APPENDIX K
GROUND RUN-UP ENCLOSURE SITING STUDY

This appendix includes a copy of the Final Ground Run-up Enclosure (GRE) Siting Study. A GRE, commonly referred to as a "hush house" was evaluated at Seattle-Tacoma International Airport (Sea-Tac Airport) concurrently with this Part 150 Noise Compatibility Study Update.

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SEATTLE-TACOMA INTERNATIONAL AIRPORT GROUND RUN-UP ENCLOSURE SITING OPTIONS

INTRODUCTION

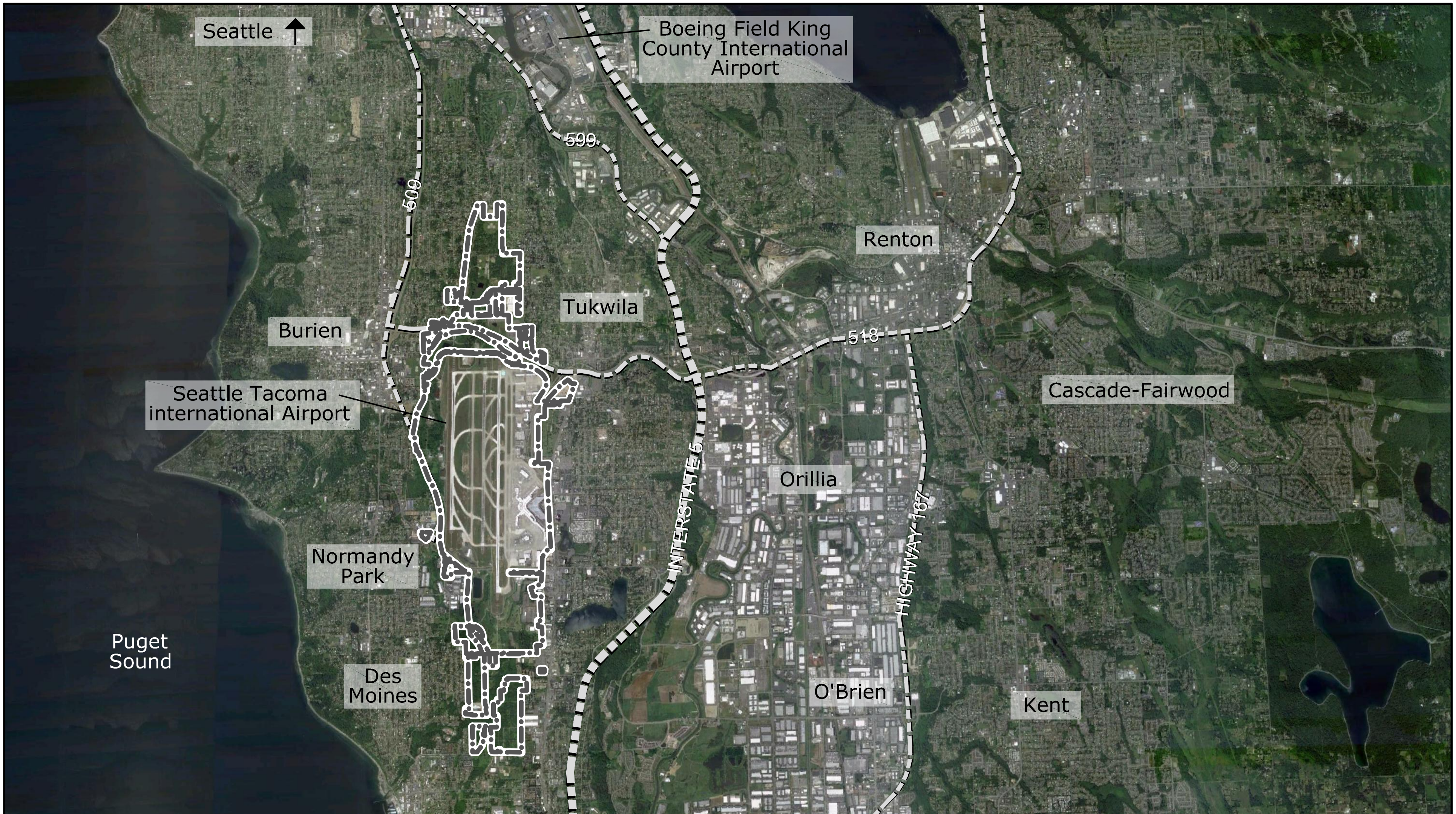
Routine aircraft maintenance activities require engines to be tested at take-off power to ensure the proper operation of the aircraft. These maintenance activities are known as Ground Run-Ups. The location of Ground Run-Up events take place at designated points on the airfield, taking into account take-off power jet blast impacts, impacts to airfield flows, orientation of the aircraft to ensure headwinds are maintained, and the adjacency of noise sensitive areas.

Ground run-ups ensure the safety and effectiveness of aircraft engines, however may impact the surrounding community with increased noise levels. Over the last 10 years, noise complaints have consistently identified run ups as a source of concern, particularly for the areas south and southwest of the Airport. An analysis of single-event noise associated with run up activity was conducted through the use of temporary monitors and modeling using the Integrated Noise Model (INM). The results of that analysis indicated that run up activity does increase noise levels in the areas south and southwest of the Airport and is discernible from the noise related to flight activity. The construction of a Ground Run-Up Enclosure (GRE) reduces noise levels generated by maintenance activities, as well as moderating potentially hazardous jet blast. A GRE is a noise dampening structure used throughout the industry. For these reasons, it was determined that a study be conducted to identify and evaluate locations on the Airport that could support a GRE.

This document and the analyses that follow discuss the minimum requirements of a GRE structure and facility location at Seattle-Tacoma International Airport (SEA-TAC). The previous *Seattle-Tacoma International Airport Feasibility and Siting Study* dated 2001 were revalidated as part of this effort and portions of the analysis were reused as appropriate. New site alternatives have been proposed based on present day circumstances at SEA-TAC and updated fleet mixes and maintenance logs have been incorporated in this analysis to reflect current day conditions.

A GRE workshop was conducted with SEA-TAC Planning, Operations, Noise, and FAA ATCT in order to gain input on the site and design alternatives. The results of this coordination were incorporated into the site alternative evaluations. A copy of the workshop materials are found in **Appendix A.**

The location of SEA-TAC Airport and the surrounding region is illustrated in **Exhibit 1.**



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

LOCATION MAP

N W E S

DATE: JULY 2011

Exhibit 1

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBIT_LOCATION MAP ONLY.dwg Layout: 1. REGIONAL AREA

1. STUDY METHODOLOGY

The task and planning considerations that follow reflect the baseline methodology used to develop this GRE facility and site alternatives analysis:

1.1 Aircraft Types

- Evaluate aircraft maintenance logs to determine frequency, location and types of aircraft performing ground run-up procedures.
- Establish the aircraft the GRE will be designed for based upon capturing the majority of the aircraft fleet performing ground run-ups.

1.2 GRE Facility Sizing

- Provide a general overview of GRE information and facility sizing options.
- Analyze aircraft properties (engine placement, turn radius/maneuvering, jet blast, wingtip clearances) for facility sizing.

1.3 GRE Site Location

- Revisit the 2001 Siting and Feasibility Study and revalidate GRE site alternatives, reuse site options as appropriate, and identify new criteria as necessary.
- Identify new site opportunities based on area availability, impacts to existing and possible future facilities, impacts to taxiway flows, GRE orientation, and airport safety; based on present day conditions.
- Establish general unit costs for site development and GRE construction to develop order of magnitude cost estimates.
- Establish feasible GRE facility locations to be considered in further study and recommended for FAA funding eligibility.

2. DATA COLLECTION & ASSUMPTIONS

The data and assumptions used for this GRE siting analysis included the following sources:

- Existing Ground Run-Up procedures and locations
- Previous GRE Site Alternatives (found in the *Seattle-Tacoma International Airport GRE Feasibility and Siting Study*)
- Wind Analysis
- Recommendation of Optimal Orientation
- Forecast of Aviation Activity
- Airport Maintenance Logs
- Recommendation of Facility Sizing
- Existing On-Airport land use and Site Availability
- GRE Operational Assumptions
- Future facility developments

2.1 Existing Ground Run-Up Procedures

Currently there are time restrictions imposed by the Airport for conducting ground run-ups. Aircraft that must depart the airfield before 8:30am may opt to ask permission for an early run-up between the hours of 6:00am and 7:00am. There is currently a nighttime curfew prohibiting ground run-ups from 10:00pm to 7:00am, thus daily run-ups should occur between 7:00am and 10:00pm; however exceptions are made according to the maintenance logs. It is indicated in the maintenance run-up log for 2009 that ground run-ups occur both during the day and into night. The current run-up locations are identified in **Exhibit 2**. Engine run-up locations at the Airport are selected for usage based upon wind direction, airfield traffic, time of day, aircraft ownership, and the type of run-up operation performed.

2.2 Previous GRE Site Alternatives

In the *Seattle-Tacoma International Airport GRE Feasibility and Siting Study*, a number of suggested GRE sites were identified. Due to changes since the 2001 study, including new facilities construction and revisions to the Airport's Master Plan for future facilities development, new locations were selected as potential GRE sites for this analysis. Portions of the previous Feasibility Study have been refreshed or reused throughout this analysis.

GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA INTERNATIONAL AIRPORT

EXISTING GROUND RUN-UP LOCATIONS

DRAFT

1"=1400'

700 0 1400

W N S E

DATE: JULY 2011

Exhibit 2

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM-LS.dwg, Layout: 2. RUNUP LOCATIONS

2.3 Recommendation of Optimal Orientation

The GRE should be oriented in a manner that results in aircraft engines facing into the prevailing winds in order to maximize air intake and obtain optimal engine performance. Currently, ground run-ups are conducted at different locations and orientations on the airfield based upon wind directions so the aircraft can be oriented into the wind for maximum run-up efficiency.

As seen in the windrose diagrams in **Appendix B**, the historical trend suggests the winds at SEA-TAC predominantly come from the southwest, suggesting a GRE be placed in a southwest facing direction. However, there are a number of occasions when winds are coming from another direction other than southwest. Presently, airline maintenance personnel are able to choose a different location and/or orientation for each engine run-up based on the current wind direction; whereas, if a GRE was in use, the ground run-ups would only achieve optimal performance standards when the prevailing winds are from the southwest.

The optimal orientation for a GRE is determined by analyzing historic wind data for the Airport. The historic wind data indicates that the optimal orientation of a GRE is approximately 185-195 degrees. A GRE Design Study would identify the maximum wind coverage expected to be achieved at the optimal orientation.

An independent wind analysis was performed by Blast Deflectors Inc. (BDI), a GRE facility development vendor, in order to supplement the traditional analysis performed for this study. The BDI study took into account their proprietary GRE designs which ensure the appropriate air flow conditions are maintained when winds are coming from less than favorable directions. The results of the BDI wind analysis, including both assured and projected wind coverage, can be further reviewed in **Appendix C.** The information in Appendix C prepared by BDI should also be considered when determining the most appropriate orientation for a GRE facility at SEA-TAC. Emerging GRE technologies can mitigate some of the complications associated with a less than optimal facility orientation due to site constraints.

2.4 Airport Maintenance Logs

Determining the design aircraft for a GRE facility involves an evaluation of existing maintenance activity to identify the most demanding aircraft as well as identifying airline future fleet mix assumptions. Maintenance logs, as well as the SEA-TAC Part 150 Forecast of aviation activity, were reviewed in order to determine the maintenance needs of the Airport. A summarized table of ground run-up activity at SEA-TAC in 2009 is found in **Table 1** and organized according to most demanding aircraft size and turning radius**. Table 2** shows total run-ups in 2009 by airline.

Table 1 - Annual Aircraft Maintenance (2009) & Aircraft Characteristics

Aircraft Type	Historical Maintenance Operations Stats	% of Ops 2009	Overall Length (ft)	Height (ft)	Wingspan (ft)	Engine Location	Turning Radius (ft)
B747	1	0.19%	232	64	213	4-under wing	204
B777	4	0.76%	243	62	200	2-under wing	198
B787	1	0.19%	186	56	197	2-under wing	186
A330	3	0.57%	209	60	198	2-under wing	185
MD11	1	0.19%	203	59	171	2- under wing 1-tail	178
DC10	4	0.76%	183		156	2-under wing 1-tail	162
B767	7	1.34%	202	56	171	2-under wing	154
B757	51	9.73%	156	45	125	2-under wing	133
MD80	15	2.86%	148	30	108	2-back fuselage	129
MD90	3	0.57%	134	31	94	2-back fuselage	125
B737	261	49.81%	130	42	113	2-under wing	111
B737-900W	0	0	138	42	117.5	2-under wing	119
CRJ	16	3.05%	182	25	76	2-back fuselage	106
A320	9	1.72%	124	40	112	2-under wing	102
Dash 8	78	14.89%	107	28	94	2-under wing	96
Any Aircraft smaller than Dash 8[1]	70	13.36%	—	—	—	—	—

Source: Port of Seattle Maintenance Run-up Logs, 2009.

[1] Aircraft smaller than the Dash 8 would be able to perform power-in and power-out maneuvers in a GRE facility sized for B737-800 aircraft

Table 2 - Ground Run-Up Activity by Airline

Airline	2009 Existing Activity	
	2009 Ground Run-Ups (by airline)	% of Total 2009 Ground Run-Ups
Alaska Airlines	221	42.2%
American Airlines	17	3.2%
Delta Airlines	58	11.1%
FedEx	24	4.6%
Horizon Air	117	22.3%
United Airlines	42	8.0%
Others	45	8.6%
Totals	***524***	***100%***

Source: Port of Seattle Maintenance Run-up Logs, 2009.

The maintenance reports indicate that 83% of the ground run-ups at SEA-TAC are B737s or smaller. The B737 accounts for approximately 50% of the annual ground run-ups. Aircraft larger than the B737-800 account for approximately 17% of all ground run-up operations. The largest aircraft used in an engine run-up by one of the airline maintenance facilities was a B747, which occurred once in 2009.

2.5 Forecast of Aviation Activity

The Part 150 Aviation Forecast for SEA-TAC was assessed during the data collection process to develop a projection of the future fleet that may use the GRE. Future airline fleets and upgrades were considered in the analysis of the GRE size at SEA-TAC.

Maintenance logs show 524 ground run-up procedures occurred at SEA-TAC in 2009. Applying the forecast of activity and assuming operations and ground run-ups are correlated, 621 ground run-ups are expected to occur in 2021, an increase of 97 procedures, or 19 percent. Total ground run-up operations have been rounded up in order to avoid ill-defined results. The following assumptions have been made for developing a forecast of Ground Run-Ups for SEA-TAC.

Aging fleets are anticipated to be replaced with various other aircraft and the assumptions detailed in the Part 150 forecast are accounted for within the GRE fleet mix projections. The introduction of the Boeing 787 series aircraft is anticipated to replace aging fleets as well. In line with the Part 150 forecast, the GRE usage forecast assumes Delta Airlines 757-200 aircraft will be replaced with Boeing 787 series aircraft. According to the latest forecast available when this study was initiated, it is anticipated that approximately 1,200 Boeing 787 series operations will occur at the Airport in the 2021 out year. Assuming operation levels and maintenance activity of other aircraft types correlate; it can be assumed that approximately 0.25% of 787 series aircraft operations will perform a ground run-up (approximately three ground run-ups annually). **Table 3** provides an overview of the anticipated ground run-up activity from 2009 to 2021 and is sorted according to aircraft performing the most ground run-ups in 2009.

2.6 Recommendation of Facility Sizing

Determining the design aircraft for the SEA-TAC GRE is important for configuring both GRE size and location. The design aircraft used for sizing the GRE was determined using the current maintenance logs from 2009 and forecast of ground run-up activity in the year 2021 described in the section above. These reports indicate that approximately 83 percent of the ground run-ups at SEA-TAC are conducted by the B737 or smaller aircraft. The B737 alone makes up almost 50 percent of the annual ground run-ups and determined to be the design aircraft for a GRE facility. Alaska Airlines plans on purchasing B737-900s with winglets (B737-900W) in the future and the adjusted wingspan will be accounted for in the facility sizing exercise in Section 3 of this document. Designing a GRE facility to accommodate a B737-900W facility can take two separate approaches. A facility designed around tug-in and tug-out maneuvers of the B737-900W will have a smaller footprint and can only accommodate wingspans within the ADG III category. A facility designed around B737-900W power-in and power-out maneuvers has a larger facility footprint and greater clearances to accommodate ADG III aircraft entering nose-first, and executing a turn-around. Aircraft with larger wingspans would be able to tug-in and tug-out of this type of facility. Further explanation of the implications of power-in and power out versus tug-in and tug-out GRE designs is discussed in Section 3 of this document.

Table 3 - Forecast of Ground Run-Up Activity by Aircraft Type

Aircraft Type	2009 Existing Activity				2021 Forecast Activity				
	2009 Ground Run-Ups (by aircraft)	Aircraft % of Total 2009 Ground Run-Ups	Total 2009 SEA-TAC Aircraft Ops	Ground Run-Ups % of Total SEA-TAC Ops	12-Year % Fleet Mix Growth	2021 Total SEA-TAC Aircraft Ops Forecast	Aircraft % of Total 2021 Ground Run-Ups	Ground Run-Ups % of Total 2021 SEA-TAC Aircraft Ops	2021 Ground Run-Ups Forecast Estimate
B737	261	49.8%	135,625	0.19%	43%	194,605	60.4%	0.19%	**375**
Dash 8	78	14.9%	67,035	0.12%	47%	98,500	18.5%	0.12%	**115**
Other Aircraft	70	13.4%	17,409	0.40%	-35%	11,393	7.4%	0.40%	**46**
B757	51	9.7%	24,805	0.21%	-67%	8,275	2.7%	0.21%	**17**
MD80/90	18	3.4%	9,021	0.20%	-100%	-	-	-	**-**
CRJ	16	3.1%	18,118	0.09%	18%	21,300	3.1%	0.09%	**19**
A320	9	1.7%	25,491	0.04%	135%	60,027	3.5%	0.04%	**22**
B767	7	1.3%	2,787	0.25%	-55%	1,261	0.6%	0.25%	**4**
B777	4	0.8%	2,405	0.17%	32%	3,180	1.0%	0.17%	**6**
MD-10/DC10	4	0.8%	1,764	0.23%	29%	2,270	1.0%	0.23%	**6**
A330	3	0.6%	2,985	0.10%	109%	3,176	0.6%	0.10%	**4**
B747	1	0.2%	3,709	0.03%	47%	5,461	0.3%	0.03%	**2**
MD11	1	0.2%	532	0.19%	32%	700	0.3%	0.19%	**2**
B787	0	-		-	100%	1,192	0.5%	0.25%	**3**
Totals	***524***		***311,686***	***2.20%***		***411,340***		***2.25%***	***621***

Source: Port of Seattle Maintenance Run-up Logs, 2009; Landrum & Brown Analysis, 2011.

Designing the GRE around the B737-900W using power-in and power-out enables aircraft up to a B767-400 to also use the facility with tug-in and tug-out procedures. According to aircraft dimensional characteristics, any aircraft larger than a B767-400 would not be able to utilize this size of GRE. **Table 4** indicates a GRE facility designed around a B737-900W tug-in and tug-out[2] facility would accommodate approximately 93 percent of the ground run-up activity at SEA-TAC in 2021. A GRE facility designed to accommodate B737-900W power–in and power-out procedures would accommodate approximately 96 percent of all ground run-up activity, as displayed in **Table 5**. Using the B737-900W aircraft as the design aircraft for the GRE facility indicates that four percent of aircraft performing ground run-ups would be too large to use the facility with appropriate wingtip clearances and safety areas. The aircraft excluded from a B737-900W-sized GRE facility is detailed in **Table 6**. The MD-11 and MD-10/DC-10 aircraft have been excluded from the GRE size recommendations due to the placement of tail engines on the fuselage. The dimensions and operational characteristics of these aircraft could potentially be appropriate for a GRE facility designed around the B737-900W, and be used for testing the two underwing engines; however, the additional structure height needed to dampen noise from the tail engines may not justify the costs to accommodate five to eight ground run-ups per year. The remaining excluded aircraft (747, 777, 787, and A330 series aircraft) are excluded because of maneuverability to tug into a B737-900W power-in and power-out facility, as well as maintaining 45-50 feet of clearance from tail to the GRE structure for safe maneuvering and access to the aircraft in case of emergency. These safety buffers have been established by benchmarking other GRE facilities, and will require validation in the engineering phase of GRE development.

Table 4 - Aircraft Accommodate by B737-900W Tug-In/Tug-Out Sized GRE Facility

Aircraft Type	2009 Existing Activity		2021 Forecast Activity	
	2009 Ground Run-Ups (by aircraft)	% of Total 2009 Ground Run-Ups	12-Year Ground Run-Ups Forecast Estimate	% of Total 2021 Ground Run-Ups
B737	261	49.8%	**375**	60.4%
CRJ	16	3.1%	**19**	3.1%
A320	9	1.7%	**22**	3.5%
Dash 8	78	14.9%	**115**	18.5%
Other Aircraft	70	13.4%	**46**	7.4%
Totals	***434***	***83%***	***577***	***93%***

Source: Port of Seattle Maintenance Run-up Logs, 2009; Landrum & Brown Analysis, 2011.

[2] The type of facility described here and in Table 3 could also accommodate tug-in and power out operations. Facility size/space requirements would be the same if aircraft are pushed in by tug and power out as opposed to being pushed in and towed out. For future references to tug-in/tug-out operations, it is assumed that tug-in power out procedures could also be conducted at the discretion of the Port and aircraft operators.

Table 5 - Aircraft Accommodate by B737-900W Power-In/Power-Out Sized GRE Facility

Aircraft Type	2009 Existing Activity		2021 Forecast Activity	
	2009 Ground Run-Ups (by aircraft)	% of Total 2009 Ground Run-Ups	12-Year Ground Run-Ups Forecast Estimate	% of Total 2021 Ground Run-Ups
B767[3]	7	1.3%	**4**	0.6%
B7572[2]	51	9.7%	**17**	2.7%
MD80/90[2]	18	3.4%	**-**	-
B737	261	49.8%	**375**	60.4%
CRJ	16	3.1%	**19**	3.1%
A320	9	1.7%	**22**	3.5%
Dash 8	78	14.9%	**115**	18.5%
Other Aircraft	70	13.4%	**46**	7.4%
Totals	***510***	***97%***	***598***	***96%***

Source: Port of Seattle Maintenance Run-up Logs, 2009; Landrum & Brown Analysis, 2011.

Table 6 - Aircraft Excluded by B737-900W Sized GRE Facility

Aircraft Type	2009 Existing Activity		2021 Forecast Activity	
	2009 Ground Run-Ups (by aircraft)	% of Total 2009 Ground Run-Ups	12-Year Ground Run-Ups Forecast Estimate	% of Total 2021 Ground Run-Ups
B777	4	0.8%	**6**	1.0%
B747	1	0.2%	**2**	0.3%
B787	0	-	**3**	0.5%
MD11	1	0.2%	**2**	0.3%
MD-10/DC10	4	0.8%	**6**	1.0%
A330	3	0.6%	**4**	0.6%
Totals	***13***	***2%***	***23***	***4%***

Source: Port of Seattle Maintenance Run-up Logs, 2009; Landrum & Brown Analysis, 2011.

