Section 5—Aviation Demand/Capacity Analysis and Facility Requirements

5.1 Background and Benchmarking

5.1.1 Introduction

This chapter summarizes the Rhode Island Airport Corporation's (RIAC) ability to accommodate future aviation demand throughout the planning activity levels (PALs) for T.F. Green Airport (PVD or Airport). This summary was developed using the existing conditions inventory information conducted by RIAC and the consultant team to examine the adequacy of existing facilities to accommodate future demand throughout the planning period.

The requirements are based on Federal Aviation Administration (FAA) advisory circulars and design standards, as well as RIAC's vision for PVD, discussion and input from various stakeholders, and the basic condition and functionality of existing facilities, and other pertinent information.

Facility requirement determination represents planning under a "best case scenario." In reality, physical and financial resources often impose constraints on the development of some, or all, of these requirements. Furthermore, actual activity at the Airport may vary over time and be higher or lower than what the demand forecast predict. Thus, the use of planning milestones to assist RIAC in making informed decisions regarding the timing of development based on actual demand is essential. Having said that, the subsequent analysis – alternatives analysis – will carefully consider the facility requirements required to achieve RIAC's short and long-term development goals for PVD in the most financially responsible and demand-driven ways feasible.

5.1.2 Planning Activity Levels (PALs) and Design Group

To aid in the facility requirements for PVD, three planning activity levels (PALs) where derived from the approved aviation demand forecasts. These PALs represent a level of activity that requires development when a specific level is reached, that is passenger levels, operations or cargo tonnage. The PALs are shown below and used throughout this chapter.

In addition, facility requirements are guided by a design group identified from the forecasted fleet mix. The forecast chapter identified an existing Airplane Design Group (ADG) of D-IV and a Taxiway Design Group (TDG) of 5; and a future ADG of D-V and TDG 5. This information will guide the various design standards required in the development of the Airport. In FAA's forecast approval of the critical aircraft, it was noted that additional rationale or justification of ADG V activity will be required by RIAC to support the implementation and funding of improvements to meet ADG V standards.

Table 5.1 illustrates the PALs approved by RIAC to serve as a benchmark for future growth at the airport.

Table 5.1—PVD Planning Activity Levels (PALs)

Forecast Element	2017	PAL 1	PAL 2	PAL 3
Annual Operations				
Air Carrier	35,774	44,631	46,711	50,763
Air Taxi	10,057	8,775	8,617	9,596
Cargo	1,109	1,369	1,629	1,629
General Aviation	25,259	25,989	26,210	26,664
Total Annual Operations (excluding military)	72,199	81,000	83,000	89,000
Military	451	451	451	451
Annual Enplanements/Deplanements				
PMAD Peak Hour Enplanements	708	917	1,077	1,335
Total Annual Enplanements (in millions)	1.9	2.6	3.0	3.7
PMAD Peak Hour International Arrivals	252	299	354	488
Annual Cargo Tonnage				
All-Cargo Operators	42.5	55.6	66.6	97.5
Belly Freight Operators	1.0	1.2	1.4	1.8
Total Cargo Tonnage (in millions of pounds)	43.5	56.8	68.0	99.3

Acronyms: Peak-month average day (PMAD) Note: PALs have been rounded to the nearest whole number.
Source: T.F. Green Airport Master Plan, Forecasts of Demand, June 2018; Compiled by C&S Engineers, Inc., Inc., July 2018

5.2 Airfield

Planning and design of airport facilities are typically based on the role of the airport and the critical aircraft expected to operate on the airfield. Existing airfield facilities were assessed to determine if they could accommodate forecast aviation activity through the planning period. This airfield assessment includes a runway demand/capacity analysis, as well as a review of airfield geometry, taxiway lighting, taxiway nomenclature, airfield pavement and markings, and navigational aids.

5.2.1 Runway Demand/Capacity Analysis

A runway capacity analysis was conducted to determine the level of activity the existing airfield can accommodate based on the current and forecasted operations. FAA Advisory

Circular 150/5060-5, *Airport Capacity and Delay*, was used to determine capacity and delay for current and future forecasted operations.

Capacity Factors

A variety of factors and assumptions are considered when determining the airfield capacity and average delay, which include current and forecast aircraft operations, weather conditions, runway configuration, and taxiway layout.

Current and Forecast Aircraft Operations

One important factor when analyzing the computed airfield capacity is aircraft operations. The current and future aircraft operations were obtained from the aviation demand forecasts. The current aircraft operations were derived from 2017, and then three future planning activity levels (2022, 2027, and 2037) that were forecasted. The current and forecast annual operations (excluding military aircraft operations) and peak hour operations are shown in **Table 5.2**.

Table 5.2—Current and Forecast Total and Peak Hour Operations

Operations	2017	PAL 1	PAL 2	PAL 3
Annual Operations	72,199	81,000	83,000	89,000
Peak Hour Operations	16	17	17	21

Source: T.F. Green Airport Master Plan, Section 4, Forecasts of Demand, June 2018

An important factor used for determining airfield capacity is the aircraft fleet mix. When the fleet mix of aircraft is more diverse and aircraft have varying approach speeds, the airfield capacity decreases due to the increased separation requirements for aircraft in different speed and wake categories. Using the current and forecast fleet mix, the aircraft were classified by their wake turbulence category, which is dependent on the maximum design takeoff weight (MTOW) of the aircraft. The aircraft distribution based on these classifications can be seen in **Table 5.3**. Heavy aircraft are projected to slightly increase over the forecast period, which can be attributed to the projected increase to regular service by group V aircraft. Small aircraft are set to decrease seven percent over the forecast period, with large aircraft staying relatively the same.

Table 5.3—Current and Forecast Fleet Mix by Aircraft Classification

Wake Turbulence Classification	2017	PAL 1	PAL 2	PAL 3
Small	43%	41%	40%	36%
Large	52%	52%	52%	55%
Heavy	5%	7%	8%	9%

Note: Small - Aircraft with MTOW of 41,000 lb. or less
Large - Aircraft with MTOW between 41,000 lb. and 300,000 lb.
Heavy - Aircraft with MTOW greater than 300,000 lb.
Classifications recently changed as the Small classification increased from a MTOW of 12,500 lb. and below to 41,000lb.and below.
Source: T.F. Green Airport Master Plan, Section 4, Forecasts of Demand, June 2018, FAA AC 90-23G

Weather

Weather is another factor that affects airfield capacity by influencing air traffic control, airfield operations and runway choice. Weather conditions can be classified by two types of conditions: visual flight rules (VFR) and instrument flight rules (IFR). IFR conditions can then be further categorized into different approach categories: I, II, IIIa, IIIb, and IIIc. Weather observations over 20 years were used to determine the annual occurrence for each of these weather conditions, which can be seen in Section 2, Inventory of Existing Conditions. VFR conditions, when the ceiling and visibility are greater than or equal to 1,000 feet and three miles respectively, occur approximately 86 percent of the time. The remaining 14 percent is IFR conditions, with CAT I conditions accounting for nearly 13 of that 14 percent. These weather conditions fall within the assumption used for determining airfield capacity, that IFR conditions will prevail roughly 10 percent of the time.

Runway Configuration

The airfield is comprised of two runways, the primary runway (Runway 5-23) and the crosswind runway (Runway 16-34). Runway 5-23, the primary runway for commercial operations, is 150 feet wide and 8,700 feet long. Runway 16-34, the crosswind runway, is necessary to meet the 95 percent wind coverage requirement for aircraft categorized as A-I, A-II, B-I, and B-II. The runway is 6,081 feet long and 150 feet wide. All runways, with the exception of Runway 16, have instrument landing systems (ILS). Runway operations will mainly be influenced by weather and ATCT operations, but can also be influenced by pilot preference.

The two runways are not independent of each other, which impacts the airfield capacity. This means that the departure or arrival of one aircraft on one runway must be coordinated with a departure or arrival on the other runway, if both runways are being utilized. This is taken into account in the capacity calculations. It is also assumed that the runway configuration that yields the greatest hourly capacity prevails 80 percent of the time.

Taxiway Layout

Taxiway M is a full parallel taxiway that provides access to and from Runway 5-23. Runway 16-34 does not have a full parallel taxiway, but access to and from the runway is provided by a variety of taxiways. While both runways do not have full parallel taxiways or properly located runway exits, the capacity calculations assume each runway has a full parallel taxiway, adequate runway entrance and exits, and no taxiway crossing problems. Although this would decrease airfield capacity slightly, the overall capacity of the PVD airfield is well below the 60 percent range to begin planning for airfield improvements. Potential taxiway improvements will be discussed later in this section in Taxiway Requirements.

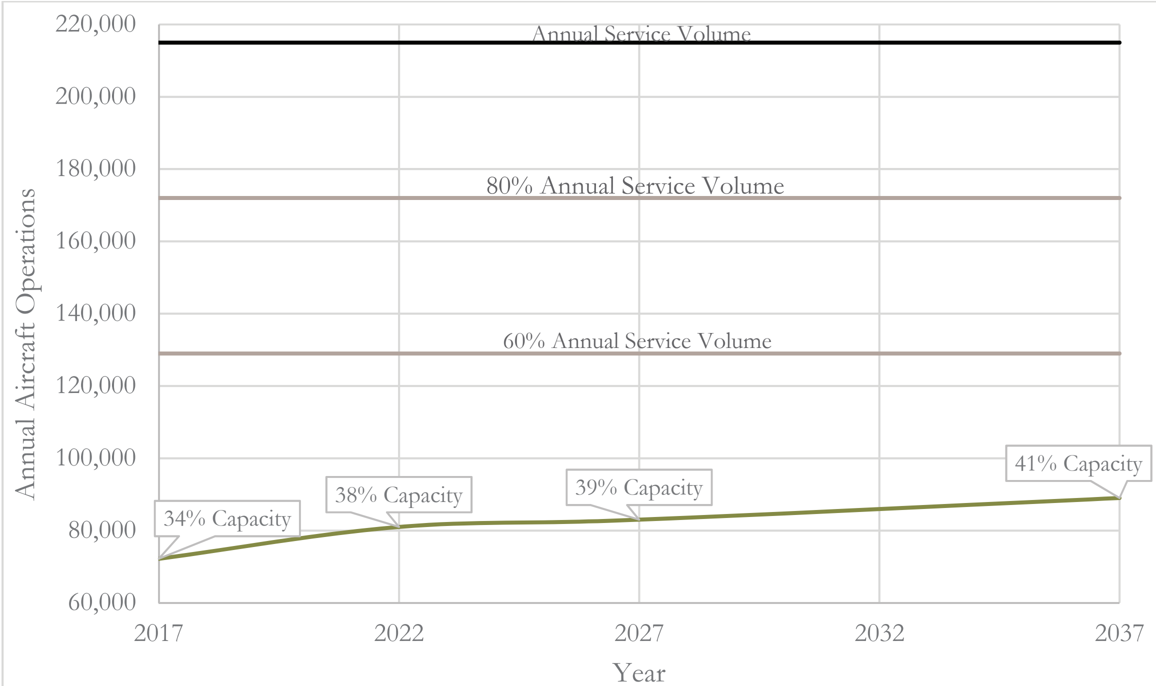
Capacity Analysis

Annual Service Volume

The annual service volume is a reasonable estimate of the airport's annual capacity taking into account factors such as aircraft mix and weather conditions. This value can then be used in conjunction with actual annual operations to determine when future facilities need to be planned and implemented. According to the FAA, when annual operations are between 60 and 75 percent of the annual service volume, planning of future airport facilities should occur so that by the time annual operations reach approximately 80 percent of the annual service volume, the planned facilities will have been constructed.

