Current Conditions Assessment

Date:	July 11, 2024
Project name:	North Transfer Station Odor Evaluation
Project no:	D3665000
Prepared by:	Megan Moreen, Chelsea Lader, Kirsi Longley

1100 112th Avenue NE
Suite 500
Bellevue, WA 98004-5118
United States
T +1.425.453.5000

1. Introduction

In light of odor complaints since its establishment, and with an escalation of odor-related concerns documented in 2021, the Seattle Public Utilities (SPU) North Transfer Station (NTS) took proactive steps to engage the services of an odor consultant, Jacobs Engineering Group Inc. (Jacobs). Jacobs was hired to investigate the origins of the odors and recommend effective measures for mitigation.

This Technical Memorandum presents the outcomes of Jacobs' current conditions assessment for the SPU NTS in Seattle, Washington. The purpose of this assessment was to identify potential odor sources at the NTS impacting the surrounding community and recommend operational improvements to reduce odor impacts. There are five specific objectives of this assessment, as follows:

1. To understand the current facility operating conditions that may contribute to odor;
2. To understand where odor complaints originate with respect to proximity and location to NTS;
3. To identify through air modelling potential areas affected by NTS odor sources;
4. To identify the effect of potential odor mitigation options on community odor impacts;
5. To present options for operational improvements and odor control technologies for further evaluation for implementation at NTS.

1.1 Current Conditions Assessment Methodology

The methodology for the current conditions assessment is multifaceted and involves the following:

- Reviewing facility documents, conducting site visits, and gathering odor samples from various exhaust points at the facility.
- Documenting feedback from Wallingford residents regarding instances of odor within the neighborhood.
- Developing a baseline air-dispersion odor model to evaluate current and future community odor impacts from NTS.
- Developing and modeling potential "what-if" scenarios involving various odor mitigation options.

The methodology for evaluating odor impacts from the NTS entailed utilizing dispersion modeling to establish baseline odor impacts by NTS odor sources and prioritize sources for control option evaluations. Essential inputs for the model (e.g., field-sampled odor concentrations, operational parameters of odor sources, local topography, and site-specific meteorological data) were collected through a comprehensive process involving facility document reviews, site visits, and odor sampling. By simulating the interplay of odor sources, operational variables, and plume dilution effects using local meteorological data specific to the NTS, the modeling predicted odor concentrations in the surrounding neighborhood, thereby establishing current baseline conditions.

1.2 Facility Background

The NTS, also known as the North Recycling and Disposal Station, is a municipal waste collection and distribution facility located at 1350 North 34th Street, Seattle, Washington. The facility is in the Wallingford neighborhood near Gas Works Park and the Burke-Gilman Trail on the north side of Lake Union. Surrounding the facility are commercial neighbors to the west and south and dense residential areas directly to the north and east. Figure 1-1 shows the facility's location and proximity to neighbors. The green boundary depicted on Figure 1-1 represents the property fence line around the facility as well as the ambient air boundary.

Figure 1-1. Seattle Public Utilities North Transfer Station's Location and Proximity to Neighbors

2. Current Facility Conditions Evaluation

This section presents the preliminary information collected through facility documents and site visits to assess the current operations and ambient conditions at the NTS facility. Operational improvements were recommended, as needed, in real time before utilizing the gathered data in baseline air dispersion modeling.

2.1 Document Review

To help evaluate the current conditions of the site and develop a full facility understanding, Jacobs submitted a document request to SPU. The following documents, pertinent to evaluating the current facility conditions, were made available for Jacobs' review:

- *Draft NTS Rebuild Project 30% Basis of Design Report* (CDM Smith, 2013)
- *Draft Operations Plan for City of Seattle Public Utilities NTS* (September 2015)
- As-built redline construction drawings (CDM Smith, 2014)
- *HVAC Operations and Maintenance Manual* (CDM Smith, 2016)
- Hunt Air unit diagrams
- Systems Manual (Ecotone, 2017) for plumbing; electrical; heating, ventilation, and air conditioning (HVAC); overhead doors; and compactors
- Good neighbor community agreements:
  - Fremont Neighborhood Council, Davis, Bigelow, and Sussex v. City of Seattle, 2011
  - Wallingford Community Council [WCC] and Seattle Public Utilities, 2012
- Odor complaints submitted to SPU

Documents requested that were not available included prior modeling files, maintenance and equipment downtime logs, solid waste and air permits, and daily operational logs.

To verify the information gathered during the document review and to further develop an understanding of current onsite conditions, Jacobs planned and executed site visits as described in Section 2.2.

2.2 Site Visits

Three site visits were conducted by Jacobs representatives in September 2022, December 2022, and June 2023. The September 2022 site visit served as a preliminary tour of the facility and involved collecting baseline odor samples. In December 2022, a site visit was conducted in accordance with a Site Visit Plan submitted to SPU on November 30, 2022. The June 2023 visit aimed to gather the second round of odor samples. Throughout these visits, Jacobs representatives observed onsite operations, toured the neighborhood, and interviewed key staff to assess the current systems and processes at the facility. Odor data was collected during the September 2022 and June 2023 site visits to establish baseline odor conditions for use in air-dispersion modeling. Odor sampling results are discussed further in Section 5.

Two additional site visits were conducted in April 2023 and September 2023 specifically to measure exhaust fan flows to support baseline and "what-if" modeling. During the first visit in April 2023, it was discovered that exhaust fan speeds were set with Variable Frequency Drives (VFDs) only operating between 57 to 65 percent and higher operation was precluded by maintenance needed due to excessive dust buildup on the VFDs inside the panels and the filters in the HVAC system. After maintenance was completed, a second site visit was conducted in September 2023 to again measure the exhaust fan flows with the VFDs set at 100 percent. The flows measured during this second site visit were used as input parameters in the modeling discussed in Section 4.

2.2.1 Site Visit Observations

A summary of the site visit observations and interview findings is presented in this section.

Odor Sources

- Most odor complaints were logged between noon and 3pm when waste remained on the tipping floor during staff breaks and after significant waste drop-offs.
- Residential and commercial waste collection is presumed to be the primary source of strong odors.
- Equipment malfunctions can worsen odors by causing waste to accumulate on the tipping floor instead of being promptly compacted. During the site visits, it was noted that the older compactors often broke down, leading to increased odors due to inadequate compaction. Compactor cylinder refurbishment was conducted in 2022 and 2023 (refer to Section 4.4). A compactor replacement project is currently underway in the design phase.
- United Site Services, the portable toilet service provider for the facility, is another potential odor source. Portable toilets are serviced weekly, and complaints of strong odors during their presence onsite, lasting for hours after servicing, have been documented.
- Bay doors 1, 2, and 4 are an exhaust point for odors from the tipping floor.
  - In warmer months, staff open doors to alleviate heat and humidity on the tipping floor, allowing odors to escape.
- Bay door 3 located on the sublevel is accessible only to NTS staff, lacks a door, and remains open to ambient conditions.
- Customers occasionally uncover their loads outside the facility instead of waiting until inside.
- Exhaust fans EF1 and EF2 exhaust air pulled from the lower level of the facility. EF3, EF4A, and EF4B exhaust a combination of air pulled from the lower level and from the tipping floor. Exhaust fans EF5, EF6, and EF7 exhaust air pulled from the tipping floor.
- The Operations Plan prescribed the installation of dispersion nozzles on exhaust fans to disperse the exhaust air and reduce odors discharged via the roof; however, these were not installed at the time of the site visits.
- Cleaning of the tipping floor, floor drains, compactors, and lower-level load out area occurs at some frequently, but was not being conducted nightly, as proposed in the Operational Plan.

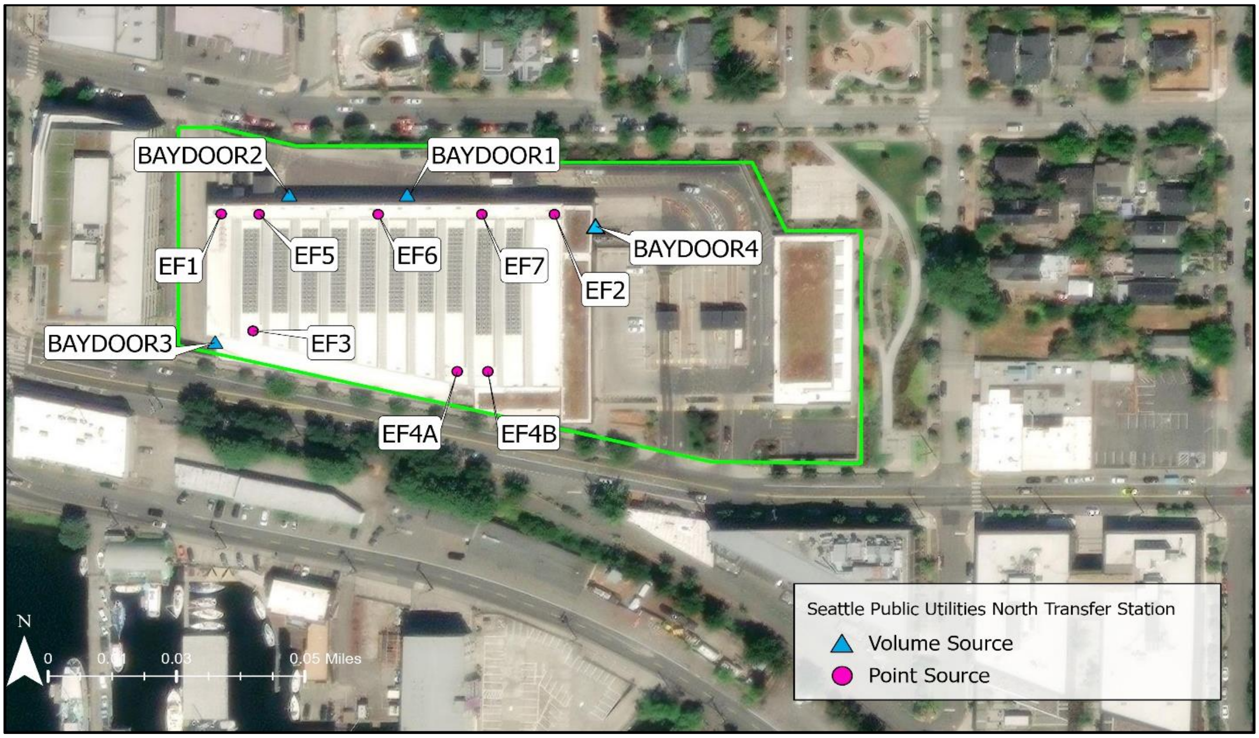


Figure 2-1. Seattle Public Utilities North Transfer Station Identified Odor Source Locations

Facility Logistics

- Commercial trucks begin waste drop-off at approximately 7:45am until 3pm.
- Exhaust fans operate from 7am until 6 pm. During the 2022 and April 2023 site visits, the fans were on VFDs set to 65 percent of operational capacity. Fan capacity was not increased to 100 percent until mid-2023.
- Food wastes are brought to the facility periodically.