2.7 Existing On-Airport Land Use and Site Availability

On-Airport land use and site availability is another important factor in determining a GRE location and orientation. The Airport facilities and buildings have been established on the east side of the airfield with all three parallel runways oriented in a north/south direction. The west side of the airfield has limited space for the construction of facilities and currently has no buildings or commercial industry requiring entry onto the airfield. The west side of Airport property also has steep

[3] Aircraft required to tug-in and tug-out of B737-900W power-in and power-out sized facility

grades, requiring extensive earthworks to accommodate aircraft related

development. A GRE facility would be best suited on the east side of the Airport in order to maintain proximity to facilities utilizing the GRE, as well as minimizing the need for aircraft requiring GRE access to cross runways.

2.8 GRE Operational Assumptions

There were a number of operational assumptions made before determining GRE design and locations. The first assumption made was that the Airport expressed no interest in the development of a GRE on the west side of the airfield. The development of a GRE on this side would cause further congestion on the taxiways and runways, as well as, create safety concerns for both the pilots and ATCT. Also, extensive grading would need to be done in order to build on this side of the airfield. Other assumptions were made based upon the location of the GRE. When looking at the location of the GRE, the proximity to housing developments was considered, as well as the current engine run-up locations. The site location was also pertinent to the current locations of the major aircraft maintenance facilities. It has been suggested that a tug-in and tug-out procedure is more cost effective than a taxi-in and taxi-out operation. The certainty of this assumption is indeterminate at this time and should be evaluated for actual influence. The provision of ADG VI taxiway dimensional criteria and safety standards were taken into consideration as to avoid limitations on operating the airfield to potentially accommodate larger wingspan aircraft.

2.9 Future Facility Developments

A preliminary evaluation was conducted to identify potential GRE site impacts upon known future development based on discussions with Port staff. Upon the completion of preliminary site identification, SEA-TAC Airport Departments should be consulted to update this analysis and determine the specific future projects that will potentially be impacted. The results of this coordination should be incorporated into each GRE site evaluation.

3. GRE FACILITY TYPES AND RECOMMENDATIONS

3.1 GRE Facility Types

After researching a number of the different GREs used throughout the industry, three GRE types were identified as possible solutions for SEA-TAC:

- Two-sided GRE
- Three-sided GRE
- Circular GRE

3.1.1 Two-Sided GRE Facilities

A two-sided GRE contains only two walls, which include one acoustical side paneled wall, and one base wall that contains the blast deflector and an acoustical paneled wall behind the deflector. This type of GRE is less expensive, however not very common. This GRE has aircraft maneuvering flexibility for aircraft access and has the advantage of flexible site design. A two sided GRE will not deflect as much noise and exhaust as a three-sided GRE or circular GRE. The exhaust and noise will be deflected off of one side and the back of the aircraft still leaving the front and opposing side open for the release of both sound and exhaust.

3.1.2 Three-Sided GRE Facilities

A three-sided GRE is the most common amongst the existing GREs in the United States. Indianapolis, Portland, and Chicago-O'Hare are prime examples of airports that have three-sided GREs. Three-sided GREs are constructed of two acoustical paneled side walls and one rear acoustical wall with a jet blast deflector. An aircraft either has the option of entering the GRE through a tug-in and tug-out operation or a power-in and power-out option depending upon the size of GRE and type of aircraft conducting the run-up. With a fleet of predominately larger aircraft, this type of GRE can take up a significant amount of ramp area and space at an airport if power-in and power-out operations are maintained. The three-sided wall option has been proven to significantly reduce noise to surrounding airport communities and deflect jet blast effectively.

Figure 1: Oakland Pontiac International Airport in Michigan

3.1.3 Circular GRE Facilities

The third design option that was evaluated was a circular GRE. This is the least common design with one being located in Germany for the engine run-up testing of the A380. It is the largest GRE facility in the world and its design originally comes from a company in Dortmund, Germany. The original design was developed to act as a large turn table for turboprop aircraft ground run-ups with the intent of acquiring the same benefits as the more recent A380 GRE design. The A380 system operates a bit different than the original design but contains the same concepts. It consists of two interworking half circles, containing the acoustic walls and blast deflectors, on rail tracks. An aircraft can both enter and exit from any angle or side of the GRE, with wind direction and GRE orientation never being an issue. This type of GRE is ideal for airports with frequent opposing winds in the area. An aircraft can pull into the A380 GRE facility without any tug operations on one end of the GRE and then exit the opposing side without any turn around needed cutting down on time, and power. This is considered the "New Generation" of GREs and can solve almost all of a three-sided GREs concerns. A circular GRE would require less space to accommodate the structure; however, to fully maximize the capabilities for 360-degree aircraft orientation, additional apron space surrounding the facility would be needed for multiple aircraft entry/exit angles. Furthermore, this facility would be significantly more expensive than a typical two-sided or three-sided GRE. This facility would require more maintenance due to the moving components of the facility, thus creating higher maintenance costs for the Airport.[4]

Figure 2: A380 Engine Run-up Facility in Germany

3.2 GRE Facility Recommendations

A summary of benefits and limitations concerning the three types of facilities analyzed are described below:

3.2.1 Two Sided GRE

Benefits

- ☐ Ease of aircraft access
- ☐ More flexibility in site placement

4 Schafhaupt, H. APS Germany GmbH, Punchheim, Germany, 2006

Limitations

- Limited noise reduction
- Fixed orientation (facility usage limited to nominal wind directions)
- Uncommon facility type (design, costing, and effectiveness indistinct)

3.2.2 Three Sided GRE

Benefits

- Maximum noise reduction
- Common facility type

Limitations

- Larger structure footprint
- Fixed orientation (facility usage may be limited to nominal wind directions; however, design elements can overcome much of the wind limitations)

3.2.3 Circular GRE

Benefits

- Ease of aircraft access
- Maximum noise reduction
- Smaller structure footprint (however, larger apron area needed surrounding facility to take advantage of rotating entry/exit)
- Flexible orientation (adjustable for wind direction)

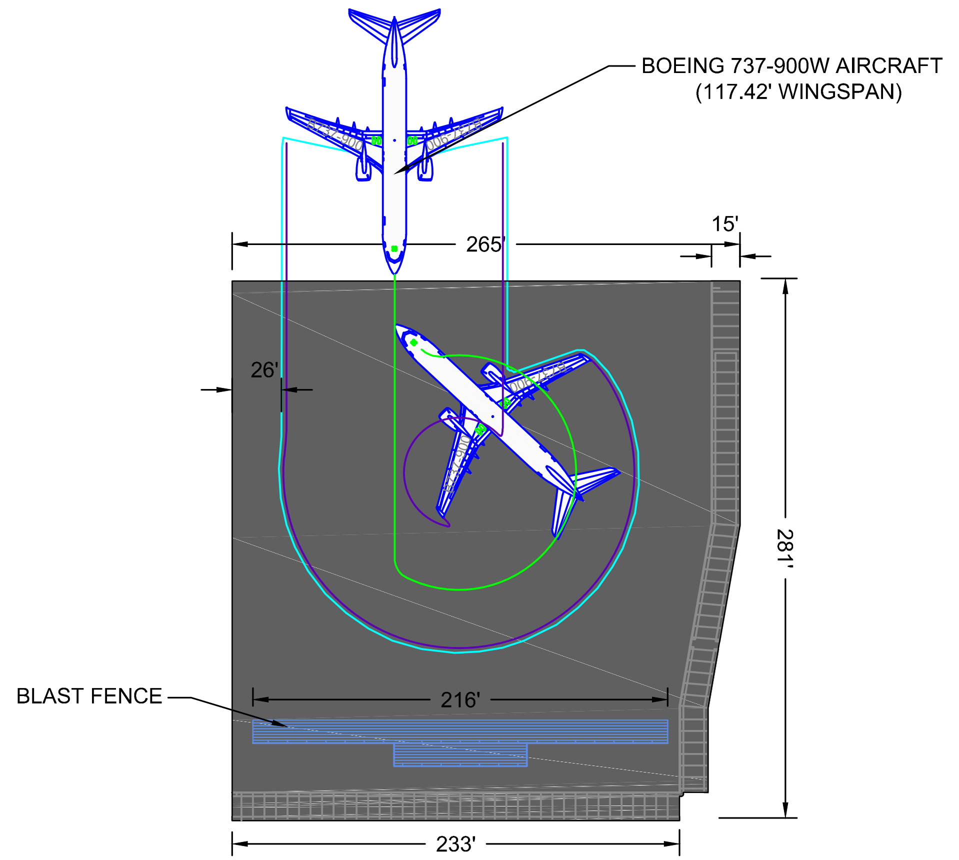
Limitations

- Uncommon facility type (design and costing indistinct)
- Costs associated with designed mechanical elements and maintenance of facility will be higher than other options.
- Larger ramp area needed

Although a two-sided GRE facility provides flexible siting for aircraft movements to and from the facility with relative ease, a two sided GRE facility will be limited in noise reduction. Both three-sided and circular GRE facilities will provide higher noise reduction benefits. The decision to implement either the common three-sided GRE facility or the new technology associated with a circular GRE will depend on funding availability and site opportunity benefits. The costs associated with each type of facility are discussed in the Alternatives section of this document. For the purposes of the site alternatives analysis, the more demanding three-sided GRE was evaluated with the thought that a circular GRE could also be accommodated.

However, this assumption does not take into account the additional space requirements for aircraft to access a circular facility from multiple angles. Such considerations should be included in a GRE design study.

In order to determine the appropriate dimensions for a B737-900W sized three-sided GRE facility, aircraft maneuvers and standard operating practices must be taken into account. Power-in and power-out procedures are preferred by airline maintenance crews. Aircraft maneuvers were evaluated with simulation software to determine a minimum-sized facility. The appropriate aircraft clearances to the GRE structure for the B737-900W are 49 feet for wingtip clearance, 31 feet for aircraft nose clearance, and 40 feet clearance from the tail of the aircraft. These clearances were determined using both existing safety area standards found in FAA Advisory Circular 150/5300-13, as well as, GRE measurements at similar airports. Exact clearances will be determined by a future GRE Design Study. A two-sided GRE designed for a B737-900W is illustrated in **Exhibit 3**. A three-sided GRE designed for a B737-900W is illustrated in **Exhibit 4**. A circular GRE designed for a B737-900W is illustrated in **Exhibit 5**.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

PROPOSED B737-900W
2-SIDED GRE DIMENSIONS

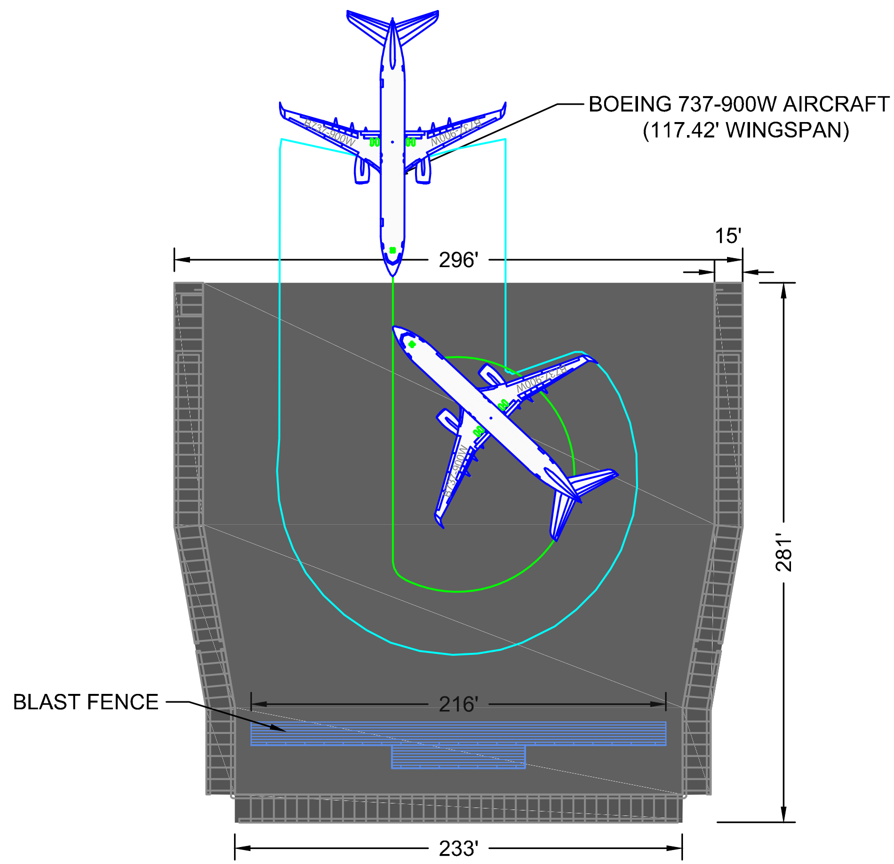
DRAFT

W N S E

DATE: JULY 2011

Exhibit
3

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 3. 2 SIDED GRE



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

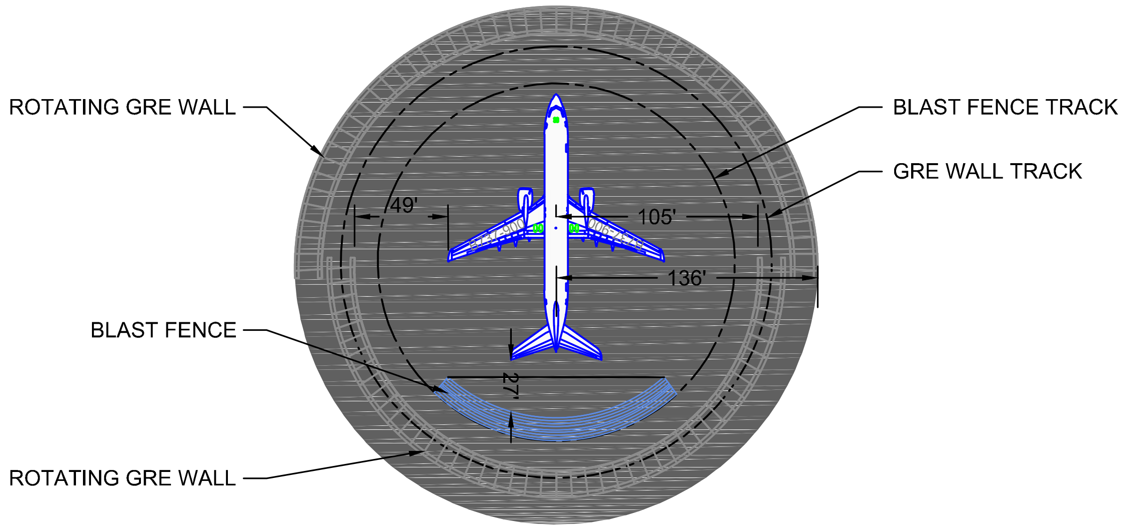
PROPOSED B737-900W THREE SIDED GRE

DRAFT

DATE: JULY 2011

Exhibit 4

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 4. 3 SIDED GRE



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

PROPOSED B737-900
CIRCULAR GRE
DIMENSIONS

DRAFT

DATE: JULY 2011

Exhibit
5

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg   Layout: 5. CIRCULAR GRE

4. GRE SITE ALTERNATIVES

4.1 Site Selection Criteria

The limited land available for new development at SEA-TAC must be considered when searching the Airport for potential GRE sites. The challenge of defining the envelope for development involves identifying a site convenient for all maintenance facilities to access the GRE, minimizing the displacement of present day uses, as well as the potential impacts of future developments. The potential for a site at SEA-TAC must also attempt to avoid impacts to existing operations to the best extent possible while providing a useful facility in the safest manner possible. The following listing of criteria was identified as the basis for searching out potential sites at SeaTac:

- Compatibility with existing facilities
- Compatibility with planned future facilities
- Optimal GRE orientation (to maximize wind coverage)
- Proximity to maintenance facilities Airfield traffic patterns (north/south flows)
- Aircraft access/taxi routing
- Airfield safety standards
- Proximity to surrounding neighborhoods for noise evaluations
- Other environmental impacts (wetlands, streams, etc.)

The previous 2001 GRE siting study indicated a general east side GRE location with no intention of an Airport west side location, which remains a valid site constraint in the present day. The placement of a GRE on the general east side of the Airport would avoid active runway crossings for aircraft accessing the GRE and ensure airfield congestion and taxi times could be minimized.

4.2 GRE Site Evaluation Criteria

Once potential site envelopes can be identified according to the general criteria above, the configuration of a GRE facility within the site is the subsequent consideration. The following listing identifies evaluation criteria used to determine airport planning related issues, impact factors to consider, and general feasibility of placing a GRE facility at each potential site.

4.2.1 Safety Considerations

The following design criteria established by FAA design regulations and standards were considered for each site alternative.

- **FAR Part 77 Surfaces -** Evaluating structure height to navigable airspace surfaces as defined in CFR 14, Part 77, Objects Affecting Navigable Airspace
- **ATCT Line of Sight impacts -** Obstruction to line of sight or limitations to structure height

- **Clear of Group VI Taxiway OFA**
  - A Group VI Taxiway OFA 193 feet perpendicular to nearby taxiway centerlines should be provided in order to not limit Group VI airfield operations in the event demand materializes
- **Clear of Runway Safety Areas**
  - Existing and Future Runway Safety Areas for the adjacent Runway 16L/34R should be maintained
- **NAVAID Critical Areas**
  - Any potential impacts to Localizer critical areas, Glide Slope critical areas, ASRs, etc.

4.2.2 Airfield Operational Impacts

Impacts to the airfield operations displacements due to the provision of a GRE, distances aircraft would have to maneuver in order to gain access to and from the facility, as well as any impacts to other Airport activities within the area of each site.

4.2.3 Impacts to Existing Facilities

Existing facility displacements, demolition requirements, relocations or limitations to adjacent facilities.

4.2.4 Impacts to Future Facilities

Identify conflicts with planned future projects in order to evaluate the significance of opportunities lost or fatal flaws. Or decide to provide redesigns for the planned projects displaced.

4.2.5 Site Preparation

Accommodating the construction of a GRE within the site may include site grading, additional pavements, provision of retaining walls, relocation of access roads or equipment storage, etc.

4.2.6 Costs

Cost associated with site preparation and construction

4.2.7 Proximity to Residential Uses

This includes a discussion of the relative change in noise levels for the nearest residences anticipated as a result of operating a GRE at each site.

4.3 GRE Facility Sites and Layout Alternatives

The previous 2001 GRE study was explored to determine if any previously identified sites were usable within the current Airport conditions. The 2001 sites were analyzed based upon the same criteria used to establish new sites.

After analyzing the sites from the 2001 study and establishing potential sites, seven recommended site alternatives were developed, identified as Sites "A" through "G" herein. **Exhibit 6** illustrates the location of these recommended site alternatives.

A community development assessment was conducted with the 2001 GRE siting study and does not require any further in-depth analysis at this time. However, the surrounding communities were re-examined for proximity to the GRE sites identified in this alternatives analysis. Each site's proximity to adjacent neighborhoods is illustrated in **Exhibit 7**.

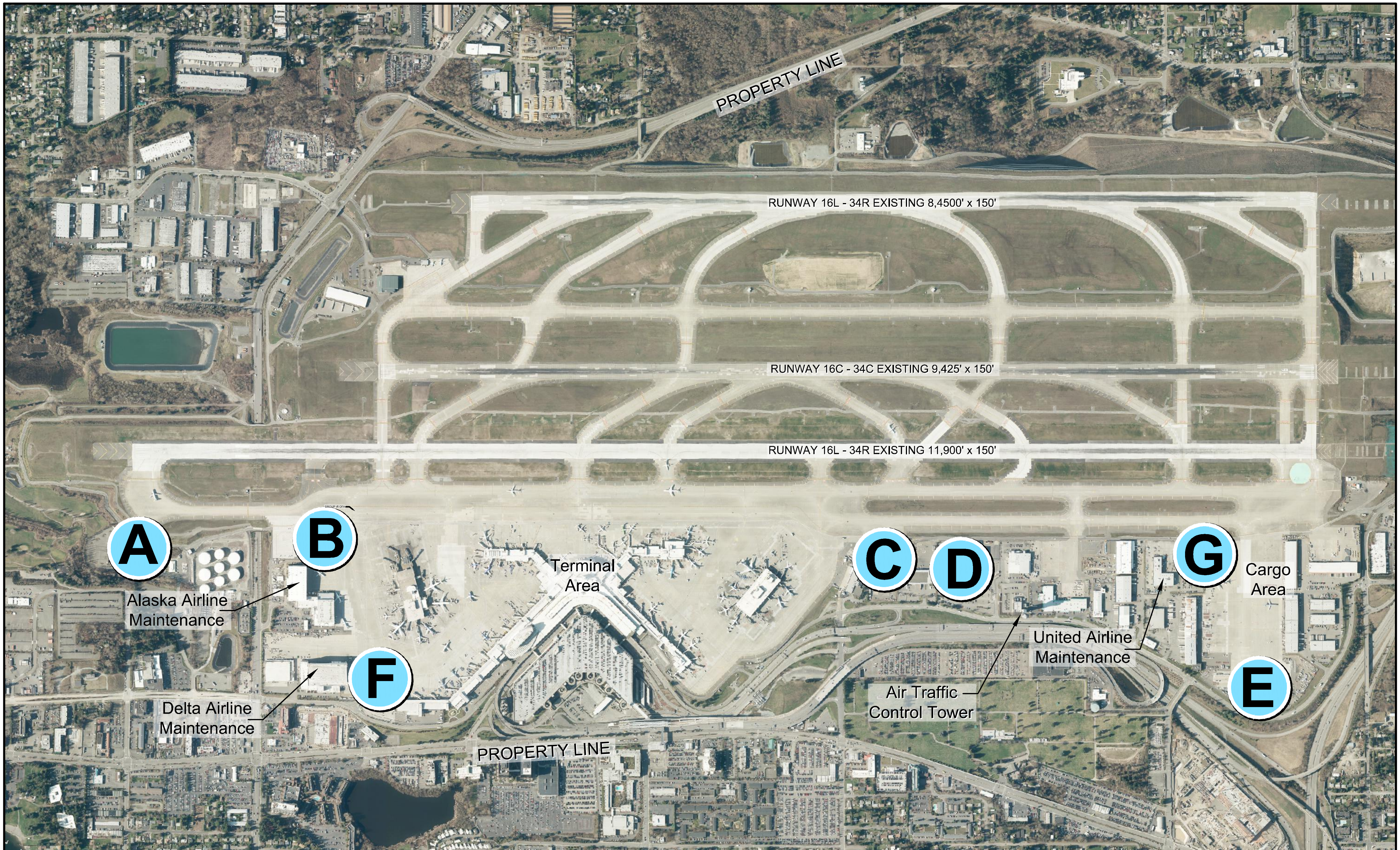
The following sections provide details concerning the seven sites identified as potential GRE facilities and the benefits and drawbacks for each site according to the criteria described above. The intent of the evaluation is to identify the feasibility limitations, and any special considerations required in order to move forward with a preferred recommendation. A summary of the evaluation of each site is included in **Table 6** at the end of this document.

