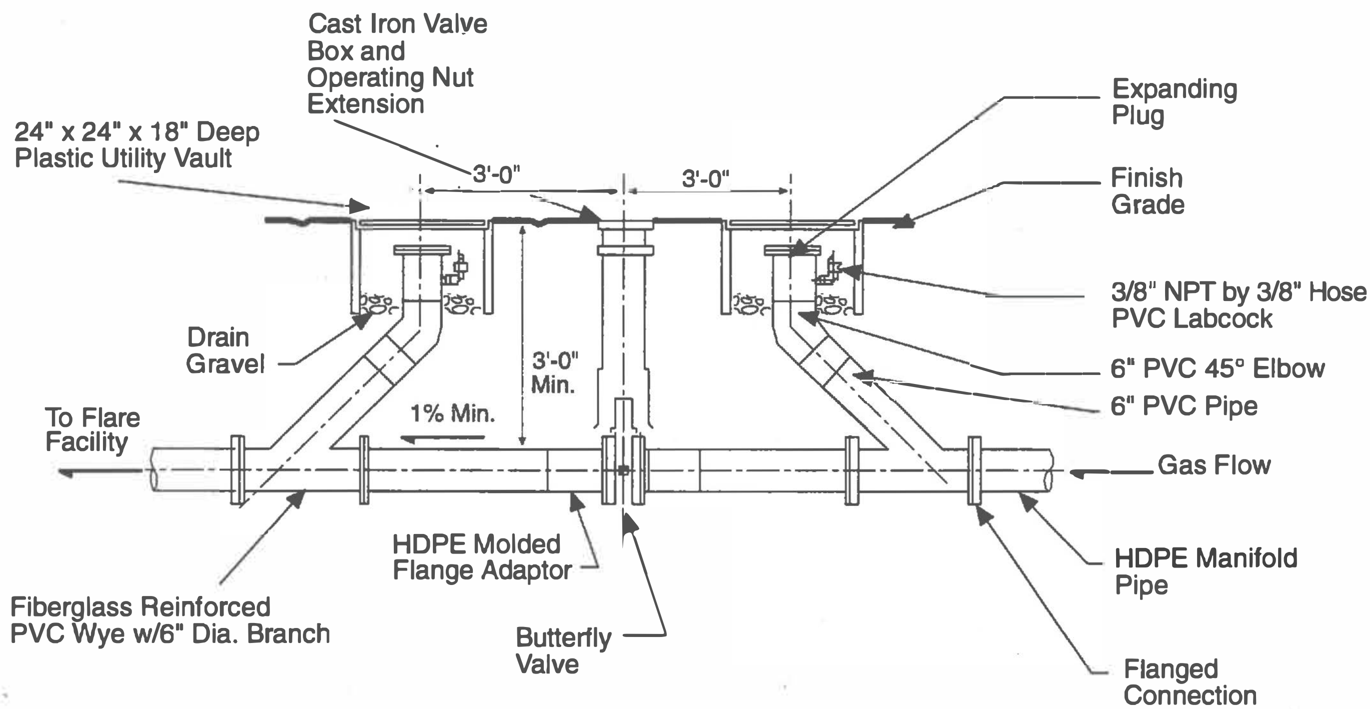


Figure 7.1-3
Typical Migration Control Well



Note: Some probes, notably KIGP-7 and KIGP-16, have 1/4-inch tubing inside the PVC pipe, which is used to provide a more rapid sample draw.