Current Odor Elimination Practices

- Crew chiefs conduct three daily walks in the neighborhood, recording observations of odors and potential sources of odors in the area.
- Staff apply odor eliminator on the floor three times daily, with direct application on foul smelling waste.
- The facility utilizes a misting system on the tipping floor and select exhaust fans, using water and Ecosorb mixture to suppress odors and dust, as shown on Figure 2-2. Water containing the odor-neutralizing chemical is pumped through a 0.5-inch pressure hose supported by aircraft cable along the roof truss. Spray nozzles are placed at 10-foot intervals and rated for 3 gallons per hour. While the tipping floor system has the capability to pump an odor-neutralizing chemical, during the site visits in September and December 2022, NTS staff indicated only water was being used.

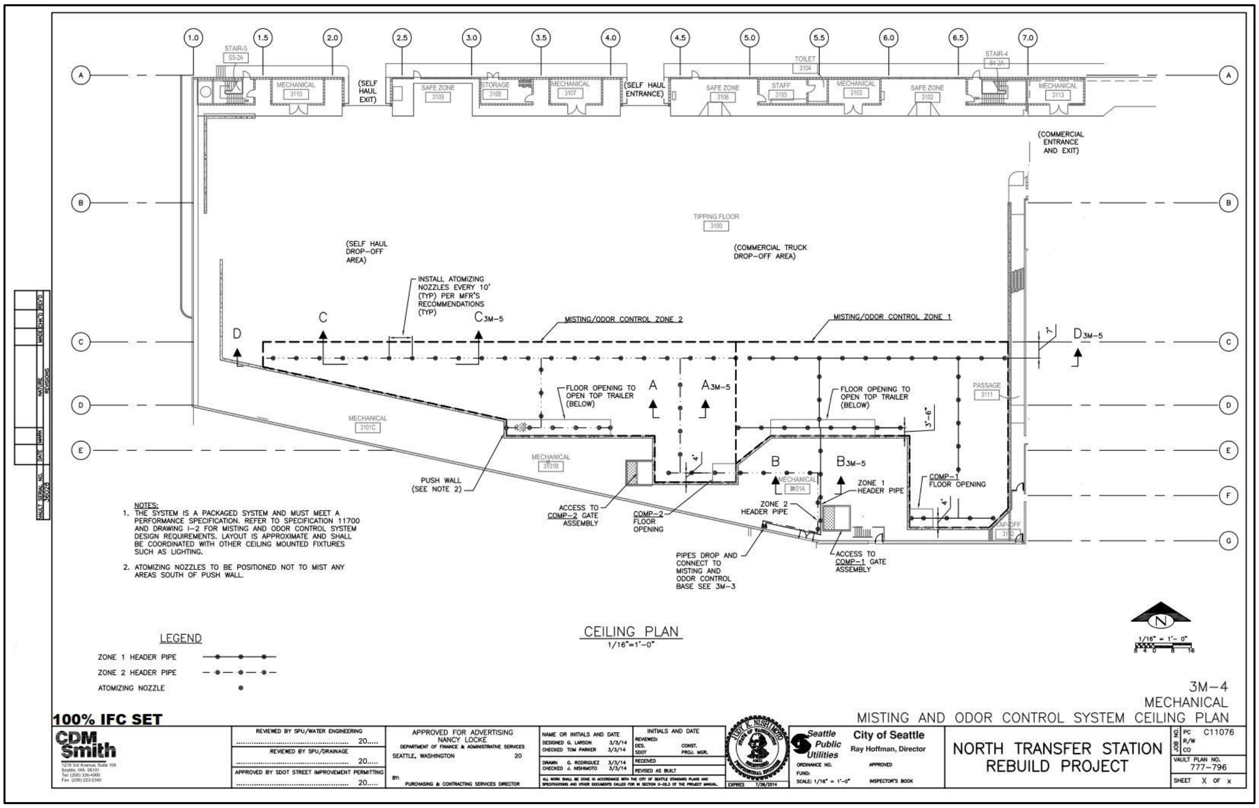


Figure 2-2: Spray Nozzle System Layout (From SPU Facility As-built drawings)

<u>Odor Complaints</u>

- Majority of odor complaints originated from residences across the street from the northeast corner stack exhaust.
- Odor complaints also reported at Ashworth Avenue and at the northeast corner of Woodlawn and North 35th Street.
- Odor complaints logged in 2022 and 2023 were predominantly during the spring and summer months.
- Descriptions of the reported odors included garbage, foul odor, and decay.

Overall, based on the observations presented above, it is presumed that the primary source of strong odors is waste left on the tipping room floor for extended periods, particularly during warmer seasons. Review of the complaint log has shown that most complaints occur in the morning or between noon and 3pm, corresponding with waste being left overnight and/or during staff lunch breaks. Increased odor occurrences may also stem from periodic breakdowns of compactors (resulting in overnight waste accumulation) and potentially inconsistent use of Ecosorb in the misting system.

Additional notable sources of odor include the opening of the tipping room bay doors, allowing odors to permeate surrounding residential areas. This issue exacerbates during warmer months due to an increase in odorous green waste. Most odor complaints have been recorded across from the northeast corner of the building, aligning with the entrance point for commercial waste drop-offs and the stack discharge location.

2.2.2 Document Review & Site Visit Findings

Completing the site document review and site visits were key in establishing an understanding of current site conditions and operations. This groundwork supported the development of the air-dispersion odor model, as well as the formulation of recommendations for operational enhancements and options for odor control technology improvements.

During the site visits and staff interviews, some inconsistencies with documentation were observed that could potentially impact odors at NTS.

One inconsistency was found within the NTS Operational Plan. While the plan stated that “exhaust air will be discharged by nozzle as to dilute any odors and to disperse the exhaust air as high above the facility and neighborhood as possible,” further review during the site visits revealed that the proposed dispersion nozzles were not installed on the exhaust fans, as discussed in Section 2.2.1. Additionally, the proposed odor reduction measures were not consistently implemented. Therefore, installing the dispersion nozzles on the exhaust fans was identified as a scenario for the “what-if” dispersion odor modeling.

Another inconsistency arose from the Operational Plan’s statement that “the tipping floor, floor drains, compactors, and lower-level load-out areas are cleaned nightly.” However, interviews with NTS operations staff and review of daily logs indicated that while cleaning of the tipping floor and compactors does occur, it is not performed nightly due to factors such as the volume of waste received, driver availability, and compactor operational status.

Furthermore, it was discovered that the exhaust fans were operating at only 65 percent of their design capacity.

Agreements with both Fremont Neighborhood Council (Fremont Neighborhood Council, Davis, Bigelow, and Sussex v. City of Seattle, 2011) and Wallingford Community Council (WCC and Seattle Public Utilities, 2012) reviewed as part of this assessment revealed important operational requirements. Most notably, the 2012 agreement with WCC specified:

- Section J – Main Transfer Station Tipping Building
  - “i) Mechanical vents will be located to direct and diffuse transmission of odors away from single family zones."
  - “n) Truck and service traffic shall be directed away from residential streets. SPU transfer truck traffic will not drive on North 35th St to the east of the entrance/exit at the NW corner of the IC property unless the street segment between the entrance and Stone Way is closed."
- Section P – Air Quality and Odor, and Noise
  - “vi) Clear the tipping floor of garbage, yard waste and food waste by the end of the working day on at least 90% of the operating days per quarter.”

However, these operational items documented in the agreements were found to be inconsistently followed within the facility. Therefore, they were noted to be possible scenarios for the “what-if” air dispersion odor modeling, presented in Section 4.3.

2.3 Implemented Operational Improvements

Through interviews with the employees, it was determined that operational changes were completed between the September 2022 and December 2022 site visits. The following operational updates were noted:

- The customer outbound overhead door (bay door 2) was replaced with a faster closing door in the fourth quarter (Q4) of 2022.

- The facility exhaust fans were cleaned during their scheduled annual cleaning in Q4 of 2022.
- Compactor 2, the western compactor, was repaired in Q4 of 2022.

Additional operational changes prior to and following the most recent June 2023 sampling event were completed. These updates included the following:

- In early 2023, the facility hired contractors to clean the HVAC filter housing, with plans to continue this practice every 6 months.
- As of Q2 of 2023, roof top fans, though initially set on VFDs at 65 percent, have been increased to 100 percent.
- Compactor 1, the eastern compactor, was repaired in Q4 of 2023/Q1 of 2024.
- The facility is currently diverting the more odorous loads to the South Transfer station and coordinating with the drivers to be more discerning in selecting dump locations to reduce the presence of odorous materials in the area.
- The facility is currently working with contractors to dump directly into functioning compactors.
- NTS is focusing on increasing the number of heavy equipment operators to reduce facility downtimes and minimize the duration waste remains on the tipping room floor.
- A compactor replacement project is underway, currently in the design phase.
- A bay door replacement project for the self-haul door (bay door 1) is underway.

While these operational changes were expected to have a positive effect on reducing odors within the facility in 2022 and early 2023, Jacobs conducted sampling and modeling to further assess existing impacts.

3. Odor Characterization and Odor Sampling

3.1 Odor Description

Odor, as a nuisance pollutant, can prompt complaints based on a combination of factors including frequency, intensity, duration, offensiveness, and location of odor detection. Various methods are used to measure odor:

- Intensity (strength) – Quantified by the amount of odor-free air needed to dilute the odorous air.
- Butanol Equivalence (odor intensity) – Represented as an equivalent concentration of n-butanol (volumetric parts per billion).
- Character – "What does it smell like?"
- Hedonic Tone – Degree of unpleasantness.

While odor is sometimes associated with specific compounds like hydrogen sulfide (H_2S), it is critical to note that H_2S is not the sole odor-causing compound of concern. Therefore, odor was chosen as the most suitable indicator of emissions rather than selecting only one representative compound.

3.1.1 Detection Threshold Definition

Measurements of odor commonly involve determining the detection threshold (DT) value. In odor laboratories, DT is established through odor tests where air samples containing odorous compounds are diluted with clean air until they reach undetectable concentrations. These diluted samples are then introduced to a gas delivery system. A panel of eight individuals trained in odor response acts as the "detectors" for the samples. The panel members smell air samples delivered to a nose cone piece and are prompted to press buttons to introduce three distinct samples: one with the diluted sample and two with clean dilution air.

The panel members are then asked if they can detect any difference in the odor among the samples. If they cannot, the sample concentration is increased by a given dilution amount, and the test is repeated. This process continues until half the panel members can detect the odor in the sample. This concentration level is termed the DT. This method determines the broad-spectrum odor concentration by assessing how many dilutions are necessary to make the odor barely perceptible to half of the odor panelists regardless of the specific odor-causing compound(s).