The calculated annual service volume for the planning period is 215,000 operations. **Figure 5.1** shows the current and projected annual operations and the percent of the calculated annual service volume for the current year and each PAL. The figure also shows the 60 and 80 percent annual service volume range, which when annual operations fall within that range, planning and construction of facilities would need to occur. As the annual operations are not projected to exceed 60 percent of the annual service volume during this planning period, major capacity improvements will not be recommended.

Figure 5.1—Annual Aircraft Operations Compared to Annual Service Volume



Sources: T.F. Green Airport Master Plan, Forecasts of Demand, June 2018 (aircraft activity); WSP USA, 2018 (capacity analysis).

Hourly Runway Capacity

Hourly runway capacity is the maximum number of aircraft operations that can be achieved on the airfield in an hour without significant delays. Hourly runway capacities are used in determining future improvement projects at the Airport. Weather conditions can have a significant impact on capacity, therefore hourly runway capacities are determined for both VFR and IFR conditions. The VFR capacity was calculated to be 77 operations per hour and the IFR capacity is 56 operations per hour as shown in **Table 5.4**. The peak hour operations are not projected to exceed these capacities in the current planning period.

Table 5.4—Peak Hour Operations vs. Calculated Hourly Runway Capacity

Operations	2017	PAL 1	PAL 2	PAL 3
Peak Hour Operations	16	17	17	21
VFR Hourly Runway Capacity	77	77	77	77
IFR Hourly Runway Capacity	56	56	56	56

Source: T.F. Green Airport Master Plan, Section 4, Forecasts of Demand, June 2018

Aircraft Delay

Average aircraft delay is the difference between an unconstrained operating time and a constrained operating time and is based on the airfield capacity compared to the current and forecast operations. As the number of operations increase towards the capacity of the airfield, delays occur. The calculated delays, expressed by average minutes of delay per aircraft operation, are determined using the calculated annual service volume compared to the current and project aircraft operations. PVD's aircraft operations are not projected to reach critical levels, which is reflected in the calculated delay which ranges between 0.22 minutes (13.2 seconds) in 2017 to 0.32 minutes (19.2 seconds) in 2037. Practical airport capacity is exceeded when operations increase to more than four minutes of average delay per aircraft operation. T.F. Green Airport is not projected to exceed average delays of more than four minutes in the planning period.

Summary

T.F. Green Airport is not projected to reach critical airfield capacity levels during the planning period. Currently, annual operations are not to exceed 60 percent of the annual service volume, hourly runway capacities are not shown to exceed either the VFR or IFR calculated hourly runway capacities, and average aircraft delays are not projected to surpass four minutes for the planning period.

5.2.2 Airfield Facility Requirements

In addition to a significant evolution in aircraft characteristics, many airports were designed long before current geometry standards came into effect and, as a result, may not meet the latest standards set forth in FAA AC 150/5300-13A, *Airport Design, Change 1*. Airfield geometry is typically tailored to the existing and future critical aircraft.

Airport Reference Code

The existing Airport Reference Code (ARC) at PVD is C-IV. Per the FAA-approved forecast prepared as part of this Master Plan Update, Airplane Design Group (ADG) V aircraft are anticipated to exceed the threshold of regular use (500 annual operations) by 2022. As such, the future ARC is D-V, with the Boeing 787-8 being a representative D-V aircraft.

Critical Aircraft

The critical aircraft is defined as the most demanding aircraft that will substantially use the Airport, with "substantially" defined as either 500 or more annual itinerant operations or scheduled service. Also, the critical aircraft can be either a single aircraft or a composite of the most demanding characteristics of several aircraft.[1] As part of this facility requirements analysis, the critical aircraft for each runway was re-evaluated based on data obtained from the PVD Airport Noise and Operations Monitoring System (ANOMS), collected between January 1, 2018 and December 31, 2018.

Runway 5-23

Table 5.5 summarizes the 2018 ANOMS records for Runway 5-23 by Airplane Design Group (ADG). Table 2.4 shows that ADG IV represents the largest ADG with 500 or more annual operations (regular use threshold). A review of the aircraft type in the ADG IV category shows that the Boeing 757-200W conducted 997 operations on Runway 5-23 at PVD in 2018, while the Boeing 767-300 conducted 495 operations and the Boeing 767-200 conducted 398 operations. Although these three aircraft types are C-IV aircraft, they have different Taxiway Design Groups (TDGs). The TDG is based on the overall width of the aircraft's main gear, as well as the distance between the main gear and the cockpit. The Boeing 757-200W has a TDG of 4, while the Boeing 767 series aircraft have a TDG of 5.

Table 5.5 - Runway 5-23 Annual Aircraft Operations

Airplane Design Group (ADG)					No Aircraft Type Recorded	Total
I	II	III	IV	V		
9,574	19,059	25,821	**1,877**	3	32	56,392

Sources: T.F. Green Airport, Airport Noise and Operations Monitoring System (ANOMS) Database, January 1, 2018 – December 31, 2018; WSP USA, April 2019.

Table 5.6 provides the characteristics of the ADG IV aircraft that most commonly use Runway 5-23, as well as their number of operations in 2018. The annual number of operations for the Boeing 767-300 includes operations by Atlas Air, which no longer operates at PVD. As a result, Atlas Air operations were removed from the Boeing 767-300 counts, to provide a baseline that is still representative of current operations and trends. This revised 2018 baseline shows that the Boeing 757 is the critical aircraft at PVD, as a ADG IV/TDG 4 aircraft.

The revised baseline also shows that the Boeing 767 aircraft conducted 432 annual operations at PVD in 2018, which is nearing the threshold of regular use (500 annual operations). These Boeing 767 operations were conducted mainly by ABX Air, Inc. (cargo) and the New England Patriots team aircraft. Should the Boeing 767 number of annual operations exceed 500, the Boeing 767 would become the critical aircraft, and consideration

1 Federal Aviation Administration, Advisory Circular 150/5000-17, *Critical Aircraft and Regular Use Determination*, June 2017.

should be given to meeting TDG 5 standards where this aircraft would be anticipated to operate.

Table 5.6 - Runway 5-23 Airplane Design Group IV Characteristics

Aircraft Type	2018 Operations	Aircraft Approach Category (AAC)	Airplane Design Group (ADG)	Taxiway Design Group (TDG)
Boeing 757-200/W	997	C	IV	4
Boeing 767-200	374	C	IV	5
Boeing 767-300	477	C	IV	5
Boeing 767-300 (without Atlas Air) 1/	58			

Note:

1/ Atlas Air operated Boeing 767-300 aircraft at PVD in 2017 and 2018, but has since ceased operations at the Airport. As such, Atlas Air Boeing 767-300 operations were removed from consideration for determining the critical aircraft.

Sources: T.F. Green Airport, Airport Noise and Operations Monitoring System (ANOMS) Database, January 1, 2018 – December 31, 2018; Federal Aviation Administration, Aircraft Characteristics Database, https://www.faa.gov/airports/engineering/aircraft_char_database/, accessed April 2019; WSP USA, April 2019.

Runway 16-34

Table 5.7 summarizes the 2018 ANOMS records for Runway 16-34 by ADG. Table 5.7 shows that ADG III represents the largest ADG with 500 or more annual operations. A review of the aircraft type in the ADG III category, shows that the Boeing 737 series aircraft conducted 1,178 annual operations on Runway 16-34, and the Airbus A320 series aircraft conducted 522 annual operations.

Table 5.7 - Runway 16-34 Annual Aircraft Operations

Airplane Design Group (ADG)					No Aircraft Type Recorded	Total
I	II	III	IV	V		
2,037	2,338	**1,989**	70	3	60	6,494

Sources: T.F. Green Airport, *Airport Noise and Operations Monitoring System (ANOMS) Database*, January 1, 2018 – December 31, 2018; WSP USA, April 2019.

Table 5.8 provides the characteristics of the ADG III aircraft that most commonly use Runway 16-34, as well as their number of operations in 2018. The critical aircraft is an ADG III/TDG 3 aircraft.

Table 5.8 - Runway 16-34 Airplane Design Group III Characteristics

Aircraft Type	2018 Operations	Aircraft Approach Category (AAC)	Airplane Design Group (ADG)	Taxiway Design Group (TDG)
Boeing 737-300/400/700	906	**C**	**III**	**3**
Airbus A319/320/321	522	**C**	**III**	**3**
Boeing 737-8/9	272	D	**III**	**3**

Sources: T.F. Green Airport, *Airport Noise and Operations Monitoring System (ANOMS) Database*, January 1, 2018 – December 31, 2018; Federal Aviation Administration, *Aircraft Characteristics Database*, https://www.faa.gov/airports/engineering/aircraft_char_database/, accessed April 2019; WSP USA, April 2019.

Critical Aircraft Summary

Table 5.9 summarizes the existing and future critical aircraft at PVD, based on historical and forecast runway use. The Boeing 757-200 series aircraft is the existing critical aircraft for Runway 5-23. The future critical aircraft for Runway 5-23 is anticipated to be an ADG V aircraft, based on the forecast developed as part of this Master Plan; it is recommended that proposed improvements to accommodate ADG V aircraft only be initiated once regular ADG V service materializes. The Boeing 737 series aircraft is anticipated to remain the critical aircraft for Runway 16-34.

Table 5.9 - Critical Aircraft Summary – Existing and Future

	Runway	Aircraft	Aircraft Approach Category (AAC)	Airplane Design Group (ADG)	Taxiway Design Group (TDG)
Existing	5-23	Boeing 757-200/W	C	IV	4
	16-34	Boeing 737-300/400/700	C	III	3
Future	5-23 1/	Boeing 787-8	C	V	5
	16-34	Boeing 737-300/400/700	C	III	3

Note:

1/ Proposed improvements to Runway 5-23 and associated taxiways to accommodate ADG V aircraft should only be initiated once regular ADG V service materializes.

Sources: T.F. Green Airport, Airport Noise and Operations Monitoring System (ANOMS) Database, January 1, 2018 – December 31, 2018; Federal Aviation Administration, Aircraft Characteristics Database, https://www.faa.gov/airports/engineering/aircraft_char_database/, accessed April 2019; WSP USA, April 2019.

Runway Length

Runway 5-23 was extended in 2017 to a total length of 8,700 feet, and is anticipated to meet runway length requirements through the planning period. A runway extension is not being considered.

Runway Orientation and Number

An analysis of wind coverage allows to determine the most advantageous orientation and number of runways required at an airport, by calculating the percentage of time certain crosswind values (10.5, 13, 16 and 20 knots) are not exceeded for each runway orientation. The desirable wind coverage for an airport is 95 percent. Two runways may be required to achieve the desired 95 percent wind coverage for all crosswind values.

At PVD, both Runways 5-23 and 16-34 individually provide 95 percent or greater wind coverage for ADG III, IV and V aircraft, as shown in **Table 5.10** and previously in Table 2.7. Neither runway alone provides sufficient wind coverage for smaller aircraft (A-I, B-I, A-II and B-II). Combined however, the two PVD runways provide 95 percent or greater wind coverage for these smaller aircraft.