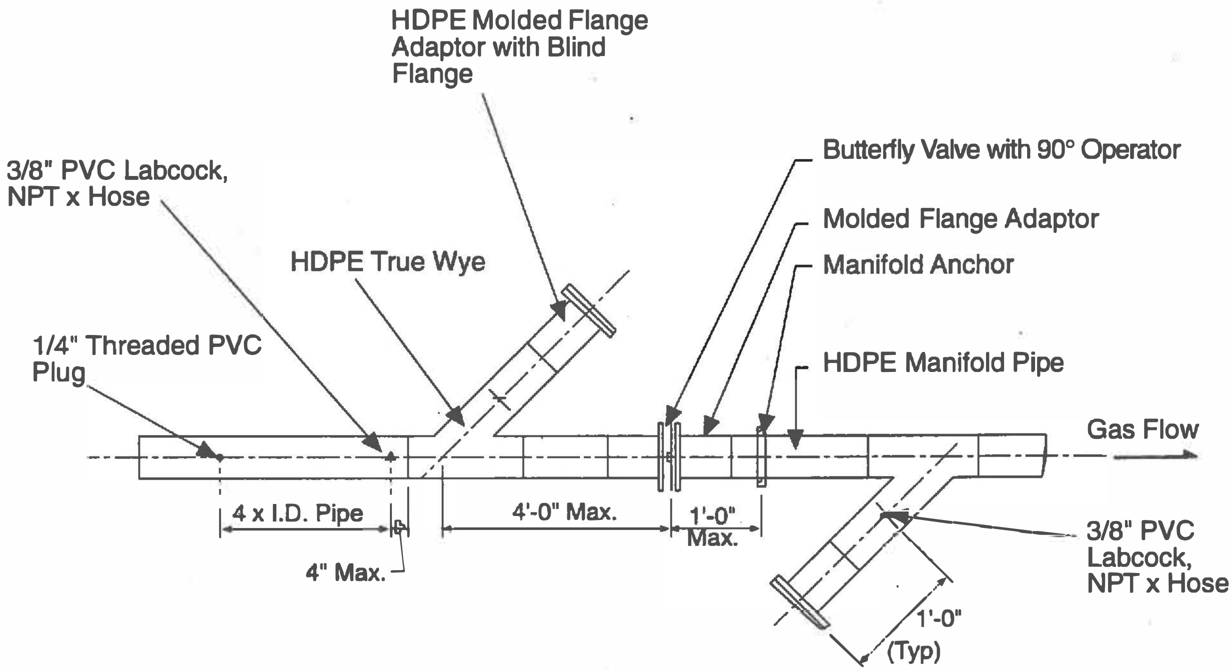
Figure 7.1-4
Typical Gas Probe



Section

Not to Scale

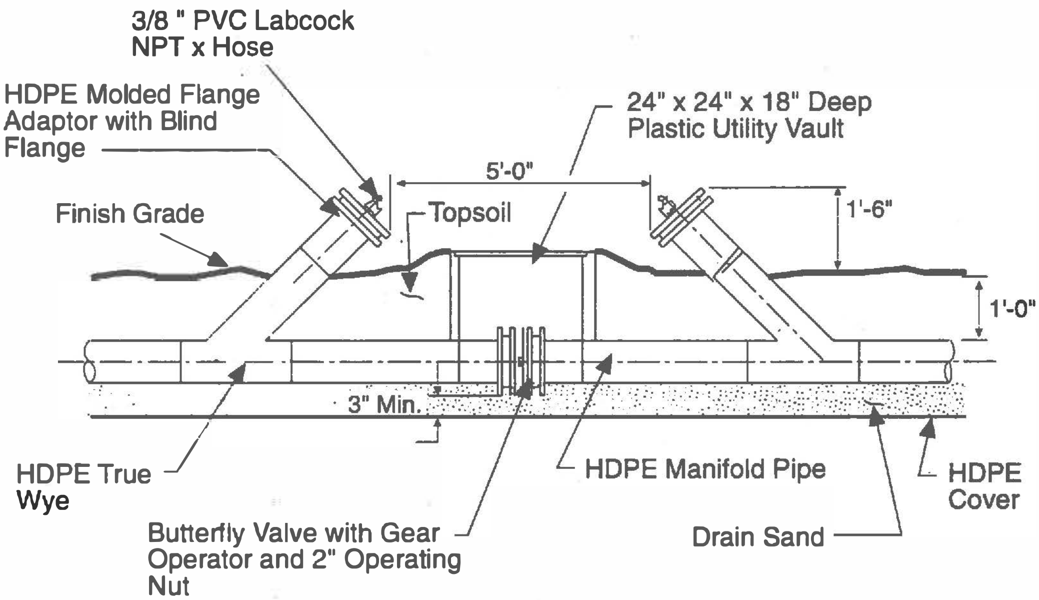
Figure 7.1-5
Perimeter Manifold Valve and Cleanout



Plan

Not to Scale

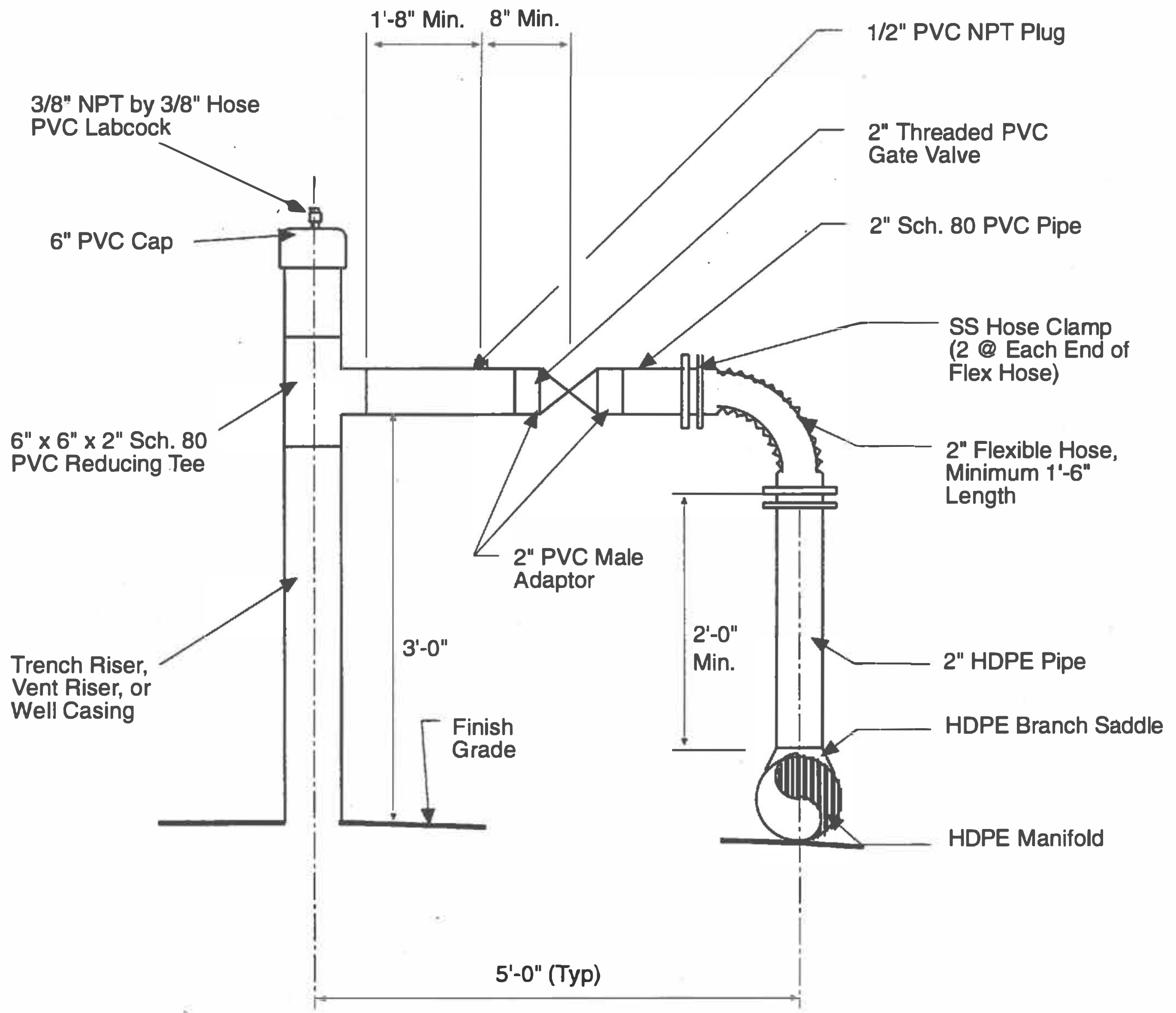
Figure 7.1-6
Interior Manifold Valve and Cleanout Over Final Cover



