Operations and Maintenance Facility South

Final Environmental Impact Statement

Appendix D: Midway Landfill Support Documents

Federal Transit Administration

SOUNDTRANSIT

June 2024

Appendix D: Midway Landfill Support Documents

Appendix D1	Midway Landfill Site Engineering Optimization Report
Appendix D2	Interim Midway Landfill Preparation Memorandum
Appendix D3	Conceptual Landfill Site Reuse Plan
Appendix D4	Midway Landfill Human Health Risk Assessment

Operations and Maintenance Facility South

Appendix D1:
Midway Landfill Site
Engineering Optimization
Report

Federal Transit Administration

SOUNDTRANSIT

January 2020

TACOMA DOME LINK EXTENSION –
Phase 2 OMFS

Midway Landfill Site Engineering Optimization Report Draft 2

SOUNDTRANSIT

CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

Tacoma Dome Link Extension
Phase 2 – OMF South

Midway Landfill Site
Engineering Optimization Report

Prepared for:
Sound Transit

Prepared by:
HDR Engineering, Inc.

January 15, 2020

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Exhibits

Tables

Appendices

1. Study Purpose

The Midway Landfill site is one of the three sites identified by the Sound Transit Board to be included in the Draft EIS as part Phase 2 of the OMF South project. The other two OMF South sites are located in South Federal Way.

The Phase 2 scope of work included a task to help optimize the Midway Landfill site layout. As a former landfill with varying depths of waste, ground settlement is a major concern that needs to be addressed during design. To accomplish this, two workshops were conducted with representatives from the City of Kent, the City of Federal Way, City of Seattle, Seattle Public Utilities (SPU), WSDOT, and various consultants and ST staff.

2. Proposed Phase 1 and Phase 2 Site Layouts

Exhibit 2.1 shows the site layout for the Midway Landfill alternative, Site 3 (North/South) that was developed during OMF South Phase 1: Alternatives Analysis. The site plan included the additional 5-acre storage area with a 30,000 sq. foot warehouse building as requested by ST. The site was adjacent to I-5 and covered the eastern portion of the landfill with the storage tracks on the eastside of the site and the maintenance building on the west side of the site.

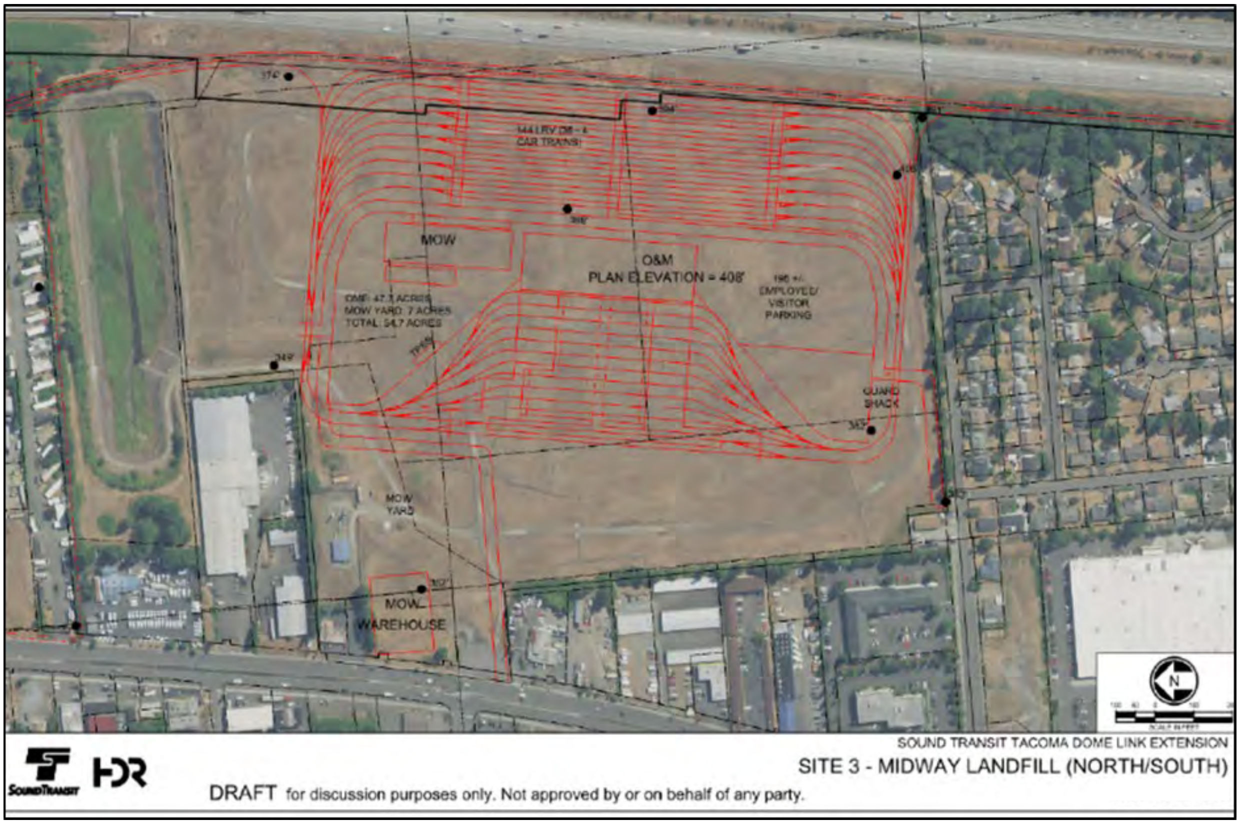


EXHIBIT 2-1
Phase 1 Site Layout

Exhibit 2.2 shows the Midway Landfill site after the Phase 2 site programming was completed. Using a Charrette process, the consultant team met with Sound Transit Operations staff to identify the key elements of the OMF South facility and yard program.

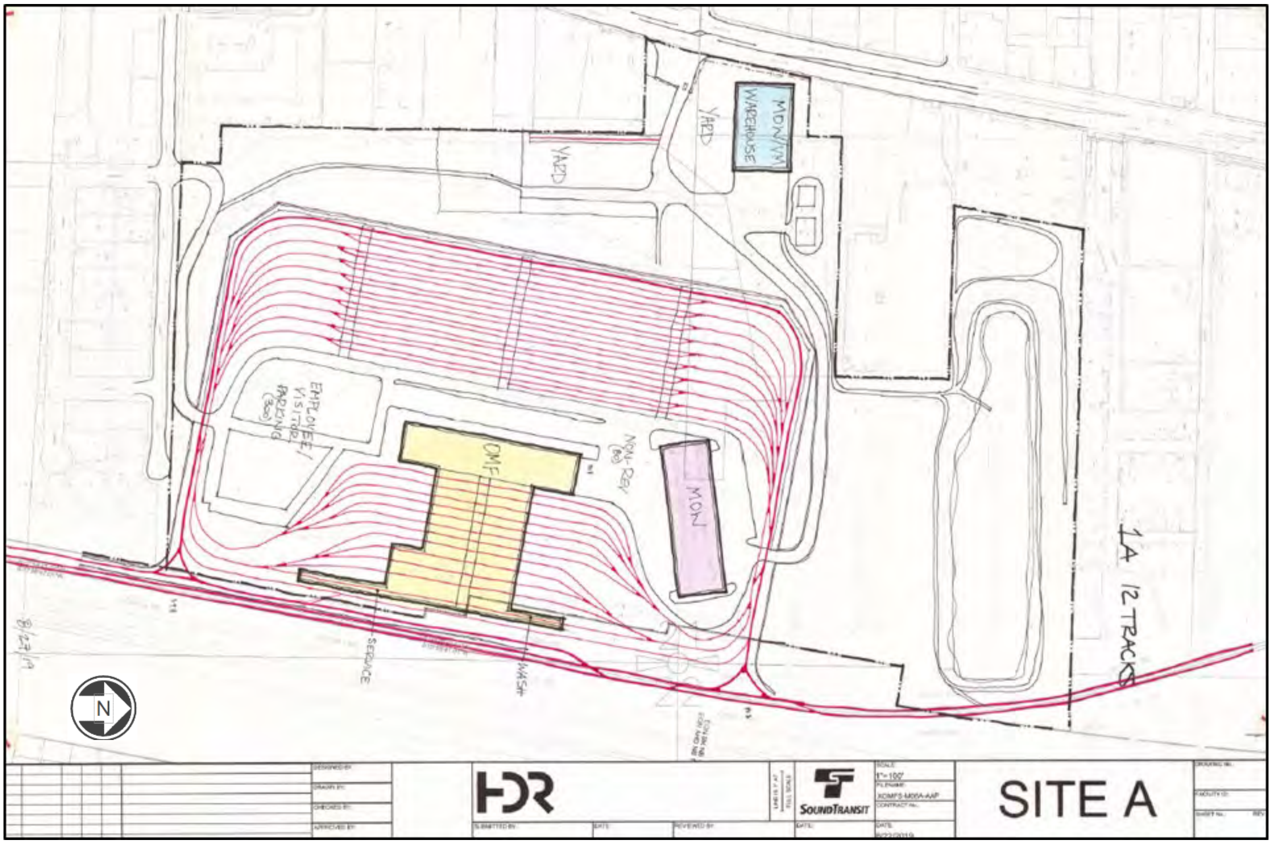


EXHIBIT 2-2
Phase 2 Site Layout per Programming Requirements

3. Midway Landfill Site Optimization Workshop No.1

The first Midway Landfill Workshop was held at Sound Transit on August 13, 2019. The purpose of the workshop was to launch a collaborative effort to understand and brainstorm Midway Landfill OMF Sound ground settlement solutions. The minutes from the workshop are attached.

3.1 Workshop Objectives

The objectives of the workshop are listed below:

- Create a shared understanding of Sound Transit's operational and maintenance criteria
- Create a shared understanding of the basis of design used to develop Sound Transit's current Midway Landfill concept for the OMFS
- Review and understand additional information that has become available on the Midway Landfill site
- Outline an action plan for how and when additional ideas will be implemented into the planning process

3.2 Light Rail Operations and Maintenance Criteria

Paul Denison, Light Rail Executive Operations Director and the person charged with overseeing their efficient, clean, and safe daily light rail operations, gave an overview of typical light rail OMF operations

Maintenance work occurs at night in regimented order, requiring about 35 minutes per train (assuming no issues). Any train requiring work beyond ordinary nightly maintenance is decoupled and brought into the shop. Paul clarified that light rail is electric propulsion train technology. These vehicles run on very precise electrical connections, which require a precise contact pattern for interface with the electrical distribution system. Tolerances are in a fractions-of-an-inch range.

The most expensive aspect of light rail operations is labor; when more labor is required due to the inefficiency of a site or its upkeep, the cost model would need to be revised.

Paul walked through Sound Transit's Design Criteria Manual (DCM) specific criteria relative to operations and maintenance facility sites. The DCM doesn't specify maintenance cycles for buildings or track, nor acceptable maintenance practices. On the site, there is a lot of special track work – crews have to regularly lubricate rail by hand on tight turns to prevent wheel climb. Also, FTA requires the facility to be in a "state of good repair" to be able to receive grant money; they consider and inspect equipment, access, and the overall program. The facility must meet certain criteria and document any adjustments through a work order process.

Other clarifications provided:

- Pantograph contact with the OCS has tight tolerances. Wires are fixed tension.
- Yard inspections are held every 30 days.
- Drainage is of critical importance. Mechanical drainage systems don't work, as the failure rate is too high.
- Grounding is floating. Must keep the grounding for the building and for the track separate.
- At the Forest Street OMF, hand tamping is completed every 3-12 months to adjust for settling. Historically, the site was a tide flat. Some fine tuning is expected. Additional details on maintenance criteria used by Operations can be found in Appendix A.

3.3 Brainstorming Ideas and Evaluation

Below is a list of brainstorming ideas which have been identified by group:

- Excavation (EX)
- Ground improvement (GI)
- Structural (STR)
- Layout optimization (LAYOUT OPT)
- Maintenance (MAINT)
- Schedule (to be ready for opening day and major milestones)
- Construction (means, methods, coordination)
- Code conformance
- Risk factors
- Ability to provide level of light rail service (efficiency and operability)
- Cost

The team went through the exercise of ranking the brainstorming ideas qualitatively as High, Low, and Medium for each category with respect to settlement risk, with respect to the brainstorming ideas listed above.

3.4 Next Steps

Sound Transit took the brainstorming ideas and put them in format that could be readily evaluated. A matrix was developed and sent to the participants with instructions on how to provide comments on the various brainstorming ideas. The result of this activity was used to develop material for the second Workshop.

4. Midway Landfill Site Settlement Workshop No. 2

The second Midway Landfill Workshop was held at Sound Transit on October 3, 2019. It provided an opportunity to review the results of the work that had taken place since Workshop No. 1 in August. The minutes from the workshop are attached.

4.1 Workshop Objectives

The objectives of the workshop are listed below:

- Review brainstorming solutions from OMF South Landfill Settlement Workshop No. 1
- Share evaluation process and initial results of brainstormed settlement design concepts
- Understand collective perspectives around design concepts
- Outline plan for designs to continue to pursue

4.2 Review of the Forest Street OMF Detail

During the first workshop, the question came up of whether or not the Forest Street OMF was built on a landfill similar to what is being considered for the Midway Landfill site. Sound Transit did some research on the Forest Street site design, including geotechnical borings that were done prior to construction of the facility. The research revealed that the Forest Street OMF is built on tidal flats that had been filled over time. The initial contract for the Forest Street OMF was for site preparation. Three to four feet of the site was excavated and the soil mixed with concrete to stabilize the soil. This was followed by the construction contract to build the facility, which included the maintenance building which is constructed on over 1,200 piles driven to a depth of up to 130 feet. The conclusion was that the Forest Street OMF site conditions are not comparable to the site conditions at the Midway Landfill site.

4.3 Optimization of Midway Landfill Site Layout

Steve Radomski explained how the optimized layout was refined with priority to operational efficiency, and analysis of brainstormed solutions from the first Settlement Workshop. This meant that, rather than defining the shallowest areas of solid waste and placing specific site elements in those locations, the site layout is currently optimized for in/out efficiency and minimization of necessary train movements on a daily basis. Layout refinements and assumptions included:

- Locating the staff parking lot entrance away from S 252nd St., which could have impacted traffic and residents in the adjacent residential area, as opposed to from SR 99.

- Moved the MOW building inside the yard.
- Increased the number of service tracks from 12 to 14 to provide additional wash and training lanes.
- No significant frontage improvements anticipated on SR 99 at the Midway Landfill site.
- Mitigating disruption to the existing stormwater detention pond on the landfill.
- Relocated the landfill gas flare facility to the west side of the detention pond.
- While refining the layout, it became apparent that proposed site layout was slightly off of the landfill. Sound Transit reviewed the Board motion language which instructed that it be built mostly on the landfill, so an additional need for some property in the vicinity of SR 99 was not deemed in conflict with Board direction.

Exhibit 4.1 shows the evolution of the Midway Landfill Site layouts as the Charrette with Sound Transit Operations staff progressed over a four-day period. The diagram in the bottom right corner of **Exhibit 4.1**, shows the final layout that will be used to document the facility requirements in a separate report.

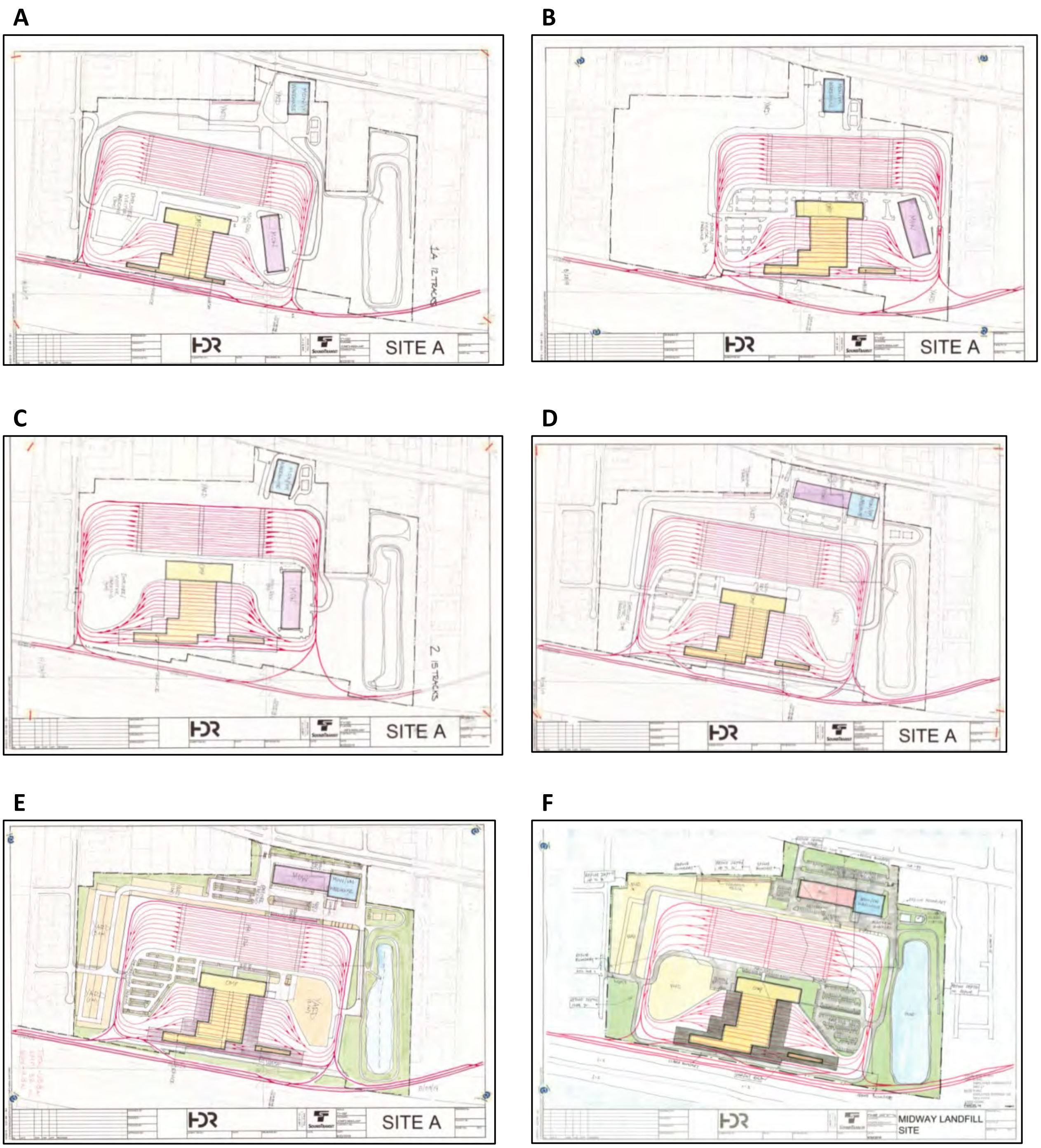


EXHIBIT 4-1
Evolution/Optimization of Midway Site Layouts

4.4 Review of the Brainstorming Design Concepts Evaluation

The brainstorming ideas from the first workshop were grouped into five major subject categories as listed below:

1. Structural
2. Excavation
3. Geotechnical
4. Layout
5. Maintenance

Within each of the categories listed above, Settlement Risk Criteria were used to evaluate the brainstorming ideas. These five criteria are listed below:

1. Regulatory
2. Schedule
3. Cost
4. Constructability
5. Maintenance and Reliability

Appendix B includes individual tables for the five major subject categories listed above. The tables also include the individual Settlement Risk Criteria listed above, applied to each of the major subject categories. The next step in the process was to rate each brainstorming concept using the color coded system shown in **Table 4.1** below.

TABLE 4-1
Rating System

1 = Low performing	(red)
2 = Medium performing	(yellow)
3 = High performing	(green)

The basis for a rating of 3 = High Performing is shown in **Table 4.2** below.

TABLE 4-2
Basis for a Rating of 3=High Performing

Settlement Risk Criteria	Measure
Regulatory Risk	Predictable Permitting (ROD, EPA. Closure Plan, Ownership, Long-Term)
Schedule	Ability to Open in 2026
Cost Rick	Meets ST3 Budget
Construction Risk	Assuming Routine Means and Methods
Maintenance & Reliability	Supports Revenue Service & Maintenance Operations without Impacts (settlement)

4.5 Review of the Brainstorming Design Concepts

Sound Transit introduced five potential design concepts based on the brainstormed ideas from the first workshop. The five design concepts are listed below:

1. High structural platform on drilled shafts with no excavation
2. Low structural platform on shorter drilled shafts with some excavation
3. Hybrid 1: Excavation with ground improvements (buildings on drilled shafts)
4. Hybrid 2: Excavation with ground improvements (slab on grade for tracks and buildings on drilled shafts.
5. Full excavation and backfill with competent soils

Each design concept has a north/south cross-section through the site which illustrates the native soils and fill depths. **Exhibit 4.2** shows the location of the “cut” through each site that was used to illustrate the cross sections.

EXHIBIT 4-2
Site Section Key Map

1. High Structural Platform on Drilled Shafts with no Excavation

- Same as Phase 1 option
- Minimum impact to landfill Cap(a goal, as we assessed the potential to impact regulatory components in case we excessively disturb the CAP)
- 3 ft. thick slab, supported by 10 ft. diameter shafts
- Requires elevated guideway to connect to transit mainline
- Approx. 70,000 CY of excavation (augured) for shafts

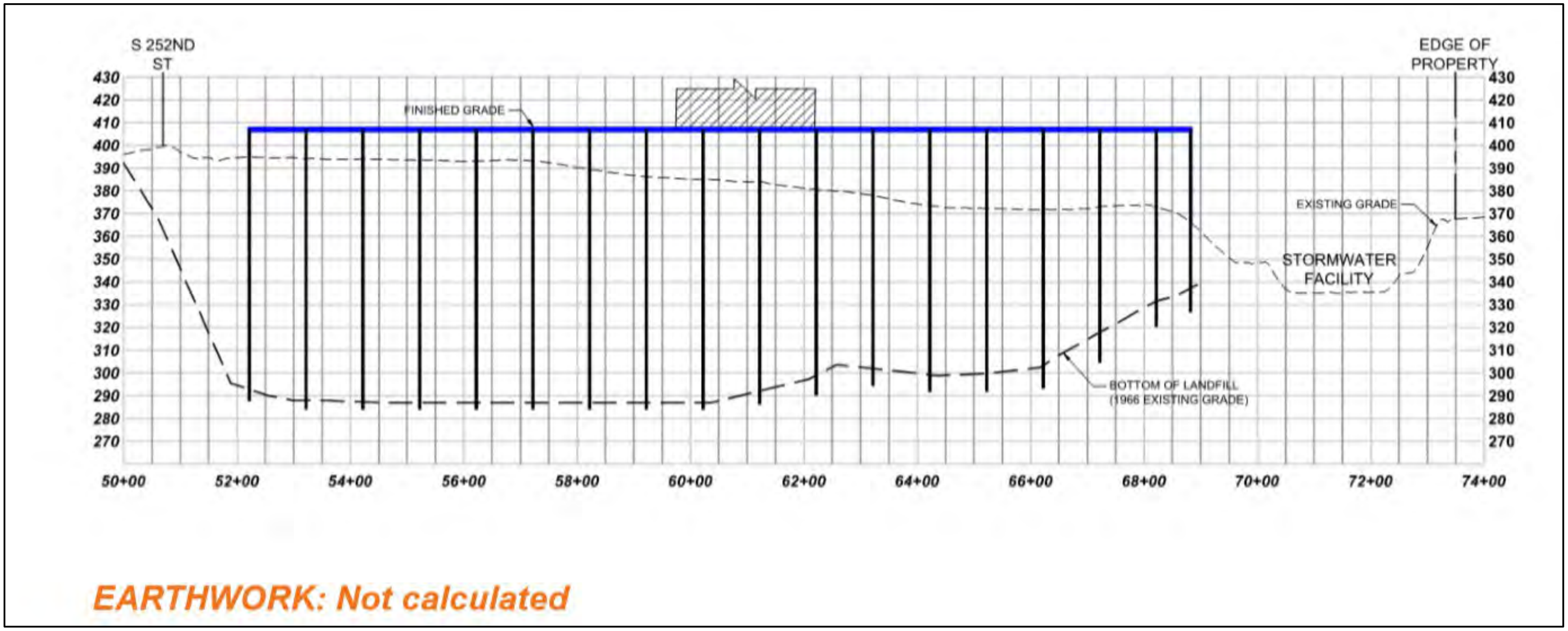


EXHIBIT 4-3

#1. High Structural Platform on Drilled Shafts with no Excavation

2. Low Structural Platform on shorter drilled shafts with some Excavation

- Remove and replace Cap
- Works with at-grade FWLE tracks (current FWLE design concept being advanced)
- 1.7 million CY (in place) equates to 2.7 million CY (loose) excavation required
- No imported material required

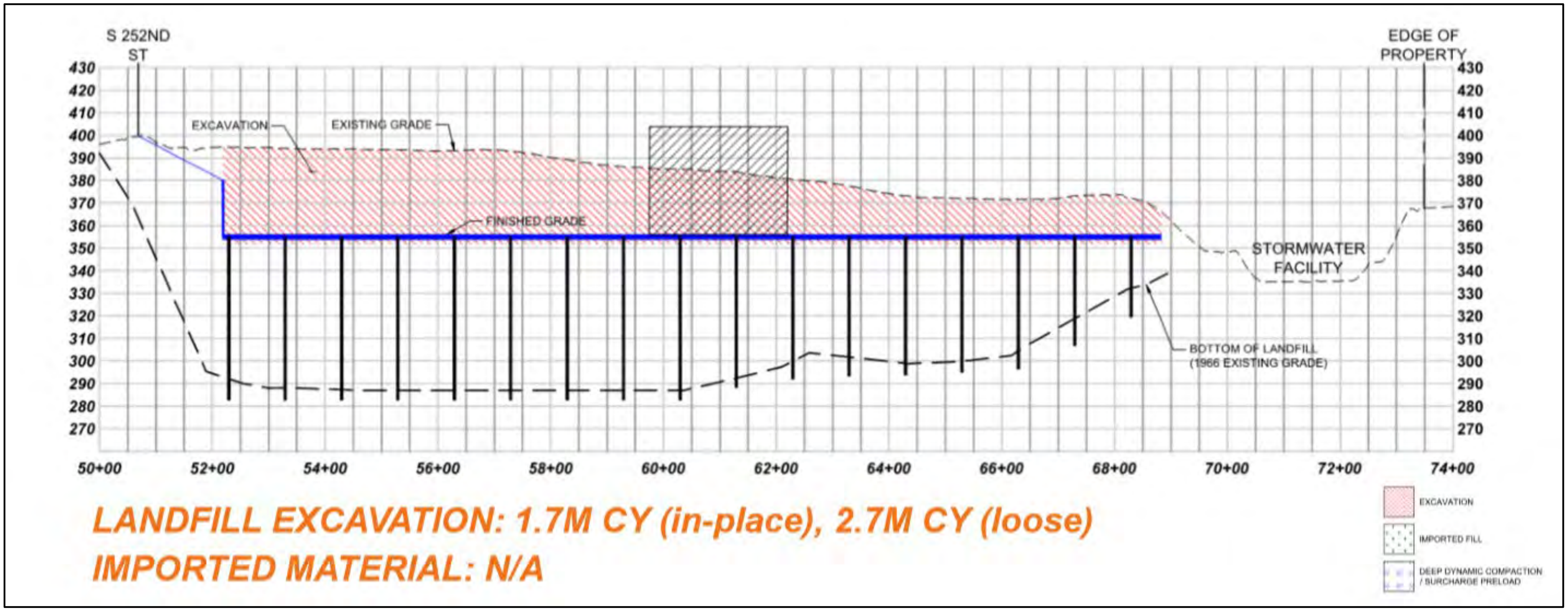


EXHIBIT 4-4

#2. Low Structural Platform with some Excavation

3. Hybrid 1: Excavation with Ground Improvements (buildings on drilled shafts)

- Remove and replace cap
- Works with at-grade FWLE tracks
- Requires over-excavation and backfill
- Deep dynamic compaction – 40 foot max. assumed
- Landfill excavation: 3.0 million CY (in-place) equates to 4.8 million CY (loose)
- Imported material: 1.6 million CY (in-place) equates to 2.6 million CY (loose)

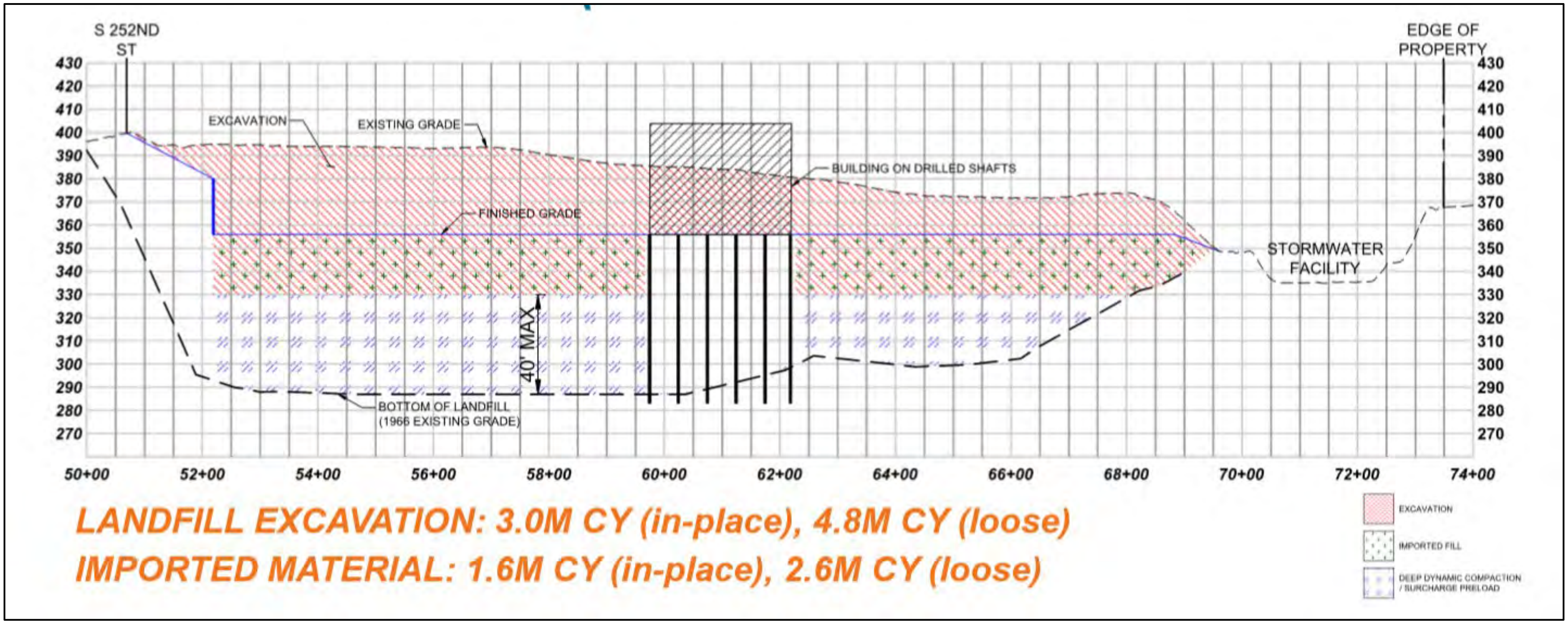


EXHIBIT 4-5
#3. Hybrid 1: Excavation with Ground Improvements (Buildings on Drilled Shafts)

4. Hybrid 2: Excavation with Ground Improvements (slab on grade for tracks and buildings on drilled shafts.

- Remove and replace cap
- Works with at-grade FWLE tracks
- Slab-on-grade to minimize settlement
- Requires over-excavation and backfill
- Deep dynamic compaction – 40 ft. max. assumed
- Landfill excavation: 3.0 million CY (in-place) equates to 4.8 million CY (loose)
- Imported material: 1.6 million CY (in-place) equates to 2.6 million CY (loose)

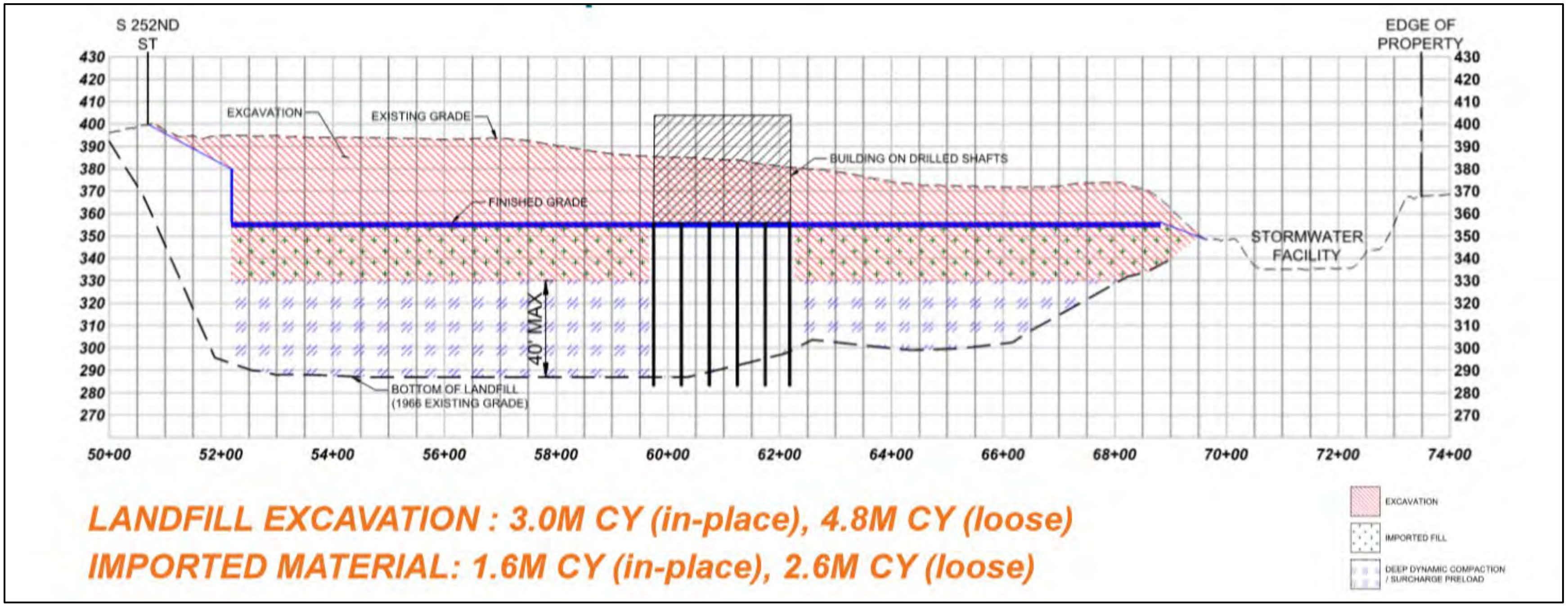


EXHIBIT 4-6

#4. Hybrid: 2: Excavation with Ground Improvements (Slab-on-Grade for Tracks)

5. Full Excavation and Backfill with Competent Soils

- Works with at-grade FWLE tracks
- Landfill excavation: 5.0 million CY (in-place) equates to 8.0 million CY (loose), with the quantity to be removed and hauled away estimated to be 8.0 million CY
- Imported material: 2.9 million CY (in-place) equates to 4.6 million CY (loose)

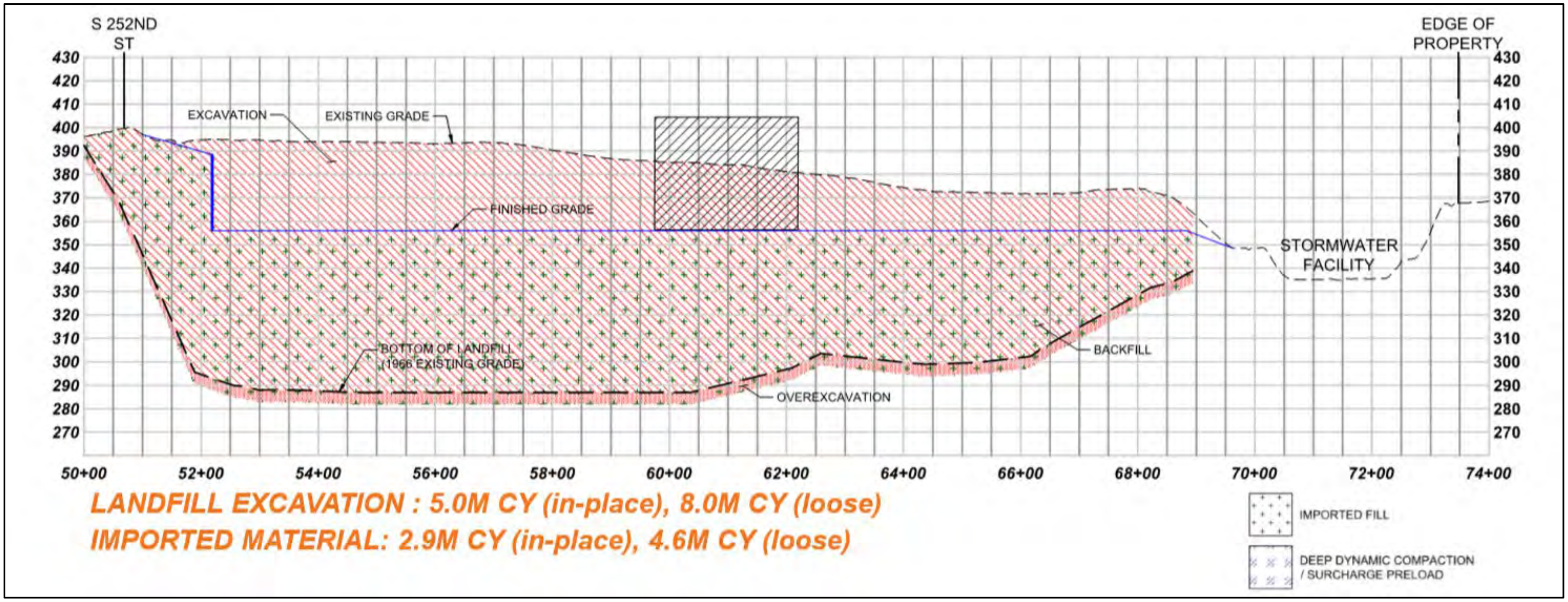


EXHIBIT 4-7
#5. Full Excavation and Backfill with Competent Soils

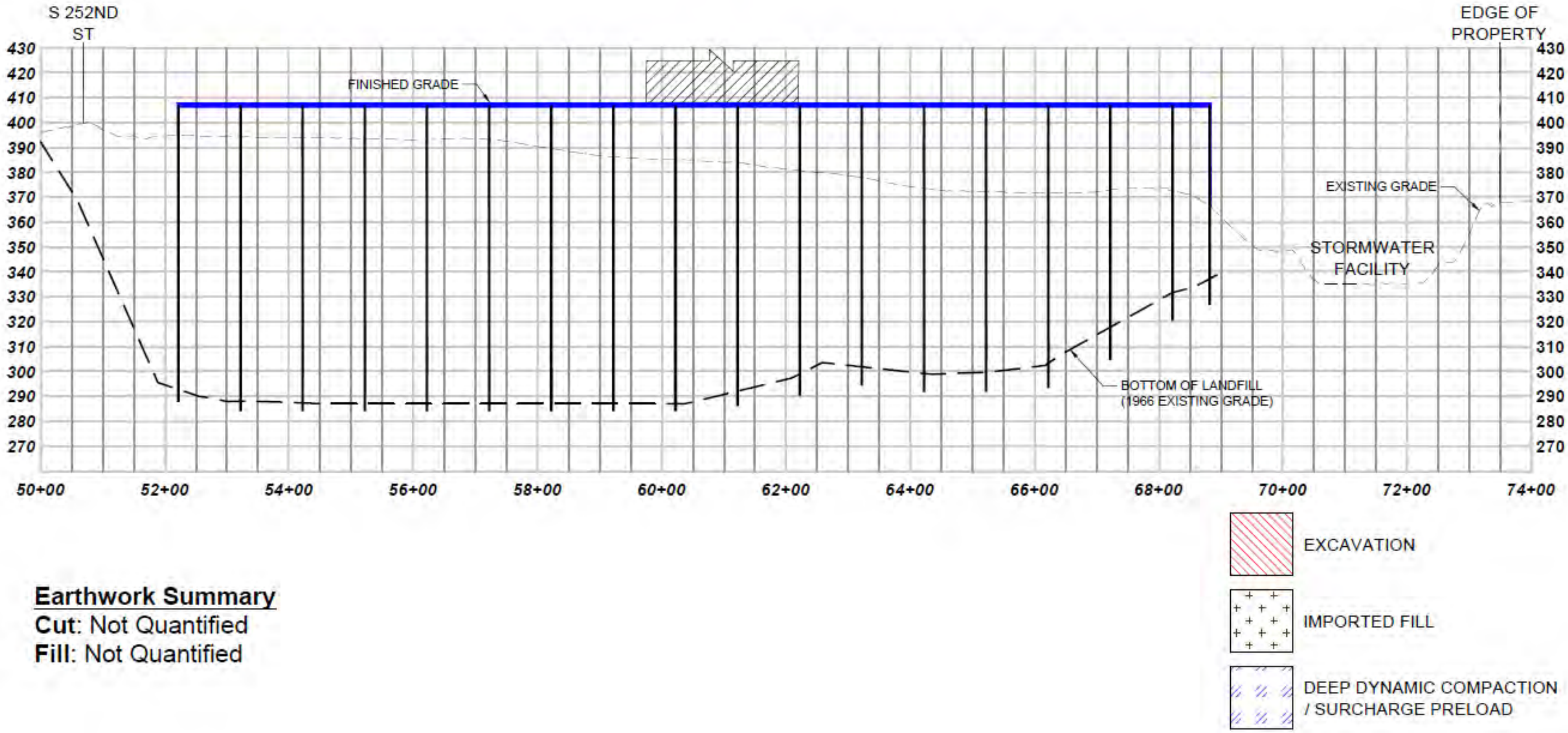
4.6 Refinements to Design Concepts

At the conclusion of the second workshop the cross-sections for the initial design concepts were modified as shown in **Exhibits 4.8 through 4.12** on the following pages.

The new cross-sections include an earthwork summary with the estimated amount of cut and fill. They also show the limits of the excavation, the imported fill, and the deep dynamic compaction and surcharge preload, if applicable. The design concepts will be refined during the 10% design based on the Federal Way Link extension guideway alignment as well as the landfill excavation and reuse information from the Design Builder.

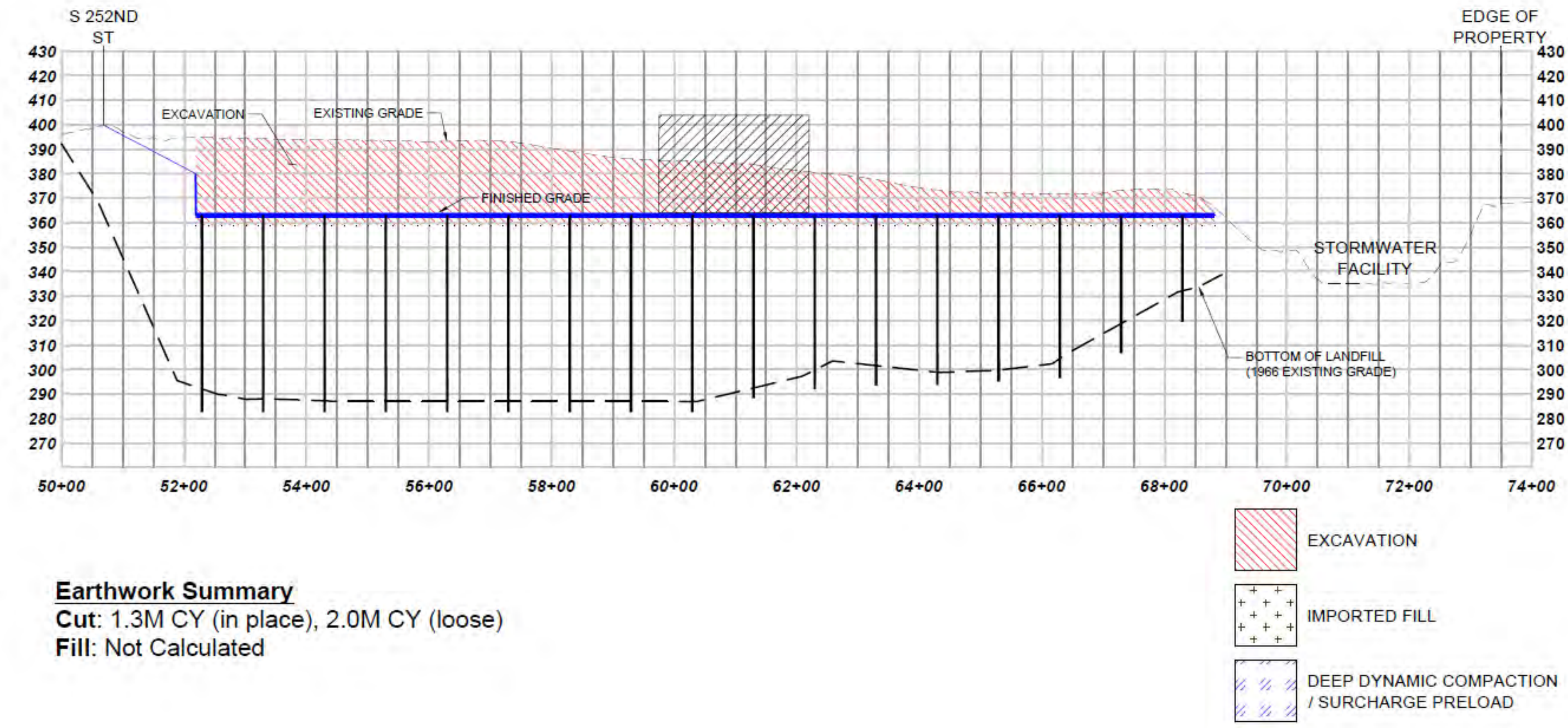
4.7 Summary of Next Steps

1) 5 approaches to be carried forward to 10% CE design; will continue to investigate ways to optimize the approaches
2) Assessment of schedule, budget, and constructability for each approach
3) Meetings with Ecology, EPA, KC Public Health & SPU to understand regulatory framework
4) ST Legal Department review of property rights, conditions/covenants, risks
5) Preparation of a Human Health Risk Assessment



Earthwork Summary
Cut: Not Quantified
Fill: Not Quantified

EXHIBIT 4-8
High Structural Platform with No Excavation



Earthwork Summary
Cut: 1.3M CY (in place), 2.0M CY (loose)
Fill: Not Calculated

EXHIBIT 4-9
Low Structural Platform with Some Excavation

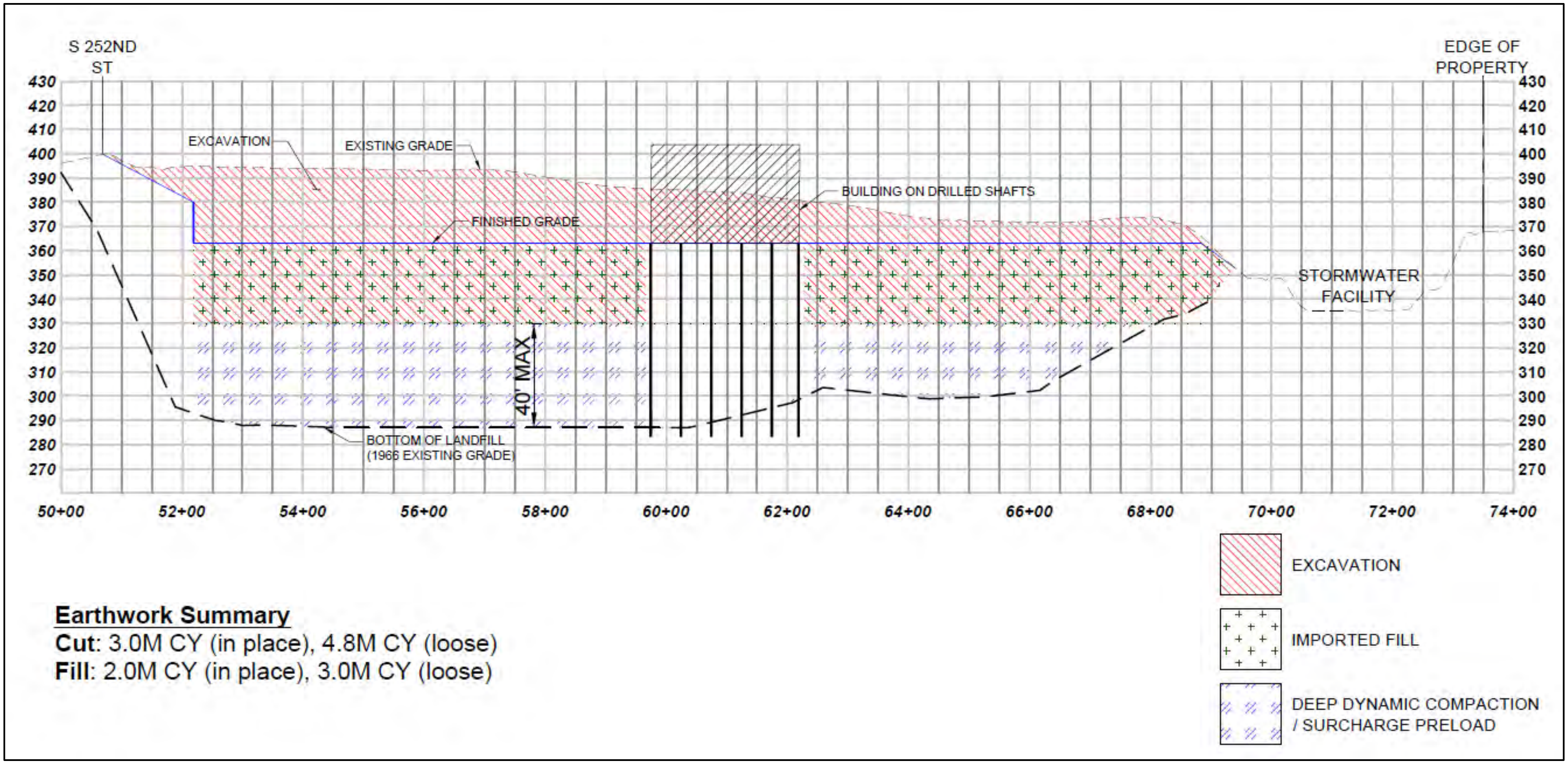


EXHIBIT 4-10

Hybrid 1: Excavation with Ground Improvements (Buildings on Drilled Shafts)

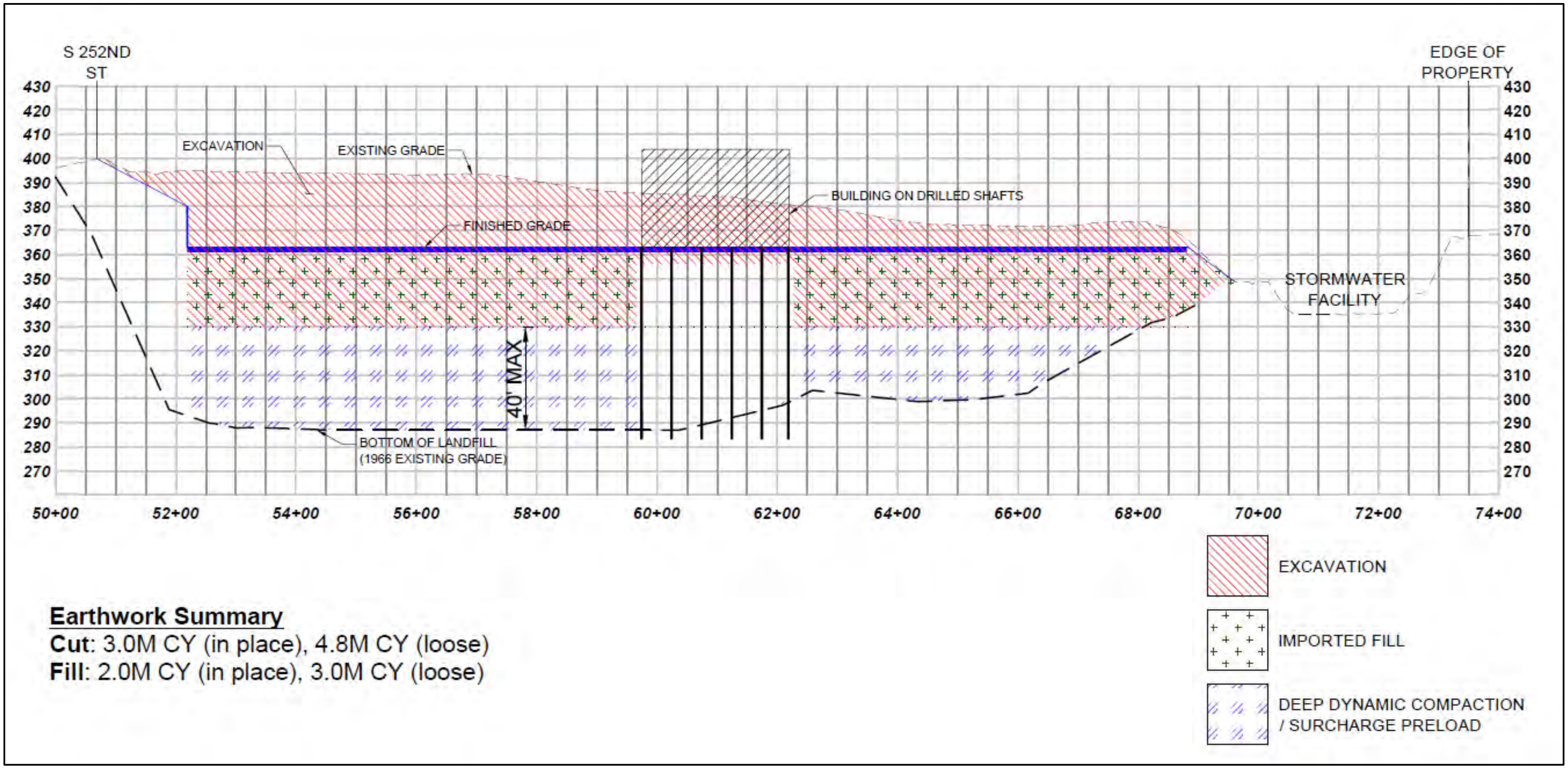
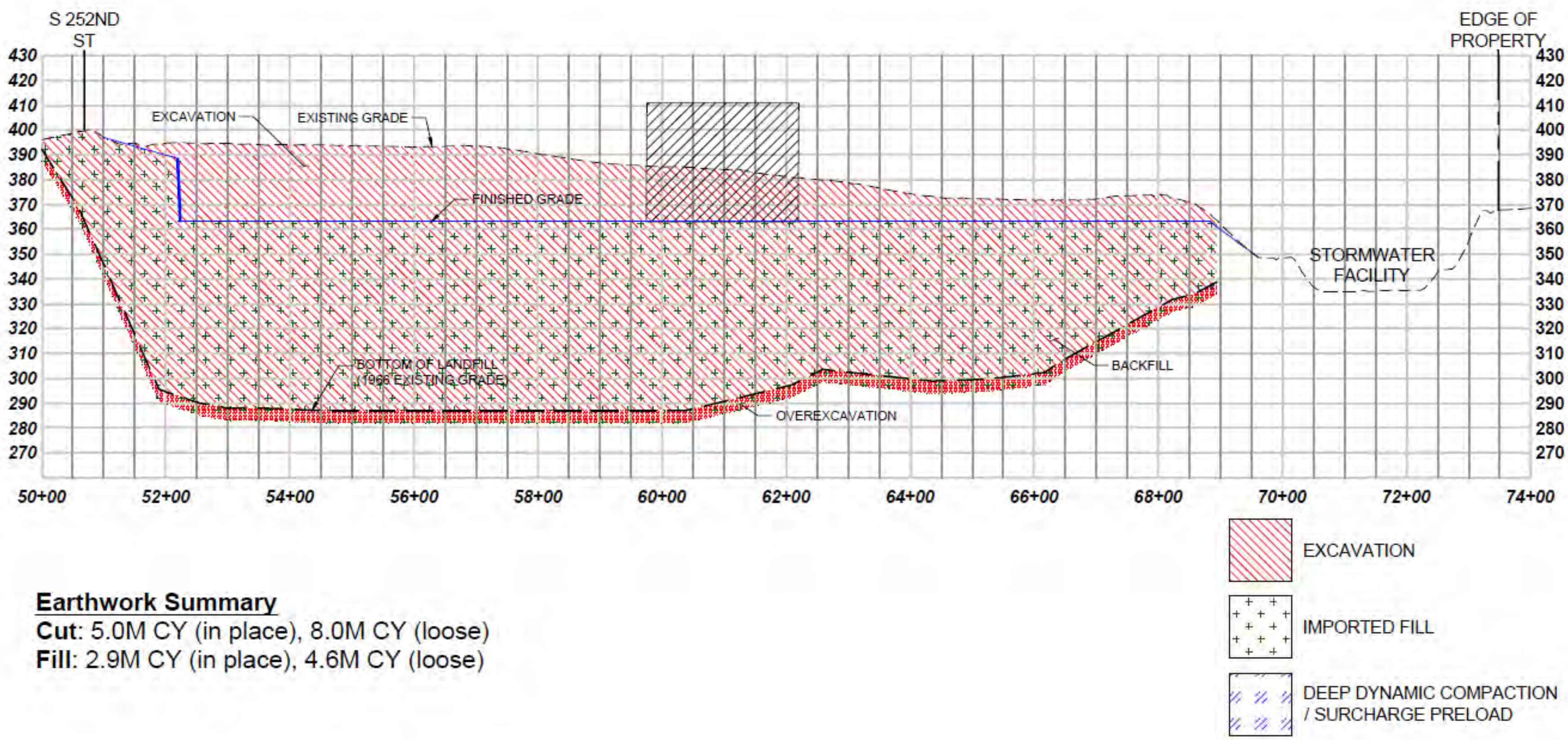


EXHIBIT 4-11

Hybrid 2: Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Shafts)



Earthwork Summary

Cut: 5.0M CY (in place), 8.0M CY (loose)

Fill: 2.9M CY (in place), 4.6M CY (loose)

EXHIBIT 4-12

Hybrid 2: Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Shafts)

Appendix A

WORKSHOP SUMMARY
Operations and Maintenance Facility South

Meeting Subject: Midway Landfill Site Settlement Workshop No. 1
Meeting Date: August 13, 2019
Meeting Time: 8:30 AM – 4:0 PM
Meeting Location: Sound Transit, 401 S Jackson, Santa Fe Room
Meeting Purpose Launch collaborative effort to understand and brainstorm Midway Landfill OMF South ground settlement solutions

Meeting Objectives

- Create shared understanding of Sound Transit's operational and maintenance criteria
- Create shared understanding of basis of design used to develop Sound Transit's current Landfill concept for the OMF South
- Review and Understand additional information that has become available on the Midway Landfill site
- Outline and action plan for how and when additional ideas will be implemented

Time	Agenda Topic	Lead(s)
8:30	Introductions and expectations	Taylor, Long and All
	Erin welcomed the group and expressed appreciation for their participation for the day. She asked for a round of introductions with question: "what do you hope to begin today for the Operations and Maintenance Facility South (OMF South) Midway Landfill site?" The group introduced themselves and provided hopes for the day. The group committed to the following ground rules for the workshop: • Be present (phones) • Listen • Speak from intentions (not entrenched positions) • Offer space to everyone to speak • Remember: we are unlikely to solve everything today, but we are setting a course/path forward together	
8:45	Safety Moment	Bennett
	Paul offered safety/evacuation information for being in Sound Transit offices.	

Time	Agenda Topic	Lead(s)
8:50	Review Meeting Agenda, Objectives	Taylor
	Erin covered the workshop agenda and objectives. She noted that it that some ideas or issues that came out of the day may be very relevant to Midway Landfill analysis, but unrelated to the settlement workshop purpose, and would be noted as a parking lot item.	
9:00	OMF South: Process to date and looking ahead	Hawkins

	Curvie provided a project overview for the group. He clarified that the OMF South was included in the Sound Transit 3 plan, to be one of four OMFs in the region (others are central/Forest Street operating today, East under construction, and north to be sited in the future). The facility will support multiple projects, and ultimately entire light rail network; timing for its opening is anticipated support Tacoma Dome and West Seattle extensions when they are slated to open in 2030.
	• Sites under consideration. Curvie clarified that while there is a focus on the Midway Landfill today, there are three sites under consideration as part of SEPA Environmental Review: the Midway Landfill in Kent, and two sites in Federal Way. These three are narrowed from an initial screen of 24 sites identified through public early scoping in April 2018. The environmental process will evaluate all sites equally, with the end goal of identifying the best site possible to serve the south corridor.
	  • Site needs. Curvie covered multiple needs to site this facility to store and maintain light rail vehicles at the end of each operational day (1-4 a.m.): it must be minimum of 30 acres, but due to topography and site circulation a likelihood of 40-50 acres in size. It must connect to the Federal Way or Tacoma Dome Link extensions, and provide system-wide operational needs. It will require 18 storage tracks to accommodate 140+ vehicles, Maintenance of Way building, parking, track leads.
	  • Schedule. Curvie provided the timing of the project as a key driver for feasibility analysis of settlement solutions. The site must be open by 2026 to receive and hold vehicles as they are commissioned for service ahead of TDLE in 2030. He clarified that each of the two Federal Way sites, if selected, would necessitate building guideway ahead of TDLE schedule. A Draft EIS for the OMF South is expected in late 2020, and the Board Decision on the site to be built is anticipated for mid/late 2021.	

9:15	Light rail operations and maintenance criteria	Dobbins, Denison,
	Paul Denison provided an overview of typical light rail maintenance and operations as the person charged with overseeing their efficient, clean and safe daily operations. Maintenance work occurs at night in regimented order, requiring about 35 minutes per train (assuming no issues). Any train beyond ordinary nightly maintenance is decoupled and brought into the shop. Paul clarified that Light rail is electrical train technology. These vehicles run on very precise connections, which requires correct contact pattern necessary for electrical interface. Tolerances are fractions-of-an-inch range.	

Time	Agenda Topic	Lead(s)

	• Paul provided perspective that the most expensive aspect of light rail operations is labor; when more labor is required due to inefficiency of a site or its upkeep, he needs to revise the cost model.
	  • Paul walked through Sound Transit's DCM specific criteria relative to operations and maintenance sites (see previous slides). The DCM doesn't specify how long the building or track must be maintained. On the site, there is a lot of special track work – crews have to lubricate rail by hand on tight turns to prevent wheel climb. FTA requires the facility to be in a "state of good repair" to be able to receive grant money; they consider and inspect equipment, access, and overall program. The facility must meet certain criteria and document any adjustments through work order process. Other clarifications he provided:
	    o Pantograph, tight tolerances. Wires are fixed tension.
	    o Yard inspections are held every 30 days.
	    o Drainage is of critical importance. Mechanical drainage system doesn't work, failure rate is too high.
	    o Grounding is floating. Must keep the grounding for the building and for the track separate.
	    o At Forest Street, hand tamping is completed every 3-12 months to adjust for settling. Historically, the site was a tide flat. Some fine tuning is expected.	

9:30	Perspectives from other agencies (5 min each)	All

	1. SPU / City of Seattle
	  • The Midway Landfill began to accept waste in 1960s (existing quarry before then). It discontinued accepting waste in 1983, and the cleanup remedy was complete in 1991.
	  • Over the past 25 years, numerous proposals for re-use of the site; this particular proposal may be the best potential match.
	  • SPU will help facilitate exploring the feasibility of the site. From their perspective: "if it works out, great. If not, we gave it our best try."
	  • Reflecting on the age of the remedy and settlement to date, the site is "running out of gas", and settlement is reduced.
	  • Waste varies in thickness in different zones (0-60-100 feet), and settlement will follow that trend.
	  • Settlement mapping has been completed since 1988, and there are more current aerial surveys.
	2. City of Kent
	  • Kelly: Reflected is has already been a difficult process to locate this OMF so far, but the City of Kent welcomes the OMF South with open arms on the landfill location. The city believes this is a good solution for the region and wants help make it work.	

Time	Agenda Topic	Lead(s)
	3. City of Federal Way • Tony: Other two site options for the OMF South are located in Federal Way, but both likely come with major impacts – including industrial/business and church relocations. The Midway Landfill site is the City's preferred location. 4. WSDOT • WSDOT will be most interested where this site could potentially tie into the mainline, and protect WSDOT assets. They want to help Sound Transit understand, then get through the protocols.	
9:45	Break and conversations	
10:00	Q&A for previous presentations	Taylor
	• Erin and Blane asked for questions from the orientation presentations earlier in the morning. o Kate S: Is there work specific to storage track vs. the rest of maintenance track? ▪ Paul D: We want to avoid working on trains while on the tracks. We do not allow anyone in/around trains when they're on storage tracks, as they trains move around. The shop is where most of the maintenance takes place. When the yard is at capacity, that means even more moves, tighter work area. o Jeff N: Would more "elbow room" increase curvature tolerances? Would it help to make yard bigger? ▪ Paul D: Our maintenance staff walk, so their efficiency is a consideration due to their ability to do the job, and number of people to do so/paid to be on site at any given time. But yes, if we had bigger curves, wouldn't have to hand grease them. ▪ Jason B: Physically, you can increase turn radius, but larger turnouts take up a lot more room. In addition, the turns we have are interchangeable across our system, so changing these would be a consideration. o Kate S: What is the preferred method for drainage to work? ▪ Jason B: Preferred way is a ditch with a 33% slope. We do use under drains; the track is flat, so we make up that hydraulic gradient under track. Drains placed every two tracks. For collection and discharge, Forest Street had existing storm/sewer lines, and we have an agreement with city for discharge. ▪ Jeff N: For understanding, the landfill has a detention pond, that was sized in 1991. [The group considered the potential need to bring the pond to code.] ▪ Landfill is impermeable, and it has existing underdrains that drain to a pond. o Jeff N: Is there a way to rank in descending order the heaviest programming elements to the lightest?	

Time	Agenda Topic	Lead(s)
	▪ Paul D. – The building is the most important and heaviest element, and must be stationary due to vehicles entering/existing. ▪ Jason B: Building would be biggest load, then storage tracks, we cannot adjust the building if there's settlement. [DCM states loads required] ▪ Steve R: Forest Street is a good example. Parking lot has tolerances, but parking areas fit into dead areas, surrounded by track areas. Most of the site has very small tolerances, it needs to be very stable. ▪ Mike W: At Forest Street, the building was constructed on 1200 piles (on tidal flat), pounded in. Today, there are limits to what can be done with that building due to its foundational structure. For example, a newer refurbishment required selection of an above-ground lift because to accommodate inability to cut into the floor of the structure. o Ian S: The building is supported by piles, but surrounding area is not? ▪ Jason B: At Forest Street, the building is supported by piles with a transition area. There was ground improved to support loads under ballast. Impact slabs, concrete aprons on either side that support gradual transition out to yard. o Kate S: It was mentioned that five more acres would be beneficial – why? ▪ Paul D: Ideally, we need an area for "laydown" to store items for the entire system. At Forest Street there is no place to store things specific to service. Need a 30,000 SF building to store stuff like spare rails, spare switches, machines, clips, and glasswork. If we cannot site a building of this nature at OMF South, it could require a separately staffed facility. All three sites include this building (included in programming). o Kelly: Are there issues with OCS settlement at Forest Street? ▪ Paul D. – There were issues with door bridges early on, but was not due to settlement. Each OCS was constructed on real piles; the guideway piles are around 15 feet deep; OCS structure throughout the yard has been stable. o Jason B: Is there a historic record of aerial photography of the landfill? ▪ Jeff N: Yes, supplemented by on the ground work from GeoEngineers in April 2019 ▪ Ed H: In April 2019, the TDLE team flew the entire corridor at .2 feet. The comparison work has not been completed.	
9:40	Overview of current ST design	Mudayankavil/ Harris
	▪ **T**homas presented the current design. At this level of design, it has used a typical, non-modified layout (also used for all sites considered). This meant a template was dropped in for Phase 1. The unique aspect at this location was connection tracks to mainline (to be refined in Phase 2 of the project). ▪ Based on potential settlement considerations, the current design placed the entire site on slab supported by piles. Piles are 160 feet deep. For a conservative approach, everything was assumed to be above grade, with	

Time	Agenda Topic	Lead(s)
	nothing on the landfill itself. An underlying assumption was the requirement to maintain the landfill below the slab. ▪ In the upcoming design work (to 10% design), the site will be modified for an optimized site fit. The Sound Transit Board direction identifies the site as on the landfill itself; this limits any acquisition of private parcels west of the site. ▪ Dave Peters clarified that assuming we stay above the existing cap, this would govern elevation, but some pits within the facility are required to maintain trains from beneath (roughly six feet deep). ▪ Ed Herald provided context that the existing landfill structural design was completed as the project also considered 22 sites over a 3-week period, so there was limited time invested in the site solution. The team did come up with platform solution but not sure that's the best solution. The team provided the perspective that settlement understanding will be the key to how we optimize this site.	
10:10	Overview of GeoEngineers report for City of Kent	Kent/ GeoEngineers
	• **Tim Bailey** outlined the study that the City of Kent commissioned in order to investigate if landfill is "old and not settling much." This work included comparison of LiDAR data from 2005-2016, predicted future settlement, and compared to actual settlement 2016-2019. Overall, the actual measure of settlement was less than what they predicted with the model. • Tim also projected forward 50 years out from closure (1991), which would expect to see less than a foot of settlement anywhere across site except for WSDOT ROW. He reflected in comparison to the criteria provide for operations and maintenance by Sound Transit, that "that's not where we need it to be, but at least bounds the problem." In general, the site has completed primary and secondary settlement; now there is long-term component, which indicates a steady rates of settling moving towards zero. • Doug: What is settling and what is causing it? Tim: Based on records/borings, landfill waste has a lot of soil intermixed so long term settlement is due to degradation of the waste. The site is capped, keeping stormwater out. Jeff N: There is reduce stormwater-contaminated runoff. Groundwater levels are below the waste. Shallower waste is extremely dry. A lack of moisture has slowed the degradation/ creation of gas. Landfill gas is down 85% from where it was in the 1990s. The settlement curve flattens out for a long time. If waste gets wet, that could change decomposition rate. • Gwen: Any common themes about why previous site proposals would not work? Jeff N: As a theme, those proposers found better alternatives for their development sites. • Dwight: Will employees working at site be affected by anything? Jeff N: If we do our job, no. There is no exposure pathway for groundwater.	

Time	Agenda Topic	Lead(s)
	Kate: Landfill is required by EPA to prevent pathways for exposure. The City of Seattle needs to maintain those controls in perpetuity. We can reconstruct landfill cap as part of doing the site. • Jason B: What's the maintenance life of a cap? Kate: It depends on how you design it, but a cap is designed to last in perpetuity. • Curvie: We must be sensitive to schedule, and it is not clear on what is involved in breaking cap and regulations associated with that, and impacts to schedule. Kate: The City is working on a separate path with FWLE to work through regulatory process, so will have answers for timing on pathway when agreement done by next June (2020). • Dwight: In terms of degradation and settlement, are there other ideas to preloading? How much consolidation would you get out of this? Tim: In general, there will need to be a design so that any/all of the primary and secondary settlement is taken care of. Preloading time depends on thickness of area. Perhaps years, but could be accelerated.	
10:45	Discussion/brainstorm alternatives for consideration	Long and All
	• Blane Long conducted a brainstorm to generate settlement and site alternatives for consideration based on the seed ideas. [See attachment to summary for brainstormed and categorized ideas in raw form, from the workshop for documentation purposes]	
11:30	Lunch	
12:40	Additional clarification for each of the brainstormed ideas	Long and All
	• Blane Long continued the discussion of brainstormed ideas for settlement, clarifying details and grouping the ideas into categories for additional analysis and detail: o Excavation (EX) o Ground improvement (GI) o Structural (STR) o Layout optimization (LAYOUT OPT) o Maintenance (MAINT) [See attachment to summary for brainstormed and categorized ideas in raw form, from the workshop for documentation purposes]	
1:30	Review, add to, and confirm evaluation criteria (requirements vs. performance attributes), alternatives to be examined and extent of study	Long and All
	• Blane Long conducted a brainstorm of criteria to evaluate settlement alternatives relative to each other: o Schedule (to ready for opening day and major milestones) o Construction (means, methods, coordination) o Code conformance	

Time	Agenda Topic	Lead(s)
	o Risk factors o Ability to provide light rail service (efficiency and operability) o Cost [See attachment to summary for brainstormed and categorized criteria in raw form, from the workshop for documentation purposes]	
2:00	Define follow-up activity/report • In concluding the workshop, the team asked: "What have we forgotten?" for the good of the order: o Ian – Please consider needs around property transaction, acquisition, property rights, regulatory engagement. Opening of ROD could impact schedules o Jeff N. – Request for tour of Forest Street Facility, offers a site visit at Midway Landfill. The team said that could be arranged, and late night when the site is most active would be most illustrative.	Sound Transit
2:30	Adjourn and Next Steps/future for meetings 2 and 3: Erin concluded the meeting asking for the group to reflect on a learning item from the meeting; many reflected they learned from one another and appreciated the collaborative environment. Future meetings were detailed as follows: - Meeting 2: Draft evaluation report of alternatives from HDR and feedback (TBD timing, likely mid-September) - Meeting 3: Sound Transit communicates solution(s) taken into the design as reflected in Draft EIS (TBD timing)	

Handouts/Reference Materials:

- Midway Landfill Early Conceptual Site Plan
- Midway Landfill Basis of Design
- GeoEngineers' Report for City of Kent

Attendees:

Dave Peters, Curvie Hawkins, Gwen McCullough, Chelsea Levy, Mark Jusayan, Kate Snider, Ian Sutton, Hui (Hugh) Yang, Jeff Neuner, Tim Bailey, Allison Dobbins, Jason Baily, Michael Williams, Steve Radomski, Paul Bennett, Tony Doucette, Kelly Peterson, John Sleavin, Paul Denison, Hussein Rehmat, Jessica Giblin, Thomas Mudayankavil, Brian Harris, Bob Mitchell, Jason Funk, Ed Herald, Cristina Seo, Dwight Miller, Andrew Austin, Ben Wolters, Erin Taylor, Blane Long

Appendix B

STRUCTURAL

NO.	BRAINSTORM IDEAS	RISK: REGULATORY	RISK: SCHEDULE	RISK: COST	RISK: CONSTRUCT-ABILITY	RISK: MAINTENANCE / RELIABILITY	FACTORS CONSIDERED FOR RANKING
1	Heaviest building loads toward middle of site with piles, with transition slabs, west dynamically compacted and/or partially excavated – Kate, depending on area of site	1 (a, b,e,f)	2 (a, b, c)	1 (a, b,c)	1 (a, b, c,)	1 (d)	a. Dynamic compaction impacts to exist. solid waste b. Landfill excavation c. Transition slabs - some settlement expected d. Settlement concern e. Potential groundwater contamination f. Construction noise and vibration
2	On east side, consider a floating mat foundation that is connected by hinged slabs – Kate (landfill grading would be necessary)	2 (a,b)	2 (a,b,c)	1 (a,c)	2 (a,c)	1 (d)	a. Floating slab b. Some excavation c. Non-traditional construction methods d. Uneven settlement concern
3	Take current track bridge technology being used on I-90 bridge; alternatively use track bridge throughout the site – Paul	2 (b)	1 (b,e)	1 (a,b,c,e)	1 (b, e)	1 (c,d,e)	a. Layout impact b. Includes excavation c. Maintainance d. Uneven settlement concern e. New technology was designed for bridges
4	Consider track on rigid structure, as opposed to the entire site on structure (e.g., pin piles/bridge structures) - David	2 (a,c)	2 (a,c)	1 (a,b,c)	2 (a,c)	3 (a,b)	a. Buildings on deep piles b. Track on slab supported by piles c. Includes excavation
5	Consider track on floating slab so that tracks are settling as a unit on a rigid slab Note: Difficult transitions to the buildings	2 (a)	2 (a,c)	1 (a,c)	1 (a,c)	1 (b)	a. Includes some excavation b. Uneven settlement concerns c. Non-traditional construction methods
6	Consider OCS on shallow foundations – Tim Note: Minor element compared to larger OMFS considerations and effectiveness depends on adjacent track construction	NA	NA	NA	NA	NA	a. Settlement concerns
7	Consider storage tracks on floating slab and pin piles on turnouts/ladders with carefully monitored transition slabs between the two (monitor drainage) - Jason Note: Transition design will be critical to the success of this approach	2 (a)	2 (a,b)	1 (a,b)	1 (b)	1 (c)	a. Includes excavation b. Non traditional construction methods c. Uneven settlement between transition slabs
8	Consider lightweight fill materials for mass grading areas Note: May help reduce settlement	2 (a)	2 (b,c)	1 (b,c)	2 (c)	1 (d)	a. No special permits b. Includes excavation c. Special construction methods d. Long-term settlement concerns
9	Optimize current ST-proposed design for column size/structure size and ensure have right design to evaluate; use other deep foundation alternatives that do not create a pathway (groundwater) Notes: Expected to occur during detailed design if option is selected	2 (a,b)	2 (a,b)	1 (a,b)	3 (a,b)	3 (a)	a. Structural slab supported by optimum size piles b. Replace cap
10	Manage settlement/create interfaces and have redundancy to do so (e.g., extra runaround where you expect differential settlement) - Kate Note: This should be in combination with other options	2 (a)	2 (a,b)	1 (a,b,d)	2 (a)	1 (c)	a. Includes some excavation b. Added ROW and construction cost c. Differential settlement d. Manage settlement (maintenance cost)

LAYOUT

		RISK					
NO.	BRAINSTORM IDEAS	REGULATORY	SCHEDULE	COST	CONSTRUCTABILITY	MAINTENANCE/ RELIABILITY	FACTORS CONSIDERED FOR RANKING
1	Relocate SPU flare facility (on NW corner of site) to get area on native soils (where exist) – Jeff	2 (a)	NA	1 (a,b)	NA	1 (b)	a. Relocation of flare facility b. Layout on landfill
2	Use property to Northwest of site (west of pond, owned by SPU) due to availability of native soils - Jeff	NA	NA	1 (a,b)	NA	1 (b)	a. Requires additional ROW b. Layout on landfill
3	Move Maintenance of Way building location as depicted in initial concept to west, so that not just in center of site; optimize track yard layout to shift as much as possible to west, which may adjust to be a non-regular rectangle (some area between tracks in middle of site would be spread out)	NA	NA	1 (a,b)	NA	1 (b)	a. Requires additional ROW b. Layout on landfill
4	Move farther north with the track and turnouts, as well as some storage facilities - Dwight	NA	NA	1 (a,b)	NA	1 (b)	a. Requires additional ROW b. Layout on landfill
5	Manage settlement/create interfaces and have redundancy to do so (e.g., extra runaround where you expect differential settlement) - Kate	NA	NA	1 (a,b)	NA	1 (a,b)	a. Requires additional ROW b. Layout on landfill
6	Sophisticated, automatic-alerting settlement monitoring systems (use them) - Kate	NA	NA	NA	NA	1 (a)	a. Layout on landfill
7	Consider flipping building and storage tracks or layout of storage tracks - Blane	NA	NA	NA	NA	1 (a)	a. Layout on landfill
8	Relocate existing pond as it is on native soil/take advantage of north edge of the site - Thomas	NA	NA	1 (a)	NA	1 (b)	a. Requires additional ROW b. Layout on landfill
9	Make pond a vault underneath the yard/site	NA	NA	1 (a)	NA	1 (a)	a. Layout on landfill
10	Pervious pavement for parking lot/use gravel	NA	NA	1 (a)	NA	1 (a)	a. Layout on landfill
11	Reconfigure as a dogleg to take advantage of the shallow areas (in spite of track inefficiencies) – Paul	NA	NA	1 (a)	NA	1 (b)	a. Requires additional ROW b. Operationally inefficient

EXCAVATION

NO.	BRAINSTORM IDEAS	RISK: REGULATORY	RISK: SCHEDULE	RISK: COST	RISK: CONSTRUCTABILITY	RISK: MAINTENANCE/ RELIABILITY	FACTORS CONSIDERED FOR RANKING
1	Remove landfill/excavate - Dave	1 (a,b)	1 (a,b)	1 (b)	1 (b)	3	a. May need to reopen ROD b. Landfill excavation, disposal and backfill
2	Landfill mining to recover and use for engineered fill – Dwight	1 (a,b)	1 (a,b)	1 (b)	1 (b)	3	a. May need to reopen ROD b. Landfill excavation, disposal and backfill
3	Partial removal/west side - Remove areas where solid waste is less thick (western side of landfill), engineered backfill (Requires adjusting site layout) – Kate	2 (a)	2 (a,b)	1 (a,b)	2 (a,b)	1 (b)	a. Landfill excavation, disposal and backfill b.Combined with other design options
4	Partial removal of "dome" of landfill to make some level areas – Ian	1 (a)	1 (a,b)	1 (a,b)	1 (a,b)	1 (b)	a. Landfill excavation, disposal and backfill b. Combined with other design options
5	4-18 feet of overburden over the waste that is clean, engineered material and could be reused, Reuse overburden material as backfill or elsewhere on site	2 (a)	1 (a,b)	1 (a,b)	2 (a,b)	1 (a,b)	a. Landfill excavation, disposal and backfill b. Combined with other design options

GEOTECHNICAL

		RISK					
NO.	BRAINSTORM IDEAS	REGULATORY	SCHEDULE	COST	CONSTRUCTABILITY	MAINTENANCE/ RELIABILITY	FACTORS CONSIDERED FOR RANKING
1	Deep dynamic compaction – drop huge weight (down to 30') on top of an area - Tim	1 (a,b,d,e)	1 (a,b)	1 (a,b)	1 (a,b)	1 (c)	a. Dynamic compaction impacts on exist. solid waste b. Includes some landfill excavation c. Settlement concern d. Potential groundwater contamination e. Construction noise and vibration
2	Injection or compaction grouting to improve the waste – Tim	1 (a,b)	1 (b,c,d)	1 (c,d)	1 (a,b,c)	3 (d)	a. Groundwater contamination b. Some excavation c. Non-traditional construction methods d. Large grout volume needed
3	Stone columns - Jason	2 (a,c)	1 (a,b)	1 (a,b)	1 (b)	2 (d)	a. Includes some excavation b. Non-traditional construction methods c. Construction noise and vibration d. Uneven settlement concern
4	Surcharge and pre-load the site – Tim	2 (a)	1 (a,b)	1 (a,b)	2 (a)	2 (c)	a. Includes some excavation b. Schedule constraint c. Settlement concern
5	Look at thicker subgrade (6' deep subgrade) for area with geogrid reinforcement rather than concrete slab – Ian	2 (a)	2 (b)	1 (a,b)	2 (a,b)	2 (c)	a. Includes some excavation b. Non-traditional construction methods c. Uneven settlement concerns
6	Preload site now – as soon as possible – to be ready for project construction	1 (a)	1 (a, b)	1 (b,d)	2 (b,d)	2 (c,d)	a. Reqiuires approval b. Includes some excavation c. Uneven settlement concerns d. Combined with other design options
7	Waste treatment: thermal treatment and removal/replacement of residue – Mark	1 (a)	1 (a,b)	1 (b,c)	1 (b)	3 (c)	a. Need permit for onsite treatment plan b. Non-traditional construction methods c. Assumes approved backfill

Midway Landfill Alternatives Evaluation

		Alternative				
		High Structural Platform on Piles with No Excavation	Lower Structural Platform on Piles with Some Excavation	Hybrid 1 : Excavation with Ground Improvements (bldgs. on piles)	Hybrid 2 : Excavation with Ground Improvements (slab on grade for tracks and bldgs. on piles)	Full Excavation and Backfill with Competent Soils
	Criteria	1	2	3	4	5
Structural	Regulatory Risk	Medium	Medium	Low	Low	N/A
	Schedule Risk	Medium	Medium	Medium	Medium	N/A
	Cost Risk	Low	Low	Low	Low	N/A
	Constructability Risk	Medium	Medium	Medium	Low	N/A
	Maintenance/Reliability	High	High	Low	Medium	N/A
Layout	Regulatory Risk	N/A	N/A	N/A	N/A	N/A
	Schedule Risk	N/A	N/A	N/A	N/A	N/A
	Cost Risk	N/A	N/A	N/A	N/A	N/A
	Constructability Risk	N/A	N/A	N/A	N/A	N/A
	Maintenance/Reliability	N/A	N/A	N/A	N/A	N/A
Excavation	Regulatory Risk	N/A	Low	Low	Low	Low
	Schedule Risk	N/A	Medium	Medium	Medium	Low
	Cost Risk	N/A	Low	Low	Low	Low
	Constructability Risk	N/A	Medium	Medium	Medium	Low
	Maintenance/Reliability	N/A	High	Low	Low	High
Geotechnical	Regulatory Risk	Medium	Medium	Medium	Medium	N/A
	Schedule Risk	Medium	Medium	Medium	Medium	N/A
	Cost Risk	Low	Low	Low	Low	N/A
	Constructability Risk	Medium	Medium	Medium	Medium	N/A
	Maintenance/Reliability	High	High	Low	Low	N/A

Low = (red)

Medium = (yellow)

High = (green)

OMF South Landfill Site Settlement Workshop #2

Date: **Thursday, October 3, 2019 - 8:30 a.m. to 3 p.m.:**
Location: **Sound Transit, 401 S. Jackson**
Room: 625 Building, Floor 2, Downtown Room

Meeting objective(s):

- Review brainstormed solutions from Operations and Maintenance Facility South (OMF South) Landfill Site Settlement Workshop #1;
- Share evaluation process and initial results of brainstormed settlement design concepts;
- Understand collective perspectives around design concepts; and
- Outline plan for designs to continue to pursue

Review in advance of meeting:

- Landfill Site Settlement Workshop #1 Summary
- Settlement Design Concepts Evaluation Matrix Template

Time	Agenda item	Lead
8:30 a.m.	**Introductions and expectations** • Agenda review - • Workshop Summary #1 review, (as needed) corrections and/or clarifications from workshop • Overview of materials available	Erin Taylor
	Erin Taylor welcomed the group and expressed appreciation for their participation. She asked attendees to identify whether or not they were present at the first workshop and led the group in a round of introductions. Attendees committed to the The group committed to the following ground rules for the workshop: • Be present (phones) • Listen • Speak from intentions (not entrenched positions) • Offer space to everyone to speak • Remember: we are unlikely to solve everything today, but we are setting a course/path forward together **Erin** then provided an overview of the agenda for the workshop.	
8:55 a.m.	**Safety Moment**	*Paul Bennett*
	Paul Bennett *offered safety/evacuation information for being in Sound Transit offices.*	
9:00 a.m.	**Sound Transit status updates** • Other ongoing evaluation of priority concerns • Forest Street facility additional detail	Curvie Hawkins Paul Bennett Gwen McCullough

	Erin introduced this section of the agenda and informed the group that Sound Transit would provide updates about other ongoing evaluation and address inquires posed in the first workshop related to the existing Forest Street OMF.
	Gwen McCullough shared that in addition to the settlement analysis, the Sound Transit team is also working to address health and safety and regulatory areas of priority concern for the Midway Landfill site.
	
