REGIONAL AVIATION BASELINE STUDY
WORKING PAPER 2

Airport Needs Analysis

June 2020

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Contents

Tables

Figures

Acronyms

ARC ... Airport Reference Code
ASV ... Annual Service Volume
BRT ... Bus Rapid Transit
FAA ... Federal Aviation Administration
FBO ... Fixed-Base Operator
IAP ... Instrument Approach Procedures
IFR ... Instrument Flight Rules
KCIA ... King County International Airport
MSA ... Metropolitan Statistical Area
PSRC ... Puget Sound Regional Council
SAMP ... Sustainable Airport Master Plan
SASA ... South Aviation Support Area
SPB ... Sea Plane Base
TAF ... Terminal Area Forecast
TNC ... Transportation Network Companies
VFR ... Visual Flight Rules
WASP ... Washington Aviation System Plans

1. Introduction

1.1 STUDY BACKGROUND AND PURPOSE

The central Puget Sound region plays a pivotal role in aviation in the Pacific Northwest. The region serves as the hub for the 5th largest airline by enplanements (Alaska Airlines), serves as the West Coast gateway for the nation's 2nd largest airline by enplanements (Delta Air Lines), contains the 8th busiest airport in the nation (Seattle-Tacoma International Airport [Sea-Tac]), and hosts major manufacturing and operations activities of the largest aerospace company in the world—the Boeing Company. The aviation system is a critical part of an ecosystem that supports high paying jobs, housing, and economic development.

The purpose of the Regional Aviation Baseline Study is to provide a clear picture of the different roles and purposes of each aviation activity at each of the region's airports, describe how these activities interact, and identify future needs in the central Puget Sound region (King, Pierce, Snohomish, and Kitsap counties) to set the stage for future planning. This study is expected to provide a common baseline for policymakers about the region's aviation needs and options to consider for meeting those needs in the future. This study is the first phase of potentially more focused studies on specific areas of emphasis.

Recent rapid growth is likely to affect the quality and level of aviation service. State and regional leaders need solid and reliable information about the current usage and projected regional growth to adequately plan and provide for future aviation needs. The desired outcomes of the Regional Aviation Baseline Study follow:

- Identify the roles of each airport and the aviation activities within the region.
- Provide a regional perspective on how aviation activities at airports in the study area interact with each other, the community, and the broader economy.
- Obtain input from stakeholders about their needs and build a common understanding about aviation and airspace constraints.
- Identify future aviation needs within central Puget Sound region and set the stage for future planning.

The study will provide a regional understanding of the aviation system. In addition to data gathered about the system and from aviation stakeholders, the study will leverage data from current airport master planning efforts and other regional/statewide aviation studies.

1.2 STUDY PROCESS

Key phases for the study include the following:

- **Airport and Aviation Activity Analysis Phase –** During this phase, the study team examined existing conditions, regional demand forecasts, goals, objectives, and metrics for the system, and analyzed socioeconomic conditions, market trends, airspace flow, and multimodal connections. Working Paper 1 was the key deliverable.
- **Future Aviation Issues Analysis Phase –** During this phase, the study team analyzed the feasibility of airports in the region to accommodate demand. Working Paper 2 is the key deliverable as was a separate analysis of the airspace flow.
- **Scenarios Definition and Evaluation Phase –** During this phase, the study team will define and evaluate scenarios for accommodating future aviation demand as well as the regional economic effects of the aviation industry. Working Paper 3 will be the key deliverable.
- **Final Report and Project Completion –** During this phase, the study team will publish key findings in a report.

To support study transparency and ensure timely stakeholder input during each phase, the study team will consult stakeholders so that their perspectives can be considered in the development of findings and recommendations. As a part of this effort, a Technical Working Group, comprised of representative airports, airlines and other major stakeholders in the aviation industry, was established. It will meet at three points during the study to review draft technical papers. The Puget Sound Regional Council's (PSRC) Executive Board is overseeing the study. Between these periods of more active communications, the PSRC will pursue opportunities to report on study findings and to reinforce key messages about the purpose and need for the study.

1.3 STUDY STATUS

Working Paper 1 was completed and shared with the Technical Working Group in June 2019. Comments were incorporated and the final working paper was distributed to the Technical Working Group. That working paper established the baseline existing conditions, identified key relevant trends and issues, and included unconstrained forecasts for the various aviation sectors in the region.

Over the course of summer 2019, the project team assessed the ability of the various airports in the region to meet the commercial, general aviation, and air cargo forecasts. This Working Paper 2 analyzes the aviation needs of the region through 2050 and will form the basis for several scenarios designed to address the needs that will be developed and evaluated in Working Paper 3.

1.4 ORGANIZATION OF WORKING PAPER 2

This working paper is organized into five chapters:

- Chapter 1 summarizes the study background and the purpose of the working paper.
- Chapter 2 reports the results of key metrics for commercial, general aviation and air cargo sectors that were established in Working Paper 1. It also benchmarks the region's performance against comparable regions and airports across the country.
- Chapter 3 contains the aviation needs analysis. It starts with a methodology section and then compares capacity to demand for airside, landside and ground access by aviation sector. It includes individual discussion of some of the larger airports.
- Chapter 4 presents opportunities and challenges for each aviation sector.
- Chapter 5 assesses the long-term facility requirements of the Puget Sound aviation system regarding commercial service, air cargo, general aviation, and intermodality.

2. Benchmarks

This chapter will be based on the benchmarks matrix, which will be appended to the working paper. It will serve as a summary of Working Paper 1 and a foundation for the needs analysis in Chapter 3.

2.1 BACKGROUND ON METRICS AND METHODS

Metrics, developed at the beginning of the project, are used to better understand the individual airports as well as the regional system overall. Benchmarks for the metrics were developed based on analysis of statewide system plans and Federal Aviation Administration (FAA) requirements and are used to determine how the overall system meets the needs of the central Puget Sound region. The baseline data, which can be found in Working Paper 1, was compared to the benchmarks to analyze the system.

2.2 COMMERCIAL SERVICE

Commercial service benchmarks were developed for the Working Paper 1 metrics based on analysis of statewide system plans, expert determination, and FAA guidelines. The inventory baseline data was compared to the benchmarks to determine how the current and future systems meet, or are expected to meet, the needs of the region. By National Plan of Integrated Airport Systems definition, Seattle-Tacoma International (Sea-Tac), King County International/Boeing Field (KCIA), and Paine Field/Snohomish County International (Paine Field) are the commercial service airports in the central Puget Sound region. For purposes of the forecast and certain metrics, however, only airports that provide regularly scheduled passenger airline service are considered and only Sea-Tac and Paine Field meet that definition.[1] Seattle was analyzed along with other cities around the country that have multi-airport-airport systems as defined by the U.S. Department of Transportation to determine general guidelines for when a city requires an additional commercial service airport.

2.2.1 Commercial Benchmarks

Commercial passenger service area coverage is important both to the region's population and economy. The benchmark for commercial service access is 80 percent of a region's population and 90 percent of its jobs within a 60-minute drive to a commercial service airports.[2] This average coverage from these statewide system plans was adjusted to reflect the regional nature of the central Puget Sound region aviation system. The benchmarks developed through the methodology used in the statewide system plans use the same travelshed for the base and forecast years, where the underlying population and employment change over time. This methodology was used in Working Paper 1, which illustrated the travelshed created

[1] Part 121 carriers

[2] Established by analyzing statewide system plans in Kansas, Kentucky, Louisiana, Massachusetts, Montana, Ohio, and Wisconsin

for the 2017 base year using HERE[3] data with congestion and applies the same travelshed to the 2050 forecast year data.

For this working paper, a separate analysis was conducted using the PSRC travel demand model to illustrate population and employment access changes as congestion grows between the base year and 2050 forecast year. In addition, this analysis considers Sea-Tac separately as well as Sea-Tac and Paine Field together since the service offered at the two airports differs considerably. Figure 2-1 and Figure 2-2 show the coverages for Sea-Tac and combined coverage of Sea-Tac and Paine Field using the PSRC travel demand model.

Results from the analysis indicate that when considering only Sea-Tac, the region does not meet the benchmark for either population or employment access to commercial service within 60 minutes. In 2017, 62 percent of the population had access to Sea-Tac within 60 minutes and is projected to drop to 42 percent by 2050. As population density and congestion increases, Sea-Tac is projected to remain accessible to much of King County's population base. However, the airport loses coverage in northern King County and does not serve the majority of Kitsap, Pierce, and Snohomish Counties. The result is that 58 percent of the region's population is not expected to have 60-minute access to Sea-Tac.

While Sea-Tac serves as the primary commercial service hub for the region, Paine Field introduced commercial service in 2019 and adds passenger accessibility for the northern part of the region, specifically in Snohomish County. Figure 2-2 illustrates coverage for 2017 and 2050 when including both of these commercial service airports.[4]

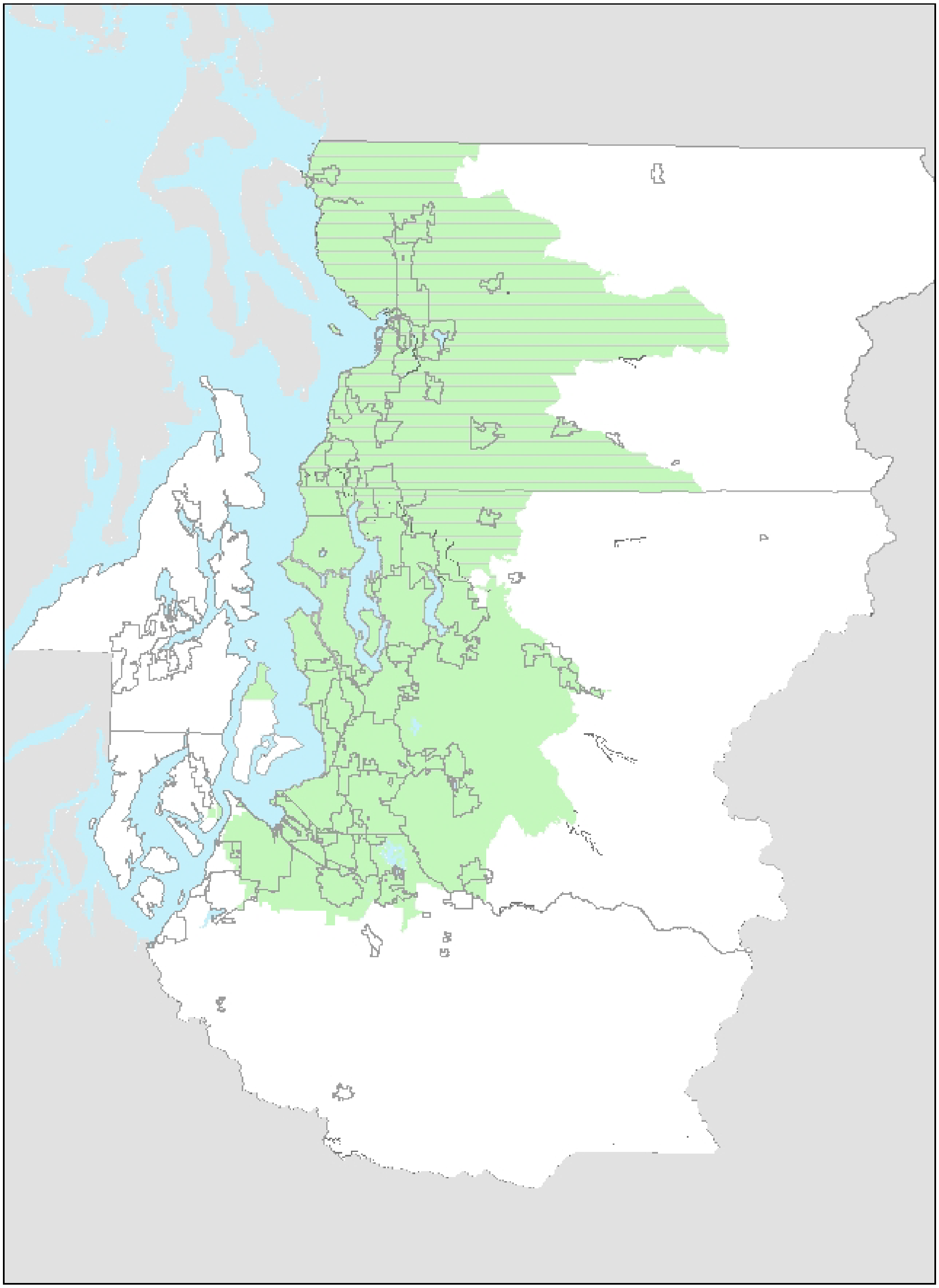
Results from the analysis indicate that when considering the combined Sea-Tac and Paine Field travelsheds, the region meets the 80 percent benchmark for population and employment access to commercial service within 60 minutes in the base year but not in 2050. In 2017, 83 percent of the population had access to combined Sea-Tac and Paine Field within 60 minutes but is projected to drop under the benchmark at 70 percent by 2050. The combined coverage area excludes areas such as Kitsap County, most of Pierce County, and much of the eastern halves of King and Snohomish Counties. Major cities expected to lose 60-minute access to Sea-Tac in 2050 include Tacoma and Puyallup. Shoreline and Redmond both had 60-minute access to Sea-Tac in 2017 but are expected to lose that by 2050. These two cities, however, would retain access to Paine Field in 2050. Stanwood, on the other hand, is an example of a city that is anticipated to lose 60-minute access to Paine Field.

Employee access to commercial service is also an important metric. The region meets the metric for 60-minute access in the base year but not in the future. In 2017 90 percent of the regional jobs were within 60 minutes of either Sea-Tac or Paine Field, but by 2050 this metric is expected to drop below the benchmark, to 80 percent.

[3] HERE is a company that provides nearly real-time tracking of vehicular travel using GPS and other technologies.

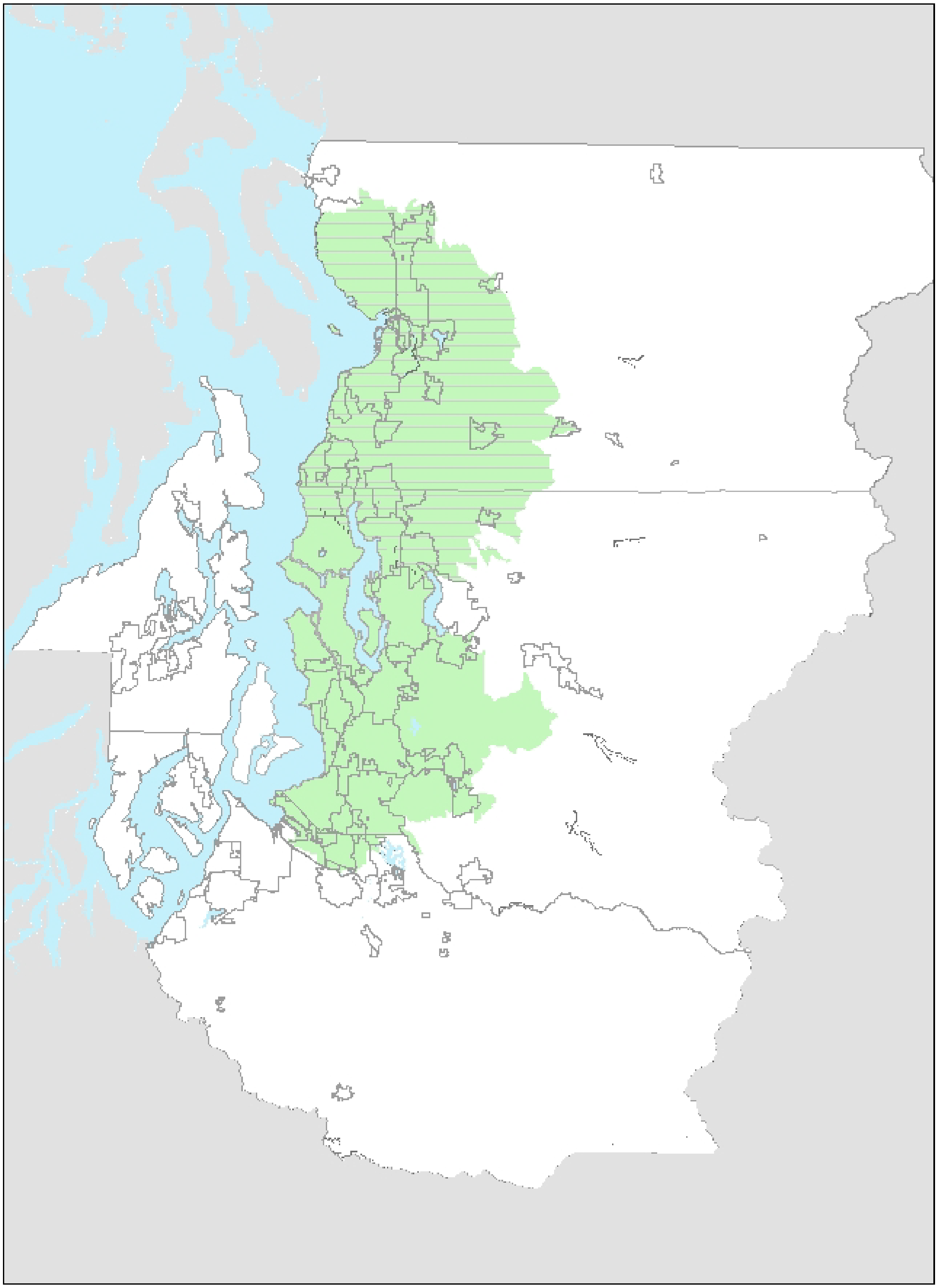
[4] Airlines at both Sea-Tac and Paine Field are FAA Part 121 air carriers. King County International Airport does not have Part 121 air carriers, only Part 135 and Part 380 air carriers providing minor commercial air service.

Figure 2-1. 60-Minute Drive-Time Access to Commercial Passenger Service (Seattle-Tacoma International and Paine Field) in Base Year



Notes:
1. The drive time is derived from Puget Sound Regional Council's travel model for 2014.
2. Cross-hatching indicates Paine Field coverage.

Figure 2-2. 60-Minute Drive-Time Access to Commercial Passenger Service (Seattle-Tacoma International and Paine Field) in 2050



Notes:

1 The drive time is derived from Puget Sound Regional Council's travel model for 2050

2. Cross-hatching indicates Paine Field coverage.

Benchmarks for this study state that all airports with commercial passenger service should have access from airport property to a 4-lane arterial or better. It is also desirable for airports with commercial passenger service to have access to a limited access highway and to have access to an interstate within five miles. Sea-Tac alone meets all these benchmarks, whereas when Paine Field is included, the benchmark for high-capacity transit access was not met. However, the recent addition of the Community Transit Swift Green Line in early 2019 improved the high-capacity transit access metric to 100 percent. Table 2-1 summarizes the commercial service benchmarks and how well the region meets these benchmarks now and predictions for meeting them in the future.

Table 2-1. Benchmarks for Commercial Service Airport Coverage and Access (Seattle-Tacoma International and Paine Field)

		SEA-TAC		SEA-TAC AND PAINE FIELD	
	BENCHMARK	2017	2050	2017	2050
Percentage Population within 60 minutes	80%[1]	62%[2]	42%[2]	83%[2]	70%[2]
Percentage Employment within 60 minutes	90%[1]	74[3]	57%[3]	90%[3]	80%[3]
Interstate Highway or Major Expressway within 5 miles	100%[4]	100%[5]	100%[5]	100%[5]	100%[6]
Highway or State Route within 2 miles	100%[4]	100%[5]	100%[5]	100%[5]	100%[6]
Direct Access to 4-lane Arterial Road	100%[4]	100%[5]	100%[5]	100%[5]	100%[6]
High-Capacity Transit Access at the Airport	100%[4]	100%[5]	100%[5]	50%[5]	100%[7]

[1]Based on analysis of relevant statewide aviation system plans
[2]Drive sheds from PSRC travel model for 2014 and 2050 and population for 2017 and 2050
[3]Drive sheds from PSRC travel model for 2014 and 2050 and employment for 2017 and 2050
[4]Desirable for commercial service airports based on subject matter expert knowledge
[5] Determined from Google Earth analysis and SoundTransit website
[6]Assumes no changes in roadway access from the current conditions
[7]As of 2017, Paine Field did not yet have high-capacity transit. Service started in 2019.

Expansion capability is important in determining the ability of an airport to be able to develop to handle future demand if that demand exceeds the current and forecasted capacity. Additionally, it is important for the future growth of airports, to have county and/or city codes that protect the airport by enacting encroachment protection from incompatible land uses near the airport and height restrictions as not to affect the surrounding airspace. U.S. Customs availability is useful to determine airports that have a capability to handle international commercial traffic if required by the system demands (Table 2-2).

Table 2-2. Comparison of Expansion Capability, Obstacle Restrictions, Zoning, Land Use and Customs (Seattle-Tacoma International, Paine Field, and King County International)

	SEA-TAC	PAINE FIELD	KCIA
Expansion Capability[1]	Limited	Limited	Limited
Height Restriction Ordinances	Yes[2,3]	Yes[5]	Yes[2]
Zoning for Encroachment Protection	No[4]	Yes[5]	No[4]
Land Use Incompatibility within 1 mile of Runway End[6]	Yes	Yes	Yes
U.S. Customs Available[7]	Yes	Yes	Yes

Source: Airport Manager Survey, Google Maps, County and City Codes, U.S. Customs and Border Protection Ports of Entry
[1]Based on airport manager survey responses and Google Earth analysis
[2]Based on King County Title 21A.12.190 Zoning – Height Limits near Major Airports
[3]Based on Sea-Tac Municipal Code Title 15.400.340 Zoning Code – Height Limits
[4]Based on King County Title 21A Zoning which only has encroachment protection for non-commercial service airports
[5]Based on Snohomish County Code Title 30.32E Airport Compatibility
[6]Based on Google Earth Analysis
[7]Based on U.S. Customs and Border Protection Port of Entry Data

2.2.2 Multi-Airport City Analysis and Conclusions

Many regions across the country are home to multiple commercial service airports, with each airport contributing to a specific role to meet the needs of the system. As demand at Sea-Tac continues to grow and with Paine Field opening with tightly limited commercial service, it is important to look at other cities as a way of understanding potential strategies to meeting future aviation needs within the central Puget Sound region. The airports for which data was collected were chosen due to their location within the metropolitan statistical area (MSA) of the city being analyzed. In some cases, there are airports with similar proximity to the downtown area, but because they are located outside the MSA, they were not included. In addition, the U.S. Department of Transportation defines certain areas as markets for the purposes of collecting airline passenger data. If an airport is located outside a city's market, as defined by the U.S. Department of Transportation, it was also excluded from the analysis.

For this analysis, the Seattle metropolitan area was compared to nine other metropolitan areas:

- Los Angeles
- Chicago
- Dallas
- Houston
- Washington DC
- Miami
- Boston
- Phoenix
- San Francisco

The remainder of this section presents a summary of the findings. Appendix B contains more details for each metropolitan area. Sea-Tac is the largest airport in the region and has been the only commercial service airport for the Seattle MSA until March 2019, when Paine Field started passenger service. Sea-Tac is a connecting hub for two airlines and, as an international gateway, has a variety of domestic and international destinations. The initial purpose of this comparison was to determine if one or more catalysts prompted the justification/need for an additional commercial service airport in other regions. The data collected did not support this hypothesis. However, it did highlight several interesting comparisons between the central Puget Sound region and other regions with multiple commercial service airports.

Overall, the central Puget Sound region has many similarities to other multi-airport cities studied:

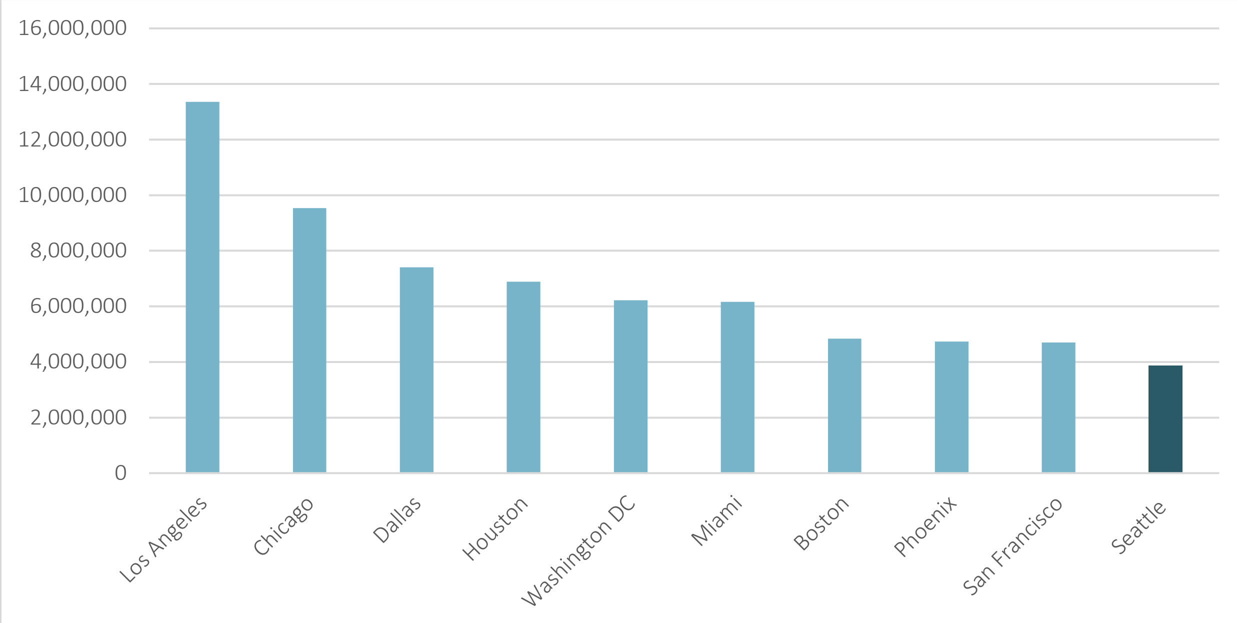
- Although the Seattle metropolitan area has the lowest population of the regions compared, it has a higher per-capita income, which is a key factor in driving the availability of air service growth.
- Additionally, Sea-Tac has more enplanements, operations, and a high seats per-capita ratio, when compared to cities that have multiple airports (see Figure 2-5, Figure 2-6, and Figure 2-7). The high seats per-capita ratio can be attributed to larger aircraft being utilized at the airport, which results in more seats per departure. Sea-Tac has similar enplanements and operations to Phoenix Sky Harbor International Airport and also San Francisco International Airport, which has a high number of enplanements and seats per capita. Several regions have airports that are connecting hubs for multiple airlines, contributing to the larger percentage of enplanements due to connecting passengers. This could show a demand for air service that is not linked to population and income, but rather an airline's decision to connect passengers through a strategically located airport. Airlines can use larger planes to accommodate more passengers without adding additional aircraft operations at an already constrained airport, but a more diverse fleet of aircraft featuring larger aircraft may have greater spacing requirements, therefore limiting air passenger increases if airside capacity constraints exists.
- In the Houston and Washington DC regions, for example, secondary commercial service airports were added to the system once the first airport in the area became constrained and the cities felt an additional airport was necessary to meet the needs of the area. For these cities, the first airports are located closer to the downtowns and the second airport was developed farther from the city, typically with ample amounts of land to provide additional airfield facilities to accommodate aircraft operations during peak periods.
- Sea-Tac and Paine Field, in contrast, are both similar distances from downtown Seattle, with one located north of the city and the other south of the city. On this parameter, Sea-Tac and Paine Field bear more similarity to Los Angeles International Airport and Hollywood Burbank Airport, which are both located 15 miles from downtown Los Angeles, on opposite sides of the city. Los Angeles International Airport is the main commercial service airport for the Los Angeles region, serving a variety of domestic and international destinations. It is also a hub for multiple airlines. Hollywood Burbank Airport is more convenient for some residents and has a regional destination focus, with significantly fewer destinations than Los Angeles International Airport and few that extend past the West Coast. It also is not a connecting hub for any airline.

- Sea-Tac and Paine Field could also be compared to San Francisco International Airport and Oakland International Airport in San Francisco. Both are located similar distances to the downtown area, on opposite sides of the bay. San Francisco International Airport, which is a hub for multiple airlines and serves a variety of domestic and international destinations, is the largest airport in the region with a variety of domestic and international destinations. Oakland International Airport began as the low-cost airport for the region, and while it is not a hub for any airline, it has grown to include a variety of domestic destinations and limited international destinations.
- The Miami region is home to three commercial service airports: Miami International Airport, Fort Lauderdale-Hollywood International Airport, and Palm Beach International. Miami International Airport is a hub for American Airlines, serving many international and domestic destinations with a focus on Latin America and the Caribbean. Fort Lauderdale-Hollywood and Palm Beach International Airports also serve both domestic and international destinations; however, they are primarily origin-and-destination traffic, focused on domestic markets with a large mix of carriers. For instance, Fort Lauderdale-Hollywood International Airport is a focus city for Southwest and Allegiant, as well as hub for JetBlue; however, no carrier has more than 25 percent of the total enplanement share. This region is comparable to the central Puget Sound region in that Sea-Tac is a hub for two of the largest air carriers in the United States, with Delta focused on serving the Asian market, while Paine Field, with just two airlines, serves a domestic origin-and-destination market.

This benchmarking analysis identified several factors that appear to drive the need for an additional airport(s) within a region. While the Seattle MSA is smaller in terms of population than the other cities (Figure 2-3), its high per-capita income and the presence of two airlines having connecting hub operations at Sea-Tac make it comparable with the multi-airport cities studied (Figure 2-4). The Seattle MSA's rankings for both 2017 enplanements (six of nine) and 2017 air carrier departures (eight of nine) are presented in Figure 2-5 and Figure 2-6, respectively.

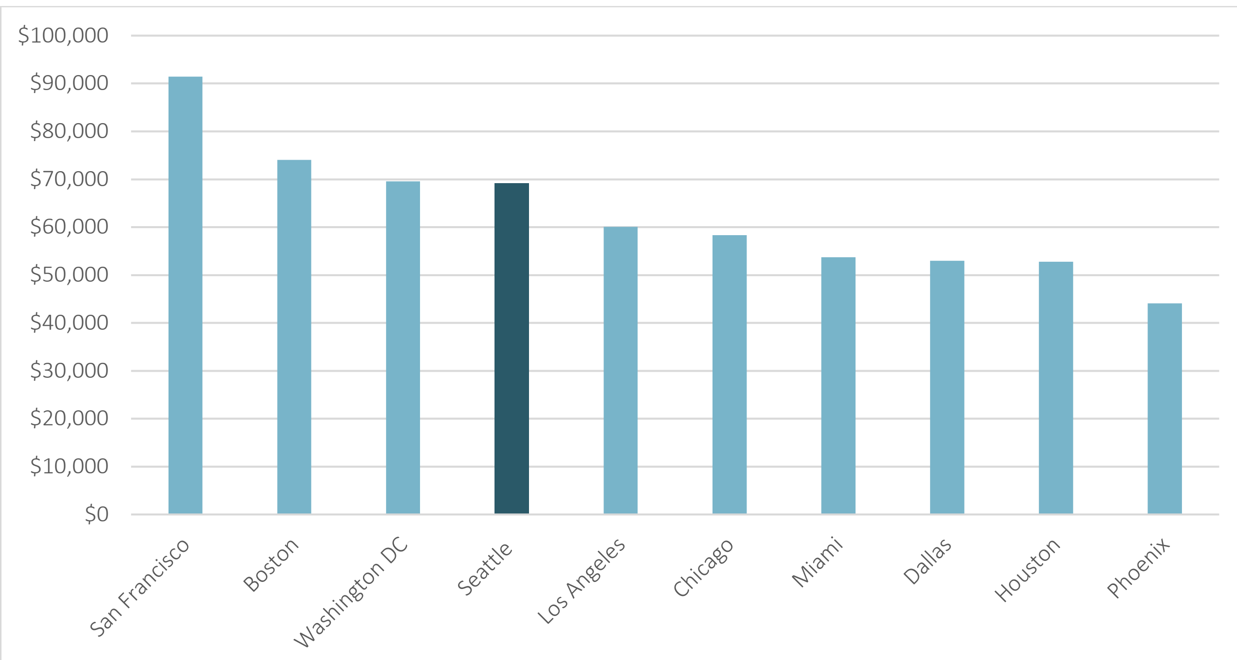
However, differences in geography and historic development among the cities or regions—such as population density—make it impossible to make straight-line comparisons. A more detailed analysis of aviation demand and supply in the central Puget Sound region is required to ascertain the local needs for growth at these or potentially another airport.

Figure 2-3. Metropolitan Statistical Area Population for Multi-Airport Cities (2017)



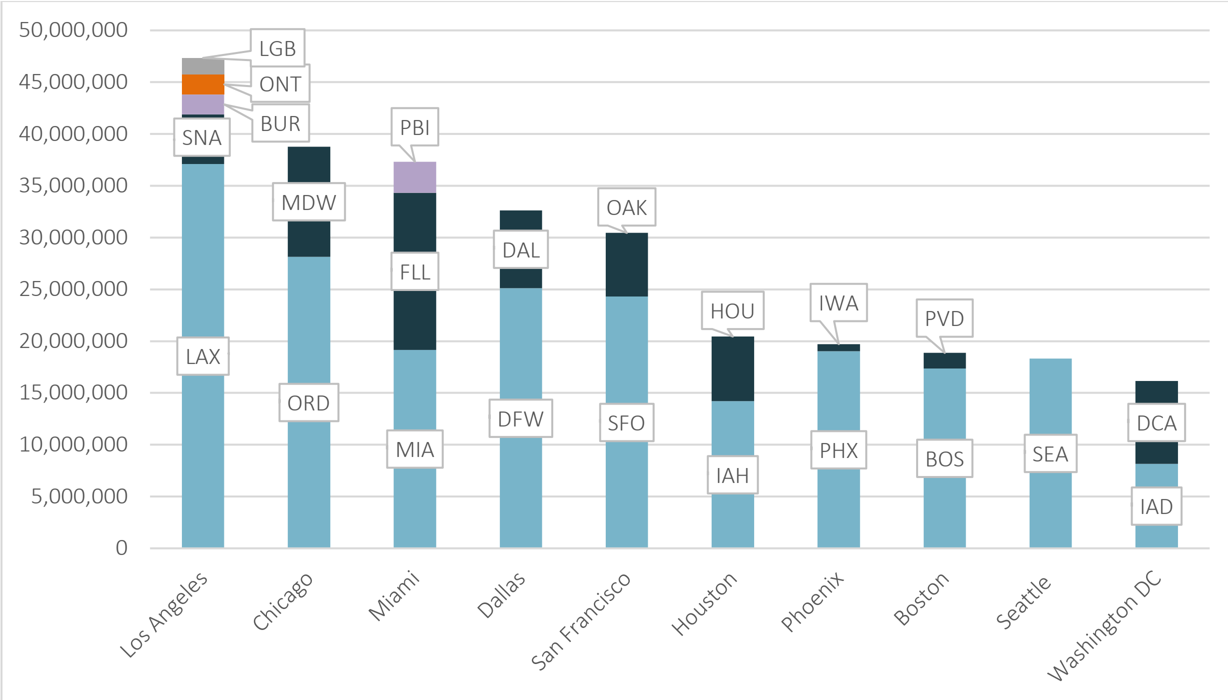
Source: United States Census Bureau Metropolitan Statistical Area Population, 2017

Figure 2-4. Metropolitan Statistical Area Per-Capita Income (2017)



Source: Bureau of Economic Analysis Personal Income by Metro, 2017

Figure 2-5. Enplanements by Airport (2017)



Source: Federal Aviation Administration Enplanement Data, 2017

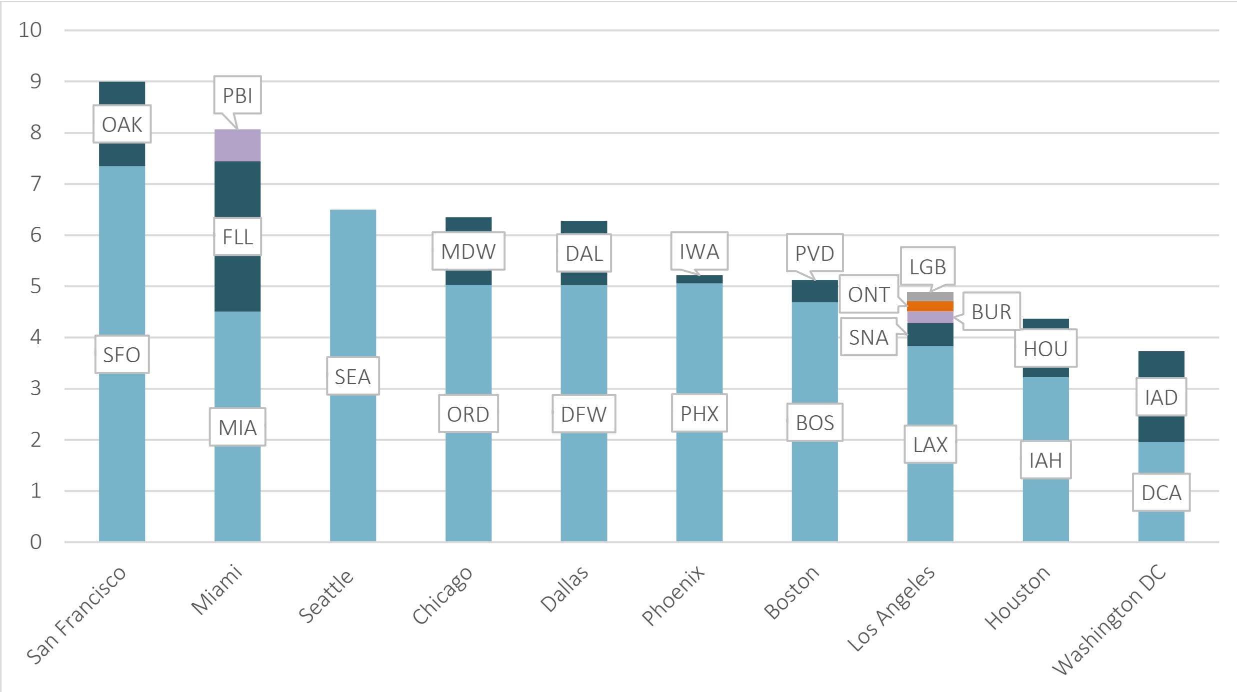
Note: Only Air Carrier Activity is included. Enplanements are departing passengers.

Figure 2-6. Airline Departures by Airport (2017)

Source: Federal Aviation Administration Air Traffic Activity System, 2017

Note: Only Air Carrier Activity is included. Departures include all air carrier takeoffs.

Figure 2-7. Airline Seats Per Capita by Airport (2017)



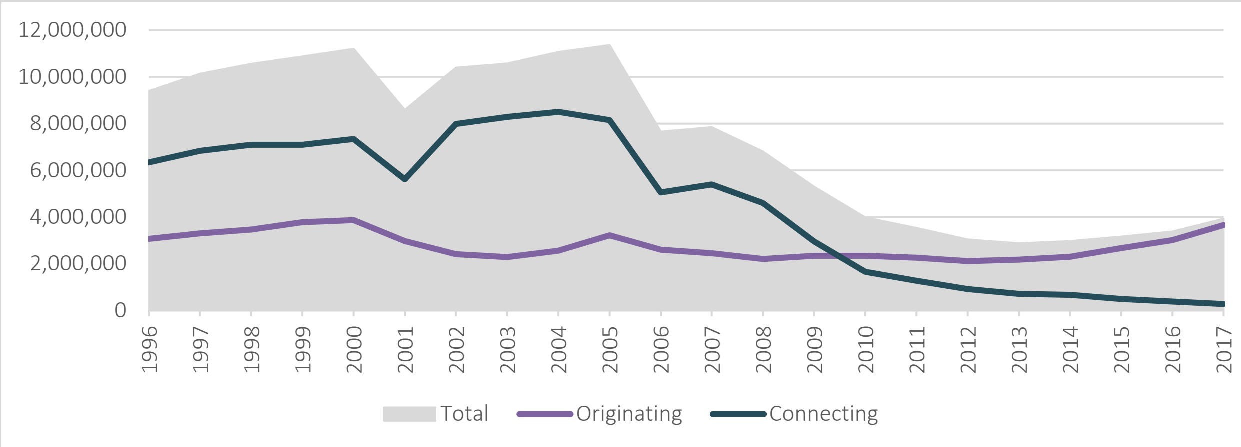
Source: United States Census Bureau Metropolitan Statistical Area Population, and Federal Aviation Administration Traffic Flow Management System Counts, 2017

Note: Only Air Carrier Activity is included.

2.2.3 Airline Dehubbing Effect on Airports Analysis

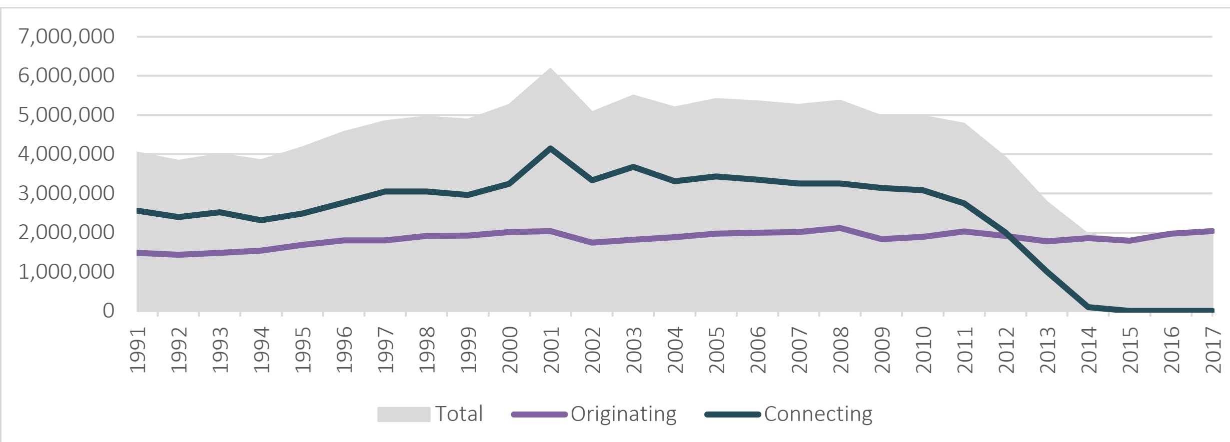
Connecting hubs can stimulate traffic and because Sea-Tac has two airlines hubs, dehubbing could reduce traffic simply by an airline business decision; therefore, this section summarizes several case studies. Numerous airports have served as connecting hubs for major airlines and have subsequently been dehubbed for various reasons. Both Memphis International Airport and Cincinnati/Northern Kentucky International Airport served as hubs for Delta Air Lines. Cincinnati/Northern Kentucky International Airport reached its peak in 2005 (Figure 2-8), prior to Delta declaring bankruptcy. At the peak, approximately 78 percent of enplanements were connecting. Following, Delta began cutting flights and officially removed Cincinnati/Northern Kentucky International Airport from its list of hubs in 2017. As for Memphis International Airport, it was originally a hub for Northwest Airlines which was acquired by Delta in 2008, which coincides with the onset of dehubbing. At the peak, connecting enplanements accounted for approximately 67 percent of total enplanements (Figure 2-9). It was officially removed as a hub for Delta Air Lines in 2013. For both airports, once dehubbing began, it was approximately five years until originating passengers exceeded connecting passengers. Since being dehubbed, enplanements have not reached peak-year levels at either of these airports.

Figure 2-8. Connecting and Originating Historical Enplanements (Cincinnati/Northern Kentucky International Airport)



Source: Kenton County Airport Board Official Bond Statements

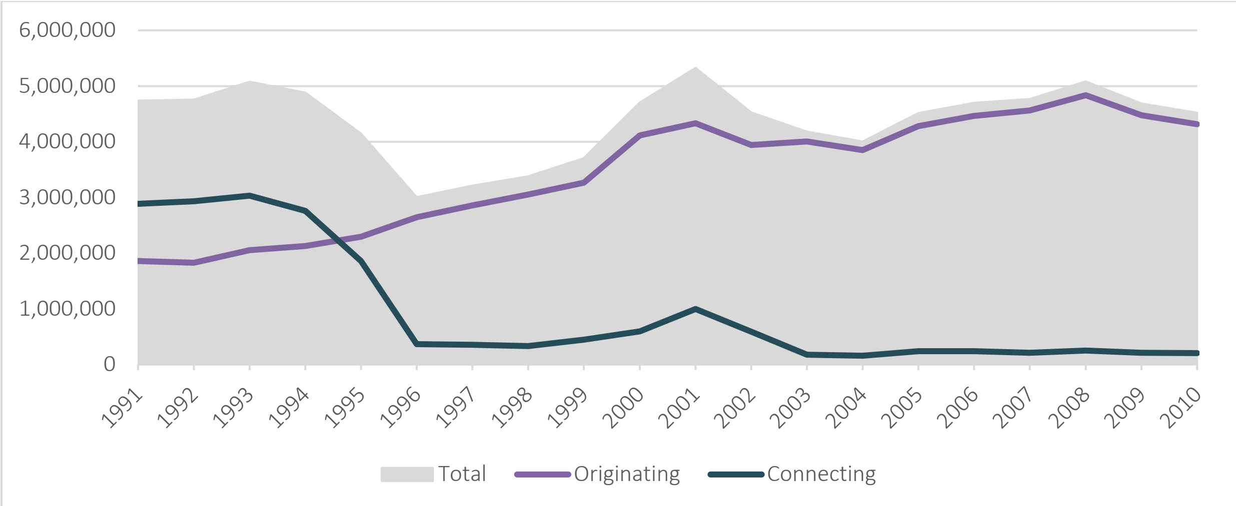
Figure 2-9. Connecting and Originating Historical Enplanements (Memphis International Airport)



Source: Memphis Shelby County Airport Authority Official Bond Statements

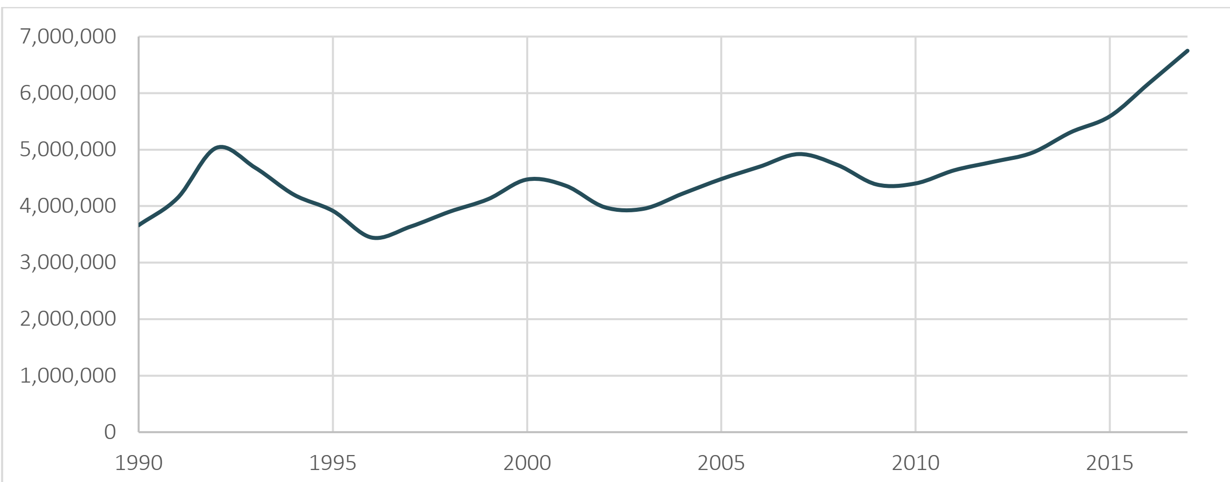
Raleigh-Durham International Airport and Nashville International Airport both served as American Airlines hubs until 1996. At the peak for Raleigh-Durham International Airport, connecting enplanements accounted for nearly 61 percent of total enplanements, dropping to nearly 5 percent in recent years (Figure 2-10). Dehubbing was announced in 1995 and hub operations ceased in 1996 due to competition from US Airways in Charlotte and Delta in Atlanta. In 1995, originating enplanements exceeded connecting enplanements. The airport then exceeded peak enplanements approximately 5 years later and is still growing. As for Nashville International Airport, American stopped hub operations in 1996. Enplanements were at their peak in 1992 at approximately 5 million. Prior to the official dehubbing at Nashville International, enplanements decreased to approximately 3.4 million in 1996. It was not until approximately 18 years later in 2014 that enplanements exceeded peak enplanements (5 million) from when the airport was a hub for American Airlines. (Figure 2-11).

Figure 2-10. Connecting and Originating Historical Enplanements (Raleigh-Durham International Airport)



Source: Raleigh-Durham Airport Authority Bond Official Statements

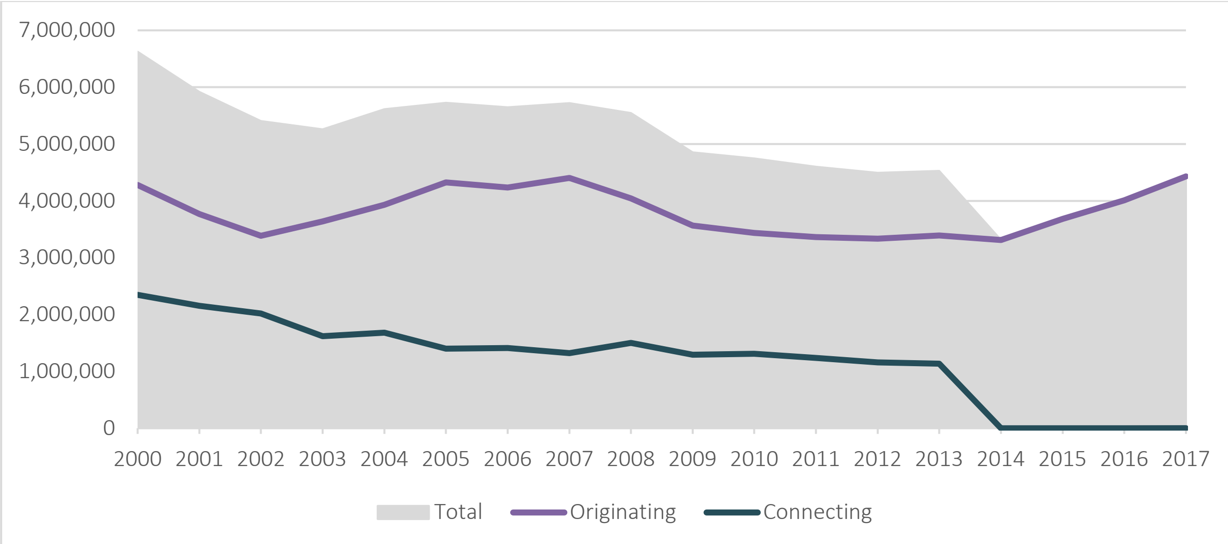
Figure 2-11. Historical Enplanements (Nashville International Airport)



Source: Federal Aviation Administration 2018 Terminal Area Forecast

Cleveland Hopkins International Airport served as a long-time hub for Continental Airlines, which then merged with United Airlines in 2010. In 2014, the airline officially removed Cleveland Hopkins International Airport as a hub, stating economic reasons. Figure 2-12 shows connecting and originating historical enplanements, indicating that originating enplanements exceeded connecting enplanements long before the airport no longer served as a hub. At the peak, connecting passengers accounted for approximately 37 percent of total passengers, with the number dropping to nearly 0 percent following dehubbing. Enplanements overall dropped in 2014, when dehubbing occurred, but have grown in more recent years following a national trend for enplanement growth. However, in 2017, enplanements were approximately 4.4 million, which is approximately 70 percent of the peak activity in 2000 of nearly 6.5 million.

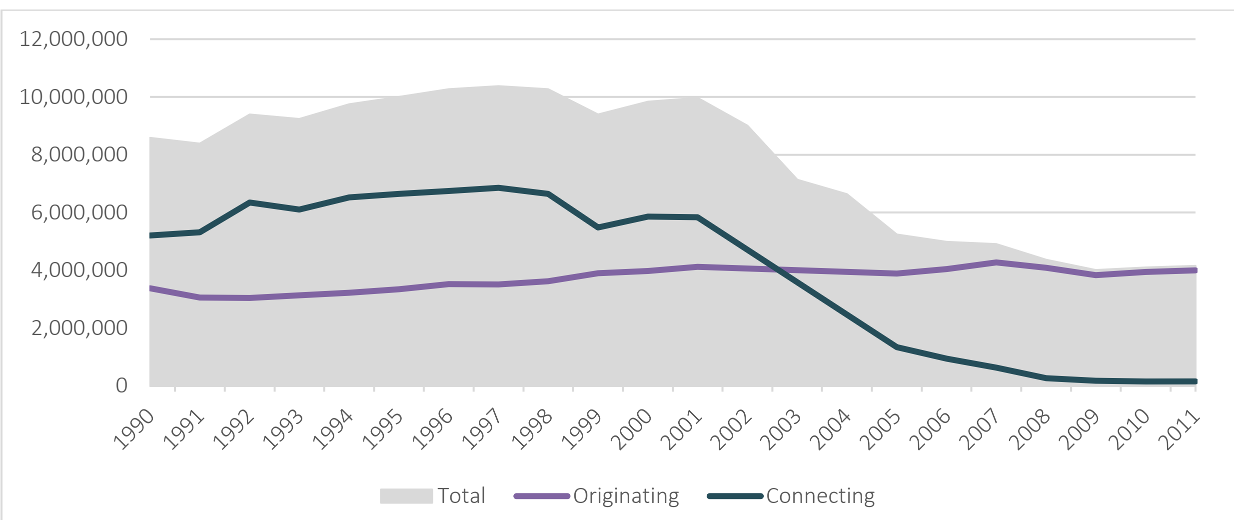
Figure 2-12. Connecting and Originating Historical Enplanements (Cleveland Hopkins International Airport)



Source: City of Cleveland Bond Official Statements

Pittsburgh International Airport served as a long-time hub for US Airways, until 2004 when the airline officially closed its hub at the airport. Cutbacks began in 2001, following 9/11. At that time, connecting passengers accounted for nearly 67 percent of all enplanements, dropping to 4 percent in recent years. Only recently, have enplanements at the airport begun growing again. Currently, enplanements are approximately 40 percent (4 million) of what they were at the peak of activity during the late 1990s and early 2000s (approximately 10 million) (Figure 2-13).

Figure 2-13. Connecting and Originating Historical Enplanements (Pittsburgh International Airport)



Source: Allegheny County Airport Authority Bond Official Statements

Table 2-3 summarizes some of the current major hubs with available information about percentage of connecting passengers.

Table 2-3. Hub Airport Percentage Connecting at a Selection of U.S. Large Hub Airports (2018)

HUB AIRPORTS	CONNECTING ENPLANEMENT PERCENTAGE
Charlotte Douglas International	69%
Dallas/Fort Worth International	58%
George Bush Intercontinental	46%
O'Hare International	46%
Salt Lake City International	43%
Seattle-Tacoma International	30%

Source: Individual Airport Bond Official Statements (all airports but Sea-Tac); Port of Seattle 2018 Annual Disclosure Form (Sea-Tac)

2.2.4 Analysis of Delay at Large Commercial Service Airports

Airport performance is crucial to air traffic controllers, airports, and airlines as they plan schedules and anticipate traffic levels. Airline operators, for example, prefer to set departure and arrival times, and the flight routes of their choice. Knowing how long an aircraft must wait to depart, operators can plan for the impacts to fuel burn, emissions, and the passenger experience. The FAA measures and reports on airport performance at locations where NextGen technologies have been implemented. Airport performance is reported based on efficiency and capacity at the FAA's Core 30 Airports, which include Sea-Tac. These airports are in major metropolitan areas with the highest volume of traffic. Complex, high-density operations airports are most likely to produce significant air traffic congestion and delays.

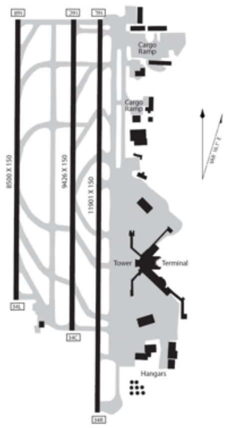
To identify areas where improvements can be made by the FAA and airport sponsors, the FAA measures an airport's daily capacity, as well as an airline's scheduled versus actual flight time performance. In addition to improvements from NextGen capabilities, a myriad of factors influences those metrics, including weather, aircraft types, traffic volume, and runway conditions.

The following seven hub airports have been selected to compare with Sea-Tac based on their relatively comparable airfield complexity and/or constrained facilities due to water and/or major highways and railways:

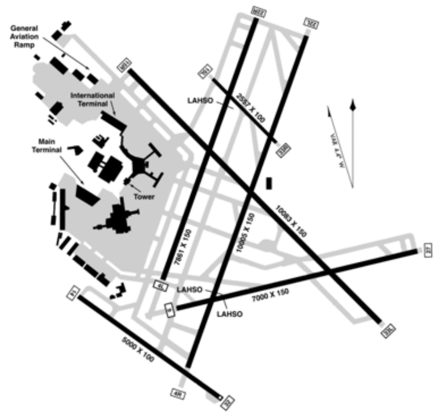
- Boston Logan International
- Reagan National Airport
- LaGuardia Airport
- Miami International Airport
- Philadelphia International Airport
- Phoenix Sky Harbor International Airport
- San Francisco International Airport

Figure 2-14 depicts each airport using FAA's official airport diagrams to provide context in comparing with Sea-Tac facilities. Table 2-4 summarizes each airport's activity levels for 2016 for comparison purposes.

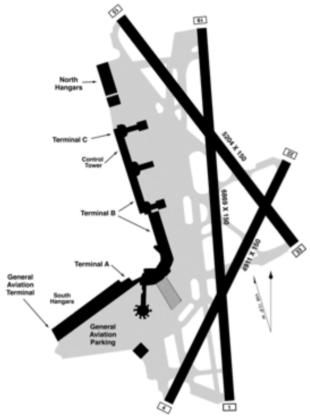
Figure 2-14. Constrained Airport Diagrams



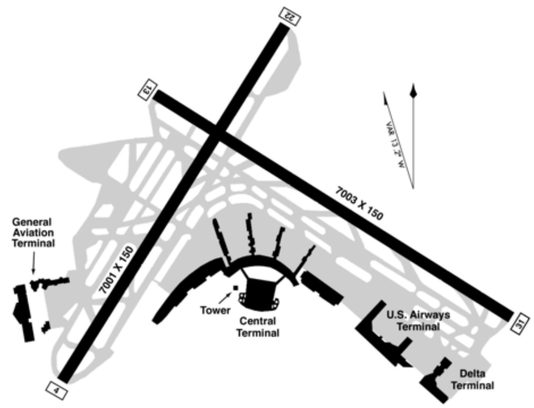
Sea-Tac (SEA) Airport Diagram



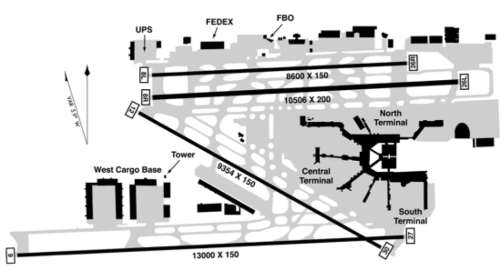
BOS Airport Diagram



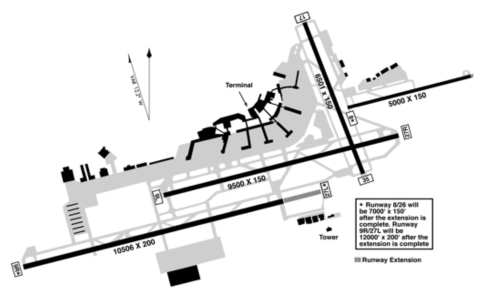
DCA Airport Diagram



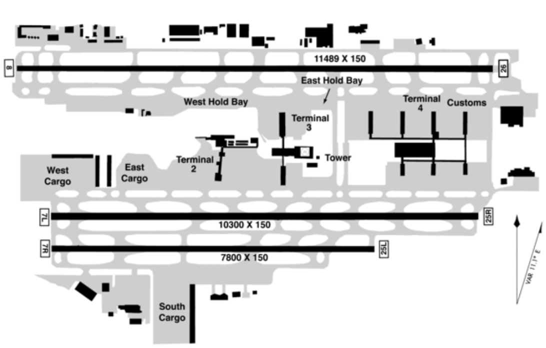
LGA Airport Diagram



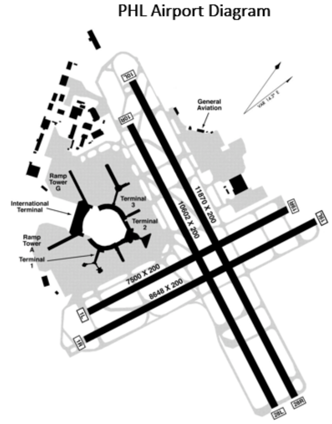
MIA Airport Diagram



PHL Airport Diagram



PHX Airport Diagram



SFO Airport Diagram

Table 2-4. Comparison Airports Activity Levels (2016)

AIRPORT NAME	FAA I.D.	PAX VOLUME (MILLIONS)	RANK PAX BUSIEST U.S. AIRPORT	OPERATIONS VOLUME	CARGO TONNAGE (METRIC TONS)	RANK CARGO BUSIEST U.S. AIRPORT
Seattle-Tacoma International	**SEA**	**45.7**	**9**	**412,170**	**366,431**	**19**
Boston Logan International	BOS	36.4	17	391,222	290,317	21
LaGuardia	LGA	29.7	20	374,720	NA	NA
Miami International	MIA	44.6	10	416,920	2,000,000	4
Philadelphia International	PHL	29.6	19	402,013	404,430	18
Reagan National	DCA	23.6	23	295,038	NA	NA
San Francisco International	SFO	53	7	412,000	483,000	15
Sky Harbor International	PHX	43.3	12	440,643	322,000	20

Note: PAX is total passengers (enplanements plus deplanements)

Table 2-5 summarizes FAA performance metrics over a large set of diverse operations at these selected airports. As such, the purpose is to reflect general trends as experienced by aircraft operators and passengers, without regard to the underlying delay drivers and for comparison purposes only.

Table 2-5. Similar Airports' Federal Aviation Administration NextGen Performance Snapshots

AIRPORT NAME	FAA I.D.	AVERAGE GATE-ARRIVAL DELAY (MIN/FLIGHT)		AVERAGE DAILY CAPACITY (NUMBER OF OPS)		AVERAGE HOURLY CAPACITY DURING IMC (NUMBER OF OPS)	
		2016	2017	2016	2017	2016	2017
Seattle-Tacoma International	**SEA**	**-0.9**	**1.1**	**1,325**	**1,395**	**81**	**83**
Boston Logan International	BOS	3.2	6.3	1,378	1,334	77	77
LaGuardia	LGA	8.1	9.4	1,090	1,084	69	68
Miami International	MIA	4.5	1.6	2,042	2,044	108	106
Philadelphia International	PHL	2.3	2.0	1,658	1,643	77	77
Reagan National	DCA	3.9	2.6	1,049	1,072	58	59
San Francisco International	SFO	7.1	14.6	1,488	1,504	78	77
Sky Harbor International	PHX	0.3	2.4	2,004	1,930	112	110

Source: FAA NextGen Performance Snapshots of BOS, DCA, LGA, MIA, PHL, PHX, SEA, and SFO.
IMC = Instrument Meteorological Conditions

2.2.4.1 Average Gate Arrival

During reportable hours, the yearly average of the difference between the Actual Gate-In Time and the Scheduled Gate-In Time for flights to the selected airport from any of the Aviation System Performance Metrics airports. The delay for each fiscal year is calculated based on the 0.5th – 99th percentile of the distributions for the years. Flights may depart outside reportable hours but must arrive during them. The reportable hours may vary by airport.

Of the comparison airports, Sea-Tac experienced the least average gate-arrival delays in 2016 and 2017. The chart above indicates, that on average, flights to Sea-Tac arrived before their scheduled time, thus the minus sign. The next least delayed were Sky Harbor International Airport and Philadelphia International Airport, which are very constrained like Sea-Tac. The most delayed in 2017 was San Francisco International Airport due to runway/taxiway construction. LaGuardia Airport is consistently the highest delayed airport, but it is currently under an $8 billion construction project to improve the terminals, roadways, parking, and airline access to and from gates.

2.2.4.2 Comparative Average Daily Capacity and Delay

During reportable hours, the average daily sum of the airport departure and arrival rates reported by fiscal year. The reportable hours vary by airport.

Of the comparison airports, Sea-Tac is in the middle of the pack regarding average daily arrival and departure capacity (see Table 2-5). Reagan National Airport (DCA) and LaGuardia Airport (LGA) have the least daily arrival and departure capacity and are both slot controlled. For highly congested airports, FAA uses runway slots to limit scheduled air traffic and as of 2019, this includes three capacity constrained airports, JFK International, Reagan National Airport and LaGuardia Airport. In addition, FAA monitors scheduled air traffic demand at other airports and has a formal schedule review and approval process at these airports. These airports are Chicago O'Hare International Airport, Los Angeles International Airport, Newark Liberty International Airport, and San Francisco International Airport.

Miami International Airport and Sky Harbor International Airport have the most daily arrival and departure capacity, and their airfields have widely spaced parallel runways and thus more capacity on average.

2.2.4.3 Comparative Average Hourly Capacity During Instrument Meteorological Conditions

The average hourly capacity reported during the Instrument Meteorological Conditions weather conditions (as defined by Aviation System Performance Metrics) is lower than during good weather (see Table 2-5). Capacity is defined as the sum of airport departure rate and airport arrival rate. It is calculated based on the reportable hours at the destination airport. The reportable hours vary by airport.

Again, Sea-Tac is in the middle of the pack with Reagan National Airport and LaGuardia Airport having the least hourly capacity in poor weather conditions and Miami International Airport and Sky Harbor International Airport having the most for the same reasons as average daily capacity.

2.3 GENERAL AVIATION

General aviation benchmarks apply to the entire central Puget Sound region system of airports. These benchmarks establish thresholds for determining how well the system performs in terms of providing general aviation services to the region. These performance measures are evaluated by calculating the percentage of either the region's population or its employment that falls within the market area of the defined group of airports. Market areas are based on the distance one can drive to or from the airport within 30 minutes.

For example, the benchmark for airports with precision instrument approaches is 65 percent of the population. This means that the system is performing adequately if at least 65 percent of the region's population (i.e., the population of King, Pierce, Snohomish and Kitsap Counties) falls within a 30-minute drive time of any system airport with a precision instrument approach. These system performance measures and benchmarks are useful in identifying gaps in coverage for specific services.

The benchmarks were established by analyzing statewide system plans in Kansas, Kentucky, Louisiana, Massachusetts, Montana, Ohio, and Wisconsin. The average coverage from these statewide system plans was adjusted to reflect the regional nature of the central Puget Sound region aviation system. For performance measures that were unique to this study, comparisons to the closest similar measure were made and professional judgment was used to determine a final benchmark.

Table 2-6 lists the system performance measures and their associated benchmarks and system analysis results under existing (2017) and future (2050) conditions.

Table 2-6. Benchmarks and Performance Measures for General Aviation Airports (2017 and 2050)

PERFORMANCE MEASURE (WITH 30-MINUTE DRIVE-TIME ACCESS)	BENCHMARK[1]	2017[3]	2050[4]
Percentage Population of Airport with Aviation Fuel	90%	90%	89%
Percentage Population of Airport with Jet Fuel	85%	86%	87%
Percentage Population of Airport with a Fixed-Base Operator (FBO)	80%	88%	88%
Percentage Population of Airport with Facilities for Handling Business Aircraft[2]	80%	71%	74%
Percentage Population of Airport with Instrument Approach	85%	82%	83%
Percentage Population of Airport with Precision Instrument Approach	65%	66%	69%
Percentage Employment of Airport with De-Icing Capabilities	70%	64%	64%
Percentage Employment of Airport with Jet Fuel	90%	95%	95%
Percentage Employment of Airport with Facilities for Handling Business Aircraft[2]	85%	83%	85%

Source: CDM Smith analysis of ESRI ArcMap Network Analyst, HERE data, and Google Maps data
[1]Based on analysis of relevant statewide aviation system plans
[2]Facilities for handling business aircraft are a runway at least 5,000 feet in length, automated weather reporting, and an instrument approach with vertical guidance.
[3]Utilizes current (2019) roadway congestion
[4]Assumes current (2019) roadway congestion remains the same into 2050

The analysis shows that the current central Puget Sound region general aviation system falls short of benchmarks for population within a 30-minute drive time to airports, which have an FBO, are business-aircraft-capable, and have instrument approach. It meets the benchmarks for population with access to aviation and jet fuel in 2017 but fall slightly below the benchmark for access to aviation fuel in 2050.

It falls short of benchmarks for employment within a 30-minute drive time to airports with de-icing capabilities. The system also does not meet the benchmark for employment within a 30-minute drive time to an airport that can handle business aircraft for 2017 but is expected to meet the benchmark by 2050 due to shifts in expected employment concentrations.

2.4 AIR CARGO

A comparison of the three main air cargo facilities of the central Puget Sound region constitutes a first level of analysis of constraints and opportunities for the future of air cargo in the central Puget Sound region using existing facilities only. Several factors are evaluated in Table 2-7.

Table 2-7. Air Cargo System Data

	SEA-TAC	KCIA	PAINE FIELD
Expansion Capability[1]	Limited[8]	No	Yes
Compliant Access Roads[2]	Yes	Yes	Yes
Foreign Trade Zone Availability[3]	Yes	Yes	Yes
Height Restriction Ordinances	Yes [4,5]	Yes [4]	Yes [7]
Zoning for Encroachment Protection	No[6]	No[6]	Yes [7]
Land Use Incompatibility within 1 mile of Runway End[2]	Yes	Yes	Yes

[1]Based on airport manager survey responses and Google Earth analysis
[2]Based on Google Earth analysis
[3]Based on U.S. Customs and Border Protection Port of Entry Data
[4]Based on King County Title 21A.12.190 Zoning – Height Limits near Major Airports
[5]Based on Sea-Tac Municipal Code Title 15.400.340 Zoning Code – Height Limits
[6]Based on King County Title 21A Zoning, which has encroachment protection only for non-commercial service airports
[7]Based on Snohomish County Code Title 30.32E Airport Compatibility
[8]The SAMP Near-Term Projects proposes existing Cargo 4 South warehouse redevelopment, two off-airport cargo warehousing facilities to the northeast, and additional air cargo aircraft ramp in the North Cargo Area (Project A08 – Hardstand (north)). The SAMP identifies major expansion of cargo facilities in the South Aviation Support Area (SASA) as part of the Long-Term Vision. SASA requires further study due to high cost and complex construction phasing.

Sea-Tac and Paine Field both have the capability to expand cargo facilities with direct airfield access. To increase the cargo capacity, Sea-Tac's Sustainable Airport Master Plan (SAMP) identifies the potential to develop aircraft accessible cargo facilities as part of the Long-Term Vision in an area called the South Aviation Support Area (SASA). The SAMP identifies SASA as a potential long-term expansion option, requiring further study, due to the high cost and complex construction phasing. Therefore, Sea-Tac and KCIA facilities cannot grow to meet the 2050 horizon demand without incorporating alternative strategies such as significant external financial resources or land acquisition. (See Chapter 4 on challenges and opportunities.)

However, all three airports have good conditions enabling the development of air cargo and international trade. For instance, they have adequate access roads for the operations of large trucks and have Foreign Trade Zones available.[5]

Their airspace is also well-protected against the creation of vertical obstacles conflicting with flight operations. The areas surrounding the three airports have height restriction ordinances but they have

[5] U.S. Foreign-Trade Zones, Enforcement and Compliance, International Trade Administration (ITA), accessed on August 22, 2019

incompatible land use within 1 mile of runway ends. Obstructions to flight operations are not necessarily a flight hazard, but they may impose restrictions such as reduced payload or aircraft range.

Ground access is vital for the development of air cargo at airports. Excessive driving time and inadequate roadway networks can deter shippers from airports that are otherwise adequate for air freight. Figure 2-15 shows the population within 60-minute drive time, considering congestion, from Sea-Tac and KCIA in 2017 and 2050. As can be seen, portions of the region at the northern, southern eastern edges that currently have 60-minute access to commercial air cargo service are expected to lose that in the future.

Both KCIA and Sea-Tac have large freighter service. However, Sea-Tac is the only airport in the central Puget Sound region providing wide-body belly cargo service. Table 2-8 shows that, considering congestion, the region is close to meeting the benchmarks for air-cargo-related 60-minute drive-time measures in 2017 but misses both by a wide margin in 2050.

Table 2-8. Benchmark and Performance Measures for Commercial Air Cargo Service

PERFORMANCE MEASURE (WITH 60-MINUTE DRIVE-TIME ACCESS)	BENCHMARK	2017	2050
Percentage Population with access to Airport with Large Freighter Service*	65%	67%	52%
Percentage Population with access to Airport with Wide-Body Belly Cargo **	65%	62%	42%

* Includes both KCIA and Sea-Tac; Drive sheds from PSRC travel model for 2014 and 2050 and population for 2017 and 2050
** Sea-Tac only

However, this assessment was conducted using average driving time. The driving time on the highway and interstate system in the central Puget Sound region is highly variable depending on the time of the day, and the main corridors are considered as congested. Also, Sea-Tac's SAMP identified needs for enhancing the access to Sea-Tac and the curbside locally.

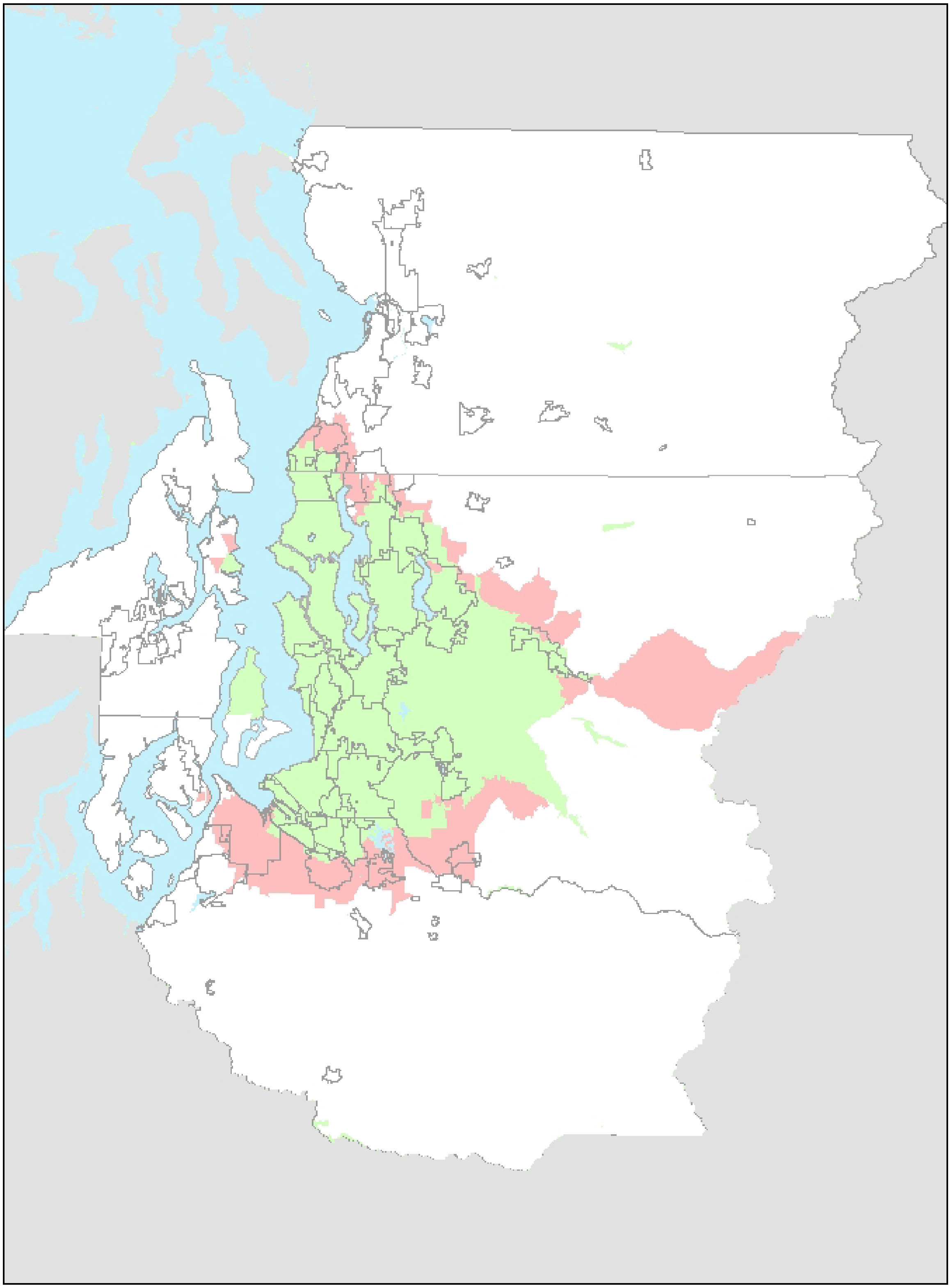
The current air cargo airports were qualitatively analyzed to determine if roadways leading from the airport to major highways and interstates were sufficient for large trucks (interstate semitrailers). Six other airports that might be considered for expanded uses in the next task were also evaluated: Arlington Municipal, Bremerton National, Renton Municipal, Harvey Field, Auburn Municipal, and Tacoma Narrows. Arlington Municipal, KCIA, Paine Field, Renton Municipal, Auburn Municipal, and Sea-Tac have good truck ground access. Bremerton National and Tacoma Narrows have fair access, while Harvey Field has poor access (Table 2-9).

Table 2-9. Accessibility of Cargo and Other Airports for Trucks

CARGO AIRPORTS			OTHER AIRPORTS					
KCIA	SEA-TAC	PAINE FIELD	ARLINGTON MUNICIPAL	BREMERTON NATIONAL	RENTON MUNICIPAL	HARVEY FIELD	AUBURN MUNICIPAL	TACOMA NARROWS
Good	Good	Good	Good	Fair	Good	Poor	Good	Fair

This qualitative evaluation is based on reviews of Google Earth aerial data, including general roadway widths, turning radii, tight intersection turns, signalization at major intersections, turning lanes, and overall proximity to interstate roadways. Any airports considered for large freight truck cargo would need more detailed analytical analysis to determine actual truck turning paths, roadway strength, and other key characteristics important to truck movements.

Figure 2-15. Change in 60-Minute Drive-Time Access to Seattle-Tacoma and King County International Airports (2017-2050)



Source: PSRC regional travel demand model analysis.

Note: Pink area represents the 60-miinute travelshed in 2017 and green is 2050.

2.5 MULTIMODAL ACCESS

Roads are the primary means of access to airports in the central Puget Sound region. Within the hierarchy of road classification, different levels provide different capabilities in access that particularly matters for some airports with commercial passenger traffic or freight vehicles moving cargo. In addition, transit access is available to some of the airports in the region.

Based on national experience and best practices, the benchmarks for multimodal access were set primarily to address commercial airports because they generate the greatest number of trips. All central Puget Sound region commercial airports should adhere to the following benchmarks:

- Be within 5 miles of an interstate highway or major expressway
- Be within 2 miles of a highway or state route
- Have direct access to a 4-lane arterial
- Have high-capacity transit access
- Have shuttle access to hotels or other areas

Table 2-10 highlights the airports meeting each of these benchmarks. The two commercial service airports meet all the benchmarks. Of the remaining airports, KCIA does not have high-capacity transit access—but Sound Transit plans to add a Link light-rail station at the south end of the airport—and Renton Municipal comes very close to meeting all five criteria. Two seaplane bases come close to meeting these criteria, but would not be feasible for major commercial service.

Planned access improvements were also considered, because new projects can alter the accessibility of an airport and can allow for new possible uses. This was considered as an informational metric because multiple factors contribute to when improvements are constructed and activated. Sea-Tac and Renton Municipal Airports are both in areas with planned additional access improvements.

Table 2-10. Multimodal Access

CATEGORY	CITY	INTERSTATE (WITHIN 5 MILES)	STATE ROUTE (WITHIN 2 MILES)	DIRECT 4 LANE ARTERIAL ACCESS	HIGH-CAPACITY TRANSIT (WITHIN 1/2 MILE)
Commercial Airports					
Paine Field	Everett	✓	✓	✓	✓
Seattle-Tacoma International	Seattle	✓	✓	✓	✓
King County International	Seattle	✓	✓	✓	♦
General Aviation Airports					
Arlington Municipal	Arlington	✓	✓		
Auburn Municipal	Auburn	✓	✓		♦
Bandera State	Bandera	✓	✓#		
Bremerton National	Bremerton		✓		
Darrington Municipal	Darrington		✓		
Swanson Field	Eatonville		✓		
Ranger Creek State	Greenwater		✓		
Kenmore Air Harbor Sea Plane Base (SPB) S60	Kenmore	✓	✓		♦
Norman Grier Field	Kent		✓		
First Air Field	Monroe		✓		
Port of Poulsbo SPB	Poulsbo		✓		
Pierce County	Puyallup		✓	✓	
Renton Municipal	Renton	✓	✓	✓	✓
Will Rogers-Wiley Post Memorial SPB	Renton	✓	✓		✓
Kenmore Air Harbor SPB W55	Seattle	✓	✓	✓	✓
Seattle Seaplanes SPB	Seattle	✓	✓	✓	♦
Apex Airpark	Silverdale		✓		
Skykomish State	Skykomish		✓		
Harvey Field	Snohomish		✓		
Shady Acres	Spanaway				
American Lake SPB	Tacoma	✓	✓#		
Tacoma Narrows	Tacoma		✓		
Vashon Municipal	Vashon				

Source: Google Maps
Note: Military airports were excluded from this analysis.
# Indicates the airport does not have United States or state route access but meets the interstate access metric.
♦ Indicates planned high-capacity transit in the future.
[1]HCT service started at Paine Field in 2019.