Section

Not to Scale

Figure 7.1-7
Interior Manifold Valve and Cleanout Within Final Cover



Not to Scale

Figure 7.1-8
Typical Control Valve Station Configuration

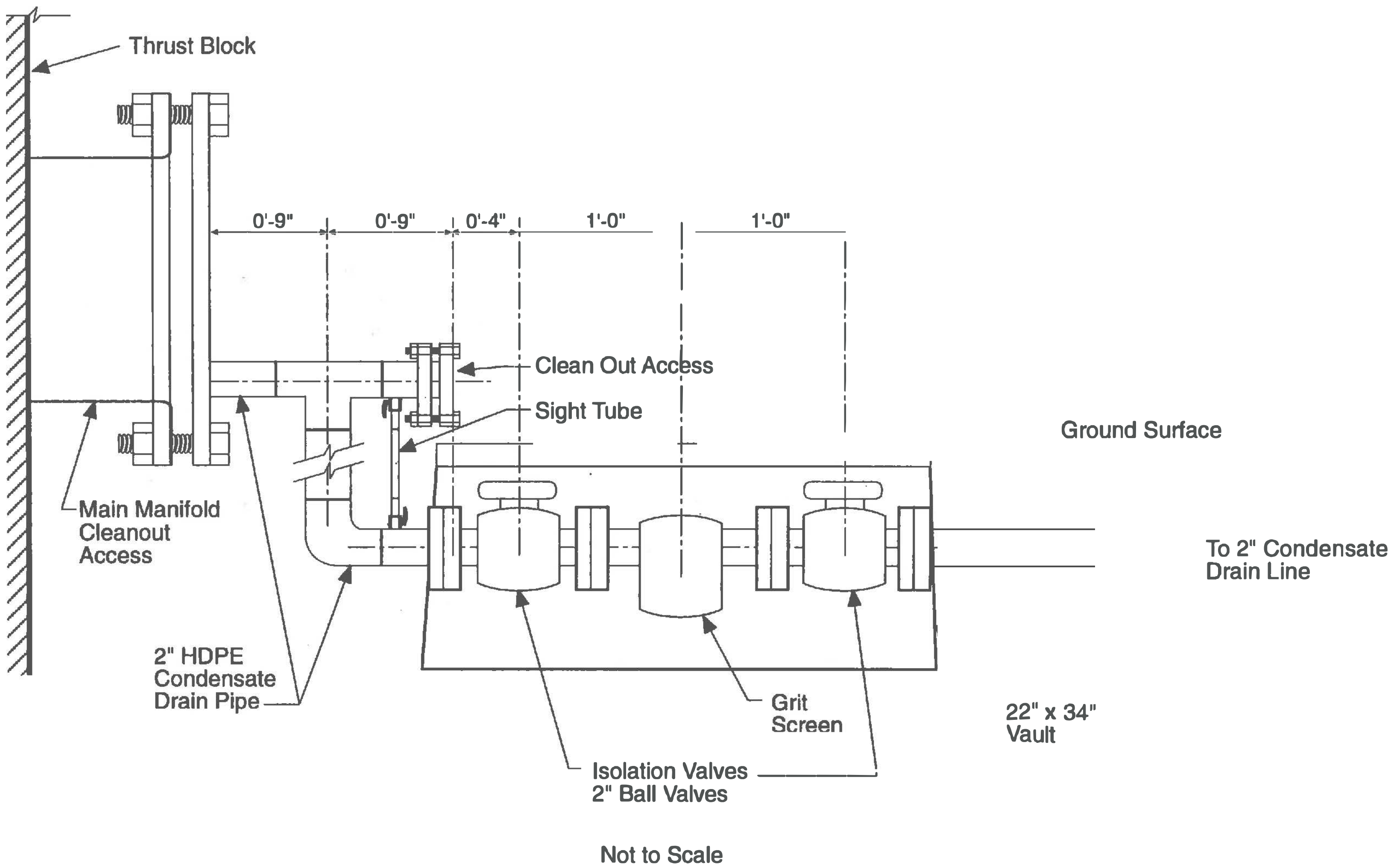


Figure 7.1-9
Condensate Drain Main Landfill Gas Manifold, Flare Facility Inlet

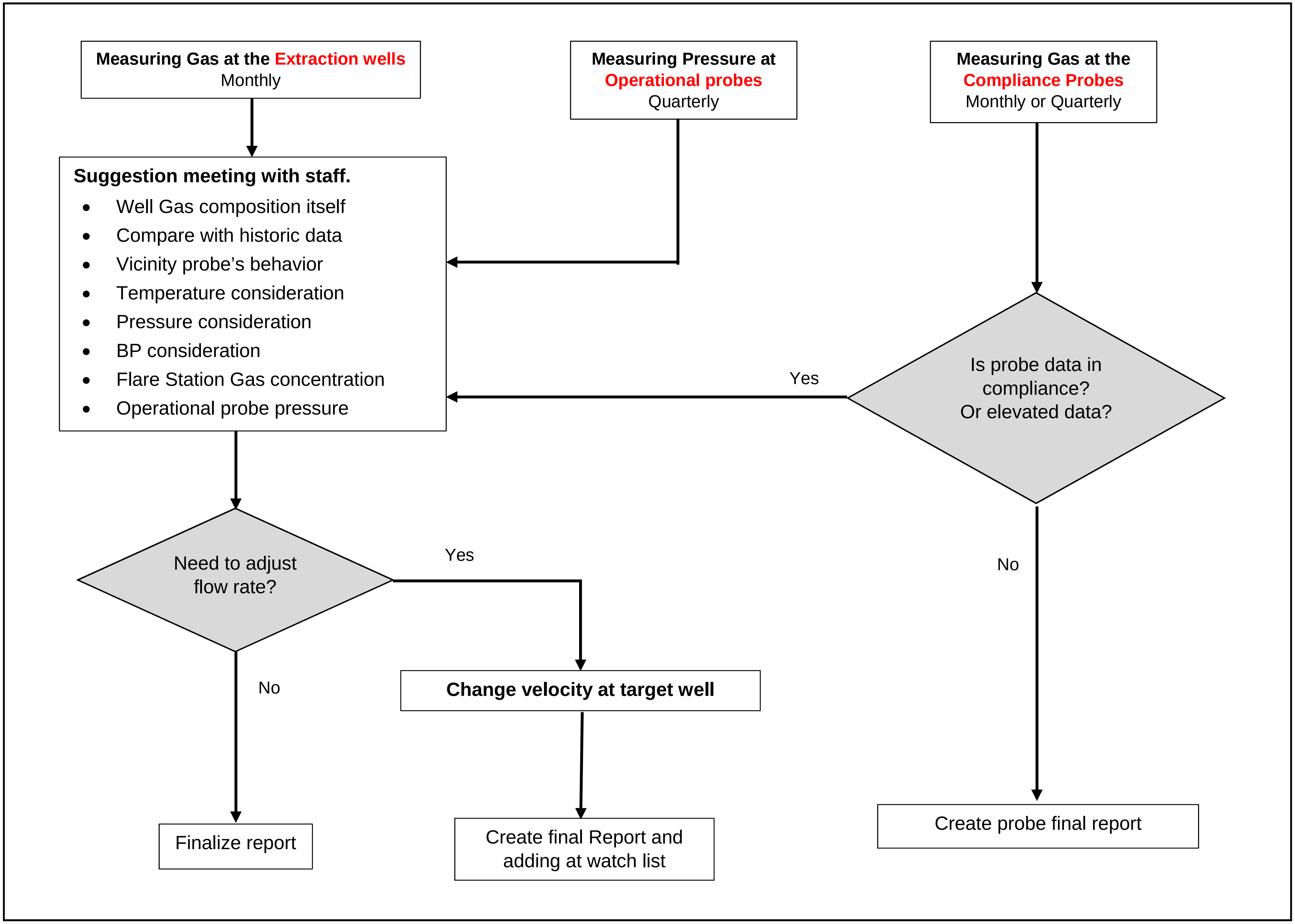


Figure 7.4-1
Landfill Gas Evaluation Procedure

Table 7.1-1. Gas Extraction and Migration Control Points

System	Type	Identifier		
Interior gas extraction	Trench riser	KIGT-1	KIGT-3	KIGT-6
		KIGT-2	KIGT-4	KIGT-7
			KIGT-5	
	Well	KIGW-1	KIGW-10	KIGW-19
		KIGW-2	KIGW-11	KIGW-20
		KIGW-3	KIGW-12	KIGW-21
		KIGW-4	KIGW-13	KIGW-22
		KIGW-5	KIGW-14	KIGW-23
		KIGW-6	KIGW-15	KIGW-24
		KIGW-7	KIGW-16	KIGW-25
		KIGW-8	KIGW-17	KIGW-26
		KIGW-9	KIGW-18	KIGW-27
	Vent riser	E-3	S-73	S-76
		E-4	S-74	S-77
	Disconnected (still in place; flex hose removed and capped)	E-6	N-29	X-3
