Seattle Public Utilities

CSO Reduction Program

Odor Management Guidelines

Technical Memorandum

TETRA TECH

November 2019

Odor Management Guidelines Technical Memorandum

Prepared for

Seattle Public Utilities

Prepared by

TETRA TECH

1420 Fifth Avenue, Suite 600
Seattle, WA 98101

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Term	Definition	Term	Definition
BOD	biochemical oxygen demand	mg/L	milligram per liter
cfm	cubic feet per minute	O&M	operations and maintenance
CSO	combined sewer overflow	ppm	parts per million
DO	dissolved oxygen	PSCAA	Puget Sound Clean Air Agency
DWW	Drainage and Wastewater Line of Business	SPU	Seattle Public Utilities
H_2S	hydrogen sulfide	WAC	Washington Administrative Code

SECTION 1

Introduction

1.1 Background

To keep Seattle the best place to live, Seattle Public Utilities (SPU) invests in programs and projects to protect its surrounding waterways while providing a high level of service to meet the infrastructure needs of the growing community. Within SPU, the Drainage and Wastewater Line of Business (DWW) maintains and operates facilities and assets including, but not limited to, pump stations, pipelines, catch basins, maintenance holes, and combined sewer overflow (CSO) storage facilities to enable untreated wastewater to be managed properly and kept out of local waterways.

Odor is a common and prevalent problem for wastewater facilities. Certain operating and maintenance conditions may cause wastewater odors to intermittently emanate or be discharged from DWW facilities and assets. Although not detrimental to the health of the public at the low-level exposures (OSHA, 2005), these odors can be perceived as a nuisance at concentrations as low as 0.02 ppm. As part of being a steward of the community and to ensure an equitable odor abatement approach across SPU's service area, DWW developed these *Odor Management Guidelines* for odor prevention and odor complaint response, with guidance on implementing odor abatement strategies for future and existing SPU wastewater system projects.

1.2 Purpose and Goals of Odor Management Plan

Over recent years, SPU has made significant achievements in reducing CSOs under a consent decree with state and federal agencies, including construction and commissioning of several CSO storage facilities. In addition, existing SPU pump stations are undergoing ventilation upgrades to ensure compliance with current code requirements. These new CSO storage facilities and pump station modifications are requiring SPU to develop a strategy for evaluating potential odor generation prior to construction or upgrade of a facility. Residences (odor receptors) have been and continue to be in locations near pump stations and CSO storage facilities. Odors from these facilities can drift across SPU property lines and potentially be perceived by nearby residents as a nuisance. The following summarizes goals for addressing odor management at SPU pump stations and CSO facilities:

- Reduce odor-related complaints within the defined wastewater service area through the implementation of planned and reactive odor abatement strategies.
- Anticipate and mitigate odors at new wastewater facilities such as pump stations and storage tanks.
- Mitigate existing corrosion caused by the presence of certain compounds (e.g., sulfuric acid) and minimize future corrosion in owned and operated infrastructure within the service area.

The Odor Management Plan will assist SPU in ensuring that these odor management goals are met. The Odor Management Plan presented in Section 4 of these guidelines provides an approach for addressing odors prior to construction or upgrade of a facility rather than reacting after odors have become a nuisance. The Odor Management Plan focuses on evaluation of odor potential from wastewater pump stations and CSO facilities. The approach outlined in this plan is based on information that is current and accurate as of the date this document was prepared (November 2019). SPU will periodically review and update this document as odor management practices are implemented and advanced with new facilities.

1.3 Objectives

The objectives of the Odor Management Plan are to assist SPU in the following areas:

- **Documentation**—Summarize the existing process for documenting odor sources and provide guidelines for documenting odor complaints and response.
- **Evaluation of Odors**—Examine and characterize existing and potential future odor problems for SPU.
- **Management of Odors—**Identify general operational and design considerations for managing odor generation and release. This includes developing a strategy to manage the discharge of gases from the wastewater collection system at or near CSO facilities and pump stations.

1.4 Air Quality Regulations

1.4.1 Puget Sound Clean Air Agency

The Puget Sound Clean Air Agency (PSCAA) is a special-purpose, regional governmental agency that seeks to protect public health, improve neighborhood air quality, and reduce greenhouse gases in the Counties of King, Kitsap, Pierce, and Snohomish. PSCAA adopts and enforces air quality regulations outlined in the federal Clean Air Act and Washington Clean Air Act, monitors air pollution, sponsors voluntary initiatives, and educates people and businesses about clean air and climate-friendly choices they can make (PSCAA, 2014).

Under its Regulation I Article 5.03, PSCAA currently requires registration of regulated air emission sources and grants operating permits. Although sewage treatment plants and odor management equipment (Article 5.03(a)(8)) are listed as regulated air emissions sources, collection system assets including "sewer manholes, junction boxes, sumps and lift stations associated with wastewater treatment systems" are categorically exempt, insignificant-emission units per WAC 173-401-532(120) and therefore do not require an operating permit per Regulation I, Article 7.

Although SPU facilities are not subject to PSCAA permits, any odor facilities should still provide reasonably available odor management technology or an operation and maintenance strategy to address any odor source. The selection of odor management facilities should consider the feasibility of the technology to treat the odors, the odor reduction to be achieved, the impact on air quality, and capital and operating costs.

1.4.2 Other Applicable Codes

The relevant section of the City of Seattle's odor standards that would pertain to the design of odor management facilities for SPU is Seattle Municipal Code 23.47A.20 (Odor Standards), which sets the following:

- The venting of odors, vapors, smoke, cinders, dust, gas, and fumes shall be at least 10 feet above finished sidewalk grade, and directed away to the extent possible from uses within 50 feet of the vent.

SPU practices will follow good engineering practices for determining stack height to ensure odor emission standards are met at the point of compliance (at the property boundaries of receptors). This may include a stack height 10 feet or greater to ensure proper dispersion or air dispersion modeling to determine the appropriate stack height (or need for a stack) to ensure compliance of the odor emission standards (see Chapter 4) .

1.5 Odors as a Nuisance

The most common approach to regulating odor impacts is through recognition of odors as a nuisance. An odor is a nuisance if it unreasonably interferes with the proper enjoyment of the property of others. Addressing odor as a nuisance does not focus on preventing odors from being creating or released but on the potential impact that odorous emissions have on receptors. The allowable threshold is not always clear. Creating a nuisance is the most common reason that odors are mitigated. While most states prohibit nuisance impacts under common law, few states define what odor concentrations are associated with nuisance odor impacts; even fewer define what the frequency and duration of those impacts should be.

In Washington State, Revised Code of Washington (RCW) 7.48.120 defines nuisance as follows:

> "Nuisance consists in unlawfully doing an act, or omitting to perform a duty, which act or omission either annoys, injures or endangers the comfort, repose, health or safety of others……"

Odor nuisance can be interpreted as follows:

- The affected receptor must not only detect an odor, but recognize the odor as being distinct from other background odors and be specific to a particular source (in this case wastewater sources).
- The duration of the odor episode must be long enough to interfere with activities at the receptor's property. The duration of the odor episode may be further extended by the requirement that a regulatory official confirm or verify that the odor is present. While a person can perceive an odor in a few seconds, it may take several minutes before the presence of the odor disrupts activities at a person's property.
- To be a nuisance, an odor episode must be unreasonable. While a single odor episode may be unpleasant and disruptive, it may also have been accidental or unavoidable. Odor episodes that re-occur over a period of time become preventable and are an unreasonable imposition on the surrounding community.

Thus the Odor Management Plan sets forth guidelines to ensure that SPU facilities do not create a chronic odor nuisance and that measures are taken during planning and design for the prevention of nuisance odors.

SECTION 2

Odor and Corrosion Background

2.1 Wastewater Compounds Causing Odor and Corrosion

Wastewater odors are a complex mixture of chemical compounds from domestic and industrial sources. Odorous compounds most often generated from domestic wastewater collection systems include inorganic and organic gases. The primary inorganic odorous gases are hydrogen sulfide (H_2S) and ammonia, which are a result of biological activity in the conveyance system or discharges of chemical waste from industrial facilities. Other odorous wastewater gases often found in collection systems include compounds such as mercaptans, organic sulfides, and amines.

The most frequently identified odors in conveyance systems throughout the country, including SPU's system, are H_2S and "general wastewater odors." Ammonia odors are more often associated with processes that treat solids at wastewater treatment plants. Wastewater characteristics that are of particular interest to the generation of odors are described below. These wastewater characteristics provide a general indication of the severity of odors and corrosion that may be expected.

2.1.1 Dissolved Sulfide

Dissolved sulfide is generated through a biological reaction between wastewater and the aerobic and anaerobic bacteria that live on pipe walls. Generally, a black, mucous-like slime layer is generated below the water level in sewer pipes. The slime layer becomes thick enough to prevent dissolved oxygen from diffusing very far into it, and an anoxic zone develops under the surface. It takes approximately two weeks to establish a fully productive slime layer in pipes.

Within this slime layer, sulfate-reducing bacteria use the sulfate ion, a common wastewater component that consists of sulfur and oxygen, as an oxygen source. When these bacteria use sulfate, dissolved sulfide is the byproduct. Dissolved sulfide is released in four forms: sulfide ion, bisulfide ion, aqueous H_2S, and H_2S gas. The level of dissolved sulfide concentration in the wastewater stream is indicative of the H_2S levels that may be generated within the system. Odor and corrosion problems increase with increasing H_2S levels, although H_2S in a dissolved form does not cause corrosion of concrete.

The term "total sulfides" refers to the total of insoluble and soluble sulfides. The term "dissolved sulfides" refers to only the dissolved sulfides. Typically the dissolved sulfides in wastewater are about 70 to 90 percent of the total sulfides. Generally, dissolved sulfide values of 0.5 mg/L or greater can result in odors and corrosive conditions, depending on the physical features of the sanitary sewer.

2.1.2 Atmospheric Hydrogen Sulfide

Hydrogen sulfide gas is colorless, flammable, and poisonous, with an unpleasant odor like rotten eggs that disappears after an exposure of several minutes. Slightly heavier than air, the gas sinks to the bottom of manholes and tends to collect in the headspace of sewer pipelines. In this environment, H_2S causes problems on several fronts:

- When H_2S gas escapes the sewer system through manholes or pump stations, it creates an objectionable odor, even in concentrations as low as 8 parts per billion.

- Workers in manholes and pipelines may be exposed to potentially toxic levels of gaseous H_2S. Extended exposure to H_2S can cause one's sense of smell to fail. Without realizing H_2S is present, a victim may be exposed to dangerous concentrations of the gas and experience headaches, dizziness, nausea, or even death.
- When H_2S is trapped in the headspace, aerobic bacteria on the crown of the sewer pipe digest the gas and convert it to sulfuric acid, a compound that corrodes concrete pipe and degrades its structural integrity.

H_2S measurements in an active system may range from 0 to 1,000 parts per million (ppm). Table 1 correlates the concentration of H_2S to the effect on humans.

Table 1. Effects of H_2S on Humans

Concentration of H_2S (ppm)	Effect
0.01 to 1.5	Odor detection threshold level (when rotten egg smell is noticeable to some)
2 to 5	Odor becomes more offensive; prolonged exposure may cause nausea, tearing of the eyes
8	National Institute for Occupational Safety and Health construction 8-hour exposure limit
20 - 100	Possible fatigue, Headache, nausea, and eye, nose, and throat irritation
100*-150	Loss of smell; National Institute for Occupational Safety and Health IDLH (immediately dangerous to life and health) limit
300 to 500	Life threatening
> 700	Immediate death

2.1.3 Dissolved Oxygen

Dissolved oxygen (DO) content within the wastewater stream is an indicator of the level of bacterial activity in the wastewater, and how aerobic or anaerobic the wastewater is. Increased bacterial activity correlates to decreased dissolved oxygen content, which correlates to the increased production of dissolved sulfides. DO measurements can range from 0 to 8 mg/L. Generally values of 1 mg/L or less result in conditions conducive to the production of H_2S.

2.1.4 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) measures the rate of oxygen uptake by micro-organisms in the wastewater. Typically, BOD values in wastewater range from 200 mg/L to 600 mg/L. Wastewater with higher BOD rates will reach anaerobic conditions faster and will favor higher sulfide generating conditions.

2.1.5 Temperature

Because sulfide generation in sewers is a biological process, elevation of temperature causes an increase in metabolic activity and an increase in sulfide production. The sulfide generation rate increases 7 percent per 1 °C increase in wastewater temperature. Typically, the rate of biological uptake, and thus oxygen utilization, doubles with every 10 °C increase in temperature. Conversely, the biological reaction rate is cut in half every time the wastewater temperature drops by 10 °C. Thus wastewater temperature has a direct effect on the rate at which anoxic conditions are reached and the rate at which sulfate ions are consumed by bacteria and dissolved sulfides are produced.

An increase in temperature also lowers the solubility of oxygen and makes it more difficult to transfer oxygen to the wastewater. The rapid uptake of oxygen by sulfate-reducing bacteria at increased temperatures, coupled with the inability of oxygen to enter the wastewater stream, leads the bacteria to readily consume sulfate ions and produce dissolved sulfides.

2.1.6 pH

When atmospheric H_2S comes in contact with the moist surfaces of a structure or pipeline, it undergoes a biological conversion to sulfuric acid, which quickly leads to the decomposition of concrete and steel. High volumes of sulfuric acid will decrease the pH of the wastewater stream. When the pH of the wastewater drops below 6, 90 percent of the dissolved sulfide is present as dissolved H_2S gas. This dissolved gas can be readily released into the sewer headspace and converted into sulfuric acid on the dry surfaces of the pipewall. Low wastewater pH encourages the release of H_2S, and high pH discourages it.

2.2 Dissolved Hydrogen Sulfide in Pipelines

An important naturally occurring process in wastewater systems is the production of H_2S from decaying organic matter. H_2S is produced from sulfates found in the wastewater by sulfate-reducing bacteria. The bacteria are found in the slime layer on the submerged portions of the pipe walls. Anaerobic conditions are required for the bacteria to reduce the sulfates to sulfides. These conditions exist just below the surface of the slime layer where the available oxygen in the wastewater has been depleted (see Figure 1). The presence of oxygen will cause the microbes to become dormant, however they will resume their sulfate reduction as soon as anaerobic conditions return.

Detention time affects the volume of sulfides that are generated. Longer detention times allow for the available oxygen to be used up, thus allowing anaerobic bacteria to convert sulfates into sulfides.

Nearly full, full, or surcharged sewers have limited or no air space. Therefore, little to no oxygen enters the wastewater to oxidize the sulfides. Without oxygen, the wastewater becomes anaerobic and sulfides are generated. This is why force mains and siphons are generally larger contributing sources for H_2S generation.

The velocity of the flow in a sewer has an effect on the quantity of sulfides generated. Higher velocities (in sewers flowing less than full) tend to suspend solids and transport them through the sewer. Higher velocities also allow oxygen to diffuse into the wastewater and into the slime layer. The scouring effects of higher velocities may also keep the slime layer thin. Thus, the slime layer produces fewer sulfides as the velocity increases. Low velocities have the opposite effect.

2.3 Hydrogen Sulfide Generation and Atmospheric Release

In SPU’s collection systems, H_2S is the main compound of concern not only for providing an odor nuisance at relatively low concentrations, but also for its toxicity to humans at high levels in unventilated confined spaces (such as pump station wet wells) and its potential to be converted into sulfuric acid.

Sulfides are not detrimental to concrete in the dissolved form; they become so only when they are released into the atmosphere. When atmospheric H_2S comes in contact with the moist surface of a structure, it undergoes a biological conversion to sulfuric acid, which quickly leads to the decomposition of concrete and steel.