	Paul Bennett explained that the Forest Street facility was not built on a landfill site and is not congruent to the Midway Landfill site, even though it is also built on a fill area. He clarified that there will be a section in the report dedicated to the Forest Street piece that illustrates this from a geotechnical borings perspective.
	
	• Tony D.: Could Sound Transit share information about the type of fill present and used on the Forest Street site?
	  o **Paul** explained that this information would be included in the report.
	
	Curvie Hawkins shared that the OMF South and Tacoma Dome Link Extension teams would be conducting outreach in November as a "project update to the community." The intent of this engagement is to remind the community of the project(s) status, and ongoing technical work.
	
	• Mark H.: How will Sound Transit reach the communities in November?
	  o **Curvie** explained it will be similar to past outreach periods—will do a postcard mailer and jurisdictional coordination in combination with other relevant project outreach efforts (e.g. FWLE open houses in November).

9:20 a.m.	**Additional status updates (if needed)** • City of Kent • SPU • City of Federal Way • WSDOT
	Jeff N. (Seattle Public Utilities) shared SPU is doing a great deal of regulatory work with Ecology and EPA for FWLE waste removal. He believes lessons learned from this process will inform how the Midway Landfill site could be remediated. **Tony D.** (City of Federal Way) shared that the most recent City Council meeting was pretty contentious and highlighted community confusion about the two potential OMF South sites in Federal Way. **Philip H**. (WSDOT) added WSDOT is still working steadily on the FWLE project.

9:40 a.m.	**Work progress since Workshop #1** • Evaluation process recap for brainstormed concepts • Review of evaluation criteria	Thomas Mudayankavil *Dave Peters*
	Thomas Mudayankavil and **Dave Peters** explained how the project team evaluated the participants' brainstormed design concepts from the first workshop. Ideas were sorted by type—structural, geotechnical, layout, and excavation—and evaluated by structural, geotechnical and solid waste engineers in each category. For each idea and based on each of the criteria members of the consultant team provided their rating on a scale of 1, 2, 3 with definitions for each. A low risk/green rating was a 3 for this exercise. The tables presented are attached to this summary. This work set the stage for settlement concepts to be developed and then also rated.	
9:50 a.m.	**Layout optimization conclusions**	*Steve Radomski*
	Steve Radomski explained how the optimized layout was refined with priority to operational efficiency, and analysis of brainstormed solutions from the first Settlement Workshop. This meant that rather than defining potentially the shallowest areas of fill and placing specific site elements in those locations, the site layout is currently optimized for in/out of and minimization of necessary train movements on a daily basis. Layout refinements and assumptions included: • Locating the staff parking lot entrance away from S 252nd St, which could have impacted traffic and residents in the adjacent residential area, instead to off SR 99. • Moved the MOW inside the yard. • Increased the number of service tracks from 12 to 15 to provide additional wash and training lanes. • No significant frontage improvements anticipated on SR 99 at the Midway Landfill site. • Mitigating disruption to the detention pond on the landfill. • Relocated the landfill gas flare facility to the west side of the detention pond. • While refining the layout, it became apparent that site was slightly off the landfill. ST consulted Board motion language which stated to build mostly on the landfill, so additional need for some property in vicinity of SR 99 ROW is not in conflict with Board direction. **Steve** reported that the optimized layout is the same for all potential OMF South sites as of now, with an eye toward operational efficiency. The optimized layout assumes the OMF is built on stable ground. • Jeff N.: How many staff in MOW? o **Steve:** Currently planning 100 employee parking spaces for MOW; 207 parking spaces for maintenance folks. A little more than 400 employees per shift.	

	• Tony D.: How can we consult this information after the meeting?
	  o **Paul:** This is all real time information. All information shared today will be in the final report.
	
	• Hui (Hugh) Y.: Why do we have the heaviest facility on I-5 (deeper section of the landfill) vs. SR 99 (shallower section of the landfill)?
	  o **Steve:** The current rectangle is the ideal shape – we resized the overall perimeter. Run around track is a little under a mile in length—big facility. Within the yard, LRV run at 7 mph on average. Time halfway around the site is about 5 minutes; 5 x 144 cars, 2x day – 25 hours per day in getting vehicle out of the yard. Costs would be incurred in mileage on the vehicles and maintenance staff time if we reoriented the facility.
	Paul explained that the "dog leg" brainstormed concept was sketched for illustrative purposes, but determined it would impede operational efficiency, and widens the footprint. The ability to run service is impacted because there's no efficient way to charge the line or maintain the trains, and therefore not cost effective. **Curvie** added, this configuration would also push impacts off the landfill, in conflict with public feedback and the Sound Transit Board's direction.	

10:30 a.m.	*Break*	
10:45 a.m.	**Settlement design concepts analysis** • Review brainstormed settlement concepts, by category *Structural and Substructure* *Geotech* *Excavation* • Current working settlement concepts	Erin Taylor Thomas Mudayankavil Dave Peters

	Thomas and **Dave** then took the group through each remaining brainstormed design concept category: structural and substructure, geotechnical and excavation. After highlighting examples in each category, workshop participants were prompted to ask clarifying questions. [See Brainstormed Settlement Concepts handouts for the basis of discussion].
	
	<u>Structural</u>
	• Jeff N.: Did you compare each brainstormed structural concept to one to one another?
	  o **Dave:** No, we did not. Each brainstormed structural concept is compared to the cost and time projections of the ST3 schedule.
	• Mark J.: Is property acquisition part of this cost?
	  o **Dave:** No, just purely construction. We did look at preliminary estimates for property acquisition in Phase 1 so we have extremely rough number.	

- Tony D.: Wil all this background analysis be summarized in report?
    - **Paul:** Yes. There will be a formal comment period on the 10% design.
- Hui (Hugh) Y: Why is "Constructability" on 9 green?
    - **Dave:** Item 9 was the concept developed in Phase 1, so we looked at a 30 ft thick slab. The diameter shaft and was similar to FWLE guideway on the landfill, so we believe it's more feasible.

Excavation

Ian Sutton shared some rough calculations about the impact of excavating the full landfill—it would require significant truck trips (18 trucks total, 3 trucks loading on the site at a time; 10-hour days), which would result in significant construction delays. This would require ~10,000+ truck trips. Getting that excavated material to rail would require some sort of construction of a transfer facility, which takes additional time to permit and construct.

Jeff N. commented that the means and methods of excavation and waste removal will inform the regulatory and schedule components of evaluation, and the project team agreed.

Geotech

Dave reported that the team was confident they could effectively compact a 30-foot layer. If the strategy was instead to excavate down to minimize settlement, you would have to excavate and then dynamically compact. He shared the team also looked into processing the waste and actually using the processed waste as fill, but there's still contamination in the material, so it may need to be disposed of despite best efforts to mitigate. Sound Transit's analysis didn't try to rank order the brainstormed ideas. In some red boxes, it's a no-go, in others it's a hurdle we can work through.

Hui (Hugh) Y. shared one potential blind spot: the structural solution had 10 ideas, some were overall/ some were detailed. Recognize potential for piles. 10 foot diameter shaft, 90 foot down – if you created steel casing, it would significantly increase cost.

- Paul D.**:** Do you have a good summary page of how you got to red/yellow/green?
    - **Dave:** See "Factors considered for ranking", which is reflective of what engineers were thinking when we ranked it. We don't have granularity yet to drill down to months over 2026 opening, for example. The number of truck trips, haul distance all contributed to an estimated number of years beyond 2026 required. In summary, all of these brainstormed ideas would require additional time beyond 2026 complete. Sound Transit partnered Geotech efforts with City of Kent report, and we're working in conjunction with them on geotechnical analysis.

Sound Transit asked attendees whether or not an explanation of the layout refinement should be included in the final report. Attendees agreed it should be included to demonstrate that the brainstormed ideas were looked at. Several of the ideas were incorporated into the optimized layouts.

Design concepts

Sound Transit introduced the five potential design concepts based on the brainstormed ideas from the first workshop. Discussion is generally directed specifically to each design concept.

Jeff N. reminded the group that there's a 24-hour landfill gas system, which is something that needs to be considered in all potential options moving forward.

1. **High structural platform on drilled shafts with no excavation.**
    a. Same as Phase 1 option.
    b. Minimum impact to landfill CAP → a goal, we accounted for potential to impact regulatory component in case we disturb the CAP too much.
    c. 3 ft. thick slab, supported by 10 ft. diameter shafts
    d. Require elevated guideway to connect
    e. Approx. 70,000 CY of excavation (augured)

2. **Low structural platform with some excavation**
    a. Remove and replace CAP
    b. Works with at-grade FWLE tracks – starts to work better with FWLE
    c. 1.7 million CY (in place); 2.7 million CY (loose) excavation required.
    d. No imported material

Discussion:

- Mark H.: Does the estimate of "tens of thousands" of truck trips (20 CY per truck) account for the cap material, or just solid waste?
    - **Thomas:** Haven't gotten to that level of detail yet, but 2-3 feet above the cap in some places/ 14 feet in others.
- **Paul**: we don't typically go down to 100 foot radius on tracks. DCM is 500 foot radius.
- There's room to optimize elevation in this option, could go up or down.
- Tony D. Would #1 or #2 work better for FWLE design assumptions?
    - **Thomas:** #2 would require less effort on FWLE part; #1 would require significant increase in FWLE elevation. This elevation is set to optimize tie-in to FWLE. FWLE will be operational in 2024 – we would want to have those sections completed before 2024 so we don't impact the opening of that line, or need to accommodate construction once the extension is operational.

3. Hybrid 1: Excavation with ground improvements (buildings on shafts)

a. Remove and replace Cap
b. Works with at-grade FWLE tracks
c. Requires over-excavation and backfill
d. Deep dynamic compaction – 40 foot max.
e. Landfill excavation: 3.0 million CY (in-place), 4.8 million CY (loose)
f. Imported material: 1.6 million CY (in-place), 2.6 million CY (loose)

Discussion:

- Potential operation noise reduction if you're down lower, rather than elevated.
- Jeff N.: Is there concern for settlement on buildings? Would deep dynamic compaction eliminate settlement risk in this option?
    - **Dave:** Yes, a bit. Assume excavation and deep dynamic compaction to get to a density that's acceptable to mitigate settlement. We would get benefit for placing backfill for preload. Solid waste weight of removed waste would likely be heavier than backfill. We would hope to improve this enough to avoid settlement.
- Hui (Hugh) Y.: Is building on piles because you expect some degree of settlement even with deep dynamic compaction?
    - **Thomas**: Yes, buildings are the heaviest part. You might not have to put them on piles, but we're being conservative. Buildings would weigh an estimated 5,000-7,000 kips.

4. Hybrid 2: Excavation with ground improvements (slab on grade for tracks and buildings on piles)

a. Remove and replace CAP
b. Works with at-grade FWLE tracks
c. Slab on grade to minimize settlement
d. Requires over-excavation and backfill
e. Deep dynamic compaction – 40 ft. max.
f. Landfill excavation: 3.0 million CY (in-place), 4.8 million CY (loose)
g. Imported material: 1.6 million CY (in-place), 2.6 million CY (loose)

Discussion:

- Hui (Hugh) Y.: Concern about building on piles because of uneven surface risk as a result of settlement underneath piles. May want to refine that piece.

5. Full excavation and backfill with competent soils

a. Works with at-grade FWLE tracks
b. Landfill excavation: 5.0 million CY (in-place), 8.0 million CY (loose)
    i. Quantity removed and taken away is 8.0 million
c. Imported material: 2.9 million CY (in-place), 4.6 million CY (loose)

Discussion:

- **Dave:** Advantage is that, after complete excavation, ground settlement, legal risk, regulatory risk, employee health and safety are totally mitigated with this issue.
- **Thomas and Ian:** Superfund designation is a result of groundwater condemnation. This means there are limitations on how much of the cap can be exposed at any given time. Given rainy seasons here, we can't have significant amount uncovered at any given time. Have to work during dry season, only 20-22 weeks of actual excavation time per year, which would take approximately 16 years. Limits you to assume include: 5-ish acres open at any given time; trucks would load up (3 at a time); 18 trucks on the road at any given time that would need to travel 20-ish miles. When considering 400,000 truck trips loaded on local roads—estimated 400,000 truck trips to empty landfill; 200,000 to backfill. Hauling to a railhead and tipping fees in OR/WA-- $650 million cost estimate.
    - **Paul:** To be direct, ST can't get permission from WSDOT for direct access to I-5 and we would need to use local roads. We assume Kent may have a concern about this and therefore potential support of the site alternative.
        - Mark H.: Good question to think about, it might. The City of Kent's preference would be for direct access to I-5 and avoid traffic on local roads.
        - Philip H.: We could look into WSDOT permission, but it's not something that's typically granted.
    - Tony D.: Could ST get direct access to I-5 if FWLE tracks are already in place?
        - **Paul:** Just north of the OMFS potential site, there is an elevated alignment. Could excavate under private property. Not a fatal flaw, but something ST is thinking about.
    - Jeff N. We're 300 miles from a landfill with capacity. It would require a transfer facility—nearest existing one is at Black River.
- Not fatal flaw: If we worked double shifts, 6 days/week, we might be able to reduce time by 7-8 years. Maybe we can up the LRV delivery to 6 per week, from 3 per week, to ramp up 2024 delivery more quickly.
- Jeff N.: So far associated with the FWLE contractor discussions, we understand in that area that the fill is up to 70% soil in the landfill by volume. Going to get rusted things, plastics and wood. This means solid waste from excavation is greatly reduced. 8 million CY loose, maybe looking at 2 million CY?
    - This evaluation is from deeper zone of the landfill, not sure what it's like in shallower sections.
    - If you sift through everything and remove solid waste, the dirt is still contaminated. I could see benefit if Ecology would let you put the dirt back.
    - SPU is doing this analysis in real time right now with Ecology—and determining if it might be possible to put dirt back. This will require an amendment to cleanup action plan and consent decree, which will be out for comment in November. Regulatory approach will be available within a week or two; Sound Transit, due to separation of projects, will want to wait to

	expand on this concept until it's in public domain. We might have a soil contamination determined before 10% design (Spring 2020). o Settlement risk and landfill gas issues are gone if fully excavate. Not trying to clean it up, just trying to get MSW out and approval for competent soils. o Except for the middle section, landfill is largely dewatered now. Where you would be working in groundwater, assume it's contaminated and would need to be treated. o With other hybrid options, would be nowhere near groundwater area. o Gross excavation is somewhere 188,000 CY or 200,000 CY. In terms of scale, significant difference o Important data point: production rates on cleanout. SPU thinks estimates is 3-4 months. • Mark J.: Shannon Wilson is doing Geotech data—maybe could get ahold of it? • **Paul:** This changes the remedy from removing the cap to fully eradicating the landfill. Could have significant regulatory impacts. We'll be having conversation with Ecology in a couple months. • Tony D. expressed concern that Hybrid 1 and 2 are too similar, so it might make sense to take two more different options into the design phase.	
12:00 p.m.	*Lunch on own*	All
1:00 p.m.	**Comparing the settlement concepts** • What do we take into design?	Erin Taylor and all
	Dave explained the Brainstormed Settlement Design Concepts: Summary handout. Different expertise evaluated each category on the summary sheet, which is why the criteria is repeated for each category. Cost is red for each design concept because it is assumed that all options will have a higher cost than the ST3-approved project. A key factor informing the color of bars in this risk analysis is the level of unknowns. You can only know so much. • Hui (Hugh) Y.**:** 160 foot shafts are significant length for deep foundation elements. Not similar to slab on grade. What's the on-center distance on 10-foot shafts? o **Dave:** 700 feet. • Jeff N.: Sound Transit expects there to be a learning curve on expedited permitting process for FWLE, which is heartening for this process. • Why is Hybrid 1 and 2 risk different (Hybrid 1 = yellow/ Hybrid 2 = red) for structural and maintenance and reliability? o **Thomas**: Different number of construction sequences. Construction schedule will be dictated by time-sensitive elements. More construction in Hybrid 2 – 40-50 acres of concrete slab. Don't want to cast a slab until we're sure it's not going anywhere, so there's levels of cost and time with additional structures built.	

Maintainability is also different between the two Hybrid options. Trade-off – more time built into the schedule/construction sequence before can cast the slab. There's a little more flexibility with the piles.

- Tony D.: How does this risk profile compare to the other two sites? Are the FW sites all green? Not talking same alternatives, but still dealing with soil conditions. Are the unknowns that much less at the other sites vs. this one?
  - **DAVE**: Don't have geotechnical borings in the Federal Way area. We've identified areas to do borings along the alignment and near the site. City of Federal Way will receive permits this month so we can do borings in the ROW. Will have to do this same analysis for the 10% design.

Erin then asked the group to highlight any potential blind spots:

Blind spots:

- Paul D..: Would prefer to have Hybrid 1 and 2 as well as full excavation compared to the cleanup happening on FWLE (e.g. Hybrid 1 with waste/soil sifting AND Hybrid 1 comparison).
- Tony D.: Is there a risk with doing FWLE and OMF South projects at the same time? (e.g. excavating significantly next to already-laid track)?
  - **Paul:** This is a real potential.
- Hui (Hugh) Y.: Alternative to Hybrid 2: Consider slab with ground improvement below to limit differential settlement with grouting ports to re-stabilize solid slab. Perhaps optimization of Hybrid 2 option. Might need a cap before you can place the slab option.
- Is Number 1 still an option with an at-grade FWLE?
  - **Paul:** Preference would be to determine if options 2-5 are feasible, then remove option 1. Conversation with Ecology and EPA would happen after final report of this workshop series.
- Mark H.: When will the fall report be ready?
  - **Gwen:** End of November. Goal is to have a final report of the Settlement Workshop series in the next 30-45 days. 10% design analysis for some of these options start tomorrow. **Paul:** In April 2020, we'll be doing cost estimating and value engineering, then constructability.
- Jeff N.: Look at FWLE lessons-learned, even though on a significantly smaller scale, and see how Option 5 could work. Would like an out for Option 5 depending on regulators' input and conversation with FWLE development.

Erin walked the group through an exercise to see what could be removed from further consideration or modified. The result of this conversation is attached to this summary, highlighting group agreements on what to carry forward and next steps. Sound Transit shared their agreement with the current set of settlement concepts to continue moving forward.

2:30 p.m.	**Attendee reflections**	Erin Taylor

	Next steps *Meeting 3: Sound Transit communicates concepts will be taken into the design as reflected in Draft EIS*	
3:00 p.m.	• Adjourn	All

Handouts/Reference Materials:

- Midway Landfill Settlement Brainstorm Settlement Concepts:
  - Structural
  - Excavation
  - Geotechnical
  - Layout
  - Summary

Attendees: Dave Peters, Curvie Hawkins, Gwen McCullough, Mark Jusayan, Ian Sutton, Hui (Hugh) Yang, Allison Dobbins, Jason Baily, Michael Williams, Steve Radomski, Paul Bennett, Tony Doucette, Kelly Peterson, Ian Sutton, John Sleavin, Paul Denison, Thomas Mudayankavil, Phil Harris, Bob Mitchell, Jason Funk, Ed Herald, Andrew Austin, Ben Wolters, Erin Taylor, Alexandra Streamer, Mike Rayburn, Yvonne Olson, Jason Bailey, Jeff Neuner, Mark Howlett

Operations and Maintenance Facility South

Appendix D2: Interim Midway Landfill Preparation Memorandum

Federal Transit Administration

SoundTransit

February 2020

OMF SOUTH

Interim Midway Landfill Preparation Memorandum – Draft 2

SOUNDTRANSIT

CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

SOUNDTRANSIT

OMF SOUTH

Interim Midway Landfill Preparation Memorandum

Prepared for:
Sound Transit

Prepared by:
HDR Engineering, Inc.

February 14, 2020

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Figures

Acronyms and Abbreviations

BNSF	Burlington Northern Santa Fe Railroad
DB	design-build
DBB	design-bid-build
EIS	Environmental Impact Statement
FFE	final floor elevation
FWLE	Federal Way Link Extension
LFG	landfill gas
OMF South	Operations and Maintenance Facility South
PCE	passenger car equivalency
RCRA	Resource Conservation and Recovery Act
ROM	rough order of magnitude
UP	Union Pacific Railroad

Units

cy	cubic yard
day/wk	days per week
hr/day	hours per day
lb/cf	pounds per cubic foot
ton/cy	tons per cubic yard
wk/yr	weeks per year

1.0 Introduction

1.1 Purpose

The Midway Landfill is currently being evaluated as one of three site alternatives in the Draft Environmental Impact Statement (EIS) for the Sound Transit Operations and Maintenance Facility South (OMF South) Project. The subsurface development of the OMF South on a landfill will require unique design considerations to maintain the in-place remedial environmental controls and protect the facility against settlement. The landfill specific design considerations are not present at the other OMF South site alternatives. Five landfill subsurface construction design options (options) are currently being explored, as described in Section 1.2. This memorandum provides a high-level, interim assessment of landfill site preparation requirements based on existing data and reasonable assumptions to compare and contrast the five options to inform the Sound Transit decision-making process when advancing options further into the siting evaluation process.

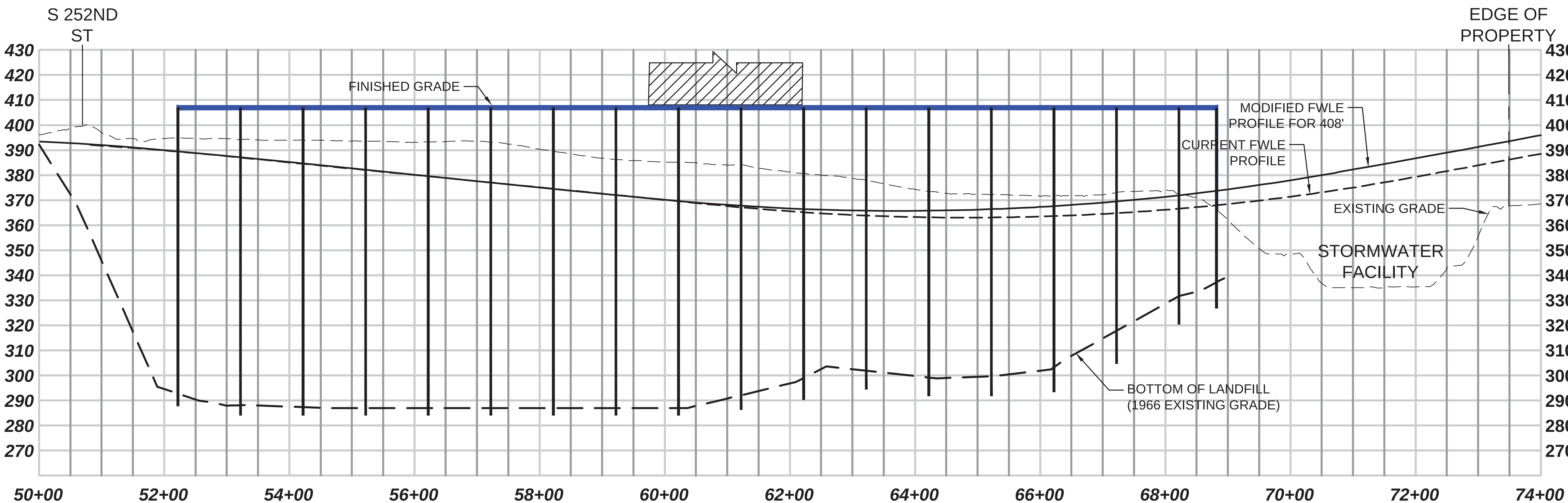
1.2 Five Landfill Subsurface Construction Design Options

Each of the five OMF South subsurface construction design options generally has the same horizontal layout and surface features. The five options primarily vary in subgrade and foundation concepts. The five options include:

1. High Platform – High Structural Platform with No Excavation
2. Low Platform – Low Structural Platform with Some Excavation
3. Hybrid 1 – Excavation with Ground Improvements (Buildings on Drilled Shafts)
4. Hybrid 2 – Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shaft)
5. Full Excavation – Full Excavation and Backfill with Competent Soils

The options are consistent with those described in the Midway Landfill Site Engineering Optimization Report. Exhibits 4-3 through 4-7 from the report have been included as Figures 1-1 through 1-5 to illustrate each concept. The report should be reviewed for more detail pertaining to the OMF South project and each construction approach.

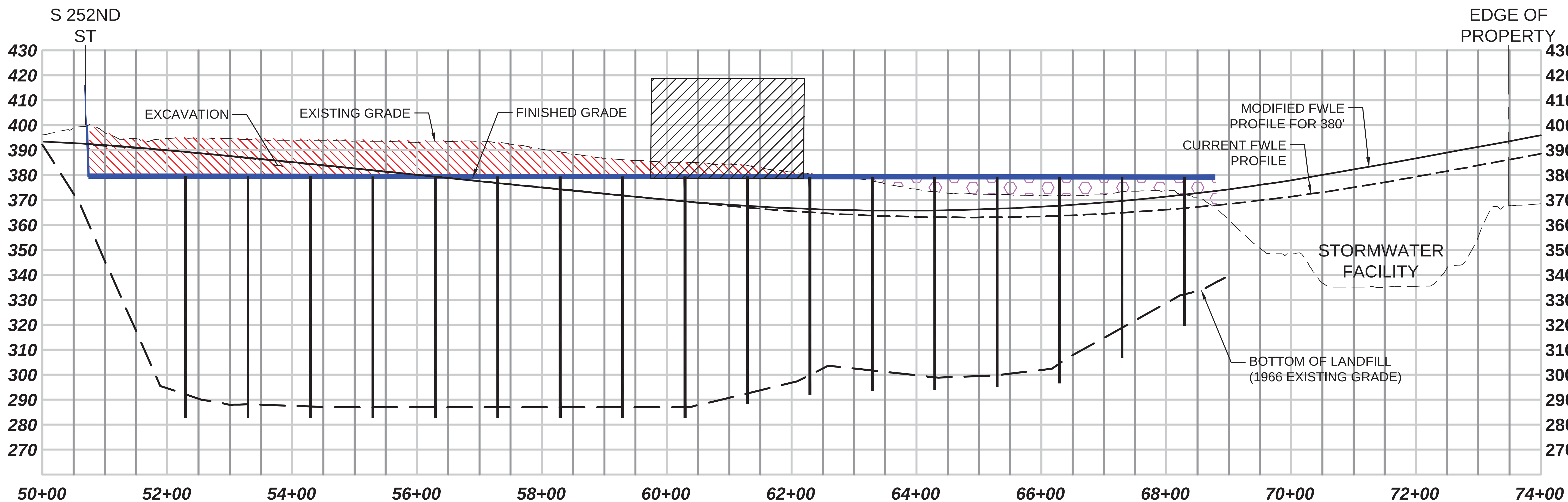
1 HIGH STRUCTURAL PLATFORM WITH NO EXCAVATION



High Platform (408 OMF FFE, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	0.1	0.1		

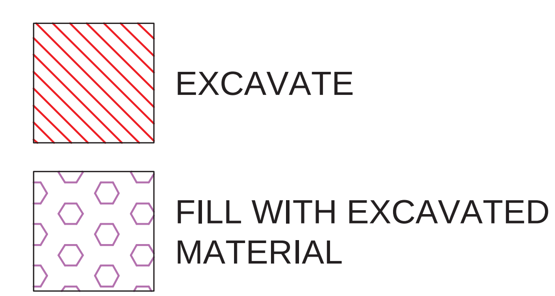
Only accounts for excavation associated with drilled shafts

2 LOW STRUCTURAL PLATFORM WITH SOME EXCAVATION

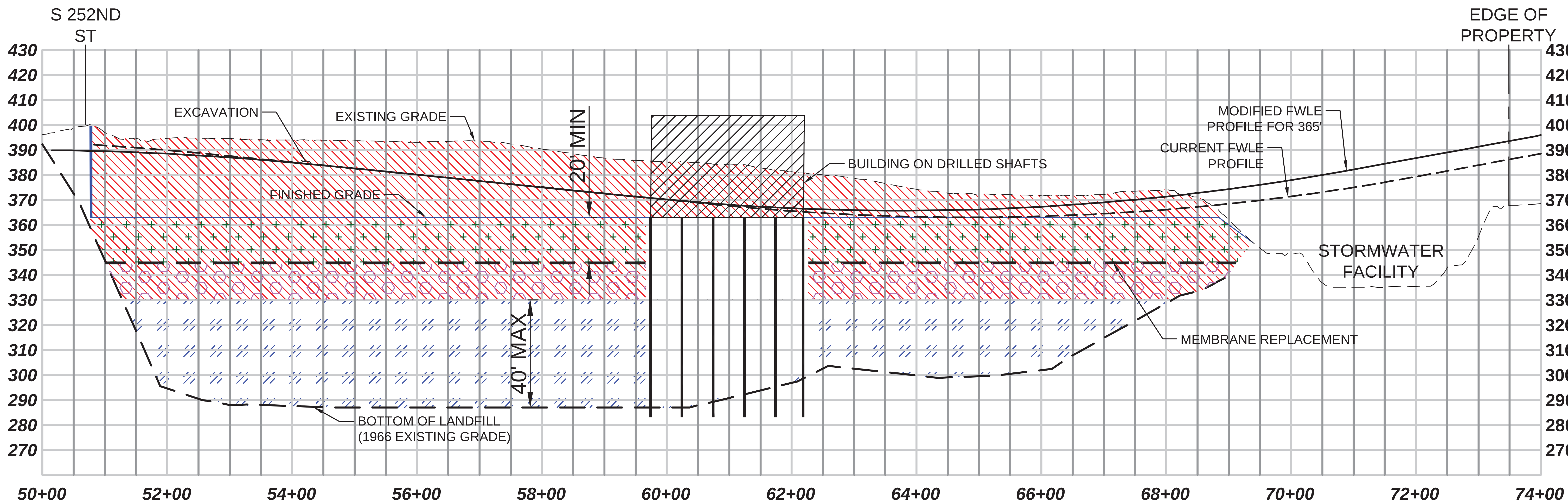


Low Platform (380 OMF FFE, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	0.46	0.05		
Borrow Fill			0	
Screen (100% Reusable)	0.41	0		0.41
Total		0.05	0	0.41

Assumes all excavated soil can be placed on site below proposed fill areas

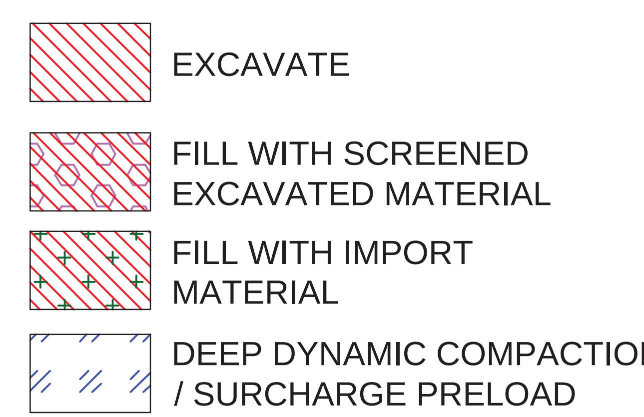


3 HYBRID 1: EXCAVATION WITH GROUND IMPROVEMENTS (BUILDINGS ON DRILLED SHAFTS)

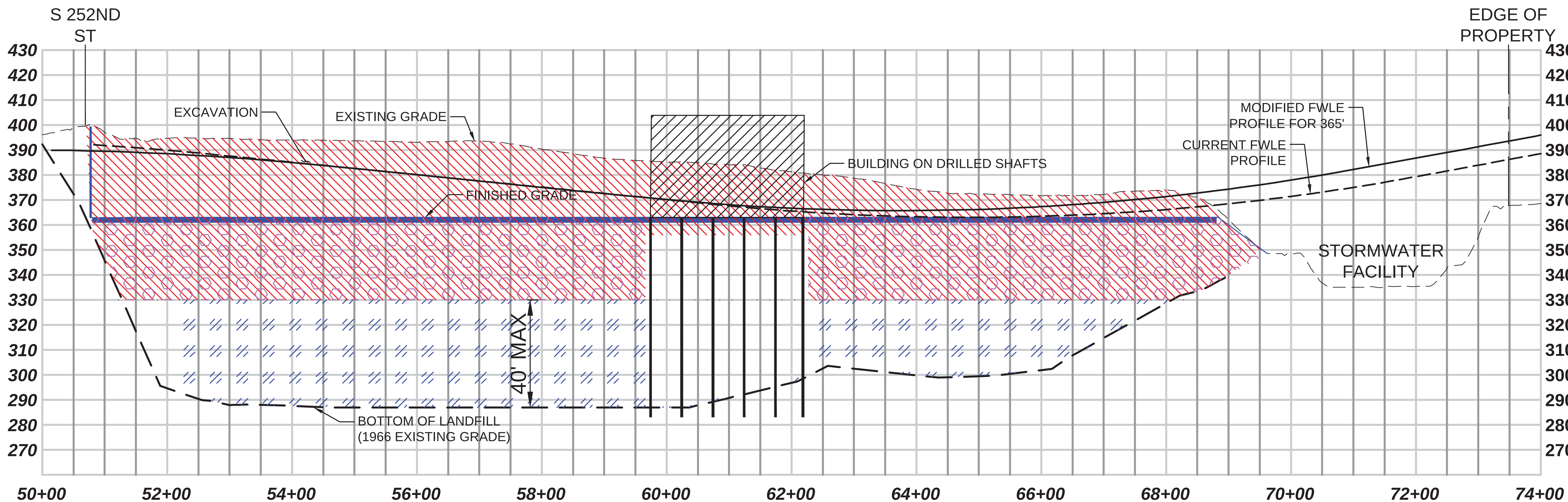


Hybrid 1 (365 OMF FFE, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	2.9	1.7		
Borrow Fill			1.1	
Screen (50% Reusable)	1.2	0.6		0.6
Total		2.3	1.1	0.6

Assumes excavation to flat elevation (330) across entire landfill area regardless of depth of landfill below

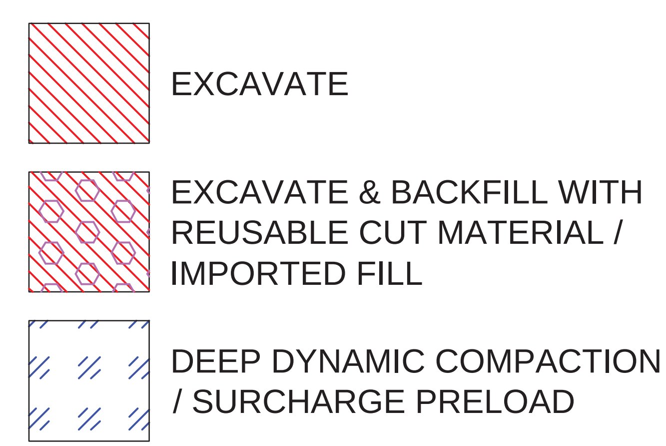


4 HYBRID 2: EXCAVATION WITH GROUND IMPROVEMENTS (SLAB ON GRADE FOR TRACKS AND BUILDINGS ON PILES)

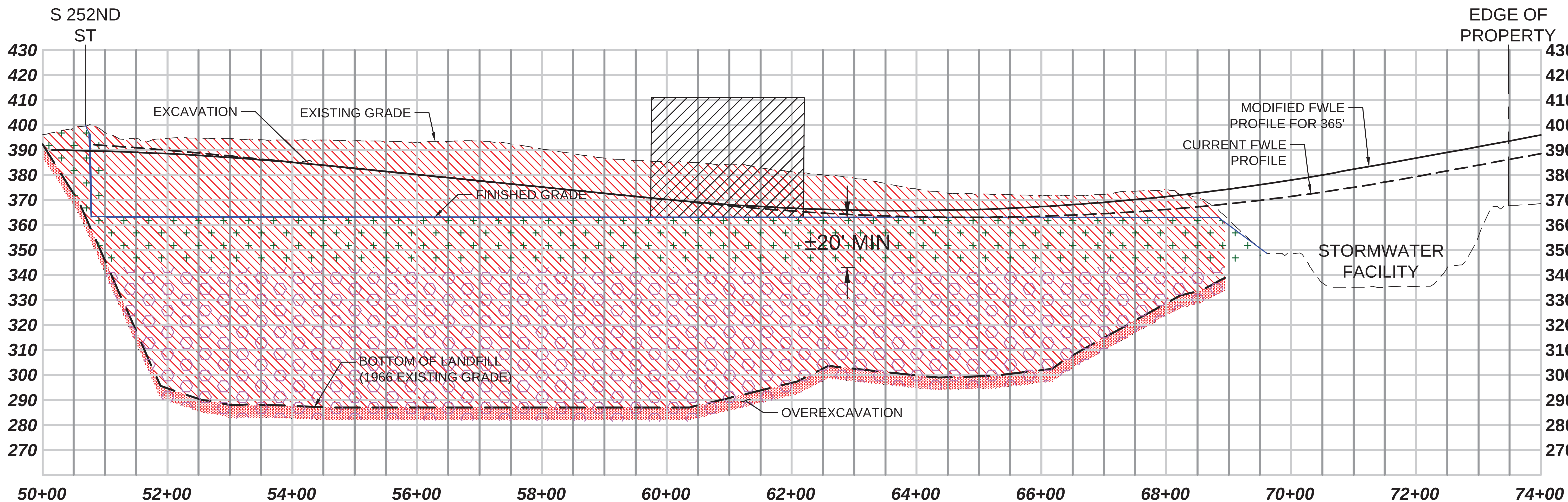


Hybrid 2 (365 OMF FFE, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	2.9	0		
Borrow Fill			0.25	
Screen (50% Reusable)	2.9	1.45		1.45
Total		1.45	0.25	1.45

Assumes excavation to flat elevation (330) across entire landfill area regardless of depth of landfill below

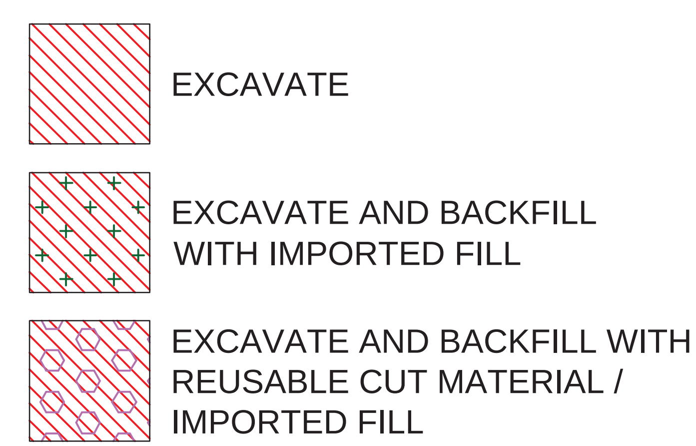


5 FULL EXCAVATION & BACKFILL WITH COMPETENT SOILS



Full Excavation (365 OMF FFE, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	5.3	0.5		
Borrow Fill			1.6	
Screen (50% Reusable)	4.8	2.4		2.4
Total		2.9	1.6	2.4

Assumes 5' depth of overexcavation required below 1966 existing grade



2.0 Construction Evaluation

The construction evaluation is a high-level discussion of landfill subsurface construction design options pertaining to the Midway Landfill site alternative for the OMF South Draft EIS. The discussion is based on operations and maintenance requirements, available information, and reasonable assumptions intended to develop a planning-level comparison among the five landfill options. As the redevelopment designs are progressed, assumptions are expected to be refined to create a more accurate assessment of landfill preparation requirements.

The discussion presents possible subsurface design options to the work in an effort to develop a planning-level estimate of earthwork and structural requirements, traffic impacts, cost, and schedule related to the landfill preparation required prior to OMF South and associated track construction. Assumptions and influencing factors may vary depending on construction contractor means and methods and regulatory requirements.

2.1 Earthwork Process

Materials anticipated to be encountered during landfill excavation include clean cover soil, landfill closure geosynthetic materials, and refuse material. Clean cover soil can be temporarily stored onsite for reuse during the OMF South construction. Closure geosynthetics and refuse material excavated will require either:

1. Export and disposal offsite,
2. Relocation onsite, or
3. Onsite material screening to retain competent soils for reuse onsite and export of deleterious materials for disposal offsite.

Using the Federal Way Link Extension (FWLE) screening approach as a guide, it is conservatively assumed that material screening will result in 50% of the landfill material reused onsite and 50% exported for disposal (FWLE assumed 70% of screened landfill material can be reused onsite [a published report is not available for reference]). This assumption will be reevaluated in the final report based on the recommendations from the geotechnical investigation of the landfill after borings are conducted at a later date. The reusable material will be contaminated and require environmental controls during handling to avoid contamination of clean material and surface water. The reuse of the material will require oversite by a geotechnical engineer to ensure proper mixing and placement for acceptable soil stability. During placement, some reuse material may be deemed unsuitable and require disposal offsite.

The Low Platform approach reuses excavated material without screening. This approach is intended to balance cut and fill quantities and reduce export requirements. The reused material is not required to be structurally competent since the Low Platform approach relies on drilled shafts for support.

Even though there is a quantity of clean cover material on the site, the amount is unknown. Based on the high-level nature of this evaluation and the proportionately larger quantity of refuse material, the entire excavation quantity calculated by the landfill site engineering optimization is assumed to be refuse. A quantity of clean cover material has not been distinguished from the bulk quantities.

The Preliminary Geotechnical Engineering Services Report Revised, by GeoEngineers, estimates the average in-place material density of the landfill is 120 pounds per cubic foot (lb/cf), or 1.62 tons per cubic yard (ton/cy). The loosening of material during the excavation process is assumed to result in an average loose material density after excavation of 100 lb/cf, or 1.35 ton/cy. This loose material conversion is an approximate factor of 1.2, which is different from the 1.6 assumed by the landfill site engineering optimization. The lower factor is being used based on the age and type of material expected to be encountered. Future geotechnical investigations are expected to refine these values.

Active excavation and hauling are assumed to be 12 hours per day (hr/day), 6 days per week (day/wk). The actual workday may be 16 hours with two shifts. Due to general inefficiencies, breaks, fueling and maintenance, irregularities at the start and finish of shifts, and other potential operational impacts, 12 hours of active hauling was assumed to be the average.

Excavation into refuse is assumed to be permitted only between May 1 and September 30, which excludes wet season construction. This results in a construction season of approximately 22 weeks each year. The construction season is assumed to be limited to reduce the amount of precipitation that may contact refuse and become contaminated water that could potentially infiltrate into the open area of the landfill, further contributing to contaminated groundwater that exists at the site. It is assumed that regulatory agencies will prohibit or restrict open landfill excavation during the wet season to protect against groundwater contamination.

Due to the irregular nature of the material typically found within a landfill, there will be the potential to encounter unexpected subsurface conditions during the excavation process. It is assumed that the construction contractor will be required to have resources available to manage irregular materials encountered during bulk excavation and redirect the work effort without delays to the project timeline. The assumed limited work area in comparison to the total site work area supports the reasonableness of this assumption.

2.2 Drilled Shaft and Slab Installation

Four of the five construction options for landfill preparation include drilled shaft and slab elements – the exception being the Full Excavation approach. The drilled shafts are assumed to be 10 feet in diameter, distributed throughout the building footprints and potentially the full extent of the track area on a 50-foot by 100-foot grid. The grid spacing has changed from the previous 100-foot by 100-foot grid assumed during the landfill optimization process. The assumed slab thickness did not change. The change is a result of design progression.

Shaft installation generally consists of a casing, reinforcement, and concrete embedded through the landfill approximately 15 feet into native, competent material. Shafts will support a structurally suspended concrete slab, approximately 3 feet thick. Hybrid 2 also includes a concrete slab on grade for the track area, without drilled shafts.

Shaft and slab installation are assumed to occur in coordination with the earthwork process, with similar material hauling hours and work season. The work will be phased in with the earthwork, with shafts installed in exposed refuse areas prior to landfill closure cover installation and clean backfill. Shafts through refuse will need to be booted through the replacement landfill closure cover to create a sealed system. Slab installation should be permitted to occur during the wet season, since this work will be performed in a completed landfill closure area without exposed refuse. Drill shaft installation may be permitted during the wet season based on a small and controllable work area pertaining to the individual shafts.

Refuse exhumed during drilling has been included in the earthwork quantities. The drilling process is assumed to be prohibitive to material screening and reuse of the exhumed material, requiring export for disposal. Concrete import is accounted for as an import quantity associated with the shafts and slabs.

2.3 Environment Considerations during Construction

As stated above, wet season construction is assumed to be prohibited during landfill preparation due to the greater potential to generate contaminated groundwater through penetrations through the existing landfill closure system. This restriction results in a May 1 to September 30 work window each year.

In general, the exposed refuse area of the work site is assumed to be limited to 5 acres in size. A specific allowable exposed refuse area size has yet to be established with the regulators. The 5-acre area was assumed as a reasonable size to perform work while managing environmental protection and preservation of the landfill environmental controls. It is assumed that a construction contractor will be able to secure (cover and manage stormwater) a 5-acre exposed area at the end of each day and in anticipation of inclement weather. The construction contractor will also need to control dust on dry and windy days. Precipitation and surface water run-on will need to be managed in the exposed refuse area to prevent water contamination and infiltration into the landfill that could result in further contamination of groundwater. Water collected within the open refuse area will need to be hauled offsite and disposed of as wastewater. It is assumed that some inclement weather will occur, which will increase the schedule duration by 5%.

It is also assumed that a 5-acre open refuse area can be managed without negatively impacting the active landfill gas (LFG) system at the landfill. The LFG collection and conveyance system will be required to remain active during construction to prevent offsite migration of LFG. During the construction, the LFG system will need to be continuously reconfigured to maintain effectiveness. Portions of the system will need to be demolished and replaced as the work progresses through the site. Additionally, the system will need to be managed to prevent air intake, from the open refuse area, that could contribute to a landfill fire.

If material screening will take place for onsite reuse of contaminated, competent backfill material, 5 acres may not be an adequate exposed refuse work area to accommodate continuous excavation, vehicle loading, screening, stockpiling, and backfill of material. The depth of excavation and layback of slopes will also factor into area requirements. If the horizontal footprint of the open refuse area is limited to 5 acres, the available work area within the excavation, or excavation floor, will be reduced in size based on depth and the space consumed by the sideslopes required for a stable excavation. Sideslopes could range from 1:1 (horizontal to vertical) to 2:1. It may be possible to use a non-open refuse area on the site for material processing and handling; however, the area would have to be set up to manage the contamination and protect clean areas.

Note that reuse of the screened material onsite will be subject to regulatory approval. Environmental regulators may require any exhumed refuse to be disposed of at a permitted facility meeting current standards without the option to reuse onsite. The FWLE project has been allowed to reuse refuse material onsite; however, the quality of that material is better understood and the scale of that work is significantly smaller than that proposed for OMF South.

The hauling of contaminated material will be in fully enclosed intermodal containers. If material is determined to be hazardous, hauling requirements will need to be verified based on the material.

Vehicles and equipment driving through a contaminated area will likely need to cross a wheel wash as they exit the area to clean the tires and avoid tracking contaminated material elsewhere onsite and offsite.

Each of the five options will result in refuse retained onsite, which will require the preservation, or reinstallation, of a permanent landfill closure cover system, LFG system, and groundwater monitoring system. The Full Excavation approach may be able to remove LFG-generating material through screening; however, contaminated soil may still result in contaminated soil vapor that will need management.

2.4 Disposal Considerations

Excavated material exported from the landfill will require disposal at a regulated facility, assumed to be a Subtitle D landfill in accordance with the Resource Conservation and Recovery Act (RCRA). Within the Pacific Northwest, it is expected that three solid waste firms have the available landfill capacity for the disposal of the material quantities required. Export disposal quantities are discussed in Section 2.7. The Full Excavation approach requires the most disposal export, at approximately 4 million tons.

The firms include Republic Services, Waste Management, and Waste Connections. The three firms each operate a regional landfill that is accessible by rail. Table 2-1 is based on the King County 2019 Comprehensive Solid Waste Management Plan and provides information on each landfill.

TABLE 2-1
Regional Disposal Capacity

Landfill	Location	Owner	Permitted Capacity (tons)	Remaining Capacity (tons, 2016)
Roosevelt Regional Landfill	Klickitat County, WA	Republic Services	244,600,000	120,000,000
Columbia Ridge Landfill and Recycling Center	Gilliam County, OR	Waste Management	345,275,000	329,000,000
Finley Buttes Regional Landfill	Morrow County, OR	Waste Connections	158,9000,000	131,000,000

The travel distance to these landfills warrants container shipment by rail. Trucks leaving the Midway Landfill will need to go to an intermodal facility for container offload onto trains. At the facility, the trucks will be reloaded with empty containers.

A number of intermodal facilities exist in the Seattle area that are owned by either a solid waste firm or a railroad. The two primary railroads are Burlington Northern Santa Fe Railroad (BNSF) and Union Pacific Railroad (UP).

The intermodal facility is expected to handle an export truck arriving every 2.5 minutes on average. It is assumed that one or multiple existing intermodal facilities in South Seattle will be able to accommodate the exported quantities from Midway Landfill. This may or may not be possible, considering the large quantity and schedule requirements, and a project-specific intermodal facility may be required or, at a minimum, an existing facility may require expansion. It is also assumed that the rail service provider can meet the train capacity requirements.

Based on an intermodal facility located in Seattle, the travel distance will be 20 miles, one way, requiring an assumed 40 minutes each direction. The queue, unload, and load time required at the intermodal facility is assumed to be 10 minutes.

Weighing of containers is assumed to occur at the intermodal facility or disposal landfill.

It is expected that the export disposal will be contracted through the construction contractor, with the solid waste firm as a subcontractor. The railroad component is expected to be a second-tier subcontractor through the solid waste firm. Due to the complexity of the solid waste handling and disposal component of the project, including the potential intermodal facility construct aspect, the bidding for this service under all the options is expected to require at least 6 months.

2.5 Construction Phasing and Material Reuse

As discussed in Section 2.3, construction phasing will be required to maintain the environmental controls at the landfill. A limited portion of the landfill will be allowed to be exposed at one time. Within this exposed refuse area, a number of activities are expected to occur simultaneously, depending on the construction approach, each activity will be in sequence after the preceding activity with the preceding activity moving on to the next area. The exposed refuse area would be able to advance once the landfill cover is reinstalled in the previous work area. Activities may include different combinations of the following.

1. Disassembly/removal and temporary reinstallation of the LFG system
2. Removal of the landfill cover system
3. Excavation of refuse material
4. Screening of refuse material
5. Export of screened unsuitable material
6. Dynamic compaction of the subgrade (if applicable)
7. Placement and compaction of screened competent reuse material
8. Drilled shaft installation (if applicable)
9. Installation of permanent landfill cover system and LFG system
10. Import and installation of competent material
11. Slab installation (if applicable)

The assumed 5-acre open refuse area will be very limiting for the space demands and to maintain efficiencies. Phasing will be further complicated with greater excavation depth requirements and the space consumption from layback slopes. There may be some relief if truck load-out and screening can be performed outside the open refuse area; however, this will create additional contamination areas to manage. Detailed construction phase planning is beyond the scope of this document.

The phased nature of the work allows the construction contractor to be able to respond to changed conditions by moving to another portion of the site, as needed, without greatly impacting schedule. This also provides the opportunity to effectively plan and execute preparatory and sequential work.

Also, the landfill preparation work can be performed concurrently with portions of the OMF South building and track construction. OMF South building and track construction can begin in areas that have achieved final grade or completion of the slab work.

2.6 Truck Trips – Export and Import

2.6.1 Disposal Export

Excavated material for export offsite is assumed to be loaded into 20-foot intermodal containers on waiting trucks. The intermodal containers will be limited to a capacity of 30 tons due to roadway load restrictions set by local agencies and the Washington State Department of Transportation. The containers will be transported offsite for direct load onto railcars at an intermodal facility.

The 5-acre open refuse area is assumed to be able to accommodate four active truck load-out locations, with an onsite load time of 10 minutes each. The number of load-out stations will depend on construction contractor means and methods to perform the work. Four stations were assumed as a possible number based on space limitations and competing work activities. This and other assumptions can be explored in accordance with the next steps described in Section 8.0.

Based on the discussion of intermodal facilities, total round-trip time for a truck will be 100 minutes. Each load station at the Midway Landfill will be able to accommodate up to 10 trucks, for a total of 40 export trucks operating during peak time.

Based on a 12-hour workday, each truck is assumed to make seven trips per day. At 40 operating trucks, this equates to 280 truck trips per day. This is an approximate value that does not account for irregularity at the beginning and end of the day.

2.6.2 Soil Import

Importing soil for backfill will need to be performed separately from the export operation for excavated refuse. There is not expected to an opportunity to gain efficiency from export trucks returning to the site with imported soil. The export trucks will use intermodal containers. The intermodal containers are used for transfer to and from the trains and are not suited for dumping import soil onsite if the containers were loaded with clean import soil on the return trip. Import trucks will need to be dump trucks with trailers with an assumed capacity of 20 cubic yards (cy).

The total round-trip time for import trucks is assumed to be 100 minutes. This assumption is based on a hypothetical material supply location in Maple Valley, Washington. When onsite, trucks will dump either in the fill area or at a stockpile location.

The demand for import material will be less than the export effort, based on assumptions pertaining to excavation screening and reusable material. The total amount of import trucks is assumed to be equally distributed throughout the export duration.

2.6.3 Concrete Import

Concrete import for shafts and slabs is assumed to arrive in 9-cubic-yard truckloads. The import is assumed to be equally distributed throughout the landfill preparation. Concrete will be locally sourced from an unknown location and is expected to be imported following the same site-access requirements as other import and export operations.

2.7 Results

The assumptions discussed above are summarized below.

Assumptions:

1. Average in-place density is 120 lb/cf, or 1.62 ton/cy
2. Average loose (post-excavation) density is 100 lb/cf, or 1.35 ton/cy
3. 50% reusable excavated material
4. Active excavation is 12 hr/day, 6 day/wk, 22 weeks per year (wk/yr)
5. Exposed refuse area is 5 acres
6. Inclement weather will increase the project duration by 5%
7. A 5-acre area can load 4 trucks at a time
8. Each truck is onsite for 10 minutes
9. Truck travel distance is 20 miles each way
10. Truck trip time each direction is 40 minutes
11. Truck time at the offsite facility is 10 minutes
12. Total truck trip time is 100 minutes per load
13. Export trucks operating per load area is 10
14. Total export trucks operating is 40
15. Export trips per day per truck is 7
16. Export truck trips per day is 280

17. Export truck capacity is 30 tons
18. Soil import truck capacity is 20 cubic yards
19. Concrete import truck capacity is 9 cubic yards

Applying these assumptions and the quantities developed during the landfill site engineering optimization to the five landfill options results in the landfill preparation requirements summarized in Table 2-2 and Table 2-3.

TABLE 2-2

Landfill Preparation Material Requirements

Construction Design Option	In-Place Excavation (cy)	Excavation (ton)	Material Export (ton)	In-Place Fill (cy)	In-Place Reuse (cy)	In-Place Import (cy)	Concrete Import (cy)
High Platform	100,000	162,000	135,000	0	0	0	200,000
Low Platform	460,000	745,200	67,500	410,000	410,000	0	180,000
Hybrid 1	2,900,000	4,698,000	3,105,000	1,700,000	600,000	1,100,000	160,000
Hybrid 2	2,900,000	4,698,000	1,957,500	1,700,000	1,450,000	250,000	8,000
Full Excavation	5,300,000	8,586,000	3,915,000	4,000,000	2,400,000	1,600,000	0

The in-place excavation volume was converted to excavation tonnage to be consistent with the industry approach to material export and disposal. In-place volume remains applicable to the assessment for import materials.

TABLE 2-3

Landfill Preparation Hauling Requirements

Construction Design Option	Export Truck Trips per Day	Soil Import Truck Trips per Day	Concrete Import Truck Trips per Day	Total Truck Trips per Day
High Platform	13	0	26	39
Low Platform	7	0	11	18
Hybrid 1	280	179	0	459
Hybrid 2	280	64	10	354
Full Excavation	280	206	0	486

The High Platform and Low Platform export and import truck trips are equally dispersed over the schedule durations for shaft and slab installation.

Hybrid 1, Hybrid 2, and Full Excavation options have landfill preparation schedules dominated by refuse export hauling durations. Soil import trucks have been equally dispersed over the required export period. Concrete import trucks have been dispersed over the concrete work period, if applicable.

Truck trips include only bulk earthwork and concrete. Other vehicle trips (i.e., landfill closure system materials and concrete reinforcement) have not been evaluated. Complete construction traffic will be evaluated as part of the Draft EIS.

3.0 Traffic Analysis

3.1 Truck Haul Routes

Access to and from the site for inbound and outbound trucks is assumed to be via right turns. No left turns into or out of the site are assumed. Left turns would increase the likelihood of onsite or offsite queueing of vehicles causing congestion. Outbound trucks exiting the site would travel north on SR 99 and access I-5 via Kent-Des Moines Road (SR 516). Inbound trucks would travel on I-5, exiting at S 272nd Street. The inbound trucks would travel westbound on S 272nd Street to SR 99, where they would turn north and travel to the site. Excavation export is assumed to be to the north to reach an intermodal facility. Trucks importing material would follow the same routes in the vicinity of the site, although the assumed origin for import concrete and soil material is unknown.

Assumed construction haul routes to the north are shown on Figure 3-1. Actual traffic routes will need to be established for the construction through coordination with the local jurisdiction permit process.

3.2 Level of Service Considerations

Trucks would traverse the haul routes during the entirety of the assumed 12-hour daily hauling period, including both directions during AM and PM peak. As described in Section 2.6, the maximum number of export trucks operating at the site is 40, each performing 7 round trips per day, for a total of 280 daily truck trips. With 280 truck trips during the daily construction period, the average number of truck trips per hour is 23-24. Trucks are assumed to be accessing the site at uniform intervals throughout the daily hauling period, with some potential for irregularity or bunching at the beginning and end of the day. Import trucks represent fewer truck trips than the maximum assumed export truck trips. Given that the daily truck trip volume is estimated to increase by about 206 trips per day to facilitate importing material for the Full Excavation option, it is estimated that 18 additional trucks would be operating at the site each hour. The other construction options also include import of concrete and soil material, but they would require fewer truck trips than the Full Excavation approach. They would range between 1 and 16 additional trucks per hour.

Given their size and slower operating speeds, trucks were assigned a passenger car equivalency (PCE) value of 2.5 for this evaluation. Additionally, each round trip includes an outbound and inbound segment, resulting in a total of 700 PCE daily trips in the study area associated with export activity (280 truck trips x 2.5 PCE). Import activity would result in nearly 515 PCE daily trips in the study area (206 truck trips x 2.5 PCE).

To estimate traffic operation impacts, the truck trips are assumed to be distributed evenly throughout the day and are based on the ability of the yard and the receiving facility to process the trucks. These assumptions are outlined in Section 2 of this memorandum. The 2.5 PCE factor is applied to the truck volume to give planners information about the number of new trips that would need to be accommodated along the truck routes. Below, Table 3-1 outlines the number of peak hour trucks and associated PCEs for each construction scenario.

TABLE 3-1
Passenger Car Equivalency for Each Approach

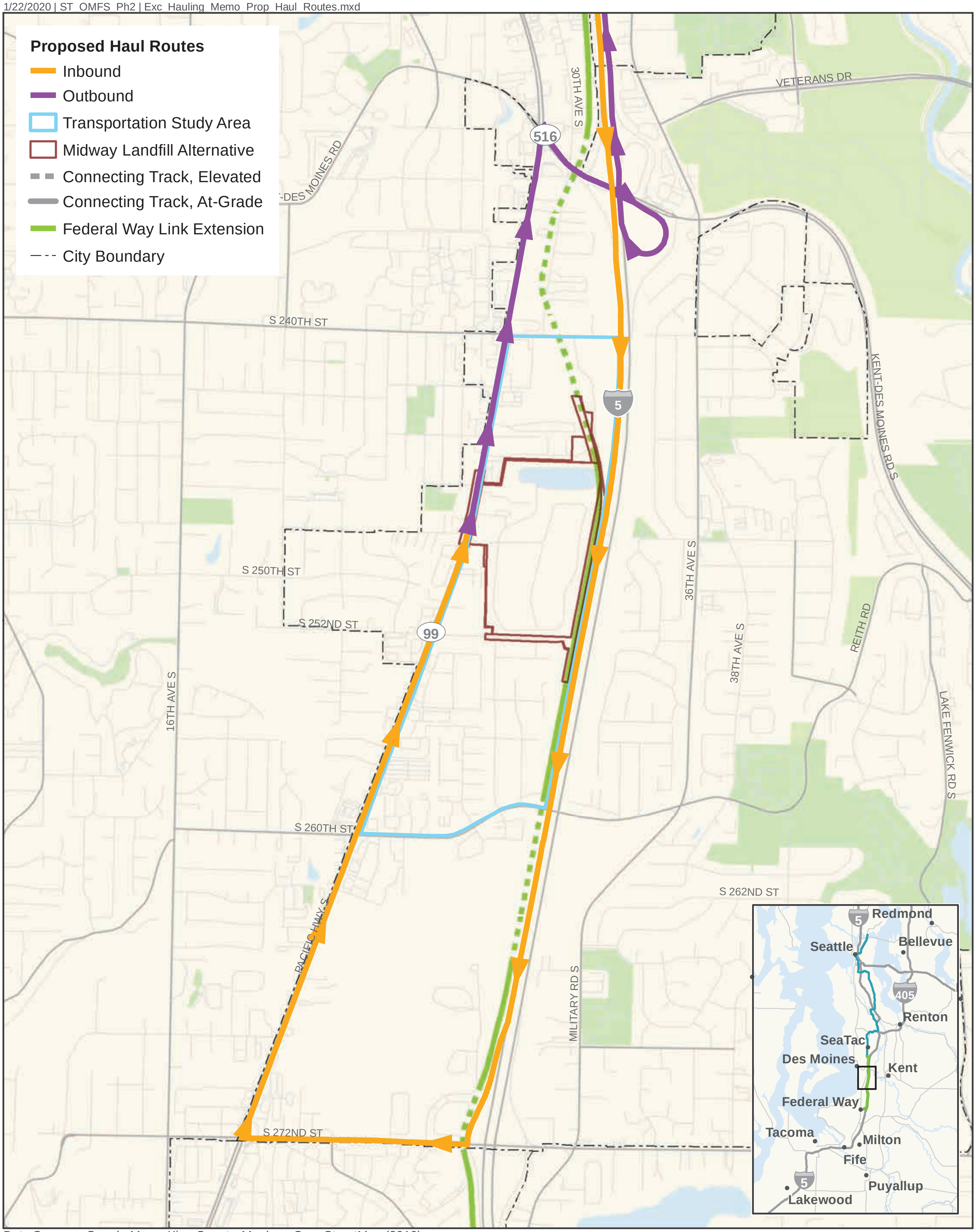
Construction Design Option	Daily			Hourly			Hourly PCE		
	Export	Import	Total	Export	Import	Total	Export	Import	Total
High Platform	13	26	39	2	3	4	5	8	13
Low Platform	7	11	18	1	1	2	3	3	6
Hybrid 1	280	179	459	24	15	39	60	38	98
Hybrid 2	280	74	354	24	7	31	60	18	78
Full Excavation	280	206	486	24	18	42	60	45	105

The PCEs shown in the table would be the same for exiting and entering the site during the peak hour. The highest-impact approach would be the Full Excavation approach, with 105 PCE.

As shown in Figures 3-2 and 3-3, Google Maps reports almost all sections of the haul routes operate at “good” or “fair” conditions during both peak periods (typical traffic on Wednesdays at 7 AM and 5 PM was used to represent the AM and PM peak periods, respectively). The exceptions are northbound SR 99 approaching Kent-Des Moines Road during the 8 AM time period and the eastbound segment of Kent-Des Moines Road at the northbound I-5 on-ramp, which operate at “poor” conditions during the AM peak period, as does the I-5 mainline. If 100 to 105 additional PCE vehicles join the backup congestion on the I-5 northbound ramp during peak hours, congestion on Kent-Des Moines Road and possibly onto SR 99 would likely occur. Dispersing the export associated with High Platform and Low Platform options over the shaft installation duration could avoid significant degradation of the operating conditions. Hybrid 2 may how some degradation of the operating conditions. Some example strategies to reduce impacts to local traffic could include: use multiple routes; limit truck activity during the peak traffic hours; and change the end point location to be south.

Given the good or fair operating conditions for other segments of the haul routes, it is assumed that the additional 105 hourly PCE trips for each route would not result in significant degradation to the operating conditions in these areas.

Trucks would enter and exit the site via SR 99. When trucks exit the facility and merge into traffic on SR 99, they would operate at slower speeds due to heavy loads. Returning trucks would also slow down to make the turn into the facility causing minor delays. In order to reduce potential impacts to mainline traffic on SR 99 at the access point, a short acceleration lane could be constructed to accommodate outbound trucks and a short deceleration lane could be constructed to accommodate inbound trucks.



Data Sources: Google Maps, King County, Mapbox, OpenStreetMap (2019).

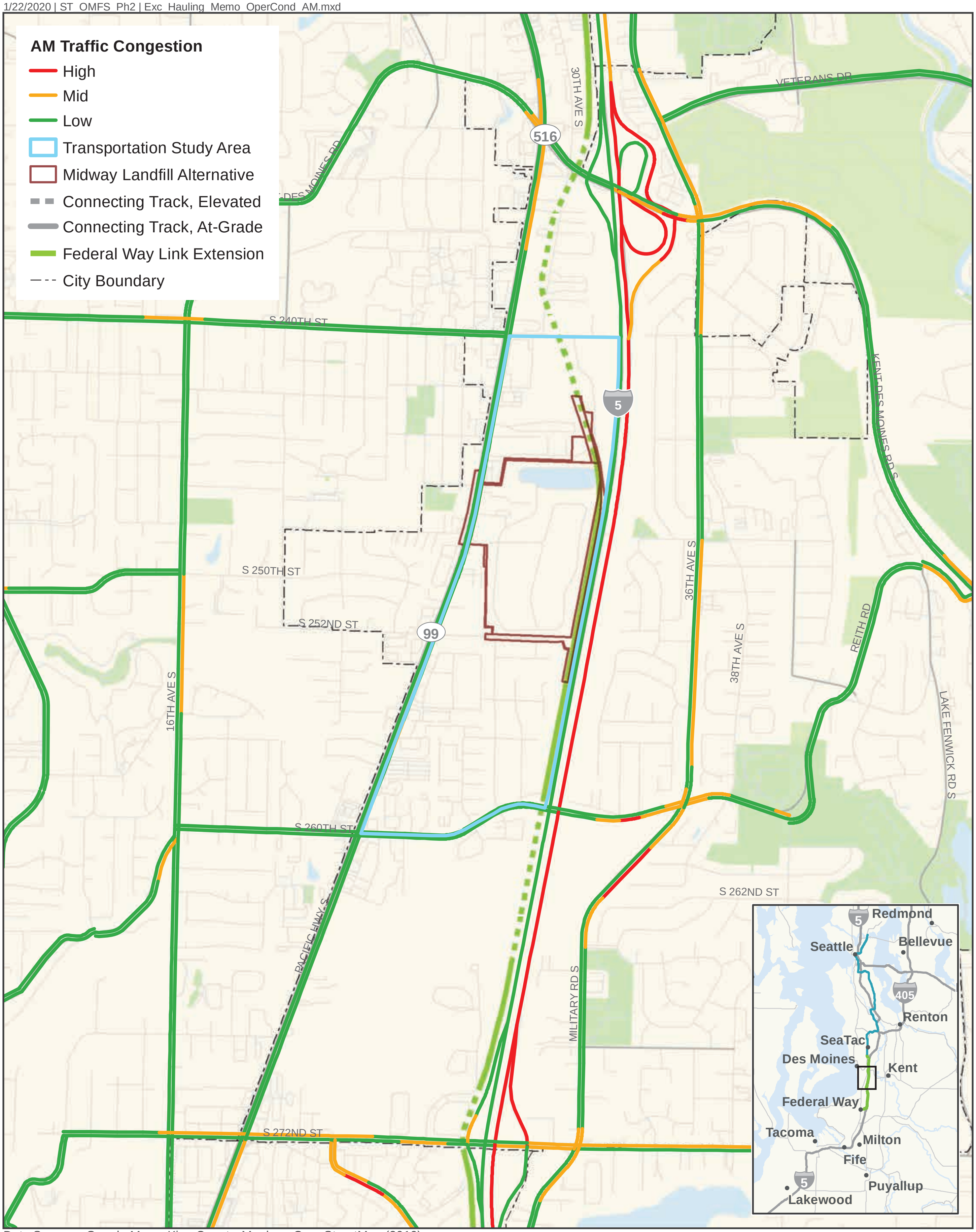
FIGURE 3-1
Proposed Haul Routes
Midway Landfill Alternative

N

0 0.25 0.5 Miles

OMF South

Internal document for the purposes of informing the design and construction approach for the Midway Landfill Alternative



Data Sources: Google Maps, King County, Mapbox, OpenStreetMap (2019).

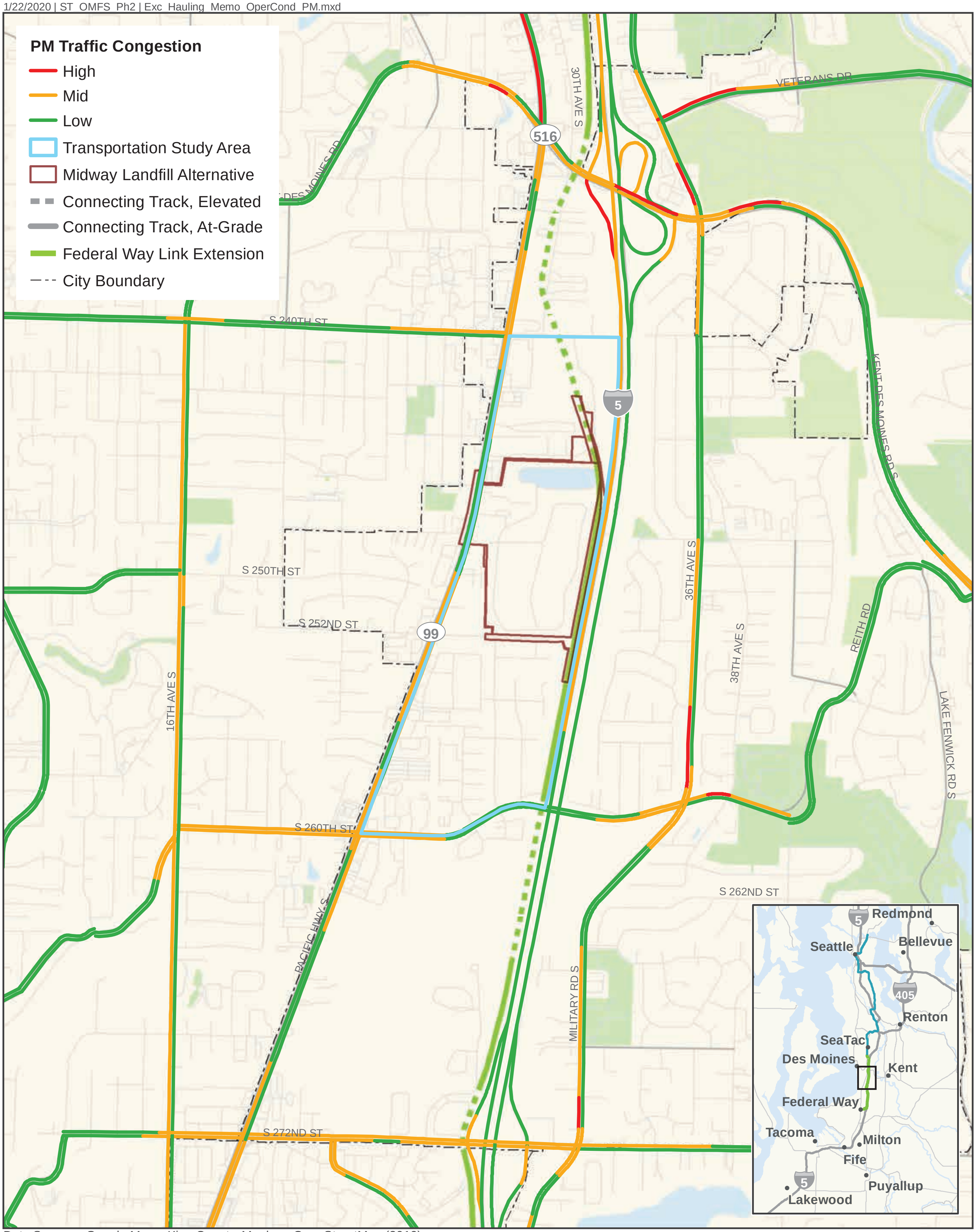
N

0 0.25 0.5 Miles

FIGURE 3-2
AM Operating Conditions
Midway Landfill Alternative

OMF South

Internal document for the purposes of informing the design and construction approach for the Midway Landfill Alternative



Data Sources: Google Maps, King County, Mapbox, OpenStreetMap (2019).

FIGURE 3-3
PM Operating Conditions
Midway Landfill Alternative

OMF South

N
0 0.25 0.5 Miles

Internal document for the purposes of informing the design and construction approach for the Midway Landfill Alternative

4.0 Schedule

Preliminary, planning-level schedules were developed for the five landfill options as part of the landfill site engineering optimization. The schedules have been revised to include the results of the landfill preparation durations and are included as Figures 4-1 through 4-5. Table 4-1 provides a results summary.

TABLE 4-1
Landfill Preparation Schedule Summary

Construction Design Option	Landfill Preparation Component (years)	OMF South Completion	Contract Delivery Method
High Platform	2.8	Apr 2027	DB
Low Platform	3.2	Oct 2027	DB
Hybrid 1	3.2	Feb 2028	DBB/DB
Hybrid 2	2.7	Sept 2027	DBB/DB
Full Excavation	3.3	Dec 2028	DBB/DB

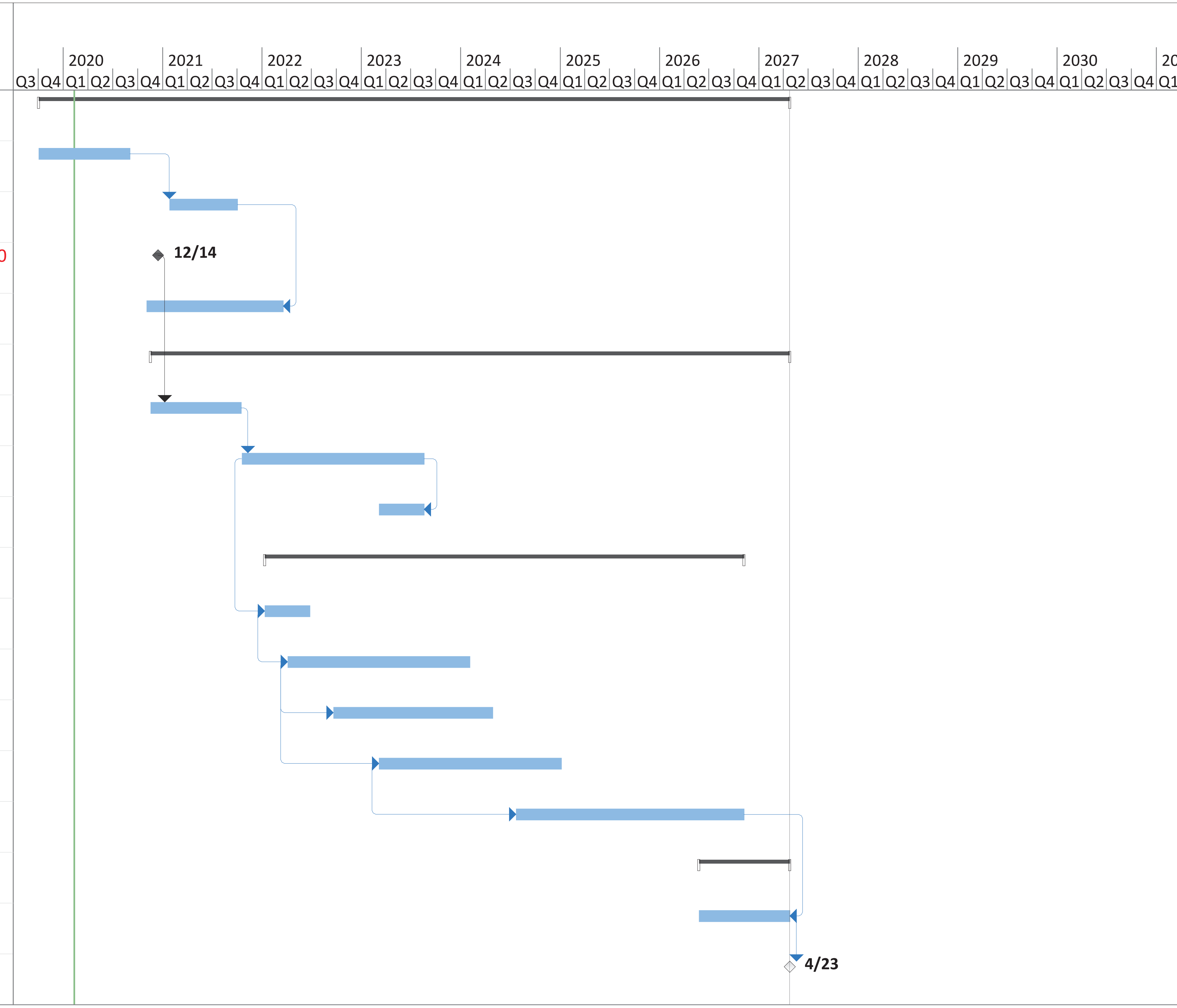
The schedule durations for the landfill preparation component in Table 4.1 generally consist of a combination of earthwork, landfill environmental controls, and shaft and slab installation activities, as applicable to each construction approach. These construction activities are generally overlapped as a result of the assumed construction phasing. Durations for the landfill preparation component of the overall construction schedule for each option will continue to be optimized as construction sequencing opportunities are further refined.