		E-7	N-32	X-7
		E-8	N-38	X-14
		N-01	N-47	X-16
		N-13	N-49	X-31
		N-15	N-55	X-34
		N-23	N-59	X-38
		N-26	N-61	X-39
				X-41
	Leachate manhole	KLM-A (GV-A)	KLM-SD	
		KLM-B (GV-B)	KLM-SL	
Perimeter gas migration control	Deep well	KDGW-17A	KGDW-94B	KGDW-103
		KGDW-89	KGDW-95	KGDW-104A
		KGDW-90	KGDW-96	KGDW-104B
		KGDW-91	KGDW-97	KGDW-105
		KGDW-92	KGDW-98	KGDW-111
		KGDW-93	KGDW-101	KGDW-112
		KGDW-94A	KGDW-102	
	Shallow well	KSGW-99	KSGW-108A	KSGW-120
		KSGW-101	KSGW-108B	KSGW-121
		KSGW-102A	KSGW-109A	KSGW-122
		KSGW-102B	KSGW-109B	KSGW-123
		KSGW-103A	KSGW-110	KSGW-124
		KSGW-103B	KSGW-111A	KSGW-125
		KSGW-104A	KSGW-112A	KSGW-126
		KSGW-104B	KSGW-113	KSGW-123
		KSGW-105A	KSGW-114	KSGW-124
		KSGW-105B	KSGW-115	KSGW-125
		KSGW-106A	KSGW-116	KSGW-126
		KSGW-106B	KSGW-117	
		KSGW-107A	KSGW-118	
		KSGW-107B	KSGW-119	
Manifold		AMAIN		