Source: American Society of Civil Engineers, 1989)

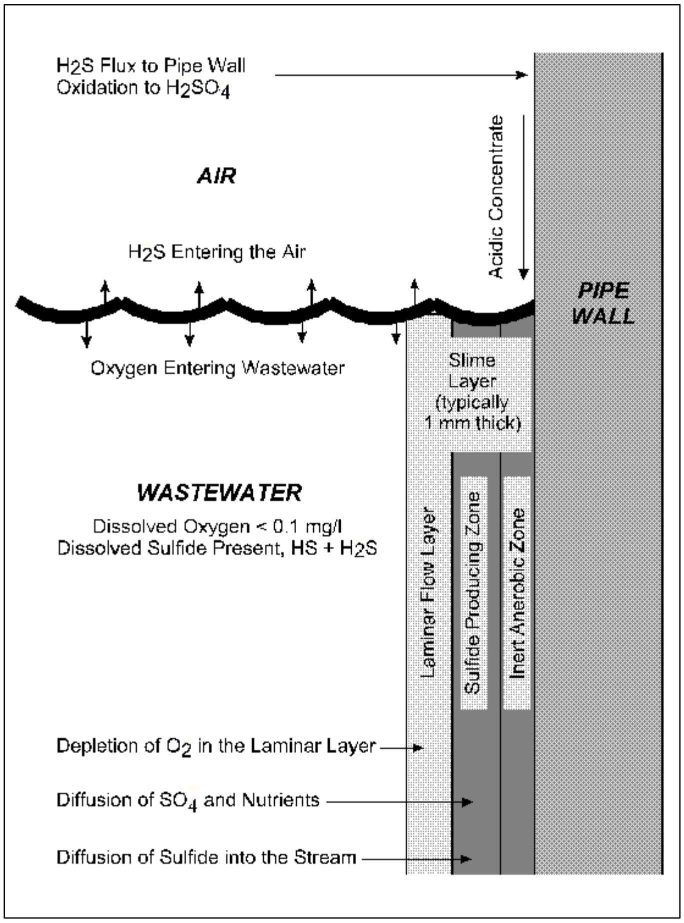

Figure 1. *Slime Layer*

Various factors can affect the release of dissolved H_2S into the atmosphere:

- **Temperature**—The solubility of H_2S in water decreases as the temperature increases.
- **pH**—In alkaline environments the majority of dissolved sulfides are bound in a form that cannot readily release into the atmosphere as H_2S. At a pH above 8, 90 percent of the dissolved sulfides are in this bound form. At a pH of 5 or less, 99 percent of the sulfides are present as H_2S and are released into the atmosphere due to the low solubility of H_2S in water.
- **Turbulence**—Turbulent flow can be both beneficial and detrimental to the sewer. If a pipe has high levels of dissolved H_2S, turbulent flow will cause it to be released into the atmosphere, creating odor, corrosion, and safety concerns. Turbulence can also introduce oxygen into the wastewater, which helps prevent downstream formation of sulfide. Figure 2 illustrates physical features that can cause turbulence that results in atmospheric H_2Srelease.

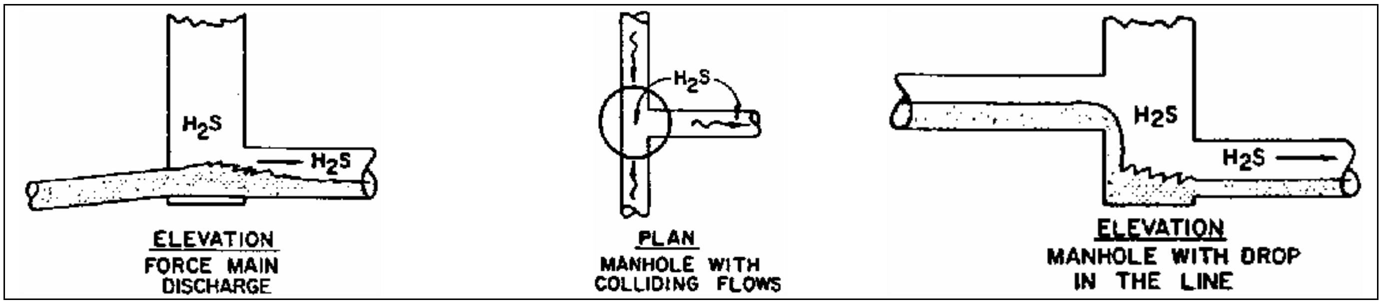

Figure 2. *Sources of Turbulent Flow in Sewers*

2.4 Corrosion Generation

The following combination of wastewater characteristics creates a collection system environment more favorable for corrosive conditions:

- **Low pH**—A low pH indicates a relatively high concentration of sulfuric acid in the wastewater, leading to corrosive conditions.
- **Low dissolved oxygen**—The biological reduction of sulfate to sulfides is accelerated in anaerobic conditions at low DO levels.
- **High dissolved sulfides**—Dissolved sulfides are biologically available to be converted into gaseous H_2S, which could in turn be converted into sulfuric acid.
- **High H_2S (gaseous state)**—Gaseous H_2S can be converted into sulfuric acid through biological activity along structure walls.
- **High biochemical oxygen demand**—Higher BOD rates cause wastewater to reach anaerobic conditions, leading to generation of sulfides.

SECTION 3

Odor and Corrosion in SPU Facilities

3.1 Current DWW Facilities

Seattle is served by a combined sewer system that handles both stormwater runoff and wastewater generated by businesses and residents. These systems are made up of many pieces that work together to protect public health and safety, including:

- 485 miles of stormwater pipes
- 33,733 catch basins
- 43 miles of creeks
- 379 miles of separated sewers
- 1,300+ miles of sewer pipe
- 68 wastewater pump stations
- 38 CSO storage tanks and large pipes

As of November 2019, odor management facilities are provided for only one pump station (in construction) and five CSO storage tank facilities, as listed in Table 2. Currently, there appear to be no SPU facilities with nuisance odors or documented odor complaints. The following sections describe the odor-related conditions at DWW facilities and current odor management prevention systems.

Table 2. SPU Odor Management Systems Characteristics

SPU Facilities	Odor Management Technology	Air changes per hour	Capacity (cubic feet/minute)	Airspace Treated
Pump Stations				
Pump Station 22	Carbon Scrubber	4	100	Wet well
CSO Storage Tank Facilities				
Windermere 13	Carbon Scrubber	6	1,500	Tank
Genesee	Carbon Scrubber	8	750	Tank
Henderson Basin 44	Carbon Scrubber	8	2,000	Tank
Henderson Basin 45	Carbon Scrubber	8	300	Tank
Henderson Basin 45	Carbon Scrubber	8	1,000	Tank/Wet well

3.2 Odors in Pump Stations

3.2.1 Description of Facilities

SPU owns and operates 68 wastewater pump stations. They include 45 wet-well/dry-well stations, 10 submersible stations, and 13 air-lift stations. Most SPU pump stations have pumping capacities of 100 to 300 gallons per minute (gpm); only three stations have capacities greater than 1,700 gpm. The largest sewer pump station that SPU currently owns and operates is Pump Station 37 in West Seattle, which has an average pump flow rate of approximately 4,700 gpm.

Pump stations serving areas of separated sewer are dedicated for sanitary sewer flows. Pump stations in partially separated or combined areas of the sewer conveyance system pump combined stormwater and sanitary sewer flows. Both types have the potential to create nuisance odors and corrosive conditions. Many of the pump stations are in residential neighborhoods.

3.2.2 Ventilation/HVAC System Upgrades

A 2015 SPU evaluation identified ventilation systems at wet well/dry well pump stations and submersible pump stations that were not meeting current codes (SPU, 2015). The evaluation listed a system-wide upgrade to these ventilation systems as one of the highest priority capital improvements for pump stations. The following summarizes the improvements that were identified for wastewater pump stations:

- Upgrade the dry well ventilation systems to comply with National Electrical Code (NEC) and National Fire Protection Association (NFPA) 820. The ventilation system will be designed to meet the “unclassified” hazard classification in the dry well at 25 stations.
- Provide new or upgraded wet well ventilation systems to reduce high humidity and corrosive atmospheres.

Existing SPU pump station ventilation systems utilize fans to actively ventilate from the dry wells to prevent buildup of sewer gases, primarily for safety of people entering the dry well space. About a third of the pump stations have a fan in the wet well to prevent buildup of hydrogen sulfide and corrosive compounds. Historically, when pump stations were constructed, they were not equipped with odor management systems. However, with the wet well ventilation upgrades currently underway or planned for future pump stations, odor management provisions are now being considered.

The wet well improvements will include new fans to better circulate air. This may exhaust more air from the wet well to the atmosphere, introducing a potential new source of odorous exhaust containing foul air from the wastewater in the wet well. Existing openings and penetrations between the wet wells and dry wells also provide the potential for odors in the wet well to escape into the dry well.

For these reasons, SPU has begun to evaluate how to manage potential nuisance odors where wet well ventilation changes are needed. SPU’s goal is to ensure reduction of potential nuisance odors associated with the pump stations by anticipating and mitigating the odors during the upgrades, rather than implementing reactive odor management measures. Chapter 4 expands on the Odor Management Plan for pump stations.

3.2.3 Current Odor Management at Pump Stations

Pump Station No. 22, located in the Magnolia neighborhood, is undergoing wet well ventilation upgrades. The odor management ventilation rate is based on providing four air changes per hour in the wet well. An active odor management system will include one intake fan, one exhaust fan and a carbon scrubber to treat odors from the wet well. The carbon scrubber process consists of moving foul air to a vessel where it is diffused through an adsorbent carbon media bed. The H_2S (or other contaminants) attaches to the surface of the carbon particles, and clean air is discharged to the atmosphere.

Several pump stations (Pump Stations 17, 35, 49, and 62) have biological dosing systems, which inoculate the wet wells of with a commercially prepared mixture of enzymes and microbial communities that help break down fats, oils, and grease and prevent their buildup in the wet well. This helps prevent odors related to the buildup of fats, oils, and grease from these pump stations, and may prevent the formation of H_2S and other volatile organic compounds by favoring the inoculated microbial community selected to prevent the formation of these odors.

There are no recorded odor management complaints associated with the pump stations as documented in the odor management prioritization matrix managed by SPU. Any odor issues have been documented at the pump stations by maintenance crews and typically associated during maintenance of that pump station or ventilation of the wet well.

3.2.4 Maintenance Strategy

Currently, SPU maintenance crews follow a maintenance plan in which all pump stations are visited monthly to inspect pumps, valves, HVAC, wet well, and other equipment. Where pump stations have consistent problems, crews visit twice a month to inspect. Where pump stations are prone to grease or odor issues, crews visit weekly to add microorganisms to the wet well to mitigate grease and odors. If, during inspections, further work is necessary, then a ticket is created, and maintenance comes back to address the concern. At each pump station there is signage with contact information to notify SPU's Operations Response Center (ORC). If ORC receives a complaint, it dispatches a crew within 48 hours to investigate.

There are currently no provisions to modify the maintenance strategy at the pump stations. There have been no documented odor complaints associated with continuous operation of the pump stations. SPU maintenance crews will continue monthly inspection and increase visits and maintenance as necessary to address any concerns that may arise.

3.3 Odors in CSO Facilities

3.3.1 Description of Facilities

SPU currently owns and operates 42 CSO storage facilities: 33 storage pipes and 9 storage tanks. Most are within the right-of-way. Forty-three percent of the facilities have a storage volume of 50,000 gallons or less; 48 percent have a storage volume between 50,000 and 1,000,000 gallons; and almost 10 percent have a storage volume over 1,000,000 gallons. The greater the storage volume, the greater the volume of potentially odorous air when the storage facility is not in use.

Twenty-three of the storage facilities are offline, and 19 are inline. The offline facilities remain empty until they are needed during a wet-weather event, creating potential for wastewater odors to form in the volume of relatively stagnant air. The inline facilities have some movement of flow through them on a regular basis to help prevent deposition of solids that would facilitate creation of wastewater odors.

3.3.2 Odor Potential

Typically, CSO flows do not have a high concentration of H_2S due to the dilution of the wastewater with rainwater and runoff. However, odors can be generated while flow is being stored until the stored volume can be transferred back into the collection system. When CSO flow arrives at a storage tank, the water is agitated, releasing H_2S from the liquid phase to the vapor phase. When the tank is drained back into the system, odors can be created from residuals left in the tank until the next filling phase. If tanks are not flushed or otherwise cleaned after each draining event, the gases are trapped in the tank's void space during the next refilling phase unless exhausted and treated. The longer the CSO is stored, the more gases will be produced, especially if some form of aeration is not provided. However, it is difficult to estimate the quantity and concentration of gases that need to be treated.

3.3.3 Current Odor Management at CSO Facilities

Currently, CSO storage facilities located in the right-of-way, including storage pipes and smaller tanks, do not have odor management systems. Most of these facilities are in space-constrained locations to fit within the footprint of the right-of-way and are passively managed (i.e., they do not require an automatic electronic or manual adjustment of controls to function).

The storage tanks built since 2010 have odor management systems. These storage tanks are located outside the right-of-way, typically near residential areas or in parks, and have a storage volume greater than 100,000 gallons. Odor management systems installed at these facilities are active systems (i.e., the air in the odorous space is pressurized and pushed or pulled through a carbon scrubber with the use of an exhaust fan). The design of a carbon scrubber consists of sizing the vessel to treat the amount of air being displaced from the storage facility. The odor management ventilation rate is based on providing 6 to 8 air changes per hour in the storage tank. The system requires an odor management supply fan to keep negative pressure and ensure the odorous air is exhausted from the storage facility when it is filling. Operation and maintenance consist of replacing the media about every 10 years and maintaining the supply fan.

There are no recorded odor management complaints associated with inline storage pipes, offline storage pipes or tanks, as documented in the odor management prioritization matrix managed by SPU.

3.3.4 Operation Strategies

Currently, SPU mechanical crews visit most sites twice a year performing preventive maintenance on pumps, valves, HVAC, storage tanks, instruments and other equipment. There have not been odor complaints at CSO sites, but, similar to pump stations, there is contact information for the neighborhood to contact ORC if problems arise. If ORC receives a complaint, it dispatches a crew within 48 hours to investigate.

As additional CSO storage facilities are implemented, SPU ORC staff will continue to ensure operation and maintenance strategies are implemented to minimize the potential of odors generated. This includes:

- Automatically cleaning the CSO storage tanks with tipping buckets to remove accumulated solids from the tank floors. Tipping buckets are installed in the storage tanks to automatically clean and flush the tank after a storm event. Fill pumps installed at the storage tank sites automatically pump non-potable water to the tipping buckets. A drain pump is used to remove the flush water after an automatic cleaning cycle is performed.
- Perform periodic pump exercising prior to the wet season to ensure drain pumps are operational.
- Monitor current maintenance strategies and increase maintenance efforts as required (e.g., potentially implement a pre-summer program to ensure storage pipes and tanks are cleaned to prevent combined sewage from becoming septic).

SECTION 4

Odor Management Plan

This section provides recommendations for the following odor management processes:

- **Documenting Odor Complaints—**SPU currently receives odor complaints from various sources. Management and documentation of odor complaint responses can provide insight if odors are related to SPU pump station and CSO facilities. A well-managed odor complaint response plan should be able to address the following:
  - ☐ Are the odors related to rotten-egg smell (indicative of wastewater-related odors)?
  - ☐ Were the odors generated during a facility disruption, such as pump station failure or operations and maintenance (O&M)?
- **Evaluating Odors—**Once odors are identified, a characterization of the odor strength is needed to determine the best approach for mitigating the problem. Evaluation of odors can include monitoring and sampling and visual inspection of the impact on existing infrastructure.
- **Managing Odors—**Depending on the strength and characteristics of the odors, odor management should consider operational and maintenance strategies first. If such strategies are unable to resolve the problem, then capital projects or mitigation strategies should be considered.

4.1 Documenting Odors

SPU currently records and addresses odor complaints and concerns from the public. Although logged odor complaints from nearby receptors are an indicator of locations of perceived presence of odor, they are not necessarily representative of the magnitude, frequency, and locations of perceived odor nuisance related to pump station and CSO facilities. Currently, logged odor complaints include odor causing sources that are unrelated to wastewater (such as decaying matter on a beach or storm drain catch basins).

Nuisance odor reports come from two primary sources:

- Complaints submitted by the public:
  - ☐ Project managers of current projects in design or construction receive complaint calls.
  - ☐ The City of Seattle has a general customer service phone number and online standardized forms for City service customers (including SPU) to log requests for service and general inquiries. Calls to the customer service team are logged by the customer service representative in a standardized form, and the data is loaded into the customer service request database.
- Observations from O&M field inspections.

Once an odor complaint is received, the odor data is populated in a spreadsheet and the following information is documented:

- Ticket ID number
- Year odor complaint received
- Odor Class: Odors or Water Odor
- Address of where reported odor problem has occurred
- Name of person with odor complaint
- Maximo work order (Maximo is the City's asset management system)

The customer's concern is followed-up by SPU O&M crews. A work order ticket is created in the City's Maximo asset management system for the appropriate O&M crew to investigate or address. If the O&M crew's investigation finds a need for a specific follow-up action that requires more extensive resources, an additional Maximo work order is created. When O&M crews service the Maximo work orders, frequently the DWW System Operations, Planning, and Analysis team is advised to help determine whether further action is needed to address the odor complaint and to provide preventive measures.