The preliminary schedule for each option assumes construction implementation through a design-bid-build (DBB) delivery for landfill preparation and design-build (DB) delivery for the OMF South building and track construction. Other schedule considerations pertaining to the landfill preparation are as follows:

1. The current target completion for the OMF South is 2026. None of the current Midway Landfill subsurface construction design options have a schedule that will meet this completion timeframe.
2. There may be an advantage in separating the landfill preparation construction from the OMF South construction. The landfill preparation could begin prior to completion of the OMF South design, which would provide an earlier construction start and result in earlier OMF South completion. An estimate of potential schedule benefit has not been prepared and is beyond the scope of this memorandum.

3. The construction contractor procurement process may require extension due to the complexity of the intermodal export and rail transport requirements. Establishing realistic bid pricing may require 6 months or more.
4. If improvements to an existing intermodal facility are required, or a new facility is required, then the schedule will be extended. It may be possible to have a reduced export rate initially, until intermodal facility construction is complete and full export can begin.
5. The schedule assumes construction phasing will provide enough flexibility and resiliency in the work to avoid delays due to changed conditions, such as encountered hazardous material.
6. The schedule assumes no significant environmental issues would be encountered that could stop the work, such as a landfill fire or contamination release.
7. The schedule assumes no significant rail transport disruptions that could stop the work.
8. The construction progress will be highly dependent on the construction contractor's means and methods to plan and execute the work. Achievable performance requirements will need to be established in the construction contract.

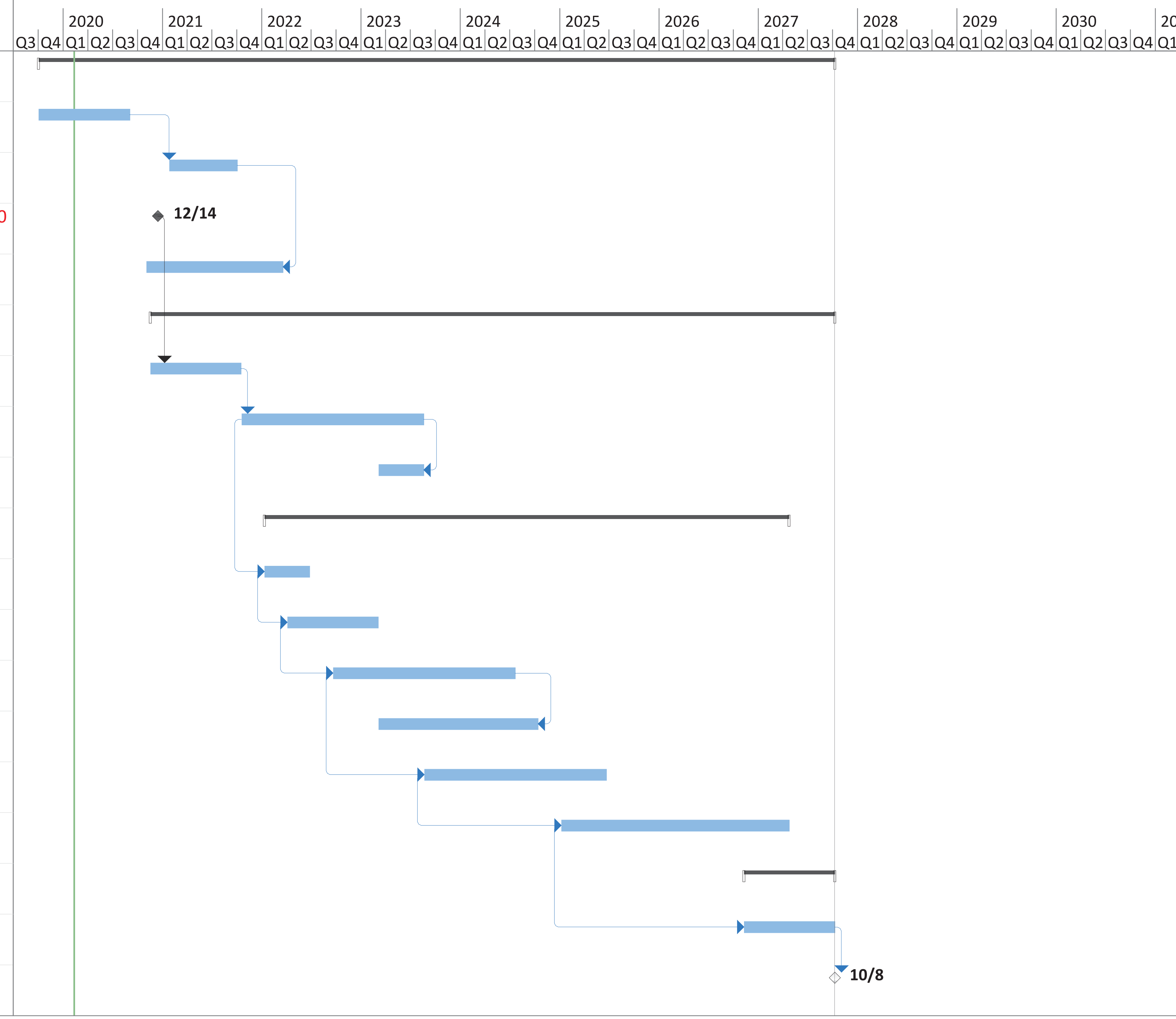
ID	Task Mode	Task Name	Duration	Start	Finish
1		**OMFS Midway High Slab Option**	**1973 days**	**Wed 10/2/19**	**Fri 4/23/27**
2		Phase 2 - Draft Environmental Impact Study	12 mons	Wed 10/2/19	Tue 9/1/20
3		Phase 3 - Final Environmental Impact Study	9 mons	Mon 1/25/21	Fri 10/1/21
4		Board Confirms Preferred Alternative	0 days	Mon 12/14/20	Mon 12/14/20
5		Property Acquisition	18 mons	Mon 11/2/20	Fri 3/18/22
6		**DB Delivery Option**	**1680 days**	**Mon 11/16/20**	**Fri 4/23/27**
7		DB - Contractor Procurement	12 mons	Mon 11/16/20	Fri 10/15/21
8		Engineering Design for DB	24 mons	Mon 10/18/21	Fri 8/18/23
9		FWLE Change order for Guideway	6 mons	Mon 3/6/23	Fri 8/18/23
10		**Construction**	**1260 days**	**Mon 1/10/22**	**Fri 11/6/26**
11		Site Prep for Construction	6 mons	Mon 1/10/22	Fri 6/24/22
12		Drilled shaft construction	24 mons	Mon 4/4/22	Fri 2/2/24
13		Landfill membrane repair	21 mons	Mon 9/19/22	Fri 4/26/24
14		Slab Construction	24 mons	Mon 3/6/23	Fri 1/3/25
15		DB-Build OMF with Tracks	30 mons	Mon 7/22/24	Fri 11/6/26
16		**Testing and Commissioning**	**240 days**	**Mon 5/25/26**	**Fri 4/23/27**
17		Testing and Commissioning	12 mons	Mon 5/25/26	Fri 4/23/27
18		Begin Operation	0 mons	Fri 4/23/27	Fri 4/23/27



Project: A! Shedule
Date: Tue 2/11/20

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	Manual Progress
Summary	Inactive Task	Duration-only	Finish-only	

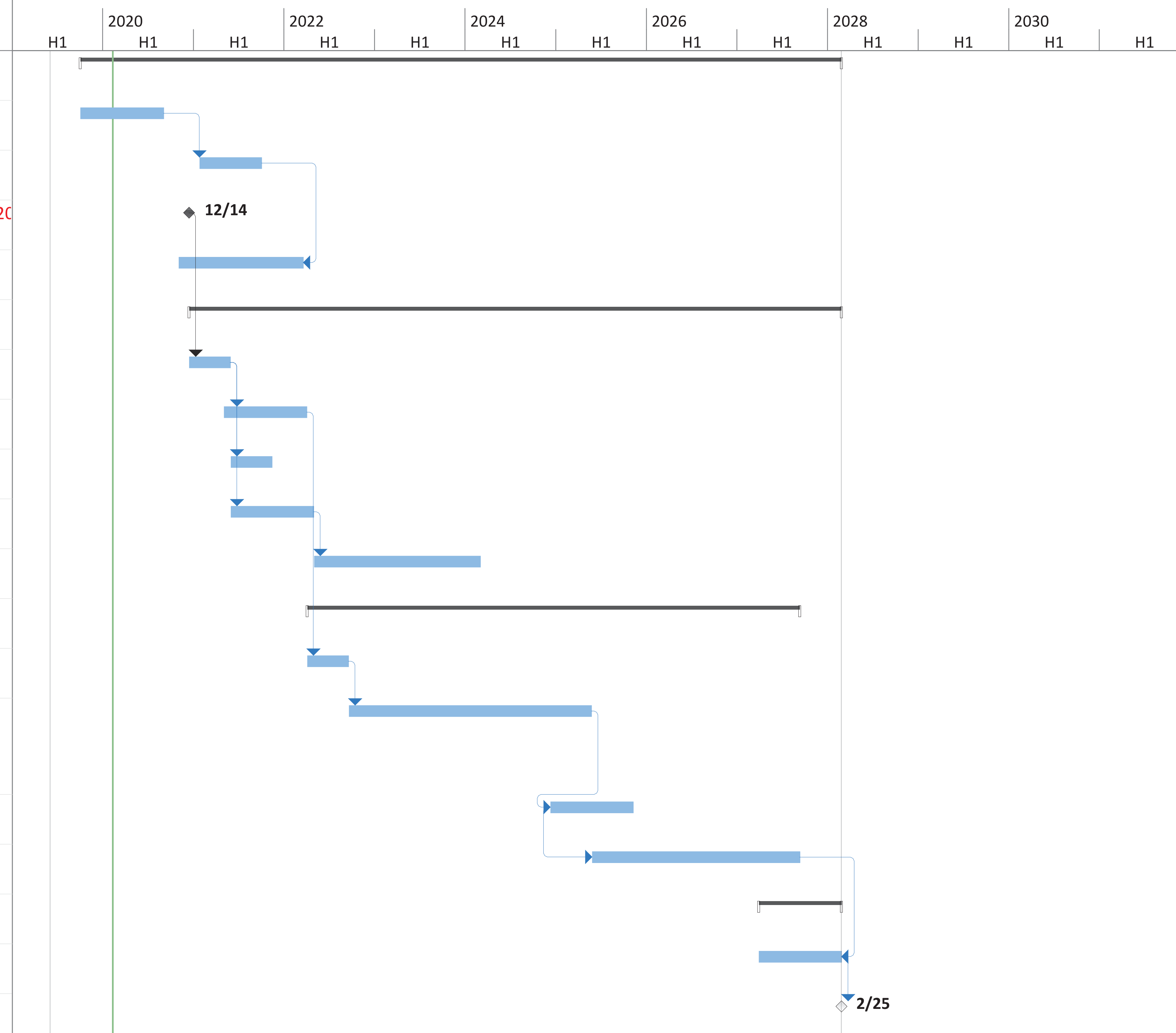
ID	Task Mode	Task Name	Duration	Start	Finish
1		**OMFS Midway Low Slab Option**	**2093 days**	**Wed 10/2/19**	**Fri 10/8/27**
2		Phase 2 - Draft Environmental Impact Study	12 mons	Wed 10/2/19	Tue 9/1/20
3		Phase 3 - Final Environmental Impact Study	9 mons	Mon 1/25/21	Fri 10/1/21
4		Board Confirms Preferred Alternative	0 days	Mon 12/14/20	Mon 12/14/20
5		Property Acquisition	18 mons	Mon 11/2/20	Fri 3/18/22
6		**DB Delivery Option**	**1800 days**	**Mon 11/16/20**	**Fri 10/8/27**
7		DB -Contractor procurement	12 mons	Mon 11/16/20	Fri 10/15/21
8		DB - Final Design	24 mons	Mon 10/18/21	Fri 8/18/23
9		FW Change Order	6 mons	Mon 3/6/23	Fri 8/18/23
10		**Construction**	**1380 days**	**Mon 1/10/22**	**Fri 4/23/27**
11		Site Prep for Construction	6 mons	Mon 1/10/22	Fri 6/24/22
12		Heavy Civil - landfill grading and leveling	12 mons	Mon 4/4/22	Fri 3/3/23
13		Drilled Shaft construction	24 mons	Mon 9/19/22	Fri 7/19/24
14		Landfill membrane repair	21 mons	Mon 3/6/23	Fri 10/11/24
15		Slab Construction	24 mons	Mon 8/21/23	Fri 6/20/25
16		Build OMF with Tracks	30 mons	Mon 1/6/25	Fri 4/23/27
17		**Testing and Commissioning**	**240 days**	**Mon 11/9/26**	**Fri 10/8/27**
18		Testing and Commissioning	12 mons	Mon 11/9/26	Fri 10/8/27
19		Begin Operation	0 mons	Fri 10/8/27	Fri 10/8/27



Project: A! Shedule
Date: Tue 2/11/20

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	Manual Progress
Summary	Inactive Task	Duration-only	Finish-only	

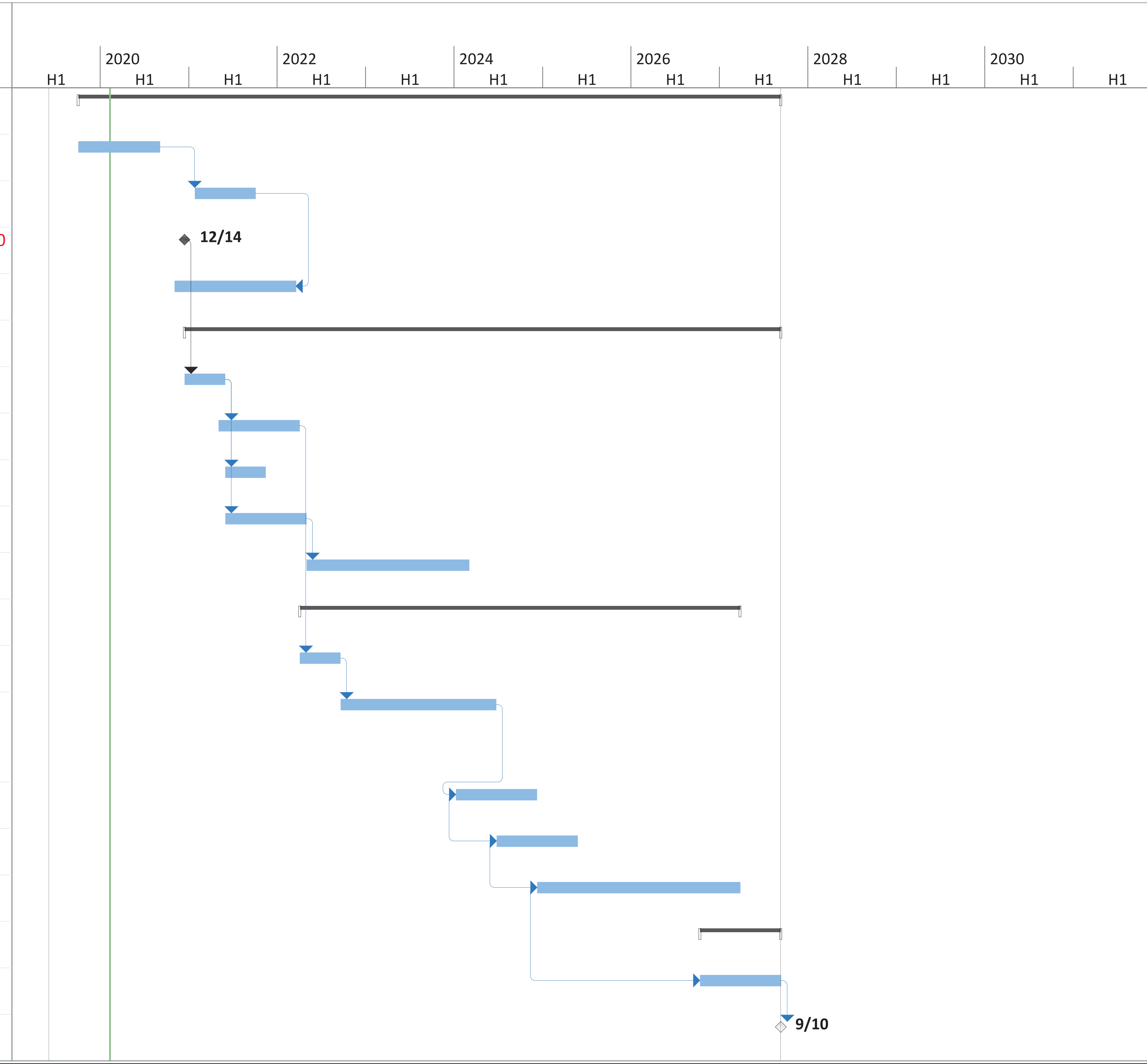
ID	Ta Mo	Task Name	Duration	Start	Finish
1		**OMFS Midway Hybrid #1 no-Slab Option**	**2193 days**	**Wed 10/2/19**	**Fri 2/25/28**
2		Phase 2 - Draft Environmental Impact Study	12 mons	Wed 10/2/19	Tue 9/1/20
3		Phase 3 - Final Environmental Impact Study	9 mons	Mon 1/25/21	Fri 10/1/21
4		Board Confirms Preferred Alternative	0 days	Mon 12/14/20	Mon 12/14/20
5		Property Acquisition	18 mons	Mon 11/2/20	Fri 3/18/22
6		**DBB/DB Delivery Option**	**1880 days**	**Mon 12/14/20**	**Fri 2/25/28**
7		Design and RFP Prep	6 mons	Mon 12/14/20	Fri 5/28/21
8		DBB - Contractor Procurement	12 mons	Mon 5/3/21	Fri 4/1/22
9		FWLE Change order for Guideway	6 mons	Mon 5/31/21	Fri 11/12/21
10		DB -Contractor procurement	12 mons	Mon 5/31/21	Fri 4/29/22
11		DB - Final Design	24 mons	Mon 5/2/22	Fri 3/1/24
12		**Construction**	**1420 days**	**Mon 4/4/22**	**Fri 9/10/27**
13		DBB- Site Prep for Construction	6 mons	Mon 4/4/22	Fri 9/16/22
14		DBB-Heavy Civil - landfill remove, haul, membrane, gas system	35 mons	Mon 9/19/22	Fri 5/23/25
15		DB - Pile Construction for Buildings	12 mons	Mon 12/9/24	Fri 11/7/25
16		DB-Build OMF with Tracks	30 mons	Mon 5/26/25	Fri 9/10/27
17		**Testing and Commissioning**	**240 days**	**Mon 3/29/27**	**Fri 2/25/28**
18		Testing and Commissioning	12 mons	Mon 3/29/27	Fri 2/25/28
19		Begin Operation	0 mons	Fri 2/25/28	Fri 2/25/28



Project: A! Shedule
Date: Tue 2/11/20

Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress
Manual Progress

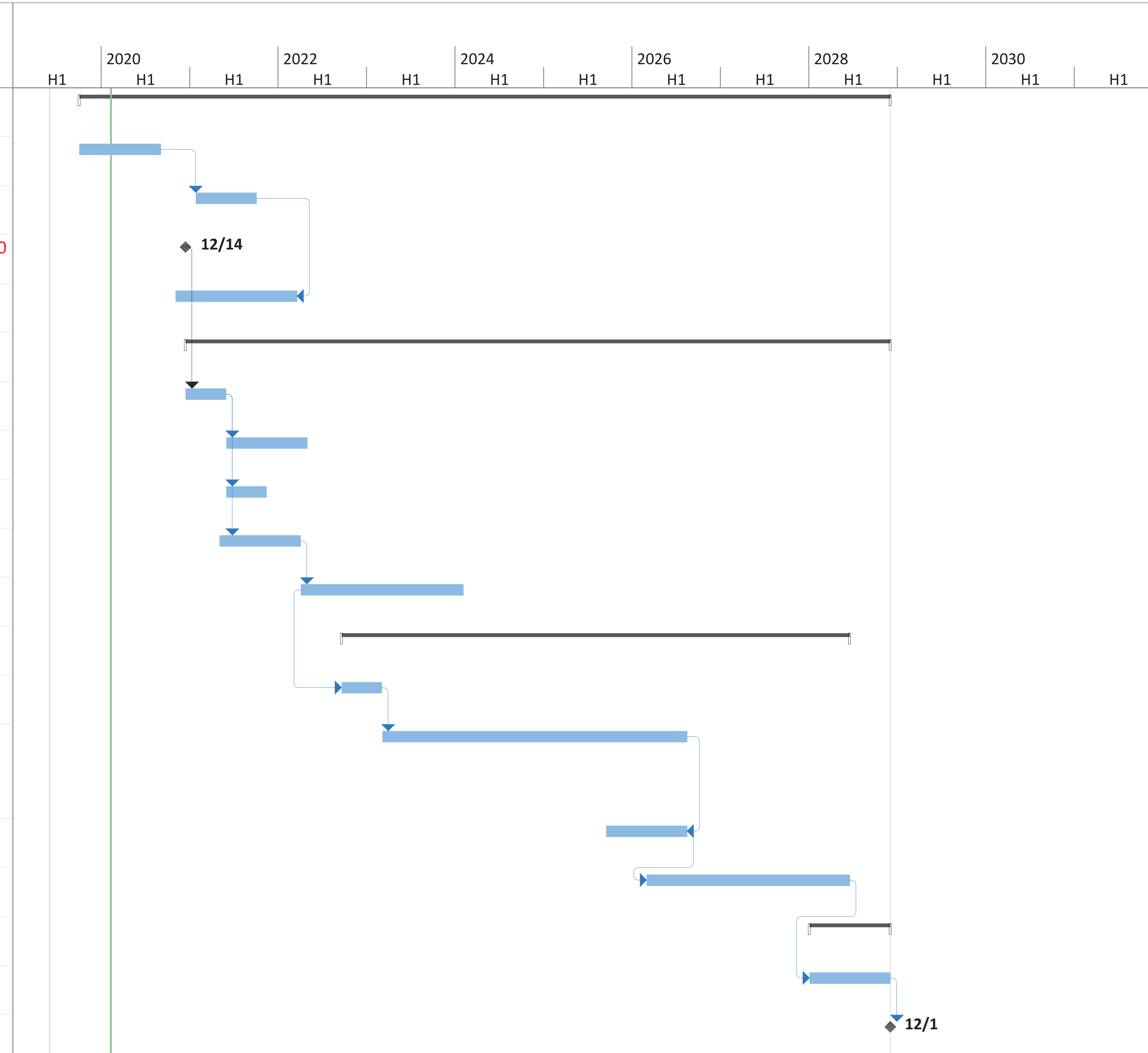
ID	Task Mode	Task Name	Duration	Start	Finish
1		**OMFS Midway Hybrid #2 with Slab Option**	**2073 days**	**Wed 10/2/19**	**Fri 9/10/27**
2		Phase 2 - Draft Environmental Impact Study	12 mons	Wed 10/2/19	Tue 9/1/20
3		Phase 3 - Final Environmental Impact Study	9 mons	Mon 1/25/21	Fri 10/1/21
4		Board Confirms Preferred Alternative	0 days	Mon 12/14/20	Mon 12/14/20
5		Property Acquisition	18 mons	Mon 11/2/20	Fri 3/18/22
6		**DBB/DB Delivery Option**	**1760 days**	**Mon 12/14/20**	**Fri 9/10/27**
7		Engineering Design for DBB	6 mons	Mon 12/14/20	Fri 5/28/21
8		DBB - Contractor Procurement	12 mons	Mon 5/3/21	Fri 4/1/22
9		FWLE Change order for Guideway	6 mons	Mon 5/31/21	Fri 11/12/21
10		DB -Contractor procurement	12 mons	Mon 5/31/21	Fri 4/29/22
11		DB- Final Design	24 mons	Mon 5/2/22	Fri 3/1/24
12		**Construction**	**1300 days**	**Mon 4/4/22**	**Fri 3/26/27**
13		DBB- Site Prep for Construction	6 mons	Mon 4/4/22	Fri 9/16/22
14		DBB-Heavy Civil - landfill remove, haul, membrane, gas system	23 mons	Mon 9/19/22	Fri 6/21/24
15		DBB - Slab on Grade	12 mons	Mon 1/8/24	Fri 12/6/24
16		DB - Pile Construction for Buildings	12 mons	Mon 6/24/24	Fri 5/23/25
17		DB-Build OMF with Tracks	30 mons	Mon 12/9/24	Fri 3/26/27
18		**Testing and Commissioning**	**240 days**	**Mon 10/12/26**	**Fri 9/10/27**
19		Testing and Commissioning	12 mons	Mon 10/12/26	Fri 9/10/27
20		Begin Operation	0 mons	Fri 9/10/27	Fri 9/10/27



Project: A! Shedule
Date: Tue 2/11/20

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress | Manual Progress

ID	Task Mode	Task Name	Duration	Start	Finish
1		**OMFS Midway Full Excavation**	**2393 days**	**Wed 10/2/19**	**Fri 12/1/28**
2		Phase 2 - Draft Environmental Impact Study	12 mons	Wed 10/2/19	Tue 9/1/20
3		Phase 3 - Final Environmental Impact Study	9 mons	Mon 1/25/21	Fri 10/1/21
4		Board Confirms Preferred Alternative	0 days	Mon 12/14/20	Mon 12/14/20
5		Property Acquisition	18 mons	Mon 11/2/20	Fri 3/18/22
6		**DBB/DB Delivery Option**	**2080 days**	**Mon 12/14/20**	**Fri 12/1/28**
7		Engineering Design for DBB	6 mons	Mon 12/14/20	Fri 5/28/21
8		DBB - Contractor Procurement	12 mons	Mon 5/31/21	Fri 4/29/22
9		FWLE Change order for Guideway	6 mons	Mon 5/31/21	Fri 11/12/21
10		DB -Contractor procurement	12 mons	Mon 5/3/21	Fri 4/1/22
11		DB - Final Design	24 mons	Mon 4/4/22	Fri 2/2/24
12		**Construction**	**1500 days**	**Mon 9/19/22**	**Fri 6/16/28**
13		DBB- Site Prep for Construction	6 mons	Mon 9/19/22	Fri 3/3/23
14		DBB-Heavy Civil - landfill remove, haul, membrane, gas system	45 mons	Mon 3/6/23	Fri 8/14/26
15		DB - Pile/Foundation Construction for Build	12 mons	Mon 9/15/25	Fri 8/14/26
16		DB-Build OMF with Tracks	30 mons	Mon 3/2/26	Fri 6/16/28
17		**Testing and Commissioning**	**240 days**	**Mon 1/3/28**	**Fri 12/1/28**
18		Testing and Commissioning	12 mons	Mon 1/3/28	Fri 12/1/28
19		Begin Operation	0 mons	Fri 12/1/28	Fri 12/1/28



Project: A! Shedule
Date: Tue 2/11/20

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	Manual Progress
Summary	Inactive Task	Duration-only	Finish-only	

5.0 Preliminary Landfill Preparation Cost Estimate

The preliminary, planning-level, rough order of magnitude (ROM) cost estimate pertains to additional work associated with the landfill preparation of each landfill redevelopment approach, including drilled shafts and slab work, as applicable. The cost estimate was prepared to compare the relative cost of the five options. The estimated costs were factored into the landfill site engineering optimization cost estimates to deliver the final project. Table 5-1 provides a summary of landfill preparation and final project delivery costs (in 2019 dollars) for each option. Table 5-2 includes detailed landfill preparation costs.

TABLE 5-1

Landfill Preparation Cost Summary

Construction Design Option	Landfill Preparation Cost	Total Project Cost (in M)
High Platform	$765,090,000	$1,529
Low Platform	$717,280,000	$1,477
Hybrid 1	$550,210,000	$1,295
Hybrid 2	$672,875,000	$1,429
Full Excavation	$748,538,000	$1,512

The estimated landfill preparation costs do not include the following:

1. Costs for mobilization and other construction preparation because these costs are in OMF South construction cost estimates.
2. Possible construction costs associated with the intermodal facility.
3. Costs to adjust OMF South design to address compatibility with the FWLE or modify FWLE.
4. Cost escalation.
5. Design and construction management costs for the landfill preparation.

The Total Project Costs do not include costs associated with connection to the FWLE or modification requirements to FWLE.

TABLE 5-2
Detailed Landfill Preparation Costs

			High Structural Platform		Low Structural Platform		Hybrid 1		Hybrid 2		Full Excavation	
Item	**Unit**	**Unit Price**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Excavation	CY	$5.00	100,000	$500,000	460,000	$2,300,000	2,900,000	$14,500,000	2,900,000	$14,500,000	5,300,000	$26,500,000
Export	TON	$10.00	135,000	$1,350,000	67,500	$680,000	3,105,000	$31,050,000	1,957,500	$19,580,000	3,915,000	$39,150,000
Rail Transport and Disposal	TON	$50.00	135,000	$6,750,000	67,500	$3,375,000	3,105,000	$155,250,000	1,957,500	$97,875,000	3,915,000	$195,750,000
Onsite Screening and Reuse (in-place)	CY	$15.00	0	$0	410,000	$6,150,000	600,000	$9,000,000	1,450,000	$21,750,000	2,400,000	$36,000,000
Import (in-place)	CY	$25.00	0	$0	0	$0	1,320,000	$33,000,000	300,000	$7,500,000	1,920,000	$48,000,000
Wastewater Management (surface water)	GAL	$0.15	1,200,000	$180,000	1,200,000	$180,000	1,200,000	$180,000	1,200,000	$180,000	1,200,000	$180,000
Wastewater Management (dewatering)	GAL	$0.15	0	$0	0	$0	0	$0	0	$0	2,118,506	$318,000
Dynamic Compaction	WK	$40,000	0	$0	0	$0	70	$2,800,000	70	$2,800,000	0	$0
Wet Season ESC	YR	$50,000	0	$0	0	$0	2	$100,000	1	$50,000	3	$150,000
Temporary LFG System	LS	$2,000,000	1	$2,000,000	1	$2,000,000	1	$2,000,000	1	$2,000,000	1	$2,000,000
Permanent LFG System	LS	$2,000,000	1	$2,000,000	1	$2,000,000	1	$2,000,000	1	$2,000,000	1	$2,000,000
Site Grading	AC	$100,000	0	$0	55	$5,500,000	0	$0	0	$0	0	$0
Concrete Shafts and Slabs	LS		1	$345,630,000	1	$312,075,000	0	$0	1	$143,600,000	0	$0
LFG Flare Relocation	LS	$1,000,000	1	$1,000,000	1	$1,000,000	1	$1,000,000	1	$1,000,000	1	$1,000,000
Capping System[1]	AC	$500,000	52	$26,000,000	52	$26,000,000	52	$26,000,000	52	$26,000,000	52	$26,000,000
GW Monitoring System	LS	$1,000,000	1	$1,000,000	1	$1,000,000	1	$1,000,000	1	$1,000,000	1	$1,000,000
Subtotal				**$386,410,000**		**$362,260,000**		**$277,880,000**		**$339,835,000**		**$378,048,000**
Contractor Markup (OH, Prof, General) (20%)				$77,280,000		$72,450,000		$55,580,000		$67,970,000		$75,610,000
Contingency (50%)				$231,850,000		$217,360,000		$166,730,000		$203,900,000		$226,830,000
Tax (10%)				$69,550,000		$65,210,000		$50,020,000		$61,170,000		$68,050,000
Total				**$765,090,000**		**$717,280,000**		**$550,210,000**		**$672,875,000**		**$748,538,000**

[1] Capping system costs include stormwater management and other general construction aspects associated with landfill closure.

6.0 Compatibility with the Known Status of FWLE Construction

If constructed at Midway Landfill, the OMF South will connect to the mainline of the FWLE. The current FWLE mainline design is not at an elevation and grade to allow direct connections to the proposed OMF South lead tracks. The five OMF South landfill options have been designed with the yard at elevations 365 feet (Hybrid 1, Hybrid 2, and Full Excavation), 380 feet (Low Platform), and 408 feet (High Platform). The FWLE will follow the general grade of I-5, while the OMF South will be flat.

There are currently five proposed track connections between the FWLE and the OMF South. To minimize the extent of mainline modification, a third track is proposed running alongside the mainline at an elevation closer to the selected OMF South elevation for compatibility with the yard-connecting tracks. The third track would have a connection to the mainline at the north and south ends only. The connection track would have No. 10 turnouts and be designed for 25 miles per hour. The connecting tracks and yard lead tracks would require a design variance for all vertical curve lengths. There are independent vertical track designs for each of the three OMF South elevation options.

Based on the current FWLE mainline design, irrespective of the construction option selected, the FWLE mainline will need to be modified to enable the connection of OMF South lead track turnouts at the required grade of 2% or less (DCM Rev 5). The extent of mainline modification varies based on the OMF South site elevation, as shown in Table 6-1 below.

TABLE 6-1
Track Summary

	Low Yard Elevation (365')	Medium Yard Elevation (380')	High Yard Elevation (408')
Northern Mainline Modifications*	Up to approximate 8' rise in elevated mainline over 3,200'.	Up to approximate 8' rise in elevated mainline over 3,200'.	Up to approximate 8' rise in elevated mainline over 3,200'.
Southern Mainline Modifications*	Up to approximate 10' lowering of at-grade mainline over 1,900'.	Up to approximate 5' lowering of at-grade mainline over 1,900'. Potential to avoid southern mainline modifications through further optimization.	Up to approximate 5' lowering of at-grade mainline over 1,900'. Potential to reduce southern mainline modifications through further optimization.
Connecting/Third Track**	At-grade connecting track. Steep grades (~6%) and significant cut toward south end. Vertical curve length design variance required.	At-grade connecting track. Moderate grades. Vertical curve length design variance required.	Elevated connecting track. Moderate grades. Vertical curve length design variance required.
Lead Tracks	At-grade lead tracks. North lead track has steep grades (~6%). Vertical curve length design variance required.	At-grade lead tracks. Moderate grades. Vertical curve length design variance required.	Elevated lead tracks connect elevated connecting track to high yard platform. Moderate grades. Vertical curve length design variance required.
Constructability	More complex. Requires deep cut of existing landfill.	Least complex.	More complex. Elevated lead tracks connect elevated connecting track to high yard platform. Complex elevated construction.
Cost	$$$$	$$$	$$$$
Schedule	Potential longer duration.	Medium duration.	Potential longer duration.

*Mainline modifications could be significantly reduced with design variance, allowing turnouts to be placed on greater than 2% grade.

**Connecting track minimizes mainline modifications but limits mainline connections to two locations. Further potential to eliminate third track to reduce lead track lengths and mainline modifications, with some operational impact.

7.0 Potential Settlement

The five options to redevelop the Midway Landfill as the OMF South will have different performance implications pertaining to potential future settlement. Site settlement will have a significant negative impact on the OMF South operation due to light rail tolerances.

Landfilled material will continue to consolidate over time due to the compressive nature of the material, overburden weight, and biodegradation of the material. Settlement will likely be differential, or uneven, throughout a landfill as a result of variable refuse thickness and heterogenus composition of the material. The differential settlement can negatively impact the integrity of building foundations, utilities, roadways, and trackways. The settlement evaluation provided by the Preliminary Geotechnical Engineering Services Report Revised, by GeoEngineers, estimates that the current landfill could have differential settlements ranging from 2 to 12 inches over the next 10 to 15 years.

The five options provide alternative designs to mitigate potential settlement as follows.

High Platform: This option will be designed to support the OMF South buildings and track on drilled shafts into competent native ground below the landfill.

Low Platform: This option will be designed to support the OMF South buildings and track on drilled shafts into competent native ground below the landfill. The option shortens the height of drilled shafts, further increasing stability.

Hybrid 1: This option removes overburden material, which will help offset the compressive loading of the OMF South on the refuse below. The option also removes a portion of the refuse mass below the facility. This will reduce the amount of degradable material. Dynamic compaction of the remaining refuse material will be intended to further compress the material and reduce future settlement. The competent backfill material thickness will help reduce differential settlement of the refuse below, creating a more uniform settlement result. Buildings will be supported on shafts drilled into the competent native ground below the landfill and the track will be supported on improved subgrade. The remaining refuse under the yard areas will have settlement implications due to material degradation and consolidation, potentially requiring operational adjustments to the yard ballast material supporting the tracks and at yard area interfaces with areas not subject to settlement.

Hybrid 2: This option removes overburden material, which will help offset the compressive loading of the OMF South on the refuse below. The option also removes a portion of the refuse mass below the facility. This will reduce the amount of degradable material. Dynamic compaction of the remaining refuse material will be intended to further compress the material and reduce future settlement. The competent backfill material thickness will help reduce differential settlement of the refuse below, creating a more uniform settlement result. Buildings will be supported on shafts drilled into the competent native ground below the landfill and the track supported on an on-grade concrete slab over improved subgrade. The remaining refuse under the yard areas will have settlement implications due to material degradation and consolidation. The provision of an on-grade concrete slab in the yard areas will further mitigate differential impacts; however, impacts may become more pronounced at slab joints and interfaces.

Full Excavation: This option removes the degradable material from the refuse mass and backfills the OMF South subgrade with competent material. Building and track will be supported by the backfilled subgrade. The option should eliminate settlement due to degradation. The depth of fill and irregularity of the large quantity of reused competent landfill material provides potential for long-term consolidation settlement.

Based on the settlement tolerance guidance from Sound Transit, all five options to redevelop the Midway Landfill will be designed to meet the long-term settlement of 1 inch over a period of 50 years, using the data analysis from planned geotechnical borings at the site. The High Platform and Low Platform options and the building portions of Hybrid 1 and Hybrid 2 options will be designed on drilled shafts to prevent settlement greater than 1 inch over a period of 50 years. The deep dynamic compaction associated with the track portions of Hybrid 1 and Hybrid 2 options is expected to have a design specification that will result in waste material compaction such that the long-term settlement of the compacted waste and overlying granular backfill would be less than 1 inch over a period of 50 years. For the Full Excavation option, the granular backfill will require compaction such that the long-term settlement would be less than 1 inch over a period of 50 years.

8.0 Conclusions and Next Steps

This interim memorandum is a high-level discussion of landfill preparation considerations pertaining to the potential redevelopment of the Midway Landfill as the OMF South. The evaluation is presented as possible approaches to the work to better inform decision-making. Assumptions and influencing factors will be dependent on construction contractor means and methods and other project factors.

A construction option evaluation matrix was developed for the five landfill options based on the evaluation sections above. The matrix is included as Table 8-1 and provides a Low (RED), Medium (YELLOW), High (GREEN) rating relative to each construction approach and category. The intent of the matrix is to provide a visual assessment of which subsurface construction design options may stand out as being potentially the most viable for further evaluation in Sound Transit's forthcoming Draft EIS.

Further consideration for the redevelopment of the Midway Landfill site as the OMF South is expected to include confirmation of more assumptions, consideration of upcoming landfill geotechnical and environmental site investigations, and constructability review of the landfill preparation options by a qualified construction contractor.

8.1 Confirm Assumptions

The evaluation of Midway Landfill redevelopment will continue in accordance with Task 9.3.1.16 – Engineering, Solid Waste Engineering, and Task 9.8 – Detailed Evaluation of Landfill Site Reuse. As these tasks are advanced, engineering and regulatory assumptions within this memorandum will continue to be refined to provide a more accurate understanding of the potential options.

Some assumptions are dependent upon construction contractor means and methods for planning and executing the work and will continue to have some uncertainty associated with them until an eventual construction contract is awarded.

8.2 Landfill Investigations

Additional geotechnical borings are being planned at the landfill. These borings may provide some insight into:

1. Depth of clean cover soil,
2. Landfill density,
3. Landfill depth,
4. Percentage of reusable material recoverable through screening,

TABLE 8-1

Subsurface Construction Design Options Evaluation Matrix[1]

Subsurface Construction Design Options	OMF South Settlement Mitigation	Environmental Protection	Ease of Material Disposal	Ease of Construction Phasing	Low Traffic Impacts	FWLE Compatibility	Least Schedule Impacts	Least Additional Cost[2]
Methods	Assessment of the option's ability to reduce future risk of settlement. High (Green) = Mitigation based on structural design, Medium (Yellow) = Mitigation susceptible to remaining refuse and/or reuse material, Low (Red) = Minimal mitigation	Assessment based on reduced risk of exposure to environmental hazards. High (Green) = Minimal contaminants handling and exposure, Medium (Yellow) = Significant onsite contaminants handling and exposure, Low (Red) = Significant onsite and offsite contaminants handling and exposure	Assessment of amount of material requiring offsite export and disposal. High (Green) = Less than 500,000 tons, Medium (Yellow) = Between 500,000 tons to 2,500,000 tons, Low (Red) = More than 2,500,000 tons	Assessment of construction complexity. High (Green) = Some excavation without screening and reuse, Medium (Yellow) = Moderate excavation depth with screening and reuse, Low (Red) = Deep excavation with screening and reuse	Assessment of traffic impacts based on PCEs. High (Green) = Less than 50 PCEs, Medium (Yellow) = Between 51 and 90 PCEs, Low (Red) = Greater than 90 PCEs.	Assessment of complexity for connection to FWLE. High (Green) = Most compatible with FWLE, Medium (Yellow) = Moderately compatible with FWLE, Low (Red) = Least compatible with FWLE	Ability to best meet the original 2026 scheduled facility opening. High (Green) = Opening within 1 year of 2026 target, Medium (Yellow) = Opening within 2 years of 2026 target, Low (Red) = Opening later than 2 years of 2026 target	Assessment of order of magnitude landfill preparation cost. High (Green) = Less than $500 million, Medium (Yellow) = Between $500 million and $700 million, Low (Red) = Greater than $700 million
High Structural Platform with No Excavation	Designed as elevated platform on shafts founded in competent material	Minimally invasive into the landfill, elevated platform with reduced landfill gas exposure	Less than 200,000 tons of export to a landfill	Least amount of landfill excavation	Passenger car equivalency would not significantly degrade operating conditions	OMF lead tracks need to be elevated , increased complexity and cost	Exceeds target 2026 opening by approximately <1 year	Over $700 million in landfill preparation costs
Low Structural Platform with Some Excavation	Designed as elevated platform on shafts founded in competent material	Significant refuse handling, facility interface with landfill surface	Less than 100,000 tons of export to a landfill	Limited work area, low depth of excavation, material screening not required	Passenger car equivalency would not significantly degrade operating conditions	At grade connection, moderate grades, least complexity and cost	Exceeds target 2026 opening by approximately <1 year	Over $700 million in landfill preparation costs
Hybrid 1: Excavation with Ground Improvements (Buildings on Drilled Shafts)	Refuse remains in the subgrade, settlement mitigation, reuse material	Significant refuse handling and export, facility interface with landfill surface	Approximately 3 million tons of export to a landfill	Limited work area, moderate depth of excavation	Passenger car equivalency would degrade northbound operating conditions	At grade connection, steep grades, increased complexity and cost	Exceeds target 2026 opening by approximately <2 year	Over $500 million in landfill preparation costs
Hybrid 2: Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shafts)	Refuse remains in the subgrade, settlement mitigation, reuse material, slab added to mitigate differential settlement	Significant refuse handling and export, facility interface with landfill surface	Approximately 2 million tons of export to a landfill	Limited work area, moderate depth of excavation	Passenger car equivalency would somewhat degrade northbound operating conditions	At grade connection, steep grades, increased complexity and cost	Exceeds target 2026 opening by approximately <1 year	Over $600 million in landfill preparation costs
Full Excavation and Backfill with Competent Soils	Deep fill, reuse, and import material	Significant refuse and wastewater handling and export, facility interface with landfill surface, reduced landfill gas generation	Approximately 4 million tons of export to a landfill	Limited work area, greatest depth of excavation	Passenger car equivalency would degrade northbound operating conditions	At grade connection, steep grades, increased complexity and cost	Exceeds target 2026 opening by approximately <2 year	Over $700 million in landfill preparation costs

[1]Relative comparison between subsurface construction design options at the Midway Landfill. The comparison is not inclusive of other potential OMF South sites.

[2]Cost comparisons do not include costs associated with FWLE connection or modifications required to FWLE.

5. Potential for irregular or hazardous material, and
6. Depth to groundwater.

LFG will also be assessed with regard to human health risk. The temporary penetrations resulting from the geotechnical investigation, LFG probes and wells, and LFG flare inlet will be sampled for methane and contaminants of concern. These data will be used in comparison with historical data to develop a better understanding of current contamination levels within the landfill.

8.3 Constructability Review

A qualified earthwork contractor will evaluate the five options and assumptions to provide a contractor means and methods perspective for planning and executing the work. The industry constructability insight will assist in confirming or refining the assumptions to develop a comprehensive understanding of the requirements associated with each approach.

8.4 Final Landfill Preparation Memorandum

Information pertaining to landfill site reuse beyond the preparation of this memorandum will be documented in a Conceptual Landfill Site Reuse Plan, planned for delivery to Sound Transit in June 2020. The plan will cover the options Sound Transit determines to carry forward for documentation in the project's Draft EIS. The plan will document the evaluation process and discuss the potential property transaction, permitting, schedule, design, risk, health and safety, unknowns, and other considerations that will continue to be developed under Task 9.8 – Detailed Evaluation of Landfill Site Reuse.

9.0 References

GeoEngineers, May 2019, Preliminary Geotechnical Engineering Services Report Revised, prepared for the City of Kent.

HDR, November 2019, Midway Landfill Site Engineering Optimization Report, prepared for Sound Transit.

King County Solid Waste Division, November 2019, 2019 Comprehensive Solid Waste Management Plan.

Sound Transit, June 2018, Design Criteria Manual – Revision 5.

Operations and Maintenance Facility South

Appendix D3: Conceptual Landfill Site Reuse Plan

Federal Transit Administration

SoundTransit

September 2020

OMF SOUTH

Conceptual Landfill Site Reuse Plan

SOUNDTRANSIT

CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

SOUNDTRANSIT

OMF SOUTH

Conceptual Landfill Site Reuse Plan

Prepared for:
Sound Transit

Prepared by:
HDR Engineering, Inc.

September 30, 2020

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Acronyms and Abbreviations

BNSF	Burlington Northern Santa Fe Railroad
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CAP	Cleanup Action Plan
COC	contaminant of concern
COI	contaminant of interest
COPC	contaminant of potential concern
CUP	Conditional Use Permit
DA	Development Agreement
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
FWLE	Federal Way Link Extension
HDPE	high density polyethylene
HHRA	Human Health Risk Assessment
I-5	Interstate 5
LFG	landfill gas
LRV	light rail vehicle
MATA	Memphis Area Transit Authority
MOW	Maintenance of Way
MTCA	Model Toxics Control Act
NEPA	National Environmental Policy Act
NPL	National Priorities List
OMF	operations and maintenance facility
OMF South	Operations and Maintenance Facility South
PCE	passenger car equivalency
RCRA	Resource Conservation and Recovery Act

RCW	Revised Code of Washington
ROD	Record of Decision
ROW	right-of-way
SPU	Seattle Public Utilities
SR	State Route
UP	Union Pacific Railroad
VOC	volatile organic compound
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Units

cy	cubic yard
day/wk	days per week
hr/day	hours per day
lb/cf	pounds per cubic foot
ton/cy	tons per cubic yard
wk/yr	weeks per year

1.0 Introduction

1.1 Project Description

Sound Transit proposes to construct and operate an operations and maintenance facility (OMF) to meet agency needs for an expanded fleet of light rail vehicles (LRVs) identified in *Sound Transit 3: The Regional Transit System Plan for Central Puget Sound*. The Sound Transit Operations and Maintenance Facility South (OMF South) project would be used to store, maintain, and deploy about 144 LRVs for daily service. It would provide facilities for vehicle storage, inspections, maintenance and repair, interior vehicle cleaning, and exterior vehicle washing. Additionally, the facility would receive, test, and commission new LRVs for the entire system.

OMF South would also be used to accommodate administrative and operational functions, such as serving as a report base for LRV operators. Included is a Maintenance of Way (MOW) building for maintenance and storage of spare parts for tracks, vehicle propulsion equipment, train signals, and other infrastructure in addition to storage facilities for the entire Link system. Other facility elements would include employee and visitor parking; operations staff offices; maintenance staff offices; dispatcher work stations; an employee report room; and areas with lockers, showers, and restrooms for both operators and maintenance personnel.

OMF South would need to have tracks connecting to an operating light rail mainline, which in southern King County is the Federal Way Link Extension (FWLE). The length and location of these connecting tracks varies by site alternative.

Three site alternatives for the proposed project are being evaluated in the Draft Environmental Impact Statement: one in Kent and two in Federal Way. These alternatives are named the Midway Landfill Alternative, South 336th Street Alternative, and South 344th Street Alternative, respectively. This plan is focused on the Midway Landfill Alternative.

1.2 Purpose

The Midway Landfill is currently being evaluated as one of three site alternatives in the Draft Environmental Impact Statement for the OMF South project.

The subsurface development of OMF South under the Midway Landfill Alternative will require unique design considerations for remedial environmental controls and to protect the facility against settlement. Landfill-specific design considerations are not required at the other OMF South site alternatives. Three landfill subsurface construction design options (options) are currently being explored for the Midway Landfill Alternative, as described in Section 2.6.

Previously, the Interim Midway Landfill Preparation Memorandum (Sound Transit 2020b) completed in February 2020 studied five options:

1. High Platform – High Structural Platform with No Excavation
2. Low Platform – Low Structural Platform with Some Excavation
3. Hybrid 1 – Excavation with Ground Improvements (Buildings on Drilled Shafts)
4. Hybrid 2 – Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shaft)
5. Full Excavation – Full Excavation and Backfill with Competent Soils

The five options identified in the Interim Midway Landfill Preparation Memorandum have been reduced to three options that address a reasonable and broad range of options for further study in this plan:

1. Low Platform – Low Structural Platform with Some Excavation
2. Hybrid 2 – Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shaft)
3. Full Excavation – Full Excavation and Backfill with Competent Soils

With the exception of cost, schedule, and legal considerations, this plan provides a comprehensive summary of the landfill-specific assessments performed to date in consideration of the Midway Landfill Alternative for the OMF South site. The assessments include regulatory considerations and permitting; landfill preparation requirements; functional design options, including settlement mitigation; operational health and safety; and remaining risks and unknowns. Cost and schedule of the three design options for the Midway Landfill, as well as legal considerations, will be assessed as part of a future process and included in the Basis of Design. Cost and schedule risks for the three design options are discussed in this plan.

This plan advances the findings of the Interim Midway Landfill Preparation Memorandum (Sound Transit 2020b) and summarizes other landfill-specific assessment deliverables to inform the Sound Transit decision-making process during the siting evaluation.

1.3 Midway Landfill Background

The Midway Landfill is a Superfund site owned by the City of Seattle and managed by Seattle Public Utilities (SPU). It is regulated by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) under an existing Consent Decree and Record of Decision (ROD).

As discussed in the Consent Decree, the Midway Landfill was originally a gravel pit, which was operated from 1945 to 1968. SPU began landfill operations at the site in 1966 primarily to accept demolition-type wastes. Landfill operations continued until 1983, when the facility was closed. Approximately 3 million cubic yards (cy) of solid waste, reported to include primarily demolition materials and wood waste, were deposited at the unlined landfill facility. Refuse depths in some areas are up to 130 feet.

Concerns for negative impacts to human health and the environment were identified in 1983 by SPU (when the landfill was closed). Environmental testing indicated landfill gas (LFG) outside the landfill's boundary, and organic and inorganic contaminants were found in groundwater.

An active LFG management system was installed in 1985, and in 1986 the Midway Landfill was placed on the National Priorities List (NPL) due to the groundwater contamination. Listing the site on the NPL provided the EPA with responsible oversight of the facility. Pursuant to the Model Toxics Control Act (MTCA), SPU entered into a Consent Decree with Ecology in 1990 to initiate cleanup work.

A final remedy for the site was identified in a ROD by EPA, with Ecology's concurrence, on September 6, 2000. The identified remedy's aim was to ensure that refuse containment is effective and maintained, groundwater quality is restored beyond the landfill boundary, and no residential exposure to landfill groundwater occurs until standards have been met.

SPU completed landfill closure construction in 1992; however, since the ROD was not signed at that time, construction completion was not officially recognized until September 21, 2000.

SPU has continued to manage and maintain the site with regular environmental reporting, including required Five-Year Review Reports by the EPA and Ecology completed in years 2005, 2010, and 2015.

The Midway Landfill is approximately 60 acres in size with buried refuse on approximately 45 of those acres. The site is situated west of Interstate 5 (I-5) and east of Highway 99 (Pacific Highway South, or State Route [SR] 99) and bounded by residences on the north and south. Some commercial areas are located between SR 99 and the landfill. Based on a February 2007 reuse planning report (City of Seattle 2007) for the Midway Landfill, the landfill reuse potential was summarized as follows:

- Four acres of the site have no refuse and minimal remedy components. These acres front SR 99 and have potential for unrestricted uses in the near term.
- Seven acres have shallow (approximately 50 to 60 feet deep) refuse and have minimal surface remedy components. These acres could potentially be used for surface uses such as a parking lot or active recreation in the future.
- Fourteen acres house the site's LFG flare station and stormwater retention pond, and these will need to remain and be operational into the foreseeable future.
- Nine acres comprise the Washington State Department of Transportation (WSDOT) right-of-way (ROW) that will be used in the future for an I-5 roadway widening for the SR 509 project. Some volume of solid waste is presumed buried on the western edge of this ROW.

- Thirty-seven acres have waste that is moderately or deeply (up to and greater than 90 feet deep) located and have extensive surface remedy components. Alternate land uses in the future may be possible in the long term.

The general fill topography of the landfill provides an elevated, irregular surface that is sloped to drain to steeper side slopes. Components and facilities at the site generally include:

- Landfill Cap: Layers from bottom to top include a 12-inch-thick layer of low permeability (1 x 10^{-7} centimeters per second) soil/clay material, a 50-mil-high density polyethylene (HDPE) geomembrane, drainage geonet, geotextile, a 12-inch-thick drainage layer, and a minimum 12-inch-thick topsoil layer. See Figure 1-1 for the landfill cap section.

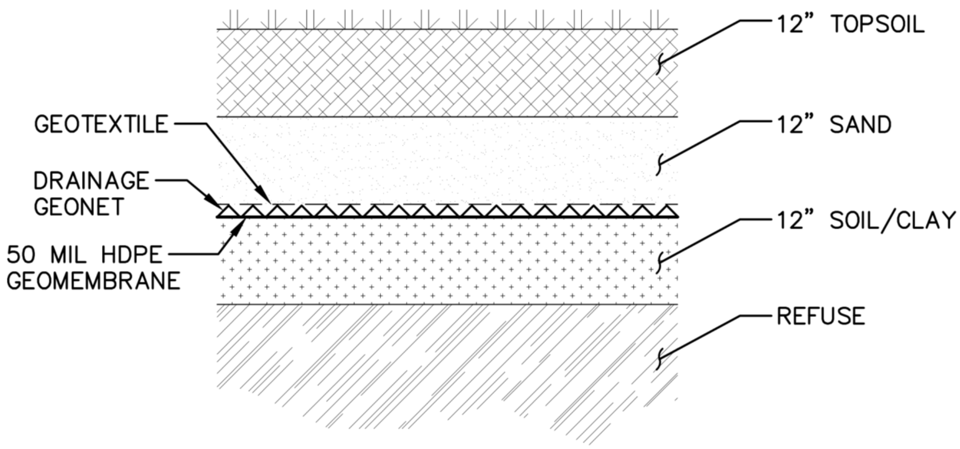

Figure 1-1. Existing Landfill Cap Section

- Landfill Surface Filling and Grading: 2 to 14 feet of soil cover over the refuse.
- The landfill cap is maintained in good condition but continues to experience differential settlement.
- Stormwater Detention: A 3-acre, 60-mil HDPE geomembrane-lined stormwater detention pond to collect landfill runoff and contributions from other areas/facilities. The pond base is below the groundwater level and has a permanent dewatering system. The pond has a discharge line to a downstream system.
- LFG System: LFG is routed to the on-site LFG flare station through header pipes.
    - 87 LFG extraction wells (56 on site and 31 off site). The off-site extraction wells have since been abandoned.
    - 70 off-site LFG monitoring probes (approximately 35 probes have been abandoned).

- Groundwater Monitoring System: The system currently includes wells for water level measurements (68 wells) and groundwater chemistry monitoring (15 wells).

1.4 OMF South Background

OMF South will store, maintain, and deploy a fleet of LRVs. OMF South will service the south and central corridor as the system wide fleet expands to more than 400 total LRVs to serve future expansion and growth in system wide ridership.

The site for the proposed OMF South needs to have the capacity to store and maintain over 144 LRVs. OMF South would contain light rail storage tracks as well as buildings, parking, storage areas, internal roads, landscaping, fencing, setbacks, stormwater facilities, electric transmission lines, and other utilities. OMF South also includes a 5-acre area for maintenance and yard storage, which includes vehicles, equipment, and a 30,000-square-foot building. OMF South needs to have tracks connecting to a light rail line. For the Midway Landfill Alternative, that light rail line is the FWLE.

A more complete description of OMF South physical and functional requirements is available in the Conceptual Basis of Design Report (Sound Transit 2020a). The conceptual site layout of the OMF South facility at the Midway Landfill is shown in Figure 1-2.

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FIGURE 1-2
OMF South Conceptual Site Layout

2.0 Landfill Site Reuse Evaluation

The landfill site reuse evaluation provides initial reuse analyses to gain an improved understanding of the potential impacts of undertaking the construction of OMF South at the Midway Landfill. The evaluation focuses on the following primary elements:

1. Landfill redevelopment feasibility,
2. Regulatory requirements,
3. Experiences at other landfill/contaminated sites,
4. Human health risk assessment,
5. Landfill site engineering and optimization, and
6. Landfill preparation requirements

2.1 Landfill Redevelopment Feasibility

The landfill redevelopment feasibility assessment introduced preliminary technical and regulatory considerations of locating OMF South on a closed landfill site and identified benefits, challenges, and risks associated with this kind of development. The assessment provided a brief background on the typical landfill life cycle and the characteristics of an older, closed landfill. The Midway Landfill was assessed based on available documents to understand the physical nature of the site and the currently imposed environmental and regulatory requirements.

A high-level review of early OMF South conceptual layouts was applied to the site. Considerations for redevelopment design and constructability were discussed, followed by some considerations for site operation and long-term maintenance requirements and potential future Sound Transit employee safety and health considerations. The study also included potential schedule impacts and a review of other facilities that have been redeveloped at landfills or otherwise contaminated sites. Cost considerations were not a component of this early study.

The study was documented in the OMFS Landfill Evaluation Report (Sound Transit 2019a). Following is a brief summary of the findings:

- Based on the evaluation conducted during the study, no criteria had been identified that would eliminate the Midway Landfill with certainty from further consideration for OMF South. Preliminary research into redevelopment projects at Superfund and/or state-led contaminated sites – in particular, other landfill sites – indicated that design and construction of a facility on a closed landfill could be a viable alternative. The fact that the site is a former landfill under state and federal regulatory oversight should not preclude it from continued consideration.

- Preliminary discussions with the property owner and regulators, review of regulatory requirements, and development of assumptions around anticipated site improvements at that time had not identified any major impacts to the design or construction schedule to preclude the OMF South project from being developed on the closed landfill. Potential landfill-related permitting dynamics and site preparation (in advance of construction) would likely be required but could be possible within the overall project schedule provided that they are considered proactively as part of overall design and construction strategy.
- More detailed research into both successful and challenging redevelopment examples at similar sites may provide information that could help inform the design process. It could also circumvent potential challenges previously faced by other landfill and contaminated site redevelopment projects around the country. This research would provide greater insight on cost implications, constructability, geotechnical considerations, and worker health and safety concerns, during both construction and operation.
- A land use attorney with Superfund-related experience should be consulted by Sound Transit to fully understand the retained and transferred liabilities associated with a potential agreement for use of the site. Prior to construction, Sound Transit may consider working with SPU and the governing agencies to proactively establish procedures for evaluating conditions during and after construction to demonstrate that redevelopment activities have resulted in no new impacts at the site.
- Development of OMF South on a closed landfill would require specific design approaches, construction technologies, and modifications to existing environmental controls. For example, the redevelopment conceptual designs for the Midway Landfill at the time of the study would construct OMF South on a reinforced concrete pile-supported platform (Phase 1, High Platform option). The platform would be elevated over the landfill to avoid landfill settlement impacts to OMF South and lessen impacts to the landfill remedial systems. Proactive communication with property owner and regulators, development of a contextual design approach consistent with the regulatory requirements, and efficient construction sequencing would be required to reduce impacts to the design and construction schedule for the development on a closed landfill relative to the overall OMF South project.
- Initial review of employee health and safety considerations indicates there would be limited exposure possibilities to contaminated groundwater and LFG. It will be critical for landfill redevelopment to maintain the existing environmental controls (i.e., LFG

collection system) to limit exposure pathways. Inclusion of additional preventative measures such as building foundation barriers, active and passive ventilation, and continuous methane monitoring in interior workspaces would likely be included in future facility design in addition to the remedial systems associated with the closed landfill. (More details on human health and safety are discuss in Section 2.4 of this plan.)

2.2 Regulatory Requirements

As identified in Section 1.2, the Midway Landfill Alternative possesses unique regulatory considerations due to the environmental liabilities associated with the landfill and its status as a Superfund site.

The Midway Landfill Site is listed as a federal Superfund Site under the National Priorities List. Under a cooperative agreement between EPA and Ecology, and as provided in the ROD, Ecology is the designated lead regulatory agency overseeing the Site and performance of the selected remedial action. The ROD, 5-year reviews, and the recently adopted Cleanup Action Plan Amendment No. 1 (for the FWLE project) identify the Applicable or Relevant and Appropriate Requirements (ARARs), which are the regulatory programs applicable to the former landfill and Site that any cleanup action must demonstrate compliance with under MTCA and the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA).

The primary basis of action under the ROD is groundwater contamination above federal drinking water standards. Original contaminants of concern (COCs) include 1,2-dichloroethane, vinyl chloride, and manganese. During the 2010 to 2015 5-year review period, 1,4-dioxane was detected above MTCA Method B levels and is also considered a potential COC. The OMFS Landfill Evaluation Report (Sound Transit 2019a) provides additional details pertaining to current COCs and required cleanup levels at Midway Landfill.

An established protective remedy is in place at the site, which is reviewed every 5 years during the EPA's standard 5-year review process. The intent of the remedy required by the ROD, in accordance with the requirements of CERCLA of 1980, is to protect human health and the environment, specifically:

- To ensure containment is effective and working. Though not explicitly stated in the ROD, containment refers to containment of the waste by a landfill cap, prevention of surface water infiltration through the landfill cap, and containment of LFG through the LFG extraction system.
- To ensure containment will be maintained when and if major changes are approved by Ecology in operation of the site.
- To return groundwater to drinking water standards and state cleanup standards downgradient of the landfill boundary.

- To ensure no residential exposure to groundwater until groundwater cleanup standards have been met.

Institutional controls require that operation and maintenance of the containment and monitoring systems must continue if the ownership or control of the property should change.

Significant changes to the existing remedies implemented at the landfill would need to be approved by Ecology, in coordination with EPA. Any potential changes would need to maintain the integrity of the remedy and required under the ROD and the Consent Decree. Major changes to the approved remedy could have the potential of reopening of the ROD and resulting in additional administrative and project scheduling challenges.

For the FWLE project, Ecology, in consultation with EPA, issued a Cleanup Action Plan Amendment (CAP Amendment) to describe the cleanup activities required at the site as part of the project. Ecology simultaneously entered into Consent Decrees with SPU (Consent Decree Amendment) and Sound Transit (Prospective Purchaser Consent Decree) to require compliance with the CAP Amendment and address other issues under MTCA. A similar sequence of activities, i.e., CAP Amendment and Consent Decrees, may be applicable for the OMF South project, pending further coordination with Ecology and EPA.

Regulatory coordination with major project stakeholders has already initiated on the potential for siting OMF South on the Midway Landfill. The OMF South project has begun coordinating with EPA and Ecology.

In 2018, Sound Transit met independently with representatives of both EPA and Ecology to discuss the potential development of OMF South at the Midway Landfill. As the lead regulatory agency for Midway Landfill, Ecology will have review and approval authority for any planned operational changes at the site. Based on the discussions in that meeting, if EPA approves the project under Superfund, the development process for Midway Landfill may be exempt from the requirement of the National Environmental Policy Act (NEPA). In addition, the existing ROD may not need to be reopened, if during the course of OMF South construction, the integrity of the existing, in-place remedies are maintained. It should be noted that a NEPA process for the project may be required by the Federal Highway Administration (FHWA) for airspace crossing of WSDOT land or other reasons outside the scope of this landfill evaluation.

In October 2019, Sound Transit and the broader project team, including SPU, met with Ecology to provide the regulators with an update of the OMF South project and redevelopment strategies being considered for Midway Landfill and to discuss the regulatory path forward if the project were advanced at the site. At the time, five subsurface construction options were being considered, as discussed in Section 2.5. Detailed information on the five options is available in the Midway Landfill Site Engineering Optimization Report (Sound Transit 2019b).

General feedback received by Sound Transit from Ecology pertaining to the redevelopment of Midway Landfill as OMF South was as follows.

- Removal and replacement of the landfill cap is feasible provided the project can demonstrate the ability to control the site and mitigate risks associated with construction methodologies consistent with the existing ROD and Consent Decree. Methodologies must be protective of human health and the environment.
- Ecology would be supportive of the redevelopment and provide resources to try to facilitate Sound Transit's schedule; however, no regulatory review durations were expressed.
- Ecology would allow reuse of solid waste on site.
- Ecology was accepting of the subsurface construction approaches presented provided they are implemented in a protective manner.
- The regulatory process was expected to be similar to the Midway Landfill work associated with FWLE, which required an amendment to the CAP and simultaneous Consent Decrees.

The Seattle-King County Department of Public Health will need to be provided the opportunity to review requested operational changes at the site.

From a project management perspective, regulatory coordination could be assessed as most significant for the Midway Landfill Alternative in its potential to impact project delivery. Significant schedule impacts come from incorporating the timelines associated with development of the legal documents, including CAP and ROD Amendments and Consent Decrees, into the OMF South project schedule. The main timing issue with the additional environmental agreements and approvals relates to the inability of the project to begin ground-disturbing activities on site to prepare for construction of the OMF building prior to agency adoption of the CAP and/or ROD Amendments, judicial entry of the Consent Decrees, and finalization of other agreements. Timing for adoption of the CAP and/or ROD Amendments, entry of the Consent Decrees, and finalization of other agreements is currently estimated to be approximately 1 year if led by Ecology, and approximately 2 years if led by EPA, starting after Preferred Alternative identification for the project in 2021. Ecology is currently anticipated as the lead agency. Construction is anticipated to begin in 2023 with operations beginning in the late 2020s.

If the Midway Landfill Alternative is advanced, ongoing and effective coordination with Ecology and EPA will be needed to ensure that the regulatory agencies are informed about the proposed design and construction approach and are prepared to approve the proposed environmental controls to be implemented during construction and at facility completion through CAP and/or ROD Amendments. Feedback will be needed from these agencies to determine what regulatory requirements will be prompted by the proposed approaches and to identify if there is an approach that may be preferable from a regulatory standpoint. Additional outcomes will be to determine a realistic approval process, approval requirements, and project milestone schedule.

A key objective of this communication will be to maintain the work within the existing regulatory framework (i.e., ROD). Additionally, acceptable construction approaches will need confirmation to determine landfill preparation impacts to the schedule and cost of the project. Current assumptions pertaining to landfill preparation requirements are discussed in Section 2.6.

Furthermore, to operate a future OMF within the City of Kent, Sound Transit would also need to develop and execute a Transit Way Agreement with the City of Kent to grant Sound Transit the right to own, operate, and maintain transit facilities in the public ROW within the City of Kent. And lastly, Sound Transit would need to negotiate and execute a Development Agreement (DA) with the City of Kent or apply for and receive a Conditional Use Permit (CUP) to establish land use and permit the OMF South construction. A DA, or CUP, would outline applicable city code requirements and development standards and would allow code departures and any required project mitigation in addition to any mutually agreed-upon enhancement partnerships related to multimodal access or otherwise. The City of Kent permitting requirements are not unlike the requirements of the other two site alternatives in Federal Way.

2.3 Experiences at Other Landfill/Contaminated Sites

Potential similar sites were researched on a limited basis to attempt to gain an understanding of the experiences of others and lessons learned that could inform and improve the OMF South design and operation if constructed at the Midway Landfill. The research could also provide insights on regulatory considerations, construction technologies, assessments related to public/employee health and safety, and monitoring. A similar site was generally considered a redeveloped contaminated site with an emphasis on rail transit and landfills.

The initial review of other landfill/contaminated sites that were redeveloped was performed as part of the OMFS Landfill Evaluation Report (Sound Transit 2019a). The report reviewed readily available internet data and found 22 example projects across the United States with some similarity to the OMF South project being developed at Midway Landfill. Most of the readily available data were limited in general to project overviews and status summaries of the redevelopment efforts. Specific details on regulatory challenges, permitting requirements, constructability considerations, and overarching health and safety concerns (both during construction and after redevelopment) were limited. Many of the redeveloped sites reviewed were relatively new, and long-term redevelopment-related studies (e.g., settlement issues, contamination migration, worker health and safety impacts, etc.) were not readily available.

The list was reduced to 16 representative developments, as shown in Table 2-1, more closely matching the Midway Landfill site, specifically on a closed landfill or former Superfund site.

TABLE 2-1
Other Landfill/Contaminated Site Redevelopments

Site Description	Location	Redevelopment
Munisport Landfill Superfund Site	North Miami, Florida	Two 25-story towers of luxury condominiums and several commercial businesses
Ringwood Mines/Landfill Superfund Site	Ringwood, New Jersey	Businesses, an industrial refuse disposal area, a municipal recycling center, the Ringwood Borough garage, a state park, and 50 private homes
Conrail Rail Yard Superfund Site	Elkhart, Indiana	Rail yard and associated maintenance facilities
Operating Industries, Inc. Landfill Superfund Site	Monterey Park, California	Commercial and retail operations
PJP Landfill Superfund Site	Jersey City, New Jersey	Prologis distribution center and structural supports for the Pulaski Skyway
Syosset Landfill Superfund Site	Oyster Bay, New York	Salt storage, storage, parking, sanitation vehicle refueling facility
Rossman Landfill	Oregon City, Oregon	Golf course, Discount Tire Store, and Home Depot (additional commercial development in the planning stages)
Cobb's Quarry Landfill	Beaverton, Oregon	Single- and multi-family homes
Northwest 58th Street Landfill Superfund Site	Hialeah, Florida	Numerous municipal-related office and operational facilities
Ogden Railroad Yard Superfund Site	Ogden, Utah	Museums, art galleries, shops, restaurants, and commuter rail line infrastructure
Western Pacific Railyard Superfund Site	Oroville, Washington	Maintenance shop, active rail line, and public drinking water well
Kentwood Landfill Superfund Site	Kentwood, Michigan	Two-story, 46,000 square foot public library facility
Santa Clara Landfill	Santa Clara, California	240-acre mixed use complex (commercial and residential)
Contaminated Site	St. Paul, Minnesota	Green Line Light Rail Transit OMF
Contaminated Site	St. Paul, Minnesota	Southwest Light Rail Transit Rail Support Facility
South Park Landfill	Seattle, Washington	Seattle South Transfer Station

Sound Transit contacted the facility owners to collect information related to their past landfill redevelopment experience. Seven of the redevelopments responded and were interviewed about their contaminated site redevelopment experience to obtain additional points of reference to better understand the advantages and disadvantages of reusing a landfill site. Sound Transit was also interested in better understanding possible long-term health impacts tied to reusing the former landfill sites and whether any special studies were required during the planning and permitting of landfill site redevelopment.

The information collected demonstrated that numerous landfill/contaminated sites have been successfully redeveloped. Several sites have also been redeveloped to support transportation infrastructure expansion, including projects where light rail and other transit infrastructure was installed. However, none of the site redevelopments significantly reflected the combined Midway Landfill site characteristics and the operational requirements of the OMF South project. For example, a rail facility developed on a stable, but contaminated, site will not require the same settlement considerations as if developed on a landfill.

There was general consensus from respondents regarding certain aspects of landfill site reuse, specifically that permitting processes were longer than for typical site development, given the requirements for coordination, review, and approval of contaminated site reuse.

None of the respondents reported knowledge of any human health-related concerns from working at or living within the redevelopment communities.

In addition to the OMFS Landfill Evaluation Report (Sound Transit 2019a), three other facility redevelopments were researched: a transit park-and-ride at McCollum Park in Snohomish County, Washington, a bus operations and maintenance facility in Memphis, Tennessee, and a mixed-use commercial/residential development in Everett, Washington.

The park-and-ride lot was of interest because it was locally known for settlement issues. In researching the site, the lot was constructed on the Emander Landfill. The landfill stopped receiving waste in 1967, and the waste mass was approximately 20 feet deep. Information was not readily available online as to any design and construction mitigation being performed at the site prior to lot construction. The site was not considered relevant to the OMF South project beyond emphasizing that settlement is expected to occur at former landfill sites.

The bus operations and maintenance facility is owned by the Memphis Area Transit Authority (MATA) and constructed on the Bellevue Landfill, with waste material 20 to 30 feet thick. Landfilling stopped in 1977, followed by facility construction in 1979. The site has experienced ongoing settlement requiring significant facility improvements to keep the facility operational. The buildings were constructed on piles, which has created large differential settlement at the building interfaces with the remaining unmitigated site infrastructure (i.e. the buildings have remained at the general installed elevation and the rest of the site has settled and pulled away from the buildings). LFG generation has also been an issue at the facility with ignitions and explosions during construction. Neither settlement nor LFG were properly mitigated during facility design and construction. No site-wide stabilization measures were instituted, and only LFG sensors and fans were installed in the buildings to account for methane generation. This site is relevant to the OMF South project as an example of the importance of engineered mitigation measures that are required for successful construction on landfills.

The mixed-use commercial/residential development is at the Everett Landfill and includes two adjacent properties. The project is in the planning stages and is expected to include construction of up to 900,000 square feet of mixed commercial use; 200,000 square feet of hotel space; and up to 1,400 residential units. The plan was approved by the Everett City Council on May 1, 2019.

The project will need to address ground settlement, human health and safety, regulatory, and legal risks similarly identified for the OMF South project if constructed at Midway Landfill. The current planned subsurface construction approach for the site is a temporary surcharge placed over the refuse area to further consolidate the material and reduce future settlement. Buildings will be constructed on piles. Construction requirements are expected to include:

- Environmental controls and health and safety requirements to be implemented during excavation including stormwater management, dust and odor control and waste handling;
- Landfill cap requirements that prevent infiltration into contained waste and prevent direct contact with waste;
- Installation and maintenance of an active LFG collection system below the cap that prevents LFG from entering enclosed spaces where it can be an explosive risk;
- Pile foundation requirements that protect underlying groundwater from migration of landfill leachate;
- Operational requirements for the existing leachate collection system to prevent leachate from entering the river; and
- Surface water management requirements to prevent infiltration into underlying waste and to prevent erosion of the surface materials.

The Everett Landfill redevelopment has not been completed but continues to advance. If Midway Landfill is selected as the preferred site for the OMF South, the Everett Landfill project could provide further information on the process and mitigation that will be required for landfill redevelopment.

2.4 Human Health Risk Assessment

A Midway Landfill Human Health Risk Assessment (HHRA) (Sound Transit 2020c) was performed for the OMF South project. The HHRA evaluated potential chronic health risks to Sound Transit personnel who work at the future site should it be selected for OMF South and waste be maintained on site. Non-toxicological hazards, including acute, physical risks associated with constructing and operating OMF South over a waste mass, were also discussed.

At the time of the HHRA, five landfill subsurface construction design options were being considered. In order to streamline the exposure assessment step of the HHRA and the non-toxicological hazards evaluation, the five subgrade construction design options were grouped into three future development concepts for OMF South based on the potential exposures associated with each construction design option. Human health risks were evaluated for the development concept that represents the worst-case exposures scenario based on current site conditions and potentially complete routes of exposure. The three concepts are described as follows.

Concept 1: OMF South built on an elevated structural platform. This concept includes an elevated platform constructed on shafts or pilings that are installed through the landfill cap and the underlying waste material. The landfill cap will be restored at penetrations and the gas system and other environmental controls will be preserved. This concept represents the High Platform option.

Concept 2: OMF South built on a slab on the surface of the landfill following full excavation and removal of underlying landfill waste. This concept includes removal of the landfill cap and underlying solid waste, screening and reuse of contaminated, but competent, soils contained in the landfill as fill, reconstruction of the landfill cap, reconstruction of environmental controls, and construction of a slab foundation. This concept represents the Full Excavation option.

Concept 3: This concept is a combination of Concepts 1 and 2 and will include removal of the landfill cap, partial removal of underlying solid waste, screening and reuse of contaminated, but competent, soils contained in the excavated portion of the landfill as fill, reconstruction of the landfill cap, reconstruction of environmental controls, and construction of the OMF South on a combination of slab foundation and an elevated platform on shafts or pilings. This concept represents the Low Platform, Hybrid 1, and Hybrid 2 options.

Based on evaluation of the historic available site data and supporting documents, the groundwater and LFG methane datasets were determined to be of sufficient quality and reliability for use in this risk assessment. However, based on the data evaluation for this HHRA, it was determined that the LFG data for volatile organic compounds (VOCs) and toxic inorganic gases were not representative of current, or future, site conditions, as they were collected more than 25 years ago from the LFG extraction system and, thus, do not accurately represent concentrations of volatile gases to which future workers may be exposed. In addition, data collected from the LFG extraction system do not provide an appropriate measure of the concentrations that workers may be exposed to at OMF South. Below is the summary of findings from the HHRA. The HHRA should be reviewed in its entirety for a complete understanding of the exposure and toxicological assessments and non-toxicological hazards evaluation. Due to the lack of recent LFG VOC data, an April 2020 sampling event was performed as discussed below.

The HHRA found that occupational exposures to VOCs in groundwater and to methane in LFG are not expected to result in adverse chronic health effects for any OMF South worker.

However, the potential risk of adverse chronic health effects associated with occupational exposures to contaminants of interest (COIs) in LFG could not be characterized due to a lack of representative data. In order to quantify occupational risk at OMF South, post-construction sampling of VOCs and toxic inorganic gases is needed (e.g., sub-slab soil gas and/or indoor air sampling) to provide an appropriate measure of the concentrations that workers may be exposed to at OMF South. Appropriate engineered protections for occupational exposures will need to be developed based on the final selected OMF South subsurface construction design option.

The non-toxicological hazards (methane explosion risk, seismic considerations, and hazards associated with construction activities) evaluated for the Midway Landfill can largely be managed through appropriate engineered protections, health and safety protocols, construction design standards, and site control and environmental protection plans. Risk management approaches for non-toxicological hazards will need to be developed based on the final selected OMF South subsurface construction design option.

Subsequent to the HHRA development, a limited, one round of select LFG sampling was performed in April 2020. The sampling and results were discussed in a Midway Landfill Human Health Risk Assessment Addendum (Sound Transit 2020d) to the HHRA and are summarized below.

The LFG analysis included samples collected directly from the LFG extraction system: one combined sample from the manifold to the flare inlet and eight from individual LFG extraction wells. In addition, two opportunistic air grab samples were collected in areas where the landfill cap had been breached during a geotechnical investigation. The intent of the LFG investigation was to provide Sound Transit with information about the types and concentrations of VOCs and inorganic gases found in LFG at the Midway Landfill under current site conditions.

Data limitations that impact the interpretation and application of these data in site characterization and risk assessment were identified during the data evaluation process. These limitations include a relatively small number of LFG sample locations within a large area (>60 acres), potential selection bias, temporal limitations associated with a one-time sampling event, limited understanding of the underlying waste type and conditions and applied vacuum pressure and resulting radius of influence for sampled wells, and limitations of using VOC concentrations found in the LFG extraction system to quantify occupation exposures and risk at OMF South.

The April 2020 LFG extraction system sample results indicate that several VOCs remain in LFG at the site; however, the VOCs with the highest concentrations in 2020 (benzene, ethylbenzene, and hydrogen sulfide) have decreased substantially since 1988, but continue to exceed one or more regulatory screening level.

VOC results from the manifold and extraction wells and from co-located wells demonstrate that concentrations can vary significantly by depth and by location throughout the landfill footprint. The sampled extraction wells with the highest concentrations of benzene, ethylbenzene, and hydrogen sulfide include those north of the planned OMF South main building (GW-42S and GW-42D) and within the east side of the planned OMF South main building (GW-48S and GW-48D).

The April 2020 LFG sampling event did not provide any new information that would result in a change in the current conceptual site model. The primary source of contaminants of potential concern (COPCs) at the site, chemical release mechanisms and environmental transport processes, and potentially complete routes of exposure for specific occupations at OMF South remain the same as those presented in the HHRA.

As discussed above and in the HHRA, samples collected directly from the LFG extraction system are not representative of VOC concentrations in subsurface gas that could pose an unacceptable risk to indoor air quality. The LFG extraction system samples should not be used to quantify occupational exposures and resulting risk. As a result, the April 2020 pre-construction sampling results were not used to identify subsurface soil gas COPCs.

However, because hydrogen sulfide was detected at relatively high concentrations in LFG samples during the April 2020 sampling event, a toxicity profile for hydrogen sulfide is included in the HHRA Addendum. Overall, the HHRA findings and conclusions have not changed by inclusion of the Midway Landfill Human Health Risk Assessment Addendum.