Table 7.1-2. Operation Probes

Identifier	Adjacent Control Wells
KDGP-89	KDGW-89
KDGP-90	KDGW-89 and KDGW-90
KDGP-93	KDGW-92 and KDGW-93
KDGP-95	KDGW-94A and KDGW-95
KDGP-98	KDGW-98 and KSGW-99
KSGP-101	KSGW-99 and KSGW-101
KDGP-101	KDGW-101 and KDGW-102
KSGP-103	KSGW-103A and KSGW-103B
KDGP-104	KDGW-104A and KDGW-104B
KGP-2M	KDGW-105 and KDGW-104B
KGP-2S	KSGW-105A and KBGW-105B
KSGP-107	KSGW-107A and KSGW-107B
KSGP-108	KSGW-108A and KSGW-108B
KSGP-109	KSGW-109A and KSGW-109B
KGP-5	KSGW-109B and KSGW-110
KSGP-113	KSGW-113 and KSGW-114
KSGP-116	KSGW-116 and KSGW-117
KSGP-119	KSGW-119 and KSGW-120
KSGP-122	KSGW-122 and KSGW-123

Table 7.1-3. Migration Control Probes

Status	Probe ID		
Active	KGP-1	KGP-16A	KGP-31
	KGP-7	KGP-17	KGP-32A
	KGP-8	KGP-20	KGP-35
	KGP-9	KGP-21	KGP-36
	KGP-10	KGP-24	KGP-38B
	KGP-11	KGP-26	KGP-40
	KGP-12	KGP-27	KGP-44
	KGP-13	KGP-28	KGP-46
	KGP-14	KGP-29	KGP-200
	KGP-15	KGP-30	
Replaced	KGP-16 (replaced with KGP-16A)		
	KGP-32 (replaced with KGP-32A)		
	KGP-38A (replaced with KGP-38BA)		
Unable to Locate	KGP-4	KGP-MW14	KGP-23
	KGP-6	KGP-19	KGP-31L
Abandoned	KGP-18	KGP-39	KGP-43
	KGP-34	KGP-41	KGP-45
	KGP-37	KGP-42	KGP-47

Table 7.2-1. Landfill Gas Collection and Transmission System Operation Guide

Observed Condition	Other Parameters	Potential Cause	Corrective Action	Intended Response
Interior Well, Trench Riser, and Vent Riser Control Valve Stations				
Methane concentration > 55%	Carbon dioxide concentration = 100% minus methane.	System not withdrawing gas at a high enough rate.	Increase flow.	Reduction of methane concentration to 55% or lower.
	Carbon dioxide < 100% minus methane. Residual nitrogen is present (oxygen : nitrogen < 1:3.8). Temperature < 120°F. Oxygen % = 0%.	Signs of previous air intrusion.	Increase flow slightly. Monitor for increasing oxygen and/or nitrogen.	Reduction of methane concentration to 55% or lower.
Methane concentration < 45%. Temperature is normal.	Carbon dioxide ≤ methane. Remainder is air (oxygen : nitrogen = 1:3.8). Static pressure is at or above average (higher negative) for extraction point.	Air intrusion, but aerobic decomposition has not yet started.	Reduce flow.	Reduction of oxygen and nitrogen. Increase in methane to 45 to 55%. Carbon dioxide ≤ methane.
	Carbon dioxide ≤ methane. Oxygen = 0%. Remainder is nitrogen.	Residual nitrogen indicates that aerobic activity is consuming oxygen.	Reduce flow.	Elimination of aerobic activity. Reduction of oxygen and nitrogen. Increase in methane to 45 to 55%. Carbon dioxide ≤ methane.
Methane concentration < 45%. Temperature > 120°F.	Carbon dioxide ≥ methane. Oxygen = 0%. Remainder is nitrogen	Possible composting reaction in refuse.	Reduce flow to very low or shut control valve. Refer to Section 7.9, Emergency Conditions.	Elimination of composting reaction. Reduction of oxygen and nitrogen. Increase in methane. Temperature should return to normal.
Oxygen concentration > 3%.	Methane ≥ carbon dioxide. High residual nitrogen. Temperature above normal, but < 120°F.	Aerobic activity is consuming oxygen.	Reduce flow.	Reduction of nitrogen and oxygen. Increase in methane. Temperature should decrease to normal level.
Increased air in gas stream (Oxygen : nitrogen = 1:3.8). Oxygen concentration > 5%.	Methane concentration < 40%. Carbon dioxide < 40%.	Damaged flexible hose.	Inspect flexible hose and repair.	Reduction of oxygen and nitrogen. Increase in methane to 45 to 55%. Carbon dioxide ≤ methane.
		Leak in extraction well or trench riser casing.	See Table 7.5-1 for troubleshooting.	
Static pressure is significantly higher or lower than average.	Similar conditions are found at adjacent extraction well or trench riser monitoring ports.	Incorrect valve position (e.g., the main inlet control) at flare facility.	Adjust valve as required (indicated by other parameters) to achieve stabilized condition.	Parameters should return to average values.
		System condition, such as blockage in gas collection manifold.	See Table 7.5-1 for troubleshooting.	
	Similar conditions are not found at adjacent extraction well or trench riser monitoring ports.	Extraction well or trench riser control valve could be misadjusted.	Check other parameters. Adjust valve as indicated by other parameters.	
		Blockage in the extraction well or trench riser.	See Table 7.5-1 for troubleshooting.	
Gas flow or static pressure is surging.	N/A	Condensate buildup behind gas collection manifold control valve or in local low spot.	See Table 7.5-1 for troubleshooting.	Restoration of stable flow.
Interior Gas Collection Manifold Monitoring Ports				
Methane concentration > 55%.	Oxygen is close to 0. Static pressure and flow are below normal.	System not extracting gas at a high enough rate or gas manifold control valve could be closed too far.	Increase flow.	Reduction of methane concentration below 55%.
Methane concentration < 45%.	Carbon dioxide ≤ methane.	Air intrusion.	Reduce flow.	Reduction of air intrusion. Increase in methane.
Temperature > 120°F.	Carbon dioxide ≥ methane. High residual nitrogen.	Severe case of air intrusion and possible underground· refuse fire.	Refer to Section 7.9, Emergency Conditions.	Reduction or elimination of air intrusion.
Oxygen concentration > 5%.	Methane and carbon dioxide < 80%.	Severe and widespread air intrusion.	Reduce flow.	Reduction of air intrusion.
		Leak in gas collection manifold.	See Table 7.5-1 for troubleshooting.	
		Leak in extraction well or trench riser casing.	See Table 7.5-1 for troubleshooting.	
Perimeter Wells and Operational Gas Probes				
Operational probe pressure ≥ 0.0 inches of water.	Carbon dioxide > zero. Oxygen < 21%. Methane > 5% and rising from previous monitoring round.	Insufficient vacuum applied by adjacent perimeter wells.	Increase flow from adjacent perimeter wells until negative pressure influence is seen at probe. Continue to monitor during each monitoring round until pressure remains stable below 0.0 inches of water.	Stable negative pressures in probe.
Migration Control Gas Probes				
Methane concentration > 1.25% by volume (25% LEL).	Carbon dioxide > zero. Oxygen < 21%. Methane > 5% and rising from previous monitoring round.	Gas migration.	Increase flow from adjacent extraction points until methane concentrations decline to below 1.25%. Continue to monitor at greater frequency until methane concentrations decline to below 1.25%.	Methane concentrations decline to below 1.25%.