3. Aviation Needs Analysis

3.1 ANALYSIS METHODOLOGY

The future airside performance at larger airports (commercial service and air cargo) is considered through demand-and-supply indicators, such as the annual service volume (ASV) and the unconstrained annual demand or annual aircraft activity. Per the FAA Advisory Circular 150/5060-5, Airport Capacity and Delay, the ASV is a reasonable estimate of an airport's annual capacity. It accounts for differences in runway use, aircraft mix, weather conditions, etc., that would be encountered over a year's time. The unconstrained annual demand is mainly based on the FAA Terminal Area Forecast (TAF).

Comparing the supply (capacity) and demand (annual demand) provides an estimate of the existing and future gap in capacity for addressing the needs of the aviation community locally at an individual airport.

Similarly, the landside (terminal) performance is described for the commercial service airports by the following indicators:

- Aircraft parking capacity/demand: number of contact aircraft gates (connected to passenger terminal facilities) and remote aircraft stands. These figures were primarily extracted from airport master plans or airport layout plans.
- Passenger terminal facility capacity/demand: enplanement (passenger boarding) capacity and forecasted demand. These figures were primarily extracted from airport master plans.
- Vehicle parking capacity (on-site): individual car park capacity/demand at the airport (on-site only). These figures were primarily extracted from airport master plans.

Ground access is analyzed for the commercial service airports as well. The distance to nearest interstate(s) (5-mile target) and state route (2-mile target) was assessed using Google Maps.

The presence of and need for organized services from taxi or Transportation Network Companies (TNC) was analyzed. Organized services include specific procedures from operators, dedicated facilities (buffer parking), and coordination with airports. Virtually all airports are served by taxis and TNCs. However, any kind of organized services increase the offer and reduce the waiting time between ride order and pickup.

Bus, ferry, and high-capacity transit services were documented from the route maps and schedules published by transit agencies and public transportation providers, and the planned development of their network and transportation infrastructure.

Air cargo activity is specifically analyzed with airport-specific supply/demand studies on air cargo tonnage, on-site warehouses, and area available for trucking operations (loading/unloading, parking and maneuvers). The main source on air cargo in the Puget Sound is the 2018 Air Cargo Study of the Joint Transportation Committee of the Washington State legislature.

General aviation airports were grouped per the categories defined in the Washington Aviation System Plan (2017 WASP): regional airports, community airports, local airports, and general use airports. For some limited criteria, figures for individual airports are presented and commented (ASV vs. annual demand and ground access). Otherwise, the level of service and capacity are considered for airport categories. Existing and future airfield performance is expressed as a ratio of the annual aviation demand (from airport master plan or the FAA TAF) on the ASV (from airport master plans or FAA AC 150/5060-5). The need for aircraft hangar storage is assessed through the proportion of airports in each category that have a waiting list. It is a good estimate of the level of saturation of general aviation hangars statewide. Similar figures are presented for the instrument approach procedures (IAP) and the airport reference code (ARC)—two indicators of the level of service and the capability of accommodating larger aircraft flying instrument flight rules (IFR). The presence of general aviation terminal facilities and fixed-base operators (FBOs), and ground access are also analyzed.

3.2 COMMERCIAL PASSENGER SERVICE

3.2.1 Airside Performance

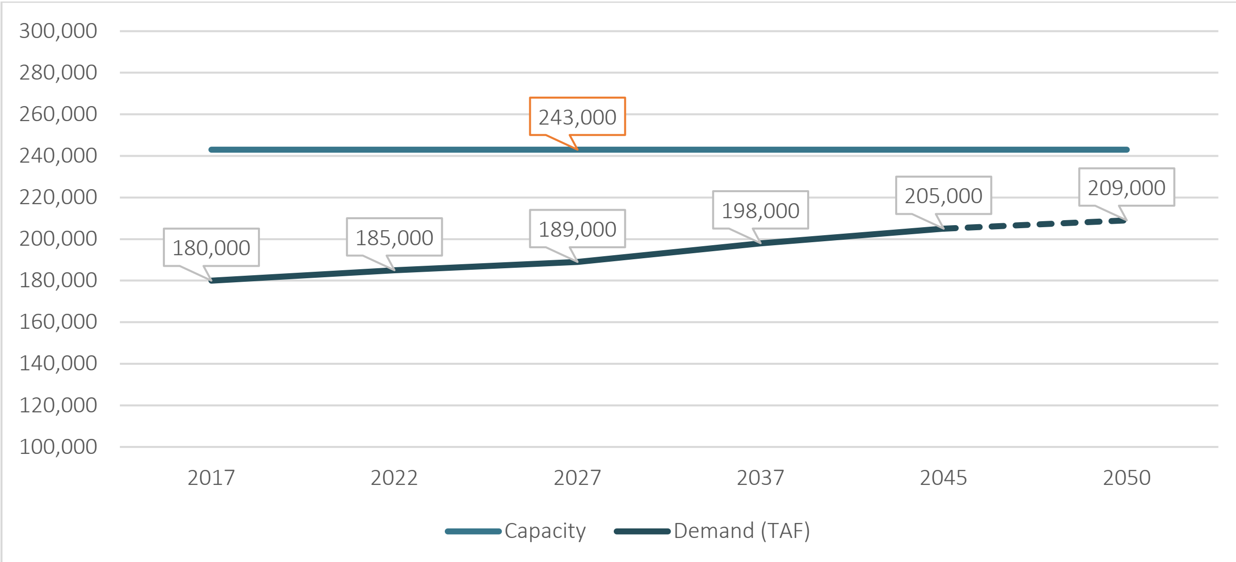
Airside performance evaluations are based on an airport's recent master plans compared with the forecasted demand presented in Working Paper 1. The ASV is used to measure annual airfield capacity, which is then compared with the annual aircraft operations forecast.

3.2.1.1 King County International/Boeing Field (KCIA)

KCIA depends on the aircraft arrival and departure streams from Sea-Tac, which means that depending on which flow Sea-Tac is flying (north or south), KCIA can be more or less affected. The issues associated with this airspace dependency is fully described in the Existing Airspace report (see Appendix A).

The ASV for KCIA is based on the 2016 Master Plan Update that determined the airport can accommodate 243,000 annual aircraft operations in an unconstrained airspace scenario. Currently, Sea-Tac, KCIA, and Renton Municipal are less than 5 NM miles apart and KCIA is under the Sea-Tac flight pattern. This results in operations at the airports that are not always independent of each other. During busy periods, Sea-Tac is the priority, and KCIA and Renton Municipal can experience delays that they would not from their traffic demands alone. NextGen flight procedures can ultimately resolve much of these issues; however, this includes changes to procedures at all of the airports including Sea-Tac. When the central Puget Sound region airspace is operating in north flow and there is incremental weather, ATC refers to this condition as Plan C. While this condition occurs only about 5% of the time, when it does occur, it puts constraints on access to KCIA because approaches to KCIA conflict with operations at Sea-Tac departing to the north. Operations from the two airports must be separated by ATC in a manner that generally reduces operations and creates delay. The forecast of total aircraft operations shown in Figure 3-1 is based on the latest FAA TAF for KCIA through 2045. The dashed line represents an extrapolation to the study period of 2050. The graph indicates that through 2045 and estimates for 2050, KCIA has sufficient airfield capacity to meet its projected demand. According to FAA Advisory Circular 150/5060-5, According to FAA Advisory Circular 150/5060-5 *Airport Capacity and Delay*, airports would experience 4-6 minutes of average delay when aircraft operations near the ASV, thus KCIA should not experience this level of delay through 2050. The airport could still accommodate about 84,000 additional aircraft movements at this horizon, assuming current fleet mix and air traffic control regulations and practices.

Figure 3-1. Annual Service Volume Runway Demand and Capacity (King County International Airport)



Source: King County International Airport Master Plan, 2016, page C.11, FAA 2018 TAF Forecast Total Aircraft Operations

Runway capacity assumes unconstrained airspace, but currently KCIA can experience delays not due to capacity constraints but due to airspace constraints with Sea-Tac.

3.2.1.2 Seattle-Tacoma International

According to the May 2018 SAMP Executive Summary, the purpose of the SAMP was to develop a facilities plan that will allow the airport to satisfy the region's air transportation needs through the next 20 years and identify measures that enable the Port of Seattle to build, manage, and operate the airport's facilities in ways that meet the Port of Seattle's sustainability goals and objectives. As described in Chapter 5 of the SAMP Executive Summary, Facility Requirements, the results of extensive airfield modeling and FAA coordination indicate that, as the airfield is currently operated, average annual aircraft delay will exceed sustainable levels by the time the airport reaches approximately 30 million enplanements (medium-term horizon).

The Sea-Tac SAMP's facility requirements for achieving 33 million annual enplanements were identified by the Port of Seattle to develop a vision for comprehensive, long-range airport development (SAMP Long-Term Vision). Near-Term Projects were identified that are consistent with the SAMP Long-Term Vision, could be constructed by 2027, and could support the level of forecast activity associated with 28 million passenger enplanements.[6] Additional projects to potentially increase airfield efficiency were identified in

[6] The Port and FAA reviewed the SAMP demand forecasts (approved September 2015) as part of the SAMP Near-Term Projects environmental review, and the FAA subsequently approved a new forecast (approved January 2020). As part of the update of the demand forecast, constrained operating growth scenarios were also developed that more realistically reflect future operating conditions with and without the Near-Term Projects. Constrained scenario numbers will be used for the SAMP NTP environmental review analysis. However, for this Regional Aviation Baseline Study, this report will reference the SAMP forecast

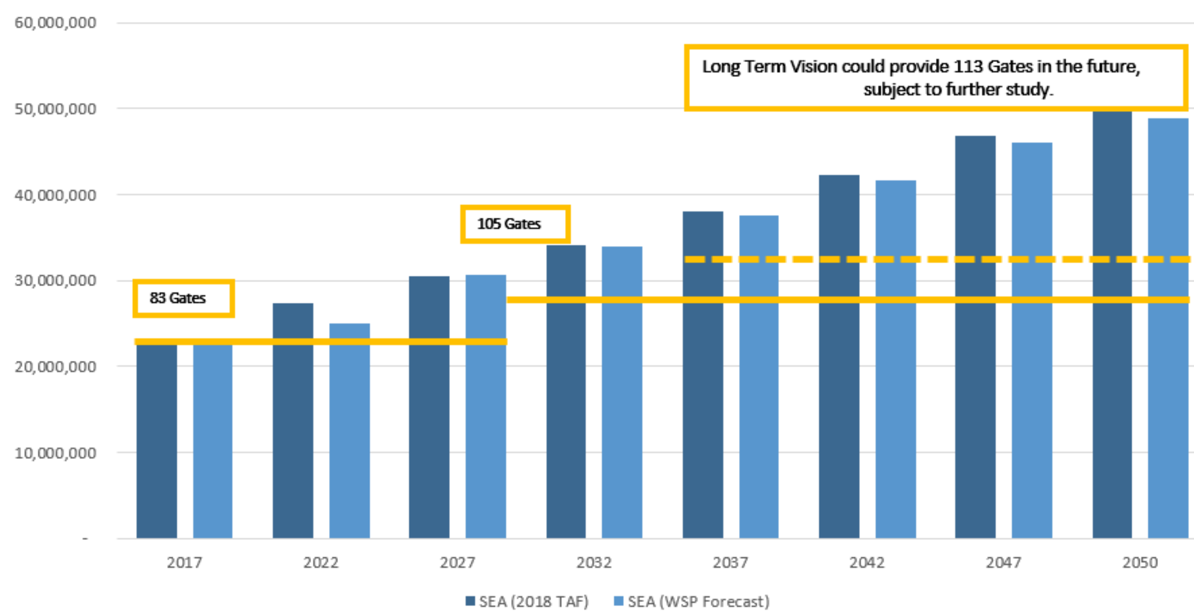
the Long-Term Vision; however, the SAMP recommends a comprehensive airfield/airspace study to further develop and assess alternatives through cost/benefit analysis.. The proposed Near-Term Projects include the following:

- A new second terminal, North Gates, consisting of 19 narrow-body equivalent gates
- High-speed taxiway exits that allow landing aircraft to exit the runway at relatively higher speeds, increasing operational efficiencies on the airfield
- Various cargo-related projects to provide the necessary facilities to meet the projected cargo demand at the airport

Passenger Terminal Capacity

Figure 3-2 compares the forecasted passenger enplanements at Sea-Tac and FAA's 2018 TAF with the SAMP's recommended terminal enhancement projects to meet the SAMP demand forecast associated with the proposed Near-Term Projects (28 million enplanements) and Long-Term Vision (33 million enplanements). The proposed gates and associated terminal expansion represent the increases in capacity for those time frames. It should be noted that increasing terminal capacity beyond the near-term activity level (28 million enplanements) is not completely defined at this time and will be studied by the Port in the future.

Figure 3-2. Passenger Enplanement Demand and Terminal Gate Comparison (Seattle-Tacoma International Airport)



Sources: WSP, FAA TAF 2018, SEA's SAMP 2018

Note: The SAMP Long-Term Vision provides 113 gates and was developed based on requirements identified in the SAMP for forecast activity associated with 33 million enplanements. Increasing terminal capacity beyond projects identified in the Near-Term Projects to satisfy requirements for forecast activity associated with 28 million enplanements is not completely defined and will be studied by the Port of Seattle. For the purpose of SAMP terminal planning, "gates" are defined as aircraft parking positions on the ramp area directly adjacent to terminal concourses—either ground loaded or passenger boarding bridge loaded.

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approved in 2015 which was the basis of SAMP planning to determine facilities required to meet near-term and long-term demand.

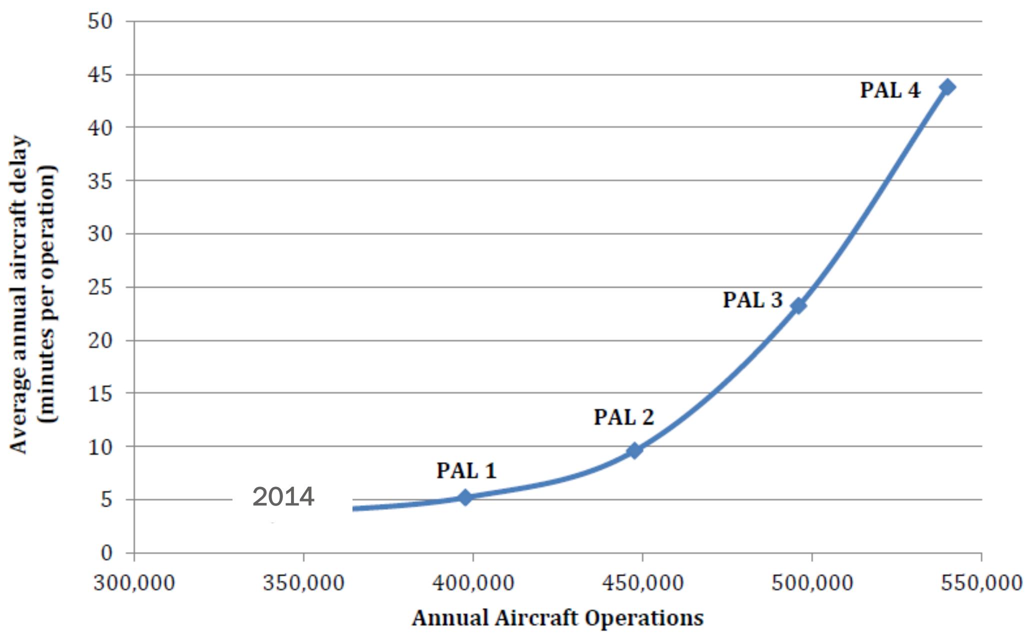
Airfield Capacity

The 2018 SAMP analyzed airfield capacity and delay for Sea-Tac and determined that, with the Near-Term Projects and an assumed medium level of improvement to airfield efficiency, , estimated average annual aircraft delay would be 16.6 minutes at a forecast activity level associated with 28 million enplanements.

ASV is a reasonable estimate of the annual capacity of an airfield configuration. ASV is not a "hard upper limit"; rather, it has been established in practice that as the level of actual annual aircraft operations approaches ASV, additional increases in aircraft operations result in disproportionate increases in aircraft delays. ASV typically equates to about 4 to 6 minutes of average annual delay per aircraft movement. ASV takes into account differences in runway utilization, weather conditions, and aircraft fleet mix.

As part of the SAMP, airfield simulation analyses were completed using the Total Airspace and Airport Modeler to evaluate the performance of the airfield and terminal ramp area with SAMP improvements. The results of spreadsheet analytical capacity analyses conducted early in the SAMP and prior to Total Airspace And Airport Modeler modeling indicated that the existing airfield could likely accommodate forecast activity between PAL2 and PAL3 with average delays of 10 minutes per operation at PAL2 and 23 minutes per operation at PAL3 (refer to Figure 3-3, taken from the SAMP).[7] However, these estimates considered mainly the runway capacity constraints with the implicit representation of the taxiway and airspace constraints represented through assumed aircraft separations and runway occupancy times.

Figure 3-3. Potential Delay per Aircraft Operations (Seattle-Tacoma International Airport)



Source: LeighFisher analyses, 2015

Note: This figure is extracted from the SAMP June 2017 Technical Memorandum No. 5 Facility Requirements and is based on unconstrained annual aircraft operations projections

[7] Planning Activity Levels are defined in the Sea-Tac Sustainable Airport Master Plan (SAMP) as milestones in passengers, air cargo, and aircraft operations. See SAMP's Technical Memorandum No. 4 on Forecasts of Aviation Activity, September 2015.

When average delays trend toward the 20-minute level airlines and airports typically make adjustments to accommodate additional passenger growth while aircraft operations may level off. For example, at the busiest commercial service airport in the United States with one runway—San Diego International Airport—keeps expanding its terminals to accommodate growing passenger levels even though airfield capacity is limited. This occurs due to changes in the type of aircraft operations to accommodate increasing commercial passengers: military and general aviation aircraft do not use San Diego International Airport and airlines are using larger aircraft.

At Sea-Tac, airfield/airspace simulation modeling was performed as part of SAMP and concluded that airfield operations with the Near-Term Projects at the level of activity associated with a forecast of 28 million enplanements (478,000 total aircraft operations, based on the approved SAMP demand forecasts) are feasible with an average annual delay of approximately 16.6 minutes. The SAMP concluded the following:

- The airfield/airspace system, as currently configured and operated, (1) can support the Near-Term Projects at the level of activity forecast, but (2) would have insufficient capacity to meet the unconstrained longer-term forecast demand at a sustainable level of delay with the improvements in the SAMP Long-Term Vision.
- Numerous airfield issues related to design criteria must be resolved and many of these issues are interrelated.

The issues and potential solutions involving airfield/airspace system effectiveness and design criteria compliance are complex and involve benefit-cost tradeoffs. Therefore, the Port of Seattle concluded that additional study is required to address long-term capacity enhancements beyond 2027.

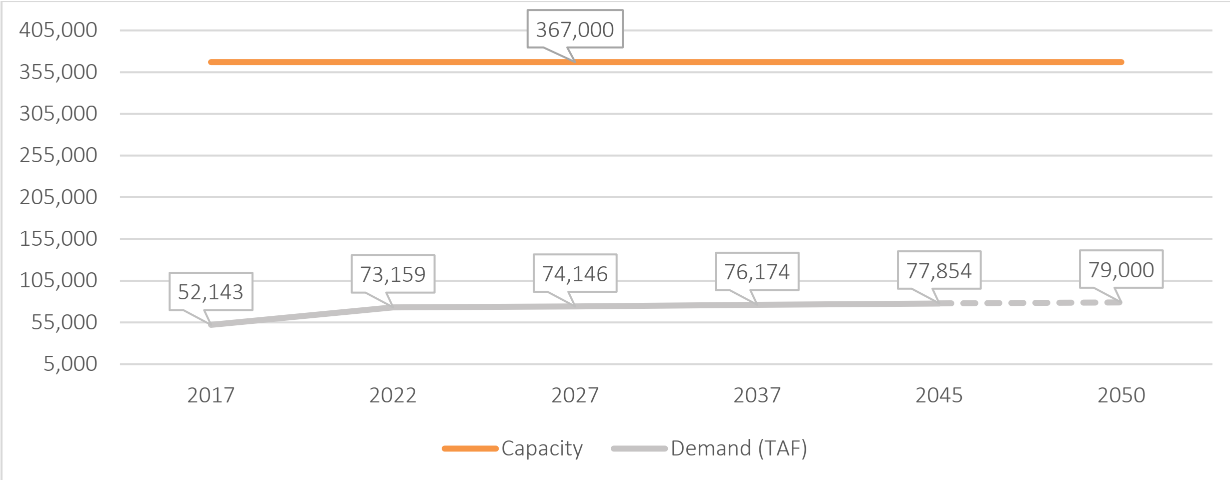
3.2.1.3 Paine Field

Figure 3-4 illustrates the comparison of Paine Field's ASV versus projected aircraft operations.

The forecast demand is based on FAA's 2018 TAF. As shown, annual capacity (ASV) for Paine Field far exceeds the current and future annual demand. The airport should be able to accommodate approximately 288,000 aircraft movements beyond the forecasted demand. However, one runway of this two-runway airport[8] is not commercial service aircraft-capable (general aviation only).

[8] The third, crosswind runway of Paine Field is physically closed and used for parking aircraft from the Boeing assembly line. There is no plan to reopen this runway, and we assume for the purpose of the study that it will remain inoperative at the 2050 horizon.

Figure 3-4. Annual Service Volume Demand and Capacity (Paine Field)



Source: Paine Field Airport Master Plan, 2002.

3.2.2 Landside Performance

3.2.2.1 King County International/Boeing Field (KCIA)

KCIA has no airline contact gates and should not need them per the current and expected type of passenger services provided. Passenger services are provided by a local commuter airline (Kenmore) operating small passenger aircraft, and California-based JetSuiteX, which started operating business-class flights in July 2019 with Oakland International Airport with small business jet aircraft. The four current remote aircraft stands should meet the future demand, as well as the existing terminal facility. The terminal parking lot is being upgraded and will accommodate 207 parking spaces; there is no known need to expand. Table 3-1 summarizes the comparison of these landside facilities with projected passenger demand.

Table 3-1. Aircraft Parking & Landside and Needs Comparison (King County International)

	EXISTING AND FUTURE NEEDS				
	2017	2022	2027	2037	2050[(1)]
Passenger Enplanements	17,297	29,500	34,000	40,000	46,000
Airline Contact Gates	0	0	0	0	0
Remote Aircraft Stands	4	4	4	4	4
Vehicle Parking Capacity (on-site)	207	207	207	207	207

Source: King County International Airport Master Plan, 2002
(1) WSP Extrapolation

3.2.2.2 Seattle-Tacoma International

The 2018 SAMP identified Near-Term Projects that are consistent with the SAMP Long-Term Vision and could be constructed by 2027 to satisfy facility requirements for 28 million passenger enplanements and 480,000 aircraft operations. The SAMP Long-Term Vision was developed based on requirements identified in the SAMP for forecast activity associated with 33 million enplanements. Table 3-2 summarizes the project enhancements required for Sea-Tac to meet demand. It should be noted that capacity enhancement projects beyond accommodating 28 million passenger enplanements are untested and will be studied by the Port in the future.

Table 3-2. Aircraft Parking & Landside Needs Comparison (Seattle-Tacoma International)

	CURRENT FACILITIES	PASSENGER FACILITY NEEDS				
		2019	2024	2029	2034	2050
Contact Gates(1)	83	95	104	106	113	NA
Off Gate Parking Positions	NA	NA	NA	NA	NA	NA
Vehicle Parking Capacity (on/off site) (1)	32,920	30,750	34,670	38,450	42,240	NA

(1) Based on Table 1-2 on page 1-14 of the SAMP Tech Memo 5 Facility Requirements

3.2.2.3 Paine Field

Table 3-3 summarizes the existing facilities available at Paine Field to accommodate the new commercial service operation that initiated in March 2019. According the supplemental environmental assessment completed in early 2019, the airport's terminal facility can accommodate 600,000 annual passenger enplanements with its two airline contact gates and one remote aircraft stand. The terminal building also has just under 1,600 vehicle parking spaces for passengers. No information is available for future passenger capacity enhancements; however, due to the success of the new airline service, a new airport master plan is proposed for 2020.

Table 3-3. Landside Capacity and Needs Comparison (Paine Field)

	EXISTING AND FUTURE NEEDS				
	2017	2022	2027	2037	2050(1)
Passenger Enplanements	500	600,000	600,000	600,000	600,000
Airline Contact Gates	2	2	2	2	2
Remote Aircraft Stands	1	1	1	1	1
Vehicle Parking Capacity (on-site)	1,594	1,594	1,594	1,594	1,594

Source: Paine Field Airport Master Plan, 2002 and Supplemental Environmental Assessment 2018.
(1) WSP Extrapolation

3.2.3 Ground Access

Since ground access criteria were defined for only the commercial service airports, the two existing commercial service airports are covered in the following sections.

3.2.3.1 Seattle-Tacoma International

Sea-Tac is within five miles of I-5 and is accessed via SR 518 from the north or SR 99 from the south. Direct access to Sea-Tac from the south is planned via a limited access south access road, which will help accommodate future demand. This future improved roadway will tie into an extended SR 509 running south and west of the airport, with a direct interchange to I-5. Current and planned roadway access should be able to meet demand.

Due to the airport's role as the primary access point for business and leisure commercial passengers, the airport has dedicated pickup zones for taxis and TNCs. More space may be needed if commercial service continues to expand at the airport.

Public transportation access at Sea-Tac is another mode offered at the airport and helps reduce demand on the roadway access and for taxis and TNCs. Link light rail, RapidRide A Line, and King County Metro buses stop at the airport. The planned I-405 Sound Transit bus rapid transit (BRT) service will stop at the Link light-rail station to the north of the airport (Tukwila International Boulevard), providing additional connections to the east side of Lake Washington (Table 3-4).

Table 3-4. Analysis of Ground Access Needs (Seattle-Tacoma International)

SUPPLY CRITERIA	MEETS EXISTING DEMAND	PLANNED TO MEET FUTURE DEMAND
Access to Interstate within 5 miles	✓	✓
Access to State Route within 2 miles	✓	✓
Taxi and Transportation Network Companies Access	✓	✓
Bus or Ferry Access	✓	✓
High-Capacity Transit Access	✓	✓

Source: Google Maps estimate.
Notes: 2017 Base Year and 2050 Future Year.

3.2.3.2 Paine Field

I-5 and SR 526 are within five and two miles, respectively, providing nearby connections to the limited access highway network. Commercial service passengers can use either the four-lane Airport Road or limited access highway SR 526, both from I-5, to reach the terminal. Swift Transit also operates BRT service along Airport Road near the terminal. Everett Transit offers local service from downtown Everett to the terminal area. These two services provide public transit access for the northern part of the region (Table 3-5).

Table 3-5. Analysis of Ground Access Needs (Paine Field)

SUPPLY CRITERIA	MEETS EXISTING DEMAND	PLANNED TO MEET FUTURE DEMAND
Access to Interstate within 5 miles	✓	✓
Access to State Route within 2 miles	✓	✓
Taxi and Transportation Network Companies Access	✓	✓
Bus or Ferry Access	✓	✓
High-Capacity Transit Access	✓	✓

Source: Google Maps estimate.
Notes: 2017 Base Year and 2050 Future Year.

3.3 AIR CARGO

3.3.1 Airside Performance

3.3.1.1 King County International

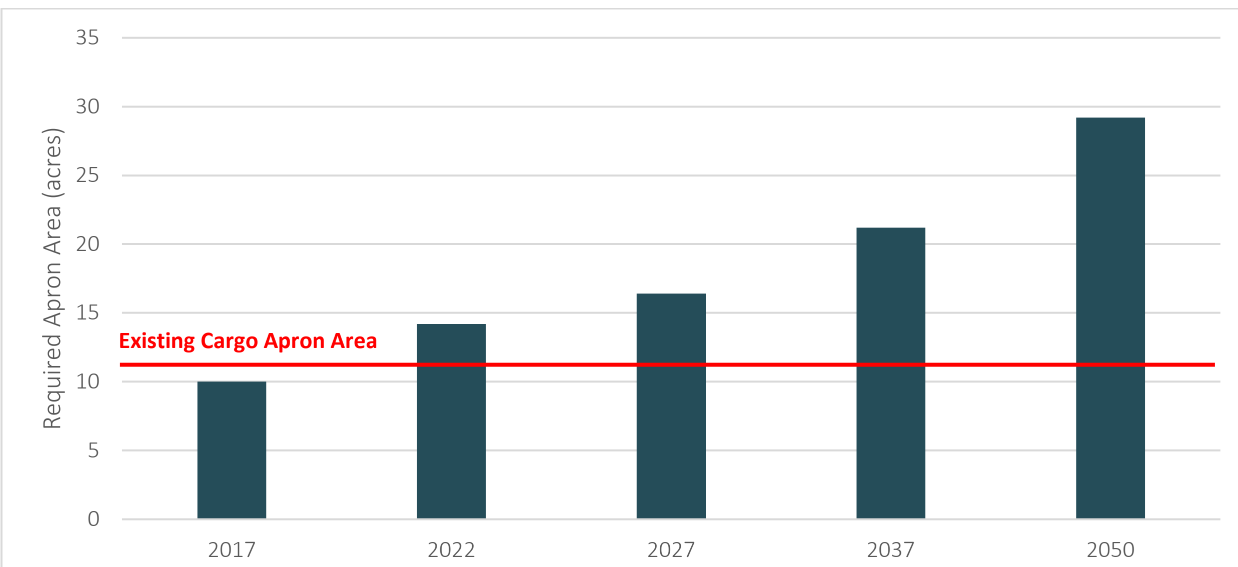
King County International's existing ramp space of 11.5 acres is slightly below the forecasted needs based on the model estimates. However, the primary cargo provider is UPS and the ramp space should be sufficient to meet the needs at the 2027 horizon due to the nature of how this carrier operates as well as the general nature of their sorting operation. The demand at the 2037 and 2050 horizons might require additional space to be determined (Table 3-6 and Figure 3-5).

Table 3-6. Airside Cargo Needs Analysis (King County International Airport)

	EXISTING CAPACITY	DEMAND				
		2017	2022	2027	2037	2050
Required Apron Area* (acres)	11.5**	10.0	14.2	16.4	21.2	29.2

* The required apron area was derived from the preferred air cargo activity forecasts presented in Chapter 6. The required apron (in acres) was obtained by applying ratios developed for the 2019 *Washington State Air Cargo Movement Study* of the Joint Transportation Committee of the Washington State Legislature based on the methodology of Airport Cooperative Research Program Report 143, Guidebook for Air Cargo Facility Planning and Development.
** Assessment based on Google Earth imagery.

Figure 3-5. Airside Cargo Capacity and Demand (King County International)



Notes: Graphic based on Table 3-6.

KCIA is preparing an update of its airport master plan, which will include developing additional ramp space to the north of the UPS ramp and adding a new facility area on the west side of the airport (north of the Museum of Flight). This facility would allow for a cargo building, ramp space, and access to East Marginal Way.

3.3.1.2 Seattle-Tacoma International

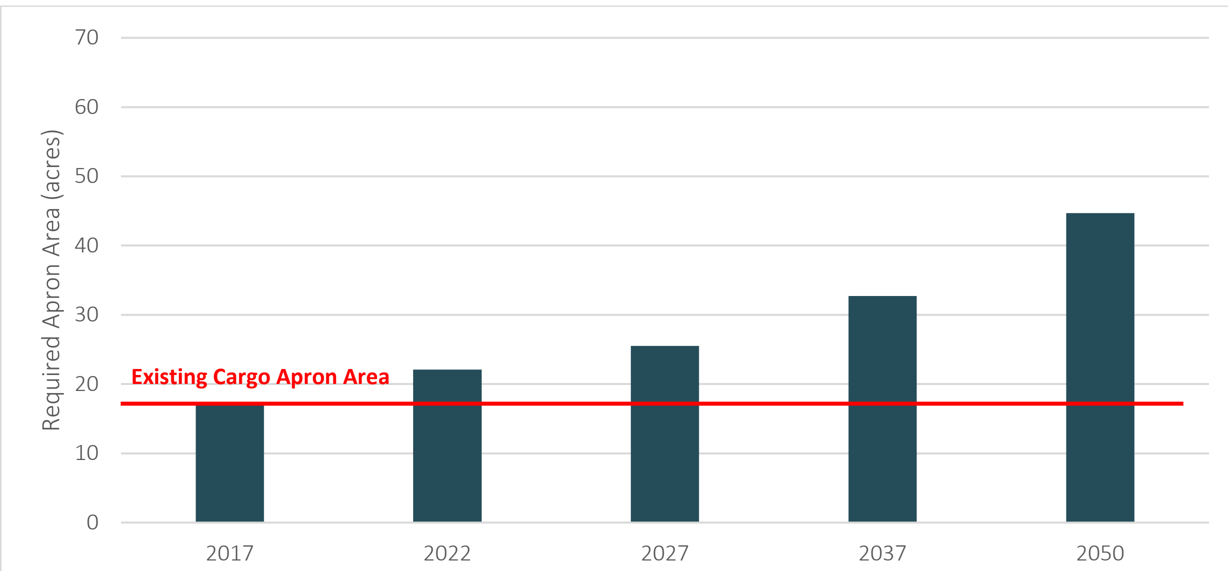
Air cargo congestion at Sea-Tac could reduce the performance of the airport and increase costs to shippers. Congestion could also force shippers to consider other regionally (West Coast) competitive airports (Table 3-7 and Figure 3-6).

Table 3-7. Airside Cargo Needs Analysis (Seattle-Tacoma International)

	EXISTING CAPACITY	DEMAND				
		2017	2022	2027	2037	2050
Required Apron Area* (acres)	17	16.9	22.1	25.5	32.7	44.7
Required Hardstands**	18	15	16	18	19	–

* The required apron area was derived from the preferred air cargo activity forecasts presented in Chapter 6. The required apron (in acres) was obtained by applying ratios developed for the 2019 *Washington State Air Cargo Movement Study* of the Joint Transportation Committee of the Washington State Legislature based on the methodology of Airport Cooperative Research Program Report 143, Guidebook for Air Cargo Facility Planning and Development.
** Existing hardstand capacity extracted from the Port of Seattle's 2018 Air Cargo Growth Potential and Facility Requirements Assessment. The required hardstands were extracted from Sea-Tac's Sustainable Airport Master Plan (SAMP). It was verified that these numbers of stands were consistent with the required apron area.

Figure 3-6. Airside Cargo Capacity and Demand (Seattle-Tacoma International)



Notes: Graphic based on Table 3-7.

3.3.1.3 Paine Field

Delivery of aircraft parts to the nearby Boeing commercial airplanes assembly lines is the only air freight activity at Paine Field. Atlas Air operates specially modified Boeing 747 BCF "Dreamlifter" for this purpose. The handling of these payloads occurs at a 9-acre-wide apron on the northwest side of the airport. Future needs will depend on the evolution of the production of wide-body aircraft at Paine Field and the possibility of Paine Field attracting non-Boeing related commercial freighter operators. There is enough land available to the south for at least doubling the size of this apron.

3.3.2 Landside Performance

3.3.2.1 King County International

The facility requirements prepared in Table 3-8 were developed based on typical air cargo operations. The primary air cargo carrier (UPS) at KCIA has a unique method of operating where the freight is temporarily stored on the ramp then loaded on trucks for sorting at off-airport distribution centers. Consequently, there is no need for on-site warehouse and reduced demand for truck parking and maneuvering area.

Table 3-8. Landside Cargo Needs Analysis (King County International)

	EXISTING CAPACITY	DEMAND				
		2017	2022	2027	2037	2050
Air Cargo Annual tonnage (metric tons)	–	113,718	145,136	168,253	217,484	299,804
Required Air Cargo Warehouse* (sq. ft.)	–	124,099	174,384	202,159	261,311	360,220
Required Truck parking and Maneuvering Area* (sq. ft.)	222,761	206,832	291,173	337,550	436,318	601,469

* The required square footage was derived from the preferred air cargo activity forecasts presented in Chapter 6. The required warehouse and trucking area (in sq. ft.) was obtained by applying ratios developed for the 2019 *Washington State Air Cargo Movement Study* of the Joint Transportation Committee of the Washington State Legislature based on the methodology of Airport Cooperative Research Program Report 143, Guidebook for Air Cargo Facility Planning and Development.

The additional ramp space planned to the north of the UPS ramp, and new facility area on the west side of the airport (north of the Museum of Flight) should provide adequate space for meeting the long-term needs of UPS. Further development of the air cargo activity or any changes in the organization of the UPS operations might require reconsidering this analysis.

3.3.2.2 Seattle-Tacoma International

Sea-Tac's air cargo buildings are dated and laid out inefficiently, hindering the airport ability to fulfill the Port of Seattle's economic mission to support growing trade. The passenger terminal will be expanded to the north, causing competition for space between terminal and air cargo facilities. The SAMP Near-Term Projects provide additional on-airport warehouse capacity to meet projected demand through 2027 with the redevelopment of the Cargo 4 South building (SAMP project C01 Cargo 4 South Redevelopment), additional cargo ramp capacity with the development of a new freighter hardstand in the North Cargo Area (SAMP project A08 Hardstand (north)), and additional off-airport cargo warehouse capacity on the Port of Seattle's L-Shape parcel north of SR 518 (SAMP projects C02 & C03 Off-Site Cargo Phases 1 & 2).

The SAMP identifies projects with the potential to address growth in cargo demand in the long-term with a redevelopment and densification of the existing cargo area, and the development of a new SASA, located south of the fuel farm. New facilities in SASA would feature up to eight hardstands available for large cargo aircraft and approximately 400,000 sq. ft. of air cargo warehouses. However, the new SASA is not included in the SAMP Near-Term Projects, is subject to further study, and would not address the long-term demand for new off-airport cargo and logistics facilities.

In addition to the SAMP L-Shape development, privately owned properties near the airport could also be developed to meet the demands for off-airport air cargo operations.

The 2019 *Washington State Air Cargo Movement Study* of the Joint Transportation Committee of the Washington State Legislature provides an assessment of the impacts of a hypothetical shift of 10 percent of cargo demand at Sea-Tac to other airports. It was found that truck vehicle-miles traveled in Washington state would increase by 320,000 to 740,000 per year. This increase would generate significant emissions of pollutants and increase the accident risk on highways. Moreover, having to truck freight to other airports would cost shippers from $760,000 to $5 million per year, depending on which airports the demand would shift to. Table 3-9 details the cargo warehouse and truck area parking and maneuvering area requirements derived from the 2019 Washington State Air Cargo Movement Study using the preferred air cargo forecasts presented in Chapter 6 of Working Paper 1. Table 3-10 details the warehouse facility requirements and air cargo forecast from the Air Cargo Growth Potential and Facility Requirements Assessment, prepared by Logistics Capital Strategy (LCS) for the Port of Seattle, September 2018 (LCS report). The LCS report uses a multifactor, Sea-Tac specific methodology to quantify warehouse demand by considering the demonstrated operational efficiency of existing on-airport cargo tenants and allocated growth of individual operators based on forecasted demand.

Table 3-9. Landside Cargo Needs Analysis (Seattle-Tacoma International)

	EXISTING CAPACITY	DEMAND				
		2017	2022	2027	2037	2050
Air Cargo Annual tonnage (metric tons)	–	425,856	504,521	581,016	745,336	1,019,458
Required Air Cargo Warehouse* (sq. ft.)	354,660**	516,368	672,928	781,362	1,002,342	1,370,987
Required Truck parking and Maneuvering Area* (sq. ft.)	–	614,948	800,840	922,263	1,183,093	1,618,214

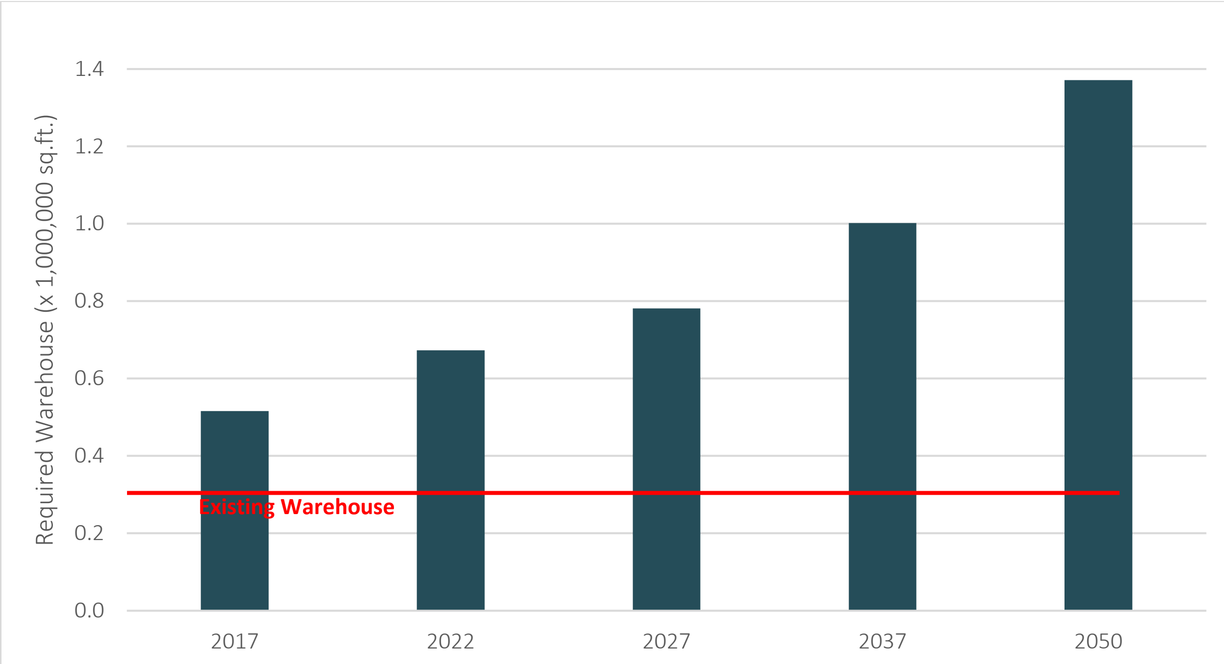
* The required square footage was derived from the preferred air cargo activity forecasts presented in Chapter 6. The required warehouse and trucking area (in sq. ft.) was obtained by applying ratios developed for the 2019 *Washington State Air Cargo Movement Study* of the Joint Transportation Committee of the Washington State Legislature based on the methodology of Airport Cooperative Research Program Report 143, Guidebook for Air Cargo Facility Planning and Development.
** Existing capacity, 2014.

Table 3-10. Landside Cargo Needs and Planned Capacity Analysis (Seattle-Tacoma International)

	DEMAND/CAPACITY				
	2017	2022	2027	2037	2050
Air Cargo Annual Demand (metric tons)	427,174	NA	613,755	NA	NA
Required Air Cargo Warehouse* (sq. ft.)	362,577	NA	483,531	NA	NA

Source: Air Cargo Growth Potential and Facility Requirements Assessment, prepared by Logistics Capital & Strategy (LCS) for the Port of Seattle, September 2018.
* The required square footage was derived with consideration of demonstrated operational efficiency of existing tenants of on-airport cargo facilities.

Figure 3-7. Landside Cargo Capacity and Demand (Seattle-Tacoma International Airport)



Notes: Graphic data based on Table 3-9.

3.3.2.3 Conclusion

Landside capacity is inadequate to meet the cargo needs of both Sea-Tac and KCIA. Planning analysis shows that, with no capacity improvement projects, Sea-Tac will begin having a deficit in cargo buildings as soon as 2021, which will reduce the efficiency of handling cargo at this airport and could lead to system congestion. This deficit could be worsened by the rapid growth of passenger demand at this airport and increasing competition for on-airport space; the SAMP plans to develop the passenger terminal area against existing cargo facilities. The SAMP Near-Term Projects provide additional on-airport warehouse capacity with the redevelopment of the Cargo 4 South building (SAMP project C01 Cargo 4 South Redevelopment), additional cargo ramp capacity with the development of a new freighter hardstand in the North Cargo Area (SAMP project A08 Hardstand (north)), and additional off-airport cargo warehouse capacity on the Port of Seattle's L-Shape parcel north of SR 518 (SAMP projects C02 & C03 Off-Site Cargo Phases 1 & 2). The 2018 LCS report validates that these SAMP Near-Term Projects satisfy the projected cargo facility requirements at Sea-Tac. While the SAMP provides needed warehouse capacity in the near-term, there are limited on-airport opportunities for expanding cargo building capacity, and so alternative strategies such as off-site facilities may be required. Air cargo-related businesses have been developing off-airport facilities and services to Kent and other regional locations. While distribution center availability in Kent has tightened considerably in the recent past, air cargo tonnages are relatively small compared to regional trucking and distribution, so that the real consequence of warehouse market conditions needs to be further explored.

KCIA has limited space to expand. However, the existing capacity meets the demand of the only air cargo carrier operating from KCIA—UPS—because it does not handle the freight on-site and trucks it to off-airport sortation centers.

Access capacity is restricted to the current regional cargo airports (Sea-Tac and KCIA) because the main access interstate, I-5, is often congested. This increases costs to shippers and trucking companies and affects the way shipments are dispatched and managed. Even so, roadway conditions may not be a material competitive disadvantage compared to the congestion surrounding the rival San Francisco and Los Angeles International Airports. Washington Department of Transportation's Puget Sound Gateway Program includes several highway projects that will improve accessibility to Sea-Tac. Access capacity is adequate at other airports in the state.

3.3.3 Ground Access

3.3.3.1 King County International

Roadway access for cargo operations at KCIA is adequate, with access to I-5 at the north and south part of the airport. Cargo entering and leaving KCIA can be easily transported to the interstate via Airport Way, which incorporates large-turn radius ramps on the south end at the South Boeing Access Road and requires only one intersection at the north access point to get to I-5 ramps. The area is conducive to cargo access and is anticipated to be adequate through the 2050 forecast year.

3.3.3.2 Seattle-Tacoma International

Air Cargo Road runs along the east side of the airport and connects several cargo operations within airport property. Access to Air Cargo Road is provided via S. 154th Street, S. 160th Street, S. 170th, and S. 188th Street. S. 154th can be accessed via SR 518 and SR 99 while the latter three are accessed via SR 99. Planned improvements such as the South Access Highway could provide direct access to Air Cargo Road from the south, which would provide a streamlined access point for freight.

3.4 GENERAL AVIATION

3.4.1 Airside Performance

The airside performance of the general aviation airports is evaluated through several measures of demand and capacity, along with assessments of certain facilities. ASV is typically used to evaluate airfield capacity and is a practical measure of the airport's operational capacity that takes into account runway configuration, the typical mix of aircraft using the airport, and weather conditions. The ratio of annual operations to ASV (the annual demand/capacity ratio) is a useful planning tool. When the ratio exceeds 0.6, it is an indication that planning efforts should be undertaken to address the airport's capacity constraints. Ideally, the planning efforts are timed so that those plans can be implemented once the demand/capacity ratio passes 0.8. Studies have shown that airport delays start rising rapidly once the demand/capacity ratio surpasses 0.8.

Data to analyze the ASV demand/capacity ratio was available for Arlington Municipal, Bremerton National, Renton Municipal, and Harvey Field. Table 3-11 shows the results of this analysis.

Table 3-11. Annual Service Volume Demand/Capacity Analysis (General Aviation Airports)

AIRPORT	EXISTING DEMAND/CAPACITY RATIO	2050 DEMAND/CAPACITY RATIO
Arlington Municipal[1]	0.51	0.73
Bremerton National[2]	0.24	0.57
Renton Municipal[3]	0.49	0.67
Harvey Field[4]	0.49	0.67

(1) Existing demand (2008) from Arlington Municipal 2012 Master Plan / Based on Federal Aviation Administration AC 150/5060-5
(2) Bremerton National 2015 Master Plan
(3) Existing demand (2015) and capacity from Renton Municipal 2018 Master Plan
(4) Existing demand (2014) and capacity from Harvey Field 2017 Master Plan

Table 3-11 shows that all of the airports are currently under the 0.6 planning threshold, with the highest demand/capacity ratio seen at Arlington Municipal with a ratio of 0.51. By 2050, three of the four airports are expected to cross the 0.6 ratio, with the fourth airport—Bremerton National—expected to have a ratio just under 0.6. All four airports should be planning for capacity improvements by 2050, with Arlington Municipal being close to implementing its plan since its ratio is expected to be approaching 0.8.

The remainder of this analysis will examine the following system airports based on their classification in the WASP:

- Regional Airports:
  - Arlington Municipal
  - Bremerton National
  - Harvey Field
  - Pierce County
  - Renton Municipal
  - Tacoma Narrows
- Community Airports:
  - Auburn Municipal
  - Norman Grier Field
  - First Air Field
  - Apex Airpark
  - Shady Acres
- Local Airports:
  - Darrington Municipal
  - Swanson Field
  - Ranger Creek State
- General Use Airport
  - Bandera State
  - Kenmore Air Harbor Sea Plane Base (SPB) S60
  - American Lake SPB
  - Port of Poulsbo SPB
  - Will Rogers-Wiley Post Memorial SPB
  - Kenmore Air Harbor SPB W55
  - Skykomish State
  - Vashon Municipal

The WASP groups airports based on similar characteristics, so evaluating the general aviation airports within each of these groups can help to identify useful statewide trends for strategic decision-making purposes.

Another common capacity constraint at general aviation airports is aircraft storage. A simple way to evaluate this is through hangar waiting lists. Airports commonly maintain waiting lists of people that are interested in renting hangar space when none is currently available. The lists demonstrate demand for additional hangar space.

Data collected from the system airports found that waiting lists dropped in frequency with airport classification. As shown in Table 3-12, all regional airports reported a hangar waiting list except Arlington Municipal. Among the community airports, 60 percent reported having a hangar waiting list. That percentage dropped to 33 percent among the local airports, and none of general use airports indicated that they had a hangar waiting list.

Table 3-12. General Aviation Airports with Hangar Waiting Lists

WASP AIRPORT CLASSIFICATION	PERCENTAGE OF AIRPORTS WITH HANGAR WAITING LIST
Regional Airports	83%
Community Airports	60%
Local Airports	33%
General Use Airports	0%
Total	**39%**

Source: WSP and CDM Smith Analysis

Two other important aspects of general aviation airports are the existence of an instrument approach procedure (IAP) and design standards, which are based on the airport reference code (ARC).

An IAP lays out the means by which an aircraft can land at an airport during periods of poor visibility. These procedures make use of either ground-based navigation signals or satellite signals. Table 3-13 summarizes the percentage of system airports with IAPs.

Table 3-13. General Aviation Airports with Instrument Approach Procedures

WASP AIRPORT CLASSIFICATION	PERCENTAGE OF AIRPORTS WITH AN INSTRUMENT APPROACH PROCEDURE
Regional Airports	100%
Community Airports	20%
Local Airports	0%
General Use Airports	0%
Total	**30%**

Source: WSP and CDM Smith analysis

As can be seen, the more capable airports tend to be equipped with IAPs. Every regional airport has an IAP, but the percentage of airports with IAPs drops off quickly from community airports and down.

The ARC is used to determine airport design standards, such as runway width or safety area dimensions. It is based on the most demanding type of aircraft, referred to as the critical aircraft, that will use the infrastructure on a regular basis, defined as 500 or more annual operations at the airport. Several different critical aircraft might be present at an airport based on approach speed and wingspan. These aircraft are used to characterize the design standards and specifications the airport will need to meet so that it can safely and effectively serve those aircraft.

The FAA groups aircraft into aircraft approach categories and airplane design groups based on their approach speed and wingspan, respectively. Table 3-14 and Table 3-15 present the criteria for these categories.

Table 3-14. Aircraft Approach Categories

AIRCRAFT APPROACH CATEGORY	APPROACH SPEED
A	< 91 knots
B	91 to < 121 knots
C	121 to < 141 knots
D	141 to < 166 knots
E	166 knots or more

Source: FAA AC 150/5300-13A Change 1

Table 3-15. Airplane Design Groups

AIRPLANE DESIGN GROUP	WINGSPAN
I	< 49 feet
II	49 to < 79 feet
III	79 to < 118 feet
IV	118 to < 171 feet
V	171 to 214 feet
VI	214 to < 262 feet

Source: FAA AC 150/5300-13A Change 1

After identifying an airport's critical aircraft, it is then possible to determine the facility's ARC. The ARC is a coding system that relates airport design criteria to the operational and physical characteristics of the airplanes that are intended to operate at an airport. An airport's ARC is a composite designation based on the aircraft approach category and airplane design group of that airport's critical aircraft. For example, an airport with a Beech King Air C90 as the critical aircraft (an approach speed of 100 knots, and a wingspan of 50.2 feet according to FAA documents) would be designated with an ARC of B-II.

Table 3-16 summarizes the ARCs for the system airports. It is notable that Tacoma Narrows is the only C-II ARC general aviation airport in the system. The other general aviation airports have an aircraft approach category of B or A. This is significant because of the substantial changes in airport design standards that take place when the critical aircraft changes from an aircraft approach category of B to C. For example, the design standard for the length of the runway safety area (a clear area beyond the ends of the runway to provide for overrun protection) goes from 300 feet for a B-II ARC airport, to 1,000 feet for a C-II ARC airport. Upgrading an airport to a C category ARC is generally an expensive proposition.

Table 3-16. General Aviation Airports by Airport Reference Code Summary

WASP AIRPORT CLASSIFICATION	C-II	B-II	B-I	A-II	A-I	UNKNOWN	TOTAL
Regional Airports	1	5	0	0	0	0	6
Community Airports	0	0	2	0	3	0	5
Local Airports	0	0	0	0	3	0	3
General Use Airports	0	0	0	0	4	5	9
Total	**1**	**5**	**2**	**0**	**10**	**5**	**23**

Source: 2017 Washington Airport System Plan.

Airports with C-II ARC or higher code are notable because these are the airports that are generally regarded as being designed to handle jet aircraft. They can typically accommodate business jet aircraft, and potentially accommodate occasionally air cargo or charter flights.

3.4.2 Terminal Facilities

Another important consideration for a general aviation airport is whether it can accommodate various user needs. Two key facilities are a general aviation terminal where pilot and passengers can meet and wait for flights, and an FBO that provides fueling and other services for general aviation aircraft.

Table 3-17 summarizes the percentage of airports with general aviation terminals. As with previously noted facilities, general aviation terminals are more frequently found at regional airports. The one general aviation terminal reported at a general use airport was at Kenmore Air Harbor (W55), a seaplane base with commercial operations.

Table 3-17. Airports with General Aviation Terminals

WASP AIRPORT CLASSIFICATION	PERCENTAGE OF AIRPORTS WITH A GENERAL AVIATION TERMINAL
Regional Airports	33%
Community Airports	20%
Local Airports	0%
General Use Airports	11%
Total	**17%**

Source: Airport Master Plans and Layout Plans.

Table 3-18 shows the percentage of airports with FBOs. Again, the regional airports demonstrate that they tend to attract services like FBOs, with all but one of those airports (Pierce County) featuring an FBO. The general use airports that have FBOs are seaplane bases—Kenmore Air Harbor (W55) with commercial operations, and Will Rogers-Wiley Post Memorial (W36) that is collocated with Renton Municipal and shares its FBO.

Table 3-18. Airports with Fixed-Base Operations

WASP AIRPORT CLASSIFICATION	PERCENTAGE OF AIRPORTS WITH A FIXED-BASE OPERATION
Regional Airports	83%
Community Airports	0%
Local Airports	0%
General Use Airports	22%
Total	**30%**

Source: Airport Master Plans and Washington State Department of Transportation Airport Facilities and Services Report.

3.4.3 Ground Access

Working Paper 1 evaluated ground access at general aviation airports by identifying airports within 5 miles of an interstate and 2 miles of a state highway or state route. This performance measure was chosen as a reasonable benchmark of access at commercial service airports and serves as a differentiator among general aviation airports. Differentiation among general aviation airports is helpful when evaluating which of these airports may be suitable for accommodating the overflow of commercial service airport operations.

Improvements to ground access at general aviation airports would generally come in the form of road improvement projects on current roadways connecting the airport. In conducting a needs assessment for ground access at general aviation airports, airport needs are summarized at a high level by WASP classification.

3.4.3.1 Regional Airports

Airports grouped in the regional classification have generally adequate access, with Auburn Municipal and Renton Municipal in particular located near interstates, which can make them strategic building points for future system expansion. While the other airports lack nearby interstate access, state routes can also provide wide clearances and capacity for users. Barring any significant changes in service type, current roadway access should remain adequate to the 2050 forecast year. Table 3-19 summarizes airport access by WASP regional classification.

Table 3-19. Regional Classification Airports

AIRPORT	WITHIN 5 MILES OF INTERSTATE	WITHIN 2 MILES OF STATE ROUTE
Arlington Municipal	✓	✓
Bremerton National	—	✓
Harvey Field	—	✓
Pierce County	—	✓
Renton Municipal	✓	✓
Tacoma Narrows	—	✓

Source: Google Maps.
Notes: Distance measured from airport terminal.

3.4.3.2 Community Airports

Airports in the WASP community airports classification (Table 3-20) have access to state routes, except for Shady Acres, which is in the southern part of the region east of I-5 and SR 7. Auburn Municipal, located in a more suburban and industrial environment, is the only airport in the grouping with access to both an interstate and state route. Based on current access demand and activity at these airports, ground access is adequate and should remain adequate through the 2050 forecast year.

Table 3-20. Community Airport Classification

AIRPORT	WITHIN 5 MILES OF INTERSTATE	WITHIN 2 MILES OF STATE ROUTE
Auburn Municipal	✓	✓
Norman Grier Field	—	✓
First Air Field	—	✓
Apex Airpark	—	✓
Shady Acres	—	—

Source: Google Maps.
Note: Distance measured from airport terminal.

3.4.3.3 *Local Airports*

Airports in the local airport classification (Table 3-21) are more remote airports serving a limited user base. Access provided via state routes should remain adequate. Every airport of this group is no more than 2 miles away from a state route.

Table 3-21. Local Airports Classification

AIRPORT	WITHIN 5 MILES OF INTERSTATE	WITHIN 2 MILES OF STATE ROUTE
Darrington Municipal	—	✓
Swanson Field	—	✓
Ranger Creek State	—	✓

Source: Google Maps estimate.
Note: Distance measured from airport terminal curbside.

3.4.3.4 *General Use Airports*

General use airports as classified by the WASP (Table 3-22) encompass a wide range of airports and includes several seaplane bases in urban areas as well as remote airports with limited access. Sea plane bases, including both Kenmore Air installations and Will Rogers-Wiley Post, are along either existing or planned high-capacity transit lines and may appeal to business and leisure travelers going to remote areas around the region. Other remote airports such as Bandera State and Port of Poulsbo Sea Plane Base maintain road access that should be adequate, considering the use of each airport. Vashon Municipal, due to its relative size, use, and location on a low population island, only has local roadway access.

Table 3-22. General Use Airports Classification

AIRPORT	WITHIN 5 MILES OF INTERSTATE	WITHIN 2 MILES OF STATE ROUTE
Bandera State	✓	✓
Kenmore Air Harbor Sea Plane Base (SPB) S60	✓	✓
American Lake SPB	✓	✓
Port of Poulsbo SPB	—	✓
Will Rogers-Wiley Post Memorial SPB	✓	✓
Kenmore Air Harbor SPB W55	✓	✓
Skykomish State	—	✓
Vashon Municipal	—	—

Source: Google Maps estimate.
Note: Distance measured from airport terminal curbside.

4. Challenges and Opportunities

Many challenges face airports and aviation in general. Two important issues are replenishing the retiring pilot population and limited funding to address deteriorating airfield pavements. For airports other than Sea-Tac, the Pavement Condition Index for the airports with in the state continues to decrease. This is an infrastructure and funding issue. WSDOT does not have enough funding to assist airports with this issue and affects many of the airports covered in this study.

4.1 COMMERCIAL SERVICE

As illustrated in Chapter 2, 60-minute commercial passenger service coverage meets the established benchmarks for population and employment coverage in 2017. However, given the limited air service available at Paine Field, the long-term coverage provided by Sea-Tac is poor, particularly for western Snohomish County and the central area of Kitsap County. Providing better coverage for Snohomish County would require either adding a strong line-up of commercial service at another airport in Snohomish County or increasing commercial service at Paine Field. Coverage for central Kitsap County could be provided by commercial service at nearby airports. Overall Sea-Tac reliever possibilities also exist but have limitations. See Section 4.3, General Aviation, for more information.

The 2018 SAMP for Sea-Tac determined that if future demand levels materialize as projected and no procedural improvements or capacity enhancements to the existing airfield are made, aircraft delay would become significant around 2029 and intolerable around 2034. The SAMP concluded that the airfield/airspace system, as currently configured and operated, can support the proposed Near-Term Projects for the passengers forecasted for 2027 (28 million enplanements). However, the airport would have insufficient capacity to meet the unconstrained 20-year forecast demand at a sustainable level of delay with the improvements identified in the SAMP Long-Term Vision developed to meet requirements associated with forecast activity of 33 million enplanements.

The issues and potential solutions involving the airfield/airspace system are complex and involve benefit-cost tradeoffs. Therefore, the Port of Seattle concluded that additional study is required to address long-term capacity enhancements beyond 2027.

KCIA depends on the aircraft arrival and departure streams from Sea-Tac and as stated previously, Southwest Airlines considered establishing a mini-hub at KCIA but abandoned the ideas due to the airspace dependency. In addition, KCIA has very limited expansion capability.

Although Paine Field started commercial service in early 2019, the airport’s terminal facility can only accommodate 500,000 annual passenger enplanements with its two airline contact gates and one remote aircraft stand, according to the supplemental environmental assessment.

Accommodating the region's projected 55 million passenger enplanements in 2050 will be a challenge. Beyond the Near-Term Projects proposed by Sea-Tac that the SAMP analysis demonstrated can accommodate approximately 28 million enplaned passengers, further growth would need to rely on potential improvements identified through additional study to be conducted by the Port of Seattle as recommended by the SAMP and/or any combination of additional efficiency and capacity gains achieved through the utilization of larger aircraft, higher passenger load factors, scheduling more flights during non-peak hours, and gains in airspace improvements with NextGen technologies, etc.

Sea-Tac and Paine Field have potentially limited opportunities to expand their airports to accommodate passengers beyond about 29 million enplanements. This translates to a gap of around 27 million annual enplanements for the region. Thus, if this demand cannot be accommodated at the existing commercial service airports, then it would need to be accommodated elsewhere.

4.1.1 Opportunities

FAA's NextGen program is continuing to improve the complex airspace in the central Puget Sound region. The following is a summary of recent and future improvements in airspace/runway capacity:

- Recent Air Traffic Control/NextGen Capacity Improvements at Sea-Tac:
  - Time-based flow management helps to improve the flow of arrivals to the runways.
  - Reduced diagonal spacing for arrivals of 1 nautical mile for runways with centerline spacing of 2,500 feet or greater provides an increase in arrival capacity.
  - Wake Recategorization Phase 2 assigns aircraft to new wake turbulence classifications based on their wake turbulence characteristics, such as wake generation, wake decay, and encounter effects. This results in closer longitudinal separation for certain aircraft types without sacrificing safety. However, no real benefit occurred for Sea-Tac but the benefit was felt by KCIA and other airports.
- Future Air Traffic Control/NextGen Improvements at Sea-Tac:
  - Improved Runway Delivery Accuracy: The combined effects of several new capabilities, including Automatic Dependent Surveillance-Broadcast (ADS-B) Out, Cockpit Display of Traffic Information, and Terminal Sequencing and Spacing in the terminal area, will improve the ability of controllers to deliver aircraft to the runway with the desired separation from the preceding aircraft. This will reduce the average spacing between arrivals and boost arrival capacity.

4.1.2 Multimodal Access

Sound Transit Stride BRT service at Tukwila International Boulevard Station, one station north of the Sea-Tac station on Link Light Rail, will extend to the eastern suburbs, creating a new connection with communities that currently lack high-capacity transit. This new service provides an alternative to personal car use or taxi and TNC connections, which add congestion to roadways and require areas for pickup and dropoff or long-term parking. In addition, Sound Transit will be expanding the Link light-rail system to the north of Seattle (to Lynnwood and eventually Everett), to the east (to Bellevue, Redmond and Issaquah) and south to Tacoma, providing expanded direct rail service to Sea-Tac and Paine Field.

Depending on the trends for taxis and TNCs, more areas may need to be dedicated to these services at all commercial service airports.

Overall, alternative modes to private car transportation provide an opportunity to alleviate congestion and reallocate landside space to other uses.

4.2 AIR CARGO

4.2.1 Challenges

Within the context of this study, the term air cargo congestion is commonly used to describe situations when demand increases beyond what an airport can efficiently handle. Effects of congestion can usually appear long before annual capacity is reached due to the cyclic nature for air cargo demand. For example, air cargo handling capacity can be significantly stressed at Sea-Tac during the summer cherry season and the winter holiday season. Yet, during other times of the year, air cargo facilities may be sufficient or even under-utilized.

There is also a need to account for the fact that the air cargo system is complex and comprises both on-airport facilities and services (airlines, ground handlers, cargo terminals, aircraft parking, on-airport parking, terminal parking, etc.) and off-airport facilities and services (freight forwarders, trucking terminals, warehouses, sort facilities, customs brokers, shippers and receivers, etc.). Capacity constraints at any one of its components can cause congestion.

The 50-year forecast for air cargo in the central Puget Sound region anticipates air cargo tonnage to increase from 539,574 metric tons in 2017 to 1,319,262 tons in 2050—a 2.7 percent compounded average annual growth rate. Air cargo freighter aircraft operations are projected to increase almost 75 percent in 20 years from 19,200 in 2017 to approximately 33,445 by 2037 and to approximately 46,000 by 2050.

As presented previously, Sea-Tac is the dominant commercial airport in both the state and the region. It has more than 35 scheduled airlines that offer nonstop narrow-body and wide-body service to over 90 domestic and 30 international destinations. In 2017, the airport accommodated 45.7 million air passengers (up 2.6 percent from 2016) and processed 425,856 metric tons of belly cargo and freighter cargo (up 16.2 percent from 2015).

KCIA (locally known as Boeing Field) is the other regional airport with commercial air cargo activity. It acts as regional gateway for the integrator/express airline for UPS, as well as serving as a center for business aviation and an industrial aerospace facility for the Boeing Company.

Paine Field shares the same market area as Sea-Tac and KCIA but has traditionally operated as an industrial general aviation airport that supports the assembly of aircraft for the Boeing Company. In this role, the airport has not developed the facilities and services to attract scheduled air cargo service. In general, air cargo service, because so much of it goes in bellies of passenger flights, is tied to commercial passenger service. So, when locating commercial passenger service, the need of air cargo should be considered as associated.

Sea-Tac will face a deficit of on-airport cargo buildings starting in 2022 that will reach 75,000 square feet by 2026 if no capacity improvements are made. The Port of Seattle's 2018 Air Cargo Growth Potential and Facility Requirements Assessment determined that the Cargo 4 South and L-Shape warehouse development projects proposed in the SAMP Near-Term Projects can accommodate growth in on-airport cargo demand through 2027. Another 400,000 square feet of on-airport cargo buildings are contemplated in the SASA; however, they are not included in the Near-Term Projects and hence would require further study after 2027. A major issue facing Sea-Tac is that potential future development of air cargo facilities in SASA would be expensive to develop and cargo facilities contemplated in the SAMP Near-Term Projects proposed for development on the existing airport footprint must compete for scarce Port of Seattle resources being used for overall airport expansion.

KCIA appears to be slightly congested with a deficit of cargo ramp space based on the estimates of land needed to support the future forecasts compared to the existing available land. Aerial views confirm this assessment, with UPS occupying approximately 11 acres available for its operations. If forecasts are realized, additional land may be required by 2026. Since the primary carrier is UPS, UPS may be able to adjust its operations and support the forecasted growth within the same ramp footprint. Two to three acres appear available from near the UPS ramp, located on the other side of Perimeter Road (currently on the landside). The relatively high RWY 14R/32L IFR minimums limit air cargo activities in poor weather. Indeed, KCIA operates a Category I ILS at both ends of its main runway. Diversions of KCIA cargo traffic to Sea-Tac occur when weather conditions are below these minimums, creating potential capacity impacts to Sea-Tac.

4.2.2 Opportunities

Opportunities for additional air cargo capacity in the central Puget Sound region lies both within the region and with the utilization of other aviation and logistics resources around the state.

According to the Port of Seattle's 2018 Air Cargo Growth Potential and Facility Requirements Assessment Report additional air cargo capacity at Sea-Tac can be accomplished by replacing old and inefficient cargo buildings with newer and more modern facilities, redesigning the North Cargo Area ramp area, and by shifting certain non-cargo handling activities away from the airport ramp area and relocating other non-ramp dependent activity to close by off-airport properties (also designated as "L" shape property" in the SAMP). The facilities requirement assessment report suggests that the redesign of existing facilities and development of nearby off-airport properties can expand the Sea-Tac air cargo facilities from approximately 400,000 square feet in 2018 to almost 650,000 square feet by 2024.

Air cargo capacity at KCIA, particularly ramp space, is limited. However, off-airport facilities are currently being utilized by UPS to leverage limited on-airport cargo terminals. KCIA will examine opportunities for additional cargo aircraft parking as part of its Master Plan update currently underway.

As outlined in the Washington State Joint Transportation Committee report Washington State Air Cargo Movement Study (published December 21, 2018), additional air cargo capacity that can benefit the region may also be achieved by supporting the development of commercial air cargo facilities at Paine Field and the utilization of Grant County Moses Lake International Airport as a cargo reliever airport during the Washington state cherry season. The integrator airlines such as Amazon, DHL, FedEx, and UPS also have the option to shift more of their peak season traffic to Spokane International Airport that is already operating as a Pacific Northwest transshipment center for the integrators today.

Finally, the Washington State Legislature can work to implement the findings of the Washington State Air Cargo Movement Study that recommended developing non-urban airports into centers for regional ground-based logistical operations. Development of airport-related logistics/ distribution centers, airport logistics parks or inland ports helps small and non-hub commercial service airports (such as Skagit Regional Airport, Ellensburg Bowers Filed, Yakima Air Terminal, etc.) to generate non-aviation revenue while building up the facilities and services necessary to attract air cargo services. Logistics facilities and services located strategically within the state could take some of the pressure off the Port of Seattle and Sea-Tac, by accommodating activities that traditionally take place at, or near these facilities today.

In the longer term, additional air cargo capacity for the region can be increased by encouraging and using multi-story logistics facilities, both on and off-airport, that can increase the usable floor space for handling air cargo with a limited ground floor footprint. A good example of a local multi-story off-airport logistics facility built recently is the Prologis Georgetown Crossroads Warehouse located 2.4 miles from KCIA. It is a 590,000-square-foot, three-story facility on 13.7 acres of land that typically would require 47 acres for a single-story facility.

On-airport, multi-story cargo facilities are more common in Asia than North America. A good example of an on-airport cargo facility is the Hong Kong Air Cargo Terminal Limited (Hactl) facility at Hong Kong International Airport. It is a two-story express center and seven-story cargo handling facility with a floor area of 4,251,745 square feet and 313 truck docks on 43.1 acres (Figure 4-1).

Figure 4-1. Air Cargo Terminal (Hong Kong)

Incentives to the creation of multi-story logistics facilities may require revised building codes and zoning requirements. Support should also be given to creating a regional cargo community system, defined as a neutral and open electronic platform, that would enable intelligent and secure information exchange between public (Port of Seattle) and private stakeholders (airlines, forwarders, warehouse operators, trucking companies) to improve the competitive position of the central Puget Sound region as a global logistics hub.

The following are typical services of an airport cargo community system:

- Information exchange between the transport operators in the airport and for the hinterland connections, the airport users, customs, airport and other authorities
- Electronic exchange of customs declarations and customs responses, and cargo releases between private parties and customs
- Electronic handling of all information regarding import and export of cargo for the airport community
- Status information and control, tracking and tracing goods through the whole logistics chain
- Processing declarations of dangerous goods with the responsible authorities

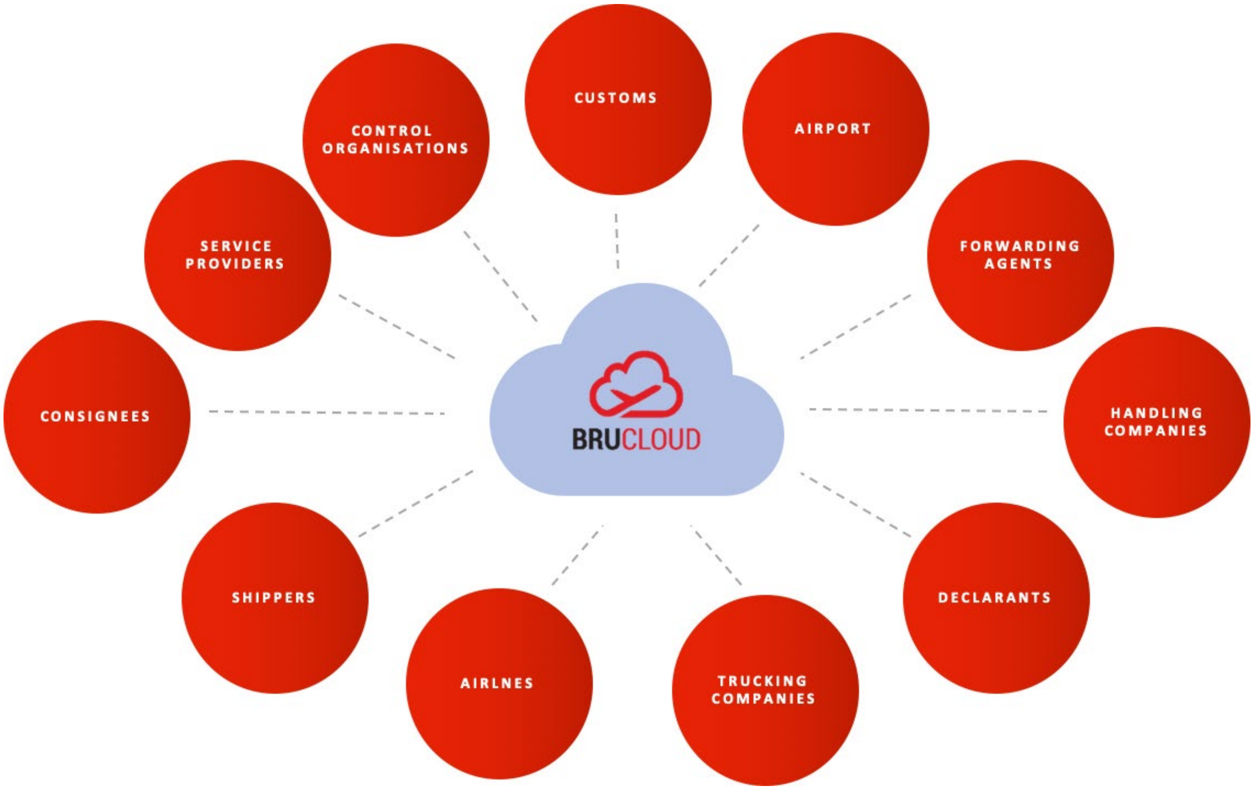
Brussels Airport in Belgium is an example of an airport making use of a cargo community system to manage the flow of trucks to and from their land-locked cargo campus and provide slot booking for trucks accessing the cargo terminals, among other things. Brussels Airport utilizes a system branded as BRUcloud, which is the umbrella name for the open-data-sharing platform with multiple collaborative applications, operational within BRUcargo and based on a third-party data sharing technology (Figure 4-2).

The truck-slot booking app available through BRUcloud provides a central window to book a time slot for freight delivery or pickup. This app allows forwarders to book single or reoccurring time slots with the air cargo terminal operator thereby smoothing the process of pickup and delivery at the air cargo terminal, eliminates waiting times (peaks) and idle times, optimizes personnel planning, and provides transparency to the airport as to scale and scope of truck activity occurring on the airport.

Utilizing multi-story cargo terminals and warehouses, combined with a cargo community system such as BRUcloud, would allow maximum efficiencies for the limited land available within the central Puget Sound region for air cargo and allow the region to grow its logistics industry and other air cargo dependent industries such as aerospace, pharmaceuticals, high value agriculture, etc.

Regarding the need to add runway capacity for the takeoff and landing of freighter aircraft, it should be noted that within the span of 50 years the state of technology will most likely have advanced to the point where the use of pilotless aircraft will be in common use. Fully autonomous aircraft will allow for significant efficiencies in the airspace system with smaller in-space aircraft separation requirements and all-weather landing capabilities, thereby increasing the region's runway capacity.

Figure 4-2. Brussels Airport BRUcloud



4.2.3 Multimodal Access

KCIA handles major deliveries to Boeing facilities located on the airport. The operation of this facility has set up the airport with good access for cargo, because many of the nearby roads can accommodate large vehicles used in delivery. At Sea-Tac, multimodal access related to cargo could be expanded by adding the proposed South Access Highway. The project is in planning stages and is estimated for completion by 2030, per Washington State Department of Transportation.

Other opportunities include working with local municipalities and transportation agencies to identify problem areas related to cargo transport as well as using intelligent transportation system capabilities to streamline freight operations on local roadways around these airports. Technology offers a cost-effective method for increasing efficiency and operations without intrusive infrastructure improvements.

4.3 GENERAL AVIATION

4.3.1 Challenges

The preceding sections have identified areas where it is anticipated general aviation airports will face future challenges. This includes airports where landings and takeoffs are expected to grow to a point where demand for airfield capacity is stressed, resulting in growing delays unless airfield capacity enhancements are undertaken. Another challenge general aviation airports face is lack of aircraft parking and hangar storage space at airports where there is greater demand for hangar space than is currently available. Growing numbers of based aircraft at these airports will only exacerbate the situation.

Based on future activity (where data were available), four of the regional airports (Arlington Municipal, Bremerton National, Renton Municipal, and Harvey Field) should be planning to enhance their airfield capacity.

The other area that general aviation airports are already facing challenges is hangar capacity. Based aircraft owners frequently want to store their aircraft inside hangars to keep them secure and protect them from the elements. However, not all airports have sufficient land space to make hangar space available to all that want it. Nearly all of the regional airports are facing hangar shortages, as evidenced by the abundance of aircraft hangar waiting lists at these airports. The other categories of airports also face this issue to some degree. Three out of five of the community airports have hangar waiting lists, and a third of the local airports do as well. The only airports that did not report hangar waiting lists were the general use airports.

Urban Air Mobility is a potential challenge for the air system, for which general aviation airports will be most affected. Urban Air Mobility encompasses the operation of small unmanned aircraft systems for delivery and new electrical “air taxis” in dense, urban environment. In the United States, both are still in a research and development stage. Based on current research and draft regulations, Urban Air Mobility “air taxis” that may start to operate in the 2025-2030 timeframe will most likely follow the same regulations and concepts of operations than helicopters, with potential slight changes to take into consideration their specificities.

4.3.2 Opportunities

Despite the above noted challenges, a number of opportunities exist at the general aviation airports, especially in terms of providing reliever capacity for the commercial service airports in the region. The airports with the greatest potential for this are the regional airports:

- Arlington Municipal operates at about half its capacity. Forecasted activity is expected to push its ASV demand capacity ratio up to 0.73 by 2050, but this presents an opportunity to plan for ways to accommodate excess cargo or passenger flights from Sea-Tac. Disadvantages of Arlington Municipal include its relatively short runway (5,332 feet), lack of an air traffic control tower, and its B-II ARC. It is likely that the airport would need to shift to a C-II or higher ARC to provide adequate service for larger jet aircraft. Arlington Municipal has relatively good roadway and interstate access, which could be brought up to benchmarks. Frequent local transit access could also be added without a lot of effort via the Smokey Point Transit Center, either through a shuttle or rerouting of existing lines.

- Bremerton National has a significant amount of airfield capacity available, operating at less than a quarter of its ASV. Its 6,000-foot-long runway is long enough to handle some large-size jets. Like most of the regional airports, its ARC is B-II, and would likely need to upgrade to C-II or better to offer adequate service to large jets. Bremerton National also lacks an air traffic control tower. Landside access is limited to two-lane highways and upgrades to area roadways may be needed. However, nearby access to interstates is not feasible. It is unlikely four-lane access and frequent transit service could be developed.
- Harvey Field operates at approximately half its capacity, indicating that it has capacity to spare. However, its short runways, both of which are less than 3,000 feet, coupled with the fact that it is a privately owned airport with no air traffic control tower, make it an unlikely candidate for handling future large jet traffic. In addition, while access to four-lane SR 9 may be possible, nearby access to interstates is not feasible. Nearby local transit might be able to be extended to the airport.
- Pierce County is limited in its ability to handle jet aircraft by its short runway (less than 3,700 feet long), and lack of an air traffic control tower. Ground access including four-lane arterials, frequent transit service, and nearby interstate access is unlikely.
- Renton Municipal operates at just under 50 percent capacity and makes its excess capacity available to air cargo or passenger airlines. Its short runway (less than 5,400 feet) may limit the operational capability of large jets, and its B-II ARC would likely need to upgrade to C-II, which could be costly. However, the airport has good surrounding four-lane arterial roadway networks and nearby interstate access. Current high-capacity BRT service is very close by and the future I-405 BRT could provide additional access through nearby connections. Renton has been utilized by Boeing for aircraft assembly and this role in the aerospace industry should be considered when looking at future uses.
- Tacoma Narrows would appear to have adequate capacity to handle overflow air cargo and passenger airline operations, even though it has fewer annual operations than Bremerton National. As a C-II ARC airport, it is capable of handling jet aircraft, although its 5,002-foot runway will limit the operational flexibility of many jets. Additionally, noise sensitive neighborhoods could also limit its ability to serve large jets. The access roadways could be improved to reach nearby limited access SR 16 with its connections to the south through Tacoma to I-5. Local bus transit service could be continued south to access the airport.