As stated in the HHRA findings, the migration of LFG through the subsurface to indoor and ambient air is currently controlled by the LFG extraction system and the landfill cap. Continued operation and maintenance of all components of the remedy is required if any portion of the property is sold, leased, transferred, or otherwise conveyed. As a result, it is expected that future development of OMF South at the Midway Landfill, if refuse remains, would include an LFG system and landfill cap and other engineered protections to mitigate and monitor vapor intrusion of LFG (including methane) to indoor air.

2.5 Landfill Site Engineering and Optimization

In Phase 1 of siting OMF South, high-level redevelopment concepts for the Midway Landfill Alternative were generated. As the Midway Landfill Alternative was advanced to Phase 2 in the evaluation process, additional engineering and site optimization was performed to more realistically evaluate the alternative. This effort is captured in the Midway Landfill Site Engineering Optimization Report (Sound Transit 2019b) and the Conceptual Basis of Design Report (Sound Transit 2020a).

The Midway Landfill Site Engineering Optimization Report summarized the development of a preferred site layout and five potential subsurface construction design options. The landfill design optimization included two workshops focused on ground-settlement solutions.

The first workshop introduced the Phase 1 Midway Landfill Alternative OMF South concepts and Sound Transit's operational and maintenance criteria (Sound Transit 2018) for the facility to a broad stakeholder group which included representatives from Sound Transit, SPU, City of Seattle, City of Kent, City of Federal Way, WSDOT, and various consultants . Based on this information, the workshop developed a range of concepts that could potentially improve the Phase 1 designs and mitigate settlement risk.

Sound Transit advanced OMF South design options based on the first workshop and presented the results to the same group of stakeholders in a second workshop. The second workshop reviewed the first workshop proposed settlement solutions and Sound Transit's evaluation process. Sound Transit presented initial Phase 2 design concepts for further discussion.

At the conclusion of the second workshop, the cross sections for the initial design concepts were modified resulting in the following five potential subsurface construction design options.

- High Platform – High Structural Platform with No Excavation
- Low Platform – Low Structural Platform with Some Excavation
- Hybrid 1 – Excavation with Ground Improvements (Buildings on Drilled Shafts)
- Hybrid 2 – Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shaft)
- Full Excavation – Full Excavation and Backfill with Competent Soils

The five options would generally share the same horizontal OMF South layout. The design options were further refined through the 10% design process, as discussed in the Conceptual Basis of Design Report (Sound Transit 2020a) and the landfill preparation assessment captured in the Interim Midway Landfill Preparation Memorandum (Sound Transit 2020b). The assessment of Alternatives Evaluation Matrix developed for the Interim Midway Landfill Preparation Memorandum resulted in the five options being reduced to three options that address a reasonable and broad range of options for further study, which are discussed in Section 2.6.

The 10% design process primarily advanced the OMF South site layout and optimum site grading to connect to FWLE mainline as well as track design for lead tracks for all three design options. The structural design of shafts and slabs was advanced based on updated design loads, design criteria on settlement, and geotechnical data. Additional geotechnical data were also used to determine the maximum depth of landfill material to remain in place and be deep dynamic compacted to meet settlement criteria for the Hybrid 2 option. The original geotechnical data were supported by additional geotechnical investigations as detailed in the OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e).

2.6 Landfill Preparation Requirements

The Interim Midway Landfill Preparation Memorandum (Sound Transit 2020b) was prepared to assess the landfill preparations required to implement the five potential subsurface construction design options at Midway Landfill that were developed during the landfill optimization process.

Since the development of the Interim Midway Landfill Preparation Memorandum, geotechnical technical investigations have been performed at Midway Landfill to further define evaluation assumptions, the design has been advanced to approximately 10% design, and a landfill preparation constructability review was conducted. The geotechnical investigation and 10% design efforts are documented in the OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e) and Conceptual Basis of Design Report (Sound Transit 2020a), respectively.

This section generally follows the organization of the Interim Midway Landfill Preparation Memorandum, with the exception of the original five potential subsurface construction design options being reduced to three. The current three potential subsurface construction design options being considered include:

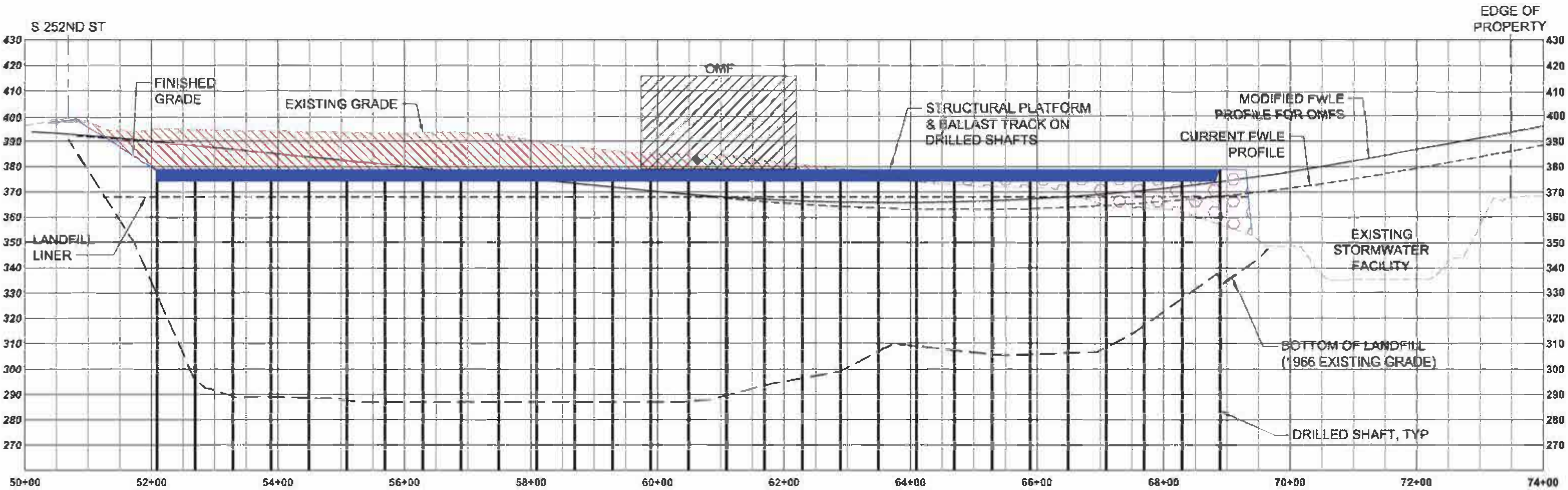
- Low Platform – Low Structural Platform with Some Excavation
- Hybrid 2 – Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shaft)
- Full Excavation – Full Excavation and Backfill with Competent Soils

The High Platform – High Structural Platform with No Excavation was eliminated in preference of the Low Platform option based on the Low Platform elevation compatibility for the connection to the FWLE main line. The Hybrid 1 – Excavation with Ground Improvements (Buildings on Drilled Shafts) was eliminated due to similarities to Hybrid 2 and a preference for the Hybrid 2 slab on grade for the tracks.

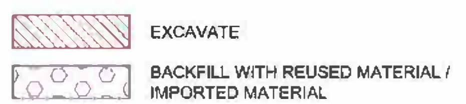
2.6.1 Three Landfill Subsurface Construction Design Options

Each of the three OMF South subsurface construction design options at Midway Landfill generally has the same horizontal layout and surface features as shown in Figure 1-2. The three options primarily vary in subgrade and foundation concepts. The three options are shown in Figures 2-1 through 2-3. The options are consistent with those described in the Conceptual Basis of Design Report. The report should be reviewed for more detail pertaining to the OMF South project and the design of each construction option.

1 LOW STRUCTURAL PLATFORM WITH SOME EXCAVATION



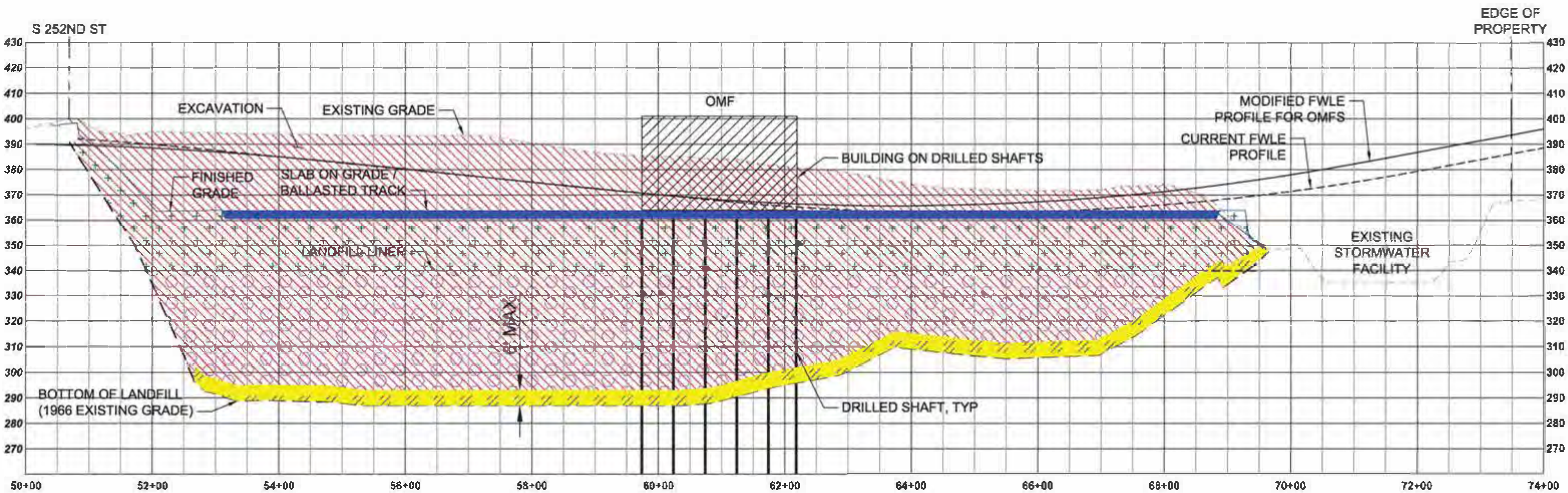
Low Platform (380 TOR, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	1.01	0.16		
Borrow Fill				
Screen (40% reusable)	0.85	0.51		0.34
Total		0.67	0.00	0.34



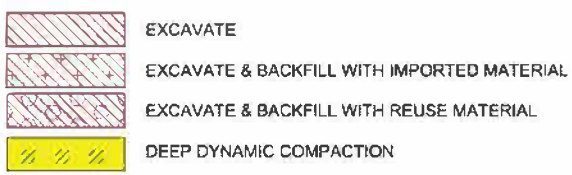
Assumptions:
- 40% of excavated material is reusable onsite based on 30% to 50% range recommended in Geotechnical Report
- Rough grading targeting 1' below finished grade
- Depth from bottom of structural platform to top of rail = 69"
- Total embedment depth of 10' diameter drilled shaft varies from 120' to 215' depending on the depth of landfill
- Includes 0.3 million CY of excavation for drilled shafts

FIGURE 2-1

2 HYBRID 2: EXCAVATION WITH GROUND IMPROVEMENTS (SLAB ON GRADE FOR TRACKS AND BUILDINGS ON PILES)



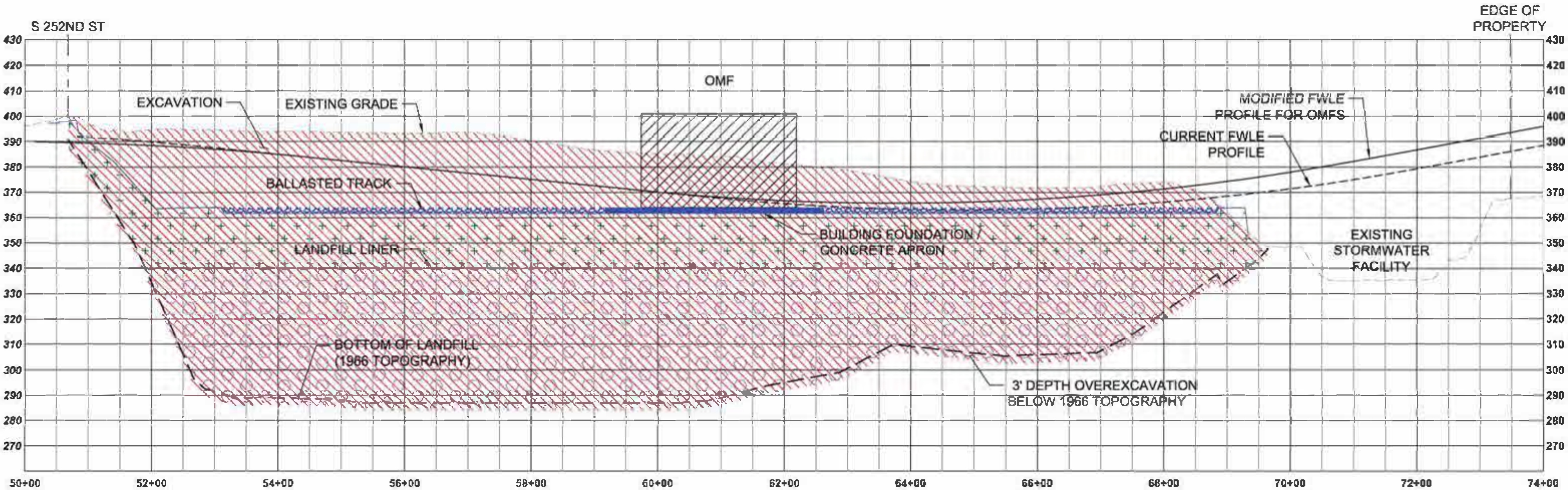
Hybrid (365 TOR, 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	4.27			
Borrow Fill			1.24	
Screen (40% reusable)	4.27	2.56		1.71
Total		2.56	1.24	1.71



Assumptions:
- 40% of excavated material is reusable onsite based on 30% to 50% range recommended in Geotechnical Report
- Rough grading targeting 1' below finished grade
- Depth from bottom of concrete slab to top of rail = 39"
- Maximum depth of deep dynamic compaction = 6' (depth reduced from 40 feet to 6 feet based on geotechnical recommendation to meet 0.75" settlement over 50 years)
- Includes 0.05 million CY of excavation for drilled shafts

FIGURE 2-2

3 FULL EXCAVATION & BACKFILL WITH COMPETENT SOILS



Full Excavation (365 TOR 356 MOW FFE)				
	(Millions of Cubic Yards in Place)			
	Total	Haul	Import	Reuse
Excavation	4.87	0.20		
Borrow Fill			1.69	
Screen (40% reusable)	4.67	2.80		1.87
Total		3.00	1.69	1.87

Assumptions:
-40% of excavated material is reusable onsite based on 30% to 50% range recommended in Geotechnical Report
-3' depth of overexcavated material assumed to be unsuitable for reuse onsite
-Rough grading targeting 1' below finished grade
-Depth from bottom of ballast material to top of rail = 27"
-Depth of overexcavation = 3' below 1966 survey

FIGURE 2-3

2.6.2 Construction Evaluation

The construction evaluation is a high-level discussion of landfill subsurface construction design options pertaining to the Midway Landfill Alternative for the OMF South Draft Environmental Impact Statement. The discussion is based on operations and maintenance requirements, available information, and reasonable assumptions intended to develop a planning-level comparison among the three design options. If the Midway Landfill Alternative advances, assumptions will be further refined to create a more detailed assessment of landfill preparation requirements.

The discussion presents possible subsurface construction approaches for the three design options to develop planning-level estimates of earthwork and structural requirements and inform the traffic analysis. Assumptions and influencing factors may vary depending on construction contractor means and methods and regulatory requirements.

2.6.2.1 Earthwork Process

Materials anticipated to be encountered during landfill excavation include clean cover soil, landfill cap geosynthetic materials, and refuse material. Clean cover soil can be temporarily stored on site for reuse during OMF South construction. Landfill cap geosynthetics and refuse material excavated will require one of the following:

1. Export and disposal off site,
2. Relocation on site, or
3. On-site material screening to retain competent soils for reuse on site and export of deleterious materials for disposal off site.

According to the OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e), the average unit weight within the refuse ranged from 50 to 90 pounds per cubic foot (lb/cf), or 1.01 tons per cubic yard (ton/cy). For calculation purposes, the evaluation used an average in-place unit weight of refuse of 75 lb/cf. The loosening of material during the excavation process is assumed to result in a lower average material density; however, it is assumed that 30 tons of export material per container will be achievable, equivalent to a loose density of 51.5 lb/cf, or 0.7 ton/cy. The recommendations also concluded that a typical soil column at the Midway landfill could be composed of between 50 and 70 percent waste, which would correspond to between 30 and 50 percent soil that could be considered for reuse. For calculation purposes, the evaluation used an average excavated material screening reuse of 40 percent, with the remaining 60 percent of material exported for disposal.

The reusable material will be contaminated and require environmental controls during handling to avoid contamination of clean material and surface water. The reuse of the material will require oversight by a geotechnical engineer to ensure proper mixing and placement for acceptable soil stability. During placement, some initially classified reuse material may be deemed unsuitable and require disposal off site.

The Low Platform option reuses excavated material without screening. This approach is intended to balance cut and fill quantities and reduce export requirements. Drilling tailings are assumed to require export. The reused material is not required to be structurally competent, since the Low Platform option relies on drilled shafts for support.

Even though there is a quantity of clean cover material on the site, the amount is unknown. Based on the high-level nature of this evaluation and the proportionately larger quantity of refuse material, the entire excavation quantity calculated and shown on Figures 2-1 through 2-3 is assumed to be refuse. A quantity of clean cover material has not been distinguished from the bulk quantities.

Active excavation and hauling are assumed to be 12 hours per day (hr/day), 6 days per week (day/wk). The actual workday may be 16 hours with two shifts. Due to general inefficiencies, breaks, fueling and maintenance, irregularities at the start and finish of shifts, and other potential operational impacts, 12 hours of active hauling was assumed to be the average.

Excavation into refuse is assumed to be permitted only between May 1 and September 30, which excludes wet season construction. This results in a construction season of approximately 22 weeks each year. The construction season is assumed to be limited to reduce the amount of precipitation that may contact refuse and become contaminated water that could potentially infiltrate into the open area of the landfill, further contributing to contaminated groundwater that exists at the site. It is assumed that regulatory agencies will prohibit or restrict open landfill excavation during the wet season to protect against groundwater contamination. Shaft installation and other work could be performed during the wet season provided the work area maintains environmental protections.

Due to the irregular nature of the material typically found within a landfill, there will be the potential to encounter unexpected subsurface conditions during the excavation process. It is assumed that the construction contractor will be required to have resources available to manage irregular materials encountered during bulk excavation and redirect the work effort without delays to the project timeline. The large available work area of the total site work area supports the reasonableness of this assumption.

2.6.2.2 Drilled Shaft and Slab Installation

The landfill preparation includes two preliminary structural options; the Low Platform and Hybrid 2 options. These two subsurface construction design options include drilled shaft and slab elements, as discussed in Section 2.5.

The Low Platform option consists of precast, prestressed void slabs supported on approximately 700 drilled shafts. The drilled shafts are 10 feet in diameter, distributed on a 35-foot by 70-foot grid under the buildings, track, and drainage vault area as shown in Figure 2-4.

Figure 2-4. Low Platform Shaft Layout

The shafts are enclosed in steel casings due to the composition of the landfill material, as evaluated from the geotechnical boring samples performed for the OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e). The grid spacing has changed from the previous 100-foot by 100-foot grid assumed during the landfill optimization process. The refined spacing was a result of advancing the OMF South design estimates for facility loads and landfill characteristics. The slab on top of the shaft was designed using WSDOT standard precast prestressed void slabs, with approximate 6-inch-thick cast-in-place concrete on top of the void slabs, to optimize the design as well as to accommodate underground utilities and drainage. The change in shaft and slab quantity is a result of design progression.

Shaft installation generally consists of excavation, placing a reinforcement cage, and pouring concrete that is embedded through the landfill and into native, competent material. Average shaft lengths range between approximate 130 feet and 180 feet from finished grade depending on the location within the landfill and associated depth to competent material. It is assumed each shaft will require 4 days for installation.

The Hybrid 2 option consists of the same shaft and slab design below buildings (approximately 105 shafts) as the Low Platform option and a cast-in-place reinforced concrete waffle plate slab structure for the track area. The Hybrid 2 shaft layout is shown in Figure 2-5. The top slab in the track yard is 1 foot thick with webs below the slab. The cross section of each web is 18 inches wide and 30 inches tall. Slab and shaft concepts are shown in Figure 2-6. The waffle plate slab structure is casted directly on the compacted soil foundation without shafts and supports the entire operation and maintenance yard, except the buildings are supported on shaft foundations.

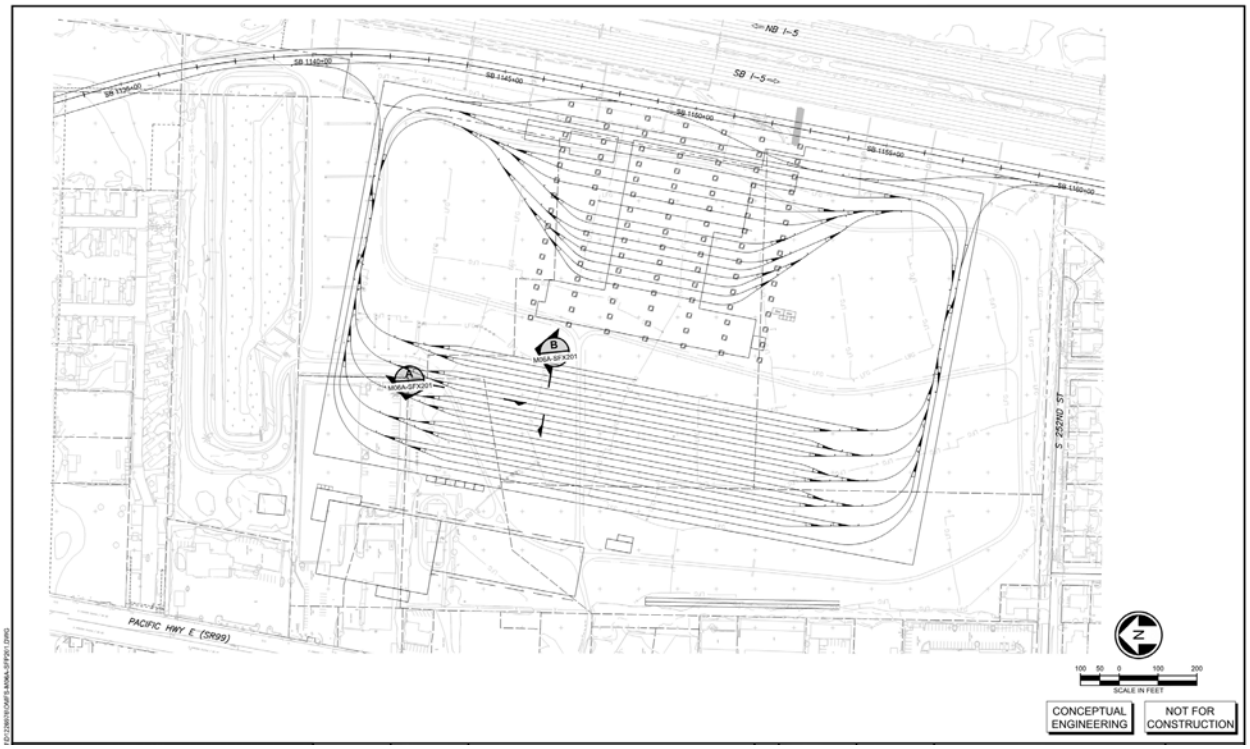


Figure 2-5. Hybrid 2 Shaft Layout

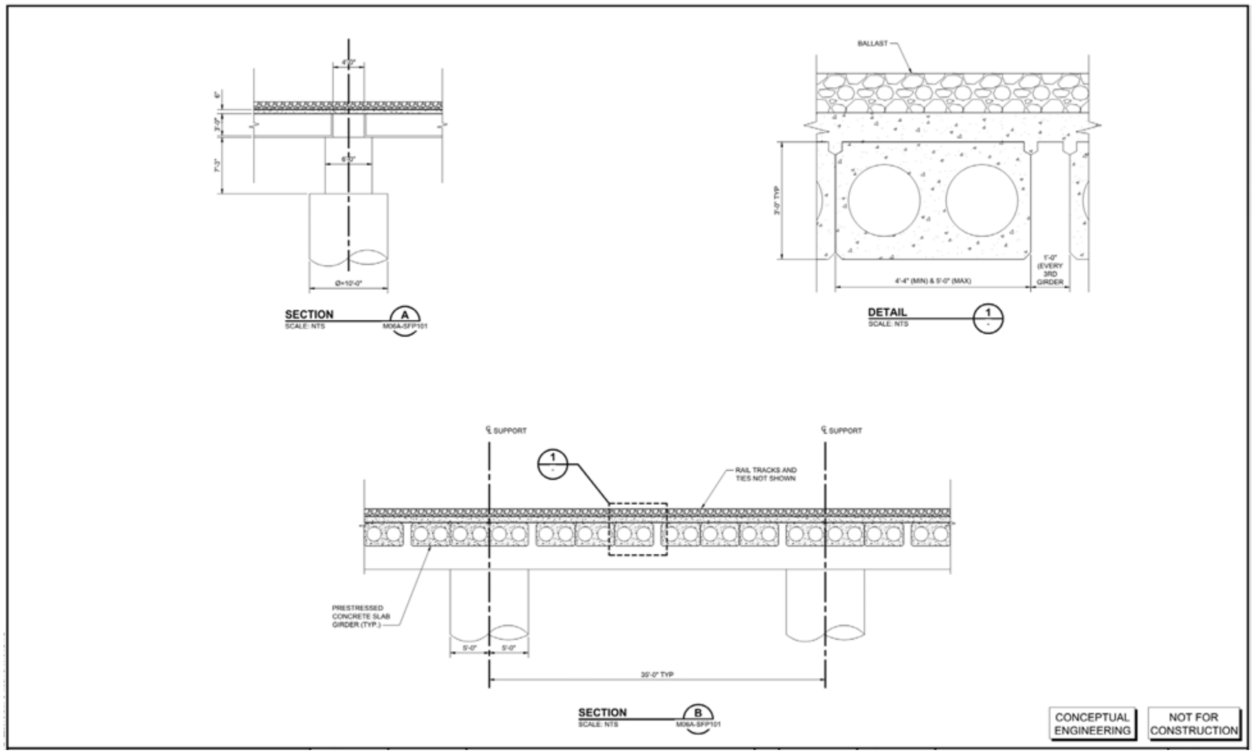


Figure 2-6. Slab and Shaft Concepts

Shaft and slab installation are assumed to occur in coordination with the earthwork process, with similar material hauling hours and work season. The work will be phased in with the earthwork, with shafts installed in exposed refuse areas prior to landfill cap installation and clean backfill. Shafts through refuse will need to be booted (watertight and airtight connection of the landfill cap geomembrane to the shaft) through the replacement landfill cap to create a sealed system. Slab installation should be permitted to occur during the wet season, since this work will be performed in a completed landfill capped area without exposed refuse. Drilled shaft installation may be permitted during the wet season based on a small and controllable work area pertaining to the individual shafts.

Refuse exhumed during drilling has been included in the earthwork quantities. The drilling process is assumed to be prohibitive to material screening and reuse of the exhumed material, requiring export for disposal. Concrete import is accounted for as an import quantity associated with the shafts and slabs.

Though Hybrid 2 includes drilled shafts under the building, these shafts would likely be removed from the design in favor of localized over excavation to competent soils below the building. The Midway Landfill Site Engineering Optimization Report (Sound Transit 2019b) assumed that a 40-foot thickness of refuse could remain in-place with deep dynamic compaction while still achieving the settlement tolerance required for the OMF South. The recent OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e) indicates that the thickness of refuse left in-place would need to be a maximum of 6 feet, as shown in Figure 2-2, still requiring deep dynamic compaction. The smaller quantity of refuse likely warrants its removal rather than the installation of full-length drilled shafts. Removing the refuse will reduce project costs and avoid introducing shaft installation activities to the construction. Leaving the 6 feet of refuse in place with deep dynamic compaction is also not an option below buildings due to the more stringent settlement criteria.

2.6.2.3 Environment Considerations during Construction

As stated above, wet season construction is assumed to be prohibited during landfill preparation due to the greater potential to generate contaminated groundwater through penetrations through the existing landfill cap. This restriction results in a May 1 to September 30 work window each year for contaminated earthwork activities. Other earthwork activities performed within the wet season, if conducted, would likely result in low productivity and efficiencies due to limitations in the workability of the material and inclement weather shutdowns.

In general, the exposed refuse area of the work site is assumed to be limited to 5 acres in size. A specific allowable exposed refuse area size has yet to be established with the regulators. The 5-acre area was assumed as a reasonable size to perform work while managing environmental protection and preservation of the landfill environmental controls. It is assumed that a construction contractor will be able to secure (cover refuse and manage stormwater) a 5-acre exposed area at the end of each day and in anticipation of inclement weather. The construction contractor will also need to control dust on dry and windy days. Precipitation and surface water run-on will need to be managed in the exposed refuse area to avoid water contamination and infiltration into the landfill that could result in further contamination of groundwater. Water collected within the open refuse area will need to be hauled off site and disposed of as wastewater. It is assumed that some inclement weather will occur during dry season construction, which will increase the schedule duration by 5 percent.

It is also assumed that a 5-acre open refuse area can be managed without negatively impacting the active LFG system at the landfill. The LFG collection and conveyance system will be required to remain active during construction to prevent off-site migration of LFG. During the construction, the LFG system will need to be continuously reconfigured to maintain effectiveness. Portions of the system will need to be demolished and replaced as the work progresses through the site. Additionally, the system will need to be managed to prevent air intrusion from the open refuse area that could contribute to a landfill fire.

The application of a 5-acre open refuse area limitation will be more manageable for the Low Platform option based on the maximum refuse excavation and fill depth of approximately 15 feet, allowing that option to utilize the entire 5-arce area for work activities. The Hybrid 2 and Full Excavation options have significant excavation depth requirements of up to and in excess of 110 feet. If the horizontal footprint of the open refuse area is limited to 5 acres, the available work area within the excavation, or excavation floor, will be reduced in size based on depth and the space consumed by the side slopes required for a stable excavation. Side slopes are assumed to range from 1:1 (horizontal to vertical) to 2:1. To maintain an effective work area size for these two options, it is likely that the excavation within thick refuse will need to progress in lifts (i.e., 30 feet deep), progressively excavating the entire landfill surface down one lift at a time. Excavation in lifts would still require the 5-acre open refuse area limitation, which could be achieved through the installation of a temporary landfill cap phased behind the progressing lift excavation.

If material screening will take place for on-site reuse of contaminated, competent backfill material, 5 acres may not be an adequate exposed refuse work area to accommodate continuous excavation, vehicle loading, screening, stockpiling, and backfill of material. The depth of excavation and layback of slopes will also factor into area requirements. It may be possible to use a non-open refuse area on the site for material processing and handling; however, the area would have to be set up to manage the contamination and protect clean areas.

If more than 5 acres of open refuse area is allowed, concurrent construction activities will have more available space; however, work progression may not directly result in a decrease in schedule requirements. If the rate of onsite excavation can increase, available trucking and road capacity and the capacity of the export receiving facility may then become limiting factors, as discussed in Sections 2.6.2.4 and 2.6.3.

Note that reuse of the screened material on site will be subject to regulatory approval. Environmental regulators may require any exhumed refuse to be disposed of at a permitted facility meeting current standards without the option to reuse on site. The FWLE project has been allowed to reuse refuse material on site; however, the quality of that material is better understood, and the scale of that work is significantly smaller than that proposed for OMF South.

The hauling of contaminated material will be in fully enclosed intermodal containers. If material is determined to be hazardous, hauling requirements will need to be verified based on the material.

Vehicles and equipment driving through a contaminated area will likely need to cross a wheel wash as they exit the area to clean the tires and avoid tracking contaminated material elsewhere on site and off site.

Each of the three options will result in refuse retained on site, which will require the preservation, or reinstallation, of a permanent landfill cap system, LFG system, and groundwater monitoring system. The Full Excavation approach may be able to remove

LFG-generating material through screening; however, contaminated soil may still result in contaminated soil vapor that will need management.

2.6.2.4 Disposal Considerations

Excavated material exported from the landfill will require disposal at a regulated facility, assumed to be a Subtitle D landfill in accordance with the Resource Conservation and Recovery Act (RCRA). The material testing performed during the development of the OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e) indicated that the primary contaminants in the refuse material sampled are petroleum hydrocarbons and that, in general, there were no chemicals present at concentrations posing significant exposure threats. However, there were some chemical concentrations that slightly exceeded MTCA Method A levels. The age of the landfill, and possible less stringent acceptance criteria, presents a risk that there will be material quantities classified as hazardous requiring disposal at a more expensive Subtitle C landfill; however, since the facility was operated as an MSW landfill, it is assumed that the majority of material encountered will be accepted at a currently permitted MSW Subtitle D landfill.

Within the Pacific Northwest, it is expected that three solid waste firms have the available landfill capacity for the disposal of the material quantities required, specifically for the Hybrid 2 and Full Excavation options. Export disposal quantities are discussed in Section 2.6.2.7. With material reuse on site, the Hybrid 2 and Full Excavation options will require 2.6 million and 3 million tons of disposal export, respectively.

The firms are Republic Services, Waste Management, and Waste Connections. The three firms each operate a regional Subtitle D landfill that is accessible by rail. Table 2-2 is based on the King County 2019 Comprehensive Solid Waste Management Plan (King County Solid Waste Division 2019) and provides information on each landfill.

TABLE 2-2
Regional Disposal Capacity

Landfill	Location	Owner	Permitted Capacity (tons)	Remaining Capacity (tons, 2016)
Roosevelt Regional Landfill	Klickitat County, WA	Republic Services	244,600,000	120,000,000
Columbia Ridge Landfill and Recycling Center	Gilliam County, OR	Waste Management	345,275,000	329,000,000
Finley Buttes Regional Landfill	Morrow County, OR	Waste Connections	158,9000,000	131,000,000

The travel distance to these landfills warrants container shipment by rail. Trucks leaving the Midway Landfill will need to go to an intermodal facility for container offload onto trains. At the facility, the trucks will be reloaded with empty containers.

A number of intermodal facilities exist in the Seattle area that are owned by either a solid waste firm or a railroad. The two primary railroads are Burlington Northern Santa Fe Railroad (BNSF) and Union Pacific Railroad (UP).

Based on the hauling scenario discussed in Section 2.6.2.6, the intermodal facility is expected to handle an export truck arriving every 2.5 minutes on average. It is assumed that one or multiple existing intermodal facilities in South Seattle will be able to accommodate the exported quantities from the Midway Landfill. This may or may not be possible for the Hybrid 2 and Full Excavation options considering the large quantity and schedule requirements, and a project-specific intermodal facility may be required or, at a minimum, an existing facility may require expansion. It is also assumed that the rail service provider can meet the train capacity requirements.

Based on an intermodal facility located in Seattle, the travel distance will be 20 miles one way, requiring an assumed 40 minutes each direction. The queue, unload, and load time required at the intermodal facility is assumed to be 10 minutes.

Weighing of containers is assumed to occur at the intermodal facility or disposal landfill.

It is expected that the export disposal will be contracted through the construction contractor, with the solid waste firm as a subcontractor. The railroad component is expected to be a second-tier subcontractor through the solid waste firm. Due to the complexity of the solid waste handling and disposal component of the project, including the potential intermodal facility construct aspect, the bidding for this service under all the options is expected to require at least 6 months.

2.6.2.5 Construction Phasing and Material Reuse

As discussed in Section 2.6.2.3, construction phasing will be required to maintain the environmental controls at the landfill. A limited portion of the landfill will be allowed to be exposed at one time. Within this exposed refuse area, a number of activities are expected to occur simultaneously, depending on the construction approach, with each activity in sequence after the preceding activity and the preceding activity moving on to the next area. The exposed refuse area would be able to advance once the landfill cap, temporary or permanent, is reinstalled in the previous work area. Activities may include different combinations of the following.

1. Disassembly/removal and temporary reinstallation of the LFG system
2. Removal of the landfill cap system
3. Excavation of refuse material
4. Screening of refuse material
5. Export of screened unsuitable material

6. Dynamic compaction of the subgrade (if applicable)
7. Mixing, placement, and compaction of screened competent reuse material
8. Drilled shaft installation (if applicable)
9. Import and installation of competent material
10. Installation of permanent landfill cap system and LFG system
11. Slab installation (if applicable)

The assumed 5-acre open refuse area will be very limiting for the space demands and to maintain efficiencies. Phasing will be further complicated with greater excavation depth requirements and the space consumption from layback slopes. There may be some relief if the area can be increased and truck load-out and screening can be performed outside the open refuse area; however, this will create additional contamination areas to manage.

The phased nature of the work allows the construction contractor to be able to respond to changed conditions by moving to another portion of the site, as needed, without greatly impacting schedule. This also provides the opportunity to effectively plan and execute preparatory and sequential work.

Also, the landfill preparation work can be performed concurrently with portions of the OMF South building and track construction. The OMF South building and track construction can begin in areas that have achieved final grade or completion of the slab work. Phasing of OMF South construction will be dependent on the excavation and backfill approach (i.e., excavation in lifts). While it's too early in the project to get into detailed construction phase planning, those plans will be required by regulatory agencies prior to approval of ground disturbing work.

2.6.2.6 Truck Trips – Export and Import

Disposal Export

Excavated material for export off site is assumed to be loaded into 20-foot intermodal containers on waiting trucks. The intermodal containers will be limited to a capacity of 30 tons due to roadway load restrictions set by local agencies and WSDOT. The containers will be transported off site for direct load onto railcars at an intermodal facility.

The 5-acre open refuse area is assumed to be able to accommodate four active truck load-out locations, with an on-site load time of 10 minutes each. The number of load-out stations will depend on construction contractor means and methods to perform the work. Four stations were assumed as a possible number based on space limitations and competing work activities.

Based on the discussion of intermodal facilities, total round-trip time for a truck will be 100 minutes. Each load station at the Midway Landfill will be able to accommodate up to 10 circulating trucks, for a total of 40 export trucks operating during peak time.

Based on a 12-hour workday, each truck is assumed to make seven trips per day. At 40 operating trucks, this equates to 280 truck trips per day. This is an approximate value that does not account for irregularity at the beginning and end of the day.

Disposal export quantity estimates are shown in Table 2-3 in Section 2.6.2.7.

Soil Import

Importing soil for backfill will need to be performed separately from the export operation for excavated refuse. There is not expected to be an opportunity to gain efficiency from export trucks returning to the site with imported soil. The export trucks will use intermodal containers. The intermodal containers are used for transfer to and from the trains and are not suited for dumping import soil on site if the containers were loaded with clean import soil on the return trip. Import trucks will need to be dump trucks with trailers with an assumed capacity of 20 cy. Import material is assumed to arrive in a loose density equivalent to 130 percent of the volume of in-place fill.

The total round-trip time for import trucks is assumed to be 100 minutes. This assumption is based on a hypothetical material supply location in Maple Valley, Washington. When on site, trucks will dump either in the fill area or at a stockpile location.

The demand for import material will be reduced based on assumptions pertaining to excavation screening and reusable material and a lower final site elevation than the existing condition. The total amount of import trucks is assumed to be equally distributed throughout the export duration.

Soil import quantity estimates are shown in Table 2-3 in Section 2.6.2.7.

Concrete Import

Concrete import for shafts and slabs is assumed to arrive in 9 cy truckloads. The import is assumed to be equally distributed throughout the shaft and slab installation period. Concrete will be locally sourced from an unknown location and is expected to be imported following the same site-access requirements as other import and export operations.

Concrete import quantity estimates are shown in Table 2-3 in Section 2.6.2.7.

2.6.2.7 Results

The assumptions discussed above are summarized below.

Assumptions:

1. Average in-place refuse density is 75 lb/cf, or 1.01 ton/cy.
2. Average export density is 51.5 lb/cf, or 0.70 ton/cy, minimum.
3. 40 percent by volume reusable excavated material.
4. Average import soil density ratio is 1.3 in-place/loose.

5. Active excavation is 12 hr/day, 6 day/wk, 22 weeks per year (wk/yr).
6. Exposed refuse area is 5 acres.
7. Inclement weather will increase the project duration by 5 percent.
8. A 5-acre area can load four export trucks at a time.
9. Each export truck is on site for 10 minutes.
10. Export truck travel distance is 20 miles each way.
11. Export truck trip time each direction is 40 minutes.
12. Export truck time at the off-site facility is 10 minutes.
13. Total export truck trip time is 100 minutes per load.
14. Circulating export trucks operating per load area is 10.
15. Total export trucks operating is 40.
16. Export trips per day per truck is seven.
17. Export truck trips per day is 280.
18. Export truck capacity is 30 tons
19. Soil import truck capacity is 20 cy.
20. Concrete import truck capacity is 9 cy.

Applying these assumptions and the quantities developed during the 10% design to the three landfill subsurface construction design options results in the landfill preparation requirements summarized in Table 2-3 and Table 2-4.

TABLE 2-3
Landfill Preparation Material Requirements

Construction Design Option	In-Place Excavation (cy)	Excavation (ton)	Material Export (ton)	In-Place Fill (cy)	In-Place Reuse (cy)	In-Place Import (cy)	Concrete Import (cy)
Low Platform	1,010,000	1,023,000	678,000	340,000	340,000	0	531,000
Hybrid 2	4,270,000	4,323,000	2,592,000	2,890,000	1,710,000	1,180,000	165,000
Full Excavation	4,870,000	4,931,000	2,956,500	3,510,000	1,950,000	1,560,000	0

The in-place excavation volume was converted to excavation tonnage to be consistent with the industry approach to material export and disposal. In-place volume remains applicable to the assessment for import materials. The in-place reuse volume directly applies reuse at 40 percent of the in-place excavation volume and does not account for volume differences between screened reuse and export material.

TABLE 2-4
Landfill Preparation Daily Hauling Requirements

Construction Design Option	Export Truck Trips per Day	Soil Import Truck Trips per Day	Concrete Import Truck Trips per Day	Total Truck Trips per Day
Low Platform	20	0	51	71
Hybrid 2	280	237	47	564
Full Excavation	280	274	0	554

Concrete import truck trips are equally dispersed over the general schedule durations for shaft and slab installation. Export and soil import truck trips for the Low Platform option are also dispersed over the general schedule durations for shaft and slab installation. Export and soil import truck trips for the Hybrid 2 and Full Excavation options have been equally dispersed over the assumed landfill preparation period, dry season hauling only.

Truck trips include only bulk earthwork and concrete. Other vehicle trips (i.e., landfill closure system materials and concrete reinforcement) have not been evaluated. Complete construction traffic will be evaluated as part of the Draft Environmental Impact Statement.

2.6.3 Traffic Analysis

2.6.3.1 Truck Haul Routes

Access to and from the site for inbound and outbound trucks is assumed to be via right turns. No left turns into or out of the site are assumed. Left turns would increase the likelihood of on-site or off-site queueing of vehicles, causing congestion. Outbound trucks exiting the site would travel north on SR 99 and access I-5 via Kent-Des Moines Road (SR 516). Inbound trucks would travel on I-5, exiting at S 272nd Street. The inbound trucks would travel westbound on S 272nd Street to SR 99, where they would turn north and travel to the site. Excavation export is assumed to be to the north to reach an intermodal facility. Trucks importing material would follow the same routes in the vicinity of the site, although the origin for import concrete and soil material is unknown.

Assumed construction haul routes to the north are shown on Figure 2-4. Actual traffic routes will need to be established for the construction through coordination with the local jurisdiction permit process.

2.6.3.2 Level of Service Considerations

Trucks would traverse the haul routes during the entirety of the assumed 12-hour daily hauling period, including both directions during AM and PM peak. As described in Section 2.6.2.6, the maximum number of export trucks operating at the site is 40, each performing 7 round trips per day, for a total of 280 daily truck trips. With 280 truck trips during the daily construction period, the average number of truck trips per hour is 23-24. Trucks are assumed to be accessing the site at uniform intervals throughout the daily hauling period, with some potential for irregularity or bunching at the beginning and end of the day. Import trucks for the Hybrid 2 and Full Excavation options represent truck trips similar to the maximum assumed export truck trips. Given that the daily truck trip volume is estimated to increase by about 284 and 274 trips per day to facilitate importing material for the Hybrid 2 and Full Excavation options, respectively, it is estimated that 24 additional trucks would be operating at the site each hour, for a total of about 48 truck trips per hour. The Low Platform construction option includes import of concrete but would require fewer truck trips than the other two options. The Low Platform option would have a total of approximately 6 trucks per hour.

Given their size and slower operating speeds, trucks were assigned a passenger car equivalency (PCE) value of 2.5 for this evaluation. Additionally, each round trip includes an outbound and inbound segment, resulting in a total of 700 PCE daily trips in the study area associated with export activity (280 truck trips x 2.5 PCE) for the Hybrid 2 and Full Excavation options. Import activity for the Hybrid 2 option would be worst case and result in approximately 710 PCE daily trips in the study area (284 truck trips x 2.5 PCE).

To estimate traffic operation impacts, the truck trips are assumed to be distributed evenly throughout the day and are based on the ability of the yard and the receiving facility to process the trucks. These assumptions are outlined in Section 2.6 of this plan. The 2.5 PCE factor is applied to the truck volume to give planners information about the number of new trips that would need to be accommodated along the truck routes. Below, Table 2-5 outlines the number of peak hour trucks and associated PCEs for each construction scenario.

TABLE 2-5

Passenger Car Equivalency for Each Approach

Construction Design Option	Daily			Hourly			Hourly PCE		
	Export	Import	Total	Export	Import	Total	Export	Import	Total
Low Platform	20	51	71	2	5	7	5	13	18
Hybrid 2	280	284	564	24	24	48	60	60	120
Full Excavation	280	274	554	24	24	48	60	60	120

The PCEs shown in the table would be the same for exiting and entering the site during the peak hour. The highest-impact approach would be the Hybrid 2 and Full Excavation options, with 120 PCE.

As shown in Figures 2-5 and 2-6, Google Maps (January 2020) reports almost all sections of the haul routes operate at “good” or “fair” conditions during both peak periods (typical traffic on Wednesdays at 7 a.m. and 5 p.m. was used to represent the AM and PM peak periods, respectively). The exceptions are northbound SR 99 approaching Kent-Des Moines Road during the 8 a.m. time period and the eastbound segment of Kent-Des Moines Road at the northbound

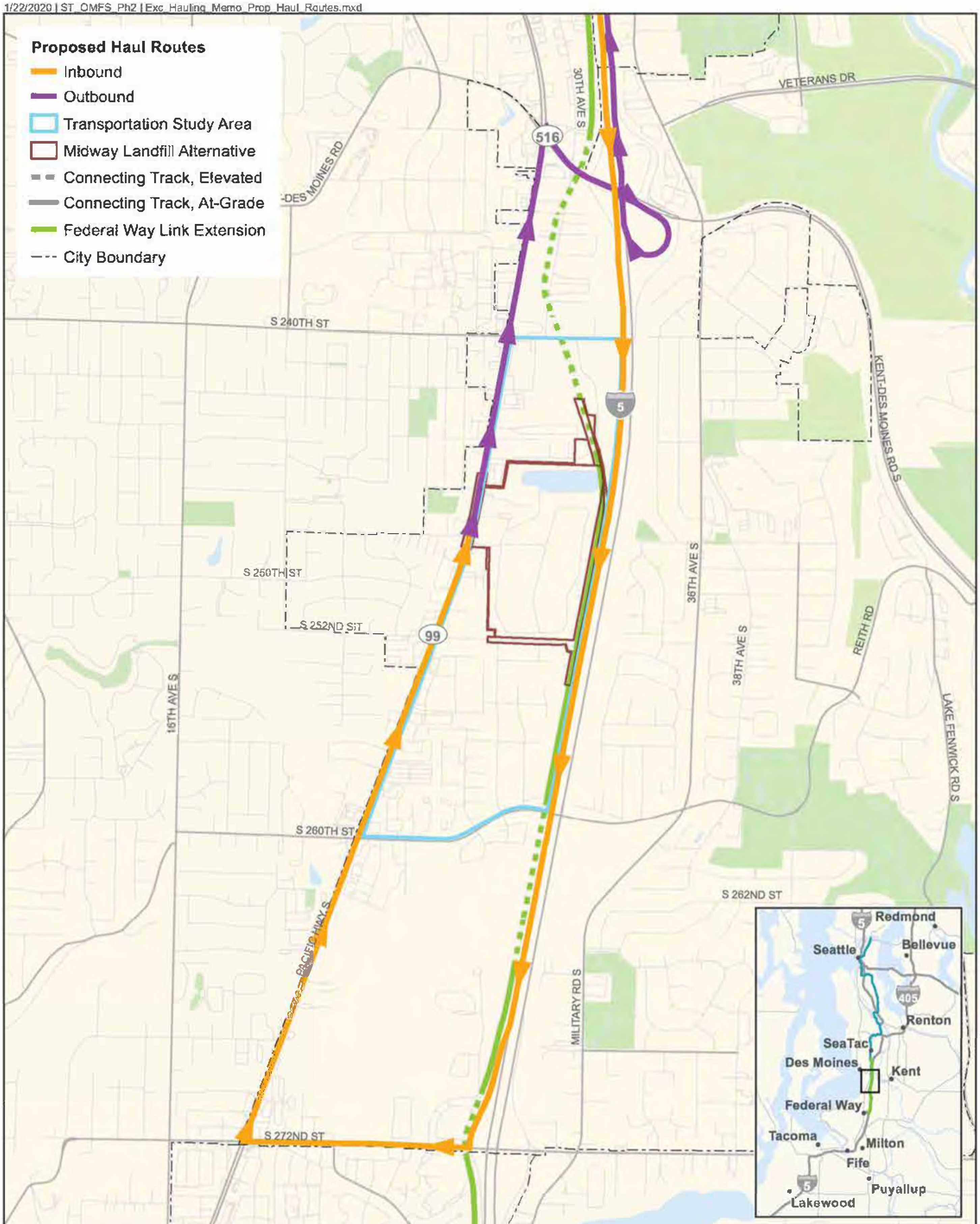
I-5 on-ramp, which operate at “poor” conditions during the AM peak period, as does the I-5 mainline. If 120 additional PCE vehicles of either the Hybrid 2 or Full Excavation options join the backup congestion on the I-5 northbound ramp during peak hours, congestion on Kent-Des Moines Road and possibly SR 99 would likely occur. Some example strategies to reduce impacts to local traffic could include using multiple routes, limiting truck activity during the peak traffic hours, and changing the end point location to be south.

If one or more end point hauling locations can be to the south, traffic impacts could be reduced through provision of direct access to I-5 southbound from the site. A potential haul route may be able to be developed north of the existing stormwater pond, which would allow for site access under the elevated FWLE guideway and to I-5. Access would also be subject to WSDOT and FHWA approval.

Given the good or fair operating conditions for other segments of the haul routes, it is assumed that the additional 120 hourly PCE trips for each route would not result in significant degradation to the operating conditions in these areas.

Trucks would enter and exit the site via SR 99. When trucks exit the facility and merge into traffic on SR 99, they would operate at slower speeds due to heavy loads. Returning trucks would also slow down to make the turn into the facility, causing minor delays. In order to reduce potential impacts to mainline traffic on SR 99 at the access point, a short acceleration lane could be constructed to accommodate outbound trucks and a short deceleration lane could be constructed to accommodate inbound trucks.

1/22/2020 | ST_OMFS_Ph2 | Exc_Hauling_Memo_Prop_Haul_Routes.mxd



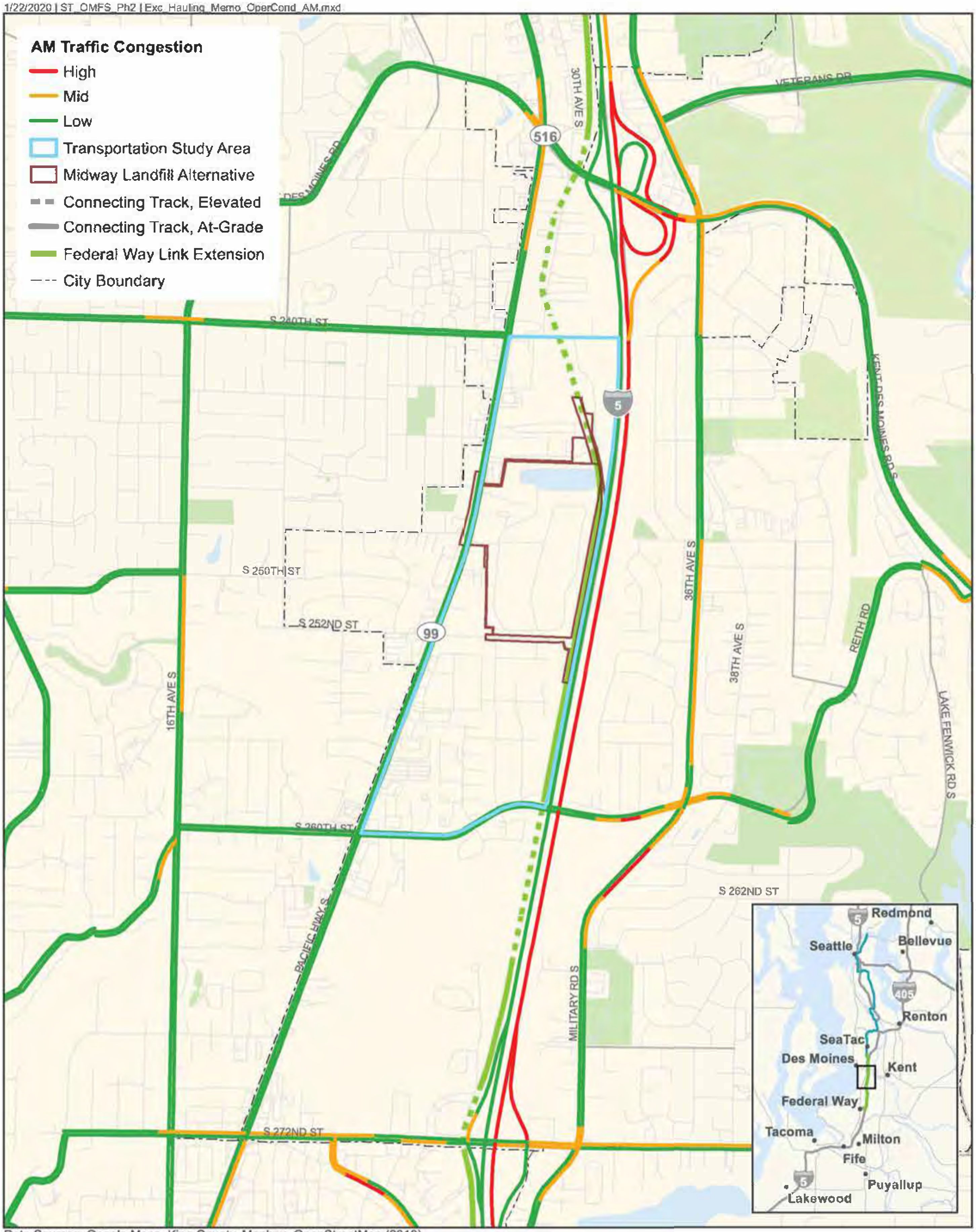
Data Sources: Google Maps, King County, Mapbox, OpenStreetMap (2019).

FIGURE 2-7
Proposed Haul Routes
Midway Landfill Alternative

N
0 0.25 0.5 Miles

OMF South

Internal document for the purposes of informing the design and construction approach for the Midway Landfill Alternative



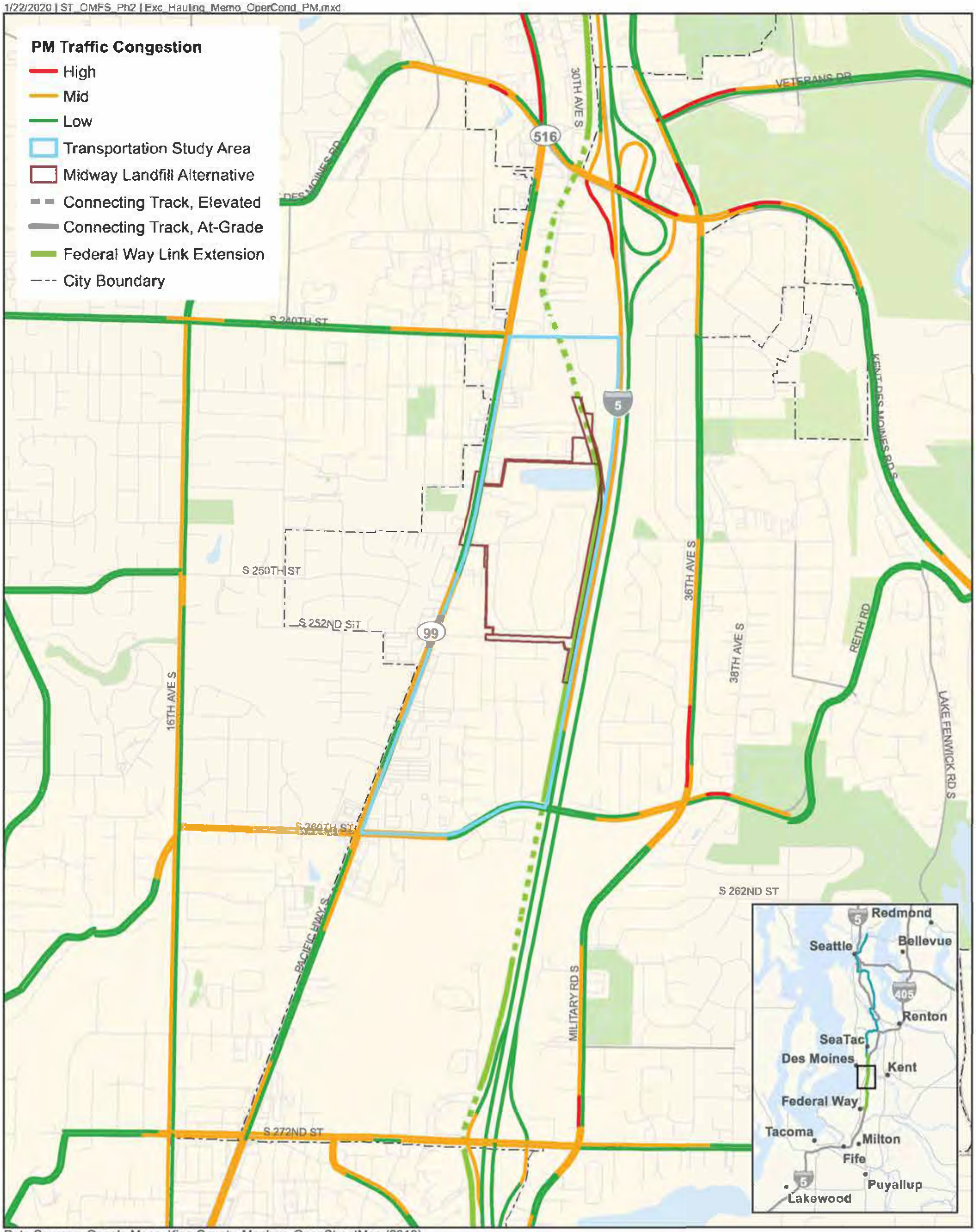
Data Sources: Google Maps, King County, Mapbox, OpenStreetMap (2019).

N

0 0.25 0.5 Miles

FIGURE 2-8
AM Operating Conditions
Midway Landfill Alternative

OMF South



Data Sources: Google Maps, King County, Mapbox, OpenStreetMap (2019).

FIGURE 2-9
PM Operating Conditions
Midway Landfill Alternative

OMF South

Internal document for the purposes of informing the design and construction approach for the Midway Landfill Alternative

2.6.4 Compatibility with the Known Status of FWLE Construction

If constructed at Midway Landfill, OMF South will connect to the mainline of the FWLE. The current FWLE mainline design is not at an elevation and grade to allow direct connections to the proposed OMF South lead tracks. The three OMF South Midway Landfill design options have been developed, with the yard at elevations 365 feet (Hybrid 2 and Full Excavation) and 380 feet (Low Platform). The FWLE will follow the general grade of I-5, while OMF South will be flat.

There are currently five proposed track connections between the FWLE and OMF South. To minimize the extent of mainline modification, a third track is proposed running alongside the mainline at an elevation closer to the selected OMF South elevation for compatibility with the yard-connecting tracks. The third track would have a connection to the mainline at the north and south ends only. The connection track would have No. 10 turnouts and be designed for 25 miles per hour. The connecting tracks and yard lead tracks would require a design variance for all vertical curve lengths. There are independent vertical track designs for the two OMF South elevation options.

Based on the current FWLE mainline design, irrespective of the construction option selected, the FWLE mainline will need to be modified to enable the connection of OMF South lead track turnouts at the required grade of 2 percent or less (Sound Transit 2018). The extent of mainline modification varies based on the OMF South site elevation, as shown in Table 2-6 below.

As of September 2020, FWLE project has accepted a change order to modify the profile to accommodate future lead track connections from OMF South at the landfill site that will meet the needs of either yard elevation of 365 feet or 380 feet.

TABLE 2-6
Track Summary

	Low Yard Elevation (365')	Medium Yard Elevation (380')
Northern Mainline Modifications*	Up to approximate 8' rise in elevated mainline over 3,200'.	Up to approximate 8' rise in elevated mainline over 3,200'.
Southern Mainline Modifications*	Up to approximate 10' lowering of at-grade mainline over 1,900'.	Up to approximate 5' lowering of at-grade mainline over 1,900'. Potential to avoid southern mainline modifications through further optimization.
Connecting/Third Track**	At-grade connecting track. Steep grades (~6%) and significant cut toward south end. Vertical curve length design variance required.	At-grade connecting track. Moderate grades. Vertical curve length design variance required.
Lead Tracks	At-grade lead tracks. North lead track has steep grades (~6%). Vertical curve length design variance required.	At-grade lead tracks. Moderate grades. Vertical curve length design variance required.
Constructability	More complex. Requires deep cut of existing landfill.	Least complex.
Cost	$$$$	$$$
Schedule	Potential longer duration.	Medium duration.

2.6.5 Potential Long-Term Settlement

The three subsurface construction design options to redevelop the Midway Landfill as OMF South will have different performance implications pertaining to potential future settlement. Without modification to the existing landfill, site settlement will have a significant negative impact on OMF South operation due to facility tolerances. The settlement design criteria for the OMF South evaluation is a maximum differential settlement of 0.75 inches over 100 feet and a maximum total settlement of 1 inch over a 50-year period. Settlement is considered over the long-term as major structural facilities for Link are to be designed for a 100-year design life, and buildings (including the OMF) are designed for continued operation over a minimum design life of 50 years. Each design option has been evaluated to determine the ability to meet this criteria which is consistent with the WSDOT Geotechnical Design Manual.

Landfilled material will continue to consolidate over time due to the compressive nature of the material, overburden weight, and biodegradation of the material. Settlement will likely be differential, or uneven, throughout a landfill as a result of variable refuse thickness and heterogeneous composition of the material. Without mitigation, settlement can negatively impact the integrity of building foundations, utilities, roadways, and trackways. The settlement evaluation provided by the OMFS Preliminary Geotechnical Recommendations (Sound Transit 2020e), estimates that the current landfill could have total settlements ranging from 1 to over 50 inches over the next 50 years.

The three options provide alternative designs to mitigate potential settlement as follows.

Low Platform: This option will be designed to support the OMF South buildings and track on a shaft-supported platform. The drilled shafts will be embedded in glacial soil encountered below the existing landfill. Long-term settlement impacts to the platform are not anticipated.

Hybrid 2: This option removes a majority of the landfill material, and the remaining portion of the landfill will be compacted with deep dynamic compaction ground improvement. The dynamic compaction ground improvement will reduce the compressibility of the remaining landfill material. To achieve the total and differential settlement design criteria, only 6 feet of compacted refuse will remain, which is a substantial change from the Midway Landfill Site Engineering Optimization Report (Sound Transit 2019b), which had a 40-foot refuse thickness remaining on site. The dynamic compaction of the remaining 6 feet of refuse material will compress the material and reduce post-construction total and differential settlement to achieve the design criteria. The competent backfill material placed and compacted over the remaining dynamically compacted refuse will reduce differential settlement experience at the ground surface, creating a more uniform settlement result. Buildings will be supported on shaft-supported platforms embedded in glacial soil consistent with the Low Platform option. The track will be supported on an on-grade concrete slab over the improved subgrade. The provision of an on-grade concrete slab in the yard areas will further mitigate differential impacts; however, impacts may become more pronounced at slab joints and interfaces.

Full Excavation: This option removes the degradable material from the refuse mass and backfills the OMF South subgrade with competent compacted granular material. Buildings and track will be supported by the backfilled subgrade. The option will eliminate settlement due to subgrade material degradation. Long-term settlements are not anticipated.

Based on the settlement tolerance guidance from Sound Transit, these three options to redevelop the Midway Landfill will be designed to meet the long-term maximum total and differential settlement design requirements.

3.0 Summary

This conceptual landfill site reuse plan is a high-level discussion of landfill preparation considerations pertaining to the potential redevelopment of the Midway Landfill as OMF South. The evaluation is presented as three possible subsurface construction design options to mitigate the landfill characteristics of the site.

- Low Platform – Low Structural Platform with Some Excavation
- Hybrid 2 – Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shaft)
- Full Excavation – Full Excavation and Backfill with Competent Soils

The three options were analyzed conceptually to inform decision-making as to whether redevelopment of the Midway Landfill is a viable option for OMF South and, if so, which subsurface construction option stands out as the preferred approach.

Sound Transit has identified four major risks that are unique to the Midway Landfill Alternative based on the site's prior use as a disposal facility and classification as a Superfund site. These four risks are ground settlement, human health and safety, legal, and regulatory. Three of these risks (ground settlement, human health and safety, and regulatory) risks have been discussed and expanded upon in this plan to include risks to the cost and schedule for OMF South construction. Legal risks will be addressed under separate cover. The results are summarized below.

3.1 Ground Settlement

The conceptual design for each option has effectively mitigated the potential settlement risk; however, the Hybrid 2 option maintains more risk than the Low Platform and Full Excavation options. OMF South will be subject to the settlement of the remaining refuse associated with the Hybrid 2 option, and due to the irregular bottom surface of the landfill, there will be uncertainty as to whether the maximum refuse thickness has been achieved in all areas. Additionally, the small proportion of material to remain in place in comparison with the overall excavation quantity for Hybrid 2, and the required deep dynamic compaction to treat the material, likely does not provide a benefit that would outweigh the potential settlement risk.

The Low Platform and Full Excavation are preferred options to mitigate settlement.

3.2 Human Health and Safety

Human health and safety risk can be categorized as short-term and long-term. The short-term risk is related to OMF South construction, while the long-term risk would be for the operation of the facility into the foreseeable future.

The design of each option can effectively mitigate human health and safety risks; however, there are different risks associated with each option. The Low Platform option has the least short-term risk due to having the least amount of landfill disturbance in comparison with the other two options. The Low Platform option does have the most significant long-term risk because it leaves the largest amount of refuse material at the site and will continue to generate the most LFG.

The Hybrid 2 and Full Excavation options will handle and process significantly more refuse during construction than the Low Platform option, which increases the short-term risk associated with these two options to both construction workers and the public. The two options will have lower long-term risk due to having less contaminated material at the site and significantly less LFG generation potential. The Hybrid 2 option has the potential to generate more LFG than the Full Excavation option; however, the amount will likely be low.

3.3 Regulatory

The regulatory risks are similar for the three options. As identified above, there is a risk to the schedule based on the time required to get Ecology and/or EPA approval of the project relative to the ROD/CAP for the site, together with related agreements and permits, which is currently assumed to require 1 to 2 years.

The Hybrid 2 and Full Excavation options have greater short-term risks associated with construction and the regulatory uncertainties for refuse exposure, reuse, and work windows. The Low Platform option will have more long-term risk due to more ongoing cleanup management obligations throughout the life of the facility, and a greater risk to human health and the environment in the long-term due to the larger, unstable waste mass remaining in place.

3.4 Risks to Cost and Schedule

The high-level landfill preparation evaluation includes many unknowns that create risk that can significantly impact project cost and schedule. Some select items are discussed below.

- In-place material density is assumed to be 75 lb/cf. An increase in density will result in more truck trips based on a limit of 30 tons per truck trip and a longer export duration, increasing both schedule and cost. A decrease in density may require a larger container type to maintain the capacity of 30 tons per trip and would decrease the export duration, reducing schedule and cost. The Hybrid 2 and Full Excavation options are most at risk due to the large earthwork material quantities associated with these options.

- Material reuse is estimated at 40 percent. A decrease in reuse quantity will increase export and import requirements, increasing cost and extending the schedule. The opposite will occur for an increase in reusable material. The Hybrid 2 and Full Excavation options are most at risk due to the large earthwork material quantities associated with these options.
- Material export and disposal assumes a regulated Subtitle D landfill can accept the material. If a significant portion of the material is classified as hazardous requiring Subtitle C landfill disposal, costs will increase and disposal facility availability will become a concern. The Hybrid 2 and Full Excavation options are most at risk due to the large earthwork material quantities associated with these options.
- Intermodal facility availability for long-haul export of material is a risk. Available capacity has not been confirmed. Available capacity confirmed at this time may not be representative of when the facility is needed for OMF South construction. The facility may have access constraints based on disposal location and contractor negotiations. The location of the facility will impact haul routes, travel distances and times, and cost. If available capacity does not exist, intermodal facility development could become a project element, increasing cost and extending the schedule. The Hybrid 2 and Full Excavation options are most at risk due to the large earthwork material quantities associated with these options.

Detailed project costs and schedules will be addressed under separate cover.

3.5 Conclusions

Table 3-1 is based on the results of the landfill preparation evaluation and the summary of risks discussed in this section. The table content is relative among the three subsurface construction design options.

TABLE 3-1
Landfill Preparation Evaluation

Subsurface Construction Design Options	Settlement	Human Health and Safety	Regulatory	Cost (Landfill Preparation)	Schedule
Low Structural Platform with Some Excavation	Meets settlement criteria	Can effectively mitigate health and safety risks (with less short-term risk and more long-term risk)	More long-term regulatory risk associated with the waste mass remaining in place	Less risk due to design certainties	Less risk due to design certainties
Hybrid 2: Excavation with Ground Improvements (Slab on Grade for Tracks and Buildings on Drilled Shafts)	Meets settlement criteria (with more potential uncertainty)	Can effectively mitigate health and safety risks (more short-term risk, less long-term risk)	More short-term risk associated with regulatory requirements during construction	More risk due to material and handling unknowns	More risk due to material and handling unknowns
Full Excavation and Backfill with Competent Soils	Meets settlement criteria	Can effectively mitigate health and safety risks (more short-term risk, less long-term risk)	More short-term risk associated with regulatory requirements during construction	More risk due to material and handling unknowns	More risk due to material and handling unknowns

With the reduced amount of refuse left in place for the Hybrid 2 option, the option has become very similar to the Full Excavation option, except that by maintaining refuse below the facility, greater settlement risk exists. Additionally, the benefit of leaving the small portion of refuse in Hybrid 2 is outweighed by the cost associated with constructing buildings on shaft-supported platforms and track on a concrete slab on grade.

The evaluation indicates that the Low Platform and Full Excavation options may be preferred subsurface construction design options for the Midway Landfill Alternative. The Low Platform option generally carries more long-term risk as opposed to the Full Excavation, which has more emphasis on short-term risks. The Full Excavation option has more cost and schedule risk.

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Sound Transit. 2020b. Interim Midway Landfill Preparation Memorandum. Prepared by HDR. February 2020.

Sound Transit. 2020c. Midway Landfill Human Health Risk Assessment. Prepared by HDR. January 2020.

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Operations and Maintenance Facility South

Appendix D4: Midway Landfill Human Health Risk Assessment

Federal Transit Administration

SoundTransit

January 2020

OMF SOUTH

Midway Landfill Human Health Risk Assessment – Final

SOUNDTRANSIT

CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

OMF SOUTH

Midway Landfill Human Health Risk Assessment

Prepared for:
Sound Transit

Prepared by:
HDR Engineering, Inc.

January 23, 2020

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Acronyms and Abbreviations

ARI	Analytical Resources, Incorporated
bgs	below ground surface
COI	Contaminant Of Interest
COPC	Contaminant Of Potential Concern
CSM	Conceptual Site Model
Ecology	Washington State Department of Ecology
FS	Feasibility Study
GC/MS	Gas Chromatography/Mass Spectrometry
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	High-Density Polyethylene
HDR	HDR Engineering, Inc.
HHRA	Human Health Risk Assessment
HSL	Hazardous Substances List
I-5	Interstate-5
IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Information System
LEL	Lower Explosive Limit
MCL	Maximum Contaminant Level
MSL	Mean Sea Level
MTCA	State of Washington Model Toxics Control Act
NCEA	USEPA National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGA	Northern Gravel Aquifer
NJDOH	New Jersey Department of Health
NRC	National Research Council
OMF South	Operations and Maintenance Facility: South

Parametrix	Parametrix, Inc.
PPE	Personal Protective Equipment
PPRTV	Provisional Peer Reviewed Toxicity Values
PVC	Poly-Vinyl Chloride
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
ROD	Record of Decision
SA	Sand Aquifer
SGA	Southern Gravel Aquifer
SIM	Selective Ion Monitoring
SPU	Seattle Public Utilities
UGA	Upper Gravel Aquifer
USEPA	U.S. Environmental Protection Agency
VISL	Vapor Intrusion Screening Levels
VOC	Volatile Organic Compound
WAC	Washington Administrative Code

Units

μg/L	micrograms per Liter
μg/m^3	micrograms per cubic meter
mg/m^3	milligrams per cubic meter
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per Liter
mg/min	milligrams per minute
ppb	parts per billion
ppm	parts per million

Executive Summary

This Human Health Risk Assessment (HHRA) has been prepared for the Midway Landfill as a potential site for Sound Transit's Operations and Maintenance Facility South (OMF South). Sound Transit is currently implementing a system-wide expansion of the Link light rail system and recently evaluated Midway Landfill as a potential site for the OMF South (HDR 2019a).

The purpose of the HHRA is to evaluate potential chronic health risks to Sound Transit personnel who work at the future site should it be selected for the OMF South and waste be maintained on site. Non-Toxicological hazards including acute, physical risks associated with constructing and operating the OMF South over a waste mass are also discussed.

Background

The Midway Landfill is located between Interstate-5 (I-5) and Highway 99, and South 252nd Street and South 246th Street in Kent, Washington. Between 1966 and 1983, approximately three million cubic yards of solid waste were deposited at the Midway Landfill. Records indicate that from 1980 to 1983 paint sludge, dyes, preservatives for decorative plants, alkaline wastes, oily sludges, waste coolant, truck steam cleaning wastes, and some oily wastes were deposited at the site (Parametrix 1988a). Approximately two million gallons of bulk industrial liquids from a single source were placed in the landfill (USEPA 2015a). However, the nature and type of industrial liquids disposed of in the Midway Landfill is not known. The City of Seattle (City) closed the landfill in 1983.

Cleanup work began in 1984 under the direction of the Washington State Department of Ecology (Ecology) and construction of a landfill gas extraction system began in 1985. The site was listed by the U.S. Environmental Protection Agency (USEPA) as a National Superfund Site in May 1986 (CERCLIS Identification Number: WAD 980638910). The City completed the cleanup in November 1992; however, because the Record of Decision (ROD) was not signed at that time, construction completion was not officially recognized until September 21, 2000.

Current and Future Site Uses

The landfill is currently owned by the City (USEPA 2000a) and operated by Seattle Public Utilities (SPU). The landfill is covered with a multilayered engineered cap (landfill cap) designed to reduce surface water infiltration into landfill waste and leachate discharge into underlying aquifers. A gas extraction system is in place and operating throughout the landfill to control subsurface migration of landfill gas (USEPA 2015a). Ecology oversees the City's operation and maintenance for the landfill cover system, gas extraction system, and surface water control systems constructed under the Consent Decree[1]. The landfill is fenced and no public access is allowed.

No one is known to be currently drinking the groundwater from any aquifer within almost a mile of the landfill and there are no current plans to use the groundwater near the landfill for drinking water. In addition, state regulations (WAC 173-160-171) do not allow any new private drinking water wells within 1,000 feet of a solid waste landfill or 100 feet of all other sources or potential sources of contamination and Ecology must be notified prior to the construction of any new well (USEPA 2015a).

OMF South Construction Approaches

As part of the process of evaluating the Midway Landfill for reuse as the OMF South site, Sound Transit has developed a preferred preliminary site layout and five construction design approaches for review and consideration. Differences in these five construction approaches could result in differences in occupational exposures to both toxic and non-toxic hazards at the OMF South. In order to streamline the exposure assessment step of the HHRA and the non-toxicological hazards evaluation, the five construction approaches are grouped into three future development concepts for the OMF South based on the potential exposures associated with each construction approach. Non-toxicological risks associated with each of these future development concepts are evaluated and discussed in Section 7. Human health risks are evaluated for the development concept that represents the worst case exposures scenario based on current site conditions and potentially complete routes of exposure.

Data Evaluation

Annual groundwater data collected between 2010 and 2014 from five wells located within or just outside of the landfill boundaries were available for review at the time of this assessment. These groundwater samples were analyzed for the following contaminants of interest (COIs): 1,4-dioxane, vinyl chloride, volatile organic compounds (VOCs), dissolved iron, and dissolved manganese. Detected concentrations of COIs in groundwater samples are shown in Table 1. Sample locations are shown in Figure 2-10 in Appendix A.

Monthly gas monitoring data collected from 106 onsite sample locations (e.g., landfill extraction wells and flares) between January 2015 and August 2019 were available for review at the time of this assessment. These landfill gas samples were analyzed for combustible gas (primarily methane), oxygen, carbon dioxide, temperature, static pressure, and other

[1] A Consent Decree is a legal agreement entered into by the United States (through USEPA and the Department of Justice) and potentially responsible parties and lodged with a court. A consent decree dictates the final cleanup phase (remedial action) at a Superfund site.

parameters. Methane gas concentrations in onsite landfill extraction wells and flares are summarized in Tables 2 and 3. Sample locations are shown in Figure 8 in Appendix A.

Two available sources of data on the composition of subsurface gas in the vicinity of the Midway Landfill were identified during document review for this HHRA. These sources include a gas characterization study completed in 1988 as part of the Remedial Investigation (RI) (Parametrix 1988a), and a source emission evaluation completed in 1992 to quantify gas flare emission levels at the Midway Landfill (Am Test-Air Quality Inc. 1992). Gas samples collected in 1988 from onsite gas extraction wells and pre-combustion flares were analyzed for Hazardous Substance VOCs (Parametrix 1988a) and samples collected in 1992 from pre-combustion flare gas (flare inlet gas) were analyzed for VOCs (Am Test-Air Quality Inc. 1992). VOC concentrations in landfill gas samples are summarized in Tables 4, 5a and 6. Gas samples collected in 1988 and 1992 were also analyzed for inorganic gases (e.g., hydrogen sulfide and/or carbon monoxide). Hydrogen sulfide concentrations reported in the RI are shown in Table 5b. Carbon monoxide results were either not reported (Parametrix 1988a) or were not detected (Am Test-Air Quality Inc. 1992).

The quality of the available environmental data for the Midway Landfill was evaluated in the HHRA. Sample collection and analysis methods, sample location and frequency, and data characteristics were considered when evaluating overall data quality, appropriateness, and usability (USEPA 1992).

Based on evaluation of the available site data and supporting documents, the groundwater and methane datasets were determined to be of sufficient quality and reliability for use in this risk assessment. However, the data evaluation for this HHRA determined that the landfill gas data for VOCs and inorganic gases were not representative of current or future site conditions as they were collected more than 25 years ago from the landfill gas extraction system and thus do not represent concentrations of volatile gases to which future workers may be exposed. In addition, data collected from the landfill extraction system do not provide an appropriate measure of the concentrations that workers may be exposed to at the OMF South.

Exposure Assessment

The Midway Landfill will be used for occupational purposes if it is selected as the location of the future OMF South. As a result, various onsite workers (not residents) will have the greatest potential to contact impacted soil gas, groundwater, or air. These workers include long-term Onsite Office, Maintenance Shop, and Yard Workers and short-term Construction Workers.

Based on the knowledge of the current conditions at the Midway Landfill and planned future OMF South site uses, several potential occupational routes of exposure to COIs in landfill waste, gas, and groundwater were identified and evaluated (see the Conceptual Site Model, Figure 1).

The following routes of exposure were determined to be potentially complete for specific occupations at the OMF South:

- Inhalation of Indoor Air for Onsite Office and Maintenance Shop Workers,
- Inhalation of Air in Subsurface Confined Spaces (e.g., utility trenches and vaults) for Construction Workers,
- Inhalation of Outdoor Air for Maintenance Shop, Yard, and Construction Workers, and
- Direct Contact with Waste and Contaminated Soil for Construction Workers

Groundwater ingestion was determined to be an incomplete route of exposure because no one is known to be drinking groundwater from any aquifer within almost a mile of the landfill (USEPA 2015a), there are no water supply wells at the landfill, and state regulations (WAC 173-160-171) do not allow the development of drinking water wells in the vicinity of a landfill.

These potential routes of exposure are based on the assumptions that construction of the OMF South may result in future site conditions that could allow for vapor intrusion from subsurface gas and underlying groundwater to indoor air.

Contaminants of Potential Concern

Maximum concentrations of COIs detected in groundwater and landfill gas were compared to occupational screening levels for potentially complete routes of exposures in order to identify Contaminants of Potential Concern (COPCs). COPCs are those contaminants with the potential to cause adverse health effects in workers who are exposed to them over an extended period of time. These occupational screening levels were reviewed to verify that they were sufficiently protective of the occupational exposures expected to occur at the OMF South.

Groundwater data were compared to occupational screening levels for vapor intrusion to indoor air (e.g., MTCA Method C Groundwater Vapor Intrusion screening levels and the USEPA Worker Air VISLs for Groundwater) (see in Table 1). No COIs in groundwater exceed these screening levels.