4.1.1 Documentation and Mapping of Odor Complaints

All logged odor complaints are populated and documented in a spreadsheet. Each odor complaint has been populated in a geographic information system to create the Odor Complaint Map. Odor complaints from the fourth quarter of 2006 through the second quarter of 2018 are shown in Figure 3. There is little information that can be deduced other than location of where the odor complaint was received and whether odors were related to water quality facilities. The map visually depicts where odor complaints have been received and the proximity of the complaints to SPU facilities and key King County wastewater facilities.

4.1.2 Documentation of Odor Reports from O&M Field Inspections

Documented O&M field inspections are crucial for obtaining an accurate understanding of the potential of odor and corrosion problems at facilities. SPU O&M inspections documents any odor-related field observations. Table 3 summarizes the type of field observations documented.

Current field observations provide an indication of odor and corrosion potential at a few pump stations; however, they do not clearly document whether these are wastewater-related. As SPU moves forward with pump station upgrades, field observations from pump station inspections should expand to provide additional information that can indicate the potential of an existing odor problem:

- Objectional odors—Provide a description (or array of odor descriptors to choose from) of the potential smell (rotten eggs, smoke, etc.)
- Expand on corrosion description—Identify any concrete or equipment corrosion to understand potential of H_2S impact

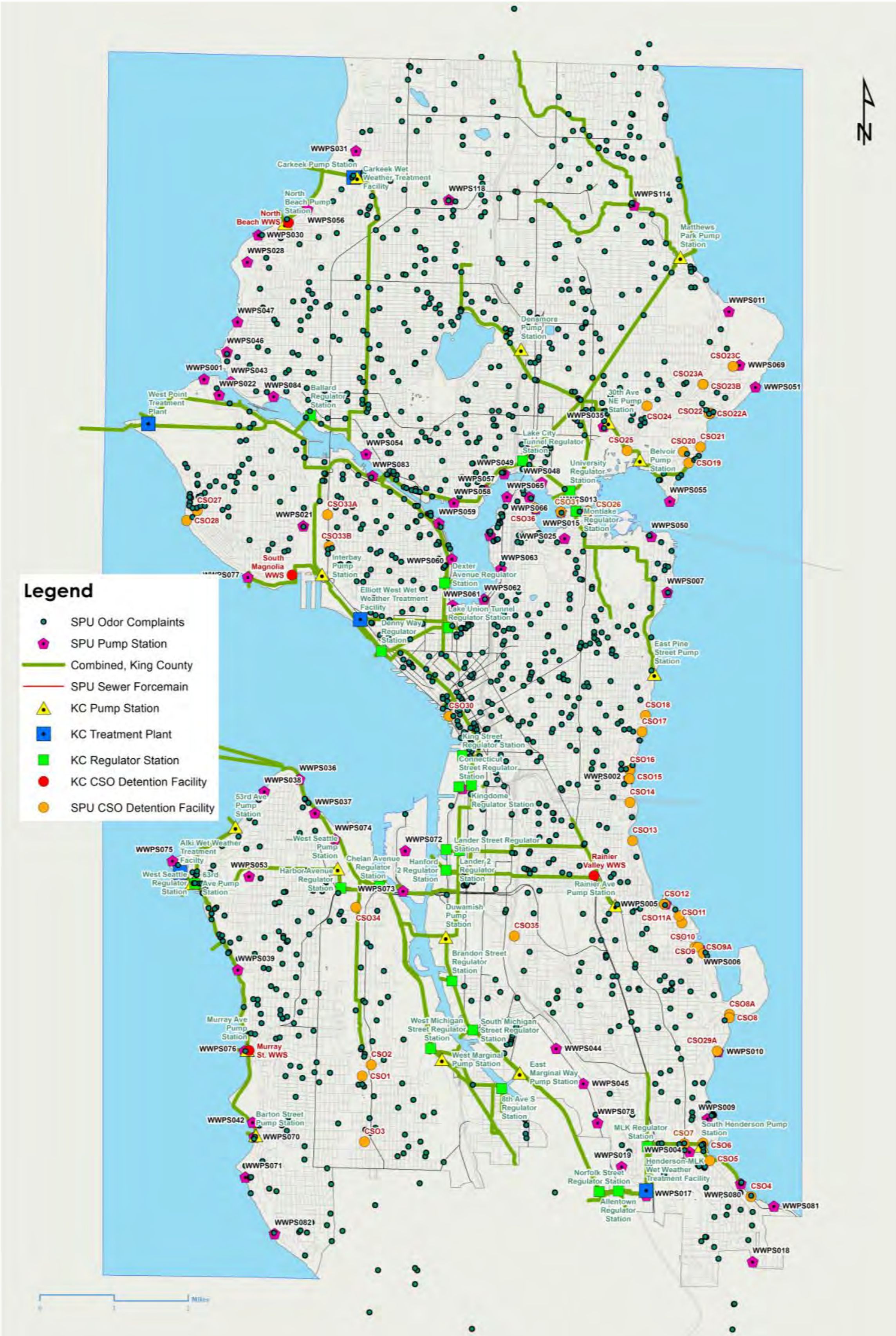

Figure 3. DWW Odor Complaints (Fourth Quarter 2006 through Second Quarter 2018)

Table 3. SPU Odor Field Inspection Observations

Pump Stations	Field Observations	**Receptors Nearby**
Pump Station 1	Odor issues typically present. Excess condensation even running positive pressure in wet well.	Residential, single-family
Pump Station 5	Odor complaints increase in summer due to more people using nearby park, especially during Seafair.	Residential, single-family; Park, Stan Sayres Memorial
Pump Station 25	Odor issues typically present. Was ventilating wet well at negative pressure, but when switched to positive, may have coincidentally seen fewer odor complaints.	Residential, single-family; Park, Montlake Playground
Pump Station 35	Odor issues typically present during maintenance of pipelines, and pump starts.	Commercial, U-Village
Pump Station 62	Corrosion an issue.	Park, Cheshiahud Lake Union Loop; Commercial, restaurant beyond 75'
Pump Station 70	Relatively frequent odor complaints here. May be due to briny water and decaying plants in summer, and also close to Barton Pump Station.	Residential, single-family; Park, Lincoln Park Beach; Commercial, ferry terminal
Pump Station 71	Corrosion an issue.	Residential, single-family; Park, Lincoln Park Beach
Pump Station 76	Corrosion an issue, also in conveyance.	Residential, single-family; Park, Lowman Beach Park
Pump Station 77	Corrosion an issue, possibly due to salts in the air.	Residential, single-family

4.1.3 Improvements to Documentation of Odor Complaints

Proper documentation will help better characterize odors generated from SPU pump stations and CSO storage facilities, helping to establish a baseline odor problem assessment. Currently, there is not a centralized group to accept odor complaint calls. Odor complaints are received by various entities, and different information is collected. The following are suggested improvements to the odor documentation and response process:

- Create a centralized odor complaint response center:
  - ☐ Create a toll-free number for complaint calls. This would allow for complaint calls 24 hours a day, 7 days a week. During business hours, calls would be answered by an attendant.
  - ☐ Establish an online complaint system specifically to address odors. Complaints would be received by SPU staff.
- Standardize the information documented to provide insight on the odor source and strength:
  - ☐ Name and address of alleged odor source
  - ☐ Reporter's contact information
  - ☐ What time was the odor noticed?
  - ☐ How long did the odor last (hours and minutes)?
  - ☐ Is the odor constant or intermittent?
  - ☐ What does the odor smell like (smoke, rotten eggs, spoiled cabbage, burned plastic, chlorine, asphalt or some other familiar material)?
  - ☐ How strong is the odor?
  - ☐ Where does the odor seem to be coming from?

- ☐ Where were you when you noticed the odor?
- ☐ Has the odor problem been experienced in the past?
- ☐ What were the weather conditions: temperature, wind direction and estimated wind speed

The standardized odor complaint information can also be collected by a typical on-line complaint system. The following are examples of on-line odor complaint systems:

- Department of Environmental Quality, Oregon: https://hdccmw1.deq.state.or.us/ncident/nform/app/?allowAnonymous=true#/formversion/4931c602-f3ad-4457-bf31-8a491bb3d394?FormTag=INCIDENT_REPORT_FORM&skipLandingPage
- South Coast Air Quality Management District: http://www3.aqmd.gov/webappl/complaintsystemonline/NewComplaint.aspx

Agencies also have set up a 24/7 call-in numbers to collect odor complaints. Such numbers can be set up to collect information similar to that identified above for the on-line data collection. Agencies with odor complaint hotlines include:

- King County: https://www.kingcounty.gov/depts/dnrp/wtd/response/odor-control.aspx
- Orange County Sanitation: https://www.ocsd.com/residents/requests/odor-complaint

Figure 4 shows a process overview for handling received odor complaints. An example SPU complaint form is included in Appendix D.

4.1.4 Prioritization of SPU Pump Stations

SPU needs to establish a priority classification system to determine which pump stations may have a higher odor generation potential. The data collected through odor complaints—coupled with inspection records, proximity to potential receptors, and known timing of capital improvements—can be used to prioritize which facilities should be prioritized for further evaluation and management of odors. For pump stations, the classification ratings shown in Table 4 can be used to prioritize which facilities to further evaluate for potential nuisance odors. Figure 5 shows a process for assigning priorities for odor management.

Table 4. Classification Rating System

	Priority 1	**Priority 2**	**Priority 3**	**Priority 4**
Prioritization Criteria	• Proposed ventilation upgrades in the next 10 years • Existing odor and corrosion issues (via field observations) • Existing odor complaints within 75 feet of facility	• Proposed ventilation upgrades in the next 10 years • Existing odor complaints within 200 feet of facility • Proximity to residential and commercial receptors (within 75 feet, indicative of high priority receptors within a block range)	• Proposed ventilation upgrades in the next 10 years • No existing odor complaints within 200 feet of facility • Proximity to industrial receptors (within 75 feet, indicative of lower priority receptors within a block range)	• No proposed ventilation upgrades • No existing odor complaints within 75 feet of facility

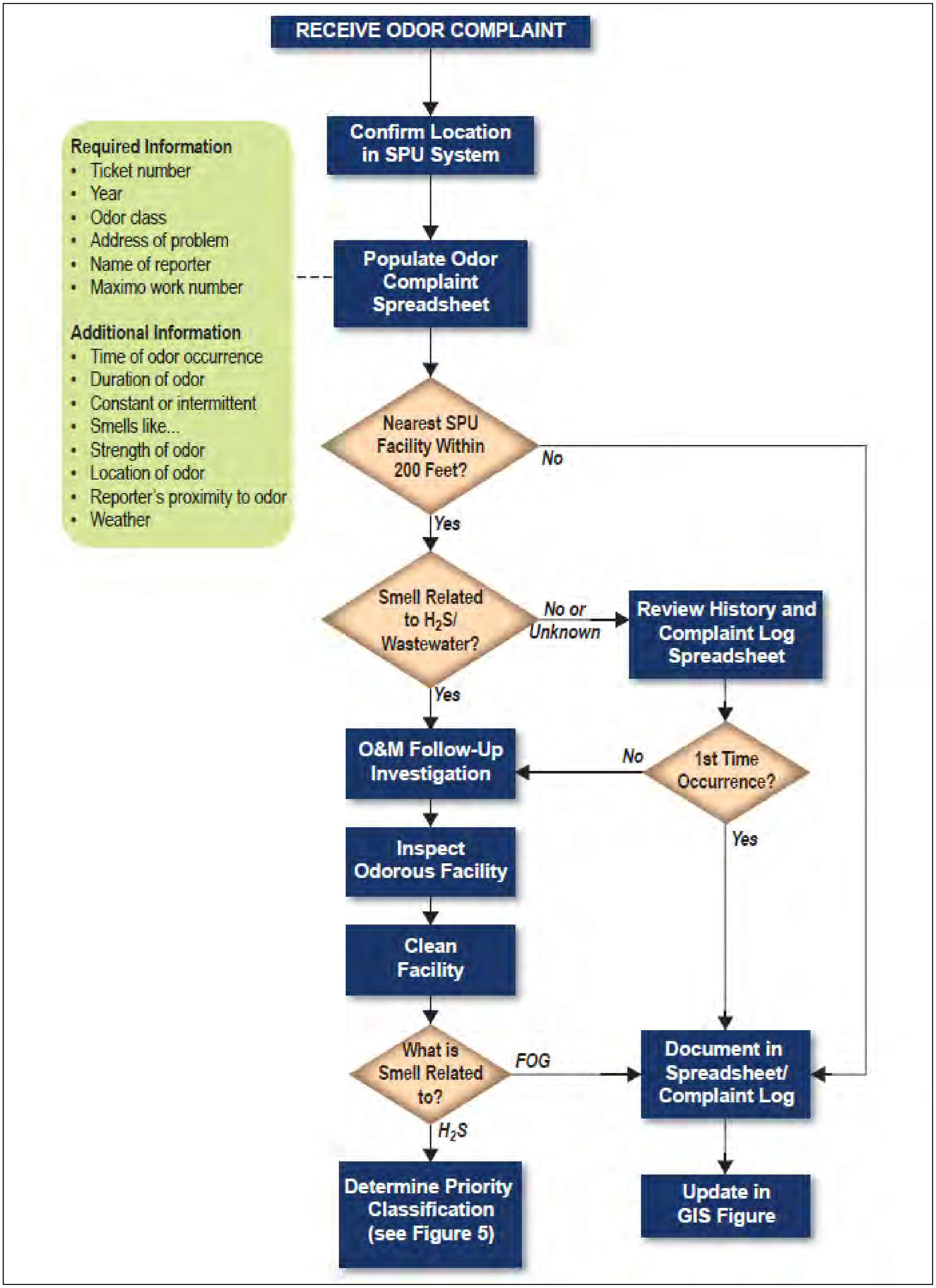

Figure 4. Odor Complaint Handling Process

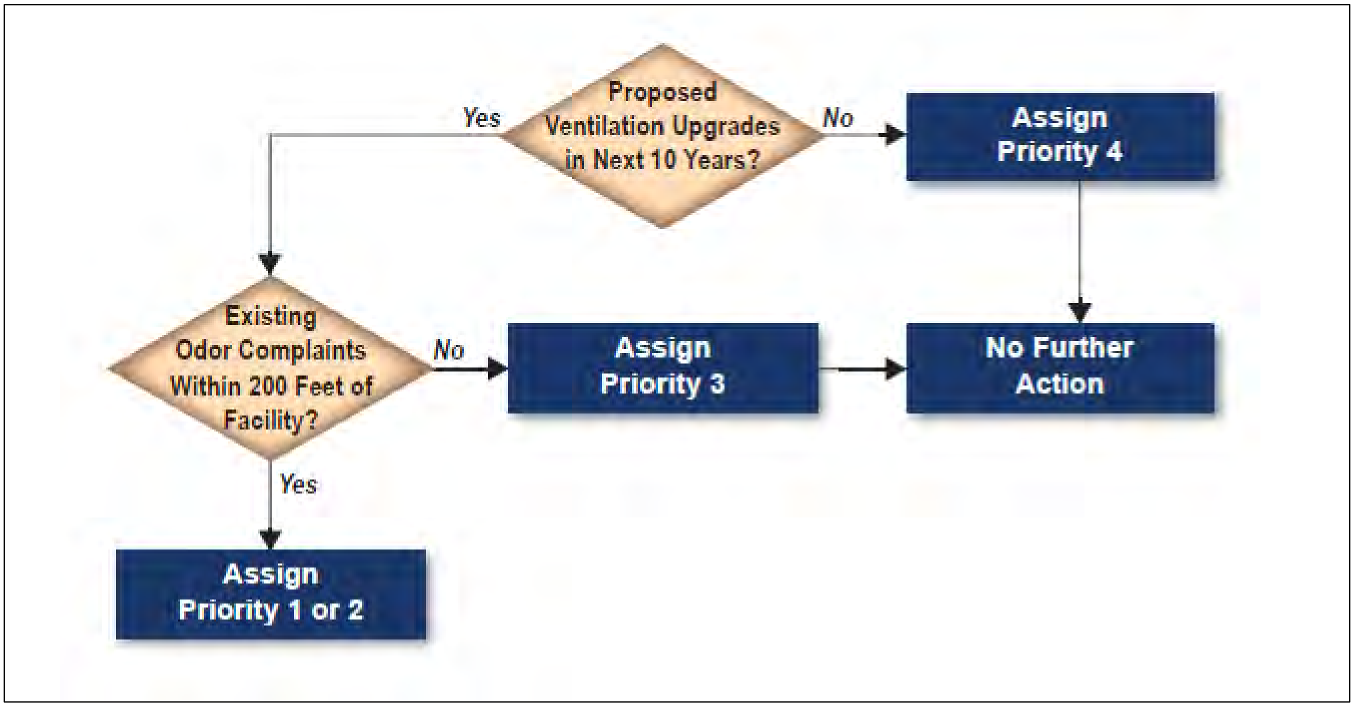

Figure 5. Priority Assignment Process

Based on this classification system, the following can be summarized of the existing 68 pump stations:

- 15 pump stations with planned ventilation modifications have documentation of existing odor and corrosion issues as noted from field inspections and have documented odor complaints within a radius of 75 feet from the pump station. There is insufficient information to determine if the odor complaints are wastewater related and associated with the pump station.
- 35 pump stations with planned ventilation modifications have documented odor complaints within a radius of 200 feet from the pump station and are within 75 feet of a residential and/or commercial receptor. There is insufficient information to determine if the odor complaints are wastewater related and associated with the pump station.
- 6 pump stations have planned ventilation modifications and no documented odor complaints within a radius of 200 feet and are located within 200 feet of industrial receptors.
- 12 pump stations currently do not have any planned ventilation modifications within the next 10 years and have no documented odor complaints within a radius of 75 feet from the pump station.