While there are opportunities for commercial use at some GA airports, those uses, including the use of ramp space and not limited to operations (takeoffs and landings), typically constrains the growth of general aviation when airports are land-constrained. Commercial use of facilities at both Renton Municipal Airport and Paine Field are projected to increase; this use includes airfield land leases associated with Part 121 manufacturing, and direct use of the airfield and airspace for both Part 121 and Part 135 operations. At Renton, manufacturing of aircraft necessitates that aircraft parking occupy large portions of airport-controlled land adjacent to the airfield, limiting the expansion of general aviation facilities such as hangars or aircraft tie-down spaces. At Paine Field, increases in Part 121 commercial operations will constrain general aviation through intangible means. One intangible impact might be administrative (CFR) and/or legislative (USC) changes resulting in altered Transportation Security Administration policies, procedures, and practices concerning the access and use of airport facilities. Even if those policies are not specifically borne of a general aviation conflict or directly consequential to general aviation operations, the convenience of airport access and access to adjacent airspace are strong considerations for many general aviation pilots.

A decline in general aviation operations at an airport is a precursor to a reduction in available capacity as FBOs, unable to service Part 121 operations even if they service large Part 135 aircraft, face a shrinking market. Even were a significant number of general aviation aircraft to remain at Paine Field, a loss of convenient access and the subsequent reduction in operations would alter airport activity, also impacting funding models and the projections that businesses use to determine the viability of an airport. Both direct and indirect consequences lead to the lack of investment for new GA-related businesses and, in some cases, the failure of existing businesses, the latter being FBOs, in particular.

4.3.3 Multimodal Access

General aviation airports are primarily accessed by roadway, with many of the airports in the region meeting the project benchmark for location within two miles of a state route. Several general aviation airports could expand their services in order to help meet the aviation needs of the region.

However, congestion and available land present challenges for some airports that may see a change in service. Potential improvements to make these airports more accessible for commercial passengers include the addition of high-capacity transit, dedicated space for pickup and dropoff by taxis and TNCs, as well as rental car services or shuttles for travelers.

Current general aviation airports with opportunities for multimodal access upgrades include Auburn Municipal and Renton Municipal, both located near interstates and a mix of land uses. Rapid Ride F is already in service near Renton Municipal and Rapid Ride I is planned to connect the cities of Renton and Auburn in 2023.

5. Assessment of System Requirements

5.1 COMMERCIAL SERVICE

The commercial service passenger demand is estimated to grow from 22 million enplanements in 2017 to between 49 and 56 million enplanements in 2050, as discussed in Chapter 4. Existing space available at Sea-Tac and Paine Field to accommodate the 2050 commercial service demand is limited. While facilities expansion at Sea-Tac to accommodate growing passenger and cargo demand requires significant financial investment and reconfiguration/relocation of existing facilities, Sea-Tac's SAMP identifies a program of improvements referred to as "Near-Term Projects" to accommodate 28 million enplanements by 2027. The SAMP also identifies a Long-Term Vision developed to accommodate facility requirements associated with forecast activity of approximately 33 million enplanements; However, due to airside capacity and financial constraints, any improvements outside of the Near-Term Projects would require further evaluation as part of a future airfield/airspace study. Currently, KCIA is under the Sea-Tac flight pattern, resulting in operations at the airports that are not always independent of each other. During busy periods, Sea-Tac is the priority, and KCIA can experience delays NextGen flight procedures can ultimately resolve much of these issues. Also, when the airspace is operating in north flow, a condition that occurs only about 5% of the time KCIA approaches conflict with operations at Sea-Tac departing to the north. Operations from the two airports must be separated by ATC in a manner that generally reduces operations and creates delay.

Paine Field's existing passenger terminal can accommodate 500,000 annual passenger enplanements with space for three aircraft positions. Although there is no plan to expand this facility at this time, the airport is proposing to conduct an airport master plan to address the success of the new airline service that initiated in March 2019.

Table 5-1 compares the high forecast for passenger enplanement to the plans and potential growth for Sea-Tac and Paine Field. The high forecast is used to answer the study's question: "Can all the forecasted passengers be accommodated in the future?" Two capacity scenarios have been prepared based on the airports' vision plans:

- Scenario 1. Sea-Tac can accommodate up to the SAMP Near-Term Project capacity of 28 million enplanements plus Paine Field is limited to its existing terminal building.
- Scenario 2. Sea-Tac can accommodate up to the SAMP Long-Term Vision capacity of 33 million enplanements plus Paine Field is limited to its existing terminal building.

Table 5-1. Commercial Service Passenger Needs through 2050

CENTRAL PUGET SOUND REGION	FORECAST OF PASSENGER ENPLANEMENTS				
	2017	2022	2027	2037	2050
Passenger Enplanements (High Forecast)	22,450,500	25,400,000	31,100,000	38,000,000	55,600,000

Source: Working Paper 1, WSP, KPA, CDM

Note: Low forecast for 2050 is 49,300,0000 enplanements

PAINE FIELD + SEA-TAC	2017	2022	2027	2050
Constrained to Near-Term Project SAMP Scenario[1,2]	23,050,000	25,655,000	28,600,000	28,600,000
Constrained to Long-Range SAMP Vision Scenario[1,3]	22,050,500	25,655,000	28,600,000	33,600,000

Source: SAMP 2016, FAA TAF 2018

CENTRAL PUGET SOUND REGION	2017	2022	2027	2050
Constrained to Near-Term Project SAMP Scenario[1,2]	0	0	-2,500,000	-27,000,000
Constrained to Long-Range Vision SAMP Scenario[1,3]	0	0	-2,500,000	-22,000,000

Note:

(1) Assumes Paine Field only accommodates 600,000 annual enplanements, per supplemental environmental assessment.

(2) Based on Sea-Tac SAMP Near-Term Projects, accommodating up to 28 million annual enplaned passengers.

(3) Based on Sea-Tac SAMP Long-Term Vision, possibly accommodating up to 33 million annual enplaned passengers.

5.2 AIR CARGO

The space available for warehouses (and their landside component) with direct access to the airfield is a scarce resource at both Sea-Tac and KCIA. Considering the redevelopment of cargo facilities planned for Sea-Tac in their Near-Term Projects (SAMP) and the facility requirements for the two airports, the central Puget Sound region system will fall short in supplying enough warehouse space to air cargo beyond 2027, as the Port's LCS study confirms that the SAMP Near-Term Projects satisfy demand for on-airport cargo facilities through 2027. As described previously, while the SASA identified in the SAMP Long-Term Vision would provide substantial additional on-airport cargo capacity, SASA is not included in the SAMP Near-Term Projects, is subject to further study, and would not address the long-term demand for new off-airport cargo and logistics facilities.

Developing off-airport facilities on the Port of Seattle's L-Shape property (SAMP projects C02 & C03 Off-Site Cargo Phases 1 & 2) and the on-airport warehouse redevelopment at Cargo 4 South (SAMP project C01 Cargo 4 South Redevelopment) addresses the near-term needs at Sea-Tac. KCIA has one air cargo operator (UPS) that does not use on-airport warehousing but trucks the freight in and out the airport for sorting at an off-airport distribution center.

Sea-Tac and KCIA combined have enough airside ramp space to accommodate the 2050 demand (aircraft parking and GSE/container storage). Locally, Sea-Tac will compensate for the loss of ramp space available to air freight operations caused by the expansion of the passenger terminal complex to the north by reorganizing the northern part of the existing air cargo area. Table 5-2 presents the air cargo needs for the

PSRC Central Region, and Table 5-3 depicts the planned capacity for Sea-Tac and KCIA. Although two different methodologies were utilized by Sea-Tac consultants for the SAMP and LCS, the Port of Seattle's LCS study confirms that the SAMP Near-Term Projects satisfy demand for on-airport cargo facilities through 2027.

Table 5-2. Air Cargo Requirement Needs through 2050 (Seattle-Tacoma and King County International Airports)

		FACILITY REQUIREMENTS (SQ.FT.)			
	EXISTING	2017	2027	2037	2050
Cargo Apron	4,473,612	1,171,764	1,825,164	2,347,884	3,219,084
Warehouse & Landside[1,2]	577,421	1,269,020	1,692,359	1,873,130	2,561,321

Source: SAMP Executive Summary (2018), LCS (2018), Google Earth
(1) Landside comprises truck parking and maneuvering areas.
(2) Warehouse square feet based on the Port of Seattle's LCS report through 2027; landside square feet based on ACRP~~7~~.

Table 5-3. Air Cargo Planned Capacity Areas through 2037 (Sea-Tac and King County International Airports)

	AREA (SQ. FT.)
Existing (2017) Apron	4,473,612
Existing (2017) Warehouse & Landside	577,421
Near-Term Vision (2027) Capacity for Apron	4,833,612
Near-Term Vision (2027) Capacity for Landside & Warehouse (LCS)	1,739,545
Long-Term Vision (2034) Capacity for Apron	4,184,612
Long-Term Vision (2034) Capacity for Landside & Warehouse	2,024,784

(1) Based on Sea-Tac SAMP, the Near-Term Projects improve the existing North Cargo Area, with two additional off-airport warehouses and then loss of existing cargo apron occurs due to Long-Term Vision passenger facility expansion.
(2) Warehouse SF based on the Port of Seattle's LCS report through 2027, Landside SF based on ACRP.

While Sea-Tac and KCIA can maintain their respective roles of major international gateways for air freight and regional hub for UPS, Chapter 3 of this document identifies potential challenges in addressing the 2050 demand for warehousing. Table 5-4 describes the "gap" between the need and what is planned to accommodate some of the demand. The combination of both airports' cargo aircraft apron areas meet demand while there is a need for warehousing and associated landside facilities in 2037 and 2050. Additional off-airport warehousing and other opportunities to accommodate air cargo, including outside of the region should be considered.

Table 5-4. Air Cargo Facility Gaps through 2050 (Seattle-Tacoma and King County International Airports)

	GAP (SQ.FT.) (1)			
	2017	2027	2037	2050
Existing vs. Required Apron	3,301,848	2,648,448	2,125,728	1,254,528
Existing vs. Required Warehouse & Landside	-691,599	-1,114,938	-1,295,709	-1,983,900
Near-Term Vision (2027) Capacity vs. Required Apron	3,661,848	3,008,448	2,485,728	1,614,528
Near-Term Vision (2027) Capacity vs. Required Landside & Warehouse (LCS)	470,526	47,187	-133,585	-821,776
Long-Term Vision (2034) Capacity vs. Required Apron	—	—	1,836,728	965,528
Long-Term Vision (2034) Capacity vs. Required Landside & Warehouse	—	—	-133,585	-821,776

(1) Gaps compared planned capacity areas of Table 5-3 with the required needs of Table 5-2.

5.3 GENERAL AVIATION

A key study goal related to general aviation in the central Puget Sound region is to identify the aviation requirements of the system and individual airports. This was accomplished by developing performance measures and benchmarks that gauged whether airports were performing as expected in various areas. General aviation services were evaluated for the coverage they provided the population and employment of the region. Individual general aviation airports were assessed for their suitability to provide adequate facilities and capacity in terms of airside, landside, and ground access. Forecasts of future activity were used to determine if any airports were likely to experience capacity constraints.

The airport system performance measures and benchmarks consisted of coverage by business-aircraft-capable airports (i.e., those airports with jet fuel, de-icing, or a precision instrument approach). These system analyses identified shortfalls in population coverage by airports capable of handling business aircraft, and employment coverage of airports with de-icing capabilities, indicating a need for these services at general aviation airports in the region.

The analysis of adequate capacity found a need for more airport airfield capacity in the region. Three airports—Arlington Municipal, Renton Municipal, and Harvey Field—were found to be approaching their airfield capacity limits by 2050. Arlington Municipal would need to implement airfield capacity improvements to accommodate its anticipated growth in aviation activity, while Renton Municipal and Harvey Field would need to commence planning for such improvements to avoid capacity issues before the end of the planning period. Other airports in the region were identified as having excess capacity that could be used to accommodate aviation operations from other airports in the region.

5.4 SUMMARY OF INTERMODAL NEEDS AND OPPORTUNITIES

This chapter will serve as a summary and conclusion regarding the system-wide multimodal access needs and opportunities.

As the central Puget Sound region continues to grow, multimodal access to the different airports in the area will change and be influenced by a multitude of factors. At the time of this analysis, current connections and planned projects were considered to gauge the needs and opportunities related to access.

5.4.1 Commercial Service

At commercial service airports, high-capacity transit modes connect passengers at Sea-Tac and Paine Field with planned high-capacity access planned near KCIA, allowing all three airports to provide affordable and alternative connections to many areas throughout the region. All three airports also have adequate roadway access provided by I-5 and various state routes.

The creation of direct connections to airports from limited access highways is a potential area that can be evaluated in future planning efforts and a second such access is already in planning stages at Sea-Tac. Providing direct access allows for efficient pickup and dropoff or direction to parking lots and structures. Areas for taxi and TNCs may also need to be expanded, with the inclusion of more curb space for these uses as well as staging areas. Overall, the region is well connected and accommodating for commercial service passengers, but growth and mode share should be monitored to ensure that proper connections are being provided for.

5.4.2 Cargo

Of the three airports in the region capable of accommodating wide-body air cargo operations, two operate within the context of major Boeing facilities and the third is the main source of international freighter service and belly cargo through commercial passenger aircraft operations. Paine Field and KCIA, with current Boeing operations, are set up with good access from wide roadways and locations near interstates and state highways that can manage freight vehicles. Paine Field has rail freight access that operates to the Boeing facilities and could be an incentive for attracting cargo logistics companies to the airport. KCIA has rail access on either side of the airport including a spur line to the west and mainline and major yards to the east. Sea-Tac is the third airport with air cargo operations and is the primary center for air cargo in the aviation system. Multimodal access for cargo vehicles is maintained through roadways that offer good connections for freight vehicles to interstates and state highways. Since the airport is experiencing rapid growth on the passenger side, air cargo access is constrained due to congestion on arterial and local roadways. The south airport access road, which is in planning stages, could alleviate potential congestion and offer a new connection for air cargo at Sea-Tac.

5.4.3 Other Airports

Several airports in the region that might have potential for an expanded role were considered for their vehicular access. The results are summarized below:

- **Arlington Municipal Airport: Good** – The airport has nearby access to I-5, which provides ideal connections to the north Puget Sound region. A two-lane road (172nd Street NW / SR 531) used by heavy vehicles, as evidenced by nearby land uses, connects the airport to the interstate. Connection from the two-lane road onto airport property may need to be improved, but existing infrastructure is conducive to cargo vehicle access.

- **Auburn Municipal Airport: Good** – This airport is near two limited access state routes, SR 167 and SR 18, that provide access to the rest of the region. The airport is accessed via a two-lane road that connects to a four-lane arterial (15th Street NW). Once off the four-lane arterial, trucks may have difficulty accessing specific areas of the airport, but most of the road network nearby appears to be able to handle larger trucks owning to the large number of light industrial and distribution warehouses immediately east, west, and north of the airport. Consequently, the existing infrastructure is conducive to cargo vehicle access.
- **Bremerton National: Fair** – The airport's location within the central Puget Sound region is both a positive and a negative for providing access to cargo. The airport is well suited to provide cargo to communities on the west side of the central Puget Sound region but is not in an ideal location to serve the entire region. Bremerton National is accessed from a two-lane state highway that can handle larger vehicles. However, connections to limited access highways (SR 3 and SR 16) are over four miles from the airport. The existing infrastructure is conducive to light cargo vehicle access.
- **Renton Municipal Airport: Good** – The airport has good access to nearby I-405 via a four-lane arterial (Logan Avenue North and North Southport Drive) to the east of the airport. Due to the airport's role in Boeing production, heavy vehicle traffic is already common on the east side of the airport which also includes rail access used by Boeing. The south and west sides of the airport have access to four-lane arterials (Airport Way and Rainier Avenue South). Both east and west sides of the airport have on-property circulator roads (East and West Perimeter Road). Renton Municipal's location and roadway access is conducive to cargo operations, although local congestion might need to be considered.
- **Harvey Field: Poor** – The airport is privately owned and located in a more rural area of the region. A four-lane state route, SR9, and rail line run near airport property, but the airport is accessed by only a two-lane roadway (Airport Way) with tight curves and very narrow shoulders and is far from limited access highways (3.5 miles to US 2 and 9 miles to SR 522). Consequently, roadway access and location is not likely conducive to cargo access and operations.
- **Tacoma Narrows: Fair** – The airport is located on a two-lane local road, about 1.5 miles off an exit of SR 16. There are 90 degree turns on the two-lane roadways, as well as local traffic from residential subdivisions. While the location may be suitable for covering the south central Puget Sound region, the lack of direct access from SR 16 inhibits cargo usage at the airport. The roadway connection from the airport to SR 16 would likely need improvement.

The above summarizes access potential at several area airports. To the extent these airports are considered for larger aviation role, a series of other considerations related to airport infrastructure, available land, market demand and airspace restrictions will need to be applied, depending on the particular use.

Appendix A – Existing Airspace Report

REGIONAL AVIATION BASELINE STUDY

Existing Airspace

September 30, 2019

Prepared for

Puget Sound Regional Council

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Contents

Tables

Figures

Acronyms

AGL .... Above Ground Level
ATC .... Air Traffic Control
DA .... Decision Altitude
DRNP .... Dynamic Required Navigation Performance
FAA .... Federal Aviation Administration
HAT .... Height Above Touchdown
IAP .... Instrument-Approach Procedures
IFR .... Instrument Flight Rules
ILS .... Instrument Landing System
IRU .... Inertial Reference Unit
LNAV .... Lateral Navigation/Vertical Navigation
LP .... Localizer Performance
LPV .... Localizer Performance with Vertical
NAS .... National Airspace System
NDB .... Non-Directional Beacon
NM .... Nautical Mile
PBN .... Performance-Based Navigation
PinS .... Point in Space
PSRC .... Puget Sound Regional Council
RAIM .... Receiver Autonomous Integrity Monitoring
RNAV .... Area Navigation
RNP .... Required Navigation Performance
Sea-Tac .... Seattle-Tacoma International Airport
SID .... Standard Instrument Departure
STAR .... Standard Terminal Arrival Route
SWIM .... System Wide Information Management
TRACON .... Terminal Radar Approach Control Facility
VNAV .... Vertical Navigation
VOR .... Very High Frequency Omnidirectional Range
WAAS .... Wide Area Augmentation System

Appendices

1. Introduction

The central Puget Sound region is a vibrant, growing region served by a large commercial and general aviation user community with a number of active airport facilities. The Puget Sound Regional Council (PSRC), in conjunction with the Federal Aviation Administration (FAA), is conducting a study to analyze the regional aviation issues. This chapter presents baseline information relative to the National Airspace System (NAS), how it is being modernized and an inventory of the existing airspace, navigational aids, and flight procedures within the study area. The report also contains information on current constraints to the NAS with respect to the airports within the study area.

This study also includes specific data for Seattle-Tacoma International Airport (Sea-Tac) due to its influence on operations at the region’s other airports. Because airspace extends beyond the boundary of the study area, a number of airports (including military facilities) that can influence the airspace operations within and beyond the study area are also included.

This analysis includes airports within the study area but also includes airports that “influence” the airspace; therefore, this analysis includes all airports that have an instrument procedure in the general region. Airports were excluded if they didn’t have any flight procedures. Specifically, the airspace analysis includes the following:

- Airports with an instrument procedure
- Airports that are not in the study area but were analyzed because their presence can influence the airspace. (Whidbey Island Naval Air Station (Ault Field) is an example because the airport uses a lot of airspace and influences the overall airspace interactions. But it is not an airport in the study area list.)

2. Background Information on the National Airspace System and Next Generation Air Transportation System

2.1 NEXT GENERATION AIR TRANSPORTATION SYSTEM

The regional airspace includes a combination of conventional technology and new generation modern systems introduced as part of Next Generation Air Transportation System (NextGen). NextGen is a very large and complex set of FAA programs goal of modernizing the NAS by 2025. NextGen includes improvements to technology, infrastructure, policies, procedures, and training. As NextGen procedures are implemented, capacity increases, delay reductions, fuel saving, lowered user costs, reduced noise, and safety enhancements are expected. The flight efficiencies created by NextGen procedures will allow the nation's airports and NAS to accommodate the significant growth that is expected over the next few decades. FAA long-range forecasts predict total annual aircraft operations at airports with air traffic control towers will grow at an average annual compounded growth rate of 0.89% – from 50 million to 70 million between 2012–2040.

NextGen offers many opportunities to airports and airport users, because it can ultimately optimize airspace/airside capacity, reduce delay, and enhance resilience facing adverse conditions. Airport master planning projects are typically looking at a +20-year horizon. Addressing the airspace throughput limitations, especially in poor weather operations, can be difficult. In some cases, these throughput limitations can be addressed with the opportunities of NextGen technology at a much lower cost than solutions that might involve building airport facilities. NextGen can address the following airspace and common infrastructure questions:

- Should a future runway be planned using traditional runway Instrument Right Rules (IFR) separation criteria?
- Should other potential NextGen options or criteria be considered that may be available at a much lower cost?

The airspace information presented in this document includes both conventional and NextGen programs. Since the past PSRC Studies completed in 2015, there has been many enhancements to the procedures at the general aviation airports in the central Puget Sound region. These are included in this baseline information chapter.

Background information with respect to NextGen and airspace navigation is presented in the following paragraphs. The study airports will benefit primarily from Performance-Based Navigation (PBN) and the enabling technology programs—Automated Dependent Surveillance-Broadcast (ADS-B) and Wide Area Augmentation System (WAAS).

The study also identifies issues and constraints at existing airports within the central Puget Sound region. These issues will be addressed using NextGen technology. Therefore, it is important to understand the modern programs that are being implemented today and in the future. The following section summarizes key NextGen technologies/procedures that, when implemented, will satisfy the FAA's NextGen priority capabilities related to the study airports.

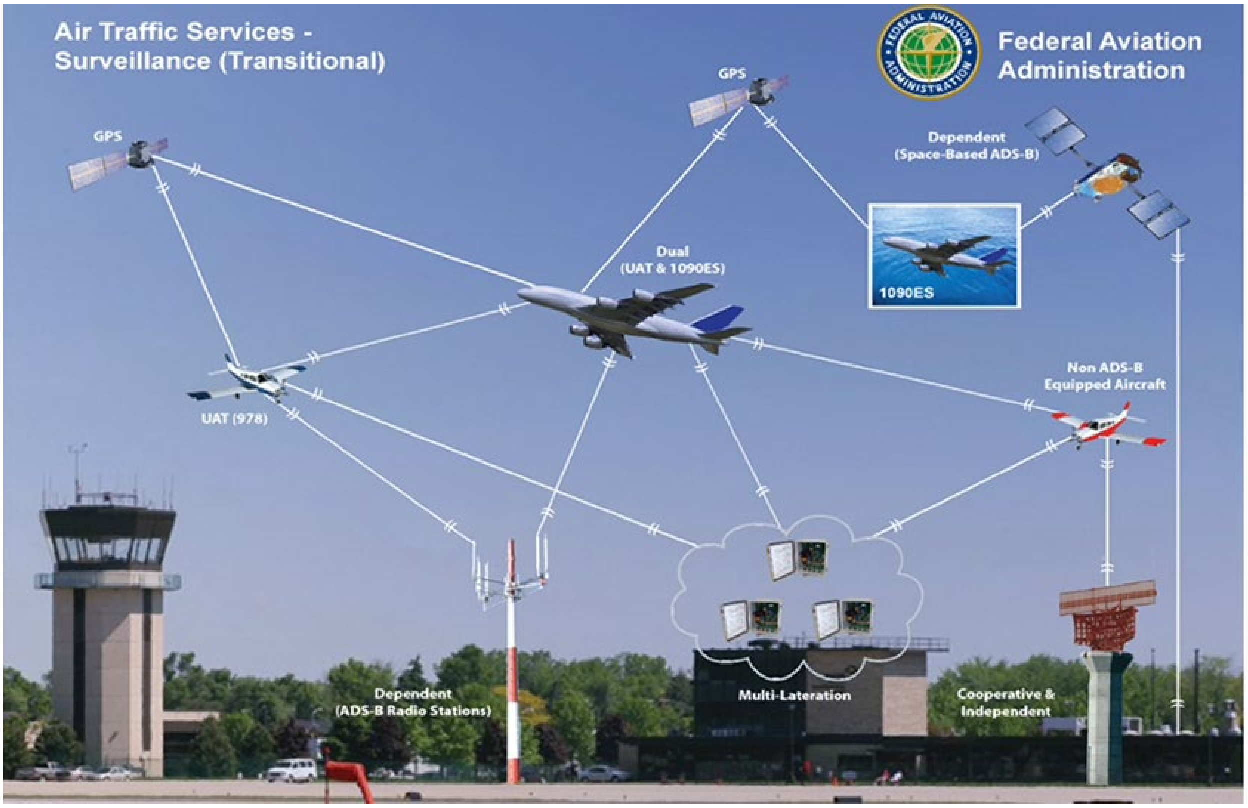
2.2 AUTOMATED DEPENDENT SURVEILLANCE-BROADCAST

ADS-B, an enabling technology program, is a critical surveillance component to implementing NextGen. ADS-B uses global positioning system (GPS) signals instead of radar to determine aircraft location. Aircraft operating in controlled airspace must be equipped with technology ADS-B Out by January 1, 2020. With ADS-B technology, the aircraft broadcasts its position information to ADS-B ground stations and other aircraft. This is called ADS-B Out. Position information includes altitude, airspace, and location. Ground stations are also broadcasting valuable information to the aircraft, such that the aircraft can receive it using ADS-B In technology. Aircraft equipped with ADS-B In receive traffic and weather data in the cockpit. As of July 1, 2019, approximately 91,000 general aviation aircraft are equipped for ADS-B Out, which is approximately 43% of the general aviation fleet in the United States. According to the FAA, in 2018 approximately 212,000 general aviation aircraft were registered in the United States. (Note many of the registered aircraft are rarely flown or do not fly in an airspace that requires aircraft to be equipped.) Generally, within the central Puget Sound region most operating aircraft would be expected to be equipped. Some outlying areas would not require equipage, but most operations at airports in the central Puget Sound region operate in or near controlled airspace. Figure 1 shows how the components of ADS-B communicate with aircraft and air traffic control facilities.

Traffic Information Service – Broadcast (TIS-B), Flight Information Service – Broadcast (FIS-B), and Automatic Dependent Surveillance–Rebroadcast (ADS-R) provide aircraft equipped with ADS-B "In" with situational awareness of other aircraft within a 15 nautical mile (NM) radius (±3,500 feet). The traffic information includes the following:

- Altitude
- Ground track
- Speed and distance of other aircraft
- Airport surface data
- Graphic based weather data
- Text-based weather advisories
- Notices to Airmen (NOTAM)

Figure 1. Automated Dependent Surveillance-Broadcast Architecture



Source: Federal Aviation Administration, 2019

Installing an ADS-B receiver in the cockpit provides a situational display and an audio alert to warn the pilot of approaching traffic. If aircraft are flying intercept courses, the ADS-B In avionics will sound an alert, enabling the pilots to take evasive action to avoid a collision. ADS-B In provides additional benefits specific to general aviation aircraft, including receiving and displaying weather and other aeronautical information to enhance pilots' situational awareness of in-flight hazards and help prevent accidents. Three types of FAA broadcast services provide benefits to pilots of ADS-B In-equipped aircraft:

- **Traffic Information Service–Broadcast (TIS-B)** provides the altitude, ground track, speed, and distance of aircraft flying in radar contact with controllers and within a 15 NM radius, up to 3,500 feet above or below the receiving aircraft's position. A general aviation aircraft equipped with ADS-B In can also receive position data directly from other aircraft broadcasting on the same ADS-B Out frequency. TIS-B also enables pilots to see Non-ADS-B equipped aircraft with transponders flying nearby.
- **Automatic Dependent Surveillance–Rebroadcast (ADS-R)**_takes position information received on the ground from equipped aircraft and rebroadcasts it to commercial aircraft. In concert with TIS-B, ADS-R provides all ADS-B In-equipped aircraft with a comprehensive view of the airspace and airport situation. ADS-R delivers traffic data within a 15 NM radius 5,000 feet above or below relative to the receiving aircraft's position.
- **Flight Information Service– Broadcast (FIS-B)** broadcasts graphical and text-based weather information to the cockpit, providing a weather radar-like display similar to commercial aircraft, without the need

to invest in expensive radar avionics. In addition, FIS-B broadcasts text-based advisories including Notice to Airmen messages and reports on significant weather such as thunderstorm activity. Properly equipped general aviation aircraft can receive this information at altitudes up to 24,000 feet.

The FAA has completed the baseline deployment of more than 600 ADS-B ground stations, making TIS-B, ADS-R, and FIS-B services available across the United States. The FAA is working with the aviation community to set standards for how ADS-B In provides pilots with a low-cost traffic alerting capability. The traffic-alert application uses ADS-B data to identify conflicting traffic nearby, alerting the pilot to look out the window and see the traffic being called out. Figure 2 shows the ADS-B ground station coverage map.

ADS-B Out equipped aircraft will also receive traffic and weather information for display on some mobile devices. Many general aviation pilots routinely use electronic tablets (such as iPads) to view aeronautical charts, so using these devices to depict weather and traffic information is a natural fit. The FAA is also exploring the possibility of setting standards for battery-powered ADS-B Out transmitters that can be used on gliders and general aviation aircraft certificated without an electrical system.

In the central Puget Sound region, the baseline ADS-B infrastructure is complete. TIS-B, ADS-R, and FIS-B are available services to equipped users. Aircraft operating in a controlled airspace (which includes much of the study area) are mandated to be equipped by January 1, 2020.

2.3 WIDE AREA AUGMENTATION SYSTEM PROGRESS

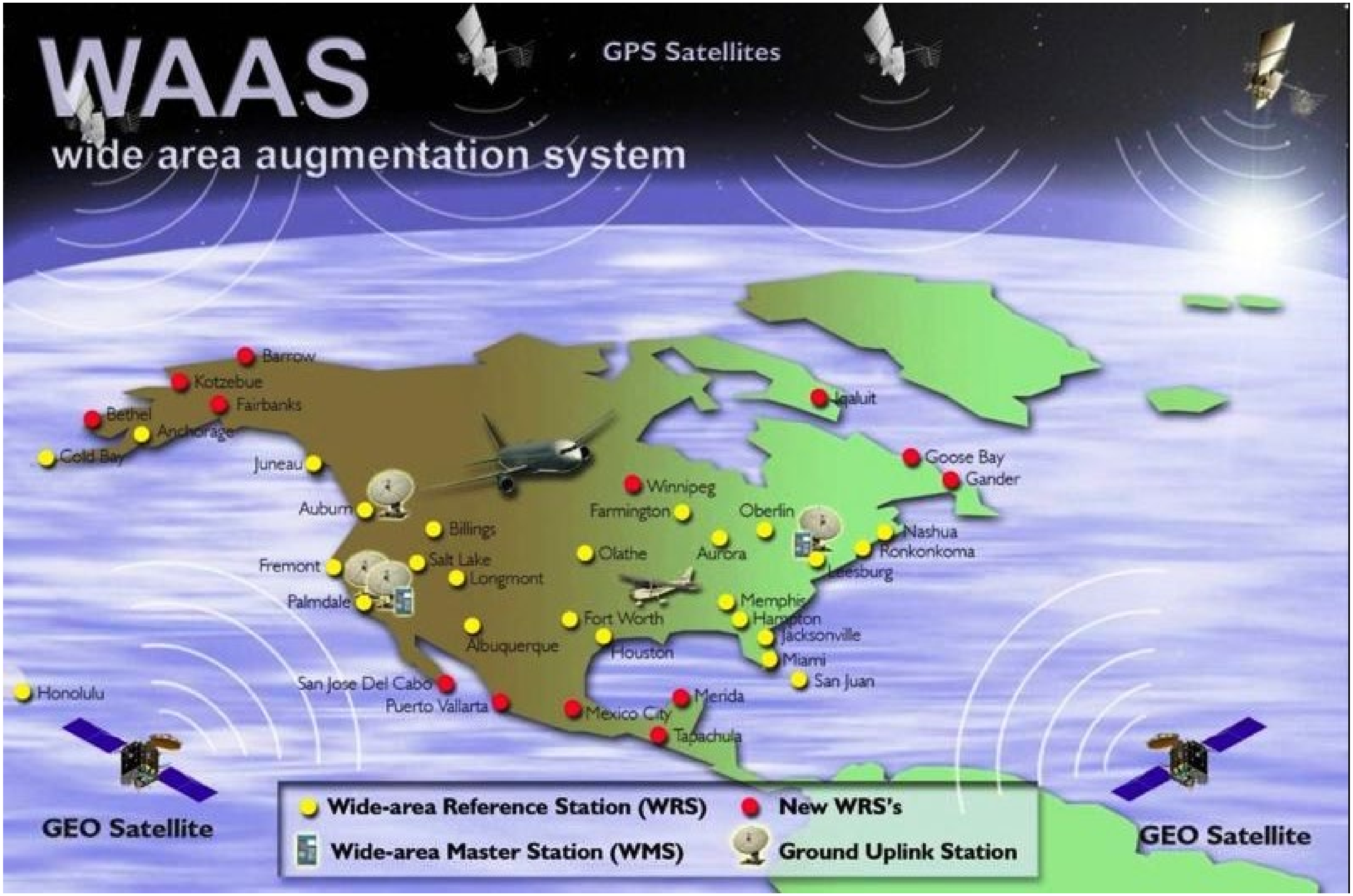
WAAS provides general aviation pilots with Area Navigation (RNAV) capabilities that in many cases rival or exceed what is used by commercial aircraft. This technology is used at most airports within the study area. WAAS enables aircraft to use vertically guided approach procedures to any qualifying airport in most of North America with minimums as low as 200 feet decision altitude (DA), without the need to install costly instrument landing system (ILS) equipment. These minimums can be lower than other conventional based navigation aide approaches. When rising terrain is an issue near an airport, precise vertical guidance enhances safety regardless of visibility and whether the approach is being flown during the day or at night. Figure 3 shows the current satellite and ground stations.

As of January 31, 2019, there are 3,969 WAAS Localizer Performance with Vertical (LPV) guidance approach procedures serving 1,931 airports. Of these airports, 1,164 are non-ILS airports. (Section 4 of this report presents the specific airports with LPV procedures in the study area.) From a pilot’s perspective, LPV approaches operate in a similar manner to traditional ILS approaches with vertical guidance similar to an ILS Cat I approach, which doesn’t require advanced specialized training. This is a technology that can be used at airports without an ILS to improve access. Users say that LPV procedures are more accurate and easier to fly than ILS approaches because the flight paths are generated within the aircraft avionics, rather than from ground-based signals that are plagued by beam bends and interruptions from aircraft taxiing on the airport surface. Nationwide, more than 70,000 general aviation aircraft are equipped with the WAAS receivers needed to fly WAAS-enabled procedures with LPV minima or WAAS-enabled non-precision approach procedures with localizer performance (LP) minima.

Figure 2. Automated Dependent Surveillance-Broadcast Ground Stations Coverage Map (including the location of 600 ground stations)

Source: Federal Aviation Administration, 2019

Figure 3. Wide Area Augmentation System Infrastructure



Source: Federal Aviation Administration, 2019

LPV provides an access benefit especially to general aviation aircraft. RNAV (GPS) approaches with LPV minima to airports that have no ILS now make these destinations accessible when visibility is limited, rather than ruling them out, thus enhancing airport access for many users. An airport must have at least 3,200 feet of paved runway to qualify for an RNAV procedure with either LP or LPV minima. Harvey Field is the only study area airport that does not meet this criterion. As of January 2015, the FAA had published 12 WAAS-enabled approach procedures that feature LPV minima at the study area airports.

As of January 2019, 698 LP approach procedures in the United States serve 522 airports with LP minima that employ WAAS for lateral guidance but without the added safety benefit of vertical guidance. These approaches are needed at runways where obstacles or other infrastructure limitations prevent the FAA from publishing a vertically guided approach. Non-precision LP minima are generally higher than LPV minima, with somewhat reduced airport access in poor weather.

The widespread and growing availability of LPV and LP procedures and the high equipage rate in the general aviation fleet is making it possible for the FAA to retire some ground-based NAVAIDs from service, including non-directional beacon (NDB) and very high frequency omnidirectional range (VOR) equipment. Many general aviation aircraft owners have removed the now obsolete avionics needed to fly an NDB procedure and the FAA continues to shut down NDBs on the ground. LPV procedures can provide lower minima than are available with NDB approaches.

The FAA plans to meet any new requirements for Category 1 approach procedures with WAAS and LPV while maintaining an existing network of ILS to provide alternative approach and landing capability. The agency also intends to transition from defining airways, routes and procedures using VOR, and more to RNAV procedures using GPS and DME/DME/IRU (inertial reference unit) in the NAS. An IRU is an internal navigation system used on large aircraft. The network of distance measuring equipment stations provides an RNAV backup to GPS for suitably equipped commercial aircraft. A minimum operational network of VOR stations will be maintained to provide a conventional navigation capability for aircraft that don’t have DME/DME/IRU avionics.

The current en route air traffic control structure will also migrate away from VOR navigation to RNAV. But instead of merely replacing the existing VOR airways with RNAV routes, the en route system will adopt a new concept called “Structure Where Necessary, and Point-to-Point Navigation Where Structure is not Needed.” This phrase simplifies the overall plan for redesigning the en route system. “Structure where necessary” means that PBN routes will not replace VOR airways one-for-one. Instead, PBN routes will be published where they are actually needed (for example, between Chicago, Boston, New York, Washington, Atlanta, and along the North-South corridor of the west coast.) Many VOR routes are not used and air traffic control (ATC) relies on playbooks, wind routes, and other uncharted traffic flow schemes instead of the published routes to actually make the system work. The existing route system of VOR airways is no longer needed.

“Point-to-Point Where Structure is not needed” means that outside of the busy en route flows, no published routes are needed and aircraft will fly point-to-point direct. The reality is that most aircraft file flight plans based on VOR airways and then after they are airborne ask for a more direct route. The airways are really not used other than for a flight planning exercise and for radio outage procedures, neither of which is a sufficient justification for keeping them. The intent is to provide an en route system that matches both how aircraft actually fly and how ATC manages the flow.

As the NAS is modernized, communications, navigation, surveillance, and automation systems will enable traffic outside congested areas to proceed to their destination using the most direct great-circle routes without the need for dedicated airways. RNAV Q/T Routes will be established where structure is needed for en route traffic. Routes will also be necessary to ensure the smooth flow of traffic around restricted airspace and busy terminal metroplex areas. Overall, the expectation is that most VOR airways will be removed and a smaller number of Q/T Routes will replace them. As described in Section 4, Q/T routes have been implemented for the north/south corridor and for aircraft departing to northeast destinations.

2.4 PERFORMANCE-BASED NAVIGATION

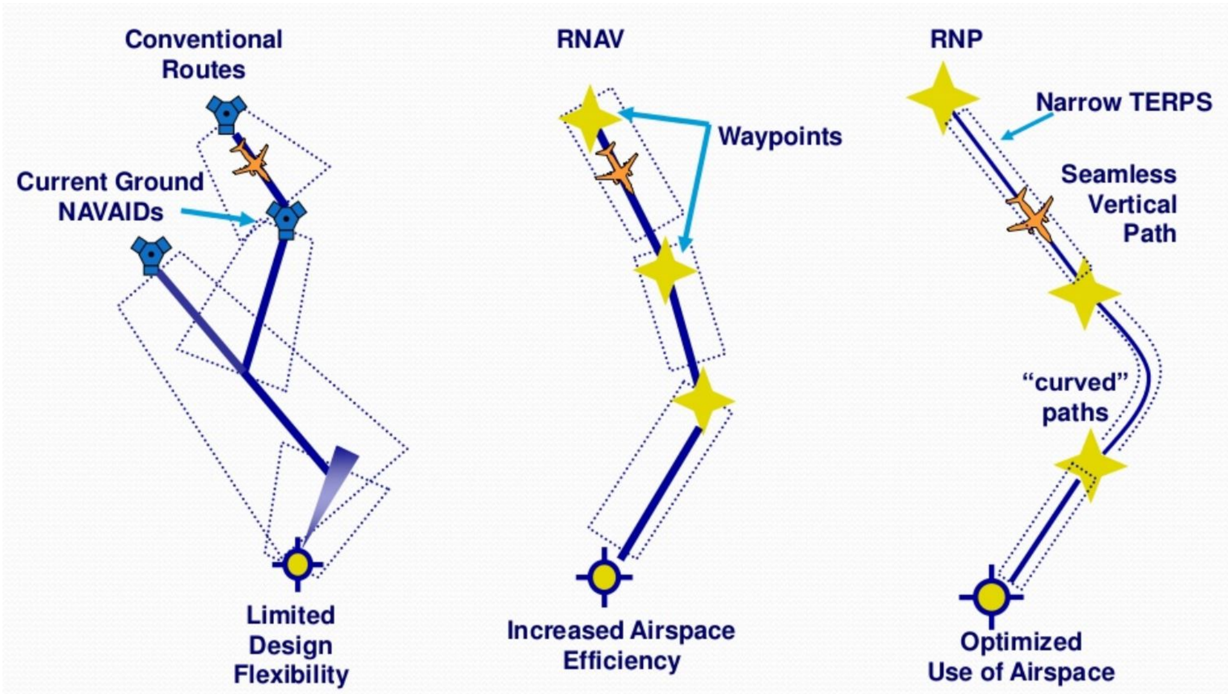
One of the opportunities NextGen offers is PBN, which allows more efficient use of airspace through point-to-point navigation. Rather than restricting flight paths between ground-based radio navigation systems. PBN procedures consist of RNAV and required navigation performance (RNP). The FAA's strategy for implementing PBN is to provide "RNAV Everywhere and RNP Where Beneficial." All RNAV and RNP approach procedures rely on satellite-based navigation, breaking free of the dependency on ground-based navigation aids. PBN enables procedure designers to maximize the efficient use of the airspace, altering the traditional flight paths around an airport.

The FAA is in the process of modernizing the study area airspace with PBN procedures. These procedures are being implemented for both Sea-Tac and the surrounding airports. The process occurs through multiple projects that will take a number of years to implement. Section 4 of this report presents the current procedures, highlighting those that use conventional navigation as well as the new NextGen PBN navigation. All new procedures that will be developed to enhance and improve the NAS in the study area will be based upon PBN technology as the old technology is phased out.

One of the primary benefits of PBN procedures is the ability to operate aircraft with the procedure and not require direct controller intervention. One of the constraints of the study area airspace is the close proximity of many of the airports. For example, Sea-Tac, King County International Airport (KCIA) and Renton Municipal airports all operate in close proximity. PBN procedures will provide controllers greater flexibility to manage and separate aircraft, thereby reducing or eliminating many of the current constraints that exist within the NAS.

Figure 4 shows the change between ground-based NAVAIDs and RNAV/RNP procedures, and highlights the difference between current point-to-point navigation and new, more flexible, PBN navigation, which offers increased efficiency.

Figure 4. Performance-Based Navigation



Source: Federal Aviation Administration, 2019

One of the differences of the new technology is the narrowing of the flight path. These paths are more concentrated then those procedures based upon conventional technology. This has been a challenge to implement the procedures in that there has been community opposition to the more concentrated flight path. Additionally, PBN procedures are no longer constrained by the need for ground-based navigational aids, allowing aircraft to fly potentially new paths that are currently not flown. This has also been met with community opposition. Given the long history of environmental sensitivity in the central Puget Sound region, implementing these new PBN procedures could face community resistance, thereby slowing or stopping the implementation process.

2.5 DATA COMMUNICATIONS

Over the long term, pilot/controller communications will transition from voice-to-data communications, contributing significantly to increased efficiency, throughput, and safety of the NAS. The data/communications (data/comm) program will gradually implement new technology to transition from the current analog voice system to an International Civil Aviation Organization compliant system in which digital communication becomes an alternate and eventually predominant mode of communication. Data/comm is an essential enabler to shift ATC from a workload-intensive tactical control to automation-assisted strategic traffic management. To achieve this goal, more efficient data communications between aircraft and air traffic management must be implemented. The data/comm program is a key element in implementing NextGen.

In addition, the FAA is developing concepts for dynamic RNP (DRNP), a capability that enables real-time management of traffic flow and throughput when the airspace is constrained as a result of weather, high traffic density, or the presence of special activity airspace or a combination of these. The premise is that more solutions to the problem can be made available through generating DRNP routes that can be uplinked to affected aircraft. This is accomplished by moving traffic streams closer together and by making minimal route adjustments to circumvent the constraint. Ultimately, DRNP will save fuel for operators by generating RNP routes that have minimal impact on the original flight plan trajectory.

Over the long term the FAA will implement DRNP in domestic airspace. To capture the benefits, aircraft must equip with Future Air Navigation System 1A equipment. The cost of this equipment will likely be prohibitive for all but the high-end general aviation aircraft. However, general aviation aircraft operating in the vicinity of high density airports may benefit from fewer disruptions as large aircraft fly more predictable paths using the available airspace more efficiently.

3. Airspace Study Area Airports

The airspace study area airports were derived from the project study area airports that have been identified for analysis along with nearby airports that have operations that may influence the airspace in the region. Generally, the airspace range of influence extends beyond the overall project study area. The airspace study area includes airports within or near the Seattle Terminal Radar Approach Control Facility (TRACON), which is an area around major airports where air traffic controllers use radar and radios to guide aircraft approaching and departing airports. These are generally within a 30- to 50-mile radius of the primary airport. Civil and military airports that are near the boundary of the TRACON where their operations could have an influence on the regional airspace are also included. Table 1 presents the study area airports along with airports that may influence the airspace in the region. The table also presents additional information about the airport, including the type of runway, the category, ownership, if there is an air traffic control tower, and if there are any publish instrument flight procedures.

Airports that will be evaluated within the airspace study are those airports that have at least one published departure, arrival or instrument approach procedure. These 18 airports are highlighted in orange in Table 1 and are also summarized in Table 2. This table also includes a description of whether this airport is civil or military, if there is an ATC tower, the number of published flight procedures, and the corresponding appendix of this document where additional information on that airport is presented. Figure 5 shows these airports along with Seattle TRACON boundary. The Seattle TRACON is known as S46 and is generally centered around Sea-Tac, extending just north of Paine Field and just south of McChord Field.

Appendix A contains a number of figures that present the study area airports over various different base maps. This includes street maps, terrain and aviation charts. Each of these figures are described below and presented within Appendix A. Each airport is also labeled on the figures.

- Figure A-1 Airports in Airspace Study Area (Street Background)
- Figure A-2 Airports in Airspace Study Area (Satellite Background)
- Figure A-3 Airports in Airspace Study Area (Terrain Background)
- Figure A-4 Airports in Airspace Study Area (Land Area Background)
- Figure A-5 Airports in Airspace Study Area (Section Aviation Chart Background)
- Figure A-6 Airports in Airspace Study Area (Low-Altitude Aviation Chart Background)
- Figure A-7 Airports in Airspace Study Area (High Altitude Aviation Chart Background)

Table 1. Airports in Study Area or Influence Area for Airspace Analysis

AIRPORT STUDY NUMBER	AIRPORT CODE	AIRPORT NAME	CITY	COUNTY	DESIGNATION	CATEGORY	OWNERSHIP	TOTAL RUNWAYS	MAIN RUNWAY SURFACE	MAIN RUNWAY LENGTH (FT)	ATC TOWER	INSTRUMENT PROCEDURES
1	SEA	Seattle-Tacoma International (Sea-Tac)	Seattle	King	NPIAS	Commercial service - primary	Public	3	Concrete	11900	Yes	Yes
2	BFI	King County International/Boeing Field	Seattle	King	NPIAS	Commercial service - primary	Public	2	Asphalt	10007	Yes	Yes
3	PAE	Snohomish County International (Paine Field)	Everett	Snohomish	NPIAS	New Commercial service 2019	Public	3	Asphalt	9010	Yes	Yes
4	RNT	Renton Municipal	Renton	King	NPIAS	Reliever	Public	1	Asphalt	5382	Yes	Yes
5	S50	Auburn Municipal	Auburn	King	NPIAS	Reliever	Public	1	Asphalt	3400	No	Yes
6	S43	Harvey Field	Snohomish	Snohomish	NPIAS	Reliever	Private	2	Asphalt	2672	No	Yes
7	S60	Kenmore Air Harbor Sea Plane Base (SPB)	Kenmore	King	NPIAS	General Aviation	Private	2	Water	10000	No	No
8	2S1	Vashon Municipal	Vashon	King	NPIAS	General Aviation	Public	1	Land	2001	No	No
9	PWT	Bremerton National	Bremerton	Kitsap	NPIAS	General Aviation	Public	1	Asphalt	6000	No	Yes
10	PLU	Pierce County	Puyallup	Pierce	NPIAS	General Aviation	Public	1	Asphalt	3650	No	Yes
11	TIW	Tacoma Narrows	Tacoma	Pierce	NPIAS	General Aviation	Public	1	Asphalt	5002	Yes	Yes
12	AWO	Arlington Municipal	Arlington	Snohomish	NPIAS	General Aviation	Public	2	Asphalt	5332	No	Yes
13	4W0	Bandera State	Bandera	King	Non-NPIAS	General Aviation	Public	1	Turf	2344	No	No
14	15S	Lester State	Lester	King	Non-NPIAS	General Aviation	Public	1	Turf	200	No	No
15	S88	Skykomish State	Skykomish	King	Non-NPIAS	General Aviation	Public	1	Turf	2050	No	No
16	S36	Norman Grier Field	Kent	King	Non-NPIAS	General Aviation	Private	1	Asphalt	3288	No	No
17	W55	Kenmore Air Harbor SPB	Seattle	King	Non-NPIAS	General Aviation	Private	1	Water	5000	No	No
18	0W0	Seattle Seaplanes SPB	Seattle	King	Non-NPIAS	General Aviation	Private	1	Water	9500	No	No
19	W36	Will Rogers—Wiley Post Memorial SPB	Renton	King	Non-NPIAS	General Aviation	Public	1	Water	5000	No	No
20	8W5	Apex Airpark	Silverdale	Kitsap	Non-NPIAS	General Aviation	Private	1	Asphalt	2500	No	No
21	83Q	Port of Poulsbo SPB	Poulsbo	Kitsap	Non-NPIAS	General Aviation	Public	1	Water	12000	No	No
22	21W	Ranger Creek State	Greenwater	Pierce	Non-NPIAS	General Aviation	Public	1	Asphalt	2875	No	No
23	2W3	Swanson Field	Eatonville	Pierce	Non-NPIAS	General Aviation	Public	1	Asphalt	2990	No	No
24	3B8	Shady Acres Airport	Spanaway	Pierce	Non-NPIAS	General Aviation	Private	1	Asphalt	1800	No	No
25	W37	American Lake SPB	Tacoma	Pierce	Non-NPIAS	General Aviation	Public	1	Water	550	No	No
26	1S2	Darrington Municipal	Darrington	Snohomish	Non-NPIAS	General Aviation	Public	1	Asphalt	2491	No	No
27	W16	First Air Field	Monroe	Snohomish	Non-NPIAS	General Aviation	Private	1	Asphalt	2087	No	No
28	TCM	McChord Field	Tacoma	Pierce	Non-NPIAS	Military	Air Force	2	Asphalt	10108	Yes	Yes
28	GRF	Gray Army Airfield	Tacoma	Pierce	Non-NPIAS	Military	Army	1	Asphalt	6125	Yes	Yes
Airports to be considered due to their influence on the Airspace of the Central Puget Sound												
	BLI	Bellingham International	Bellingham	Whatcom	NPIAS	Commercial Service	Public	1	Asphalt	6700	Yes	Yes
	OLM	Olympia Regional	Olympia	Thurston	NPIAS	General Aviation	Public	2	Asphalt	5500	Yes	Yes
	NUW	Whidbey Island Naval Air Station (Ault Field)	Oak Harbor	Island	Non-NPIAS	Military	Navy	2	Concrete	8000	Yes	Yes
	BVS	Skagit Regional	Burlington	Skagit	NPIAS	Regional	Public	2	Asphalt	5478	No	Yes
	OKH	AJ Eisenberg	Oak Harbor	Island	Non-NPIAS	General Aviation	Private	1	Asphalt	3265	No	Yes
	0S9	Jefferson County	Port Townsend	Jefferson	Non-NPIAS	General Aviation	Public	1	Asphalt	3000	No	Yes
	MWH	Grant County International	Moses Lake	Grant	NPIAS	General Aviation	Public	5	Asphalt	13503	Yes	Yes
	GEG	Spokane International	Spokane	Spokane	NPIAS	Commercial Service	Public	2	Asphalt	11002	Yes	Yes

Source: Federal Aviation Administration
Note: Shaded airports have at least one published departure, arrival or instrument approach procedure.

Table 2. Airports in Study Area or Influence Area with at least One Published Flight Procedure

AIRPORT	NAME	TYPE	ATC TOWER	NUMBER OF PROCEDURES			APPENDIX
				STANDARD INSTRUMENT DEPARTURE	STANDARD TERMINAL ARRIVAL	INSTRUMENT APPROACH PROCEDURE	
SEA	Seattle-Tacoma International Airport	Civil	Yes	9	7	30	B
BFI	Boeing Field/King County International Airport	Civil	Yes	4	5	5	C
RNT	Renton Municipal Airport	Civil	Yes	2	4	2	D
PAE	Snohomish County Airport (Paine Field)	Civil	Yes	1	3	7	E
BLI	Bellingham International Airport	Civil	Yes	1	1	6	F
TIW	Tacoma Narrows Airport	Civil	Yes	1	0	3	G
OLM	Olympia Regional Airport	Civil	Yes	1	0	5	H
AWO	Arlington Municipal Airport	Civil	No	1	0	3	I
S50	Auburn Municipal Airport	Civil	No	1	0	1	J
TCM	McChord Field Airport (Joint Base Lewis-McChord)	Military	Yes	4	6	7	K
GRF	Gray Army Airfield (Joint Base Lewis-McChord)	Military	Yes	1	0	6	L
NUW	Whidbey Island Naval Air Station (Ault Field)	Military	Yes	2	0	13	M
BVS	Skagit Regional Airport	Civil	No	0	0	3	N
OKH	AJ Eisenberg Airport	Civil	No	0	0	1	O
PLU	Pierce County Airport - Thun Field	Civil	No	0	0	1	P
PWT	Bremerton National Airport	Civil	No	0	0	3	Q
S43	Harvey Field Airport	Civil	No	0	0	1	R
0S9	Jefferson County Airport	Civil	No	0	0	1	S
			Total Procedures	28	26	98	
			Total Unique Procedures	28	13	98	
					TOTAL:	139	

Source: Federal Aviation Administration and BridgeNet International, 2019

Figure 5. Airports in the Airspace Study Area or Influence Area that have at least one Published Flight Procedures

Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

4. Inventory of Existing Airspace Facilities

Section 4 provides an inventory of navigation and aeronautical information for the study area and the airports within the study area. Information includes navigation infrastructure, airspace information, and flight procedures. This also includes data for Sea-Tac due to its influence on operations at the remaining airports.

The FAA has jurisdiction over the study area and United States airspace. This authority was granted by Congress via the Federal Aviation Act of 1958. The FAA established the NAS to protect persons and property on the ground and to establish a safe and efficient airspace environment for civil, commercial, and military aviation. The NAS is defined as the common network of US airspace, including air navigation facilities; airports and landing areas; aeronautical charts; associated rules, regulations, and procedures; technical information; personnel; and material. This section also discusses system components shared jointly between civilian users and the military.

Based upon the existing operational and navigation information, various findings in terms of airspace constraints will be identified.

4.1 GROUND-BASED NAVAIDS AND INFRASTRUCTURE

4.1.1 VHF Omnidirectional Range

Within the TRACON boundary the FAA maintains two VORs located at Sea-Tac and Paine Field. The Olympia VOR, Olympia Regional Airport, is the TRACON 9,000-foot shelf to the south in Olympia. In addition, the Air Force maintains a VOR at McChord Field that is also used for civilian navigation in the NAS. To the north, the FAA maintains two VORs located in Coupeville and in Bellingham. A VOR in Victoria Canada is also used for navigation in the region. The FAA VORs are part of the NAS VOR infrastructure that the FAA is evaluating as to which VORs are to be decommissioned. The McChord VOR is maintained by the Air Force. Generally, the Air Force does not need to maintain the McChord VOR facility for military use – this VOR is now more commonly used by civil aircraft.

The maintenance cost of a VOR is roughly $80,000 per year. Table 3 lists the VORs in the study area. Terminal VOR operates near or on an airport and is used within the terminal airspace; Low VOR operates 1,000–14,000 feet above ground level (AGL) and High VOR operates 14,001–60,000 feet AGL. As described in more detail in Chapter 2 of this report, VORs in a NextGen airspace environment are becoming obsolete and in many cases are no longer needed for navigation. Appendix A, Figure A-8, presents the location of these VORs in a base map along with each study area airport.

Table 3. Very High Frequency Omnidirectional Radio Range in Study Area

VOR	NAME	TYPE*	OWNER	USE
Sea-Tac	Seattle	Vortac	FAA	High
Paine Field	Paine	VOR/DME	FAA	Low
OLM	Olympia	Vortac	FAA	High
TCM	McChord	Vortac	Air Force	Terminal
CVV	Penn Cove	VOR/DME	FAA	Low
HUH	Whatcom	Vortac	FAA	High
YYJ	Victoria	VOR/DME	Nav Canada	Low

Source: BridgeNet International, 2019
*VOR = Very High Frequency Omnidirectional Radio Range (a ground-located navigation aid)
*DME = Distance Measuring Equipment (a ground-located aid providing distance)
* Vortac = military counterpart of the VOR/DME providing VOR/DME signals to civilian users.

4.1.2 Non-Directional Beacon

The FAA maintains two NDBs within the study area. An NDB is a ground-based, low frequency radio transmitter used as an instrument approach for airports. It is an older technology that is being obsoleted in the NAS. No new NDBs will be installed, and current NDBs are being removed from services with a number of them having been de-commissioned in the study area over the past few years.

4.1.3 Weather Information

Weather patterns have a large role in determining the direction aircraft fly. In the central Puget Sound region, the winds flow predominately from the south in winter and from the north in summer. Aircraft generally depart and arrive into the wind; therefore, most winter operations are in a southern flow. In addition to the direction aircraft fly, precipitation, visibility, and cloud cover determine if aircraft operate under Visual Flight Rules or IFR.

For the seven FAA towered general aviation airports in the study area, aircraft use IFR for 32% of the operations. KCIA has the highest share of IFR operations (41%) while Renton Municipal Airport has the lowest (11%). Generally, airports with a higher level of business aviation (such as KCIA) have users who need to fly in all types of weather conditions, while recreational pilots tend to fly more in favorable weather conditions. There are 12 Automated Weather Observation System stations within the study area.

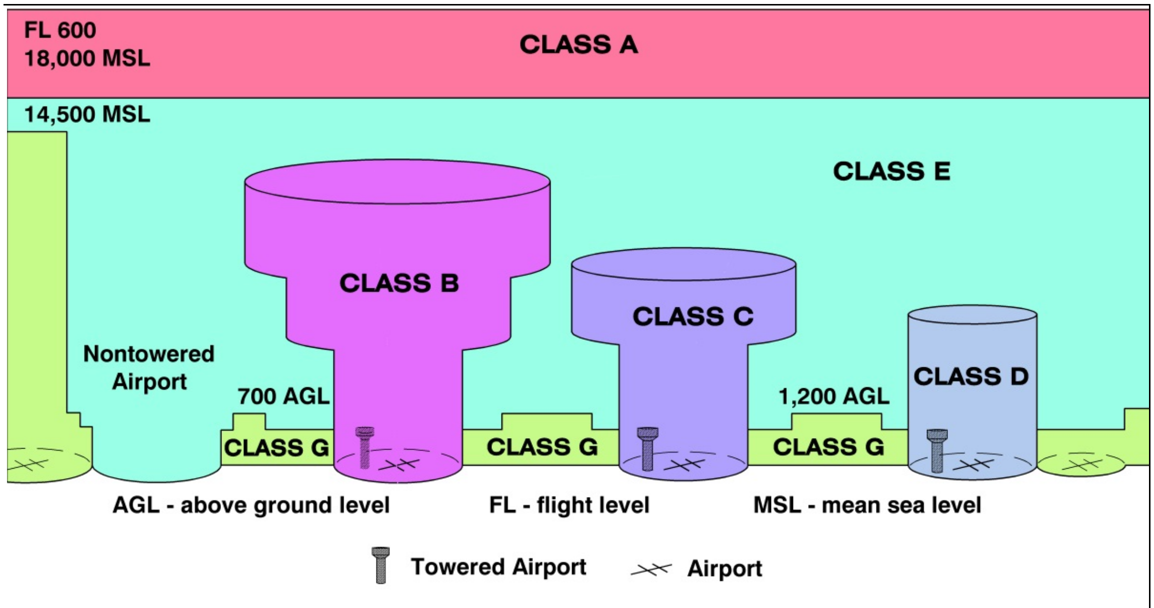
The central Puget Sound region generally has wind patterns from the south in the winter time, where aircraft will depart and land in a south flow heading. In summer, the patterns shift with more operations departing and arriving to the north. Roughly two-thirds of the time aircraft land and depart to the south and one-third to the north. The poor weather tends to occur in the winter time, when airports are operating in south flow. Thus, more instrument flight procedures are implemented in south flow than north flow, in that it is the primary flow when weather conditions are poor.

4.2 AIRSPACES

4.2.1 Airspace Classifications

Federal Aviation Regulations define six categories of airspace, each with distinct operating requirements, which conform in both name and description with airspace designations used internationally. The categories are Class A, B, C, D, E, and G, and each has decreasingly restrictive requirements regarding ATC communications, aircraft entry, aircraft separation, and Visual Flight Rules operations. Figure 6 shows the general shape and requirements of each airspace class. Appendix A, Figure A-9, presents the airspace in the vicinity of the study area. Most of the study area is within the Class B airspace.

Figure 6. Airspace Classifications



AGL = above ground level FL = flight level MSL = mean sea level

Airspace Class	Communication with ATC	Entry Requirements	Separation Services	Special VFR in Surface Area
A	Required for all operations	ATC clearance	All	N/A (No surface area)
B	Required for all operations	ATC clearance	All	Yes
C	Required for all operations	Two-way communications required prior to entry	VFR/IFR	Yes
D	Required for operations	Two-way communications required prior to entry	Runway operations	Yes
E	Required for IFR operations	Required for IFR operations	Required for IFR operations only	Yes
G	Not required	None	None	N/A (No surface area)

4.2.2 Military Operating Areas

Table 4 lists the five military operating areas in the study area (see also Appendix A, Figure A-10). The two largest areas are associated with McChord Air Force Base (now McChord Field, part of Joint Base Lewis-McChord, located near Tacoma) and Port Townsend National Security Area to the north.

Table 4. Military Operating Areas within Study Area

Bremerton National Security Area
Everett National Security Area
McChord Air Force Base/McChord Field
P-51 Bangor
Port Townsend National Security Area

Source: BridgeNet International, 2019

Appendix A, Figure A-11, presents a combined map showing the Class Airspaces, the military operating areas and restricted areas along with each of the airspace study airports.

4.3 EN ROUTE SYSTEM

The FAA has developed an en route structure to guide and separate aircraft as they transition from airport to airport and throughout the country. These are part of the federal airways outlined in FAA Order JO 7400.11. The routes described in this section are used for low altitude, high altitude, and military.

4.3.1 Low Altitude

The original low-altitude en route was called Victor Airways (V-Route). These are essentially straight-line connections between the VOR network. They are for flights below 18,000 feet and primarily used by the general aviation community. The FAA has also developed T Routes, which are RNAV (GPS) based routes that do not rely on the VOR network. Most routes in the study area are still V-Routes.

Appendix A, Figure A-12, presents the low-altitude airways within the study area. Most V-Routes pass through or connect to the Sea-Tac or Olympia Regional Airport VORs. These routes were also presented in the FAA published low-altitude airways map presented in Appendix A, Figure A-6.

4.3.2 High Altitude

The original high altitude en route was called Jet Airways (J-Route). These are also essentially straight-line connections between the VOR network. They are for flights above 18,000 feet and are primarily used by the commercial jets and the general aviation jet community. The FAA has also developed Q-Routes, which are RNAV (GPS) based routes that do not rely on the VOR network. Most routes in the study area are still J-Routes with new Q-Routes being developed for high-capacity routes.

Appendix A, Figure A-13, presents the low-altitude airways within the study area. Most J-Routes pass through or are connect to the Sea-Tac VOR. These routes were also presented in the FAA published low-altitude airways map presented in Appendix A, Figure A-7.

4.3.3 Routes Used by the Military

The FAA provided routes that are used by the military within or near the study area. Aircraft operating to or from the military airports in the region use these routes. This includes McChord, Gray Army Airfield and Whidbey Island. A total of 120 routes are provided. These includes routes that may be part of the civilian network (V and T Routes) or are specific to military operations. They are used to transition the area flying to and from different airports, circular training areas and routes to training areas.

Appendix A, Figure A-14, presents these military operating routes. Most come from McChord or Whidbey Island.

4.4 EXISTING FLIGHT PROCEDURES

There is a total of 139 published flight procedures for the study area airports and Sea-Tac. This includes Standard Terminal Arrival Procedures (STAR), Standard Instrument Departure Procedures (SID), and Instrument-Approach Procedures (IAP). Included in these categories are conventional and NextGen procedures. Because of the shared airspace of the study area airports with Sea-Tac and the shared use of many procedures, Sea-Tac and the study area airport procedures are presented. Appendices B through S present airport-specific graphical displays of each of these procedures.

4.4.1 Standard Instrument Departure Procedures

The top of Table 5 presents the 28 SIDs within the study area for the 12 airports that have published SIDs. Most of these procedures are for Sea-Tac. Four RNAV SIDs are specific to Sea-Tac, two for KCIA and one for McChord Field Airport (Joint Base Lewis-McChord), while the remaining procedures are conventional procedures. Each airport has separate SIDs, where unlike with STARs, there are no shared SIDs among airports. As is typical in the NAS, the lower activity regional/reliever airports do not have SID procedures. Most departures are conventional radar vector procedures where controllers provide guidance to pilots. The NextGen departure procedures are being implemented in the region, however there is no firm date for the implementation.

Appendix A, Figure A-15 and Figure A-16, present graphics for all SIDs for the study area airports for south and north flow, respectively. Appendix B through Appendix M present graphics of each of the SIDs individually for the individual airports.

Table 5. Existing Standard Instrument Departure Procedures and Standard Terminal Arrivals Procedures

Standard Instrument Departures (SIDs)

SID	TYPE	FLOWS	SEA	BFI	RNT	PAE	BLI	TIW	OLM	AWO	S50	TCM	GRF	NUW
			Civil	Civil	Civil	Civil	Civil	Civil	Civil	Civil	Civil	Mil	Mil	Mil
		Appendix:	B	C	D	E	F	G	H	I	J	K	L	M
		Number:	9	4	2	1	1	1	1	1	1	4	1	2
BANGR NINE	RNAV	BOTH	X											
ELMAA THREE	CONV	SOUTH	X											
HAROB SIX	RNAV	BOTH	X											
ISBRG ONE	RNAV	NORTH NIGHT	X											
JEFPO ONE	RNAV	NORTH NIGHT	X											
MOUNTAIN NINE	CONV	BOTH	X											
OZWLD ONE	RNAV	NORTH NIGHT	X											
SEATTLE SEVEN	CONV RV	BOTH	X											
SUMMA ONE	CONV	BOTH	X											
CBAIN ONE	RNAV	NORTH		X										
KENT EIGHT	CONV	SOUTH		X										
NEEDLE ONE	CONV	NORTH		X										
NRVNA ONE	RNAV	SOUTH		X										
BELLEVUE FOUR	CONV RV	NORTH			X									
RENTN THREE	CONV RV	SOUTH			X									
PAINE SIX	CONV RV	BOTH				X								
KIENO SIX	CONV RV	BOTH					X							
NARROWS ONE	CONV RV	BOTH						X						
YELM FIVE	CONV RV	BOTH							X					
ARLINGTON TWO	CONV RV	BOTH								X				
BLANCO ONE	RNAV OBS	BOTH									X			
ALDER TWO	CONV	BOTH										X		
MOCCA THREE	RNAV	BOTH										X		
OLYMPIC FOUR	CONV RV	BOTH										X		
PUGET SIX	CONV RV	BOTH										X		
LEWIS THREE	CONV RV	BOTH											X	
PENN COVE FOUR	CONV	WEST												X
NASWI ONE	CONV RV OBS	ALL												X

Standard Terminal Arrivals (STARs)

STAR	TYPE	FLOWS	SEA	BFI	RNT	PAE	BLI	TIW	OLM	AWO	S50	TCM	GRF	NUW
			Civil	Civil	Civil	Civil	Civil	Civil	Civil	Civil	Civil	Mil	Mil	Mil
		Appendix:	B	C	D	E	F	G	H	I	J	K	L	M
		Number:	7	5	4	3	1	0	0	0	0	6	0	0
CHINS THREE	CONV	North/South	X	X	X	X								
EPHRATA EIGHT	CONV	North/South	X	X	X									
GLASR ONE	CONV	North/South	X		X							X		
HAWKZ SEVEN	RNAV	North/South	X											
JAWBN SIX	CONV	North/South	X	X								X		
MARNR SEVEN	RNAV	North/South	X											
OLYMPIA TWO	CONV	North/South	X	X	X	X								
DEVYN TWO	RNAV	North/South				X								
MADEE FOUR	RANV	North/South					X							
ADYMS TWO	RNAV	North/South										X		
ARRIE SEVEN	CONV	North/South										X		
ELLENSBURG THREE	RNAV	North/South										X		
WHYTE FIVE	CONV	North/South										X		

4.4.2 Standard Terminal Arrivals Procedures

The bottom of Table 5 presents the 13 STARs within the study area, which comprise seven conventional and six RNAV procedures. Two RNAV procedures are for Sea-Tac, while conventional procedures are shared by Sea-Tac, KCIA, Renton Municipal Airport, Paine Field and others. For example, aircraft arriving at Sea-Tac, KCIA, Renton Municipal Airport, or Paine Field from the east will all be assigned the CHINNS STAR. Sea-

Tac has two RNAV STARs that are used as the primary arrival paths from the southwest and northwest. As is typical in the NAS, the lower activity general aviation airports serving primarily recreational users do not have STAR procedures. Both Paine Field and Bellingham International Airport have recently implemented RNAV STAR procedures.

Appendix A, Figure A-17 and Figure A-18, present graphics for all STARs for the study area airports for south and north flow, respectively. Appendix B through Appendix M present graphics of each of the STARs individually for the individual airports.

4.5 INSTRUMENT-APPROACH PROCEDURES

There are many different conventional and NextGen Instrument Approaches at the airports within the study area. As far as conventional landing systems, within the study area there are 11 ILSs, with six at Sea-Tac (one serving each of the airport's runway ends). Of the remaining airports located within the study area, four have ILSs. Two ILSs at KCIA provide instrument approaches to both runway ends, and one each at Paine Field, Tacoma Narrows Airport, and Bremerton National Airport serve south flow arrivals. The military airports also have ILSs south flow is the primary flow during inclement weather. The ILSs at Sea-Tac and Paine Field are CAT II while all other ILSs are CAT I. For informational purposes, the annual maintenance cost for a CAT I ILS is $125,000 while a CAT II/III is $325,000 per year.

Table 6 presents each of the published IAPs for the study area airports and Sea-Tac. The table presents the category and type of procedure available at each airport based upon the navigation technology, including both conventional and NextGen procedures. Table 7 displays the best available Height Above Touchdown (HAT) for each approach procedure for the study airports. This is presented for both north and south flow operations, which can be used to evaluate the accessibility of the airport in poor weather as well as in different flow conditions. Each of the types of NextGen RNAV (GPS) procedures are described below:

- <u>LPV</u> approaches take advantage of the refined accuracy of WAAS lateral and vertical guidance to provide an approach very similar to a Category I ILS. Like an ILS, an LPV has horizontal and vertical guidance and is flown to a DA. The design of an LPV approach incorporates angular guidance with increasing sensitivity as an aircraft gets closer to the runway [or point in space (PinS) type approaches for helicopters]. Sensitivities are nearly identical to those of the ILS at similar distances. This is intentional to aid pilots in transferring their ILS flying skills to LPV approaches. The production schedule for LPV procedures is presented in Figure 7, LPV and LP Production Schedule. This has slowed in recent years; however, in the past 3 years most airports in the study area now have WAAS enable procedures.
- <u>LNAV/VNAV</u> approaches provide both horizontal and approved vertical approach guidance. Vertical Navigation (VNAV) utilizes an internally generated glideslope based on WAAS or baro-VNAV systems. A baro-VNAV system determines barometric altitude and RNAV information. Minimums are published as a DA. If baro-VNAV is used instead of WAAS, the pilot may have approach restrictions as a result of temperature limitations and must check predictive receiver autonomous integrity monitoring (RAIM). RAIM monitors the integrity of the GPS signal.

- **LPs** are non-precision approaches with WAAS lateral guidance. They are added in locations where terrain or obstructions do not allow publication of vertically guided LPV procedures. Lateral sensitivity increases as an aircraft gets closer to the runway (or PinS type approaches for helicopters). Unlike an ILS, LP is not a fail-down system. While flying an ILS, if the glideslope goes out of service, the pilot can continue the approach using just the localizer and switching from descent to a decision height to the higher minimum descent altitudes. LPV does not have the feature to fail down to the LP (localizer equivalent). LP and LPV are independent procedures. LP minimums will not be public with lines of minima that contain approved vertical guidance (LNAV/VNAV or LPV). LP lines of minima are minimum descent altitudes rather than DAs. It is possible to have LP published on the same approach chart; an LP is published if it provides lower minima than the LNAV.
- **LNAV** approaches are non-precision approaches that provide lateral guidance. The pilot must check RAIM prior to the approach when not using WAAS equipment. Both LP and LNAV lines of minima are minimum descent altitudes rather than DAs. It is possible to have LP and LNAV published on the same approach chart. An LP is published if it provides lower minima than the LNAV.

Some legacy GPS approaches use GPS without the benefit of WAAS. They are being updated and replaced over time with one of the above WAAS-enabled procedures.

There are 19 LPV procedures in the study area, of which six are at Sea-Tac. At Bellingham International Airport, Tacoma Narrows Airport, and Bremerton National Airport, the LPVs are in both runway directions, while the remaining have just the one direction or other RNAV (GPS) procedures in the other direction. The LPVs from the north at Paine Field, Bellingham International Airport, Olympia Regional Airport, Arlington Municipal Airport, and Bremerton National Airport have HAT values of 200 feet, while all the other LPVs do not achieve the optimum 200 HAT value.

The IAPs are presented graphically in the appendices. This includes both combined graphics and individual graphics. The combined figures are described below. The individual procedures are presented in Appendices B through S for each airport specifically.

Appendix A, Figure A-19 and Figure A-20, present the ILS approaches for each airport with an ILS in both south flow and north flow, respectively. Including Sea-Tac, 10 airports are with ILSs in south flow and three airports are with ILSs in north flow. This reflects the weather patterns where incremental weather occurs when winds are more often from the south, and thus planes are landing to the south.

Appendix A, Figure A-21 and Figure A-22, present the RNP approaches for each airport with an RNP in south flow and north flow, respectively. Including Sea-Tac, there are three airports with RNPs in south flow and two airports with RNPs in north flow. Currently, these procedures are lightly used with greater use expected in the future.

Appendix A, Figure A-23 and Figure A-24, present the RNAV (GPS) approaches for each airport with a RNAV(GPS) procedure in south flow and north flow, respectively. For these figures the RNAV(GPS) procedures that are referenced are the more advanced procedures that were described earlier. Including Sea-Tac, there are 12 airports with RNAV(GPS) in south flow and 11 airports with RNAV(GPS) in north flow.

Table 6. Existing Instrument-Approach Procedures

Airports in Study Area with at least 1 SID or STAR

IAP Category	TYPE		SEA	BFI	RNT	PAE	BLI	TIW	OLM	AWO	S50	TCM	GRF	NUW
			Civil	Civil	Civil	Civil	Civil	Civil	Civil	Civil	Civil	Mil	Mil	Mil
		Appendix:	B	C	D	E	F	G	H	I	J	K	L	M
TOTAL IAPs			30	5	2	7	6	3	5	3	1	7	6	13
CHARTED VISUALS	Conventional		3	1										
ILS or LOC	Conventional		6	2		2	1	1	1			2	1	1
ILS SA CAT I II III	Conventional		9			1	1					1		
LOC Only	Conventional									1				
RNAV (GPS)	NextGen		6	1	2	3	2	2	2	1		2	2	4
(GPS)-A	NextGen										1			
RNAV (RNP)	NextGen		6	1			2							
VOR A	Conventional					1			2					
NDB	Conventional									1			2	
TACAN (Military)	Conventional											2		8
NDB HELO (Military)	Conventional												1	
ILS in Both Flows	Conventional		Yes	Yes	None	South	South	South	South	None	None	Yes	South	South
RNAV (GPS) in All Flows	NextGen		Yes	South	South	Yes	Yes	Yes	Yes	North	None	Yes	Yes	Yes
RNPs in Both Flows	NextGen		Yes	South	None	None	Yes	None	None	None	None	None	None	None

Other Airports in Study Area

IAP Category	TYPE		BVS	OKH	PLU	PWT	S43	0S9
			Civil	Civil	Civil	Civil	Civil	Civil
		Appendix:	N	O	P	Q	R	S
TOTAL IAPs			3	1	1	3	1	1
CHARTED VISUALS	Conventional							
ILS or LOC	Conventional					1		
ILS SA CAT I II III	Conventional							
LOC Only	Conventional							
RNAV (GPS)	NextGen		2	1	1	2		
(GPS)-A	NextGen						1	1
RNAV (RNP)	NextGen							
VOR A	Conventional							
NDB	Conventional		1					
TACAN (Military)	Conventional							
NDB HELO (Military)	Conventional							
ILS in Both Flows	Conventional		None	None	None	South	None	None
RNAV (GPS) in All Flows	NextGen		Yes	East	North	Yes	None	None
RNPs in Both Flows	NextGen		None	None	None	None	None	None

Source: BridgeNet International, 2019

Table 7. Type of Instrument-Approach Procedures and Best Height Above Touchdown

South Flow

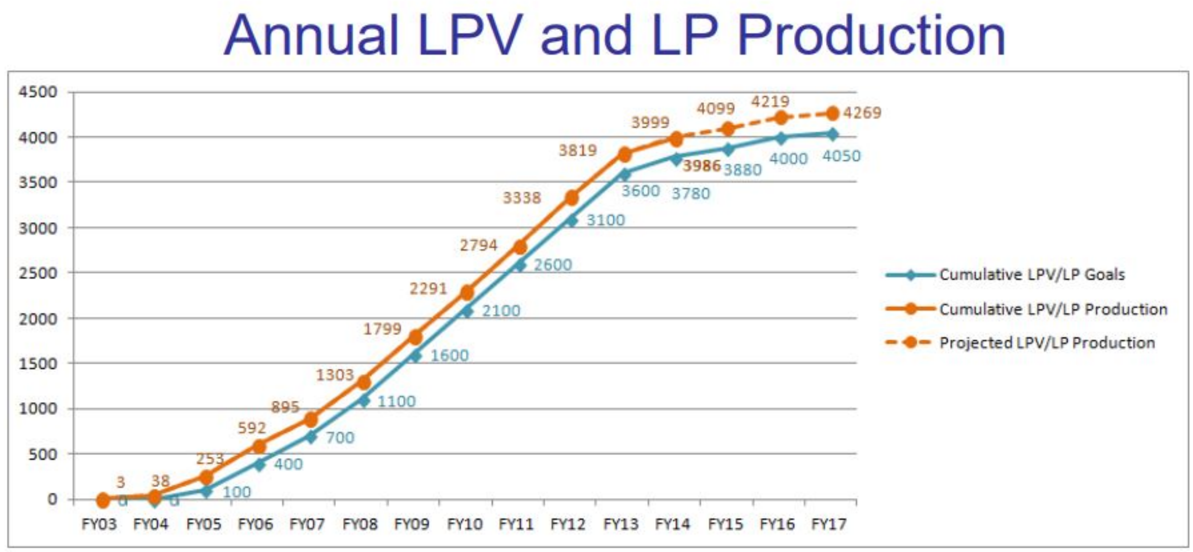
IAP Category	Type	Study Area Civil Airports (Best HAT-Height Above Touchdown -- Feet)														
		SEA	BFI	RNT	PAE	BLI	TIW	OLM	AWO	S50	BVS	OKH	PLU	PWT	S43	0S9
ILS CAT II	Conventional	100			100											
ILS CAT I	Conventional	150	290		200	150	200	200						200		
Localizer	Conventional	370	562		370	337	466	473						758		
VOR/DME	Conventional				492											
VOR	Conventional							672								
NDB	Conventional										1,255					
LPV	NextGen	200		500	200	200	344	200			355			200		
LNAV/VNAV	NextGen	334		642	324	328	698	422			504			954		
LNAV	NextGen	408	662	754	430	397	686	473			475	427		858		
GPS	NextGen									857					1,198	890
RNP AR	NextGen	328	524			285										
Circling	NextGen/Conv	567	738	824	492	450	465	512	663	857	535	427	542	716	1,198	890

North Flow

IAP Category	Type	Study Area Civil Airports (Best HAT-Height Above Touchdown -- Feet)														
		SEA	BFI	RNT	PAE	BLI	TIW	OLM	AWO	S50	BVS	OKH	PLU	PWT	S43	0S9
ILS CAT II	Conventional	100														
ILS CAT I	Conventional	150	407													
Localizer	Conventional	368	679						445							
VOR/DME	Conventional							632								
VOR	Conventional							672								
NDB	Conventional								725							
LPV	NextGen	200				250	266		200		250		339	328		
LNAV/VNAV	NextGen	429				332	474		375		348		452	469		
LNAV	NextGen	468			436	470	546	632	385		453		462	716		
GPS	NextGen									857					1,198	890
RNP AR	NextGen	316				292										
Circling	NextGen/Conv	567	738	824	492	450	465	512	663	857	535	427	542	716	1,198	890

Source: BridgeNet International, 2019

Figure 7. Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Production Schedule



	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
Non-ILS Runway Ends	0	7	83	191	198	266	263	379	420	468	446	158	0	0	0
ILS Runway Ends	3	28	132	148	105	142	233	113	83	76	35	9	0	0	0
LPVs/LPs	3	35	215	339	303	408	496	492	503	544	481	167	0	0	0
Annual LPV/LP Goals	0	0	100	300	300	400	500	500	500	500	500	180	100	120	50
Cumulative LPV/LP Goals	0	0	100	400	700	1100	1600	2100	2600	3100	3600	3780	3880	4000	4050
Cumulative LPV/LP Production	3	38	253	592	895	1303	1799	2291	2794	3338	3819	3986	3986	3986	3986

Source: Tetra Tech

4.6 RADAR AND AUTOMATED DEPENDENT SURVEILLANCE-BROADCAST SURVEILLANCE

The NextGen ADS-B infrastructure has been installed and is operational within the project study area. The infrastructure was completed a number of years ago. This includes four ground stations that provide the ADS-B surveillance coverage. These are located at Sea-Tac (two with one site focused on surface movement), Paine Field, and Bremerton International. The surveillance coverage is generally the same or better than what occurs with the current radar technology.