3.1.2 Dilutions to Threshold Definition

Field olfactometry utilizes a field olfactometer, which dynamically mixes ambient air with carbon-filtered air at distinct dilution ratios known as dilutions to threshold (D/T). This matrix indicates the number of dilutions of pure air needed to reach the threshold of detection. D/T is used to represent odor concentrations predicted from modeling analysis.

While the calculation method for field olfactometry (D/T) slightly differs from that of laboratory olfactometry (DT), both concepts measure odors in terms of broad-spectrum odor impact by quantifying the number of dilutions required to reach the threshold value. As they produce statistically similar results, for the purposes of this memorandum, both terms are considered synonymous.

3.1.3 Odor Levels

The higher the DT or D/T value, the stronger the odor. Human reactions to varying odor strengths are summarized in Table 3-1.

Table 3-1. Human Reactions to Odor Levels

Odor	Description	Reaction
1-2	Lowest concentration at which average noses can detect odor.	Human nose can determine a difference from normal background air in a lab. Odor has no character, just noticeably different from background air.
3-5	Odor slightly noticeable above background for some people.	Human nose may recognize character if previously experienced at higher strengths. The odor may cause slight discomfort to some individuals, but typically not alarming.
7-10	Odor is weak but distinct above background air.	Human nose can recognize the character, regardless of if it has been previously detected or not (may cause a nuisance if it occurs frequently).
20	Odor is distinct above background levels.	Human nose can recognize character and be offended (may cause a nuisance odor reaction at short durations).
50	Odor is very noticeable above background levels.	Human nose can easily determine source and can result in nuisance odor reaction for most individuals.

Impacts from odor sources that cannot be solely quantified by odor characterization; dispersion of odor, or transport, must also be considered. Odor dispersion refers to the phenomenon where odor concentrations decrease, potentially falling below recognition or detection thresholds. Plume dispersion is influenced by various factors, including meteorological conditions, source type, terrain, building downwash and deposition (e.g., contact with ground, rain). Meteorological conditions, one of the most important factors in determining the spread and shape of a plume, encompass wind speed and direction, as well as vertical buoyant mixing.

3.1.4 NTS Facility Offsite Odor Goals

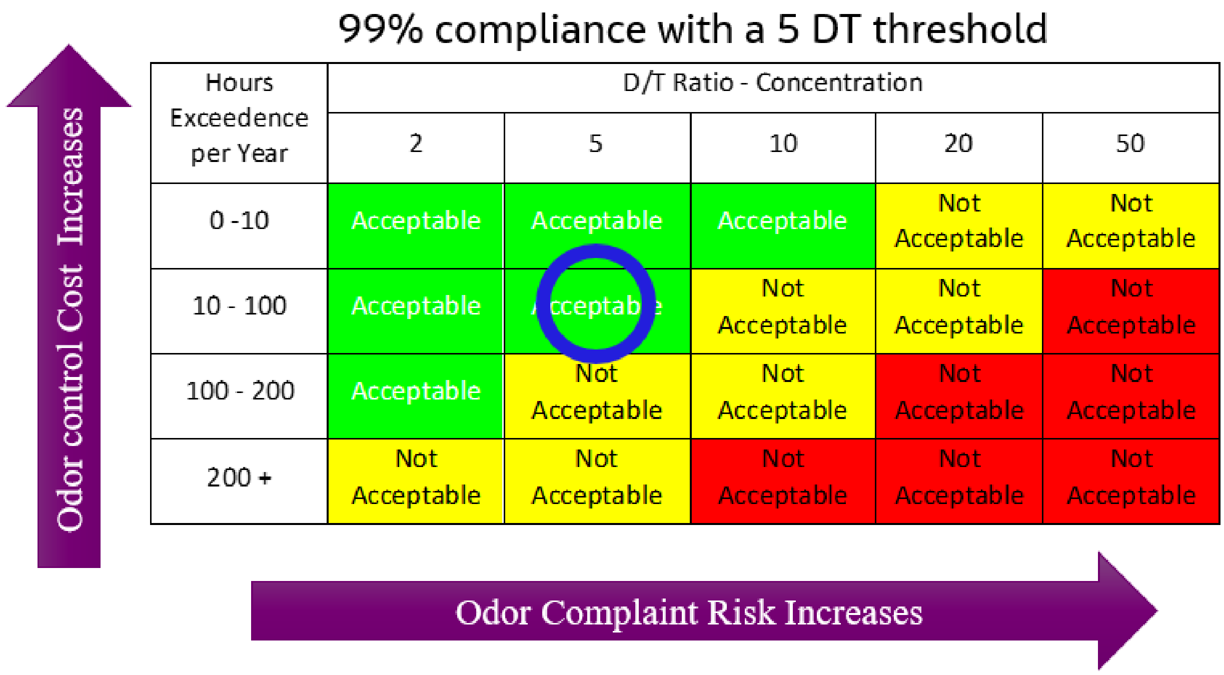
Currently, offsite odor requirements for operations at the NTS are defined in the Wallingford Community Council and SPU Agreement (WCC and Seattle Public Utilities, 2012). Section P of the Wallingford Community Council agreement states the following:

> *Design, construct and operate the project so that there shall be no Level 2 odors documented by an official PSCAA representative, per the terms of PSCAA Regulation I. This will be (sic) considered the project's "mandatory standard" for odor control.*

The Puget Sound Clean Air Agency's (PSCAA) Regulation 1, §9.11 defines offsite nuisance or annoyance odor as the following:

> *With respect to odor, the Agency may take enforcement action under this section if the Control Officer or a duly authorized representative has documented all of the following:*
>
> *(1) The detection by the Control Officer or a duly authorized representative of an odor at a level 2 or greater, according to the following odor scale:*
>
> > *level 0 – no odor detected;*
> >
> > *level 1 – odor barely detected;*
> >
> > *level 2 – odor is distinct and definite, any unpleasant characteristics recognizable;*
> >
> > *level 3 – odor is objectionable enough or strong enough to cause attempts at avoidance;*
> >
> > *level 4 – odor is so strong that a person does not want to remain present;*

Odor goals at and beyond the NTS property line were established to set a benchmark target for meeting the prescriptive nuisance guidelines by defining an Ambient Odor Standard. This approach sets a quantitative value or values that must not be exceeded offsite. Values may be expressed as DT. In addition, the level of compliance is defined. For example, a 99 percent compliance means the specified value cannot exceed 1 percent of the time as expressed in hours. This equates to up to roughly 87 hours annually of noncompliance. Finally, an averaging time must be established that is used to “smooth out” odor spikes because odor complaints are related to duration. Figure 3-1 shows how exceedances and odor concentrations play a part in determining an offsite odor standard.



Hours Exceedence per Year	D/T Ratio - Concentration				
	2	5	10	20	50
0 -10	Acceptable	Acceptable	Acceptable	Not Acceptable	Not Acceptable
10 - 100	Acceptable	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
100 - 200	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
200 +	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable

Figure 3-1. Determination of Offsite Odor Standards by Exceedance and Concentration

Odor impacts can lead to complaints when the offsite concentrations significantly exceed the odor goal, or when offsite concentrations regularly approach odor threshold levels. It is important to note that odor nuisances are typically transient, associated with puff conditions, or exposure times in the order of seconds or minutes rather than hours. The 1-hour output produced by air dispersion modeling (AERMOD) helps to smooth out concentration peaks. After discussions with NTS staff members, an aspirational goal of 5 DT with 99 percent compliance (i.e., no more than 87 hours above the goal DT) was chosen over a 7 DT goal, which is typical of standards at comparable facilities. This initial goal of 7 DT was selected to evaluate modeled offsite impacts. Additionally, a more conservative, aspirational odor level of 5 DT compliance was also chosen due to the highly interpretive neighborhood agreement requirements and sensitivity of the local community.

3.2 Facility Odor Sampling

3.2.1 Sampling Methodology and Locations

In September 2022 and June 2023, odor sampling was conducted at the NTS facility. The sampling events occurred 9 months apart to encompass various meteorological and operational conditions across different seasons. The June 2023 sampling event specifically targeted a period of warm weather with consecutive days of near-80-degree Fahrenheit temperatures. Sample collection methodology and analyses conformed to industry best practice and approved U.S. Environmental Protection Agency (EPA) protocols.

The purpose of the sampling was to characterize and quantify emissions from odor sources and to evaluate their impact on the surrounding neighborhood using AERMOD. Sample collection methods included the following techniques, although not all methods were utilized at each location:

- Fugitive Interior Space Sources: Sampling from sources within the facility. This method uses the vacuum chamber technique in interior spaces to (1) limit dilution effects from open doors and windows, (2) ensure thorough mixing of odors, and (3) minimize dilution from makeup air systems.
- Point Sources: Sampling from specific emission points such as ducts and stacks. This involves using a vacuum chamber connected to the source via an airtight connection and inert (such as Teflon) tubing. Multi-point sampling was deemed unnecessary, as uniformity and homogeneous mixing within the ducts were assumed (EPA 2012).
- Offsite Odor Impacts: To identify neighborhood hotspots and investigate areas of odor concern, Jacobs staff utilized a field olfactometer for real-time determination of odor concentration.

Sampling methods employed at the facility are further discussed below. The draft sampling plan, submitted to SPU on September 8, 2022, is included as Appendix A.

3.2.1.1 Bag Sampling (for Flux Chamber Emissions and Point Sources)

Samples collected using Tedlar bags were directly obtained from the vacuum chamber connected to the stack or duct sources (point sources). These bags were then sent to the defined laboratory for odor analysis. A sampling rate of less than 2.0 liters per minute was maintained from the vacuum chamber. Sample bags were filled by connecting the sampler to the source, drawing a vacuum on the vacuum chamber, and then filling the bag collecting a 10-liter sample. Prior to taking the final sample, sample bags were preconditioned by partially filling, then expelling the bag contents.

Odor concentration was determined through olfactometry following American Society for Testing and Materials E679-04 Standard of Practice with a presentation rate of 20 liters per minute (per EN 13725) utilizing odor panel analyses from St. Croix Sensory, Inc. As discussed in Section 3.1.2, to calculate the DT, the odor samples were diluted to below olfactory detection limits, then introduced to a gas delivery system. A panel of eight members trained in odor response served as the odor detectors. Panel members were asked to smell the air samples and concentrations of the samples were increased until half of the odor panel members could detect the odor. Odor concentrations are expressed as the number of dilutions that were required for half of the panel members to record detection and report the DT level.

3.2.1.2 Field Olfactometry

A field olfactometer was employed to conduct ambient odor sampling in the neighborhood. This method enabled rapid sample collection during fluctuating wind conditions. Additionally, field olfactometry eliminated sample bag interference and degradation during holding time, which can pose challenges for laboratory analysis of ambient samples. Field olfactometry proved valuable in identifying locations of odor concerns and gathering supplementary odor measurements.