There are no toxicity- or risk-based screening levels for methane concentrations; therefore, no comparisons were made for methane concentrations in landfill gas. In addition, due to the absence of representative landfill gas results for VOCs and inorganic gases, no comparisons were made between concentrations of these COIs in landfill gas and applicable risk-based screening levels.

As a result, no COPCs were identified in groundwater or landfill gas for further quantitative risk assessment.

Toxicological Assessment

Although no COPCs were identified for the Midway Landfill, toxicity information for those VOCs in landfill gas that were detected frequently and at high concentrations in previous investigations (Parametrix 1988a; Am Test-Air Quality Inc. 1992) is included in the Toxicity Assessment for informational purposes only. A toxicity profile for methane gas and a brief summary of the non-toxicological hazards associated with methane gas (flammability and asphyxiation) are also included.

HHRA Findings

The OMF South will be connected to the municipal water system and will not use groundwater at the facility. Groundwater ingestion is considered to be an incomplete route of exposure for all occupational exposure scenarios at the OMF South and therefore groundwater ingestion does not pose a chronic health risk to any OMF South worker.

Exposure to vapors from landfill gas and groundwater were considered as a potentially complete route of exposure under the worst-case scenario assumption that a long-term failure in engineered protections (including the landfill cap and gas collection system) occurs at the OMF South, allowing for vapor intrusion from subsurface gas and underlying groundwater to indoor air.

Based on the comparison of maximum concentrations of COIs detected in groundwater to applicable risk-based screening levels, occupational exposure to COIs in groundwater at the Midway Landfill via vapor intrusion is not expected to result in adverse chronic health effects for any OMF South worker.

In addition, occupational exposure to methane gas is not expected to result in adverse chronic health effects due to the relatively non-toxic nature of the gas. However, other occupational hazards associated with methane gas, such as flammability, at the Midway Landfill may need to be considered and addressed through risk management efforts if Sound Transit selects the site for the future OMF South.

A high level of uncertainty remains regarding the potential risks associated with occupational exposures to VOCs and inorganic gases at the site due to a lack of sufficient and reliable data necessary to characterize human health risks and uncertainty regarding the potential for occupational exposure to landfill gases based on current and future site conditions and engineered controls.

In order to effectively quantify the risk associated with occupational exposures to COIs in landfill gas, additional sampling is needed to characterize site conditions and identify potential routes of exposure. Future sampling of landfill gas constituents should be conducted following an approach that generates the appropriate environmental data needed to characterize occupational exposures and evaluate potential health risks at the OMF South (e.g., post-construction sub-slab soil gas and/or indoor air sampling).

Pre-construction sampling of flare inlet gas and gas extraction wells could also be conducted to provide information on the COIs present in landfill gas at this time; however, concentrations of COIs in samples collected from the landfill gas collection system would not be appropriate for use in the assessment of occupational exposures at the OMF South as they are likely not representative of concentrations in the subsurface that may pose an unacceptable threat to indoor air quality in site buildings. At this point, quantification of any long-term worker risk is premature until representative data can be acquired.

In order to better assess current concentrations of COIs in gas collected from the landfill, if requested by Sound Transit, follow-up sampling and analysis could be conducted. Potential landfill gas sampling options are discussed in Appendix B.

Non-Toxicological Hazards Evaluation

Some of the primary non-toxicological risk factors associated with redevelopment on a landfill include methane explosion and subsurface fire risk, seismic considerations, and occupational exposures to site COIs and environmental hazards during construction activities.

Methane Explosion Risk

Explosion risk is present at the site and needs to be mitigated through engineered controls. Common means for protection would be the re-establishment of the landfill cap and gas collection system impacted during construction of the OMF South. Additional engineered protections can also be incorporated into the OMF South design to mitigate the risk associated with a potential landfill cap leak and/or gas collection system failure for areas in contact with the landfill surface. Depending on the selected construction design, these engineered protections may include an independent, under slab methane barrier with passive gas ventilation and/or gas sensors installed in occupied areas and in areas where site operations provide an ignition source.

Methane migration to in-ground, non-building, confined spaces could occur through a leak in the landfill cap resulting in a methane explosion or asphyxiation hazard. These hazards can be managed through adherence to required confined space entry procedures, including monitoring of methane and oxygen concentrations prior to entry.

Seismic Considerations

Stability concerns have not been identified at Midway Landfill. The site configuration is primarily a backfill of a previous excavation and site slopes have no reported signs of instability. All of the construction design approaches for the OMF South are expected to improve site stability and further geotechnical analysis can be performed to evaluate site seismic and static stability with the planned landfill modifications and OMF South loading.

Hazards Associated with Construction Activities

The construction of the OMF South under all of the construction design approaches requires the disruption of established remedial systems which, without adequate and proper controls, could temporarily expose construction workers to solid waste and landfill gas and may generate dust and contaminated runoff that could impact the surrounding environment. Air intrusion into the landfill will also need to be prevented since this could result in a landfill fire. Appropriate planning and an adherence to applicable regulations will be required to provide continued protection of human health and the environment during construction of the OMF South.

An Environmental Protection Plan will likely be required to establish procedures to manage and monitor the waste excavation and handling process. A project-specific Health and Safety Plan and Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) training will be required.

Conclusions

The HHRA found that occupational exposures to VOCs in groundwater and to methane in landfill gas are not expected to result in adverse chronic health effects for any OMF South worker. However, the potential risk associated with occupational exposures to COIs in landfill gases could not be characterized due to a lack of representative data. In order to quantify occupational risk at the OMF South, post-construction sampling of VOCs and inorganic gases is needed (e.g., sub-slab soil gas and/or indoor air sampling) to provide an appropriate measure of the concentrations that workers may be exposed to at the OMF South.

In order to assess current COI concentrations in landfill gas, a pre-construction landfill gas investigation could be conducted. Potential landfill gas sampling options are discussed in Appendix B.

The non-toxicological hazards evaluated for the Midway Landfill can largely be managed through appropriate engineered protections, health and safety protocols, construction design standards, and site control and environmental protection plans. Risk management approaches for non-toxicological hazards will need to be developed based on the final selected OMF South construction approach.

1.0 Introduction

This Human Health Risk Assessment (HHRA) has been prepared for the Midway Landfill as a potential site for Sound Transit's Operations and Maintenance Facility South (OMF South).

Sound Transit is currently implementing a system-wide expansion of the Link light rail system and is evaluating the Midway Landfill as a potential site for the OMF South (HDR 2019a). The purpose of the HHRA is to evaluate potential chronic health risks to Sound Transit personnel who work at the future site should it be selected for the OMF South and waste be maintained on site. Non-Toxicological hazards including acute, physical risks associated with constructing and operating the OMF South over a waste mass are also discussed briefly.

From this point forward, this report is organized in the following sections described below. The key components of the HHRA are discussed in Sections 2 through 6 and a discussion of non-toxicological hazards is contained in Section 7.

Section 2 Background provides a brief summary of background information on the Midway Landfill, including the site setting, history, geology, and hydrogeology of the area, current and reasonably likely future beneficial uses of land and water, and current redevelopment conceptual designs for OMF South.

Section 3 Data Evaluation provides a summary of the nature and extent of contamination at the Midway Landfill, past site investigation and characterization activities, contaminants of interest (COIs), and environmental data available for use in the risk assessment. Data quality is evaluated for appropriateness and usability and data gaps are identified in this Section.

Section 4 Exposure Assessment provides an estimation of the amount, frequency, duration, and routes of exposure that an OMF South worker may have to contaminants found at the Midway Landfill. This section describes the scenarios in which OMF South workers could be exposed to contaminants based on likely future site use and compares concentrations of COIs in specific media to risk-based screening levels in order to identify contaminants of potential concern (COPCs) at the landfill.

Section 5 Toxicity Assessment summarizes the nature and degree of toxicity of each COPC in order to characterize potential chronic health risks associated with exposure to COPCs at the Midway Landfill. Two types of health effects are discussed: 1) non-carcinogenic health effects, and 2) carcinogenic health effects. The same chemical may exert both kinds of effects.

Section 6 HHRA Findings provides an overview and discussion of the nature and magnitude of potential risks to OMF South workers at the Midway Landfill.

Section 7 Non-Toxicological Hazards Evaluation describes other risk factors associated with siting the OMF South at the Midway Landfill including a discussion of methane explosion hazards, seismic considerations, and worker health and safety during construction activities.

2.0 Background

2.1 Site Setting

The Midway Landfill is located between Interstate-5 (I-5) and Highway 99 and South 252nd Street and South 246th Street in Kent, Washington. The landfill is roughly 60 acres in size with solid waste buried on about 40 acres at depths of up to 100 feet. Between 1966 and 1983, approximately three million cubic yards of solid waste were deposited at the Midway Landfill. The landfill is currently owned by the City of Seattle (City) (USEPA 2000a) and operated by Seattle Public Utilities (SPU).

The landfill is covered with a multilayered engineered cap (landfill cap) designed to reduce surface water infiltration into landfill waste and leachate discharge into underlying aquifers. The landfill is fenced and no public access is allowed. A gas extraction system is in place and operating throughout the landfill to control subsurface migration of landfill gas (USEPA 2015a).

Surrounding land use is primarily commercial and residential. Commercial businesses, light industry and manufacturing border Highway 99. Most of the nearby residences are detached single-family dwellings, with some multi-unit residential developments and mobile home parks in the vicinity. Two schools, Sunnycrest Elementary School and Parkside Elementary School, and a city park, Linda Heights Park, are within a half-mile of the landfill (USEPA 2015a).

2.2 Site History

The site of the current Midway Landfill was operated as a gravel pit from 1945 until 1966. In 1966, the City leased the site for use as a landfill for demolition materials, wood waste, and other slowly decomposing materials (USEPA 2015a). Records indicate that from 1980 to 1983 paint sludge, dyes, preservatives for decorative plants, alkaline wastes, oily sludges, waste coolant, truck steam cleaning wastes, and some oily wastes were deposited at the site (Parametrix 1988a). Approximately two million gallons of bulk industrial liquids from a single source were placed in the landfill (USEPA 2015a). The nature and type of industrial liquids disposed of in the Midway Landfill is not known. The City closed the landfill in 1983.

Following closure of the landfill, the City began sampling groundwater and landfill gas in and around the site. Organic and inorganic contaminants were detected in groundwater from monitoring wells and in gas samples from gas probes both within and outside the landfill boundary (USEPA 2015a).

Cleanup work began in 1984 under the direction of the Washington State Department of Ecology (Ecology) and construction of a landfill gas extraction system began in 1985. The site was listed by the U.S. Environmental Protection Agency (USEPA) as a National Superfund Site in

May 1986 (CERCLIS Identification Number: WAD 980638910). In September 1988, the City and Ecology prepared a Remedial Investigation (RI) and a Remedial Action Feasibility Study (FS) (USEPA 2015a).

The RI investigated the impact of the landfill on the environment and included monitoring of the landfill gas, air emissions, leachate, groundwater, and surface water on or adjacent to the site (Parametrix 1988a). Findings of the RI are summarized briefly below.

- Gas samples from onsite gas extraction wells and pre-combustion flare were analyzed for a number of contaminants including numerous USEPA Hazardous Substances List (HSL) volatile organic compounds (VOCs). The VOCs found most frequently and in the highest concentrations in onsite subsurface gas included ethylbenzene, vinyl chloride, total xylenes, toluene, and benzene. The inorganic gases, hydrogen sulfide and carbon monoxide, were also reported present in onsite gas in the low parts per million (ppm) range (Parametrix 1988a).
- Landfill emissions to ambient air were evaluated by comparing contaminant concentrations in samples collected from upwind and downwind of the Midway Landfill. Samples were analyzed for VOCs. Many contaminants were found at higher concentrations upwind of the landfill and at offsite locations that were not downwind from the landfill which indicated the presence of offsite sources of emissions unrelated to the Midway Landfill (e.g., I-5 and Highway 99). In addition, ambient air quality near the landfill was not found to be measurably different from typical urban air and onsite air quality monitoring found no evidence of gas emission through the surface of the landfill sufficient to cause adverse ambient air impacts (Parametrix 1988a).
- Leachate generated by infiltration from precipitation and direct discharge of stormwater into the solid waste contained in the landfill was sampled from three wells and analyzed for USEPA HSL contaminants, including metals, VOCs, pesticides, and other potentially hazardous substances during the RI. Leachate samples were found to contain a variety of HSL compounds at trace levels (Parametrix 1988a).
- Groundwater samples were collected from approximately 40 locations in and around the landfill including 29 monitoring wells, 8 boreholes, and 2 private wells. Samples were analyzed for conventional water quality parameters as well as HSL compounds. A number of HSL VOCs were found in groundwater and five wells exceeded drinking water standards for one to three VOCs each. The VOCs detected in groundwater fall into three major groups: ketones, benzenes, and chlorinated solvents. The specific compounds detected are all involved in the use of paints, varnishes, resins and plastics, either as solvents, swelling agents, thinners, or removers (Parametrix 1988a).

- The RI found no evidence of offsite transport of contaminants in surface water or leachate contamination into nearby seeps or springs (Parametrix 1988a).

In May 1990, the City and Ecology entered into a Consent Decree pursuant to State of Washington Model Toxics Control Act (MTCA). In this Consent Decree, the City agreed to perform specific cleanup work. This cleanup work, or remedial action, had the following elements:

1) A multi-layered landfill cover system (landfill cap) designed to reduce surface water infiltration into the landfill and the release of hazardous emissions from the landfill (completed in May 1991) (USEPA 2000a, 2015a);
2) An active gas extraction system (construction began in September 1985 and was completed in March 1991) (USEPA 2015a);
3) A surface water management system to control surface water drainage and prevent surface water from infiltrating the landfill including a 10 million-gallon stormwater detention pond with a permanent dewatering system, a controlled discharge structure, and rerouting of stormwater from the Linda Heights Park drain and I-5 to the detention pond to prevent it from entering the landfill (completed in 1991) (USEPA 2015a); and,
4) A comprehensive plan for short- and long-term operations and maintenance for the systems constructed under the Consent Decree (prepared by the City and approved by Ecology in April 1992) (USEPA 2015a).

The City completed the cleanup in November 1992. However, since the Record of Decision (ROD) was not signed at that time, construction completion was not officially recognized until September 21, 2000.

An amendment to the 1990 Consent Decree specified a requirement to implement a compliance monitoring plan at the landfill to track the presence, concentration, and migration of groundwater contaminants both upgradient and downgradient of the landfill and to assess the effectiveness of the remedial action. Compliance monitoring began in 1990. In addition, the City initiated performance monitoring in 1989 to track the response of landfill leachate levels and shallow groundwater levels to the implementation actions required by the Consent Decree. Both compliance and performance monitoring programs are ongoing (USEPA 2000a, 2015a).

Landfill gas monitoring (which consists of checks for concentration, composition, temperature, flow, and velocity of gases in and around the landfill) is conducted by the City on a regular basis (USEPA 2000a, 2015a).

Available post-cleanup groundwater and landfill gas monitoring results are discussed further in Section 3.

2.3 Site Conditions

Information on the site geology, site hydrogeology, surface water and stormwater systems, landfill cap, and landfill gas extraction system is included in numerous site documents and is summarized in the sections below.

2.3.1 Site Geology and Subsurface Conditions

The Midway Landfill occupies a shallow, bowl-shaped depression (a former gravel pit) near the crest of a narrow north-south trending glacier feature known as the Des Moines Drift Plain (USEPA 2015a). The Des Moines Drift Plain lies between the Olympic Mountains on the west and the Cascade Mountains on the east and is underlain by a thick sequence of Quaternary glacial, fluvial (riverine), and lacustrine (lake bed) deposits overlying Tertiary volcanic and sedimentary bedrock (USEPA 2000a). Depth to bedrock is thought to exceed 1,000 feet near Midway Landfill (USEPA 2015a).

Subsurface materials under the site are of glacial origin and consist for the most part of mixed sands and gravels, with some silt and clay (Parametrix 1988a). The ground surface of the landfill has been modified by the placement of waste and cover material.

Based on studies of the area and analysis of geological samples collected during the installation of monitoring wells for the RI, nine stratigraphically distinct deposits were identified from the land surface down approximately 400 feet to sediments that are near current mean sea level (MSL). Because of the complex layering in all the sediments underlying the landfill, vertical and horizontal permeabilities are highly variable and produce a complex groundwater flow pattern (USEPA 2000a).

2.3.2 Site Hydrogeology

Groundwater movement within and below the landfill has been characterized to an approximate depth of 300 to 350 feet below ground surface (bgs) (50 to 100 feet above MSL). Several groundwater units have been identified within this interval. From shallowest to deepest these aquifers are: Shallow Groundwater; Saturated Refuse; Upper Gravel Aquifer (UGA); Sand Aquifer (SA); Southern Gravel Aquifer (SGA); and Northern Gravel Aquifer (NGA) (USEPA 2015a).

2.3.2.1 Shallow Groundwater

According to the ROD (USEPA 2000a), this zone of saturation is shallow, discontinuous lenses of groundwater. The majority of these shallow zones are found north and south of the landfill. The general water elevation of the shallow groundwater zone adjacent to the landfill is generally at about 325 feet above MSL north and south of the landfill, and lower, and more discontinuous to the east and west (USEPA 2000a).

The landfill's detention pond dewatering system affects shallow groundwater flow through the northern periphery of the landfill. Shallow groundwater north of the landfill (at 320 feet or above) is captured by the dewatering system and routed to North McSorley Creek. The dewatering system limits the shallow groundwater that discharges into the landfill from the north (USEPA 2000a).

2.3.2.2 Saturated Refuse

Prior to the remediation required by the 1990 Consent Decree, the major sources of water to the landfill were: surface water infiltrating from the landfill surface and from areas north of the landfill that drained into the landfill; stormwater discharge from the Linda Heights neighborhood, and I-5 drainage that was routed into the landfill as part of the construction of I-5; and shallow groundwater from north and south of the landfill (USEPA 2000a).

The Saturated Refuse consists of leachate within the landfill and is located below elevations of approximately 325 feet. Flow in the Saturated Refuse is generally from the north and west toward the south-central section of the landfill, where the pit excavations were deepest. Leachate likely discharges vertically throughout much of the landfill base, but the greatest volume of vertical flow is in the south-central area, where leachate discharges to the underlying UGA (USEPA 2000a).

Since construction of the engineered cap and stormwater diversion systems, the majority of surface water that entered the landfill has been diverted and leachate levels have dropped by as much as 20 feet (USEPA 2000a).

2.3.2.3 Upper Gravel Aquifer

The UGA is located at the base of the landfill (100 to 170 feet bgs) and consists of interbedded zones of permeable gravels and less permeable mixtures of silt, sand, and gravels. Leachate from the landfill discharges into the underlying UGA. Groundwater flow in the UGA is generally from both the north and south inward toward an area beneath the southern end of the landfill where the groundwater discharges downward into the underlying SA. The UGA and SA are separated by a discontinuous layer of fine-grained silt, clayey silt, and silty fine sand that is present throughout most of the study area known as the Upper Silt Aquitard. Vertical flow from the UGA into the SA is most pronounced where the aquitard is absent (e.g., beneath the southern end of the landfill) (USEPA 2000a).

The remediation required by the 1990 Consent Decree and the dewatering of the refuse have greatly reduced the amount of recharge entering the UGA. Within the landfill footprint and around the perimeter, the UGA monitoring wells have been dry since 1992 (USEPA 2000a).

The UGA beneath the landfill is under vacuum from the landfill gas extraction system which helps to reduce volatile organics in leachate from being released to the underlying groundwater system (USEPA 2000a).

2.3.2.4 Sand Aquifer

The SA occurs as a widespread deposit of interbedded sands and silts approximately 200 to 300 feet bgs. Flow in this aquifer is generally from the north and west to the southeast toward a hydraulic sink that occurs across a broad area beneath the southern part of the landfill and extends several hundred feet to the east. Groundwater entering this sink flows downward into the SGA (USEPA 2000a).

2.3.2.5 Southern Gravel Aquifer

The SA and SGA are separated by the Lower Silt Aquitard. Similar to the Upper Silt Aquitard, the Lower Silt Aquitard is discontinuous in places allowing for the downward flow from the SA into the SGA (USEPA 2000a).

The SGA is found beneath the southern half of the landfill at approximately 300 to 350 feet bgs and extends to the east, south, and west. It consists of permeable sands and gravel interbedded with silts and silty gravel. The SGA appears to be recharged by the SA and by lateral flow from the south. A groundwater mound in the SGA, below the hydraulic sink in the SA, is believed to be an expression of regional flow through the sink (USEPA 2000a). Groundwater flow is generally northeast-northwest and the SGA eventually discharges west to Puget Sound and east to the Green River Valley (USEPA 2015a).

2.3.2.6 Northern Gravel Aquifer

The NGA is found beneath the northern half of the landfill at approximately 300 to 350 feet bgs and extends to the north and northeast. Similar to the SGA, the NGA consists of permeable sands and gravel interbedded with silts and silty gravel. Flow from the NGA is generally from north to south toward the SGA and, like SGA, the NGA eventually discharges to Puget Sound and the Green River Valley (USEPA 2015a).

2.3.3 Surface Water and Storm Water System

Midway Creek is located northeast of the landfill, and two other streams, the north and south forks of McSorley Creek, are located to the west and southwest, respectively (USEPA 2015a).

There are no major surface water bodies in the immediate vicinity of the Midway Landfill. The closest are Lake Fenwick, located approximately one mile to the southeast, and Star Lake, located approximately 1.5 miles to the south (USEPA 2015a).

A six-acre wetland, the Parkside Wetland, located to the east of the Parkside Elementary School and west of the landfill is a naturally occurring detention basin for local surface water runoff, primarily from the west side of Highway 99 (USEPA 2000a).

A stormwater collection system was installed as part of the 1990 Consent Decree to control surface water drainage and prevent surface water infiltration into the landfill. The stormwater collection system includes a 10 million-gallon stormwater detention pond with a permanent dewatering system, a controlled discharge structure, and rerouting of clean stormwater from the site into McSorley Creek, which is a salmon-bearing stream containing coho and chum salmon, steelhead and cutthroat trout (USEPA 2000a).

2.3.4 Landfill Cover System

The Midway Landfill is currently covered by a multi-layered landfill cap comprised (from bottom to top) of a 12-inch-thick layer of low permeability soil/clay material, a 50-mil high-density polyethylene (HDPE) flexible membrane, drainage net, filter fabric, a 12-inch-thick drainage layer, and a 12-inch-thick topsoil layer planted with shallow rooted grasses (USEPA 2000a, 2015a). The landfill cap reduces surface water infiltration into the landfill and controls the release of hazardous emissions from the landfill.

2.3.5 Landfill Gas Extraction System

Construction of an active gas extraction system at the Midway Landfill began in September 1985 and was completed in March 1991. The gas extraction system originally included 87 gas extraction wells; however, 31 offsite gas extraction wells located outside of the landfill footprint in native soil have since been abandoned or capped because offsite gas has been removed from the offsite locations and is currently controlled via onsite extraction wells. Landfill gas is extracted through the onsite extraction wells at the landfill and routed to a permanent blower/flare system where the extracted gas is supplemented with natural gas and then burned before discharge to the atmosphere (USEPA 2000a, 2015a). The natural gas is needed for combustion due to the low volume of landfill gas currently generated at the site. It was noted in the Third Five-Year Review of the Midway Landfill (USEPA 2015a) that during a June 2015 site inspection, the mechanical equipment for the gas extraction system appeared to be in good operating condition.

2.3.6 Operations and Maintenance Requirements

Ecology oversees the City’s operation and maintenance for the landfill cover system, gas extraction system, and surface water control systems constructed under the Consent Decree. The short-term and long-term operation and maintenance requirements for Midway Landfill are described in the Midway Landfill Operation and Maintenance Manual (Parametrix 1992) which was approved by Ecology in April 1992. The manual addresses operation and maintenance of all components of the remedy including: gas system, surface water systems, pump stations, landfill cover system, and roadway and site control. There are no reporting requirements associated with the landfill cap, gas collection system, or surface water drainage system; however, routine maintenance records are kept onsite (USEPA 2015a). The Third Five-Year Review noted that the Midway Landfill Operations and Maintenance Manual has not been updated since 1992 and should be updated to include the current landfill gas sampling locations and schedule and location of operational gas extraction wells (USEPA 2015a).

2.4 Beneficial Uses of Land and Water

The following sections briefly describe the current and future uses of land and water at the Midway Landfill site.

2.4.1 Current and Future Land Uses

Currently the landfill is capped and fenced. No public access is allowed.

As part of the Consent Decree (Ecology 1990) and as described in the ROD (USEPA 2000a), the City is required to place a notice in the records of real property kept by the King County auditor alerting any future purchaser of the landfill property, in perpetuity, that this property had been used as a landfill, was on the USEPA's National Priorities List, and that future use of the property is restricted. The use restriction shall comply with the post-closure use restrictions under the State of Washington's Criteria for Municipal Solid Waste Landfills, Washington Administrative Code (WAC) 173-351-500. The City is responsible for ensuring that future owners and operators are made aware of these restrictions and that restrictions remain in effect and are complied with even in the event the property is sold or transferred (USEPA 2015a).

The City is required to ensure continued operation and maintenance of all components of the remedy if any portion of the property is sold, leased, transferred, or otherwise conveyed (USEPA 2015a).

Sound Transit is currently implementing a system-wide expansion of the Link light rail system and recently evaluated Midway Landfill as a potential site for the OMF South (HDR 2019a). The current redevelopment conceptual designs for the Midway Landfill would construct the OMF South at the site. The proposed OMF South site is described in more detail in Section 2.4.3 below.

2.4.2 Current and Future Water Uses

According to the Third Five-Year Review for the Midway Landfill Superfund Site, no one is known to be drinking the groundwater from any aquifer within almost a mile of the landfill and there are no current plans to use the groundwater near the landfill for drinking water. The closest wells currently in use for drinking water are the Lake Fenwick wells almost one mile southeast of the Midway Landfill (USEPA 2015a).

State regulations (WAC 173-160-171) do not allow any new private drinking water wells within 1,000 feet of a solid waste landfill or 100 feet of all other sources or potential sources of contamination and Ecology must be notified prior to the construction of any new well (USEPA 2015a). Per the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Midway Landfill is considered a waste management area and thus is not considered a future drinking water source by the USEPA (USEPA 2015a).

2.4.3 Operation and Maintenance Facility South (OMF South)

As part of the process of evaluating the Midway Landfill for reuse as the OMF South site, Sound Transit has developed a preferred preliminary site layout and five construction design approaches for review and consideration. The preliminary site OMF South layout is approximately 68 total acres including an Operation and Maintenance Building and the capability to store and maintain 144 vehicles. The site also includes a 5-acre storage area with a Maintenance of Way Warehouse. The total site area includes the lead tracks from the mainline to the site and other support areas. The five construction approaches include:

- **Approach 1:** High structural platform with no excavation
- **Approach 2:** Low structural platform with some excavation
- **Approach 3:** Hybrid 1: Excavation with ground improvements (buildings on drilled shafts)
- **Approach 4:** Hybrid 2: Excavation with ground improvements (slab-on-grade for tracks and buildings on drilled shafts)
- **Approach 5:** Full excavation and backfill with competent soils

The site layout and construction approaches are discussed in detail in the Midway Landfill Site Engineering Optimization Report (HDR 2019b).

The horizontal layout of the OMF South is consistent between all of the construction approaches. However, the construction approaches differ vertically based on alternative construction designs developed to mitigate landfill settlement and other environmental impacts associated with construction in a landfill. The differences in vertical construction approaches could result in differences in occupational exposures to both toxic and non-toxic hazards at the OMF South.

In order to streamline the exposure assessment step of the HHRA and the non-toxicological hazards evaluation, the construction approaches listed above are grouped into three future development concepts for the OMF South based on the potential exposures associated with each construction approach. The concepts are as follows.

> **Concept 1:** OMF South built on an elevated structural platform. This concept includes an elevated platform constructed on shafts or pilings that are installed through the landfill cap and the underlying waste material. The landfill cap will be restored at penetrations and the gas system and other environmental controls will be preserved. This concept represents the high structural platform construction approach (Approach 1).
>
> **Concept 2:** OMF South built on a slab on the surface of the landfill following full excavation and removal of underlying landfill waste. This concept includes removal of the landfill cap and underlying solid waste, screening and reuse of contaminated, but competent, soils contained in the landfill as fill, reconstruction of the landfill cap, reconstruction of environmental controls, and construction of a slab foundation. This concept represents the full excavation and backfill with competent soils construction approach (Approach 5).
>
> **Concept 3:** This concept is a combination of Concepts 1 and 2 and will include removal of the landfill cap, partial removal of underlying solid waste, screening and reuse of contaminated, but competent, soils contained in the excavated portion of the landfill as fill, reconstruction of the landfill cap, reconstruction of environmental controls, and construction of the OMF South on a combination of slab foundation and an elevated platform on shafts or pilings. This concept represents the low structural platform, Hybrid 1, and Hybrid 2 construction approaches (Approaches 2, 3, and 4).

The activities carried out at the OMF South are generally expected to range from administrative work, warehouse management, and vehicle maintenance to track and yard maintenance. Work environments will vary between an office, shop, warehouse, or the outdoors. Regardless of the implemented construction design, Sound Transit operations work activities will remain above the landfill cap and are not expected to disrupt in-place remedies.

Non-toxicological risks associated with each of these future development concepts are evaluated and discussed in Section 7. Human health risks are evaluated for the worst case exposures scenario, which is represented by Concept 3, based on current site conditions and potentially complete routes of exposure.

3.0 Data Evaluation

The first step in the data evaluation process for the Midway Landfill is to identify any and all available environmental data for COIs for use in this HHRA[2]. The following reports contain relevant environmental data; however, some parts of these reports were not available for review at the time of this assessment resulting in a lack of supporting information needed to conduct a full data evaluation[3]. The reports that contained environmental data and that were available for review (full or partial) include:

- Midway Landfill Remedial Investigation Summary Report. Parametrix. July 1988.
- Source Emissions Evaluation for the Midway Sanitary Landfill, Landfill Gas Flare Testing. Am Test-Air Quality Inc. February 1992.
- Midway Landfill EPA ID: WAD980638910 OU 01, Kent, Washington Record of Decision. USEPA. September 2000.
- ARI Analytical Data Quality Review for the Midway Groundwater Monitoring Event 57. Analytical Resources, Incorporated (ARI). May 2010.
- Midway Landfill Groundwater Monitoring 2010 Annual Report. Parametrix. July 2011.
- Midway Landfill Groundwater Monitoring Status Report 2010-2014. Parametrix. May 2015.
- Third Five-Year Review for the Midway Landfill Superfund Site, Kent, Washington. USEPA Region 10. September 2015.

The second step in the data evaluation process is to review the available data to determine whether they are of sufficient quality and reliability to support a quantitative comparison to recommended risk-based screening levels (USEPA 1992). The following questions are considered when evaluating data quality:

- Were the samples collected and analyzed by reliable and acceptable methods?
- How old are the data? Are the data representative of current site conditions?

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[2]At the time of this assessment, the most recent compliance groundwater monitoring data (2015 to present) were not publicly available; therefore, the most current publicly available compliance groundwater monitoring data from 2010-2014 were evaluated.
[3]The process for requesting and obtaining some reports or supporting information from Ecology and SPU was prohibitive given the timeline of this assessment.

- Were the laboratory reporting limits sufficiently low for comparison with applicable screening levels?
- Were multiple locations sampled to assess spatial variability of the results?
- Were multiple sampling events conducted to assess temporal variability of the results?

These considerations are discussed for available groundwater and landfill gas data in the data review and summary section (Section 3.2) below.

3.1 Contaminants of Interest

The RI and subsequent groundwater and landfill gas monitoring evaluated a wide range of potential contaminants in groundwater and landfill gas (Parametrix 1988a, 2011, and 2015; ARI 2010; Am Test-Air Quality Inc. 1992). Those chemicals detected in groundwater and landfill gas and reported in the documents listed above in this section are considered COIs for the purposes of this HHRA. These COIs are shown in Tables 1 through 6 of this report.

3.2 Data Review and Summary

3.2.1 Groundwater Data Review

Under the ROD, the City has conducted performance and compliance groundwater monitoring programs at the Midway Landfill since 1989. Groundwater chemistry monitoring was initiated in February 1990 and has been conducted on a quarterly or semi-annual basis until 2010 when the monitoring frequency was changed to annual sampling in the spring (April or May) (Parametrix 2015). Groundwater samples are collected from monitoring wells located upgradient and downgradient of the landfill. The current groundwater chemistry monitoring program consists of the annual sampling of 11 wells completed in the UGA, SA, and SGA. Annual sampling events were conducted by SPU staff in May of each year. Four additional wells are part of the monitoring program but are not currently sampled because they are dry. Groundwater samples are analyzed for conventional parameters, metals, and VOCs (Parametrix 2015).

At the time of this assessment, annual groundwater results from 2010 through 2014 were available for review in the Midway Landfill Groundwater Monitoring Status Report 2010-2014 (Parametrix 2015) and the Midway Landfill Groundwater Monitoring 2010 Annual Report (Parametrix 2011). Original laboratory results were also available for the May 2010 sampling event (ARI 2010). While more recent groundwater data (2015 to the present) have been collected as part of the performance and compliance groundwater monitoring programs, these data were not available for review at the time of this assessment.

Per the Midway Landfill Groundwater Monitoring Status Report 2010-2014 (Parametrix 2015), all samples were collected in accordance with the methods outlined in the approved Midway

Landfill Monitoring Plan (Parametrix 2000). The Midway Landfill Monitoring Plan (Parametrix 2000) and Appendix C of the Midway Landfill Groundwater Monitoring Status Report 2010-2014, which contains the data quality summaries for groundwater results from 2010 through 2014, were not available for review at the time of this assessment. However, one data quality summary for groundwater samples collected in May 2010 (ARI Analytical Data Quality Review for the Midway Groundwater Monitoring Event 57; ARI 2010) was available and was reviewed to assess overall data quality (including accuracy, precision, and sensitivity of the sampling results).

Based on the existing information, the following determinations were made regarding the available groundwater monitoring data:

- Although the Midway Landfill Monitoring Plan (Parametrix 2000) and all original laboratory reports and data quality summaries for the annual groundwater sampling events from 2010-2014 were not available at the time of this assessment, these documents were previously approved by Ecology, and therefore, it was assumed that groundwater samples were likely collected and analyzed by reliable and acceptable methods.
- The groundwater data were collected within the last ten years and although there are more recent data (2015-2019), it is unlikely that conditions at the landfill have changed significantly during this time period. Therefore, it was determined that the data are likely to be representative of current site conditions.
- Original analytical laboratory reports were not available at the time of this assessment for data collected in 2011 through 2014, and as a result, reporting limits for those years were not available for comparison with applicable screening levels. However, the original laboratory results for the 2010 groundwater monitoring event were available for review and original laboratory reports and data quality summaries for 2011-2014 groundwater sampling events were previously approved by Ecology. Based on this information, it was assumed that the laboratory reporting limits are sufficiently low for comparison with any applicable screening levels.
- Results for 11 wells that were sampled annually from 2010 through 2014 were available for this assessment. This number of sampling locations and frequency of sampling events were sufficient to assess spatial and temporal variability for groundwater underlying and within the vicinity of the landfill. However, as discussed in Section 3.2.2, results for five wells that were within or just outside the landfill boundaries were considered for this HHRA and two of these wells had not been sampled in several years because they were dry. While this reduced number of sample locations within the landfill footprint limits the assessment of spatial variability for groundwater results, it

has been determined that the number of sample locations and sample events were sufficient to assess the spatial and temporal variability of the results.

Based on the determinations noted above, the 2010-2014 groundwater results are considered to be of sufficient quality and reliability for use in this HHRA. These groundwater data are summarized in Section 3.2.2 and presented for comparison to applicable screening levels in Section 4.2.1.

3.2.2 Groundwater Data Summary

Of the 11 wells sampled as part of the performance and compliance groundwater monitoring programs at the Midway Landfill, the following wells were identified as being located within or just outside of the landfill boundaries (see Figure 2-10 from the Midway Landfill Groundwater Monitoring Status Report 2010-2014 in Appendix A of this report):

- MW-7A is one of three wells located in the UGA and is downgradient and near the southern boundary of the Midway Landfill. MW-7A has not been sampled since 1992 because the well has been dry.
- MW-7B is one of seven wells located in the SA and is downgradient and near the southern boundary of the Midway Landfill. MW-7B was added to the monitoring program beginning in 2011 based on the recommendations of the Second Five-Year Review (USEPA 2015a).
- MW-14B is one of five downgradient wells located in the SGA and is near the eastern boundary of the landfill.
- MW-20A is one of seven wells located in the SA and is downgradient and located just west of the landfill. This well has shown historical groundwater quality impacts but has not been sampled since 1994 because the well has been dry.
- MW-20B is one of five downgradient wells located in the SGA and is located just west of the landfill.

Groundwater samples are analyzed for field and conventional parameters (temperature, specific conductivity, pH, chloride, and sulfate) and the following compounds: 1,4-dioxane by USEPA Method 8270 (USEPA 1996a), vinyl chloride by USEPA Method 8260-Selective Ion Monitoring (SIM) (USEPA 1996b), VOCs by USEPA Method 8260 (USEPA 1996b), and dissolved iron and dissolved manganese by USEPA Method 6010B (USEPA 1996c). Detected concentrations of COIs found in groundwater samples collected from the wells listed above are summarized in Table 1 for comparison to the applicable screening levels discussed further in Section 4.2.1. The groundwater cleanup levels established in the ROD (USEPA 2000a) are also included in Table 1 for reference and are discussed briefly below.

The ROD established cleanup levels for groundwater and required ongoing monitoring of groundwater by the City until groundwater cleanup standards have been achieved. These cleanup levels are listed below.

- 1,2-dichloroethane- 5.0 micrograms per liter (µg/L) based on the Federal Drinking Water Standard Maximum Contaminant Level (MCL),
- Vinyl chloride- 0.29 µg/L based on the MTCA Method B* Groundwater cleanup level (WAC 173-340-720) with an adjusted cancer risk of 10^{-5}, and
- Manganese- 2.2 milligrams per liter (mg/L) based on the MTCA Method B* Groundwater cleanup level.

**MTCA Method B cleanup levels are for unrestricted site uses.*

In 2011, 1,4-dioxane was added to the list of parameters for the routinely monitored wells and a special sampling event was conducted in 2012 for 1,4-dioxane in five additional wells to investigate its extent upgradient of the landfill (Parametrix 2015). Although, no cleanup level was established for 1,4-Dioxane in the ROD, detected concentrations are compared to the MTCA Method B Groundwater cleanup level.

1,2-dichloroethane was not detected in any of the wells located within or just outside of the landfill boundaries during the 2010-2014 sampling rounds.

Vinyl chloride exceeded the ROD cleanup level (0.29 µg/L) in the SA in MW-7B during the 2011-2013 sampling rounds; in the SGA in MW-14B during the 2010-2013 sampling rounds; and in MW-20B during 2013-2014 sampling rounds. In 2014, wells MW-7B and MW-14B had dropped below the cleanup level. In general, the levels of vinyl chloride in all wells located downgradient from the Midway Landfill are declining (USEPA 2015a).

Manganese exceeded the ROD cleanup level in the SA in MW-7B during the 2011-2014 sampling rounds and in the SGA in MW-20B during the 2010-2014 sampling rounds. Manganese continues to decrease in these two wells (USEPA 2015a).

1,4-Dioxane exceeded the MTCA Method B Groundwater cleanup level in the SA in MW-7B during the 2012 sampling round and in the SGA in MW-14B and MW-20B during the 2010-2014 sampling rounds (MW-20B was not sampled in 2010). 1,4-Dioxane concentrations are generally decreasing; however, the levels in the SGA are up to 80 times the MTCA Method B Groundwater cleanup level (USEPA 2015a).

3.2.3 Landfill Gas Data Review

3.2.3.1 Methane Sampling Results (2015-2019)

Landfill gas monitoring has been conducted at the landfill on a regular basis beginning in 1984. Landfill gas is collected from the landfill extraction wells and flares by SPU and analyzed for combustible gas (primarily methane), oxygen, carbon dioxide, temperature, static pressure, and other parameters. SPU provided monthly gas monitoring results for 106 sample locations collected between January 2015 and August 2019 for review as part of this assessment. The sampling and analysis methods for landfill gas (methane) are outlined in the approved Midway Landfill Monitoring Plan (Parametrix 2000). However, as mentioned previously, the Midway Landfill Monitoring Plan (Parametrix 2000) was not available for review and limited-to-no information was available regarding sample locations, frequencies, sample protocols, analytical methods, or data quality at the time of this assessment.

Based on the existing information, the following determinations were made regarding the available landfill gas (methane) monitoring data:

- Although the Midway Landfill Monitoring Plan (Parametrix 2000) was not available for review, it was previously approved by Ecology, and therefore, it was assumed that landfill gas samples were likely collected and analyzed by reliable and acceptable methods.
- Methane gas samples were collected on a monthly basis over the last six years and are considered representative of current site conditions.
- Original analytical laboratory reports and supporting data quality summaries were not available at the time of this assessment and as a result, reporting limits were not available for comparison with any applicable screening levels.
- Methane gas samples were collected from 106 locations on a monthly basis over the last six years. This number of sampling locations and frequency of sampling events are sufficient to assess spatial and temporal variability for methane concentrations in landfill gas.

Based on the determinations noted above, the available landfill gas results for methane are considered to be of sufficient quality and reliability for use in this HHRA. These methane data are summarized in Section 3.2.4 and shown in Tables 2 and 3.

3.2.3.2 VOC and Inorganic Gas Sampling Results (1988 and 1992)

Two available sources of data on the composition of subsurface gas in the vicinity of the Midway Landfill were identified during document review for this HHRA. These sources include a gas characterization study completed in 1988 as part of the RI and a source emission evaluation completed in 1992 to quantify gas flare emission levels at the Midway Landfill.

The 1988 gas characterization study was included in its entirety in Appendix E of the Landfill Gas Technical Report (Parametrix 1988b), which at the time of this assessment was not available for review. However, the Landfill Gas Technical Report is summarized in Section 6.4 of the RI (Parametrix 1988a), which was available for review at the time of this assessment.

According to the RI summary (Parametrix 1988a), one objective of the gas characterization study was to characterize the chemical composition of subsurface gas in the vicinity of and within the landfill. As part of the gas characterization study, gas from individual onsite gas extraction wells was sampled and analyzed for compounds known to be present at specific locations deep within the landfill. In addition, flare inlet gas, representing the combined gas extracted from the numerous individual onsite gas extraction wells, was also characterized to provide a description of the average composition of gas extracted from the landfill (Parametrix 1988a).

Gas samples were collected in Tedlar bags from onsite gas extraction wells and pre-combustion flare gas (flare inlet gas) and analyzed for HSL VOCs by Analytical Technologies, Inc. using gas chromatography/mass spectrometry (GC/MS) in accordance with USEPA Method 624 guidance (Parametrix 1988a).

Concentrations of VOCs detected in subsurface and flare inlet gas during the 1988 gas characterization study were presented in the RI in summary form (mean and/or maximum concentrations) in Table 6-1 and Table 8-1 of the RI (Parametrix 1988a). These data are summarized in Section 3.2.4 and shown in Tables 4 and 5a of this report. The inorganic gases, hydrogen sulfide and carbon monoxide, were also detected in onsite subsurface gas in the low ppm range (Parametrix 1988a). Hydrogen sulfide concentrations reported in Table 7-6 the RI are shown in Table 5b. Carbon monoxide results were not reported (Parametrix 1988a).

The 1992 source emission evaluation, conducted by Am Test-Air Quality Inc. to quantify gas combustor emission levels at the Midway Landfill, includes measured concentrations of VOCs found in pre-combustion flare gas (flare inlet gas) and post-incineration emissions. Subsurface gas extracted from the landfill was sampled during three runs at the inlet and the outlet of one of four landfill gas combustors in order to determine the inlet and outlet emission concentrations, emission rates, and the destruction efficiencies for VOCs in landfill gas. The inlet and outlet gas at Flare #3 were measured to quantify velocity, temperature, and moisture and concentrations of carbon dioxide, oxygen, carbon monoxide, hydrochloric acid, sulfur dioxide, nitrogen oxides, and VOCs. Gas samples were collected at the inlet and outlet of Flare #3 and analyzed for VOCs by Coast-to-Coast Analytical Services in accordance with Compendium Method TO-14 (USEPA 1999) (Am Test-Air Quality Inc. 1992).

The laboratory reported VOCs in micrograms per cubic meter ($\mu g/m^3$) were converted in the source emission evaluation (Am Test-Air Quality Inc. 1992) to emission rate units of milligrams per minute (mg/min) for use in the calculation of destruction efficiencies. The emission rate results for each of the three runs at the inlet and outlet of Flare #3 were presented in summary tables on pages 12 (inlet) and 13 (outlet) of the source emission evaluation report (Am Test-Air Quality Inc. 1992). These data are summarized in Section 3.2.4 and shown in Table 6 of this report. A copy of the original laboratory report was included as Appendix B of the source emission evaluation (Am Test-Air Quality Inc. 1992); however, this appendix was not available at the time of this assessment. Carbon monoxide was not detected in flare inlet gas samples collected during the 1992 source emission evaluation.

Based on the existing information, the following determinations were made regarding the available landfill gas (VOCs and inorganic gases) data:

- Documentation detailing the sampling and analysis methods for the landfill gas characterization study (Appendix E of the Landfill Gas Technical Report; Parametrix 1988b) was not available at the time of this assessment. However, the landfill gas characterization study was conducted as part of the RI (under regulatory oversight) and, therefore, the samples were likely collected and analyzed by reliable and acceptable methods.
- The sampling and analysis methods for the source emission evaluation conducted in 1992 were described in Section 5.0 Sampling and Analysis Procedures of the report; however, at the time of this assessment, only Sections 1.0 through 3.0 of the report were available for review and the following sections and appendices were not available; Methodology References (Section 4.0), Sampling and Analysis Procedures (Section 5.0), Calculation Results (Section 6.0), Quality Assurance Plan (Section 7.0), and Laboratory Analysis Results (Appendix B). In addition, it is not clear if the sampling was collected under regulatory oversight. Therefore, a determination could not be made regarding the reliability and acceptability of the methods used for the 1992 source emission evaluation.
- VOC and inorganic gas data from the 1988 landfill gas characterization study and the 1992 source emission evaluation were collected more than 25 years ago and are not expected to be representative of current site conditions.
- The original analytical laboratory data and supporting data quality summaries were not available for the 1988 landfill gas characterization study and the 1992 source emission evaluation at the time of this assessment and as a result, reporting limits were not available for comparison with applicable screening levels.
- It is not clear how many locations were sampled and how many sample events were conducted as part of the 1988 landfill gas characterization study because these details were not provided in the RI summary and Appendix E of the Landfill Gas Technical Report was not available at the time of this assessment. In addition, VOC results were presented in the RI in summary form (mean and/or maximum concentrations only) with no notation of the number of samples collected (see Tables 6-1 and 8-1 of the RI). Therefore, it is not known if the number of sample locations or frequency of sample events were sufficient to assess spatial and temporal variability for VOCs or inorganic

gas concentrations in landfill gas. Hydrogen sulfide results for only two samples collected from the north and south flare inlet were presented in the RI.

- During the 1992 source emission evaluation, three gas samples were collected from one flare inlet and one flare outlet each during a single sample event (February 7, 1992). Additional samples were collected November 7 and 8, 1991, but were not presented in the source emission evaluation after data from this sampling event indicated that there had been a leak in the inlet sampling system. The limited number of sample locations (one flare inlet) and frequency of sample events (one day) are not sufficient to assess spatial and temporal variability for VOC concentrations in landfill gas.

Based on the determinations noted above, the available landfill gas results for VOCs and inorganic gases are not considered to be of sufficient quality and reliability for use in this HHRA and should not be compared to risk-based screening levels. However, to document the available data and for informational purposes, these data are summarized in Section 3.2.4 and Tables 4, 5a, 5b and 6 of this report. When reviewing these data, it is important to note that landfill gas samples collected from the landfill gas extraction system do not provide a representative measure of the COI concentrations that workers may be exposed to at the OMF South for the following reasons: 1) these gas samples were collected under vacuum conditions from varying depths within the landfill and therefore are not likely to be representative of gases that may be escaping the landfill cap, and 2) these gas samples are not likely to be representative of gas concentrations that would be found near the surface due to differences in attenuation prior to sample collection.

3.2.4 Landfill Gas Data Summary

3.2.4.1 Methane Sampling Results (2015-2019)

Monthly methane sample results for January 2015 through August 2019 were provided by SPU for this HHRA. These results included methane concentrations for 106 locations within the landfill gas extraction system (e.g., extraction wells, vacuum manifolds, etc.). Raw data were provided in excel format with limited information on the well locations. However, to confirm their onsite location, well identification numbers were compared to onsite extraction wells and vacuum manifold shown on Figure 8 of the Third Five-Year Review (USEPA 2015a) and included in Appendix A of this report. Wells labeled as 1, 50, 52, MAN, MAN-N, and MAN-S could not be located, but are included in the methane summary tables (Tables 2 and 3). All other wells were confirmed as onsite based on Figure 8 of the Third Five-Year Review (USEPA 2015a).

No applicable toxicity- or risk-based screening levels are available for comparison to methane concentrations detected in landfill gas. However, state regulations (WAC 173-304-460) establish that methane concentrations at a landfill shall not exceed the following:

- 25% of the lower explosive limit (LEL) in facility structures (excluding gas control or recovery system components);
- 100% of the LEL at the property boundary or beyond; and
- 100 ppm by volume of hydrocarbons (expressed as methane) in offsite structures.

Available methane data were summarized by sample location (e.g., onsite extraction well or vacuum manifold) and by year in Table 2 and Table 3. Methane concentrations above the LEL of 5% by volume were found at 75 of the onsite locations (e.g., at least one or more samples collected from these locations between January 2015 and August 2019 were greater than the LEL). The majority (>50%) of all samples collected between January 2015 and August 2019 exceed the LEL (Table 3). Methane concentrations from onsite locations sampled between January 2019 and August 2019 range from 0 to 27.9% with an average concentration of 7.3% (Table 3).

According to the Third Five-Year Review for the Midway Landfill Superfund Site, methane concentrations above the LEL have been detected outside the landfill boundary at one probe location (AM) from 2010 through 2014 (USEPA 2015a). Methane concentrations are highest in the shallow completion of the AM probe, screened from 25 to 40 feet bgs (USEPA 2015a). The AM gas probe is located at the northeast corner of the landfill and is outside the influence of the current gas extraction system (USEPA 2015a) (see Figure 9 of the Third Five-Year Review in Appendix A of this report). No additional offsite probes have shown detected concentrations of methane above the LEL from 2010 through 2014.

3.2.4.2 VOC and Inorganic Gas Sampling Results (1988 and 1992)

A wide variety of substances, including 23 HSL VOCs, were found in subsurface gas collected from the onsite gas extraction wells and flare manifolds during the gas characterization study and source emissions evaluation. The RI noted that ethylbenzene, vinyl chloride, total xylenes, toluene, and benzene were found most frequently and in the highest concentrations in onsite subsurface gas (Parametrix 1988a) and the mean and maximum concentrations of these select compounds were presented in Table 6-1 of the RI. Maximum observed concentrations of additional VOCs detected in onsite subsurface gas and flare inlet gas samples were presented in Table 8-1 of the RI (Parametrix 1988a). These results were presented in parts per billion (ppb) in the RI and were converted to $\mu g/m^3$, as shown in Tables 4 and 5a. Hydrogen sulfide concentrations reported in Table 7-6 of the RI are shown in Table 5b.

Fifteen VOCs were detected in inlet gas (Flare #3) during the 1992 source emission evaluation. The original laboratory analysis reported VOCs in concentration units of $\mu g/m^3$; however, these concentration units were converted to emission rate units of mg/min for use in calculating destruction efficiencies for the evaluation. The original laboratory analysis was not available at the time of this assessment. Therefore, the emission rate results presented in the report (mg/min) were converted back to $\mu g/m^3$ using the air flow rates (dry standard cubic feet per minute) for the inlet of Flare #3 provided in the summary table on page 8 of the source emissions evaluation. These results are shown in Table 6 of this report.

Because these VOC and inorganic gas sampling results (1988 and 1992) are not of sufficient quality and reliability and are not considered to be representative of current site conditions, a quantitative comparison between detected concentrations and applicable screening levels will not be made. However, regulatory screening levels for sub-slab, deep soil, and near source soil gas for occupational exposures are included in Table 7 of this report for reference.

3.3 Potential Data Gaps

Based on an examination of available environmental data and supporting documents, the groundwater and methane datasets are considered to be of sufficient quality and reliability to support a quantitative comparison to risk-based screening levels as part of this HHRA.

However, additional sampling is needed to develop a sufficient and reliable dataset to characterize site conditions and human health risks associated with potential exposures to COIs in landfill gas. Future sampling of landfill gas constituents should be conducted following an approach that generates the appropriate environmental data needed to characterize occupational exposures and evaluate potential health risks at the OMF South. Some representative measures of occupational exposure to VOCs and inorganic gases in landfill gas may include post-construction sub-slab soil gas concentrations and/or indoor air concentrations.

4.0 Exposure Assessment

The first step in an exposure assessment is the development of a Conceptual Site Model (CSM). The CSM describes the physical characteristics of the site, site-specific exposure scenarios, potential exposure pathways (or routes of exposure), and potentially exposed populations. Following development of the CSM, site COPCs are identified by comparing concentrations of COIs found in groundwater and landfill gas to risk-based screening levels.

Once site COPCs are identified through this screening process, the magnitude, frequency, and duration of exposures at the site can then be quantified based on COPC concentrations and chemical- and pathway-specific intake parameters.

This section presents the CSM, a quantitative comparison of exposure concentrations to risk-based screening levels, and a discussion of site COPCs.

4.1 Conceptual Site Model

The CSM for the Midway Landfill describes potential chemical sources, release mechanisms, environmental transport processes, exposure scenarios, potential routes of exposure, and potentially exposed populations. The primary purpose of the CSM is to describe pathways by which human receptors may be exposed to COIs at a site. According to the USEPA (1989), a complete exposure pathway consists of four necessary elements: 1) a source and mechanism of chemical release to the environment, 2) an environmental transport medium for a released chemical, 3) a point of potential contact with the impacted medium (referred to as the exposure point), and 4) an exposure route (e.g., groundwater ingestion, vapor intrusion) at the exposure point.

The CSM, based on available information, is shown in Figure 1 and primary sources of landfill COIs, human receptors, and potentially complete routes of exposure are discussed below.

4.1.1 Primary Sources

The majority of chemical impacts to groundwater and subsurface gas at the Midway Landfill result from landfill waste. However, site investigations indicated that some chemicals found in onsite groundwater and subsurface gas were also found in upgradient groundwater monitoring wells and therefore may be from unidentified, upgradient sources (USEPA 2015a).

As discussed in Section 2.2, the Midway Landfill was used as a landfill for demolition materials, wood waste, and other slowly decomposing materials (USEPA 2015a). Records from the early 1980s indicate that paint sludge, dyes, preservatives for decorative plants, alkaline wastes, oily sludge, waste coolant, truck steam cleaning wastes, and some oily wastes were deposited at the site (Parametrix 1988a). In addition, approximately two million gallons of bulk industrial liquids from a single source were placed in the landfill (USEPA 2015a). However, the nature and type of industrial liquids disposed of in the Midway Landfill is not known.

According to the RI, an estimated three million cubic yards of solid waste were deposited in the Midway Landfill (Parametrix 1988a). Landfill gas is a byproduct of decomposition of organic materials in landfills. Landfill gas is composed mainly of methane and carbon dioxide. However, VOCs (such as benzene and vinyl chloride) can also be found in landfill gas.

During the RI, onsite landfill gas was found to contain numerous USEPA HSL VOCs with ethylbenzene, vinyl chloride, total xylenes, toluene, and benzene found most frequently and in the highest concentrations onsite. Hydrogen sulfide and carbon monoxide were also detected in onsite landfill gas samples (Parametrix 1988a).

The RI identified a number of HSL compounds in groundwater and the ROD established groundwater cleanup levels for manganese, 1,2-dichloroethane, and vinyl chloride based on the protection of downgradient drinking water. The most recent groundwater quality results from 2010-2014 (Parametrix 2015) showed the following exceedances in groundwater wells in the vicinity of the Midway Landfill:

- One downgradient well in the SGA exceeded the 1,2-dichloroethane cleanup level in 2013.
- One upgradient well in the SA and three downgradient wells in the SGA exceeded the vinyl chloride cleanup level during the 2010-2014 sampling rounds with one upgradient well in the SA and one downgradient well in the SGA dropping below the vinyl chloride cleanup level in 2014.
- Two downgradient wells (one in the SA and one in the SGA) exceeded the manganese cleanup level during the 2010-2014 sampling rounds.
- 1,1-dichloroethene, tetrachloroethene, and trichloroethene have consistently been detected in two upgradient wells in the SA at concentrations greater than MTCA Method B Groundwater cleanup levels. However, high tetrachloroethene concentrations (ranging from 110-130 µg/L) in one of the upgradient wells indicates the presence of an upgradient source of this contaminant.
- 1,4-Dioxane has been detected in two upgradient wells and one downgradient well in the SA at concentrations greater than the MTCA Method B Groundwater cleanup level. All downgradient wells in the SGA have exceedances of 1,4-dioxane in all rounds of sampling from 2010-2014. The boundary of the 1,4-dioxane plume is unknown at this time, and additional characterization is needed to determine its extent (USEPA 2015a).

4.1.2 Fate and Transport

The primary release mechanisms that affect the fate and transport of COIs released from waste contained in the Midway Landfill include leaching from waste to underlying groundwater and the migration of landfill gas into and through subsurface soil (see Figure 1).

Secondary release mechanisms include the volatilization of COIs from groundwater into subsurface soil and the transport of subsurface soil gas through the subsurface or through the landfill cover. COIs may also migrate through underlying groundwater.

Advection and dispersion in groundwater, sorption to the soil, and natural degradation processes also play a role in the fate and transport of each COI depending on its individual chemical and physical properties. In addition, the properties of soil and the dynamics of groundwater flow also impact contaminant fate and transport. Once in groundwater, dissolved COIs may be transported by diffusion and advection in groundwater. In general, the potential for a chemical to migrate in groundwater increases as a function of chemical solubility. Dispersion, retardation, and biodegradation act to reduce dissolved concentrations of COIs in groundwater downgradient of the source area.

Some COIs found in waste, soil, soil gas, or groundwater may volatilize into soil pore spaces and migrate via diffusion and advection through the soil into indoor and/or outdoor air. Diffusive transport generally moves in the direction of lower soil gas concentrations while advective transport occurs in the direction of lower air pressure. Advection can occur near buildings due to differences in temperatures between the building and the subsurface environment or the operation of heating and cooling systems and fans that create pressure differentials and influence soil gas entry. Advection of soil gas may also occur due to fluctuations in barometric pressure. In addition, landfills where methane is generated in sufficient quantities may induce advective transport. Overall, soil gas concentrations decrease as the volatile chemicals move from the source through subsurface soil and into indoor or outdoor air (USEPA 2015b).

The infiltration of water into the landfill waste and subsequent leaching to groundwater and the migration of landfill gas through the subsurface to indoor and ambient air is currently controlled by the gas extraction system and the landfill cap. The cap provides a barrier which, along with the gas extraction system, reduces the migration of volatile compounds found in landfill gas and groundwater to the surface where they may enter onsite buildings and/or outdoor air. Migration of volatile compounds through the landfill cover is possible if the gas extraction and cover system were compromised.

If buildings are located directly over an area where the landfill cap has been compromised, it is possible that vapors may enter indoor air by penetrating cracks in a building floor, slab, or foundation, or via mechanical systems. Once in outdoor air, mixing with ambient air is expected to reduce COI concentrations substantially (USEPA 2015b).

4.1.3 Exposure Scenarios

The Midway Landfill will be used for occupational purposes if it is selected as the location of the future OMF South. As a result, various workers (not residents) will have the greatest potential to contact impacted soil gas, groundwater, or air. These workers include long-term Onsite Office, Maintenance Shop, and Yard Workers and short-term Construction Workers.

The following potential exposure scenarios were identified for OMF South personnel at the Midway Landfill. The exposure scenarios described below are not exhaustive but rather are intended to represent exposure profiles for broad occupational categories for those personnel with similar work environments, activities, and exertion levels. Potential occupational routes of exposure to COIs found in landfill waste, gas, and groundwater are described in the CSM (Figure 1) and discussed in Section 4.1.4.

4.1.3.1 Onsite Office Worker

The Onsite Office Worker spends most, if not all of the workday indoors conducting relatively sedentary activities (e.g., desk work, meetings). This exposure scenario assumes that the Onsite Office Worker is a long-term, full-time employee at the OMF South. The Onsite Office Worker is assumed to work at the OMF South for 8 hours a day, 5 days a week for 30 years.

4.1.3.2 Maintenance Shop Worker

The Maintenance Shop Worker spends most, if not all of the workday conducting maintenance activities inside a shop that can be opened to the outdoors during good weather. This exposure scenario assumes that the Maintenance Shop Worker is a long-term, full-time employee at the OMF South who spends a portion of the year working in an enclosed indoor environment and within depressed maintenance pits and a portion of the year working in an environment where s/he is exposed to a mix of indoor and outdoor air. The Maintenance Shop Worker is assumed to work at the OMF South for 8 hours a day, 5 days a week for 30 years.

4.1.3.3 Yard Worker

The Yard Worker spends most, if not all of the workday conducting relatively vigorous work activities outdoors. This exposure scenario assumes that the Yard Worker is a long-term, full-time employee at the OMF South. The Yard Worker is assumed to work at the OMF South for 8 hours a day, 5 days a week for 30 years.

4.1.3.4 Construction Worker

The Construction Worker spends most, if not all of the workday conducting vigorous construction activities outdoors. This exposure scenario assumes that the Construction Worker is a short-term, full-time employee at the OMF South. The Construction Worker may periodically enter onsite utility trenches and underground stormwater vaults for repair and maintenance. The Construction Worker is assumed to work at the OMF South for 10 hours a day, 5 days a week for 6 years.

4.1.4 Potential Routes of Exposure

Based on the knowledge of the current conditions at the Midway Landfill and possible future site uses, the following potential occupational routes of exposure to COIs in landfill waste, gas, and groundwater were identified and evaluated (see Figure 1):

- Inhalation of Indoor Air
- Inhalation of Air in Subsurface Confined Spaces (e.g., utility trenches and vaults),
- Inhalation of Outdoor Air,
- Groundwater Ingestion, and
- Direct Contact with Waste and Contaminated Soil.

These potential routes of exposure are based on the assumptions that construction of the OMF South may result in future site conditions that could allow for vapor intrusion from subsurface gas and underlying groundwater to indoor air (see the description of Concept 3 in Section 2.4.3).

4.1.4.1 Inhalation of Indoor Air

It is assumed that onsite workers could have indirect exposure to COIs in vapors from subsurface soil gas and/or groundwater due to vapor intrusion into indoor or confined spaces (including depressed maintenance pits) and subsequent inhalation of indoor air.

According to the USEPA (2015b), the vapor intrusion pathway is considered complete when the following conditions are met:

1) A subsurface source of vapor-forming chemicals is present underneath or near buildings;
2) Vapors form and have a route along which to migrate toward the building;
3) Openings exist for vapors to enter the building and driving ‘forces’ (e.g., air pressure differences between the building and the subsurface environment) exist to draw the vapors from the subsurface through the openings into the buildings;
4) One or more vapor-forming chemicals comprising the subsurface vapor sources are found to be present in the indoor environment; and
5) The buildings are occupied by one or more individuals when the vapor-forming chemicals are present indoors.

Although the migration of landfill gas is currently controlled by the gas extraction system and the landfill cap and no buildings are located at the landfill at this time, future buildings could be constructed in such a way that vapors from subsurface soil gas or groundwater could breach the cap and enter indoor air through cracks in a building's foundation where they could then be inhaled by workers. This route of exposure is likely to be complete if adequate engineered protections including a functioning gas extraction system and landfill cap are not in place to prevent vapor intrusion. This is a potentially complete route of exposure for Onsite Office and Maintenance Shop Workers.

4.1.4.2 Inhalation of Air in Confined Spaces

OMF South workers could have indirect exposure to volatile COIs in subsurface soil gas and groundwater via vapor migration through the subsurface to confined spaces such as utility trenches and stormwater vaults where they could then be inhaled by workers. This route of exposure is likely to be complete if adequate engineered protections, (e.g., a functioning gas extraction system and landfill cap) are not in place to prevent vapor migration and if worker health and safety protocols for confined spaces are not followed. This is a potentially complete route of exposure for Construction Workers.

4.1.4.3 Inhalation of Outdoor Air

Another pathway by which workers could have indirect exposure to volatile COIs in subsurface soil gas and groundwater is vapor migration through the landfill cap into outdoor air where they could then be inhaled by workers. This route of exposure is likely to be complete if adequate engineered protections (e.g., a functioning gas extraction system and landfill cap) are not in place to prevent vapor migration to the surface. This is a potentially complete route of exposure for Maintenance Shop, Yard, and Construction Workers.

4.1.4.4 Groundwater Ingestion

Currently, no one is known to be drinking groundwater from any aquifer within almost a mile of the landfill (USEPA 2015a) and there are no water supply wells at the landfill. Further, state regulations (WAC 173-160-171) do not allow any new private drinking water wells within 1,000 feet of a solid waste landfill or 100 feet of all other sources or potential sources of contamination and Ecology must be notified prior to the construction of any well (USEPA 2015a). Per the NCP, the Midway Landfill is considered a waste management area and thus is not considered a future drinking water source by the USEPA (USEPA 2015a). As a result, this route of exposure is considered to be incomplete for all occupational exposure scenarios described above.

4.1.4.5 Direct Contact with Waste and Contaminated Soil

Landfill waste and contaminated soil are currently covered by the landfill cap which prevents workers from directly contacting subsurface contamination. However, it is assumed that this landfill cap will be temporarily removed to allow for excavation into the underlying waste and soils during construction of the OMF South. Without the use of proper personal protective equipment (PPE) and site controls, Construction Workers may be exposed to contaminants through incidental inhalation, dermal exposure, and incidental ingestion of exposed waste and contaminated soil during construction and excavation activities. This is a potentially complete route of exposure for Construction Workers.

4.2 Selection of COPCs for the HHRA

To focus the HHRA on COIs with the potential to cause health risks to workers who may come in contact with them through a potentially complete or complete exposure route, the list of chemicals detected at the Midway Landfill was evaluated and reduced. COPCs have been selected using criteria recommended by the USEPA (1989) and best scientific judgment. Chemicals were selected primarily on the basis of measured concentrations and inherent toxicity.

COPCs were selected by comparing the maximum detected concentration to applicable risk-based screening levels. These risk-based screening levels are media-specific concentrations derived from conservative exposure assumptions and available toxicity values.

Screening values are compared to chemical concentrations in site media to qualitatively assess risk to future OMF South workers and to determine if COPC concentrations warrant additional investigation and/or a more detailed, site-specific risk assessment before adequate risk management decisions can be made.

Groundwater concentrations were compared to vapor intrusion screening levels for occupational exposure scenarios (MTCA Method C Groundwater Vapor Intrusion Screening Level; Ecology 2018a and 2018b; WAC 173-340-750) and USEPA Worker Air Vapor Intrusion Screening Levels (VISLs) for Groundwater (USEPA 2018a) (Table 1).

As mentioned earlier, no risk-based screening levels for methane are available for comparison in the HHRA due to a lack of toxicological effects (see the toxicological profile for methane in Section 5.1.2). However, methane is highly flammable, can explode at concentrations between 5% (LEL) and 15% (upper explosive limit), and is a simple asphyxiant that can cause death at concentrations much higher than the explosive range (5-15%). Non-toxicological hazards associated with methane are discussed in more detail in Section 5.1.2 and Section 7.

During data evaluation, it was determined that available landfill gas results for VOCs and inorganic gases are not of sufficient quality and reliability for use in this HHRA and do not represent current conditions at the Midway Landfill. Therefore, VOCs and inorganic gases found in landfill gas are not considered for quantitative risk assessment and are not compared to applicable screening levels. Instead, the data are presented in Tables 4, 5a, and 6 and the toxicities of select VOCs (e.g., those with historically high concentrations) are discussed in Section 5.1.1 for informational purposes only. Regulatory screening levels for sub-slab, deep soil, and near source soil gas for occupational exposures are also presented in Table 7 for reference.

Screening levels for groundwater vapor intrusion and sub-slab, deep soil, and near source gas, along with the exposure assumptions and target risk levels used to derive these screening levels, are discussed in detail in Section 4.2.1.

4.2.1 Screening Levels

Applicable risk-based screening levels were selected for comparison with COI concentrations based on the future occupational use of the site, the occupational (worker) exposure scenarios, and the potentially completed routes of exposure identified in Sections 4.1.3 and 4.1.4. These screening levels were reviewed to verify that they were sufficiently protective of the occupational exposures expected to occur at the OMF South. The basis for the risk-based screening levels selected for comparison (or reference, in the case of subsurface soil gas) is described below.

In order to derive groundwater vapor intrusion and soil gas vapor intrusion screening levels that are protective of indoor air, acceptable indoor air concentrations must first be established. These acceptable air concentrations (USEPA Indoor Worker VISL [USEPA 2018a] and MTCA Method C Indoor Air cleanup levels [WAC 173-340-750] for facilities qualifying as industrial properties under WAC 173-340-745 and for utility vaults and manholes [WAC 173-340-706]) are based on exposure assumptions that are highly protective in nature and are derived using the assumptions and equations shown in Figures 2 and 3.

Indoor air screening levels are calculated using conservative assumptions regarding inhalation rate, exposure duration, and other exposure factors for occupational workers. For example, the USEPA Indoor Worker VISLs have been developed assuming workers have chronic exposure to impacted indoor air over most of their careers (i.e., 250 days per year, 8 hours a day for 25 years for carcinogens and non-carcinogens) and the MTCA Method C Indoor Air cleanup levels for occupational scenarios have been developed with similar conservative exposure assumptions (i.e., 365 days per year, 24 hours per day for 30 years for carcinogens and 365 days per year, 24 hours per day for 6 years for non-carcinogens) (See Figures 2 and 3 for these screening level equations and exposure parameters).

The target risk levels used by the USEPA when developing these screening levels are the same as those used in the MTCA Method C Indoor Air cleanup level equations (see Figures 2 and 3).

Target risk levels for carcinogens is one in a one hundred thousand (10^{-5}) excess cancer risk over a lifetime or the probability that a lifetime exposure to a substance increases a person's chance of developing cancer by one chance in one hundred thousand or less. For the non-carcinogens, the target risk is a hazard quotient of one. A hazard quotient is the ratio of the potential exposure to a substance (or dose) and the level at which no adverse effects are expected. If the hazard quotient is calculated to be greater than one, then adverse health effects are possible.

Both the USEPA Indoor Worker VISL and MTCA Method C Indoor Air cleanup level for a carcinogenic chemical are expressed as a concentration associated with a one in a one hundred thousand (10^{-5}) excess cancer risk over a lifetime. For a non-carcinogen, these screening levels are expressed as the concentration associated with a hazard quotient of one.

Once acceptable risk-based indoor air concentrations have been established, screening levels for Soil Gas and Groundwater Vapor Intrusion are derived by applying USEPA-recommended generic vapor attenuation factors that are protective of worst case vapor intrusion scenarios. Generic vapor attenuation factors and equations for groundwater, and sub-slab, near source, and deep soil gas are shown in Figures 4 and 5.

Soil Gas and Groundwater Vapor Intrusion screening levels that are protective of acceptable indoor air concentrations are also expected to be protective of acceptable outdoor air concentrations due to the substantial reduction of COIs in outdoor air concentrations when mixed with ambient air. However, these screening levels are not expected to be protective of air concentrations in underground confined spaces.

4.2.2 Contaminants of Potential Concern

Maximum concentrations of those COIs detected in groundwater samples from 2010 through 2014 were compared to occupational screening levels for vapor intrusion (e.g., MTCA Method C Groundwater Vapor Intrusion screening levels or the USEPA Worker Air VISLs for Groundwater) in Table 1. Because the groundwater ingestion pathway is not currently complete and will not be complete in the future, groundwater results were not compared to screening levels for groundwater ingestion.

No COIs detected in underlying groundwater at the Midway Landfill exceed the respective MTCA Method C Groundwater Vapor Intrusion Screening Levels or the USEPA Worker Air VISLs for Groundwater (Table 1). As a result, based on the exposure scenarios and potentially complete exposure routes identified in the CSM (Figure 1) and discussed in detail in Section 4.1, no groundwater COPCs were selected for quantitative risk assessment.

As discussed in Section 4.2, due to the absence of representative landfill gas results for VOCs and inorganic gases, no subsurface soil gas COPCs were identified. However, because a number of VOCs in landfill gas were detected relatively frequently and, in some cases, at high concentrations in previous investigations, they have been included in the Toxicity Assessment in

Section 5.1.1 below. A toxicity profile for methane gas is also included in Section 5.1.2 and non-toxicological hazards associated with methane gas are discussed in Section 7.

5.0 Toxicity Assessment

In order to characterize potential carcinogenic and non-carcinogenic risks associated with complete exposure routes, toxicity information for each potential site contaminant is evaluated as part of the toxicity assessment. The recommended hierarchy of toxicological sources for use in human health risk assessment involves three tiers. Tier 1 is the USEPA Integrated Risk Information System (IRIS); the first source of toxicity data. Tier 2 is the USEPA Provisional Peer Reviewed Toxicity Values (PPRTV). Many of the PPRTVs are developed by the USEPA National Center for Environmental Assessment (NCEA). Finally, Tier 3 includes additional USEPA and non-USEPA toxicity sources.

Two general types of health effects are considered in human health risk assessment: cancer effects and adverse non-cancer effects. This distinction is made because the USEPA generally assumes that a dose threshold exists for non-carcinogens, and that adverse health effects are unlikely to occur if humans are exposed to chemical doses below the threshold. No such threshold is generally assumed for carcinogens. Instead, it is assumed that there is a finite probability of developing cancer associated with any exposure to a carcinogen.

As a result, carcinogens and non-carcinogens have separate toxicity criteria. Reference dose or reference concentration values are used to evaluate non-carcinogenic health effects, and slope factors or unit risk factors are used to evaluate carcinogenic health risks. In general, the toxicological effects of a compound are the dominant health effects of the chemical as determined by the USEPA.

5.1 Toxicological Profiles for VOCs in Landfill Gas

Benzene

Benzene is a known human carcinogen for all routes of exposure (inhalation, oral, and dermal) based upon convincing human evidence as well as supporting evidence from animal studies. Epidemiologic studies and case studies provide clear evidence of a causal association between exposure to benzene and acute myelogenous leukemia, which is a cancer of the blood-forming organs, and also suggest evidence for other subtypes of leukemia such as non-Hodgkin's lymphoma (a cancer that forms in lymphocytes) and multiple myeloma (a cancer that forms in plasma cells) (ATSDR 2007a, 2015a). These human data are supported by animal studies. The experimental animal data add to the argument that exposure to benzene increases the risk of cancer in multiple species at multiple organ sites. Recent evidence supports the viewpoint that there are likely multiple mechanistic pathways leading to cancer and, in particular, to the development of leukemia from exposure to benzene (ATSDR 2007a, 2015a). The oral slope factor[4] for benzene is 1.5×10^{-2} to 5.5×10^{-2} milligrams per kilogram per day^{-1} (mg/kg-day)$^{-1}$ (IRIS 2003a).

Benzene has a low solubility rate and resulting low bioaccumulation in marine life. Benzene is mobile in soil and leaches into groundwater depending on soil type, amount of rainfall, depth of the groundwater, and extent of degradation. It tends to adsorb to aquifer solids and greater soil adsorption was observed with high organic matter content. Benzene is highly volatile and benzene released to the environment partitions mainly to the atmosphere. Biodegradation, principally aerobic, is the most important fate process of benzene in water and benzene can persist in groundwater (ATSDR 2007a).

Chlorobenzene

Chlorobenzene is a colorless liquid with an almond-like odor. The compound does not occur widely in nature, but is manufactured for use as a solvent and is used in the production of other chemicals. Chlorobenzene persists in soil (several months), in air (3.5 days), and water (less than 1 day) (ATSDR 1990).

Chlorobenzene is not classifiable as a human carcinogen based on no human data and inadequate animal data (IRIS 1990a). Occupational exposure occurs primarily through breathing the chemical. Workers exposed to high levels of chlorobenzene complained of headaches, numbness, sleepiness, nausea, and vomiting. However, it is not known if chlorobenzene alone was responsible for these health effects since the workers may have also been exposed to other chemicals at the same time (ATSDR 1990). The reference dose (RfD) is 2×10^{-2} mg/kg-day and affects the liver (IRIS 1990a).

1,4-Dichlorobenzene

Dichlorobenzenes do not occur naturally; chemical companies produce them to make products for home use and other chemicals such as herbicides and plastics. 1,4-Dichlorobenzene, the most important of the three chemicals (1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene), is a colorless to white solid. It smells like mothballs and it is one of two chemicals commonly used to make mothballs. 1,4-Dichlorobenzene also is used to make deodorant blocks used in garbage cans and restrooms, and to help control odors in animal-holding facilities. 1,4-Dichlorobenzene has been used as an insecticide on fruit and as an agent to control mold and mildew growth on tobacco seeds, leather, and some fabrics (ATSDR 2006a).

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[4]An oral slope factor is a measure of a chemical's carcinogenicity. More precisely, it is an estimate of the probability that an individual will develop cancer if orally exposed to a specified amount or dose of the chemical every day for a lifetime.

The U.S. Department of Health and Human Services has determined that 1,4-dichlorobenzene might be a human carcinogen. The International Agency for Research on Cancer (IARC) (an expert group that is part of the World Health Organization) determined that 1,4-dichlorobenzene is possibly carcinogenic to humans (ATSDR 2006a; IRIS 1994). It has a reference concentration (RfC) of $8x10^{-1}$ milligrams per cubic meter (mg/m^3) (IRIS 1994). Humans are exposed to 1,4-dichlorobenzene mainly by breathing vapors from 1,4-dichlorobenzene products. Inhaling the vapor or dusts of 1,2-dichlorobenzene and 1,4-dichlorobenzene at very high concentrations could be very irritating to the eyes and nose and cause burning and tearing of the eyes, coughing, difficult breathing, and an upset stomach. Animal studies also found that 1,4-dichlorobenzene caused effects in the kidneys and blood. Lifetime exposure to 1,4-dichlorobenzene by breathing or eating induced liver cancer in mice.

1,1-Dichloroethane

1,1-Dichloroethane is a colorless oily liquid with a chloroform-like odor and is a chemical used mostly as an intermediate in the manufacture of 1,1,1-trichloroethane. 1,1-Dichloroethane is also used in limited amounts as a solvent for cleaning and degreasing, and in the manufacture of plastic wrap, adhesives, and synthetic fiber (ATSDR 2015b).

Based on no human data and limited evidence of carcinogenicity in animals (rats and mice), 1,1-dichloroethane is a possible human carcinogen. In those studies using high doses of 1,1-dichloroethane in rats and mice, there is an increased incidence of mammary gland adenocarcinomas (cancer of the glandular tissues) and hemangiosarcomas (cancer of the blood vessels) in female rats and an increased incidence of hepatocellular carcinomas (liver cancer) and benign uterine polyps in mice (IRIS 1990b).

Relatively little information is available on the health effects of 1,1-dichloroethane in humans or animals. 1,1-Dichloroethane is in a class of chemicals, called chlorinated aliphatics, which are known to cause central nervous system depression and respiratory tract and dermal irritation when humans are exposed by inhalation to sufficiently high levels. In the past, 1,1-dichloroethane was used as an anesthetic; however, this use was discontinued due to the risk of causing heart rhythm problems (cardiac arrhythmias) in humans at anesthetic doses (approximately 26,000 ppm). A small number of animal studies have examined the toxicity and carcinogenicity of 1,1-dichloroethane; these studies have failed to conclusively identify the critical targets of toxicity (ATSDR 2015b). There is neither a RfD for oral exposure nor a RfC for inhalation exposure (IRIS 1990b).

1,1-Dichloroethane does not degrade quickly in water, but it can evaporate from the water into the air. 1,1-Dichloroethane released to soil surfaces evaporates rapidly to the air. Residual 1,1-dichloroethane remaining on soil surfaces would be available for transport into groundwater, since it is not expected to bind to soil particulates unless the organic content of the soil is high (ATSDR 2015b).

1,2-Dichloroethane

1,2-Dichloroethane is a manufactured chemical that is not found naturally in the environment. It is a clear liquid and has a pleasant smell and sweet taste. The most common use of 1,2-dichloroethane is in the production of vinyl chloride which is used to make a variety of plastic and vinyl products including polyvinyl chloride (PVC) pipes, furniture and automobile upholstery, wall coverings, housewares, and automobile parts. It is also used as a solvent and is added to leaded gasoline to remove lead (ATSDR 2001).

1,2-Dichloroethane is a probable human carcinogen based on sufficient evidence of carcinogenicity in animals. In those studies, several tumor types in rats and mice treated by feeding tube were found and benign cell growths (papillomas) in the lungs of mice were found after they were fed large doses of 1,2-dichloroethane. There are no human data to support this carcinogenic finding (IRIS 1987). People who were accidentally exposed to large amounts of 1,2-dichloroethane in the air or who swallowed 1,2-dichloroethane by accident or on purpose often developed nervous system disorders and liver and kidney disease. Lung effects were also seen after a large amount of 1,2-dichloroethane was inhaled. Studies in laboratory animals also found that breathing or swallowing large amounts of 1,2-dichloroethane produced nervous system disorders, kidney disease, or lung effects. Reduced ability to fight infection was also seen in laboratory animals who breathed or swallowed 1,2-dichloroethane, but it is not known if this also occurs in humans. Longer-term exposure to lower doses also caused kidney disease in animals (ATSDR 2001). The oral slope factor for 1,2-dichloroethane is 9.1×10^{-2} (mg/kg-day)$^{-1}$. Oral RfD and inhalation RfC have not been evaluated (IRIS 1987).