The current radar in the study area includes one terminal radar near Sea-Tac and one long-range radar near Magnolia, northwest of downtown Seattle. No other long-range radars are within 100 NM of Sea-Tac; six are within 250 NM. The 250 NM distance is generally considered the outer limit of line-of-sight coverage of the long-range radar. Similar to radar coverage, the 250 NM distance is generally considered the outer limit of line-of-sight coverage for ADS-B.

To evaluate current flight tracks and operations, historical radar data was collected. The source of this radar data is the FAA's System Wide Information Management data (SWIM) and third-party ADS-B receivers (not the official FAA ADS-B Surveillance, but ADS-B ground receivers that passively receive the ADS-B signal). The SWIM data included radar from June through August of 2018. The unofficial ADS-B data is recent data for the holiday period around July 4, 2019. This data was collected for the study area airports and Sea-Tac. Radar data for Sea-Tac was also collected because operations and flight tracks associated with Sea-Tac influence the operations at the region's other airports. This data was used as the base period for this study.

An example of SWIM radar data for airport other than Sea-Tac are presented in Appendix A, Figure A-25. An example of the unofficial ADS-B data for ADS-B equipped aircraft is presented in Appendix A, Figure A-26. The data is also presented for individual airports within Appendix B through Appendix S.

5. Potential Airspace Constraints

There are a number of constraints with respect to the current airspace within the central Puget Sound region study area. The FAA is constantly improving and enhancing the airspace to meet the increasing demands and to improve how aircraft are managed. These changes are implemented to take advantage of the improvements that new NextGen technology offers from a safety and efficiency standpoint.

Some issues identified in this chapter can be mitigated or eliminated by implementing new NextGen technology along with potential adjustments to the implementation priorities. Other issues (such as terrain) are fixed and cannot change, while others (such as flight procedures that could change historical noise patterns) are possible but may be very challenging to implement. This chapter presents these identified airspace issues, causes of these issues, and what are the existing constraints. Graphical images that illustrate these constraints are presented in Appendix T of this document.

5.1 POTENTIAL AIRSPACE ISSUES IN THE PUGET SOUND REGION

The airspace constraints within the study area were organized into four general categories: access, deconfliction, data/comm, and weather. These initial categories of airspace issues are defined to identify which airports may be constrained and what are the available solutions. These airspace issues present the initial findings, and as the study evolves will be expanded and evaluated with respect to each of the airports within the study area. Note that Sea-Tac plays a major role in influencing the issues at each of the study area airports. Sea-Tac operations can dictate the flow of aircraft and its operations can constrain where other airport operations can fly. These four categories are described below:

- Access – ability to fly into and out of a facility at the desired time on efficient routes without undue delays or less efficient routing.
- Deconfliction – flight procedures that are unable to operate simultaneously at two or more separate airports, occurring during busy times and in resulting in delays or the inability to operate at the desired time and optimum operational parameters.
- Data/Communication (data/comm) – flight procedures limited by the ability of communications in the area or the ability for ATC to establish radar contact.
- Weather – The central Puget Sound region will often have overcast weather conditions that limit the ability for aircraft to fly except under Instrument Flight Rules. The weather patterns also affect the direction of aircraft flow and the runways that are available for use during these challenging weather conditions.

5.2 CONSTRAINTS THAT CAN CAUSE AIRSPACE ISSUES

The constraints that cause airspace issues within the study area have initially been put into five categories: proximity, high activity, weather, airspace limitations, and flight procedures. The cause(s) of an airspace issue are the lack of specific infrastructure or capabilities to airspace users. These five categories are represented by the following:

- Proximity – location of airports with respect to each other and flight procedures used by the facilities. The proximity to Sea-Tac can constrain the operations at other airports and dictate how that airport operates.
- High Activity – the number of operations at an airport or adjoining airports that can affect the ability to operate efficiently or handle additional traffic.
- Weather – lack of infrastructure and/or procedures to allow operations during periods of inclement weather during each of the runway configuration and aircraft flows that airports operate under.
- Overall Airspace – limitations of available airspace and related area, including terrain. Other airspace factors include military restrictions and the operations at Sea-Tac that occupy much of the airspace in the study area. An additional factor is community noise issues that may limit where and how aircraft can fly, and the ability to change flight patterns.
- Flight Procedures – limitations of existing procedures for aircraft arriving and departing from an airport or adjoining airports. These procedures may not be available in all weather conditions, or not independent from nearby busy airports. Limitation on flight procedures maybe a result of an airfield constraint, such as obstructions that preclude the ability to create an improved/new approach procedure.

5.3 PRELIMINARY IDENTIFIED AIRSPACE CONSTRAINTS

This section describes a preliminary set of identified airspace constraints. The constraints were derived by examining existing conditions information and identifying issues that may constrain airspace growth. The key improvement measures include deconfliction, efficiency, access, and safety. A number of different factors constrain the airspace in the central Puget Sound region. With NextGen technology and programs, many of these constraints can be overcome or partially mitigated. The primary cause of constraints to some airports is the close proximity to Sea-Tac, and these airports must share the airspace. Other factors include the mountainous terrain, weather, obstacles (man-made and natural), and land use (noise impacts) patterns that limit how and where aircraft can fly. Many of the actions described in the following sections are designed to allow aircraft to fly and operate independently of Sea-Tac and to take advantage of the different ways airspace can be designed with NextGen technologies.

The constraints considered in this section are described below:

- **Airports in close proximity to Sea-Tac (de-confliction)**

   - Sea-Tac, Boeing Field, and Renton Municipal are less than 5 NM miles apart and Boeing Field is under the Sea-Tac flight pattern. This results in operations at the airports that are not always independent of each other. During busy periods, Sea-Tac is the priority, and Boeing Field and Renton Municipal can experience delays that they would not from their traffic demands alone. NextGen flight procedures can ultimately resolve much of these issues; however, this includes changes to procedures at all of the airports including Sea-Tac.
   - When the central Puget Sound region airspace is operating in north flow and there is incremental weather, ATC refers to this condition as Plan C. While this condition occurs only about 5% of the time, when it does occur, it puts constraints on access to KCIA because approaches to KCIA conflict with operations at Sea-Tac departing to the north. Operations from the two airports must be separated by ATC in a manner that generally reduces operations and creates delay.
- Constrained and limited airspace
   - While the central Puget Sound region airspace is large, there are many different users of that airspace and constraints as to how aircraft can fly. Each of these constraints is listed below, which potentially affect all airports, within the study area:
      1. The airspace is designed for the efficient use and operation of Sea-Tac Airport. Other airport operations are designed to operate without the operational and efficiency goals of operating Sea-Tac. This can limit the efficiency at other airports in the region.
      2. Cascade Mountains and Mount Rainier to the east can limit where aircraft can fly to the east.
      3. Civil operations must avoid military bases and restricted airspace for the military, which are generally to the west.
      4. Topography and land use patterns also play a role. The water areas have often been a location for aircraft to fly to avoid overflying residences and reduce noise impacts. These can become restricted in that many types of operations at different airports can be competing for the same limited airspace.
      5. The historical noise patterns often dictate where aircraft fly today. This may not be the most efficient way to operate but these routes are difficult to modify or change due to local concerns.
- Access in north flow during poor weather conditions
   - Poor weather usually occurs when wind conditions dictate aircraft land to the south. However, there are times that the weather is poor, and the airspace is in north flow. For commercial operators, it is important to have good and similar access in all operational flows. Improving north flow poor weather operations to airports such as Renton Municipal Airport, Paine Field, KCIA, and Olympia Regional Airport would improve access to these airports during difficult weather conditions in all potential operating flows.
   - When Sea-Tac and the airports of the region are in north flow and the weather is poor, there currently is not a north flow IAP to Renton Municipal Airport. Aircraft must approach from the

north and land to the south or perform a circle-to-land. While this situation occurs only approximately 5% of the time, it does increase the complexity of the airspace operations and access to Renton Municipal Airport when these conditions occur. Note that a new instrument approach to Renton Municipal for approaches to the north is scheduled for end of 2019. Thus, this constraint maybe be resolved when this procedure is implemented.

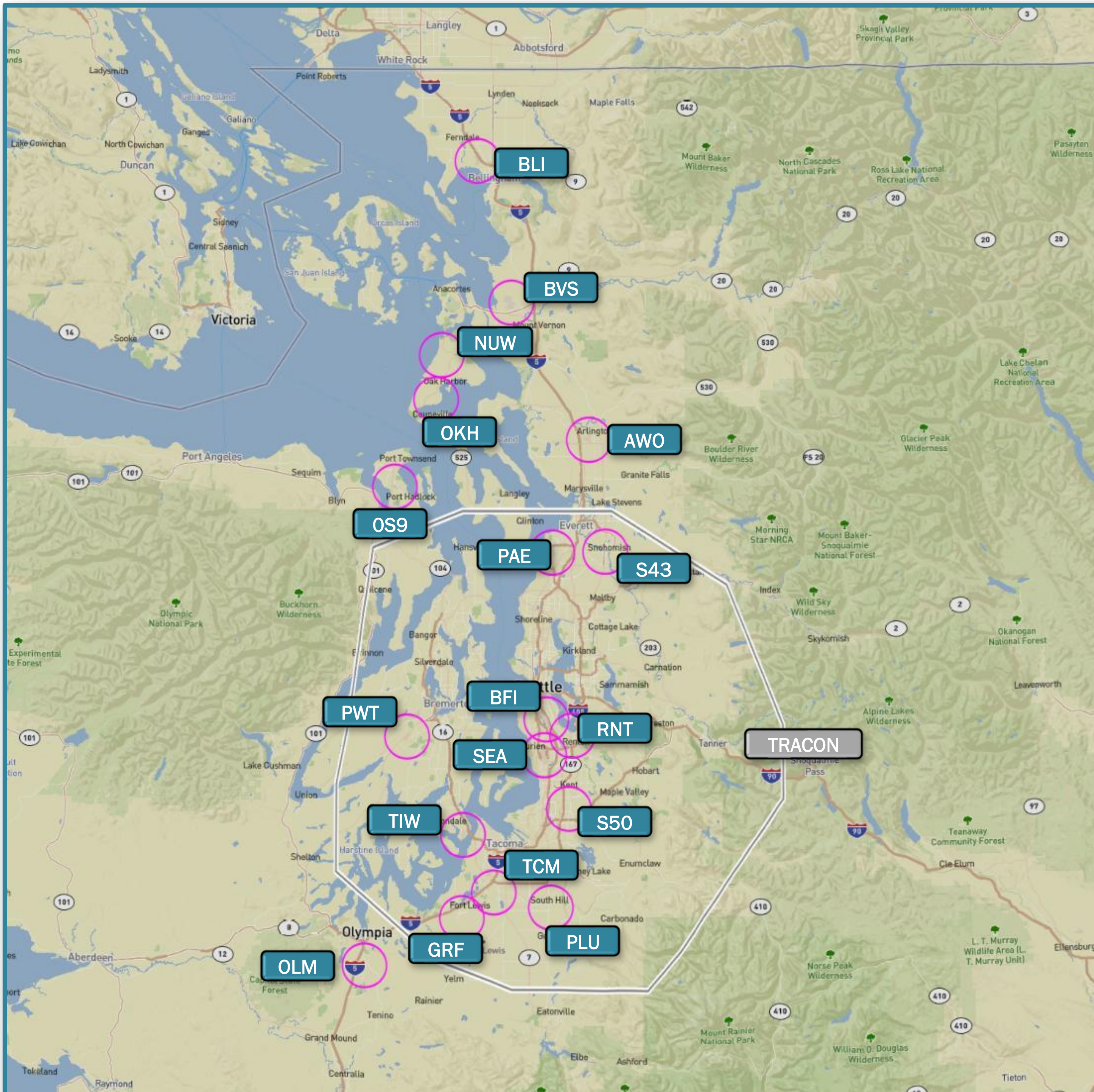
- **Shared-use standard terminal arrival route (STAR) arrival procedures –** A number of the airports within the airspace study area share STAR arrival procedures, which is common when the level of activity does not support independent procedures per airport. However, with growth and the potential use of a regional airport for commercial service, dedicated STARs to each airport may become advantageous. The FAA has been implementing new NextGen RNAV STARS at selected airports on selected routes, including Sea-Tac, Paine Field, and Bellingham International. Currently, airports with some of the arrival procedure routes using shared conventional STARs include procedures to KCIA and Renton Municipal Airport. Paine Field Airport to the north and McChord Field Airport to the south also share STAR procedures with these airports. Use of shared procedures among airports can lead to delays. Note that these conventional procedures are also published to be useable to Sea-Tac. However, Sea-Tac also has dedicated RNAV STARS on two of these routes that are more commonly used by Sea-Tac. The conventional procedures (OLYMPIA, JAWBN AND EPHRATA) are available for use at SEA by those small number of aircraft that are not equipped to fly the RNAV procedures or during busy times to offload operations.
- **Shared departure airspace with Sea-Tac –** Many of the airports share routes when their aircraft exit the terminal area. As growth occurs, the continued development of RNAV SIDs will allow these aircraft to operate independently of Sea-Tac. This primarily occurs for east operations. Example airports are Sea-Tac, Renton Municipal Airport and KCIA. Currently, these airports are largely de-conflicted by the use of radar vectors issued by ATC/Sea-Tac TRACON. This results in a dependent operation between the three airports and inefficient procedures/routes to be flown by departing aircraft from the general aviation airports.
- **Mixed flow airspace –** The wind patterns in the central Puget Sound region are such that the wind direction in the north is different than in the south. It is not uncommon for Sea-Tac to operate in south flow, and Paine Field to operate in north flow. These mixed flows can make efficient operations more challenging in that the arrivals for both airports are occupying the same airspace. The development of flight procedures for less common operational conditions can help mitigate delays and reduce complexity during these less frequent but important operational conditions.
- **Local airport terrain/obstructions constraints –** Instrument flight procedures (arrival and departure) provide for access to airports in more adverse weather conditions at desired minimums. This is an important element to successfully support commercial service operations. To implement these procedures, the airfield must be able to technically support these procedures. Meaning the airport must be free of obstructions and have acceptable space on the ground for approach lighting systems. For example, Renton Municipal Airport has challenges in north flow. Similarly, the minimums are high for KCIA in north flow.

Appendix A
Study Wide Figures

AWO = Arlington Municipal Airport
BFI = King County International/Boeing Field
BLI = Bellingham International Airport
BVS = Skagit Regional Airport
GRF = Gray Army Airfield (Joint Base Lewis-McChord)
NUW = Whidbey Island Naval Air Station (Ault Field)
OKH = AJ Eisenberg Airport
OLM = Olympia Regional Airport
PAE = Paine Field/Snohomish County International
PLU = Pierce County Airport
PWT = Bremerton National Airport
RNT = Renton Municipal Airport
S43 = Harvey Field Airport
S50 = Auburn Municipal Airport
SEA = Seattle-Tacoma International
TCM = McChord Field Airport (Joint Base Lewis-McChord)
TIW = Tacoma Narrows Airport
0S9 = Jefferson County Airport

Source: BridgeNet International 2019

Figure A-1
Airports in Airspace Study Area
Streets Background



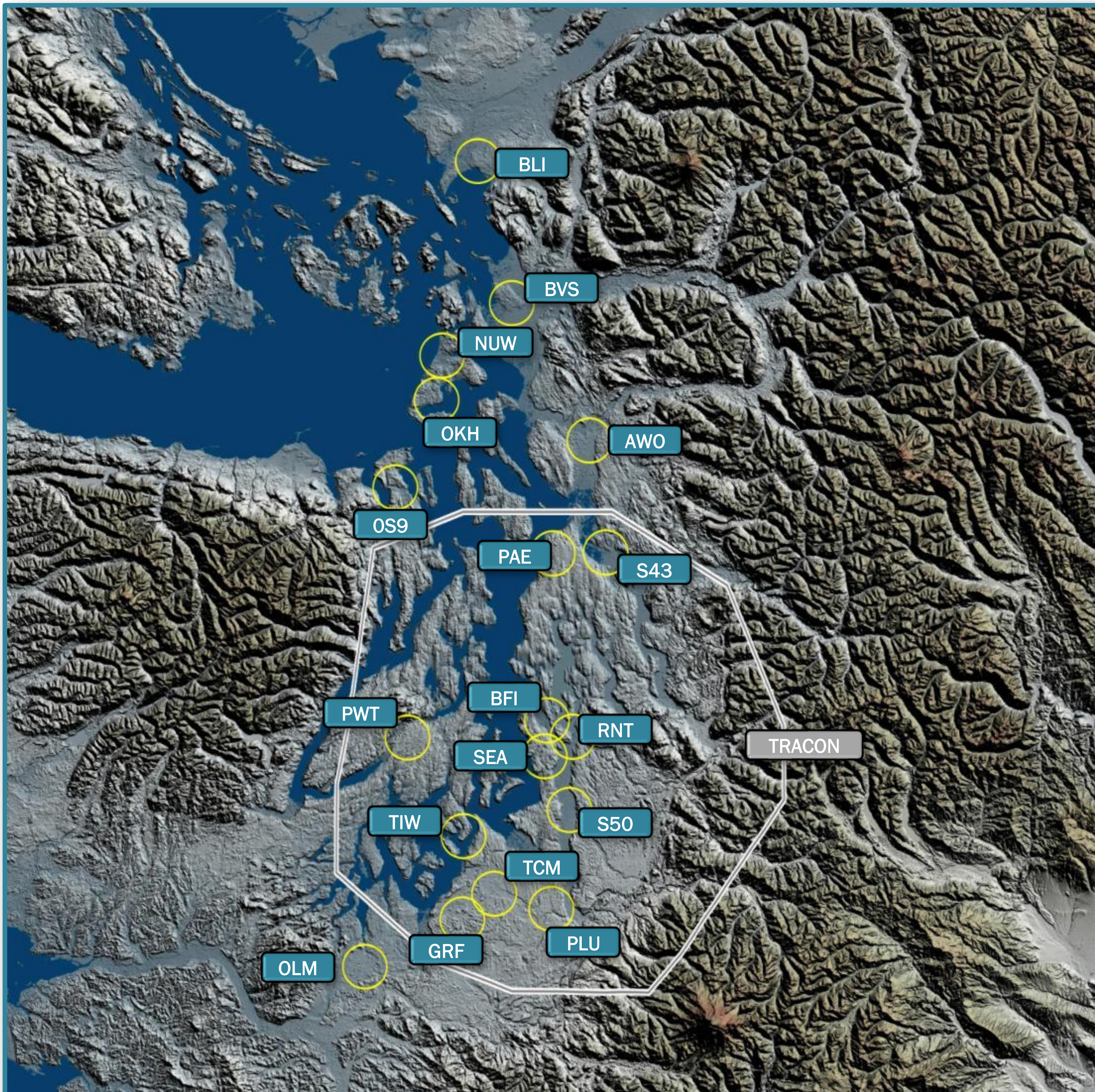
Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Figure A-2
Airports in Airspace Study Area
Satellite Background

Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

Figure A-3
Airports in Airspace Study Area
Terrain Background



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

Figure A-4
Airports in Airspace Study Area
Land Area Background

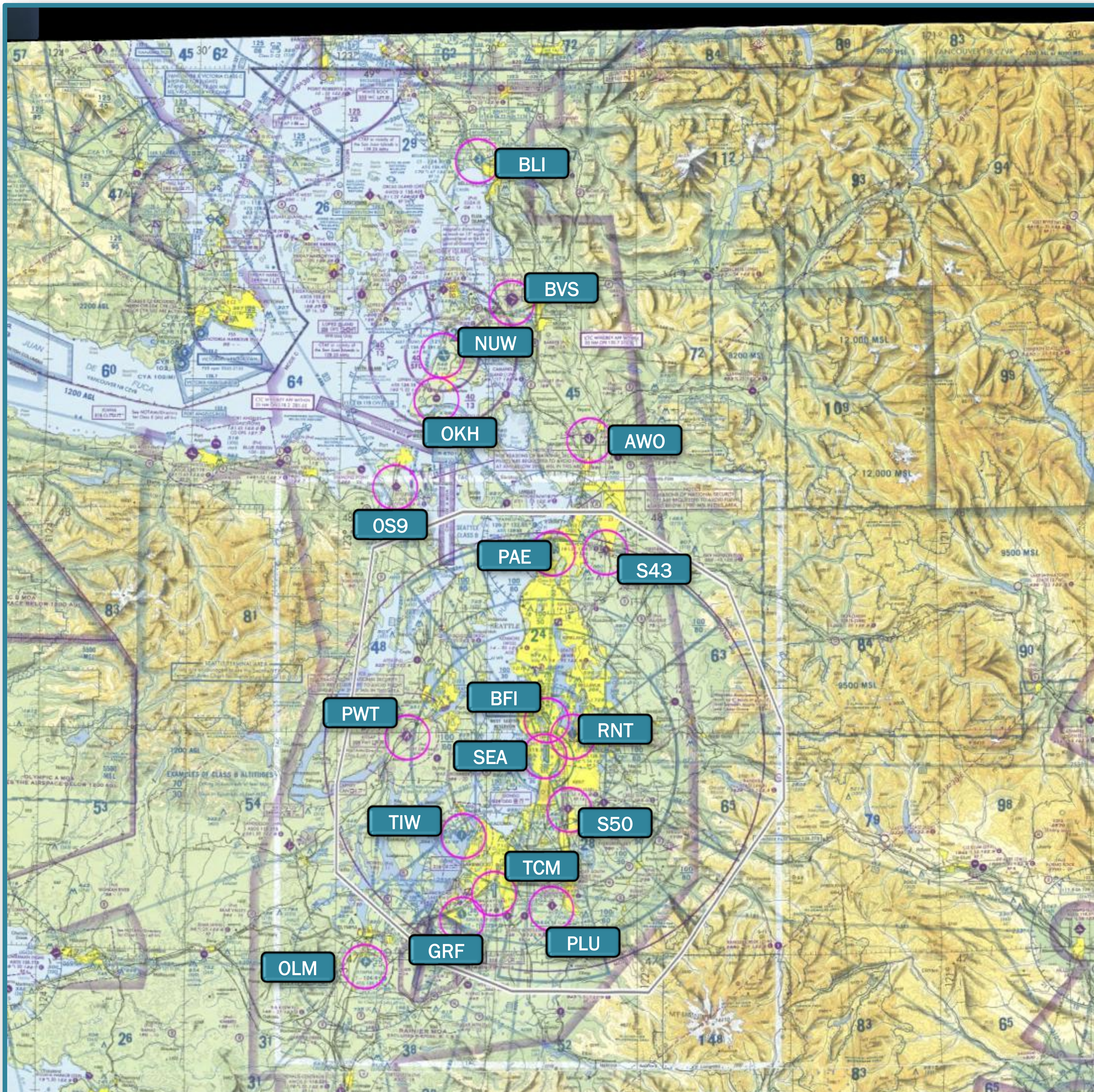
Puget Sound Regional Council

Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

Figure A-5
Airports in Airspace Study Area
Sectional Charts Background

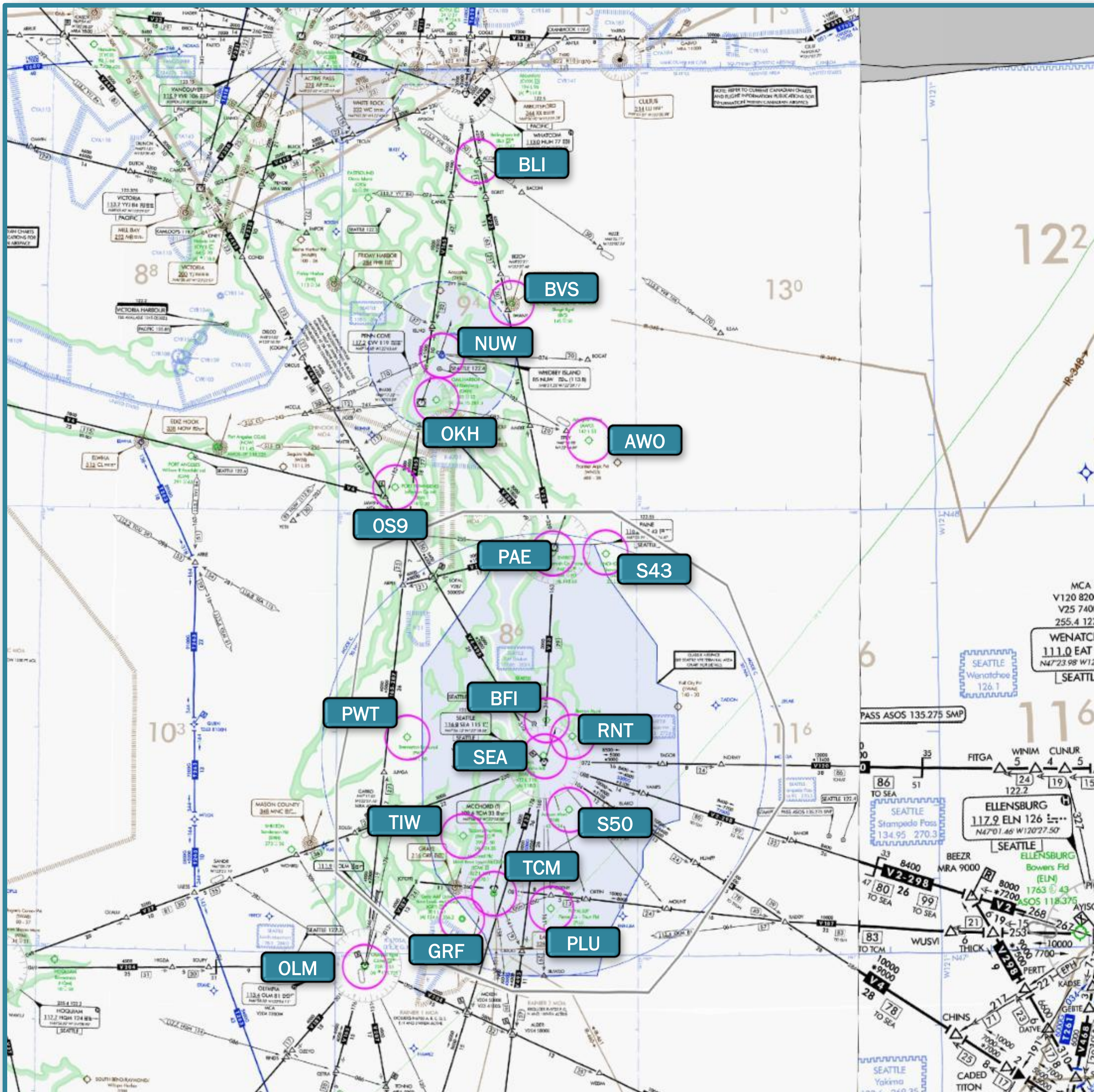
Puget Sound Regional Council



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Figure A-6
Airports in Airspace Study Area
Low Altitude Chart Background

Puget Sound Regional Council

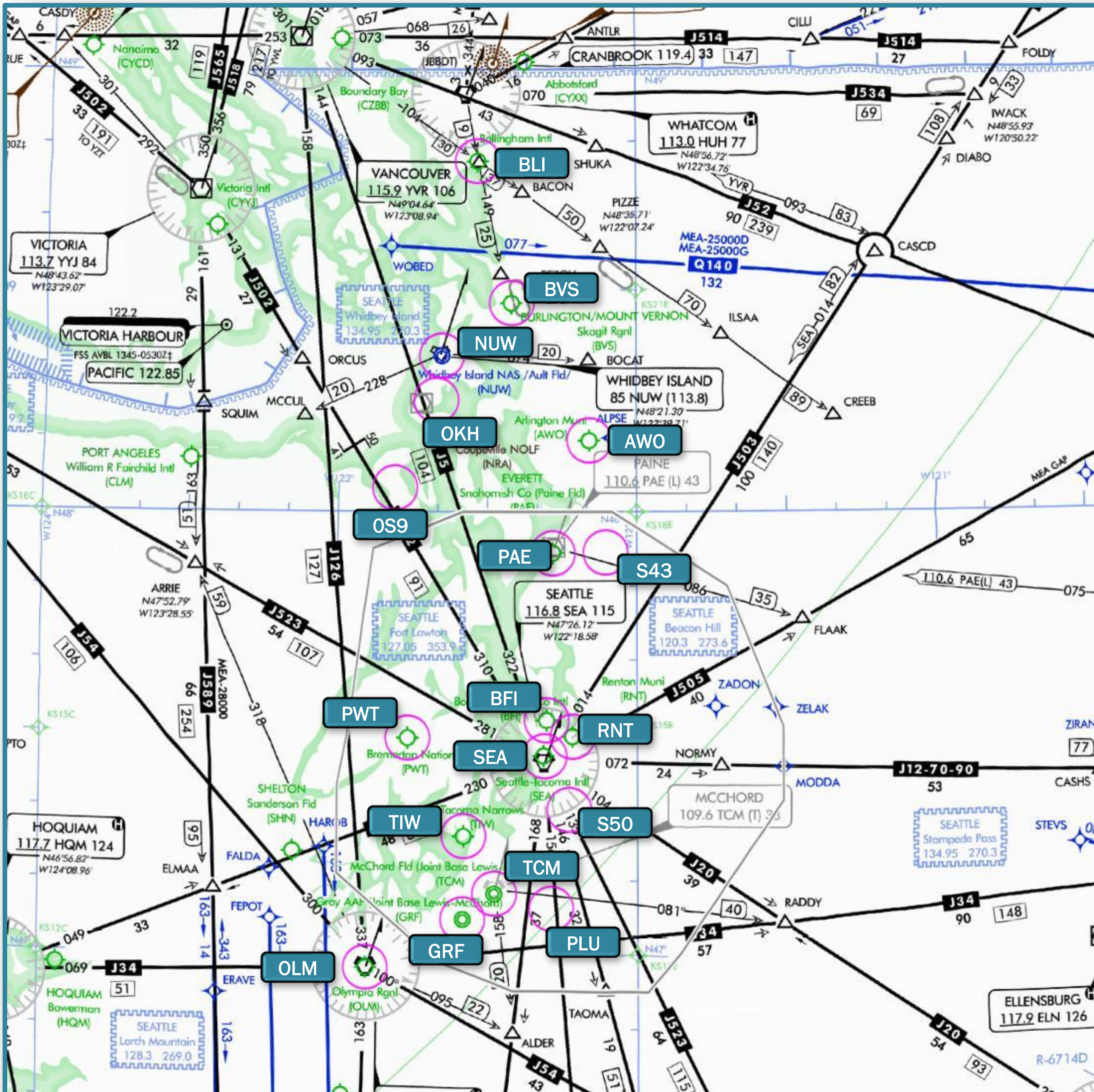


Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

Figure A-7
Airports in Airspace Study Area
High Altitude Chart Background

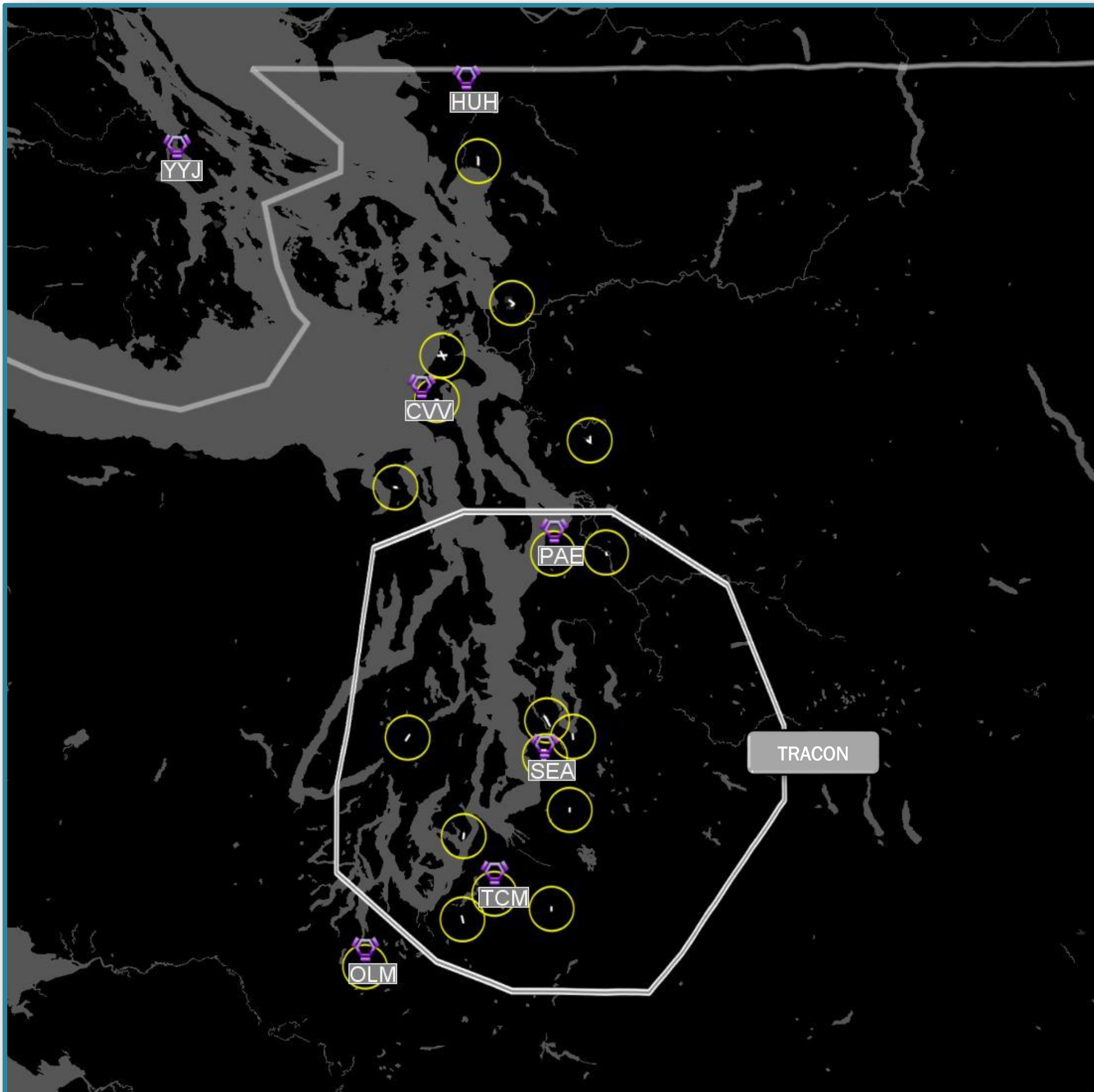
Puget Sound Regional Council



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

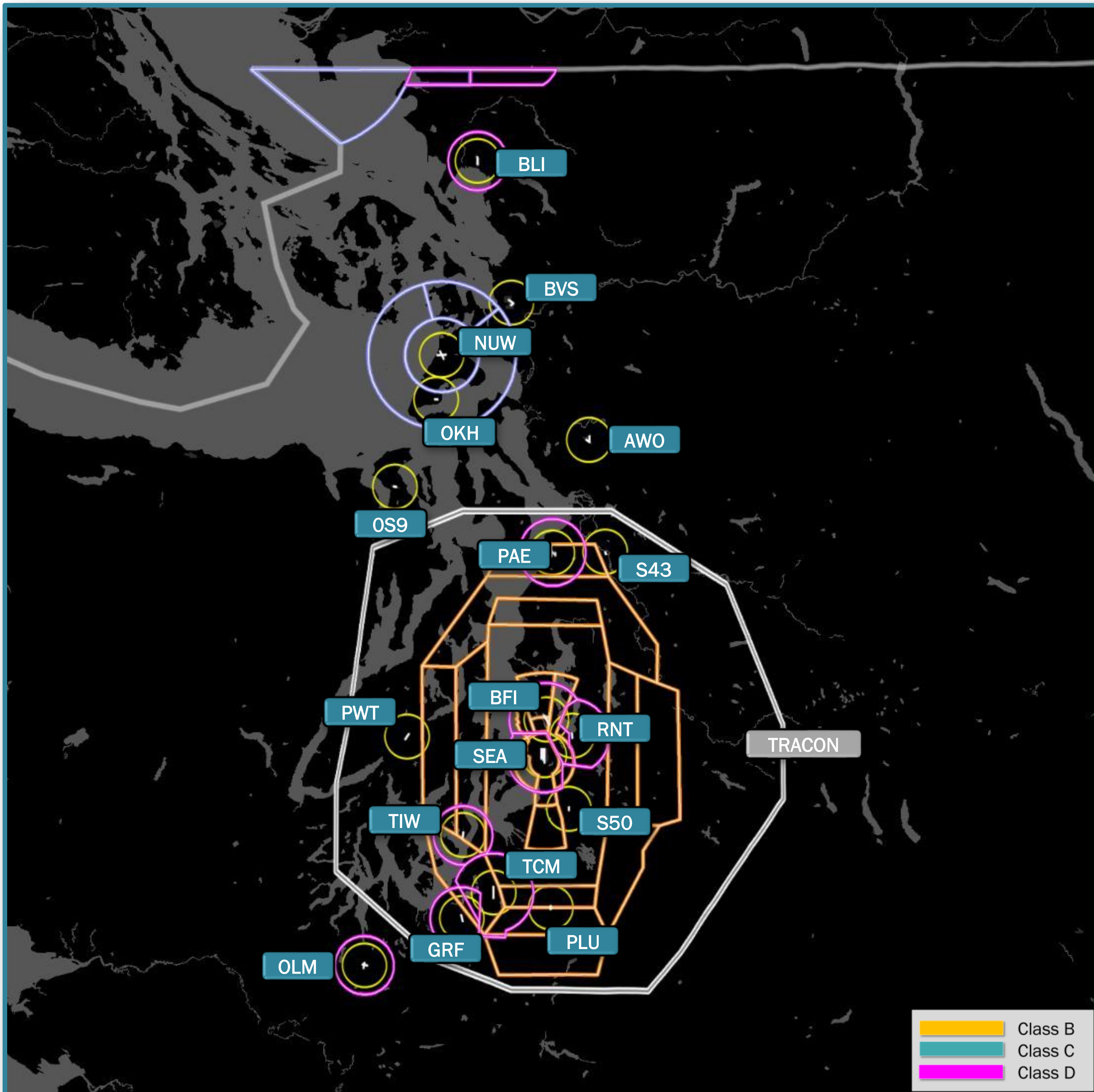
Figure A-8
VORs within Airspace Study Area
VOR and VOR/DME



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

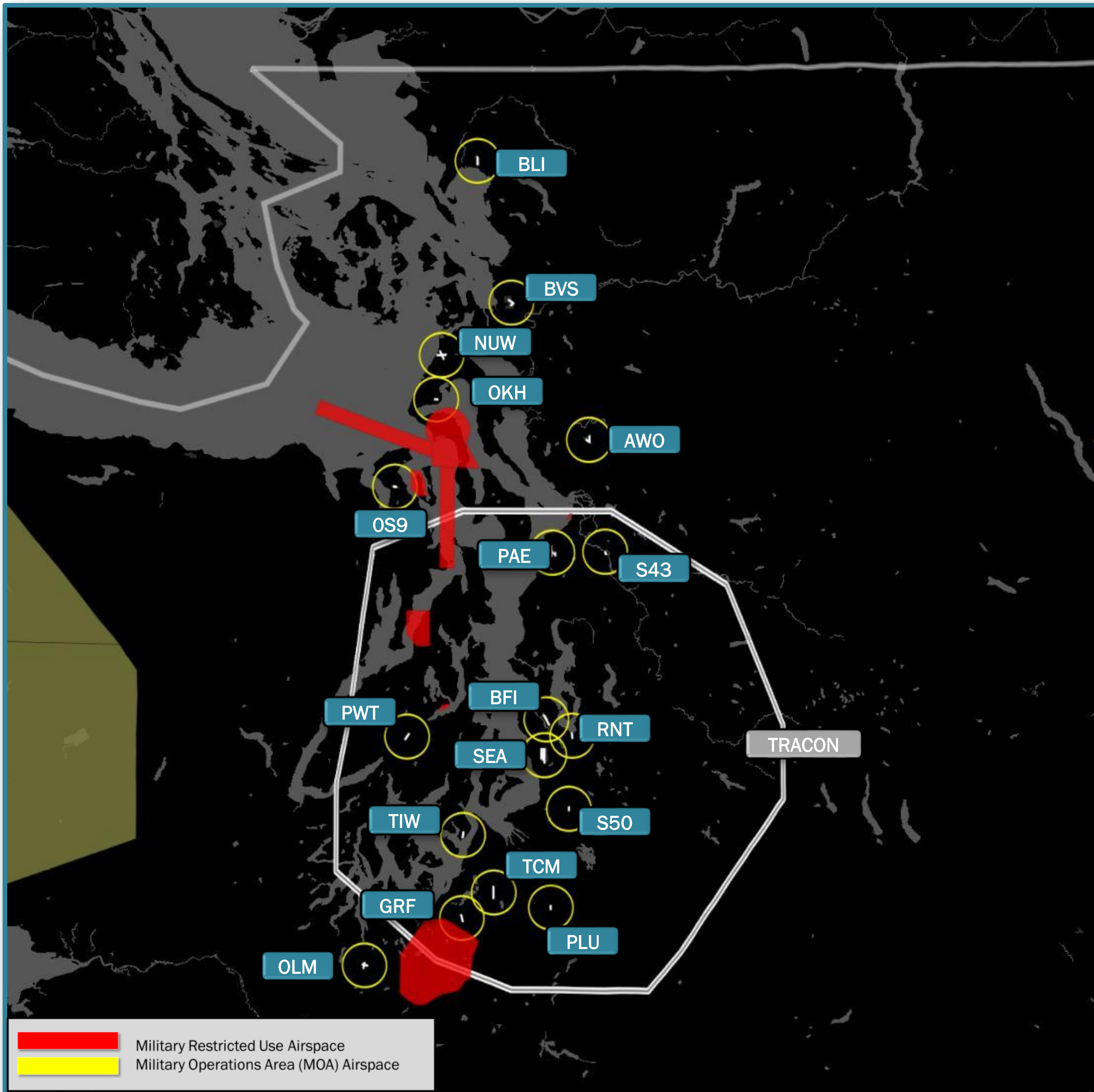
Figure A-9
Class Airspaces within Airspace Study Area
Class B, C, D and E Airspaces



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

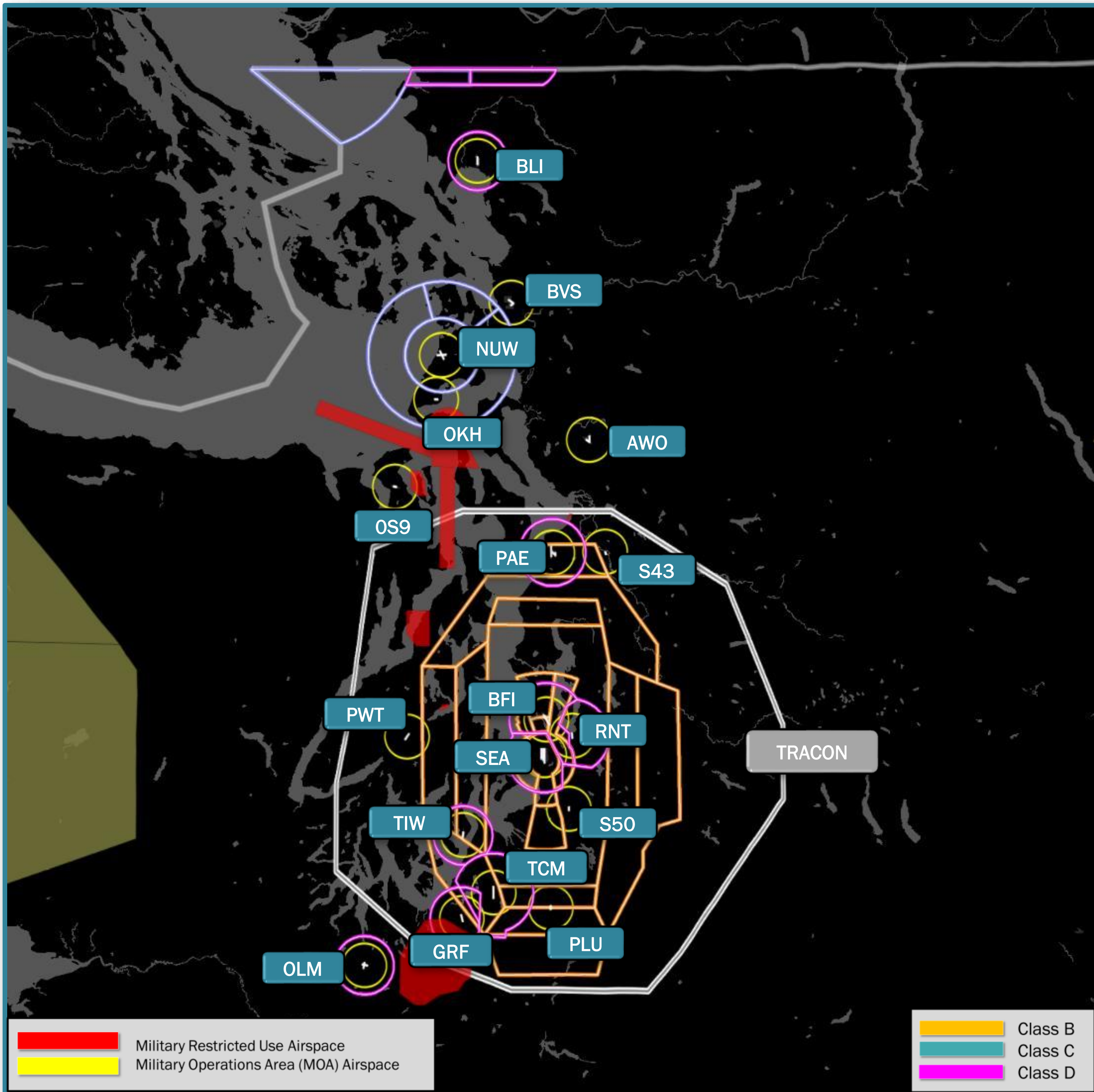
Figure A-10
Military Restricted and MOA Airspace in Airspace Study Area

Puget Sound Regional Council



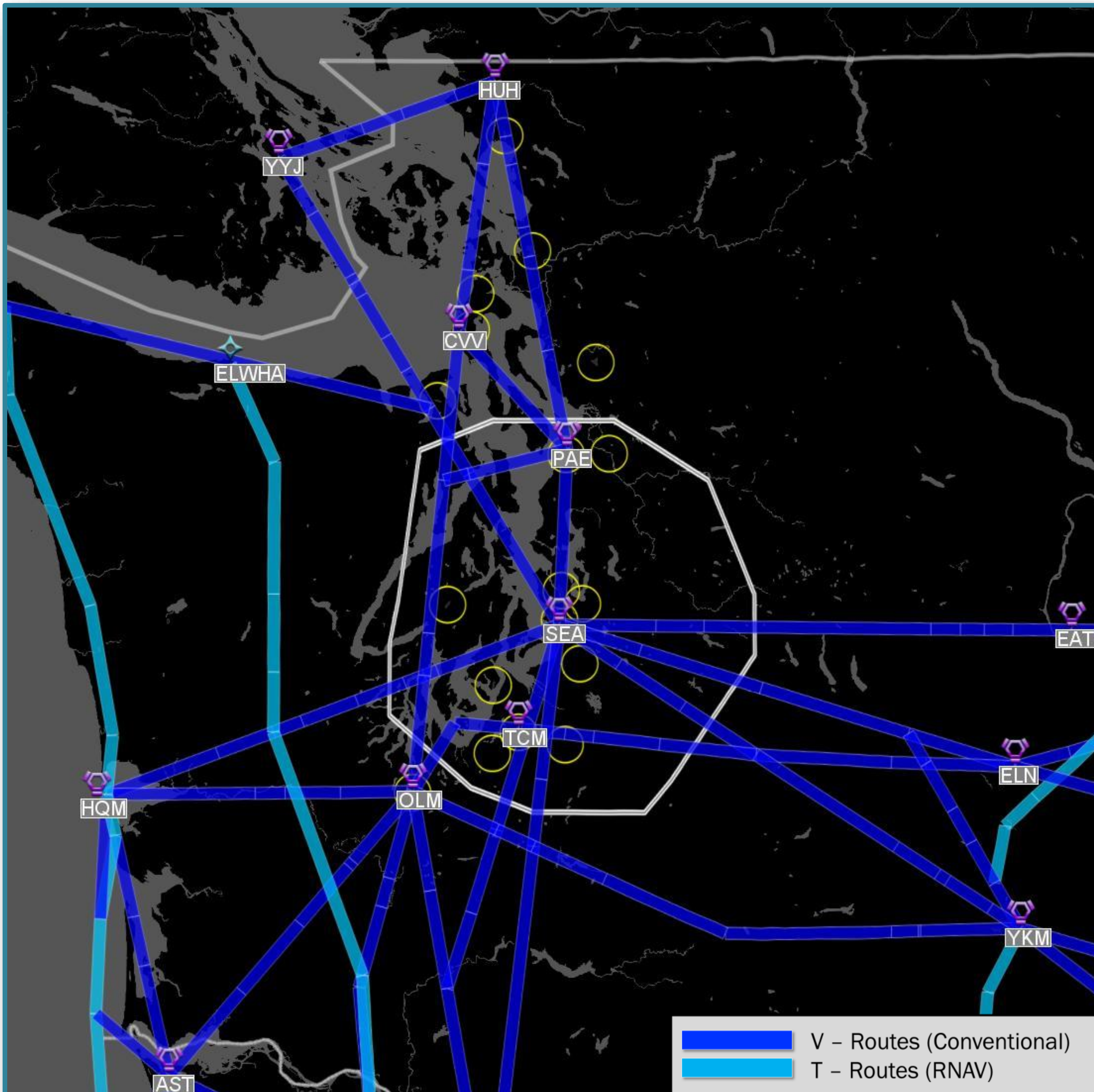
Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and OS9.

Figure A-11
Combined Class and Restricted Airspaces



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and OS9.

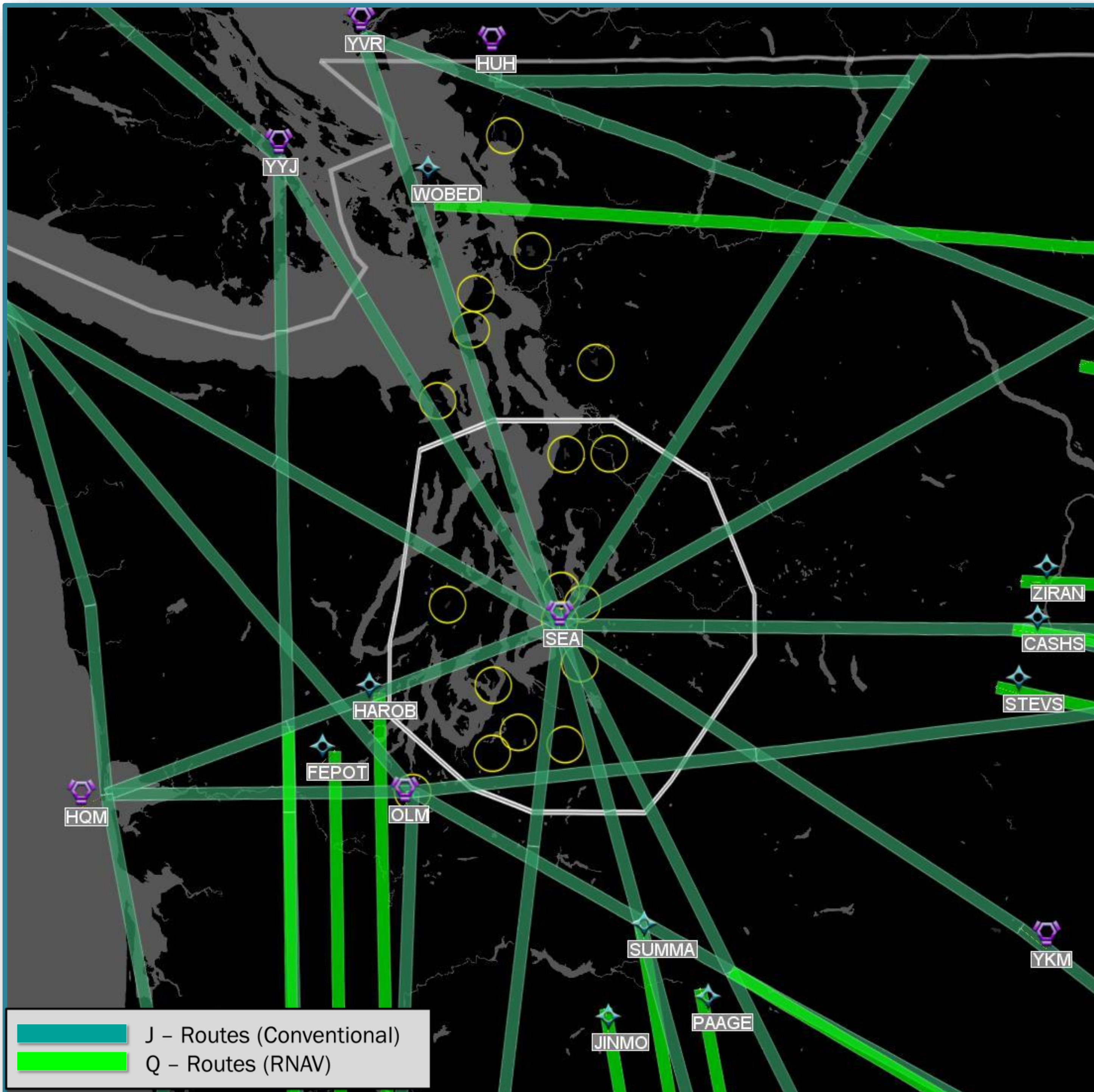
Figure A-12
Airports in Airspace Study Area
Low Altitude V and T Routes



Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

Figure A-13
Airports in Airspace Study Area
High Altitude J and Q Routes

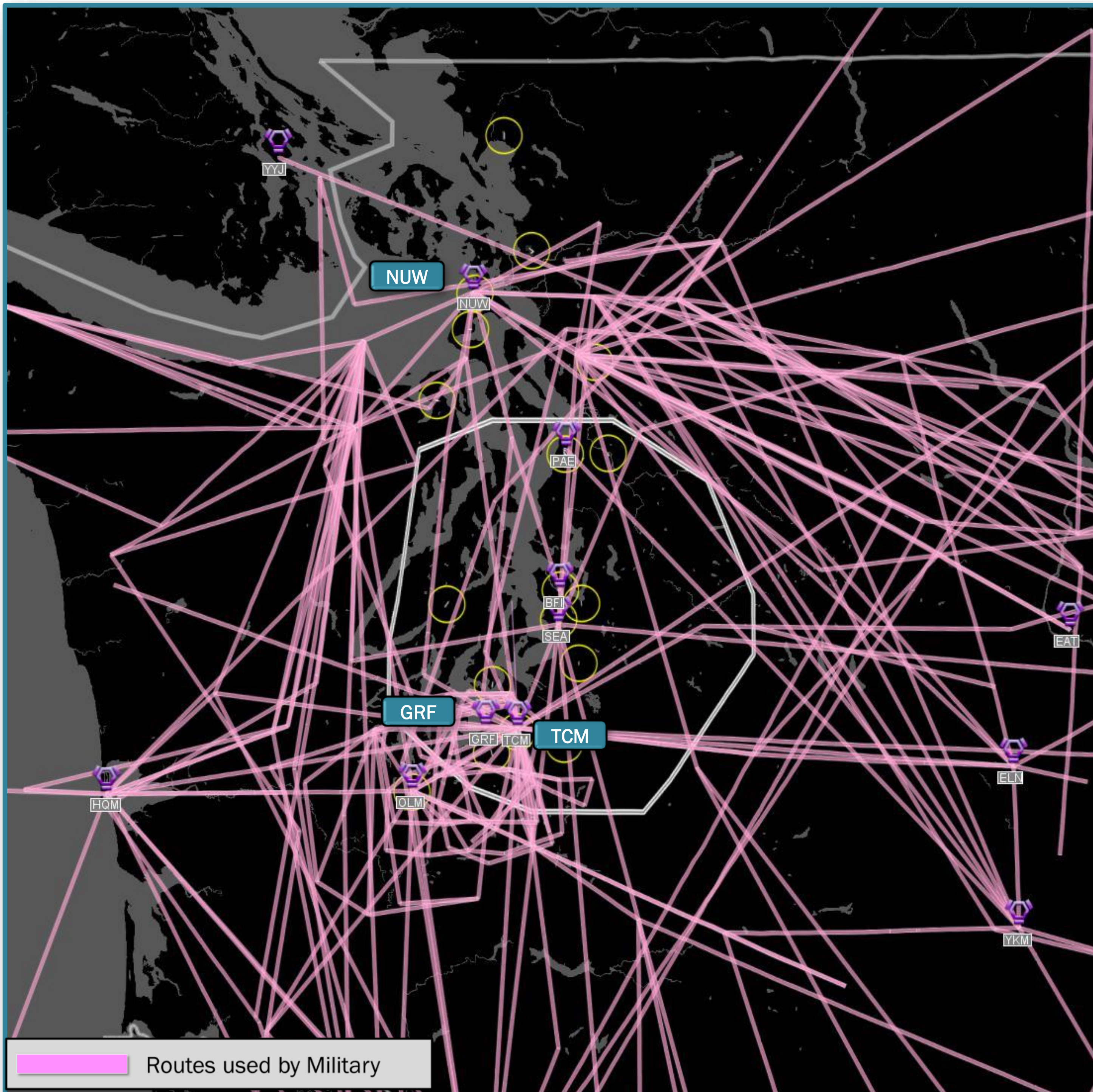


Notes: AWO, BFI, BLI, BVS GRF, NUW, OKH OLM, PAE, PLU, PWT, RNT, S43, S50, SEA, TCM, TIW and 0S9.

Source: BridgeNet International 2019

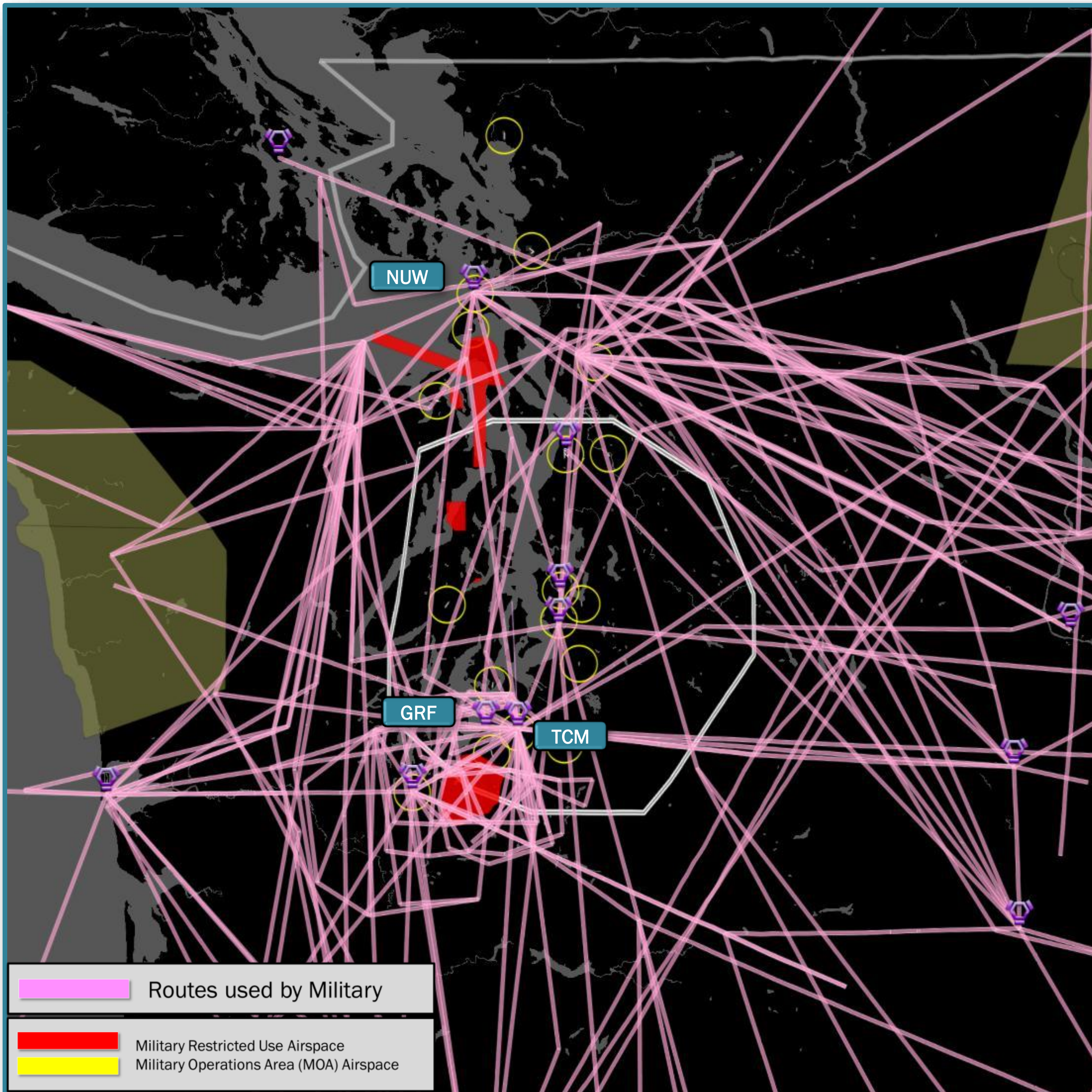
Figure A-14a
Military Routes in Airspace Study Area
Military Routes to/from NUW, TCM, and GRF

Puget Sound Regional Council



Notes: NUW, TCM, GRF.

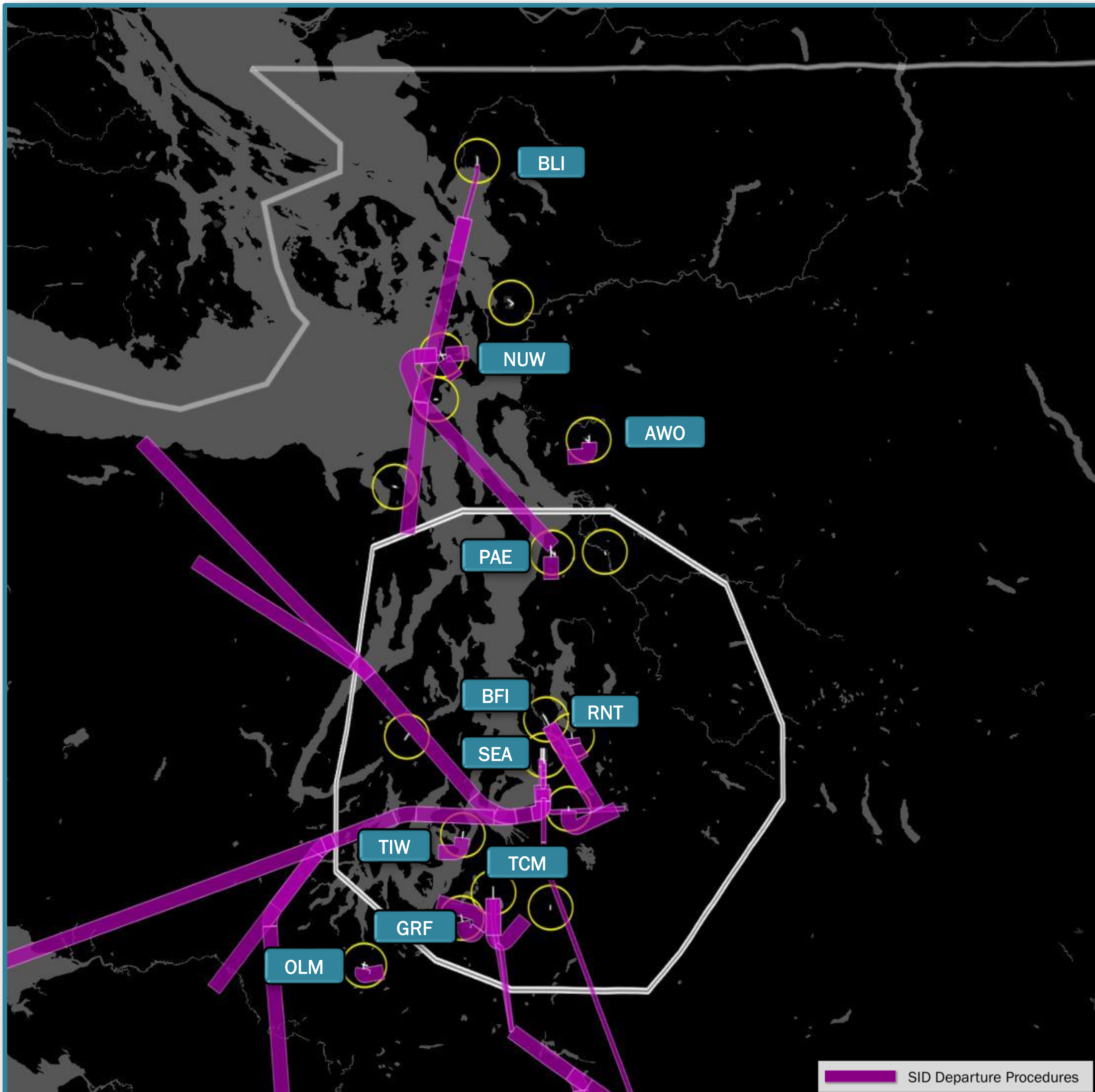
Figure A-14b
Military Routes with Military Restricted and MOA Airspace
Military Routes to/from NUW, TCM, and GRF



Notes: NUW, TCM, GRF.

Figure A-15
Standard Instrument Departures (SIDs)
All SIDs in South Flow

Puget Sound Regional Council

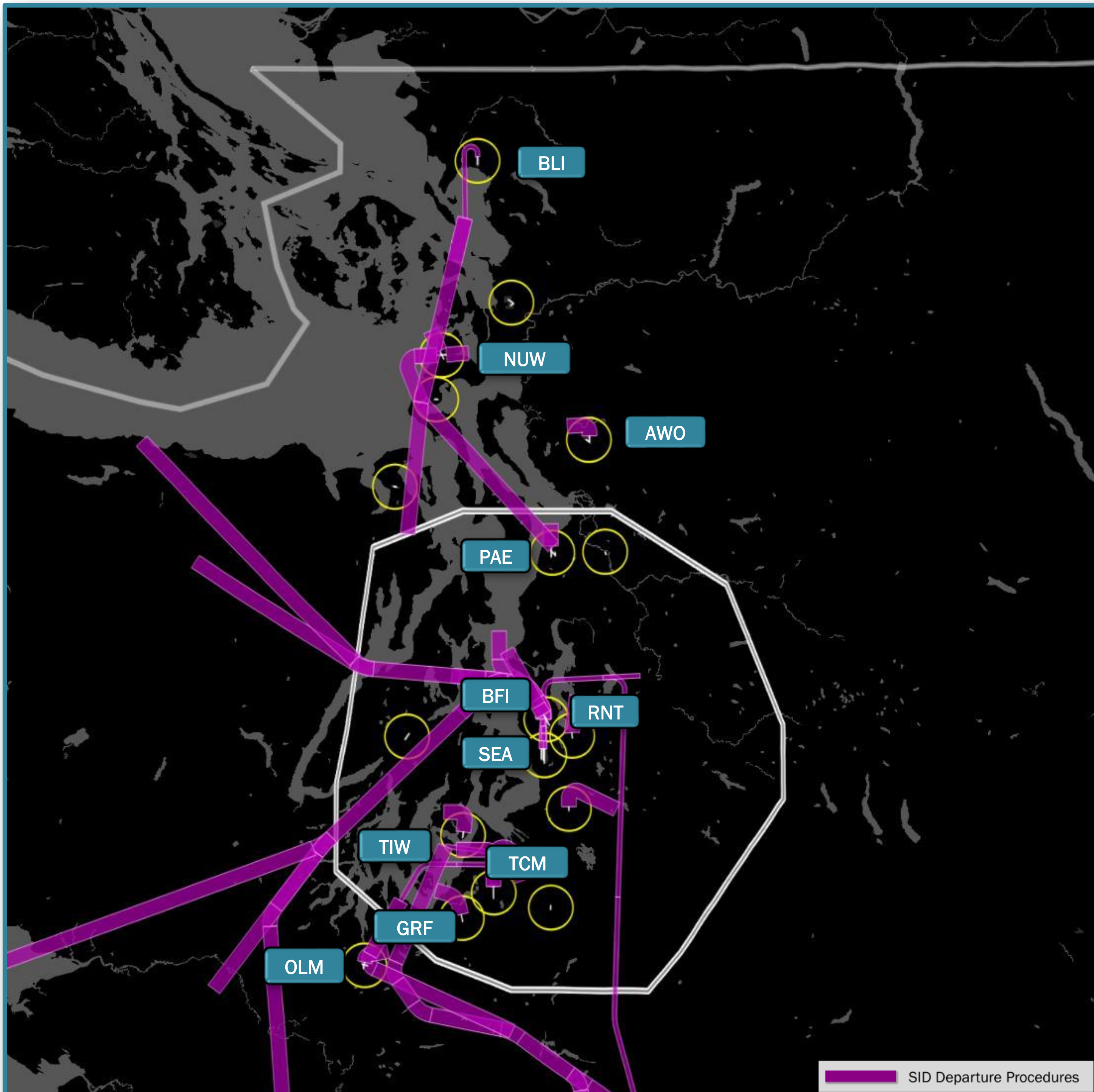


Notes: AWO, BFI, BLI, GRF, NUW, OLM, PAE, RNT, SEA, TCM and TIW have Published SIDs.

Source: BridgeNet International 2019

Figure A-16
Standard Instrument Departures (SIDs)
All SIDs in North Flow

Puget Sound Regional Council

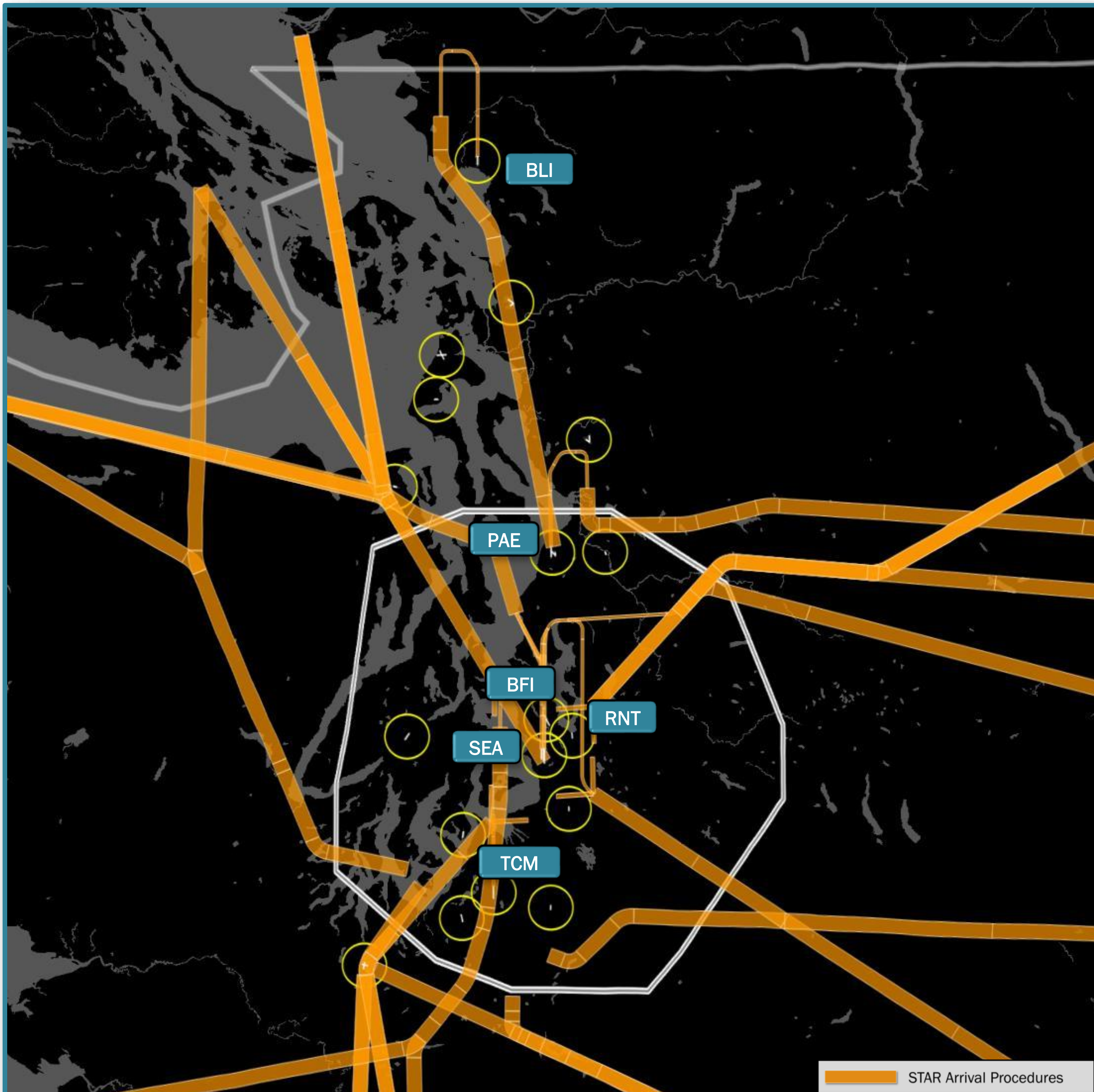


Notes: AWO, BFI, BLI, GRF, NUW, OLM, PAE, RNT, SEA, TCM and TIW have Published SIDs.

Source: BridgeNet International 2019

Figure A-17
Standard Terminal Arrival Procedures (STARs)
All STARs in South Flow

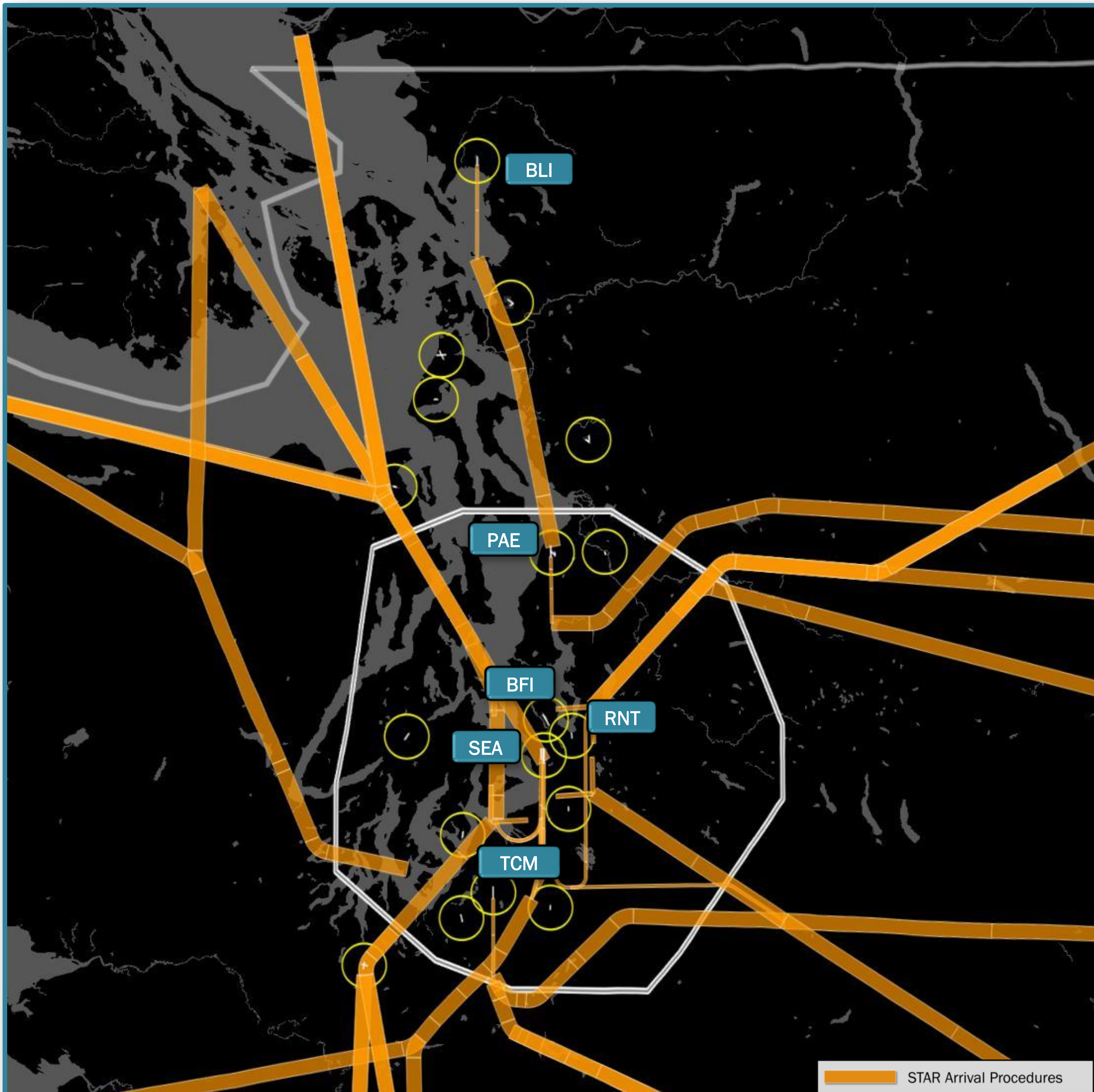
Puget Sound Regional Council



Notes: BFI, BLI, PAE, RNT, SEA and TCM have Published STARs.

Figure A-18
Standard Terminal Arrival Procedures (STARs)
All STARs in North Flow

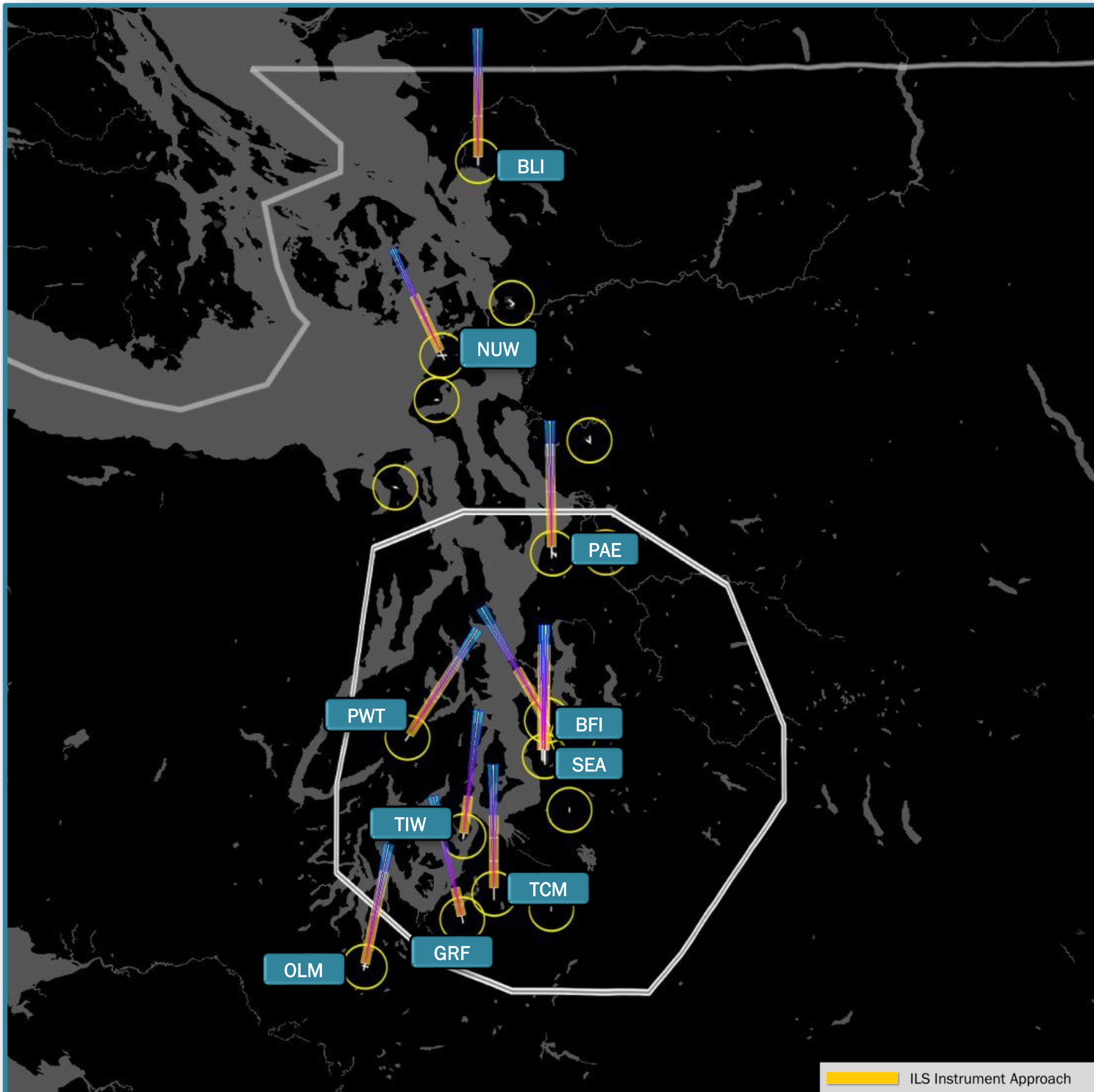
Puget Sound Regional Council



Notes: BFI, BLI, PAE, RNT, SEA and TCM have Published STARs.