N/A = Not Applicable

Table 7.2-2. Landfill Gas Manifold Control Valve Configuration

Manifold and Valve Location	Purpose	Normal Operating Condition	Alternative Operating Conditions
South interior, near vent riser X-7	Controls cross-connection between perimeter manifold, near KDGW-112 and south interior manifold.	Closed	Open this valve to provide a transmission pathway to the flare facility when: 1. Any perimeter manifold valve is closed between the main manifold junction and KDGW-112. 2. Any south interior manifold valve is closed between the main manifold junction and riser X-7. 3. The 14-inch south perimeter manifold valve at the main manifold junction is closed.
South interior, near vent riser N-59	Controls cross-connection between perimeter manifold near KSGW-102A and south interior manifold.	Closed	Open this valve to provide a transmission pathway to the flare facility when: 1. Any perimeter manifold valve is closed between KDGW-112 and KSGW-102A. 2. Any south interior manifold valve is closed between riser S-73 and riser N-59. 3. Any perimeter manifold valve is closed between KSGW-102A and KDGW-96.
North interior, east of vent riser N-47	1. Controls connection to backup flare station from interior manifold. 2. Controls cross-connection between perimeter manifold near KDGW-96 and north interior manifold.	Closed	Open to provide transmission to the backup flare station from the north interior manifold or a transmission pathway to the main flare facility when: 1. Any perimeter manifold valve is closed between the main manifold junction and KDGW-96. 2. Any north interior manifold valve is closed between the main manifold junction and the cross-connection east of riser N-47.
Perimeter, near KDGW-96	1. Controls connection to backup flare station from perimeter manifold. 2. Controls cross-connection between north interior manifold east of N-47 and perimeter manifold.	Closed	Open to provide transmission to the backup flare station from the perimeter manifold or a transmission pathway to the main flare facility when: 1. Any perimeter manifold valve is closed between the main manifold junction and KDGW-96. 2. Any north interior manifold valve is closed between the main manifold junction and the cross-connection east of riser N-47.
North interior, near N-49 South interior, near KIGW-18	Controls cross-connection between south interior manifold and north interior manifold.	Open	Open either valve during normal operations. Open both valves to provide transmission pathway to the flare facility when any manifold valve on either the north or south interior manifolds is closed between this cross-connection and the main manifold junction.
All manifold valves, other than those listed above	1. Adjust the amount of vacuum applied to large sections of the manifold. 2. Isolate manifold sections for cleaning, inspection, and repair.	Open	1. Partially close a valve to adjust the amount of vacuum applied to the manifold upstream of the valve. 2. Close any two valves to isolate the manifold between the valves and take it out of service.