1,2-Dichloroethane evaporates into the air very fast from soil and water. In the air, it breaks down by reacting with other compounds formed by the sunlight. 1,2-Dichloroethane will stay in the air for more than 5 months before it is broken down. It may also be removed from air in rain or snow. Since it stays in the air for a while, the wind may carry it over large distances. In water, 1,2-dichloroethane breaks down very slowly and most of it will evaporate to the air. In soil, 1,2-dichloroethane either evaporates into the air or travels down through soil and enters underground water. Small organisms living in soil and groundwater may transform it into other less harmful compounds, although this happens slowly (ATSDR 2001).

Ethylbenzene

Ethylbenzene is a colorless liquid that smells like gasoline. It moves easily into the air from water and soil. Ethylbenzene in soil can also contaminate groundwater. However, ethylbenzene is not considered highly persistent in the environment. Biodegradation under aerobic conditions and indirect photolysis are important degradation mechanisms for ethylbenzene in soil and water. Volatilization from water and soil surfaces is expected to be an important environmental fate process for ethylbenzene (ATSDR 2010).

Ethylbenzene is not classifiable as to human carcinogenicity due to lack of animal and human studies (IRIS 1988); however, the IARC has determined that long-term exposure to ethylbenzene may cause cancer in humans (ATSDR 2010). Ethylbenzene has an RfD of $1x10^{-1}$ mg/kg-day (IRIS 1988). In humans, exposure to high levels of ethylbenzene in the air for short periods can cause eye and throat irritation. Exposure to higher levels of ethylbenzene in short periods can result in vertigo and dizziness.

1,1,2,2-Tetrachloroethane

1,1,2,2-Tetrachloroethane is a synthetic, colorless, dense liquid that does not burn easily. It has a penetrating, sweet odor similar to chloroform. In the past, it was used in large amounts to produce other chemicals and as an industrial solvent. 1,1,2,2-Tetrachloroethane was also used to separate fats and oils from other substances, to clean and degrease metals, and in paints and pesticides. Although at one time it was used as an insecticide, fumigant, and weed killer, it presently is not registered for any of these purposes. Less toxic chemicals are now available to replace this solvent and large scale commercial production has stopped, although some production still occurs. It is presently used as a chemical intermediate, and information about this use is limited (ATSDR 2008).

1,1,2,2-Tetrachloroethane is likely to be carcinogenic to humans based on animal data (IRIS 2010). Breathing high levels in a closed room can cause fatigue, vomiting, dizziness, and possibly unconsciousness. Breathing, drinking, or touching large amounts of 1,1,2,2-tetrachloroethane for a long period of time can cause liver damage, stomachaches, or dizziness (ATSDR 2008). The oral slope factor and chronic RfD for 1,1,2,2-tetrachloroethane is $2x10^{-1}$ $(mg/kg\text{-}day)^{-1}$ and $2x10^{-3}$ (mg/kg-day), respectively.

Most 1,1,2,2-tetrachloroethane released to the environment eventually moves to the air or ground water. It does not attach to soil particles when released to land. When released to surface water, much of it will evaporate to the air while the rest may break down in the water. It takes about one year for half of the chemical to disappear from groundwater and two months in air.

Trichloroethene

Trichloroethene (also known as trichloroethylene) is a colorless, volatile liquid. It is nonflammable and has a sweet odor. The two major uses of trichloroethene are as a solvent to remove grease from metal parts and as a chemical that is used to make other chemicals. Trichloroethene has also been used as an extraction solvent for greases, oils, fats, waxes, and tars; by the textile processing industry to scour cotton, wool, and other fabrics; in dry cleaning operations; and as a component of adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners (ATSDR 2019)

Based on sufficient evidence in humans regarding trichloroethene exposure and cancer, and evidence that high doses of trichloroethene can cause cancer in animals, trichloroethene is classified as a human carcinogen. There is strong evidence that trichloroethene can cause kidney cancer in people and some evidence that it causes liver cancer and malignant lymphoma (a blood cancer). Lifetime exposure to trichloroethene resulted in increased liver cancer in mice and increased kidney cancer in rats at relatively high exposure levels. There is some evidence for trichloroethene-induced testicular cancer and leukemia in rats and lymphomas and lung tumors in mice. There is also some evidence of an association between trichloroethene exposure and non-Hodgkin's lymphoma in humans (IRIS 2011; ATSDR 2019).

People who are overexposed to moderate amounts of trichloroethene may experience headaches, dizziness, and sleepiness; large amounts of trichloroethene may cause coma and even death. Some people who breathe high levels of trichloroethene may develop damage to some of the nerves in the face. Other effects seen in people exposed to high levels of trichloroethene include evidence of nervous system effects related to hearing, vision, and balance, changes in the rhythm of the heartbeat, liver damage, and evidence of kidney damage. Some people who get concentrated solutions of trichloroethene on their skin develop rashes. Relatively short-term exposure of animals to trichloroethene resulted in harmful effects on the nervous system, liver, respiratory system, kidneys, blood, immune system, heart, and body weight (ATSDR 2019). The oral slope factor and RfD for trichloroethene is 4.6×10^{-2} (mg/kg-day$)^{-1}$ and 5×10^{-4} (mg/kg-day), respectively (IRIS 2011).

Trichloroethene shows high mobility in soil. Trichloroethene partitions rapidly to the atmosphere from surface water. It has low volatility in soil. Trichloroethene has a low tendency to bioaccumulate in aquatic organisms and biomagnification does not seem to be important, although bioaccumulation in plants has been indicated (ATSDR 2019).

Vinyl chloride

Vinyl chloride is a manufactured substance that does not occur naturally; however, it can be formed in the environment when other manufactured substances, such as trichloroethene, trichloroethane, and tetrachloroethylene, are broken down by certain microorganisms. At room temperature and pressure, vinyl chloride is a colorless gas with a mild, sweet odor. Vinyl chloride is poorly soluble in water. Most of the vinyl chloride produced in the United States is used to make PVC, which consists of long repeating units of vinyl chloride. Vinyl chloride can migrate to groundwater and can be in groundwater due to the breakdown of other chemicals. Some vinyl chloride can dissolve in water (IRIS 2000). Overall, the data indicate that neither vinyl chloride nor its metabolites are likely to accumulate in plants, animals, or the human body (ATSDR 2006b; IRIS 2000).

Vinyl chloride is a known human carcinogen. The vinyl chloride RfD is $3x10^{-3}$ mg/kg-day and the RfC is $1x10^{-1}$ mg/m^3 (IRIS 2000). Because vinyl chloride usually exists in a gaseous state, you are most likely to be exposed to it by breathing it. If you breathe high levels of vinyl chloride, you will feel dizzy or sleepy. These effects occur within 5 minutes if you are exposed to about 10,000 ppm of vinyl chloride. People who breathe extremely high levels of vinyl chloride can die. Studies in animals show that extremely high levels of vinyl chloride can damage the liver, lungs, and kidneys. These levels also can damage the heart and prevent blood clotting. You can also be exposed to vinyl chloride by drinking water from contaminated wells. The effects of ingesting vinyl chloride are unknown. The liver is the most sensitive target organ for vinyl chloride toxicity for both intermediate- and chronic-duration inhalation and chronic-duration oral exposures (ATSDR 2006b).

Xylenes

Xylene, also known as xylol or dimethylbenzene, is primarily a synthetic chemical. It is a colorless, flammable liquid with a sweet odor. The term total xylenes refers to all three isomers of xylene (m-, o-, and p-xylene). Since xylene evaporates easily, most xylene that gets into soil and water (if not trapped underground) is expected to move into the air where it is broken down by sunlight into other less harmful chemicals within a couple of days. People are most likely to be exposed to xylene by breathing it in air contaminated with xylene vapors. Xylenes tend not to accumulate in the body, but may be sequestered briefly in fat tissues; elimination of xylene is slower in individuals with a greater percentage of body fat (ATSDR 2007b; IRIS 2003b).

There is insufficient information to determine whether or not xylene is carcinogenic (ATSDR 2007b; IRIS 2003b). The xylenes RfD is $2x10^{-1}$ mg/kg-day and the RfC is $1x10^{-1}$ mg/m^3 (IRIS 2003b). The primary effects of xylene exposure involve the nervous system by all routes of exposure, the respiratory tract by inhalation exposure, and, at higher oral exposure levels, liver, kidney, and body weight effects. Scientists have found that the three forms of xylene have very similar effects on health. Short-term exposure of people to high levels of xylene can cause irritation of the skin, eyes, nose, and throat; difficulty in breathing; impaired function of the lungs; delayed response to a visual stimulus; impaired memory; stomach discomfort; and possible changes in the liver and kidneys. Both short- and long-term exposure to high concentrations of xylene can also cause a number of effects on the nervous system, such as headaches, lack of muscle coordination, dizziness, confusion, and changes in one's sense of balance (ATSDR 2007b). The available studies indicate that xylenes are rapidly absorbed following both inhalation and oral exposure. Following absorption, considerable metabolism occurs, with the liver being the primary site of metabolism (IRIS 2003b).

5.2 Toxicological Profile for Methane

Methane is a colorless, odorless, flammable gas and the major component of natural gas (NRC 1984). In nature, methane is produced by the anaerobic bacterial decomposition of vegetable matter. Methane is an important source of hydrogen and some organic chemicals. Methane reacts with steam at high temperatures to yield carbon monoxide and hydrogen; the latter is used in the manufacture of ammonia for fertilizers and explosives. Other valuable chemicals derived from methane include methanol, chloroform, carbon tetrachloride, and nitromethane (Encyclopædia Britannica 2019).

Methane is lighter than air, having a specific gravity of 0.554. It is only slightly soluble in water. Methane in general is very stable, but mixtures of methane and air, with the methane content between 5 and 14 percent by volume, are explosive (Encyclopædia Britannica 2019). Methane is liquid under pressure (NJDOH 2016).

Little information is available on the toxicity of methane. It appears that toxic effects of methane, considered biologically inert, are related to the oxygen deprivation (asphyxiation) that occurs when methane is present in air at a high concentration (NRC 1984). Very high levels of methane can cause suffocation with symptoms of headache, dizziness, weakness, nausea, vomiting, loss of coordination and judgment, increased breathing rate, and loss of consciousness. Skin contact with liquefied methane can cause frostbite (NJDOH 2016).

6.0 Human Health Risk Assessment Findings

Risk characterization is the final step in an HHRA during which exposure estimates are combined with toxicity information to make qualitative and quantitative statements about risk and the conditions under which risk may occur. Risk characterization provides an overall depiction of the nature, magnitude, and likelihood of human health risks at a site and provides the basis for the selection of appropriate risk management options.

Exposure to vapors in landfill gas and groundwater were considered as a potentially complete route of exposure under the worst-case scenario assumption that a long-term failure in engineered protections (including the landfill cap and gas collection system) occurs at the OMF South, allowing for vapor intrusion from subsurface gas and underlying groundwater to indoor air.

Based on the comparison of available groundwater data to applicable risk-based screening levels, occupational exposure to COIs detected in underlying groundwater at the Midway Landfill via vapor intrusion is not expected to result in adverse chronic health effects.

In addition, occupational exposure to methane gas is not expected to result in adverse chronic health effects due to the relatively non-toxic nature of the gas. However, other occupational hazards associated with methane gas at the Midway Landfill may need to be considered and addressed through risk management efforts if Sound Transit selects the site for the future OMF South (see Section 7).

A high level of uncertainty remains regarding the potential risks associated with occupational exposures to VOCs and inorganic gases at the site due to a lack of sufficient and reliable data necessary to characterize human health risks. Although a number of toxic volatile compounds were identified in previous site investigations, these data were collected more than 25 years ago and likely do not represent current and future site conditions. An additional level of uncertainty exists regarding the potential for occupational exposure to COIs in landfill gas based on current and future site conditions and engineered controls. At this time, the migration of landfill gas through the subsurface to indoor and ambient air is controlled by the gas extraction system and the landfill cap. Based on the ROD, the City is required to ensure continued operation and maintenance of all components of the remedy (including the gas extraction system and the landfill cap) if any portion of the property is sold, leased, transferred, or otherwise conveyed. It is expected that future development of the OMF South at the Midway Landfill would include a gas extraction system and the landfill cap and other engineered protections to mitigate and monitor vapor intrusion of landfill gas (including methane) to indoor air.

However, in order to effectively quantify the risk associated with occupational exposures to COIs in landfill gas, additional sampling is needed to characterize site conditions and identify potential routes of exposure. Future sampling of landfill gas constituents should be conducted following an approach that generates the appropriate environmental data needed to characterize occupational exposures and evaluate potential health risks at the OMF South (e.g., post construction sub-slab soil gas and/or indoor air sampling). Pre-construction sampling of flare inlet gas and gas extraction wells could also be conducted to provide information on the COIs present in landfill gas at this time; however, concentrations of COIs in samples collected from the landfill gas collection system would not be appropriate for use in the assessment of occupational exposures at the OMF South as they are likely not representative of concentrations in the subsurface that may pose an unacceptable threat to indoor air quality in site buildings. At this point, quantification of any long-term worker risk is premature until representative data can be acquired.

7.0 Non-Toxicological Hazards Evaluation

Potential non-toxicological hazards at the OMF South are less a factor of exposure to the contaminants within the landfill and are more focused on site conditions at the landfill as a whole. As the landfill ages, material changes occur through the degradation of the solid waste material and the resulting production of liquid and gas. A more detailed background discussion of the landfill life cycle is available in the OMF South Landfill Evaluation Report (HDR 2019a). Some of the primary non-toxicological risk factors associated with redevelopment on a landfill include methane explosion risk, seismic events, and occupational exposure to site COIs during construction activities which are discussed below.

7.1 Methane Explosion

Decomposing solid waste generates landfill gas, of which methane is a primary constituent. The percentage of methane within landfill gas varies with time and other site-specific factors. Methane is an explosive hazard in the right concentration and under the right conditions. The Midway Landfill is currently generating landfill gas, which is collected by landfill gas wells, conveyed to a flare station by surface piping and vacuum blowers, and safely combusted. The landfill cap is a critical component of landfill gas control, eliminating the opportunity for gas to move through the landfill surface, and requiring landfill gas to progress through the landfill gas system. The development of the OMF South will require the reconstruction of portions, or all, of the landfill cap and gas collection system, depending on the construction design.

Further, the direct proximity of the OMF South to the landfill can create explosion risk if methane is able to intrude and build up in a confined space within the OMF South. In this case, if an ignition source was provided, an explosion could occur.

Explosion risk is present at the site and needs to be mitigated through engineering controls. Common means for protection would be the re-establishment of the landfill cap and gas collection system impacted during construction of the OMF South. This approach provides a methane barrier at the landfill surface and an active landfill gas collection system to create a positive draw on gas within the landfill.

Additional engineered protections can be incorporated into the OMF South design to mitigate the risk associated with a potential landfill cap leak and/or gas collection system failure for areas in contact with the landfill surface and subsequent migration of landfill gas into indoor air and confined spaces within the OMF South. An independent under slab methane barrier with passive gas ventilation could also be installed below building foundations and slabs to prevent vapor intrusion. This option would only be appropriate for three of the construction design approaches (Approaches 2, 3, and 4), which has portions of the OMF South constructed in contact with the landfill surface and a risk of gas intrusion through cracks in the slab and other vulnerabilities (see Section 2.4.3 for brief description of the each of the five construction design approaches). A methane barrier would not be required for yard slabs as these areas are able to vent to atmosphere. Approach 1 incorporates construction of the OMF South on an elevated platform making vapor intrusion of landfill gas unlikely since gas escaping from the landfill cap would dissipate prior to being able to enter the OMF South structure. Approach 5 incorporates construction of the OMF South on a slab foundation following the excavation of underlying solid waste. This approach would remove most of the landfill gas producing material during construction such that vapor intrusion would no longer be a concern. Approach 5 would not likely require an active landfill gas system, if one is required at all. However, if one were required, the system would be expected to be passive.

In addition to, or instead of, an independent methane barrier, gas sensors can be installed in occupied areas and in areas where site operations provide an ignition source. Sensors could be set to alarm at methane levels of 10% and 25% of the LEL. Appropriately classified electrical equipment can also help reduce potential ignition sources; however, considering the function of the OMF South, it is not reasonable to expect that all potential ignition sources can be eliminated.

Methane migration to in-ground, non-building, confined spaces, such as manholes and vaults, could occur through a leak in the landfill cap resulting in a methane explosion or asphyxiation hazard. These hazards can be managed through adherence to required confined space entry procedures including monitoring of methane and oxygen concentrations prior to entry.

If a seismic event were to occur, the site can be reviewed for visual indications of instability.

7.2 Seismic Considerations

Stability of a landfill mass can be different from developed sites on typical earth. A seismic and static stability analysis to demonstrate that a proposed landfill configuration will be stable is a requirement for new landfills. Old landfills may also have stability analysis requirements and are regularly inspected for signs of instability. Stability concerns have not been identified at Midway Landfill. The site configuration is primarily a backfill of a previous excavation and site slopes have no reported signs of instability.

All of the construction design approaches for the OMF South are expected to improve site stability. If Approach 1 is developed, the elevated platform will be designed to meet seismic standards. Approaches 2, 3, 4 and 5 will lower the landfill elevation and increase stability through the use of competent soil. Further geotechnical analysis can be performed to evaluate site seismic and static stability with the OMF South loading.

7.3 Hazards Associated with Construction Activities

The construction of the OMF South under all five construction design approaches require the disruption of established remedial systems, such as the continuity of the landfill cap and landfill gas collection system. These disruptions which, without adequate and proper controls, could temporarily expose construction workers to solid waste and landfill gas. Additionally, exposed areas may also generate dust and contaminated runoff that could impact the surrounding environment. Applicable regulatory requirements will need to be followed to provide continued protection of human health and the environment during construction of the OMF South.

An Environmental Protection Plan will likely be required to establish procedures to manage and monitor the waste excavation and handling process, including management of stormwater and landfill gas. In addition to continuous landfill gas management, measures will need to be established to prevent air intrusion into the landfill that could result in a landfill fire.

A project-specific Health and Safety Plan will also be required and will include stipulations that construction workers who may be exposed to potentially hazardous substances will be required to obtain the appropriate level of Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) training.

8.0 Conclusions

The HHRA found that occupational exposures to VOCs in groundwater and to methane in landfill gas are not expected to result in adverse chronic health effects for any OMF South worker. However, the potential risk associated with occupational exposures to COIs in landfill gases could not be characterized due to a lack representative data. In order to quantify occupational risk at the OMF South, post-construction sampling of VOCs and toxic inorganic gases is needed (e.g., sub-slab soil gas and/or indoor air sampling) to provide an appropriate measure of the concentrations that workers may be exposed to at the OMF South.

In order to assess current COI concentrations in landfill gas, a pre-construction landfill gas investigation could be conducted. Potential landfill gas sampling options are discussed in Appendix B.

The non-toxicological hazards evaluated for the Midway Landfill can largely be managed through appropriate engineered protections, health and safety protocols, construction design standards, and site control and environmental protection plans. Risk management approaches for non-toxicological hazards will need to be developed based on the final selected OMF South construction approach.

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Tables

Table 1 Groundwater Results for Onsite Monitoring Wells (2010-2014)[a]

Screening Level			Dissolved Iron	1,4-Dioxane	1,1-dichloroethane	cis-1,2-dichloroethene	Chloride	Sulfate	Manganese	Vinyl Chloride
ROD Cleanup Level			-	4.4*	-	-	-	-	2.2	0.29
MTCA Method C Groundwater Vapor Intrusion Screening Level[b] (µg/L)			not a volatile analyte	-	-	not a volatile analyte	not a volatile analyte	not a volatile analyte	not a volatile analyte	3.5 CA
USEPA Worker Air Vapor Intrusion Screening Levels (VISL) for Groundwater[c] (µg/L)			not a volatile analyte	12,500 CA	821 NC	no inhalation toxicity information	not a volatile analyte	not a volatile analyte	not a volatile analyte	4.45 CA
Well	**Aquifer**	**Sample Date**	**mg/L**	**µg/L**	**µg/L**	**µg/L**	**mg/L**	**mg/L**	**mg/L**	**µg/L**
MW-7A	Upper Gravel Aquifer	Not sampled since 1992 because the well has been dry.								
MW-7B	Sand Aquifer	5/4/2011	3.57	4.3	2.1	1.0 U	25.0	39.2	3.07	0.30
		5/9/2012	3.57	6.0	2.9	1.0 U	28.1	27.9	3.20	0.31
		5/15/2013[d]	3.32	3.6	2.2	1.0 U	19.7	29.4	2.94	0.32
		5/21/2014	3.05	2.0	1.9	1.0 U	14.4	29.9	2.63	0.20
MW-20A		Not sampled since 1994 because the well has been dry.								
MW-14B	Southern Gravel Aquifer	5/4/2010	11.2	17	1.5	4.5	18.0	30.9	0.961	0.63
		5/3/2011	11.0	13	1.3	3.8	19.4	32.2	0.897	0.64
		5/8/2012	10.1	12	1.4	3.9	16.6	34.6	0.908	0.41
		5/14/2013	10.3	9.3	1.2	3.3	16.3	24.8	0.913	0.39
		5/20/2014	10.3	9.1	1.1	3.1	14.8	25.2	0.904	0.28
MW-20B		5/3/2010	9.5	-	1.0 U	1.0 U	44.7	8.9	3.24	0.27
		5/4/2011	8.8	53	1.0 U	1.0 U	44.9	10.1	2.99	0.24
		5/9/2012	8.2	48	1.0 U	1.0 U	35.2	13.0	2.95	0.22
		5/15/2013	7.5	39	1.0 U	1.0 U	30.6	11.5	2.77	0.34
		5/21/2014	6.9	35	1.0 U	1.0 U	26.6	9.9	2.43	0.30

[a]Report in the Midway Landfill Groundwater Monitoring Status Report 2010-2014 (Parametrix 2015)

[b]https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables
MTCA Method C Screening Levels are protective of industrial exposures and derived using the exposure assumptions shown in Figures 2-5.

[c]https://epa-visl.ornl.gov/cgi-bin/visl_search
USEPA Worker Air VISLs are protective of commercial exposures and derived using the exposure assumptions shown in Figures 2-5.

[d]Original and duplicate samples were collected from MW-7B during this round. The higher of the two results is shown.

*A cleanup level was not established for 1,4-Dioxane in the ROD. Detected concentrations are compared to the MTCA Method B cleanup level.

A shaded cell indicates that the concentrations exceeds ROD cleanup level.
- = not established
U = indicates the compound was undetected at the reported concentration
CA = based on cancer health risk
NC = based on non-cancer risk

Table 2. Methane Gas Results for Onsite Extraction Wells by Location and Year (2015-2019)

Location	Number of Samples	Number of Samples > LEL	% of Samples > LEL	Minimum	Maximum	Average	Std Dev
1*	56	0	0%	0.0	0.2	0.0	0.1
2	56	53	95%	1.2	25.8	12.4	5.3
3	56	44	79%	0.0	11.9	7.1	3.2
4	55	0	0%	0.0	0.2	0.0	0.0
5	56	56	100%	5.8	35.3	14.3	5.0
6	56	1	2%	0.0	5.3	0.6	1.2
7	56	31	55%	0.6	13.4	5.9	3.2
8	56	55	98%	4.8	14.4	10.5	1.8
9	56	56	100%	6.6	19.7	12.7	2.3
10	56	56	100%	12.1	23.0	17.2	2.8
11	56	43	77%	1.1	18.2	6.5	2.5
12	56	0	0%	0.0	3.0	0.3	0.5
13	56	1	2%	0.0	5.3	0.3	0.9
14	56	30	54%	0.0	11.0	5.2	2.1
15	56	55	98%	2.4	14.2	9.7	2.2
16	56	34	61%	0.0	23.2	8.6	7.4
17	56	40	71%	0.0	19.4	8.0	5.1
18	56	31	55%	0.5	15.4	6.0	3.9
19	56	53	95%	0.0	14.5	9.1	2.8
20	56	11	20%	0.0	12.7	2.4	4.1
21	56	41	73%	2.1	16.7	8.5	4.4
22	56	1	2%	0.0	14.7	0.4	2.0
23	56	53	95%	3.4	24.9	10.4	4.8
24	56	4	7%	0.0	18.8	1.1	3.8
25	56	27	48%	1.5	23.6	6.3	4.5
26	56	56	100%	7.0	25.4	17.7	4.6
27	56	55	98%	4.7	22.6	15.9	4.7
28	56	24	43%	0.5	16.1	5.4	3.9
29	56	51	91%	3.4	24.1	9.7	4.7
30	56	56	100%	15.9	21.1	18.6	1.2
31	56	35	63%	0.0	37.3	10.8	9.6
32	56	7	13%	0.0	8.3	1.1	2.6
33	56	56	100%	7.9	27.6	13.2	3.5
34	56	56	100%	5.7	13.4	9.7	1.7
55	56	31	55%	1.9	9.0	5.3	1.8
35D	56	51	91%	0.0	20.4	11.3	4.9
35S	56	52	93%	1.3	20.4	11.5	4.9
36D	56	0	0%	0.0	0.8	0.1	0.1
36S	56	0	0%	0.0	0.9	0.1	0.2
37D	56	55	98%	0.7	18.3	11.3	3.5
37S	56	53	95%	1.0	16.7	9.1	3.4
38D	56	56	100%	19.8	29.2	24.6	2.2
38S	56	56	100%	10.6	19.5	14.0	2.4
39D	56	56	100%	14.2	22.7	18.0	2.1
39S	56	56	100%	9.2	15.7	12.8	1.3
40D	56	55	98%	0.0	22.8	18.1	3.2
40S	56	6	11%	0.0	16.6	1.5	4.0
41D	56	7	13%	0.0	36.0	3.0	8.0
41S	56	8	14%	0.0	35.7	4.2	10.1
42D	56	56	100%	14.7	21.3	17.6	1.6
42S	56	56	100%	15.1	20.4	17.7	1.4
43D	56	56	100%	15.0	19.8	17.9	1.1
43S	56	56	100%	10.5	17.7	14.2	1.4
44D	56	56	100%	15.8	22.2	19.4	1.6
44S	56	56	100%	9.1	14.2	11.7	1.2
45D	56	56	100%	13.6	25.3	19.0	1.9
45S	56	15	27%	0.0	8.5	2.7	2.6
46D	56	56	100%	14.7	22.3	19.5	1.6
46S	56	15	27%	0.0	12.7	2.7	4.2
47D	56	5	9%	0.0	21.0	2.7	4.8
47S	56	9	16%	1.4	23.2	4.6	3.9
48D	56	56	100%	11.4	24.4	17.9	2.3
48S	56	56	100%	10.5	18.4	12.8	1.5
49D	56	56	100%	12.4	20.4	17.8	1.4
49S	56	52	93%	3.8	13.5	9.1	2.2
50D*	56	56	100%	5.7	18.9	14.3	2.9
50S*	56	56	100%	15.8	21.6	18.9	1.5
51D	56	51	91%	0.1	16.2	9.4	3.7
51S	56	56	100%	13.0	18.8	16.0	1.4

Table 2. Methane Gas Results for Onsite Extraction Wells by Location and Year (2015-2019)

Location	Number of Samples	Number of Samples > LEL	% of Samples > LEL	Minimum	Maximum	Average	Std Dev
52D*	56	56	100%	16.5	21.3	18.6	1.3
52S*	56	56	100%	11.6	16.4	13.9	1.2
53D	56	56	100%	13.3	19.5	16.4	1.7
53S	56	40	71%	0.0	12.9	7.9	5.0
54D	56	5	9%	0.0	10.0	1.0	2.4
54S	56	56	100%	11.9	17.6	14.2	1.5
56D	56	55	98%	0.1	17.3	13.6	2.5
56S	56	0	0%	0.0	0.2	0.0	0.1
C-11	56	0	0%	0.0	0.1	0.0	0.0
MAN*	112	112	100%	14.3	19.9	17.2	1.1
MAN-N*	112	112	100%	13.0	19.9	16.9	1.1
MAN-S*	112	112	100%	14.4	19.8	17.1	1.2
PA10D	56	0	0%	0.0	0.2	0.0	0.0
PA10S	56	0	0%	0.0	0.2	0.0	0.1
PA1D	56	0	0%	0.0	0.1	0.0	0.0
PA1S	56	0	0%	0.0	0.1	0.0	0.0
PA2D	56	0	0%	0.0	0.1	0.0	0.0
PA2S	56	0	0%	0.0	0.1	0.0	0.0
PA3D	56	0	0%	0.0	0.1	0.0	0.0
PA3S	56	0	0%	0.0	0.2	0.0	0.0
PA4D	56	0	0%	0.0	0.1	0.0	0.0
PA4S	56	0	0%	0.0	0.1	0.0	0.0
PA5D	56	0	0%	0.0	0.1	0.0	0.0
PA5S	56	0	0%	0.0	0.2	0.0	0.0
PA6D	56	0	0%	0.0	0.2	0.0	0.0
PA6S	56	0	0%	0.0	0.2	0.0	0.0
PA7D	56	55	98%	1.6	26.6	17.6	4.5
PA7S	56	0	0%	0.0	0.1	0.0	0.0
PA8D	56	0	0%	0.0	0.1	0.0	0.0
PA8S	56	0	0%	0.0	0.1	0.0	0.0
PA9D	56	0	0%	0.0	0.2	0.0	0.1
PA9S	57	0	0%	0.0	0.2	0.1	0.1
PD1D	56	0	0%	0.0	0.1	0.0	0.0
PD1S	56	0	0%	0.0	0.1	0.0	0.0

All concentrations reported in percent by volume of air
LEL = lower explosive limit, which is 5% methane by volume
*These wells were not shown on Figure 8 of the Second Five-Year Review for the Midway Landfill Superfund Site.

Table 3. Methane Gas Results for Onsite Extraction System by Year (2015-2019)

Year	Number of Samples	Number of Samples > LEL	% of Samples > LEL	Minimum	Maximum	Average	Std Dev
2015	1272	742	58%	0	33.8	8.9	8.1
2016	1272	725	57%	0	34.7	8.6	8.1
2017	1272	756	59%	0	37.3	8.7	7.8
2018	1272	686	54%	0	33.4	7.7	7.4
2019	848	451	53%	0	27.9	7.3	7.1

All concentrations reported in percent by volume of air

LEL = lower explosive limit, which is 5% methane by volume

Std Dev = standard deviation

Table 4 Select VOC Results for Onsite Subsurface Gas Samples[ab] (1988a)

Concentration[b]	Units	Benzene	Ethyl Benzene	Styrene	Toluene	Vinyl Chloride	Xylenes (Total)
Mean	ppb	318	2,825	41	1,920	2,807	3,419
	µg/m^3	1,016	12,266	175	7,235	7,175	14,846
Maximum	ppb	1,384	16,610	508	24,044	31,215	29,195
	µg/m^3	4,421	72,119	2,164	90,600	79,793	126,774

[a]Midway Landfill Remedial Investigation Summary Report, Table 6-1, page 6-29 (Parametrix 1988a)

Table 5a VOCs Results for Onsite Subsurface Gas and Flare Inlet Samples[a] (1988a)

Maximum Concentration	unit	Benzene	Chlorobenzene	Chloroethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	trans-1,2-Dichloroethene	Ethyl Benzene	Methylene chloride	4-Methyl-2-Pentanone (MIBK)	Styrene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	Trichloroethene	Vinyl Acetate	Vinyl Chloride	Xylenes (Total)	Tetrahydrofuran	Trichlorofluoromethane	1,1,2-Trichloro-1,2,2-trifluoroethane
On-site Sub-surface Gas	ppbV	1,384	258	708 E	748	126	112	79	16,610	2,648 E	6	508	ND	80	24,044	ND	97	483	31,215	29,195	2,099	357	106
	μg/m^3	4,421	1,188	1,868	3,028	510	444	313	72,119	9,199	25	2,164	ND	543	90,600	ND	521	1,701	79,793	126,774	6,190	2,006	812
Flare Inlet Gas	ppbV	944	260	301	340	ND	1,004	822	5,749	314	ND	ND	37	ND	6,579	60	683	ND	1,056	22,489	NR	196	451
	μg/m^3	3,016	1,197	794	1,376	ND	3,981	3,259	24,962	1,091	ND	ND	254	ND	24,790	327	3,671	ND	2,699	97,655	-	1,101	3,456

[a]Midway Landfill Remedial Investigation Summary Report, Table 8-1, page 8-10 (Parametrix 1988a)

E = estimated value

Table 5b Hydrogen Sulfide Results for North and South Flare Inlet Samples[a] (1988a)

Concentration	unit	Hydrogen Sulfide
North Flare Inlet	ppbV	26,000
	μg/m^3	36,240
South Flare Inlet	ppbV	17,000
	μg/m^3	23,696

[a]Midway Landfill Remedial Investigation Summary Report, Table 7-6, page 7-24 (Parametrix 1988a)

Table 6 VOC Results for Flare Inlet Duct Gas Samples (1992)[a]

Sample Location	Units	Benzene	Chlorobenzene	Chloroethane	Chloromethane	1,2-Dichlorobenzene	1,4-Dichlorobenzene	1,1-Dichloroethane	cis-1,2-Dichloroethene	Ethyl Benzene	4-Methyl-2-Pentanone (MIBK)	Styrene	Toluene	Trichlorofluoromethane	Vinyl Chloride	Xylenes (Total)
#3 Flare Inlet Duct (Run 1)	µg/m^3	1,598	2,801	280	941	479	1,598	400	1,099	45,005	270.1	491	6,501	150	2,901	47,003
#3 Flare Inlet Duct (Run 2)	µg/m^3	1,501	2,600	250	1,002	260	1,002	380	1,002	43,001	270.1	440	6,400	170	3,001	44,003
#3 Flare Inlet Duct (Run 3)	µg/m^3	1,700	2,799	280	981	360	1,201	410	1,099	46,002	270.2	520	6,901	160	3,002	47,004
Maximum (all runs)	µg/m^3	1,700	2,801	280	1,002	479	1,598	410	1,099	46,002	270.2	520	6,901	170	3,002	47,004
Average (all runs)	µg/m^3	1,600	2,733	270	974	366	1,267	397	1,067	44,670	270.1	484	6,600	160	2,968	46,003

[a]Reported in the Midway Sanitary Landfill Landfill Gas Flare Testing Source Emissions Evaluation, page 12 (Am Test-air Quality Inc. 1992)

Table 7 Sub-Slab and Deep Soil Gas Screening Levels for COIs Detected in Subsurface and Flare Inlet Gas Samples

Screening Level	Units	Benzene[ab]	Chlorobenzene[ab]	Chloroethane[ab]	Chloromethane[b]	1,2-Dichlorobenzene[b]	1,4-Dichlorobenzene[b]	1,1-Dichloroethane[ab]	1,2-Dichloroethane[a]	1,1-Dichloroethene[a]	cis-1,2-Dichloroethene[b]	trans-1,2-Dichloroethene[a]	Ethyl Benzene[ab]	Hydrogen Sulfide	Methylene Chloride[a]	4-Methyl-2-Pentanone (MIBK)[ab]	Styrene[ab]	1,1,2,2-Tetrachloroethane[a]	Tetrachloroethene[a]	Toluene[ab]	1,1,1-Trichloroethane[a]	Trichloroethene[a]	Vinyl Acetate[a]	Vinyl Chloride[ab]	Xylenes (Total)[ab]	Tetrahydrofuran[a]	Trichlorofluoromethane[ab]	1,1,2-Trichloro-1,2,2-trifluoromethane[a]
MTCA Method C Sub-slab Soil Gas Screening Level[c]	μg/m³	**110** [CA]	**1,700** [NC]	330,000 [NC]	3,000 [NC]	6,700 [NC]	**76** [CA]	**520** [CA]	**32** [CA]	6,700 [NC]	-	-	**33,000** [NC]	**-**	20,000 [NC]	100,000 [NC]	33,000 [NC]	**14** [CA]	1,300 [NC]	170,000 [NC]	170,000 [NC]	**67** [NC]	6,700 [NC]	**93** [CA]	**3,300** [NC]	-	23,000 [NC]	170,000 [NC]
MTCA Method C Deep Soil Gas Screening Level[c]	μg/m³	**320** [CA]	5,000 [NC]	1,000,000 [NC]	9,000 [NC]	20,000 [NC]	**230** [CA]	**1,600** [CA]	**96** [CA]	20,000 [NC]	-	-	100,000 [NC]	-	60,000 [NC]	300,000 [NC]	100,000 [NC]	**43** [CA]	4,000 [NC]	500,000 [NC]	500,000 [NC]	**200** [NC]	20,000 [NC]	**280** [CA]	**10,000** [NC]	-	70,000 [NC]	500,000 [NC]
USEPA Worker Air Vapor Intrusion Screening Levels (VISL) for Sub-slab or Near Source Soil Gas[d]	μg/m³	**524** [CA]	7,300 [NC]	1,460,000 [NC]	13,100 [NC]	29,200 [NC]	**372** [CA]	**2,560** [CA]	**157** [CA]	29,200 [NC]	No Inhal. Tox. Info	No Inhal. Tox. Info	**1,640** [CA]	292 [NC]	87,600 [NC]	438,000 [NC]	146,000 [NC]	**70.5** [CA]	5,840 [NC]	730,000 [NC]	730,000 [NC]	**292** [NC]	29,200 [NC]	**929** [CA]	**14,600** [NC]	292,000 [NC]	No Inhal. Tox. Info	730,000 [NC]

[a]Reported as a detected constituent in sub-surface landfill gas in the Midway Landfill Remedial Investigation Summary Report, Table 6-1, page 6-29 and/or Table 8-1, page 8-10 (Parametrix 1988a)

[b]Reported as a detected constituent in inlet flare gas in the Midway Sanitary Landfill Landfill Gas Flare Testing Source Emissions Evaluation (Am Test-air Quality Inc. 1992)

[c]https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables;
MTCA Method C Screening Levels are protective of industrial exposures and derived using the exposure assumptions shown in Figures 2-5.

[d]https://epa-visl.ornl.gov/cgi-bin/visl_search
USEPA Worker Air VISLs are protective of commercial exposures and derived using the exposure assumptions shown in Figures 2-5.

Bold screening levels indicate one or more landfill gas samples had a concentration exceeding this value.

- = not established

CA = based on cancer health risk

NC = based on non-cancer risk

Figures

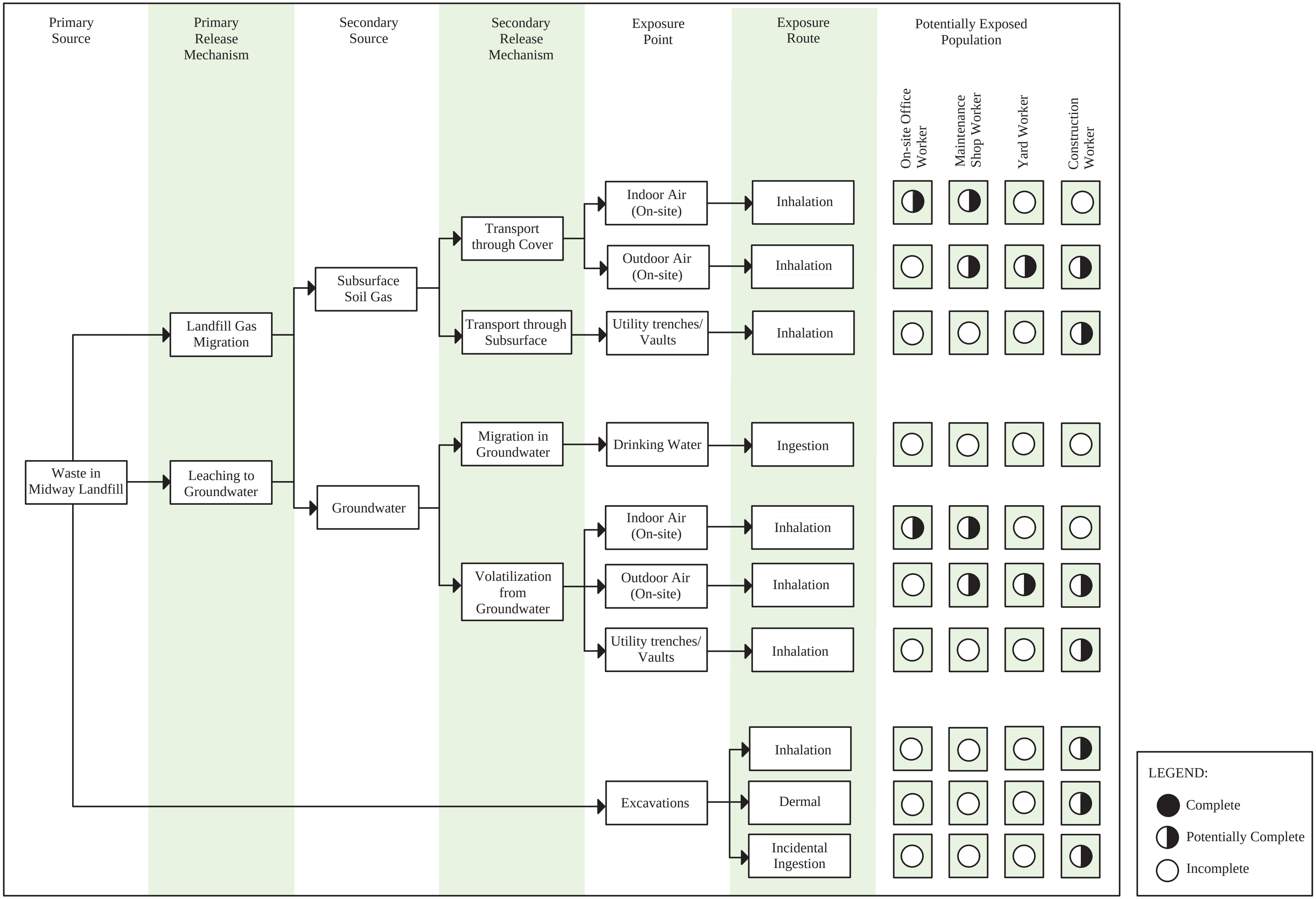

FIGURE 1

Preliminary Conceptual Site Model Exposure Pathway Evaluation for Midway Landfill

Figure 2: Indoor Air Screening Level Equations and Exposure Assumptions for Non-carcinogens
Comparison of Model Toxics Control Act (MTCA) Method C: Industrial Scenario and EPA Vapor Intrusion (VISL) Worker Scenario

	Method C: Indoor Air Cleanup Level – Noncarcinogens (Equation 750-1)	**USEPA VISL Worker Indoor Air Screening Level - Noncarcinogens**
Where:	$SL_{IA\,(nc)} = \frac{RfD \times ABW \times UCF \times HQ \times AT}{BR \times ABS \times ED \times EF \times ET}$	$SL_{IA\,(nc)} = \frac{UCF \times HQ \times AT}{ED \times EF \times ET \times \left(\frac{1}{RfC}\right)}$
Screening Level for Indoor Air (SL_{IA})	calculated (µg/m^3)	calculated (µg/m^3)
Noncancer (nc) Toxicity Values	contaminant specific Reference Dose (RfD) (mg/kg-day) as specified in WAC 173-340-708(7)	contaminant specific Reference Concentrations (RfC) (mg/m3)
Average Body Weight (ABW)	70 kg (adult)	NA
Unit Conversion Factor (UCF)	1,000 µg/mg	1,000 µg/mg
Breathing Rate (BR)	20 m^3/day (adult)	NA
Absorption Factor (ABS)	1 (unitless)	NA
Hazard Quotient (HQ)	1 (unitless)	1 (unitless)
Averaging Time (AT)	6 years	25 years
Exposure Duration (ED)	6 years	25 years
Exposure Frequency (EF)	365 days per year	250 days per year
Exposure Time	24 hours per day	8 hours per day

Figure 3: Indoor Air Screening Level Equations and Exposure Assumptions for Carcinogens
Comparison of Model Toxics Control Act (MTCA) Method C: Industrial Scenario and EPA Vapor Intrusion (VISL) Worker Scenario

	MTCA Method C: Indoor Air Cleanup Level – Carcinogens (Equation 750-2)	**USEPA VISL Worker Indoor Air Screening Level - Carcinogens**
Where:	$$SL_{IA\,(c)} = \frac{Risk \times ABW \times UCF \times AT}{CPF \times BR \times ABS \times ED \times EF}$$	$$SL_{IA\,(c)} = \frac{Risk \times AT}{ED \times EF \times ET \times IUR}$$
Screening Level for Indoor Air (SL_{IA})	calculated (µg/m^3)	calculated (µg/m^3)
Cancer (c) Toxicity Values	contaminant specific cancer potency factor (CPF) (kg-day/mg) as specified in WAC 173-340-708(8)	contaminant specific inhalation unit risk (IUR) $(\mu g/mg^3)^{-1}$
Average Body Weight (ABW)	70 kg (adult)	NA
Unit Conversion Factor (UCF)	1,000 µg/mg	NA
Breathing Rate (BR)	20 m^3/day (adult)	NA
Absorption Factor (ABS)	1 (unitless)	NA
Acceptable Cancer Risk	1 in 100,000 (unitless) or 10^{-5}	1 in 100,000 (unitless) or 10^{-5}
Averaging Time (AT)	75 years	70 years
Exposure Duration (ED)	30 years	25 years
Exposure Frequency (EF)	365 days per year	250 days per year
Exposure Time (ET)	24 hours per day	8 hours per day

Figure 4: Soil Vapor Intrusion Screening Level Equation (MTCA and USEPA VISL)

	Soil Gas Vapor Intrusion Screening Level Equation
Where:	$SL_{SG} = \frac{SL_{IA}}{VAF}$
Screening Level for Soil Gas based on Indoor Air Screening Level (SL_{SG})	calculated (µg/m^3)
Screening Level for Indoor Air (SL_{IA})	µg/m^3
Vapor Attenuation Factor (VAF)	0.03 for sub-slab/near source soil gas; 0.01 for deep soil gas[a] (unitless)

[a] Deep soil gas vapor screening levels are calculated for MTCA only.

Figure 5: Groundwater Vapor Intrusion Screening Level Equation (MTCA and USEPA VISL)

	Groundwater Vapor Intrusion Screening Level Equation
Where:	$SL_{GW} = \frac{SL_{IA}}{VAF \times UCF \times H_{cc}}$
Screening Level for Groundwater based on Indoor Air Screening Level (SL_{GW})	calculated (µg/L)
Screening Level for Indoor Air (SL_{IA})	µg/m^3
Vapor Attenuation Factor (VAF)	0.001 for groundwater (unitless)
UCF	1,000 L/m^3
Henry's Law constant (H_{cc})	chemical specific parameter (unitless)

Appendix A: Supplementary Site Figures

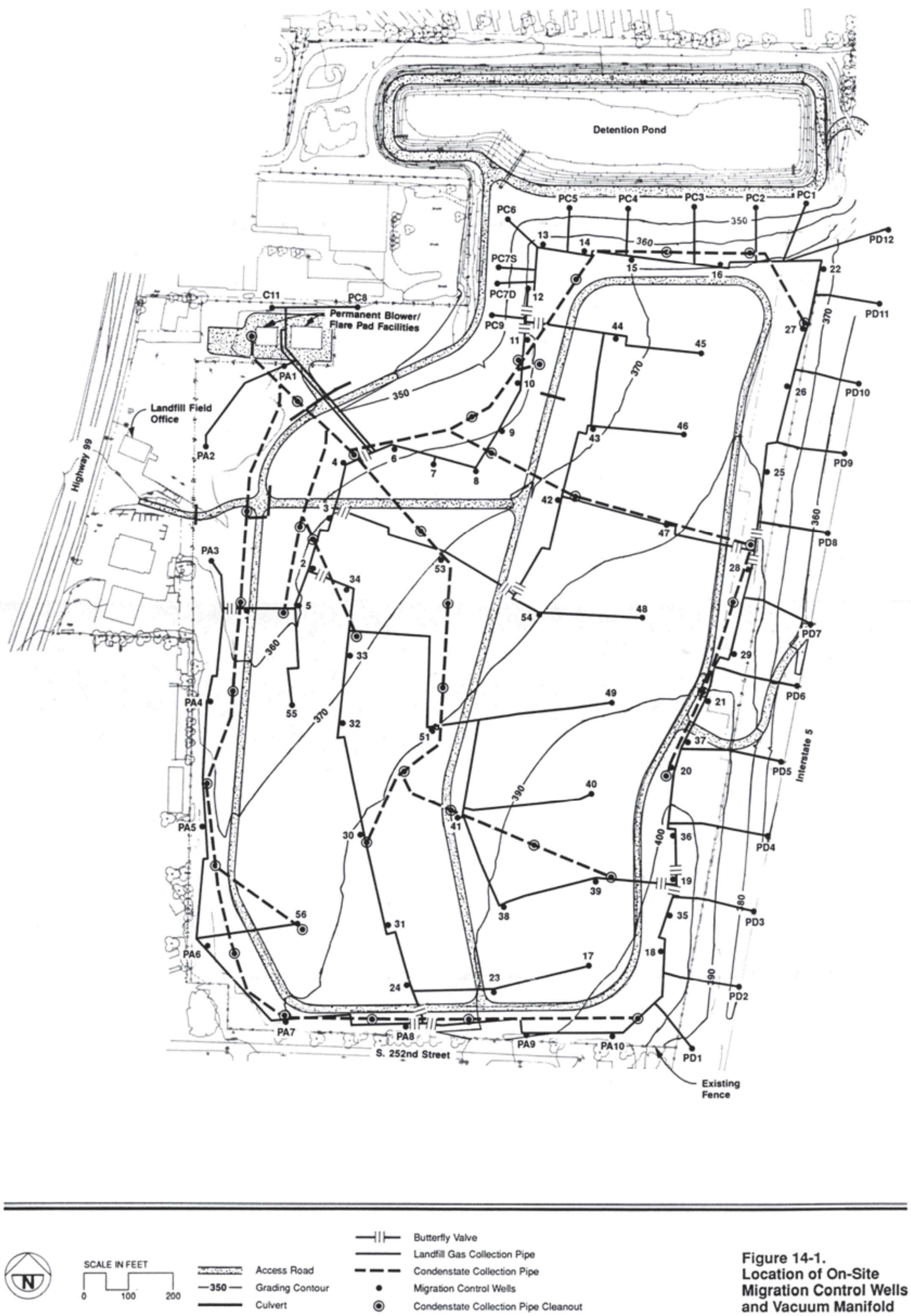

Figure 8. On-site gas extraction wells, flare/blower, and detention pod.

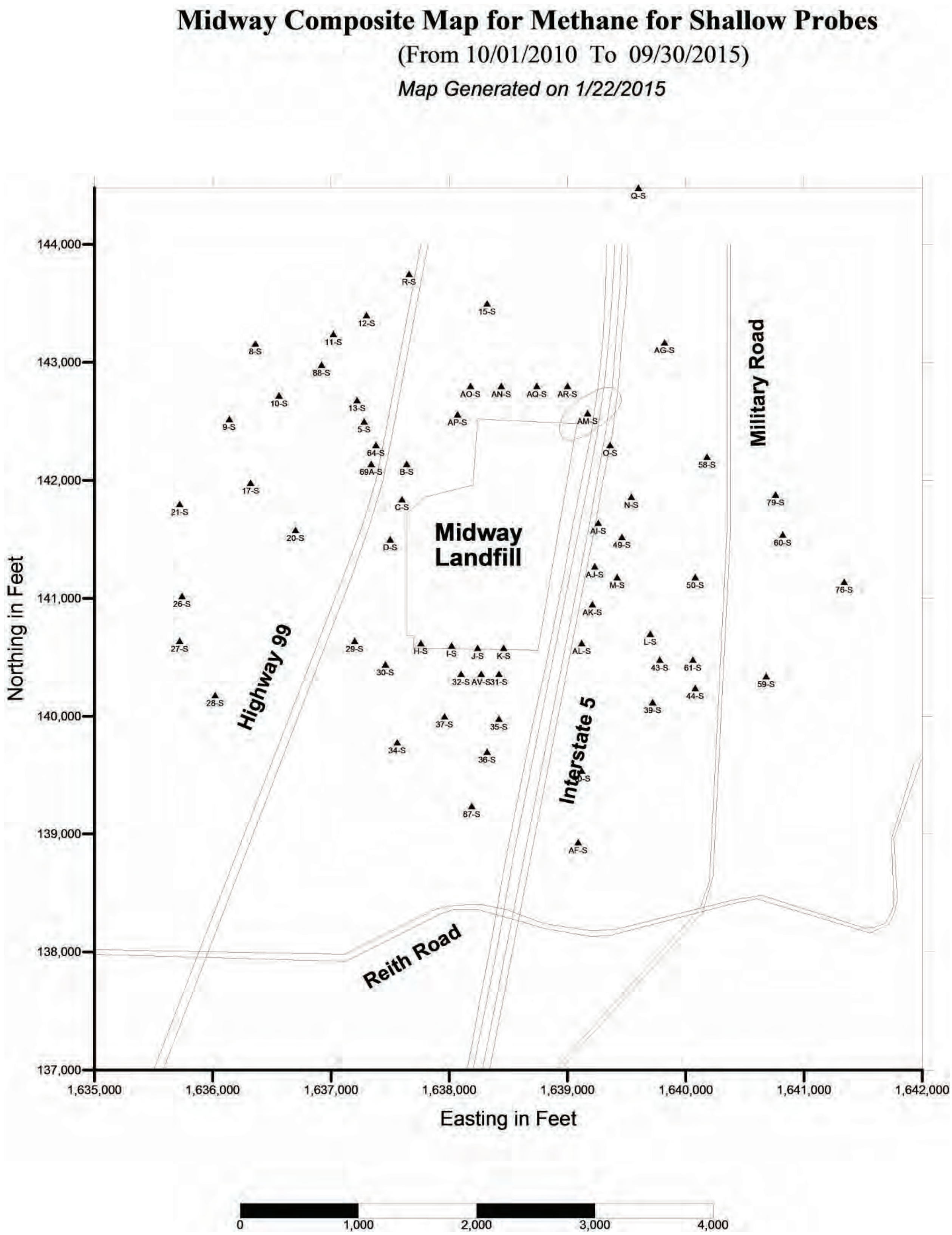

Figure 9. Shallow Gas Probes

Appendix B: Landfill Gas Sampling Options

Landfill Gas Sampling Options

Introduction

This appendix discusses potential options for pre-construction sampling of landfill gas constituents (e.g., VOCs and inorganic gases) at the Midway Landfill. Landfill gas sample results can provide Sound Transit with a better understanding of the current conditions at the Midway Landfill and information about the types and concentrations of COIs found in the landfill gas. Sample results can inform decisions about the mitigation and/or management of risks associated with the potential exposure to VOCs and inorganic gases at the OMF South. However, pre-construction sample results would not be appropriate for use in quantitative exposure or risk assessment as they do not necessarily reflect the levels of contamination to which OMF South workers may be exposed in the future.

Potential Sampling Options

Potential landfill gas sampling options include: 1) flare inlet and extraction well gas sampling, 2) near surface gas sampling, and 3) shallow soil gas sampling. These sampling options and the applications and limitations of each in the context of the Midway Landfill are described below.

Collection of flare inlet and extraction well gas samples: Measurements of landfill gas constituents can be taken at depth using the existing landfill gas extraction system. Samples may be collected at the flare inlet and at individual wells located throughout the landfill. Samples collected from the flare inlet represent a composite of all gases and vapors contained within the landfill under the landfill cap. The flare inlet sample results could be compared to historic landfill gas data from the 1988 gas characterization study completed as part of the RI (Parametrix 1988a) and the 1992 source emission evaluation (Am Test-Air Quality Inc. 1992). This comparison may provide insight into changes in concentrations in landfill gas constituents over the last 30 years. Samples collected from individual extraction wells may also provide information about the distribution of VOC-containing waste and/or areas of higher or lower VOC concentrations at specific locations within the landfill.

These landfill gas data would not provide an actual measure of the concentrations of VOCs and inorganic gases that workers at the OMF South may come in contact with. These samples are collected deep beneath the landfill cap and landfill gas constituent concentrations are expected to change as the gases move horizontally and vertically in the subsurface prior to possible exposure through a leak in the landfill cap and into ambient air. Consequently, these data should not be used for quantitative exposure or risk assessment.

Monitoring of near surface gas: Near surface gas monitoring measures the concentrations of gases at a point no higher than 4 inches above the surface of the landfill. This type of sampling can qualitatively indicate whether high levels of landfill gas are escaping from the landfill surface or if the landfill cap and gas extraction system are working effectively. Near surface gas monitoring often uses a portable instrument to screen for high levels of landfill gas along with collection of grab samples for laboratory analysis. Results from near surface gas sampling can be greatly influenced by meteorological conditions. Moderate winds can quickly dilute near surface gas concentrations.

Near surface gas data can help identify point sources of high concentrations of landfill gases (caused by leaks in the landfill cap). However, because of expected changes to the site due to the construction of the OMF South (e.g., the possible removal of underlying waste material and changes in the configuration of the landfill cap, etc.), pre-construction near surface gas samples are not expected to provide an actual measure of the concentrations of VOCs and inorganic gases that workers at the OMF South may come in contact with in the future. Changes in site conditions are likely to result in a difference in pre- and post-construction near surface gas results.

Near surface gas sampling can be conducted following a planned or unplanned breach in the landfill cap. In this case, once the landfill cap is penetrated, near surface gas sampling can be used to measure landfill gas constituent concentrations in gas escaping from the landfill. These data provide information about potential exposures to VOCs and inorganic gases at the specific location and time of the breach. Because VOC and inorganic gas concentrations can vary spatially throughout a landfill, near surface gas results from a breach in one location within the landfill may not be representative of near surface gas results at other locations where a breach may occur.

Exposure to VOCs and inorganic gases caused by a breach in the landfill cap would be influenced by the size and location of the breach, the location of waste within the landfill relative to the breach, the construction and configuration of the OMF South, and other site-specific factors. Pre-construction sampling of a breach in the landfill cap would not be expected to reflect the levels of contamination to which OMF South workers may be exposed in the future.

A planned breach or penetration of the landfill cap would likely require regulatory coordination and approval, and the logistics and costs of sampling a planned breach are likely to be prohibitive; as a result, near surface gas sampling of a planned breach are not recommended.

Collection of shallow soil gas samples: Shallow soil gas samples can be used to provide a measure of VOC and inorganic gas concentrations in soil gas near buildings or developable areas. Sample results can then be used to determine if constituent concentrations in the subsurface are high enough to pose a potentially unacceptable threat to indoor air quality in current or future site buildings.

Shallow soil gas sampling involves the installation of a temporary or permanent soil gas sampling probe to a recommended depth of no less than 5 feet bgs followed by the collection of a sample into an evacuated sampling canister. Due to the possibility of diluting the collected soil gas with atmospheric air and to minimize barometric pumping effects, samples should seldom be collected from depths shallower than 5 feet bgs (Ecology 2018a).

The Midway Landfill is currently covered by a multi-layered landfill cap comprised of a top layer of 12-inch-thick topsoil planted with shallow rooted grasses followed by a 12-inch-thick drainage layer, a layer of filter fabric, drainage net, and 50-mil HDPE flexible membrane. Below the HDPE membrane is a 12-inch-thick layer of low permeability soil/clay material (USEPA 2000a, 2015a). The depth of the prescribed cover over the geosynthetic membrane in the landfill cap is variable throughout the landfill due to grading activities conducted to maintain effective surface water management over the life of the landfill. Cover soil is estimated to be as deep as 14 feet in places.

If this sampling option was selected for the Midway Landfill prior to construction of the OMF South, shallow soil gas samples would need to be collected at locations where the cover soil is greater than 5 feet in order to avoid disturbing the integrity of geosynthetic membrane in the landfill cap. Shallow soil gas results should be reviewed with the understanding that sample results are likely to vary based on sample location relative to VOC and inorganic gases concentrations in the landfill, whether there is a leak in the landfill cap in the vicinity of the sample location, and other site-specific factors.

As discussed earlier in the context of near surface gas sampling, shallow soil gas samples could be collected following a breach in the cap; however, pre-construction shallow soil gas results are not expected to be representative of levels of contamination to which OMF South workers may be exposed in the future.

Potential Sampling Approach

In order to provide Sound Transit with information about the types and concentrations of VOCs and inorganic gases found in landfill gas at the Midway Landfill under current site conditions, the following sampling approach could be implemented prior to construction of the OMF South.

- Phase 1: Landfill Gas Characterization

  Conduct limited landfill gas sampling of the flare inlet for comparison to historical data from the 1988 gas characterization study (Parametrix 1988a) and the 1992 source emission evaluation (Am Test-Air Quality Inc. 1992). Samples collected from the flare inlet would be analyzed for those VOCs and inorganic gases detected in the 1988 and

1992 samples. Flare inlet sample results would provide information on VOCs and inorganic gases currently present in extracted landfill gas.

- Phase 2: Landfill Gas Constituent Distribution

  Depending on the results of flare inlet gas sampling, Sound Transit may opt to conduct landfill gas sampling of individual extraction wells throughout the landfill footprint. Samples collected from the individual wells would be analyzed for those VOCs and inorganic gases detected in flare inlet gas samples. Individual extraction well sample results would provide information on the distribution of VOCs and inorganic gases by well location throughout the landfill and within the proposed OMF South footprint.

Near surface sampling and shallow soil gas sampling are not recommended at this time but may be considered in the future depending on the selected construction approach, potential changes in site conditions, and the results of the landfill gas characterization and constituent distribution sampling described above.

August 2020

OMF SOUTH

Midway Landfill Human Health Risk Assessment Addendum – Final

SOUNDTRANSIT

CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

OMF SOUTH

Midway Landfill Human Health Risk Assessment Addendum-Final

Prepared for:
Sound Transit

Prepared by:
HDR Engineering, Inc.

August 10, 2020

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Appendices

Tables

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Acronyms and Abbreviations

Alta	Alta Science and Engineering, Inc.
bgs	below ground surface
City	City of Seattle
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
COI	Contaminant Of Interest
COPC	Contaminant Of Potential Concern
CSM	Conceptual Site Model
EAS	Environmental Analytical Service, Inc.
HDPE	High-Density Polyethylene
HHRA	Human Health Risk Assessment
LEL	Lower Explosive Limit
LFG	landfill gas
MTCA	State of Washington Model Toxics Control Act
OMF South	Operations and Maintenance Facility: South
Parametrix	Parametrix, Inc.
QAO	Quality Assurance Officer
QA/QC	quality assurance/quality control
RI	Remedial Investigation
SPU	Seattle Public Utilities
USEPA	U.S. Environmental Protection Agency
VISL	Vapor Intrusion Screening Levels
VOC	Volatile Organic Compound

Units

μg/m^3	micrograms per cubic meter

Executive Summary

A Human Health Risk Assessment (HHRA) was prepared for the Midway Landfill as a potential site alternative for Sound Transit's Operations and Maintenance Facility South (OMF South) in January 2020 (HDR 2020). Sound Transit is currently implementing a system-wide expansion of the Link light rail system and is evaluating the Midway Landfill (Comprehensive Environmental Response, Compensation, and Liability Information System [CERCLIS] Identification Number: WAD 980638910) as a potential site alternative in the OMF South Draft Environmental Impact Statement (EIS) (HDR 2019a).

The HHRA evaluated several contaminants of interest (COIs) identified during previous site investigations of the Midway Landfill including a number of volatile organic compounds (VOCs), hydrogen sulfide, and methane (HDR 2020).

Several potentially complete occupational routes of exposure to COIs in landfill waste, gas, and groundwater at the OMF South were also identified in the HHRA (HDR 2020). These potentially complete exposure routes include:

- Inhalation of Indoor Air for Onsite Office and Maintenance Shop Workers,
- Inhalation of Air in Subsurface Confined Spaces (e.g., utility trenches and vaults) for Construction Workers,
- Inhalation of Outdoor Air for Maintenance Shop, Yard, and Construction Workers, and
- Direct Contact with Waste and Contaminated Soil for Construction Workers (HDR 2020).

The HHRA found that occupational exposures to VOCs in groundwater and to methane in landfill gas (LFG) are not expected to result in adverse chronic health effects for potential future OMF South workers (HDR 2020). However, the potential risk associated with occupational exposures to VOCs and inorganic gases detected in LFGs could not be characterized due to a lack representative data (HDR 2020).

In order to provide Sound Transit with information about the types and concentrations of VOCs and inorganic gases found in LFG at the Midway Landfill under current site conditions, Parametrix, Inc. (Parametrix) conducted a pre-construction LFG sampling event at the Midway Landfill on April 9, 2020. While these data are not intended (or appropriate) for use in quantitative risk assessment at OMF South, they can inform decisions about the mitigation and/or management of risks associated with the potential exposure to VOCs and inorganic gases during the construction and operation of OMF South.

LFG samples were collected directly from the active gas extraction system. LFG is extracted through the onsite extraction wells at the landfill and routed to a permanent blower/flare system where the extracted gas is supplemented with natural gas and then burned before discharge to the atmosphere (USEPA 2000, 2015).

LFG samples were collected from a manifold inlet to the flare and several gas extraction wells located within the proposed OMF South facility footprint that were still producing a measureable amount of LFG (according to information provided by SPU). Sampled wells were selected based on their proximity to proposed geotechnical borings. In addition, air grab sampling was conducted in areas where the landfill cap had been breached prior to repair during a geotechnical investigation completed in March-April 2020.

This addendum supplements the Midway Landfill HHRA (HDR 2020) with a summary of the April 2020 sampling activities and results, and compares results to historic (1988 and 1992) LFG concentrations previously presented in the HHRA. A qualitative evaluation of the April 2020 results and subsequent updates to the information presented in the HHRA are also included.

LFG Sampling

On April 9, 2020, Parametrix collected 11 samples from a manifold inlet and nine landfill extraction system wells. Three near-surface gas samples were collected in the vicinity of three geotechnical borings where the landfill cover system had been breached (see Figure 1 for approximate sample locations). The LFG extraction system was operating during the sample event and as a result, gas contained in the landfill was under vacuum conditions at the time of sample collection.

All samples were analyzed by Environmental Analytical Services, Inc. (EAS) for:

- VOCs by U.S. Environmental Protection Agency (USEPA) Method TO-15 (USEPA 1999),
- Hydrogen sulfide by USEPA Method M16 (USEPA 2017a), and
- Carbon dioxide and methane by ASTM D1945 (ASTM 2019).

LFG Sample Results

Benzene, ethylbenzene, and hydrogen sulfide were found in the manifold inlet and several extraction wells at concentrations that exceed one or more regulatory screening levels. Methane was detected in the manifold inlet and all of the extraction well samples (with the exception of GW-7) at concentrations that exceed the lower explosive limit (LEL) of 5% (WAC 173-304-460).

Three VOCs (ethylbenzene, toluene, and total xylenes) were detected in one air grab sample. Methane was not detected in any air grab samples.

Comparison to Historic LFG Data

Manifold inlet and extraction well sample results from the April 2020 sampling event were compared to the 1988 gas characterization study which was completed as part of the Remedial Investigation (RI) (Parametrix 1988) and the 1992 source emission evaluation (Am Test-Air Quality Inc. 1992) in order to provide insight into changes in concentrations in LFG constituents over the last 25 to 30 years. The RI was conducted by the City of Seattle (City) and the Washington State Department of Ecology (Ecology) in 1988 to investigate the impact of the landfill on the environment.

Average VOC concentrations in subsurface and flare inlet (or manifold inlet) gas combined have decreased since 1988 and 1992 for all detected VOCs. Compared to 1988 LFG results, the average concentrations of vinyl chloride, toluene, total xylenes, benzene, and ethylbenzene in subsurface gas (LFG extraction wells and manifold or flare inlet combined) have decreased by 98%, 91%, 85%, 52% and 35%, respectively. Hydrogen sulfide concentrations have decreased by 66% since 1988. When compared to the 1992 flare inlet results, vinyl chloride, toluene, total xylenes, benzene, and ethylbenzene concentrations have decreased by 95%, 90%, 95%, 70% and 82%, respectively.

Methane concentration data collected from the LFG extraction system by Seattle Public Utilities (SPU) on a monthly basis from January 2015 to August 2019 were compared to April 2020 methane results for sampled extraction wells. Methane was detected in all extraction wells and the manifold inlet sample at concentrations within (near the lower end of) the range of the 2015-2019 data.

LFG Sampling Findings

The April 2020 LFG extraction system sample results indicate that several VOCs remain in LFG at the site; however, the VOCs with the highest concentrations in 2020 (benzene, ethylbenzene, and hydrogen sulfide) have decreased substantially since 1988.

VOC results from the manifold inlet and extraction wells and from co-located wells demonstrate that concentrations can vary significantly by depth and by location throughout the landfill footprint.

The sampled extraction wells with the highest concentrations of benzene, ethylbenzene, and hydrogen sulfide include GW-42S and GW-42D and GW-48S and GW-48D.

HHRA Updates and Conclusions

The April 2020 LFG sampling event did not provide any new information that would result in a change in the current conceptual site model (CSM) included in Appendix A of this addendum and described in detail in the HHRA (HDR 2020). The primary source of Contaminants of Potential Concern (COPCs) at the site, chemical release mechanisms and environmental transport processes, and potentially complete routes of exposure for specific occupations at the OMF South depicted in the CSM remain the same as those presented in the HHRA (HDR 2020). Overall, the HHRA findings and conclusions have not changed.

1.0 Introduction

A HHRA was prepared for the Midway Landfill as a potential site alternative for Sound Transit's OMF South in January 2020 (HDR 2020). Sound Transit is currently implementing a system-wide expansion of the Link light rail system and is evaluating the Midway Landfill (CERCLIS Identification Number: WAD 980638910) as a potential site alternative in the OMF South Draft Environmental Impact Statement (EIS) (HDR 2019a).

The purpose of the HHRA was to assess potential chronic health risks to Sound Transit personnel who work at the future site should it be selected for the OMF South and waste be maintained on site. Non-Toxicological hazards including acute, physical risks associated with constructing and operating the OMF South over a waste mass were also discussed.

The HHRA evaluated several COIs detected in groundwater and LFG during previous site investigations of the Midway Landfill. The COIs found in onsite groundwater wells include dissolved iron, manganese, chloride, sulfate, 1,4-dioxane, 1,1-dichloroethane, cis-1,2-dichloroethene, and vinyl chloride. The COIs found in onsite LFGs include methane, hydrogen sulfide, and numerous volatile organic compounds (VOCs) (including ethylbenzene, vinyl chloride, total xylenes, toluene, and benzene which were found most frequently and in the highest concentrations). The HHRA provides a summary of findings and additional details about the previous site investigations (HDR 2020).

Several potentially complete occupational routes of exposure to COIs in landfill waste, gas, and groundwater at the OMF South were also identified in the HHRA (HDR 2020). These potentially complete exposure routes include:

- Inhalation of Indoor Air for Onsite Office and Maintenance Shop Workers,
- Inhalation of Air in Subsurface Confined Spaces (e.g., utility trenches and vaults) for Construction Workers,
- Inhalation of Outdoor Air for Maintenance Shop, Yard, and Construction Workers, and
- Direct Contact with Waste and Contaminated Soil for Construction Workers

These potential routes of exposure are based on the assumptions that construction of the OMF South may result in future site conditions that could allow for vapor intrusion from subsurface gas and underlying groundwater to indoor air (HDR 2020).

The HHRA found that occupational exposures to VOCs in groundwater and to methane in LFG are not expected to result in adverse chronic health effects for potential future OMF South workers (HDR 2020). However, the potential risk associated with occupational exposures to VOCs and inorganic gases detected in LFGs could not be characterized due to a lack representative data (HDR 2020). Although a number of toxic VOCs were identified in previous site investigations, these data were collected more than 25 years prior to completion of the HHRA and likely do not represent current or future site conditions.

The HHRA determined that in order to quantify potential future occupational risk to LFGs, *post-construction* sampling of VOCs and toxic inorganic gases is needed to provide a representative measure of the concentrations that workers may be exposed to at OMF South. Any future post-construction sampling of LFG constituents should be conducted following an approach that generates the representative environmental data needed to characterize occupational exposures and to evaluate potential health risks at the OMF South (such as sub-slab soil gas and/or indoor air sampling). Post-construction sub-slab soil gas and/or indoor air sampling results could then be compared to the appropriate risk-based screening levels (e.g., USEPA Worker Air Vapor Intrusion Screening Levels [VISLs] for Sub-slab or Near Source Soil Gas [USEPA 2019], USEPA Worker VISLs for Indoor Air [USEPA 2019], Model Toxics Control Act [MTCA] Method C Sub-slab Soil Gas Screening Levels [WAC 173-340-745], and MTCA Method C Indoor Air Screening Levels [WAC 173-340-750]).

However, in order to provide Sound Transit with information about the types and concentrations of VOCs and inorganic gases found in LFG at the Midway Landfill under current site conditions, Parametrix conducted a pre-construction LFG sampling event at the Midway Landfill on April 9, 2020.

LFG samples were collected directly from the active LFG extraction system which has been in operation since 1985. The extraction system places the landfill under vacuum conditions to pull gases from the underlying waste material. LFG is extracted through the onsite extraction wells at the landfill and routed to a permanent blower/flare system where the extracted gas is supplemented with natural gas and then burned before discharge to the atmosphere (USEPA 2000, 2015).

LFG samples were collected from a manifold inlet to the flare and several gas extraction wells located within the proposed OMF South facility footprint that were still producing a measureable amount of LFG (according to information provided by SPU). Sampled wells were selected based on their proximity to proposed geotechnical borings. In addition, three air grab samples were collected in areas where the landfill cap had been breached prior to repair during a geotechnical investigation conducted in March-April 2020.

This addendum supplements the Midway Landfill HHRA (HDR 2020) with a summary of the April 2020 sampling activities and results, and compares these results to historic LFG concentrations presented in the HHRA. An evaluation of the April 2020 results and subsequent updates to the information presented in the HHRA are also included.

2.0 LFG Sampling

The Midway Landfill is covered with a multilayered engineered cap (landfill cap) and a gas extraction system is in place and operating throughout the landfill to control subsurface migration of LFG to indoor and ambient air. Ecology oversees the City's operation and maintenance for the landfill cover system, gas extraction system, and surface water control systems constructed under the Consent Decree (Ecology 1990).

LFG is extracted through the onsite extraction wells at the landfill and routed to a permanent blower/flare system where the extracted gas is supplemented with natural gas and then burned before discharge to the atmosphere (USEPA 2000, 2015). Additional natural gas is needed for combustion due to the low volume of LFG currently generated at the site.

The landfill cap is comprised of a top layer of 12-inch-thick topsoil planted with shallow rooted grasses followed by a 12-inch-thick drainage layer, a layer of filter fabric, drainage net, and 50-mil High-Density Polyethylene (HDPE) flexible membrane. Below the HDPE membrane is a 12-inch-thick layer of low permeability soil/clay material (USEPA 2000, 2015). The depth of the prescribed cover over the geosynthetic membrane in the landfill cap is variable throughout the landfill due to grading activities conducted to maintain effective surface water management over the life of the landfill. Cover soil is estimated to be as deep as 14 feet in places.

The cap provides a barrier which, along with the operating gas extraction system (constructed in 1985), reduces the migration of volatile compounds found in LFG and groundwater to the surface where they may enter future onsite buildings and/or outdoor air. Migration of volatile compounds through the landfill cover is only possible if the gas extraction and cover system were compromised.

The HHRA considers exposure to vapors from LFG and groundwater a potentially complete route of exposure under the worst-case scenario assumption that a long-term failure in engineered protections (including the landfill cap and gas collection system) occurs at the OMF South, allowing for vapor intrusion from subsurface gas and underlying groundwater to indoor air (HDR 2020).

In order to characterize the types and concentrations of COIs currently found in the LFG, samples were collected directly from the LFG extraction system and analyzed for those COIs that were previously detected in historic LFG samples. In addition, air grab samples were collected in the vicinity of three geotechnical borings where the landfill cover system had been breached. The sampling approach, sample locations, and depths of the sampled wells are described in Section 2.2. Appendix B contains well logs for the sampled wells and Figure 1 shows the sampled wells and boring locations.

2.1 Sampling Approach

Prior to sampling, Parametrix selected several extraction wells within the proposed OMF South facility footprint that were producing measurable amounts of methane gas (according to information provided by SPU). These extraction wells were also selected based on their proximity to the proposed geotechnical borings where air samples were collected. Co-located shallow and deep wells were selected where possible. A manifold inlet to the flare station (located to the north/northwest of the sampled wells) was also identified for sampling.

The sampled LFG extraction wells are listed below along with nearby proposed (or completed) borings (Figure 1 shows the sampling locations).

- GW-52S [S=shallow] and GW-52D [D=deep] located near B-1.
- GW-7 located near B-2.
- GW-38S and GW-38D located near B-3.
- GW-48S and GW-48D located near B-4.
- GW-42S and GW-42D located near B-5.

Only borings B-2, B-4, and B-5 were completed at the time of the gas sampling.

Collection of Manifold and Extraction Well Gas Samples:

Samples were collected from a manifold inlet and individual extraction wells located throughout the landfill. Samples were collected directly from manifold inlet and extraction well sample ports. Samples collected from the manifold inlet represent a composite of all gases and vapors contained within the landfill under the landfill cap. Measurements of LFG constituents were taken at depth using existing gas extraction wells. Samples collected from individual extraction wells provide information about the distribution of VOC-containing waste and/or areas of higher or lower VOC concentrations at specific locations within the landfill.

Collection of Air Grab Samples:

In addition to samples collected directly from the LFG extraction system, air grab samples were collected in areas where the landfill cap had been breached during a geotechnical investigation conducted in March-April 2020. Samples were collected a couple inches above the ground at the breach in the liner.

2.2 April 2020 Sampling Event

On April 9, 2020, Parametrix collected 11 samples from a manifold inlet (MAN-1 and MAN-2 [duplicate]) and nine landfill extraction system wells (GW-7, GW-38S and GW-38D, GW-42S and GW-42D, GW-48S and GW-48D, and GW-52S and GW-52D). Three near-surface gas samples were collected in the vicinity of three geotechnical borings (B-2, B-4, and B-5) where the landfill cover system had been breached. The LFG extraction system was operating during the sample event and as a result, gas contained in the landfill was under vacuum conditions at the time of sampling. Figure 1 shows approximate sample locations.

The following samples were collected from the manifold inlet on April 9, 2020.

- MAN-1
- MAN-2 (duplicate sample of MAN 1)

LFG system extraction wells have been installed at specific locations and depths throughout the landfill to apply different vacuum pressure at different depths in underlying waste material. Shallow and deep wells are co-located in several locations throughout the landfill footprint. The depth of each sampled gas extraction well is provided below. Well logs are included in Appendix B. The following samples were collected on April 9, 2020.

- GW-7 – This sample was collected from extraction well GW-7 which has a depth of 70 feet below ground surface (bgs).
- GW-38S and GW-38D – These samples were collected from two co-located extraction wells (GW-38S and GW-38D). GW-38S has a depth of 56 feet bgs and GW-38D has a depth of 112 feet bgs.
- GW-42S and GW-42D – These samples were collected from two co-located extraction wells (GW-42S and GW-42D). GW-42S has a depth of 32 feet bgs and GW-42D has a depth of 64 feet bgs.
- GW-48S and GW-48D – these samples were collected from two co-located extraction wells (GW-48S and GW-48D). GW-48S has a depth of 49 feet bgs and GW-48D has a depth of 112 feet bgs.
- GW-52S and GW-52D – These samples were collected from two co-located extraction wells (GW-52S and GW-52D). GW-52S has a depth of 30 feet bgs and GW-52D has a depth of 64 feet bgs.

Three geotechnical borings were completed through the exposed and breached landfill cap between March 24 and April 1, 2020. Two borings could not be completed at the time of sampling due to restrictions associated with the Covid-19 pandemic. The completed borings ranged in depth from 120 feet bgs to 150 feet bgs. Air grab samples B-2, B-4, and B-5 were collected in the vicinity of these borings on April 9, 2020. At the time of sampling, the temperature was 42 degrees Celsius. The weather was noted as mostly sunny with calm winds and a steady barometric pressure of 30.30 inches mercury throughout the sampling.

Figure 1 shows the sampled wells and boring locations.

The field crew sampled the manifold inlet and extraction wells using Entech Bottle Vacs with a Quick Connect Adapter. The field crew collected the samples by connecting the Quick Connect

Adapter to the sample port and then connecting the Entech Bottle Vac to the adapter/sample port assembly. The field crew listened for air rushing into the canister and kept the Bottle Vac on the assembly for at least 1 minute or until the Bottle Vac reached a maximum pressure of 5 pound-force per square inch. The field crew then removed the Quick Connect Adapter to stop sampling. Air grab samples were collected by attaching sample tubing to an Entech Bottle Vac and opening the bottle for at least 1 minute or until the Bottle Vac reached a maximum pressure of 5 pound-force per square inch. After collection, all samples were shipped to EAS for analysis.

EAS analyzed samples for the following COIs previously detected in historic LFG samples:

- VOCs including benzene, chlorobenzene, chloromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, dichloromethane (or methylene chloride), 4-methyl-2-pentanone (or methyl isobutyl ketone), styrene, 1,1,2,2-tetrachloroethane, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, vinyl acetate, vinyl chloride, total xylenes, tetrahydrofuran, trichlorofluoromethane, chloroethane (ethyl chloride), 1,1,2-trichloro-1,2,2-trifluoromethane (Freon 113), cis-1,2-dichloroethene, 1,4-dichlorobenzene, and 1,2-dichlorobenzene by USEPA Method TO-15 (USEPA 1999),
- Hydrogen sulfide by USEPA Method M16 (USEPA 2017a), and
- Carbon dioxide and methane by ASTM D1945 (ASTM 2019).

2.3 Data Validation

A Stage 2A data validation and data quality assessment was performed by Alta on the sample results for the additional site characterization efforts conducted by Parametrix on April 9, 2020, at the Midway Landfill (see Appendix C for the full quality assurance/quality control [QA/QC] review memorandum). Sampling procedures and the QA/QC review followed guidelines set forth in the following documents:

≠ Sampling Instructions for Collecting Samples in Entech Bottle Vacs (EAS no date) – This sampling procedure is provided in Appendix C. Parametrix followed this sampling procedure in lieu of a Quality Assurance Project Plan.

≠ National Functional Guidelines for Organic Superfund Methods Data Review (USEPA 2017b)

≠ Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (USEPA 2009)

≠ USEPA Guidance on Environmental Data Verification and Data Validation (USEPA 2002)

2.3.1 Data Accuracy and Precision

Based on the data quality review, Alta determined the laboratory and field data to be of acceptable quality, with the exception of MAN-1, B-2, and GW-52D, which were rejected (R) based on insufficient sample volume.