An airport only needs one runway to provide the required wind coverage; as a result, Runway 16-34 is considered a "crosswind runway" with the purpose of providing the required wind coverage for smaller aircraft. However, the availability of two ADG IV runways at PVD presents many benefits:

- Runway 16-34 is favored by all aircraft sizes after winter storms have passed
- Backup runway:
  - During snow removal operations on Runway 5-23
  - During maintenance/accident/incident on Runway 5-23
- Noise dispersion
- Operational efficiency for airlines parked at north end of concourse
  - Arrivals on Runway 34/departures on Runway 16 result in a shorter taxi time, lower fuel consumption, and less emissions

Table 5.10 – Runway Wind Coverage

Crosswind Component	Airplane Design Group (ADG)	Wind Coverage		
		Runway 5-23	Runway 16-34	Combined
10.5 knots	A-I, B-I	88.32%	87.60%	96.43%
13 knots	A-II, B-II	93.66%	92.66%	98.79%
16 knots	A-III, B-III C-I through C-III D-I through D-III	98.23%	97.55%	99.65%
20 knots	All others	99.64%	99.36%	99.94%

Sources: Federal Aviation Administration, Advisory Circular 150/5300-13A, Change 1, *Airport Design*, February 2014; PVD ASOS for 2008-2017, C&S Engineers, Inc. 2019.

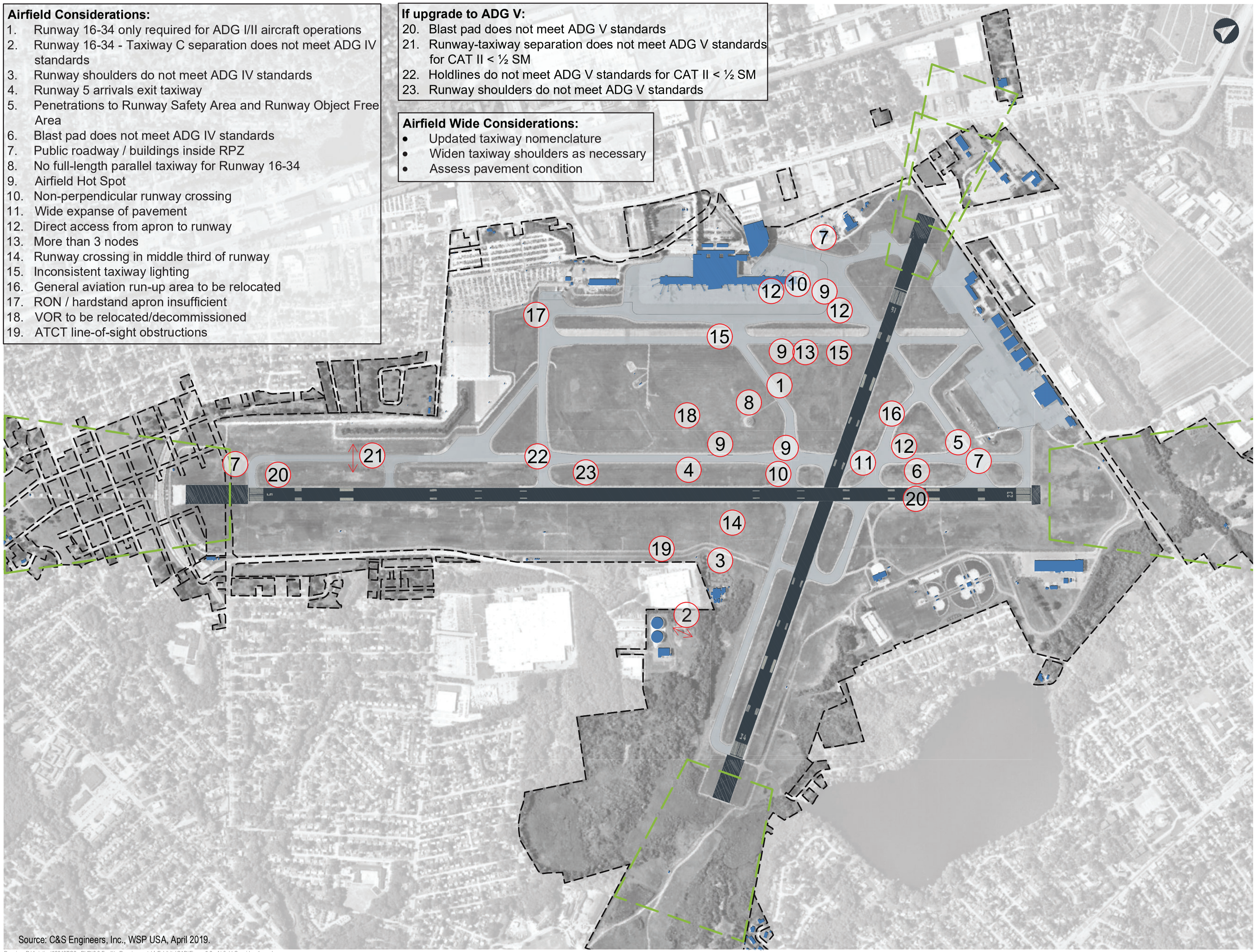
Runway Design and Runway Areas

With a current ARC of C-IV, most of the runway facilities at PVD meet ADG IV design standards. This section will assess whether airfield facilities meet the existing ADG IV standards, and what additional improvements would be required to upgrade to ADG V, should the forecast ADG V aircraft activity materialize. It is anticipated that only Runway 5-23 and associated taxiways would be upgraded to meet ADG V standards. **Figure 5.2** identifies the various airfield considerations discussed in the following subsections.

Green Airport

T.F. Green Airport
Master Plan

Figure 5.2
Airfield Considerations



Airfield Considerations:

1. Runway 16-34 only required for ADG I/II aircraft operations
2. Runway 16-34 - Taxiway C separation does not meet ADG IV standards
3. Runway shoulders do not meet ADG IV standards
4. Runway 5 arrivals exit taxiway
5. Penetrations to Runway Safety Area and Runway Object Free Area
6. Blast pad does not meet ADG IV standards
7. Public roadway / buildings inside RPZ
8. No full-length parallel taxiway for Runway 16-34
9. Airfield Hot Spot
10. Non-perpendicular runway crossing
11. Wide expanse of pavement
12. Direct access from apron to runway
13. More than 3 nodes
14. Runway crossing in middle third of runway
15. Inconsistent taxiway lighting
16. General aviation run-up area to be relocated
17. RON / hardstand apron insufficient
18. VOR to be relocated/decommissioned
19. ATCT line-of-sight obstructions

If upgrade to ADG V:

20. Blast pad does not meet ADG V standards
21. Runway-taxiway separation does not meet ADG V standards for CAT II < ½ SM
22. Holdlines do not meet ADG V standards for CAT II < ½ SM
23. Runway shoulders do not meet ADG V standards

Airfield Wide Considerations:

- Updated taxiway nomenclature
- Widen taxiway shoulders as necessary
- Assess pavement condition

Legend

- Property Line
- Existing Buildings
- Existing Airfield Pavement
- Runway Protection Zone

500' 0' 500' 1,000'

Source: C&S Engineers, Inc., WSP USA, April 2019.

Drawing: R:\Aviation\62843TO2 - PVD\9.0 Facility Requirements\4-Exhibits\CAD\Figure 5.2 - Airfield Considerations.dwg

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Runway 5-23

Table 5.11 compares Runway 5-23 existing conditions to both C-IV (existing) and C-V (forecast) design standards, and indicates whether improvements are needed for each set of standards. A 'No' indicates a standard is not met. A "No[3]" indicates a standard is not met but the condition is grandfathered in or approved by the FAA.

Runway, Runway Shoulders and Blast Pads

The current Runway 5-23 width, shoulders and blast pads dimensions meet ADG IV standards, except for the Runway 23 end blast pad, which needs to be lengthened by 100 feet.

The runway width meets ADG V standards; however, the runway shoulder widths would need to be increased by 10 feet, and the length and width of the blast pads would need to be increased to 220 feet by 500 feet to meet ADG V standards.

Runway Safety Areas

The runway safety area (RSA) is an area around the runway that is designed to reduce the risk of damage to aircraft if it deviates from the runway. RSA design standards are based on containing about 90 percent of aircraft that overrun the runway within the RSA. RSA design standards are the same for ADG IV and V.

An Engineered Materials Arresting System (EMAS) is an alternative for runways where the RSA design standard cannot be achieved beyond the runway end. FAA AC 150/5300-13A states that the RSA effective length beyond the runway end can be reduced when a standard EMAS is present (one that stops the EMAS critical aircraft exiting the runway at 70 knots or less). Runway ends with a standard EMAS are considered equivalent to a full dimension RSA. The Runway 5 end has a standard EMAS, which was designed based on the EMAS critical aircraft at the time. The EMAS systems will need to be re-evaluated to ensure compliance with design standards should the critical aircraft for Runway 5-23 change.

Table 5.11—Runway 5-23 Facility Requirements

	Existing Conditions (in Feet)	Design Standards (in Feet)		Meets Design Standard?	
		C-IV	C-V	C-IV	C-V
Runway Width	150	150	150	Yes	Yes
Shoulder Width	25	25	35	Yes	No
Blast Pad Width/Length	5 end: 200/690 23 end: 200/100	200/200	220/400	Yes No	No No
Runway Safety Area					
Length beyond departure end	5 end: 685 2/ 23 end: 1,000	1,000	1,000	Yes	Yes
Length prior to landing threshold	5 end: 685 2/ 23 end: 600	600	600	Yes	Yes
Width	5 end: 500 23 end: 390 and	500	500	Yes No4/	Yes No4/
Runway Object Free Area					
Length beyond departure end	5 end: 685 2/ 23 end: 1,000	1,000	1,000	Yes	Yes
Length prior to landing threshold	5 end: 685 2/ 23 end: 600	600	600	Yes	Yes
Width	5 end: 800 23 end: 540 and	800	800	Yes No4/	Yes No4/
Runway Obstacle Free Zone					
Length beyond runway end	200	200	200	Yes	Yes
Width	400	400	400	Yes	Yes
Approach Runway Protection Zone					
Length/Inner/Outer Width	2,500/1,000/1,75	2,500/1,000/1,750		No3/	No3/
Departure Runway Protection Zone					
Length/Inner/Outer Width	1,700/500/1,010	1,700/500/1,010		No3/	No3/
Precision Obstacle Free Zone					
Length/Width	200/800	200/800	200/800	Yes	Yes
Runway Separations					
Hold Positions	250	250	280	Yes	No
Parallel Taxiway Centerline	400	400	400/500[1]	Yes	Yes
Aircraft Parking Area	530 and up	500	500	Yes	Yes

Notes on the following page

Table 5.12 Notes:

1/ 500-foot separation only required for ADG V CAT II approaches with visibility under ½ statute miles.

2/ EMAS bed installed.

3/ Incompatible land uses in the Runway Protection Zone are grandfathered in.

4/ An FAA RSA Determination states that the Runway 23 end “RSA does not meet standards but is impractical to improve”.

Sources: Federal Aviation Administration, Advisory Circular 150/5300-13A, Change 1, *Airport Design*, February 2014; C&S Companies, *DRAFT T.F. Green Airport Layout Plan*, 2018; WSP USA, April 2019.