Table 7.3-1. Landfill Gas Collection and Transmission System Inspection Guide

Activity	Frequency	Observed Problem	Potential Associated Problems	Action Required		
				Maintenance	Troubleshooting	Repair
Check control valve stations, including control valve bodies, flanged connections, flexible hoses and connections, reducing tee and cap slip-on connections, and labcock valves.	Quarterly	Damaged or broken fittings. Leaking slip-on connections (condensate is dripping or residue is visible). Flexible hose is too tight. Hoses are cracked. Bonnet on control valve body is cracked. Loose flanged connections. Bolts are missing. Labcock valve damaged or broken.	Air intrusion (see Table 7.2-1)		X	X
Check gas collection manifold valve and cleanout station, including control valve bodies, flanged connections, expanding plugs, and labcock valves.	Quarterly	Damaged or broken fittings. Expanding plugs are leaking, loose or cracked. Flanged connections or blind flanges are leaking. Bolts are missing. Labcock valve damaged or broken.	Air intrusion (see Table 7.2-1)		X	X
Check casings and ground surface at extraction well, trench riser, and vent riser control valve stations.	Monthly	Cracked well, trench riser, or vent riser casing.	Air intrusion (see Table 7.2-1)			X
Check landfill gas manifold anchor blocks.	Monthly	Anchor blocks are not securely imbedded. Evidence of rocking and movement.	Damage to manifold pipe (cracking, deformation, air intrusion). Condensate ponding in manifold pipe (restricted landfill gas flow, surging) see Table 7.5-1.	X		X
Check perimeter well casing and grout seal.	Monthly	Grout is cracked or has pulled away from casing. Casing is cracked or broken.	Air intrusion into perimeter manifold (see Table 7.2-1).		X	X
Check sight tube on condensate trap and drain	Every 2 weeks when monitoring gas system	Liquid in sight tube.	Grit screen is plugged.	X		
		Tube is discolored or obscured.	Cannot see liquid level to determine screen condition.	X		

N/A = Not Applicable

Table 7.3-2. Landfill Gas Collection and Transmission System Monitoring Guide

Component	Frequency	Activity	Normal Condition	Monitoring Guidance
Interior well, trench riser, and vent riser monitoring ports	Monthly	Record static pressure.	Zero or lower.	Adjust pressure gauge to 0 static pressure before monitoring.
		Record fixed gas concentrations for: 1. methane 2. oxygen 3. carbon dioxide	 1. 40 to 55% 2. 0 to 3% 3. 25 to 45%	Calibrate per instrument manual instructions before monitoring.
		Record temperature.	50 to 120°F	N/A
		Record velocity (flow).	N/A	N/A
	When refuse fire is suspected	Record carbon monoxide.	Concentrations less than 50 ppm.	Once refuse fire is suspected, monitoring frequency for carbon monoxide should be increased to daily. Refer to Chapter 13.
Interior gas collection manifold monitoring ports	Monthly	Record static pressure.	Zero or lower.	Adjust pressure gauge to 0 static pressure before monitoring.
		Record fixed gas concentrations for: 1. methane 2. oxygen 3. carbon dioxide	 1. 40 to 55% 2. 0 to 3% 3. 25 to 40%	Calibrate per instrument manual instructions before monitoring.
		Record temperature.	70 to 120°F	N/A
		Record velocity (flow).	Varies with location.	If flow does not increase closer to flare facility, check for blockage.
Perimeter well monitoring ports	Monthly	Record static pressure.	Zero or lower.	Readings should be within normal limits based on previous data. If large changes occur, look for changes in valve position in well or manifold.
		Record fixed gas concentrations for: 1. methane 2. oxygen 3. carbon dioxide Record temperature. Record velocity (flow).	Gas concentrations should be within normal limits based on previous data. Temperature should be within 30-90°F.	Perimeter well adjustments should be made to increase vacuum and flow if adjacent migration control probes or operational probes show evidence of LFG migration.
Perimeter manifold monitoring ports on the cleanouts	Monthly	Record static pressure.	Zero or lower.	Readings should be within normal limits based on previous data. If large changes occur, look for changes in valve position in well or manifold.
		Record fixed gas concentrations for: 1. methane 2. oxygen 3. carbon dioxide Record temperature. Record velocity (flow).	Varies with location. Temperature should be within 30-90°F.	Concentrations should be within normal limits based on previous data. Calibrate per instrument manual instructions before monitoring.
Operational gas probes	Quarterly for one year	Record static pressure.	Pressure is less than zero.	If pressure is positive, readjust adjacent perimeter wells to reestablish negative pressure in probe.
		Record fixed gas concentrations for: 1. methane 2. oxygen 3. carbon dioxide	Gas concentrations are within normal limits based on previous da ta.	Adjust adjacent perimeter wells. Refer to Table 7.2-2.
Migration control gas probes	See Section 11.4, Landfill Gas Monitoring	Record static pressure	Zero or lower.	High positive pressure can indicate gas migration. Refer to Table 7.2-1 for corrective action.
		Record fixed gas concentrations for: 1. methane 2. oxygen	 1. 0% to 1.25% 2. 21%	If methane is detected above 1.25% volume (25% LEL), refer to Table 7.2-1 for corrective action. If methane is above 5% (100% LEL), see Section 11.4, Landfill Gas Monitoring.

N/A = Not Applicable

Table 7.3-3. Landfill Gas Control System Monitoring Equipment

Item	Use	Comments
Gem 5000	Measuring combustible gas, oxygen, and carbon dioxide concentrations and pressure in the gas system	Has data logging capability.
Kurz Hot-Wire Anemometer	Measuring gas velocity in the system piping	Necessary to derive flow rate.