3.2.2 September 2022 Odor Sampling

Jacobs personnel collected odor samples from both exhaust stacks and the interior of the facility. Three samples were collected for odor (DT) analysis. Two samples were collected from the exhaust stacks, specifically from exhaust fans EF2 and EF4A. An additional ambient air sample was collected from the floor opening just above one of the compactors, identified as compactor 1. Samples were collected using Tedlar bags and a vacuum chamber. The results of the analysis are discussed below in Table 3-2. The laboratory odor evaluation is included as Appendix B.

Table 3-2. September 2022 Odor Sampling

#	Field No.	Sample Description	DT	Characteristics (% of assessors detected the smell)
1	EF2	Stack 2 (EF2)	230	Decay 75% Petroleum 25% Burnt Wood 25% Earth 25% Spice 25% Confectionary 25%
2	EF4A	Stack 4 (EF4A)	450	Decay 100%
3	Compactor 1	Ambient Near Compactor	200	Plastics 50% Chemical 50%

It is important to note that exhaust fan EF2 ventilates air from the lower level, while exhaust fan EF4 ventilates air from the lower level near the compactor and tipping room floor opening. These samples were collected at the respective exhaust fans and represent detections at the source and not at the fence line or in the neighborhood. At the time these samples were collected, the misting system was reportedly only using water. Additionally, Jacobs notes that odor emitted from the stack exhaust dissipates as the plume rises and is diluted by the prevailing wind. The results presented above were incorporated into Jacobs' dispersion model to predict the impact to the surrounding area.

3.2.3 June 2023 Sampling

During the second sampling event, samples were collected to assess seasonal variation. Samples were collected from the same locations as the previous sampling event, including the exhaust stack for fan EF2 and EF4A. Additionally, a sample was also collected from the exhaust stack for fan EF3. The ambient air sample was again collected adjacent to compactor 1. Samples were collected using the Tedlar bags and vacuum chamber.

For additional screening, samples were collected in the field using a Nasal Ranger. Four areas were assessed, as depicted on Figure 3-1, including near bay door 1 in the tipping room, near bay door 4 in the tipping room, near the exit door in the tipping room, and across the street from the trucking ramp. The results of the DT analysis and Nasal Ranger field readings are discussed below. Additionally, a survey was conducted in the neighborhood north of the facility. Although no odor measurements were recorded during the neighborhood survey, the team observed very brief instances of detectable odor. Results are presented in Tables 3-3 and 3-4. The laboratory odor evaluation is included as Appendix B.

Table 3-3. June 2023 Odor Sampling

No.	Field No.	Sample Description	DT	Characteristics (% of assessors detected the smell)
1	EF4A	Stack 4 (EF4A)	190	Decay 25% Sulfur 15% Chemical 50% Confectionary 15% No Odor 15%
2	EF2	Stack 2 (EF2)	130	Decay 15% Plastics 35% Chemical 15% Confectionary 15% No odor 25%
3	EF3	Stack 3 (EF3)	140	Decay 15% Plastics 38% Chemical 38% Confectionary 15% No Odor 15%
4	Compactor 1	Ambient Near Compactor	180	Decay 15% Sulfur 15% Plastics 15% Chemical 25% Confectionary 15% No Odor 25%

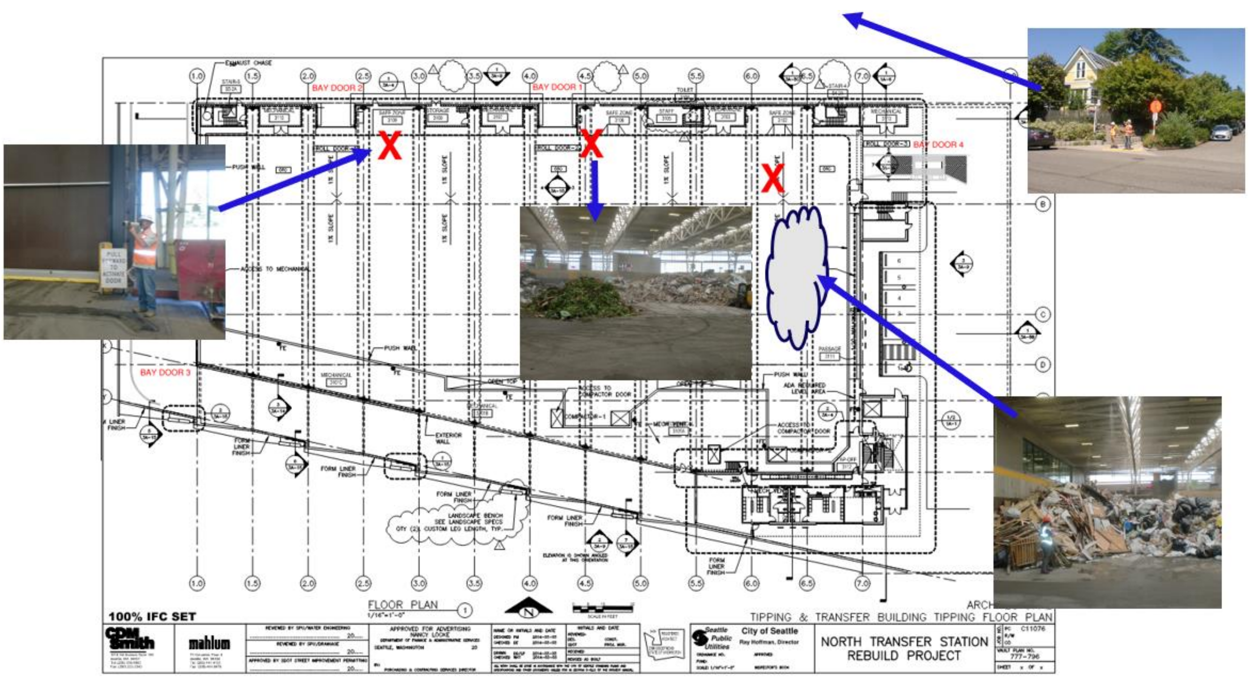


Figure 3-1. June 2023 Nasal Ranger Odor Locations

Table 3-4. June 2023 Nasal Ranger Odor Readings

Location	Time	Odor Strength
On tipping floor near bay door 1	Noon	>60 DT
On tipping floor near bay door 4 (near EF2 intake)	Noon	1. 30-60 DT, 2. (2) >60 DT
On tipping floor next to exit door (Bay door 2)	12:15 pm	1. 7-15 DT, 2. (2) 4-7 DT
Trucking ramp across street	12:30 pm	<4 DT

The results presented above were also utilized in Jacobs' dispersion model to predict the impact on the surrounding area.

3.3 Sampling Conclusions

Odor samples were collected in September 2022 and June 2023 to gather data representing seasonal variations. Notably, the odor levels measured from the exhaust stacks during warmer weather were found to be lower than the levels measured during cooler weather. The ambient air samples taken near the compactor were collected indoors and showed essentially the same characteristics during both sampling events.

The odors were characterized by hints of decay, sulfur, chemical, plastics, confectionary, burnt wood, and/or earth. However, the most prevalent characteristic within all samples was decay, which is consistent with the smells outlined within the complaint log. Based on results presented above, modeling of "what if" scenarios was conducted to evaluate possible options for odor reduction at the facility.

4. Dispersion Modeling

The methodology for assessing odor impacts from the NTS involves employing dispersion modeling, which is a close assimilation of current operations and meteorological conditions based on conservative assumptions. The intent of utilizing air modeling is to identify potential areas affected by the NTS odor sources using a dispersion model set up using site-specific data. After the model was set-up using site-specific data, the modeling for this assessment was conducted in two stages: baseline modeling and "what-if" scenario modeling. Dispersion modeling was conducted to predict the baseline impacts of the NTS as well as impacts associated with additional "what-if" scenarios. The baseline model represented typical operations at the NTS and was based on information obtained from NTS staff and two onsite odor surveys. The additional "what-if" scenarios were also modeled to predict offsite odor impacts assuming odor reduction from various control applications.

Modeling is a close approximation of current operations and meteorological conditions based on conservative assumptions. It is difficult to provide an exact representation of real conditions given the nature and variety of factors that influence odor in real time. However, the baseline modeling is being used as a gauge to conservatively predict maximum concentrations of odors. From there, “what-if” scenarios are developed to evaluate the degree to which technological improvements will assist in reducing odors.

Odor modeling data were analyzed from the following three perspectives typical of odor analysis:

- Frequency of odor above the DT goal at offsite receptors,
- Maximum offsite impacts, and
- Offsite odor impacts by source.

Setting an aspirational numerical goal of achieving 99 percent compliance with 5 DT served as a benchmark to assess current baseline odor impacts and guide the identification of effective odor reduction strategies. As odor impacts are influenced by factors such as frequency, strength, intensity, and individual sensitivity, this aspirational goal aims to comprehensively drive odor control options to mitigate the extent to which odors affect the surrounding neighborhood and reduce odor complaints.

The baseline findings in relation to the aspirational goal served as the foundation for evaluating the overall odor impacts from the NTS and pinpointing specific odor sources requiring prioritized improvements to effectively mitigate odor impacts. This assessment was conducted through "what-if" scenarios, involving the adjustment of key input parameters and exploration of various odor mitigation options.

The following subsections describe the modeling set-up, parameters used, and results.

4.1 Model Set-up

This section outlines the foundational framework employed in configuring the air-dispersion model for both baseline and "what-if" scenarios, with scenario-specific inputs discussed individually in preceding sections.

4.1.1 Model Selection

The AERMOD model (Version 23132) was utilized with regulatory default options, as recommended in the EPA Guideline on Air Quality Models (EPA 2005). The following supporting preprocessing programs for AERMOD were employed:

- Building Profile Input Program (BPIP)- Plume Rise Model Enhancement (PRIME) (Version 04274)
- AERMOD Terrain Processor (AERMAP) (Version 18081)

AERMOD is a steady-state Gaussian plume model that simulates air dispersion based on planetary boundary layer turbulence structure and scaling concepts. It accounts for both surface and elevated sources, as well as simple and complex terrain. This model is particularly suitable for short-range (less than 50 kilometers) dispersion from the source. AERMOD incorporates the PRIME algorithm for modeling building downwash. During the modeling process, AERMOD is designed to accept input data prepared by two specific preprocessor programs, AERMET and AERMAP. During the modeling process, AERMOD is configured with the following options:

- Regulatory default options,
- Urban dispersion option,
- Direction-specific building downwash, and
- Actual receptor elevations and hill-height scales obtained from AERMAP.

4.1.2 Building Wake Effects

Building influences on stacks are calculated by incorporating the updated EPA BPIP for use with the PRIME algorithm (BPIP-PRIME). The stack heights used in the dispersion modeling were estimated from known building roof heights, satellite imagery, photographs, and CAD drawings.