4.4 GRE Site A

4.4.1 GRE Site A Location

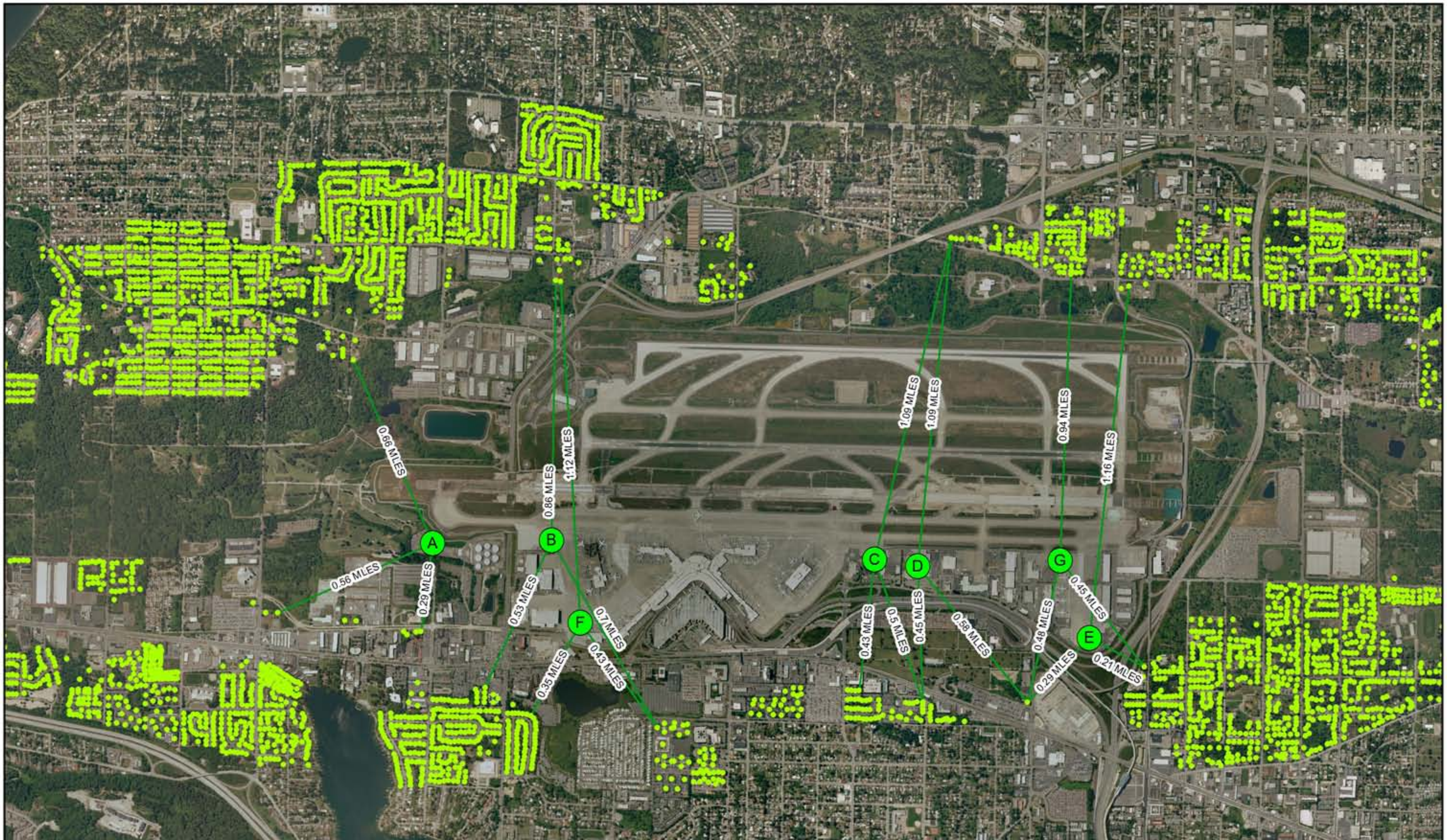
Site A is located on the far southeast end of the Airport nearest the fuel farm and end of Runway 34R. The distance to the Alaska Airlines Maintenance and Delta Airlines Maintenance Facilities is 4,023 feet and 4,611 feet respectively, whereas United Airlines Maintenance Facility is 11,835 feet away from Site A. The taxiing time to the maintenance facilities is as follows: approximately 6-8 minutes from the Alaska Airlines Maintenance Facility, 7-9 minutes from the Delta Airlines Maintenance Facility, and about 17-22 minutes from the United Airlines Maintenance Facility based upon unimpeded traffic flow.

Both a golf course and wetland reside due south of the selected site. This site may expose both of those areas to some form of jet blast if a GRE were constructed in this location. The wetland is immediately south of the proposed site. There are currently no buildings in the way preventing the Airport from building the GRE here. Thus, no demolition would need to take place. The site is clear of the FAR Part 77 Transitional Surface for Runway 16L/34R and there are no ATCT line of sight obstructions. The southeast side of the Airport has steep topography where Site A is located. Furthermore, **Exhibit 8** displays the location and surrounding facilities of GRE Site A. Significant earthwork and grading is required in order to prep the site for the construction of a GRE.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS	STUDIED GRE LOCATIONS	1"=1400'	DATE: JULY 2011
SEATTLE TACOMA INTERNATIONAL AIRPORT	DRAFT	700 0 1400	Exhibit 6

File: \\w3kcvgfs1\clients\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM-LS.dwg Layout: 6. PROPOSED GRE LOCATIONS



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA
INTERNATIONAL AIRPORT

RESIDENTIAL PROXIMITY ASSESSMENT

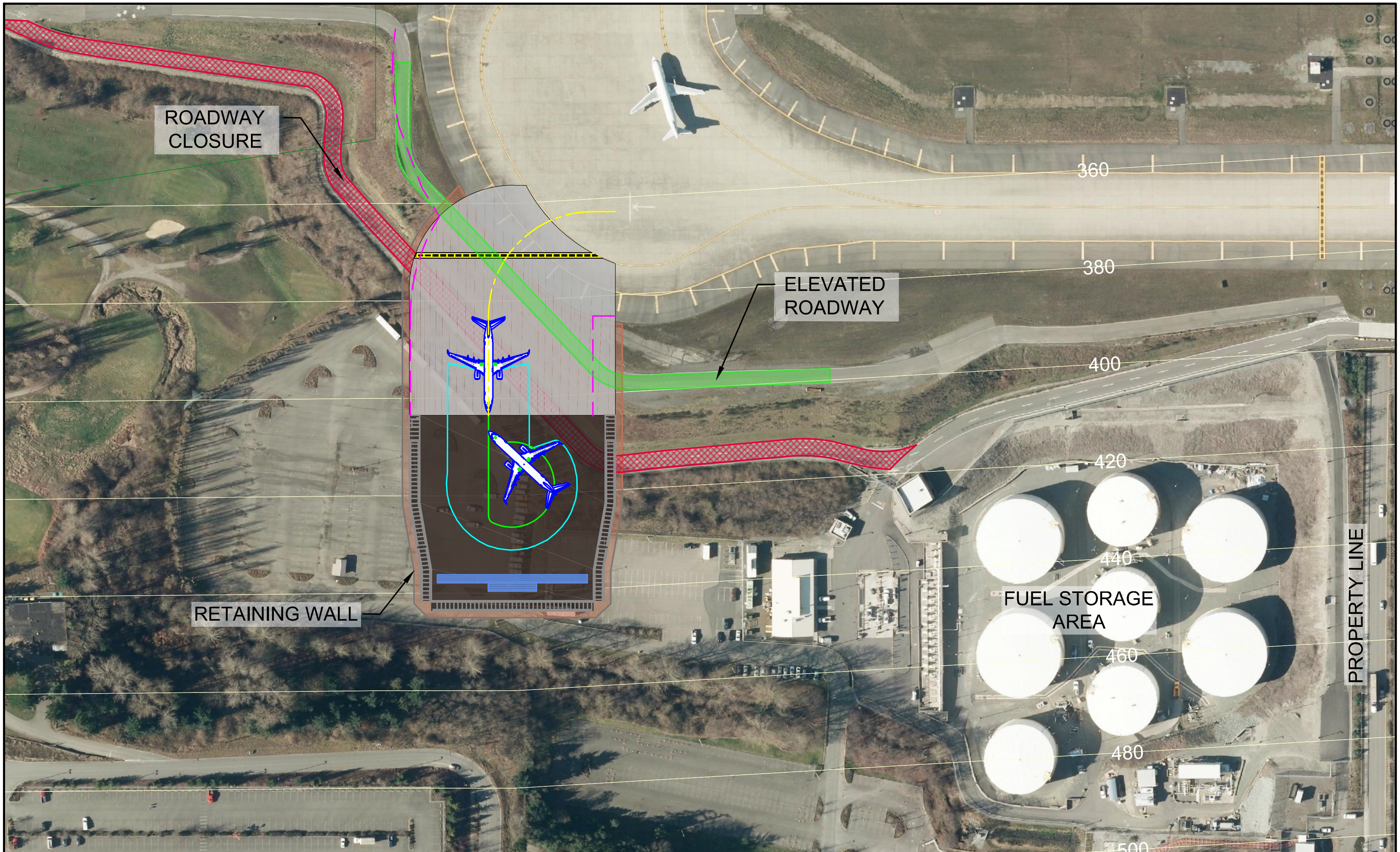
DRAFT

1" = 2,500'

0 2,500

DATE: JULY 2011

EXHIBIT 7



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE A

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 8

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT A

4.4.2 GRE Site A Evaluation

One of the benefits of Site A is that it is in close proximity to Alaska Airlines Maintenance Facility, reducing aircraft taxi time to the GRE site by the primary maintenance operator at SEA-TAC. The site would be an expansion of the airfield and so would have a minimal impact on aircraft operations. There are no impacts to FAR Part 77 surfaces or ATCT line of sight.

The site does not impact any currently operational facilities or displace any current RON parking; however, it would displace a portion of the former South Employee Parking Lot (SEPL). The Port plans to reopen and expand SEPL if and when warranted by employee parking demand. A GRE at this location would limit the number of stalls that could be provided in the future. The location Site A would be the longest taxi time from the United Airlines Maintenance Facility. Site A also requires a considerable amount of earthwork and fill to be able to accommodate aircraft movements from the existing airfield to the proposed site in order to meet minimum taxiway grade requirements.

This new associated taxiway would also need a hold short of the glide slope critical area associated with Runway End 34R and poses potential complications to aircraft movements in this area. Another drawback to the site is that breakaway and idle jet blast may impact portions of the golf course and may need to be further studied to determine if the construction of jet blast fence is necessary. The Object Free Area associated with the taxiway accessing the GRE could possibly impact the golf course just south of the proposed facility.

Site A is approximately the same distance from the Alaska Airlines and Delta Airlines maintenance facilities than to the existing south primary run-up pad; and it is a shorter distance than from the Delta and Alaska maintenance facilities to existing north primary run-up pad. Site A is about the same distance from the United Airlines Maintenance Facility as it is to the existing south primary run-up pad; although it is longer distance than to the existing north primary run-up pad.

Site A is located 0.29 miles from the nearest residential uses. This is slightly closer than the existing primary run up location located on the ramp adjacent to the threshold of Runway 34R. However, because the GRE facility will reduce noise levels all around the site by an estimated 15-20 dB, noise levels associated with run ups would be reduced for these residents.

The costs associated with Site A include: grading and earthwork, new pavement, road removal and relocation, a 15 foot retaining wall, and structure construction totaling approximately $33,000,000.

4.5 GRE Site B

Site B has two available options that would be potential GRE sites. Site B is also located on the south side of the Airport roughly 1,003 feet west of the Alaska Airlines Maintenance Facility; however the taxiing time for an Alaska Airlines aircraft from their facility would be about 4-5 minutes. The Delta Airlines Maintenance

Facility and United Airlines Maintenance Facility are farther away with aircraft taxiing times of 5-7 and 15-20 minutes respectively and distances of 3,215 feet and 10,252 feet respectively. Site B is the closest site to the Alaska Airlines and Delta Airlines maintenance facilities. On the north side of the site is the south satellite terminal building and a fuel building. This site has flat topography. **Exhibit 9** depicts the location of Site B as well as the surrounding area. Both siting options are clear of the ATCT LOS, the Group VI OFA, and the FAR Part 77 Transitional Surface for Runway 16L/34R. Site B is located 0.53 miles from the nearest residential neighborhoods. This is slightly farther than the existing south primary run up location. Because the GRE facility will reduce noise levels all around the site by an estimated 15-20 dB, noise levels associated with run ups would be reduced for these residents.

The costs associated with Site B include: grading, new pavement, and structure construction costs of approximately $16,700,000. Two potential GRE configurations, B1 and B2, were assessed at Site B.

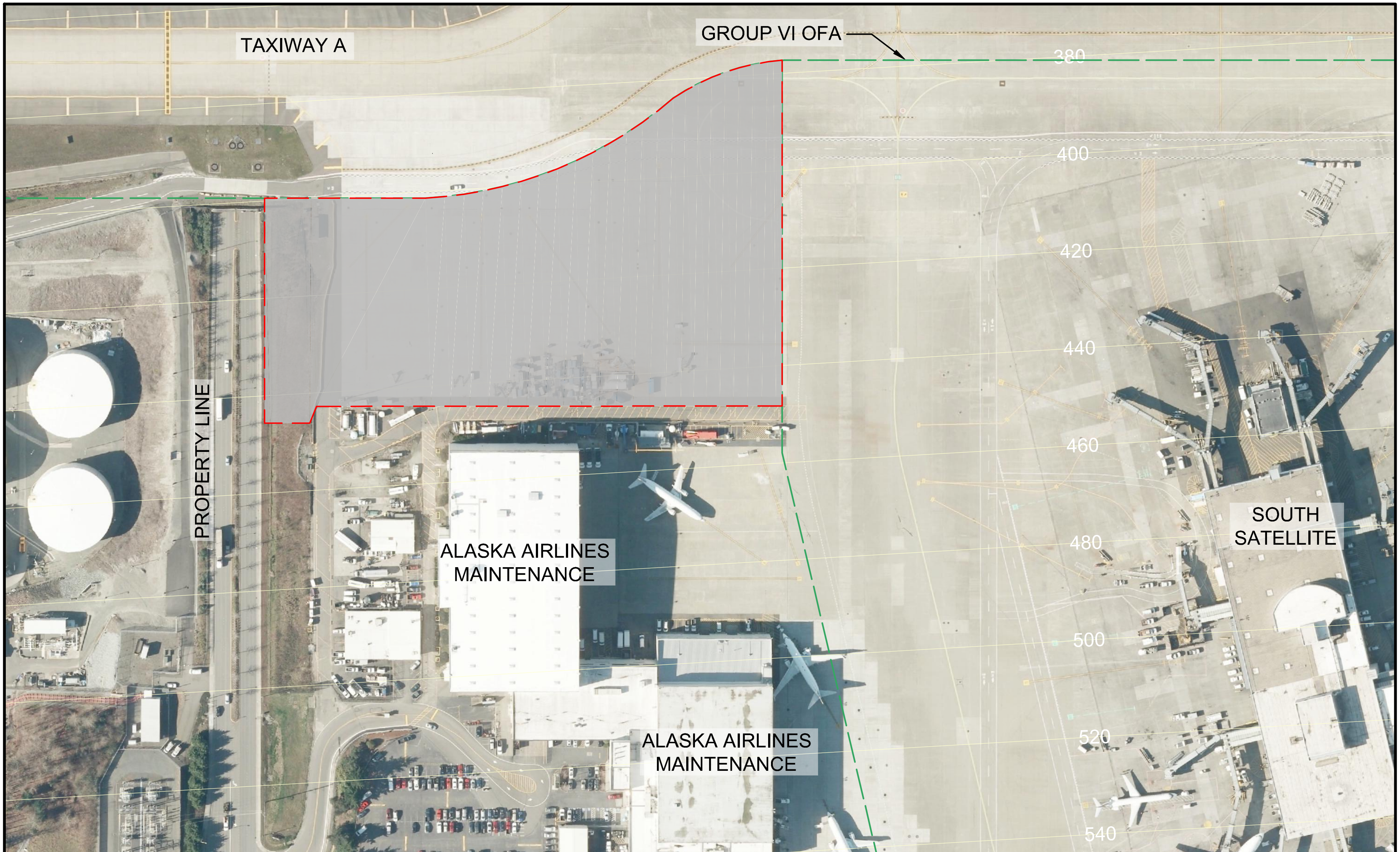
4.5.1 GRE Site B1

GRE Site B1 Location: Site B1 is located on the eastern side of Site B adjacent to the Alaska Airlines Maintenance Facility. It is a tug-in and tug-out GRE designed around a B737-900W. The GRE on B1 faces southwest. Site B1 is further depicted in **Exhibit 10**.

GRE Site B1 Evaluation: This siting option contains a number of benefits and drawbacks. The GRE on Site B1 is oriented in the ideal direction facing southwest. This allows the greatest wind coverage out of all of the options. This configuration provides easy access to the Alaska Airlines Maintenance Facility. A GRE on this site would not require the demolition of any structures; however, would require the relocation of 6 overnight aircraft parking positions west of the Alaska Airlines Maintenance Facility, as well as the construction of more load bearing pavement on the south side of the site. While displaced RON parking can be accommodated through new construction to the north of the terminal, without expansion of the airfield, displacement of any RON parking today will limit any future RON hardstand capacity. This option could also cause minor congestion for other aircraft taxiing on Taxiway A.

4.5.2 GRE Site B2

GRE Site B2 Location: Site B2 sits in the south end of the site directly east of the Group VI OFA and faces west. It sits adjacent to a GSE parking area. Site B2 contains more usable space than Site B1 and may possibly allow for either minimal RON parking or future Airport projects depending upon future airport needs. Site B2 is depicted in **Exhibit 11**.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE B

DRAFT

1"=200'

100 0 200

W N E S

DATE: JULY 2011

Exhibit
9

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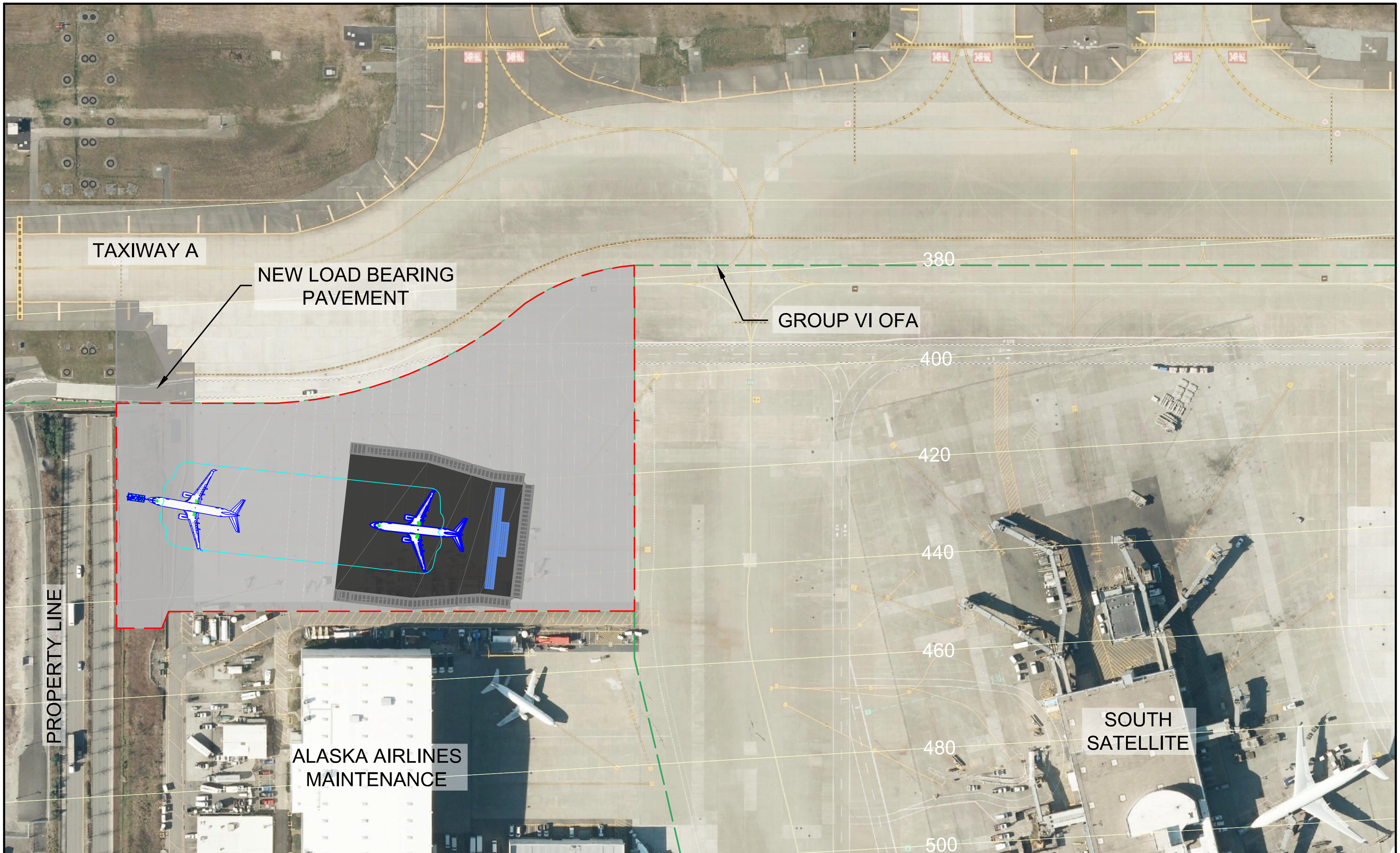


GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE B1

DRAFT

DATE: JULY 2011

Exhibit 10

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT B1

MAINTENANCE

GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE B2

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 11

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT B2

GRE Site B2 Evaluation: Site B2 has a number of benefits associated with facility placement including minimal impacts to existing facilities. There is easy Taxiway A access due to the westward facing direction. The orientation and location of the GRE also maximizes the space at the site allowing for other uses of the apron area on the north side of the site in comparison to Site B1. A couple of drawbacks associated with the site include the impact to the GSE parking area. The impact to this area would be approximately 9,000 square feet. Efforts to relocate this storage area would need further discussion amongst Airport representatives. Another drawback would include the possibility of creating minor congestion along Taxiway A near the terminal area. Locating a GRE here would increase the traffic flow to the GRE but the impact of this potential problem would need further research. Two existing RON parking spots at Site B2 would be displaced.