Figure A-19
Instrument Approach Procedures (IAPs)
All Conventional ILSs in South Flow

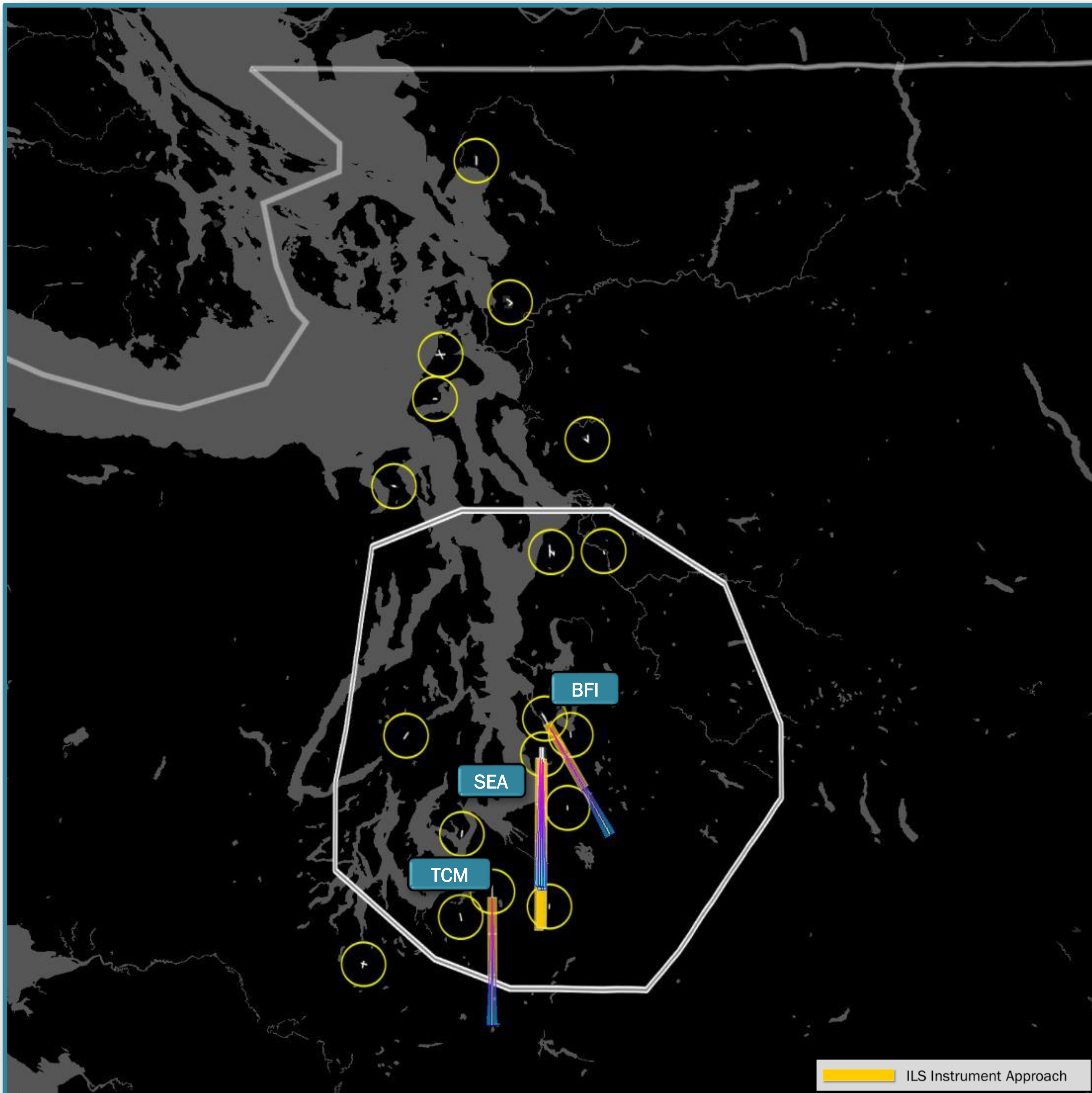
Puget Sound Regional Council



Notes: BFI, BLI, GRF, NUW OLM, PAE, PWT, SEA, TCM and TIW have Published ILS approaches in South Flow.

Source: BridgeNet International 2019

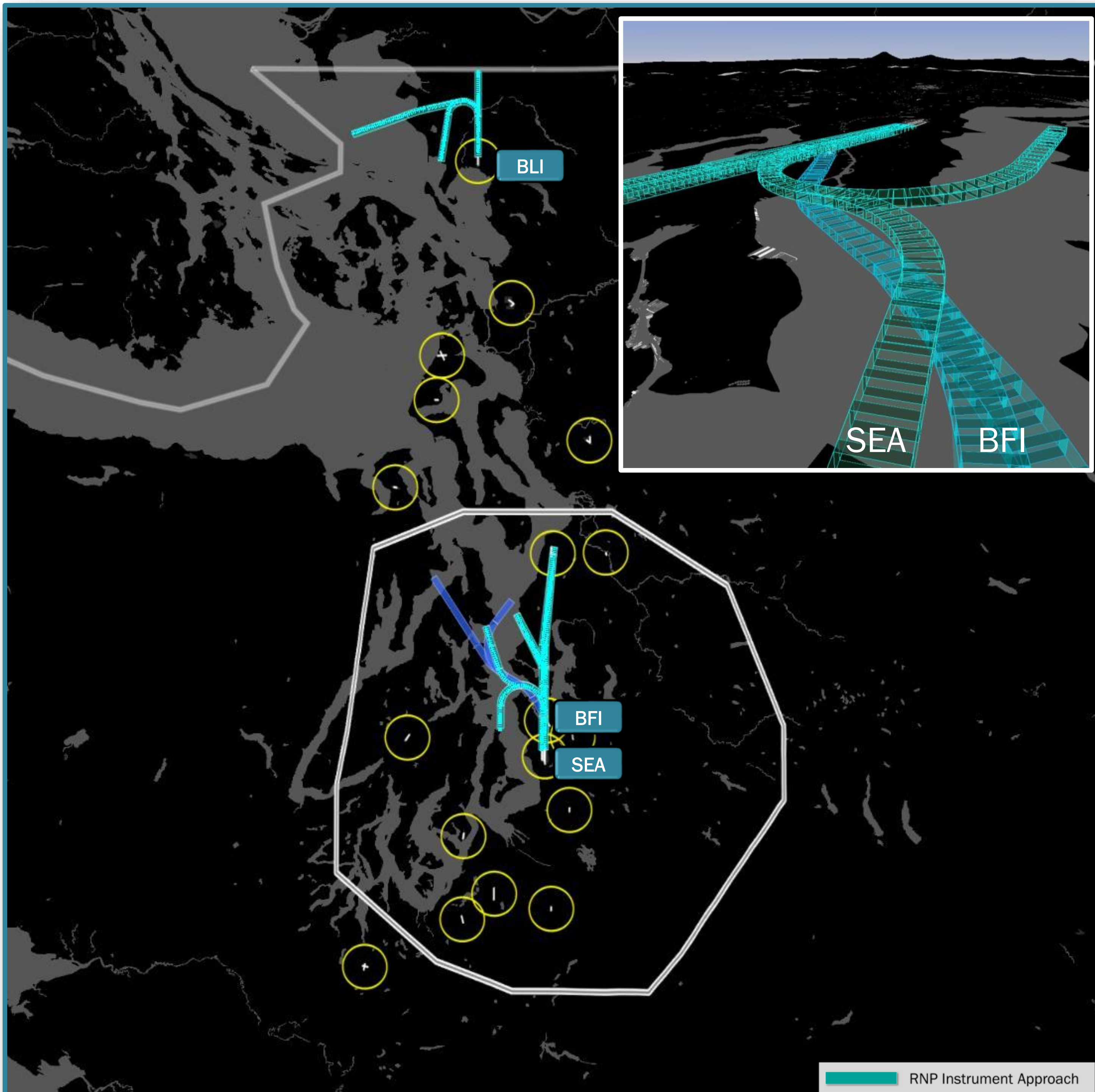
Figure A-20
Instrument Approach Procedures (IAPs)
All Conventional ILSs in North Flow



Notes: BFI, SEA, and TCM have Published ILS approaches in North Flow.

Figure A-21
Instrument Approach Procedures (IAPs)
All NextGen RNPs in South Flow

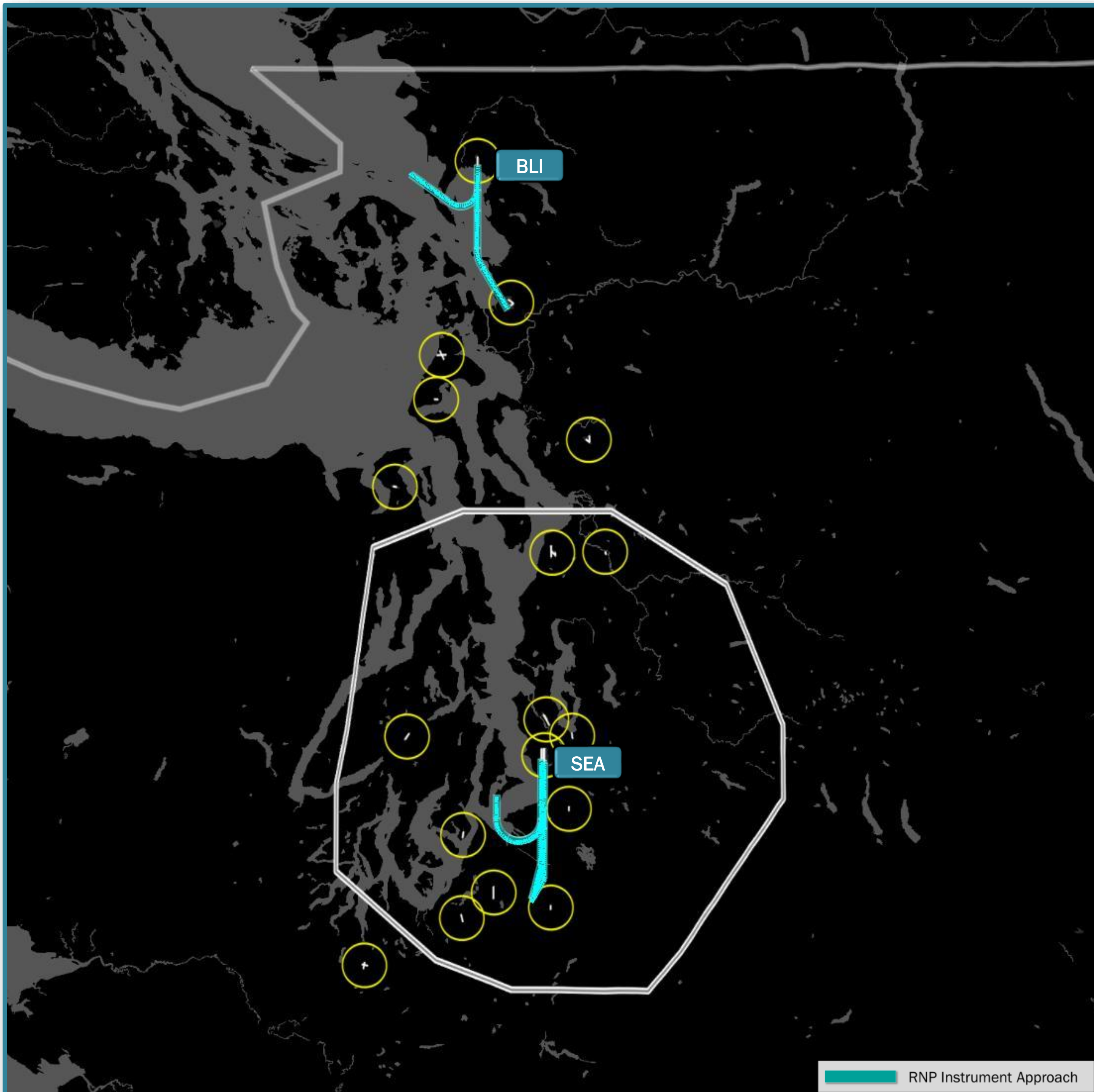
Puget Sound Regional Council



Notes: BFI, BLI, and SEA have Published RNP approaches in South Flow.
BFI RNPs shown in blue to differentiate from the SEA procedures.
Insert shows a closeup of the BFI and SEA interaction with the SEA procedures above the BFI procedures.

Figure A-22
Instrument Approach Procedures (IAPs)
All NextGen RNPs in North Flow

Puget Sound Regional Council

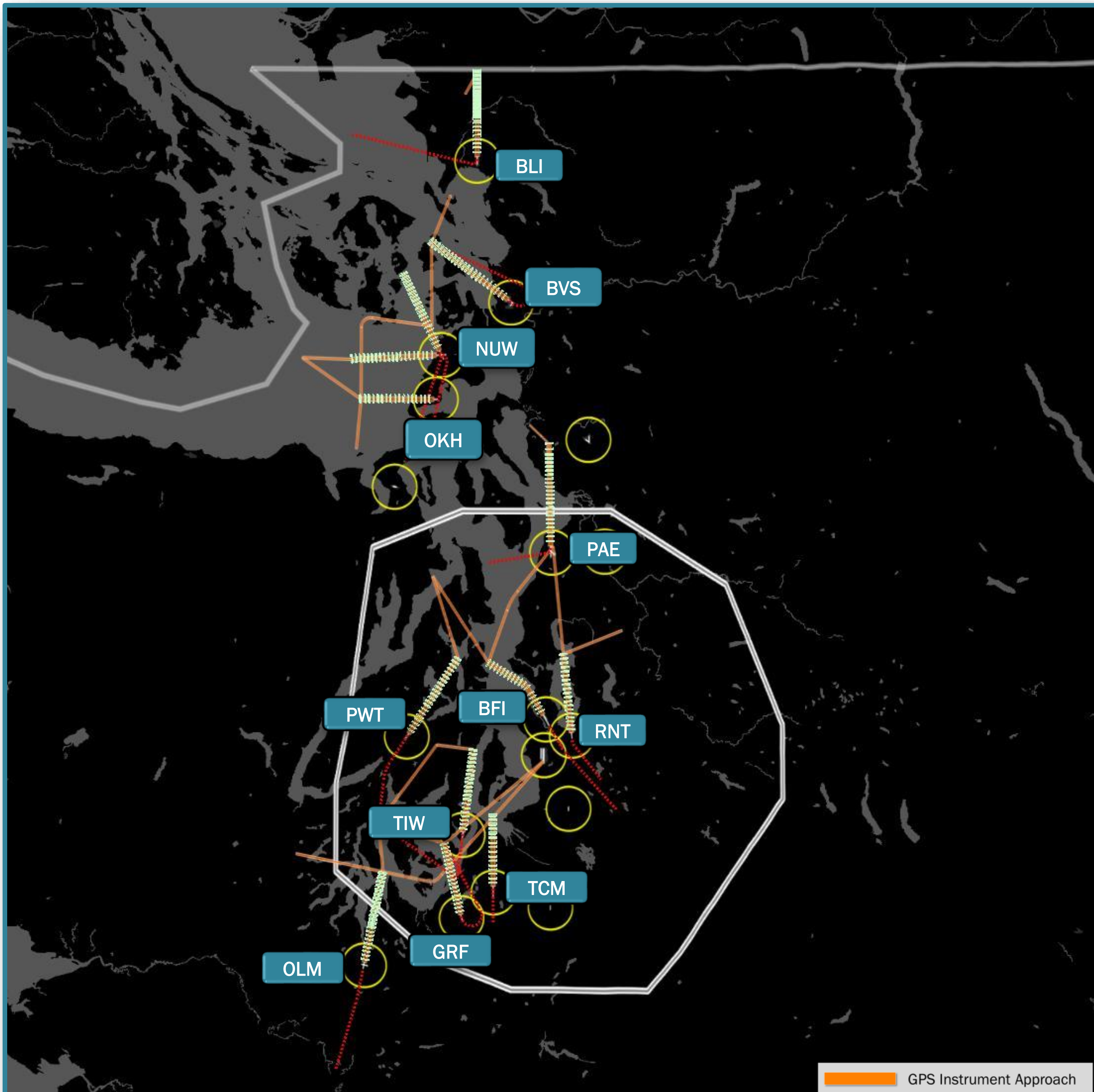


Notes: BLI and SEA have Published RNP approaches in North Flow.

Source: BridgeNet International 2019

Figure A-23
Instrument Approach Procedures (IAPs)
All Advanced NextGen GPSs Approaches in South Flow

Puget Sound Regional Council

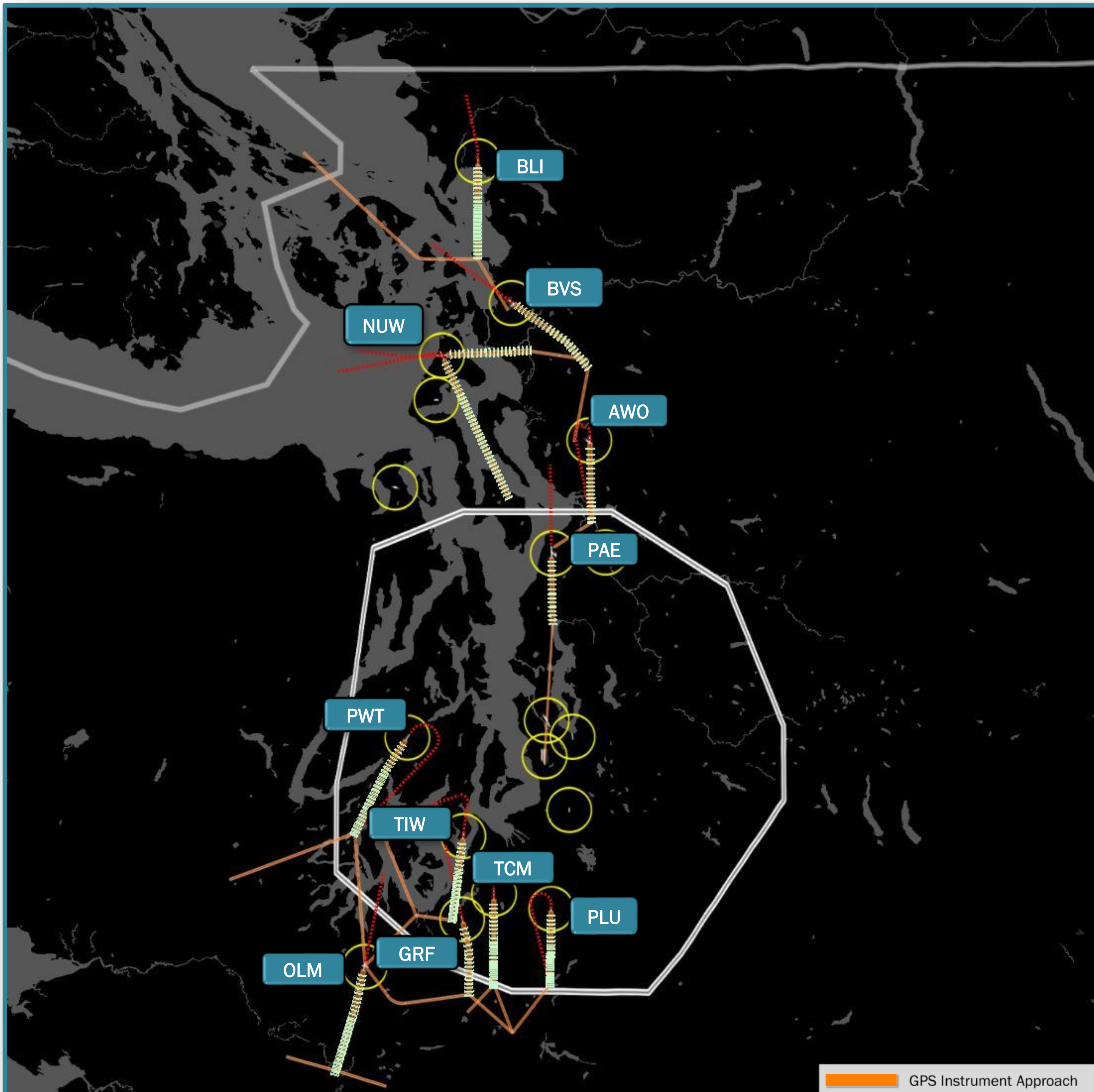


Notes: BFI, BLI, BVS, GRF, NUW, OKH, OLM, PAE, PWT, RNT, TCM and TIW have Published GPS approaches in South Flow.
To reduce clutter, SEA procedures are not shown.
GPS procedures shown are those with both horizontal and vertical guidance (RNAV (GPS))
The procedure path is in yellow with a green box showing the path.
Narrow yellow lines are transitions to the procedures. The red dashed lines are the missed approach path.

Source: BridgeNet International 2019

Figure A-24
Instrument Approach Procedures (IAPs)
All Advanced NextGen GPSs Approaches in North Flow

Puget Sound Regional Council

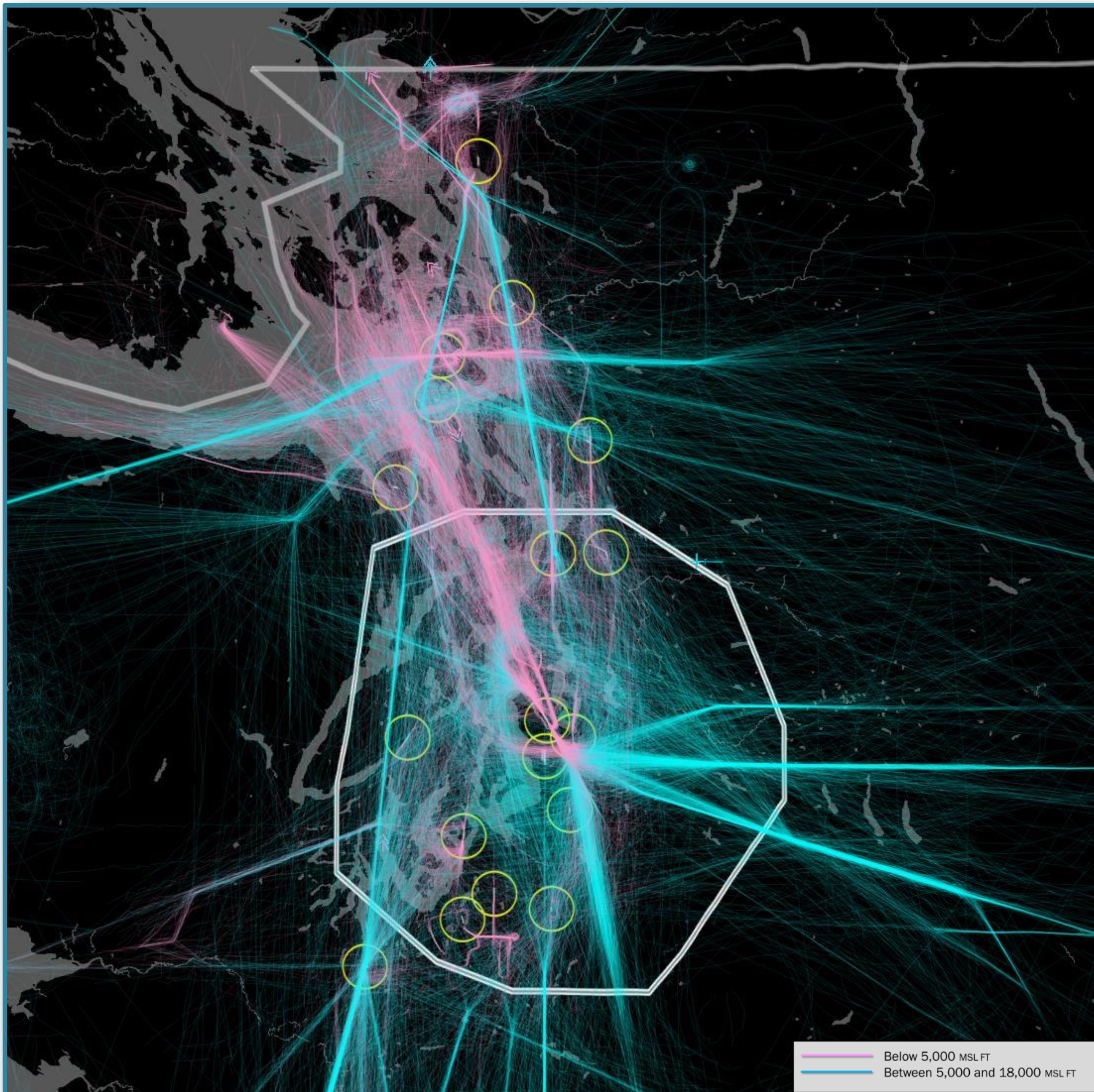


Notes: AWO, BLI, BVS, GRF, NUW, OLM, PAE, PLU, PWT, TCM and TIW have Published GPS approaches in South Flow.
To reduce clutter, SEA procedures are not shown.
GPS procedures shown are those with both horizontal and vertical guidance (RNAV (GPS))
The procedure path is in yellow with a green box showing the path.
Narrow yellow lines are transitions to the procedures. The red dashed lines are the missed approach path.

Source: BridgeNet International 2019

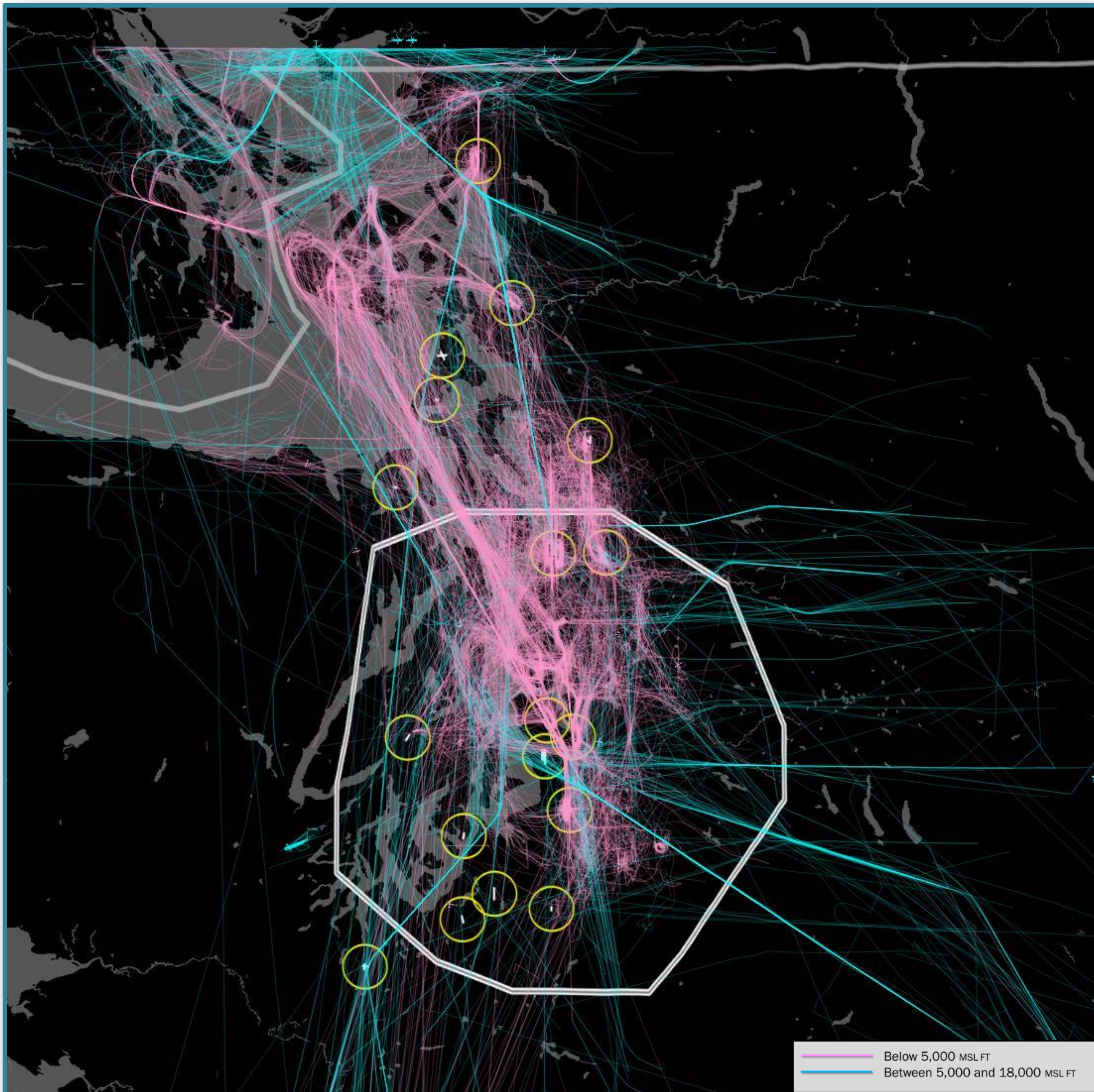
Figure A-25
SWIM Surveillance Aircraft Flight Tracks
(SEA Activity excluded)

Puget Sound Regional Council



Notes: Random 17,000 sample Flight Tracks from SWIM aircraft between June 1st through August 31st 2018

Figure A-26
ADS-B Surveillance Aircraft Flight Tracks
(SEA Activity Excluded)



Notes: Flight Tracks from ADS-B surveillance of ADS-B equipped aircraft between July4th through July 7th 2019

Appendix B
Seattle-Tacoma International Airport Flight Procedure Graphics

Figure B-1
SEA Standard Instrument Departures (SIDs)
Primary SIDs in South Flow

Notes: SEA - Seattle-Tacoma International Airport

Source: BridgeNet International 2019

Figure B-2

SEA Standard Instrument Departures (SIDs)

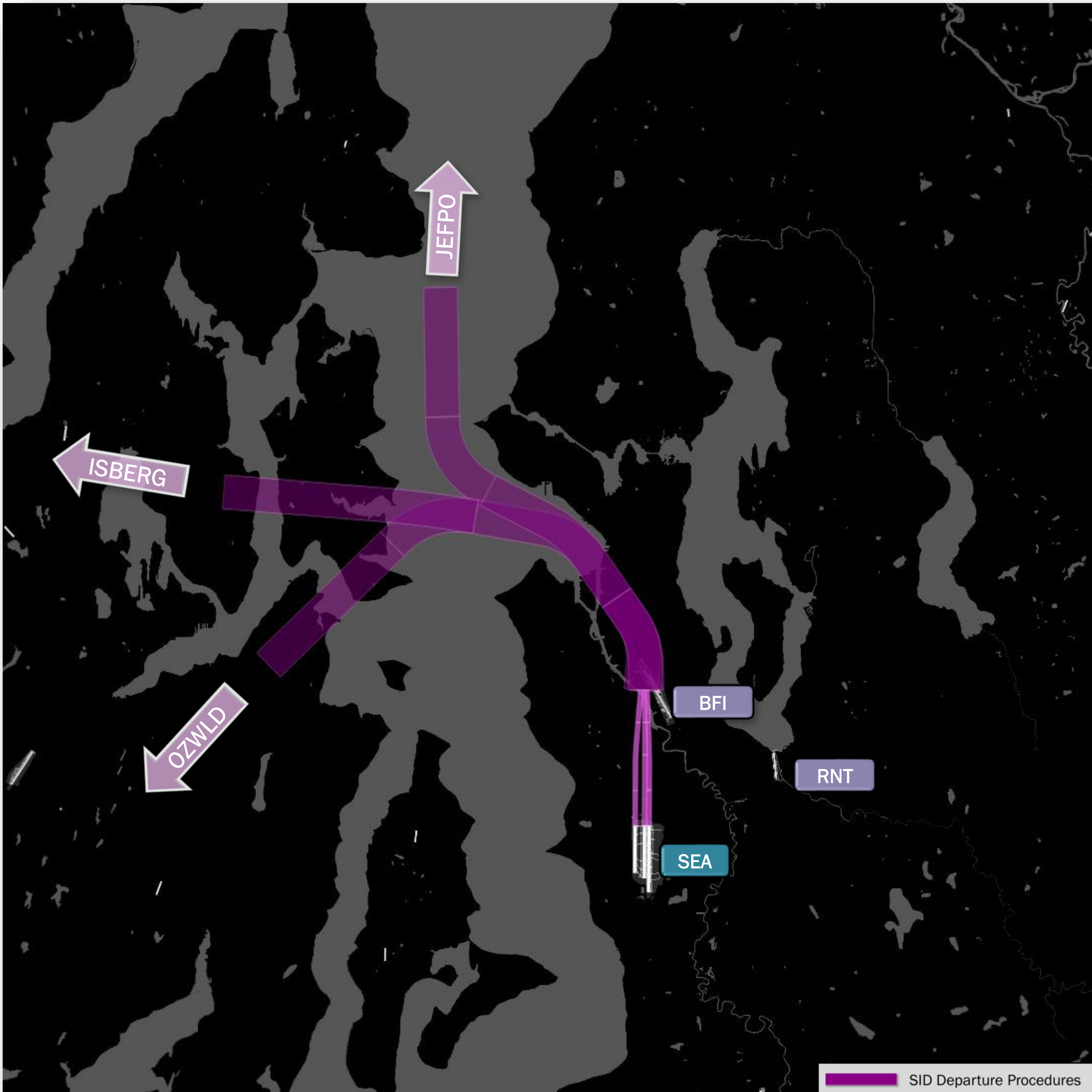
Primary SIDs in North Flow

Puget Sound Regional Council

Notes: SEA - Seattle-Tacoma International Airport

Source: BridgeNet International 2019

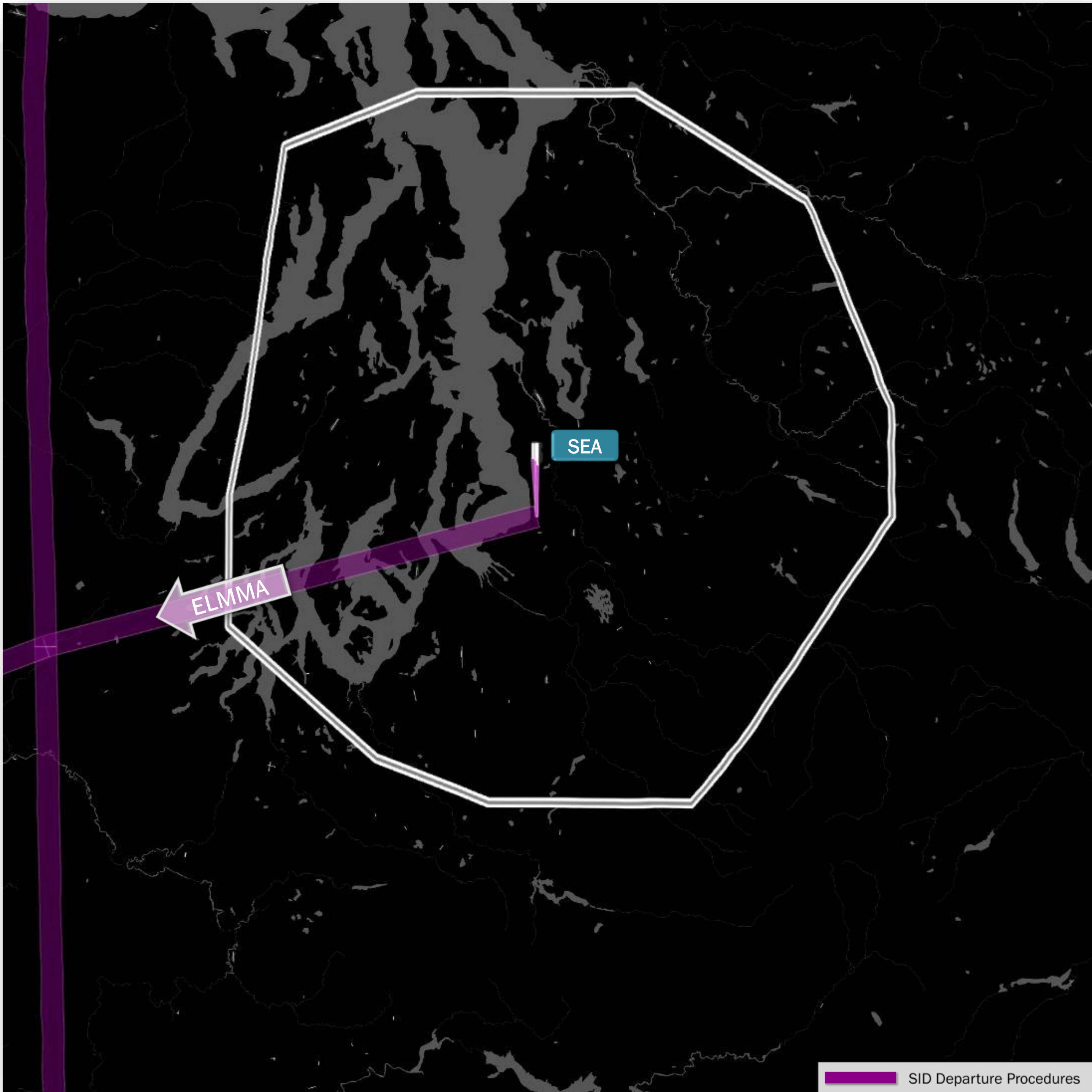
Figure B-3
SEA Standard Instrument Departures (SIDs)
SIDs North Flow Nighttime (10:00 pm to 6:00 am)



Notes: SEA - Seattle-Tacoma International Airport

Figure B-4
SEA Standard Instrument Departures (SIDs)
ELMMA SID South Flow Only

Puget Sound Regional Council

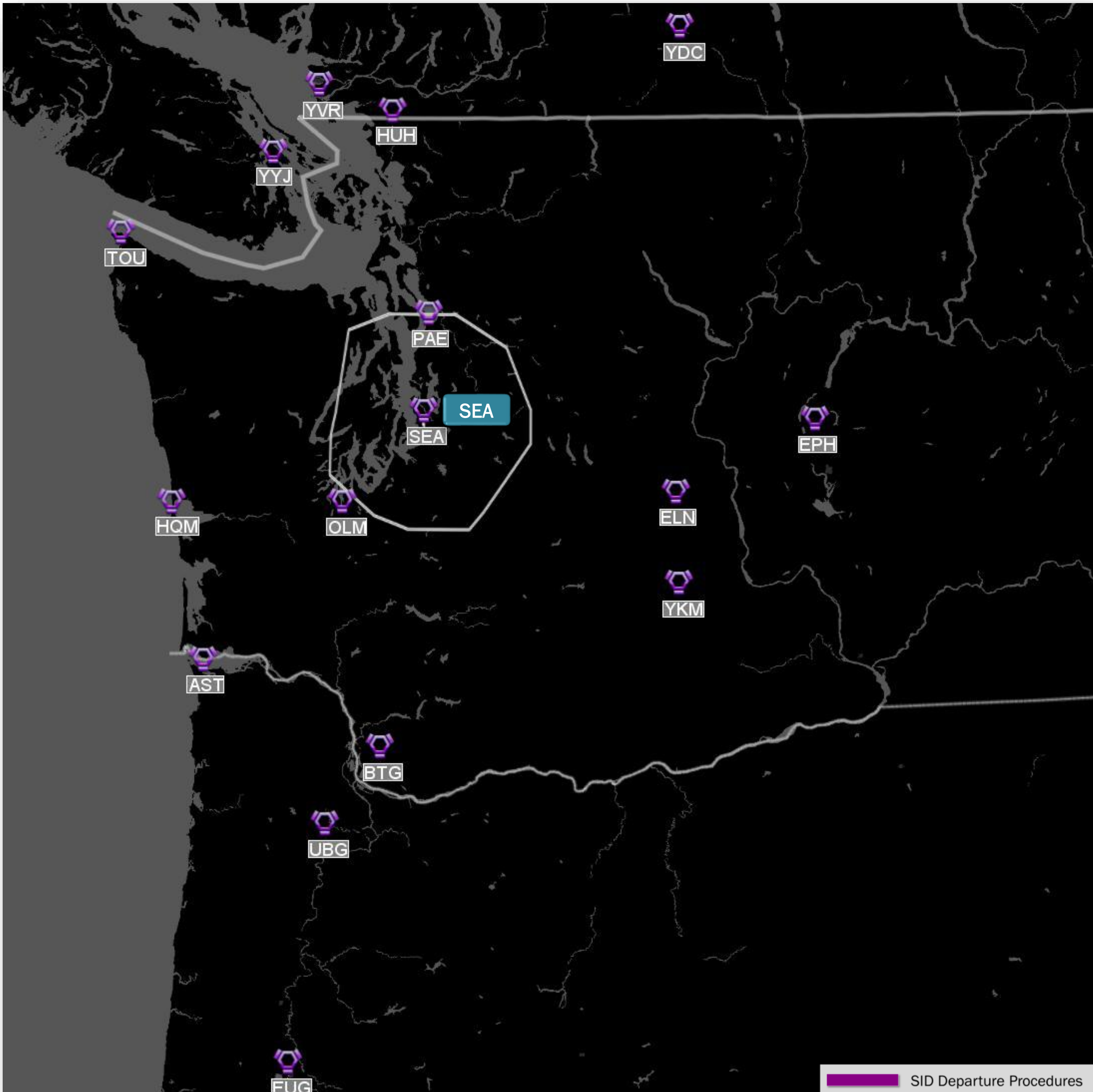


Notes: SEA - Seattle-Tacoma International Airport
Lightly Used Conventional Departure Procedure in South Flow Only

Figure B-5

SEA Standard Instrument Departures (SIDs)

SEATTLE SEVEN SID Used in Both North and South Flows



Notes: SEA - Seattle-Tacoma International Airport

Lightly used conventional radar vector departure procedure used for smaller aircraft in all flows and directions

Source: BridgeNet International 2019

Figure B-6
SEA Standard Terminal Arrival Procedures (STARs)
Primary STARs in South Flow

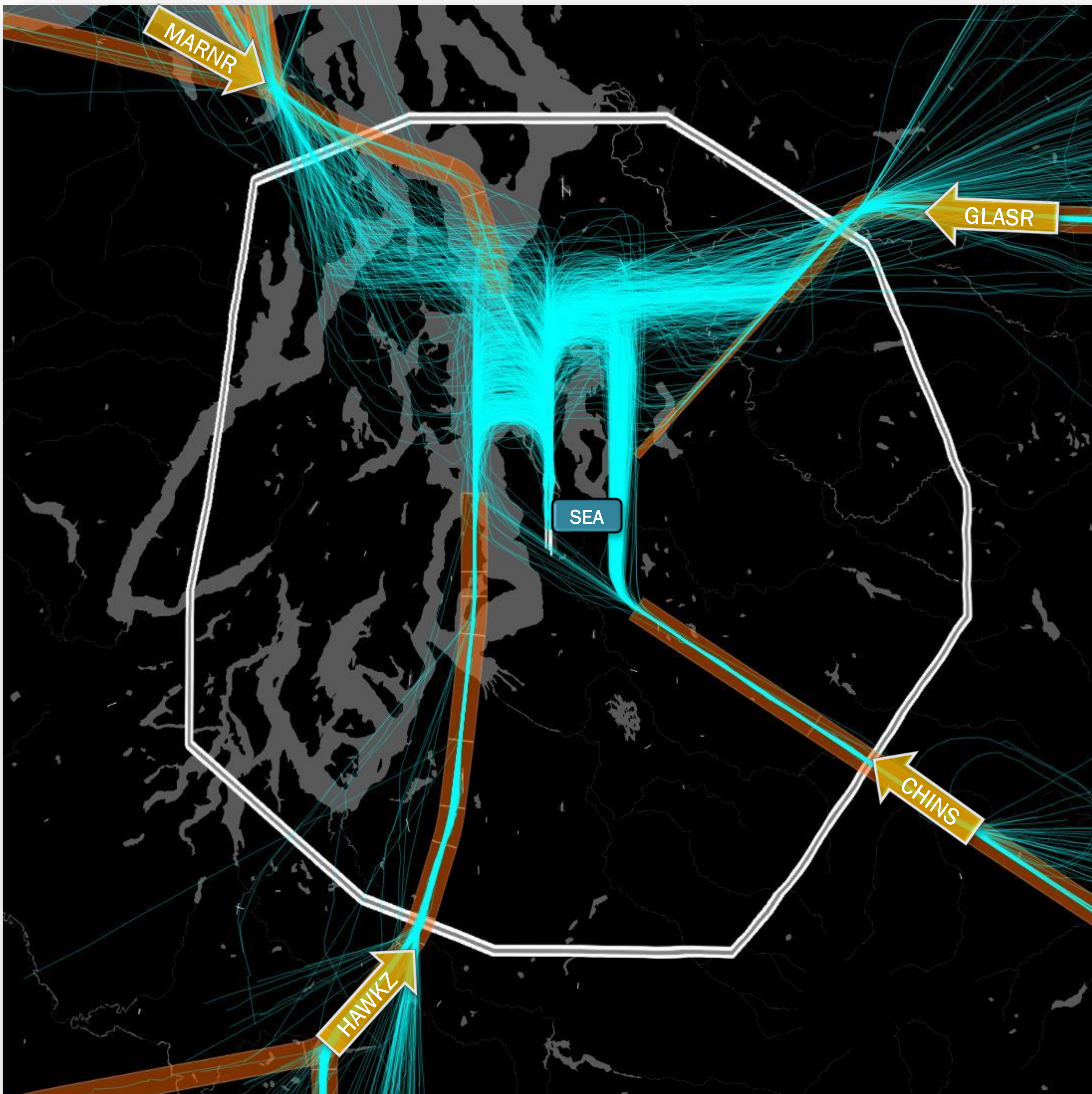
Puget Sound Regional Council

Notes: SEA - Seattle-Tacoma International Airport

Source: BridgeNet International 2019

Figure B-7
SEA Standard Terminal Arrival Procedures (STARs)
Primary STARs in South Flow with Radar Tracks

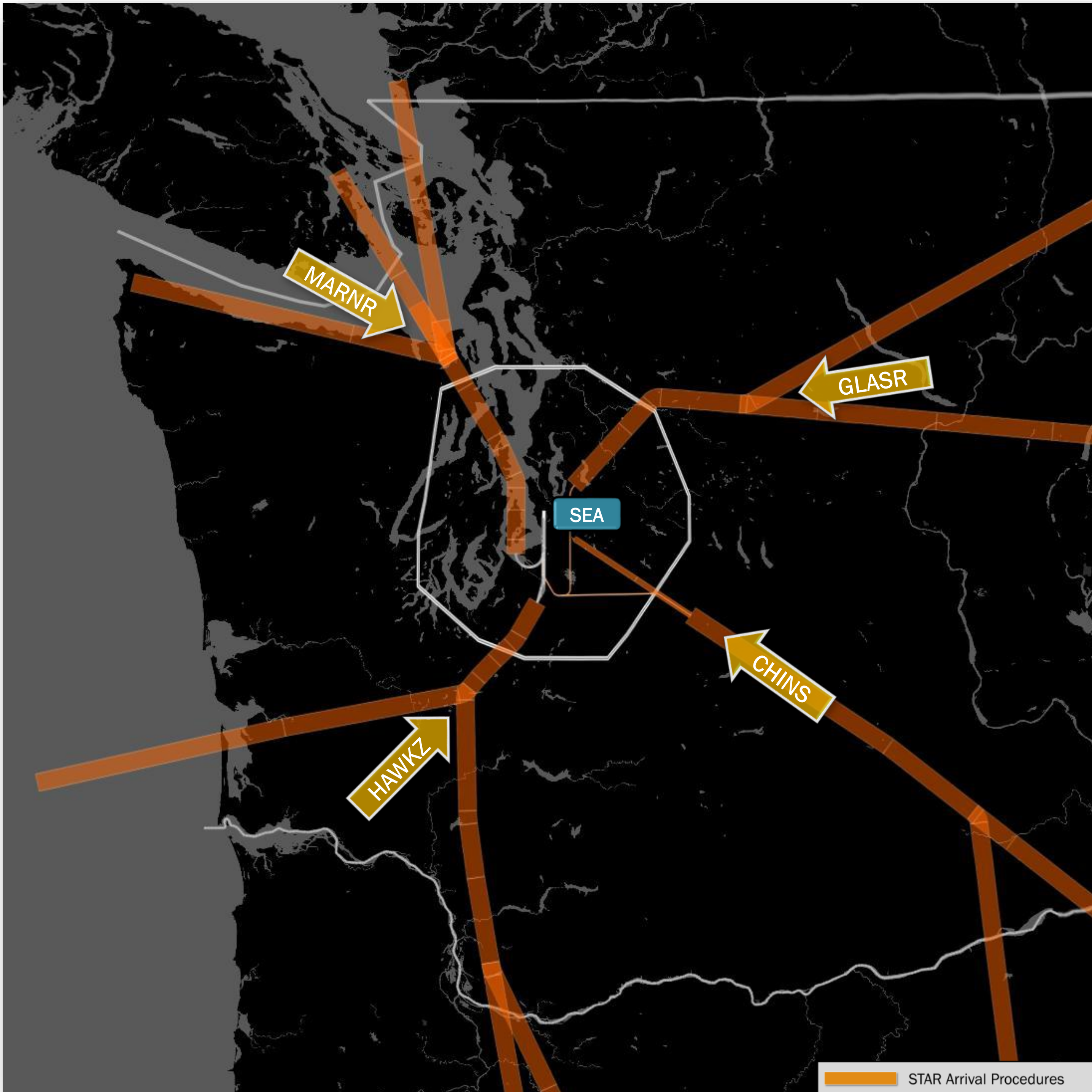
Puget Sound Regional Council



Notes: SEA - Seattle-Tacoma International Airport

Figure B-8
SEA Standard Terminal Arrival Procedures (STARs)
Primary STARs in North Flow

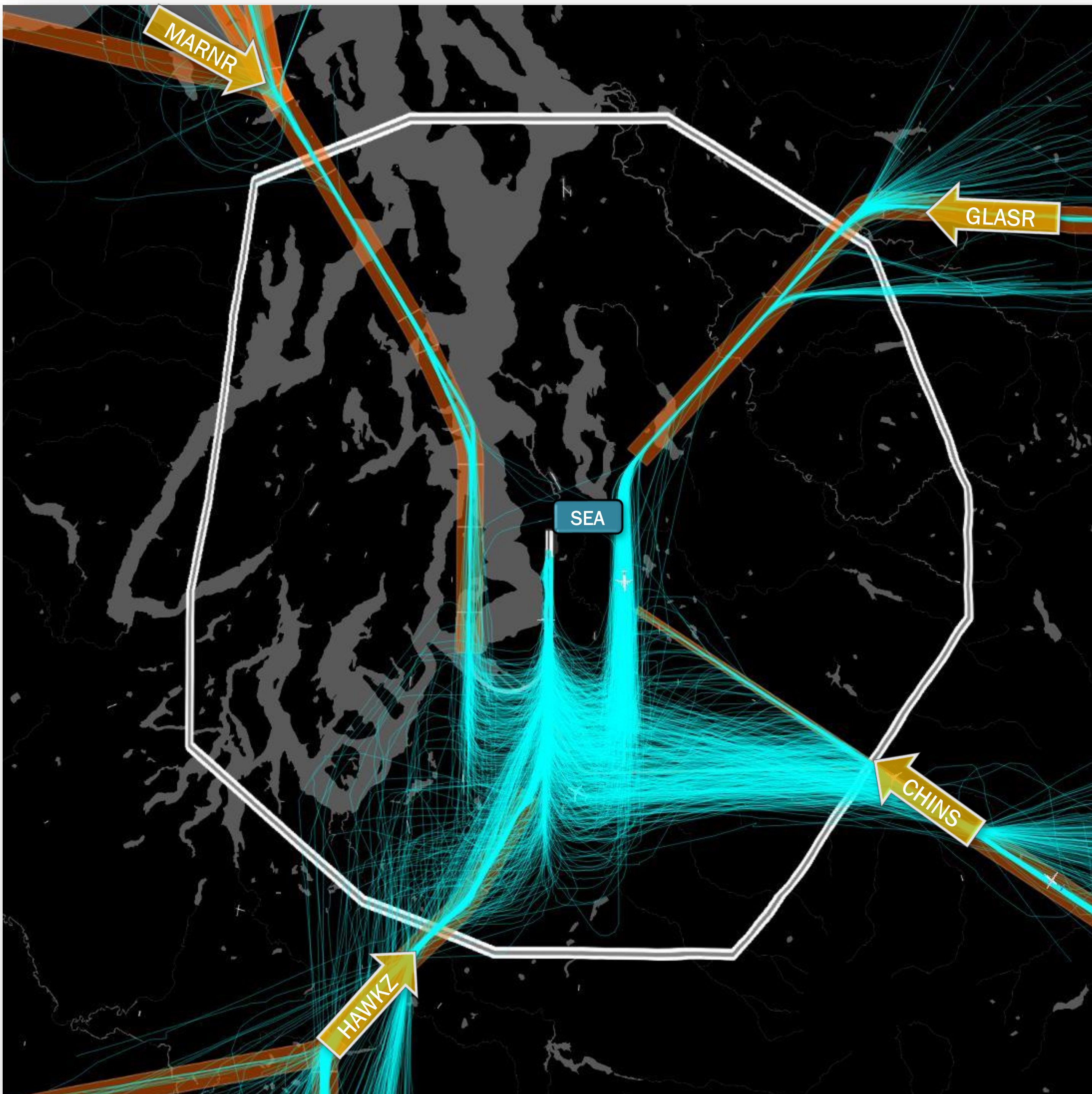
Puget Sound Regional Council



Notes: SEA - Seattle-Tacoma International Airport

Figure B-9
SEA Standard Terminal Arrival Procedures (STARs)
Primary STARs in North Flow with Radar Tracks

Puget Sound Regional Council

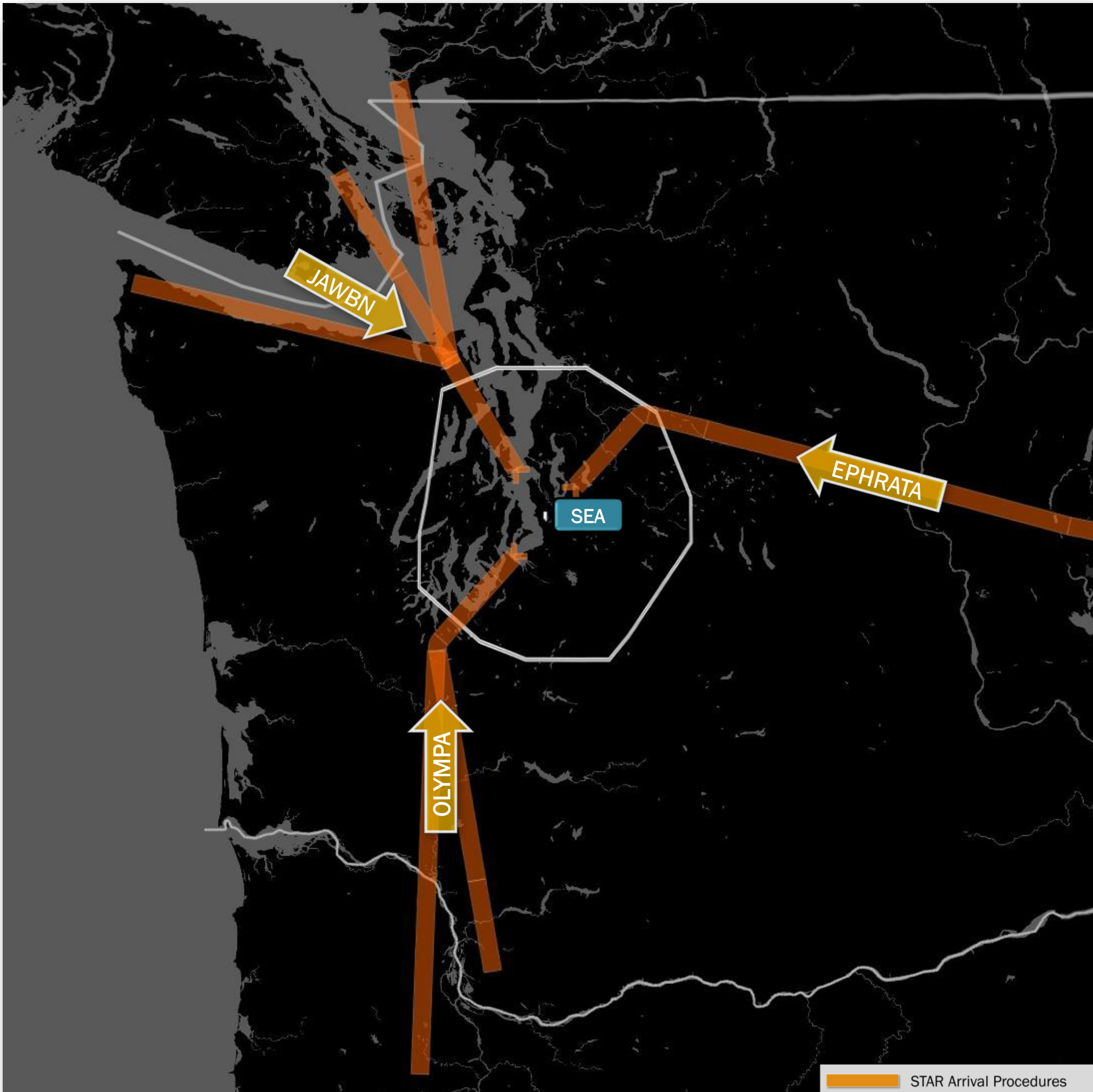


Notes: SEA - Seattle-Tacoma International Airport

Figure B-10

SEA Standard Terminal Arrival Procedures (STARs)

Lightly Used STARs used in Both Flows



Notes: SEA - Seattle-Tacoma International Airport

Source: BridgeNet International 2019

Figure B-11
SEA Instrument Approach Procedures (IAPs)
ILS for South Flow (Runway 16C, 16L, 16R)

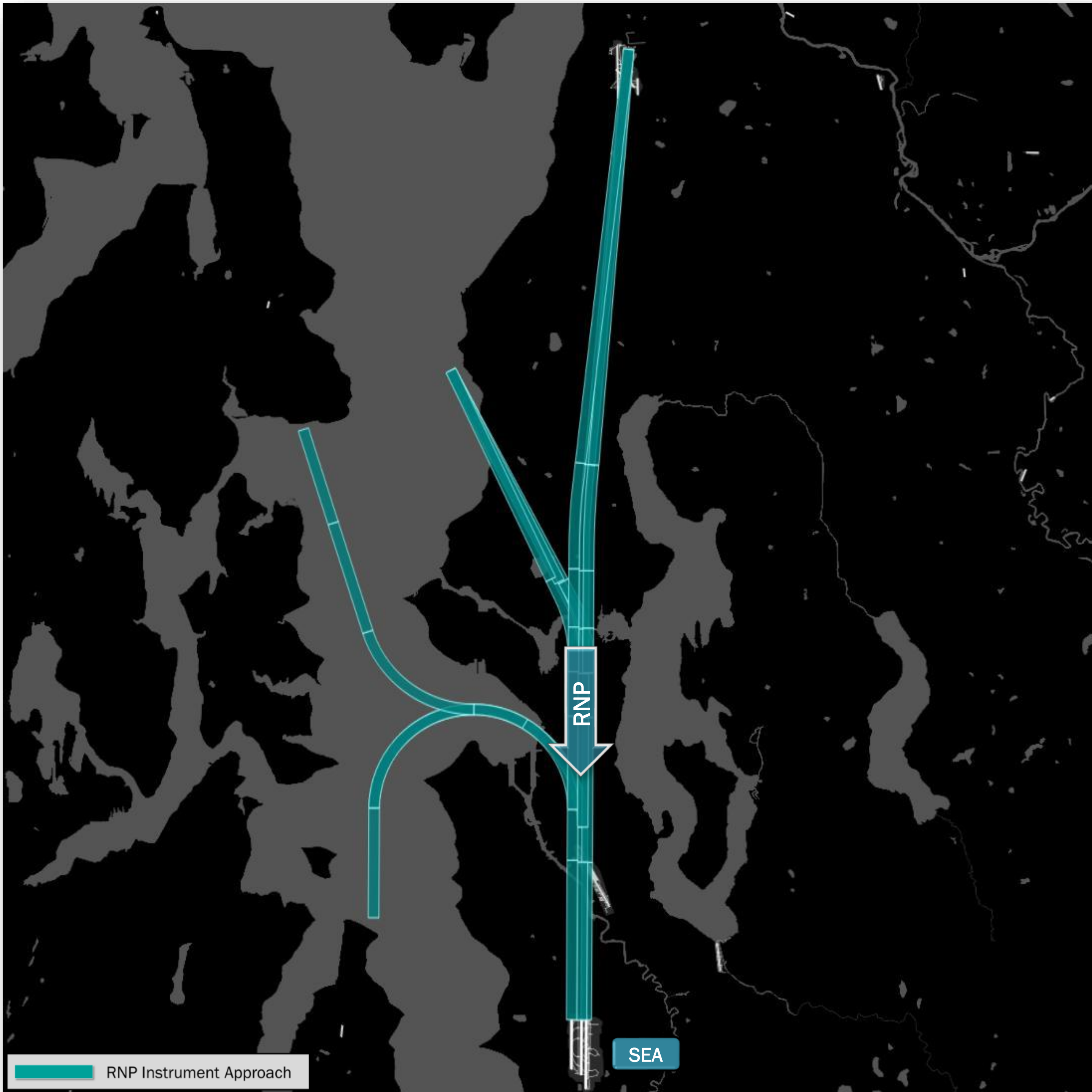
Puget Sound Regional Council

Notes: SEA - Seattle-Tacoma International Airport
Approach procedures for Runways 16C, 16L AND 16R.
ILS and GPS Instrument Approach Procedures are overlays of the same ground path.

Source: BridgeNet International 2019

Figure B-12
SEA Instrument Approach Procedures (IAPs)
RNP for South Flow (Runway 16C, 16L, 16R)

Puget Sound Regional Council

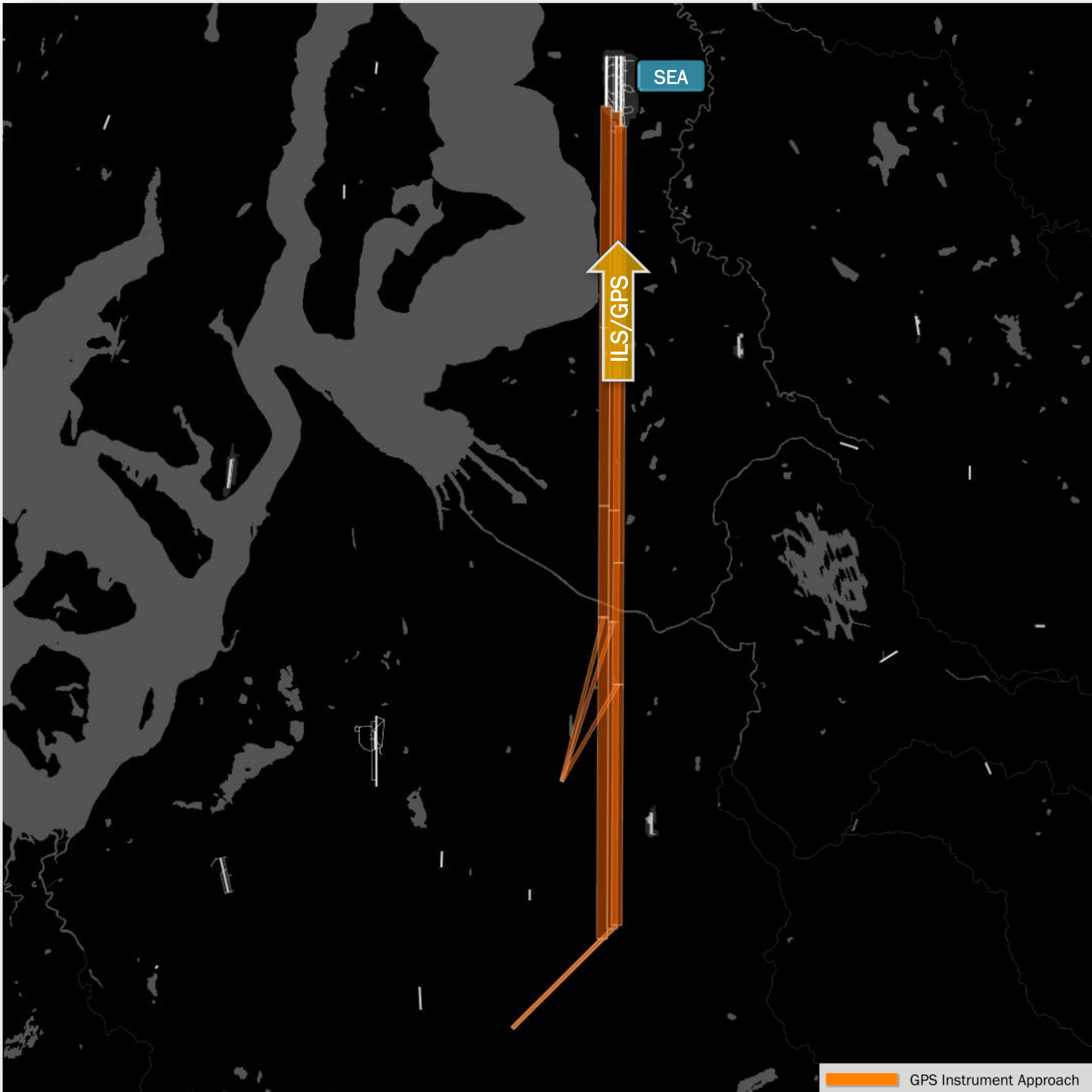


Notes: SEA - Seattle-Tacoma International Airport
Approach procedures for Runways 34C, 34L AND 34R.

Source: BridgeNet International 2019

Figure B-13
SEA Instrument Approach Procedures (IAPs)
ILS for North Flow (Runway 34C, 34L, 34R)

Puget Sound Regional Council

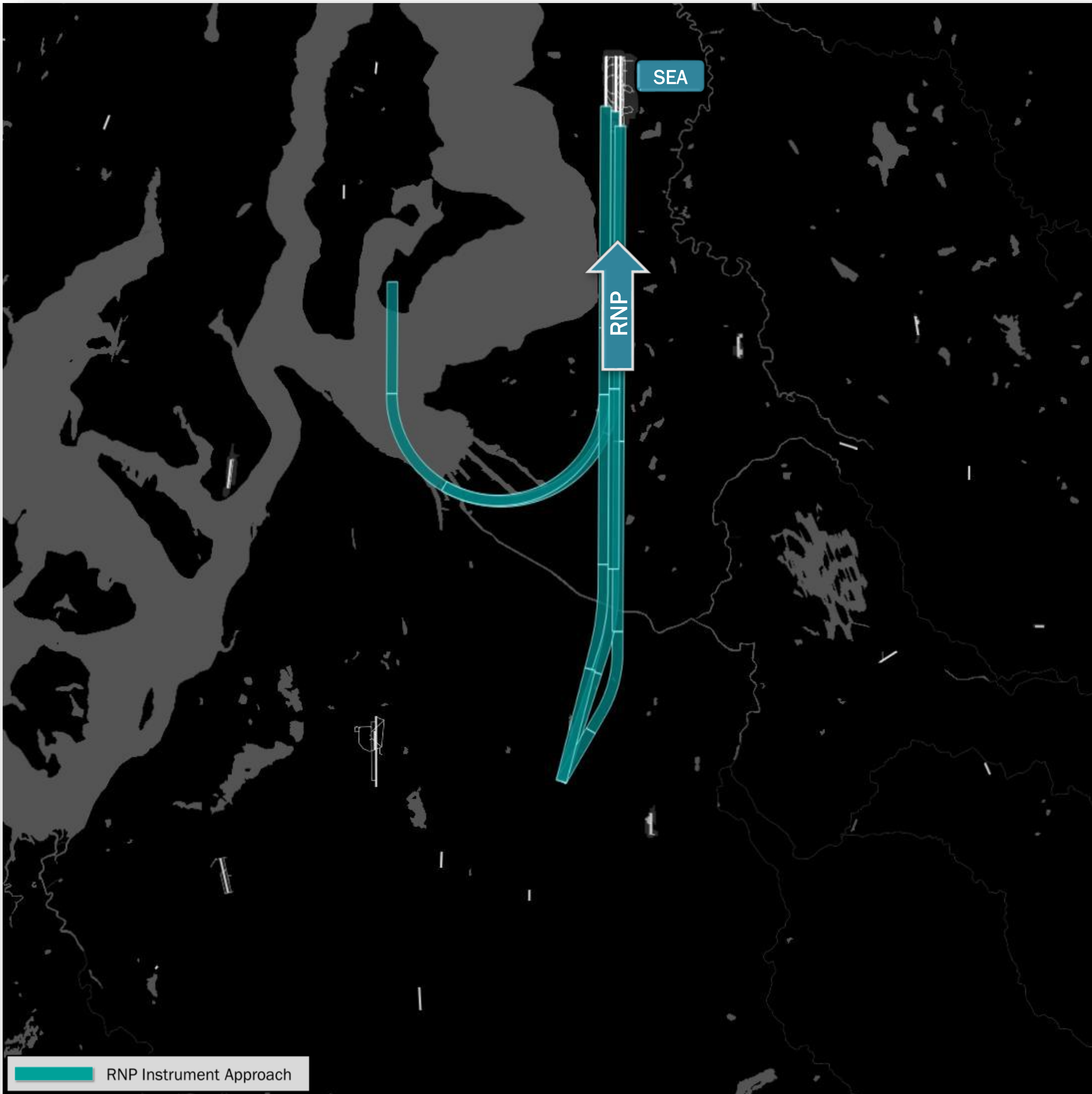


Notes: SEA - Seattle-Tacoma International Airport
Approach procedures for Runways 34C, 34L AND 34R.
ILS and GPS Instrument Approach Procedures are overlays of the same ground path.

Source: BridgeNet International 2019

Figure B-14
SEA Instrument Approach Procedures (IAPs)
RNP for North Flow (Runway 34C, 34L, 34R)

Puget Sound Regional Council

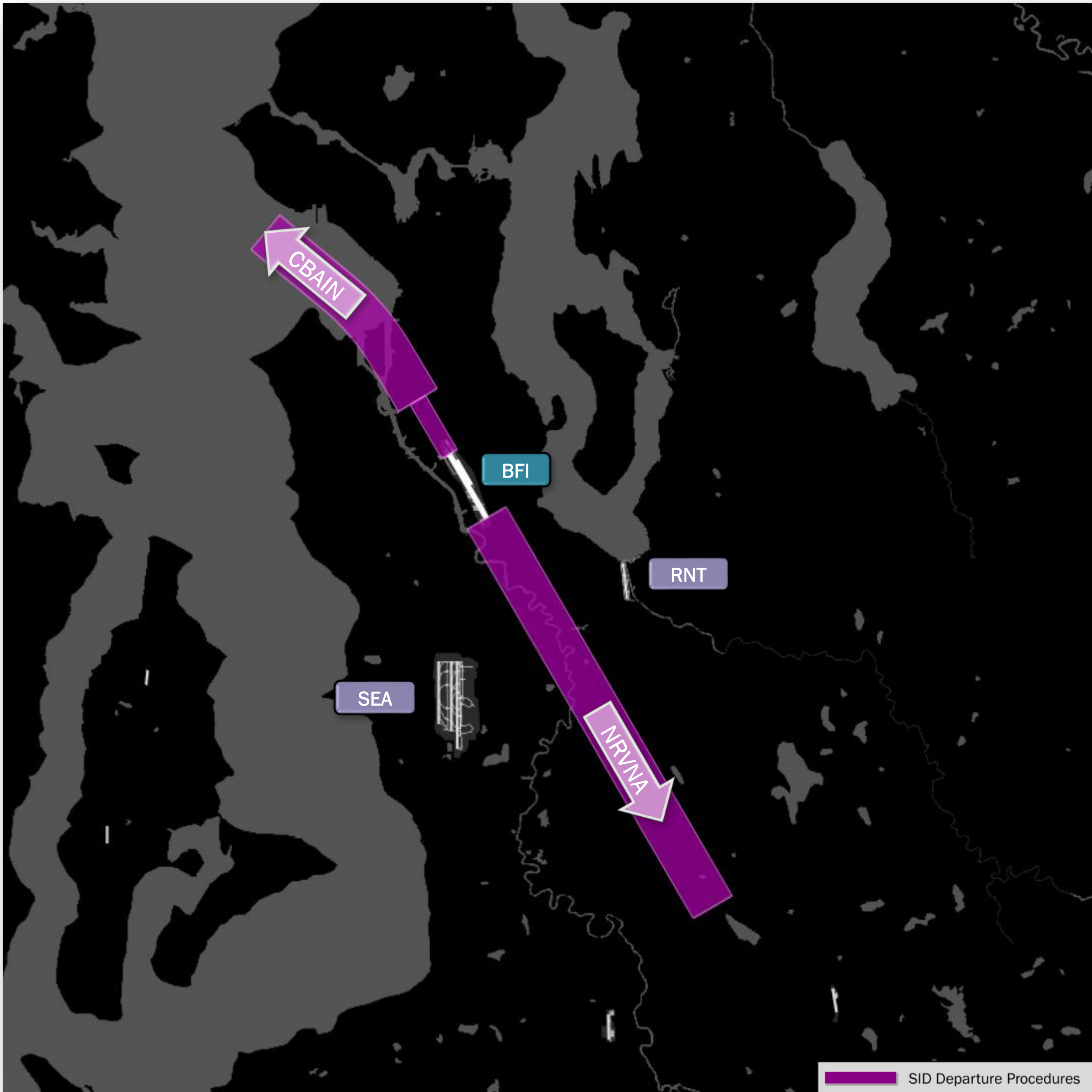


Notes: SEA - Seattle-Tacoma International Airport
Approach procedures for Runways 16C, 16L AND 16R.