The Runway 23 end does not have EMAS, and as such, full-dimension RSA standards apply: the RSA should extend past the runway end by 1,000 feet and have a width of 500 feet, and should be properly graded and have no objects located within the area, except for frangible objects that require being in the RSA due to function. Currently, a public roadway and fence penetrate the RSA at the end of Runway 23. The Runway 5 Localizer Antenna is also located inside the RSA, and is mounted on frangible supports. The FAA issued a RSA Determination in 2012 stating that the Runway 23 end “RSA does not meet standards but is impractical to improve”. As such, no further mitigation is required.

Runway Object Free Areas

The runway object free area (ROFA) requires that no objects contained in the area extend above the nearest point of the RSA. The ROFA design standards are the same for ADG IV and V. When EMAS is installed, the far end of the ROFA coincides with the end of the EMAS bed. The ROFA width standard for ADG IV and V is 800 feet. There are ROFA penetrations on the Runway 23 end (public roadway and fence). The FAA issued a RSA Determination in 2012 stating that the Runway 23 end “RSA does not meet standards but is impractical to improve”. This determination also applies to the associated ROFA. As such, no further mitigation is required.

Runway Obstacle Free Zones

The Obstacle Free Zone (OFZ) shall be clear of objects and other penetrations during aircraft operations, except for frangible navigational aids fixed by function. The OFZ is composed of a Runway Object Free Zone (ROFZ), an Inner-approach OFZ, and an Inner-transitional OFZ, as applicable.

There are no penetrations to the Runway 5-23 ADG IV and V OFZ.

Runway Protection Zones

The function of the runway protection zone (RPZ) is to “enhance the protection of people and property.” FAA AC 150/5300-13A recommends that the airport have control of the RPZ and have it “clear of all above ground objects”. When it is not practical to have complete control of the entire RPZ, the airport should at a minimum obtain avigation easements to keep the RPZ clear of incompatible objects and activities. The RPZ design dimension are based on the aircraft approach category and design group, along with the visibility minimums for the runway end. RPZ standards are the same for both ADG IV and V, with the only variations between visibility minimums.

The RPZ on the Runway 5 and 23 ends encompass public roadways and buildings, including residences. Two of these residences are located inside the Runway 5 central portion of the RPZ. These incompatible land uses are grandfathered in until a change in the runway location or capacity is implemented.

Runway Hold Positions

The separation between the Runway 5-23 centerline and its hold positions markings meets ADG IV standards, but should be increased by 30 feet, to a total of 280 feet, should Runway 5-23 be upgraded to an ADG V runway.

Runway-Taxiway Separation

Runway 5-23 meets ADG IV separation standards with parallel Taxiway M.

Should Runway 5-23 be upgraded to an ADG V runway, the Runway 5-23 separation with Taxiway M would no longer meet ADG V standards for ILS CAT II approaches with visibility minimums lower than ½ statute miles (SM) on Runway 5-23, while aircraft are present on parallel Taxiway M. Mitigation options will be explored in Section 6, Alternatives Analysis.

Runway-Apron Separation

The separation between Runway 5-23 and aprons meets FAA design standards.

Runway 16-34

Table 5.12 on the following page compares Runway 16-34 existing conditions to ADG IV design standards (current runway classification), assuming Runway 34 approaches occur with not lower than ¾ SM visibility and Runway 16 approaches with no less than 1 SM visibility. ADG II and III standards are also provided for reference during the Alternatives Analysis process, to evaluate a runway downgrade. A 'No' indicates a standard is not met. A 'No' with a superscript note indicates a standard is not met but the condition is grandfathered in or approved by the FAA.

Runway, Runway Shoulders and Blast Pads

The current Runway 16-34 width meets ADG IV standards. Runway shoulders would need to be widened by 10 feet on each side of Runway 16-34 to meet ADG IV standards (except for the first 1,500 feet of Runway 34, which has 25-foot wide shoulders). Blast pads dimensions meet ADG IV standards.

Table 5.12—Runway 16-34 Facility Requirements

	Existing Conditions (in Feet)	Design Standards (in Feet)			Meets Design Standard?		
		B-II	C-III	C-IV	B-II	C-III	C-IV
Runway Width	150	75	150	150	Yes	Yes	Yes
Shoulder Width	15-25	None	25 [1/]	25	Yes	Yes	No
Blast Pad Width/ Length	16 end: 200/290 34 end: 200/500	95/150	200/200	200/200	Yes	Yes	Yes
Runway Safety Area							
Length beyond departure end	16 end: 290 [2/] 34 end: 1,000	300	1,000	1,000	Yes	No[2/] No[2/]	No[2/] No[2/]
Length prior to landing threshold	16 end: 630 34 end: 1,000	300	600	600	Yes	Yes Yes	Yes Yes
Width	16 end: 410-500 [2/] 34 end: 500	150	500	500	Yes	No[2/] Yes	No[2/] Yes
Runway Object Free Area							
Length beyond departure end	16 end: 290 [2/] 34 end: 1,000	300	1,000	1,000	Yes	No[2/] No[2/]	No[2/] No[2/]
Length prior to landing threshold	16 end: 630 34 end: 1,000	300	600	600	Yes	Yes Yes	Yes Yes
Width	16 end: 560-800 [2/] 34 end: 800	500	800	800	Yes	No[2/] No[2/]	No[2/] No[2/]
Runway Obstacle Free Zone							
Length beyond	200	200	200	200	Yes	Yes	Yes
Width	400	250	400	400			
Approach Runway Protection Zone							
Length/Inner Width/ Outer Width	16 end: 1,700/500/1,010 [3/]	1,000/500/700	1,700/500/1,010		No	No	No
	34 end: 1,700/1,000/1,510	1,700/1,000/1,510	1,700/1,000/1,510		Yes	Yes	Yes
Departure Runway Protection Zone							
Length/Inner Width/ Outer Width	1,700/500/1,010 [3/]	1,000/500/700	1,700/500/1,010		No	No	No
Runway Separations							
Hold Positions	250	200	250	250	Yes	Yes	Yes
Parallel Taxiway	300	240	400	400	Yes	No	No
Aircraft Parking Area	420 and up	250	500	500	Yes	No	No

Notes:
1/Recommended only
2/ EMAS bed installed
3/ Incompatible land uses in the Runway Protection Zone

Sources: Federal Aviation Administration, Advisory Circular 150/5300-13A, Change 1, *Airport Design*, February 2014; C&S Companies, *DRAFT T.F. Green Airport Layout Plan*, 2018.

Runway Safety Areas

Both runway ends have an EMAS, which was designed based on the EMAS critical aircraft at the time. The Runway 34 end EMAS is a standard EMAS. Because of space limitations, the Runway 16 end EMAS is a non-standard EMAS (ie, it can stop the EMAS critical aircraft exiting the runway at a speed of 40 knots or less, vs. 70 knots or less for a standard EMAS).

These EMAS systems will need to be re-evaluated to ensure compliance with design standards should the critical aircraft for the associated runway change.

Runway Object Free Areas

An uncontrolled airport service road penetrates the full-width ROFA on the Runway 34 end, while a public roadway, a service road, a blast fence and property fence penetrate the full-width ROFA on the Runway 16 end. However, since both runway ends were assessed as part of a *Runway Safety Area Determination* in 2012, which resulted in the installation of EMAS beds on both ends, the Runway 16-34 OFA is assumed to meet FAA ADG IV design standards.

Runway Obstacle Free Zones

There are no penetrations to the Runway 16-34 ADG IV OFZ.

Runway Protection Zones

The RPZ on the Runway 16 end includes incompatible land uses such as public roadway and buildings. These incompatible land uses are grandfathered in until a change in the runway location or capacity is implemented. There are no incompatible land uses to the Runway 34 end RPZ.

Runway Hold Positions

The separation between the Runway 16-34 centerline and its hold positions markings are adequate for an ADG IV runway.

Runway-Taxiway Separation

The separation between Runway 16-34 and Taxiway C is 300 feet, instead of the 400 feet required for ADG IV runways. A Modification of Standards (MOS) is currently in effect, expiring in 2019. Mitigation options will be explored in Section 6, Alternatives Analysis.

Runway-Apron Separation

The separation between Runway 16-34 and aprons meets FAA design standards.

Runway Requirements Summary

The following improvements are required for **Runway 5-23 to meet ADG IV standards**:

- Lengthen Runway 23 end blast pad to 200 feet
- Reassess EMAS bed if critical aircraft changes
- Reassess taxiway shoulders width and fillets if critical aircraft changes to TDG 5

The following improvements are required to **upgrade Runway 5-23 to ADG V standards** (in addition to meeting ADG IV standards):

- Increase blast pads widths to 220 feet and lengths to 400 feet
- Increase runway shoulder width to 35 feet
- Increase distance between the runway centerline and holding positions to 280 feet
- Increase separation between the runway centerline and parallel Taxiway M to 500 feet
- Reassess EMAS bed if critical aircraft changes

The following improvements are required for **Runway 16-34 to meet ADG IV standards**:

- Widen runway shoulders to 25 feet along the full length of the runway
- Increase separation between the runway and parallel Taxiway C centerlines to 400 feet

Taxiway Design

Taxiways allow aircraft to move from one part of the airfield to another, by allowing for entering or exiting a runway and maneuvering around the airfield to terminal areas or other airport facilities. It is critical that taxiways be located and designed in a way that allows traffic to flow throughout the airfield safely and efficiently.

Taxiway Dimensions and Clearances

Existing taxiways at PVD meet or exceed ADG IV and Taxiway Design Group (TDG) 4 standards (existing critical aircraft). Once an ADG V and/or TDG 5 aircraft becomes the critical aircraft, ADG V and/or TDG 5 standards will apply on taxiways anticipated to accommodate such aircraft.

Table 5.13 summarizes the taxiway dimensions that are a function of the TDG, and compares existing airfield dimensions with TDG 3, 4 and 5 standards. The following aircraft are representative of these TDGs:

- TDG 3: Airbus A320, Boeing 737
- TDG 4: Boeing 757
- TDG 5: Airbus A300, Airbus A350, Boeing 747, Boeing 767, Boeing 777, Boeing 787

Table 5.13— Taxiway Design Standards by Taxiway Design Group

Dimension	Existing facilities	Taxiway Design Group Standards (in feet)		
		3	4	5
Runway Centerline to Parallel Taxiway Centerline Separation for Reverse Turns from a High-Speed Exit	Runway 5-23 – Taxiway M = 400 feet	350	427 minimum 450 recommended	
Taxiway Width	75 feet or greater, except Taxiway C1	50	50	75
Taxiway Edge Safety Margin	Further evaluation required.	10	10	15
Taxiway Shoulder Width	15 feet: Taxiways C, C1, F and V 25 feet: Taxiways A, B, E, S, T and portions of M and N 30 feet: Taxiways M1, M2, and portions of M	20	20	30
Crossover Taxiways with Direction Reversal between Taxiways	Taxiway T – Taxiway V= 250 feet	160	240	240
Taxiway Fillets	Further evaluation required.	See FAA AC 150/5300-13A (Change 1), Tables 4-6 through 8		

Sources: Federal Aviation Administration, Advisory Circular 150/5300-13A, Change 1, *Airport Design*, February 2014; C&S Companies, *DRAFT T.F. Green Airport Layout Plan*, 2018.

The existing taxiway network meets TDG 4 taxiway requirements, except for the shoulders of Taxiways C, C1, F and V, which are 15 feet wide instead of 20 feet wide.

Once a TDG 5 aircraft becomes the critical aircraft, widening of taxiway shoulders to 30 feet may be required if the taxiways in question are anticipated to be used by TDG 5 aircraft.