Appendix A summarizes the 68 pump stations and their priority ranking (see Figure 6). This priority classification indicates that SPU in the near term should focus its odor evaluation on the Priority 1 and 2 pump stations to determine the following:

- Are the odor complaints within 75 and 200 feet wastewater-related? Monitoring would be recommended to determine the H_2S concentrations at the pump station to provide insight.
- Is corrosion documented in the inspection related to H_2S? Field inspections would be required to confirm.
- What is the H_2S concentration in the wet well? H_2S monitoring would be recommended.
- Is an odor management technology needed? Depending on the concentration of H_2S, odor management would be required or provisions could be installed for future odor management.

The following section expands on the evaluation of odors at these facilities.

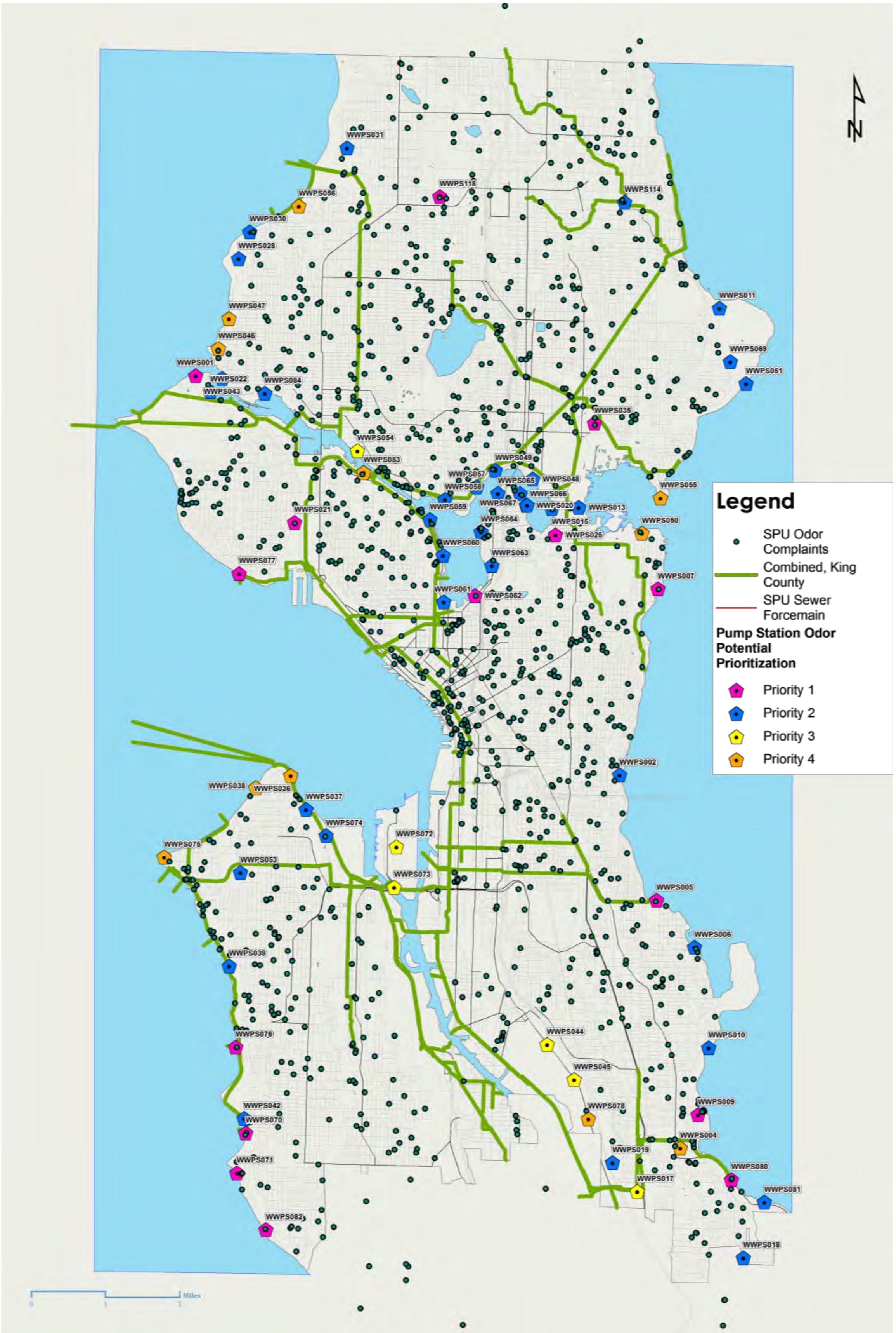

Figure 6. Pump Station Odor Potential Prioritization

4.1.5 Prioritization of SPU CSO Facilities

The 2015 *Long Term Control Plan* established design guidelines for the SPU CSO storage tank facilities. Appropriate odor control and maintenance equipment (e.g., tipping buckets) were included in the costs for all facilities. The *Long Term Control Plan* committed to mitigating traffic, odor, noise and visual impacts to be acceptable to the community. It also committed to all facilities being designed and maintained to minimize emissions of odorous compounds and including odor control components as necessary. With all CSO storage tank facilities including odor control systems, SPU does not need to establish a priority classification system to determine which CSO facilities may have a higher odor generation potential.

4.2 Evaluating Odors

4.2.1 Purpose

SPU currently does not have a program for sampling and monitoring odors. Such evaluations would help define an odor baseline and threshold-level goals.

A baseline would confirm the origin of the odor and determine the strength of the odor constituent and persistency of the problem. For existing facilities, this would help confirm the strength (odor constituent concentration) of the existing odor problem. For proposed improvements, it would help document whether odors are currently present prior to bringing new or modified facilities on line.

The existing concentrations of odors will help SPU set odor threshold-level goals to define what concentrations represent a chronic odor nuisance. Such goals would be based on the following:

- ☐ **Limit of detection**—Does the odor constituent exceed the detection threshold, so that odors will be detected by receptors?
- ☐ **Frequency of exceedance**—Is the odor constituent consistently present or associated with operating changes in the system?
- ☐ **Odor emission point of measure**—With the given influent concentrations of the odor constituents, the treated odor emission can be calculated depending on the removal efficiency of the odor management technology.

4.2.2 Methods

Odor constituent concentrations would be determined by monitoring and sampling as follows:

- **Monitoring of H_2S—**This will allow SPU to confirm the presence of H_2S in the headspace and determine the concentration levels of H_2S to confirm odor sources at a facility. H_2S monitoring data will also help establish design concentrations used to select and size odor prevention facilities.
- **Grab Sampling—**This provides information regarding the quality of the wastewater and the potential for each facility to cause odor and corrosion problems. The sewage flow can be sampled for dissolved oxygen (DO), biological oxygen demand (BOD), total dissolved sulfides, and the depth, temperature, and pH of the liquid sewage—all indicators of odor and corrosion potential. The data collected can also be used to select the appropriate technology and location for odor management equipment.

4.2.3 Odor Data Collection Approach

Monitoring and grab sampling will provide representative information on the typical characteristics of an odor source. Balancing the method (monitoring vs. sampling) and duration of data collection will ensure SPU's approach for characterizing odors and sizing odor management facilities is efficient, cost-effective and successful to achieve the odor goals. Figure 7 outlines the key steps for establishing an effective data collection approach Figure 8 presents a process for implementing monitoring and evaluation of odors.

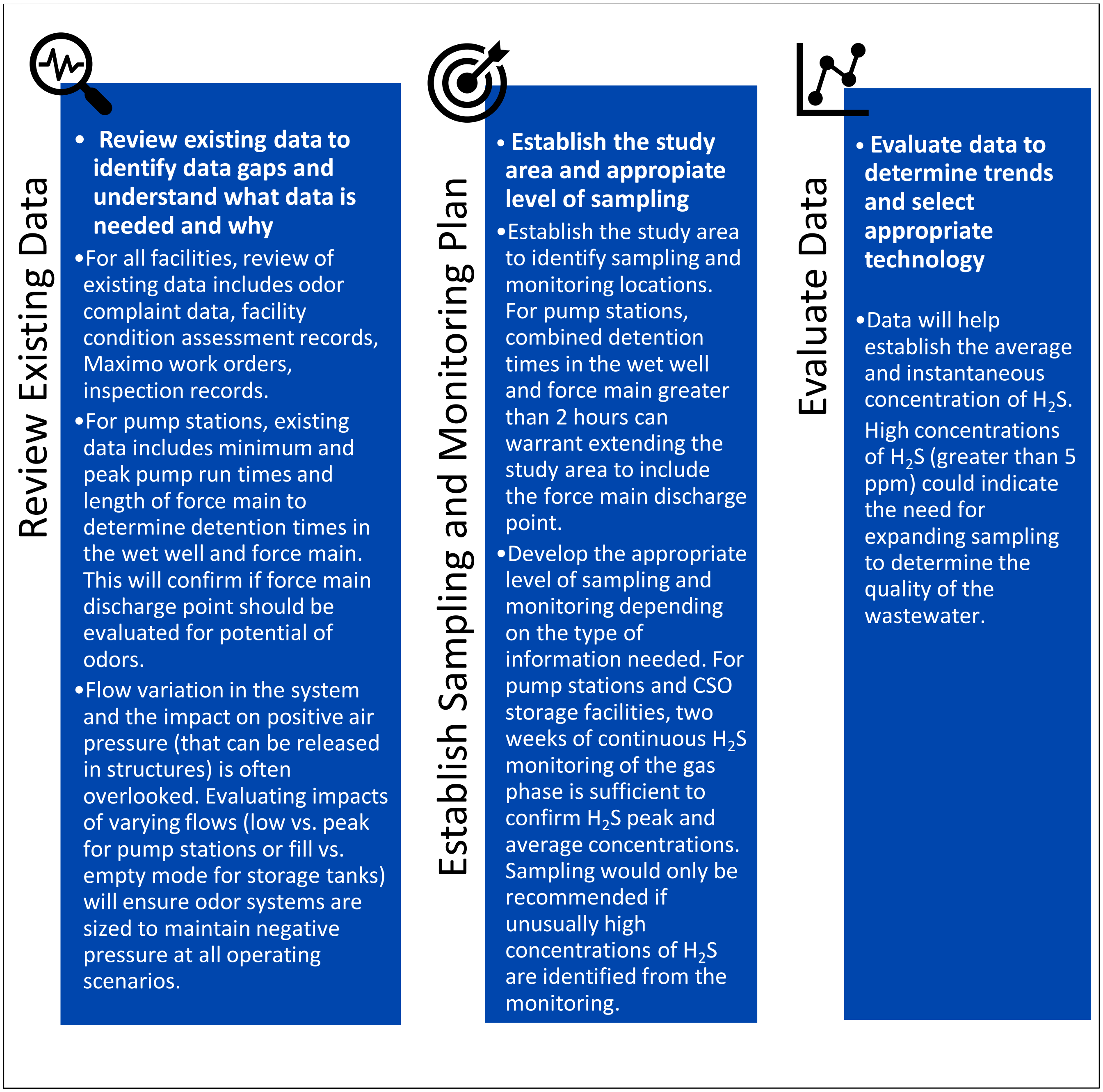

Figure 7. Key Steps for Establishing Data Collection Approach

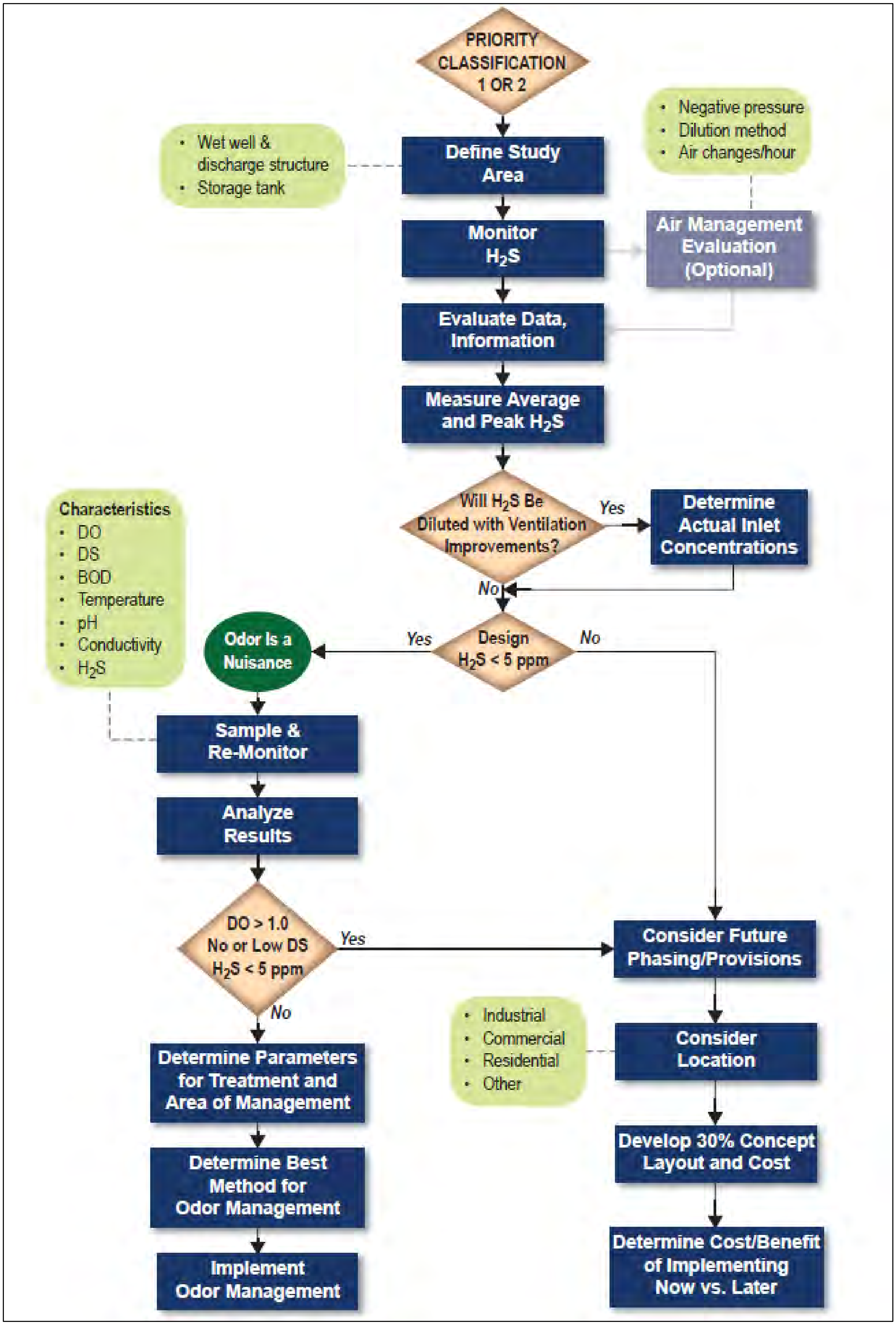

Figure 8. Monitoring and Evaluation Process

4.2.4 Odor Data Collection Levels

SPU will need to determine what sampling and monitoring data are really needed to characterize the potential odor problem. Figure 9 presents three levels of odor data collection and the value of the data that is collected. Based on the facility being evaluated, this will assist in determining the level of sampling and monitoring required.