2.3.1.1 Accuracy

Alta's Quality Assurance Officer (QAO) did not qualify any data based on accuracy results (surrogate recoveries and laboratory control samples).

2.3.1.2 Precision

Alta's QAO did not qualify any data based on precision results (laboratory control sample duplicates).

2.3.2 Data Sensitivity

All laboratory reporting limits were below screening levels.

2.3.3 Data Usability

Three samples were rejected (MAN-1, B-2, and GW-52D); therefore, the calculated completeness for this sampling event is 79%.

2.4 Data Limitations

It is important to note the limitations of the April 2020 LFG data; particularly in the application and interpretation of these data in the context of occupational exposure and risk assessment. These limitations are discussed below.

2.4.1 Subsurface LFG Data Limitations

As discussed in the HHRA (HDR 2020), samples collected directly from the LFG extraction system are not representative of VOC concentrations in subsurface gas that could pose an unacceptable risk to indoor air quality, and should not be used to quantify occupational exposures and resulting risk for the following reasons: 1) these samples were collected under vacuum conditions from varying depths within the landfill and therefore are not likely to be representative of gases that may be escaping the landfill cap, and 2) these samples are not likely to be representative of gases that would be found near the surface (where exposure occurs) due to differences in attenuation prior to sample collection.

In addition, subsurface LFG samples were collected from a relatively small number of sample locations within a large area (>60 acres), and during a single (one-day) sampling event and short sampling duration (one minute). Consequently, these results are representative of LFG concentrations at one point in time under specific conditions. These data do not capture potential fluctuations in concentrations due to seasonal variation and changes in weather, or due to changes in site conditions that might be caused by waste removal and/or OMF South construction activities. In addition, the underlying waste type and conditions and applied vacuum pressure and resulting radius of influence for each individual LFG extraction wells is not known. These factors may affect VOC and inorganic gas concentrations in the sampled wells.

Despite the limitations of these data for use in exposure assessment and quantitative risk assessment, these data are helpful in understanding current concentrations and types of VOCs and inorganic gases found in LFG at the site, and can inform decisions about the mitigation and/or management of risks associated with the potential occupational exposures during and following construction of OMF South.

2.4.2 Air Grab Sample Limitations

The interpretation and application of air grab sample results in understanding potential occupational exposures at OMF South is extremely limited due to the small sample volume (less than one liter) and short sampling duration (one minute). These factors may result in very low VOC concentrations in air (below detection limits) and do not capture fluctuations in concentrations due to changes in temperature and barometric pressure over a more representative exposure period (8 hours or more).

2.5 Comparison Screening Levels

In order to provide some context to the VOC concentrations in LFG extraction wells and the manifold inlet, the following regulatory screening levels for deep soil and near source soil gas for occupational exposures are included in Table 1 of this report:

- MTCA Method C Deep Soil Gas Screening Levels (for samples collected deeper than 15 feet bgs) (WAC 173-340-745), and
- USEPA Worker Air VISL for Sub-slab or Near Source Soil Gas (USEPA 2019).

These regulatory screening levels are provided for contextual purposes only and, as previously discussed in the HHRA (HDR 2020), are not used to identify COPCs in LFG extraction system samples.

No risk-based screening levels for methane are available for comparison due to a lack of toxicological effects. However, methane is highly flammable, can explode at concentrations between 5% (LEL) and 15% (upper explosive limit), and is a simple asphyxiant that can cause death at concentrations much higher than the explosive range (5-15%). Methane concentrations are compared to the LEL in the HHRA and in this addendum (WAC 173-304-460).

2.6 LFG Sample Results

LFG sample results from the onsite extraction wells and the manifold inlet are presented in Table 1 (VOCs) and Table 2 (methane) and are discussed in detail below.

2.6.1 Manifold Inlet Sample Results

An original/duplicate sample pair (MAN-1 and MAN-2) was collected from the manifold inlet (shown in Figure 1) and represents a composite of all gases and vapors contained within the landfill under the landfill cap. The original sample (MAN-1) did not have sufficient sample volume and was rejected; therefore, results for this sample are not discussed.

The following VOCs were found in the duplicate manifold inlet sample (MAN-2): benzene, chlorobenzene, 1,1-dichloroethane, ethylbenzene, tetrachloroethene, toluene, vinyl chloride, total xylenes, tetrahydrofuran, trichlorofluoromethane, chloroethane, cis-1,2-dichloroethene, and hydrogen sulfide. Of these detected VOCs, benzene and ethylbenzene exceeded one or more regulatory screening level (Table 1).

- MAN-2
  - Benzene = 492 µg/m^3 (compared to USEPA VISL = 524 µg/m^3 and MTCA Method C Deep Soil SL = 320 µg/m^3)
  - Ethylbenzene = 13,362 µg/m^3 (compared to USEPA VISL = 1,640 µg/m^3 and MTCA Method C Deep Soil SL = 100,000 µg/m^3)

Methane was detected in the manifold inlet sample at 13.48%, which exceeds the LEL of 5% (Table 2).

2.6.2 Extraction Well Sample Results

Nine samples were collected from LFG extraction wells; however, one sample (GW-52D) was rejected due to insufficient sample volume; therefore, results for this sample are not discussed.

The following VOCs were found in the extraction wells: benzene, chlorobenzene, 1,1-dichloroethane, ethylbenzene, dichloromethane, tetrachloroethene, toluene, trichloroethene, vinyl chloride, total xylenes, tetrahydrofuran, trichlorofluoromethane, chloroethane, cis-1,2-dichloroethene, and hydrogen sulfide. Table 1 summarizes the extraction well results. Of these detected VOCs, benzene, ethylbenzene, and hydrogen sulfide exceed one or more regulatory screening level. These results are shown in Table 1.

Of the sampled wells, benzene was detected at the highest concentration in GW-48D (1,701 µg/m^3 relative to the USEPA VISL of 524 µg/m^3 and the MTCA Method C Deep Soil SL of 320 µg/m^3). Benzene in this extraction well is approximately three times higher than in the manifold inlet and the co-located shallower well (GW-48S) (492 µg/m^3 and 549 µg/m^3, respectively). The next highest benzene concentrations were found in GW-42S and GW-42D, which are 550 µg/m^3 and 535 µg/m^3, respectively. All other extraction wells had benzene concentrations less than the average represented by the manifold inlet sample results (MAN-2).

Ethylbenzene and hydrogen sulfide were detected at the highest concentrations in GW-42S (25,679 µg/m^3 [relative to the USEPA VISL of 1,640 µg/m^3 and the MTCA Method C Deep Soil SL of 100,000 µg/m^3] and 32,297 µg/m^3 [relative to the USEPA VISL of 292 µg/m^3], respectively). This extraction well is one of the shallower sampled wells (completed to a depth of 32 feet bgs). Ethylbenzene in this extraction well is approximately two times higher than in the manifold inlet and the co-located deeper well (GW-42D) (13,362 µg/m^3 and 9,927 µg/m^3, respectively). The next highest ethylbenzene concentration detected in the extraction wells was in GW-48D at 13,207 µg/m^3; the ethylbenzene concentration for the co-located shallow well GW-48S is 1,231 µg/m^3. All other extraction wells had ethylbenzene concentrations less than the average represented by the manifold inlet sample (MAN-2).

Hydrogen sulfide in GW-42S is approximately 1.5 times higher than in the co-located deeper well (GW-42D) (18,072 µg/m^3 relative to the USEPA VISL of 292 µg/m^3) and orders of magnitude higher than in the manifold inlet sample (124 µg/m^3). The next highest hydrogen sulfide concentrations were found in GW-48S and its co-located deeper well (GW-48D) (16,288 µg/m^3 and 12,500 µg/m^3, respectively). All other extraction wells (with the exception of GW-7 which was below the detection limit) had hydrogen sulfide concentrations greater than the average represented by the manifold inlet sample results (MAN-2).

Methane was detected in all of the extraction well samples (Table 2). Results ranged from 0.72% (GW-7) and 20.42% (GW-38D). Methane exceeds the LEL in all wells with the exception of GW-7.

2.6.3 Air Grab Samples Results

Three air grab samples were collected in the vicinity of the geotechnical borings where the cap had been breached. However, one sample (B-2) was rejected due to insufficient sample volume; therefore, results for this sample are not discussed.

Three VOCs (ethylbenzene, toluene, and total xylenes) were detected in the air grab samples. The majority of analyzed VOCs were not detected in the air grab samples; however, these air samples are small volume samples collected over a short period of time (one minute) and as a result, interpretation of these data is extremely limited. Ethylbenzene, toluene, and total xylenes were detected in one sample (B-5).

As discussed in Section 2.4.2, the interpretation and application of air grab sample results in understanding potential occupational exposures at OMF South is extremely limited due to the small sample volume (less than one liter) and short sampling duration (one minute). Therefore, Table 3 summarizes air grab sample VOCs results but these results are not discussed in detail.

Methane was not detected in any air grab samples (see Table 4).

2.7 Comparison to Historic LFG Data

Manifold inlet and extraction well sample results from the April 2020 sampling event are compared to the 1988 gas characterization study (Parametrix 1988) and the 1992 source emission evaluation (Am Test-Air Quality Inc. 1992) and are discussed in the following sections to provide insight into changes in concentrations in LFG constituents over the last 25 to 30 years. Average and maximum VOC results for all sampled wells and the manifold inlet are included in Table 5 for comparison to historical data. Table 2 shows the average and range of methane sample results for January 2015 to August 2019 data, along with the April 2020 results for comparison.

2.7.1 VOC and Inorganic Gas Sampling Results (1988 and 1992)

Two historic sources of data on the composition of subsurface gas at the Midway Landfill were identified during the initial document review for the HHRA. These sources include a gas characterization study completed in 1988 as part of the RI and a source emission evaluation completed in 1992 to quantify gas flare emission levels at the Midway Landfill.

As part of the 1988 gas characterization study, gas from individual onsite gas extraction wells was sampled and analyzed for compounds known to be present at specific locations deep within the landfill. In addition, flare inlet gas, representing the combined gas extracted from the numerous individual onsite gas extraction wells, was also characterized to provide a description of the average composition of gas extracted from the landfill (Parametrix 1988).

The 1992 source emission evaluation, conducted by Am Test-Air Quality Inc. to quantify gas combustor emission levels at the Midway Landfill, measured concentrations of VOCs found in pre-combustion flare gas (flare inlet gas) and post-incineration emissions. Subsurface gas extracted from the landfill was sampled during three runs at the inlet and the outlet of one of four LFG combustors to determine the destruction efficiencies for VOCs in LFG.

A number of VOCs were detected in subsurface gas collected from the onsite gas extraction wells and flare inlets in the 1988 and 1992 sampling events.

Concentrations of VOCs detected in subsurface and flare inlet gas during the 1988 gas characterization study were presented in the RI in summary form only (mean and/or maximum concentrations) (Parametrix 1988). Concentrations of VOCs detected in flare inlet gas during the 1992 source emission evaluation were presented for each of the three sample runs. Table 5 presents these data and the April 2020 results in summary (maximum and mean concentrations).

Average VOC concentrations in subsurface and flare or manifold inlet gas combined have decreased since 1988 and 1992 for all detected VOCs. The RI noted that benzene, ethylbenzene, toluene, total xylenes, and vinyl chloride were found most frequently and in the highest concentrations in onsite subsurface gas (Parametrix 1988). Hydrogen sulfide was also detected in onsite subsurface gas in the low parts per million range (Parametrix 1988). Compared to 1988 LFG results, the average concentrations of vinyl chloride, toluene, total xylenes, benzene and ethylbenzene in subsurface gas (LFG extraction wells and manifold or flare inlet combined) have decreased by 98%, 91%, 85%, 52% and 35%, respectively. Hydrogen sulfide concentrations have decreased by 66% since 1988.

When compared to the 1992 flare inlet results, vinyl chloride, toluene, total xylenes, benzene and ethylbenzene concentrations have decreased by 95%, 90%, 95%, 70% and 82%, respectively.

2.7.2 Methane Sampling Results (2015-2019)

LFG monitoring has been conducted at the landfill on a regular basis beginning in 1984. Installation and operation of the LFG extraction system is part of the remedy for the Midway Landfill and monitoring and sampling of the extraction wells is part of the operations and maintenance of the system. The Final HHRA discusses the remedy for the Midway Landfill in more detail (HDR 2020).

LFG is collected from the landfill extraction wells and flares by SPU and analyzed for combustible gas (primarily methane), oxygen, carbon dioxide, temperature, static pressure, and other parameters. SPU provided monthly gas monitoring results for 106 sample locations collected between January 2015 and August 2019 for review as part of the HHRA. These results included methane concentrations for 106 locations within the LFG extraction system (e.g., extraction wells, vacuum manifolds, etc.).

Table 2 summarizes methane results from January 2015 - August 2019 and April 2020 for those extraction wells and the manifold inlet sampled in April 2020. Methane was detected in all extraction wells and manifold inlet samples at concentrations within (near the lower end of) the range of the 2015-2019 data.

3.0 LFG Sampling Findings

The April 2020 LFG extraction system sample results indicate that several VOCs remain in LFG at the site; however, when compared to historical data, the VOCs with the highest concentrations in 2020 (benzene, ethylbenzene, and hydrogen sulfide) have decreased substantially since 1988.

VOC results from the manifold inlet and extraction wells and from co-located wells demonstrate that concentrations can vary significantly by depth and by location throughout the landfill footprint. This variation may be due to differences in underlying waste material and conditions and to differences in the vacuum pressure exerted at these depths and locations.

The sampled extraction wells with the highest concentrations of benzene, ethylbenzene, and hydrogen sulfide include those GW-42S and GW-42D and GW-48S and GW-48D. Sampled extraction wells with the lowest VOCs concentrations include GW-7 and GW-52S.

4.0 HHRA Conclusions

The April 2020 LFG sampling event did not provide any new information that would result in a change in the current CSM included in Appendix A of this addendum and described in detail in the HHRA (HDR 2020). The primary source of COPCs at the site, chemical release mechanisms and environmental transport processes, and potentially complete routes of exposure for specific occupations at the OMF South depicted in the CSM remain the same as those presented in the HHRA (HDR 2020).

As discussed in the HHRA (HDR 2020) and in Section 2.4 of this addendum, samples collected directly from the LFG extraction system are not representative of VOC concentrations in subsurface gas that could pose an unacceptable risk to indoor air quality, and should not be used to quantify occupational exposures and resulting risk. As a result, the April 2020 pre-construction sampling results were not used to identify subsurface soil gas COPCs.

However, because hydrogen sulfide was detected at relatively high concentrations (32,297 $\mu g/m^3$ in GW-42S relative to the USEPA VISL of 292 $\mu g/m^3$) in LFG samples during the April 2020 sampling event, a toxicity profile for hydrogen sulfide is included in Appendix D. The toxicity profile is a summary of available toxicological information and known health effects for a hazardous substance. Overall, the HHRA findings and conclusions have not changed.

As stated in the HHRA findings, the migration of LFG through the subsurface to indoor and ambient air is currently controlled by the gas extraction system and the landfill cap. Continued operation and maintenance of all components of the remedy (including the gas extraction system and the landfill cap) is required if any portion of the property is sold, leased, transferred, or otherwise conveyed. As a result, it is expected that future development of the OMF South at the Midway Landfill would include a gas extraction system and the landfill cap and other engineered protections to mitigate and monitor vapor intrusion of LFG (including methane) to indoor air.

5.0 References

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Tables

Table 1. VOC Concentrations in Landfill Gas Extraction System by Sample Location (2020)

Sample ID	Date	Unit	Benzene	Chlorobenzene	Chloromethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	trans-1,2-Dichloroethene	Ethylbenzene	Dichloromethane (Methylene Chloride)	4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	Styrene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	Toluene
USEPA Worker Air Vapor Intrusion Screening Levels (VISL) for Sub-slab or Near Source Soil Gas		µg/m^3	**524**	7,300	13,100	2,560	157	29,200	No Tox Info	**1,640**	87,600	438,000	146,000	70.5	5,840	730,000
VISL Toxicity Basis			CA	NC	NC	CA	CA	NC	--	CA	NC	NC	NC	CA	NC	NC
MTCA Method C Deep Soil Gas Screening Level[b]		µg/m^3	**320**	5,000	9,000.00	1,600.0	96	20,000	No Tox Info	100,000	60,000	300,000	100,000	43	4,000	500,000
MTCA Method C Toxicity Basis			CA	NC	NC	CA	CA	NC	--	NC	NC	NC	NC	CA	NC	NC
MAN-1	4/9/2020	µg/m^3	<1.42 R	<1.02 R	<1.34 R	<0.90 R	<0.90 R	<0.88 R	<0.88 R	<2.04 R	<1.54 R	<3.64 R	<1.96 R	<1.51 R	<0.90 R	<1.67 R
MAN-2 (duplicate of MAN-1)	4/9/2020	µg/m^3	**492**	531	<1.34	29	<1.34	<1.31	<1.31	**13,362**	<2.29	<5.41	<2.91	<2.24	15	3,117
GW-7	4/9/2020	µg/m^3	<6.31	42	<2.04	<4.00	<4.00	<3.92	<3.92	37	<6.86	<16.20	<8.72	<6.72	<4.02	46
GW-38S	4/9/2020	µg/m^3	256	537	<1.65	<3.24	<3.24	<3.17	<3.17	637	<5.55	<13.11	<7.06	<5.43	<3.25	29
GW-38D	4/9/2020	µg/m^3	62	753	<1.34	<1.49	<1.49	<1.45	<1.45	**6,851**	<2.55	<6.01	<3.24	<2.49	5.88 J	291
GW-42S	4/9/2020	µg/m^3	**550**	320	<2.13	123	<4.18	<4.10	<4.10	**25,679**	<7.18	<16.94	<9.12	<7.02	<4.20	773
GW-42D	4/9/2020	µg/m^3	**535**	395	<1.34	37	<1.75	<1.71	<1.71	**9,927**	<3.00	<7.09	<3.82	<2.94	<1.76	266
GW-48S	4/9/2020	µg/m^3	**549**	677	<1.34	<2.00	<2.00	<1.96	<1.96	1,231	<3.44	<8.11	<4.37	<3.36	<2.01	176
GW-48D	4/9/2020	µg/m^3	**1,701**	370	<1.34	190	<2.48	<2.43	<2.43	**13,207**	47	<10.04	<5.40	<4.16	8.7	742
GW-52S	4/9/2020	µg/m^3	192	189	<1.34	28	<1.46	<1.43	<1.43	1,083	<2.50	<5.90	<3.18	<2.45	8.6	372
GW-52D	4/9/2020	µg/m^3	<1.79 R	<1.29 R	<1.34 R	<1.13 R	<1.13 R	<1.11 R	<1.11 R	6.95 R	<1.94 R	<4.59 R	<2.47 R	<1.90 R	<1.14 R	<2.11 R

Sample ID	Date	Unit	1,1,1-Trichloroethane	Trichloroethene	Vinyl acetate	Vinyl chloride	Xylenes[a]	Tetrahydrofuran	Trichlorofluoromethane	Chloroethane (Ethyl Chloride)	1,1,2-Trichloro-1,2,2-trifluoromethane (Freon 113)	cis-1,2-Dichloroethene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	Hydrogen Sulfide
USEPA Worker Air Vapor Intrusion Screening Levels (VISL) for Sub-slab or Near Source Soil Gas		µg/m^3	730,000	292	29,200	929	14,600	292,000	No Tox Info	1,460,000	No Tox Info	No Tox Info	372	29,200	**292**
VISL Toxicity Basis			NC	NC	NC	CA	NC	NC	--	NC	--	--	CA	NC	NC
MTCA Method C Deep Soil Gas Screening Level[b]		µg/m^3	500,000	200	20,000	280	10,000	--	70,000	--	--	--	--	--	--
MTCA Method C Toxicity Basis			NC	NC	NC	CA	NC	--	NC	--	--	--	--	--	--
MAN-1	4/9/2020	µg/m^3	<1.21 R	<0.72 R	<0.78 R	<0.57 R	<2.05 R	<1.31 R	<1.97 R	<0.59 R	<1.70 R	<1.76 R	<2.67 R	<5.34 R	<11.3 R
MAN-2 (duplicate of MAN-1)	4/9/2020	µg/m^3	<1.80	<1.06	<1.16	224	9,787	300	27	74.16	<2.53	55.94	<3.97	<7.93	124
GW-7	4/9/2020	µg/m^3	<5.39	<3.19	<3.48	<2.53	54.8 J	<5.83	<5.55	<2.61	<7.58	<7.83	<11.89	<23.77	<50.2
GW-38S	4/9/2020	µg/m^3	<4.36	<2.58	<2.82	<2.04	234	120	20.95 J	60.31	<6.13	<6.34	<9.61	<19.23	**4,348**
GW-38D	4/9/2020	µg/m^3	<2.00	11	<1.29	234	1,613	396	<2.06	27.00	<2.81	70.05	<4.41	<8.82	**6,590**
GW-42S	4/9/2020	µg/m^3	<5.64	<3.33	<3.64	212	2,170	307	86	129.16	<7.92	<8.19	<12.43	<24.85	**32,297**
GW-42D	4/9/2020	µg/m^3	<2.36	<1.39	<1.52	101	1,812	330	78	87.84	<3.31	12.41	<5.20	<10.40	**18,072**
GW-48S	4/9/2020	µg/m^3	<2.70	11.85 J	<1.74	137	418	309	<2.78	298.80	<3.79	24.53	<5.95	<11.90	**16,288**
GW-48D	4/9/2020	µg/m^3	<3.34	14.44 J	<2.16	312	3,284	278	<3.44	796.18	<4.69	43.17	<7.36	<14.72	**12,500**
GW-52S	4/9/2020	µg/m^3	<1.96	12	<1.27	55	1,016	182	13	39.22	<2.76	<2.85	<4.33	<8.65	178
GW-52D	4/9/2020	µg/m^3	<1.53 R	<0.90 R	<0.99 R	<0.72 R	32 R	<1.65 R	<1.97 R	<0.74 R	<2.15 R	<2.22 R	<3.37 R	<6.73 R	<12.7 R

Notes:

A **bolded** number in the "Results" row denotes that the laboratory detected analyte is greater than the Commercial USEPA Vapor Intrusion Screening Levels (VISLs).

[a] m,p-Xylenes and o-Xylenes were added together and compared to the Xylenes VISL.

[b] https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables;

MTCA Method C Screening Levels are protective of industrial exposures and derived using the exposure assumptions shown in Figures 2-5. - = not available

CA = Carcinogenic

NC = Non-Carcinogenic

R = rejected value

J = estimated value

Table 2. Methane Concentrations in Landfill Gas Extraction System by Sample Location (2020)

Sample ID	Date	Unit	Methane (April 2020)	Methane Range (January 2015-August 2019)	Average Methane (January 2015-August 2019)
Lower Explosive Limit (LEL)		%	5		
MAN-1	4/9/2020	%	<0.03 R	13-19.9*	17.1*
MAN-2	4/9/2020	%	13.48		
GW-7	4/9/2020	%	0.72	0.6-13.4	5.9
GW-38S	4/9/2020	%	10.55	10.6-19.5	14.0
GW-38D	4/9/2020	%	20.42	19.8-29.2	24.6
GW-42S	4/9/2020	%	12.70	15.1-20.4	17.7
GW-42D	4/9/2020	%	13.07	14.7-21.3	17.6
GW-48S	4/9/2020	%	9.37	10.5-18.4	12.8
GW-48D	4/9/2020	%	15.19	11.4-24.4	17.9
GW-52S	4/9/2020	%	7.05	11.6-16.4	13.9
GW-52D	4/9/2020	%	<0.03 R	16.5-21.3	18.6

Notes:

< = less than the laboratory method detection limit

*SPU provided results for Man, Man-N, and Man-S; these summary data are for all manifold samples combined.

Table 3. VOC Concentrations in Air Grab Samples (2020)

Sample ID	Date	Unit	Benzene	Chlorobenzene	Chloromethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	trans-1,2-Dichloroethene	Ethylbenzene	Dichloromethane (Methylene Chloride)	4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	Styrene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	Trichloroethene	Vinyl acetate	Vinyl chloride	Xylenes [a]	Tetrahydrofuran	Trichlorofluoromethane	Chloroethane (Ethyl Chloride)	1,1,2-Trichloro-1,2,2-trifluoromethane (Freon 113)	cis-1,2-Dichloroethene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	Hydrogen Sulfide
B-2	4/9/2020	$\mu g/m^3$	<1.42 R	<1.02 R	<1.34 R	<0.90 R	<0.90 R	<0.88 R	<0.88 R	<2.04 R	<1.54 R	<3.64 R	<1.96 R	<1.51 R	<0.90 R	2.98 R	<1.21 R	<0.72 R	<0.78 R	<0.57 R	10.89 R	<1.31 R	<1.97 R	<0.59 R	<1.70 R	<1.76 R	<2.67 R	<5.34 R	<11.3 R
B-4	4/9/2020	$\mu g/m^3$	<2.14	<1.54	<1.34	<1.36	<1.36	<1.33	<1.33	<3.08	<2.33	<5.50	<2.96	<2.28	<1.36	<2.53	<1.83	<1.08	<1.18	<0.86	<6.09	<1.98	<1.97	<0.88	<2.57	<2.66	<4.03	<8.07	<17.0
B-5	4/9/2020	$\mu g/m^3$	<2.47	<1.78	<1.34	<1.57	<1.57	<1.53	<1.53	12.94	<2.69	<6.35	<3.42	<2.63	<1.58	10.28	<2.11	<1.25	<1.36	<0.99	38.15	<2.28	<2.18	<1.02	<2.97	<3.07	<4.66	<9.31	<17.5

Notes:

[a] m,p-Xylenes and o-Xylenes were added together and compared to the Xylenes VISL.

R = rejected value

$\mu g/m^3$ = micrograms per cubic meter

< = less than the laboratory method detection limit

Table 4. Methane Concentrations in Air Grab Samples by Sample Location (2020)

Sample ID	Date	Unit	Methane
Lower Explosive Limit (LEL)		%	5
B-2	4/9/2020	%	<0.03 R
B-4	4/9/2020	%	<0.06
B-5	4/9/2020	%	<0.06

Notes:

< = less than the laboratory method detection limit

Table 5. Maximum and Average VOC Concentrations in Landfill Gas Extraction System (1988, 1992, and 2020)

Date	Sample ID	Unit	Benzene	Chlorobenzene	Chloroethane (Ethyl Chloride)	Chloromethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	trans-1,2-Dichloroethene	Ethylbenzene	Dichloromethane (Methylene Chloride)	4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	Styrene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	Toluene	1,1,1-Trichloroethane	Trichloroethene	Vinyl Acetate	Vinyl Chloride	Xylenes [a]	Tetrahydrofuran	Trichlorofluoromethane	1,1,2-Trichloro-1,2,2-trifluoromethane (Freon 113)	cis-1,2-Dichloroethene
1988 [b, c, d]	Maximum On-site Sub-surface Gas	μg/m³	4,421	1,188	1,868	NR	3,028	510	444	313	72,119	9,199	25	2,164	ND	543	90,600	ND	521	1,701	79,793	126,774	6,190	2,006	812	NR
	Maximum Flare Inlet Gas	μg/m³	3,016	1,197	794	NR	1,376	ND	3,981	3,259	24,962	1,091	ND	ND	254	ND	24,790	327	3,671	ND	2,699	97,655	NR	1,101	3,456	NR
	Mean Sub-surface/Flare Inlet Gas combined	μg/m³	1,016	NR	NR	NR	NR	NR	NR	NR	12,266	NR	NR	175	NR	NR	7,235	NR	NR	NR	7,175	14,846	NR	NR	NR	NR
1992 [e]	Maximum Flare Inlet (all runs)	μg/m³	1,700	2,801	280	1,002	410	NR	NR	NR	46,002	NR	270	520	NR	NR	6,901	NR	NR	NR	3,002	47,004	NR	170	NR	1,099
	Average Flare Inlet (all runs)	μg/m³	1,600	2,733	270	974	397	NR	NR	NR	44,670	NR	270	484	NR	NR	6,600	NR	NR	NR	2,968	46,003	NR	160	NR	1,067
2020	Maximum (Extraction Wells and Manifold)	μg/m³	1,701	753	796	ND	190	ND	ND	ND	25,679	47	ND	ND	ND	15	3,117	ND	14	ND	312	9,787	396	86	ND	70
	Manifold Only	μg/m³	492	531	74	<1.34	29	<1.34	<1.31	<1.31	13,362	<2.29	<5.41	<2.91	<2.24	15	3,117	<1.80	<1.06	<1.16	224	9,787	300	27	<2.53	56
	Average Sub-surface Gas (Extraction Wells and Manifold)	μg/m³	483	424	168	-	46	-	-	-	8,002	9	-	-	-	6	645	-	7	-	142	2,266	248	26	-	26

Notes:

[a] m,p-Xylenes and o-Xylenes were added together.

[b] Midway Landfill Remedial Investigation Summary Report, Table 6-1, page 6-29 (Parametrix 1988a)

[c] Midway Landfill Remedial Investigation Summary Report, Table 8-1, page 8-10 (Parametrix 1988a)

[d] Midway Landfill Remedial Investigation Summary Report, Table 7-6, page 7-24 (Parametrix 1988a)

[e] Reported in the Midway Sanitary Landfill Landfill Gas Flare Testing Source Emissions Evaluation, page 12 (AM Test-air Quality Inc. 1992)

\- = not applicable

μg/m³ = micrograms per cubic meter

Figures

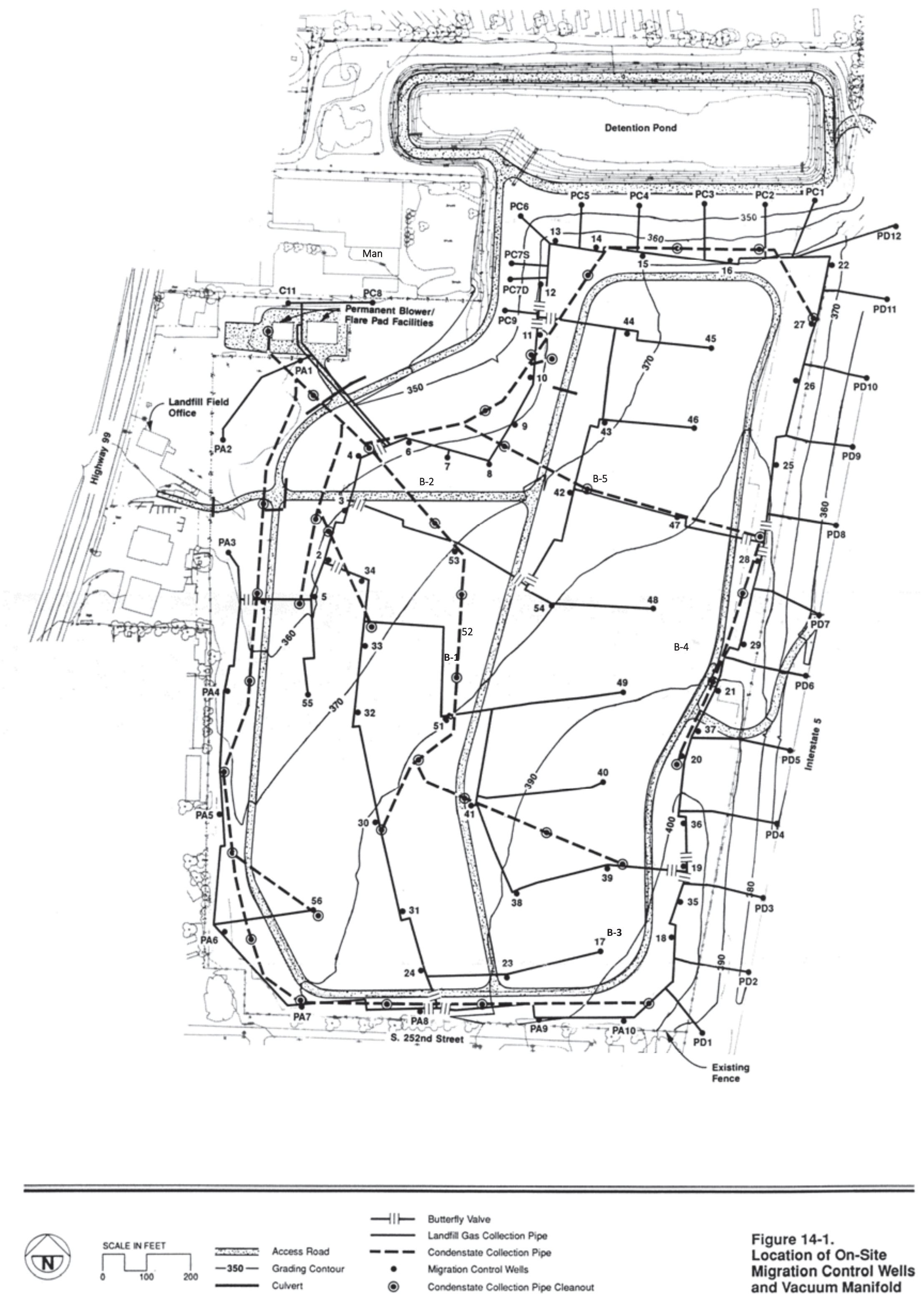


Figure 1. Approximate Sample Locations

Appendix A: Conceptual Site Model

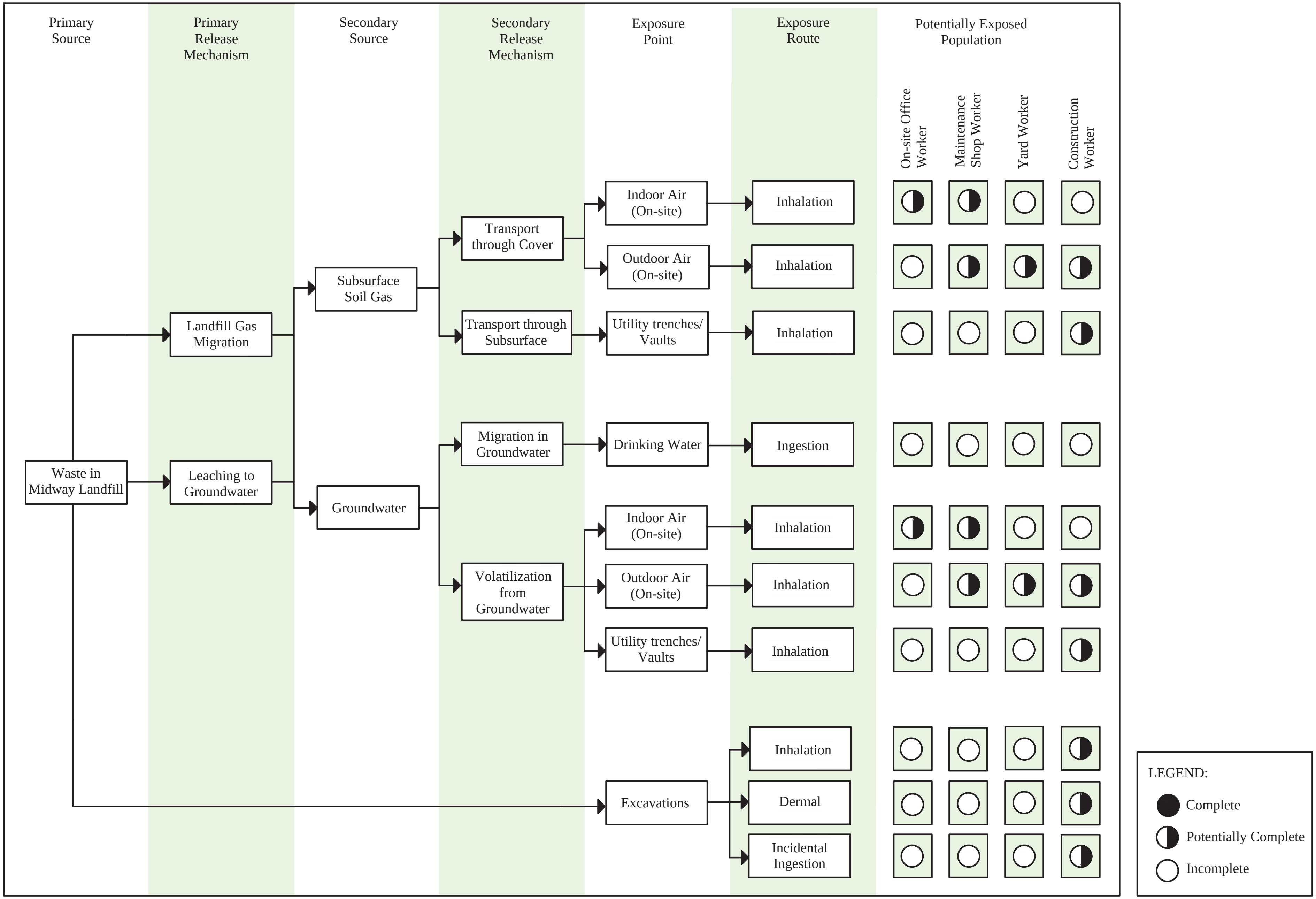


FIGURE 1

Preliminary Conceptual Site Model Exposure Pathway Evaluation for Midway Landfill

Appendix B: Well Logs

FMX 77-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 7 Coords. N 11,350 E 9723

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10-2 & 10-3-85

Time drilling 2:44 PM – 3:30 PM 10-2-85

7:00 AM – 3:27 PM 10-3-85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1.0'

Description of Spoils

1–19' PART. DECOMPOSED BLACK WOOD, PAPER, CLOTH, OCCA. TIRE

19–20 SANDY GRAVEL

20–69' PART. DECOMP. BLACK WOOD (TO 22' ON 10-2-85)

28' WET " " "

36' TIRE REMOVED

63' STEEL CABLE REMOVED

69'–70' SANDY CLAY

Total depth of well 70' (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.)

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, MARVINA OLNEY (OILER)

PMX#'5-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 7 Coord's N 11352 E 9725

Landfill name: MIDWAY GAS MIGRATION Date 10/4/85

I. DIMENSIONS:

a. Total depth of well 76'

b. Diameter of well 24"

c. Well casing interval 68'

d. Diameter of well casing 6"

e. Slotted interval of well casing from 26' to 68'

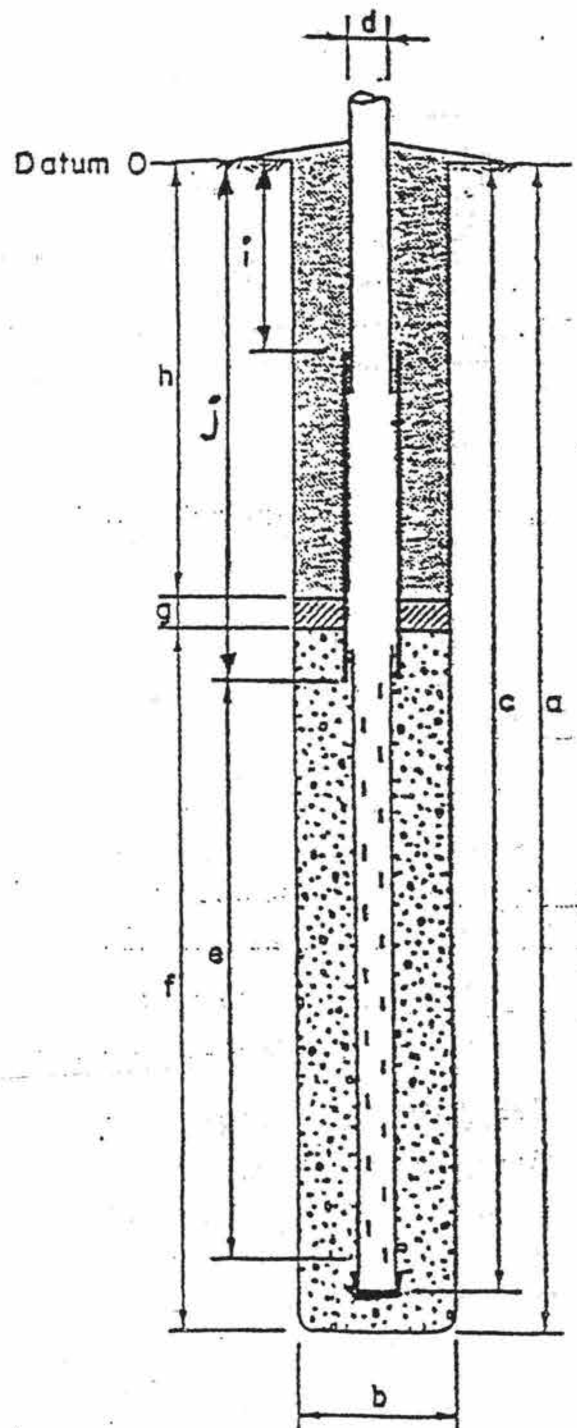
f. Permeable material interval 48'

g. Impermeable plug interval 2'

h. Backfill material interval 26'

i. Depth to Top of Slip/Settlement pipe 6'

j. " " Bottom " " " " 26'



II. MATERIALS:

Permeable material 1½"–3/4" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER (CASE 580 BACKHOE, END LOADER)

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 38 Coords N/0330.2 E 9864.3

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ____

I. DIMENSIONS:

a. Total depth of well 112'

b. Diameter of well 24"

c. Well casing interval LOWER FROM 0 TO 110' / UPPER FROM 0 TO 56'

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing
Lower from 68' to 110'
Upper from 26' to 56'

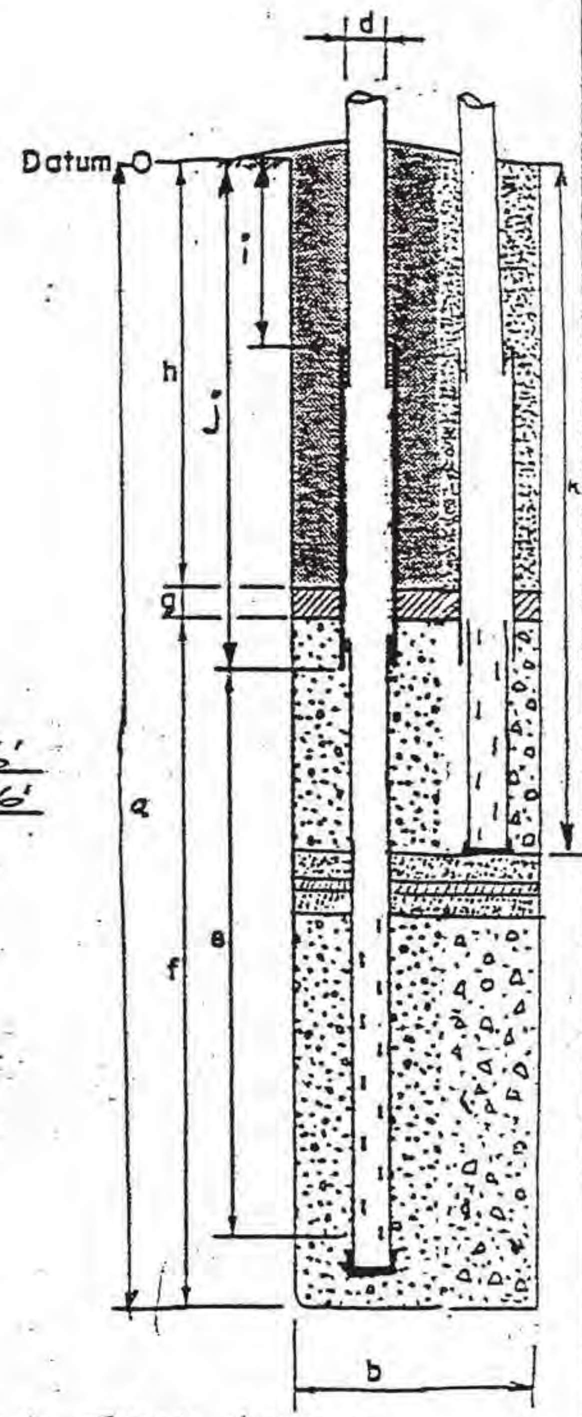
f. Permeable material interval LOWER FROM 64' TO 112' / UPPER FROM 22' TO 58'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " " 26'



II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered: ____

GAS WELL DRILLING LOG

WELL No. 38 COORDS N 10330.2 E 9864.3

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ______

Time drilling TWO (2) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' - 112'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
112'	GLACIAL TILL, FINE SILT

Total depth of well 112' (Diam. 24")

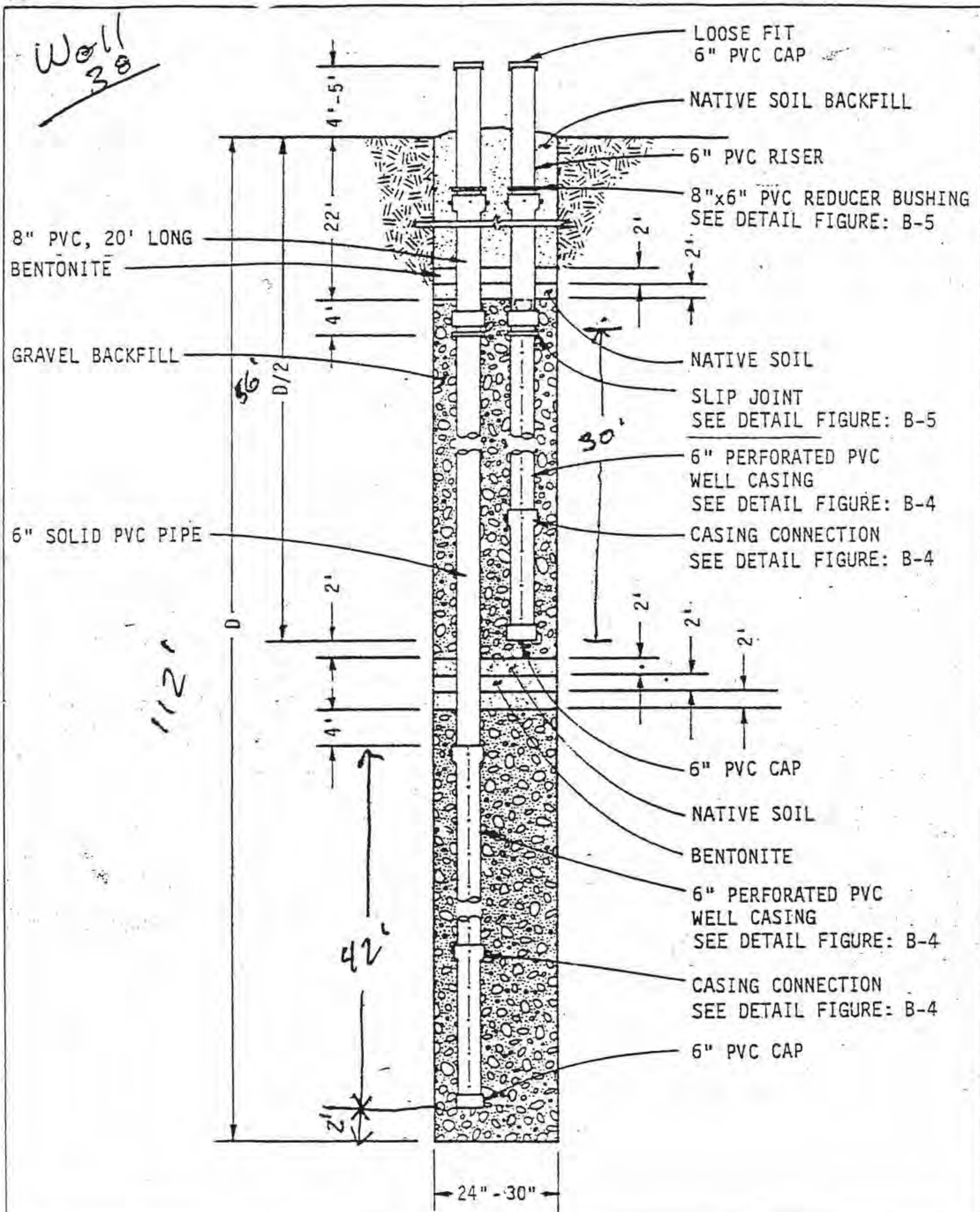
DRILLING CONDITIONS

(Weather, obstructions, etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/5000 'WATSON' DRILL MOTOR

Operators names JOH VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 38

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

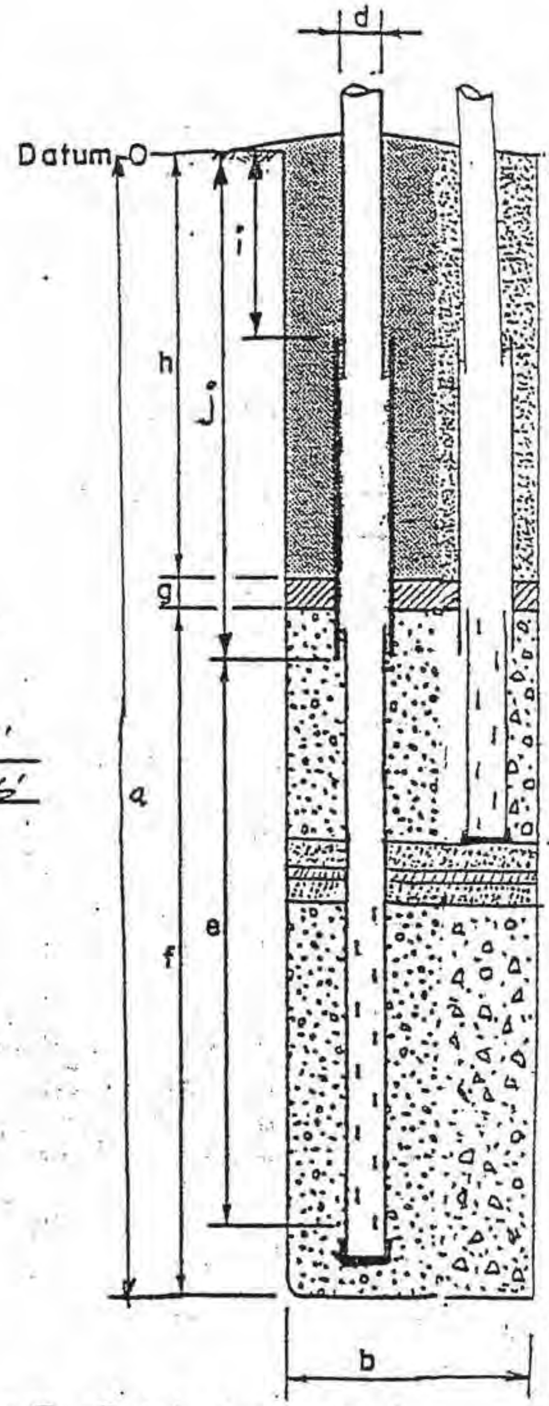
FMX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 42 Coords N11225.6 E 9987.5

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ________

I. DIMENSIONS:



a. Total depth of well 64'

b. Diameter of well 24".
LOWER FROM 0 TO 62'
UPPER FROM 0 TO 32'

c. Well casing interval ________

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing ________
Lower from 44' to 62'
Upper from 26' to 32'

f. Permeable material interval ________
LOWER FROM ~~40~~' TO 64'
UPPER FROM 22' TO 34'

g. Impermeable plug interval ________ 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " 26'

II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT. 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered: ________

GAS WELL DRILLING LOG

WELL No. 42 COORDS N 11225.6 E 9987.5

Landfill name: MIDWAY GAS MIGRATION – PHASE II Date

Time drilling TWO (2) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' - 64'	REFUSE (WOOD, PLASTIC, PAPER, ETC)
64'	GLACIAL TILL, FINE SILT

Total depth of well 64' (Diam. 24")

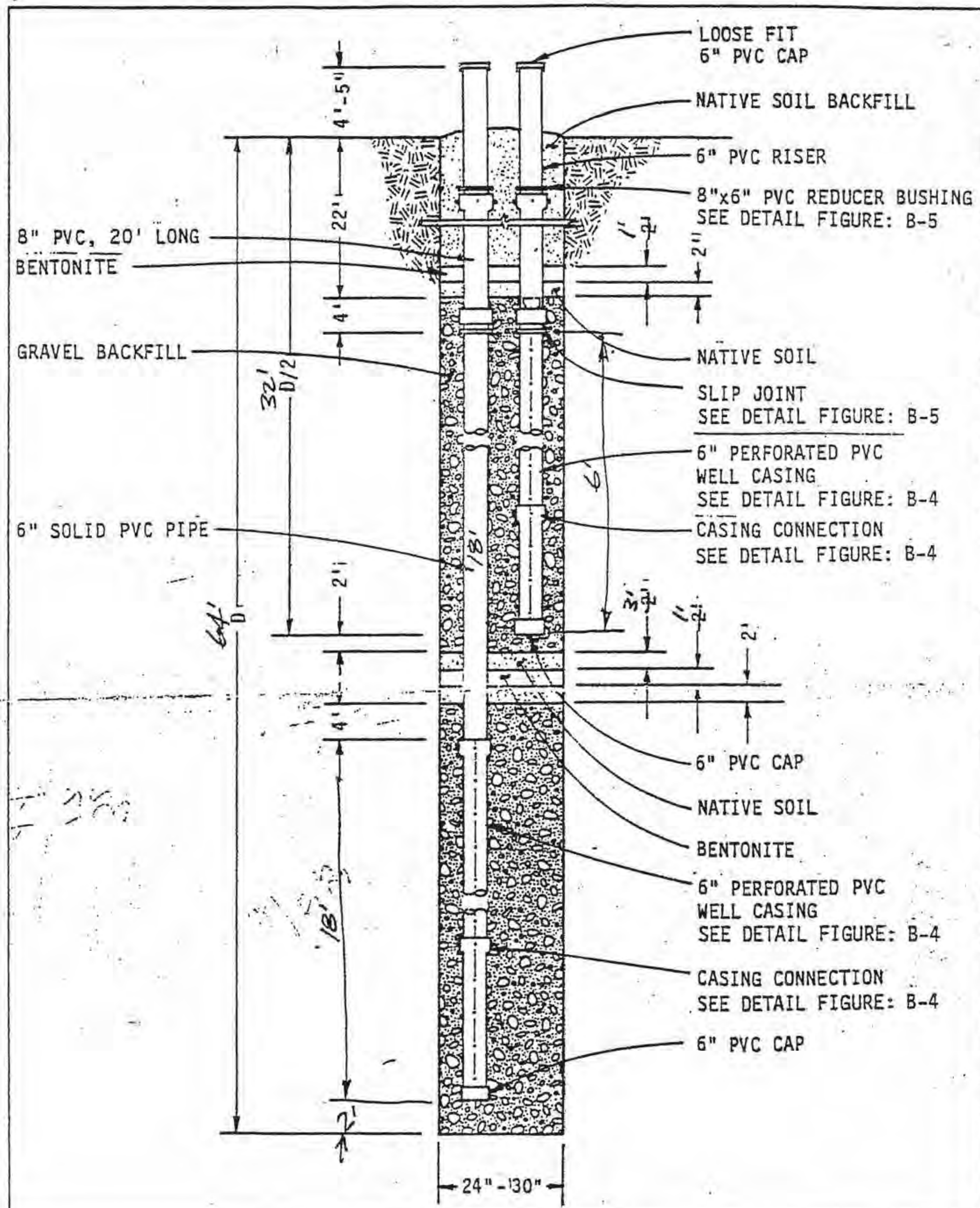
DRILLING CONDITIONS

(Weather, obstructions, etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/ 5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 42

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

Well Installation Log

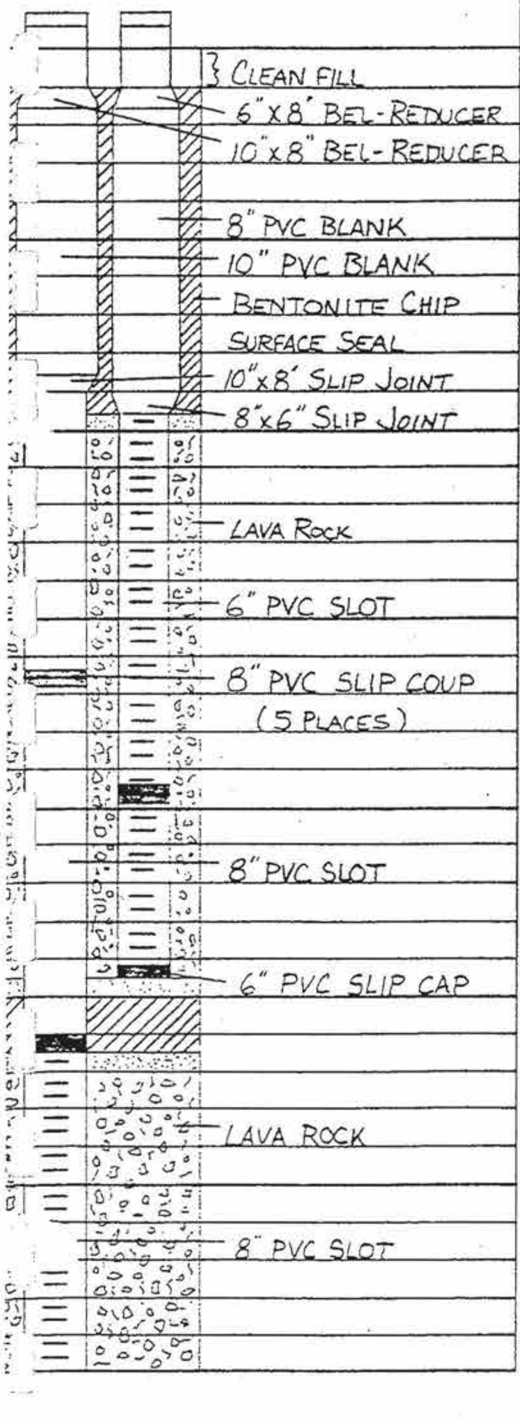
Job No. 55-1550-25 Client SEATTLE SWU Location MIDWAY LANDFILL

[CASI]NG TYPE	SCH 80 PVC
[LE]NGTH	
[JO]INT TYPE	PVC SLIP COUPLING - GLUED & SCREWED
SCREEN TYPE	HORIZONTAL SLOT - 0.050"
[SL]OT SIZE	0.050
[SE]AL TYPE	BENTONITE CHIP, PORTLAND CEMENT (BASE)
INSTALL. METHOD	BACKHOE / HOPPER / GROUT PUMP
[FIL]TER	VESICULAR LAVA ROCK
[IN]STALL	
GROUT	

DRILLING METHOD	CABLE TOOL - 24" CASING
SAMPLING METHOD	
HAMMER WT.	DROP
DATE	10-2-89
BY	J. HICKER
DRILLING CONTR.	RAMLO WELL DRILLING
WATER LEVEL	
TIME	
DATE	

WELL NO.	48
SHEET 1	OF 2
START	FINISH
8-30	9-26

[WE]LL DETAILS



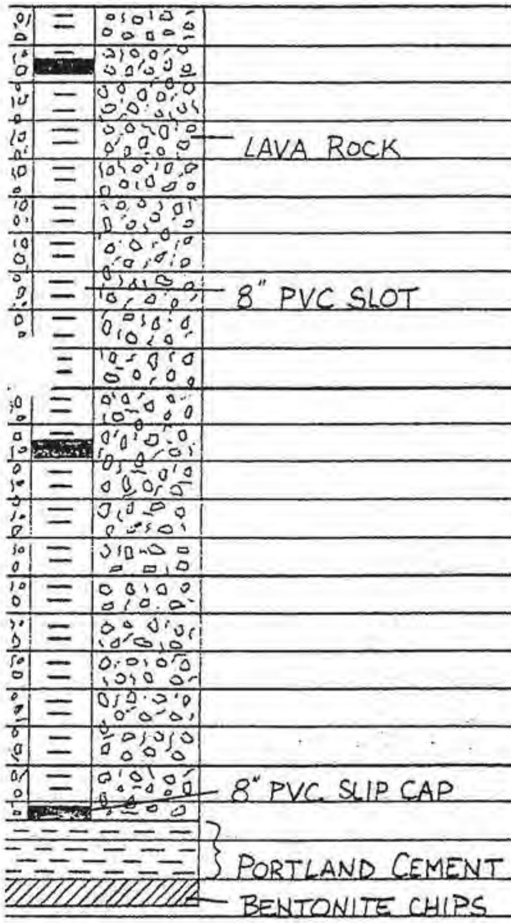
DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		SUBGRADE FILL - MED BROWN, SILTY SAND W/SOME GRAVEL, COBBLES	
10		GRAY CLAYEY SILT	
		REFUSE - NEWSPAPER, WOOD, CARDBOARD, PLASTIC, ROOFING,	
		REFUSE - WOOD, GRAVEL, METAL, PLASTIC, AUTO BATTERY, MED WASTE (I.V. DISP) HARDWARE, ELECT. MOTOR	
20			
		REFUSE - WOOD PLASTIC, RAGS, GLASS FOOD CONT'S, PILLS, COUGH SYRUP, PENCILS, BATTERYS, GRAVEL SYRINGE, MED. CLOTHING	
30			
		SAME W/ MED DISPOSAL BAGS, SYRINGE, LOTS STYROFOAM	
40		REFUSE - WOOD, PLASTIC, METAL HARDWARE, STRONG OIL SHEEN POTATO BAGS PIPE, BRICK, COBBLES	
50		REFUSE - WOOD, RUBBER HOSE, AUTO. HDWR, METAL, GLASS, BEER CANS, ELEC. RAZOR TIRES, FOOD CONT'S	
60		REFUSE - WOOD, PLASTIC, HDWR, MED. TUBE BOTTLE, SAN. DIAPER, DISP. BAGS TIRES, METAL, GRAVEL, GLASS	
70			

Well Installation Log

Job No. ______ Client ______ Location ______

ING TYPE		DRILLING METHOD	WELL NO. 48
LENGTH		SAMPLING METHOD	
JOINT TYPE		HAMMER WT. / DROP	SHEET 2
SCREEN TYPE		DATE	OF 2
SLOT SIZE		BY	
SEAL TYPE		DRILLING CONTR.	START / FINISH
INSTALL. METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL DETAILS



DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		REFUSE - WOOD, PLASTIC, METAL.	
		BRICK SAND, GRAVEL	
		PLASTIC, TIRES, ELEC, MOTOR, HDWR	
80		REFUSE - WOOD, SAND & GRAVEL,	
		METAL, HARDWARE, PAPER, PLASTIC	
		REFUSE - WOOD, PLASTIC, METAL,	
		DOLL, NEWSPAPER (MAR 21, 1968)	
90		BRICK, TILE, TRANS SPLINE	
		BEV. CANS, GLASS, TIRES	
		REFUSE - WOOD, STACK TAR PAPER,	
		FROZEN VEG BAGS, METAL, STACK	
100		TV DINNER, SAND, GRAVEL, PAPER	
		COARSE SAND W/COBBLES	
		SOME REFUSE - WOOD PLASTIC	
		GLASS	
110		REFUSE - WOOD PLASTIC, METAL,	
		GLASS, SHOES	
		BWN-GRAY TO BLUE-BWN SILTY CLAY (1 TO 2 FOOT)	
		SAND & GRAVEL	
120		END OF HOLE @ 117.5	

Well Installation Log

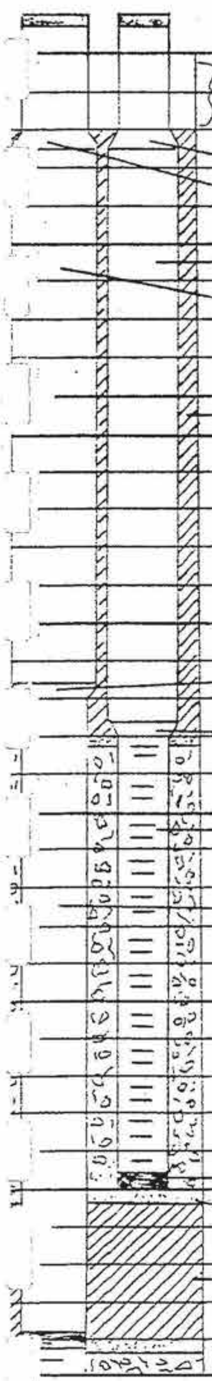
Job No. 55-1550-25 Client SEATTLE SOLID WASTE Location MIDWAY LANDFILL

CASING TYPE	6", 8' & 10" SCH 80 PVC
LENGTH	
JOINT TYPE	SLIP COUPLING - GLUED & SCREWED
SCREEN TYPE	HORIZONTAL SLOT
SLOT SIZE	.050"
SEAL TYPE	BENTONITE CHIPS (ENVIROPLUG)
INSTALL. METHOD	BACKHOE/HOPPER
FILTER	VESICULAR LAVA ROCK
INSTALL	
GROUT	

DRILLING METHOD	24" CABLE TOOL				
SAMPLING METHOD					
HAMMER WT.		DROP			
DATE	8-22-89				
BY	J. HICKER				
DRILLING CONTR.	RAMLO WELL DRILLING				
WATER LEVEL					
TIME					
DATE					

WELL NO.	52
SHEET	1
OF	2
START	FINISH
8-9-89	8-16-89

WELL DETAILS



DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		GRAY-BROWN SILTY SAND W/GRAVEL (SUBGRADE FILL)	
		GRAY SANDY SILT W/REFUSE	
5		REFUSE - WOOD, PLASTIC, TIRES, NEWSPAPER	>100% LEL
10			
		REFUSE - WOOD, PLASTIC, METAL	
15			
		REFUSE - BLACK, MULCHED WOOD, PLASTIC, METAL, HARDWARE, GRAVEL	
20		SAME W/SPOTTY OIL SHEEN	(PCB ✓ = NEG)
		BLACK COARSE SAND w/GRAVEL, COBBLES AND SOME REFUSE	
25			
		REFUSE - BLACK, MULCHED WOOD W/TRACE METAL, GRAVEL, PLASTIC	
30			
		REFUSE - BLACK MULCHED WOOD, PLASTIC, TIRES, WIRE, METAL CORD, GRAVEL	
35			

Well Installation Log

Job No. ______ Client ______ Location ______

[CASI]NG TYPE		DRILLING METHOD		WELL NO. 52
[LE]NGTH		SAMPLING METHOD		
JOINT TYPE		HAMMER WT.	DROP	SHEET 2
SCREEN TYPE		DATE		OF 2
SLOT SIZE		BY		
SEAL TYPE		DRILLING CONTR.		START / FINISH
INSTALL. METHOD		WATER LEVEL		
FILTER		TIME		
INSTALL		DATE		
GROUT				

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION	

Depth	Soil Description	Installation Notes
	INTERBEDDED COARSE SAND w/GRAVEL, COBBLES	
	REFUSE - WOOD w/METAL, TIRES ELEC. HARDWARE, GRAVEL, PLASTIC	
40	(SAME w/BLUISH OIL SHEEN - PCB ✓ = NEG)	
	REFUSE - WOOD PLASTIC, STEEL CONCRETE, FLOORING, PIPE,	
45		
	REFUSE - WOOD, NEWSPAPER, PLASTIC, HARDWARE, COPPER WIRE SOME GRAVEL	
50	REFUSE - WOOD, GRAVEL, WIRE GLASS	
55		
	REFUSE - WOOD, PLASTIC, BEVERAGE (DOMESTIC REFUSE) CANS, FOOD CONTAINERS, CLOTHING	
60	BOOKS, TIRES, TOYS, MAR '72 NEWSPAPER	
65	GRAY SILTY SAND w/GRAVEL COBBLES, TRACE REFUSE - WOOD, WIRE (DECREASING REFUSE ↓)	* CASED HOLE TO 67.5' BAILED TO 72'
70		

Appendix C: QA/QC Review Memorandum and Laboratory

alta-se.com

988 South Longmont Avenue, Suite 200
Boise, Idaho 83706
Ph: (208) 336-7080; Fax: (208) 908-4980

M E M O R A N D U M

To: Sarah Weppner, Alta, Boise

From: Rachel Gibeault, Alta, Boise

Date: April 30, 2020

Job Code: 19062-20

Subject: **QA/QC Review of the April 2020 Sampling of the Tacoma Dome Link Light Rail Data Package**

Section 1 Introduction

This memorandum provides a summary of the third party data validation and data quality assessment performed by Alta Science and Engineering, Inc. (Alta) on the sample results for the additional site characterization efforts conducted by Parametrix for HDR that occurred on April 9, 2020, at the following sample points:

- MAN-1
- MAN-2 (duplicate sample of MAN 1)
- B-2
- B-4
- B-5
- GW-7
- GW-38 (shallow [S] and deep [D] wells)
- GW-42 (S and D)
- GW-48 (S and D)
- GW-52 (S and D)

Sampling procedures and the quality assurance/quality control (QA/QC) review followed guidelines set forth in the following documents:

- *Sampling Instructions for Collecting Samples in Entech Bottle Vacs* (EAS no date) – This sampling procedure is provided in Attachment A. Parametrix followed this sampling procedure in lieu of a Quality Assurance Project Plan (QAPP).
- *National Functional Guidelines for Organic Superfund Methods Data Review* (USEPA 2017a)
- *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (USEPA 2009)
- *USEPA Guidance on Environmental Data Verification and Data Validation* (USEPA 2002)

This memorandum discusses the data quality assessment and data validation performed for the Work Orders listed in Table 1. Data qualifiers used in this review are defined by the U.S. Environmental Protection Agency (USEPA) (2017a).

Table 1. Work Order Data Validation

Laboratory	Work Orders	Analysis	Matrix	Data Validation Level (USEPA 2009)	Review Conducted by
EAS [a]	220163	VOCs [b] CH_4 and CO_2 [c] hydrogen sulfide [d]	Landfill gas and ambient air	Stage 2A	Alta

[a] Environmental Analytical Service, Inc., San Luis Obispo, California

[b] reduced list volatile organic compounds (VOCs) by USEPA Method TO-15 (1999)

[c] methane (CH_4) and carbon dioxide (CO_2) by ASTM D 1945-14 (2019)

[d] by USEPA M16 (2017b)

Section 2 Data Validation and Quality Assessment Summary of Vapor Results

Alta's Stage 2A validation of the analytical data and review of the field data are summarized in Table 2. Procedures/checks that require further discussion are explained below the table, as necessary.

Table 2. Data Quality Review Summary for Indoor Air and Outdoor Air

Data Validation Procedure or Check	Acceptable Frequency? [a]	Acceptable Performance? [a]	Data Qualified?	Discussion Item Number
Sample condition upon receipt at laboratory	--	Y	N	
Preservation	--	Y	N	
Holding times	--	Y	N	
Canister Pressure	--	N	Y	1
Laboratories followed specified analytical methods	--	Y	N	
Method Blanks	Y	Y	N	
Surrogate Recoveries/Deuterated Monitoring Compounds Recoveries (for VOCs)	Y	Y	N	
Laboratory Control Samples	Y	Y	N	
Matrix Spikes	--	--	--	
Laboratory Control Sample Duplicates	Y	Y	N	
Field Blanks	--	--	--	
Field Replicate	Y	N	N	2

[a] Based on professional judgment of the data validator.

-- = not applicable

Discussion Items

1. Canister Pressure - The samples collected by Entech Bottle Vacs (analyzed for VOCs by Method TO-15 [USEPA 1999], for CH_4 and CO_2 by ASTM D 1945-14 [ASTM 2019], and for hydrogen sulfide by USEPA M16 [USEPA 2017b]) had the following pressures in torr. The samples that had no change in torr are rejected (R) based on insufficient volumes: MAN-1, B-2, and GW-52D (as shown below).

Sample ID	Start Time 4/9/2020	Initial Pressure	Final Pressure (Laboratory measured)
MAN-1	08:29	928 torr	928 torr
B-2	09:19	924 torr	924 torr
GW-7	08:38	222 torr	989 torr
GW-38S	08:55	276 torr	884 torr
GW-38-D	08:56	687 torr	886 torr
GW-48S	09:09	508 torr	896 torr
GW-48D	09:11	383 torr	940 torr
B-4	09:57	565 torr	854 torr
GW-52S	09:33	614 torr	882 torr
GW-52D	09:35	871 torr	871 torr
GW-42S	09:42	221 torr	915 torr
GW-42D	09:44	546 torr	944 torr
B-5	10:48	552 torr	857 torr
MAN-2	10:55	689 torr	911 torr

2. Field Replicate – MAN-2 was collected as a field duplicate of MAN-1. However, as mentioned in discussion item 1, the results from MAN-1 were rejected (R) based on insufficient sample canister volume. Therefore, relative percent differences (RPDs) could not be calculated. No data are qualified in the duplicate sample based on precision.

Section 3 Overall Assessment

3.1 Data Accuracy and Precision

Based on this data quality review, Alta determines the laboratory and field data to be of acceptable quality, with the exception of MAN-1, B-2, and GW-52D, which are rejected (R) based on insufficient sample volume.

3.1.1 Accuracy

Alta's Quality Assurance Officer (QAO) did not qualify any data based on accuracy results (surrogate recoveries and laboratory control samples).

3.1.2 Precision

Alta's QAO did not qualify any data based on precision results (laboratory control sample duplicates).

3.2 Data Sensitivity

All laboratory reporting limits were below screening levels.

3.3 Data Usability

Three samples were rejected (MAN-1, B-2, and GW-52D); therefore, the calculated completeness for this sampling event is 79%.

Section 4 Cited References and Resources Used

ASTM International (ASTM), 2019. ASTM D1945: Standard Test Method for Analysis of Natural Gas by Gas Chromatography.

U.S. Environmental Protection Agency (USEPA), 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air – Second Edition. Compendium Method TO-15 (EPA/625/R-96/010b), January.

USEPA, 2002. USEPA Guidance on Environmental Data Verification and Data Validation. USEPA QA/G-8; November.

USEPA, 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. OSWER No. 9200.1-85, EPA 540-R-08-005 prepared by the Office of Solid Waste and Emergency Response; January.

USEPA, 2017a. National Functional Guidelines for Organic Superfund Methods Data Review, (SOM02.4), OLEM 9355.0-136, USEPA-540-R-2017-002; January.

USEPA, 2017b. Method 16 – Semicontinuous Determination of Sulfur Emissions from Stationary Sources. August. Available at: https://www.epa.gov/emc/method-16-sulfur-semicontinuous-determination.

Attachment A

Sampling Instructions for Collecting Samples in Entech Bottle Vacs

Sampling Instructions for Collecting Samples in Entech Bottle Vacs

Please Read The Following Important Information Before Starting

- ***The quick connect on the Bottle Vac is important to hold the Bottle Vac vacuum and protect sample integrity. The Quick Connect Adapter is used to open the Bottle Vac and let sample into the bottle.***
- ***The Bottle Vacs are sent under a vacuum of 29.5" Hg. The vacuum is checked in the laboratory before shipment. If you want to check the vacuum in the field, use a vacuum gauge. Put a Quick Connect Adapter on the gauge to connect to the Bottle Vac.***
- ***Remember that once the Quick Connect Adapter is put on the Bottle Vac Quick Connect, the bottle is open and will begin sampling. If using tubing put the tubing on the Quick Connect Adapter before connecting to the Bottle Vac.***

Bottle Vacs are Silco coated and can be used for both ambient air sampling and source sampling for VOC compounds and hydrogen sulfide. The Bottle Vacs should only be filled to a maximum pressure of 5 psig.

PROCEDURE:

- Remove the Bottle Vac from its box and do a visual check to make sure it is not broken. There should be a Quick Connect Adapter (to 1/4" Swagelok) in the box.

- Any sample tubing or sample port should be connected to the Quick Connect Adapter before the Bottle Vac is connected.

- To sample, connect the Quick Connect Adapter to the Bottle Vac Quick Connect and sample will enter the bottle. The sound of air rushing into the canister should be heard. Leave the Quick Connect Adapter attached for about 1 minute.

- Remove the Quick Connect Adapter to stop sampling. The Quick Connect serves as a valve to hold the sample in the bottle. It does not have to be capped.

- Put the Bottle Vac and Quick Connect Adapter back into the box.

- Fill out Sample Custody Sheet with date, time, location, and any additional information you desire.

- Place Bottle Vac box and custody sheet back into the main box and place the shipping label on the outside of box. Send back UPS. The value of the canisters is $250 each and the client is responsible for the canisters until they are delivered to EAS.

When Done:

Ship the Sampler and Canister back to Environmental Analytical Service, Inc.

Environmental Analytical Service, Inc.
173 Cross Street
San Luis Obispo, CA 93401

(805) 781-3585

ENVIRONMENTAL
Analytical Service, Inc.

Laboratory Report

Project Name:

Tacoma Dome Link Light Rail

EAS SDG Number: **220163**

Client Project Manager: Steve Emge

Prepared For:
Parametrix Inc.
719 2nd Ave, Suite 200
Seattle WA 98104

Project Number: 17510
Sample Event Date: 4/9/2020
Received Date: 4/13/2020
Report Date: 4/21/2020

Project Number: 554-1800-019
PO Number: None Given

This is the Laboratory Report for the samples in the indicated Sample Delivery Group (SDG). Each sample received in the group is assigned a Laboratory ID number. The combination of the SDG number and the Lab ID number is an unique identifier for the sample.

This Report Contains:

- Laboratory Work Order
- Project Sample Media
- Laboratory Case Narrative and Chain of Custody
- Method Description (when applicable)
- Quality Control Reports
- Analytical Reports

NELAC Certification: Florida E871125

173 Cross Street, San Luis Obispo, CA 93401 (805) 781-3585

Laboratory Work Order

SDG Number: 220163 **Project Number:** 17510

Client: Steve Emge **Received:** 4/13/2020

Parametrix

SAMPLE DESCRIPTION AND ANALYSIS REQUESTED

Client Sample ID	EAS Lab No.	Analysis Requested	Date Sampled
MAN 1	220163 1	EPA M16 Hydrogen Sulfide	4/9/2020
MAN 1	220163 1	EPA TO-15 Special List	4/9/2020
MAN 1	220163 1	ASTM D1945 CH4, CO2	4/9/2020
B-2	220163 2	ASTM D1945 CH4, CO2	4/9/2020
B-2	220163 2	EPA M16 Hydrogen Sulfide	4/9/2020
B-2	220163 2	EPA TO-15 Special List	4/9/2020
GW-7	220163 3	ASTM D1945 CH4, CO2	4/9/2020
GW-7	220163 3	EPA M16 Hydrogen Sulfide	4/9/2020
GW-7	220163 3	EPA TO-15 Special List	4/9/2020
GW-38S	220163 4	ASTM D1945 CH4, CO2	4/9/2020
GW-38S	220163 4	EPA M16 Hydrogen Sulfide	4/9/2020
GW-38S	220163 4	EPA TO-15 Special List	4/9/2020
GW-38D	220163 5	ASTM D1945 CH4, CO2	4/9/2020
GW-38D	220163 5	EPA M16 Hydrogen Sulfide	4/9/2020
GW-38D	220163 5	EPA TO-15 Special List	4/9/2020
GW-48S	220163 6	ASTM D1945 CH4, CO2	4/9/2020
GW-48S	220163 6	EPA M16 Hydrogen Sulfide	4/9/2020
GW-48S	220163 6	EPA TO-15 Special List	4/9/2020
GW-48D	220163 7	EPA M16 Hydrogen Sulfide	4/9/2020
GW-48D	220163 7	ASTM D1945 CH4, CO2	4/9/2020
GW-48D	220163 7	EPA TO-15 Special List	4/9/2020
B-4	220163 8	EPA M16 Hydrogen Sulfide	4/9/2020
B-4	220163 8	EPA TO-15 Special List	4/9/2020

Client Sample ID	EAS Lab No.	Analysis Requested	Date Sampled
B-4	220163 8	ASTM D1945 CH4, CO2	4/9/2020
GW-52S	220163 9	ASTM D1945 CH4, CO2	4/9/2020
GW-52S	220163 9	EPA M16 Hydrogen Sulfide	4/9/2020
GW-52S	220163 9	EPA TO-15 Special List	4/9/2020
GW-52D	220163 10	ASTM D1945 CH4, CO2	4/9/2020
GW-52D	220163 10	EPA M16 Hydrogen Sulfide	4/9/2020
GW-52D	220163 10	EPA TO-15 Special List	4/9/2020
GW-42S	220163 11	ASTM D1945 CH4, CO2	4/9/2020
GW-42S	220163 11	EPA M16 Hydrogen Sulfide	4/9/2020
GW-42S	220163 11	EPA TO-15 Special List	4/9/2020
GW-42D	220163 12	ASTM D1945 CH4, CO2	4/9/2020
GW-42D	220163 12	EPA M16 Hydrogen Sulfide	4/9/2020
GW-42D	220163 12	EPA TO-15 Special List	4/9/2020
B-5	220163 13	ASTM D1945 CH4, CO2	4/9/2020
B-5	220163 13	EPA M16 Hydrogen Sulfide	4/9/2020
B-5	220163 13	EPA TO-15 Special List	4/9/2020
MAN 2	220163 14	EPA TO-15 Special List	4/9/2020
MAN 2	220163 14	ASTM D1945 CH4, CO2	4/9/2020
MAN 2	220163 14	EPA M16 Hydrogen Sulfide	4/9/2020

Project Sample Media

SDG Number: 220163

The following sample media was used for this Sample Delivery Group (SDG). The Sample Media column identifies the type of media. For canisters, the Sample Media Batch gives the canister number followed by the cleaning batch number, which is a unique identification. Canisters that are received with sub-ambient pressures are pressurized to about 5 psig. The initial pressure of the canister when it is received is recorded along with the final pressure after pressurization. The canister dilution factor is the ratio of the final to initial pressure. The results are adjusted for the can dilution factor.

SDG	Lab ID	Client Sample No.	Sample Media	Batch	Pressure, torr Initial	Final	Can Factor
220163	1	MAN 1	259	032420A	928	928	1.00
220163	2	B-2	524	032420A	924	924	1.00
220163	3	GW-7	251	032420A	222	989	4.45
220163	4	GW-38S	261	032420A	276	884	3.20
220163	5	GW-38D	255	032420A	687	886	1.29
220163	6	GW-48S	486	032420A	508	896	1.76
220163	7	GW-48D	256	032320A	383	940	2.45
220163	8	B-4	482	032320A	565	854	1.51
220163	9	GW-52S	258	032420A	614	882	1.44
220163	10	GW-52D	253	032420A	871	871	1.00
220163	11	GW-42S	521	032320A	221	915	4.14
220163	12	GW-42D	11736	032320A	546	944	1.73
220163	13	B-5	322	032320A	552	857	1.55
220163	14	MAN 2	252	032320A	689	911	1.32

Laboratory Case Narrative

EAS SDG Number: 220163 **Project Number:** 17510

Client: Parametrix

The Laboratory Case Narrative for the SDG is below. The Chain of Custody form(s) follow the Laboratory Case Narrative.