It is also recommended that a separate study be conducted to assess taxiway fillets against cockpit-over-centerline maneuvering, as many taxiways were designed based on judgmental oversteer maneuvering.

Table 5.14 summarizes taxiway dimensions that are a function of ADG, and compares existing dimensions with ADG II, III, IV and V standards. The following aircraft are representative of these ADGs:

- ADG II: Beechcraft King Air, Bombardier Challenger 604, Cessna Citation, Gulfstream G450
- ADG III: Airbus A320, Boeing 737, Bombardier CRJ, Embraer 175, Bombardier Global Express
- ADG IV: Airbus A300, Boeing 757, Boeing 767
- ADG V: Airbus A350, Boeing 747, Boeing 777, Boeing 787

Table 5.14— Taxiway Design Standards by Airplane Design Group

	Existing (in Feet)	Design Standards (in Feet)			
		ADG II	ADG III	ADG IV	ADG V
Taxiway Protection					
Taxiway Safety Area	All: 171	79	118	171	214
Taxiway Object Free Area	All: 259	131	186	259	320
Taxilane Object Free Area	N/A	115	162	225	276
Taxiway Separations					
Parallel Taxiway/Taxilane Centerline	250	105	152	215	267
Fixed or Movable Object	Varies	65.5	93	129.5	160
Taxilane Separations					
Parallel Taxilane Centerline	N/A	97	140	198	245
Fixed or Movable Object	Varies	57.5	81	112.5	138

Sources: Federal Aviation Administration, Advisory Circular 150/5300-13A, Change 1, *Airport Design*, February 2014; C&S Companies, *DRAFT T.F. Green Airport Layout Plan*, 2018.

The existing airfield layout meets ADG IV taxiway design requirements.

Once an ADG V aircraft becomes the critical aircraft, protection zones and separation distances for taxiways that will accommodate ADG V aircraft operations will need to be assessed to ensure compliance. For example, the current separation of 250 feet between Taxiways T and V would not meet the ADG V standard of 267 feet, requiring the taxiways to be realigned, or operational limitations to be implemented.

Parallel Taxiways

Runway 5-23 is served by a full-length parallel taxiway, Taxiway M. Runway 16-34 is served by two partial-length parallel taxiways, Taxiway C on the Runway 34 end, and Taxiway B near the center of the runway. FAA AC 150/5300-13A requires a full-length parallel taxiway for instrument approach procedures with visibility minimums below 1 SM, which applies to Runway 16-34. Alternatives to provide a full-length parallel taxiway will be explored in Section 6, Alternatives Analysis.

High-Speed Exit Taxiway

With the extension of the Runway 5 end, aircraft land further south and reach turn-off speed before Taxiway C. The previous Master Plan recommended a high-speed exit taxiway for Runway 5, to improve the flow of aircraft, reduce Runway Occupancy Time (ROT) and maximize runway capacity. This would allow aircraft to exit sooner when landing. High-speed exit taxiways are generally recommended to enhance airfield capacity; however, the runway capacity analysis conducted as part of the Master Plan did not reveal any capacity issues. Additionally, FAA AC 150/5300-13A states that a properly located 90° runway exit is effective up to 30 aircraft operations in the peak hour. The FAA-approved forecast developed as part of the Master Plan shows no more than 21 peak hour operations through the planning period. As a result, a properly located 90° runway exit is recommended to reduce ROTs on Runway 5.

Non-Compliant Taxiway Geometry

An assessment of airfield geometry principles was conducted, based on guidance set forth in FAA AC 150/5300-13A. A short description of each area of non-compliance follows, by type of issue.

<u>Non-perpendicular runway entrance/crossing:</u>

Taxiway M is a full-length parallel taxiway serving Runway 5-23, with seven entrances and exit taxiways to Runway 5-23. All taxiways connect to Runway 5-23 at a 90° angle, except for Taxiway B. FAA AC 150/5300-13A recommends all taxiways connecting to a runway should be at a 90° angle to provide the pilot with the best visual perspective and maximize safety. However, Taxiway B is also a partial parallel taxiway to Runway 16-34, which explains the non-perpendicular crossing.

Additional non-perpendicular runway crossings exist at Taxiways N and V, which intersect with Runway 16-34 in one location, resulting in complex and confusing taxiway geometry.

Taxiways F and S are non-perpendicular entrance taxiways to the Runway 16 end, reducing pilot situational awareness and visibility.

Direct access from apron to runway:

The Taxiway A connection to Runway 5-23 provides direct access from the general aviation apron to the Runway 23 end, which is discouraged by the FAA as it fosters runway incursions. It is recommended this taxiway segment be redesigned to eliminate direct access, especially since student pilots from the flight school located near Taxiway A frequently use this taxiway.

Likewise, Taxiways F and S provide direct access to the Runway 16 end from both the commercial apron and general aviation apron. Taxiway S is also designated as a hot spot. It is recommended that these intersections be redesigned to eliminate direct access.

More than 3 nodes:

Taxiway N intersects Taxiway V at Runway 16-34, resulting in four taxiway connection points at the runway, for a total of six nodes. FAA AC 150/5300-13A recommends no more than 3 nodes (or choices) at each intersection. This intersection is also designated as a hot spot.

In addition, Taxiway T connects to Taxiway N in close proximity to Taxiway N's intersection with Taxiways V and Runway 16-34. This complex configuration can cause pilot confusion and increase the change of pilot error. It is recommended that this area be redesigned as to allow only one taxiway crossing at a 90° angle to increase safety and pilot visual perspective.

Complex geometry:

The high number of taxiways, taxiway intersections and their complex geometry in the area between Runways 16 and 23 (general aviation and cargo ramps), may cause pilot confusion, increasing the potential for pilot error and therefore decreasing airfield safety. The taxiways in this area should to be redesigned to comply with the latest FAA taxiway geometry design principles, while maintaining adequate ramp access for general aviation and cargo tenants. There are two designated hot spots at the intersections of Taxiway M with Taxiways C and B.

The north terminal area, which includes Taxiway F, N, T, and V should be redesigned to reduce the number of "Y" intersections in favor of 90° taxiway intersections.

Taxiway Requirements Summary

Various taxiway improvements are recommended **to meet ADG IV/TDG 4** design standards:

- Widen shoulders of Taxiways C, C1, F and V from 15 feet to 20 feet
- Provide full-length parallel taxiway for Runway 16-34
- Add perpendicular exit taxiway for Runway 5 arrivals to reduce runway occupancy times

- Redesign intersection of Taxiways V, N, and Runway 16-34 to reduce number of nodes and provide perpendicular runway crossings
- Redesign Taxiways F, S, and A to eliminate direct access from apron to runway
- Redesign taxiway layout between Runways 16 and 23 to simplify layout
- Implement consistent taxiway lighting to reduce pilot confusion at night or in low visibility conditions

Should the **Boeing 767 become the critical aircraft**, **ADG IV/TDG 5** standards would apply, in addition to ADG IV/TDG 4 standards, requiring the following improvements:

- Widen fillets/shoulders of taxiways anticipated to accommodate TDG 5 aircraft

To **upgrade the airfield to ADG V/TDG 5**, the following improvements are recommended:

- Assess protection zones and separation distance for taxiways that will allow for ADG V/TDG 5 aircraft operations
- Widen fillets/shoulders of taxiways anticipated to accommodate ADG V/TDG 5 aircraft

Taxiway Lighting

Issues with limited lighting near the run-up area on Taxiway T, as discussed by ATC, causes pilots to often turn onto Taxiway V instead of continuing on Taxiway T to the terminal. It is recommended additional lighting be added to increase pilot situational awareness.

Taxiway V currently has elevated edge lights along the east side of the taxiway, taxiway centerline lights, and reflectors along the west side of the taxiway. The lack of consistency on Taxiway V and with the rest of the airfield is confusing to airfield users at night or in low visibility weather conditions.

Lights for several taxiways are combined on the same circuit. During maintenance or other events requiring the closure of a specific taxiway, turning off the lights for this taxiway will result in several taxiways to have their lights turned off.

Taxiway Nomenclature

The taxiway nomenclature at PVD does not meet the latest guidance provided in FAA Engineering Brief 89. Upon finalizing the airport development plan as part of this Mater Plan Update, a subsequent study should be undertaken to revise taxiway nomenclature and incorporate the changes with the implementation of the proposed improvements.

Airfield Pavement

A pavement condition assessment is currently underway for PVD, and is expected to result in a robust Pavement Management Program (PMP).

Actual pavement strength will be assessed against the critical aircraft pavement requirements.

Required pavement rehabilitation/reconstruction will be coordinated with Master Plan projects, to the extent practical. The pavement of Runway 16-34 and Taxiway C has already been identified as needing rehabilitation or reconstruction.

Airfield Markings

Currently, all runways at PVD have precision instrument markings, which are required for runways that have an ILS. The airfield markings at PVD meet or exceed the FAA design standards outlined in FAA AC 150/5300-13A and FAA AC 150/5340-1M.

Navigational Aids

Navigational aids and approach lighting systems are used by pilots for navigating to the airport airspace and aiding in landings in a variety of weather conditions.

Instrument Approach Aids

At PVD, three runway ends are equipped with an Instrument Landing System (ILS), a ground-based navigational aid: Runways 5, 23 and 34. ILS approaches are precision instrument approaches, divided into three weather minimums categories (CAT): CAT I, II, and III, with CAT III subdivided into IIIa, IIIb, and IIIc, based on cloud ceiling and visibility minimums. Characteristics of each ILS category and subcategory, along with the annual occurrence rate at PVD and which runway end is equipped, are presented in **Table 5.15**.

Table 5.15—Instrument Landing System Categories and Weather Occurrence

Equipment Installed on Runway	ILS Category	Ceiling (Feet)	Visibility	Annual Occurrence
5, 23, 34	CAT I	≥ 200 and < 1,000	≥ ½ mile and < 3 miles	12.85%
5	CAT II	≥ 100 and < 200	≥ ¼ mile and < ½ mile	1.03%
5	CAT IIIa	< 100	≥ 700 feet and < ¼ mile	0.18%
5	CAT IIIb	< 100	≥ 150 feet and < 700 feet	0.12%
5	CAT IIIc	< 100	< 150 feet	0.06%

Source: EarthInfo, Inc. from the National Climatic Data Center (NCDC) database, National Weather Service (NWS) hourly surface aviation observations, 1980 – 1999 (excluding 1989 and 1994 for bad data)

IFR conditions occur 14.24 percent of the time at PVD, with the majority being CAT I conditions, occurring 12.85 percent of the time.

Runway 5 is equipped with ILS CAT IIIc , and Runways 23 and 34 are equipped with ILS CAT I. Runway 16 is the only runway without an ILS, but it has non-precision approaches (VOR/DME and RNAV), which are adequate for operations on Runway 16. With the advent of NextGen, ground navigation equipment will no longer be needed, as it is being replaced with GPS and RNAV-based navigation. Therefore, the current instrumentation is adequate and space does not need to be preserved for an ILS for Runway 16.

Approach Lighting Systems and Runway Lighting

Runway 5 has an approach lighting system with sequence flashing lights (ALSF-II), while Runways 23 and 34 have medium intensity approach lighting systems with runway alignment indicator lights (MALSR). Runway 5-23 has runway centerline lights and Runway 5 has touchdown zone lights, both of which are required for a CAT II/III approaches. Therefore, current approach lighting systems and runway lighting are adequate.