4.1.3 Ambient Air Boundary

Ambient air, as defined by EPA is "that portion of the atmosphere, external to buildings, to which the general public has access" [40 C.F.R §50.1(e)]. The ambient air boundary (AAB) was defined by the NTS property fence line. Figure 2-1 shows the facility's AAB in green.

4.1.4 Receptor Grid

Known sensitive receptors around the NTS include residential neighborhoods to the north and east. Due to the nature of the area surrounding the NTS, a higher resolution receptor grid surrounding the facility (10 meters) was extended out from the facility.

The dispersion modeling used a nested Cartesian receptor grid with 3,862 discrete receptors as follows:

- Receptors along facility's AAB were spaced 10 meters apart.
- Near-field receptors were situated on a 10-meter grid extending 250 meters beyond the AAB.
- Far-field receptors (250 to 500 meters from the facility) were located on a 25-meter grid.

AERMAP (Version 18081) was used to process terrain elevation data for all sources and receptors using National Elevation Dataset files prepared by the U.S. Geological Survey. Due to the complex terrain surrounding the facility high resolution 1/9 arc-second U.S. Geological Survey Digital Elevation Model files were used. AERMAP first determines the base elevation at each source and receptor. For complex terrain situations, AERMOD captures the physics of dispersion and creates elevation data for the surrounding terrain identified by a parameter called hill-height scale.

AERMAP creates hill-height scale by searching for the terrain height and location that has the greatest influence on dispersion for each individual source and receptor. Both the base elevation and hill-height scale data are produced for each receptor by AERMAP as a file or files that can be directly accessed by AERMOD.

Receptors and source locations are expressed in the Universal Transverse Mercator North American Datum 1983, Zone 10 coordinate system.

4.1.5 Meteorological Data

A sonic anemometer was installed on the facility's roof in December 2022 to track local weather patterns in relation to odor complaints. The anemometer measures various parameters including total particulate matter, pollutants (e.g., carbon dioxide, ozone, nitrogen dioxide, nitric oxide, carbon monoxide), as well as temperature, relative humidity, and wind speed and direction. Positioned on the southeastern corner of the building, in the upgradient predominant wind direction, the anemometer provides valuable data. These data, illustrated on Figure 4-1, are downloaded on a bimonthly basis, and analyzed alongside logged odor complaints.

Figure 4-1. Anemometer located on the southern corner of the facility roof.

To select the most suitable meteorological data for modeling, onsite meteorological data from January to July 2023, were compared to that of the Boeing Field site, located approximately 12 miles south of the NTS. The Boeing Field site is the closest meteorological station with a comprehensive dataset and has similar prevailing wind patterns as the site. Figure 4-1 illustrates the comparison between the meteorological data from Boeing Field and the site-specific data collected from the anemometer installed at the NTS. The meteorological data from Boeing Field was determined to be representative of NTS. Therefore, the processed meteorological data used in the model were obtained from the Boeing Field sitefor the 5-year period from 2016 to 2021, with the exclusion of 2019 due to insufficient data. Yearly exceedances for the 5-year period, 2016 to 2021, showed slight variation in baseline impacts. Therefore, the year with the highest frequency of offsite impacts (2020) was chosen as a representative year for the baseline and "what-if" scenarios. The meteorological data were processed using the EPA-approved AERMET (Version 21112) meteorological data preprocessor.

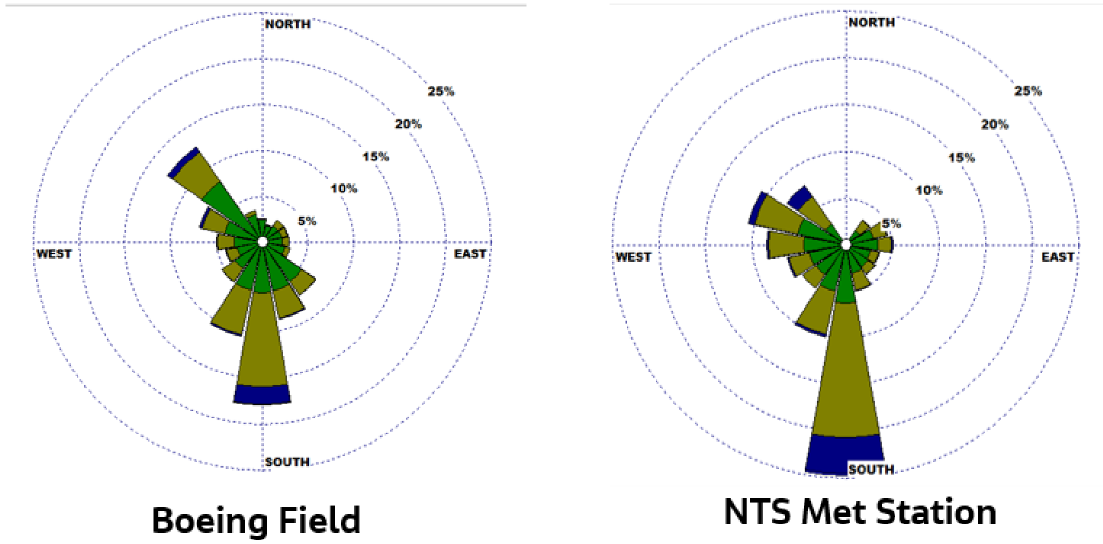


Figure 4-2. Onsite and Boeing Field Meteorological Data Comparison

4.1.6 Odor Emission Sources

Twelve odor emission sources were identified for both baseline and "what-if" scenario modeling at the NTS, comprising eight rooftop stacks and four bay doors. Figure 4-3 illustrates the location of each modeled odor source, as well as the type of source used to represent them in the baseline AERMOD dispersion model (i.e., point sources for rooftop stack and volume sources for bay doors).

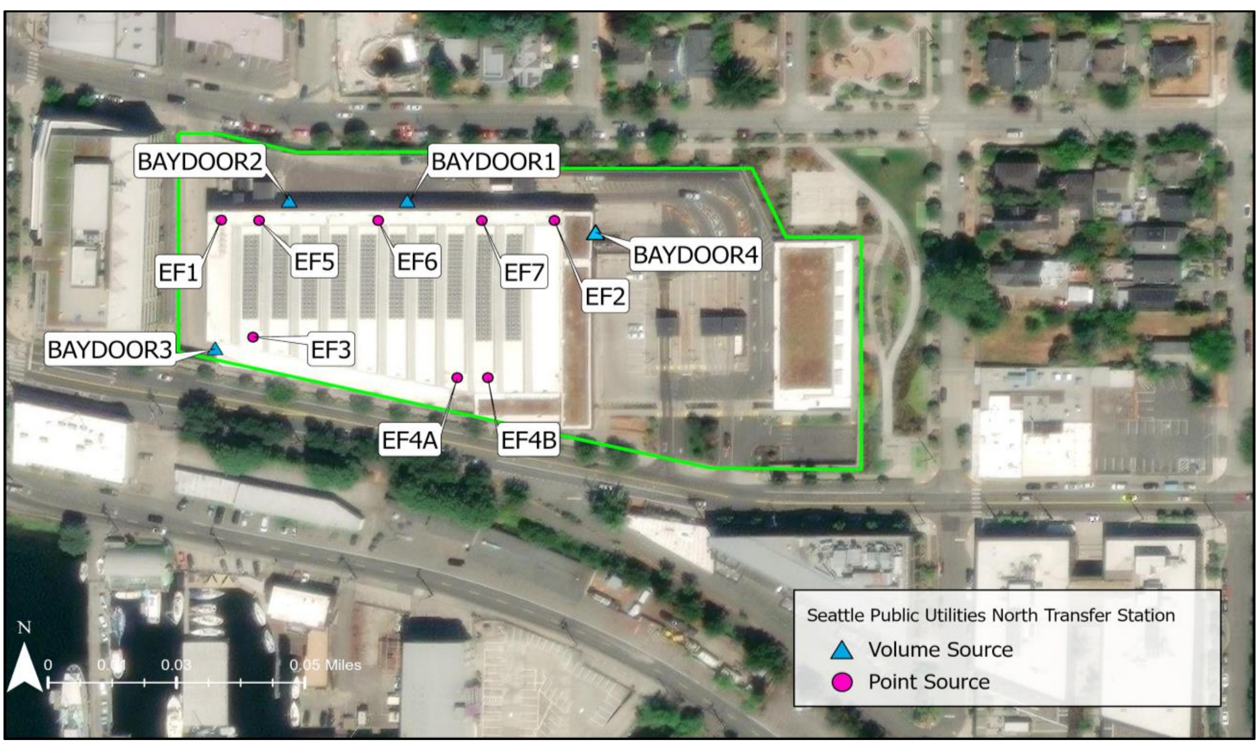


Figure 4-3. Seattle Public Utilities North Transfer Station Modeled Odor Source Locations

4.1.7 Odor Emission Rates

Source odor concentrations (DT) and emissions rates (odors per second [OU/s]) for the baseline scenario were derived from data collected during sampling in September 2022 and June 2023. The June 2023 samples represent conditions after the exhaust fans were increased to operate at 100 percent.

Emission rates for both the baseline odor and "what-if" scenarios were established by merging individual source odor concentrations with associated flux rates or measured exhaust flows for each source (Table 6-4). For both point and volume sources, the odor emission rate is expressed in OU/s and is calculated as follows:

$$DT \times Air\ Flow/60 = OU/s$$

Where:

DT = peak odor strength (per laboratory sample results)

Air Flow = air flow rate out stack or bay door, meters/second

4.2 Baseline Dispersion Modeling

The following section discusses the sources and parameters used for the baseline model, followed by the modeling results.

4.2.1 Odor Emission Sources and Parameters

Twelve odor emission sources were identified for modeling at the NTS, comprising eight rooftop stacks used for exhaust and four bay doors. Figure 4-3 illustrates the location of each modeled odor source, as well as the type of source used to represent them in the baseline AERMOD dispersion model (i.e., point sources for rooftop stack and volume sources for bay doors).

Odor emission sources must be defined in terms of their odor emission rates, configuration, and physical properties to be accurately modeled. At the NTS, odor emission sources were classified into two categories: point and volume sources. Point sources exhaust air through a duct or vent at a known rate, allowing for the specification of parameters (e.g., the height of the release, outlet diameter, exit velocity, exit gas temperature). On the other hand, volume sources are releases that are not easily defined as point sources and include sources such as bay doors. The determination of source types and stack parameters relies on data collection in-field, manufacturer's specifications, or engineering expertise.