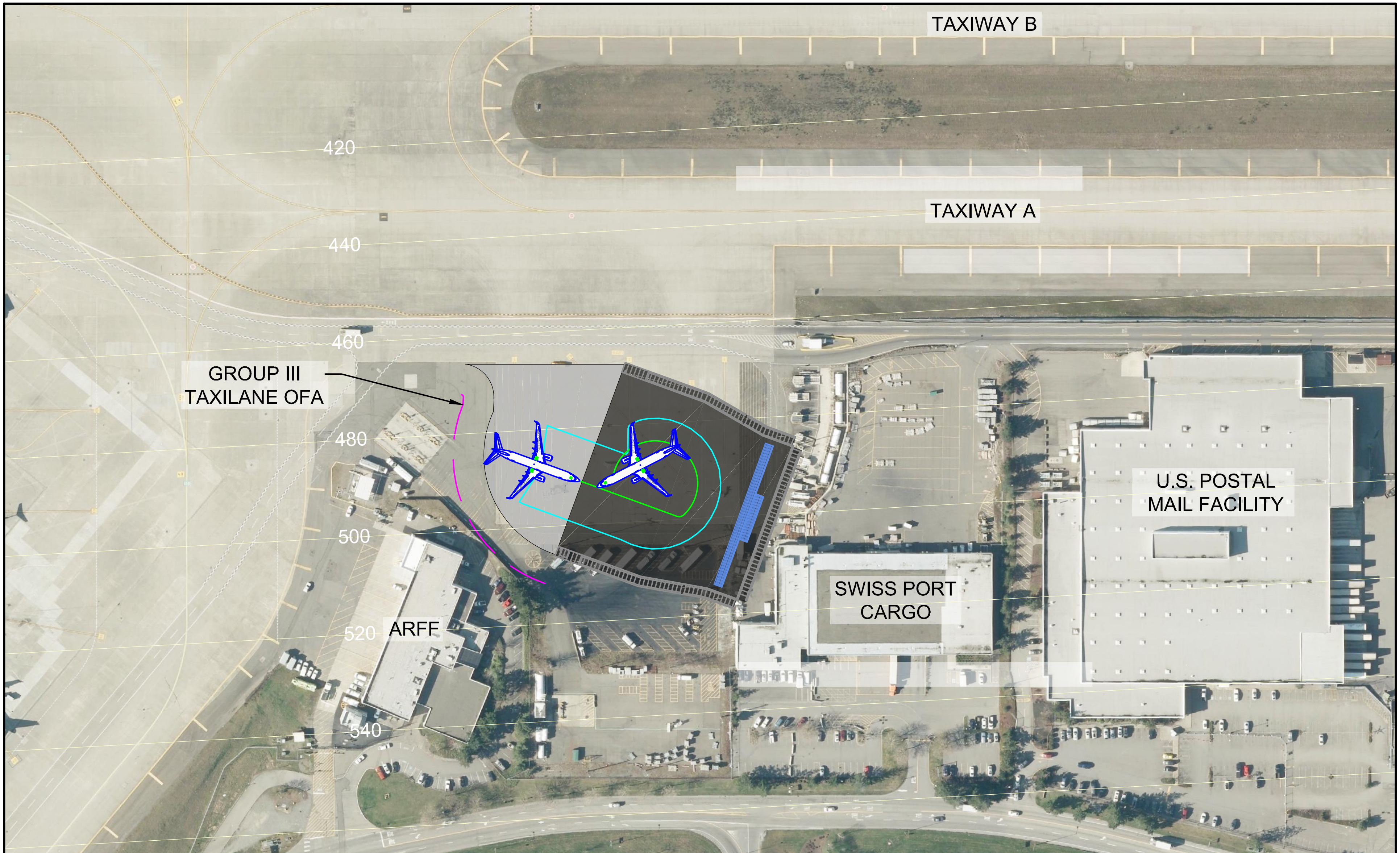
4.6 GRE Site C

4.6.1 GRE Site C Location

Site C is located north of the terminal area, approximately 130 feet from the ARFF facility and could cause potential impacts. The site is 6,416 feet from the Alaska Airlines Maintenance Facility, 7,056 feet from the Delta Airlines Maintenance Facility, and 4,171 feet from the United Airlines Maintenance Facility. This site is farther for both Alaska and Delta Airlines than the existing south run-up pad. The taxi time to the Delta maintenance building, adjacent Taxiway A, is approximately 10-13 minutes. The closest airline maintenance facility is United Airlines with an aircraft taxiing time of approximately 6-8 minutes. The Alaska Airlines Maintenance Facility is approximately 10-13 minutes away from Site C. There are no violations to any transitional surfaces, ATCT line-of-site, or NAVAID Critical areas associated with Site C. **Exhibit 12** illustrates the details of GRE Site C.

4.6.2 GRE Site C Evaluation

It is anticipated that there are minimal jet blast impacts to surrounding facilities by aircraft accessing and exiting the GRE facility on Site C. Noise levels generated by the GRE would not exceed the current noise levels of typical runway operations on Runway 34R/16L.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE C

DRAFT

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100 0 200

W N E S

DATE: JULY 2011

Exhibit
12

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 10. ALTERNATIVE C

There are major drawbacks associated with the development of Site C that make it unfeasible. A number of facilities would need to be relocated including the Port-owned cargo warehouses currently occupied by Swissport to the northeast of the GRE, one cargo hardstand, fuel truck parking, and limited access to the Airport's only fuel rack. The relocation of these facilities to a practical site elsewhere on the Airport would prove to be a disadvantage to airfield operators. ARFF response and activities would also take precedence to GRE activity and may limit GRE access/usability. The cost to regrade this site would pose a significant problem as well. Site C sits in the future expansion of the North Satellite, as well as, the taxilanes to serve the expanded satellite. This future project would only allow for a temporary GRE at this site. These operational and physical drawbacks, along with the conflict with the future expansion of the North Satellite, are considered to outweigh the limited benefits of Site C.

Site C is farther away from the Alaska Airlines and Delta Airlines maintenance facilities than the existing south primary run-up pad; although it is about the same distance away as the existing north primary run-up pad. Site C is closer to the United Airlines Maintenance Facility than the existing south primary run-up pad and about the same distance away from the United Facility as the existing north primary run-up pad.

Site C is located 0.43 miles from the nearest residential neighborhoods. This is slightly closer than the existing primary run up location located on the ramp adjacent to the threshold of Runway 16L. However, because the GRE facility will reduce noise levels all around the site by an estimated 15-20 dB, noise levels associated with run ups would be reduced for these residents.

The estimated cost of constructing a GRE on Site C is approximately $10,000,000.

4.7 GRE Site D

Site D is located north of Site C adjacent to the United Airlines Cargo Facility off Taxiway A. Site D has a total of eight perspective GRE configurations, however there are a number of commonalities they all share. AutoCAD Path Planner was used to analyze aircraft movement at the site.

Site D assumes the demolition of the USPS Facility, which is currently inoperative, regardless of the development of a GRE at this site. In this case, load bearing pavement is needed at Site D in order to accommodate aircraft movement at this site following the demolition of the USPS facility.

Site D is one of the more equidistant options from all three of the airline maintenance facilities. Taxiing times to and from Site D will vary depending on the original location of the aircraft and were based upon unimpeded traffic flow. Alaska Airlines aircraft performing ground run-ups at this location have a taxiing time of 10.50 to 14 minutes. Delta and United Airlines Maintenance Facilities taxiing times for aircraft are 11-14 and 4-5 minutes respectively. The site is 7,396 feet from the Alaska Maintenance Facility, 8,034 feet from the Delta Maintenance Facility, and 3,358 feet from the United Maintenance Facility. Site D is farther away from the

Alaska Airlines and Delta Airlines maintenance facilities than the existing south primary run-up pad; although it is closer than the existing north primary run-up pad. Site D is closer to the United Airlines Maintenance Facility than the existing south primary run-up pad and slightly farther away from the existing north primary run-up pad.

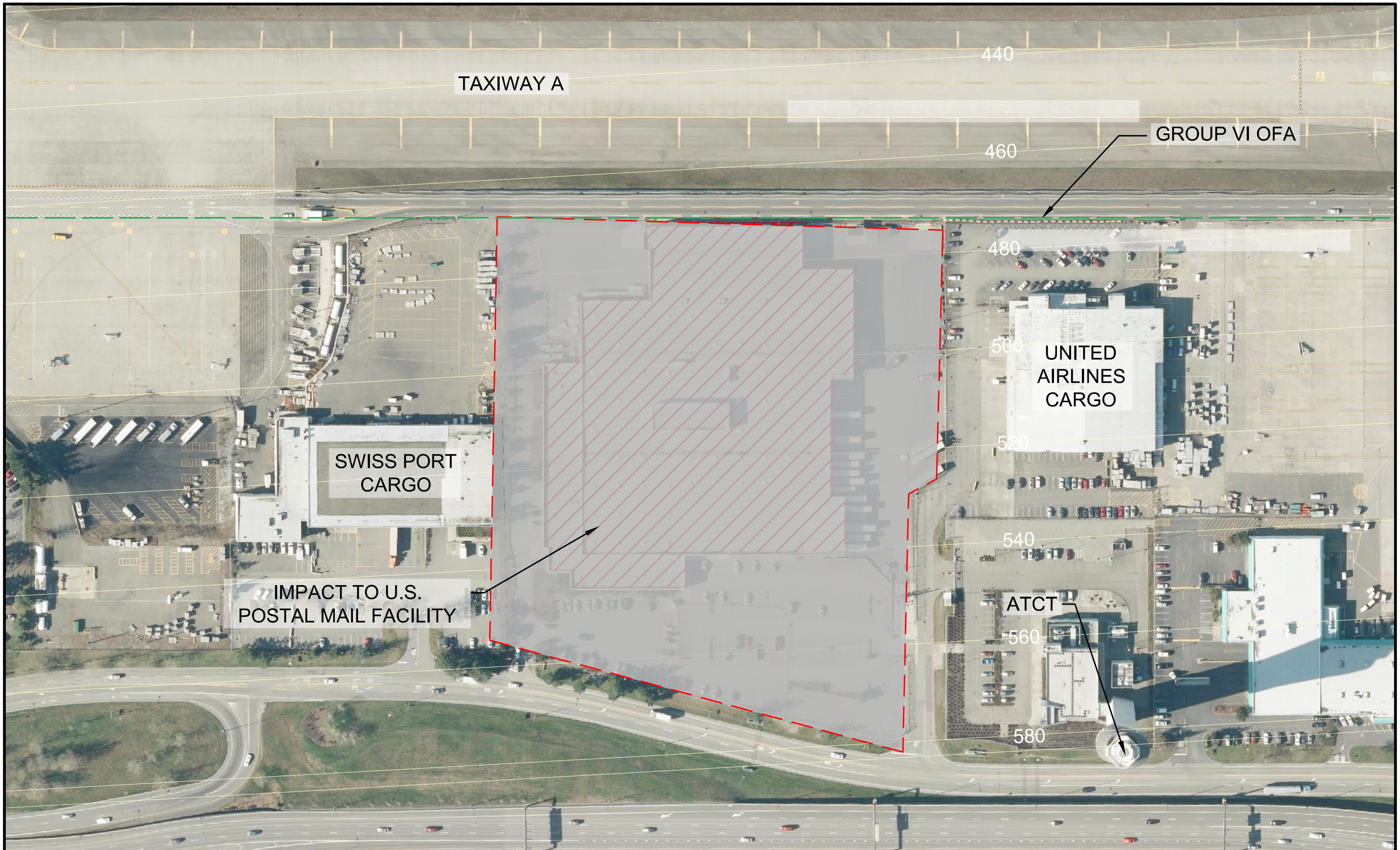
Site D was also analyzed for residential proximity to the site. The results indicate that residential houses reside 0.58 miles north, 0.45 miles east, and 1.09 miles west of the site. **Exhibit 13** below further depicts the location and surrounding area of Site D.

All of the options at Site D would be constructed at or below 55 feet. This means that the site would be clear of Runway 16L/34R Part 77 Transitional Surfaces. This will not cause any problems since the GRE is predicted to stand between 35 and 45 feet tall. There are also no line of sight issues related to the Air Traffic Control Tower for any of the configurations at Site D. No violations to NAVAID Critical areas are associated with Site D as well.

It is anticipated that there are minimal noise and jet blast impacts to surrounding facilities by aircraft accessing and exiting Site D. However, further analysis would need to be completed on the significance of the noise impacts of a GRE at Site D to the ATCT. Minor congestion could also occur near the Cargo VI ramp area, as well as, aircraft trying to taxi south after completing a ground run-up would be taxing into departing aircraft taxi flow. Both of these potential issues would need further analysis to determine the significance of either impact. Environmental issues also possibly surround the development of Site D due to previously contaminated soils from prior uses of the site. Further analysis would need to be completed in order to determine the significance of this issue. By placing a GRE at this site, future RON parking at this facility will be impacted. These impacts are seen below within each Site D option.

Site D is located 0.45 miles from the nearest residential neighborhoods. This is slightly closer than the existing primary run up location located on the ramp adjacent to the threshold of Runway 16L. However, because the GRE facility will reduce noise levels all around the site by an estimated 15-20 dB, noise levels associated with run ups would be reduced for these residents.

There are ten potential GRE configurations within Site D that were evaluated and identified as Site D1 through Site D10. The costs associated with Site D include additional pavement along with a pavement extension in sites D9 and D10. The demolition of the USPS facility was not considered a monetary cost due to the fact that it will be demolished regardless of the construction of the GRE. The approximate cost of a GRE on any of the site D options may range from $8,000,000 to $9,000,000.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS	GROUND RUN-UP ENCLOSURE SITE D	1"=200'	DATE: JULY 2011
L&B SEATTLE TACOMA INTERNATIONAL AIRPORT	DRAFT	100 0 200	Exhibit 13

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 11. ALTERNATIVE D EMPTY

4.7.1 GRE Site D1

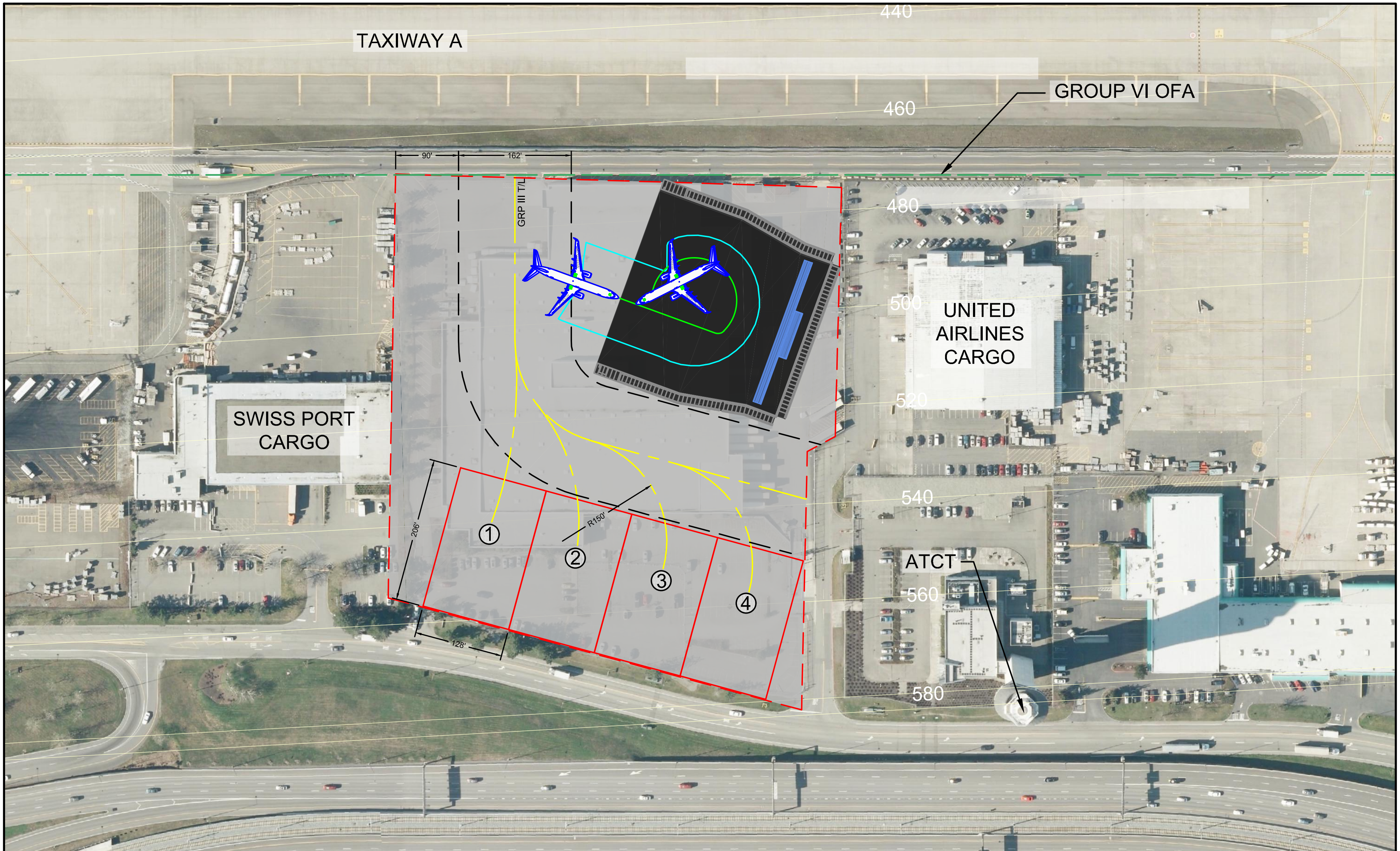
GRE Site D1 Location: The first siting option is seen below in **Exhibit 14**. The sizing of the facility remains consistent with a power-in and power-out operation of a B737-900W. This size GRE can also accommodate tug-in and tug-out operations of any aircraft in size up to a B767-400. The GRE faces a Southwest direction in this option. This option allows for four RON parking spaces that can accommodate Group III aircraft or smaller along with a Group III taxilane.

GRE Site D1 Evaluation: There are a couple benefits associated with this option. Both power and tug procedures can take place allowing a wider range of aircraft to use this GRE than some of the other options. This GRE also has more wind coverage than the other options due to the ideal southwest placement of the GRE. This site has a number of benefits associated with it, however, does not provide the ability to accommodate as much RON parking as some of the other options that will be discussed. This site only has four RON parking positions, whereas, some of the other options can accommodate up to seven positions. The Group III taxilane takes up a lot of usable space on this site in addition to both the RON parking positions and the GRE both using the same taxilane. This could possibly cause minor congestion and would need further research in order to determine this impact.

4.7.2 GRE Site D2

GRE Site D2 Location: The second option available at Site D is shown below in **Exhibit 15**. This site faces south and is placed in the northwestern corner of the site. This position can accommodate both a tug-in and tug-out and power-in and power-out designed GRE allowing any aircraft up to a B737-900W aircraft taxi-in and taxi-out of the GRE. Aircraft larger than a B737-900W and up to a B767-400 can also be tugged in and out of the facility. The site has ample room to accommodate up to six Group III RON parking positions which include five north to south facing positions and one east to west facing position.

GRE Site D2 Evaluation: There are a number of benefits and drawbacks associated with this site. The site can provide up to six RON parking positions, only one less than the optimal number of parking positions seen in other options. This GRE can accommodate more aircraft than just the tug-in and tug-out only GRE design. Some of the drawbacks associated with Site D2 include a shared taxilane which may cause minor congestion between aircraft utilizing RON parking and aircraft utilizing the GRE. Also, another entry and exit would need to be created for the east to west facing parking position so it could access Taxiway A.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE D1

DRAFT

1"=200'

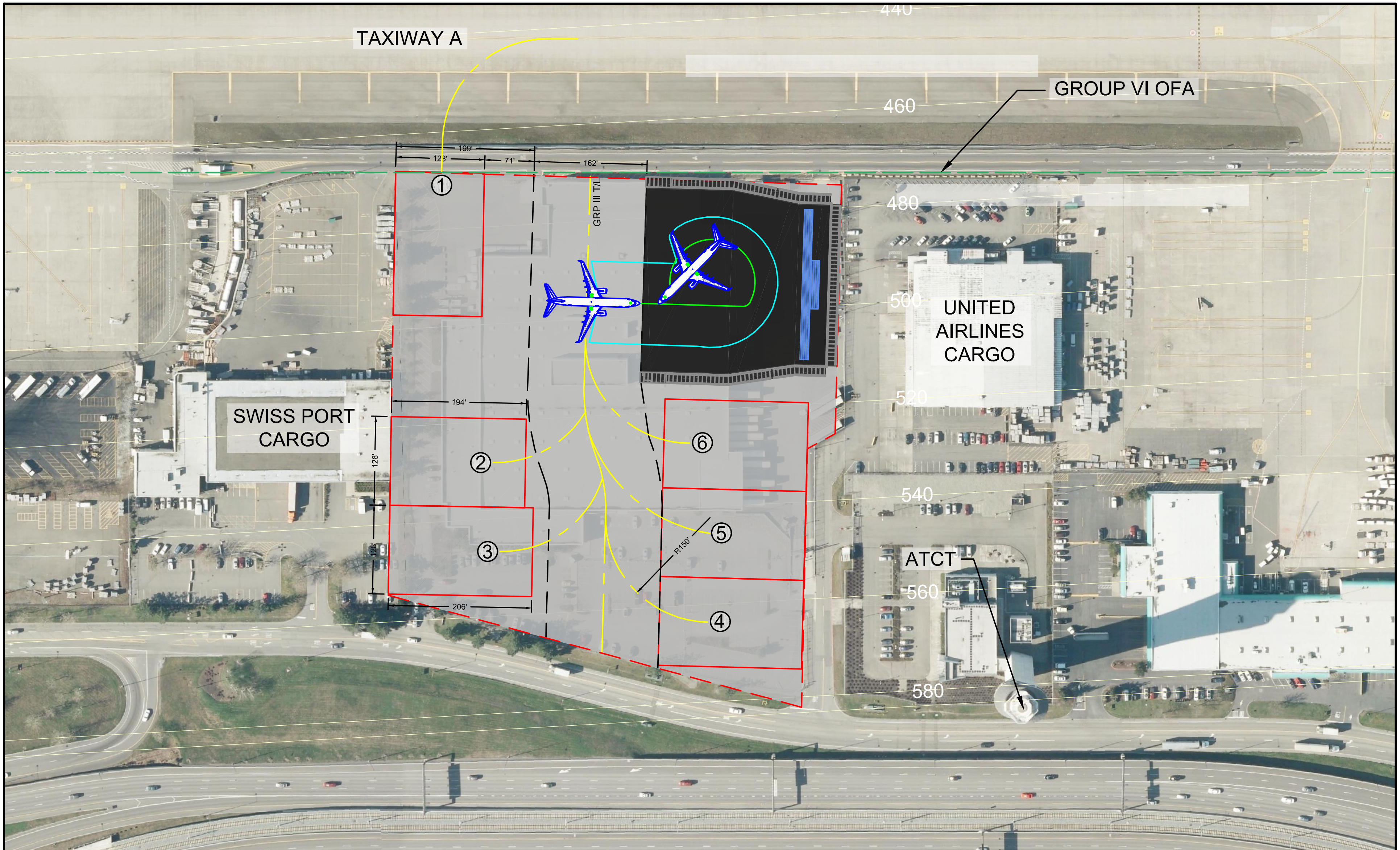
100 0 200

W N S E

DATE: JULY 2011

Exhibit
14

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 11. ALTERNATIVE D-1



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE D2

DRAFT

1"=200'