Level 1: Confirm Presence and Concentration of H_2S	
How:	***What data tells you:***
• Install H_2S monitors in the headspace of wet wells for continuous H_2S monitoring	• Confirm presence of H_2S in wet wells or collection system prior to upgrades • Provide instantaneous concentrations of H_2S (ppm) • Determine average and peak concentrations for selecting and sizing odor management system if needed.
Level 2: Determine H_2S Concentration and Characterize Odor/Corrosion Potential in System	
How:	***What data tells you:***
• Install H_2S monitors in the headspace for continuous H_2S monitoring • Sample sewage flow for DO, BOD, total dissolved sulfides, and the depth, temperature, and pH of the liquid sewage, all indicators of odor and corrosion. Grab sampling by either: o Field sampling kits o Liquid sample taken to lab for testing	• Confirm presence of H_2S in wet wells or collection system prior to upgrades • Provide instantaneous concentrations of H_2S (ppm) • Determine average and peak concentrations for selecting and sizing odor management system if needed. • Determine if high initial sulfide concentrations and low dissolved oxygen concentrations indicate potential of corrosion in system • Indication of odor issue to persist downstream of the given facility.
Level 3: Determine H_2S, Characterize Odor/Corrosion Potential in System, Identify Potential of Odors Escaping	
How:	***What data tells you:***
• Install H_2S monitors in the headspace for continuous H_2S monitoring • Grab sampling by either: o Field sampling kits o Liquid sample taken to lab for testing • Pressure monitors located in structures with complex flow variations in system	• Confirm presence of H_2S in wet wells or collection system prior to upgrades • Provide instantaneous concentrations of H_2S (ppm) • Determine average and peak concentrations for selecting and sizing odor management system if needed. • Determine if high initial sulfide concentrations and low dissolved oxygen concentrations indicate potential of corrosion in system • Determine positive or negative pressure in structures to indicate potential of odors escaping.

Figure 9. Tiered Odor Data Collection Approach

4.2.4.1 Levels of Monitoring and Sampling for Pump Stations

The levels of monitoring and sampling for pump stations should be selected based on the following considerations:

- Level 1 should suffice for confirming presence of H_2S and determining concentration to confirm if an odor management facility should be considered.
- If H_2S concentrations are high (greater than 5 ppm) and/or H_2S-induced corrosion is identified, Level 2 should be considered to document and characterize wastewater strength and source of H_2S impact in the system.

- If previous odor complaints are directly related to H_2S and located in an area of high receptors, Level 2 should be considered to document the source and impact of the existing odor complaints.
- Level 3 would be considered only if a piping and structure system creates a complex air management issue.

4.2.4.2 Levels of Monitoring and Sampling for CSO Facilities

It is anticipated that CSO flows will not have a high concentration of H_2S due to the dilution of the wastewater with rainwater and runoff, combined with the expected velocity in the conveyance line, which causes turbulence and induces oxygen. Monitoring and sampling for CSO facilities are not deemed necessary unless there is an indication of existing odor problems in the area (e.g., existing odor complaints) or if the CSO facility is sited in a high-profile receptor area (e.g., waterfront, public parks) and H_2S data documentation will help better define baseline conditions.

The levels of monitoring and sampling for CSO facilities should be selected based on the following considerations:

- Level 1 should suffice for confirming presence of H_2S and determining concentration to confirm inlet H2S design concentrations for the odor management facility.
- If H_2S concentrations are high (greater than 5 ppm) and/or H_2S-induced corrosion is identified, Level 2 should be considered to document and characterize wastewater strength and source of H_2S impact in the system.
- If previous odor complaints are directly related to H_2S and located in an area of high receptors, Level 2 should be considered to document the source and impact of the existing odor complaints.
- For future siting of CSO facilities, if there are no existing odor complaints, then odor data collection is not required.
- For future siting of CSO facilities, if there are existing odor complaints, then Level 1 should be considered to characterize existing H_2S concentrations in nearby structures system prior to dilution with rain water.
- Level 3 would be considered only if a piping and structure system creates a complex air management issue.

4.2.5 Monitoring Methodology

Costs need to be considered in developing the sampling and monitoring plan. Appendix B describes the sampling and monitoring techniques and provides high-level estimates of cost. The most cost-effective odor monitoring approach for SPU is as follows:

- Perform Level 1 H_2S monitoring for Priority 1 and 2 pump stations.
- Purchase an OdaLog H_2S logger that can be temporarily installed in pump station wet wells and monitor H_2S
- Document daily temperatures and wind conditions during the monitoring period
- Minimum continuous monitoring period: 2 weeks with an OdaLog logger to monitor instantaneous H_2S concentrations in the wet well
- Monitoring to occur during odor season: May to early September
- Determine the average and peak H_2S concentrations in the wet well or existing facilities adjacent to proposed CSO facilities, that in turn can be used for sizing odor management systems if needed.

For the pump stations, the OdaLog loggers can be located in the wet well where the potential source of H_2S will emanate from. However, for pump stations with documented odor complaints within 200 feet and long force mains, it would be important to consider measuring the H_2S concentrations in the force main discharge structure. This would currently apply to four pump stations, with force main lengths between 1,000 and 1,500 feet that could have long detention times and release H_2S gas downstream.

4.3 Managing Odors

SPU needs to develop an odor management strategy to reduce the likelihood of nuisance odors as a result of facility improvements or mitigate nuisance odors of existing facilities. The strategy should include the following steps:

- Implement O&M solutions to prevent unwanted odors during the operation of the facility.
- If O&M solutions are implemented, consider re-monitoring for H_2S concentrations to determine if the O&M solutions reduced odor potential.
- Provide odor management solutions to treat and reduce odors if they cannot be avoided.
- Establish an outreach plan with the local community to inform them of approaches to ensure that chronic odor nuisances are addressed.

This strategy is shown in Figure 10.

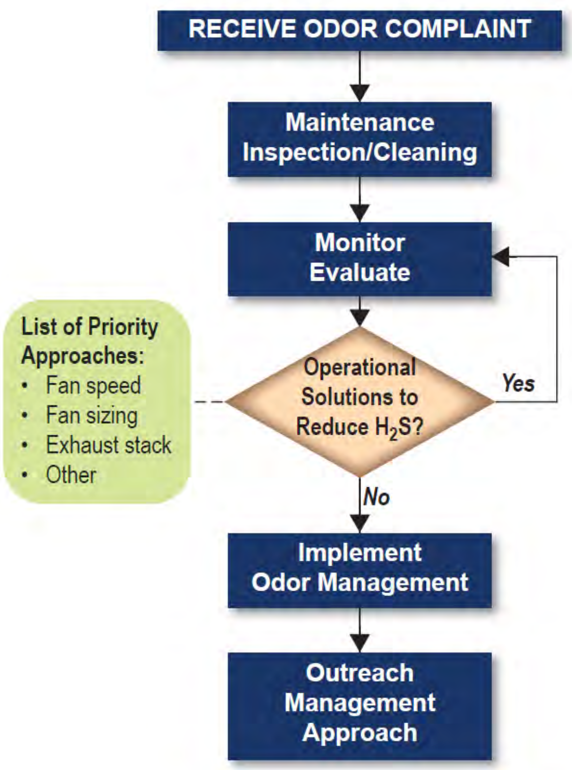

Figure 10. Odor Management Strategy

4.3.1 Operations and Maintenance Practices

The presence of wastewater odors in the collection system can generally be exacerbated by longer time intervals between preventive maintenance activities. However, some maintenance activities or operating conditions of the collection system can lead to intermittent release of wastewater odors. Implementing and then evaluating the following O&M activities can help determine if the generation of odors can be reduced:

- Clean wet wells and storage facilities—In all wet wells, there are areas that allow solids to drop out of suspension. These areas need to be eliminated or a method provided to resuspend the solids so that they are moved along.

- Modify pumping cycles to prevent or limit anaerobic conditions in the wet well—Generally speaking, if the detention in either the wet well or force main based on the average flow is less than 30 minutes, then there should be few problems. The wet well should be properly vented to the atmosphere.
- Operate pumps daily at a high capacity to produce scouring velocities in the pump station force mains.
- Ensure that force main check valves seal and do not allow force mains to drain between pumping cycles.

During pump station design, consideration should be given to optimizing the wet well size. Ideally the station will not operate in fill and draw modes, but should be designed with variable-speed pumping capability. Pump cycling frequency, force main size, detention times, and discharge design all can contribute to odor issues. Infrequent pumping can result in the wastewater becoming septic in the wet well or force main and can result in slugs of high-concentration H_2S being emitted at the force main discharge. Additionally, the more frequent the pump cycle, the more wear and tear on the pumps—hence the preference for variable speed units. If any O&M activities are implemented to reduce the odor potential, re-monitoring of H_2S should be considered to document the effectiveness of the changes.

4.3.2 Odor and Corrosion Management Technology

If O&M practices cannot reduce odors at an identified facility, then odor management technology solutions are necessary. Such solutions manage odors by maintaining a negative air pressure within the wet well or structure to prevent buildup of odorous or corrosive gases. If an odor management solution is needed for gases vented under this strategy, the type and size of the unit will depend on the type and concentration of odorous compounds and the ventilation rate. Appendix C provides general design standards for odor treatment technology. For SPU, this will typically consist of the following:

- Fiberglas-reinforced plastic (FRP) ductwork
- Sound traps
- Centrifugal FRP fans and blowers
- Mist/grease eliminators
- Activated carbon odor control units

Sizing of the odor treatment technology will be dictated by two factors:

- Active or passive ventilation to ensure odors are captured and treated
- Air flow rates

4.3.2.1 Active or Passive Ventilation

The odor treatment technology needs to effectively capture and treat odorous air from the source using either of the two following approaches to ventilation:

- Passive ventilation requires a positively pressurized space to force air through the activated carbon odor control unit. Passive odor management can be used if the air flow consistently follows the direction of the wastewater flow. If no significant outside pressure source acts on the air, the friction effect causes the upstream portion of the sewer system to retain negative pressure and the odorous air passes through the pipeline and structures and through the odor control system. This would be applicable for force main discharge structures with potential of positively pressurized air from the force mains. Passive ventilation eliminates the need for exhaust fans and associated sound traps, thus minimizing the footprint.
- Active ventilation requires a constantly operated fan to mechanically ventilate and provide a negative pressure through the wet well or CSO storage tank. This would be applicable for wet wells with open ventilation spaces and

various filling rates that require a negative pressure to effectively capture odors. Similarly, CSO facilities require active ventilation. Active ventilation rates need to be sized for the greater of two scenarios: established air changes per hour or air flow during filling events.

4.3.2.2 Recommended Air Changes per Hour

Air flow rates are selected to ensure negative pressure is maintained to overcome the air displacement that results from filling the wet well and storage tanks. This will ensure that the mechanical ventilation will provide a relatively stable negative pressure in the structure. Wet wells require forced ventilation and can be sized to achieve one of the following:

- Provide odor management (i.e., maintain a negative pressure): typically 2 to 4 air changes per hour
- Provide corrosion protection: typically 4 to 6 air changes per hour
- Provide ventilation for SPU manned entry (per NFPA 820): 12 air changes per hour
- Provide ventilation for strong odors in occupied spaces: 20 air changes per hour

For SPU pump stations, the following ventilation rates are recommended:

- For pump stations with no documented corrosion issues: The greater of 4 air changes per hour or peak inflow rate
- For pump stations with documented corrosion issues (related to H_2S): The greater of 6 air changes per hour or peak air displacement

Based on these ventilation rates, the largest odor management system for the Priority 1 and 2 pump stations would be 550 cubic feet per minute (cfm) for Pump Station 37, at 6 air changes per hour. However, there is no existing data from field inspection reports to indicate that there are any corrosion issues; thus the ventilation rate could be selected for 4 air changes per hour, resulting in a 370 cfm carbon scrubber system.

For SPU CSO storage facilities, the recommended ventilation rate is the greater of 2 to 4 air changes per hour or peak air displacement. Currently, existing CSO storage facilities for both SPU and King County have been sized for 2 air changes per hour. SPU's Pearl Street SSO facility is currently being designed to provide odor control technology designed for 2 air changes per hour, with an upgrade option of 4 air changes per hour.

Once it has been determined if the odor control system is an active or passive system, and the quantity of air changes per hour has been established, the odor control technology can be sized and configured based on the design standards in Appendix C.

4.4 Public Outreach

Conducting outreach for an odor management program provides the opportunity to involve community stakeholders in all aspects of project planning and decision-making. The level of involvement or influence is up to SPU and the needs associated with the effort. It is recommended that the community be educated and understand how odors are generated and managed by SPU. Creating fact sheets is a great tool for educating the community on odors. The following fact sheets can be created to start the community input and build trust:

- **Odor Complaint Procedures**—This fact sheet would describe SPUs odor complaint process, how to detect an odor, how to make a complaint (tips on describing odors), and how SPU handles complaints.
- **Frequently Asked Questions on Odor Sources**—This fact sheet would describe where potential odor sources can be generated within SPU's facilities and how they can be addressed. Frequently asked questions can include:

- ☐ How does odor control work?
- ☐ Where in system where can odors be generated?
- ☐ Why does sewage stink?
- ☐ What is the odor management plan (tailored for specific projects)

Figure 11 shows an example of a public outreach graphic that can be used to communicate with the public.

Figure 11. Odor Public Outreach Example

SECTION 5

Future Steps

SPU will continue to respond to and investigate odor complaints and perform odor surveillance. As part of its ongoing efforts to address existing odors and ensure that new and modified facilities address odors, staff should focus on the following:

- Perform odor evaluation on existing facilities with indication of odors. This evaluation should begin with monitoring of pump stations identified as Priority 1 or 2 odor problems. Key work items are as follows:
    - ☐ Purchase OdaLog loggers
    - ☐ Conduct monitoring of Priority 1 pump stations for a minimum of two weeks during the "odor season"
    - ☐ Confirm whether the pump stations remain Priority 1
    - ☐ Conduct monitoring of Priority 2 pump stations
- Update odor complaint intake form template for the following:
    - ☐ Complaints coming into a call center or online
    - ☐ Complaints coming from O&M during inspections
- Update odor management O&M protocols and develop a standard odor management approach
- Conduct public outreach with community members on odor

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SPU. 2015. Sewer Pump Station Prioritized Capital Improvement Plan Report

Appendix A: Pump Station Odor Potential Prioritization

Station	Wet Well Volume (ft^3)	CFM @ 4 air changes /hour	CFM @ 6 air changes /hour	Approximate Force Main Length (feet)	Known Odor Complaints within 200 feet	Known Odor Complaints within 75 feet	Receptors Within 75 Feet of Pump Station	Field Observations	Upgrade Planned 2020-2030 (Y/N)	Priority
WWPS001	4,013	268	401	1512	N	N	Residential-SF	Odor issues typically present. Excess condensation even running positive pressure in wet well.	Y	1
WWPS002	5,224	348	522	60	N	N	Residential-SF		Y	2
WWPS003	4,048	270	405						N	4
WWPS004	N/A	N/A	N/A	360	N	N	Residential-SF, Neighborhood Commercial		N	4
WWPS005	3,542	236	354	107	Y	N	Residential-SF, Park-Stan Sayres Memorial	Odor complaints increase in summer due to more people using nearby park, especially during Seafair.	Y	1
WWPS006	3,542	236	354	47	Y	N	Park-Lk Washington Blvd Trail		Y	2
WWPS007	4,048	270	405	1014	Y	Y	Residential-SF		Y	1
WWPS009	3,069	205	307	16	N	N	Residential-SF, Park-Pritchard Island Beach	Has issues with excess condensation. Was operating with positive pressure, then it was switched to negative which is causing condensation and makes hatches and doors difficult to open.	?	1
WWPS010	1,514	101	151	11	N	N	Residential-SF, Park-Martha Washington Park		Y	2
WWPS011	693	46	69	19	N	N	Commercial-NOAA		Y	2
WWPS013	1,649	110	165	112	N	N	Residential-SF, Park-East Montlake Park		Y	2
WWPS015	3,233	216	323	74	Y	N	Residential-SF, Park-West Montlake Park		Y	2
WWPS017	3,180	212	318	112	N	N	Industrial		Y	3
WWPS018	424	28	42	736	N	N	Neighborhood Commercial		Y	2
WWPS019	424	28	42	623	N	N	Residential-SF		Y	2
WWPS020	1,704	114	170	1007	N	N	Residential-SF		Y	2