Source: BridgeNet International 2019

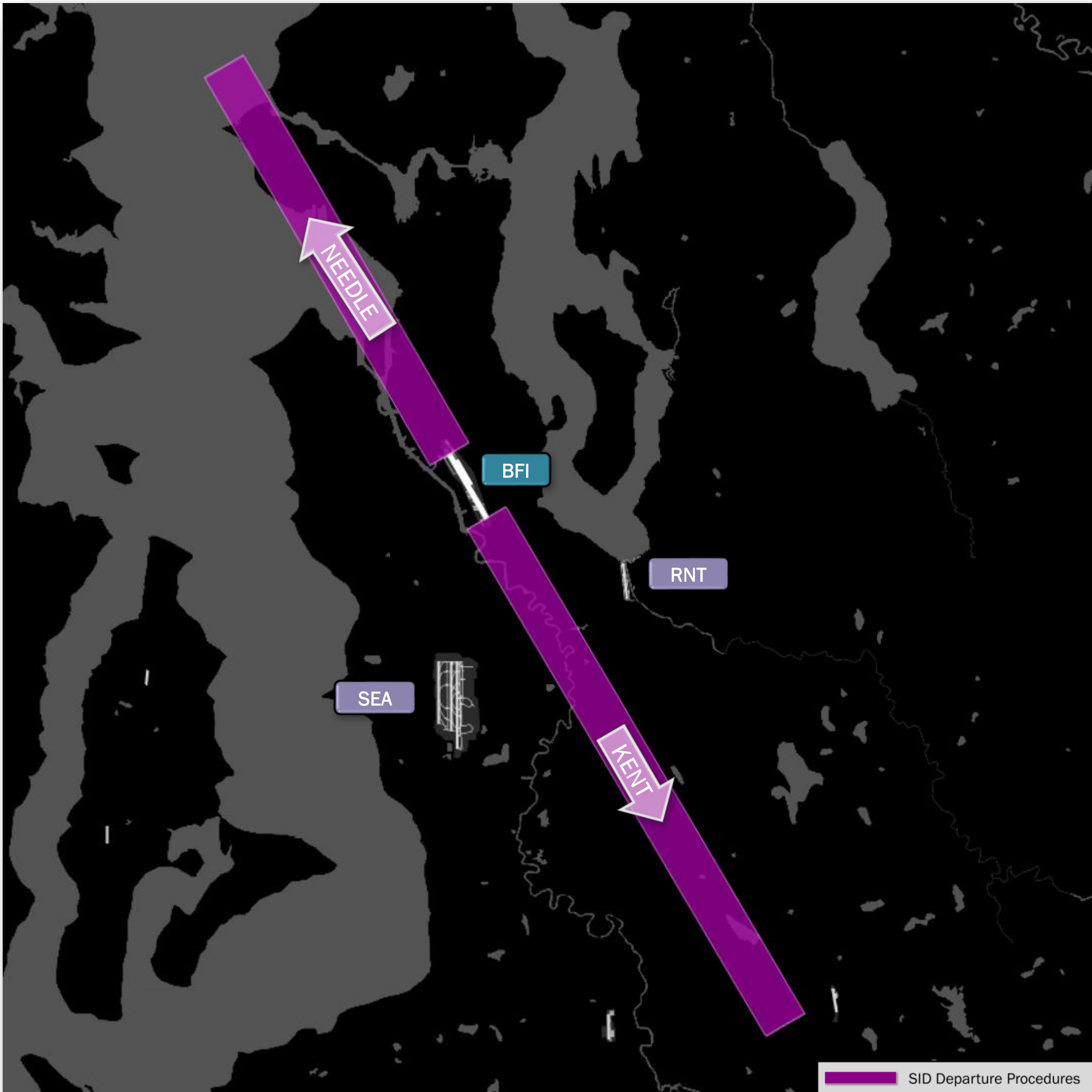
Appendix C
King County International/Boeing Field Flight Procedure Graphics

Figure C-1
BFI Standard Instrument Departures (SIDs)
RNAV SIDs in Both North and South Flow



Notes: BFI - Boeing Field/King County International Airport

Figure C-2
BFI Standard Instrument Departures (SIDs)
Conventional SIDs in Both North and South Flow



Notes: BFI - Boeing Field/King County International Airport

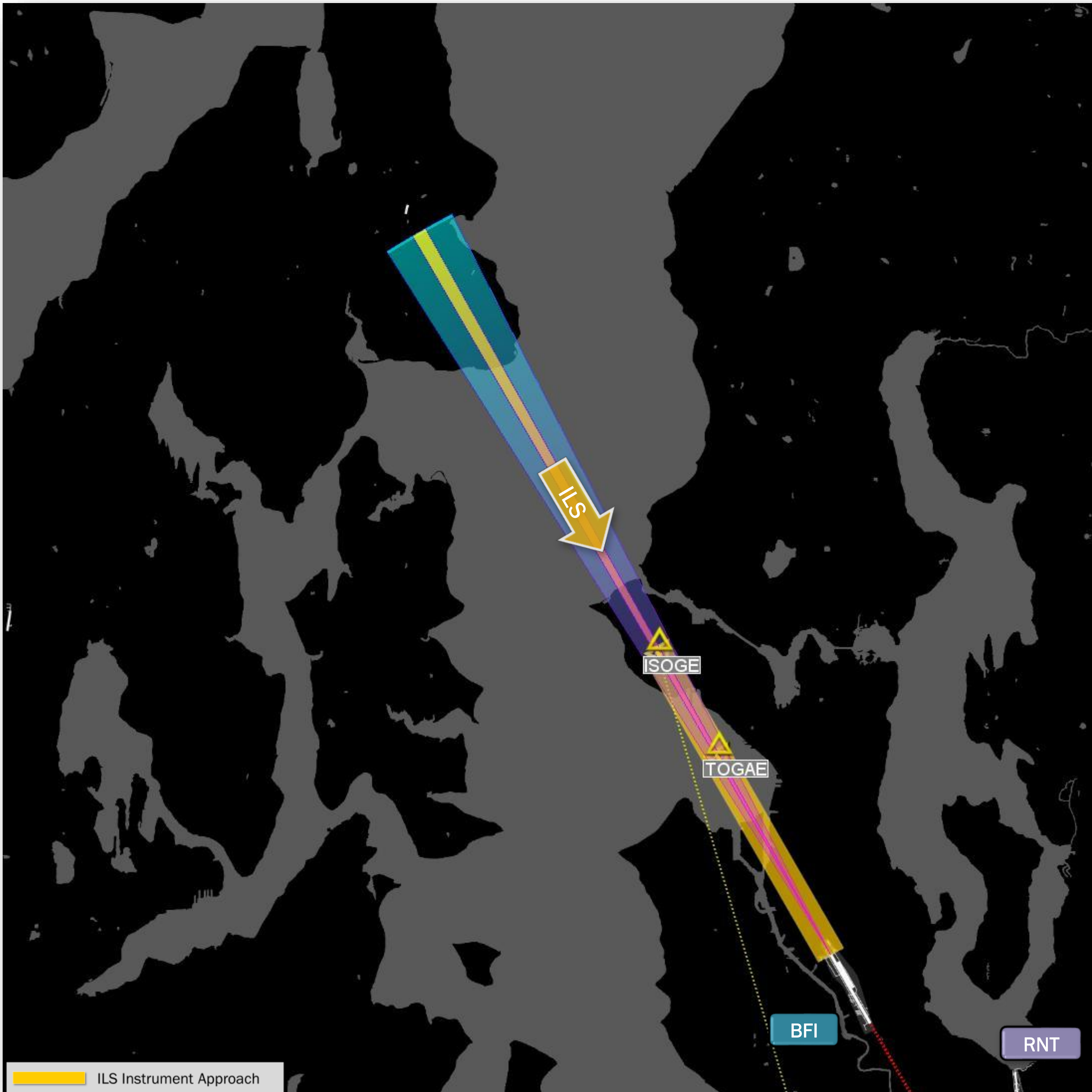
Figure C-3
BFI Standard Terminal Arrival Procedures (STARs)
STARs for Both North and South Flow

Notes: BFI - Boeing Field/King County International Airport

Source: BridgeNet International 2019

Figure C-4
BFI Instrument Approach Procedures (IAPs)
ILS South Flow (Runway 14R)

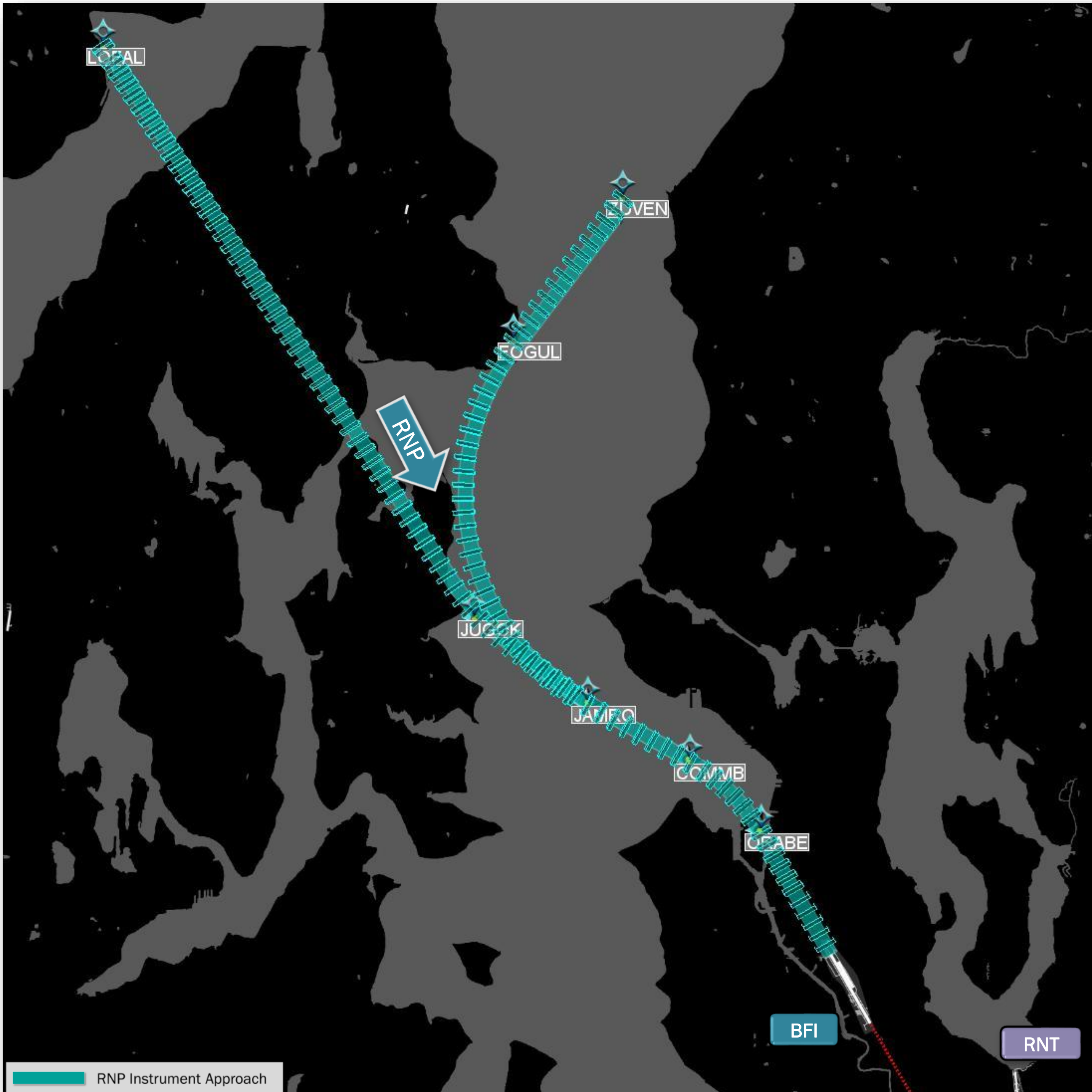
Puget Sound Regional Council



Notes: BFI - Boeing Field/King County International Airport

Figure C-5
BFI Instrument Approach Procedures (IAPs)
RNP South Flow (Runway 14R)

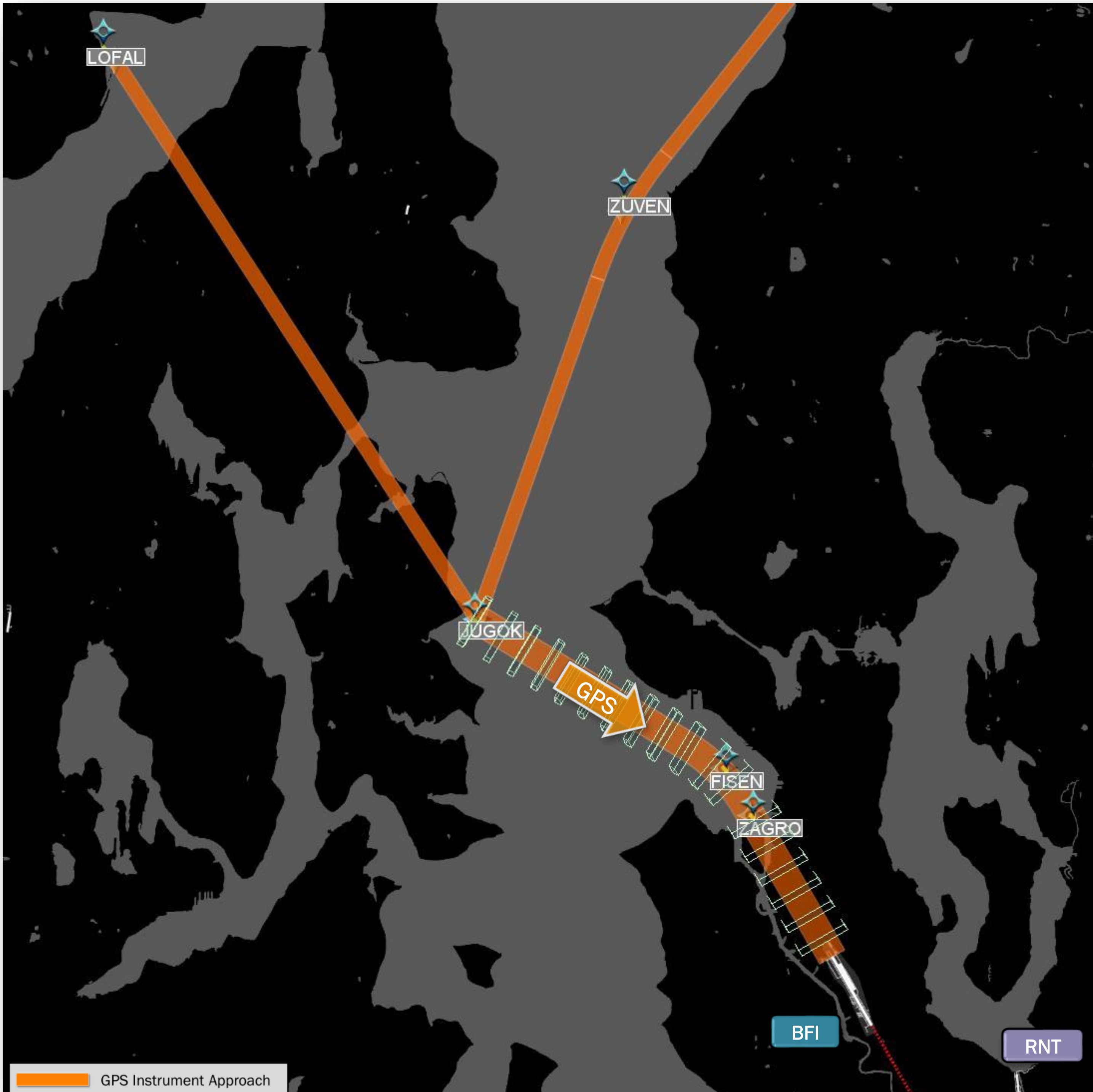
Puget Sound Regional Council



Notes: BFI - Boeing Field/King County International Airport

Figure C-6
BFI Instrument Approach Procedures (IAPs)
GPS South Flow (Runway 14R)

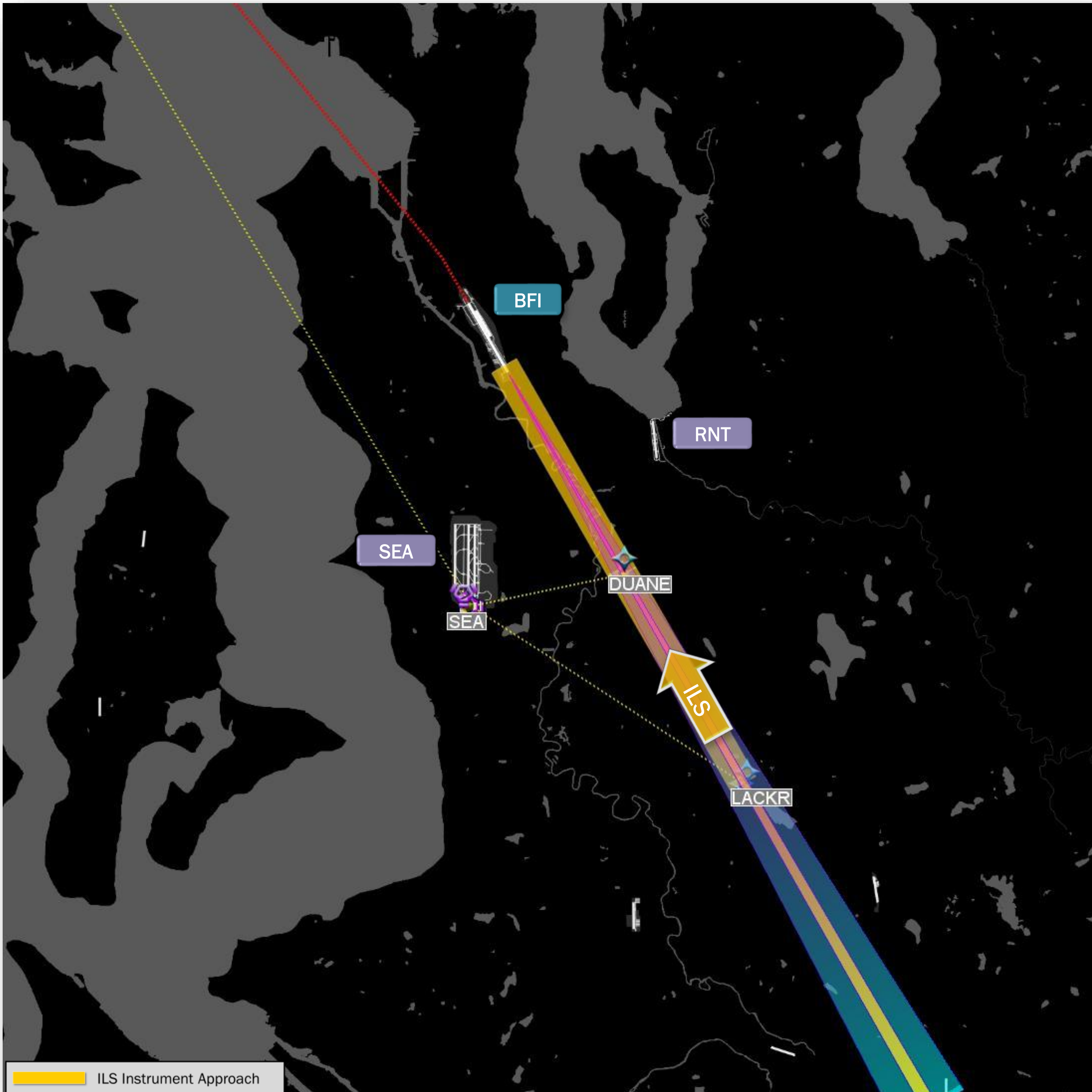
Puget Sound Regional Council



Notes: BFI - Boeing Field/King County International Airport

Figure C-7
BFI Instrument Approach Procedures (IAPs)
ILS South Flow (Runway 32L)

Puget Sound Regional Council



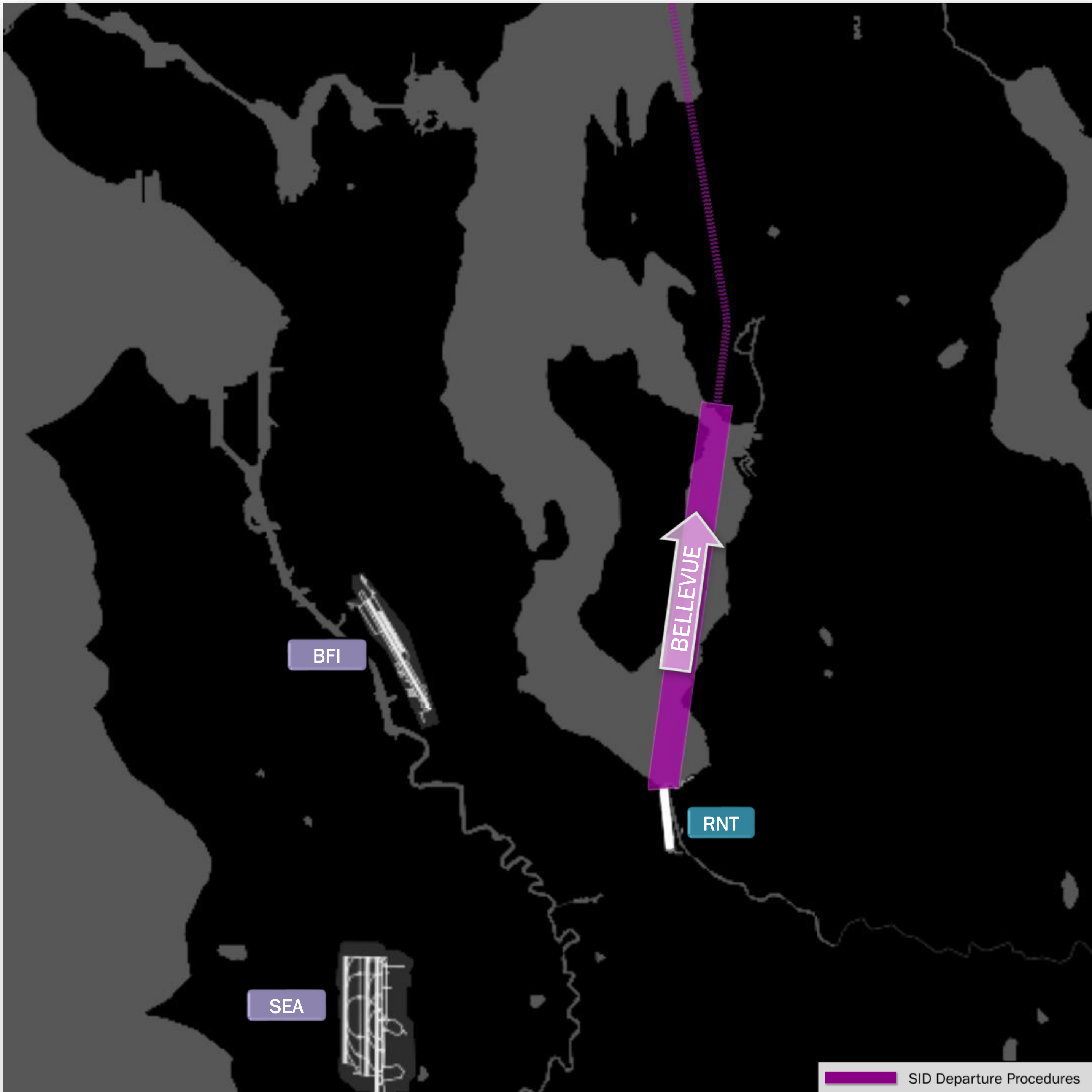
Notes: BFI - Boeing Field/King County International Airport

Source: BridgeNet International 2019

Appendix D
Renton Municipal Airport Flight Procedure Graphics

Figure D-1
RNT Standard Instrument Departures (SIDs)
BELLEVUE FOUR (RNAV) SIDs North Flow Only

Puget Sound Regional Council

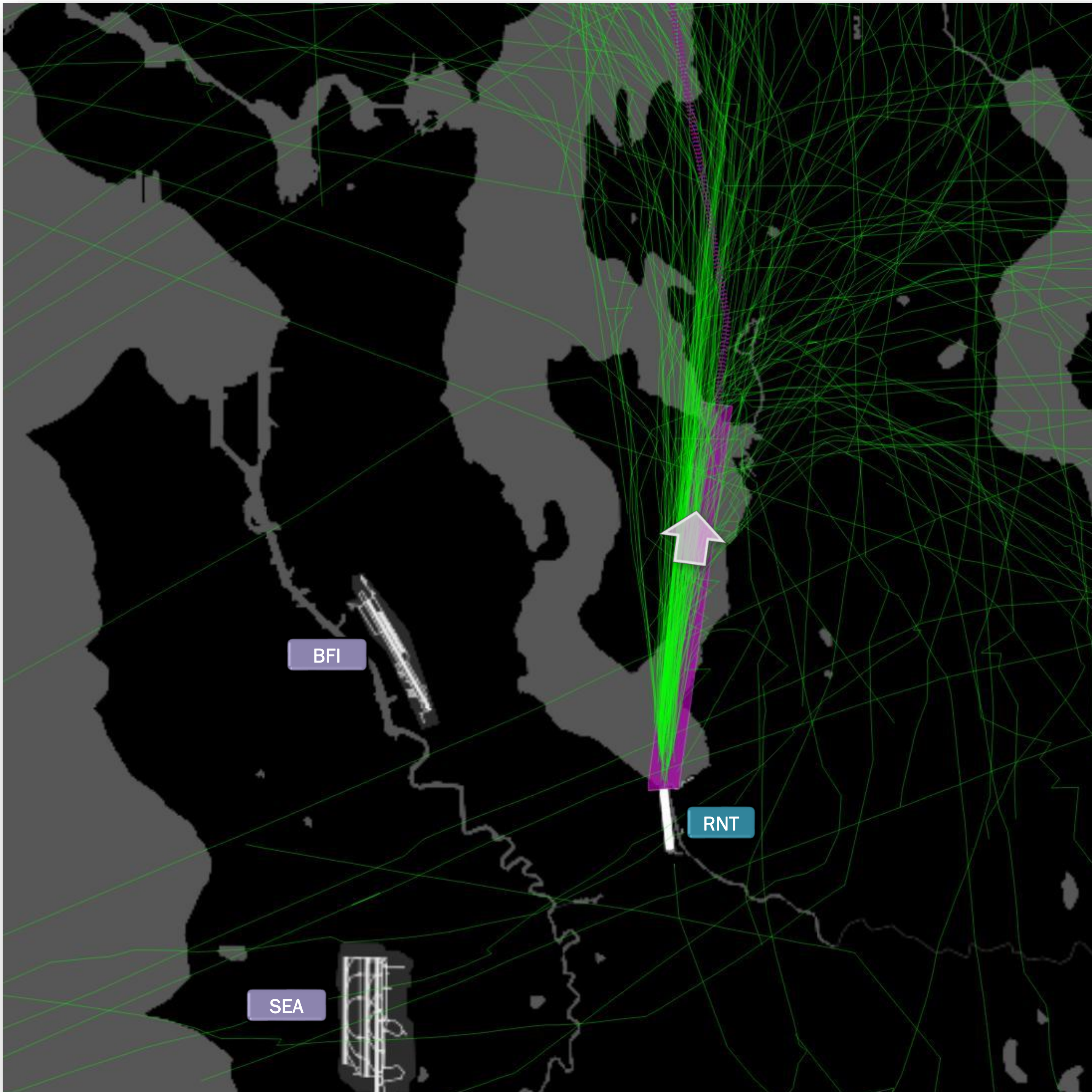


Notes: RNT - Renton Municipal Airport

Figure D-2

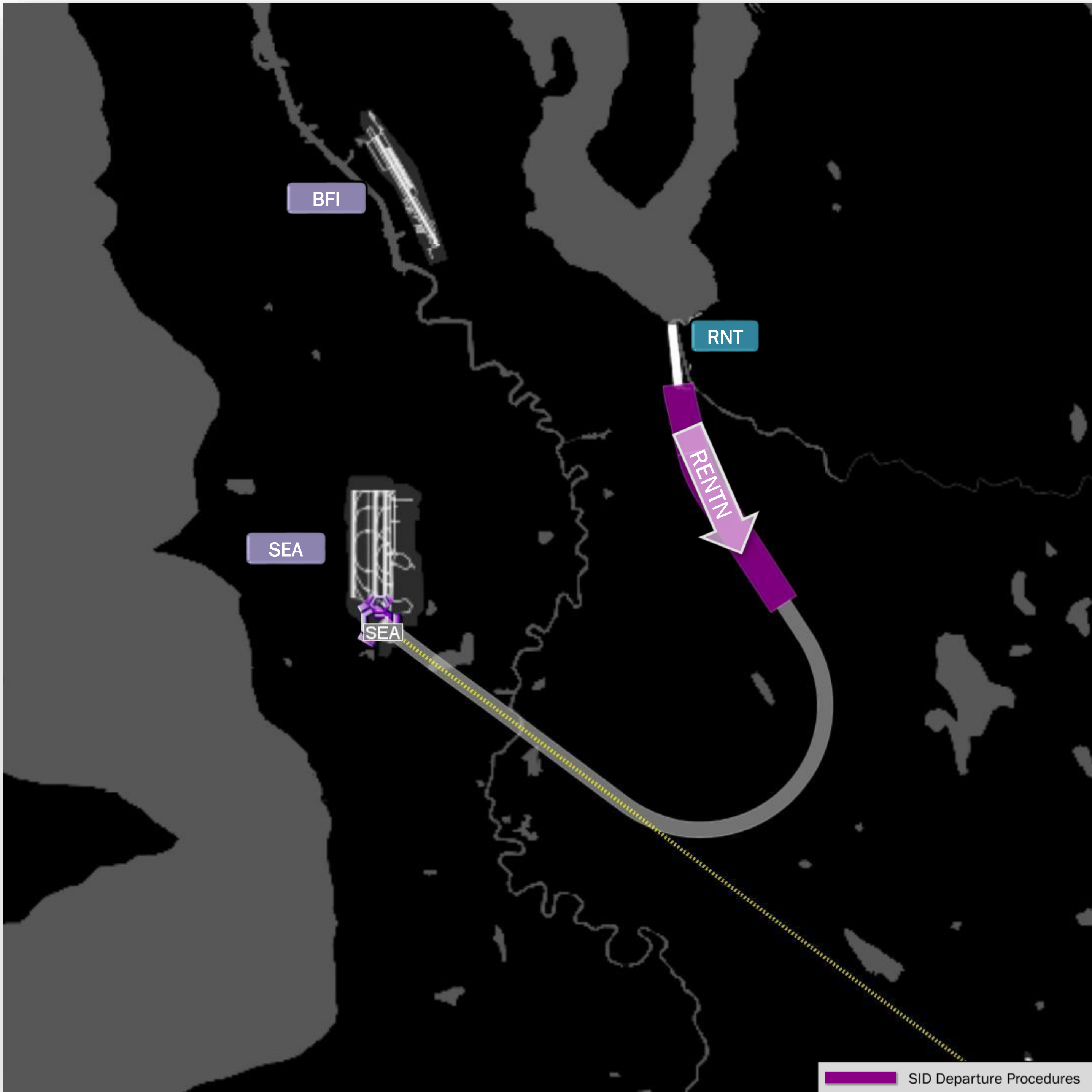
RNT Standard Instrument Departures (SIDs)

BELLEVUE FOUR (RNAV) SIDs North Flow Only with Radar Tracks



Notes: RNT - Renton Municipal Airport

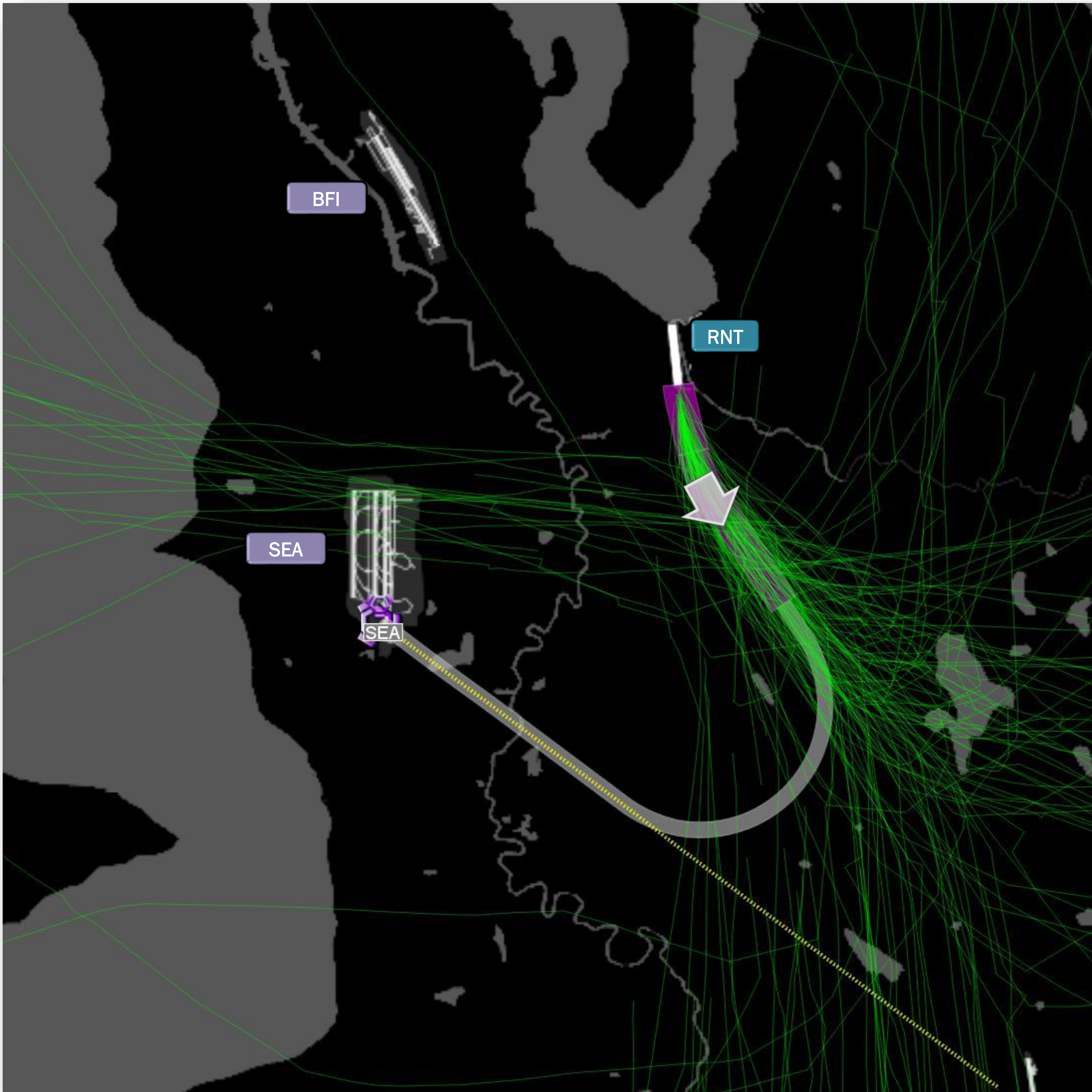
Figure D-3
RNT Standard Instrument Departures (SIDs)
RENTN THREE (RNAV) SIDs South Flow Only



Notes: RNT - Renton Municipal Airport

Source: BridgeNet International 2019

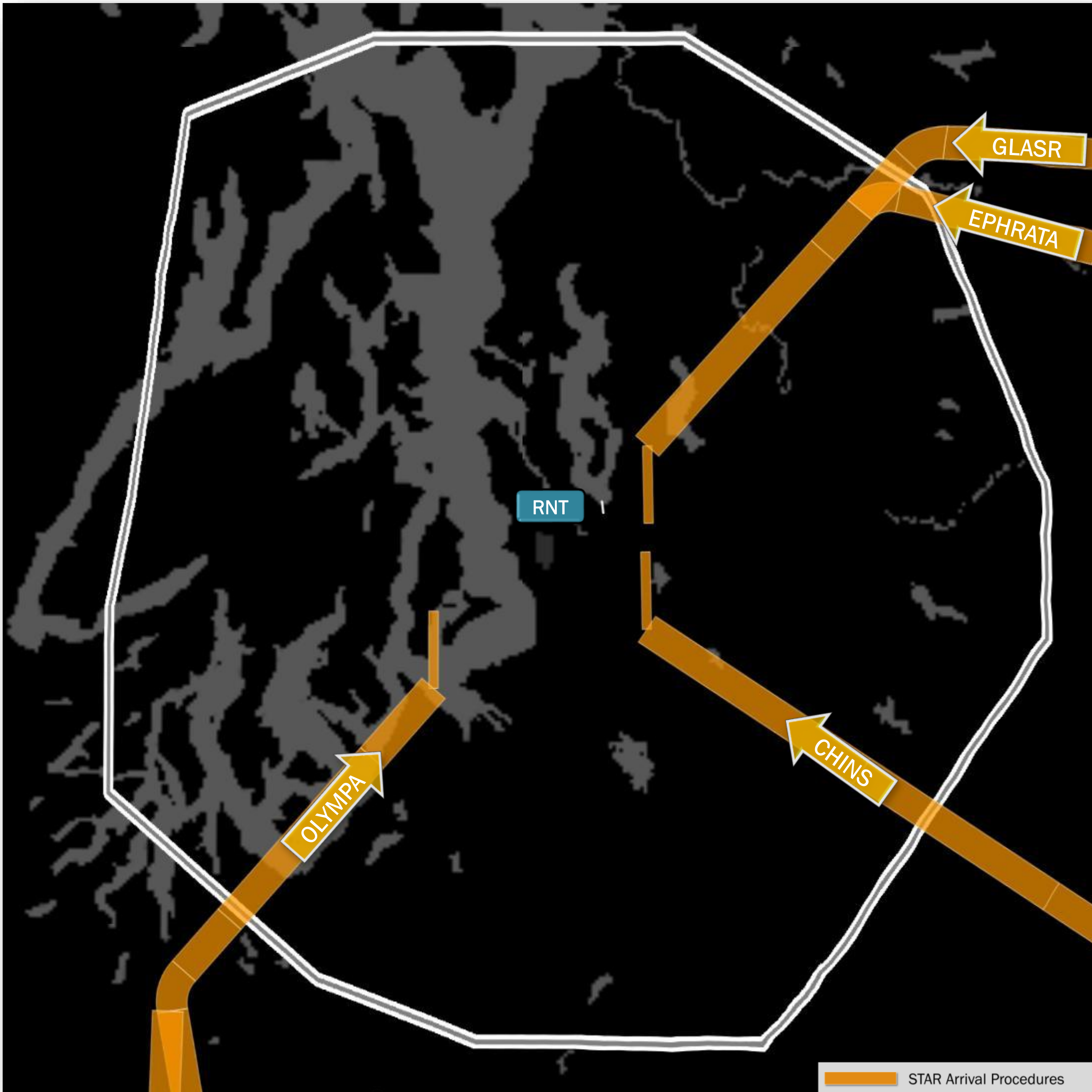
Figure D-4
RNT Standard Instrument Departures (SIDs)
RENTN THREE (RNAV) SIDs South Flow Only with Radar Tracks



Notes: RNT - Renton Municipal Airport

Figure D-5
RNT Standard Terminal Arrival Procedures (STARs)
STARs for Both North and South Flow

Puget Sound Regional Council



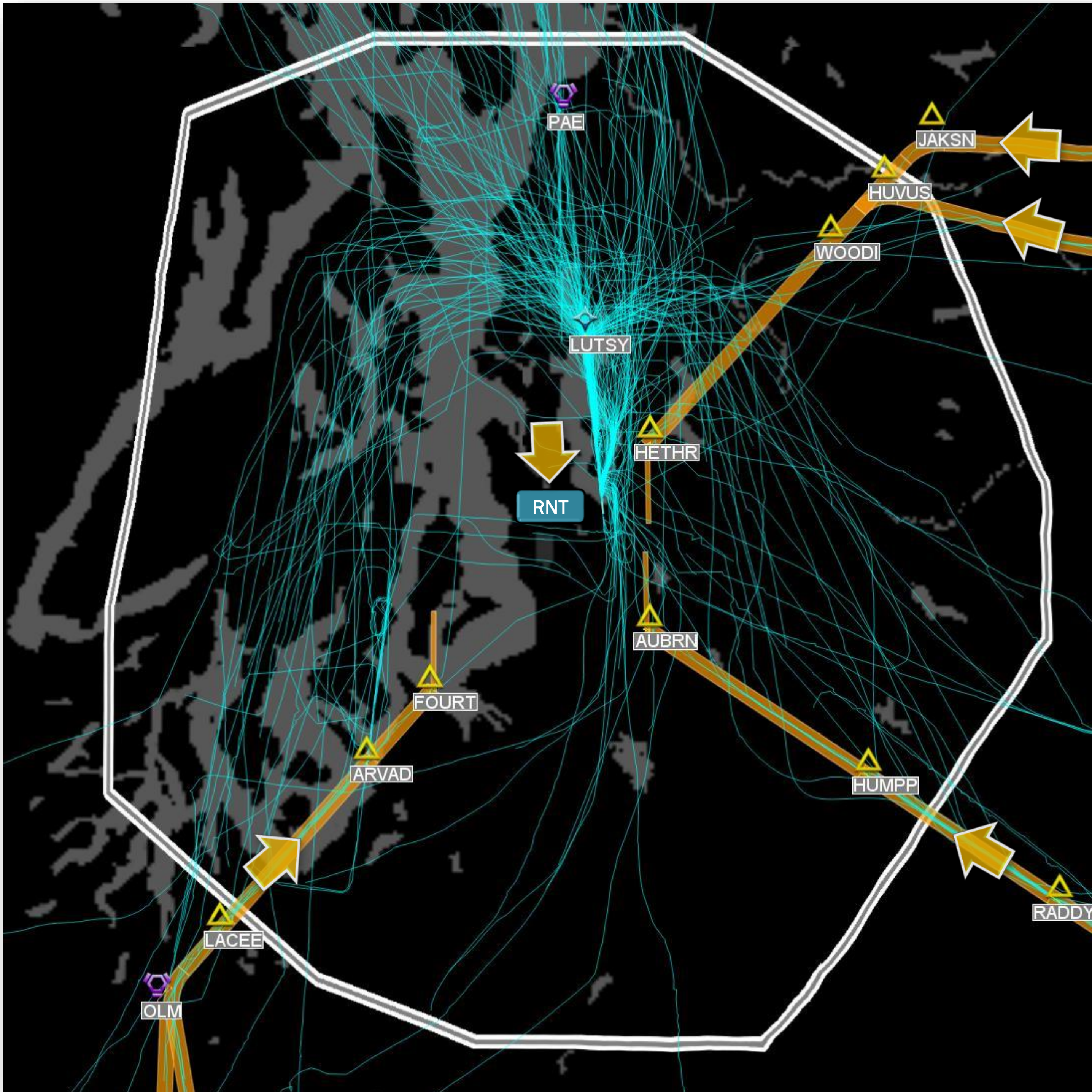
Notes:

Source: BridgeNet International 2019

Figure D-6

RNT Standard Terminal Arrival Procedures (STARs)

STARs for South Flow with Radar Tracks

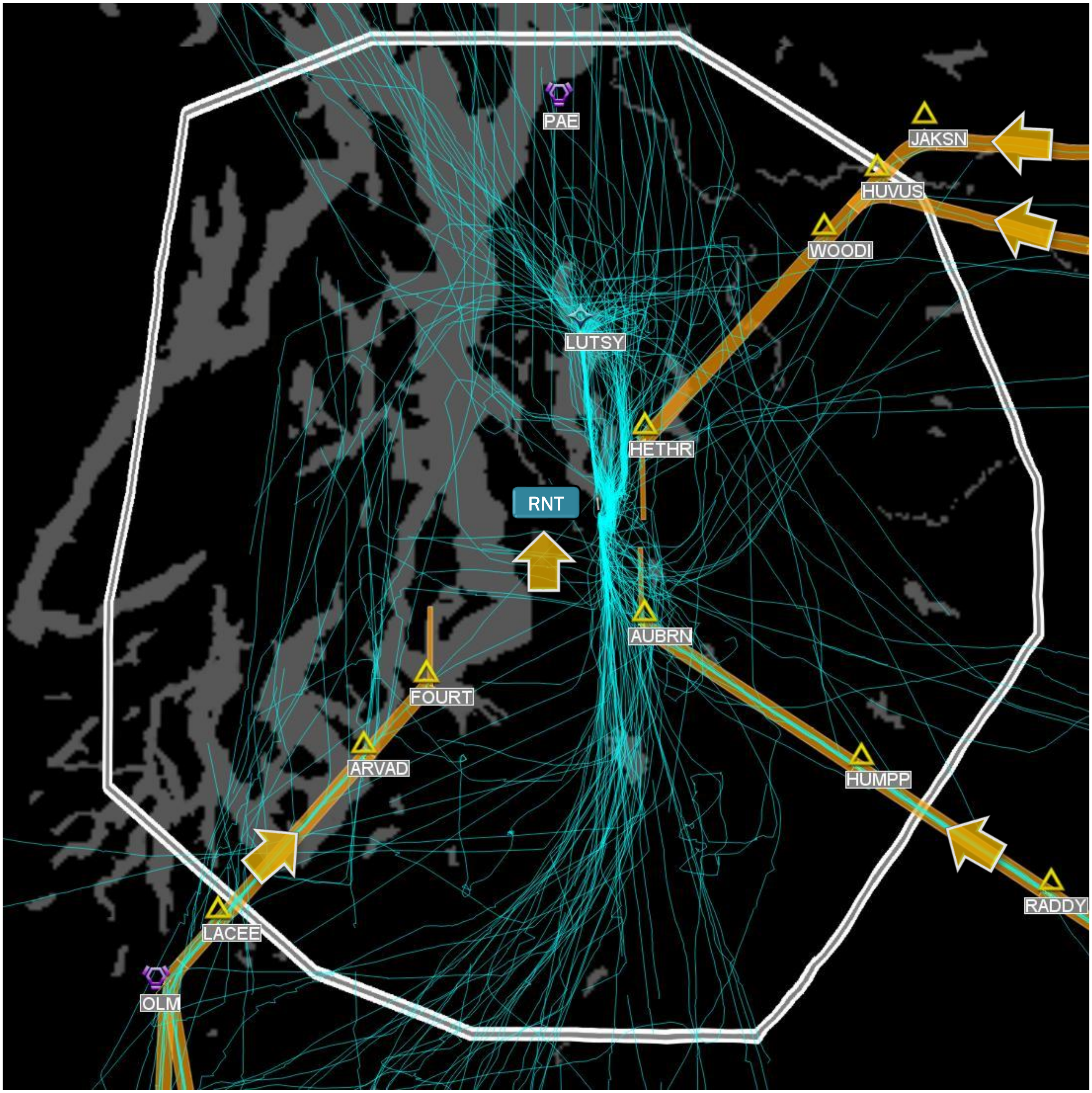


Notes: RNT - Renton Municipal Airport

Source: BridgeNet International 2019

Figure D-7
RNT Standard Terminal Arrival Procedures (STARs)
STARs for Both North Flow with Radar Tracks

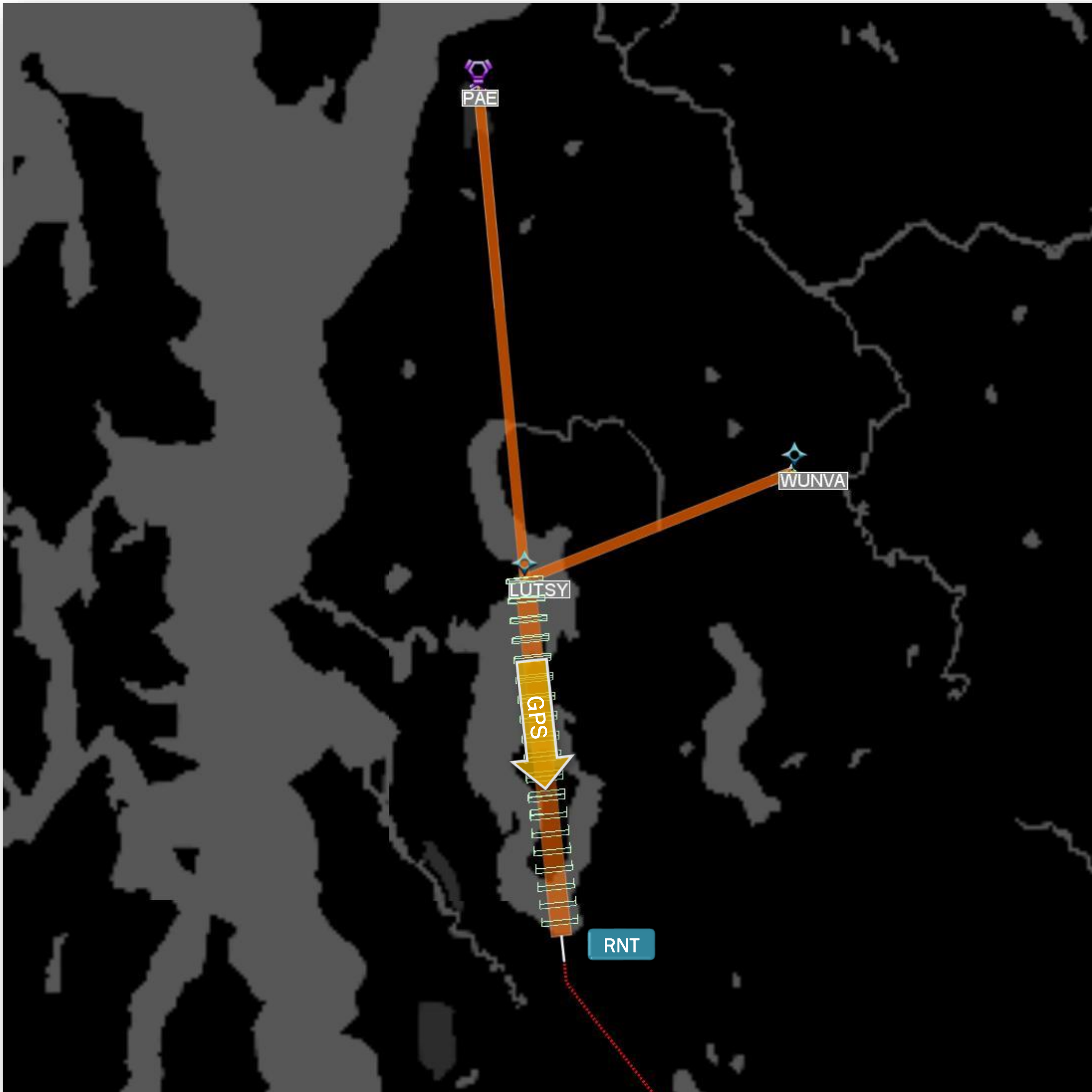
Puget Sound Regional Council



Notes:

Source: BridgeNet International 2019

Figure D-8
RNT Instrument Approach Procedures (IAPs)
RNAV (GPS) Z RWY 16 South Flow



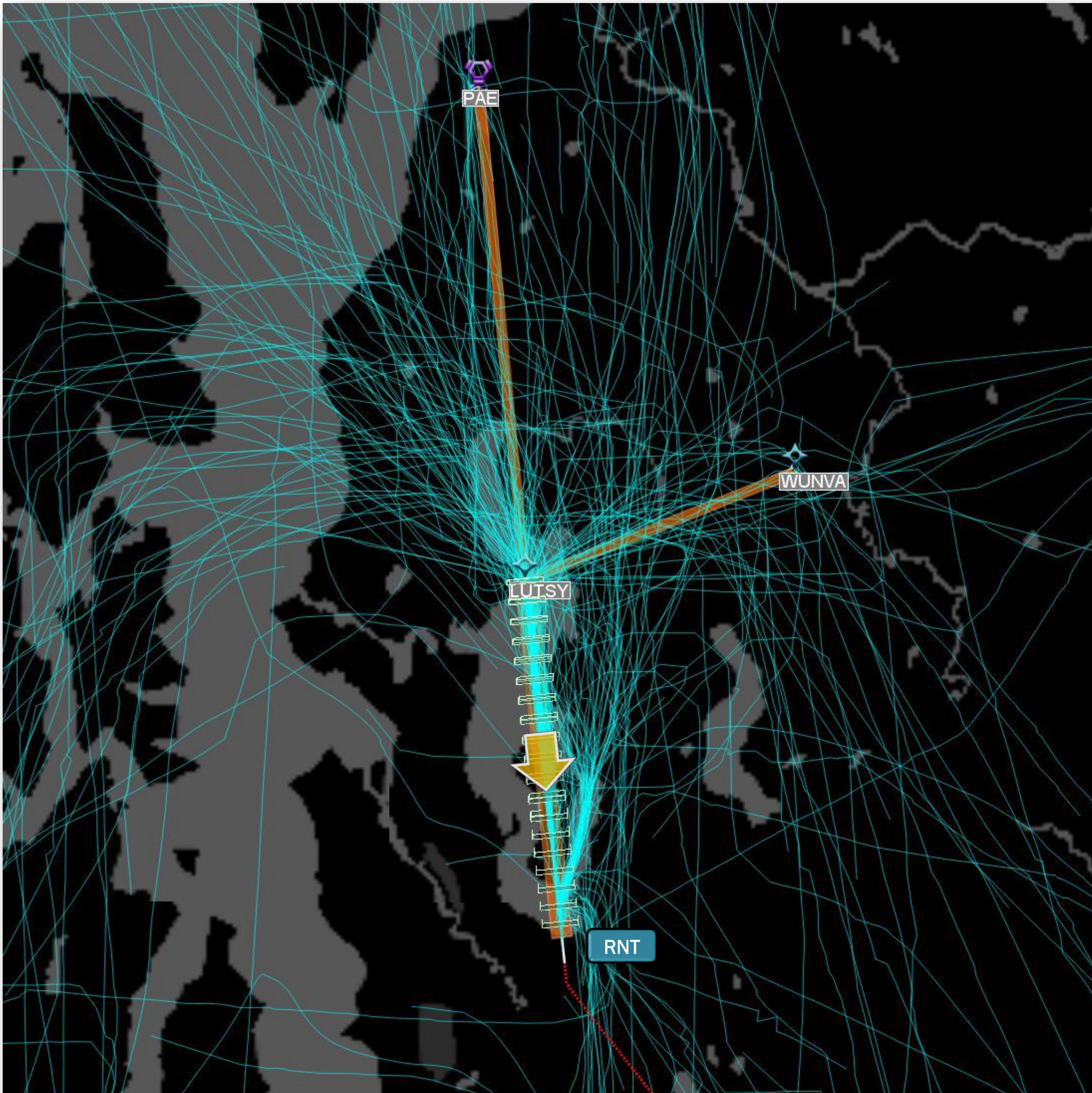
Notes: RNT - Renton Municipal Airport

Figure D-9

RNT Instrument Approach Procedures (IAPs)

RNAV (GPS) Z RWY 16 South Flow

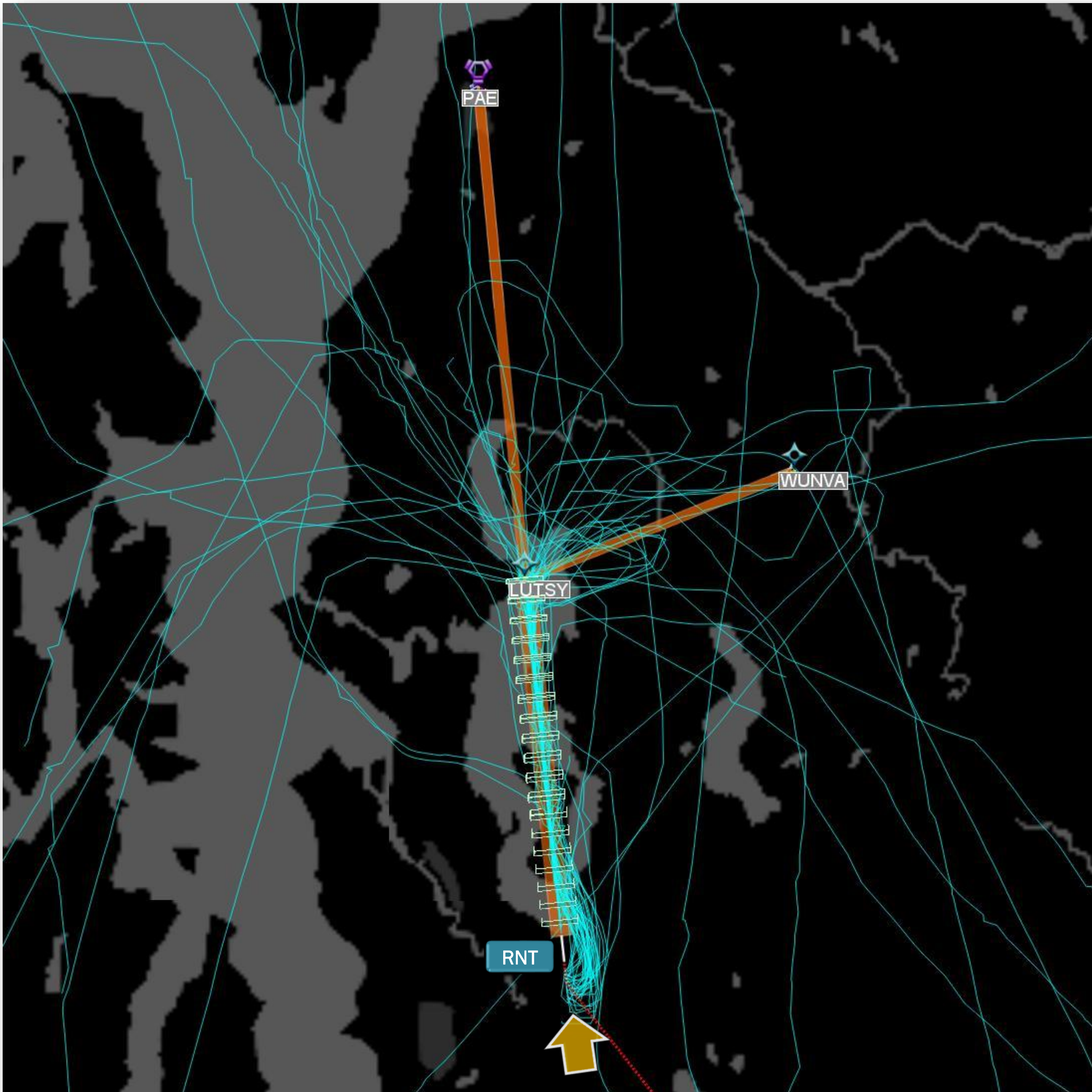
Puget Sound Regional Council



Notes: RNT - Renton Municipal Airport

Source: BridgeNet International 2019

Figure D-10
RNT Instrument Approach Procedures (IAPs)
RNAV (GPS) Z RWY 16 North Flow Landing on Runway 34



Notes: RNT - Renton Municipal Airport

Source: BridgeNet International 2019

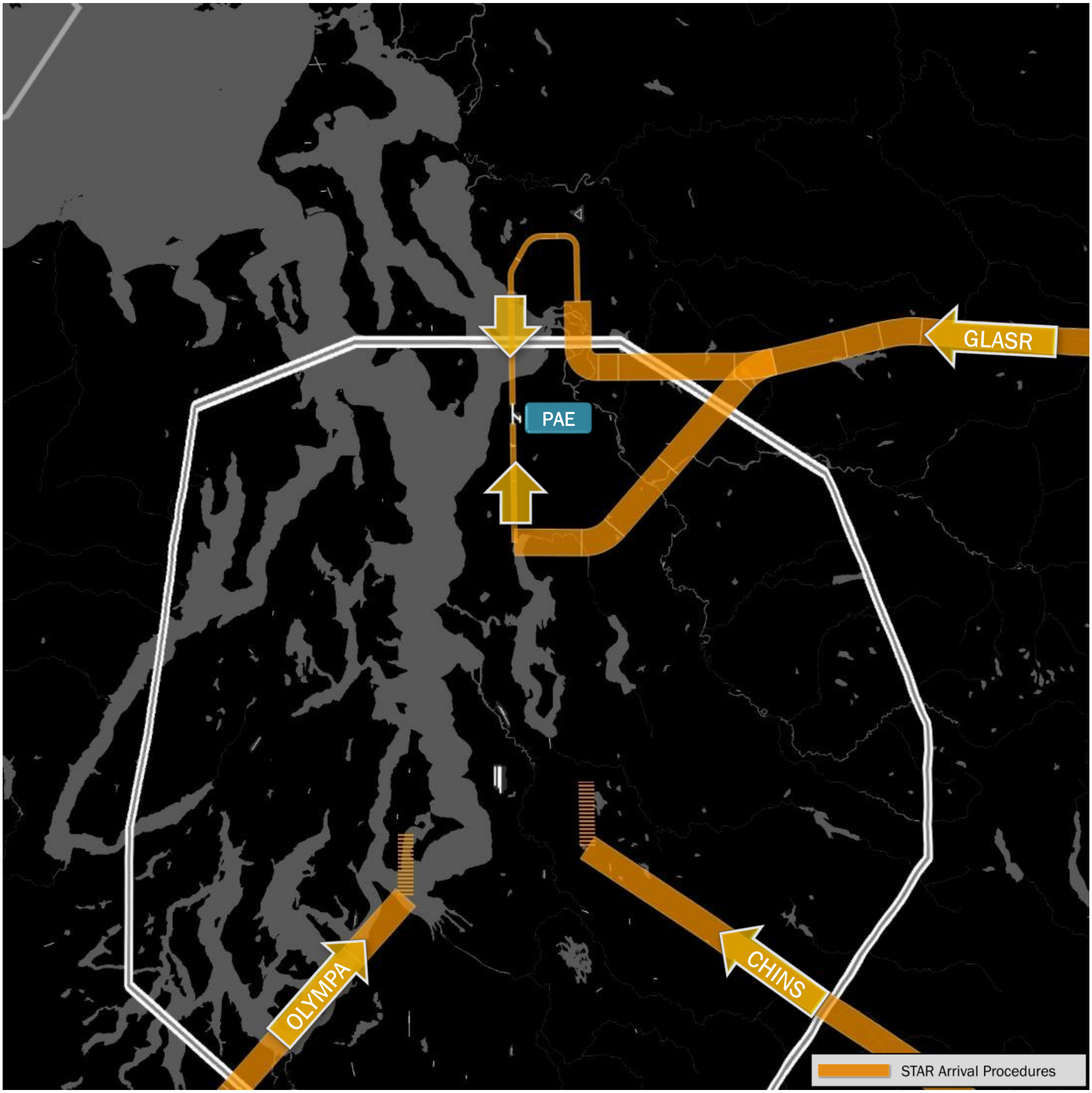
Appendix E
Paine Field/Snohomish County International Flight Procedure Graphics

Figure E-1
PAE Standard Instrument Departures (SIDs)
Conventional SIDs in Both North and South Flow

Puget Sound Regional Council

Notes: PAE - Snohomish County Airport (Paine Field)

Figure E-2
PAE Standard Terminal Arrival Procedures (STARs)
STARs for Both North and South Flow



Notes: PAE - Snohomish County Airport (Paine Field)

Source: BridgeNet International 2019

Figure E-3

PAE Instrument Approach Procedures (IAPs)

ILS RWY 16R (South Flow)

Puget Sound Regional Council

Notes: PAE - Snohomish County Airport (Paine Field)

Figure E-4
PAE Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 16R (South Flow)

Puget Sound Regional Council

Notes: PAE - Snohomish County Airport (Paine Field)

Figure E-5

PAE Instrument Approach Procedures (IAPs)

RNAV (GPS) RWY 34L (North Flow)

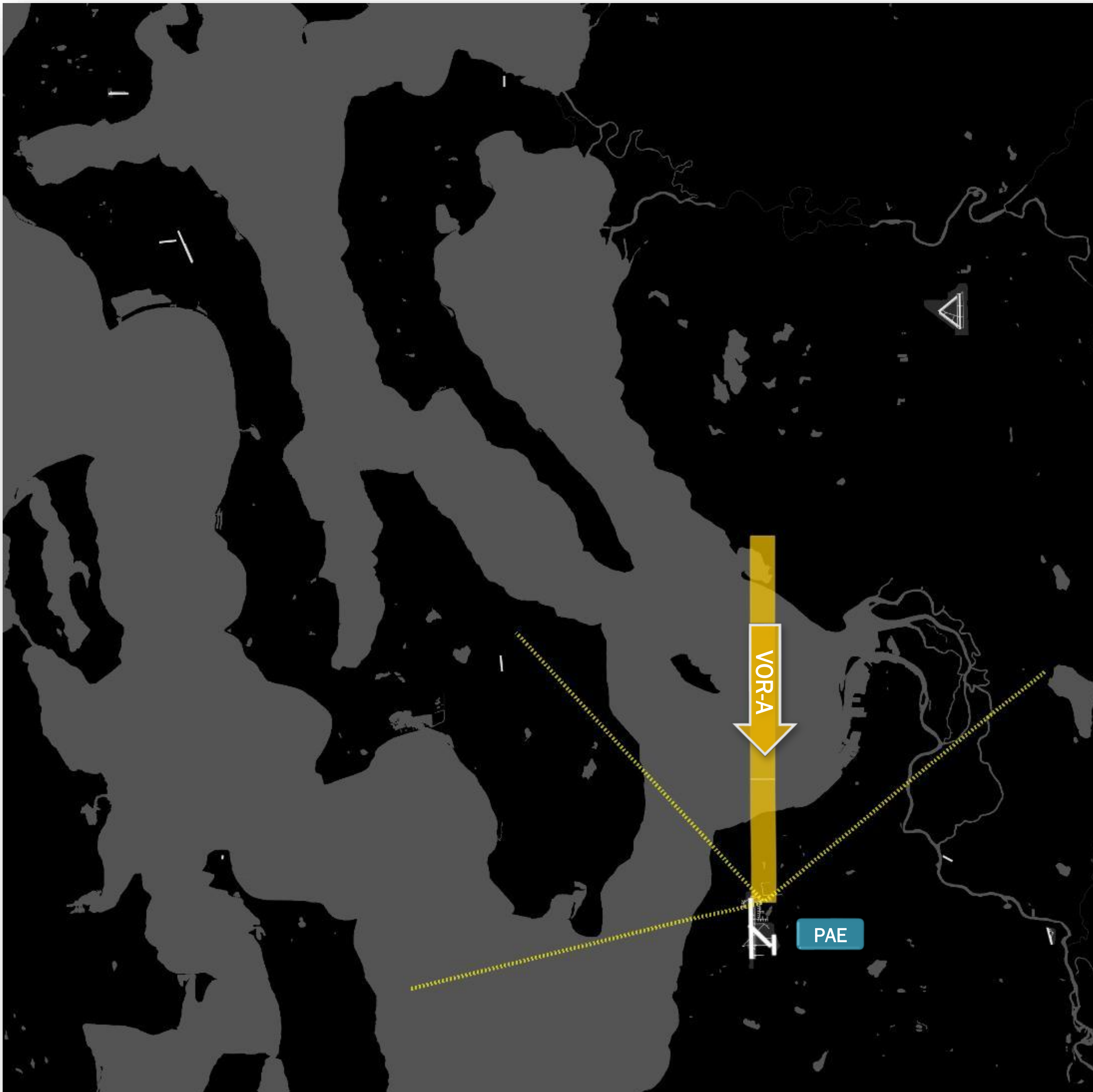
Notes: PAE - Snohomish County Airport (Paine Field)

Source: BridgeNet International 2019

Figure E-6

PAE Instrument Approach Procedures (IAPs)

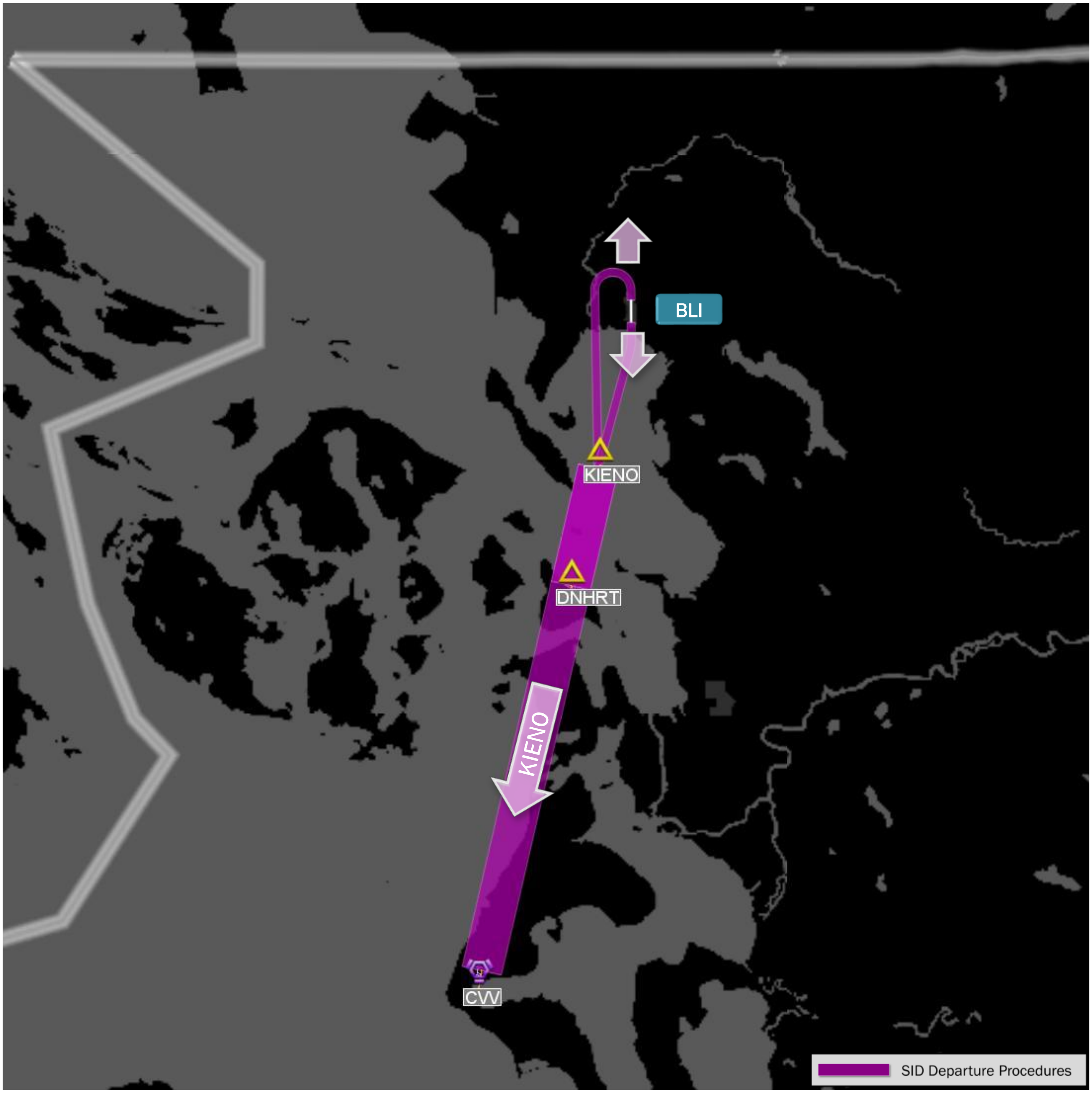
VOR-A RWY 16R (South Flow)



Notes: PAE - Snohomish County Airport (Paine Field)

Appendix F
Bellingham International Airport Flight Procedure Graphics

Figure F-1
BLI Standard Instrument Departures (SIDs)
KIENO SIX SIDs in Both North and South Flow



Notes: BLI - Bellingham International Airport

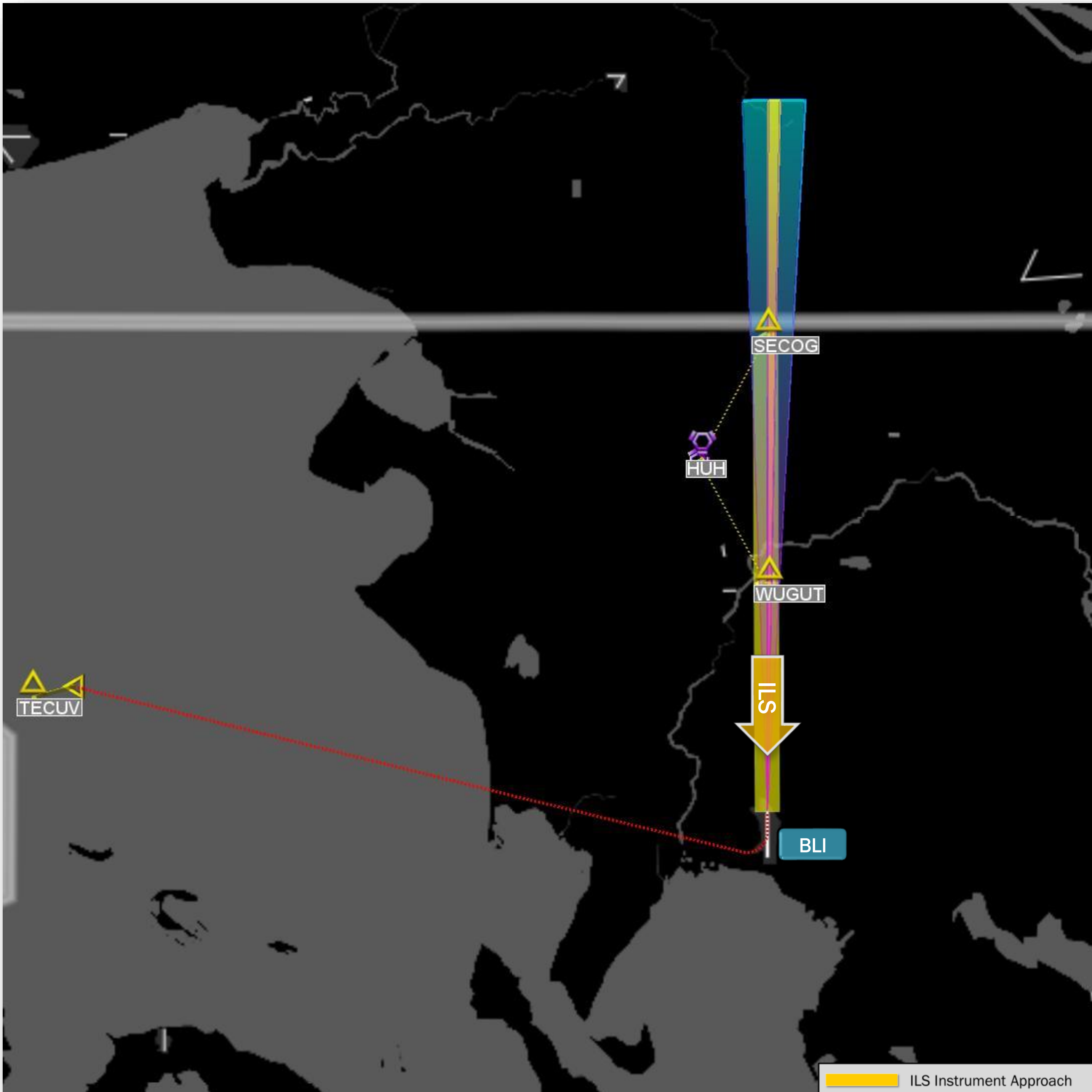
Source: BridgeNet International 2019

Figure F-2
BLI Terminal Arrival Procedures (STARs)
MADEE (RNAV) FOUR Both North and South Flow

Notes: BLI - Bellingham International Airport

Figure F-3
BLI Instrument Approach Procedures (IAPs)
ILS RWY 16 (South Flow)

Puget Sound Regional Council

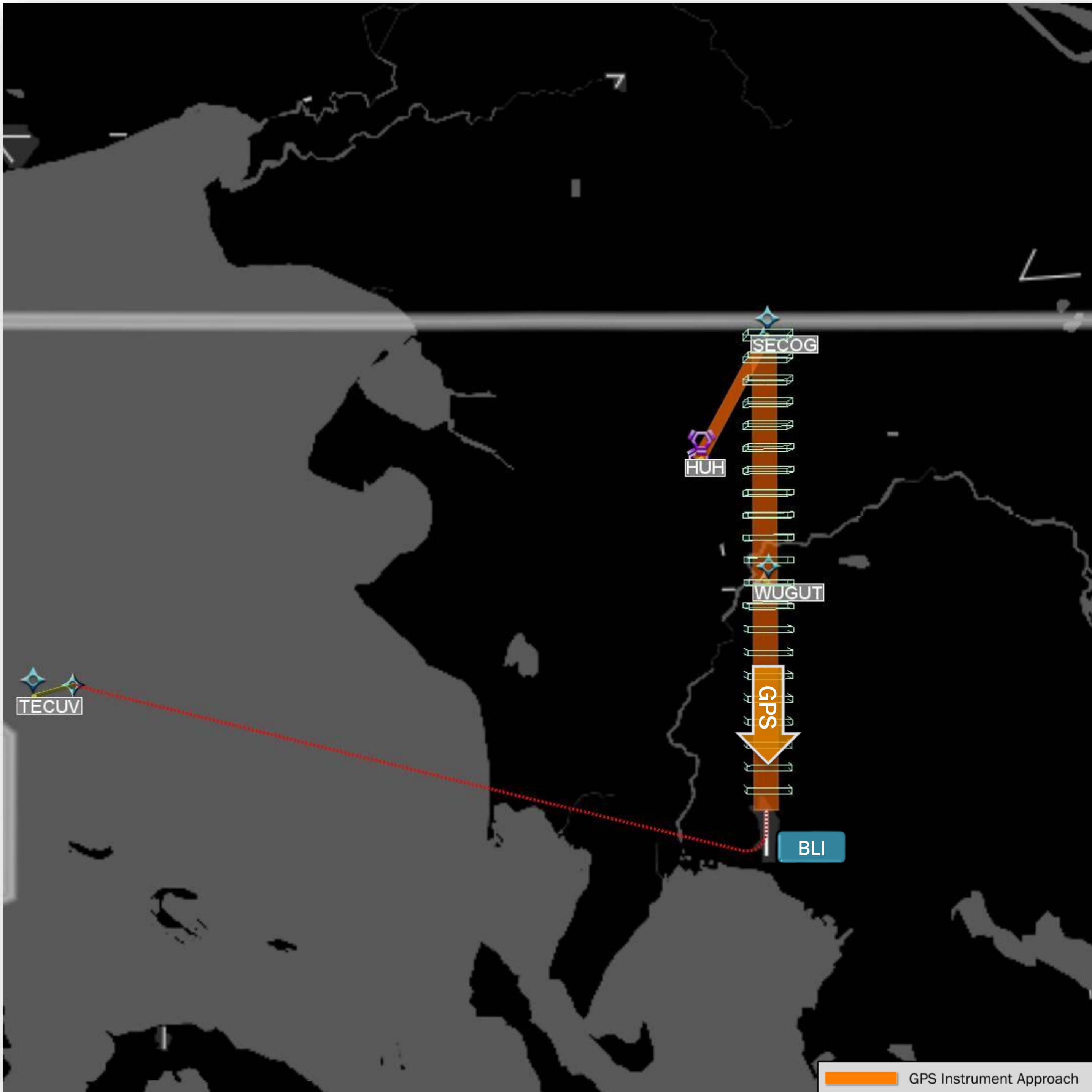


Notes: BLI - Bellingham International Airport

Source: BridgeNet International 2019

Puget Sound Regional Council

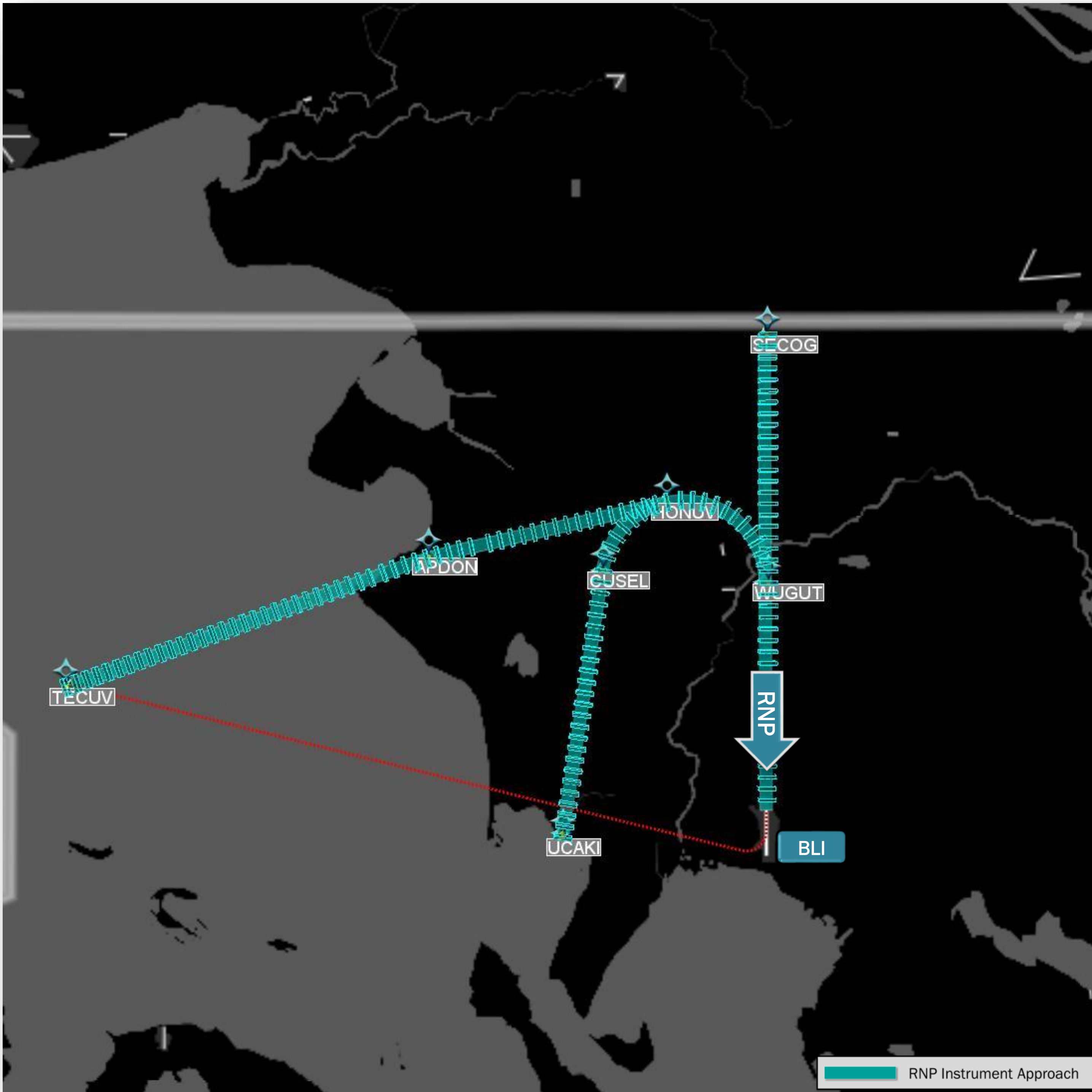
Figure F-4
BLI Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 16 (South Flow)



Notes: BLI - Bellingham International Airport

Source: BridgeNet International 2019

Figure F-5
BLI Instrument Approach Procedures (IAPs)
RNAV (RNP) RWY 16 (South Flow)

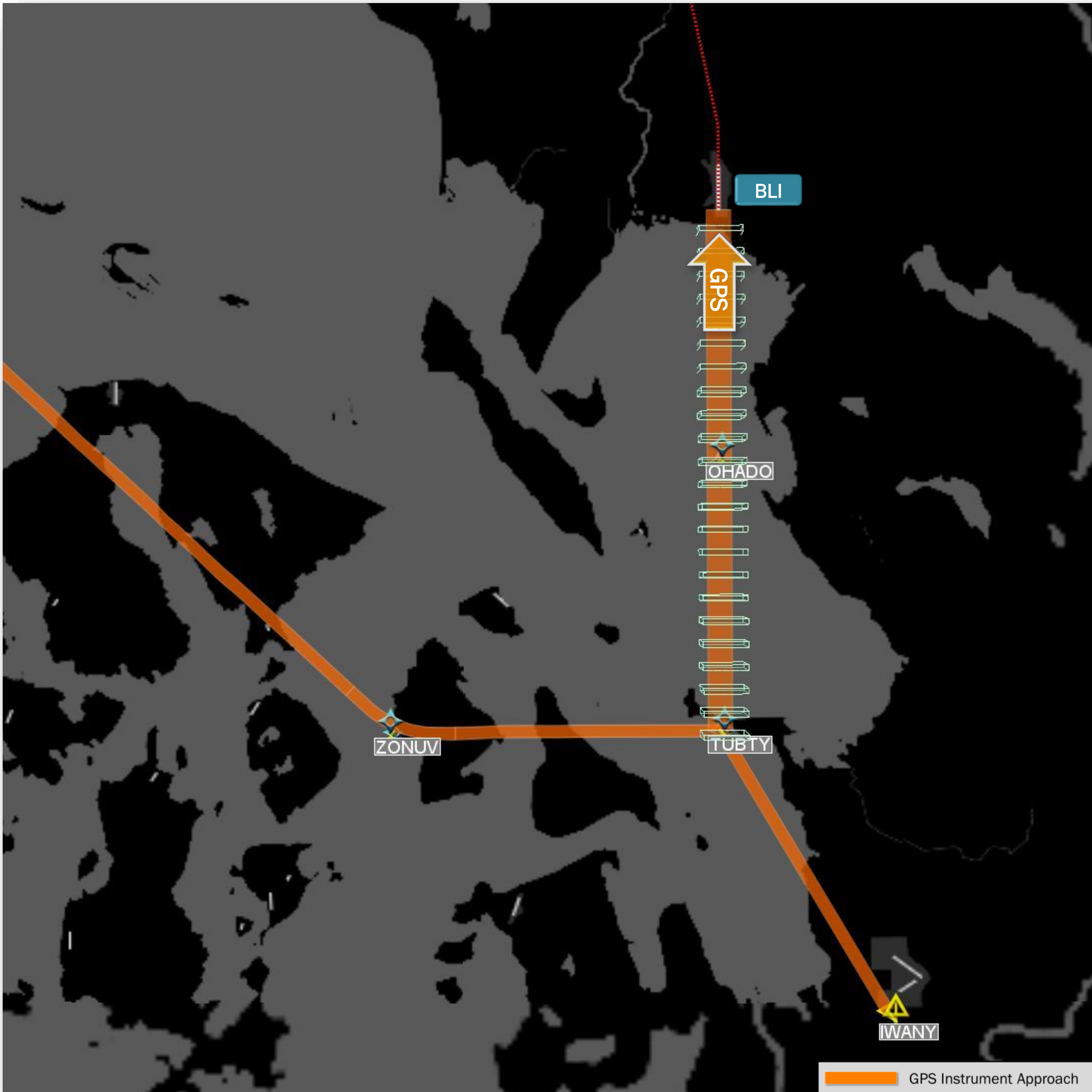


Notes: BLI - Bellingham International Airport

Source: BridgeNet International 2019

Figure F-6
BLI Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 34 (North Flow)

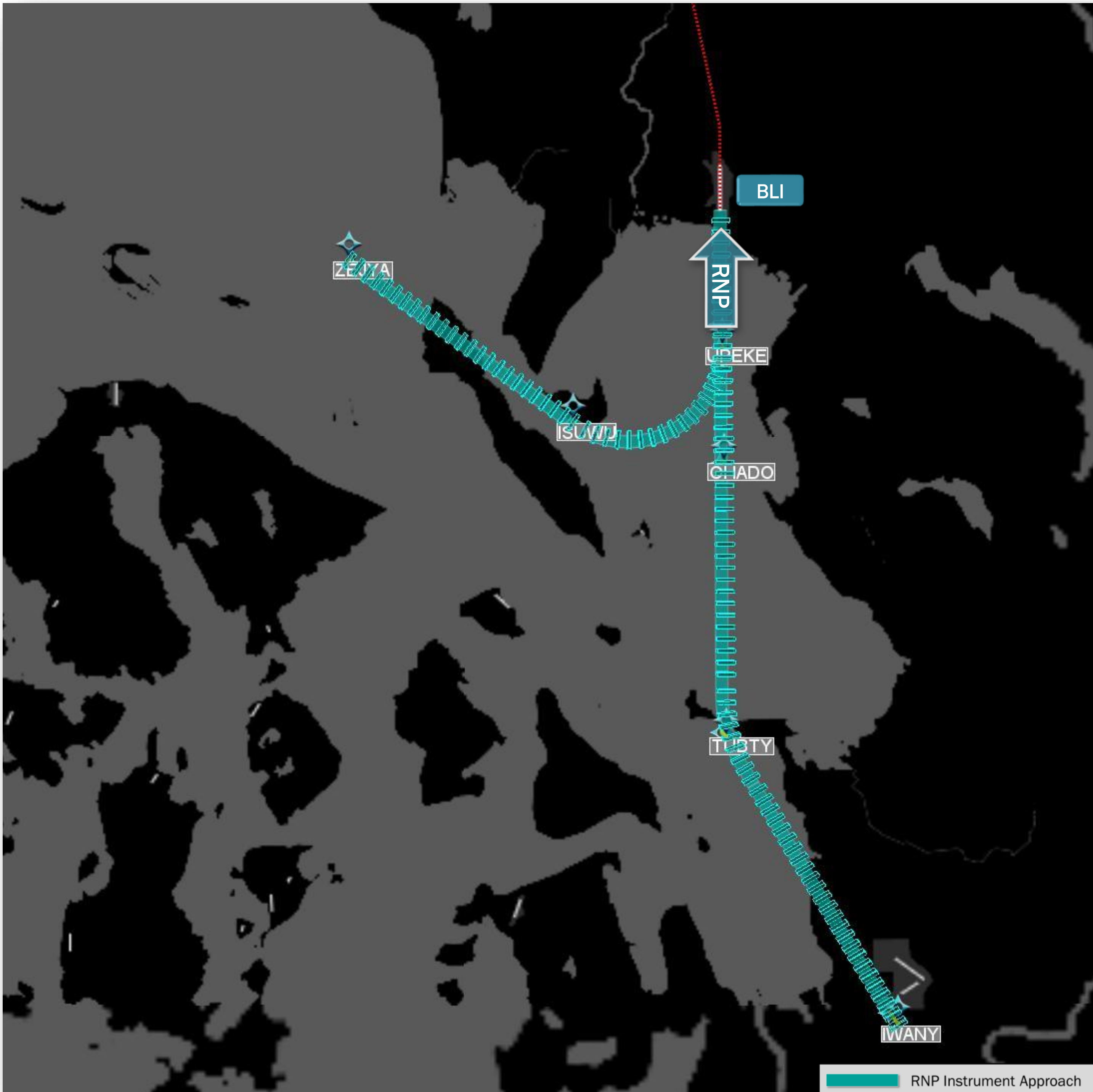
Puget Sound Regional Council



Notes: BLI - Bellingham International Airport

Figure F-6
BLI Instrument Approach Procedures (IAPs)
RNAV (RNP) RWY 34 (North Flow)