4.2.1.1 Rooftop Stacks

Eight rooftop stacks (EF1 through EF7; depicted on Figure 4-3) are responsible for exhausting air from the tipping floor and sublevel of the NTS. The fans on these stacks operate from 7am to 6pm during business hours. During the September odor survey, both the heights (measured 3 feet above rooftop) and diameters were recorded. The temperature of the stack exhaust was assumed to be ambient. However, due to variance noted in the exhaust's VFD setting between visits by Jacobs' staff, flow measurements in cubic feet per minute (CFM) at a VFD setting of 100 percent were measured on September 29, 2023, and utilized as an input to the dispersion model. Table 4-1 presents the exhaust fan and stack parameters used in the baseline modeling process.

Table 4-1. Baseline Rooftop Stack Operating Parameters

Stack ID	Stack Height (feet)[a]	Exit Velocity (fps)	Stack Diameter (inches)	Rated CFM	Measured CFM[b]	Location of Pulled Air
EF1	44	59.9	50	55,000	49,000	Lower level from duct along the north wall
EF2	44	55.0	50	55,000	45,000	Lower level from duct along east wall
EF3	44	58.7	50	55,000	48,000	35,000 cfm from the lower level and 20,000 cfm from the tipping floor level
EF4A	44	86.8	50	150,000 (75,000 each)	71,000	135,000 cfm (90%) comes from the lower level (near compactors) and 15,000 cfm (10%) comes from the tipping floor level (duct above floor opening to compactor).
EF4B	44	85.6	50		70,000	
EF5	44	78.2	50	60,000	64,000	Tipping floor thru louvers along the north wall
EF6	44	72.1	50	60,000	59,000	Tipping floor thru louvers along the north wall
EF7	44	81.9	50	60,000	67,000	Tipping floor thru louvers along the north wall

[a] Exhaust is three feet above rooftop.
[b] Average measurement, rounded to the nearest 1,000 cfm. Collected after exhaust fan maintenance.

4.2.1.2 Bay Doors

Four bay doors provide access for commercial and facility traffic at the NTS. Three bay doors (1, 2, and 4) are situated on the tipping floor level and serve as an exhaust point for that floor. Bay doors 1 and 2 are open to the public from 8am to 5pm, though they may be closed depending on traffic flow, generally remaining open to allow access to the tipping floor. Bay door 4, exclusively for commercial trucks, operates from 8am to 3pm. Bay door 3, located on the sublevel and accessible only to NTS staff, lacks a door and remains open to ambient conditions.

Partial ventilation of the NTS is achieved via the bay doors, driven by wind-induced low pressure, and mixing on leeward surfaces. Interior pressures were assumed to be slightly negative to account for bay door ventilation, with a face velocity of 50 feet per minute utilized for the open doors based on wind induction and best engineering judgment.

Bay doors 1, 2, and 4 dimensions were assumed to be 23 feet tall by 20 feet wide, while Bay door 3 dimensions were assumed to be 23 feet tall by 23 feet wide. All four bay doors were modeled as volume sources in the AERMOD dispersion model. The input parameters for volume sources, including release height, initial horizontal dimensions, and initial vertical dimensions, were modified based on the physical characteristics of the odor emission sources, and were calculated as follows:

- Release Height (Relhgt): Center of volume source aboveground, calculated as the height of source divided by 2 and reported in meters.
- Initial Horizontal Dimension (σyo): Modeled as a single volume source, horizontal dimension of the side, divided by 4.3 and reported in meters.
- Initial Vertical Dimension (σzo): Modeled as a surface-based source, vertical dimension of source, divided by 2.15 and reported in meters.

Table 4-2 summarizes the physical and modeled parameters for the bay doors.

Table 4-2. Baseline Bay Door Operating Parameters

Source ID	Source Description	Physical Height (feet)	Release Height (m)	Physical Width (feet)	Initial Horizontal Dimension (m)	Initial Vertical Dimension (m)
BAYDOOR 1	Tipping floor roll-up door	23.0	3.5	20.0	1.4	3.3
BAYDOOR 2	Tipping floor roll-up door	23.0	3.5	20.0	1.4	3.3
BAYDOOR 3	Transfer truck roll-up door	23.0	3.5	23.0	1.6	3.3
BAYDOOR 4	Commercial entrance	23.0	3.5	20.0	1.4	3.3

m = meter(s)

4.2.2 Baseline Scenario Emission Rates and Supporting Parameters

Baseline emission rates were developed utilizing the formula presented in section 4.1.7 and data collected during sampling in September 2022 and June 2023 (when exhaust fan speeds were at 100 percent) for source odor concentrations (DT) and emissions rates (OU/s). Table 4-3 summarizes the odor concentration and methodology, air flow, and odor emission rate (converted to metric units for modeling purposes) for each odor source in the baseline scenario.

Table 4-3. Baseline Odor Emission Rates and Supporting Parameters

Odor Source	Odor (DT)	Odor DT Methodology	Flux Rate (fpm)	Airflow (cfm)	Airflow (m^3/s)	Odor Emission Rate (OU/s)
EF1	340	Average of sublevel measured odor concentrations	--	49,000	23.1	7,863
EF2	230	Source sampled maximum	--	45,000	21.2	4,885
EF3	332	Ratio of measured EF4A and EF3 odor concentrations. Ratio applied to maximum EF4A concentration	--	48,000	22.7	7,511
EF4A	450	Source sampled maximum concentration	--	71,000	33.5	15,079
EF4B	450	Source sampled maximum concentration	--	70,000	33.0	14,866
EF5	340	Average of sublevel measured odor concentrations (EF2 and EF4) max	--	64,000	30.2	10,270
EF6	340	Average of sublevel measured odor concentrations (EF2 and EF4) max	--	59,000	27.8	9,467
EF7	340	Average of sublevel measured odor concentrations (EF2 and EF4) max	--	67,000	31.6	10,751
BAYDOOR 1	60	Nasal Ranger odor strength from tipping room floor near source	50	23,000	10.9	651
BAYDOOR 2	60	Nasal Ranger odor strength from tipping room floor near source	50	23,000	10.9	651
BAYDOOR 3	4	Nasal Ranger odor strength from near source	50	26,450	12.5	50
BAYDOOR 4	60	Nasal Ranger odor strength from tipping room floor near source	50	23,000	10.9	651

OU/s calculated as DT multiplied by m^3/s. Conversion of source flow rate units from cfm to m^3/s was made prior to calculation.
fpm = foot/feet per minute
m^3/s = cubic meter(s) per second

4.2.3 Baseline Odor Modeling Results

All modeled scenarios incorporated odor-emitting sources identified at the NTS. These sources were included in the EPA-developed AERMOD dispersion model, which predicts 1-hour average pollutant concentrations. Yearly exceedances for the 5-year period modeled, 2016 to 2021, showed only slight variation year to year in baseline impacts. Therefore, the year modeled with the highest frequency of offsite impacts (2020) was chosen as a representative year for the baseline and additional odor reduction scenarios, presented in Section 4.3.

Figure 4-4 illustrates the model-predicted frequency extent of offsite impacts. The yellow contour represents the number of hours, as predicted by the model, when odor levels surpass the odor threshold at offsite receptors. Receptors within the contour exceed the 5 DT goal at least 1 percent of hours per year (87 hours) or more. Receptors outside the contour are expected to be compliant at least 99 percent of hours per year. The red star in Figure 4-4 denotes the location with the highest model-predicted odor.

Figure 4-4. Odor Frequency Above the 5DT Goal and Maximum predicted Odor Concentration

As seen on Figure 4-4, the maximum odor impacts and frequency of impacts do not always align. Frequency of impacts is utilized to identify areas with the highest likelihood of experiencing a goal exceedance (i.e., the most predicted hours above the goal), whereas maximum impacts indicate the strength of the predicted ground-level odor. Sensitive receptors situated in the neighborhood to the north of the facility are predicted to have the highest odor concentrations, although these impacts are predicted to be less frequent than locations northwest of the facility. AERMOD predicts 1-hour average pollutant concentrations that may smooth out concentration peaks. However, these peaks of high odor concentrations, particularly when associated with anomalous meteorological conditions, may drive odor complaints. Table 4-4 presents key metrics for evaluating odor impacts at the NTS.

Table 4-4. Baseline Odor Impacts at Worst-Case Receptor

Scenario	Exceedances At Worst-Case Receptor (Hours)	% Compliance At Worst-Case Receptor	Maximum Predicted Concentration (DT)
Baseline 5 DT Goal	581	93.2	14.9

The maximum modeled 1-hour average concentration for a sensitive residential receptor was 14.9 DT, occurred north of the NTS near North 35th Street and Ashworth Avenue North, at the fence line. This value surpasses the odor goal of 5 DT and is perceivable by the human nose.

4.3 "What-if" Odor Control Scenario Modeling

Despite incorporation of operational improvements in 2022 and early 2023, baseline modeling revealed these enhancements were not enough to achieve the aspirational goal of 5 DT with 99 percent compliance. Therefore, additional "what-if" odor control modeling scenarios were created to assess the effectiveness of add-on technologies and odor suppression measures in mitigating odor impacts.

Two primary scenarios were formulated: Scenario 1) Installation of Vari-Plume® (VP) nozzles exclusively at the exhaust fans, and Scenario 2) Deployment of odor neutralizing compounds. Scenario 2 comprised five sub-options, each involving a different percentage of odor suppression applied to all odor sources. The baseline input parameters of the air dispersion model were adjusted to simulate operational conditions with the proposed control options. After baseline modeling was completed, additional "what-if" scenarios were also simulated by modifying baseline parameters.

4.3.1 Scenario 1 – Technology Enhancement at Rooftop Stacks the Source

Scenario 1 involved the hypothetical addition of VP nozzles to improve exhaust dispersion via plume dilution. This technology was selected for "what-if" modeling because it was prescribed in the NTS Operations Plan as being part of the exhaust system.

As illustrated on Figure 4-5, with the hypothetical installation of the VP nozzles, the stack height was raised by approximately 8 feet (94.75 inches), the stack diameter increased to 55 inches, and the exhaust velocity was elevated as compared to parameters used in the baseline model.

Parameters for "what-if" Scenario 1 are shown in Table 4-5. Calculated airflow measured in CFM is the total exhaust flow including the ambient dilution air plus the building exhaust flow, as depicted on Figure 4-5.