Station	Wet Well Volume (ft³)	CFM @ 4 air changes /hour	CFM @ 6 air changes /hour	Approximate Force Main Length (feet)	Known Odor Complaints within 200 feet	Known Odor Complaints within 75 feet	Receptors Within 75 Feet of Pump Station	Field Observations	Upgrade Planned 2020-2030 (Y/N)	Priority
WWPS021	656	44	66	582	Y	Y	Residential-MF, Commercial		Y	**1**
WWPS022	1,050	70	105	754	N	N	Residential-SF		Y	**2**
WWPS025	1,712	114	171	69	N	N	Residential-SF, Park-Montlake Playground	Odor issues typically present. Was ventilating wet well at negative pressure, but when switched to positive, may have coincidentally seen fewer odor complaints.	Y	**1**
WWPS028	770	51	77	344	N	N	Residential-SF		Y	**2**
WWPS030	1,649	110	165	553	N	N	Residential-SF		Y	**2**
WWPS031	628	42	63	561	N	N	Residential-SF		Y	**2**
WWPS035	905	60	90	795	Y	N	Commercial-Uvillage	Odor issues typically present during maintenance of pipelines, and pumps start.	Y	**1**
WWPS036	298	20	30	37	N	N	Residential-MF, Park-Don Armeni Boat Ramp and Alki Trail		N	**4**
WWPS037	5,504	367	550	81	N	N	Commercial-Neighborhood, Park-Seacrest Park		Y	**2**
WWPS038	500	33	50	47	N	N	Residential-MF and SF, Park-Alki Trail		N	**4**
WWPS039	737	49	74	158	N	N	Residential-SF		Y	**2**
WWPS042	608	41	61	444	N	N	Residential-SF		Y	**2**
WWPS043	5,216	348	522	747	N	N	Residential-SF, MF		Y	**2**
WWPS044	990	66	99	326	N	N	Industrial-airfield and surrounding commercial		Y	**3**
WWPS045	829	55	83	180	N	N	Industrial-airfield and surrounding commercial		Y	**3**
WWPS046	N/A	N/A	N/A	316	Y	N	Commercial-restaurants businesses, Parks-Burke Gilman Trail		N	**4**
WWPS047	N/A	N/A	N/A	15	N	N	Commercial-parking lot of marina		N	**4**

Station	Wet Well Volume (ft^3)	CFM @ 4 air changes /hour	CFM @ 6 air changes /hour	Approximate Force Main Length (feet)	Known Odor Complaints within 200 feet	Known Odor Complaints within 75 feet	Receptors Within 75 Feet of Pump Station	Field Observations	Upgrade Planned 2020-2030 (Y/N)	Priority
WWPS048	2,222	148	222	987	N	N	Commercial-restaurants, Commercial-UW campus		Y	2
WWPS049	324	22	32	400	Y	N	Commercial-retail and warehouse		Y	2
WWPS050	N/A	N/A	N/A	399	Y	N	Residential-SF		?	4
WWPS051	577	38	58	682	N	N	Residential-SF		Y	2
WWPS053	370	25	37	555	N	N	Residential-SF, Park-Schmitz Park		Y	2
WWPS054	1,848	123	185	135	N	N	Industrial-marine and warehouse		Y	3
WWPS055	N/A	N/A	N/A	212	N	N	Residential-SF		?	4
WWPS056	N/A	N/A	N/A	389	N	N	Residential-SF		?	4
WWPS057	918	61	92	180	N	N	Commercial-marine		Y	2
WWPS058	1,150	77	115	163	N	N	Commercial		Y	2
WWPS059	1,150	77	115	635	N	N	Commercial-marine		Y	2
WWPS060	1,208	81	121	296	N	N	Commercial-marine		Y	2
WWPS061	1,179	79	118	93	N	N	Commercial, Park-Lake Union Park		Y	2
WWPS062	1,034	69	103	35	Y	Y	Park-Cheshiahud Lake Union Loop, Commercial-restaurant beyond 75'	Corrosion an issue.	Y	1
WWPS063	1,266	84	127	26	N	N	Residential-MF, Commercial-neighborhood		Y	2
WWPS064	783	52	78	549	Y	N	Residential-MF		Y	2
WWPS065	1,150	77	115	282	N	N	Commercial		Y	2
WWPS066	754	50	75	334	Y	N	Residential-SF		Y	2
WWPS067	754	50	75	33	N	N	Residential-SF		Y	2
WWPS068	N/A	N/A	N/A						?	
WWPS069	715	48	72	898	N	N	Commercial		Y	2
WWPS070	1,502	100	150	92	Y	Y	Residential-SF, Park-Lincoln Park Beach, Commercial-ferry terminal	Relatively frequent odor complaints may be due to briny water and decaying plants in summer, and also close to Barton Pump Station.	Y	1
WWPS071	623	42	62	8.5	N	N	Residential-SF, Park-Lincoln Park Beach	Corrosion an issue.	Y	1

Station	Wet Well Volume (ft^3)	CFM @ 4 air changes /hour	CFM @ 6 air changes /hour	Approximate Force Main Length (feet)	Known Odor Complaints within 200 feet	Known Odor Complaints within 75 feet	Receptors Within 75 Feet of Pump Station	Field Observations	Upgrade Planned 2020-2030 (Y/N)	Priority
WWPS072	4,122	275	412	32	N	N	Industrial-Harbor Island		Y	3
WWPS073	3,600	240	360	779	N	N	Industrial-Harbor Island		Y	3
WWPS074	980	65	98	1016	Y	N	Industrial		Y	2
WWPS075	N/A	N/A	N/A	35	N	N	Residential-MF, SF		?	4
WWPS076	1,404	94	140	183	Y	Y	Residential-MF, Park-Lowman Beach Park	Corrosion an issue, also in conveyance.	Y	1
WWPS077	2,835	189	284	313	N	N	Residential-SF	Corrosion an issue, possibly due to salts in the air.	Y	1
WWPS078	N/A	N/A	N/A	13	N	N	Industrial-airfield and surrounding commercial		?	4
WWPS080	N/A	N/A	N/A	91	Y	Y	Residential-SF		?	1
WWPS081	783	52	78	174	N	N	Residential-SF		Y	2
WWPS082	N/A	N/A	N/A	10	Y	Y	Residential-SF		?	1
WWPS083	N/A	N/A	N/A	217	Y	N	Commercial-light industrial		?	4
WWPS084	909	61	91	214	N	N	Commercial-light industrial		Y	2
WWPS114	784	52	78	43	Y	N	Park-Meadowbrook Pond, with Residential-SF beyond		Y	2
WWPS118	495	33	50	70	Y	Y	Commercial-light industrial, Residential-MF		Y	1

Priority	1	Odor complaint within 75 feet	Field inspection odor/corrosion documented	Upgrades Planned
Priority	2	Odor complaint within 200 feet	Receptor Residential or Commercial or Park	Upgrades Planned
Priority	3	No Odor complaint within 200 feet	Receptor Industrial	Upgrades Planned
Priority	4	No odor complaints within 75 feet	Receptor Residential or Commercial or Industrial	No upgrades planned

Appendix B: Sampling and Monitoring Techniques

This appendix elaborates on the sampling and monitoring techniques available to execute odor data collection.

ATMOSPHERIC H_2S MONITORING

Atmospheric H_2S measurements can be recorded with OdaLog Gas Data Loggers manufactured by App-Tek Ltd. OdaLog loggers are installed at locations near suspected sources of H_2S emissions such as within pump station wet wells and force main discharge manholes. The OdaLog is designed specifically to monitor hydrogen sulfide gas emissions from wastewater. It continuously logs the time of day, temperature, and levels of H_2S. The data can be collected at selectable intervals from 1 second to 1 hour. The data is downloaded in graphical and tabular form and can provide peak and average H_2S levels as shown in Figure A-1.

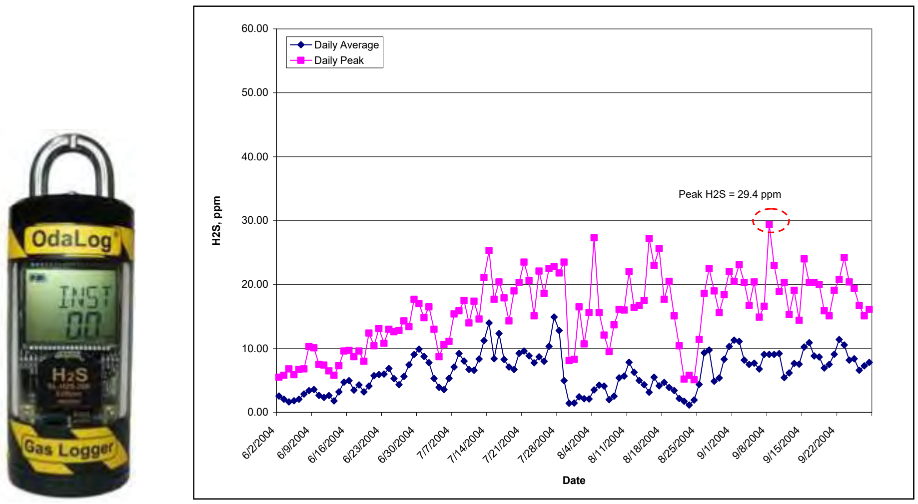

Figure A-1. *OdaLog*

Consideration needs to be given in selecting the appropriate OdaLog with the data range to best capture the expected H_2S measurements. The ranges of the loggers available include 0 to 2 parts per million (ppm), 0 to 200 ppm, 0 to 800 ppm and 0 to 1,000 ppm. For the SPU facilities, the 0 to 200 ppm range will allow for measurement of H_2S in the headspace.

The cost of an OdaLog logger is approximately $2,500, including both the instrument and the required software. Additional information can be found at: http://detectioninstruments.com/products/

GRAB SAMPLING

Grab samples can be taken at wet wells or manholes and delivered to a laboratory for analysis. Samples are analyzed for biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, temperature, and dissolved sulfides. Grab samples are collected from several locations to obtain representative wastewater quality data. In order to get representative data for different times of the day, samples are taken multiple times per day over multiple days. The samples are immediately tested for total sulfides, dissolved sulfides, temperature, pH, and dissolved oxygen.

Temperature, dissolved oxygen, and pH can be analyzed using a Horiba U-22 multi-parameter water quality probe (see Figure A-2). Total and dissolved sulfide can be tested with a LaMotte sulfide test kit (see Figure A-3). The total sulfides are the sum concentration of sulfide (S2-), hydrosulfide (HS-), and hydrogen sulfide (H_2S). A LaMotte sulfide test kit uses the Pomeroy methylene blue method to test for sulfides in a wastewater sample collected in the field. The titration method uses colorimetric standards to determine total sulfide. Total sulfide, dissolved sulfide, and H_2S can be separated in the titration test. The total sulfide is determined using a color dye that is added to an un-reacted sample until it matches a reacted sample. Total sulfides may be measured at every site, while dissolved sulfides are measured at sites that exhibit higher levels of total sulfides (usually above 0.5 mg/L) or high atmospheric H_2S levels.

Figure A-2. *Horiba U-22*

Figure A-3. *Lamotte Sulfide Test Kit*

PRESSURE MONITORS

Pressure monitors are utilized to measure differential pressure at locations along the conveyance system. Typically, a diurnal pattern can be established at each location and used to determine the potential time frame for odor emissions. A location that exhibits extended periods of positive pressure has the greatest potential for emitting odors. The pressure monitors are capable of monitoring pressure differences within a range of +/- 2 inches W.C. (water column). Figures A-4 and Figure A-5 illustrate example pressure monitors.

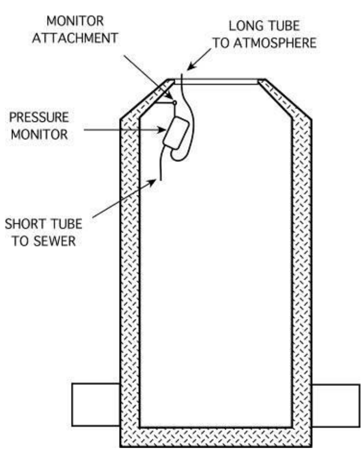

Figure A-4. *Pressure Monitor Installation Diagram*

Figure A-5. *Installed Pressure Monitor*

Appendix C: Design Standards

The following are standards and preferences for design of odor and corrosion management systems. These design standards provide a general guidance for odor control facility design and should be coordinated with SPU's design and engineering standards.

General Odor Management System Standards

Odor management systems must be designed to meet the following standards:

- Design systems to minimize electric, water, and media/chemical costs and equipment maintenance requirements.
- Make all service access hatches and fill ports easily accessible to O&M personnel.
- Design site access such that SPU's maintenance trucks can easily access hatches and equipment.
- Size systems with a ventilation rate sufficient to maintain a negative pressure in the ventilated space with respect to the ambient atmosphere.
- Design all facilities to operate unattended.
- Provide local monitoring, control, and alarms for odor management fans so that operators can check and respond to low air flow and high scrubber pressure differential conditions.
- For systems that are not totally enclosed within a building, minimize collection of debris (such as leaves and dirt) and simplify access for cleaning and for sample collection from media sampling ports.
- Monitor for H_2S, oxygen, and lower explosive limit.
- Evaluate noise reduction measures for equipment.
- Consider means to bypass the odor control scrubber when the scrubber needs to be taken offline for maintenance.
- Keep airborne fats, oils, and grease and moisture out of fans, scrubbers, and as much ductwork as possible through the use of mist/grease eliminators placed upstream of scrubbers.
- All mechanical connected fasteners and anchor bolts shall be stainless steel, 316 grade.

Technical Specifications

Use SPU's guide specifications for fiberglass-reinforced plastic, foul air scrubbers, scrubber media, ductwork, and other odor and corrosion management systems and associated components for all projects. SPU technical specifications for odor control facilities should be updated based on the application to a project. The following specifications are part of SPU's design resources:

- 23 31 17 FRP Ductwork
- 23 33 19 Sound Traps
- 23 34 16 Centrifugal FRP Fans and Blowers
- 23 41 19 Mist/Grease Eliminators
- 23 42 15 Activated Carbon Odor Control Units

The following sections outline general design standards for odor control systems. These design standards should be consistent with the requirements in the specifications. Modifications to the design standards should be updated in the specifications as they are refined from project to project.

FRP Ductwork

Table C-1 summarizes the standards for design of odor management system ductwork. Other standards for ductwork are as follows:

- Duct noise must be kept to a level that is not a nuisance to neighbors and that complies with local codes.
- Ductwork must be installed with the proper slope and a condensate drain with a P-trap, sized as required for ductwork pressure.
- Buried section of foul air duct can be constructed of HDPE or FRP pipe. Above grade section of foul air duct should be constructed of FRP.
- Buried duct should be flexibly coupled to the above-grade rigid FRP duct.
- Select buried ductwork wall thickness based on site-specific design loads and depth of cover.
- Slope ductwork to drain condensation back towards the structure/wet well where air is extracted.

Table C-1. Ductwork Design Standards

Fresh supply air duct material (and gooseneck)	Fiberglass-reinforced plastic
Fresh supply duct air velocity	1,000 feet per minute
Foul air duct material	Fiberglass-reinforced plastic HDPE (buried applications)
Foul Air duct air velocity	2,000—2,500 feet per minute
Air friction loss	0.1 to 0.15 inch WC per 100 feet
Dispersion stack exit velocity	3,000 fpm

Exhaust Stacks

Exhaust stacks are fabricated from corrosion-resistant materials such as FRP. Design standards for the exhaust stack should follow the ductwork standards identified above, and should also include the following:

- Typical stack height should be based on avoiding exhausting treated air at the pedestrian level (typically below 10 feet above surrounding grade level).
- Use dispersion modeling to determine design criteria for stack height for projects that have regulatory (permit) requirement, highly political and public sensitivity, or opportunity to lower the stack height at grade level due to lower H2S concentrations associated with diluted CSO wastewater.
- Exhausting air at grade level (or less than 10 feet above the surrounding grade level) can be considered as long as dispersion modeling is used to determine design criteria for stack height for projects that have regulatory (permit) requirements.