Puget Sound Regional Council



Notes: BLI - Bellingham International Airport

Source: BridgeNet International 2019

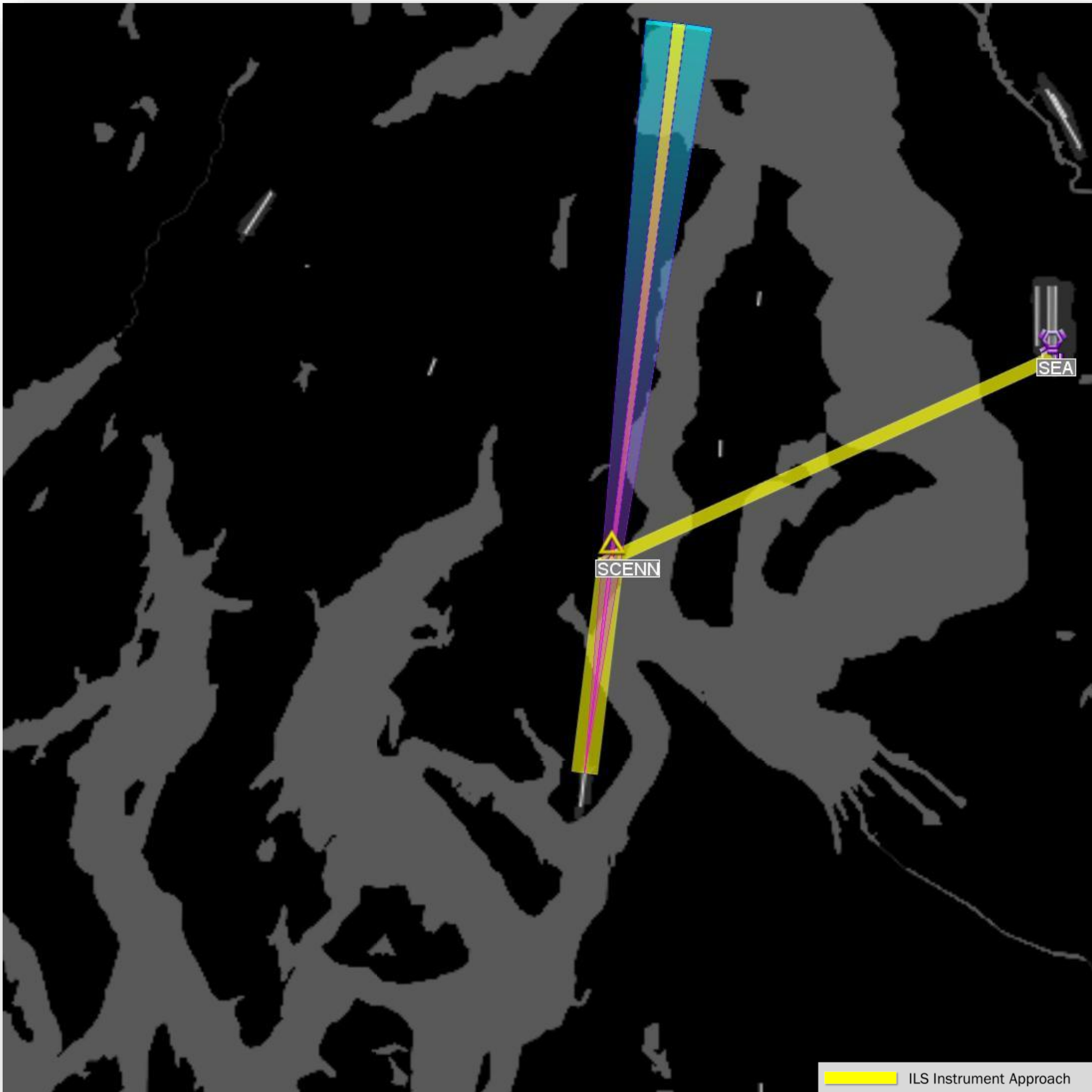
Appendix G
Tacoma Narrows Airport Flight Procedure Graphics

Figure G-1
TIW Standard Instrument Departures (SIDs)
NARROWS ONE Conventional SIDs North and South Flow

Puget Sound Regional Council

Notes: TIW - Tacoma Narrows Airport

Figure G-2
TIW Instrument Approach Procedures (IAPs)
ILS RWY 17 South Flow



Notes: TIW - Tacoma Narrows Airport

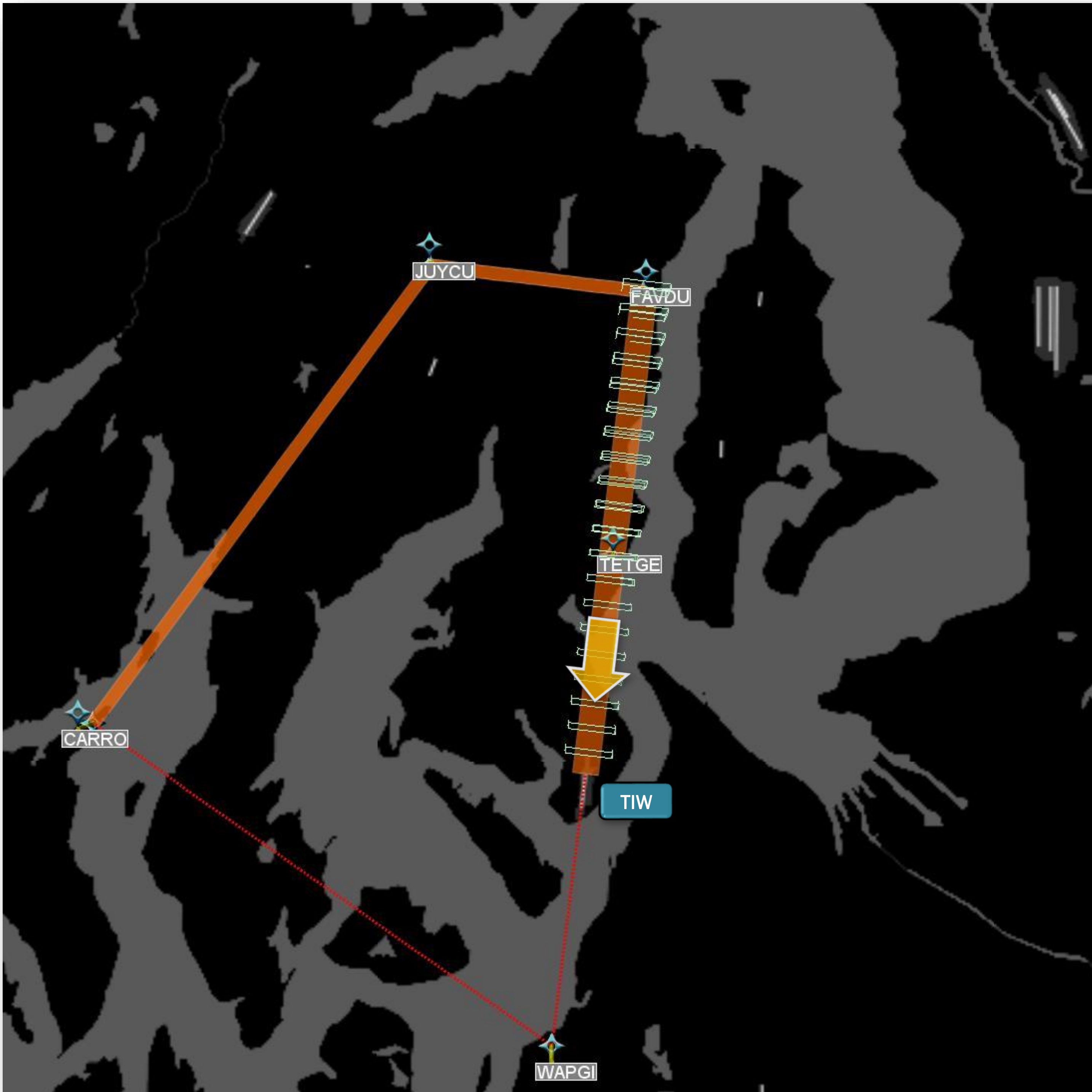
Source: BridgeNet International 2019

Figure G-3

TIW Instrument Approach Procedures (IAPs)

RNAV (GPS) RWY 17 South Flow

Puget Sound Regional Council

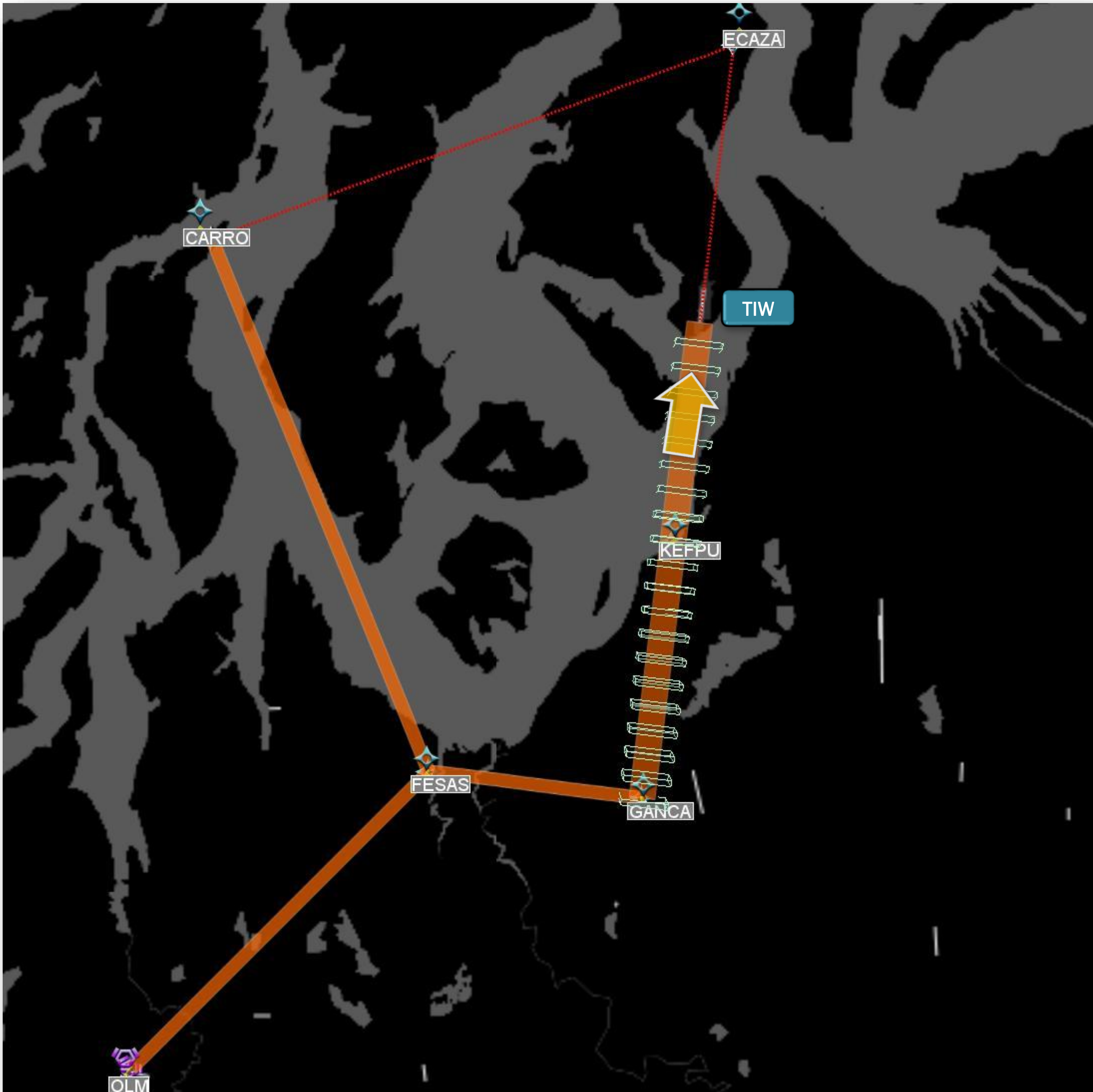


Notes: TIW - Tacoma Narrows Airport

Source: BridgeNet International 2019

Figure G-4
TIW Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 35 North Flow

Puget Sound Regional Council



Notes: TIW - Tacoma Narrows Airport

Appendix H
Olympia Regional Airport Flight Procedure Graphics

Figure H-1

OLM Standard Instrument Departures (SIDs)

YELM FIVE Conventional SIDs North and South Flow

Puget Sound Regional Council

Notes: OLM - Olympia Regional Airport

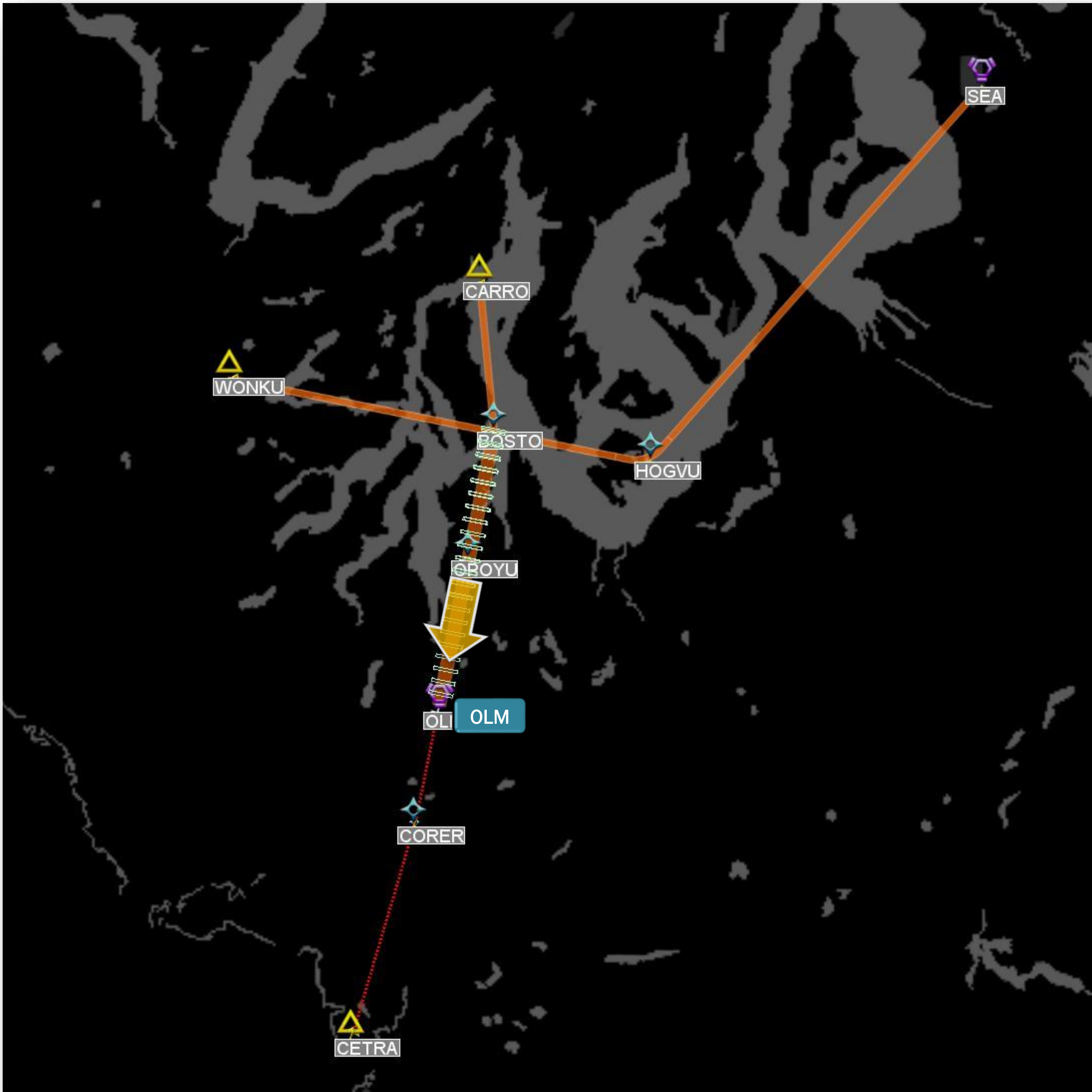
Figure H-2
OLM Instrument Approach Procedures (IAPs)
ILS RWY 17 South Flow

Notes: OLM - Olympia Regional Airport

Figure H-3

OLM Instrument Approach Procedures (IAPs)

RNAV (GPS) RWY 17 South Flow



Notes: OLM - Olympia Regional Airport

Source: BridgeNet International 2019

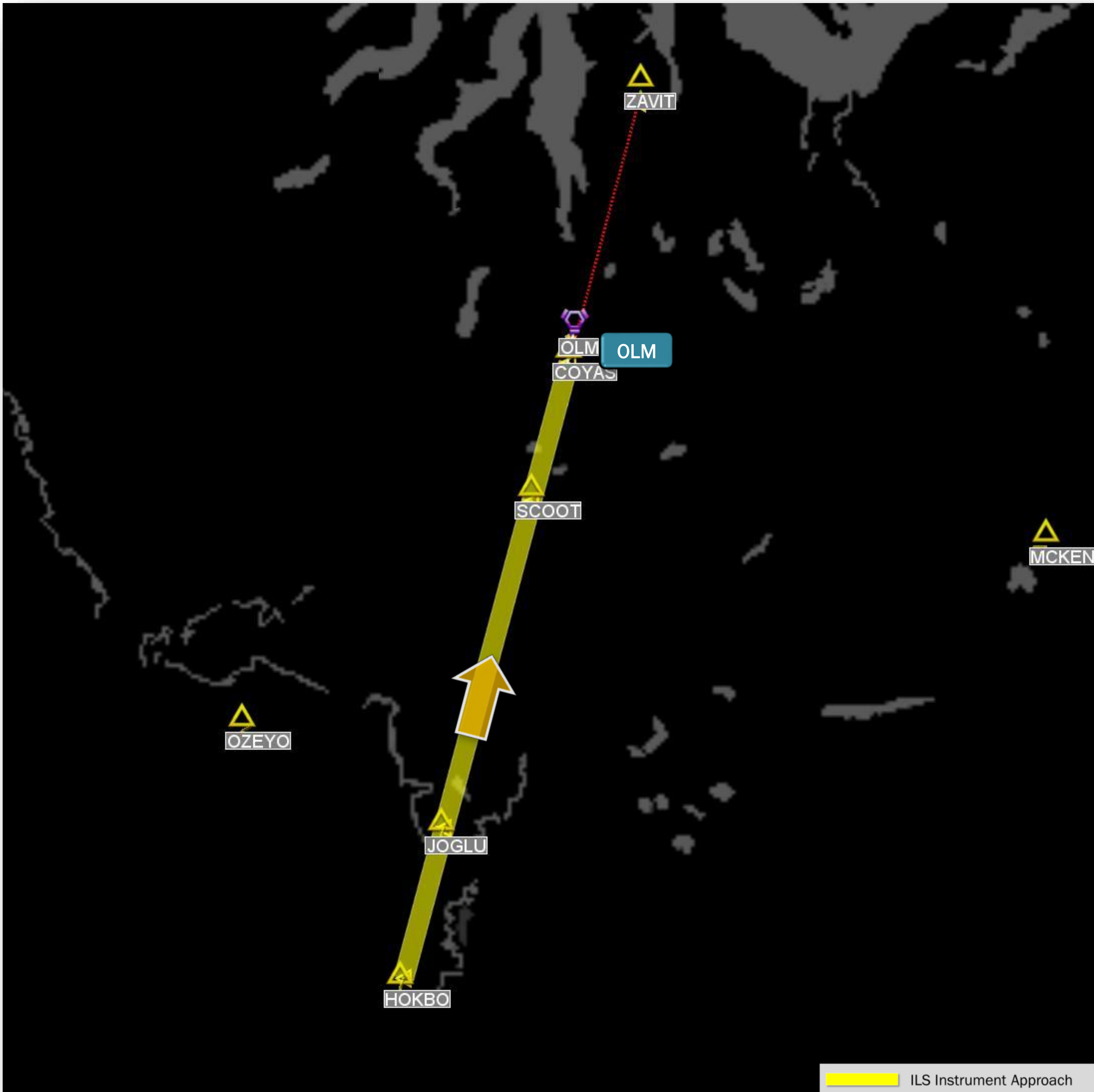
Figure H-4

OLM Instrument Approach Procedures (IAPs)

RNAV (GPS) RWY 35 South Flow

Notes: OLM - Olympia Regional Airport

Figure H-5
OLM Instrument Approach Procedures (IAPs)
Conventional VOR RWY 35 North Flow



Notes: OLM - Olympia Regional Airport

Figure H-6
OLM Instrument Approach Procedures (IAPs)
VOR-A All Flows

Notes: OLM - Olympia Regional Airport

Appendix I
Arlington Municipal Airport Flight Procedure Graphics

Figure I-1

AWO Standard Instrument Departures (SIDs)

ARLINGTON TWO Conventional SIDs North and South Flow

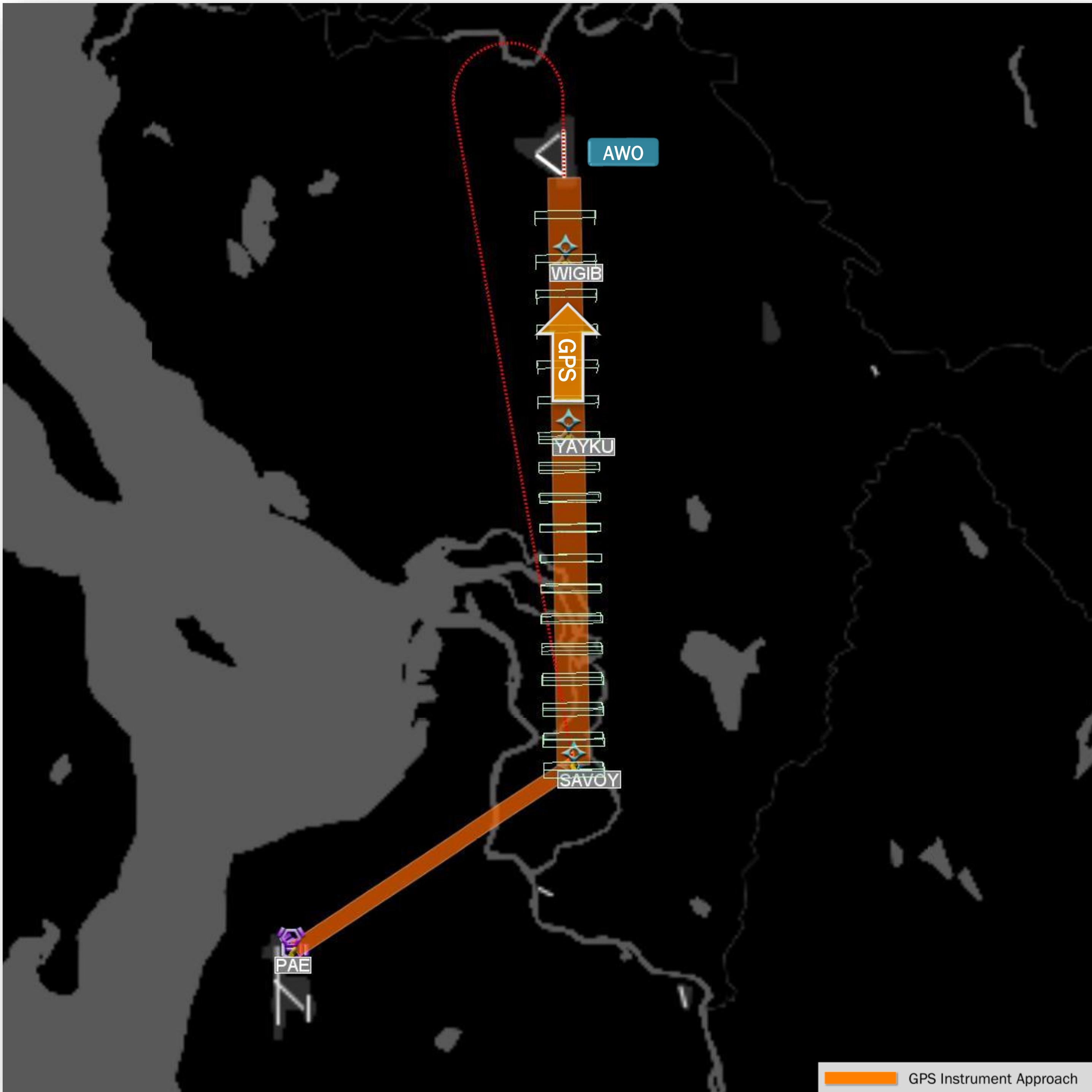
Notes: AWO - Arlington Municipal Airport

Source: BridgeNet International 2019

Figure I-2

AWO Instrument Approach Procedures (IAPs)

RNAV (GPS) RWY 34 (North Flow)



Notes: AWO - Arlington Municipal Airport

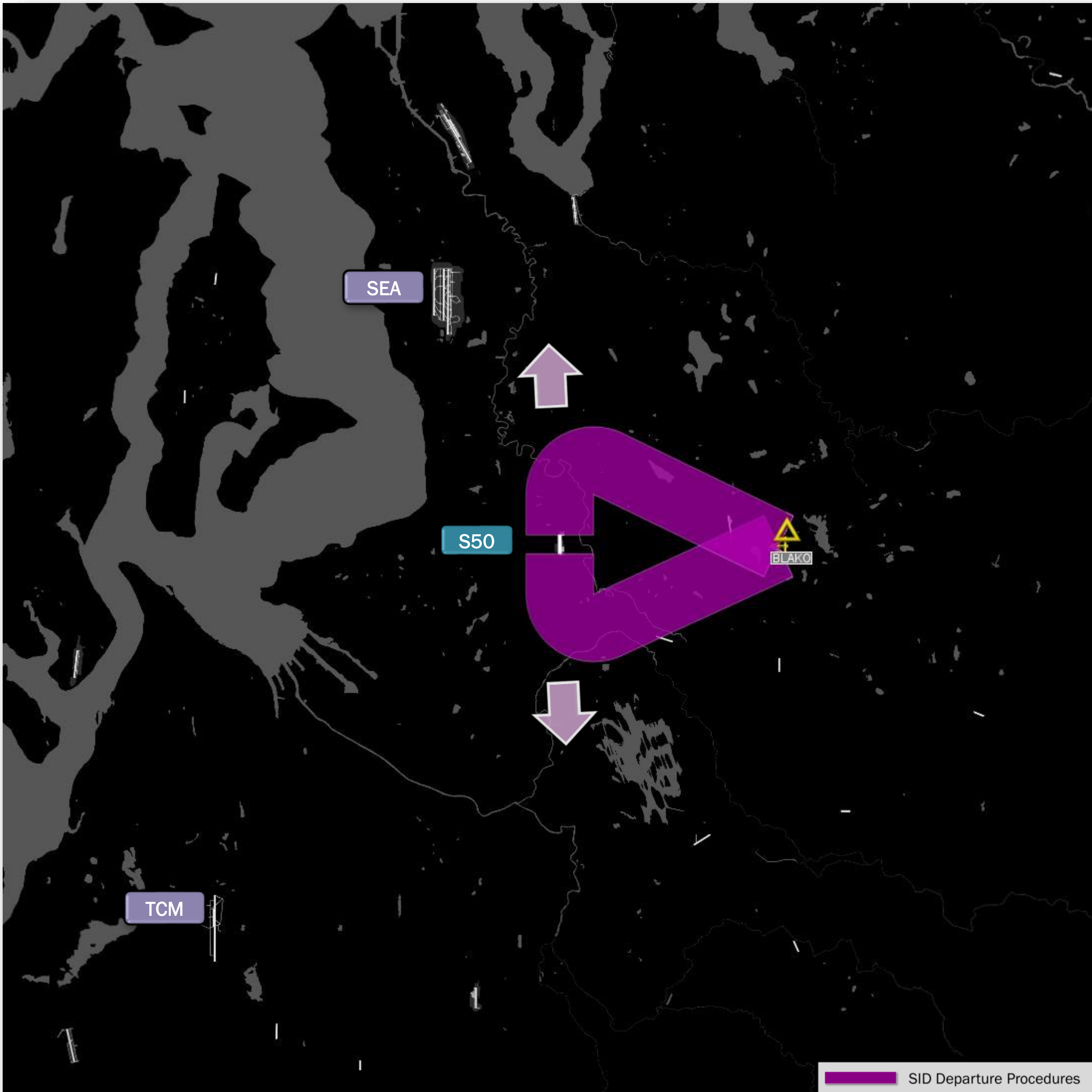
LOC and NDB Approaches on Runway 34 follow same ground path.

No Instrument Approaches from the North

Appendix J
Auburn Municipal Airport Flight Procedure Graphics

Figure J-1
S50 Standard Instrument Departures (SIDs)
BLAKO ONE NextGen Obstacle SID North and South Flow

Puget Sound Regional Council



Notes: S50 - Auburn Municipal Airport

Appendix K
McChord Field Airport (Joint Base Lewis-McChord) Flight Procedure Graphics

Figure K-1
TCM Standard Instrument Departures (SIDs)
MOCAA THREE (RNAV) SIDs North and South Flow

Puget Sound Regional Council

Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Figure K-2
TCM Standard Instrument Departures (SIDs)
MOCAA THREE (RNAV) SIDs North and South Flow

Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Source: BridgeNet International 2019

Figure K-3

TCM Standard Instrument Departures (SIDs)

OLYMPIC FOUR Conventional SIDs North and South Flow

Puget Sound Regional Council

Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Figure K-4
TCM Standard Instrument Departures (SIDs)
PUGET SIX Conventional SIDs North and South Flow

Puget Sound Regional Council

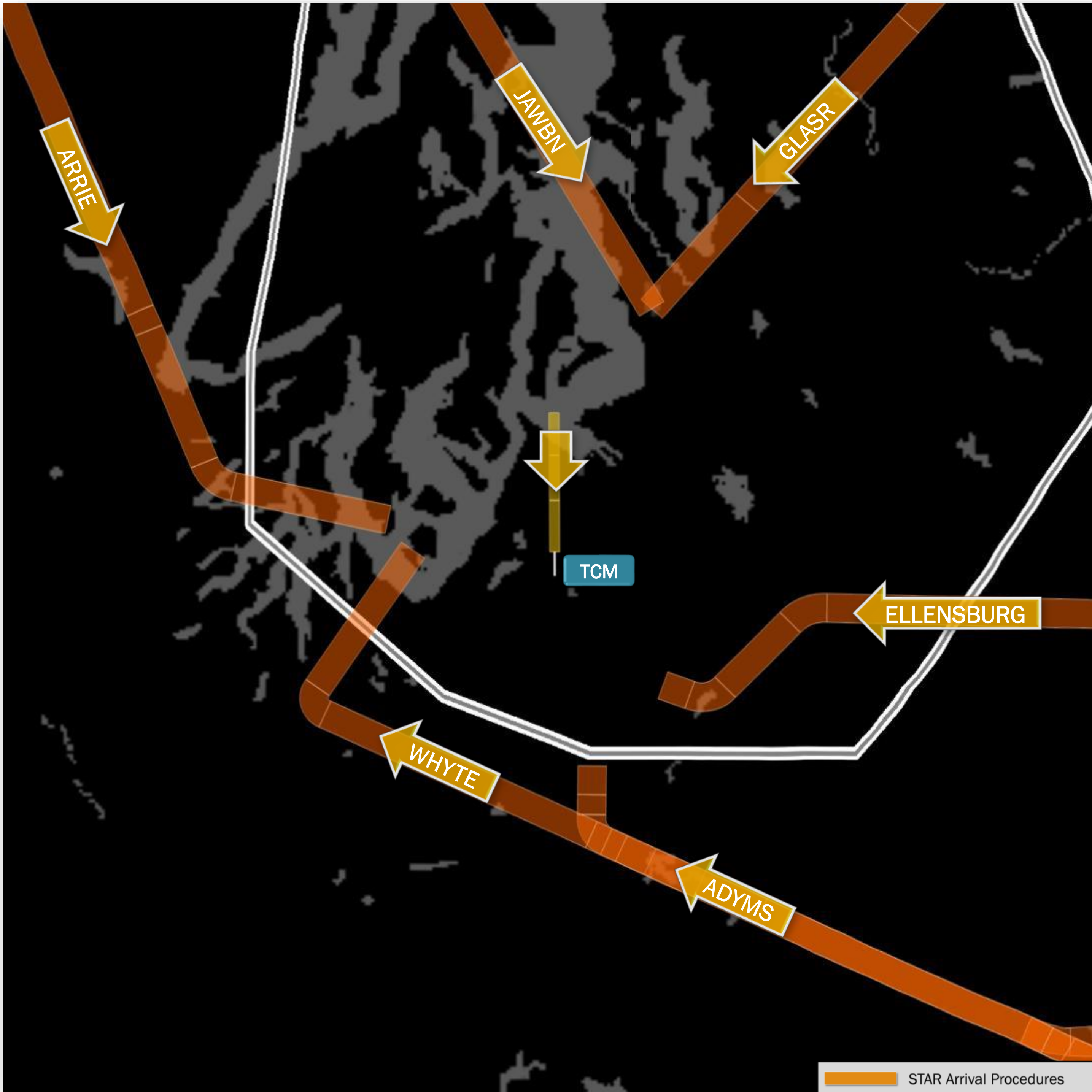
Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Figure K-5

TCM Standard Terminal Arrival Procedures (STARs)

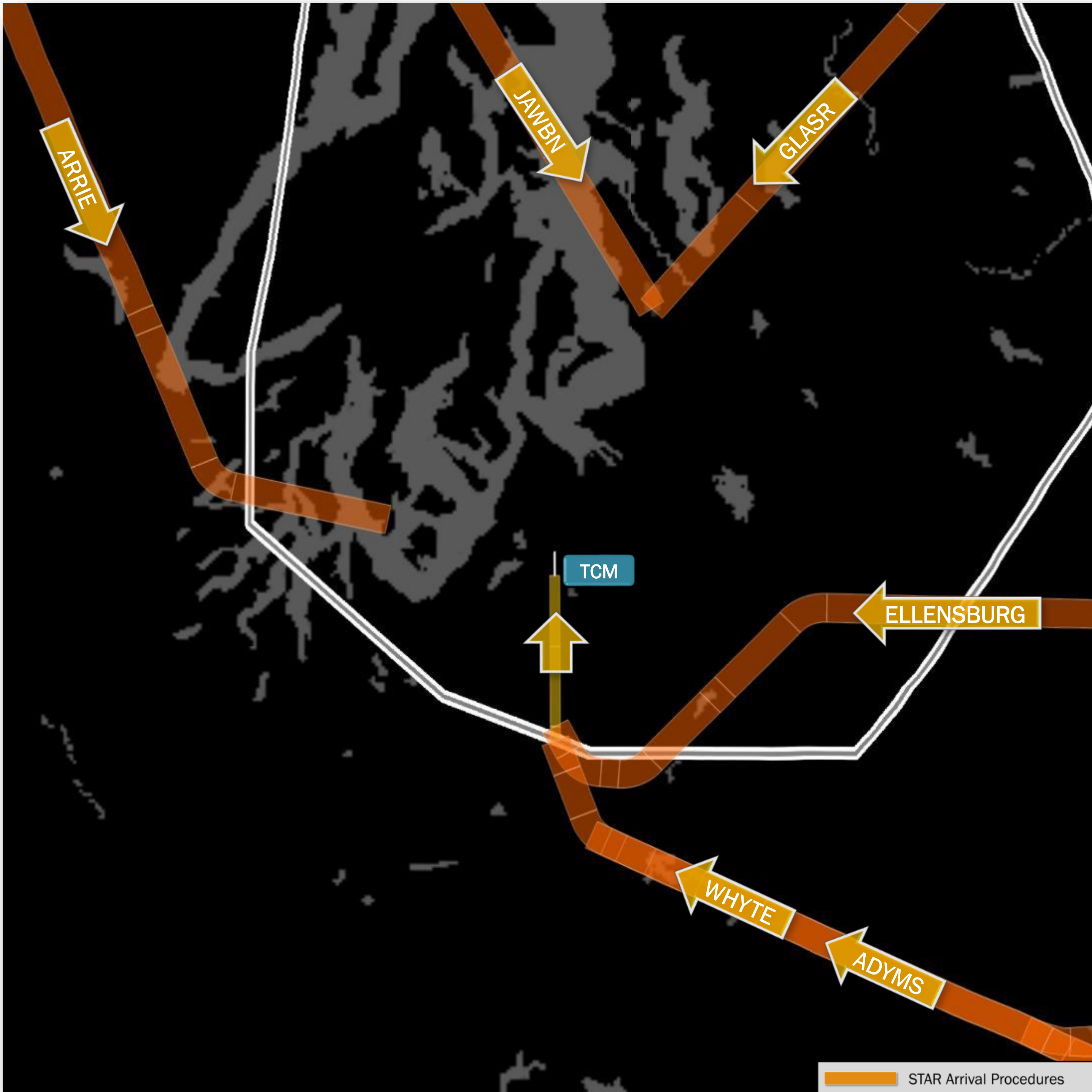
STARs for South Flow

Puget Sound Regional Council



Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

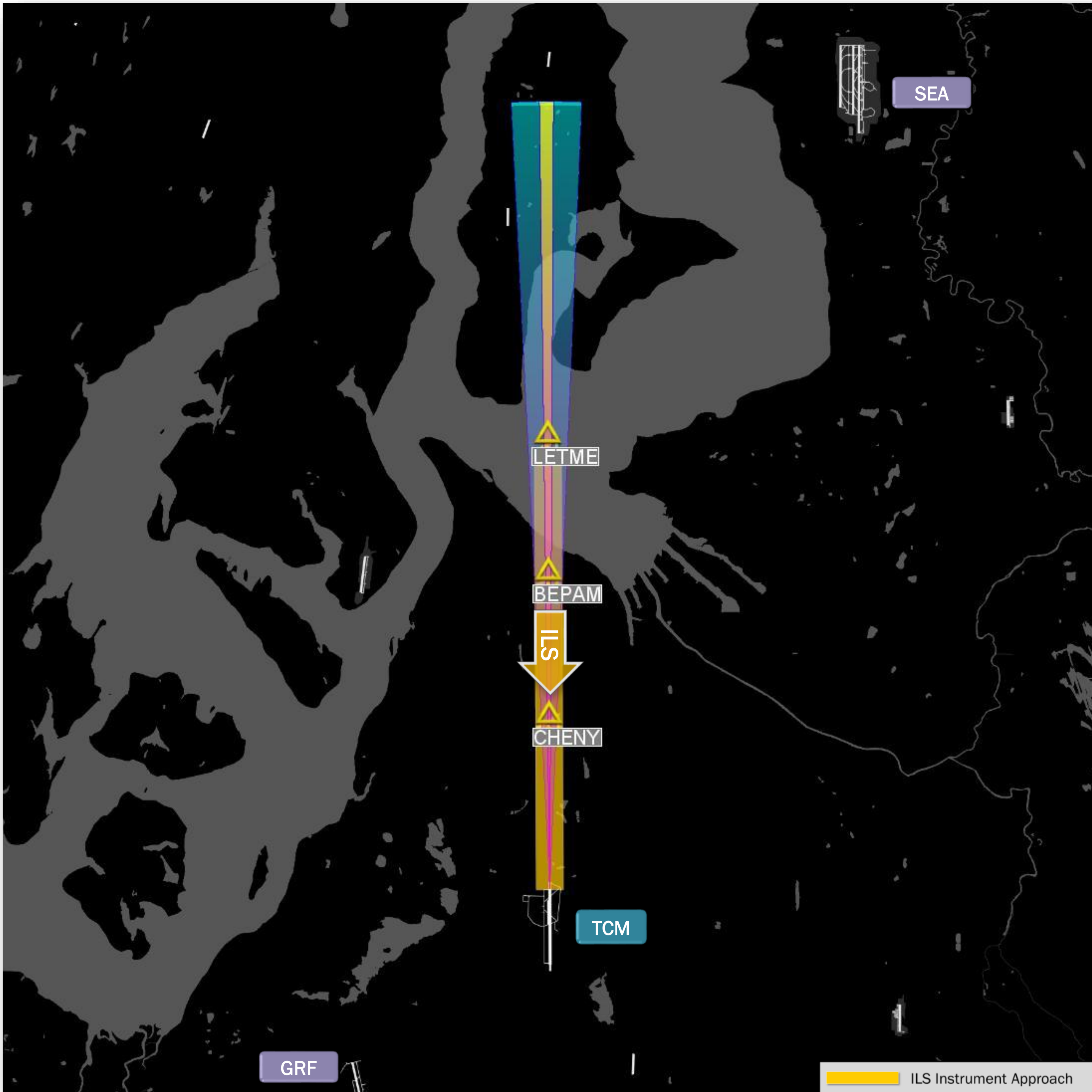
Figure K-6
TCM Standard Terminal Arrival Procedures (STARs)
STARs for North Flow



Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Figure K-7
TCM Instrument Approach Procedures (IAPs)
ILS RWY 16 (South Flow)

Puget Sound Regional Council



Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Source: BridgeNet International 2019

Figure K-8
TCM Instrument Approach Procedures (IAPs)
ILS RWY 34 North Flow

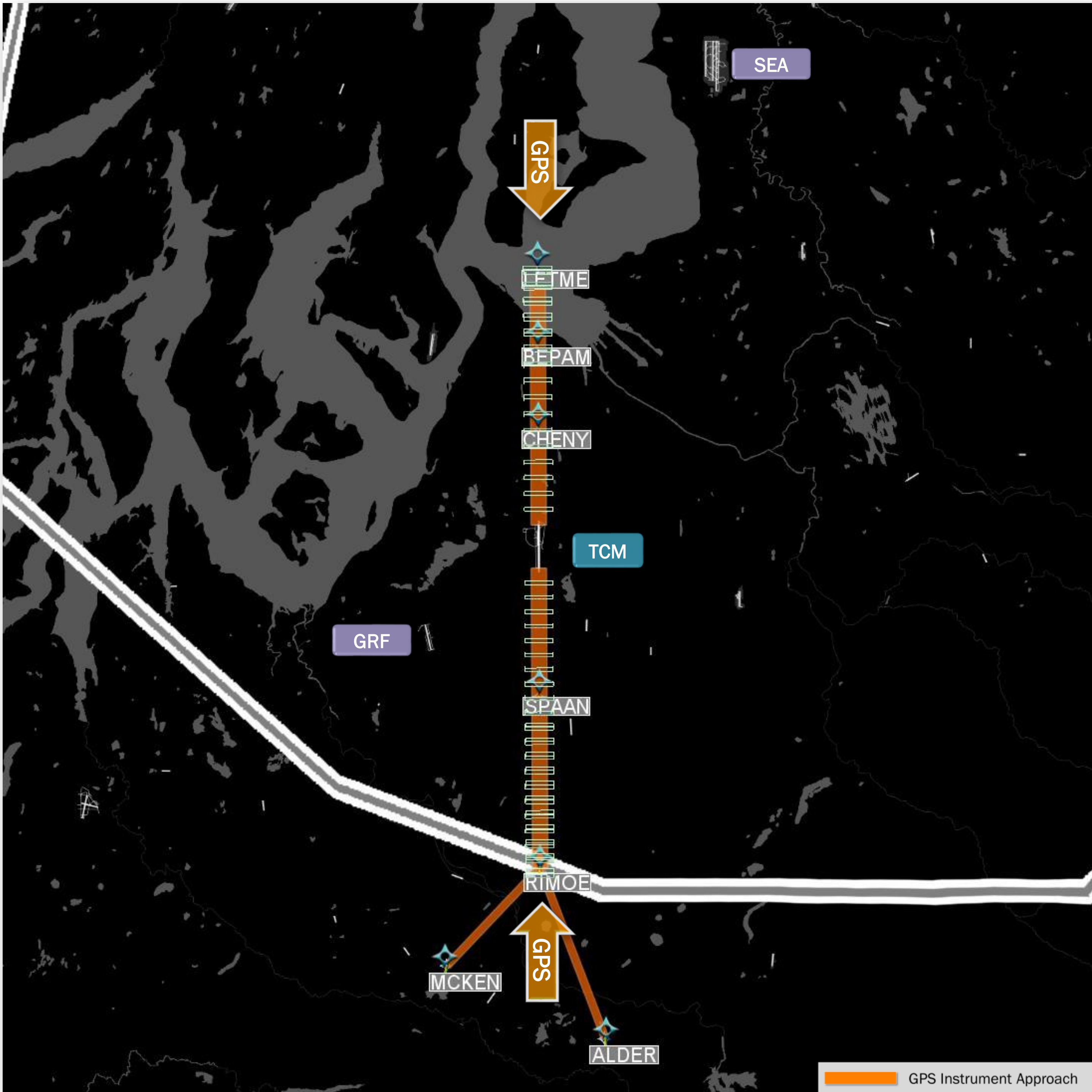
Puget Sound Regional Council

Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Source: BridgeNet International 2019

Figure K-9
TCM Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 16 AND RWY 34 (North and South Flow)

Puget Sound Regional Council



Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

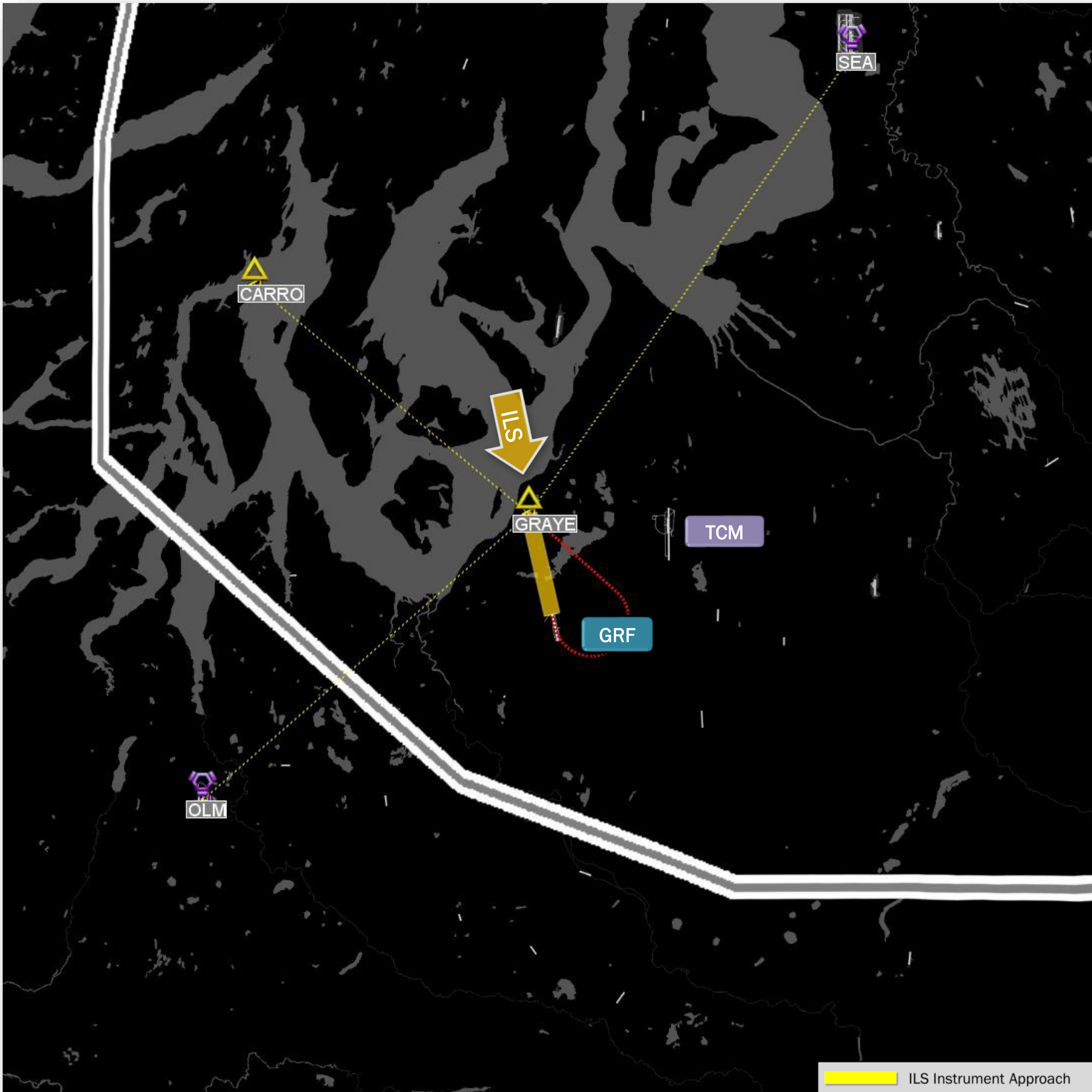
Source: BridgeNet International 2019

Appendix L
Gray Army Airfield (Joint Base Lewis-McChord) Flight Procedure Graphics

Figure L-1
GRF Standard Instrument Departures (SIDs)
LEWIS THREE Conventional SID North and South Flow

Notes: GRF - Gray Army Airfield (Joint Base Lewis-McChord)

Figure L-2
GRF Instrument Approach Procedures (IAPs)
ILS RWY 15 South Flow



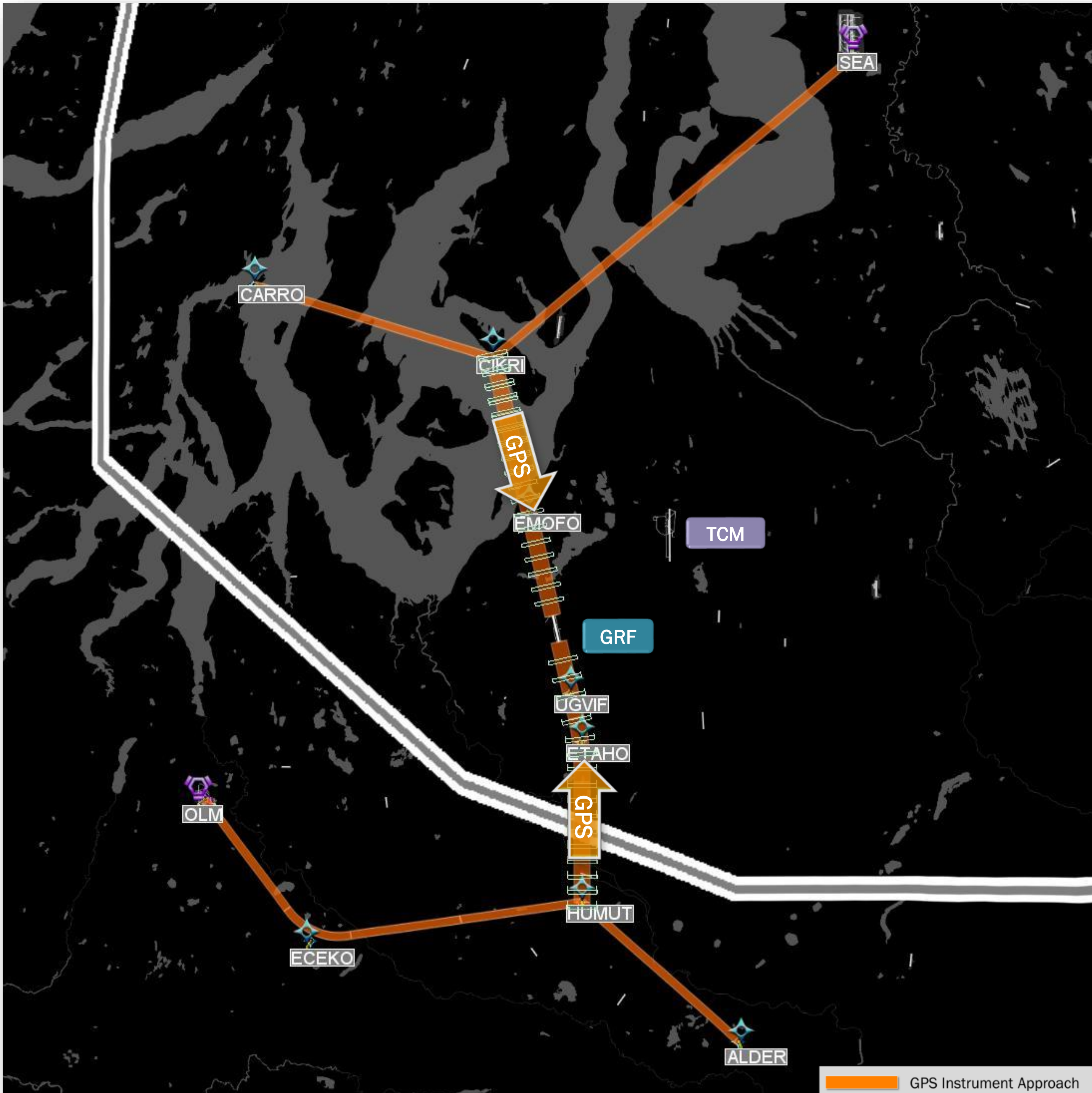
Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Source: BridgeNet International 2019

Figure L-3

GRF Instrument Approach Procedures (IAPs)

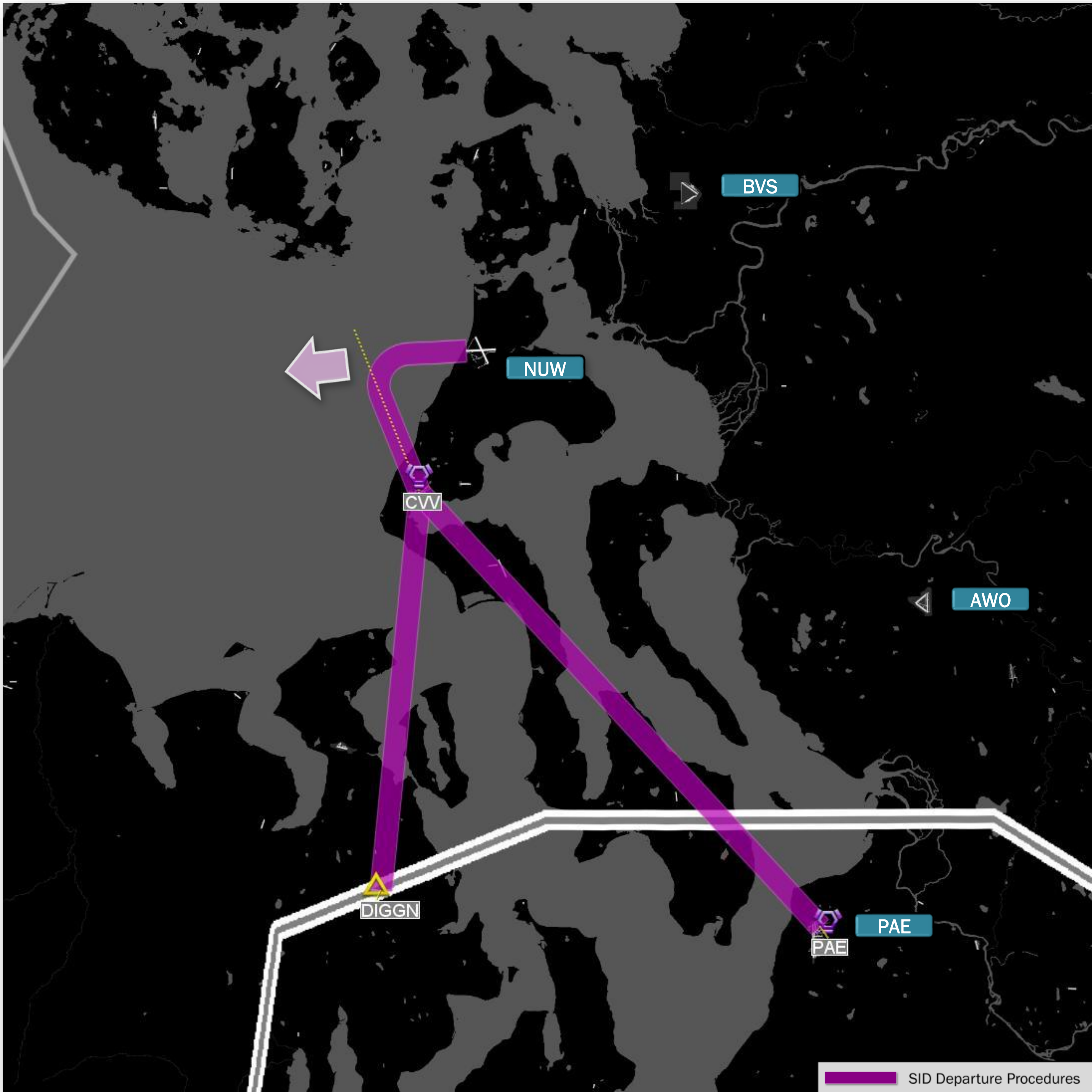
RNAV (GPS) RWY 15 AND RWY 33 Both Flows



Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

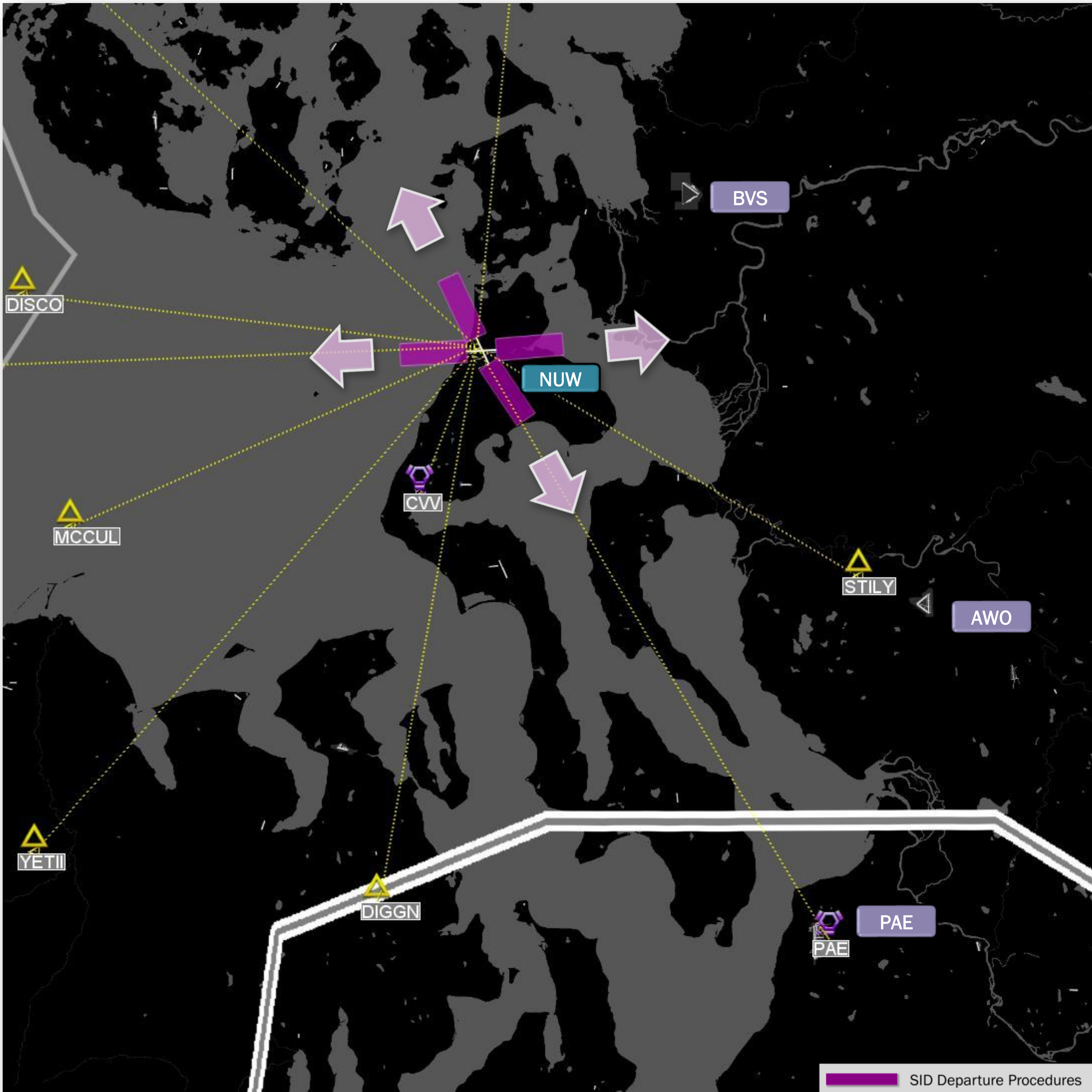
Appendix M
Whidbey Island Naval Air Station (Ault Field) Flight Procedure Graphics

Figure M-1
NUW Standard Instrument Departures (SIDs)
PENN COVE FOUR Conventional SID West Flow



Notes: NUW - Whidbey Island Naval Air Station (Ault Field)

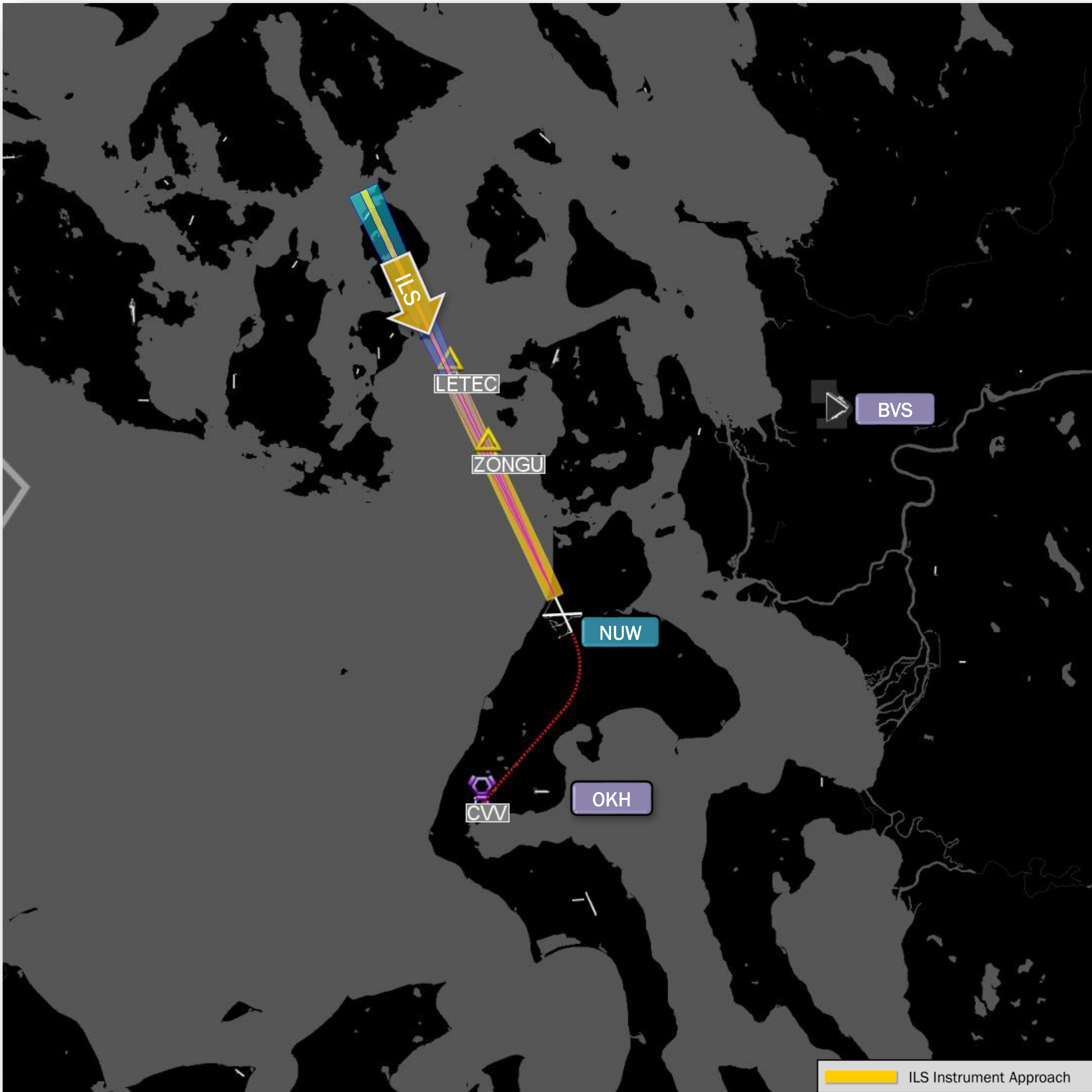
Figure M-2
NUW Standard Instrument Departures (SIDs)
NASWI ONE (OBSTACLE) Conventional SID All Flow



Notes: NUW - Whidbey Island Naval Air Station (Ault Field)

Source: BridgeNet International 2019

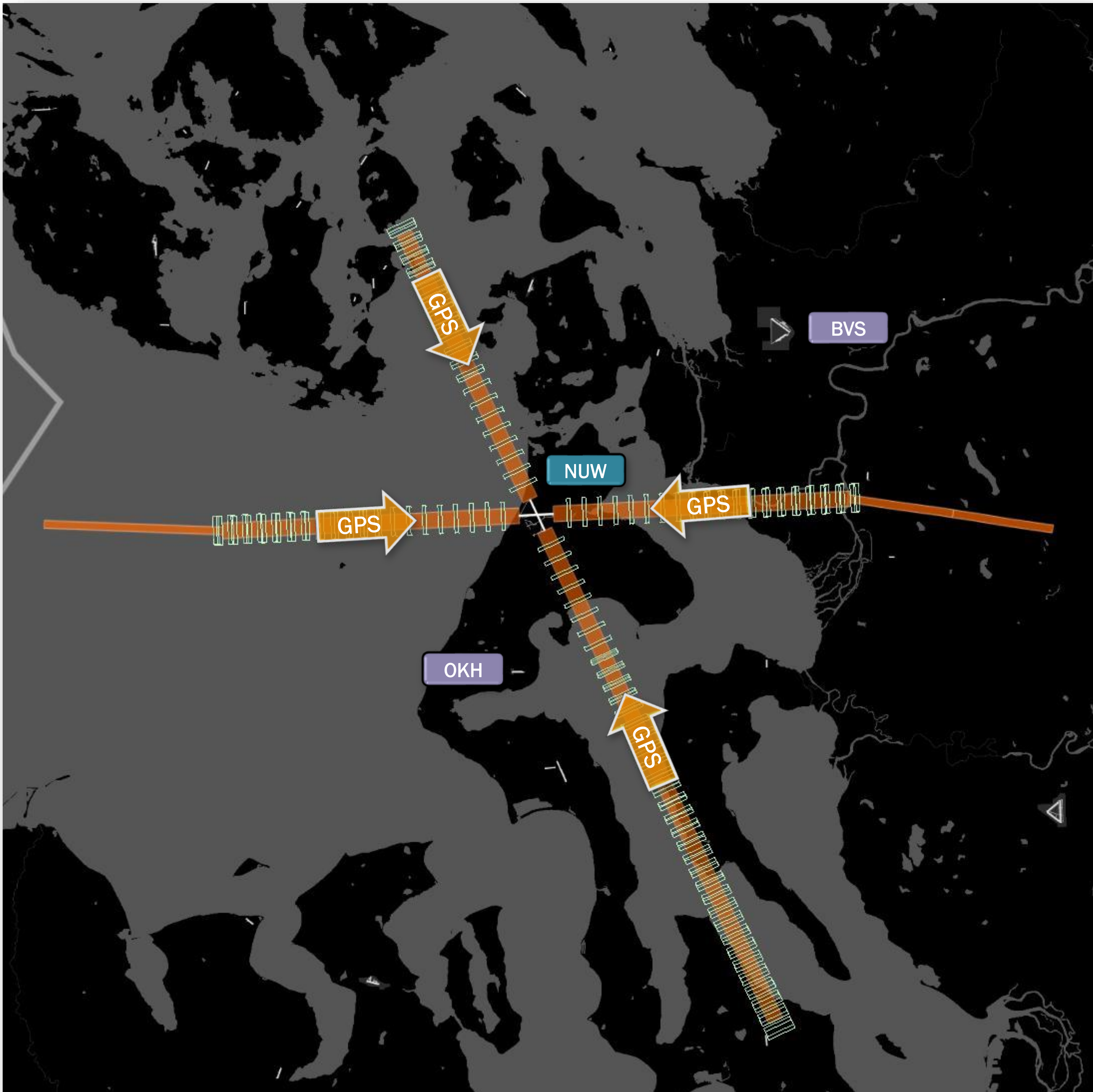
Figure M-3
NUW Instrument Approach Procedures (IAPs)
ILS RWY 14 South Flow



Notes: NUW - Whidbey Island Naval Air Station (Ault Field)

Source: BridgeNet International 2019

Figure M-3
NUW Instrument Approach Procedures (IAPs)
RNAV (GPS) RWYS 07 14 25 AND 32 All Flows



Notes: TCM - McChord Field Airport (Joint Base Lewis-McChord)

Source: BridgeNet International 2019

Appendix N
Skagit Regional Airport Flight Procedure Graphics

Figure N-1
BVS Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 11 AND RWY 29 (North and South Flow)

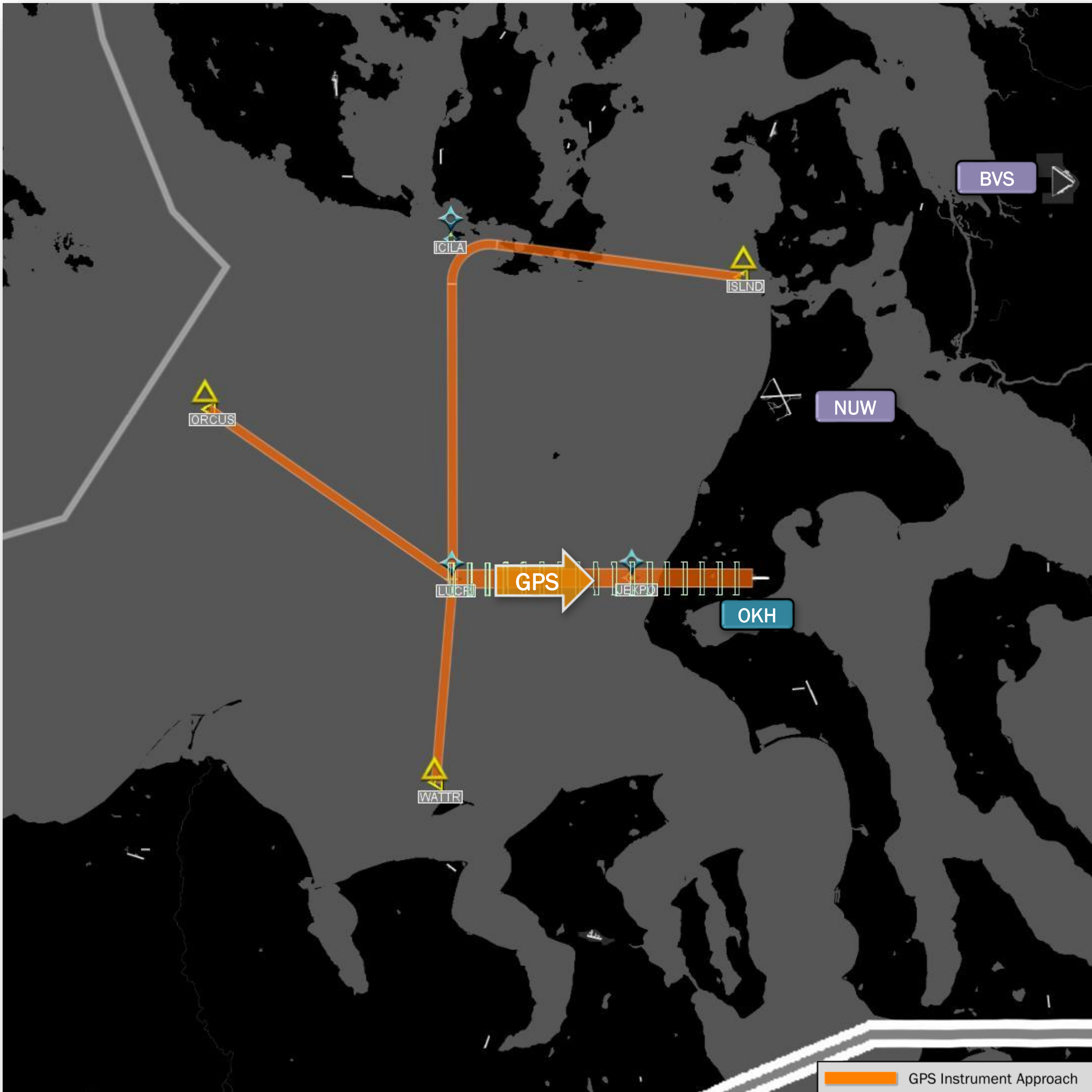
Puget Sound Regional Council

Notes: BVS - Skagit Regional Airport

Appendix O
AJ Eisenberg Airport Flight Procedure Graphics

Figure O-1
OKH Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 07 (East Flow)

Puget Sound Regional Council



Notes: OKH - AJ Eisenberg Airport

Appendix P
Pierce County Airport Flight Procedure Graphics

Figure P-1
PLU Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 35 (North Flow)

Notes: PLU - Pierce County Airport - Thun Field
No Instrument Approaches in South Flow

Source: BridgeNet International 2019

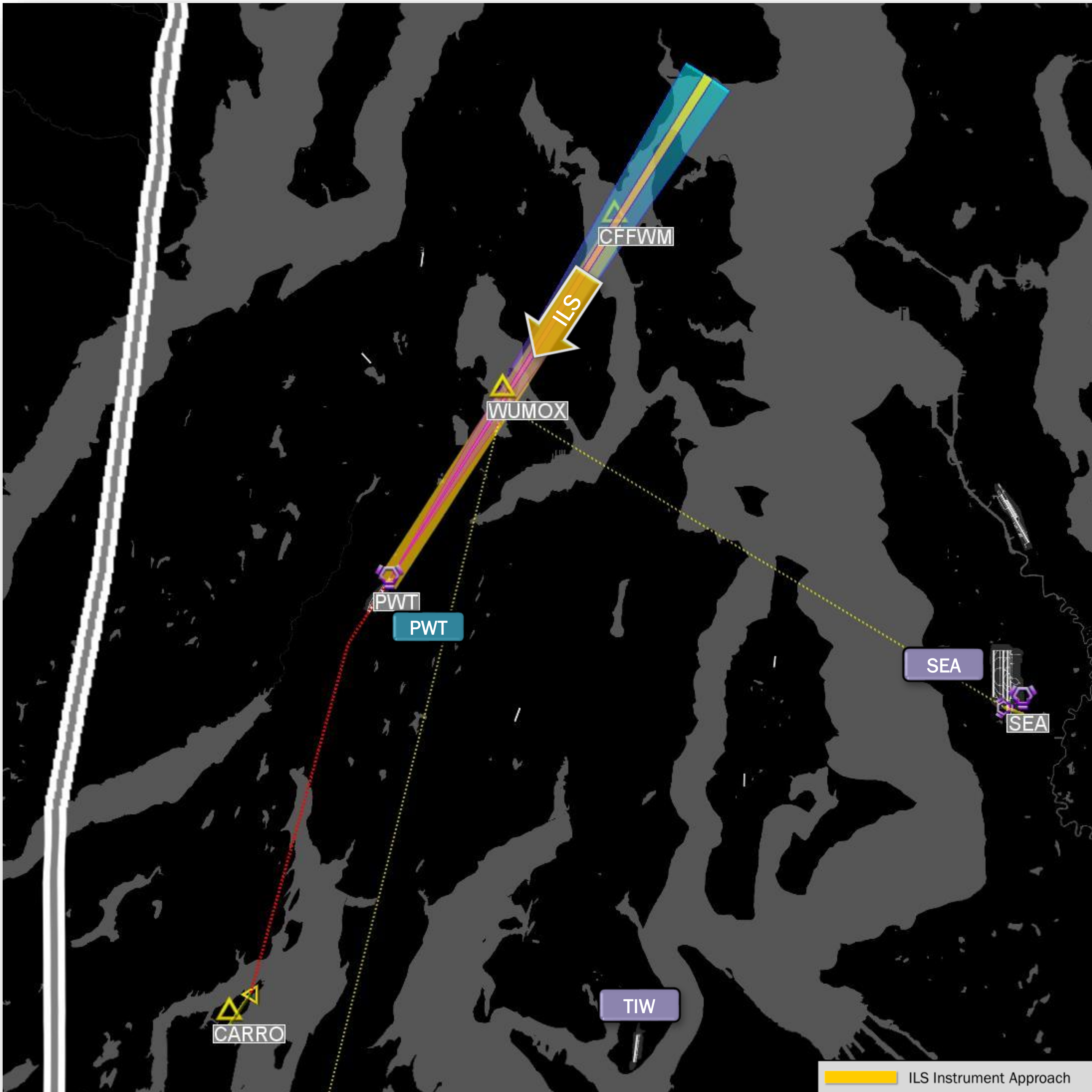
Appendix Q
Bremerton National Airport Flight Procedure Graphics

Figure Q-1

PWT Instrument Approach Procedures (IAPs)

ILS RWY 20 (South Flow)

Puget Sound Regional Council



Notes: PWT - Bremerton National Airport
No ILS in North Flow

Figure Q-2
PWT Instrument Approach Procedures (IAPs)
RNAV (GPS) RWY 02 AND RWY 20 (North and South Flow)

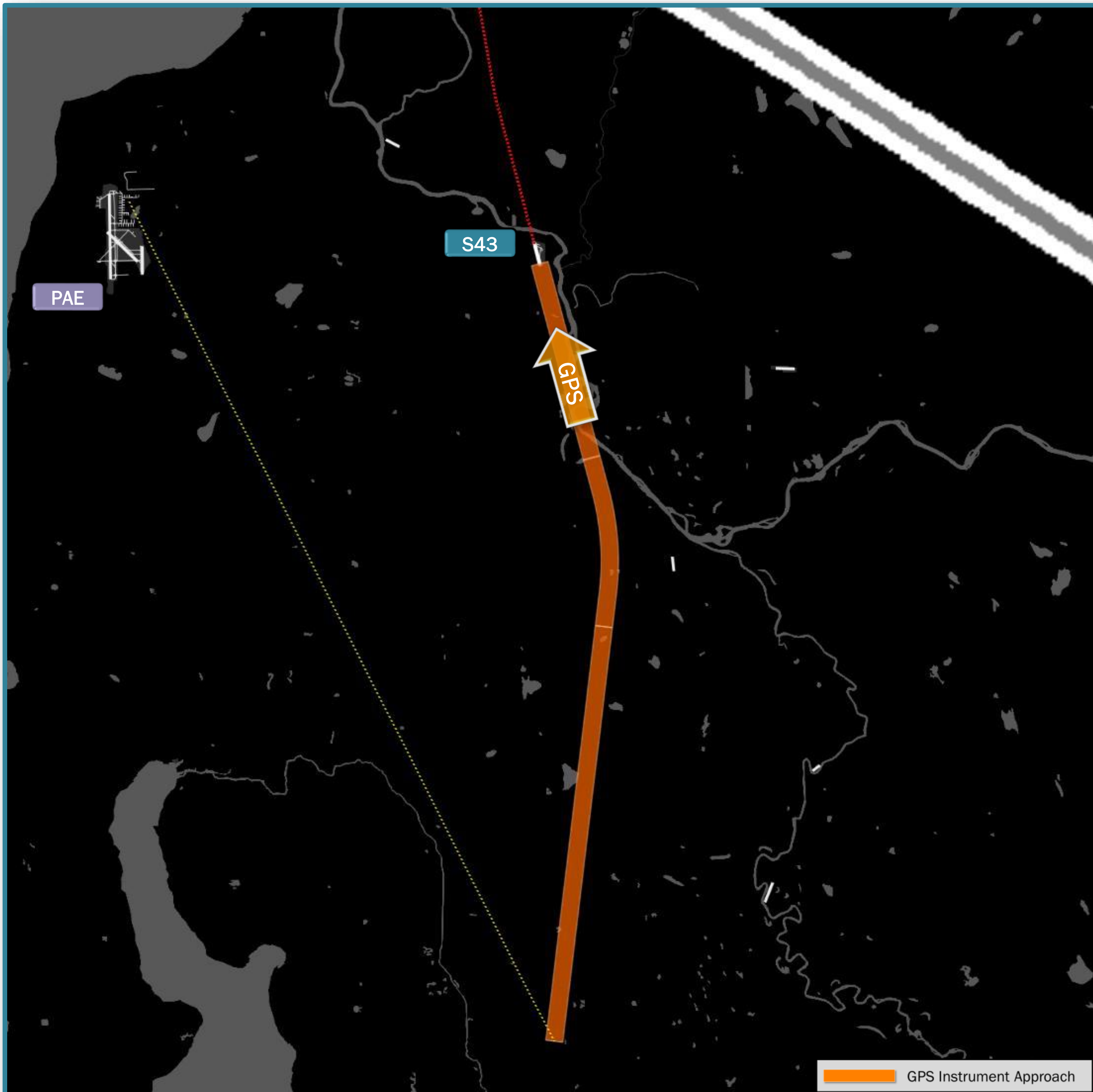
Puget Sound Regional Council

Notes: PWT - Bremerton National Airport

Appendix R
Harvey Field Airport Flight Procedure Graphics

Figure R-1
S43 Instrument Approach Procedures (IAPs)
RNAV (GPS)-A (North Flow)