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W N E S

DATE: JULY 2011

Exhibit
15

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 11. ALTERNATIVE D-2

4.7.3 GRE Site D3

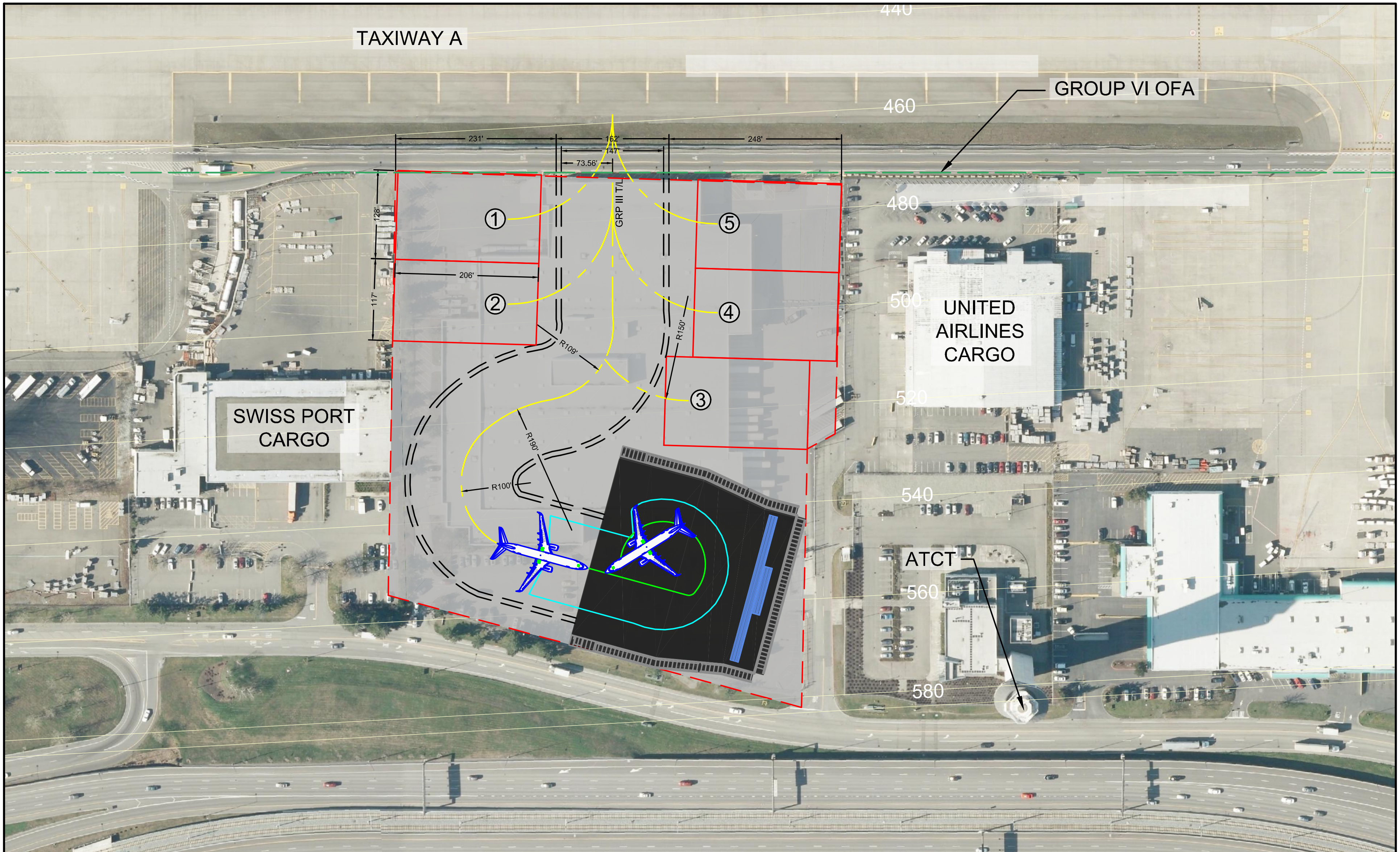
GRE Site D3 Location: GRE Site D3 is able to accommodate both power-in and power-out aircraft along with larger aircraft using tug-in and tug-out operations. The GRE remains in the northeastern corner of the site facing a southwest direction. The site contains a group three taxilane which will be used by both aircraft using the GRE as well as aircraft movement in and out of the RON parking positions. With this configuration, five RON spaces for Group III aircraft or smaller can be developed for future use. **Exhibit 16** shows the configuration and location of Site D3.

GRE Site D3 Evaluation: There are a number of benefits and drawbacks associated with this site. The orientation of the GRE on this site is ideal. The GRE in this siting option also allows for a greater range of aircraft to use the facility. It can accommodate aircraft up to a B737-900W using power-in and power-out maneuvers as well as B767-400 using tug operations, whereas some of the other siting options only allow for a B737-900W tug-in and tug-out GRE. There are also a number of drawbacks associated with Site D3. The entry and exit taxilane into and out of the site would need to be used by bot RON aircraft and GRE users. This may create minor congestion and more research would be needed in order to determine the impact. Aircraft maneuverability into and out of the GRE would be difficult based upon the taxilane configuration as well. Another drawback to this option is the fact that is it only 280 feet from the air traffic control tower. This could possibly cause some of the projected noise to disperse near the top of the air traffic control tower creating a noise issue nearest the area where the tower employees work.

4.7.4 GRE Site D4

GRE Site D4 Location: The fourth option available at Site D is D4, shown below in **Exhibit 17**. The GRE sits in the northwestern corner of the site. At this site, three entrances would need to be constructed; one for the GRE, another for the north to south facing RON parking positions, and a third for the RON parking position facing west. A Group III taxilane would be developed in order to access the RON parking positions within the site. This site allows for up to six RON parking positions that can all handle Group III aircraft or smaller.

GRE Site D4 Evaluation: There are a number of benefits and drawbacks associated with this site. Some of the benefits include the size of the GRE. The GRE will be developed to contain up to a B737-900W power-in and power-out operation or a tug-in and tug-out operation of any aircraft smaller than a B767-400. This allows for a diverse amount of aircraft to utilize the facility. The facility also contains its own entry and exit into and out of the facility. This would allow RON aircraft to maneuver into and out of the rest of Site D with no



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D3

DRAFT

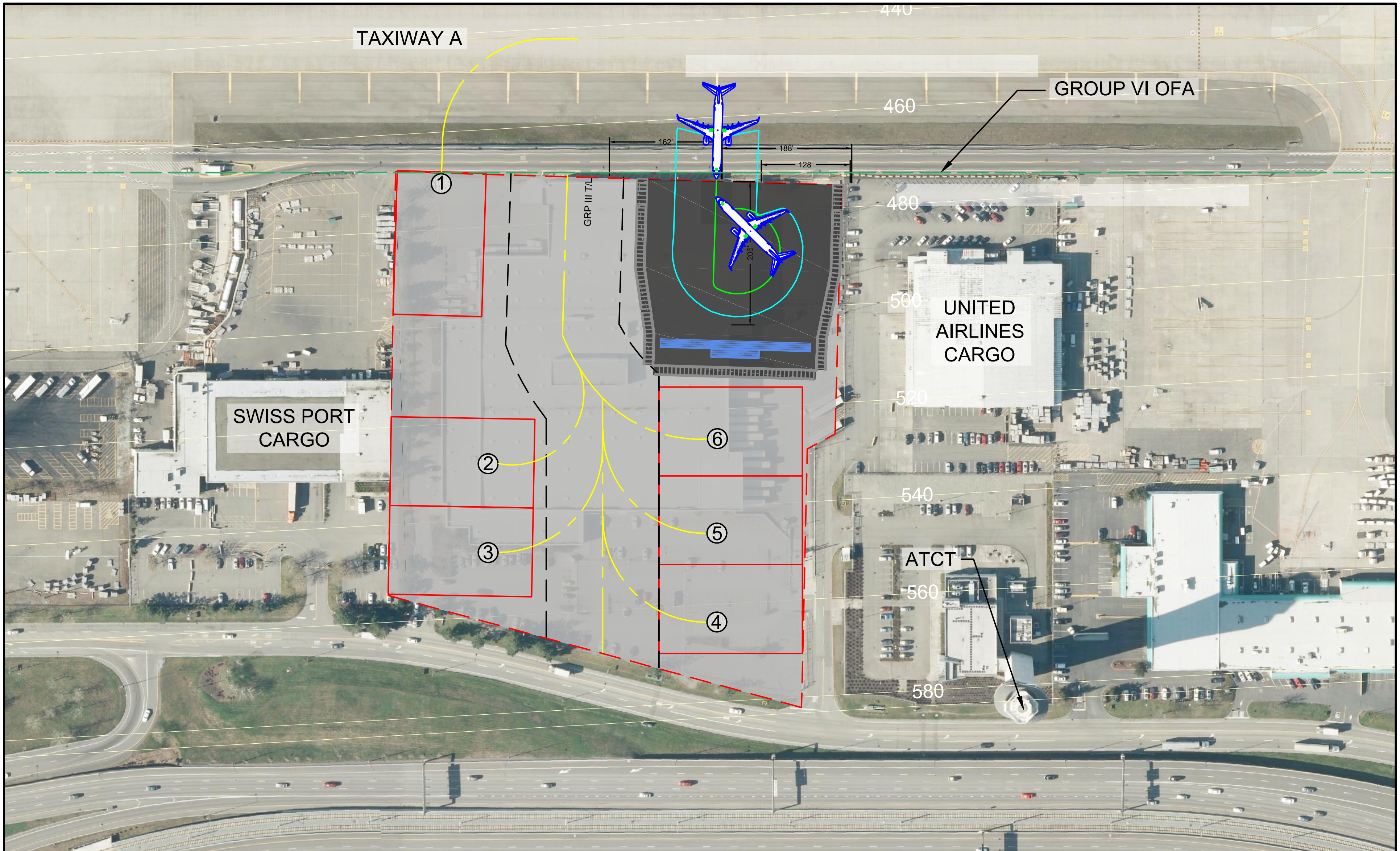
1"=200'

100 0 200

DATE: JULY 2011

Exhibit 16

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 11. ALTERNATIVE D-3



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D4

DRAFT

1"=200'

100 0 200

W N E S

DATE: JULY 2011

Exhibit 17

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 11. ALTERNATIVE D-4

congestion problems at all hours of the day. The space in this Site D4 configuration is a great utilization of space as well. Here the Airport can develop up to six RON parking spaces. Three separate entry and exit taxilanes would need to be constructed for the GRE, north to south facing RON parking positions, and the one RON parking position that would have direct access to the adjacent taxiway.

4.7.5 GRE Site D5

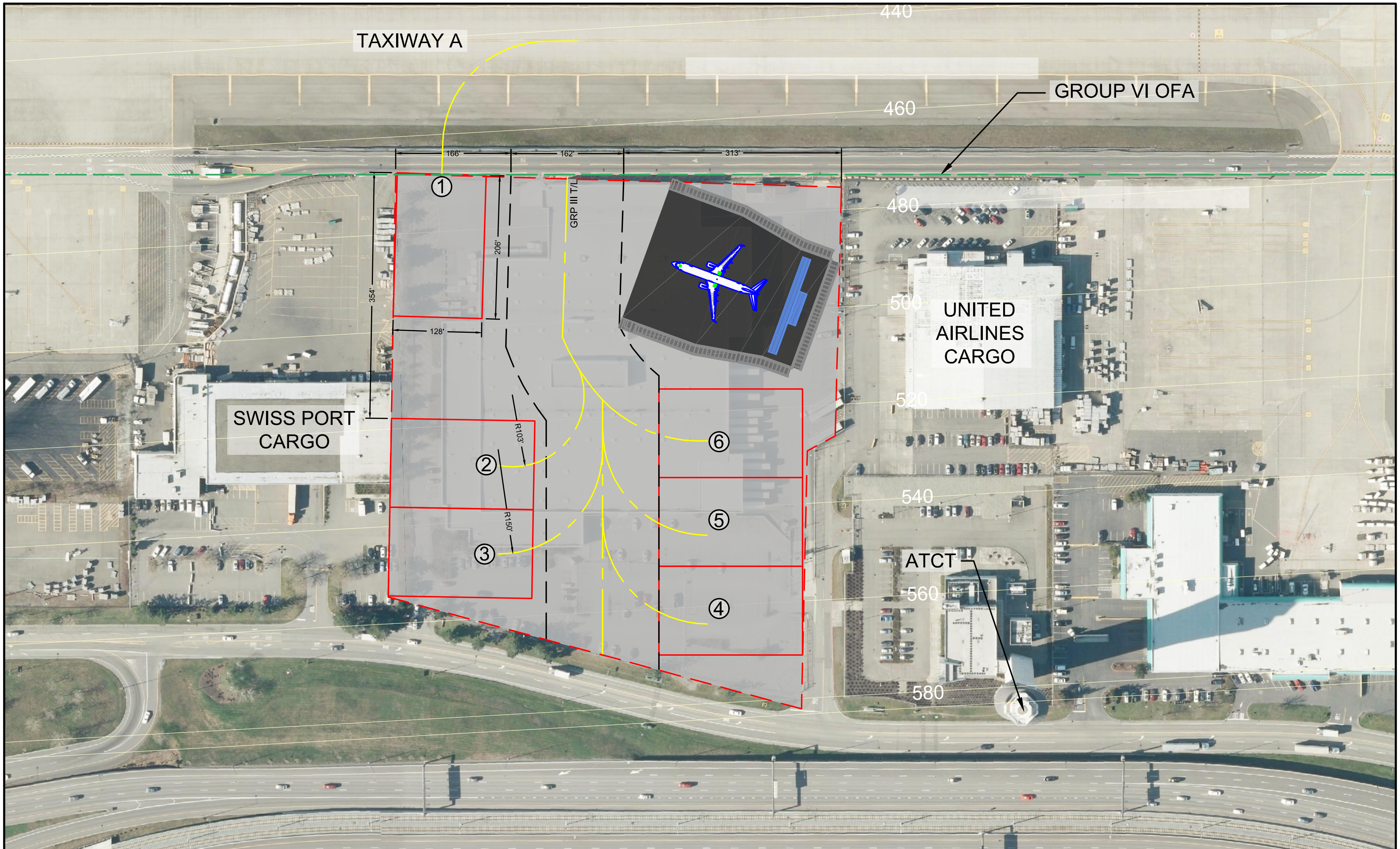
GRE Site D5 Location: Site D5 contains a tug-in and tug-out GRE that can accommodate a B737-900W or smaller. This GRE faces a southwest direction and sits in the northwestern corner or the site. The site can also accommodate six RON parking positions in addition to the GRE. The site contains a Group III taxilane that provides entry and exit to the GRE as well as five of the six RON parking positions. The sixth position will have its own entry and exit to the adjacent taxiway due to its westward facing direction. This site is shown below in **Exhibit 18**.

GRE Site D5 Evaluation: There are both benefits and drawbacks associated with Site D5. This site maximizes apron space by accommodating six RON parking spaces and a Group III taxilane, in addition to the GRE. The site is not estimated to impact any nearby facilities such as the ATCT or the United Airlines Cargo facility. The anticipated drawbacks associated with the site include minor congestion due to the traffic of both RON aircraft and aircraft using the GRE and the size of the GRE. The GRE used in this site option only allows for the smaller tug-in and tug-out GRE which can handle any aircraft up to a B737-900W.

4.7.6 GRE Site D6

GRE Site D6 Location: Site D6 contains a south facing tug-in and tug-out GRE that can accommodate up to a B737-900W. The GRE sits in the northwestern corner of the site. Also located on the site are seven Group III aircraft RON parking positions with a Group III associated taxilane that accommodates both the GRE and RON parking positions. **Exhibit 19** shows this site below.

GRE Site D6 Evaluation: Site D6 has a number of benefits associated with it and only a few drawbacks. The site best maximizes the space available by using the tug-in and tug-out GRE, capable of holding a B737-900W or smaller. This orientation and placement allows for a total of seven RON parking positions to be placed on this site in addition to the GRE. This option offers the most number of RON parking positions; however, sacrifices both wind coverage and the number of aircraft able to use the GRE facility. The size of the GRE allows aircraft up to a B737-900W to be tugged into and out of the facility.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE D5

DRAFT

1"=200'

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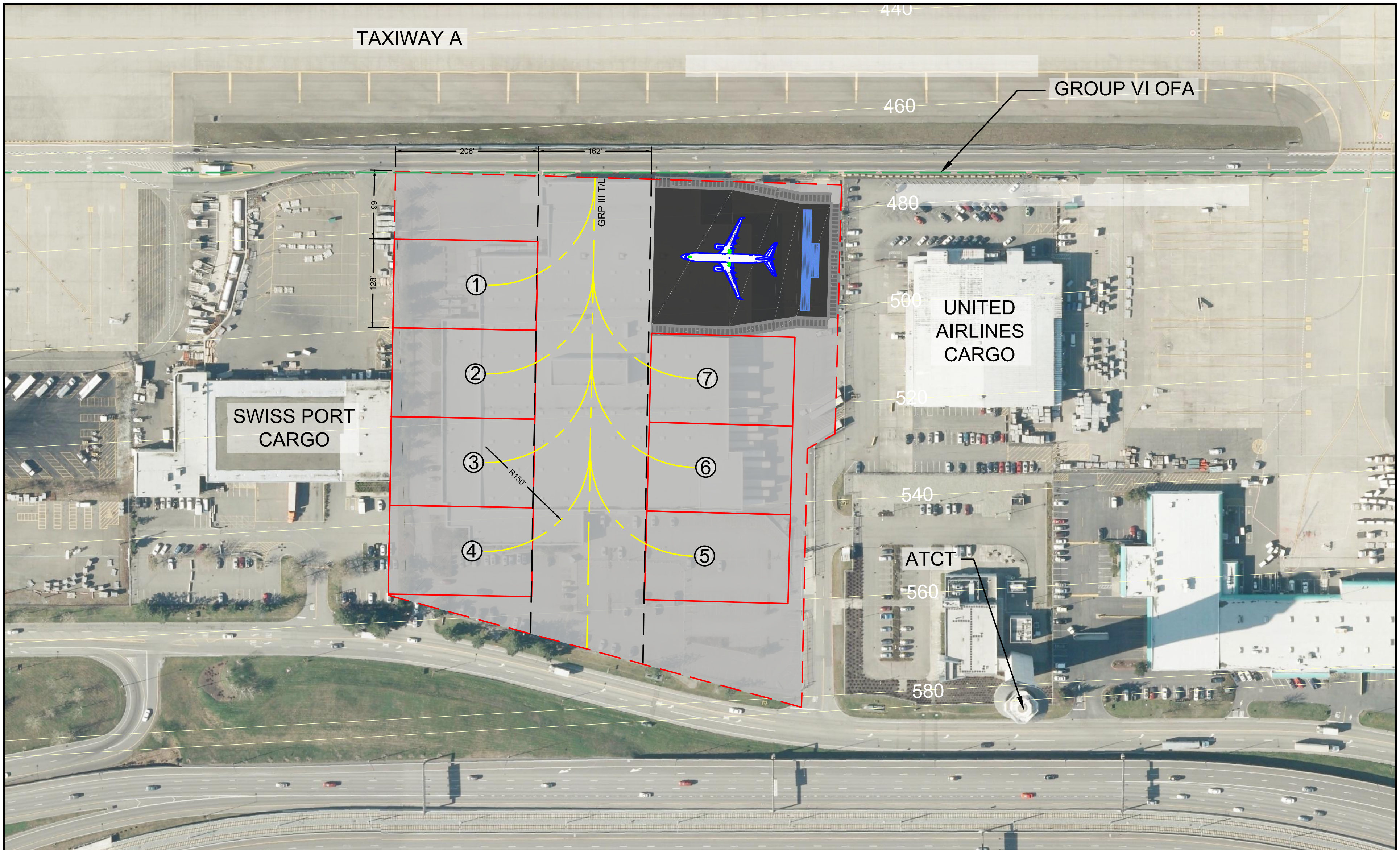
W N E S

DATE: JULY 2011

Exhibit
18

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 11. ALTERNATIVE D5



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D6

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 19

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: L1. ALTERNATIVE D6

4.7.7 GRE Site D7

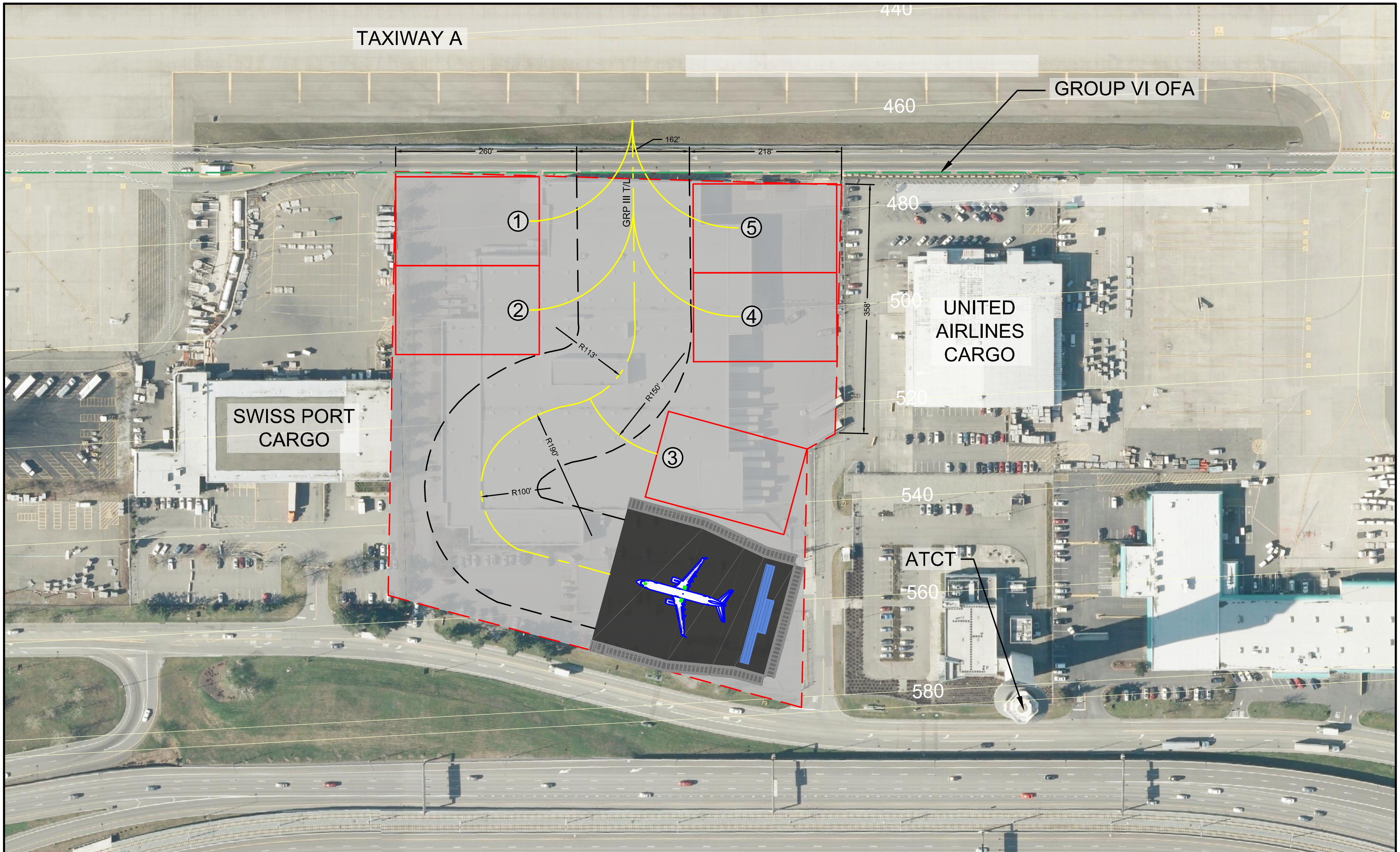
GRE Site D7 Location: Site D7 contains a tug-in and tug-out operational GRE for aircraft up to B737-900W. In this option, the GRE sits in the northeastern corner of the site and faces a southwest direction. This option also contains a Group III taxilane in addition to 5 RON parking positions suited for Group III aircraft or smaller. **Exhibit 20** depicts this below.