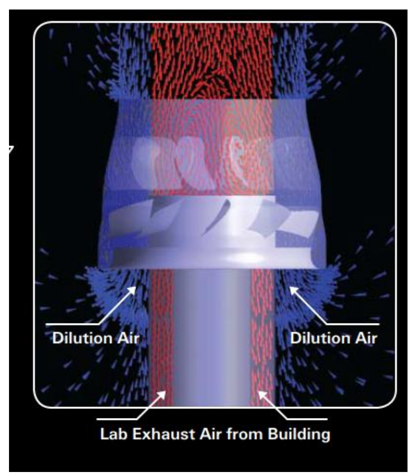


Figure 4-5. VP Nozzle

Table 4-5. Scenario 1 Rooftop Stack Source Parameters

Stack ID	Stack Height (feet)	Exit Velocity (fps)	Stack Diameter (inches)	Calculated Airflow (CFM)
EF1	52	74.2	55	73,500
EF2	52	68.2	55	67,500
EF3	52	72.7	55	72,000
EF4A	52	107.6	55	106,500
EF4B	52	106.1	55	105,000
EF5	52	97.0	55	96,000
EF6	52	89.4	55	88,500
EF7	52	101.5	55	100,500

4.3.2 "What-If" Scenario 1 Modeling Results

Scenario 1 included the hypothetical addition of VP nozzles on the exhaust fans to improve exhaust dispersion via plume dilution. Figure 4-6 presents results for individual source impacts with the VP nozzles as compared to the baseline results for each roof exhaust fan.

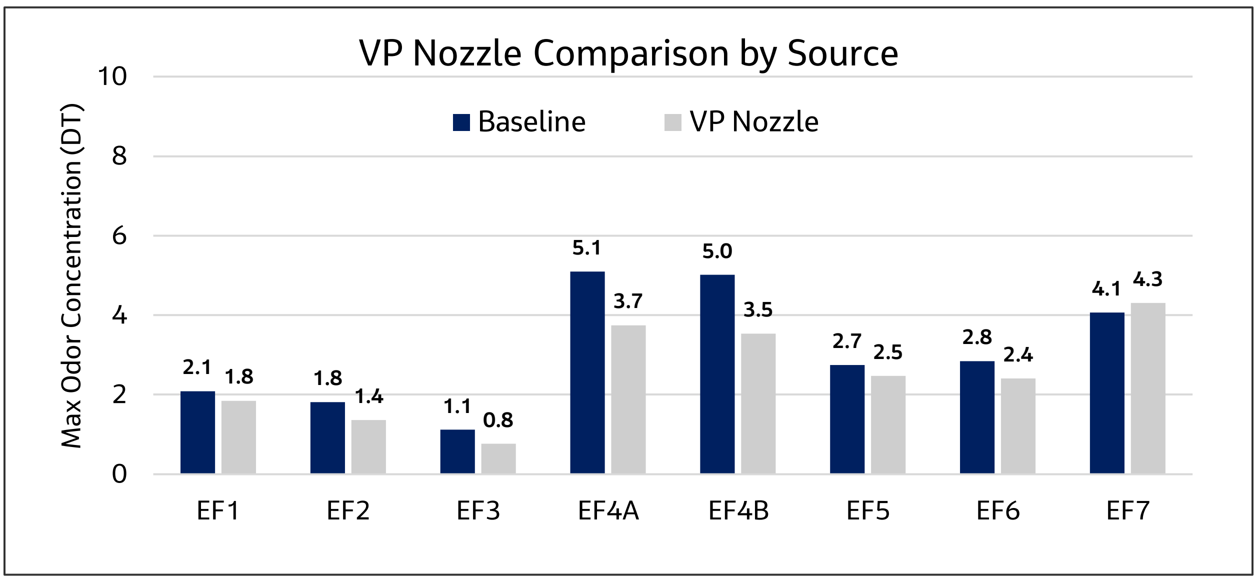


Figure 4-6. Source Odor Impacts with Addition of VP Nozzle

Results of Scenario 1 with the VP nozzles indicated minimal odor reductions across most individual units, with slightly greater reductions observed with EF4A and EF4B. This minimal improvement in odor dispersion was attributed to the complex terrain surrounding the facility, characterized by steep inclines north of the site, as well as the facility's location. The minimal improvement observed combined with the significant capital costs associated with the VP nozzles (approximately $25,000 per nozzle, plus installation costs) rendered this option unfeasible.

4.3.3 Scenario 2 – Odor Neutralizing Compounds at the Odor Source

After identifying areas that would provide the most benefit to offsite impacts, Scenario 2 focused on modeling selective hypothetical control scenarios, employing odor-neutralizing agents at the stack exhausts, on the tipping floor, at the compactor level through a misting system, and an airlock system installed only at the bay doors to reduce odor emissions.

As mentioned previously, NTS staff stated odor neutralization on the tipping floor and at the exhaust stacks was carried out regularly. However, during onsite visits by Jacobs staff, this process was not consistently observed; the misting system was not operating and/or the misting system contained only water during visits. Consequently, for each scenario, controls incorporating a neutralizing odor agent in the existing misting system on the tipping floor was added as an odor-mitigation measure. Therefore, using the neutralizing odor agent in the misting system was applied as a control measure to odor survey sampled concentrations that did not take into account the implementation of this control technique.

The feasible reduction achieved through neutralizing odor agents assumed a conservative 20 percent odor reduction when applied. This results in only 80 percent of the baseline odor being emitted. The bay door air lock assumed an 80 percent reduction in odor. This results in only 20 percent of the baseline odor being emitted.

These hypothetical emission reduction control percentages were applied to the baseline odor emission rates while maintaining baseline exhaust parameters. Various combinations of control measures were applied to the point and volume source emission rates during the Scenario 2 modeling to determine the greatest odor reduction that could be achieved at all point and volume sources. The odor concentration measured from bay door 3 was below the aspirational goal; therefore, no further controls were applied at this location.

The Scenario 2 model runs are described as follows:

- Scenario 2.1 consists of continuous misting of neutralizer on tipping floor using existing misting infrastructure. The model used a 20 percent odor reduction on emissions at all open bay doors (1, 2, and 4) and all roof stacks exhausting air pulled from the tipping floor (EF3, EF4A, EF4B, EF5, EF6, and EF7).
- Scenario 2.2 consists of installing an airlock (air curtain) system on tipping floor bay doors. The model used an 80 percent reduction of odor emissions from bay doors 1, 2 and 4.
- Scenario 2.3 consists of continuous misting of the odor neutralizer agent on the lower-level compactor area utilizing a vapor misting system. The model used a 20 percent odor reduction on all roof stacks exhausting ventilated air from the lower level (EF1 and EF2 and portions of EF3, EF4A, and EF4B).
- Scenario 2.4 consists of continuous misting of the odor neutralizer on all roof stacks. The model used a 20 percent odor reduction on all roof stacks exhausting ventilated air from the tipping floor and lower level.
- Scenario 2.5 consists of the maximum control on all point and volume sources. This includes installing an airlock (air curtain) system on the tipping floor bay doors (1, 2, and 4). The model used an 80 percent odor reduction of odor emissions from open bay doors. This scenario also includes continuous misting of odor neutralizer on the tipping floor, on the lower-level compactor area, and on all roof stacks with existing misting infrastructure (EF1, EF2, EF5, EF6, and EF7) using a 20 percent odor reduction on roof stacks.

Table 4-6 shows the assumed percentage of the resulting baseline odor concentrations being emitted at each point and volume source that was modeled for each odor reduction scenario. For example, since Scenarios 2.1 and 2.2 did not factor in odor neutralization on the lower level, 100 percent of the baseline odor emitted from EF1 and EF2 is assumed to continue to be emitted in Scenarios 2.1 and 2.2. For Scenarios 2.3 through 2.5, odor neutralization on either the lower level or the roof stacks is assumed to reduce odors by 20 percent, so the resulting odor emitted from EF1 and EF2 is 80 percent of the baseline odor.

Table 4-6. Scenario 2 Percentage of Baseline DT

Odor Source	Baseline Odor (DT)	Scenario 2.1 (%) [a]	Scenario 2.2 (%) [a]	Scenario 2.3 (%) [a]	Scenario 2.4 (%) [a]	Scenario 2.5 (%) [a]
EF1	340	100.0	100.0	80.0	80.0	80.0
EF2	230	100.0	100.0	80.0	80.0	80.0
EF3	332	92.7 [b]	100.0	87.3 [d]	80.0	80.0
EF4A	450	98.0 [c]	100.0	82.0 [e]	80.0	80.0
EF4B	450	98.0 [c]	100.0	82.0 [e]	80.0	80.0
EF5	340	80.0	100.0	100.0	80.0	80.0
EF6	340	80.0	100.0	100.0	80.0	80.0
EF7	340	80.0	100.0	100.0	80.0	80.0
BAYDOOR 1	60	80.0	20.0	100.0	100.0	20.0
BAYDOOR 2	60	80.0	20.0	100.0	100.0	20.0
BAYDOOR 3	4	80.0	100.0	100.0	100.0	100.0
BAYDOOR 4	60	80.0	20.0	100.0	100.0	20.0

[a] Percentage of baseline
[b] EF3: 36.4 percent from tipping floor only
[c] EF4A and EF4B: 10 percent from tipping floor only
[d] EF3: 63.6 percent from lower-level compactor area only
[e] EF4A and EF4B: 90 percent from lower-level compactor area only

Table 4-7 shows the resultant odor emission rates for the five options under Scenario 2 used in the dispersion model. Scenario 2 emission rates were developed utilizing the formula presented in Section 4.1.7, data collected during sampling in September 2022 and June 2023 for source odor concentrations (DT), flow rates measured in April 2023, emissions rates (OU/s), and the respective odor suppression percentage provided in Table 4-6. The locations that experienced the highest odor concentrations under baseline conditions (EF4A and EF4B) also experienced the highest odor emission rates in Scenario 2 under all five scenario options.

Table 4-7. Scenario 2 Odor Emission Rates

Odor Source	Scenario 2.1 Odor Emission Rate (OU/s)	Scenario 2.2 Odor Emission Rate (OU/s)	Scenario 2.3 Odor Emission Rate (OU/s)	Scenario 2.4 Odor Emission Rate (OU/s)	Scenario 2.5 Odor Emission Rate (OU/s)
EF1	7,863	7,863	6,290	6,290	6,290
EF2	4,885	4,885	3,908	3,908	3,908
EF3	6,965	7,511	6,555	6,009	6,009
EF4A	14,777	15,079	12,365	12,063	12,063
EF4B	14,569	14,866	12,190	11,893	11,893
EF5	8,216	10,270	10,270	8,216	8,216
EF6	7,574	9,467	9,467	7,574	7,574
EF7	8,601	10,751	10,751	8,601	8,601
BAYDOOR 1	521	130	651	651	130
BAYDOOR 2	521	130	651	651	130
BAYDOOR 3	40	50	50	50	50
BAYDOOR 4	521	130	651	651	130

4.3.4 "What-If" Scenario 2 Modeling Results

Table 4-8 summarizes key metrics for evaluating Scenario 2 odor impacts at the NTS, while Figure 4-7 depicts the model-predicted frequency extent of offsite impacts for Scenarios 2.1 through 2.5.