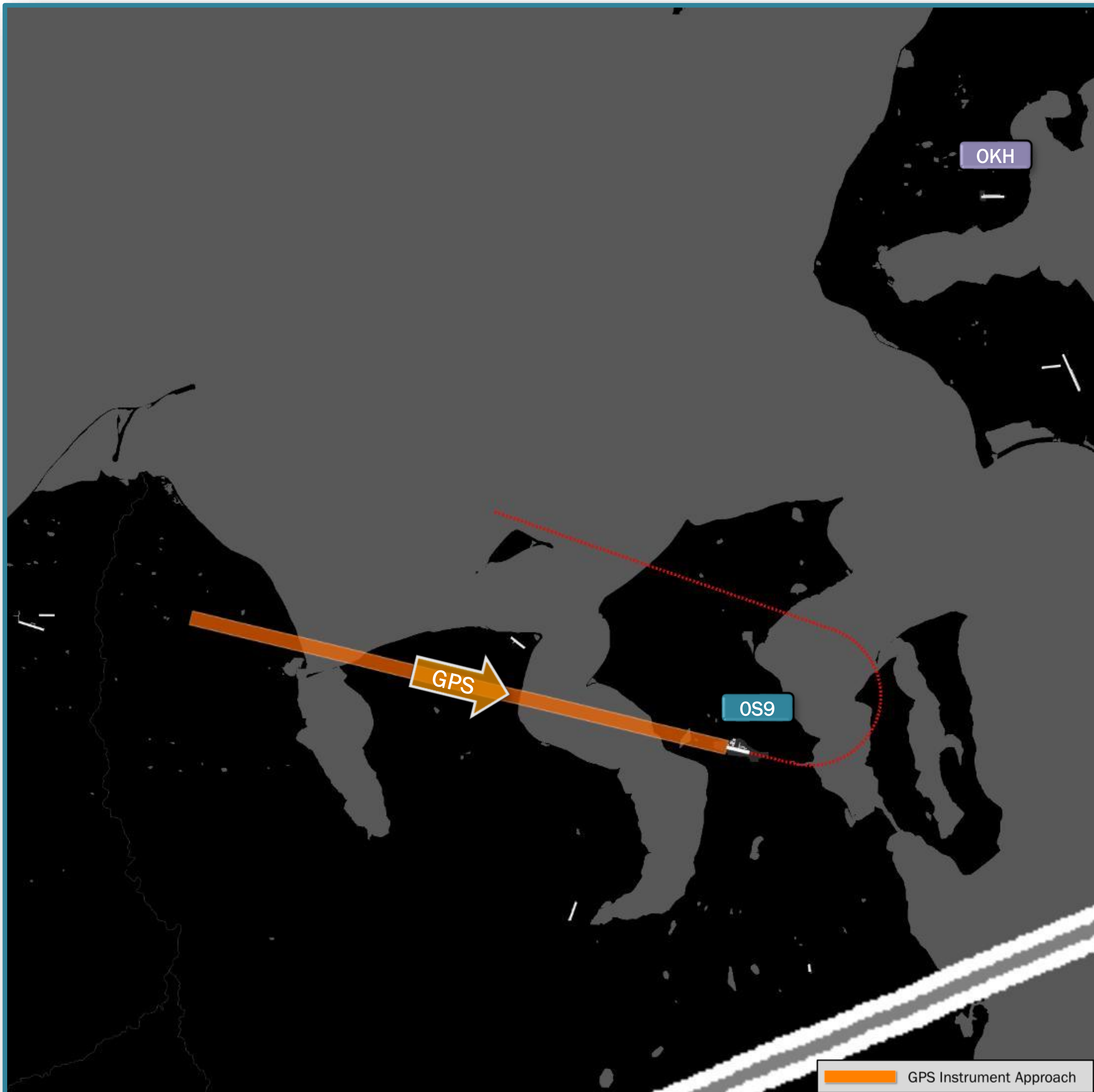
Puget Sound Regional Council



Notes: S43 – Harvey Field Airport

Appendix S
Jefferson County Airport Flight Procedure Graphics

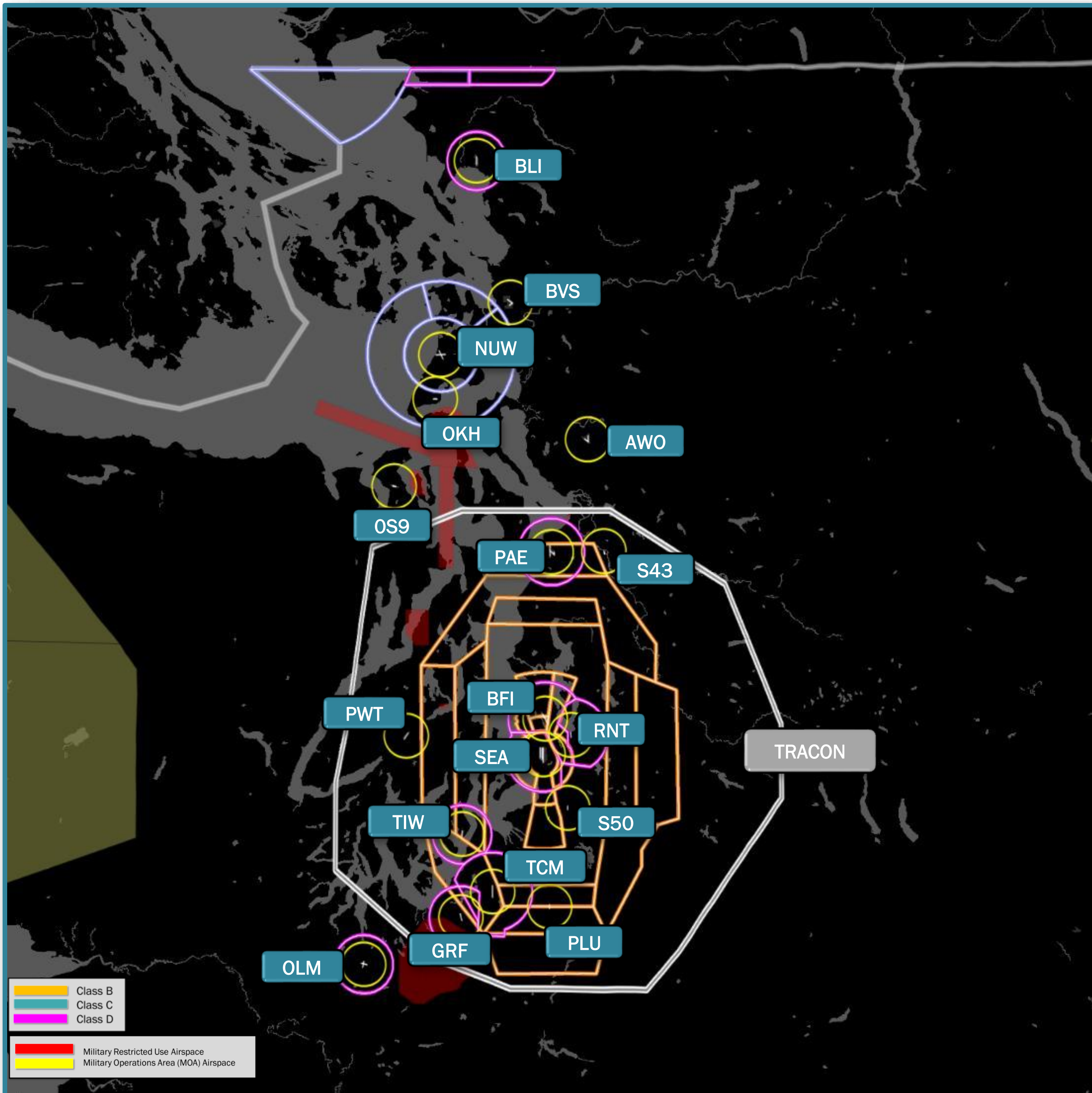
Figure S-1
0S9 Instrument Approach Procedures (IAPs)
RNAV (GPS)-A (East Flow)



Notes: 0S9 – Jefferson County International Airport

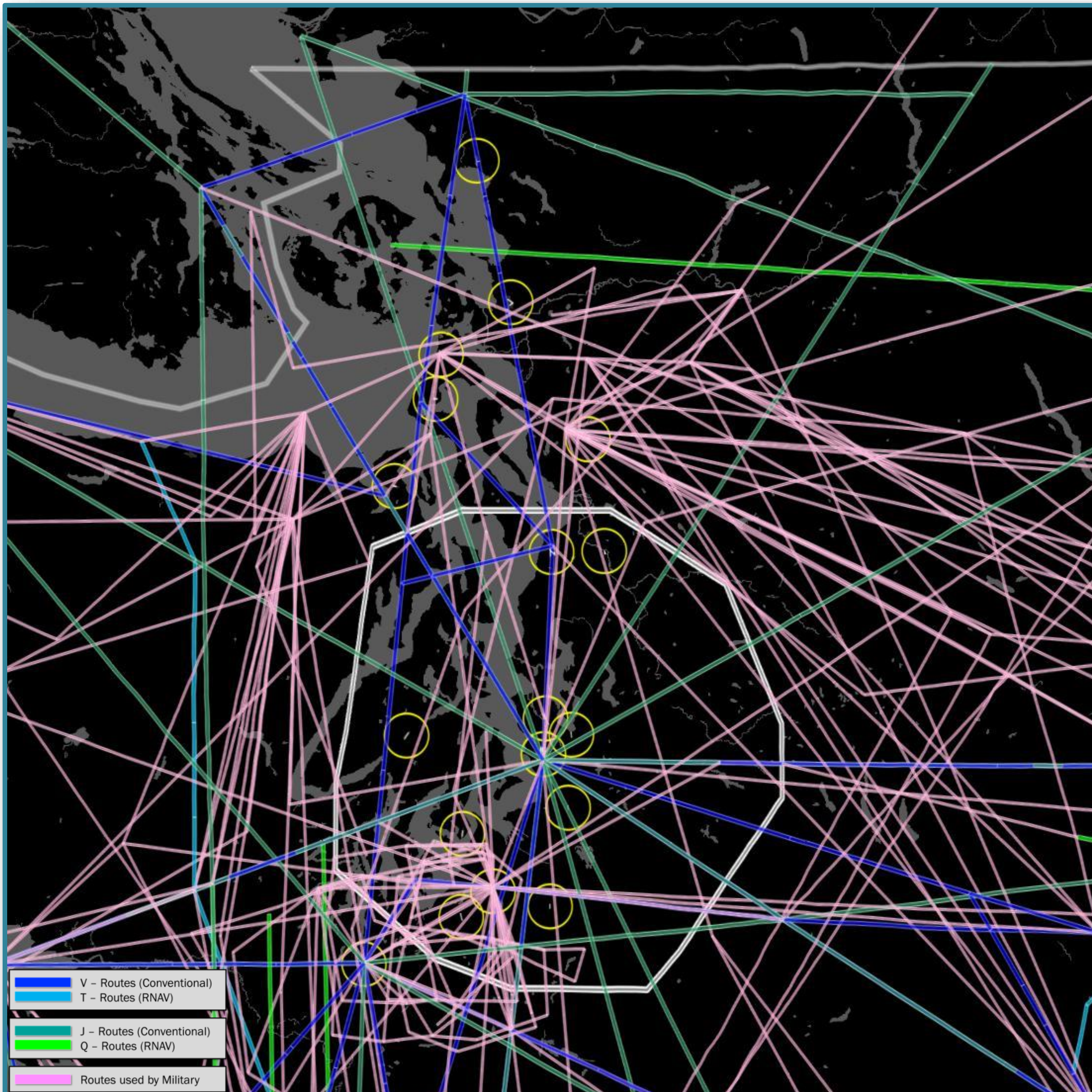
Appendix T
Illustrations of Current Airspace Constraints

Figure T-1
All Airspaces within Study Area



Source: BridgeNet International 2019

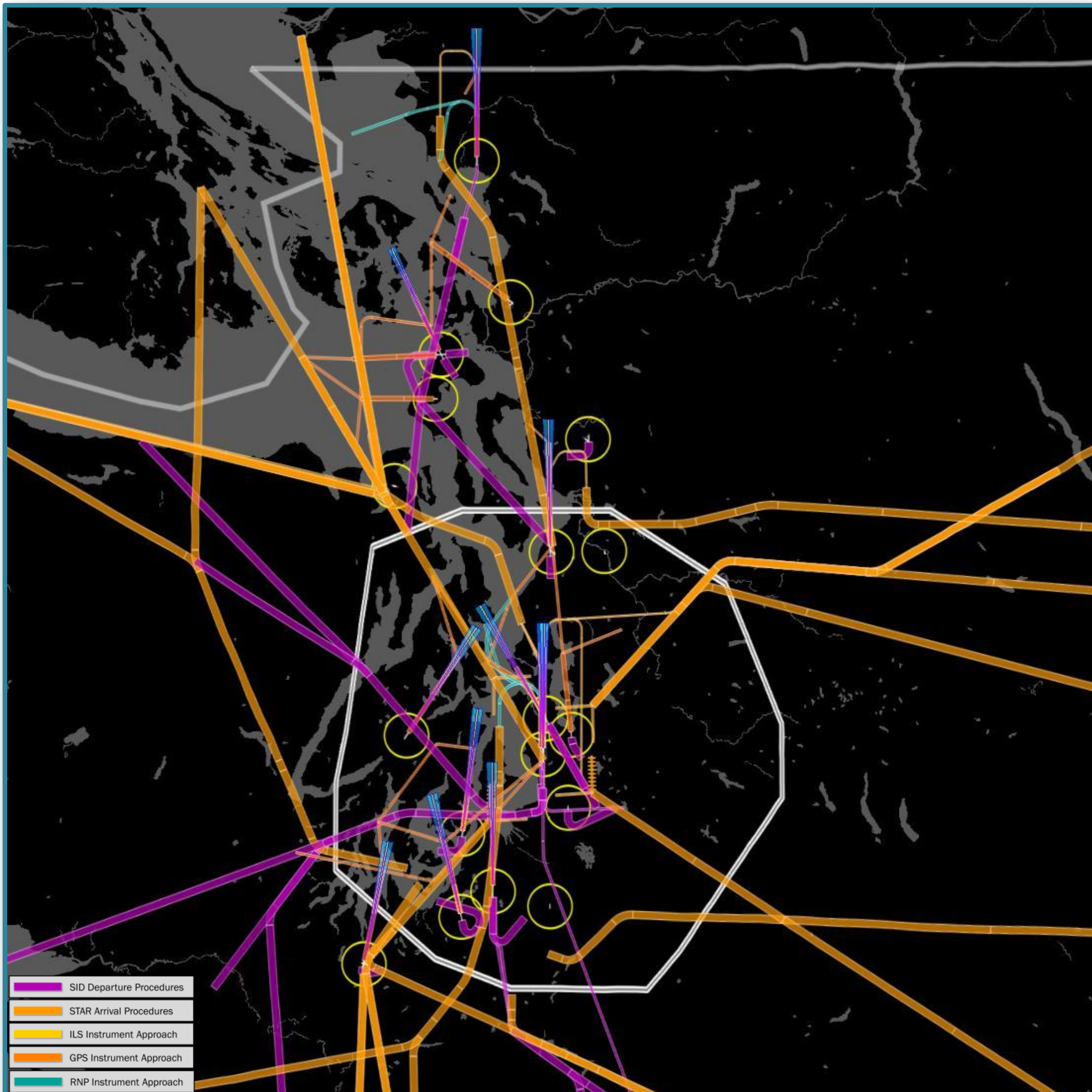
Figure T-2
All Enroute within Study Area
J, Q, V, T and Military Enroute



Source: BridgeNet International 2019

Figure T-3
All Flight Procedures in South Flow within Study Area
SIDs, STARs, and IAPs

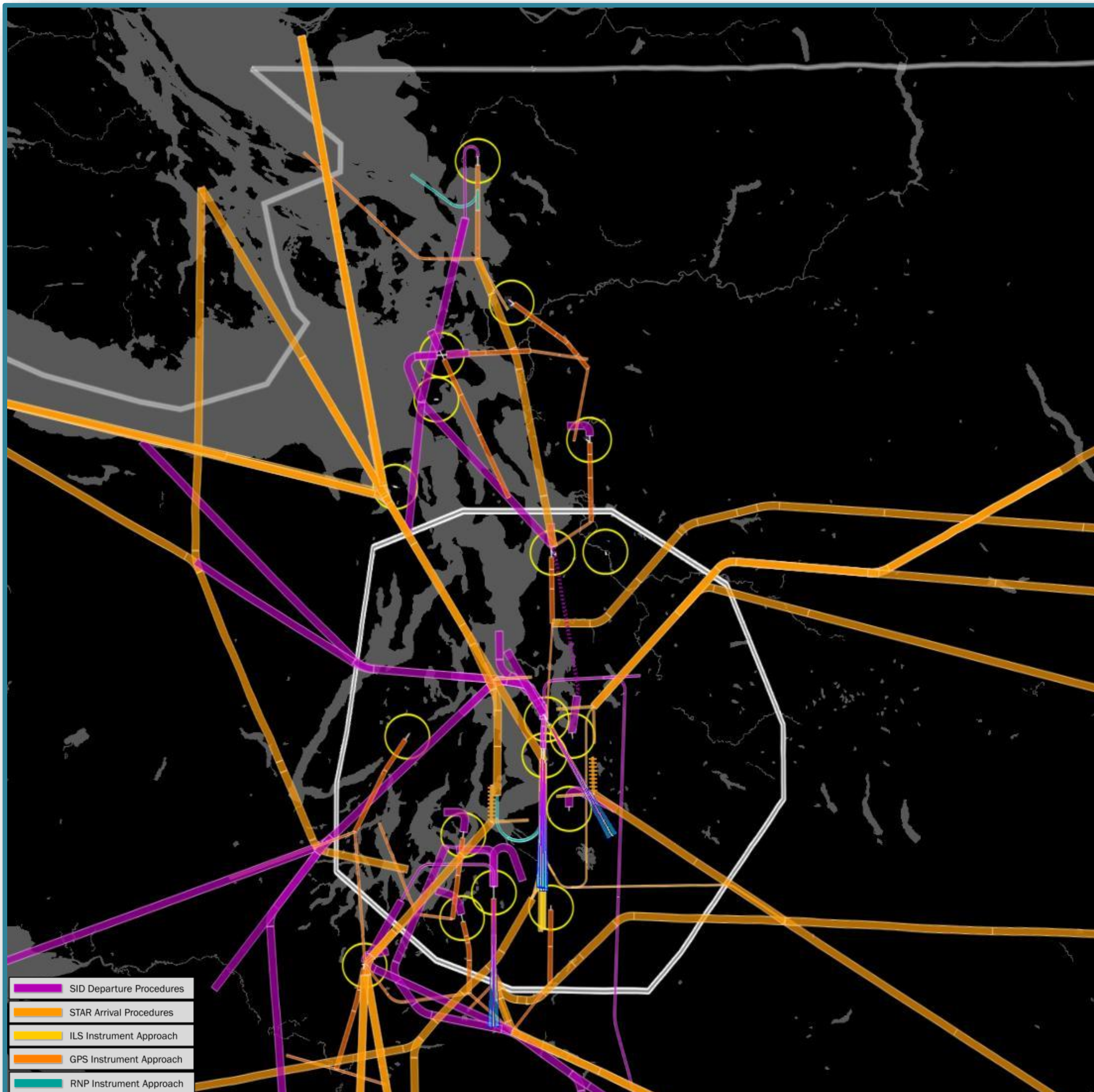
Puget Sound Regional Council



Source: BridgeNet International 2019

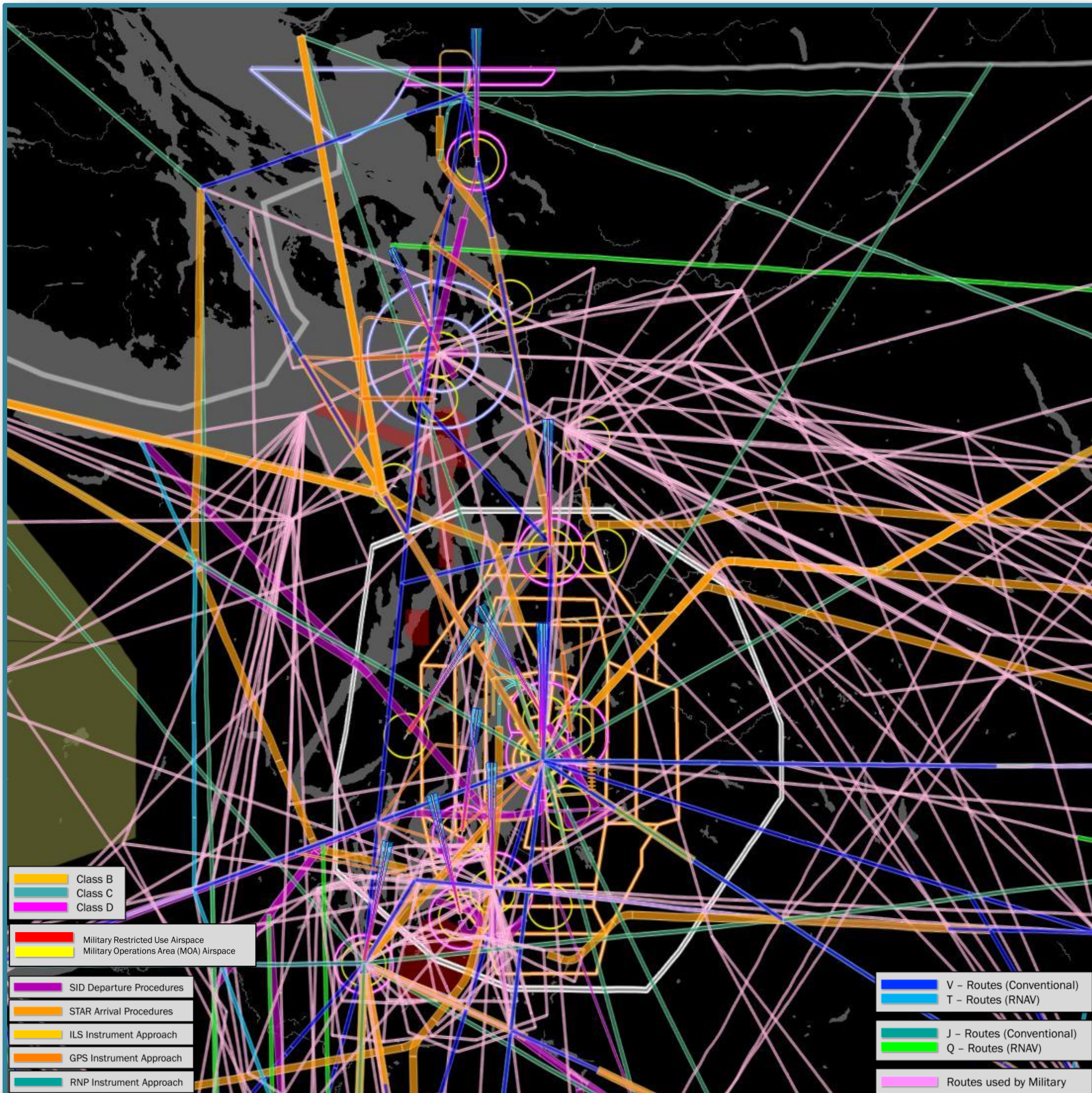
Figure T-4
All Flight Procedures in North Flow within Study Area
SIDs, STARs, and IAPs

Puget Sound Regional Council



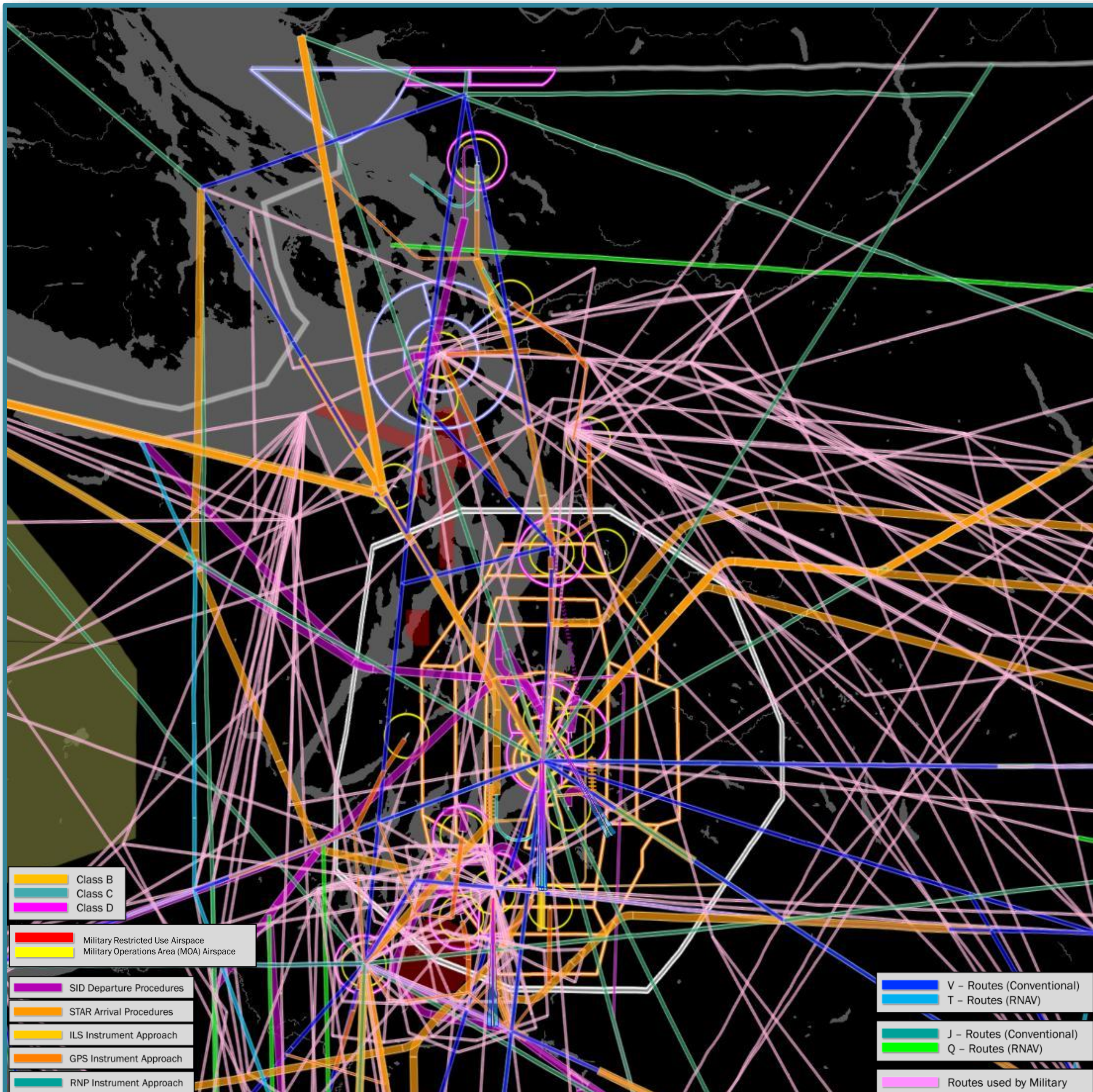
Source: BridgeNet International 2019

Figure T-5
Airspaces, Enroute and Flight Procedures in South Flow within Study Area
SIDs, STARs, and IAPs



Source: BridgeNet International 2019

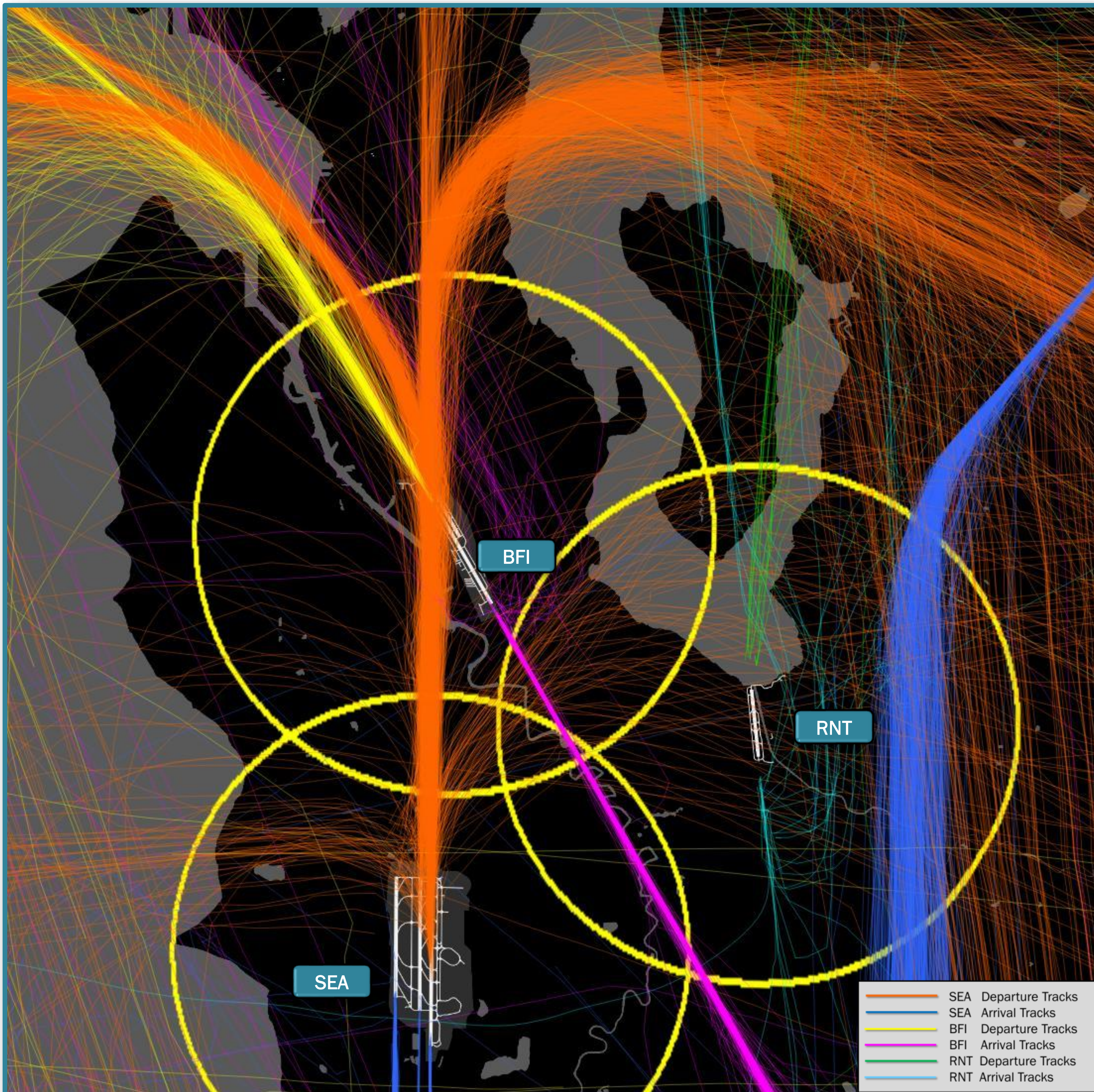
Figure T-6
Airspaces, Enroute and Flight Procedures in North Flow within Study Area
SIDs, STARs, and IAPs



Source: BridgeNet International 2019

Figure T-7a
Constraint – Close Proximity of SEA, BFI, RNT

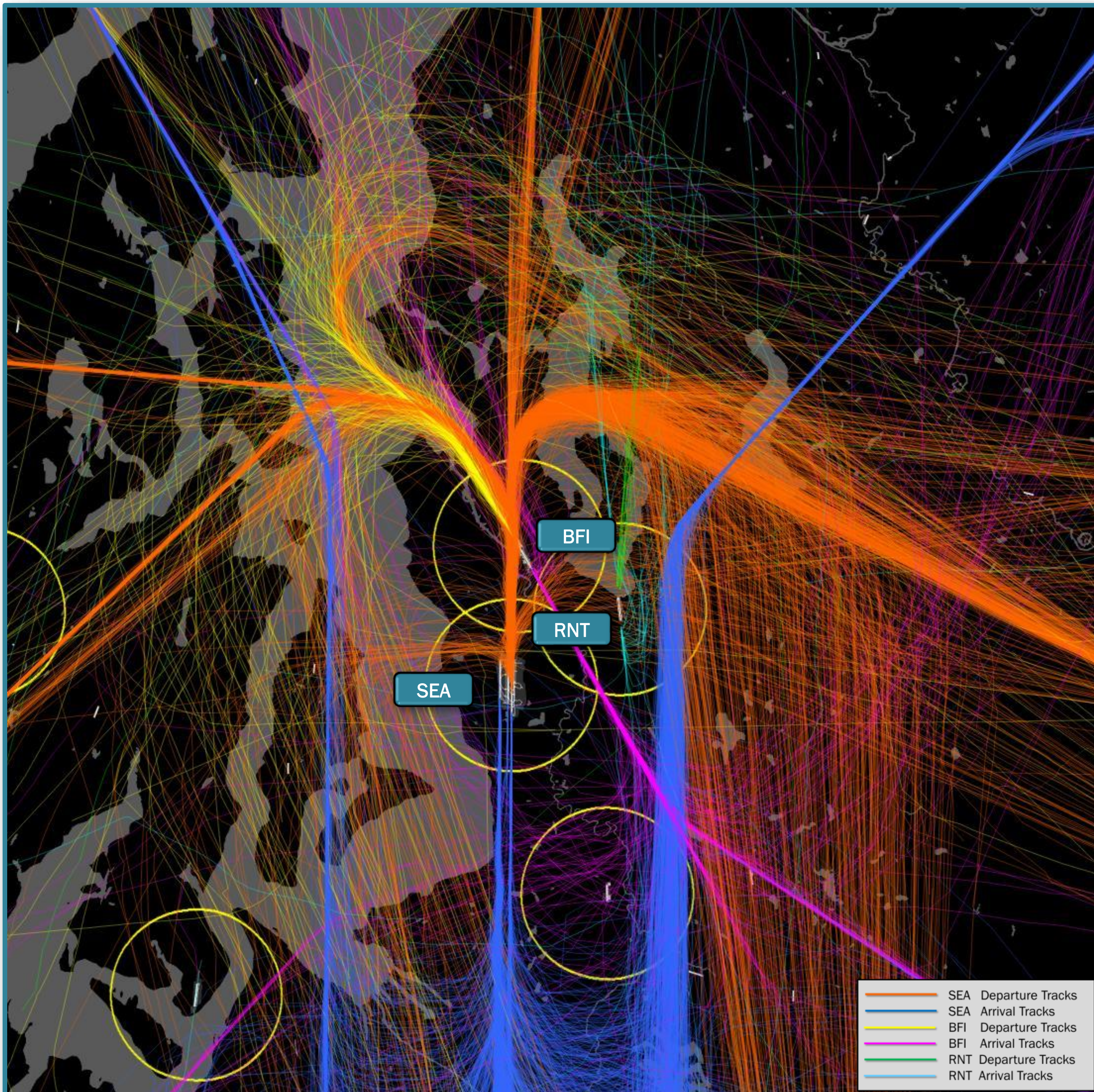
Puget Sound Regional Council



Notes: North Flow Operations (August 14 and 15, 2018)

Source: BridgeNet International 2019

Figure T-7b
Constraint – Close Proximity of SEA, BFI, RNT

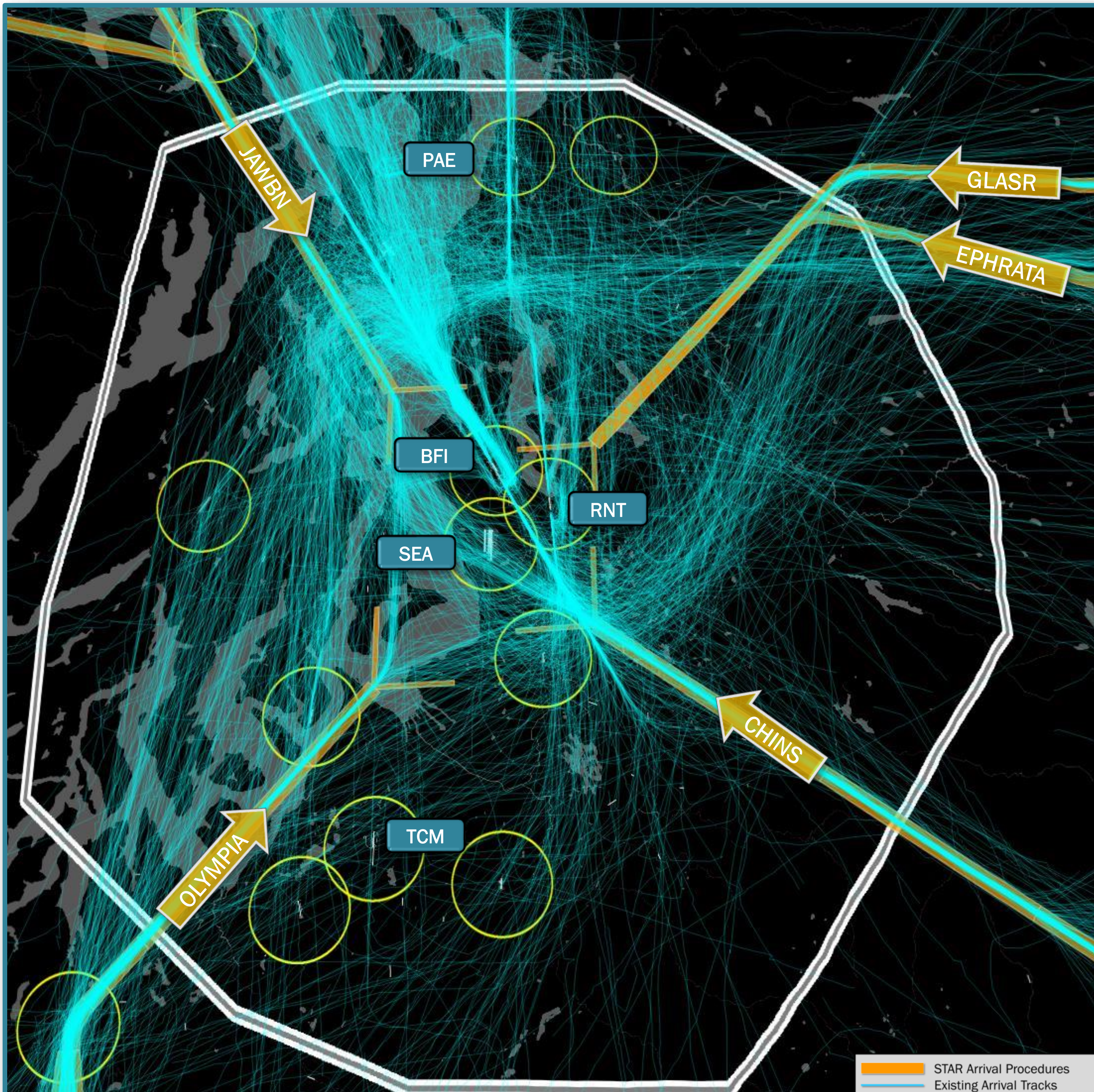


Notes: North Flow Operations (August 14 and 15, 2018)

Source: BridgeNet International 2019

Figure T-8
Constraint – Shared STARs

Puget Sound Regional Council

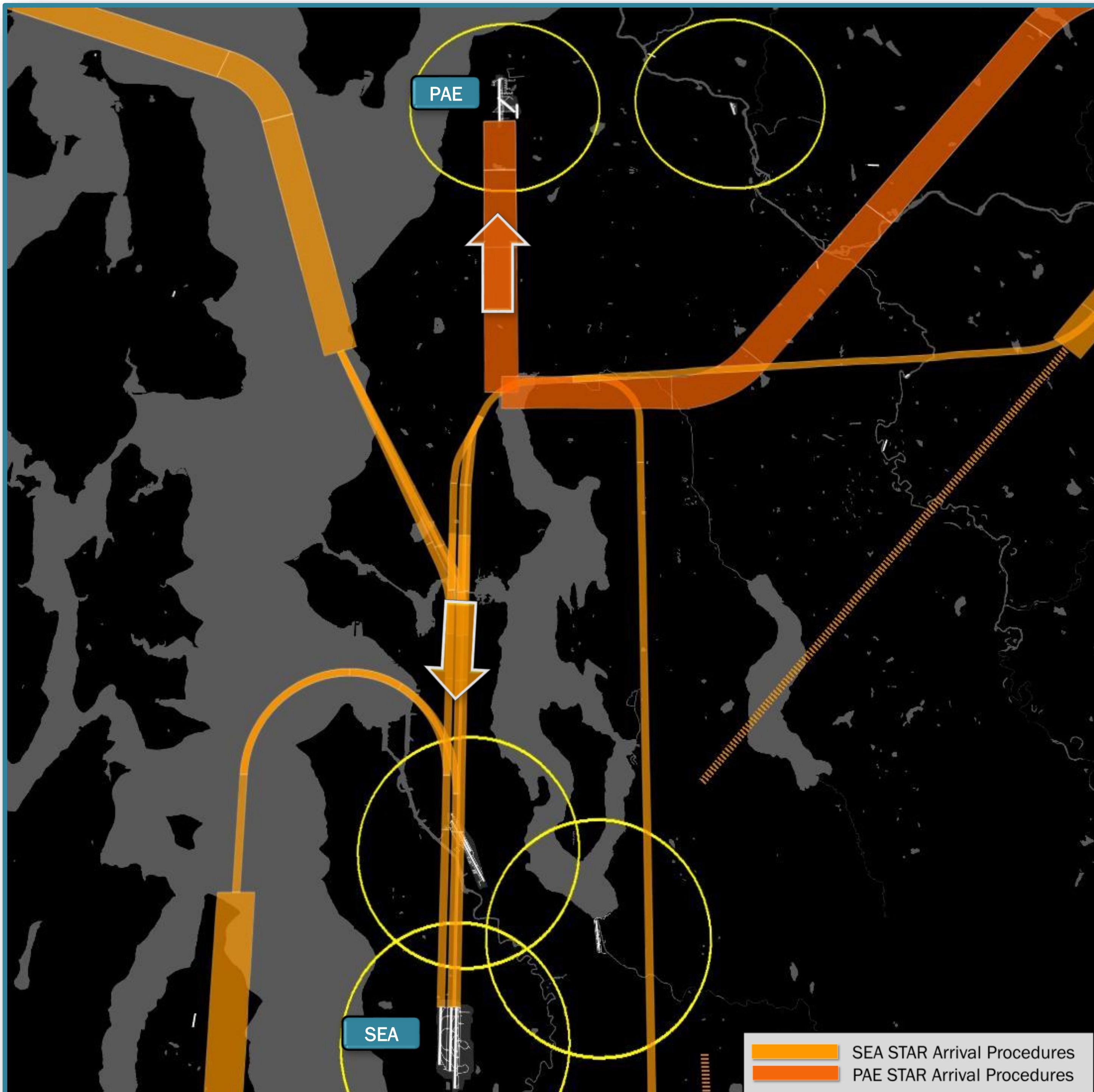


Notes: Arrival Tracks using STARS into BFI, RNT, PAE and TCM. These STARs are also available to SEA but OLYMPIA, JAWBN AND EPHRATA are lightly used.

Source: BridgeNet International 2019

Puget Sound Regional Council

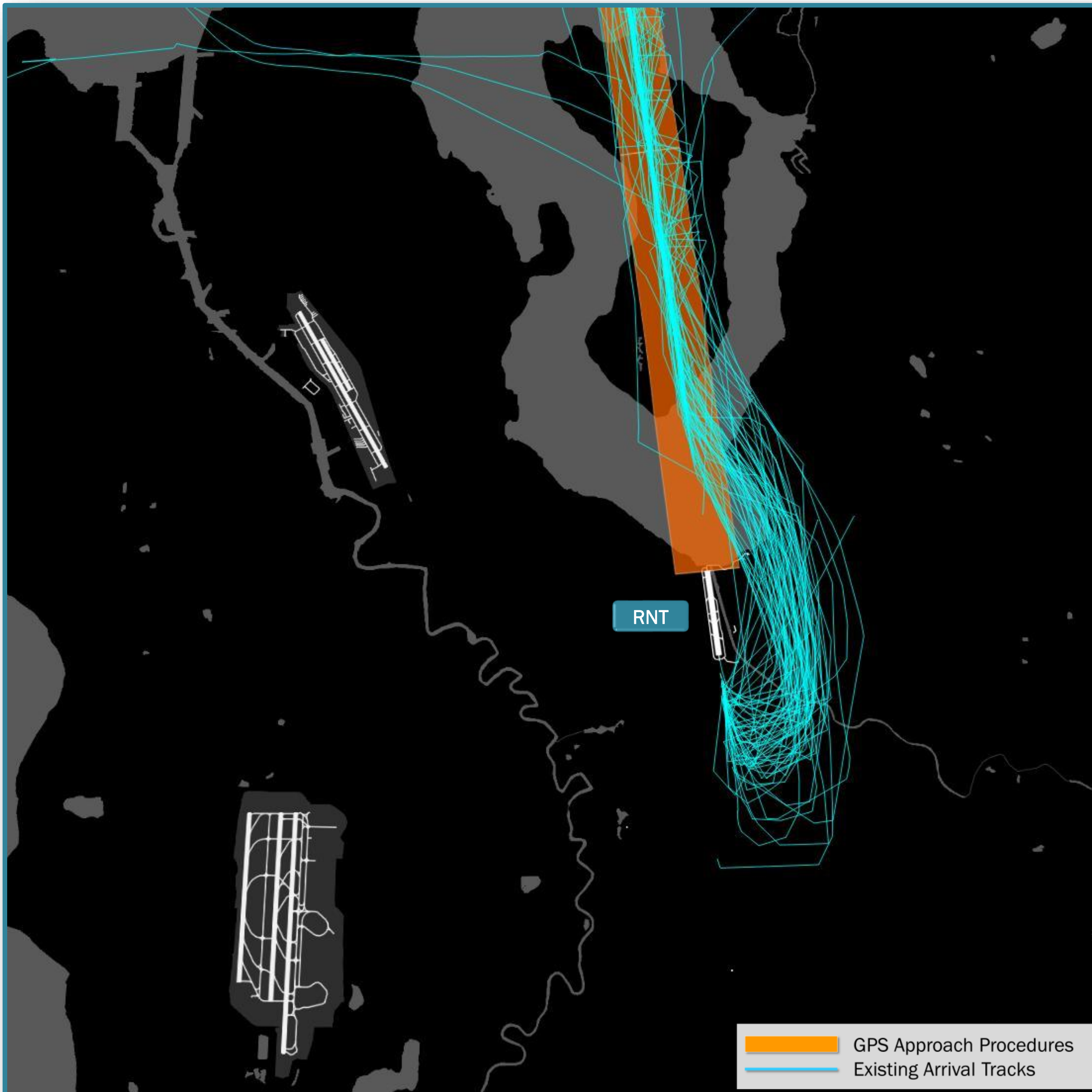
Figure T-9
Constraint – Mixed Flow with SEA and PAE
STARs for SEA in South Flow and PAE in North Flow



Source: BridgeNet International 2019

Figure T-10
Constraint – RNT with South Flow IAP Only
In North Flow IFR Weather Conditions RNT Access is Constrained

Puget Sound Regional Council



Notes: Without an approach in North Flow, in IMC weather, aircraft either can not access the airport, or must fly the south flow approach And then circle to land to the north. A more constrained operating environment.

Appendix B – Multi-Airport City Analysis

REGIONAL AVIATION BASELINE STUDY
WORKING PAPER 2

Airport Needs Analysis:
Appendix B – Multi-Airport City Analysis

October 1, 2019

Prepared for

Puget Sound Regional Council

Prepared by

wsp

In association with

CDM Smith

KPA KEISER PHILLIPS ASSOCIATES

PRR

BridgeNet INTERNATIONAL A TETRA TECH COMPANY

Contents

Tables

Figures

Appendix B. Multi Airport Cities

B.1 LOS ANGELES, CA

Los Angeles International Airport (LAX) is governed by Los Angeles World Airports. Commercial service at LAX began in 1946 and the airport and number of passengers it serves has continued to grow since. LAX is the main airport for Los Angeles, located approximately 15 miles southwest of downtown Los Angeles and the $5.5-billion Landside Access Modernization Program (LAMP) will connect LAX to the City's Metro system by 2023. With approximately 75 air carriers operating at the airport, it is a connecting hub for Alaska, American, Delta, and United Airlines. Hollywood Burbank Airport (BUR) is also located approximately 15 miles northwest of downtown Los Angeles. BUR was opened in 1930 to serve downtown and the northern greater Los Angeles area and is the only airport in the area with direct rail access to downtown Los Angeles. The airport is owned and operated by the Burbank-Glendale-Pasadena Airport Authority. BUR has 7 airlines operating at the airport serving 18 destinations. Long Beach Airport (LGB), located approximately 25 miles south of Los Angeles, is owned and operated by the City of Long Beach. It is situated halfway between the major business and tourism areas of Orange and Los Angeles Counties. LGB has 18 destinations served by 5 airlines. Ontario International Airport (ONT) is located approximately 35 miles east of downtown Los Angeles. The airport is operated by the Ontario International Airport Authority. ONT is served by 9 airlines operating to 21 destinations. The airport service area includes San Bernardino and Riverside counties, along with portions of Orange and Los Angeles counties. John Wayne Airport (SNA) is located 40 miles southeast of downtown Los Angeles and is 20 miles southeast of LGB. It is owned by Orange County and is the only commercial service airport in the county. SNA has 7 airlines serving 24 domestic and international destinations.

Figure B-1 shows LAX, BUR, LGB, and ONT locations in relation to downtown Los Angeles, along with drive times without traffic from each airport to the downtown area. Table B-1 shows information for Los Angeles, CA, and Table B-2 shows information about. All information is based on 2017 data.

Figure B-1. Los Angeles Vicinity Map

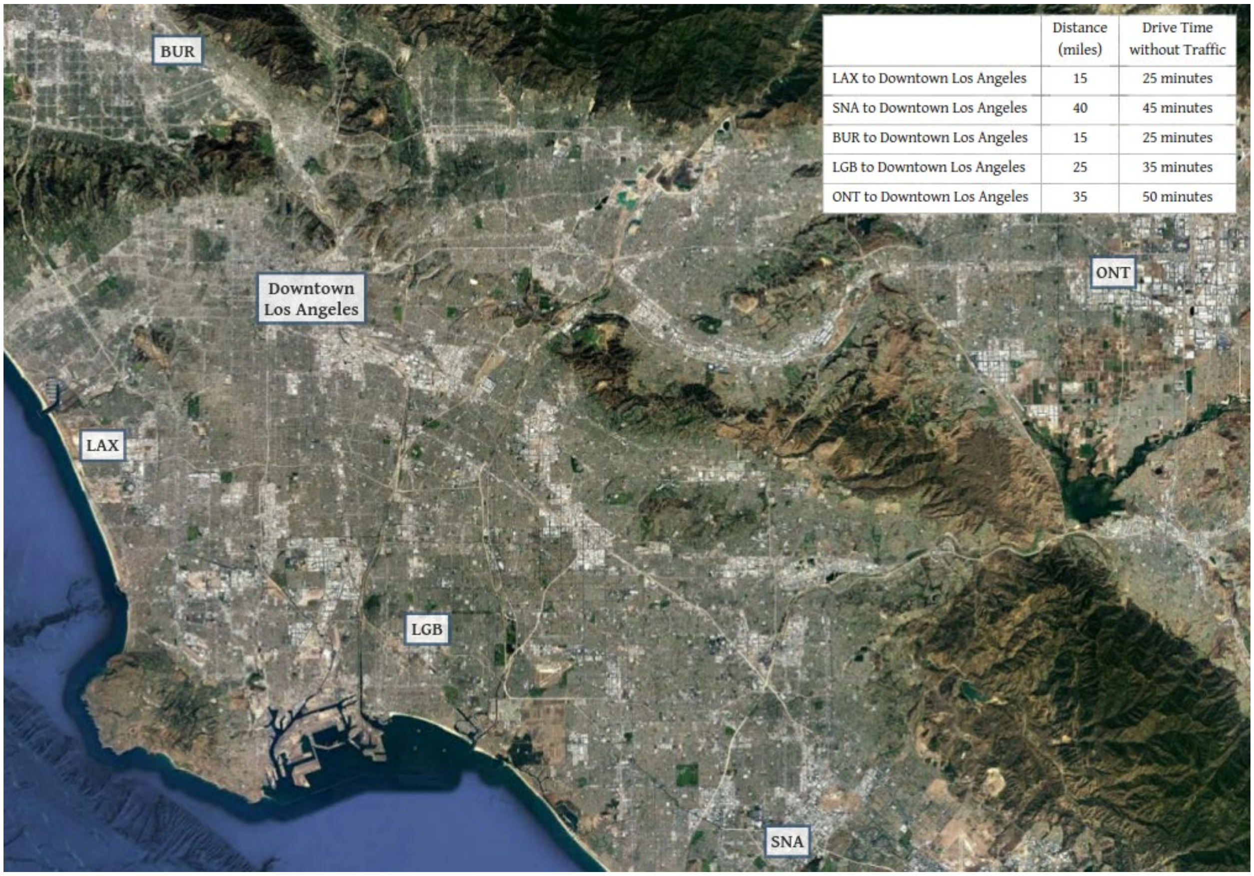


Table B-1. Los Angeles, CA Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Los Angeles, CA	Los Angeles-Long Beach-Anaheim	13,353,907	$60,087	4	.033

Table B-2. LAX, ONT, BUR, and LGB Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
LAX	37,109,094	322,091	157	Metro (2023)	132
SNA	4,768,202	45,321	119	None	20
BUR	1,940,618	24,635	102	Metrolink	14
LGB	1,589,801	17,201	137	None	11
ONT	1,931,653	29,540	101	None	26
Total	47,339,368	438,786	123		183

B.2 CHICAGO, IL

Chicago Department of Aviation oversees both Chicago O'Hare International Airport (ORD) and Chicago Midway International Airport (MDW). Both airports are connected to downtown Chicago by the CTA Rail. MDW, located approximately 10 miles southwest from central downtown Chicago, was opened in 1927 and served as the primary airport for Chicago, but as passengers increased, the need for a new airport grew. O'Hare, located approximately 20 miles northwest from central downtown Chicago, began commercial service in 1955 and has continued to grow into Chicago's primary airport, handling nearly four times more passengers and operations than Midway. Currently, O'Hare is a hub for both United and American Airlines, while Midway is a hub for Southwest Airlines.

Figure B-2 shows ORD and MDW locations in relation to downtown Chicago, along with drive times without traffic from each airport to the downtown area. Table B-3 shows information for Chicago, IL and Table B-4 shows information about Midway and O'Hare. All information is based on 2017 data.

Figure B-2. Chicago Vicinity Map

	Distance (miles)	Drive Time without Traffic
ORD to Downtown Chicago	20	25 minutes
MDW to Downtown Chicago	10	25 minutes

Table B-3. Chicago, IL Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Chicago, IL	Chicago-Naperville-Elgin	9,533,040	$58,345	6	.043

Table B-4. ORD and MDW Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
ORD	28,154,046	312,387	118	CTA Rail	191
MDW	10,606,091	93,152	124	CTA Rail	48
Total	38,760,137	405,539	121		239

B.3 DALLAS, TX

Both Dallas-Fort Worth International Airport (DFW) and Dallas Love Field (DAL) are located northwest of the central Dallas business district and are 12 miles apart, with DAL being approximately 7 miles and DFW being approximately 20 miles from the Dallas central business district, respectively. In 1927 Dallas proposed a joint airport with Fort Worth, which Fort Worth declined and subsequently each city opened an airport with commercial service, where DAL served Dallas. In 1940, the Civil Aeronautics Administration set aside funding for a joint airport between Dallas and Fort Worth, but the cities could not come to an agreement over the location and the project was abandoned. In 1953 Fort Worth moved its flights to the airfield that is now DFW. DAL is a city-owned airport operated by the Dallas Department of Aviation. Currently, DAL is a hub for Southwest, and has three airlines total that operate at the airport. DFW is the largest hub for American Airlines, and has 23 airlines that operate at the airport that serve 253 destinations worldwide.

Figure B-3 shows DFW and DAL locations in relation to downtown Dallas and Fort Worth, along with drive times without traffic from each airport to the downtown area. Table B-5 shows information for Dallas, TX and Table B-6 shows information about DFW and DAL. All information is based on 2017 data.

Figure B-3. Dallas and Fort Worth Vicinity Map

	Distance (miles)	Drive Time without Traffic
DFW to Downtown Dallas	20	25 minutes
DFW to Downtown Fort Worth	20	30 minutes
DAL to Downtown Dallas	7	20 minutes
DAL to Downtown Fort Worth	30	45 minutes

Table B-5. Dallas, TX Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Dallas, TX	Dallas-Fort Worth-Arlington	7,399,662	$52,995	6	0.047

Table B-6. DFW and DAL Data

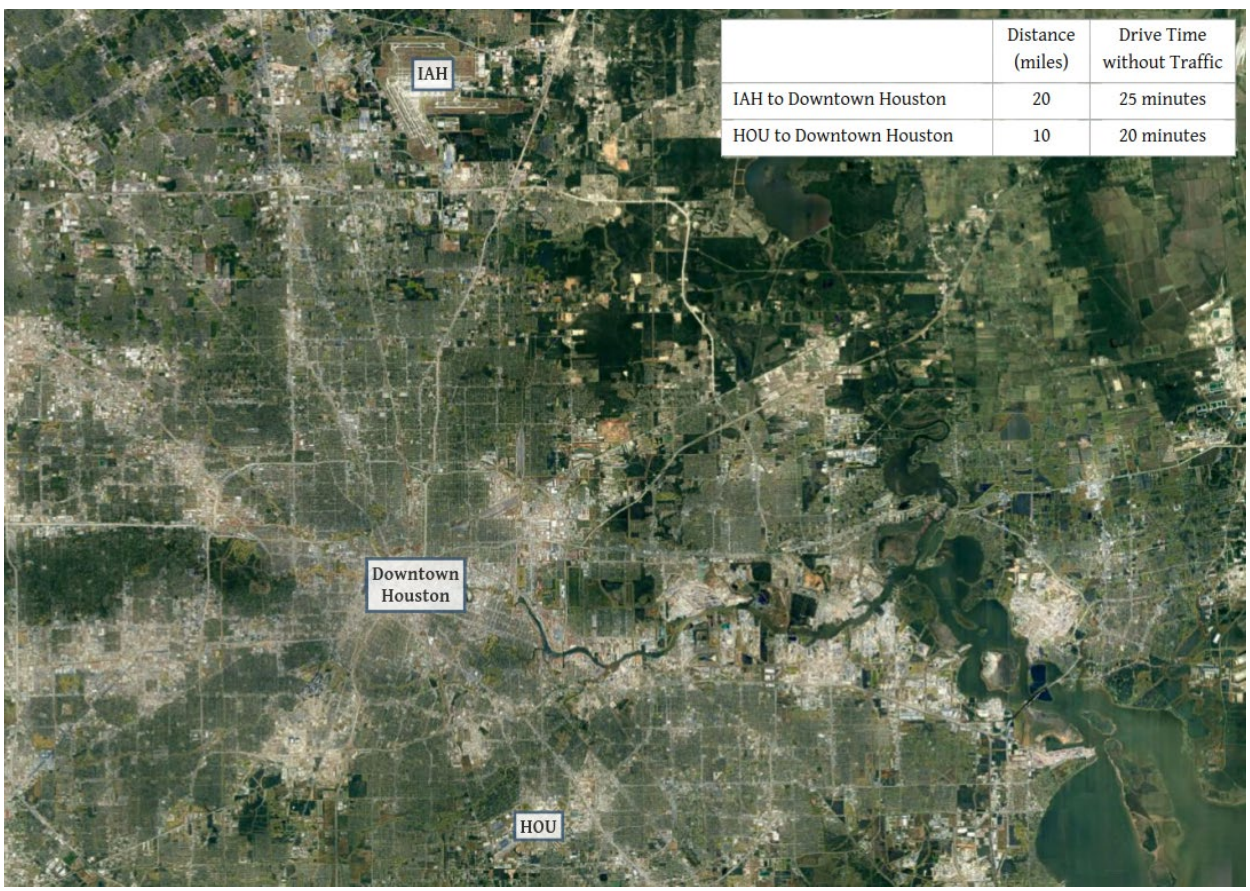
	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
DFW	25,108,983	277,739	134	DART Rail (Dallas) TEXRail (Fort Worth)	164
DAL	7,519,288	69,473	120	DART Rail via Love Link Bus	20
Total	32,628,271	347,212	127		184

B.4 HOUSTON, TX

Houston Airport System operates both George Bush Intercontinental Airport (IAH), located approximately 20 miles north of central Houston, and William P. Hobby Airport (HOU), located approximately 10 miles southeast of central Houston. HOU was the first major commercial airport in Houston in 1937. IAH was added to the Houston Airport System in 1969, as the city of Houston was growing. Currently, IAH is a long-haul international airport that serves as a United Airlines largest hub. 27 airlines operate at IAH serving over 180 destinations. HOU is a hub for Southwest Airlines and has 4 airlines that serve over 65 destinations, including international locations. Houston Metro is considering extending light rail transit to Hobby Airport as of 2019. No rail connection exists to IAH, but a Houston Metro is considering adding a connection to IAH as part of their new 20-year transit plan.

Figure B-4 shows IAH and HOU locations in relation to downtown Houston, along with drive times without traffic from each airport to the downtown area. Table B-7 shows information for Houston, TX and Table B-8 shows information about IAH and HOU. All information is based on 2017 data.

Figure B-4. Houston Vicinity Map



	Distance (miles)	Drive Time without Traffic
IAH to Downtown Houston	20	25 minutes
HOU to Downtown Houston	10	20 minutes

Table B-7. Houston, TX Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Houston, TX	Houston-The Woodlands-Sugar Land	6,892,427	$52,765	4	0.033

Table B-8. IAH and HOU Data

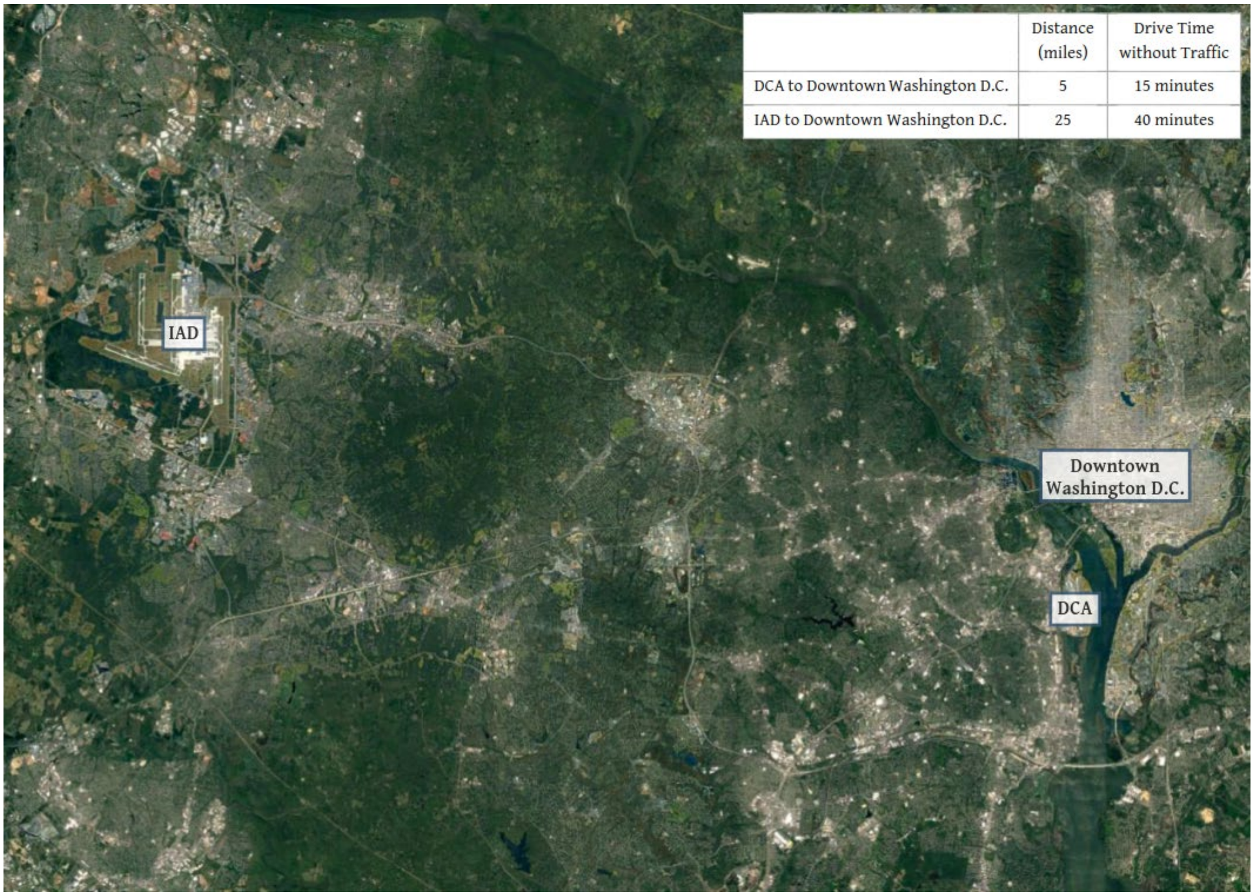
	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
IAH	14,201,264	167,513	120	None	130
HOU	6,244,203	59,032	121	None	30
Total	20,445,467	226,544	121		160

B.5 WASHINGTON D.C.

Ronald Reagan Washington National Airport (DCA) opened in 1941 primarily as a short haul airport and is located 5 miles from downtown Washington D.C. In 1962, Dulles International Airport (IAD) opened 25 miles northwest of downtown Washington D.C. and was built due to demand for additional service for the area for long haul and international flights. The Perimeter Rule was established for DCA in 1966, when jet aircraft began operations. The original rule limited flights from DCA to destinations not further than 650 statute miles, with a few exceptions for existing destination. In the mid 1980's the perimeter rule was increased to 1,250 statute miles. Currently, DCA serves 10 cities outside the perimeter. The Slot Rules were established for DCA and other airports in 1969 and allowed for no more than 60 IFR operations per hour at DCA. Over the years, the number of slots has been increased to add an additional 54 slots per day. Both airports are owned and operated by the Metropolitan Washington Airport Authority. DCA is a domestic connecting hub for American Airlines and IAD is a hub for United Airlines. Both airports have a similar number of enplanements and aircraft operations. Washington Metro has direct rail access to DCA, the Silver line is set to open in Summer 2020 to IAD. IAD provides service to international and many other destinations that are outside the confines of the perimeter rule at DCA. Baltimore/Washington International Thurgood Marshall Airport (BWI) is located approximately 30 miles northwest of downtown Washington D.C. with an approximate drive time of 45 minutes without traffic. While it is within close proximity of Washington D.C., it is not included in the Washington D.C. MSA nor part of the Washington D.C. market per the USDOT and therefore has been excluded from this study.

Figure B-5 shows IAD and DCA locations in relation to downtown Washington D.C., along with drive times without traffic from each airport to the downtown area. Table B-9 shows information for Washington D.C. and Table B-10 shows information about DCA and IAD. All information is based on 2017 data.

Figure B-5. Washington D.C. Vicinity Map



	Distance (miles)	Drive Time without Traffic
DCA to Downtown Washington D.C.	5	15 minutes
IAD to Downtown Washington D.C.	25	40 minutes

Table B-9. Washington D.C. Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Washington D.C.	Washington-Arlington-Alexandria	6,216,589	$69,581	4	0.034

Table B-10. DCA and IAD Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
DCA	7,993,630	120,997	114	Washington Metro	44
IAD	8,153,655	89,902	157	Washington Metro (2020)	135
Total	16,147,285	210,898	136		179

B.6 MIAMI, FL

Miami International Airport (MIA), located approximately seven miles from downtown Miami, is operated by the Miami-Date Aviation Department. The airport was founded in 1928 and now offers more flights to Latin America and the Caribbean than any other U.S. Airport. MIA is a hub for American Airlines. Overall, 80 airlines operate at MIA serving approximately 150 destinations. MIA is served by MetroRail's Orange line to downtown Miami. Fort Lauderdale-Hollywood International Airport (FLL) is located approximately 25 miles north of Miami and is operated by the Broward County Aviation Department. The airport was established in 1929, with commercial service beginning in 1956. FLL has 26 airlines that serve over 75 domestic and international destinations Tri-Rail provide rail serve but not directly connect to airport. Passengers must use bus to connect to the train station, which serves both Ft. Lauderdale and Miami. Palm Beach International Airport (PBI) is located approximately 50 miles north of FLL and 70 miles north of downtown Miami. PBI is operated by Palm Beach County and is conveniently located to serve Palm Beach County. PBI has 11 airlines that serve nearly 30 destinations. PBI also has access to Tri-Rail via a bus connection.

Figure B-6 shows MIA, FLL, and PBI locations in relation to downtown Miami, along with drive times without traffic from each airport to the downtown area. Table B-11 shows information for Miami, FL and Table B-12 shows information about MIA, FLL, and PBI. All information is based on 2017 data.

Figure B-6. Miami Vicinity Map

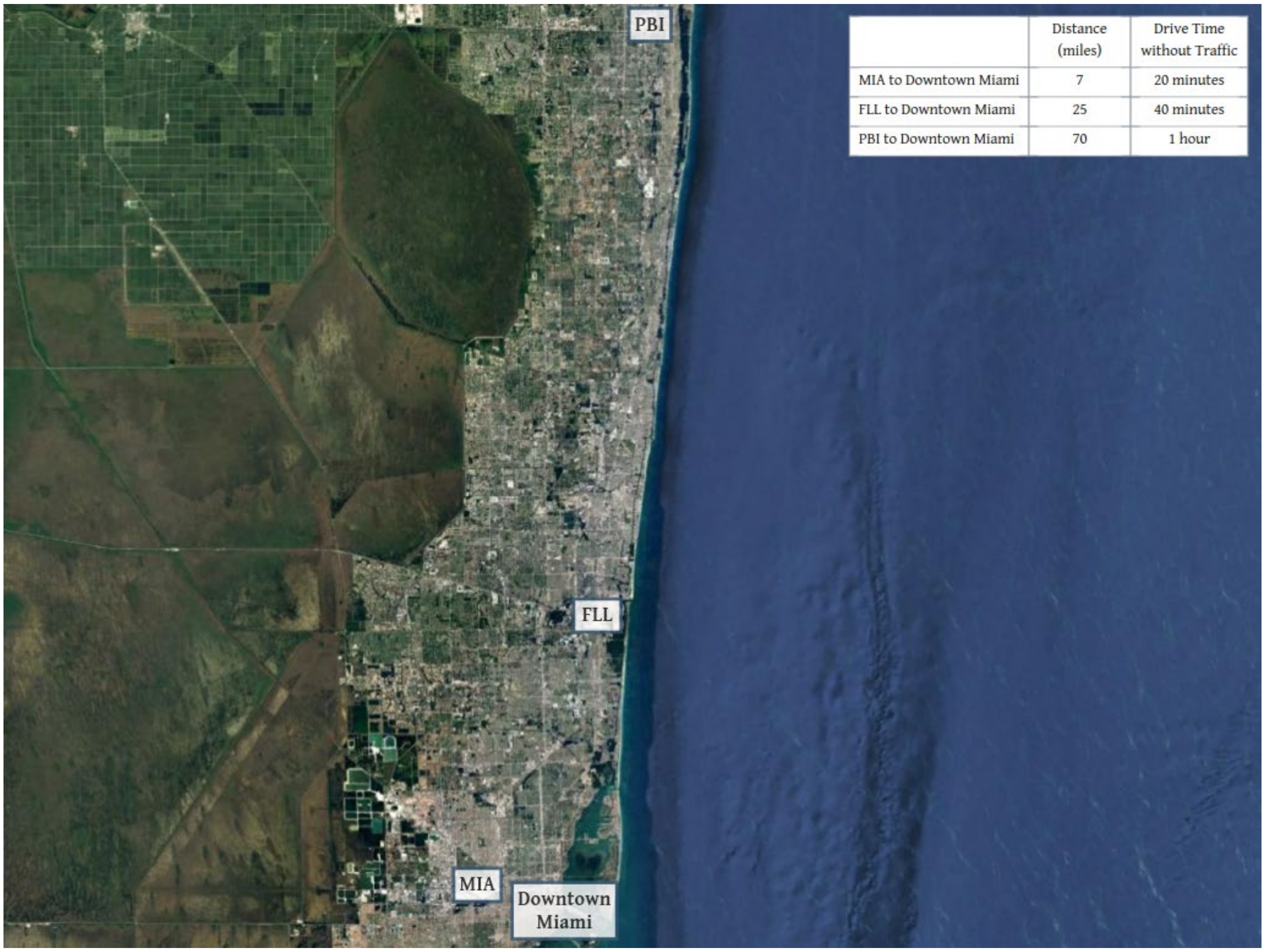


Table B-11. Miami, FL Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Miami, FL	Miami-Fort Lauderdale-West Palm Beach	6,158,824	$53,732	8	0.052

Table B-12. MIA, FLL, and PBI Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
MIA	19,167,117	177,076	150	Metrorail	131
FLL	15,147,017	117,418	138	Tri-Rail via Commuter Connector	63
PBI	3,008,050	26,456	110	Tri-Rail via Tri-Rail Shuttle	28
Total	37,322,184	320,950	133		222

B.7 BOSTON, MA

Boston Logan International Airport (BOS), located approximately 2 miles from central Boston, began commercial service in the late 1920s. It is owned by the Massachusetts Port Authority and is the primary airport serving New England. The airport is a connecting international hub for Delta Air lines and Cape Air. Currently, BOS has more than 40 airlines serving more than 100 destinations. BOS is served by direct bus rapid transit and rail service via MBTA's Silver and Blue lines. T.F. Green Airport (PVD) is located approximately 10 miles south of downtown Providence, RI and is approximately 60 miles southwest of BOS. The airport is owned by the Rhode Island Airport Corporation and was the first state-owned and operated airport in the United States, opening for business in 1931. The airport has 11 airlines and serves 31 domestic and international destinations. MBTA provides commuter rail to PVD as does Amtrak, which is connected to the airport via a connector bridge (10-minute walk).

Figure B-7 shows BOS and PVD locations in relation to downtown Boston, along with drive times without traffic from each airport to the downtown area. Table B-13 shows information for Boston, MA and Table B-14 shows information about BOS and PVD. All information is based on 2017 data.

Figure B-7. Boston Vicinity Map

Table B-13. Boston, MA Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Boston, MA	Boston-Cambridge-Newton	4,836,531	$74,024	5	0.036

Table B-14. BOS and PVD Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
BOS	17,373,525	157,847	124	MRTA	94
PVD	1,490,993	17,038	110	MRTA, Amtrak	22
Total	18,864,518	174,885	117		116

B.8 PHOENIX, AZ

Phoenix Sky Harbor International Airport (PHX) is operated by the Phoenix Airport System. The airport was purchased by the city in 1935 and is located approximately 4 miles east of downtown Phoenix. PHX is a hub for American Airlines. The airport serves more than 105 domestic destinations and 23 international destinations by 19 airlines. PHX Sky Train links the airport to Valley Metro Rail which connects the airport to downtown Phoenix. Phoenix-Mesa Gateway Airport (IWA) is operated by the Phoenix-Mesa Gateway Airport Authority. IWA is located approximately 30 miles east of PHX. IWA was an air force base until 1993, when the base was closed and the airport opened for commercial traffic. Currently, the airport serves more than 45 destinations by three airlines. Two of the three airlines are ultra-low-cost carries only serve one destination. Access to Valley Metro Rail is via several bus connections and not convenient.

Figure B-8 shows PHX and IWA locations in relation to downtown Phoenix, along with drive times without traffic from each airport to the downtown area. Table B-15 shows information for Phoenix, AZ and

Table B-16 shows information about PHX and IWA. All information is based on 2017 data.

Figure B-8. Phoenix Vicinity Map

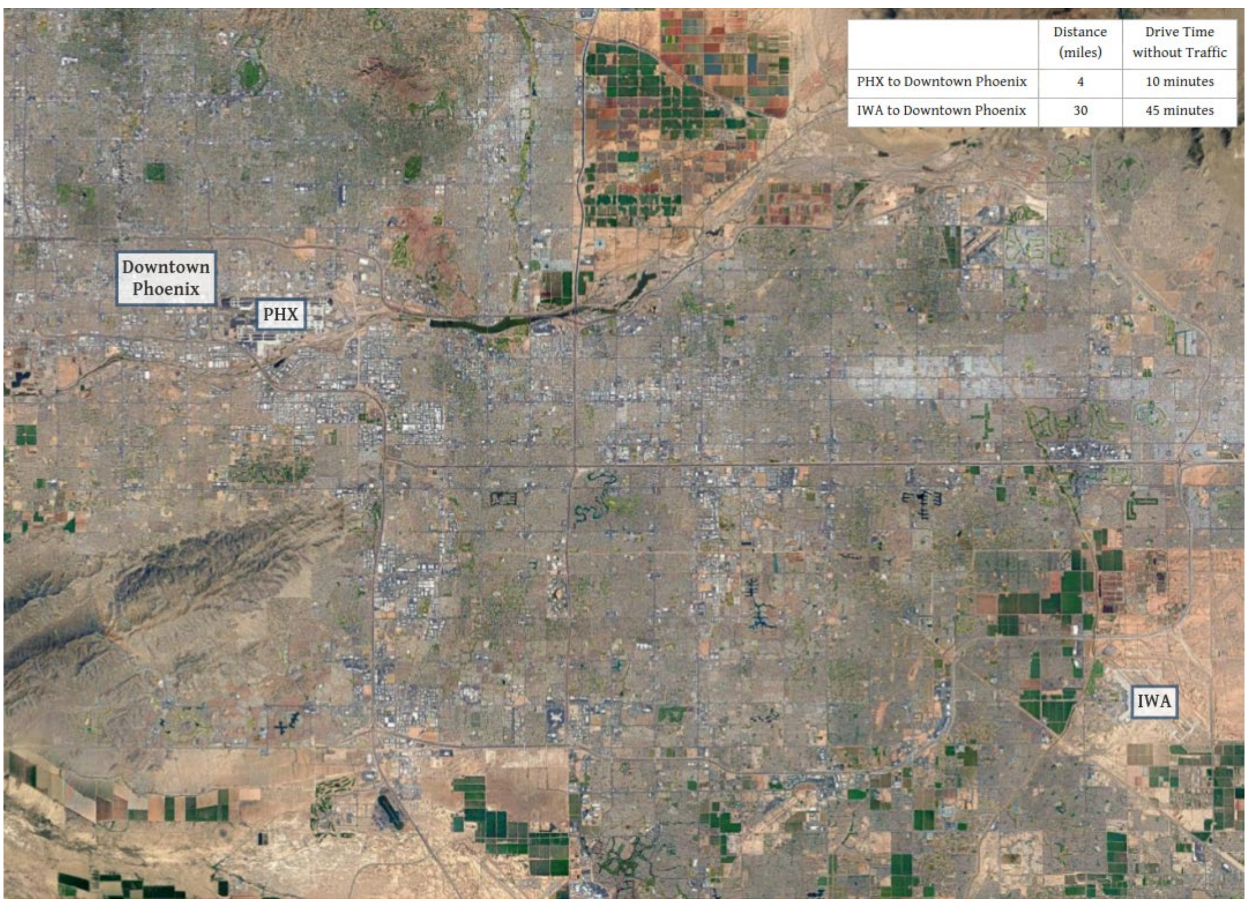


Table B-15. Phoenix, AZ Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
Phoenix, AZ	Phoenix-Mesa-Scottsdale	4,737,270	$44,096	5	0.041

Table B-16: PHX and IWA Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
PHX	19,021,765	188,344	139	Valley Metro Rail	116
IWA	689,954	5,683	114	None	10
Total	19,711,719	194,026	127		126

B.9 SAN FRANCISCO, CA

The first commercial flight at the site that is now San Francisco International Airport (SFO) took place in 1927. SFO is located on the bay 12 miles south of downtown San Francisco. SFO is owned by the city and county of San Francisco. SFO is a hub for Alaska Airlines and United Airlines. It has 55 airlines that operate at the airport serving more than 130 domestic and international destinations. Oakland International Airport (OAK) is located across the bay 20 miles west of downtown San Francisco and began service in 1927 as the Bay Area's low-cost airport. Today, the airport serves 55 international and domestic destination by 13 airlines. Both airports have direct rail connects to both downtowns via Bay Area Rapid Transit. SFO uses the AirTrain to connect passengers to the train station and OAK's passenger have a short walk from the terminal to the train station.

Figure B-9 shows PHX and IWA locations in relation to downtown Phoenix, along with drive times without traffic from each airport to the downtown area. Table B-17 shows information for San Francisco, CA and Table B-18 shows information about SFO and OAK. All information is based on 2017 data.

Figure B-9. San Francisco Vicinity Map

Table B-17. San Francisco, CA Data

	METROPOLITAN STATISTICAL AREA	POPULATION	INCOME PER CAPITA	AIRLINE SEATS PER CAPITA	DEPARTURES PER CAPITA
San Francisco, CA	San Francisco-Oakland-Hayward	4,699,077	$91,459	9	0.055

Table B-18. SFO and OAK Data

	PASSENGER ENPLANEMENTS	AIRLINE DEPARTURES	AVERAGE SEATS PER DEPARTURE	HIGH CAPACITY TRANSIT	NUMBER OF GATES
SFO	24,298,468	195,188	158	Bay Rapid Transit	115
OAK	6,149,350	64,195	120	Bay Rapid Transit	30
Total	30,447,818	259,383	139		145