GRE Site D7 Evaluation: This siting option contains the most drawbacks. The only benefit to this design and location would be that if an aircraft were maneuvering in and about the GRE, than the aircraft utilizing the RON parking spaces would be out of the way of the GRE. This allows for the aircraft using RON parking to easily move in and about their spots. If the GRE were placed in the western portion of the site, increased congestion may occur due to the maneuvering of the aircraft into the GRE, however, there are many more drawbacks that outweigh this one benefit. This option can only fit up to five Group III RON parking positions, whereas some of the other options could fit up to seven with a tug-in and tug-out GRE. The size of the GRE can also only accommodate tug-in and tug-out procedures for aircraft up to a B737-900W with no opportunity for aircraft to use power-in and power-out operations. The taxilane that is also presented in this option would require extensive maneuverability for any aircraft using the GRE.

4.7.8 GRE Site D8

GRE Site D8 Location: Another tug-in and tug-out GRE option is D8. This site can accommodate aircraft up to and including a B737-900W. This can be seen in **Exhibit 21** below. The tug-in and tug-out GRE faces a western facing direction and is located in the northwestern corner of the site. The site also maintains a Group III taxilane and can hold up to seven Group III RON parking positions.

GRE Site D8 Evaluation: There are number of benefits associated with this site. This site is the most simplistic when looking at maneuverability. The Group III taxilane is an easy in and easy out taxilane that sites perpendicular to Taxiway A. The RON parking positions are also neatly laid out and organized. The apron space in this option is better utilized than other presented options. This sized GRE can only accommodate B737-900W aircraft or smaller by utilizing tug-in and tug-out operations.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D7

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 20

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: L1. ALTERNATIVE D7

GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D8

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 21

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg , Layout: 11. ALTERNATIVE D8

4.7.9 GRE Site D9

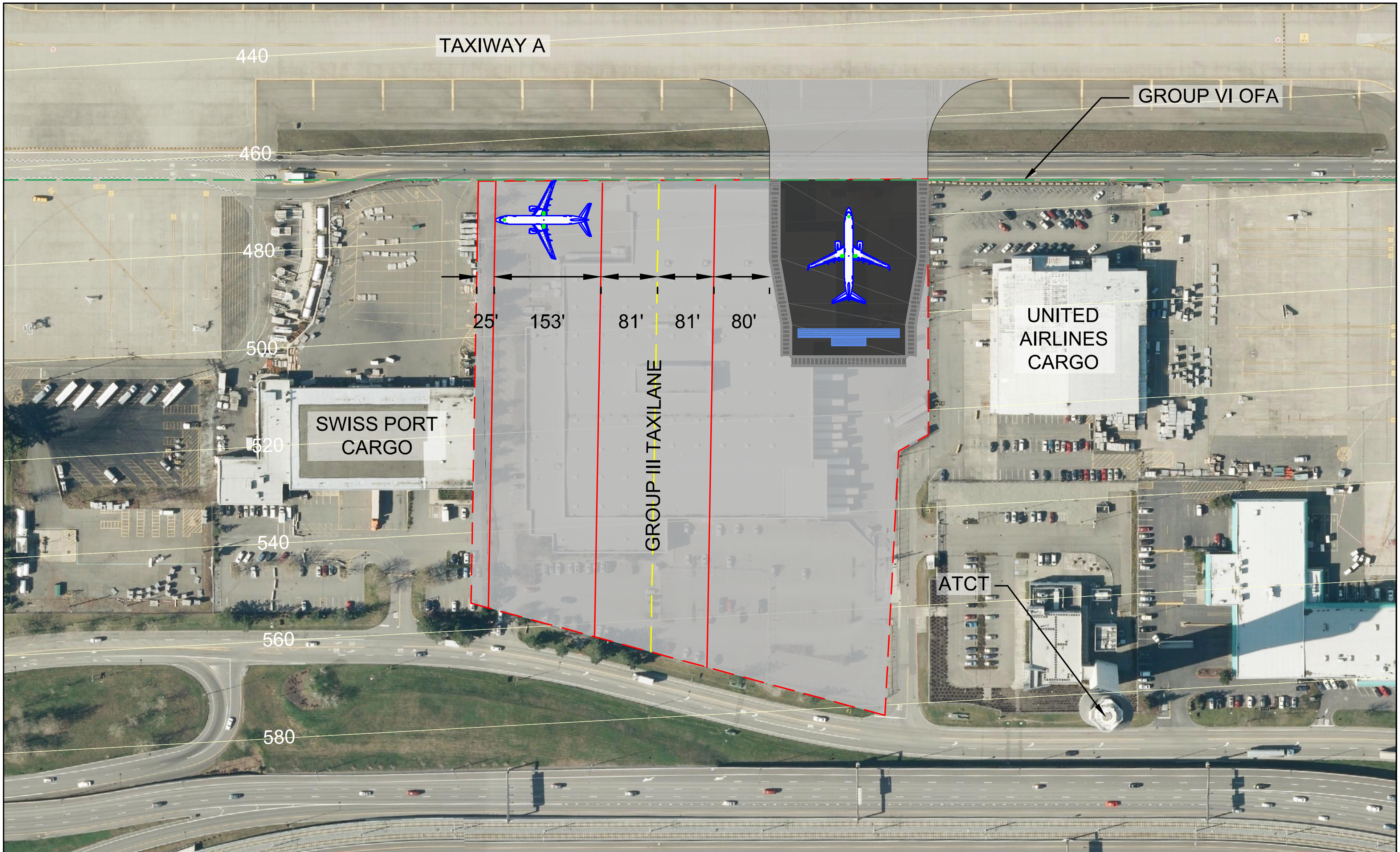
GRE Site D9 Location: Site D9 is derived from the original Site D configuration with an expansion of pavement in the northwestern corner of the site. The site was expanded to utilize the space of the old USPS site for future projects. The GRE on D9 is placed as far northwest as possible on the site with the northern wall up against the United Airlines Cargo building. The entry and exit to the GRE will face west. The GRE will maintain a separate entry and exit to and from the site via Taxiway A. The remainder of Site D9 could be used for RON parking or future Airport projects. This section of Site D9 would contain its own entry and exit to and from Taxiway A. This is depicted below in **Exhibit 22**.

GRE Site D9 Evaluation: Site D9 has a number of benefits associated with the placement and site utilization. The placement of the GRE in the northwestern facing corner of the site allows for easy access to and from Taxiway A. This configuration also utilizes the space the best of all the alternatives at Site D. This is due to the smaller sized GRE being used here as well as the western facing opening allows aircraft using only the GRE to surpass any other portions of the site. This creates less congestion for aircraft movement on the rest of the ramp at Site D. Site D9 has a number of operational benefits to it, however, does come with its drawbacks as well. The GRE contains one wall right up against the United Airlines Cargo building. This could create noise or jet blast problems for the United Airlines Cargo employees. This would need further research and analysis in order to determine the actual impacts of these potential problems, but it is seen as a negative in this evaluation.

4.7.10 GRE Site D10

GRE Site D10 Location: Site D10 contains a power-in and power-out GRE that sits facing a southern direction in the far northwestern corner of the site. The original site was expanded to create more aircraft movement space on Site D. This places the back wall of the GRE up against the United Airlines Cargo facility. The remainder of the Site D10 area could be utilized for RON parking or future Airport projects. Both the GRE and any future aircraft movement on Site D9 would share an entry and exit point to and from Taxiway A. This is seen below in **Exhibit 23**.

GRE Site D10 Evaluation: Site D10 contains both benefits and drawbacks to constructing a GRE on this site. The expansion of pavement in the northwestern corner allows for more usable area for future projects. The size of the GRE on this site also allows for larger aircraft to utilize the GRE on this site as well as some aircraft will have the ability to use a power-in and power-out option. A number of drawbacks also surround this option. The entry and exit for Site D10 would be shared by both aircraft utilizing the GRE as well as aircraft involved in any future projects on the site. This could cause minor congestion and further research would need to be completed in order to determine the impact. Further research would also be needed on the impact of the GRE up against the United Airlines Cargo facility. The GRE may cause noise or jet blast problems being located immediately up against the south side of the building, which is a negative for this evaluation.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D9

DRAFT

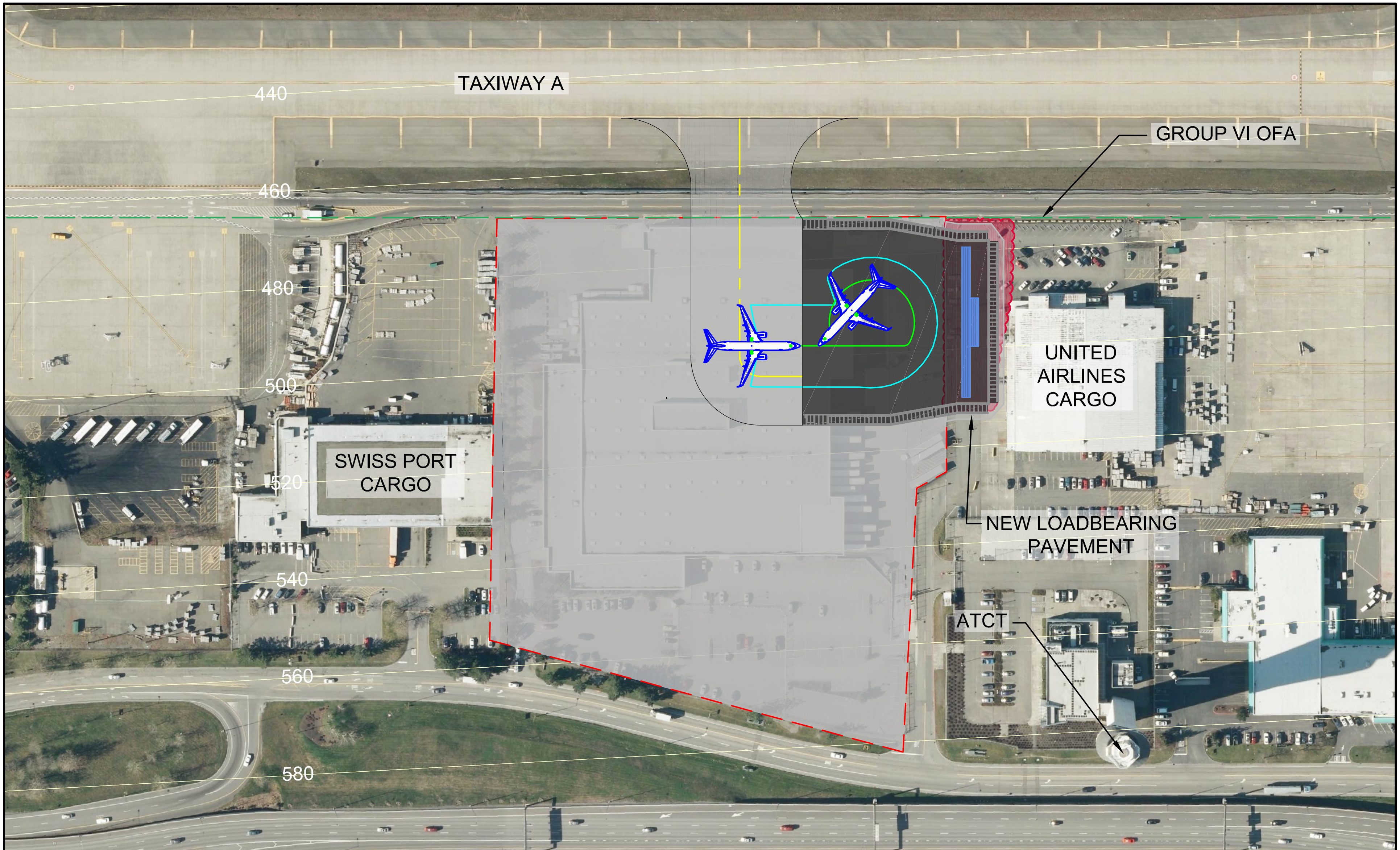
1"=200'

100 0 200

DATE: JULY 2011

Exhibit 22

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT D9



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE D10

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit
23

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg _Layout: ALT D10

4.8 GRE Site E

4.8.1 GRE Site E Location

Site E is the northernmost proposed site. A GRE of any reasonable size constructed at site E is clear of Runway 16L/34R Part 77 transitional surfaces and has no impact to ATCT line of sight due to its location on the east side of the Airport. The GRE would have to be taller than 80 feet in order for there to be line of site issues at this site. The site is located in close proximity to both the FedEx facility and Transiplex Air Cargo 1 Facility.

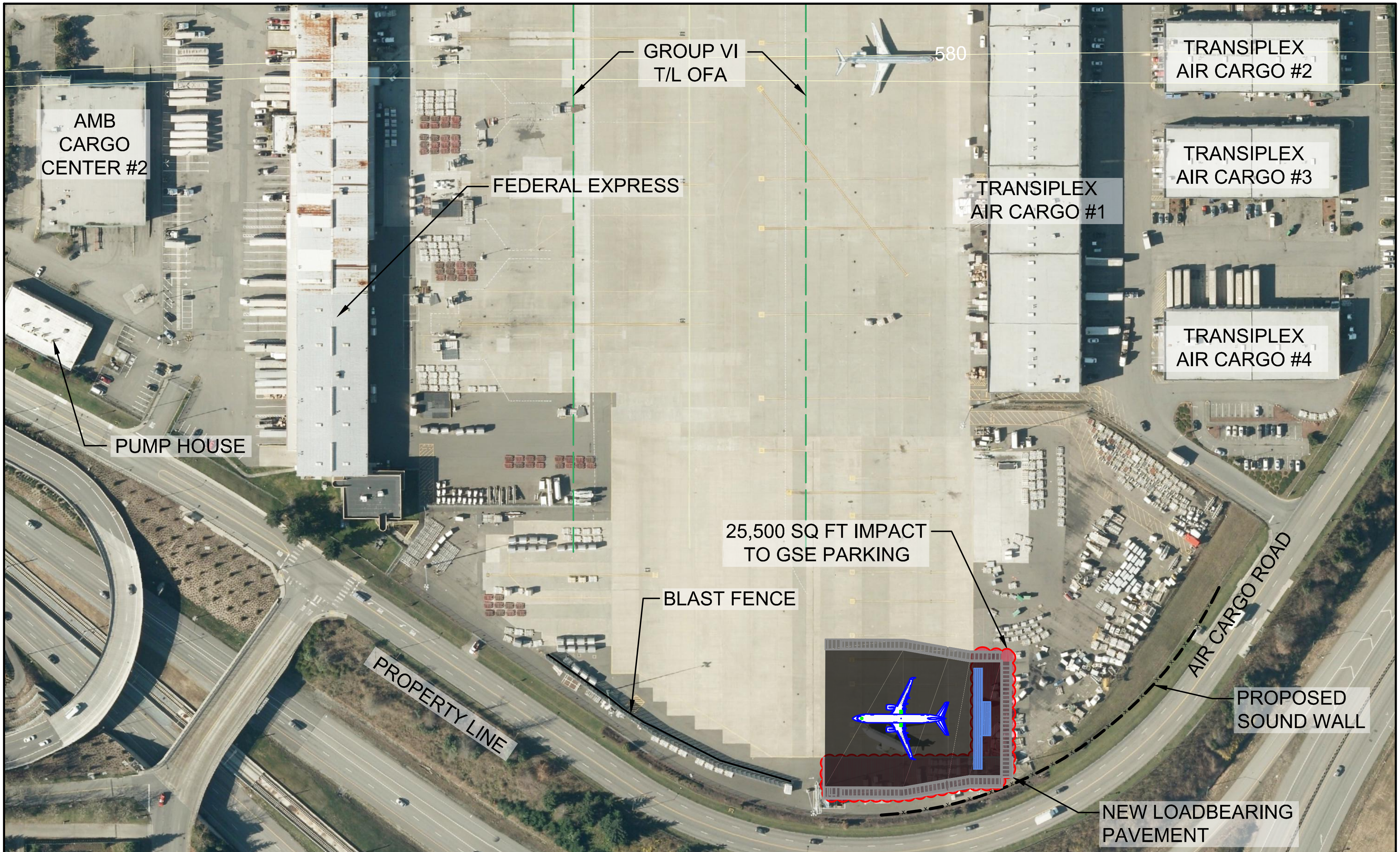
This GRE site is the closest site for the United Airline Maintenance Facility with a taxiing time of 4-5 minutes. Alaska Airlines maintenance aircraft will have a taxiing time of 17-22 minutes and Delta Airlines aircraft will have a taxiing time of 18-24 minutes. Alaska Airlines and Delta Airlines Maintenance Facilities are 12,186 feet and 12,836 feet respectively from Site E. United Maintenance Facility is only 2,493 feet from this site. Site E is the furthest site for the Alaska Airlines and Delta Airlines maintenance facilities. It requires further travel time than they currently have going to both the north and south run-up sites. Site E is closer to the United Airlines Maintenance Facility than the existing south primary run-up pad and only slightly farther away from the United Facility as the existing north primary run-up pad.

The orientation of the GRE at this site remains consistent with the other sites in a southwest facing direction. **Exhibit 24** illustrates the details of GRE Site E.

4.8.2 GRE Site E Evaluation

One of the benefits associated with this site is the remote location away from the majority of terminal operations. Challenges related to jet blast impacts in this area are expected to be minimal considering aircraft movements in this area are routine. This site would require no grading or major site development. The pavement associated with Site E is anticipated to be sufficient to accommodate aircraft movements.

However, this GRE placement requires the longest taxi distances and times for maintenance facilities on the south side of the Airport including Delta and Alaska Airlines. Those long taxi times could be even longer since aircraft taxiing back to the south side maintenance facilities will be taxiing opposite the flow of all other aircraft. Further analysis would need to be completed in order to understand the significance of this potential problem. Alaska Airlines and Delta Airlines Maintenance Facilities are both located on the south side of the Airport and would have a two to two-and-a-half mile taxi distance. This site will require some aircraft parking and ground equipment storage to be relocated elsewhere on the Airport. This site could also potentially interfere with FedEx’s access to their easterly hardstand.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE E

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 24

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT E

Site E is located 0.21 miles from the nearest residential areas. This is slightly closer than the existing primary run up location located on the ramp adjacent to the threshold of Runway 16L. However, because the GRE facility will reduce noise levels all around the site by an estimated 15-20 dB, noise levels associated with run ups would be reduced for these residents.

Construction of a GRE at Site E would cost approximately $16,000,000 to $17,000,000; however, the costs associated with cargo parking or equipment relocation are not accounted for in this estimate.

4.9 GRE Site F

4.9.1 GRE Site F Location

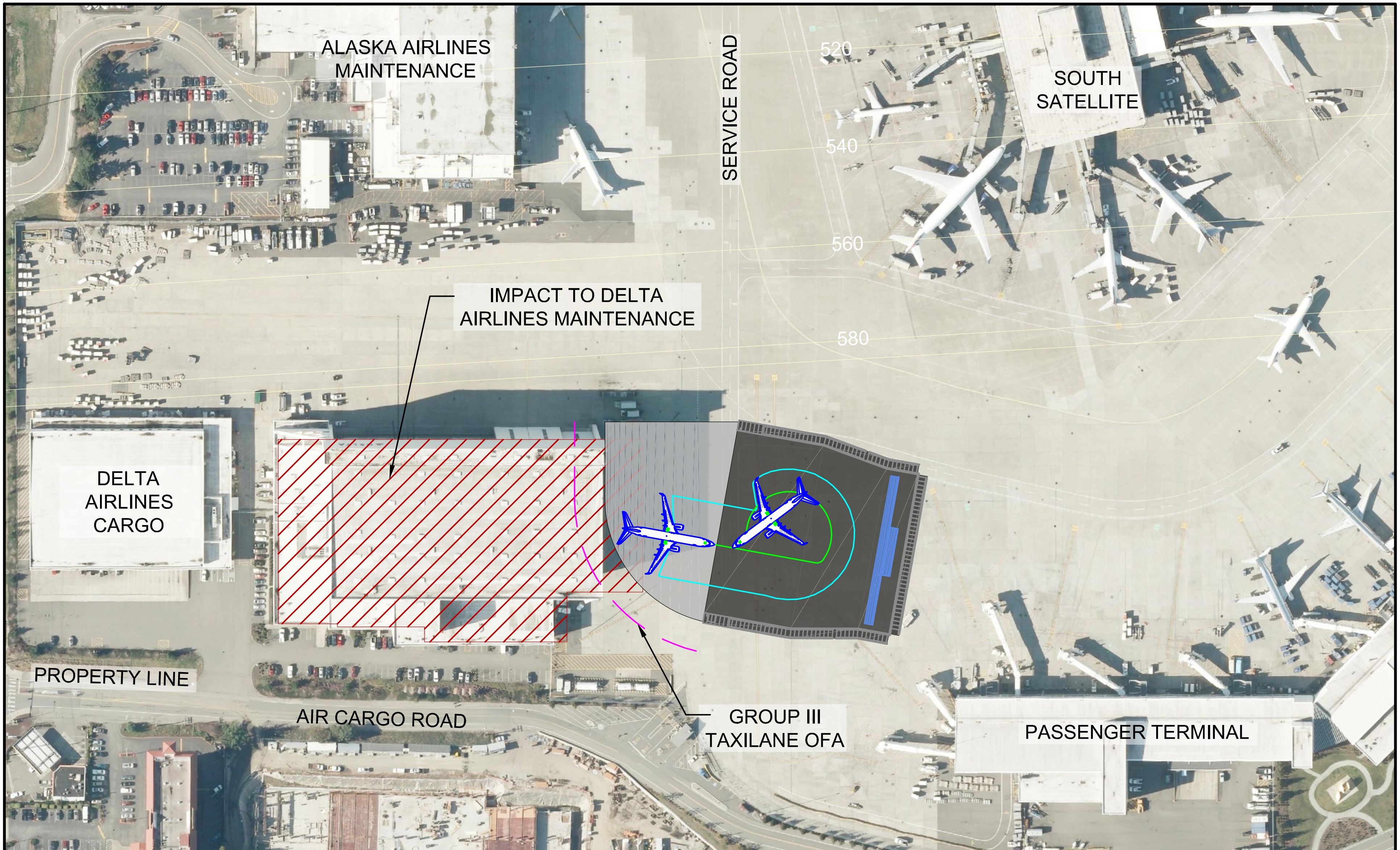
Site F was initially analyzed in the 2001 Feasibility and Siting Study. At that time there was a large open area of ramp. Currently, a section of Concourse A protrudes out into the site area on the north side of the site. The south satellite terminal extension is new as of 2001 and would require relocation for this GRE site.