Very High Frequency Omnidirectional Range

PVD has a very high frequency omnidirectional range (VOR) located west of Runway 5-23 and south of Runway 16-34, within 1,500 feet of the terminal building. It has a 1,000-foot radius critical area. RIAC is in discussions with the FAA and the Rhode Island Air National Guard (ANG), which is the main user of the VOR, to determine if this VOR, although classified as critical to the ANG, could be relocated or decommissioned, opening significant area for terminal and airfield expansion. A VOR relocation assessment by FAA Technical Operations is anticipated soon.

5.3 Passenger Terminal

The following section summarizes the passenger terminal facility requirements and related assumptions. These requirements were developed based on meetings with RIAC staff, discussions with key airport tenants, on-site walk-throughs, knowledge of industry-wide trends, and published guidelines including International Air Transport Association (IATA's) *Airport Development Reference Manual*, FAA Advisory Circular (AC) 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities*, and ACRP 25, *Airport Passenger Terminal Planning and Design, Airport Technical Design Standard*, and other industry publications. **Figure 5.3** explains how IATA determines level of service (LOS). "Optimum" LOS is the industry standard goal for developing terminal facilities. For each of the major functional areas described below, requirements will be calculated to achieve the Optimum LOS for the average day, peak month (ADPM).

Figure 5.3—IATA Level of Service Standards

		Overdesign	Optimum	Sub-Optimum
		Excessive or empty space	Sufficient space to accommodate necessary functions in a comfortable environment	Crowded and uncomfortable
Overdesign	Overprovision of resources	OVERDESIGN	OPTIMUM	SUB-OPTIMUM Consider Improvements
Optimum	Acceptable processing and waiting times	OPTIMUM	OPTIMUM	SUB-OPTIMUM Consider Improvements
Sub-Optimum	Unacceptable processing and waiting times	SUB-OPTIMUM Consider Improvements	SUB-OPTIMUM Consider Improvements	UNDER-PROVIDED Reconfigure

Source: Adapted from IATA Airport Development Reference Manual 10th Edition

Requirements were generated for the Baseline, which are the requirements to meet the 2017 demand, and each of the future PALs for aircraft parking positions/gates, public circulation, check-in positions, passenger and baggage security screening, hold rooms, concessions, restrooms, baggage handling systems, domestic baggage claim, and international arriving processing areas.

5.3.1 Aircraft Parking Position Assessment and Requirements

The airport has a mix of legacy and low cost commercial airlines. This can generate unusual or inconsistent gate requirements because of the different business models of these airlines. The forecast developed airport-wide annual enplanements, then developed airport-wide Average Day Peak Month (ADPM) operations, not distinguishing by airlines. The gate requirements were modeled based on this approach and the following planning assumptions:

- Create an average gate requirement comparing an Enplaned Passengers per Gate Approach and a Departure per Gate Approach. These two methods take the historical trends and interpolate them to predict future requirements. This method was used in lieu of developing flight schedules.
- Compared average created above against the forecast output for peak hour operations to confirm there is agreement.
- Gate requirement were allocated by Aircraft Design Group (ADG) percentages from the forecast. This includes changes to fleet mix throughout the planning period.

By the end of the planning period, the Airport will require 32 gates, varying between different aircraft size, or 35 narrow-body equivalent gates (NBEG). **Table 5.16** depicts the anticipated aircraft parking position requirements.

Table 5.16— Aircraft Parking Position by ADG Type

Design Standards	Existing	Baseline	PAL 1	PAL 2	PAL 3
ADG-II	4	2	1	1	1
ADG-III	16	18	18	19	24
ADG-IV	2	3	4	4	5
ADG-V	0	0	1	1	2
Total	**22**	**23**	**24**	**25**	**32**
NB Equivalent (NBEG)	21.6	23.6	26.1	27.1	35.3
Equivalent Aircraft (EQA)	22.6	24.5	28.8	29.8	39.5

Source: C&S Engineers, Inc.

NBEG is an industry standard way to compute gate requirements equalized to a narrow-body aircraft. For example, a B777 gate is equal to 1.8 B737 gates Equivalent Aircraft (EQA) is an industry standard way to normalize aircraft gates for the purposes of understanding seating capacity within the terminal. For example, A B777 is 2.8 times the seating capacity of a B737.

This requirement reflects an average gate utilization of two and a half daily departures per gate during the peak month average day. If the airport's operating model changes or the gate utilization philosophy changes, the gate requirements could significantly change. The airport could also implement minimum requirements for gate utilization, which would increase utilization and minimize facility requirements.

The current domestic and international passenger airline fleet mix, which is overwhelmingly narrow-body aircraft, is not expected to change significantly over the planning period. However, with the expectation of attracting international charters and/or foreign carriers, it would be prudent for the airport to have a few wide-body capable gates as noted in the table above.

5.3.2 Circulation Area Assessment and Requirements

Adequate circulation is critical to move passengers from one functional area to the next in an efficient and comfortable manner. Often times, circulation is based on available space created by another functional area or constraints such as concourse width. Circulation is typically split into three areas: public circulation, Federal Inspection Service (FIS) sterile arrivals circulations, and non-public walkways. Minimum clear circulation widths for public areas is typically 25 feet between major functional elements. For a concourse, the minimum width is 20 feet for a single loaded concourse, and 30 feet for a double loaded concourse without a moving walkway. For FIS sterile corridors, the minimum width standard is 15 feet for a single direction flow. For non-public areas, such as back-of-house spaces, office space, etc., the width should be determined by the function (i.e. moving supplies in a corridor near a loading dock) and local building codes.

The check-in lobby, the baggage claim area, the entrances to both, and the circulation between levels are adequate now, and should remain acceptable in the future. The exception is near the JetBlue and Southwest check-in counters where circulation is reduced due to the diagonal design of the facility. More depth in the check-in lobbies for circulation, queuing, and processing will be needed. The circulation in the baggage claim hall is adequate. Based on visual inspections and site walk-throughs, the non-public or back-of-house circulation is in accordance with local building codes.

Concourse circulation ranges from 20 to 25 feet throughout. This is on the narrow side during peak periods, but an acceptable level of service for an airport of this size. However, as passenger demand grows, the circulation aisle will continue to get more congested, particularly in peak periods. The biggest pinch point is immediately after the security checkpoint before the concessions area. This is the busiest area, and also the narrowest part of the concourse.

5.3.3 Passenger Check-In/Bag Drop Requirements

There are two check-in areas, the North and South side. Primary carriers to the North are predominately low cost or ultra-low cost carriers, except Delta. Primary carriers to the South are predominately legacy carriers, except for JetBlue. Future check-in requirements were based on the following assumptions:

- The forecast did not separate peak hour numbers by carrier; therefore, check-in demand was evaluated as a whole system, and not separated between North and South check-in zones or by individual carrier.
- Some existing check-in type percentages and processing times were provided by carriers; an average of the data provided was used to calculate requirements.
    - Different check-in types process passengers at different rates. While the percentage by processing type change, it is assumed that processing rates for each will remain consistent. This is a conservative assumption since there is a lot of uncertainty as to the efficiency of new processes.
- Future requirements were estimated based on airport-wide peak hour enplanement values. A 10 percent surge factor was used to add flexibility, and to accommodate individual airline peaks, but this may not capture the true peak of an individual airline.

Table 5.17 shows that the current number of positions combined can accommodate the check-in demand throughout the planning period. It also shows the trends in what is expected to occur in the future, related to processing. Over time, the number of passengers who arrive at the airport already checked-in via mobile will continue to increase. They either have no bags or just need a place to check their bag. Also, as new technology is added, such as biometrics, the process for verification at bag drop will decrease, reflecting less need for positions. Additionally, as more people go mobile or airlines introduce biometric check-in, the need for kiosks without bag drop will diminish. Concluding, that even though the total number of traditional check-in and kiosks will grow through the planning period, the percentage of each in the future, compared to what they are today, will dramatically change.

In the current airline business model, there will always be a need to accommodate the premium passenger, and those airlines who wish to provide a curbside drop off service. Therefore, the number of premium counters will increase over the planning period, consistent with passenger growth. It is assumed that throughout the planning period, Southwest is the only carrier who will continue to offer curbside check-in, and will need another position by the end of the planning period.

Overall area for check-in and immediate queuing area is more than sufficient when looked at the area as a whole. This excludes circulation. However, when observing an individual operation, certain airlines like Southwest, Frontier, or JetBlue are more congested and constrained because of the diagonal layout of the check-in lobby. With the airlines input, a suggested reallocation of airlines, may be a way to increase utilization of the existing check-in lobby, and allow for new carrier entrants.

Table 5.17— Passenger Check-In/Bag Drop Requirements (Number of Positions)

Area Type	Existing	Baseline	PAL 1	PAL 2	PAL 3
Remote check-in, no bag check	0	0	0	0	0
Traditional/full-service	43	8	10	12	15
Kiosk, no bag drop	27	7	9	11	13
Kiosk or remote, with bag drop	8	10	13	15	19
Premium	8	8	8	12	16
Total	**86**	**33**	**40**	**50**	**63**
Curbside	2	2	2	2	3

Source: C&S Engineers, Inc.

5.3.4 Explosive Detection System Baggage Screening

There are two TSA baggage screening areas, one for each check-in area. There are four explosive detection screening (EDS) machines in each of the screening areas. TSA is in the process of swapping out machines that will increase the processing capacity of the system. Future requirements are based on the following assumptions:

- Average percentage of domestic passengers checking bags is 58 percent. (source: Some PVD airlines)
- On average, 1.0 checked bags per domestic passenger. (source: Some PVD airlines)
- EDS screening equipment throughput is 400 bags per hour. (source: Industry assumption)
- Current processing rates continue throughout the planning period. (source: C&S Engineers, Inc.)

As a whole, the current system, will be able to handle demand throughout the planning period. This is based on limited information provided by TSA regarding the update of the EDS screening machines and lanes which improves throughput to 400 plus bags per hour. As with the check-in lobby requirements, this analysis does not account for individual airlines peaks or existing airline allocation. Therefore, while the system can accommodate the demand, one side or the other may not be able to handle the demand of the given airlines on that side of the facility. During an onsite visit, Airport staff noted that because of the airlines on the North side, the demand on the North screening matrix was three times that of the south side. Like the check-in requirements, alternatives should consider how to balance the load between airlines to maximize the use of the existing infrastructure. **Table 5.18** outlines the checked baggage system requirements for the planning period.

Table 5.18—Explosive Detection System Baggage Screening Requirements

Type	Existing	Baseline	PAL 1	PAL 2	PAL 3
Level 1 EDS screening machines	8	2	3	3	3

Source: C&S Engineers, Inc.

5.3.5 Outbound Baggage Assessment and Requirements

Outbound baggage is sorted and loaded onto airline carts for each departing flight. This function occurs in two areas, north and south, consistent with the two check-in and baggage screening areas. Typically, baggage makeup requirements are calculated in terms of the area needed for the number of carts required to accommodate aircraft in the peak departure peak, with an allowance for baggage tug circulation. Requirements are based on size of the aircraft (e.g. ADG-III aircraft is 1.0 equivalent gate, but smaller aircraft like a medium regional jet is 0.7 equivalent gates or larger aircraft like an ADG-IV is 1.2 equivalent gates).