Table 7.5-1. Landfill Gas Collection and Transmission System Maintenance Guide

Component	Frequency	Activity	Maintenance Guidance
Control valve stations, manifold control valve and cleanout stations, and branch and cross-connection control valves	Quarterly	Exercise valves.	Turn valve operator through entire range.
PVC pipe fittings at wells, trench risers, vent riser, and control valve stations	Monthly	Check seal and add or replace lithium grease.	N/A
Control valve pipe supports	Every 6 months	Adjust height of supports.	Maintain support on pipe and control valve to prevent stress on pipe.
Manifold pipe supports	Every 6 months	Adjust supports to maintain positive slope for condensate drainage.	Maintain slope of manifold towards flare facility.
Flexible hose	Annually, as required	Paint flexible hose with latex-based paint to protect from ultraviolet light degradation.	N/A
PVC pipe	Annually, as required	Paint PVC pipe with latex-based paint to protect from ultraviolet light degradation.	N/A
Grit screen on condensate trap and drain	As required by inspection	Remove and clean screen.	To remove screen: 1. Open vault 2 Close both ball valves 3 Loosen bolts 4 Remove lid Liquid and sediments taken from the screen are contaminated. Observe proper precautions, wear protective gear, handle material carefully, and dispose of material properly. When finished, replace screen and lid and reopen valves.

N/A = Not Applicable

Table 7.6-1. Landfill Gas Collection and Transmission System Troubleshooting Guide

Problem	Possible Cause	Troubleshooting Activities	Troubleshooting Guidance/Limitations	Action Required	
				Maintenance	Repair
Increased air in gas stream (oxygen : nitrogen = 1:3.8) and oxygen concentration greater than 5 percent at extraction well or trench riser monitoring port	Leak in extraction well or trench riser casing above cover system	Check for possible leaks in casing above cover system by exposing casing and inspecting for damage. If casing is damaged, conduct repair.	Expose casing using shovels. Use extreme caution to not cause damage to geomembrane.		X
Excessive oxygen in manifold	Leak in the vacuum system	Visually inspect all exposed pipe between the inlet port and the manifold branch separations and check each manifold branch immediately. Isolate the leaking branch of the manifold.			X
Static pressure is significantly higher or lower than average only at individual extraction well, trench riser, or vent riser monitoring port	Blockage in extraction well, trench riser, or vent riser	Check for blockage by flushing water through extraction well, trench riser, or vent riser casing.	Close extraction well, trench riser, or vent riser control valve.		
Reduced velocity/increased vacuum in manifold	Flow restriction	Check to see that all the valves controlling the restricted section of manifold are in normal (open) operating positions. Check for condensate buildup in all low spots of the manifold by listening for the sound of water in the manifold. Adjust the pipe slope in the low spot.			
Rhythmic fluctuations in velocity or vacuum in manifold	Condensate build- up behind gas collection manifold control valve	Check for condensate buildup by measuring static pressure at gas collection manifold control valves upstream and downstream to pinpoint location. Open identified control valve. Readjust other control valves to return static pressures to normal levels. If condensate is not built-up behind control valve, check for condensate blockage at low spot.	N/A		
	Condensate blockage at low spot in gas collection manifold	Consider checking for condensate blockage by video inspecting pipe. If condensate blockage occurs at low spot, expose gas collection manifold and readjust pipe slope to drain.	Expose gas collection manifold using shovels. Use extreme caution to not cause damage to geomembrane.		X
Oxygen concentration greater than 5 percent at gas collection manifold monitoring port	Leak or break in gas collection manifold	Check oxygen concentration at gas collection manifold control valves upstream and downstream to pinpoint location. Consider checking for possible leaks or breaks in gas collection manifold by video inspecting condition of pipe. If leak or break is observed, expose gas collection manifold pipe and inspect for damage. If pipe is damaged, conduct repair.	Expose gas collection manifold using shovels. Use extreme caution to not cause damage to geomembrane.		X
	Leak in extraction well, trench riser, or vent riser casing	Check for increased air in gas stream (oxygen : nitrogen = 1:3.8) at extraction well, trench riser, or vent riser control valve station. Check for possible leaks in casing above cover system by exposing casing and inspecting for damage. If casing is damaged, conduct repair.	Expose casing using shovels. Use extreme caution to not cause damage to geomembrane.		X
Static pressure is significantly higher or lower than average at upstream extraction well, trench riser, or vent riser monitoring ports	Blockage in gas collection manifold	Check for blockage at condensate drain and trap at flare facility. If condensate drain and trap is not clogged, check for blockage in gas collection manifold pipe by using a snake from upstream gas collection manifold cleanout. If clogged area is identified, expose gas collection manifold pipe at blocked location and conduct repair.	Expose gas collection manifold using shovels. Use extreme caution to not cause damage to geomembrane.		X
Water gurgling in gas extraction well	High ground water levels	Check for indication of high ground water levels by reviewing the piezometer water level data log and measuring the ground water level in gas extraction well. Check gas extraction well installation records. If the water level is not near the top of the well screen, check for evidence of condensate blockage in gas collection manifold.	N/A		
Sink hole	Underground refuse fire	Check for: 1. Gas temperature > 130°F 2. Exhaust gas escaping from surface cracks 3. Depression (pit) in landfill cover surface 4. Carbon monoxide concentrations above 50 ppm	Close all extraction well and trench riser control valves in affected area immediately. Refer to Chapter 13. Seek expert help.		

N/A = Not Applicable

Table 7.7-1. Landfill Gas Collection and Transmission System Repair Guide

Problem	Action	Repair Guidance/Limitations
Control valve fails	Replace control valve with spare.	Close control valves on gas collection manifold to isolate area.
Leaking or cracked gas extraction well, trench riser, or vent riser casing	Replace casing and fittings.	Close control valves at monitoring port to isolate area.
Leaking, clogged, or broken gas collection manifold pipe	Obtain replacement pipe if required, and reweld or use RayChem fittings.	Use certified HDPE contractor.
Broken flexible hose	Replace with new flexible hose.	Close control valves on gas collection manifold to isolate area.