Aircraft taxiing from the Alaska Airlines Maintenance Facility could get to the site in a little over a minute. Aircraft coming from the United Airlines Maintenance Facility, would need anywhere from 14 up to 18 minutes of taxi time in order to reach Site F. The distance from the following facilities is as follows: Alaska Maintenance Facility is 913 feet; Delta Maintenance Facility is 767 feet; and the United Maintenance Facility is the farthest at 10,209 feet. There are no line of sight issues at this site. There are two main residential areas that are equally close to the site at 0.43 miles east and 0.35 miles south of the site. Another residential area is located 1.12 miles west of the site. The proposed GRE Site F location and surroundings are seen in **Exhibit 25** below.

4.9.2 GRE Site F Evaluation

The benefits of Site F include no impact to airfield safety areas in regards to FAR Part 77 and ATCT LOS clearances, proximity to relevant facilities, as well as minimal impacts to environmental and noise impacts.

The drawbacks to Site F are impacts to existing facilities, operations, and site preparation. The Delta Airline Maintenance Facility would need to be demolished and relocated in order for the GRE to have ample room for typical operations at this site. Interference with terminal operations would also be a problem. Terminal operations on the southeast end would need to be relocated or eliminated, which includes three to four operational gates. Presently, Site F does not provide enough space to provide a facility function other than aircraft maneuvering capability for terminal operations and access to maintenance facilities.



GROUND RUN-UP ENCLOSURE SITING ANALYSIS	GROUND RUN-UP ENCLOSURE SITE F	1"=200'	DATE: JULY 2011
L&B SEATTLE TACOMA INTERNATIONAL AIRPORT	DRAFT	100 0 200	Exhibit 25

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 13. ALTERNATIVE F

Site F is farther away from the United Airlines maintenance facility than the existing north primary run-up pad; although it is closer than the existing south primary run-up pad. Site F is closer to both the Alaska and Delta Maintenance Facilities than both the south and north run-up pad.

The costs for preparing the site and building a GRE at Site F would be costly because of nearby structure demolitions, totaling approximately $58,880,000. Due to the impact to existing structures, this site is not considered viable.

4.10 GRE Site G

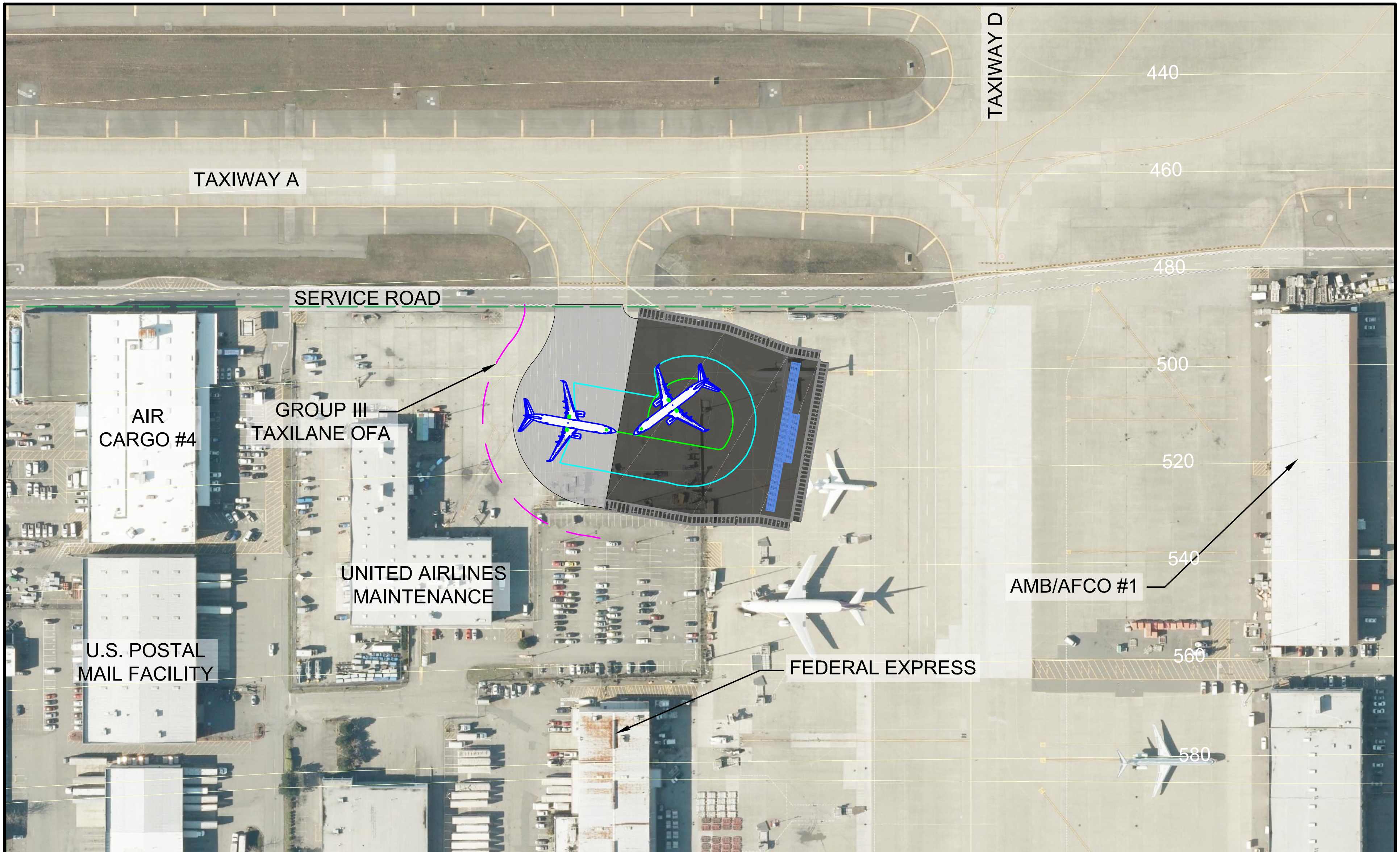
4.10.1 GRE Site G Location

Site G is located on the northernmost side of the airfield closest to Runway 16L. It is 296 feet from the FedEx facility and 457 feet from the United Airlines Maintenance Facility, making their taxi time under a minute for United Airlines aircraft performing ground run-ups at this GRE site. Alaska Airlines and Delta would be farther away with distances of 10,396 feet and 10,536 feet respectively. Alaska Airlines and Delta Airlines also both have longer taxiing times of approximately 15-20 minutes apiece. With a GRE on this site, it would be limited to 47 feet above grade in order to avoid impacting the Runway 16L/34R Part 77 Transitional Surface. There are also no LOS issues placing a GRE at Site G at this point in time. There are also residential areas in close proximity to this GRE site. There are residential houses located within 0.45 miles north, 0.48 miles east, and 0.94 miles west of the site. These are further depicted in **Exhibit 26**. The location of this site and surrounding area is also shown below in the exhibit.

4.10.2 GRE Site G Evaluation

The benefits of Site G include no impact to airfield safety areas in regards to FAR Part 77 and ATCT LOS clearances, proximity to relevant facilities, as well as minimal impacts to environmental and noise impacts. Site G provides proximity benefits for the maintenance facilities on the north side of the Airport. The pavement associated with Site G is anticipated to be sufficient to accommodate aircraft movements, but may need some minor load bearing pavement extension. It is anticipated that there are minimal jet blast impacts to surrounding facilities by aircraft accessing and exiting the GRE facility on Site G.

The drawbacks associated with Site G include significant impacts to existing operations. Maintenance facilities on the south side of the Airport would have approximately a 15 minute taxi time to the facility. Demolition of structures are not anticipated with the development of GRE Site G, however, portions of United Airlines maintenance vehicle parking and FedEx aircraft parking positions in the



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE G

DRAFT

1"=200'

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DATE: JULY 2011

Exhibit 26

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_LMM.dwg Layout: 14. ALTERNATIVE G area would require relocation elsewhere on the Airport. The displacement of the existing FedEx activity and future expansion of the existing FedEx facility in this area is considered a major drawback. A GRE near the United Airlines Maintenance ramp area will cause congestion in the area and access for both the maintenance facility and GRE facility would be hindered. These operational and physical drawbacks are considered to outweigh the limited benefits of Site G.

Site G is located 0.45 miles from the nearest residential areas. This is slightly closer than the existing primary run up location located on the ramp adjacent to the threshold of Runway 16L. However, because the GRE facility will reduce noise levels all around the site by an estimated 15-20 dB, noise levels associated with run ups would be reduced for these residents.

Site G is significantly farther away from the Alaska Airlines and Delta Airlines maintenance facilities than the existing south primary run-up pad; although it is slightly closer than the existing north primary run-up pad. Site G is closer to the United Airlines Maintenance Facility than the existing south primary run-up pad and also closer than the existing north primary run-up pad.

The cost of developing a GRE on Site G would be approximately $5,600,000. Due to the impact to existing structures, this site is not considered viable.

5. RECOMMENDATIONS

The subsequent sections discuss the site alternatives eliminated and the sites deemed appropriate for consideration if the Port moves forward with the development of a GRE facility at SEA-TAC. A matrix summarizing the benefits and impacts of each site that was considered is included at the end of this section in **Table 6**.

5.1 Eliminated Alternatives

The drawbacks associated with Site C, Site F, and Site G as stated in the evaluation of alternatives contained in Section 4, eliminate their viability for further consideration. The following discussion summarizes the drawbacks of each of these alternatives.

5.1.1 Site C

The drawbacks associated with Site C eliminate this site from further review. This includes the displacement of a Port owned cargo facility currently occupied by Swissport and fuel truck parking that cannot be relocated to a practical site elsewhere on the Airport, as well as, conflicts with future expansion of the North Satellite and potential impacts to the ARFF facility. Other site alternatives offer a better balance of benefits and drawbacks.

5.1.2 Site F

The drawbacks associated with Site F eliminate this site from further review. This includes the site location within the vicinity of the Delta Airline Maintenance Facility and Concourse A and subsequent impacts to aircraft flows, terminal operations and the potential demolition of structures to provide adequate room for a GRE. Other site alternatives offer a better balance of benefits and drawbacks.

5.1.3 Site G

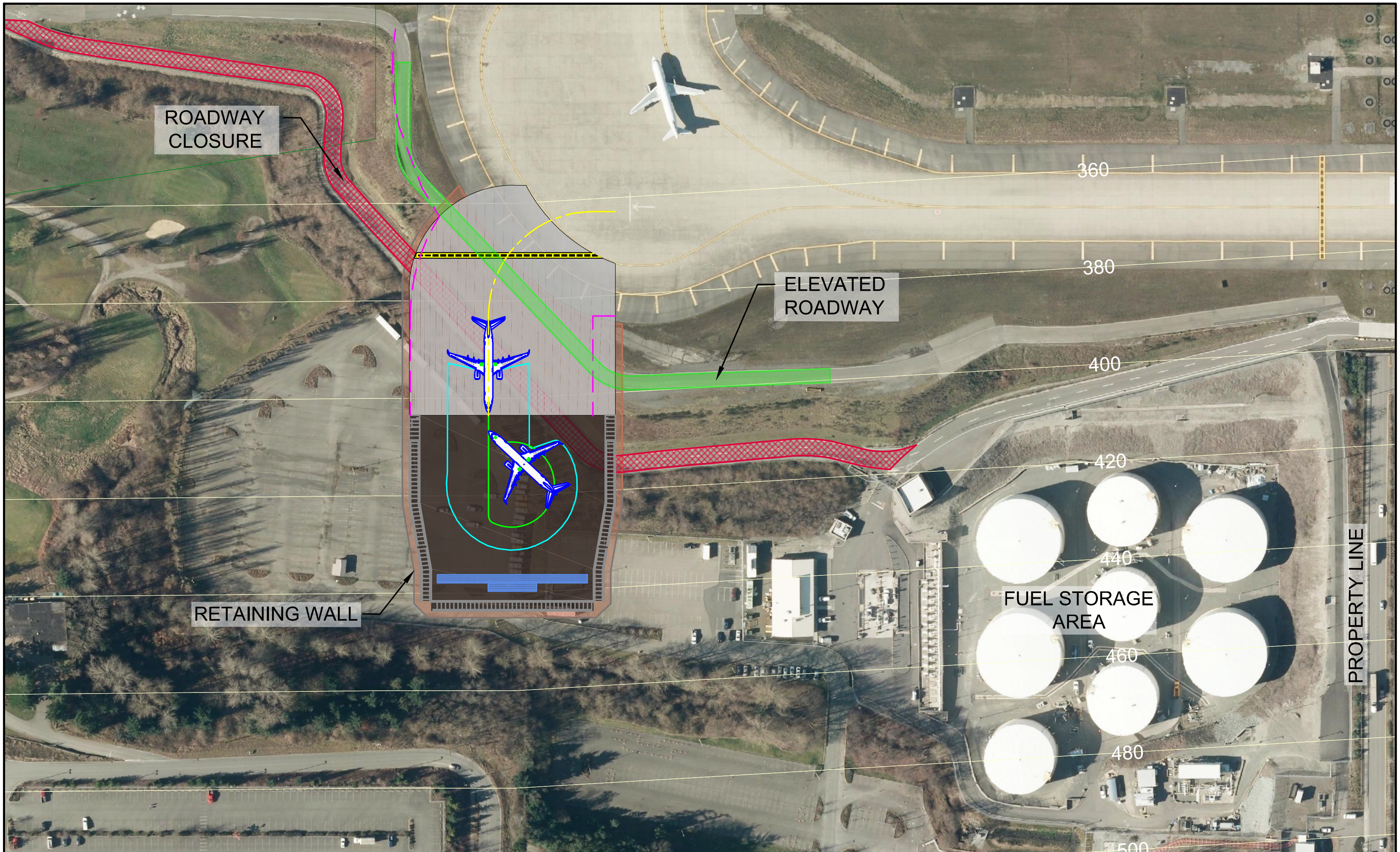
The drawbacks associated with Site G eliminate this site from further review. This includes the site location within the vicinity of the United Airlines Maintenance Facility and FedEx Cargo hardstands and subsequent impacts to the existing operation and future facilities, displacement of vehicle parking, cargo activity, and airfield access. Other site alternatives offer a better balance of benefits and drawbacks.

5.2 Recommended Alternatives

The remaining alternatives, Site A, Site B, Site D, and Site E as described in the previous Alternatives Section, are the recommended site options for potential GRE development. The following discussion summarizes the planning factors that should be considered if the Port chooses to move forward with the development of a GRE facility.

For reference, the preferred site locations and GRE facility orientations have been appended on the pages that follow and identified as follows:

- **Exhibit 27 - Site A**
- **Exhibit 28 - Site B1**
- **Exhibit 29 - Site B2**
- **Exhibit 30 - Site D9**
- **Exhibit 31 - Site D10**
- **Exhibit 32 - Site E**



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

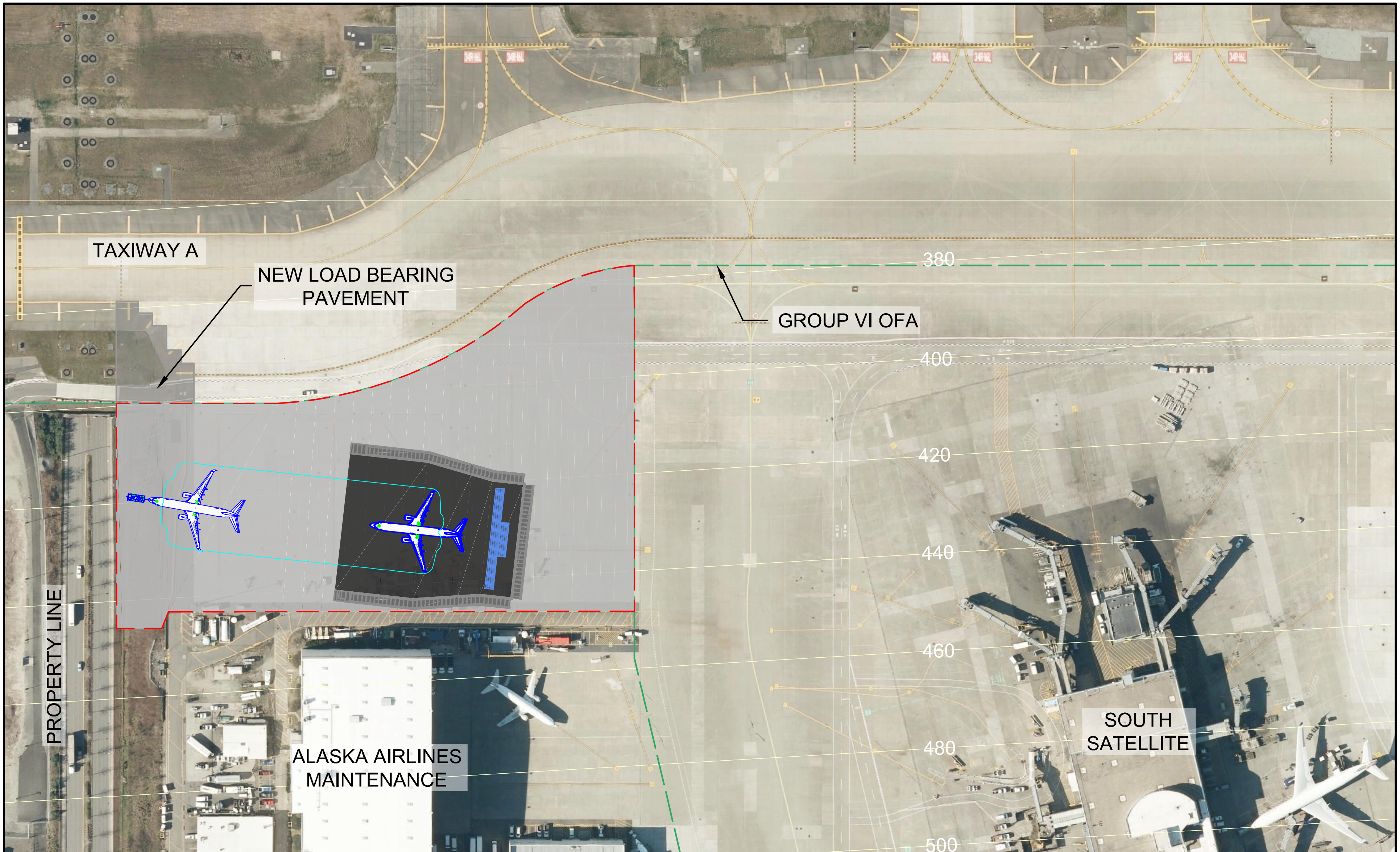
GROUND RUN-UP ENCLOSURE SITE A

DRAFT

DATE: JULY 2011

Exhibit 27

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT A (CHAP 5)



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE B1

DRAFT

1"=200'

100 0 200

DATE: JULY 2011

Exhibit 28

MAINTENANCE

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT B1 (CHAP 5)

GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE B2

DRAFT

1"=200'

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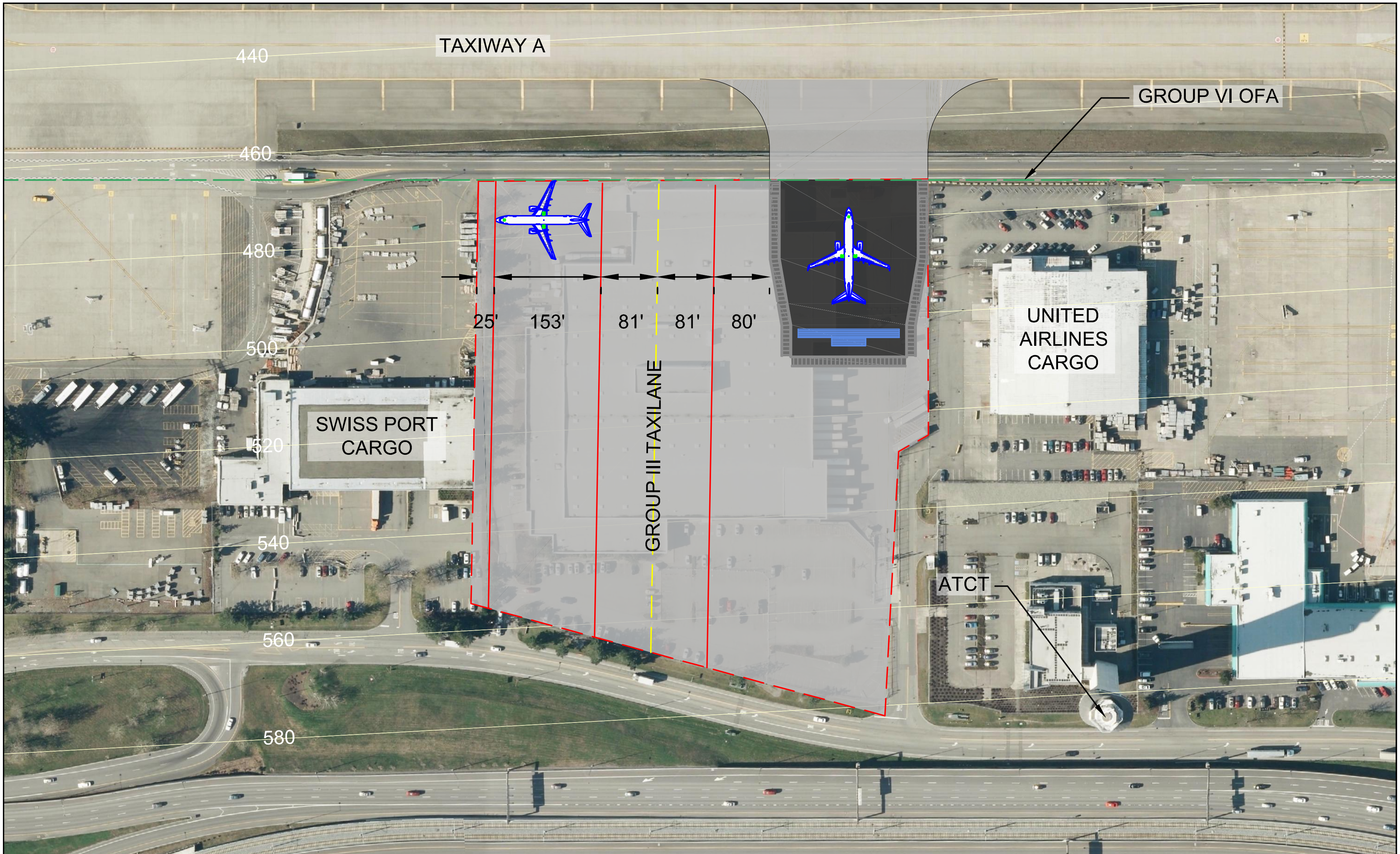
DATE: JULY 2011

Exhibit 29

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT B2 (CHAP 5)



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D9

DRAFT

1"=200'