Table 4-8. Scenario 2 Odor Emission Rates

Scenario	Exceedances At Worst-Case Receptor (Hours)	% Compliance At Worst-Case Receptor	Maximum Predicted Concentration (DT)
Aspirational Goal	**87**	**99**	**5**
Baseline	581	93.2	14.9
Scenario 2.1	479	94.4	13.2
Scenario 2.2	457	94.6	14.2
Scenario 2.3	414	95.2	13.5
Scenario 2.4	359	95.8	12.1
Scenario 2.5	108	98.7	11.4

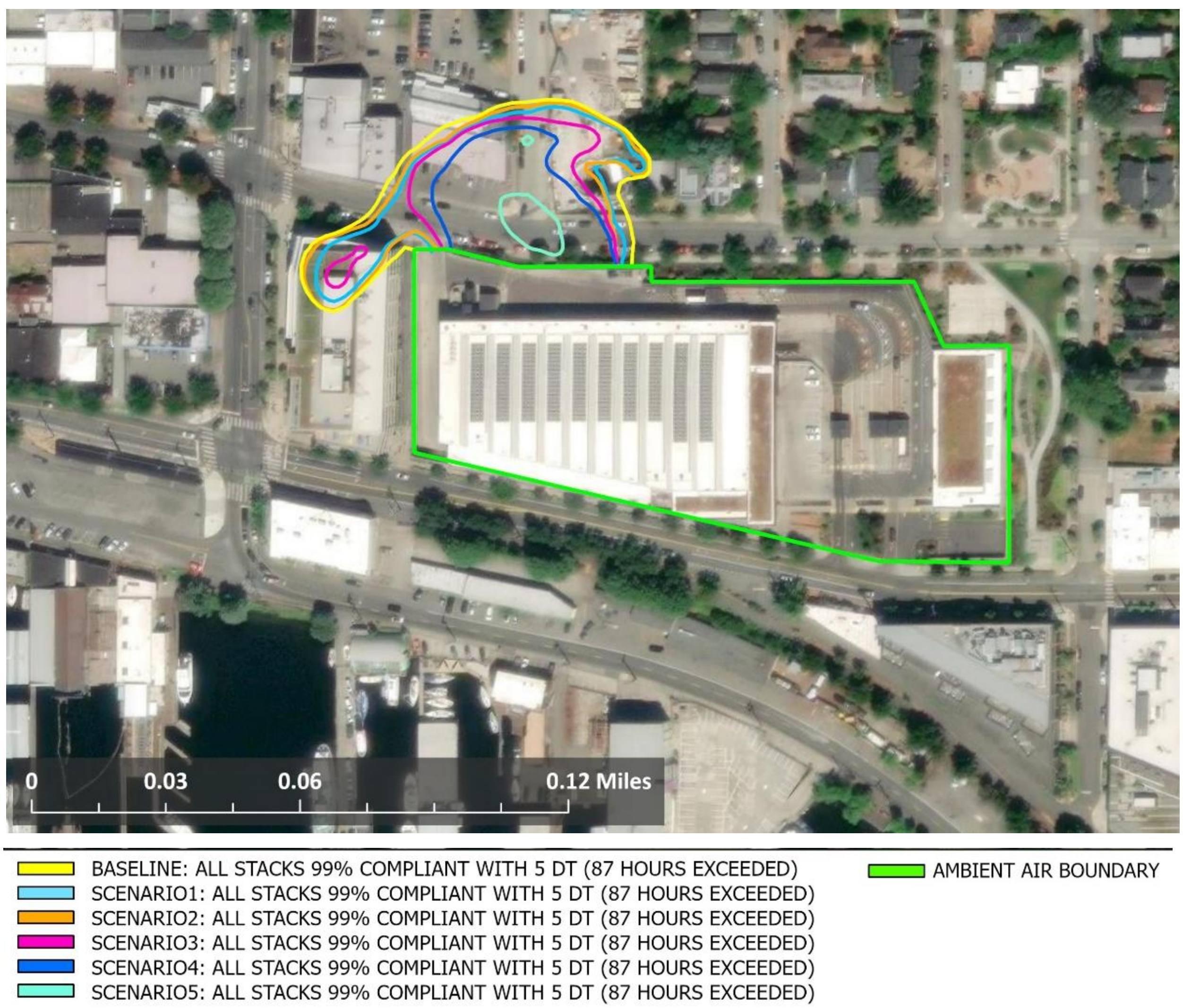


Figure 4-7. Odor Frequency Above the 5DT Goal and Maximum Predicted Odor Concentration

The Scenario 2 results indicate that with each successive scenario (2.1 through 2.5), the odor emissions are reduced. Scenario 2.5 provides the greatest reduction from baseline conditions, with a reduction of exceedances from 581 hours to 108 hours, a percentage increase from 93.2 to 98.7 percent compliance.

5. Conclusions & Recommendations

The overarching goal of this assessment was to understand existing conditions and identify potential operational improvements to assist in minimizing odor dispersion. To achieve that goal, the work was broken down into five objectives, as presented in Section 1 and as follows:

1. To understand the current facility operating conditions that may contribute to odor.
2. To understand where odor complaints are coming from with respect to proximity and location to the NTS.
3. To identify through air modeling potential areas affected by the NTS odor sources.
4. To identify the effect of potential odor mitigation options on community odor impacts.
5. To present options for operational improvements and odor control technologies for further evaluation for implementation at the NTS.

By addressing each of these objectives the following tasks were achieved:

- Insight was gained into the current operations at the NTS and their role in influencing odor generation.
- Existing (baseline) conditions regarding odor concentrations and weather patterns were determined.
- Modeling was utilized to assess baseline impact of NTS odor sources on the surrounding community.
- Opportunities for operational enhancements were identified, some of which have already been put into action by SPU staff.
- Conservative "what-if" scenario modeling was conducted to gauge the potential effectiveness of these controls in improving the overall odor environment in the surrounding neighborhood by implementing controls that targeted reducing the frequency, intensity, and offensiveness of odors.

5.1 Operational Improvements

Since the beginning of SPU's odor evaluation assessment at the NTS, the following operational improvements have been implemented:

- The customer outbound overhead door was replaced with a faster closing door in Q4 of 2022.
- The facility exhaust fans were cleaned during their scheduled annual cleaning in Q4 of 2022.
- Compactor 2, the western compactor, was repaired in Q4 of 2022.
- In early 2023, the facility hired contractors to clean the HVAC filter housing, with plans to continue this practice every 6 months.
- As of Q2 of 2023, roof top fans, though initially set on VFDs at 65 percent, have been increased to 100 percent.
- Compactor 1, the eastern compactor, was repaired in Q4 of 2023/Q1 of 2024.
- The facility is currently diverting the more odorous loads to the South Transfer station and coordinating with drivers to be more discerning in selecting dump locations to reduce the presence of odorous materials in the area.
- The facility is currently working with contractors to directly dump into functioning compactors.
- NTS is focusing on increasing the number of heavy equipment operators to reduce facility downtimes and minimize the duration waste remains on the tipping room floor.

Additional operational recommendations identified during the course of this assessment include the following:

- Clean the tipping floor, floor drains, compactors, and lower-level load out area nightly, as proposed in the Operational Plan.
- Reduce the frequency and quantity of waste left overnight on the tipping room floor.
- Consistently implement odor reduction measures (i.e., spreading Ecosorb directly on waste and utilizing Ecosorb in the misting system).
- Reduce bay door opening in warmer months only for customer traffic.
- Restrict customers from un-tarping outside of the facility.
- Confirm mechanical vents are located to direct and diffuse transmission of odors away from single family zones.
- Confirm truck and service traffic shall be directed away from residential streets. SPU transfer truck traffic will not drive on North 35th Street east of the entrance/exit at the northwest corner of the IC property unless the street segment between the entrance and Stone Way is closed.
- Operation of the exhaust fans is recommended to remain at 100 percent.

5.2 Modeling Findings

After reviewing neighborhood agreements and consulting with NTS staff members, a conservative goal of achieving 5 DT with 99 percent compliance was chosen over the typical 7 DT threshold found at comparable facilities. This aspirational target was selected to assess modeled offsite impacts rather than serving as a fixed threshold.

In the baseline model, exhaust from roof stack point sources EF4A and EF4B were identified as the primary contributors to baseline odors in the neighborhood. The maximum modeled 1-hour average concentration at a sensitive residential receptor was 14.5 DT, exceeding the 5 DT odor goal and thus detectable by humans. Sensitive receptors north of the NTS facility are predicted to experience the highest odor concentrations, albeit less frequently than locations northwest of the facility, indicating the likelihood of detectable odors and potential complaints.

To address possible remedies, two odor reduction scenarios were considered in the "what if" modeling: 1) installing VP nozzles on rooftop stacks (Scenario 1) and 2) implementing five other source odor reduction applications (Scenarios 2.1 through 2.5). Results showed minimal odor reductions with VP nozzles, rendering them unfeasible due to significant associated costs.

Scenario 2 results demonstrated decreasing odor emissions with each successive scenario, with Scenario 2.5 significantly reducing the odor footprint from baseline conditions. Although none of the scenarios met the aspirational goal, Scenario 2.5 notably reduced exceedances from 581 to 108 hours, reaching 98.7 percent compliance.

While each odor reduction scenario decreased offsite odor impacts, Scenario 2.5 showed the most improvement, particularly through combined approaches like installing airlocks (air curtains) on bay doors and continuous misting on all roof stack exhausts.

5.3 Recommendations and Next Steps

Moving forward, we recommend a multi-faceted approach to odor reduction, beginning with implementing operational improvements mentioned herein. Subsequently, we will assess three technology options for odor mitigation, considering factors such as reduction efficacy, cost, and non-financial criteria. The three recommended technologies for evaluation include upgrading the tipping floor misting system (including using the odor neutralizer for the misting systems where it is used at exit exhaust stacks), installing a new vapor misting system for the lower-level compactor area, and installation of air curtains on bay doors. Results and recommendations will be documented in a separate Technical Memorandum before proceeding to the design phase.

6. References

CDM Smith. 2013. *Draft NTS Rebuild Project 30% Basis of Design Report*.

CDM Smith. 2014. As-built redline construction drawings.

CDM Smith. 2016. *HVAC Operations and Maintenance Manual*.

Ecotone. 2017. *Systems Manual*

Fremont Neighborhood Council, Davis, Bigelow, and Sussex v. City of Seattle, Docket Number 6498-4-I, (2011).

City of Seattle. 2015. *Draft Operations Plan for City of Seattle Public Utilities NTS*. September.

U.S. Environmental Protection Agency (EPA). 2005. *Guideline on Air Quality Models.*

U.S. Environmental Protection Agency (EPA). 2012. *Emission Testing Methodology for Air Pollution*.

Wallingford Community Council and Seattle Public Utilities, 2012, *Agreement between Wallingford Community Council (WCC) and Seattle Public Utilities (SPU) on the Redevelopment of the North Transfer Station (NTS)*, dated February 27, 2012.

Appendix A
Draft Sampling Plan

Appendix B
Laboratory Odor Evaluation