Sample Control Narrative

The samples were all received in good condition and with proper preservation.

Analytical Methods

The methods used for sample analysis are listed on the Analytyical Report header, and have been modified as described in the EAS Quality Manual..

Case Narrative

QC Narrative

All analyses met EAS method criteria as defined in the Quality Manual, except as noted in the report or QC reports with data qualifiers.

Subcontract Narrative

No sample analysis was subcontracted for this project

Laboratory Certification

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness other than the condition(s) noted above. The Laboratory Report is property of EAS and its client. The entire report has been reviewed and approved.

Date Approved: 4/21/2020

Steven D. Hoyt, Ph.D.
Environmental Analytical Service
Laboratory Director

ENVIRONMENTAL
Analytical Service, Inc.

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

CHAIN OF CUSTODY RECORD

Project Number 554-1800-019 | Project Name MIDWAY | Quote 12355 | Requested TAT

REPORT TO:

Attention	STEVE EMGE
Company	PARAMETRIX
Address	719 2ND, Suite 200
City, State, Zip	SEATTLE, WA 98104
Phone/Fax	425-422-6812
e-mail	semge@parametrix.com

Matrix
A - Ambient Air
SG - Soil Gas
S - Source
I - Indoor Air

SDG 22063

Analytical Tests: TO-15S, H2S, CH4, CO2

Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Matrix	Initial Pressure	Final Pressure	Laboratory ID	TO-15S	H2S	CH4	CO2		Comments
MAN 1	4/9/20	829	4/9/20		259		S			01						
B-2	↓	919	↓		524		S			02						
GW-7	↓	838	↓		251		S			03						
GW-38S	↓	855	↓		~~[illegible]~~		S			04						
D	↓	856	↓		255		S			05						
GW-48S	↓	909	↓		484		S			06						
D	↓	911	↓		254		S			07						
B-4	↓	957	↓		482		S			08						

Comments

BILLING INFORMATION:

ATTENTION	
Company	
Address	
City, State, Zip	
Purchase Order	

SAMPLED BY	Date/Time
STEVE EMGE	4/9/20
[signature]	
RECEIVED FOR LAB	
[signature]	4/13/2020 13:00

COC Number	
Cooler Temp	
Airbill	

ENVIRONMENTAL
Analytical Service, Inc.

173 Cross Street
San Luis Obispo, CA 93401
805 781-3585

CHAIN OF CUSTODY RECORD

Project Number 554-1800-019	Project Name MIDWAY	Quote 12355	Requested TAT

REPORT TO:

Attention	STEVE EMGE
Company	PARAMETRIX
Address	719 2ND, Suite 200
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Phone/Fax	425-422-6812
e-mail	semge@parametrix.com

Matrix
A - Ambient Air
SG - Soil Gas
S - Source
I - Indoor Air

SDG 22063

Analytical Tests: TO-15S, H_2S, CH_4, CO_2

Sample Description	Sample Date	Start Time	Stop Date	Stop Time	Canister Number	Flow Reg Number	Matrix	Initial Pressure	Final Pressure	Laboratory ID	TO-15S	H_2S	CH_4	CO_2		Comments
GW-52S	4/9/20	933	4/9/20		258					09						
D	↓	935	↓		253					10						
GW-42S	↓	942	↓		521					11						
D	↓	944	↓		11736					12						
B-5	↓	1048	↓		322					13						
MAN 2	↓	1055	↓		452					14						

Comments

BILLING INFORMATION:

ATTENTION	
Company	
Address	
City, State, Zip	
Purchase Order	

SAMPLED BY	Date/Time
STEVE EMGE	4/9/20
[signature]	
RECEIVED FOR LAB	
[signature]	4/13/2020 13:00

COC Number	
Cooler Temp	
Airbill	

Quality Control Report

EAS SDG Number 220163

Project Number: 17510

QC Narrative

Samples were anlayzed in a daily analytical batch (DAB) designated by a QC batch number, and were analyzed using EAS standard laboratory QC specified in the EAS Quality Manual which may be different then the referrenced agency method. Any deviations from the EAS QC criteria are flagged in the Laboratory Control Reports or in the sample Analytical Reports.

Standard Laboratory QC Report

Unless project specific QC was requested, this Section containing the standard laboratory QC (Level 2) supplied with the Analytical Reports. Each sample is analyzed in a Daily Analytical Batch (DAB) which includes the method blank, a laboratory control spike (LCS) and a laboratory control duplicate (LCD). A Daily Analytical Batch QC report is supplied for each method requested.

Method Blank

The method blank is a laboratory generated sample which assesses the degree to which laboratory operations cause a false positive. The target analytes in the analytical reports for a daily analytical batch are "B" flagged if their concentrations are present in the Method Blank above the RL, unless the result is greater then ten times the blank value..

Laboratory Control Spike

A laboratory control spike is a well characterized matrix similar to the sample which is spiked and run in duplicate with each Daily Analytical Batch. The laboratory control spike results are reported as a percent recovery. The QC Criteria for the control spike is listed in the Laboratory Control Report. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report. The control spike contains an abbreviated list of compounds in the method, and may contain compounds not on the target list for the specified report.

Laboratory Control Duplicate

The laboratory control duplicate is a duplicate analysis of the laboratory control spike, a standard, or a sample depending on the method. The results are reported as a relative percent difference (RPD). The criteria for the duplicate is in the Laboratory Control Report for the Daily Analytical Batch. Any results outside the control limits are flagged with a "Q" on the Laboratory Control Report.

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: LABQC

Analytical Method: TO-15

Laboratory ID: B04150

File Name: B04150D.D
Description: METHOD BLANK
Canister:
QC_Batch: 041520-MA1

Date Sampled: Time:
Date Analyzed: 4/15/2020 Time: 13:04
Can Dilution Factor: 1.00
Air Volume: 225.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.12	ND	1.34	2.31	ND	
75-01-4	Vinyl chloride	0.22	1.12	ND	0.57	2.86	ND	
75-00-3	Chloroethane	0.22	1.12	ND	0.59	2.95	ND	
75-69-4	Trichlorofluoromethane	0.35	1.12	ND	1.97	6.29	ND	
75-35-4	1,1-Dichloroethene	0.22	1.10	ND	0.88	4.37	ND	
76-13-1	Freon 113	0.22	1.06	ND	1.70	8.14	ND	
75-09-2	Dichloromethane	0.44	1.07	ND	1.54	3.71	ND	
156-60-5	trans-1,2-Dichloroethene	0.22	0.80	ND	0.88	3.18	ND	
75-34-3	1,1-Dichloroethane	0.22	1.11	ND	0.90	4.49	ND	
108-05-4	Vinyl acetate	0.22	0.98	ND	0.78	3.44	ND	
109-99-9	Tetrahydrofuran	0.44	1.12	ND	1.31	3.29	ND	
156-59-2	cis-1,2-Dichloroethene	0.44	1.20	ND	1.76	4.74	ND	
71-55-6	1,1,1-Trichloroethane	0.22	0.99	ND	1.21	5.38	ND	
107-06-2	1,2-Dichloroethane	0.22	1.01	ND	0.90	4.10	ND	
71-43-2	Benzene	0.44	0.89	ND	1.42	2.84	ND	
79-01-6	Trichloroethene	0.13	1.04	ND	0.72	5.56	ND	
108-10-1	4-Methyl-2-pentanone	0.89	3.36	ND	3.64	13.78	ND	
108-88-3	Toluene	0.44	1.16	ND	1.67	4.37	ND	
127-18-4	Tetrachloroethene	0.13	0.54	ND	0.90	3.67	ND	
108-90-7	Chlorobenzene	0.22	1.01	ND	1.02	4.65	ND	
100-41-4	Ethylbenzene	0.47	1.17	ND	2.04	5.10	ND	
1330-20-7	m,p-Xylenes	0.47	1.18	ND	2.05	5.11	ND	
100-42-5	Styrene	0.46	1.15	ND	1.96	4.90	ND	
95-47-6	o-Xylene	0.46	1.15	ND	1.99	4.97	ND	
79-34-5	1,1,2,2-Tetrachloroethane	0.22	0.55	ND	1.51	3.77	ND	
106-46-7	1,4-Dichlorobenzene	0.44	0.77	ND	2.67	4.62	ND	
95-50-1	1,2-Dichlorobenzene	0.89	1.11	ND	5.34	6.68	ND	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	100	70	130	

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: LABQC

Analytical Method: TO-15

Laboratory ID: B04160

File Name: B04160C.D
Description: METHOD BLANK
Canister:
QC_Batch: 041620-MA1

Date Sampled: Time:
Date Analyzed: 4/16/2020 Time: 13:38
Can Dilution Factor: 1.00
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.26	ND	1.34	2.60	ND	
75-01-4	Vinyl chloride	0.25	1.26	ND	0.64	3.21	ND	
75-00-3	Chloroethane	0.25	1.26	ND	0.66	3.32	ND	
75-69-4	Trichlorofluoromethane	0.35	1.26	ND	1.97	7.08	ND	
75-35-4	1,1-Dichloroethene	0.25	1.24	ND	0.99	4.91	ND	
76-13-1	Freon 113	0.25	1.20	ND	1.92	9.16	ND	
75-09-2	Dichloromethane	0.50	1.20	ND	1.74	4.18	ND	
156-60-5	trans-1,2-Dichloroethene	0.25	0.90	ND	0.99	3.58	ND	
75-34-3	1,1-Dichloroethane	0.25	1.25	ND	1.01	5.05	ND	
108-05-4	Vinyl acetate	0.25	1.10	ND	0.88	3.87	ND	
109-99-9	Tetrahydrofuran	0.50	1.26	ND	1.47	3.71	ND	
156-59-2	cis-1,2-Dichloroethene	0.50	1.35	ND	1.98	5.33	ND	
71-55-6	1,1,1-Trichloroethane	0.25	1.11	ND	1.36	6.05	ND	
107-06-2	1,2-Dichloroethane	0.25	1.14	ND	1.01	4.62	ND	
71-43-2	Benzene	0.50	1.00	ND	1.60	3.19	ND	
79-01-6	Trichloroethene	0.15	1.16	ND	0.81	6.26	ND	
108-10-1	4-Methyl-2-pentanone	1.00	3.79	ND	4.10	15.50	ND	
108-88-3	Toluene	0.50	1.31	ND	1.88	4.91	ND	
127-18-4	Tetrachloroethene	0.15	0.61	ND	1.02	4.12	ND	
108-90-7	Chlorobenzene	0.25	1.14	ND	1.15	5.24	ND	
100-41-4	Ethylbenzene	0.53	1.32	ND	2.29	5.74	ND	
1330-20-7	m,p-Xylenes	0.53	1.32	ND	2.30	5.75	ND	
100-42-5	Styrene	0.52	1.29	ND	2.21	5.51	ND	
95-47-6	o-Xylene	0.52	1.29	ND	2.24	5.59	ND	
79-34-5	1,1,2,2-Tetrachloroethane	0.25	0.62	ND	1.70	4.25	ND	
106-46-7	1,4-Dichlorobenzene	0.50	0.87	ND	3.00	5.20	ND	
95-50-1	1,2-Dichlorobenzene	1.00	1.25	ND	6.01	7.51	ND	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	102	70	130	

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: LABQC

Analytical Method: TO-15

Laboratory ID: B04170

File Name: B04170D.D
Description: METHOD BLANK
Canister:
QC_Batch: 041720-MA1

Date Sampled:
Time:
Date Analyzed: 4/17/2020
Time: 13:54
Can Dilution Factor: 1.00
Air Volume: 5.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	10.0	50.4	ND	20.6	104.0	ND	
75-01-4	Vinyl chloride	10.0	50.3	ND	25.5	128.5	ND	
75-00-3	Chloroethane	10.0	50.3	ND	26.4	132.6	ND	
75-69-4	Trichlorofluoromethane	10.0	50.4	ND	56.2	283.1	ND	
75-35-4	1,1-Dichloroethene	10.0	49.6	ND	39.6	196.5	ND	
76-13-1	Freon 113	10.0	47.8	ND	76.6	366.5	ND	
75-09-2	Dichloromethane	20.0	48.2	ND	69.4	167.2	ND	
156-60-5	trans-1,2-Dichloroethene	10.0	36.1	ND	39.6	143.0	ND	
75-34-3	1,1-Dichloroethane	10.0	49.9	ND	40.5	201.8	ND	
108-05-4	Vinyl acetate	10.0	43.9	ND	35.2	154.6	ND	
109-99-9	Tetrahydrofuran	20.0	50.3	ND	58.9	148.3	ND	
156-59-2	cis-1,2-Dichloroethene	20.0	53.8	ND	79.2	213.1	ND	
71-55-6	1,1,1-Trichloroethane	10.0	44.4	ND	54.5	242.1	ND	
107-06-2	1,2-Dichloroethane	10.0	45.6	ND	40.5	184.6	ND	
71-43-2	Benzene	20.0	40.0	ND	63.9	127.7	ND	
79-01-6	Trichloroethene	6.0	46.6	ND	32.2	250.2	ND	
108-10-1	4-Methyl-2-pentanone	40.0	151.4	ND	163.8	620.2	ND	
108-88-3	Toluene	20.0	52.2	ND	75.3	196.5	ND	
127-18-4	Tetrachloroethene	6.0	24.3	ND	40.7	165.0	ND	
108-90-7	Chlorobenzene	10.0	45.5	ND	46.0	209.5	ND	
100-41-4	Ethylbenzene	21.1	52.9	ND	91.8	229.5	ND	
1330-20-7	m,p-Xylenes	21.2	53.0	ND	92.0	230.1	ND	
100-42-5	Styrene	20.7	51.8	ND	88.2	220.5	ND	
95-47-6	o-Xylene	20.6	51.5	ND	89.5	223.8	ND	
79-34-5	1,1,2,2-Tetrachloroethane	9.9	24.8	ND	67.9	169.8	ND	
106-46-7	1,4-Dichlorobenzene	20.0	34.6	ND	120.2	207.9	ND	
95-50-1	1,2-Dichlorobenzene	40.0	50.0	ND	240.4	300.5	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	QC Limits UCL	Flag
2037-26-5	Toluene-d8	102	70	130	

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	**D1945**	**SDG:**	**LABQC**
		Laboratory Number:	**B04140**

File Name:	B04140A	**Date Sampled:**		**Time:**	
Description:	METHOD BLANK	**Date Analyzed:**	04/14/20	**Time:**	8:59
Can/Tube#:		**Can Dilution Factor:**	1.00		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	ND	100	300	ND	ND
124-38-9	Carbon Dioxide	0.01	0.03	ND	100	300	ND	ND

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: LABQC

Analytical Method: EPA 16

Laboratory ID: **B04130**

File Name:	B04130A	**Date Sampled:**		**Time:**	
Sample ID	METHOD BALNK	**Date Analyzed:**	04/13/20	**Time:**	9:33
Can/Tube#:		**Can Dilution Factor:**	1.00		
QC_Batch:	041320-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	8.1	24.3	ND	11.3	33.9	ND	

METHOD BLANK REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: LABQC

Analytical Method: EPA 16

Laboratory ID: B04140

File Name: B04140B
Sample ID METHOD BALNK
Can/Tube#:
QC_Batch: 041420-GCP

Date Sampled: **Time:**
Date Analyzed: 04/14/20 **Time:** 12:30
Can Dilution Factor: 1.00
Air Volume: 10.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	8.1	24.3	ND	11.3	33.9	ND	

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

Laboratory Control Spike and Spike Duplicate Report

TO15 Volatile Organic Compounds by GC/MS

QC_Batch: 041520-MA1
Date: 04/15/20

CAS#	Compound	LCS Recovery %	Flag	LCD Recovery %	Flag	Spike Limit LCL %	Spike Limit UCL %	Duplicate %	Duplicate Limit %	Flag
75-01-4	Vinyl chloride	88		84		70	130	4	25	
75-35-4	1,1-Dichloroethene	85		82		70	130	3	25	
75-09-2	Dichloromethane	88		81		70	130	8	25	
75-34-3	1,1-Dichloroethane	86		84		70	130	2	25	
156-59-2	cis-1,2-Dichloroethene	86		82		70	130	5	25	
67-66-3	Chloroform	83		81		70	130	2	25	
71-55-6	1,1,1-Trichloroethane	92		89		70	130	3	25	
107-06-2	1,2-Dichloroethane	94		88		70	130	7	25	
71-43-2	Benzene	99		94		70	130	5	25	
56-23-5	Carbon tetrachloride	92		88		70	130	4	25	
79-01-6	Trichloroethene	106		102		70	130	4	25	
108-88-3	Toluene	101		98		70	130	2	25	
79-00-5	1,1,2-Trichloroethane	101		93		70	130	8	25	
106-93-4	1,2-Dibromoethane	105		100		70	130	4	25	
127-18-4	Tetrachloroethene	121		119		70	130	2	25	
100-41-4	Ethylbenzene	97		110		70	130	12	25	
1330-20-7	m,p-Xylenes	97		108		70	130	11	25	
95-47-6	o-Xylene	96		109		70	130	12	25	
108-67-8	1,3,5-Trimethylbenzene	100		111		70	130	10	25	
95-63-6	1,2,4-Trimethylbenzene	98		108		70	130	10	25	

LCS - Laboratory Control Spike
LCD - Laboratory Control Duplicate

Flag - Q indicated out of Limits

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

Laboratory Control Spike and Spike Duplicate Report

TO15 Volatile Organic Compounds by GC/MS

QC_Batch: 041620-MA1
Date: 04/16/20

CAS#	Compound	LCS Recovery %	Flag	LCD Recovery %	Flag	Spike Limit LCL %	Spike Limit UCL %	Duplicate %	Duplicate Limit %	Flag
75-01-4	Vinyl chloride	93		112		70	130	18	25	
75-35-4	1,1-Dichloroethene	101		113		70	130	12	25	
75-09-2	Dichloromethane	103		108		70	130	5	25	
75-34-3	1,1-Dichloroethane	108		115		70	130	6	25	
156-59-2	cis-1,2-Dichloroethene	103		111		70	130	7	25	
67-66-3	Chloroform	102		110		70	130	8	25	
71-55-6	1,1,1-Trichloroethane	94		103		70	130	9	25	
107-06-2	1,2-Dichloroethane	100		109		70	130	9	25	
71-43-2	Benzene	101		112		70	130	10	25	
56-23-5	Carbon tetrachloride	89		97		70	130	8	25	
79-01-6	Trichloroethene	98		102		70	130	3	25	
108-88-3	Toluene	101		112		70	130	10	25	
79-00-5	1,1,2-Trichloroethane	103		106		70	130	3	25	
106-93-4	1,2-Dibromoethane	102		111		70	130	8	25	
127-18-4	Tetrachloroethene	107		118		70	130	10	25	
100-41-4	Ethylbenzene	102		129		70	130	23	25	
1330-20-7	m,p-Xylenes	101		127		70	130	22	25	
95-47-6	o-Xylene	101		127		70	130	23	25	
108-67-8	1,3,5-Trimethylbenzene	98		125		70	130	24	25	
95-63-6	1,2,4-Trimethylbenzene	99		125		70	130	23	25	

LCS - Laboratory Control Spike
LCD - Laboratory Control Duplicate

Flag - Q indicated out of Limits

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

Laboratory Control Spike and Spike Duplicate Report

TO15 Volatile Organic Compounds by GC/MS

QC_Batch: 041720-MA1
Date: 04/17/20

CAS#	Compound	LCS Recovery %	Flag	LCD Recovery %	Flag	Spike Limit LCL %	Spike Limit UCL %	Duplicate %	Duplicate Limit %	Flag
75-01-4	Vinyl chloride	105		91		70	130	15	25	
75-35-4	1,1-Dichloroethene	101		96		70	130	6	25	
75-09-2	Dichloromethane	104		93		70	130	12	25	
75-34-3	1,1-Dichloroethane	104		97		70	130	6	25	
156-59-2	cis-1,2-Dichloroethene	103		92		70	130	11	25	
67-66-3	Chloroform	103		93		70	130	10	25	
71-55-6	1,1,1-Trichloroethane	102		94		70	130	8	25	
107-06-2	1,2-Dichloroethane	103		96		70	130	6	25	
71-43-2	Benzene	109		102		70	130	7	25	
56-23-5	Carbon tetrachloride	97		90		70	130	7	25	
79-01-6	Trichloroethene	111		98		70	130	12	25	
108-88-3	Toluene	111		102		70	130	8	25	
79-00-5	1,1,2-Trichloroethane	115		98		70	130	16	25	
106-93-4	1,2-Dibromoethane	117		103		70	130	12	25	
127-18-4	Tetrachloroethene	128		113		70	130	13	25	
100-41-4	Ethylbenzene	102		108		70	130	5	25	
1330-20-7	m,p-Xylenes	101		109		70	130	7	25	
95-47-6	o-Xylene	102		104		70	130	3	25	
108-67-8	1,3,5-Trimethylbenzene	106		110		70	130	4	25	
95-63-6	1,2,4-Trimethylbenzene	104		108		70	130	4	25	

LCS - Laboratory Control Spike
LCD - Laboratory Control Duplicate

Flag - Q indicated out of Limits

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

Laboratory Control Spike and Laboratory Control Duplicate

ASTM D 1945 GC/TCD

Analytical Method: D1945

QC_Batch: 041420-GCO

Date Analyzed: 04/14/20

		LCS		LCD		Spike Limit			Duplicate	
		Recovery		Recovery		LCL	UCL	Duplicate	Limit	
CAS#	Compound	%	Flag	%	Flag	%	%	%	%	Flag
7782-44-7	Oxygen	97		100		70	130	3	25	
7727-37-9	Nitrogen	102		101		70	130	1	25	
74-82-8	Methane	107		107		70	130	0	25	
630-08-0	Carbon Monoxide	94		94		70	130	0	25	
124-38-9	Carbon Dioxide	97		97		70	130	0	25	

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

Analytical Method: EPA 16

Date: 04/13/20
QC_Batch: 041320-GCP

CAS#	Compound	Standard Recovery	Standard Recovery	LCL %	UCL %	RSD %	RSD Limit
7783-06-4	Hydrogen Sulfide	98	105	80	120	4	15

RSD = Relative standard deviation of triplicate standard analysis
Limits are based on fixed laboratory analysis by GC/FPD

QUALITY CONTROL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

Analytical Method: **EPA 16**

Date: 04/14/20
QC_Batch: 041420-GCP

CAS#	Compound	Standard Recovery	Standard Recovery	LCL %	UCL %	RSD %	RSD Limit
7783-06-4	Hydrogen Sulfide	103	99	80	120	3	15

RSD = Relative standard deviation of triplicate standard analysis
Limits are based on fixed laboratory analysis by GC/FPD

Analytical Reports

EAS SDG Number 220163

Project Number: 17510

The following pages contain the certified Analytical Reports for the samples submitted in the Sample Delivery Group (SDG) and are in order of the EAS Lab ID number. All of the analytical methods used are modifications of the published methods. Procedural method modifications, QC modifications, QC Criteria modifications, target lists, definitions of detection limits, and flags are all explained in detail in the EAS Quality Manual.

The Analytical Report has columns for the method detection limit (MDL), the reporting limit (RL), and the Amount. The Amount is the concentration of the compound in the sample. The report usually has the results reported with two commonly used units. The MDL, RL, and Amount are adjusted for the canister dilution factor and any dilution caused by sample matrix effects.

NELAC CERTIFICATION

EAS is accredited by the National Environmental Laboratory Accreditation (NELAC) with the Florida Department of Health, one of the NELAC certifying states. EAS is certified for the EPA TO-15, EPA TO-11 and EPA TO-4 methods. A list of accredited compounds is available on request.

DETECTION LIMITS

MDL: The MDL is lowest concentration that can be measured to be statistically above the noise level and is determined using the EPA 2016 method which uses the standard deviation of replicate measurements made over time. The method also incorporates systematic instrumentation blank levels. See Quality Manual for detailed explanation.

RL: The reporting limit (RL) is the lowest concentration that can be reliably reported for each compound that meets the QC Criteria for the method, background levels, or project specific considerations. The QC criteria level for the method blank is to be less then the RL See Quality Manual for more information.

DATA FLAGS

In the standard report, if a compound is not detected above the method detection limit, a "ND" is in the Amount column. The flag column is used for both the not detect flag and for any data flags.

B - This compound was detected in the batch method blank above the reporting limit and is greater then one tenth the amount in the sample.

E - This compound exceeds the calibration range for this sample volume.

J - The amount reported is estimated because it was below the RL and could be below the lowest calibration point, have higher uncertainty, or could be the result of system background

UNITS

PPBV or PPMV: Parts-per-billion (or million) by volume is a mole (volume) ratio of the moles of analyte divided by the moles of air (gas). This is the primary unit used to report air or gas concentrations and is independent of temperature and pressure.

UG/M3 OR MG/M3: The reported result was calculated based on 1 atm pressure and a temperature of 25C. The conversion from PPBV is: UG/M3 = PPBV x MW/24.46 where 24.26 is the gas constant and MW is the Compounds Molecular Weight (sometimes called Formula Weight)

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 01

File Name: 2016301A.D
Description: MAN-1
Canister: 259
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 08:29
Date Analyzed: 4/15/2020 Time: 15:42
Can Dilution Factor: 1.00
Air Volume: 225.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.12	ND	1.34	2.31	ND	
75-01-4	Vinyl chloride	0.22	1.12	ND	0.57	2.86	ND	
75-00-3	Chloroethane	0.22	1.12	ND	0.59	2.95	ND	
75-69-4	Trichlorofluoromethane	0.35	1.12	ND	1.97	6.29	ND	
75-35-4	1,1-Dichloroethene	0.22	1.10	ND	0.88	4.37	ND	
76-13-1	Freon 113	0.22	1.06	ND	1.70	8.14	ND	
75-09-2	Dichloromethane	0.44	1.07	ND	1.54	3.71	ND	
156-60-5	trans-1,2-Dichloroethene	0.22	0.80	ND	0.88	3.18	ND	
75-34-3	1,1-Dichloroethane	0.22	1.11	ND	0.90	4.49	ND	
108-05-4	Vinyl acetate	0.22	0.98	ND	0.78	3.44	ND	
109-99-9	Tetrahydrofuran	0.44	1.12	ND	1.31	3.29	ND	
156-59-2	cis-1,2-Dichloroethene	0.44	1.20	ND	1.76	4.74	ND	
71-55-6	1,1,1-Trichloroethane	0.22	0.99	ND	1.21	5.38	ND	
107-06-2	1,2-Dichloroethane	0.22	1.01	ND	0.90	4.10	ND	
71-43-2	Benzene	0.44	0.89	ND	1.42	2.84	ND	
79-01-6	Trichloroethene	0.13	1.04	ND	0.72	5.56	ND	
108-10-1	4-Methyl-2-pentanone	0.89	3.36	ND	3.64	13.78	ND	
108-88-3	Toluene	0.44	1.16	ND	1.67	4.37	ND	
127-18-4	Tetrachloroethene	0.13	0.54	ND	0.90	3.67	ND	
108-90-7	Chlorobenzene	0.22	1.01	ND	1.02	4.65	ND	
100-41-4	Ethylbenzene	0.47	1.17	ND	2.04	5.10	ND	
1330-20-7	m,p-Xylenes	0.47	1.18	ND	2.05	5.11	ND	
100-42-5	Styrene	0.46	1.15	ND	1.96	4.90	ND	
95-47-6	o-Xylene	0.46	1.15	ND	1.99	4.97	ND	
79-34-5	1,1,2,2-Tetrachloroethane	0.22	0.55	ND	1.51	3.77	ND	
106-46-7	1,4-Dichlorobenzene	0.44	0.77	ND	2.67	4.62	ND	
95-50-1	1,2-Dichlorobenzene	0.89	1.11	ND	5.34	6.68	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	QC Limits UCL	Flag
2037-26-5	Toluene-d8	96	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	Laboratory Number:	01
		SDG:	220163

File Name:	2016301A	Date Sampled:	04/09/20	Time:	8:29
Description:	MAN 1	Date Analyzed:	04/14/20	Time:	9:09
Can/Tube#:	259	Can Dilution Factor:	1.00		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	ND	100	300	ND	ND
124-38-9	Carbon Dioxide	0.01	0.03	ND	100	300	ND	ND

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: **EPA 16** **Laboratory ID:** **1**

File Name:	2016301A	**Date Sampled:**	04/09/20	**Time:**	8:29
Sample ID	MAN 1	**Date Analyzed:**	04/13/20	**Time:**	15:32
Can/Tube#:	259	**Can Dilution Factor:**	1.00		
QC_Batch:	041320-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	8.1	24.3	ND	11.3	33.9	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

Analytical Method: TO-15

SDG: 220163
Laboratory ID: 02

File Name: 2016302A.D
Description: B-2
Canister: 524
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 09:19
Date Analyzed: 4/15/2020 Time: 13:40
Can Dilution Factor: 1.00
Air Volume: 225.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.12	ND	1.34	2.31	ND	
75-01-4	Vinyl chloride	0.22	1.12	ND	0.57	2.86	ND	
75-00-3	Chloroethane	0.22	1.12	ND	0.59	2.95	ND	
75-69-4	Trichlorofluoromethane	0.35	1.12	ND	1.97	6.29	ND	
75-35-4	1,1-Dichloroethene	0.22	1.10	ND	0.88	4.37	ND	
76-13-1	Freon 113	0.22	1.06	ND	1.70	8.14	ND	
75-09-2	Dichloromethane	0.44	1.07	ND	1.54	3.71	ND	
156-60-5	trans-1,2-Dichloroethene	0.22	0.80	ND	0.88	3.18	ND	
75-34-3	1,1-Dichloroethane	0.22	1.11	ND	0.90	4.49	ND	
108-05-4	Vinyl acetate	0.22	0.98	ND	0.78	3.44	ND	
109-99-9	Tetrahydrofuran	0.44	1.12	ND	1.31	3.29	ND	
156-59-2	cis-1,2-Dichloroethene	0.44	1.20	ND	1.76	4.74	ND	
71-55-6	1,1,1-Trichloroethane	0.22	0.99	ND	1.21	5.38	ND	
107-06-2	1,2-Dichloroethane	0.22	1.01	ND	0.90	4.10	ND	
71-43-2	Benzene	0.44	0.89	ND	1.42	2.84	ND	
79-01-6	Trichloroethene	0.13	1.04	ND	0.72	5.56	ND	
108-10-1	4-Methyl-2-pentanone	0.89	3.36	ND	3.64	13.78	ND	
108-88-3	Toluene	0.44	1.16	0.79	1.67	4.37	2.98	J
127-18-4	Tetrachloroethene	0.13	0.54	ND	0.90	3.67	ND	
108-90-7	Chlorobenzene	0.22	1.01	ND	1.02	4.65	ND	
100-41-4	Ethylbenzene	0.47	1.17	ND	2.04	5.10	ND	
1330-20-7	m,p-Xylenes	0.47	1.18	1.71	2.05	5.11	7.44	
100-42-5	Styrene	0.46	1.15	ND	1.96	4.90	ND	
95-47-6	o-Xylene	0.46	1.15	0.79	1.99	4.97	3.45	J
79-34-5	1,1,2,2-Tetrachloroethane	0.22	0.55	ND	1.51	3.77	ND	
106-46-7	1,4-Dichlorobenzene	0.44	0.77	ND	2.67	4.62	ND	
95-50-1	1,2-Dichlorobenzene	0.89	1.11	ND	5.34	6.68	ND	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	97	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	02

File Name:	2016302A	Date Sampled:	04/09/20	Time:	9:19
Description:	B-2	Date Analyzed:	04/14/20	Time:	9:16
Can/Tube#:	524	Can Dilution Factor:	1.00		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	ND	100	300	ND	ND
124-38-9	Carbon Dioxide	0.01	0.03	ND	100	300	ND	ND

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: 220163

Analytical Method: EPA 16

Laboratory ID: 2

File Name:	2016302A	**Date Sampled:**	04/09/20	**Time:**	9:19
Sample ID	B-2	**Date Analyzed:**	04/13/20	**Time:**	16:04
Can/Tube#:	524	**Can Dilution Factor:**	1.00		
QC_Batch:	041320-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	8.1	24.3	ND	11.3	33.9	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 03

File Name: 2016303A.D
Description: GW-7
Canister: 251
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 08:38
Date Analyzed: 4/15/2020 Time: 16:54
Can Dilution Factor: 4.45
Air Volume: 225.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.99	4.98	ND	2.04	10.29	ND	
75-01-4	Vinyl chloride	0.99	4.97	ND	2.53	12.71	ND	
75-00-3	Chloroethane	0.99	4.97	ND	2.61	13.12	ND	
75-69-4	Trichlorofluoromethane	0.99	4.98	ND	5.55	27.99	ND	
75-35-4	1,1-Dichloroethene	0.99	4.90	ND	3.92	19.43	ND	
76-13-1	Freon 113	0.99	4.73	ND	7.58	36.24	ND	
75-09-2	Dichloromethane	1.98	4.76	ND	6.86	16.53	ND	
156-60-5	trans-1,2-Dichloroethene	0.99	3.57	ND	3.92	14.14	ND	
75-34-3	1,1-Dichloroethane	0.99	4.93	ND	4.00	19.96	ND	
108-05-4	Vinyl acetate	0.99	4.34	ND	3.48	15.29	ND	
109-99-9	Tetrahydrofuran	1.98	4.97	ND	5.83	14.66	ND	
156-59-2	cis-1,2-Dichloroethene	1.98	5.32	ND	7.83	21.07	ND	
71-55-6	1,1,1-Trichloroethane	0.99	4.39	ND	5.39	23.94	ND	
107-06-2	1,2-Dichloroethane	0.99	4.51	ND	4.00	18.26	ND	
71-43-2	Benzene	1.98	3.96	ND	6.31	12.63	ND	
79-01-6	Trichloroethene	0.59	4.61	ND	3.19	24.74	ND	
108-10-1	4-Methyl-2-pentanone	3.96	14.97	ND	16.20	61.33	ND	
108-88-3	Toluene	1.98	5.16	12.09	7.45	19.43	45.51	
127-18-4	Tetrachloroethene	0.59	2.41	ND	4.02	16.31	ND	
108-90-7	Chlorobenzene	0.99	4.50	9.19	4.55	20.71	42.29	
100-41-4	Ethylbenzene	2.09	5.23	8.49	9.08	22.69	36.88	
1330-20-7	m,p-Xylenes	2.10	5.24	9.45	9.10	22.75	41.03	
100-42-5	Styrene	2.05	5.12	ND	8.72	21.81	ND	
95-47-6	o-Xylene	2.04	5.10	3.17	8.85	22.13	13.77	J
79-34-5	1,1,2,2-Tetrachloroethane	0.98	2.45	ND	6.72	16.79	ND	
106-46-7	1,4-Dichlorobenzene	1.98	3.42	ND	11.89	20.56	ND	
95-50-1	1,2-Dichlorobenzene	3.96	4.94	ND	23.77	29.71	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	104	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	03

File Name:	2016303A	Date Sampled:	04/09/20	Time:	8:38
Description:	GW-7	Date Analyzed:	04/14/20	Time:	9:23
Can/Tube#:	251	Can Dilution Factor:	4.45		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.04	0.12	0.72	445	1,335	7,176	
124-38-9	Carbon Dioxide	0.04	0.12	11.10	445	1,335	111,024	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: 220163

Analytical Method: EPA 16

Laboratory ID: 3

File Name:	2016303A	**Date Sampled:**	04/09/20	**Time:**	8:38
Sample ID	GW-7	**Date Analyzed:**	04/13/20	**Time:**	16:30
Can/Tube#:	251	**Can Dilution Factor:**	4.45		
QC_Batch:	041320-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	36.0	107.9	ND	50.2	150.7	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 04

File Name: 2016304A.D
Description: GW-38S
Canister: 261
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 08:55
Date Analyzed: 4/15/2020 Time: 18:05
Can Dilution Factor: 3.20
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.80	4.03	ND	1.65	8.32	ND	
75-01-4	Vinyl chloride	0.80	4.02	ND	2.04	10.28	ND	
75-00-3	Chloroethane	0.80	4.02	22.87	2.11	10.61	60.31	
75-69-4	Trichlorofluoromethane	0.80	4.03	3.73	4.49	22.65	20.95	J
75-35-4	1,1-Dichloroethene	0.80	3.97	ND	3.17	15.72	ND	
76-13-1	Freon 113	0.80	3.83	ND	6.13	29.32	ND	
75-09-2	Dichloromethane	1.60	3.85	ND	5.55	13.37	ND	
156-60-5	trans-1,2-Dichloroethene	0.80	2.89	ND	3.17	11.44	ND	
75-34-3	1,1-Dichloroethane	0.80	3.99	ND	3.24	16.15	ND	
108-05-4	Vinyl acetate	0.80	3.51	ND	2.82	12.37	ND	
109-99-9	Tetrahydrofuran	1.60	4.02	40.70	4.72	11.86	119.96	
156-59-2	cis-1,2-Dichloroethene	1.60	4.30	ND	6.34	17.05	ND	
71-55-6	1,1,1-Trichloroethane	0.80	3.55	ND	4.36	19.37	ND	
107-06-2	1,2-Dichloroethane	0.80	3.65	ND	3.24	14.77	ND	
71-43-2	Benzene	1.60	3.20	80.03	5.11	10.22	255.50	
79-01-6	Trichloroethene	0.48	3.73	ND	2.58	20.02	ND	
108-10-1	4-Methyl-2-pentanone	3.20	12.11	ND	13.11	49.61	ND	
108-88-3	Toluene	1.60	4.18	7.59	6.02	15.72	28.56	
127-18-4	Tetrachloroethene	0.48	1.95	ND	3.25	13.20	ND	
108-90-7	Chlorobenzene	0.80	3.64	116.67	3.68	16.76	537.01	
100-41-4	Ethylbenzene	1.69	4.23	146.79	7.34	18.36	637.28	
1330-20-7	m,p-Xylenes	1.70	4.24	33.96	7.36	18.41	147.42	
100-42-5	Styrene	1.66	4.14	ND	7.06	17.64	ND	
95-47-6	o-Xylene	1.65	4.12	19.88	7.16	17.90	86.31	
79-34-5	1,1,2,2-Tetrachloroethane	0.79	1.98	ND	5.43	13.59	ND	
106-46-7	1,4-Dichlorobenzene	1.60	2.77	ND	9.61	16.63	ND	
95-50-1	1,2-Dichlorobenzene	3.20	4.00	ND	19.23	24.04	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	98	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	04

File Name:	2016304A	Date Sampled:	04/09/20	Time:	8:55
Description:	GW-38S	Date Analyzed:	04/14/20	Time:	9:30
Can/Tube#:	261	Can Dilution Factor:	3.20		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.03	0.09	10.55	320	960	105,550	
124-38-9	Carbon Dioxide	0.03	0.09	13.54	320	960	135,427	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: EPA 16

Laboratory ID: **4**

File Name:	2016304A	**Date Sampled:**	04/09/20	**Time:**	8:55
Sample ID	GW-38S	**Date Analyzed:**	04/13/20	**Time:**	16:56
Can/Tube#:	261	**Can Dilution Factor:**	3.20		
QC_Batch:	041320-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	25.9	77.6	3,113.1	36.1	108.4	4,348.1	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 05

File Name: 2016305A.D
Description: GW-38D
Canister: 255
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 08:56
Date Analyzed: 4/15/2020 Time: 19:55
Can Dilution Factor: 1.47
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.85	ND	1.34	3.82	ND	
75-01-4	Vinyl chloride	0.37	1.85	91.45	0.94	4.72	233.66	
75-00-3	Chloroethane	0.37	1.85	10.24	0.97	4.87	27.00	
75-69-4	Trichlorofluoromethane	0.37	1.85	ND	2.06	10.39	ND	
75-35-4	1,1-Dichloroethene	0.37	1.82	ND	1.45	7.21	ND	
76-13-1	Freon 113	0.37	1.76	ND	2.81	13.45	ND	
75-09-2	Dichloromethane	0.73	1.77	ND	2.55	6.13	ND	
156-60-5	trans-1,2-Dichloroethene	0.37	1.32	ND	1.45	5.25	ND	
75-34-3	1,1-Dichloroethane	0.37	1.83	ND	1.49	7.41	ND	
108-05-4	Vinyl acetate	0.37	1.61	ND	1.29	5.68	ND	
109-99-9	Tetrahydrofuran	0.73	1.85	134.39	2.16	5.44	396.09	
156-59-2	cis-1,2-Dichloroethene	0.73	1.97	17.68	2.91	7.82	70.05	
71-55-6	1,1,1-Trichloroethane	0.37	1.63	ND	2.00	8.89	ND	
107-06-2	1,2-Dichloroethane	0.37	1.67	ND	1.49	6.78	ND	
79-01-6	Trichloroethene	0.22	1.71	2.07	1.18	9.18	11.14	
108-10-1	4-Methyl-2-pentanone	1.47	5.56	ND	6.01	22.76	ND	
108-88-3	Toluene	0.73	1.92	77.28	2.76	7.21	290.96	
127-18-4	Tetrachloroethene	0.22	0.89	0.87	1.49	6.05	5.88	J
108-90-7	Chlorobenzene	0.37	1.67	163.56	1.69	7.69	752.88	
1330-20-7	m,p-Xylenes	0.78	1.94	276.05	3.38	8.44	1,198.44	
100-42-5	Styrene	0.76	1.90	ND	3.24	8.09	ND	
95-47-6	o-Xylene	0.76	1.89	95.54	3.28	8.21	414.79	
79-34-5	1,1,2,2-Tetrachloroethane	0.36	0.91	ND	2.49	6.23	ND	
106-46-7	1,4-Dichlorobenzene	0.73	1.27	ND	4.41	7.63	ND	
95-50-1	1,2-Dichlorobenzene	1.47	1.84	ND	8.82	11.03	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	96	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 05

File Name: 2016305A.D
Description: GW-38D
Canister: 255
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 Time: 08:56
Date Analyzed: 4/16/2020 Time: 18:04
Can Dilution Factor: 1.47
Air Volume: 25.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
71-43-2	Benzene	5.87	11.74	19.51	18.75	37.49	62.29	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	98	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 05

File Name:	2016305A.D	Date Sampled: 4/9/2020	Time: 08:56
Description:	GW-38D	Date Analyzed: 4/17/2020	Time: 18:17
Canister:	255	Can Dilution Factor: 1.99	
QC_Batch:	041720-MA1	Air Volume: 5.00	ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
100-41-4	Ethylbenzene	42.08	105.20	1,578.10	182.68	456.70	6,851.16	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	98	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD | **SDG: 220163**

Analytical Method: D1945 | **Laboratory Number:** 05

File Name:	2016305A	**Date Sampled:**	04/09/20	**Time:**	8:56
Description:	GW-38D	**Date Analyzed:**	04/14/20	**Time:**	9:52
Can/Tube#:	255	**Can Dilution Factor:**	1.38		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	20.42	138	414	204,202	
124-38-9	Carbon Dioxide	0.01	0.03	15.29	138	414	152,916	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: 220163

Analytical Method: EPA 16

Laboratory ID: 5

File Name:	2016305A	Date Sampled:	04/09/20	Time:	8:56
Sample ID	GW-38D	Date Analyzed:	04/13/20	Time:	17:22
Can/Tube#:	255	Can Dilution Factor:	1.29		
QC_Batch:	041320-GCP	Air Volume:	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	10.4	31.3	4,718.0	14.6	43.7	6,589.7	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 06

File Name: 2016306A.D
Description: GW-48S
Canister: 486
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 09:09
Date Analyzed: 4/15/2020 Time: 20:31
Can Dilution Factor: 1.98
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	2.49	ND	1.34	5.15	ND	
75-01-4	Vinyl chloride	0.50	2.49	53.57	1.26	6.36	136.86	
75-00-3	Chloroethane	0.50	2.49	113.32	1.31	6.57	298.80	
75-69-4	Trichlorofluoromethane	0.50	2.49	ND	2.78	14.01	ND	
75-35-4	1,1-Dichloroethene	0.50	2.46	ND	1.96	9.73	ND	
76-13-1	Freon 113	0.50	2.37	ND	3.79	18.14	ND	
75-09-2	Dichloromethane	0.99	2.38	ND	3.44	8.27	ND	
156-60-5	trans-1,2-Dichloroethene	0.50	1.79	ND	1.96	7.08	ND	
75-34-3	1,1-Dichloroethane	0.50	2.47	5.71	2.00	9.99	23.09	
108-05-4	Vinyl acetate	0.50	2.17	ND	1.74	7.65	ND	
109-99-9	Tetrahydrofuran	0.99	2.49	104.95	2.92	7.34	309.33	
156-59-2	cis-1,2-Dichloroethene	0.99	2.66	6.19	3.92	10.55	24.53	
71-55-6	1,1,1-Trichloroethane	0.50	2.20	ND	2.70	11.99	ND	
107-06-2	1,2-Dichloroethane	0.50	2.26	ND	2.00	9.14	ND	
71-43-2	Benzene	0.99	1.98	172.07	3.16	6.32	549.36	
79-01-6	Trichloroethene	0.30	2.31	2.21	1.60	12.39	11.85	J
108-10-1	4-Methyl-2-pentanone	1.98	7.49	ND	8.11	30.70	ND	
108-88-3	Toluene	0.99	2.58	46.64	3.73	9.73	175.58	
127-18-4	Tetrachloroethene	0.30	1.20	ND	2.01	8.17	ND	
108-90-7	Chlorobenzene	0.50	2.25	147.03	2.28	10.37	676.79	
100-41-4	Ethylbenzene	1.05	2.62	283.56	4.54	11.36	1,231.06	
1330-20-7	m,p-Xylenes	1.05	2.62	69.90	4.56	11.39	303.47	
100-42-5	Styrene	1.03	2.56	ND	4.37	10.92	ND	
95-47-6	o-Xylene	1.02	2.55	26.49	4.43	11.08	115.02	
79-34-5	1,1,2,2-Tetrachloroethane	0.49	1.23	ND	3.36	8.41	ND	
106-46-7	1,4-Dichlorobenzene	0.99	1.71	ND	5.95	10.29	ND	
95-50-1	1,2-Dichlorobenzene	1.98	2.48	ND	11.90	14.87	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	100	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	06

File Name:	2016306A	Date Sampled:	04/09/20	Time:	9:09
Description:	GW-48S	Date Analyzed:	04/14/20	Time:	13:54
Can/Tube#:	486	Can Dilution Factor:	1.98		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.02	0.06	9.37	198	594	93,746	
124-38-9	Carbon Dioxide	0.02	0.06	16.08	198	594	160,787	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: EPA 16

Laboratory ID: **6**

File Name:	2016306A	**Date Sampled:**	04/09/20	**Time:**	9:09
Sample ID	GW-48S	**Date Analyzed:**	04/14/20	**Time:**	13:55
Can/Tube#:	486	**Can Dilution Factor:**	1.98		
QC_Batch:	041420-GCP	**Air Volume:**	5.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	32.0	96.0	11,661.8	44.7	134.1	16,288.3	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 07

File Name: 2016307A.D
Description: GW-48D
Canister: 256
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 09:11
Date Analyzed: 4/15/2020 Time: 18:42
Can Dilution Factor: 2.45
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	3.09	ND	1.34	6.37	ND	
75-01-4	Vinyl chloride	0.61	3.08	122.06	1.56	7.87	311.85	
75-00-3	Chloroethane	0.61	3.08	301.96	1.61	8.12	796.18	
75-69-4	Trichlorofluoromethane	0.61	3.09	ND	3.44	17.34	ND	
75-35-4	1,1-Dichloroethene	0.61	3.04	ND	2.43	12.03	ND	
76-13-1	Freon 113	0.61	2.93	ND	4.69	22.45	ND	
75-09-2	Dichloromethane	1.23	2.95	13.53	4.25	10.24	46.96	
156-60-5	trans-1,2-Dichloroethene	0.61	2.21	ND	2.43	8.76	ND	
75-34-3	1,1-Dichloroethane	0.61	3.05	46.95	2.48	12.36	190.02	
108-05-4	Vinyl acetate	0.61	2.69	ND	2.16	9.47	ND	
109-99-9	Tetrahydrofuran	1.23	3.08	94.39	3.61	9.08	278.21	
156-59-2	cis-1,2-Dichloroethene	1.23	3.30	10.90	4.85	13.05	43.17	
71-55-6	1,1,1-Trichloroethane	0.61	2.72	ND	3.34	14.83	ND	
107-06-2	1,2-Dichloroethane	0.61	2.79	ND	2.48	11.31	ND	
79-01-6	Trichloroethene	0.37	2.85	2.69	1.97	15.32	14.44	J
108-10-1	4-Methyl-2-pentanone	2.45	9.27	ND	10.04	37.98	ND	
108-88-3	Toluene	1.23	3.20	197.00	4.61	12.04	741.72	
127-18-4	Tetrachloroethene	0.37	1.49	1.28	2.49	10.10	8.65	J
108-90-7	Chlorobenzene	0.61	2.79	80.45	2.82	12.83	370.29	
1330-20-7	m,p-Xylenes	1.30	3.25	442.71	5.64	14.09	1,922.00	
100-42-5	Styrene	1.27	3.17	ND	5.40	13.51	ND	
95-47-6	o-Xylene	1.26	3.16	313.83	5.48	13.71	1,362.46	
79-34-5	1,1,2,2-Tetrachloroethane	0.61	1.52	ND	4.16	10.40	ND	
106-46-7	1,4-Dichlorobenzene	1.23	2.12	ND	7.36	12.74	ND	
95-50-1	1,2-Dichlorobenzene	2.45	3.06	ND	14.72	18.40	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	91	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 07

File Name: 2016307A.D
Description: GW-48D
Canister: 256
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 **Time:** 09:11
Date Analyzed: 4/16/2020 **Time:** 15:34
Can Dilution Factor: 2.45
Air Volume: 25.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
71-43-2	Benzene	9.80	19.60	532.86	31.29	62.58	1,701.24	
100-41-4	Ethylbenzene	10.36	25.90	3,042.19	44.98	112.45	13,207.35	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	91	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	07

File Name:	2016307A	Date Sampled:	04/09/20	Time:	9:11
Description:	GW-48D	Date Analyzed:	04/14/20	Time:	14:19
Can/Tube#:	256	Can Dilution Factor:	2.45		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.02	0.06	15.19	245	735	151,879	
124-38-9	Carbon Dioxide	0.02	0.06	16.43	245	735	164,317	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: EPA 16

Laboratory ID: **7**

File Name:	2016307A	**Date Sampled:**	04/09/20	**Time:**	9:11
Sample ID	GW-48D	**Date Analyzed:**	04/14/20	**Time:**	14:19
Can/Tube#:	256	**Can Dilution Factor:**	2.45		
QC_Batch:	041420-GCP	**Air Volume:**	5.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	39.6	118.8	8,949.6	55.3	166.0	12,500.1	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 08

File Name: 2016308A.D
Description: B-4
Canister: 482
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 **Time:** 09:57
Date Analyzed: 4/15/2020 **Time:** 14:17
Can Dilution Factor: 1.51
Air Volume: 225.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.69	ND	1.34	3.49	ND	
75-01-4	Vinyl chloride	0.34	1.69	ND	0.86	4.31	ND	
75-00-3	Chloroethane	0.34	1.69	ND	0.88	4.45	ND	
75-69-4	Trichlorofluoromethane	0.35	1.69	ND	1.97	9.50	ND	
75-35-4	1,1-Dichloroethene	0.34	1.66	ND	1.33	6.59	ND	
76-13-1	Freon 113	0.34	1.61	ND	2.57	12.30	ND	
75-09-2	Dichloromethane	0.67	1.62	ND	2.33	5.61	ND	
156-60-5	trans-1,2-Dichloroethene	0.34	1.21	ND	1.33	4.80	ND	
75-34-3	1,1-Dichloroethane	0.34	1.67	ND	1.36	6.77	ND	
108-05-4	Vinyl acetate	0.34	1.47	ND	1.18	5.19	ND	
109-99-9	Tetrahydrofuran	0.67	1.69	ND	1.98	4.97	ND	
156-59-2	cis-1,2-Dichloroethene	0.67	1.81	ND	2.66	7.15	ND	
71-55-6	1,1,1-Trichloroethane	0.34	1.49	ND	1.83	8.12	ND	
107-06-2	1,2-Dichloroethane	0.34	1.53	ND	1.36	6.19	ND	
71-43-2	Benzene	0.67	1.34	ND	2.14	4.29	ND	
79-01-6	Trichloroethene	0.20	1.56	ND	1.08	8.40	ND	
108-10-1	4-Methyl-2-pentanone	1.34	5.08	ND	5.50	20.81	ND	
108-88-3	Toluene	0.67	1.75	ND	2.53	6.59	ND	
127-18-4	Tetrachloroethene	0.20	0.82	ND	1.36	5.54	ND	
108-90-7	Chlorobenzene	0.34	1.53	ND	1.54	7.03	ND	
100-41-4	Ethylbenzene	0.71	1.77	ND	3.08	7.70	ND	
1330-20-7	m,p-Xylenes	0.71	1.78	ND	3.09	7.72	ND	
100-42-5	Styrene	0.69	1.74	ND	2.96	7.40	ND	
95-47-6	o-Xylene	0.69	1.73	ND	3.00	7.51	ND	
79-34-5	1,1,2,2-Tetrachloroethane	0.33	0.83	ND	2.28	5.70	ND	
106-46-7	1,4-Dichlorobenzene	0.67	1.16	ND	4.03	6.98	ND	
95-50-1	1,2-Dichlorobenzene	1.34	1.68	ND	8.07	10.08	ND	

			QC	Limits	
	Surrogate Recovery	% Rec.	LCL	UCL	Flag
2037-26-5	Toluene-d8	98	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	**SDG:**	**220163**
		Laboratory Number:	**08**

File Name:	2016308A	**Date Sampled:**	04/09/20	**Time:**	9:57
Description:	B-4	**Date Analyzed:**	04/14/20	**Time:**	10:01
Can/Tube#:	482	**Can Dilution Factor:**	1.51		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.02	0.06	ND	151	453	ND	ND
124-38-9	Carbon Dioxide	0.02	0.06	0.08	151	453	761	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

Analytical Method:	EPA 16	SDG:	220163
		Laboratory ID:	8

File Name:	2016308A	Date Sampled:	04/09/20	Time:	9:57
Sample ID	B-4	Date Analyzed:	04/13/20	Time:	18:37
Can/Tube#:	482	Can Dilution Factor:	1.51		
QC_Batch:	041320-GCP	Air Volume:	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	12.2	36.6	ND	17.0	51.1	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 09

File Name: 2016309A.D
Description: GW-52S
Canister: 258
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 09:33
Date Analyzed: 4/15/2020 Time: 19:19
Can Dilution Factor: 1.44
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.81	ND	1.34	3.75	ND	
75-01-4	Vinyl chloride	0.36	1.81	21.58	0.92	4.63	55.12	
75-00-3	Chloroethane	0.36	1.81	14.87	0.95	4.77	39.22	
75-69-4	Trichlorofluoromethane	0.36	1.81	2.25	2.02	10.19	12.65	
75-35-4	1,1-Dichloroethene	0.36	1.79	ND	1.43	7.07	ND	
76-13-1	Freon 113	0.36	1.72	ND	2.76	13.19	ND	
75-09-2	Dichloromethane	0.72	1.73	ND	2.50	6.02	ND	
156-60-5	trans-1,2-Dichloroethene	0.36	1.30	ND	1.43	5.15	ND	
75-34-3	1,1-Dichloroethane	0.36	1.80	6.88	1.46	7.27	27.82	
108-05-4	Vinyl acetate	0.36	1.58	ND	1.27	5.57	ND	
109-99-9	Tetrahydrofuran	0.72	1.81	61.78	2.12	5.34	182.10	
156-59-2	cis-1,2-Dichloroethene	0.72	1.94	ND	2.85	7.67	ND	
71-55-6	1,1,1-Trichloroethane	0.36	1.60	ND	1.96	8.72	ND	
107-06-2	1,2-Dichloroethane	0.36	1.64	ND	1.46	6.65	ND	
71-43-2	Benzene	0.72	1.44	60.18	2.30	4.60	192.13	
79-01-6	Trichloroethene	0.22	1.68	2.25	1.16	9.01	12.11	
108-10-1	4-Methyl-2-pentanone	1.44	5.45	ND	5.90	22.33	ND	
108-88-3	Toluene	0.72	1.88	98.74	2.71	7.08	371.75	
127-18-4	Tetrachloroethene	0.22	0.88	1.27	1.46	5.94	8.62	
108-90-7	Chlorobenzene	0.36	1.64	40.97	1.66	7.54	188.61	
1330-20-7	m,p-Xylenes	0.76	1.91	140.52	3.31	8.28	610.04	
100-42-5	Styrene	0.75	1.86	ND	3.18	7.94	ND	
95-47-6	o-Xylene	0.74	1.86	93.49	3.22	8.06	405.87	
79-34-5	1,1,2,2-Tetrachloroethane	0.36	0.89	ND	2.45	6.11	ND	
106-46-7	1,4-Dichlorobenzene	0.72	1.25	ND	4.33	7.49	ND	
95-50-1	1,2-Dichlorobenzene	1.44	1.80	ND	8.65	10.82	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	QC Limits UCL	Flag
2037-26-5	Toluene-d8	102	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15 **Laboratory ID:** 09

File Name:	2016309A.D	**Date Sampled:** 4/9/2020	**Time:** 09:33
Description:	GW-52S	**Date Analyzed:** 4/16/2020	**Time:** 16:53
Canister:	258	**Can Dilution Factor:** 1.44	
QC_Batch:	041620-MA1	**Air Volume:** 50.00 ml	

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
100-41-4	Ethylbenzene	3.04	7.61	249.56	13.22	33.05	1,083.44	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	95	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method: D1945

SDG: 220163
Laboratory Number: 09

File Name: 2016309A
Description: GW-52S
Can/Tube#: 258
QC_Batch: 041420-GCO

Date Sampled: 04/09/20 Time: 9:33
Date Analyzed: 04/14/20 Time: 14:42
Can Dilution Factor: 1.44

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	7.05	144	432	70,484	
124-38-9	Carbon Dioxide	0.01	0.03	6.28	144	432	62,798	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: EPA 16

Laboratory ID: **9**

File Name:	2016309A	**Date Sampled:**	04/09/20 **Time:** 9:33
Sample ID	GW-52S	**Date Analyzed:**	04/14/20 **Time:** 14:43
Can/Tube#:	258	**Can Dilution Factor:**	1.44
QC_Batch:	041420-GCP	**Air Volume:**	5.00 ml

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	23.3	69.8	127.1	32.5	97.5	177.6	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 10

File Name: 2016310A.D
Description: GW-52D
Canister: 253
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 09:35
Date Analyzed: 4/15/2020 Time: 17:29
Can Dilution Factor: 1.12
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.41	ND	1.34	2.91	ND	
75-01-4	Vinyl chloride	0.28	1.41	ND	0.72	3.60	ND	
75-00-3	Chloroethane	0.28	1.41	ND	0.74	3.71	ND	
75-69-4	Trichlorofluoromethane	0.35	1.41	ND	1.97	7.93	ND	
75-35-4	1,1-Dichloroethene	0.28	1.39	ND	1.11	5.50	ND	
76-13-1	Freon 113	0.28	1.34	ND	2.15	10.26	ND	
75-09-2	Dichloromethane	0.56	1.35	ND	1.94	4.68	ND	
156-60-5	trans-1,2-Dichloroethene	0.28	1.01	ND	1.11	4.00	ND	
75-34-3	1,1-Dichloroethane	0.28	1.40	ND	1.13	5.65	ND	
108-05-4	Vinyl acetate	0.28	1.23	ND	0.99	4.33	ND	
109-99-9	Tetrahydrofuran	0.56	1.41	ND	1.65	4.15	ND	
156-59-2	cis-1,2-Dichloroethene	0.56	1.51	ND	2.22	5.97	ND	
71-55-6	1,1,1-Trichloroethane	0.28	1.24	ND	1.53	6.78	ND	
107-06-2	1,2-Dichloroethane	0.28	1.28	ND	1.13	5.17	ND	
71-43-2	Benzene	0.56	1.12	ND	1.79	3.58	ND	
79-01-6	Trichloroethene	0.17	1.30	ND	0.90	7.01	ND	
108-10-1	4-Methyl-2-pentanone	1.12	4.24	ND	4.59	17.36	ND	
108-88-3	Toluene	0.56	1.46	ND	2.11	5.50	ND	
127-18-4	Tetrachloroethene	0.17	0.68	ND	1.14	4.62	ND	
108-90-7	Chlorobenzene	0.28	1.27	ND	1.29	5.87	ND	
100-41-4	Ethylbenzene	0.59	1.48	1.60	2.57	6.43	6.95	
1330-20-7	m,p-Xylenes	0.59	1.48	5.25	2.58	6.44	22.78	
100-42-5	Styrene	0.58	1.45	ND	2.47	6.17	ND	
95-47-6	o-Xylene	0.58	1.44	2.16	2.51	6.27	9.39	
79-34-5	1,1,2,2-Tetrachloroethane	0.28	0.69	ND	1.90	4.75	ND	
106-46-7	1,4-Dichlorobenzene	0.56	0.97	ND	3.37	5.82	ND	
95-50-1	1,2-Dichlorobenzene	1.12	1.40	ND	6.73	8.41	ND	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	102	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	10

File Name:	2016310A	Date Sampled:	04/09/20	Time:	9:35
Description:	GW-52D	Date Analyzed:	04/14/20	Time:	13:23
Can/Tube#:	253	Can Dilution Factor:	1.12		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	ND	112	337	ND	ND
124-38-9	Carbon Dioxide	0.01	0.03	ND	112	337	ND	ND

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: **EPA 16** **Laboratory ID:** **10**

File Name:	2016310A	**Date Sampled:**	04/09/20	**Time:**	9:35
Sample ID	GW-52D	**Date Analyzed:**	04/14/20	**Time:**	13:00
Can/Tube#:	253	**Can Dilution Factor:**	1.12		
QC_Batch:	041420-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	9.1	27.2	ND	12.7	38.0	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15 **Laboratory ID:** 11

File Name: 2016311A.D
Description: GW-42S
Canister: 521
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 **Time:** 09:42
Date Analyzed: 4/15/2020 **Time:** 21:06
Can Dilution Factor: 4.14
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	1.03	5.21	ND	2.13	10.76	ND	
75-01-4	Vinyl chloride	1.03	5.20	83.08	2.64	13.29	212.27	
75-00-3	Chloroethane	1.03	5.20	48.98	2.73	13.71	129.16	
75-69-4	Trichlorofluoromethane	1.03	5.21	15.29	5.81	29.27	85.89	
75-35-4	1,1-Dichloroethene	1.03	5.13	ND	4.10	20.32	ND	
76-13-1	Freon 113	1.03	4.95	ND	7.92	37.90	ND	
75-09-2	Dichloromethane	2.07	4.98	ND	7.18	17.28	ND	
156-60-5	trans-1,2-Dichloroethene	1.03	3.73	ND	4.10	14.79	ND	
75-34-3	1,1-Dichloroethane	1.03	5.16	30.47	4.18	20.87	123.31	
108-05-4	Vinyl acetate	1.03	4.54	ND	3.64	15.99	ND	
109-99-9	Tetrahydrofuran	2.07	5.20	104.16	6.10	15.33	307.00	
156-59-2	cis-1,2-Dichloroethene	2.07	5.56	ND	8.19	22.04	ND	
71-55-6	1,1,1-Trichloroethane	1.03	4.59	ND	5.64	25.04	ND	
107-06-2	1,2-Dichloroethane	1.03	4.72	ND	4.18	19.09	ND	
71-43-2	Benzene	2.07	4.14	172.34	6.60	13.20	550.22	
79-01-6	Trichloroethene	0.62	4.82	ND	3.33	25.87	ND	
108-10-1	4-Methyl-2-pentanone	4.14	15.65	ND	16.94	64.12	ND	
108-88-3	Toluene	2.07	5.40	205.26	7.79	20.32	772.78	
127-18-4	Tetrachloroethene	0.62	2.52	ND	4.20	17.06	ND	
108-90-7	Chlorobenzene	1.03	4.71	69.48	4.76	21.66	319.82	
1330-20-7	m,p-Xylenes	2.19	5.48	343.59	9.52	23.79	1,491.65	
100-42-5	Styrene	2.14	5.35	ND	9.12	22.80	ND	
95-47-6	o-Xylene	2.13	5.33	156.33	9.25	23.14	678.68	
79-34-5	1,1,2,2-Tetrachloroethane	1.02	2.56	ND	7.02	17.56	ND	
106-46-7	1,4-Dichlorobenzene	2.07	3.58	ND	12.43	21.50	ND	
95-50-1	1,2-Dichlorobenzene	4.14	5.17	ND	24.85	31.07	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	QC Limits UCL	Flag
2037-26-5	Toluene-d8	101	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 11

File Name: 2016311A.D
Description: GW-42S
Canister: 521
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 Time: 09:42
Date Analyzed: 4/16/2020 Time: 17:30
Can Dilution Factor: 4.14
Air Volume: 25.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
100-41-4	Ethylbenzene	17.49	43.73	5,914.97	75.94	189.84	25,679.21	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	99	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	11

File Name:	2016311A	Date Sampled:	04/09/20	Time:	9:42
Description:	GW-42S	Date Analyzed:	04/14/20	Time:	15:08
Can/Tube#:	521	Can Dilution Factor:	4.14		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.04	0.12	12.70	414	1,242	127,015	
124-38-9	Carbon Dioxide	0.04	0.12	14.93	414	1,242	149,305	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: 220163

Analytical Method: EPA 16 **Laboratory ID:** 11

File Name:	2016311A	**Date Sampled:**	04/09/20	**Time:**	9:42
Sample ID	GW-42S	**Date Analyzed:**	04/14/20	**Time:**	15:09
Can/Tube#:	521	**Can Dilution Factor:**	4.14		
QC_Batch:	041420-GCP	**Air Volume:**	5.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	66.9	200.6	23,123.4	93.4	280.2	32,297.0	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 12

File Name: 2016312A.D
Description: GW-42D
Canister: 11736
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 Time: 09:44
Date Analyzed: 4/16/2020 Time: 14:56
Can Dilution Factor: 1.73
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	2.18	ND	1.34	4.50	ND	
75-01-4	Vinyl chloride	0.43	2.18	39.50	1.11	5.56	100.92	
75-00-3	Chloroethane	0.43	2.18	33.32	1.14	5.74	87.84	
75-69-4	Trichlorofluoromethane	0.43	2.18	13.88	2.43	12.24	77.95	
75-35-4	1,1-Dichloroethene	0.43	2.15	ND	1.71	8.50	ND	
76-13-1	Freon 113	0.43	2.07	ND	3.31	15.85	ND	
75-09-2	Dichloromethane	0.87	2.08	ND	3.00	7.23	ND	
156-60-5	trans-1,2-Dichloroethene	0.43	1.56	ND	1.71	6.19	ND	
75-34-3	1,1-Dichloroethane	0.43	2.16	9.18	1.75	8.73	37.13	
108-05-4	Vinyl acetate	0.43	1.90	ND	1.52	6.69	ND	
109-99-9	Tetrahydrofuran	0.87	2.18	111.99	2.55	6.41	330.09	
156-59-2	cis-1,2-Dichloroethene	0.87	2.33	3.13	3.43	9.22	12.41	
71-55-6	1,1,1-Trichloroethane	0.43	1.92	ND	2.36	10.47	ND	
107-06-2	1,2-Dichloroethane	0.43	1.97	ND	1.75	7.98	ND	
71-43-2	Benzene	0.87	1.73	167.62	2.76	5.52	535.16	
79-01-6	Trichloroethene	0.26	2.01	ND	1.39	10.82	ND	
108-10-1	4-Methyl-2-pentanone	1.73	6.55	ND	7.09	26.82	ND	
108-88-3	Toluene	0.87	2.26	70.54	3.26	8.50	265.59	
127-18-4	Tetrachloroethene	0.26	1.05	ND	1.76	7.13	ND	
108-90-7	Chlorobenzene	0.43	1.97	85.76	1.99	9.06	394.75	
1330-20-7	m,p-Xylenes	0.92	2.29	284.37	3.98	9.95	1,234.56	
100-42-5	Styrene	0.90	2.24	ND	3.82	9.54	ND	
95-47-6	o-Xylene	0.89	2.23	133.04	3.87	9.68	577.59	
79-34-5	1,1,2,2-Tetrachloroethane	0.43	1.07	ND	2.94	7.34	ND	
106-46-7	1,4-Dichlorobenzene	0.87	1.50	ND	5.20	8.99	ND	
95-50-1	1,2-Dichlorobenzene	1.73	2.16	ND	10.40	13.00	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	93	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

Analytical Method: TO-15

SDG: 220163
Laboratory ID: 12

File Name: 2016312B.D
Description: GW-42D
Canister: 11736
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 Time: 09:44
Date Analyzed: 4/16/2020 Time: 18:39
Can Dilution Factor: 1.73
Air Volume: 25.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
100-41-4	Ethylbenzene	7.32	18.29	2,286.49	31.76	79.41	9,926.53	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	108	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	12

File Name:	2016312A	Date Sampled:	04/09/20	Time:	9:44
Description:	GW-42D	Date Analyzed:	04/14/20	Time:	15:33
Can/Tube#:	11736	Can Dilution Factor:	1.73		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.02	0.06	13.07	173	519	130,718	
124-38-9	Carbon Dioxide	0.02	0.06	15.50	173	519	155,021	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: 220163

Analytical Method: EPA 16

Laboratory ID: 12

File Name:	2016312A	**Date Sampled:**	04/09/20	**Time:**	9:44
Sample ID	GW-42D	**Date Analyzed:**	04/14/20	**Time:**	15:34
Can/Tube#:	11736	**Can Dilution Factor:**	1.73		
QC_Batch:	041420-GCP	**Air Volume:**	5.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	28.0	83.9	12,938.8	39.1	117.2	18,071.9	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 13

File Name: 2016313A.D
Description: B-5
Canister: 322
QC_Batch: 041520-MA1

Date Sampled: 4/9/2020 Time: 10:48
Date Analyzed: 4/15/2020 Time: 15:06
Can Dilution Factor: 1.55
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.95	ND	1.34	4.03	ND	
75-01-4	Vinyl chloride	0.39	1.95	ND	0.99	4.98	ND	
75-00-3	Chloroethane	0.39	1.95	ND	1.02	5.14	ND	
75-69-4	Trichlorofluoromethane	0.39	1.95	ND	2.18	10.97	ND	
75-35-4	1,1-Dichloroethene	0.39	1.92	ND	1.53	7.61	ND	
76-13-1	Freon 113	0.39	1.85	ND	2.97	14.20	ND	
75-09-2	Dichloromethane	0.78	1.87	ND	2.69	6.48	ND	
156-60-5	trans-1,2-Dichloroethene	0.39	1.40	ND	1.53	5.54	ND	
75-34-3	1,1-Dichloroethane	0.39	1.93	ND	1.57	7.82	ND	
108-05-4	Vinyl acetate	0.39	1.70	ND	1.36	5.99	ND	
109-99-9	Tetrahydrofuran	0.78	1.95	ND	2.28	5.75	ND	
156-59-2	cis-1,2-Dichloroethene	0.78	2.08	ND	3.07	8.26	ND	
71-55-6	1,1,1-Trichloroethane	0.39	1.72	ND	2.11	9.38	ND	
107-06-2	1,2-Dichloroethane	0.39	1.77	ND	1.57	7.15	ND	
71-43-2	Benzene	0.78	1.55	ND	2.47	4.95	ND	
79-01-6	Trichloroethene	0.23	1.80	ND	1.25	9.70	ND	
108-10-1	4-Methyl-2-pentanone	1.55	5.87	ND	6.35	24.03	ND	
108-88-3	Toluene	0.78	2.02	2.73	2.92	7.62	10.28	
127-18-4	Tetrachloroethene	0.23	0.94	ND	1.58	6.39	ND	
108-90-7	Chlorobenzene	0.39	1.76	ND	1.78	8.12	ND	
100-41-4	Ethylbenzene	0.82	2.05	2.98	3.56	8.89	12.94	
1330-20-7	m,p-Xylenes	0.82	2.05	6.15	3.57	8.92	26.71	
100-42-5	Styrene	0.80	2.01	ND	3.42	8.55	ND	
95-47-6	o-Xylene	0.80	2.00	2.63	3.47	8.67	11.44	
79-34-5	1,1,2,2-Tetrachloroethane	0.38	0.96	ND	2.63	6.58	ND	
106-46-7	1,4-Dichlorobenzene	0.78	1.34	ND	4.66	8.06	ND	
95-50-1	1,2-Dichlorobenzene	1.55	1.94	ND	9.31	11.64	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	100	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	13

File Name:	2016313A	Date Sampled:	04/09/20	Time:	10:48
Description:	B-5	Date Analyzed:	04/14/20	Time:	10:08
Can/Tube#:	322	Can Dilution Factor:	1.55		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.02	0.06	ND	155	465	ND	ND
124-38-9	Carbon Dioxide	0.02	0.06	0.07	155	465	708	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

SDG: **220163**

Analytical Method: EPA 16

Laboratory ID: **13**

File Name:	2016313A	**Date Sampled:**	04/09/20	**Time:**	10:48
Sample ID	B-5	**Date Analyzed:**	04/13/20	**Time:**	20:37
Can/Tube#:	322	**Can Dilution Factor:**	1.55		
QC_Batch:	041320-GCP	**Air Volume:**	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	12.5	37.6	ND	17.5	52.5	ND	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

Analytical Method: TO-15

SDG: 220163
Laboratory ID: 14

File Name: 2016314A.D
Description: MAN 2
Canister: 252
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 Time: 10:55
Date Analyzed: 4/16/2020 Time: 14:17
Can Dilution Factor: 1.32
Air Volume: 200.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
74-87-3	Chloromethane	0.65	1.66	ND	1.34	3.43	ND	
75-01-4	Vinyl chloride	0.33	1.66	87.82	0.84	4.24	224.38	
75-00-3	Chloroethane	0.33	1.66	28.12	0.87	4.38	74.16	
75-69-4	Trichlorofluoromethane	0.35	1.66	4.77	1.97	9.34	26.81	
75-35-4	1,1-Dichloroethene	0.33	1.64	ND	1.31	6.48	ND	
76-13-1	Freon 113	0.33	1.58	ND	2.53	12.10	ND	
75-09-2	Dichloromethane	0.66	1.59	ND	2.29	5.52	ND	
156-60-5	trans-1,2-Dichloroethene	0.33	1.19	ND	1.31	4.72	ND	
75-34-3	1,1-Dichloroethane	0.33	1.65	7.11	1.34	6.66	28.79	
108-05-4	Vinyl acetate	0.33	1.45	ND	1.16	5.10	ND	
109-99-9	Tetrahydrofuran	0.66	1.66	101.62	1.95	4.89	299.52	
156-59-2	cis-1,2-Dichloroethene	0.66	1.78	14.12	2.61	7.03	55.94	
71-55-6	1,1,1-Trichloroethane	0.33	1.47	ND	1.80	7.99	ND	
107-06-2	1,2-Dichloroethane	0.33	1.51	ND	1.34	6.09	ND	
71-43-2	Benzene	0.66	1.32	154.01	2.11	4.21	491.72	
79-01-6	Trichloroethene	0.20	1.54	ND	1.06	8.26	ND	
108-10-1	4-Methyl-2-pentanone	1.32	5.00	ND	5.41	20.47	ND	
127-18-4	Tetrachloroethene	0.20	0.80	2.18	1.34	5.44	14.80	
108-90-7	Chlorobenzene	0.33	1.50	115.34	1.52	6.91	530.92	
100-42-5	Styrene	0.68	1.71	ND	2.91	7.28	ND	
79-34-5	1,1,2,2-Tetrachloroethane	0.33	0.82	ND	2.24	5.60	ND	
106-46-7	1,4-Dichlorobenzene	0.66	1.14	ND	3.97	6.86	ND	
95-50-1	1,2-Dichlorobenzene	1.32	1.65	ND	7.93	9.92	ND	

	Surrogate Recovery	% Rec.	QC Limits LCL	UCL	Flag
2037-26-5	Toluene-d8	93	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 14

File Name: 2016314B.D
Description: MAN 2
Canister: 252
QC_Batch: 041620-MA1

Date Sampled: 4/9/2020 Time: 10:55
Date Analyzed: 4/16/2020 Time: 19:14
Can Dilution Factor: 1.32
Air Volume: 25.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
108-88-3	Toluene	5.28	13.78	827.88	19.88	51.88	3,116.97	
1330-20-7	m,p-Xylenes	5.60	13.99	1,845.77	24.30	60.74	8,013.21	
95-47-6	o-Xylene	5.44	13.61	408.67	23.63	59.07	1,774.18	

	Surrogate Recovery	% Rec.	QC Limits LCL	QC Limits UCL	Flag
2037-26-5	Toluene-d8	102	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method TO-15 Modified Full Scan GC/MS

SDG: 220163

Analytical Method: TO-15

Laboratory ID: 14

File Name: 2016314A.D
Description: MAN 2
Canister: 252
QC_Batch: 041720-ma1

Date Sampled: 4/9/2020 Time: 10:55
Date Analyzed: 4/17/2020 Time: 18:52
Can Dilution Factor: 2.21
Air Volume: 5.00 ml

CAS#	Compound	MDL PPBV	RL PPBV	Amount PPBV	MDL UG/M3	RL UG/M3	Amount UG/M3	Flag
100-41-4	Ethylbenzene	46.73	116.83	3,077.72	202.88	507.19	13,361.59	

	Surrogate Recovery	% Rec.	QC LCL	Limits UCL	Flag
2037-26-5	Toluene-d8	108	70	130	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

ASTM D 1945 GC/TCD

Analytical Method:	D1945	SDG:	220163
		Laboratory Number:	14

File Name:	2016313A	Date Sampled:	04/09/20	Time:	10:55
Description:	MAN 2	Date Analyzed:	04/14/20	Time:	13:30
Can/Tube#:	252	Can Dilution Factor:	1.32		
QC_Batch:	041420-GCO				

CAS#	Compound	MDL %	RL %	Result %	MDL ppmv	RL ppmv	Result ppmV	Flag
74-82-8	Methane	0.01	0.03	13.48	132	396	134,843	
124-38-9	Carbon Dioxide	0.01	0.03	14.99	132	396	149,921	

ANALYTICAL REPORT

ENVIRONMENTAL
Analytical Service, Inc.

EPA Method 16 Modified Hydrogen Sulfide GC/FPD

Analytical Method:	EPA 16	SDG:	220163
		Laboratory ID:	14

File Name:	2016314A	Date Sampled:	04/09/20	Time:	10:55
Sample ID	MAN 2	Date Analyzed:	04/14/20	Time:	13:26
Can/Tube#:	252	Can Dilution Factor:	1.32		
QC_Batch:	041420-GCP	Air Volume:	10.00 ml		

CAS#	Compound	MDL ppbv	RL ppbv	Amount ppbv	MDL ug/m3	RL ug/m3	Amount ug/m3	Flag
7783-06-4	Hydrogen Sulfide	10.7	32.0	88.4	14.9	44.7	123.5	

Appendix D: Hydrogen Sulfide Toxicological Profile

Toxicological Profile for Hydrogen Sulfide

Hydrogen sulfide is a flammable, colorless gas with a characteristic odor of rotten eggs. In a landfill, anaerobic bacteria produce hydrogen sulfide, along with methane and carbon dioxide, as a byproduct of digestion of waste. Ambient air concentrations of hydrogen sulfide from natural sources range between 0.00011 parts per million (ppm) (0.15332 micrograms per cubic meter [$\mu g/m^3$]) and 0.00033 ppm (0.45997 $\mu g/m^3$). Concentrations of hydrogen sulfide in urban areas are generally less than 0.001 ppm. The general population is primarily exposed to hydrogen sulfide via the inhalation route. Information on the toxicity of hydrogen sulfide in humans comes from case reports, occupational studies, and community studies. The human data suggest that the respiratory tract and nervous system are the most sensitive targets of hydrogen sulfide toxicity. The most commonly reported non-lethal effect found in individuals acutely exposed to high concentrations of hydrogen sulfide is unconsciousness followed by apparent recovery. Although there is an apparent recovery, many individuals report permanent or persistent neurological effects including headaches, poor concentration ability and attention span, impaired short-term memory, and impaired motor functions. Respiratory distress or arrest and pulmonary edema are also associated with exposure to very high concentrations of hydrogen sulfide (about 500 ppm for less than 1 hour). It is believed that these respiratory effects are secondary to central nervous system depression or due to tissue hypoxia. Cardiovascular effects (e.g., irregular heartbeats or abnormally rapid heart rates) have also been observed following an acute exposure to high concentrations of hydrogen sulfide (ATSDR 2016).

Exposure to lower concentrations of hydrogen sulfide can results in less severe neurological and respiratory effects. Reported neurological effects include loss of coordination, poor memory, hallucinations, personality changes and the loss of sense of smell. The respiratory effects include nasal symptoms, sore throat, cough, and difficult or labored breathing (ATSDR 2016).

The reference concentration (RfC) for hydrogen sulfide is $2x10^{-3}$ milligrams per cubic meter (mg/m^3). The information has been reviewed but a reference dose (RfD) value has not been estimated. Data are inadequate of an assessment of human carcinogenic potential (IRIS 2003).

In the atmosphere, hydrogen sulfide may be oxidized by oxygen and ozone to produce sulfur dioxide, and ultimately sulfate compounds. Sulfur dioxide and sulfates are eventually removed from the atmosphere through absorption by plants, deposition on and sorption by soils, or through precipitation. A residence time of approximately 1.7 days at an ozone concentration of 0.05 mg/m^3 has been calculated for hydrogen sulfide. The lifetime of hydrogen sulfide in air is estimated to range from approximately 1 day in summer to 42 days in the winter (ATSDR 2016).