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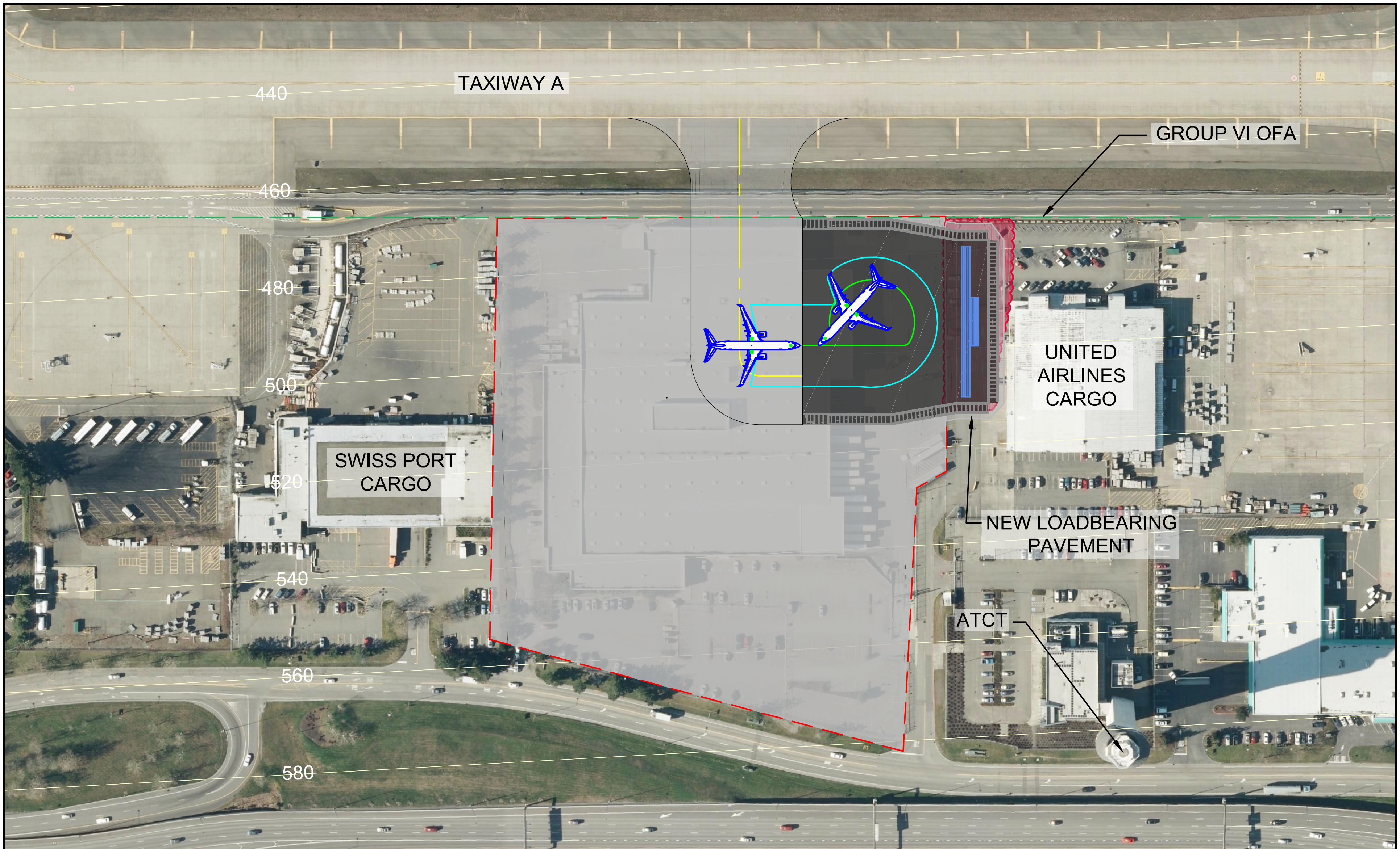
DATE: JULY 2011

Exhibit 30

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT D9 Copy (Exhibit 30)



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA INTERNATIONAL AIRPORT

GROUND RUN-UP ENCLOSURE SITE D10

DRAFT

1"=200'

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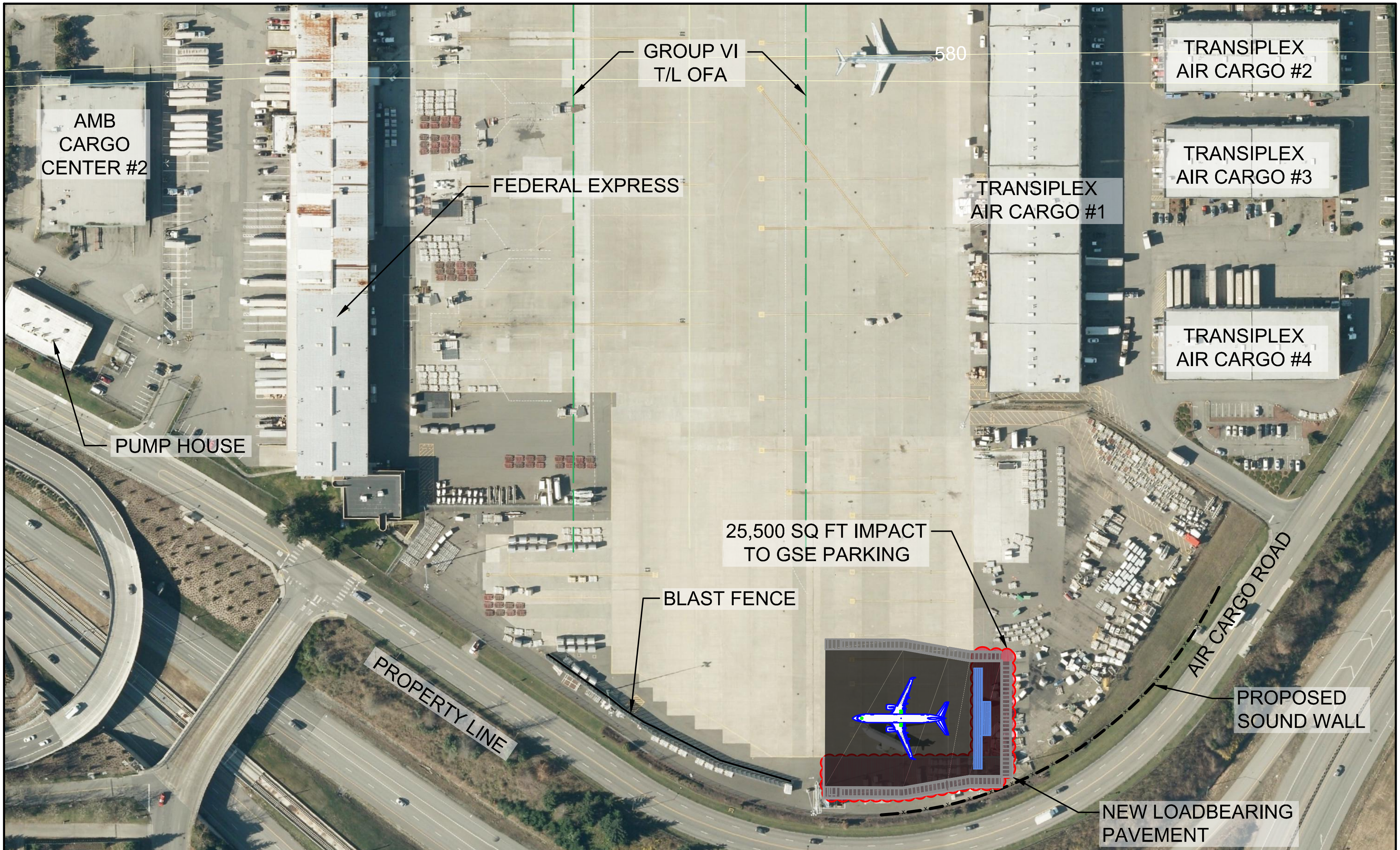
W S N E

DATE: JULY 2011

Exhibit 31

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT D10 (CHAP-5)



GROUND RUN-UP ENCLOSURE SITING ANALYSIS

L&B

SEATTLE TACOMA
INTERNATIONAL AIRPORT

GROUND RUN-UP
ENCLOSURE
SITE E

DRAFT

1"=200'

100 0 200

W N E S

DATE: JULY 2011

Exhibit
32

File: H:\SEATAC\GRE\CAD\GRE\GRE EXHIBITS_Meeting_Revisions.dwg Layout: ALT E (CHAP 5)

Table 6 – Site Option Evaluation Matrix

Site Selection Criteria	GRE Site A	GRE Site B1	GRE Site B2	GRE Site C	GRE Sites D1-D8
Safety Criteria Considerations • Interference with NAVAID Critical Area • Interference with Part 77 • Interference with ATCT LOS • Interference with Group VI taxiway OFA • Interference with RSA • Interference with NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Site would need Hold Short for ILS Glideslope Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area
Airfield Operational Considerations • Distances to Airline Maintenance Facilities • Congestion Due to Taxiway Flows	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site A: 4,023 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site A: 4,611 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site A: 11,835 Ft. -Site would need Hold Short for ILS Glideslope Critical Area -Larger Site is more flexible	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site B: 1,003 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site B: 3,215 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site B: 10,252 Ft.	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site B: 1,003 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site B: 3,215 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site B: 10,252 Ft.	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site C: 6,416 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site C: 7,056 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site C: 4,171 Ft.	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site D: 7,396 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site D: 8,034 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site D: 3,358 Ft.
Impacts to Existing Facilities • Impacts to Existing Structures or Other Uses	**Impacts to Existing Facilities** -Automobile Parking Facility (Currently not used heavily) -Wetlands/Streams would be avoided -Access Road Relocation	**Impacts to Existing Facilities** -RON Parking Facility -Lose 6 RONs -Fire Lane Relocation	**Impacts to Existing Facilities** -RON Parking Facility -Lose 2 RONs -Fire Lane Relocation -Relocate 9,000 sq. ft. GSE Storage Area	**Impacts to Existing Facilities** -Swiss Port Cargo Bays -Cargo Hardstands -Fuel Rack	**Impacts to Existing Facilities** -Assumes Prepped Site (USPS Facility)
Impacts on Future Facilities • Opportunity Cost of GRE on Each Site	**Impact on Future Facilities** -Port Maintenance Campus	**Impact on Future Facilities** -South Satellite Expansion	**Impact on Future Facilities** -South Satellite Expansion	**Impact on Future Facilities** -Reducing Future RON Parking	**Impact on Future Facilities** -Impacts to Future ARFF Layout -Reducing Future RON Parking
Residential Proximity • Distances from the Site to the Closest Residential Neighborhood for Acoustical Requirements	**Residential Proximity** -North: No Neighborhood to the North -East: 0.29 Miles -West: 0.66 Miles -South: 0.56 Miles	**Residential Proximity** -North: No Neighborhood to the North -East: 0.70 Miles -West: 0.86 Miles -South: 0.53 Miles	**Residential Proximity** -North: No Neighborhood to the North -East: 0.70 Miles -West: 0.86 Miles -South: 0.53 Miles	**Residential Proximity** -North: 0.50 Miles -East: 0.43 Miles -West: 1.09 Miles -South: No Neighborhood to the South	**Residential Proximity** -North: 0.58 Miles -East: 0.45 Miles -West: 1.09 Miles -South: No Neighborhood to the South
Cost • Monetary Cost of Each Site	**Cost** Approximately $33,000,000	**Cost** Approximately $16,700,000	**Cost** Approximately $16,700,000	**Cost** Approximately $10,000,000	**Cost** Approximately $8,000,000 to $9,000,000

Table 6 – Site Option Evaluation Matrix, *Continued*

Site Selection Criteria	GRE Site D9-D10	GRE Site E	GRE Site F	GRE Site G
Safety Criteria Considerations • Interference with NAVAID Critical Area • Interference with Part 77 • Interference with ATCT LOS • Interference with Group VI taxiway OFA • Interference with RSA • Interference with NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area	**Safety Criteria Considerations** -Clear of Part 77 Transitional: **YES** -Clear of ATCT LOS: **YES** -Clear of Group VI Taxiway OFA: **YES** -Clear of Runway RSA area: **YES** -Clear of NAVAID Critical Area
Airfield Operational Considerations • Distances to Airline Maintenance Facilities • Congestion Due to Taxiway Flows	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site D: 7,396 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site D: 8,034 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site D: 3,358 Ft.	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site E: 12,186 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site E: 12,836 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site E: 2,493 Ft. -Maintains existing operational uses in area	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site F: 913 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site F: 767 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site F: 10,209 Ft.	**Airfield Operational Considerations** -Distance from Alaska MX to NP Run-up Pad: 10,772 Ft. -Distance from Alaska MX to SP Run-up Pad: 3,416 Ft. -Distance from Alaska MX to Site G: 10,396 Ft. -Distance from Delta MX to NP Run-up Pad: 12,716 Ft. -Distance from Delta MX to SP Run-up Pad: 5,360 Ft. -Distance from Delta MX to Site G: 10,536 Ft. -Distance from United MX to NP Run-up Pad: 2,166 Ft. -Distance from United MX to SP Run-up Pad: 11,142 Ft. -Distance from United MX to Site G: 457 Ft.
Impacts to Existing Facilities • Impacts to Existing Structures or Other Uses	**Impacts to Existing Facilities** -Assumes Prepped Site (USPS Facility)	**Impacts to Existing Facilities** -GSE Equipment Storage -Lose 1-2 RONs	**Impacts to Existing Facilities** -Delta Airline Maintenance Building -3 to 4 Passenger Gates -2 Service Roads near Passenger Terminal	**Impacts to Existing Facilities** -2 United Cargo Hardstands -United Airlines Employee Parking Lot
Impacts on Future Facilities • Opportunity Cost of GRE on Each Site	**Impact on Future Facilities** -Impacts to Future ARFF Layout -Reducing Future RON Parking	**Impact on Future Facilities** -None	**Impact on Future Facilities**	**Impact on Future Facilities**
Residential Proximity • Distances from the Site to the Closest Residential Neighborhood for Acoustical Requirements	**Residential Proximity** -North: 0.58 Miles -East: 0.45 Miles -West: 1.09 Miles -South: No Neighborhood to the South	**Residential Proximity** -North: 0.21 Miles -East: 0.29 Miles -West: 1.16 Miles -South: No Neighborhood to the South	**Residential Proximity** -North: No Neighborhood to the North -East: 0.43 Miles -West: 1.12 Miles -South: 0.35 Miles	**Residential Proximity** -North: 0.45 Miles -East: 0.48 Miles -West: 0.94 Miles -South: No Neighborhood to the South
Cost • Monetary Cost of Each Site	**Cost** Approximately $8,000,000 to $9,000,000	**Cost** Approximately $16,000,000 to $17,000,000	**Cost** Approximately $58,880,000	**Cost** Approximately $10,000,000

Abbreviations: ATCT = Airport Traffic Control Tower, GSE = Ground Service Equipment, LOS = Line-of-Sight, ILS = Instrument Landing System, MX = Airline Maintenance Facility, NAVAID = Navigational Aid(s), OFA = Object Free Area, RSA = Runway Safety Area, RON = Remaining Over Night, NP = North Primary (Run-up Pad), SP = South Primary (Run-up Pad)

APPENDIX A
GRE Workshop Materials

Part 150 Presentation

Hush House Workshop

May 10, 2011

Seattle Tacoma International Airport

Aviation Planning at the Leading Edge

Agenda

- Welcome and Introductions
- Purpose of the Hush House Study
- Purpose of Today's Workshop
- Assumptions
- Evaluation of Potential Hush House Sites

L&B
Aviation Planning at the Leading Edge

Purpose of Hush House Study

- Identify potential site(s) for a hush house or ground runup enclosure (GRE)
- Provide *planning* level information for decision makers
- Develop enough information to make the facility eligible for Federal funds if Port Commission wished to apply
- Provide a starting point for a formal design study if Port Commission chooses to move forward

Aviation Planning at the Leading Edge

Purpose of Today's Workshop

- Define a hush house or GRE
- Identify the key assumptions for siting a GRE
- Present our initial findings/status for each site
- Gather *your* input on the relative pros/cons of each site
- Eliminate sites that will not work
- Discuss next steps for this study

Aviation Planning at the Leading Edge

What is a Hush House / GRE

❑Hush House / GRE Facts:

- A Hush House/GRE is a term used for an enclosed, noise suppressed, aircraft engine test facility
- Typically consists of 3 walls that deflect jet blast
- Hush House will typically reduce noise by 15-20 dB

Aviation Planning at the Leading Edge

Hush House Evaluation

- **Hush House / GRE Facts:**
  - Typical Hush Houses/GRE cost $3 - $6 million
  - Total cost is dependent on the type and final design
  - Site prep is in addition to the facility costs

Aviation Planning at the Leading Edge

Assumptions for the Workshop

- **We are not here to debate the need for a hush house/GRE**
  - Our goal is find the best site(s) for a hush house/GRE if Port Commission determines that one is wanted
- **Costs for site work will be order of magnitude or relative comparisons to other sites**
  - A follow-on engineering study would develop final site work costs
- **Impacts to existing facilities need to be identified with order of magnitude costs**

Assumptions for the Workshop

- **Impacts to future or planned facilities need to be identified and listed**
  - No attempt will be made to quantify or make value judgments about one future use versus another

- **Noise Analysis**
  - Off-airport noise impacts will be prepared after site(s) identified
  - On-airport impacts to existing facilities will focus primarily on potentially noise-sensitive uses (ATCT)

Assumptions for the Workshop

❑ Facility Sizing / Siting Criteria

- Currently there are on average 2 maintenance runups per day at SEA-TAC
- Majority conducted by Alaska Airlines B737 aircraft
- Design aircraft is 737-900 with winglets
- Dimensions of facility depend on operational modes
  - Power in/out – *preferred by airlines*
  - Tug in/out – *smaller overall footprint*
- Requires clear area in front of opening
- Orientation is dependent upon site and wind
  - Preferred is facing south
  - Other orientations result in possibility of less use

Aviation Planning at the Leading Edge

Assumptions for the Workshop

❑Facility Sizing / Siting Criteria

- Consider safety criteria
  - Part 77
  - Transitional surfaces
  - RSA/OFA
  - ATCT Line of Sight
  - Evaluating Group VI safety area clearance for airfield
- Consider airfield operational issues
  - Taxi distance
  - Impacts to taxi flows (north vs south flow)
- Impacts to existing facilities
- Impacts to future or planned facilities
- Site prep work

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Questions / Answers

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SIGN-IN SHEET

SEATAC GRE

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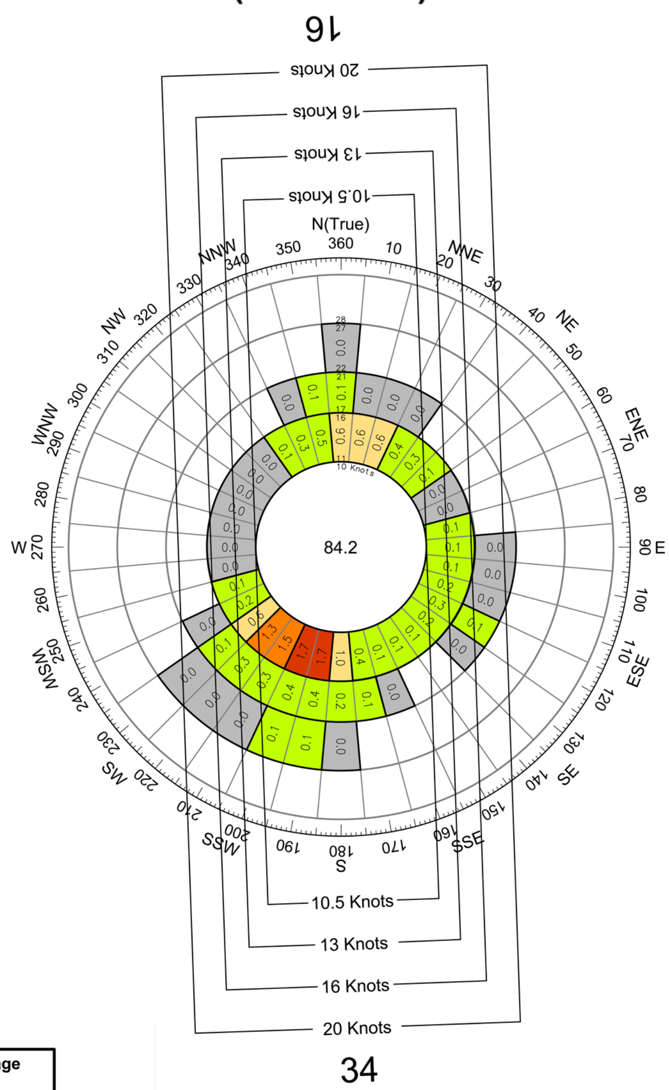
APPENDIX B
Wind Analysis

SEATAC ALL WEATHER WINDROSE
(1986-2005)



Generalized Wind-Related Usage Guidelines	
LEGEND	
<0.1	
0.1 -0.5	
0.6-1.0	
1.1-1.5	
1.6-2.0	

ALL WEATHER

APPENDIX C
Blast Deflectors Inc. Wind Analysis

Seattle, Washington
GRE Heading Ranking
Based on Medium-Bypass Usability Profile

Heading	Overall		Night		Day	
	Assured	Projected	Assured	Projected	Assured	Projected
250	72.98	93.84 *	73.49	95.15	72.68	93.05
240	74.94	93.77	75.97	94.84	74.32	93.13 *
260	71.61	93.45	72.21	94.73	71.25	92.68
230	75.99	93.41	77.79	94.34	74.91	92.86
220	77.02	93.13	79.49	94.19	75.53	92.50
210	77.62	92.60	80.85	94.26	75.68 *	91.60
150	73.37	92.55	83.62	96.72 *	67.19	90.03
270	69.07	92.54	69.62	93.52	68.74	91.95
140	72.39	92.50	84.24 *	96.62	65.24	90.02
160	74.22	92.21	82.85	96.29	69.01	89.75
130	71.24	92.19	83.59	96.25	63.80	89.75
200	77.76 *	92.14	81.69	94.44	75.39	90.75
190	77.39	91.81	82.18	94.71	74.51	90.05
170	75.57	91.69	82.61	95.50	71.32	89.39
180	76.46	91.66	82.19	95.01	73.00	89.64
280	67.69	91.52	68.23	92.27	67.37	91.07
120	70.16	91.39	82.60	95.53	62.66	88.89
110	68.79	90.03	81.14	94.33	61.35	87.45
290	66.57	89.79	67.03	90.69	66.29	89.24
100	67.88	88.97	80.02	93.38	60.56	86.31
300	65.56	88.61	65.64	89.94	65.50	87.81
90	67.06	87.90	79.02	92.35	59.86	85.22
310	63.85	87.69	63.32	89.37	64.17	86.68
80	66.73	87.05	78.32	91.58	59.74	84.32
320	62.66	86.55	62.01	88.50	63.05	85.38
70	65.78	86.29	76.69	90.80	59.21	83.58
60	64.92	85.20	74.46	89.82	59.17	82.41
330	62.00	85.13	61.67	87.01	62.21	84.01
340	61.40	83.99	61.61	85.84	61.27	82.87
50	63.31	83.70	70.92	88.24	58.73	80.96
350	61.21	82.61	62.08	84.61	60.69	81.40
40	62.78	82.36	69.00	86.63	59.04	79.79
0	60.81	81.78	62.61	84.22	59.72	80.31
10	60.92	81.12	63.71	83.96	59.24	79.41
30	62.37	80.95	67.35	84.73	59.36	78.67
20	61.81	80.59	65.91	84.00	59.34	78.54

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