Table 5.19—Outbound Baggage Makeup Requirements

Type	Existing	Baseline	PAL 1	PAL 2	PAL 3
Cart Positions	74	74	86	89	119
Total Area (square feet-SF)	28,300	48,510	57,025	59,000	78,210

Source: C&S Engineers, Inc.

The existing outbound baggage makeup areas are currently undersized for standard spacing and adjacent circulation, but the number of cart positions are adequate to meet the current demand. This discrepancy occurs when different airlines have different approaches to baggage make up functions. The number of peak hour operations are expected to be one and a half times the current level by the end planning period, and the outbound baggage makeup requirements will follow. By PAL 1, about 15-20 percent more cart positions are needed. By the end of the planning period, approximate 1.6 times more cart positions are required. By the end of the planning horizon, the outbound baggage makeup area must increase by almost three times the area that exists.

5.3.6 Passenger Security Screening Requirements

There is one centralized passenger security screening area located in the middle of the check-in hall, at the end of the check-in counters. There are 7 standard lanes and one TSA PreCheck lane. The area has reasonable depth, but the width is constrained on both sides, particularly the right side which does not have room for Ticket Document Check (TDC) or queue directly in front of the screening lanes, which has created a non-standard layout. Future passenger security screening requirements are based on the following assumptions:

- An average throughput for a standard lane is 150 passengers per lane per hour. This is a conservative assumption relative to TSA standards, but is a result of the non-standard and constrained layout.
- An average throughput for a PreCheck lane is 250 passengers per lane per hour. Throughout the planning period, there are no more than 2 PreCheck lanes.
- Airport and airline employee screening was including in the overall passenger volumes. This adds an additional 7 percent to the peak hour demand. (source: C&S Engineers, Inc.)
- Passenger wait times will not exceed 10 minutes. (source: IATA industry standard)
- Passengers require approximately 13 SF per person while waiting in the queue, equivalent to IATA's "Optimum" level of service.

The checkpoint has the appropriate number of lanes for the current operation. This is in alignment with staff discussions, which did not report any significant issues with the process. By the out years of the planning horizon, 1-2 screening lanes or another module is needed. However, as demand increases, by PAL 1, the checkpoint requires 40 percent more area than the existing area, and by the end of the planning period, almost double the square footage will be needed to run the process at an "Optimal" level of service. The requirements are presented in **Table 5.20**.

Table 5.20—Passenger Security Screening Requirements

Type	Existing	Baseline	PAL 1	PAL 2	PAL 3
Standard Lanes	7	5	6	7	8
Pre-Check Lanes	1	1	2	2	2
Required Modules	-	3	4	5	5
Queue area (SF)	3,250	1,140	1,480	1,740	2,660
Total Area (SF)	**10,400**	**10,870**	**14,490**	**18,110**	**18,110**

Source: C&S Engineers, Inc.

The TSA is working on two new technologies; Automatic Screening Lanes (ASLs) and biometrics to replace the TDC process. These two technologies have already been deployed at some large hub airports across the country. ASL's improvements include automated belts with bag pallets for passengers place all items on. The bag pallets are on an automated, continuous loop which eliminates manual replacement of bag bins. Biometrics are being used to improve the document check by taking a quick picture that can match to a passenger's identification. In the near future it's possible that a boarding pass or even identification may not be needed. Both technologies should improve processes at the checkpoint, and could enable PVD's checkpoint to remain in its current design for beyond the planning period.

5.3.7 Holdroom Assessment and Requirements

There are two common ways to calculate holdroom requirements. One is to apply a standard area to a gate based on the maximum aircraft size allowable for that gate. The approximate narrow-body holdroom area is 2,500 SF, ADG-IV aircraft holdroom area is 4,500 SF, and ADG-V aircraft holdroom is 6,500 SF. The other is to estimate the demand based on the estimated gate requirements in the peak hour of operation. The first method was chosen for this analysis because an actual flight schedule was not developed, and this method provides for more flexibility in the future. Industry standard areas by aircraft category, including holdroom areas, with gate circulation areas, agent podiums, and seating areas were applied to create the overall requirement.

Review of the existing holdroom capacity and the forecast demand determined that the existing facility is well below acceptable levels during peak periods. By PAL 1, holdrooms area should be double existing size. By the end of the planning period, the holdroom requirement is more than 2.5 times the current area. Total holdroom area required for each PAL is depicted in **Table 5.21**.

Table 5.21—Holdroom Requirements

Type	Existing	Baseline	PAL 1	PAL 2	PAL 3
Narrow-body	30,700	46,300	45,290	47,750	60,050
Wide-body	3,800	13,470	24,450	24,450	35,430
Total Area (SF)	**34,500**	**59,770**	**69,740**	**72,200**	**95,480**

Source: C&S Engineers, Inc.

5.3.8 Concession Area Assessment and Requirements

Concession areas provide an improved passenger level of service, create a sense of place for the airport, and provide an opportunity for increased revenue generation. Ultimately, the airport, working with a master concessionaire or a series of concessionaires, will determine what concessions areas are appropriate based on the airport's passenger profile. RIAC has a solid concessions program for an airport of its size. To estimate future area, demand was projected using the following industry standard planning assumptions:

- For the period of time when the airport has 1 to 2 million enplanements, approximately 12.4 SF of concessions space was calculated per every 1,000 annual enplanements; 7.9 SF for food and beverage, 1.1 SF for convenience retail, and 3.4 SF for specialty retail. (source: ACRP 54, *Resource Manual for Airport In-Terminal Concessions*)
- For the period of time when the airport has 2 to 3 million enplanements, approximately 12.0 SF of concessions space was calculated per every 1,000 annual enplanements; 7.9 SF for food and beverage, 2.1 SF for convenience retail, and 2.0 SF for specialty retail. (source: ACRP 54)
- For the period of time when the airport has 3 to 4 million enplanements, approximately 10.0 SF of concessions space was calculated per every 1,000 annual enplanements; 6.8 SF for food and beverage, 1.8 SF for convenience retail, and 1.8 SF for specialty retail. (source: ACRP 54)
- Duty free is minimally increased, in line with international passenger growth throughout the planning period.

- 85 percent or more concessions space should be allocated post-security, and 15 percent or less for pre-security. Often at smaller airports, there is a desire to have one pre-security restaurant that employees can use, which is more than the airport can support, but provides a nice perk for employees.
- On average, an additional 25 percent should be allocated for food and beverage storage, and an additional 20 percent should be added for retail storage, away from the immediate concessions area. (source: ACRP 54)

Currently, the airport has an abundance of pre-security concessions. This is primarily due to the restaurant near the security checkpoint, which is oversized. Otherwise, it is a reasonable program. The airport has a good amount of post-security concessions too. Throughout the planning period, the airport does not need to add any more pre-security concessions. By PAL 2, demand could support an additional 6,000 SF of post-security concessions. By the end of the planning horizon, the airport will need an additional 8,000 SF compared to the existing facility.

Concessions storage is undersized. This was determined by measuring existing conditions, and with various staff discussions. Typically 20 percent to 25 percent of the active concessions area is needed for storage. The airport has a sufficient loading dock, but there is minimal storage adjacent to the loading dock. Boxes of deliveries line the hallway near the loading dock. There is also no room for screening of goods, which is expected to be a TSA requirement in the future. **Table 5.22** depicts the concession area requirements.

Table 5.22—Concession Requirements

Type	Existing	Baseline	PAL 1	PAL 2	PAL 3
Pre-Security (SF)	6,500	3,660	4,600	5,400	5,800
Post-Security (SF)	24,750	20,760	26,050	30,580	32,850
Duty Free (SF)	660	660	780	920	1,270
Storage (SF)	2,840	5,660	7,140	8,380	7,790

Source: C&S Engineers, Inc.

5.3.9 Passenger Baggage Claim Requirements

The domestic baggage claim hall is located at the lower level of the terminal building. There are five flat plate baggage devices and room for another on the north side. Baggage claim requirements were calculated based on the following assumptions:

- Peak 20-minute arriving passenger counts. (source: ACRP 25) and an applied 1.18 surge factor.
- Approximately 1.0 bags per domestic passenger. (source: average PVD airline count)

- 50 percent of passengers checking bags in the peak period. (source: average PVD airline count)
- 10 percent of the total area is added for “meeters and greeters”. (source: C&S Engineers, Inc.)
- Standard narrow-body baggage carousel length is 175LF
- 35 percent of the total area is added for passenger circulation. (source: C&S Engineers, Inc.)
- Main circulation corridor through baggage claim not included in area calculations.

The baggage claim hall can accommodate demand through PAL 1. By PAL 2, the baggage claim area will be congested in the peak arrival periods, and by PAL 3, will be insufficient to accommodate the demand. **Table 5.23** depicts the domestic baggage claim requirements.

Table 5.23—Domestic Baggage Claim Requirements

Area	Existing	Baseline	PAL 1	PAL 2	PAL 3
Required Carousels	5	3	4	5	6
Linear Frontage	630	520	670	790	980
Baggage Claim (SF)	14,800	22,855	30,470	38,090	45,710

Source: C&S Engineers, Inc.

The discrepancy in linear frontage required versus required number of carousels is because the Airport currently has baggage belts approximately 140 linear feet (LF), whereas the analysis assumed 175 LF per carousel. The larger size for narrow-body carousels is due to the industry trend in up gauging narrow-body aircraft to have a higher average number of seats. Therefore, the analysis shows only a need for more carousels in PAL 3, but the need for more linear frontage in PAL 1.

Passenger baggage from arriving flights is unloaded and tugged to the inbound baggage handling area in the back-of-house side of the domestic baggage claim. There are five inbound belts, which are directly connected to the five flat-plate devices in the baggage claim hall. Inbound baggage makeup requirements are linked to baggage claim requirements. Baggage claim demand is calculated as linear feet per carousel or flat-plate device. To accommodate demand, a minimum inbound baggage belt length is required based on average aircraft size, and number of airlines using that belt. Similar to domestic baggage claim, PAL 1 activity is slightly more than what the infrastructure can accommodate during peak periods. By the end of the planning period, there will be insufficient capacity to meet the demand.

5.3.10 International Arrivals Facility Requirements

The airport completed a renovation to their International Arrivals Facility in 2017. This was to meet growing demand, and to bring the facility up to the current U.S. Customs and Border Protection (CBP) standards. By CBP standards, the improved facility will be able to process 400 passengers per hour. This can accommodate one wide-body aircraft, like the Boeing 787, or two narrow-body aircraft, such as the Airbus B738 or A320. The challenge with the improved facility is that it was renovated within the existing building footprint.

Although there are enough processing booths, queues build up in the primary inspection lanes because of 1) staggered primary processing booths, 2) narrow corridors to accommodate the multitude of passenger processing segmentation, and 3) majority of passengers adjusting to automated passport control (APC) kiosks. Because of these challenges, operationally, CBP holds staggered flights on the plane until almost the entire first plane is complete. Therefore, while there are enough booths, the facility processes closer to 200 passengers per hour instead of the 400 passengers per hour it was designed to accommodate.

As observed during a site visit, there is sufficient baggage claim length to accommodate the current demand. This is helped by the metering of passengers that naturally occurs because of the primary processing function. By PAL 3 or if there is a significant increase in peak hour international arriving flights, more baggage claim length will be needed. The IAF facility requirements are depicted in **Table 5.24**.