Sound Traps

Sound traps (silencers) limit the noise potential from air movement and equipment being transmitted outside the facility. A noise reduction study should be developed to confirm the need of a silencer to meet the project area's zoning noise level. The following standards apply to sound traps:

- Locate sound traps on the discharge side of the foul air exhaust fan ductwork.
- Identify mounting requirements in the drawings and specifications (horizontal vs vertical).
- FRP corrosion-resistant metals.

- Provide adequate structural and seismic supports.
- Provide drain piping from sound trap for condensate.

Centrifugal FRP Fans and Blowers

Odor control fans should be centrifugal FRP fan for corrosive environment. Standards for odor management system fans are as follows:

- Fans that exhaust and move foul air through the odor management system should be constructed of FRP.
- All fans must meet the requirements of NFPA 820.
- Fans should be certified by the Air Movement and Control Association.
- Redundant fans are not recommended.
- Odor management fans must be designed to run continuously.
- Energy-efficient, explosion-proof, continuous-duty motors must be specified where required by NFPA 820.
- Fans can be specified single-speed, dual-speed or variable-speed. Variable speed motors provide flexibility to incrementally adjust fan speed to achieve specific ventilation rates and optimize system performance.
- Continuous duty motors should be energy-efficient and explosion proof.
- Select exhaust fans with lower rpms (typically 1800 rpm vs 3000 rpm) to reduce noise levels from Fans.
- At minimum, provide one replacement set of bearings and belts.

Mist/Grease Eliminators

Mist/grease eliminators must be provided ahead of the carbon scrubber units and fan on all applications. The following standards apply to these devices:

- Housing material must be FRP.
- Media must be constructed of polypropylene and designed with removable sections that limit physical lifting to a maximum of 50 pounds.
- Provide access hatch for accessibility of filter pads (via above or the sides of the unit)
- Size unit with a maximum face velocity of 400 feet per minute across the unit.
- Spare filter media must be supplied and required in the specification.
- Provide manometer-type differential pressure indicators with local gauge for static pressure readings.
- From drain connection, route drain piping (with p-trap) to trench drain.

Activated Carbon Odor Control Units

The following sections give design standards for activated carbon odor control unit systems and for facilitating carbon media replacement. Carbon odor control units can be provided in two configurations, depending on the size:

- Packaged Carbon Scrubber Systems—These are skid-mounted odor control systems complete with exhaust fan, damper, interconnecting ductwork, vessel, carbon media and local control panel. The components are mounted on an epoxy-coated carbon steel skid and designed for automatic, continuous operation. Packaged systems range from 100 cfm to 1,000 cfm.
- Carbon Odor Control Scrubbers—These can be single or dual bed carbon vessels with capacity up to 20,000 cfm. These systems would be applicable for the CSO storage tanks and larger pump station wet wells and structures.

DESIGN STANDARDS

Table C-2 provides standards for the design of carbon odor control scrubbers as well as packaged carbon scrubber systems. Figures C-1 and C-2 illustrate typical vertical air flow and horizontal air flow deep-bed scrubbers respectively, including required accessories. Actual designs must conform to site conditions and constraints.

Table C-2. Carbon Odor Control Units Design Standards	
Carbon vessel material	Fiberglass-reinforced plastic
Pressure drop across dry media bed	2.0 inches WC per foot of bed (maximum)
Foul air volumetric loading/media cross- section face velocity	50 cfm per square foot (preferred) 60 cfm per square foot (maximum)
Air flow direction through carbon bed	Down-flow or horizontal
Empty bed contact time	3 to 4 seconds

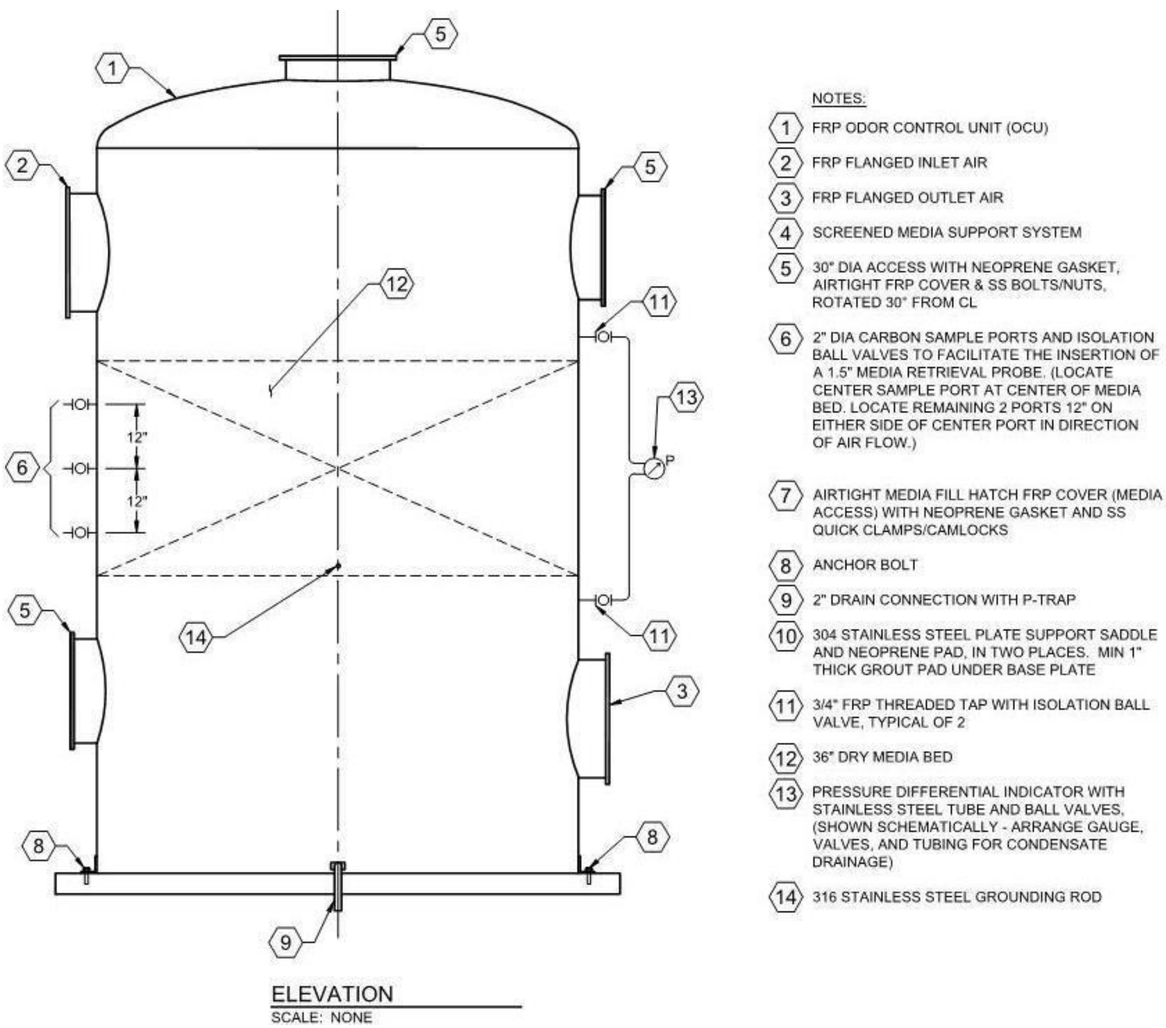

Figure C-1. *Vertical Air flow Deep-Bed Dry Media Scrubber*

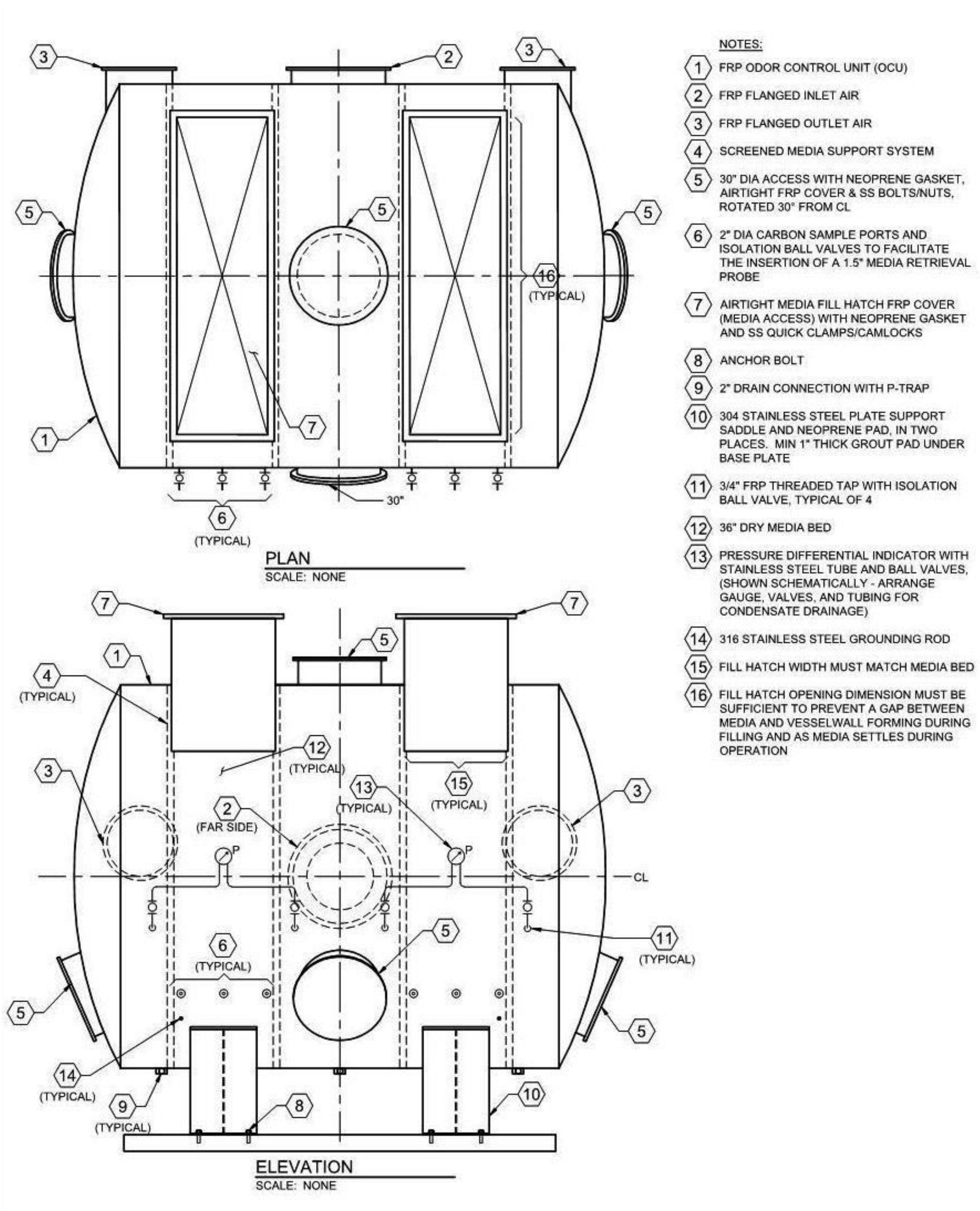

Figure C-2. *Typical Deep-Bed Dry Media Scrubber (Horizontal Air flow/Vertical Bed)*

Specific requirements for designing a carbon scrubber system are as follows:

- Carbon scrubbers typically operate under negative pressure (induced draft) to minimize the escape of odors from potential leak sources.
- Positively pressurized (forced draft) systems may be considered in order to take advantage of the noise attenuation provided by the dry media or the heating of the airstream from the fan's inherent inefficiency to reduce the relative humidity in the airstream.
- Carbon scrubbers must use the appropriate media for the anticipated average and maximum daily H_2S concentrations, as shown in Table C-3.
- The length of the hatch perpendicular to the air flow through the bed must be sufficient to allow the carbon media to completely fill the interior of the vessel and prevent the development of any gaps between the interior wall of the vessel and the media upon initial filling or if settling of the media occurs during use.
- The width of the hatch in the direction of air flow must be the full width of the media bed.
- Carbon scrubbers installed in open space must be designed with raised work platforms that comply with WISHA/OSHA requirements to allow easy and safe access to the top of the scrubber for media replacement. Ladders and work platforms with fall protection must be specified.

Table C-3. Carbon Media Standards for Hydrogen Sulfide Concentrations

Carbon Media	H_2S Concentration	
	Average	**Maximum**
Plain, virgin activated carbon	5	10
Caustic impregnated carbon	10	50
High H_2S capacity carbon	30	70
Other dry media	Manufacturer's recommendation	Manufacturer's recommendation

Carbon Media Replacement

The following standards should be followed to facilitate carbon media replacement in odor management systems:

- Carbon media replacement must be possible from above. Roof openings/hatches must be large enough for removing media and refilling with approximately 1,000-pound super-sacks.
- H_2S and overall odor removal capacity must be sufficient so that media replacement occurs no more frequently than once every six months.
- Scrubbers installed in underground vaults must be equipped with openings and above-scrubber hatches that allow for easy and safe media exchange without entering the vault.
- Scrubbers located in aboveground structures must have roof hatches and a platform immediately above for media removal and replacement.

Packaged Carbon Scrubber Systems

Packaged carbon scrubber systems are provided for flow rates less than 1,000 cfm. These are typically used in lower H2S concentrations and includes the carbon vessel, exhaust fan, and associated instruments. Optional items can include sound enclosures and mist eliminators with the system. Care must be taken in design of fill hatch dimensions for horizontal air flow/vertical bed scrubbers. Figure C-3 illustrates a typical packaged system (based on 100 cfm system). Packaged systems are typically sited above grade. The following considerations should be considered when designing a packages system:

- Ensure sufficient working clearance for maintenance activities including, carbon removal and replacement, from the top of the canister, and exhaust fan maintenance.
- Select fans with lower rpms (ie 1800 rpm) to address noise generation.
- Consider siting of package system and routing of condensate drain from canister and fan.

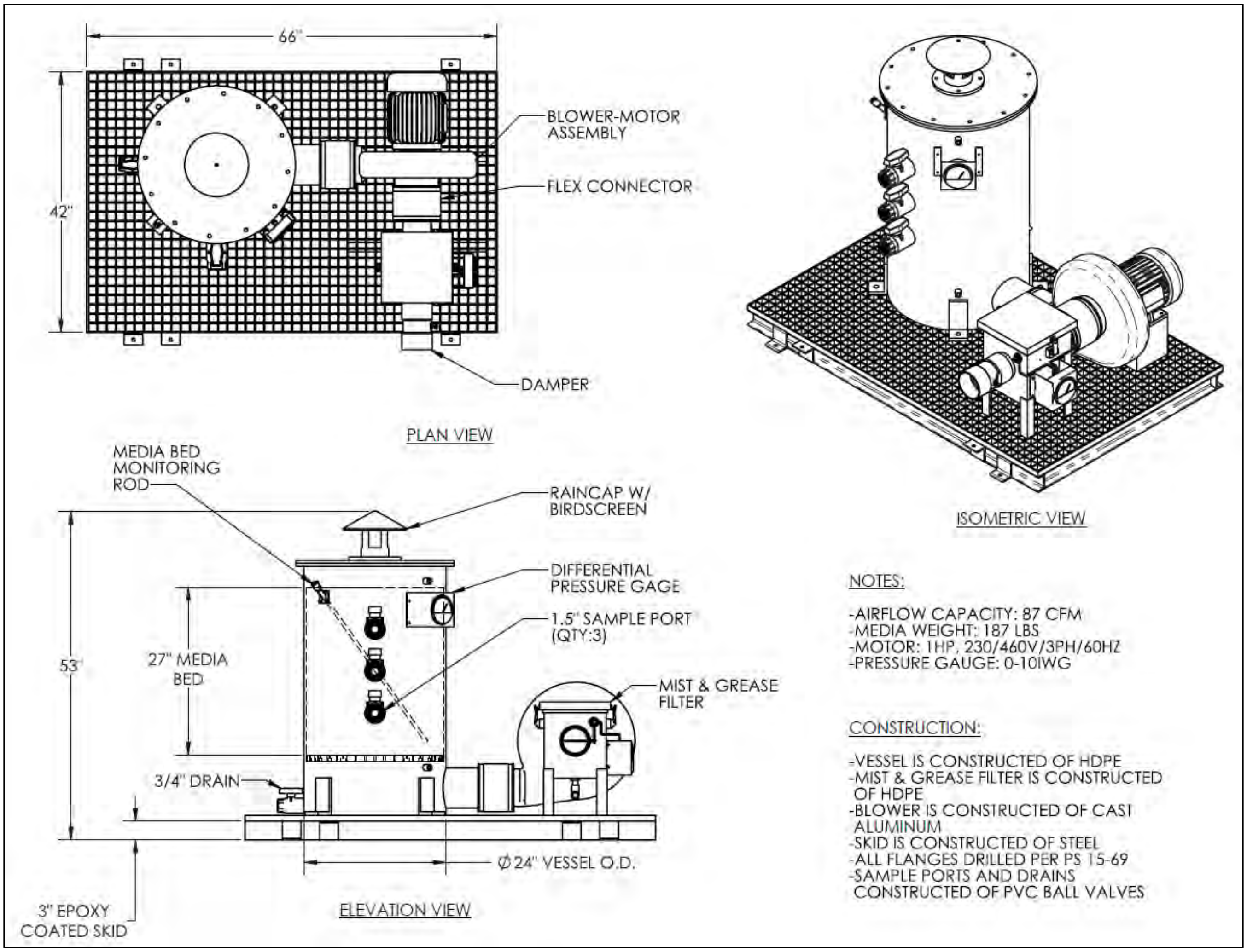

Figure C-3 *Vertical Air flow System Assembly*

AIR RELEASE VALVE ODOR CONTROL

Air release valves are located a high points of forcemains and protect the pipeline system from pressure build up. These valves vent intermittent volumes of air during filling and allow air back in to the pipeline during pump draw. These points of air release can create a potential odor nuisance, depending on the strength of the wastewater. Passive carbon canister system can be provided to passively treat the air released from the air release valves. The pressurized air released from the valve is pushed directly through ducting and through a canister contain 20 to 50 lbs of carbon media. The air is passively pushed through the canister, treated via the carbon media, and released via an exhaust duct as shown in Figure C-5.

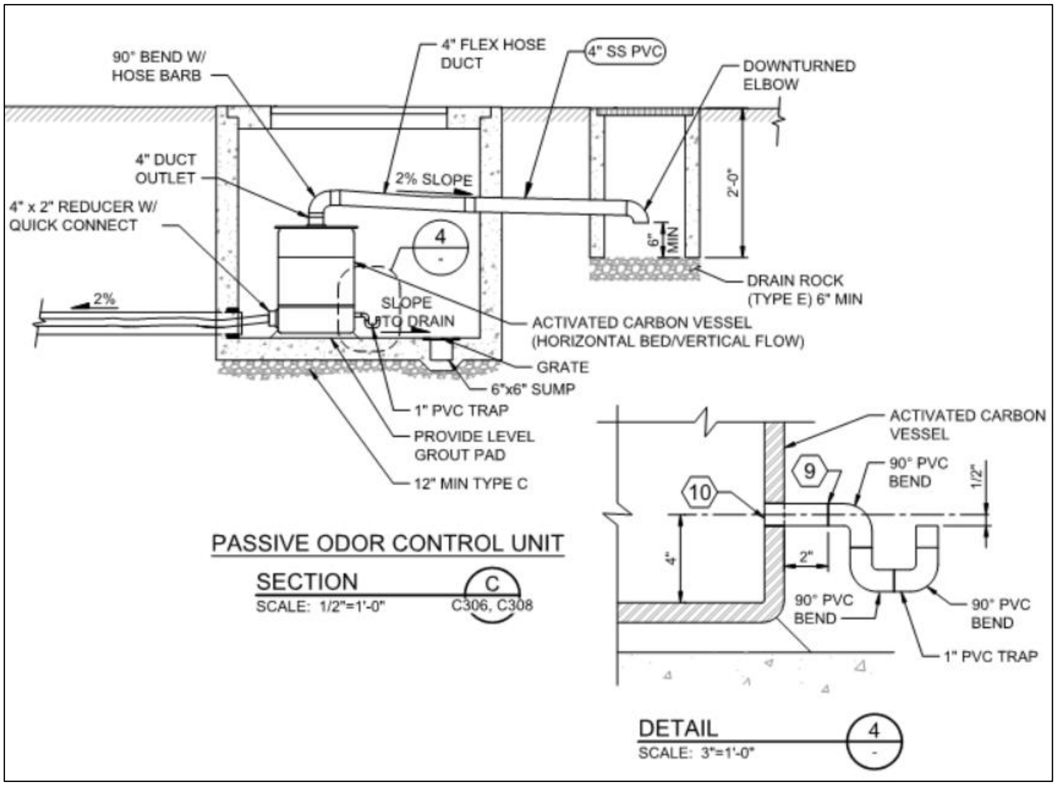

Figure C-5. *Passive Air Release Valve Odor Control System*

Linings and Coatings

The following considerations should be taken into account for addressing structures with potential of high hydrogen sulfide concentrations and concern of concrete corrosion:

- Linings and coatings should be used in structures where H_2S concentrations will be greater than 5 ppm based on a 24-hour average during any two months of the year.
- All turbulent structures or structures susceptible to H_2S corrosion must be lined with mastic-adhered PVC lining, cast-in-place inert barriers, or other barriers that have been proven successful for at least five years in an active sewer where H_2S concentrations averaged over 10 ppm.

Pump Stations

Pump cycling frequency, force main size, detention time, and discharge design can all contribute to odor impacts. The following standards apply to design of pump stations:

- Fill-and-draw mode for pump station operation causes difficulty with increased sulfide generation. Wastewater can become anaerobic from infrequent pumping and long wet well and force main detention times, resulting in slugs of high sulfide concentrations and spikes of H_2S emissions.
- Variable speed drives must be used in order to optimize operating strategies.

- Wet wells must be designed to minimize deposition and accumulation of grit and other solids, preferably through a self-cleaning configuration.
- Wet well influent sewers must be designed to provide smooth hydraulic transition in order to minimize off-gassing.
- Wet well dimensions must be optimized for proper access to the wet well and minimization of the NFPA 820 fresh air change requirement.
- Wet wells must be kept at negative pressure with respect to atmosphere as described in NFPA 820 and as required by Ecology's Orange Book.
- Allow room for installation and maintenance of an explosion-proof heater in the supply air duct to the wet well in the event that condensation control is needed after system commissioning.
- Ensure that wet well ventilation designs include the induction of a draft from the incoming sewer at 50 feet per minute over its empty cross-section without compromising the minimum fresh air change rate required by NFPA 820.

Odor Impact Modeling

Emissions from all odor management systems must be modeled during design to estimate odor impacts that may occur downwind of the system exhaust. Modeling must show that odor control systems are capable of treating hydrogen sulfides and reducing the effluent concentrations.

Acceptable modeling methods are determined on a case-by-case basis. For simple single-point-of-emission systems such as conveyance system carbon scrubbers, hand calculations described in the Water Environment Federation's *Control of Odors and Emissions from Wastewater Treatment Plants (Manual of Practice 25)* or the use of the U.S. Environmental Protection Agency (EPA) AERMOD screening version or SCREEN3 computer model may be sufficient if reasonably conservative atmospheric stability factors and winds are employed. For multiple point or area emission sources, EPA's AERMOD computer model can be used.

Appendix D: Example Odor Complaint Form

Odor Complaint Report

Seattle Public Utilities

REQUIRED INFORMATION

Ticket Number *(to be completed by SPU)*:	Click or tap here to enter text.
Date Report Submitted:	Click or tap to enter a date.
Address of Problem:	Click or tap here to enter text.
Name of Person Reporting the Odor:	Click or tap here to enter text.
Maximo Work Number *(to be completed by SPU)*:	Click or tap here to enter text.

ADDITIONAL INFORMATION

What time of day was the odor noticed?	Click or tap here to enter text.
How long was the odor noticeable?	Click or tap here to enter text.
Is the odor constant or intermittent?	Choose an item.
How would you describe what the odor smells like?	Click or tap here to enter text.
How strong is the odor, on a scale of 1 to 5? (1 = weakest; 5 = strongest)	Choose an item.
What is the location of the source of the odor at the problem address (if known)?	Click or tap here to enter text.
About how far from the source were you when you noticed the odor?	Click or tap here to enter text.
Describe the weather at the time you noticed the odor:	
Temperature	Choose an item.
Wind	Choose an item.
Raining?	Choose an item.
Cloud Cover	Choose an item.

APPENDIX B

Acrulog Calibration Certificates

DETECTION INSTRUMENTS
Corporation

Certificate of Calibration

for

Herrera Inc.

This certifies that the gas detector listed here has been calibrated and tested to manufacturer's specifications.

The procedures and methods used in calibration are in accordance with manufacturer's Service Manuals, Calibration procedures and Quality Procedures Manual QP06 - CP01.

All gases used in the calibration are certified.

Model		Serial Number	Date of Calibration		Next Factory Calibration Due
Odalog H2S Model	ACRSD50	200302579	9/14/2020		3/16/2021
		Hydrogen Sulfide Concentration	Reading PPM Before	Reading PPM After	
Fresh Air			0.0	0.0	
H2S Gas Cylinder		50 ppm	49.7	50.0	
Range PPM 0-50					
Notes					

Tested by: J. Medina

18441 North 25th Avenue • Suite 101 • Phoenix, Arizona 85023 • Phone: 602-797-0630 or 866-632-5647
Fax: 602-797-0631 • www.detectioninstruments.com

DETECTION INSTRUMENTS Corporation

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All gases used in the calibration are certified.

Model		Serial Number	Date of Calibration		Next Factory Calibration Due
Odalog H2S Model	ACRSD50	200102344	9/14/2020		3/16/2021
		Hydrogen Sulfide Concentration	Reading PPM		
			Before	After	
Fresh Air			0.0	0.0	
H2S Gas Cylinder		50 ppm	47.2	50.0	
Range PPM 0-50					
Notes					

Tested by: J. Medina

18441 North 25th Avenue • Suite 101 • Phoenix, Arizona 85023 • Phone: 602-797-0630 or 866-632-5647
Fax: 602-797-0631 • www.detectioninstruments.com

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All gases used in the calibration are certified.

Model		Serial Number	Date of Calibration		Next Factory Calibration Due
Odalog H2S Model	ACRSD50	190601625	9/14/2020		3/16/2021
		Hydrogen Sulfide Concentration	Reading PPM		
			Before	After	
Fresh Air			0.0	0.0	
H2S Gas Cylinder		50 ppm	47.2	50.0	
Range PPM 0-50					
Notes					

Tested by: J. Medina

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APPENDIX C

H_2S Odor and Toxicity Spectrum

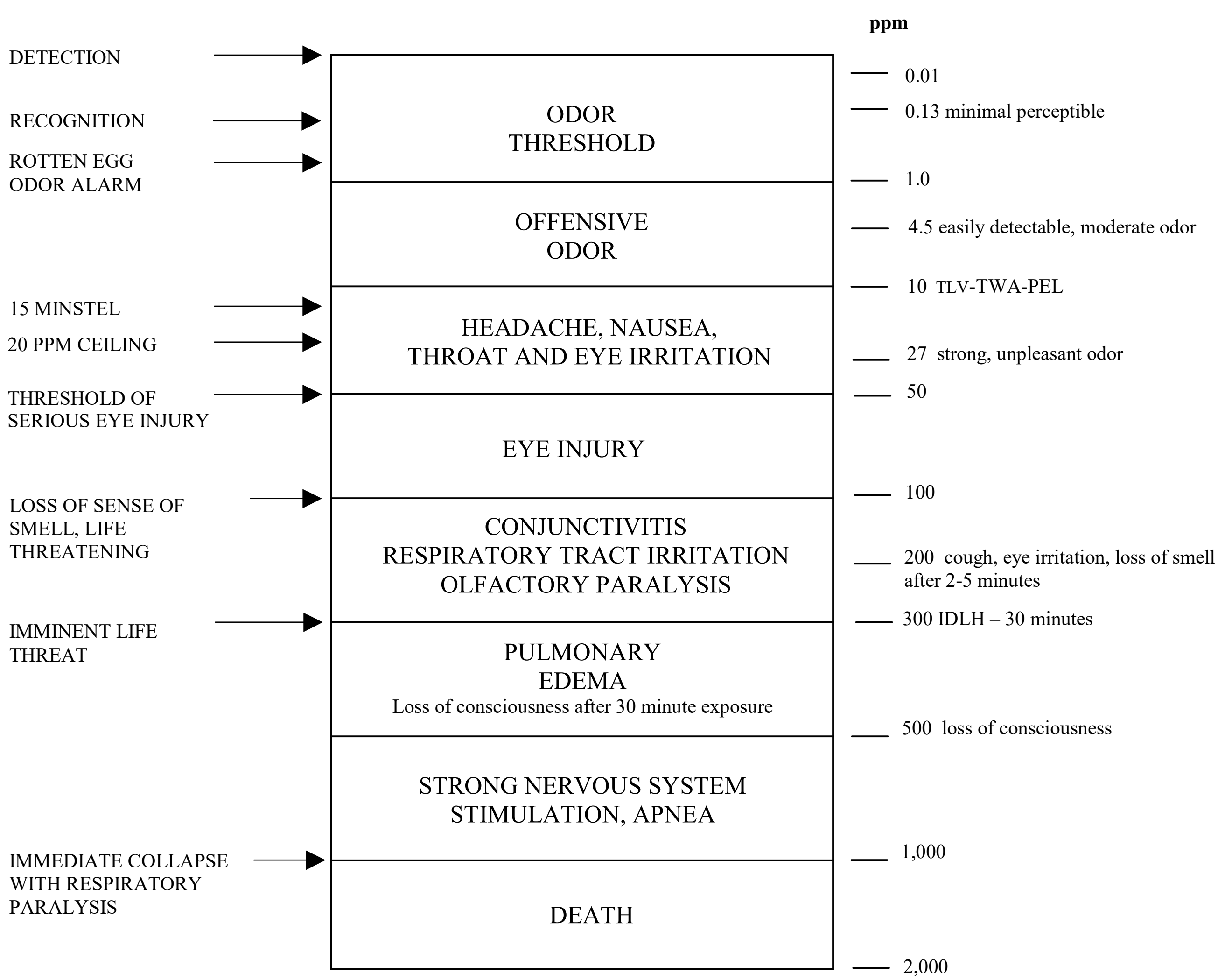
DETECTION INSTRUMENTS Corporation

Hydrogen Sulfide (Aqueous)

Hydrogen sulfide can exist as a gas dissolved in water. The polar nature of the hydrogen sulfide molecule makes it soluble in water. In the aqueous form, hydrogen sulfide does not cause odor; however, this is the only sulfide specie which can leave the aqueous phase to exist as a free gas. The rate at which hydrogen sulfide leaves the aqueous phase is governed by Henry's Law, the amount of turbulence of the wastewater and the pH of the solution. The relative H_2S concentration increases with decreasing pH. The higher the temperatures the quicker the release of H_2S.

Hydrogen Sulfide (Gaseous)

Once hydrogen sulfide leaves the dissolved phase and enters the gas phase it can cause odor and corrosion. Hydrogen sulfide gas is a colorless but extremely odorous gas that can be detected by the human sense of smell in concentrations as low as 0.0047 parts per million (ppm). It is also very hazardous to humans in high concentrations and can cause a number of health-related problems including death. In concentrations as low as 10 ppm it can cause nausea, headache, and conjunctivitis of the eyes. Above 100 ppm it can cause serious breathing problems and loss of the sense of smell along with burning of the eyes and respiratory tract. Above 300 ppm death can occur within minutes. For these reasons, the Occupational Safety and Health Administration (OSHA) has established an 8-hour, time-weighted, personal exposure limit of 10 ppm. Because it can remove the sense of smell in concentrations above 100 ppm, it is a particularly dangerous gas which tricks its victims into thinking that it is no longer present. It is the cause of death in numerous wastewater accidents every year. A hydrogen sulfide odor and toxicity spectrum is presented below.



5815 N Black Canyon Highway • Suite 103 • Phoenix, AZ 85015 • Phone: 602-797-0630 or 866-632-5647
Fax: 602-797-0631 • www.detectioninstruments.com