Table 5.24—International Arrivals Facility Requirements

Area	Existing	Baseline	PAL 1	PAL 2	PAL 3
Primary Inspection booths	6	4	4	4	6
Baggage Claim Frontage (LF)	225	125	150	175	245
Second Inspection units	1	1	1	1	1

Source: C&S Engineers, Inc.

5.3.11 Restroom Assessment and Requirements

Restrooms are an important, but often overlooked element at an airport. They are not one of the major functional terminal areas, but are often the area that receives the most passenger complaints when surveyed. Terminal and concourse restrooms requirements are calculated differently, using the following assumptions:

- For terminal buildings: 2.0 to 2.5 SF per peak hour arriving and departure passengers and well-wishers/meeters and greeters. (source: ACRP 25) Peak hour arriving was used because it was a larger number.

- For concourses: A restroom module of 10 to 12 fixtures/sex for every eight gates. (source: ACRP 25). Approximately 400 SF for one module, one for each sex.

For pre-security, the existing area is undersized for the current demand. By PAL 3, the amount of restrooms needed will more than double what currently exists. Post-security restrooms are more than sufficient to accommodate today's demand. In fact, there are sufficient number of fixtures to accommodate demand throughout the planning period. **Table 5.25** depicts the public restroom requirements.

Table 5.25—Public Restroom Requirements

Area	Existing	Baseline	PAL 1	PAL 2	PAL 3
Pre-Security (SF)					
Level 1	1,080	1,365	1,770	2,080	2,575
Level 2	1,080	1,365	1,770	2,080	2,575
Post-Security (SF)	4,800	2,450	2,880	2,980	3,950

Source: C&S Engineers, Inc.

5.3.12 Summary

The facility requirements conclude that aircraft parking gates, outbound baggage makeup, hold rooms, domestic baggage claim area, and some concessions areas are undersized even to meet the 2017 demand. By the end of the planning period, most major functional areas with the exception of check-in, international arrival areas, and the checked baggage screening system, will exceed capacity. Some of these elements will be able to process passengers or bags to meet the demand, but the area or items to achieve Optimum LOS for average day, peak month will be exceeded. **Figure 5.4** depicts major functional areas excess or deficit by PAL.

Figure 5.4—Summary of Passenger Terminal Requirements

	Existing	Baseline	PAL 1	PAL 2	PAL 3
Year	2017	2017	2022	2027	2037
Annual Enplanements	1,969,966	1,969,966	2,553,530	2,997,929	3,715,999
Peak Hour Enplanements	708	708	917	1,077	1,335
Peak hour Domestic Arrivals	1,092	1,092	1,415	1,662	2,060
Peak hour International Arrivals	252	252	299	354	488
Aircraft Parking Positions					
Domestic Only Gates	19	-	-	-	-
International Capable Gates	2	-	-	-	-
Total Gates	21	23	24	25	32
Narrowbody Equivalent Gates (NBEG)s	21.6	23.6	26.1	27.1	35.3
Check-In/Ticketing					
Remote check-in, no bags	-	-	-	-	-
Traditional	43	8	10	12	15
Kiosk no bag drop	27	7	9	11	13
kiosk/remote with bag drop	8	10	13	15	19
Premium	8	8	8	12	16
Total	86	33	40	50	63
Curbside	2	2	2	2	3
Check-In/Ticketing Queue Area	9,700	3,520	4,559	5,355	6,637
Baggage Systems					
Number of Level 1 EDS Required	8	2	3	3	3
Outbound Baggage Make-up Cart Positions	74	74	86	89	119
Outbound Baggage Make-up Area	28,300	48,510	62,208	64,368	78,210
Passenger Screening					
Regular Passenger Lanes	7	5	6	7	8
Pre-Check Passenger Lanes	1	1	2	2	2
Required Modules	4	3	4	5	5
Security Screening Area	10,400	10,870	14,490	18,110	18,110
Queue Area	3,250	1,140	1,480	1,740	2,660
Holdrooms					
Widebody Holdrooms	3,800	13,470	24,450	24,450	35,430
RJ/Narrowbody Holdrooms	30,700	46,300	45,290	47,750	60,050
Total Holdroom Area	34,500	59,770	69,740	72,200	95,480
International Arrivals Facilities					
Primary Inspection booths	6	4	4	4	6
Baggage Claim Linear Frontage	225	125	150	175	245
Secondary Inpsection	1	1	1	1	1
Domestic Baggage Claim					
Carousels	5	3	4	5	7
Linear Frontage	630	520	672	790	1,064
Baggage Claim Area	14,800	22,854	30,472	38,090	53,326
Restrooms					
Restrooms (Pre-Security)					
Level 1	1,080	1,365	1,769	2,078	2,575
Level 2	1,100	1,365	1,769	2,078	2,575
Restrooms (Post-Security)	4,800	2,450	2,880	2,980	3,950
Concessions					
Concessions Area (Pre-Security)					
Level 1	2,700	-	-	-	-
Level 2	3,800	-	-	-	-
Total	6,500	3,660	4,600	5,400	5,800
Concessions Area (Post-Security)	24,750	20,760	26,050	30,580	32,850
Duty Free	660	660	780	920	1,270
Remote Concessions Storage	2841	5,660	7,140	8,380	7,790

Legend	
(green)	= No expected issues
(yellow)	= Issues possible
(orange)	= Issues expected

5.4 Airport Ground Transportation and Roadway Access

This section summarizes estimated requirements for roadways, curbsides, and parking facilities through the planning period, 2037. Requirements were based on collected data, information from RIAC, and industry standards for methodologies and operations of traffic and parking facilities.

5.4.1 Traffic Volume Forecasting

The future 2022, 2027, and 2037 year traffic volume projections were developed based on the data contained in the Aircraft Operations Demand Forecasts. Based on the forecasts, the peak-hour enplanements are anticipated to increase as shown in **Table 5.26** from 2017 through 2037.

Table 5.26—Planning Activity Level Aircraft Operations Forecasts

Year	2017 Existing	2022 PAL[1] 1	2027 PAL 2	2037 PAL 3
PMAD Peak Hour[2]	708	917	1,077	1,335
Peak Hour Arrivals	24	26	26	32
Peak Hour Departures	15	17	17	21
Peak Hour Aircraft Operations	16	17	17	21

[1] PAL = Planning Activity Level

[2] PMAD = Peak Month, Average Day enplanements

Source: Forecasts of Aviation Demand, June 2018

Adjusting that data to reflect the differences in peak-hour enplaning and deplaning patterns and calculating the growth between each PAL year results in the following growth factors, which were applied to the traffic volumes by mode in order to create future year forecasts for airport related traffic. **Table 5.27** provides the resulting traffic growth expected at T.F. Green Airport for arrivals and departures traffic. Because some movements include both arrivals and departures traffic, a combination rate was also developed.

Table 5.27—Departures and Arrivals Traffic Growth Rates

Year	2017 - 2022	2017 - 2027	2027 - 2037
Peak Hour Departures	1.30	1.52	1.89
Peak Hour Arrivals	1.35	1.59	1.98

Source: WSP USA and Section 4, Forecasts of Aviation Demand, June 2018

Industry wide, transportation network companies (TNCs) mode share is increasing. In addition to general growth in this mode that will increase based on increasing parking charges and increasing congestion in the future, there is specific growth anticipated at T.F. Green Airport. With the recent movement of Lyft vehicles to the curbside, this mode will become more visible and desirable. In addition, the recent addition of Uber to Garage C provides a presence for that provider at the Airport. Going forward, there is the potential for future growth with other providers and potentially having all TNC providers located at the curbside. As a result, in addition to the standard airport related growth rates, in 2022 an additional 10 percent of the passenger car curbside volume was applied to the TNC volume. In 2027, that increase was estimated at 25 percent, and in 2037 that increase was estimated at 50 percent.

Although the number of users on public transit are anticipated to increase, the growth in public transit and shuttle use does not cause a 1:1 increase in transit vehicle trips. As a result, the increase in the trips to those modes was increased approximately 50 percent of the factors provided above.

Because there is also through traffic passing by the access points, an estimated growth rate of one percent per year was applied to the existing non-airport related traffic volumes on Post Road and on Airport Road. The future conditions volume diagrams are included in **Appendix C**.

5.4.2 Traffic Analyses & Results

The forecast data collected was used to inform the following analyses:

- Synchro models used to evaluate external roadway and signalized intersections operations
- Vissim models that simulate and analyze curbside pick-up and drop-off activity
- Curbside occupancy analysis using the Quick Analysis Tool for Airport Roadways (QATAR)
- Parking Facility Occupancy Analysis
- Vehicle Occupancy Analysis

Synchro Intersection Analysis

Synchro (Version 9.2.914.6), an intersection operations analysis and optimization software, was used to analyze the future operations of the four signalized intersections adjacent to the Airport, shown in Figure 2.22.

The projected volumes, field and aerial collected geometry data, signal timing observations, and signal timing data received from the Rhode Island Department of Transportation (RIDOT) were used to create future condition AM and PM peak hour Synchro models.

Synchro was then used to evaluate the intersection and movement delays, Level of Service (LOS), and queue lengths. LOS is a letter grade (A – F) measure of a roadway or intersection's congestion and delay.

2022 Conditions

The traffic volumes projected for the 2022 condition were analyzed using Synchro and the results are provided in **Table 5.28** on the following page. The Table illustrates the overall intersection delay, delay by movement, and queue length by movement for the four signalized intersections evaluated in both the AM (7:45 AM to 8:45 AM) and PM (5:00 PM to 6:00 PM) peak hours under the 2022 traffic volume condition.

The operational analysis summarized in the table indicates that under the 2022 traffic volume condition, each of the studied intersections operate at an overall LOS C or better in both the AM and PM peak hour. Additionally, the Synchro analysis shows that none of the individual intersection movements will operate at undesirable LOS (E or F).

Synchro's SimTraffic simulation module was used to analyze queue lengths at the above intersections. This analysis shows that during the PM peak hour, the 95th percentile queue length for a few movements will exceed storage capacity; however, similar to the existing condition, modification of the intersection timings will reduce the queuing down to the available storage lengths.

The 2022 Synchro and SimTraffic outputs are included in **Appendix C.**

Table 5.28—2022 Synchro Level of Service, Delay, and Queue Lengths

		AM Peak			PM Peak		
Intersection / Movement	Queue Storage[1]	LOS[2]	Delay[3]	Queue Length[4]	LOS[2]	Delay[3]	Queue Length[4]
Airport Connector Rd at Evans Ave		A	8.4		B	19.6	
EBL	200	A	5.8	63	B	14.0	105
EBT	200	B	14.4	49	B	17.5	80
EBR	140	A	6.5	Free	B	11.9	153
WBL	50	B	15.8	26	B	16.0	58
WBR	300+	A	5.8	62	B	18.8	122
NBT	300+	B	11.0	70	D	41.4	221
Post Rd at Aviation Ave		A	8.5		B	18.5	
EBT	150	C	20.4	56	D	48.0	135
NBL	100	C	27.0	38	D	41.5	27
NBT	300+	A	9.3	183	B	17.0	256
SBL	110/170	C	24.8	56	D	51.7	188
SBT	175	A	4.7	92	A	8.7	157
Post Rd at Coronado Rd		C	20.6		C	26.4	
EBL	360	C	27.0	141	C	29.1	142
EBR	100	A	5.2	61	B	11.8	58
WBL	85	D	39.1	11	D	48.0	26
WBT	125	D	39.0	92	D	47.5	159
WBR	150	A	2.2	0	B	14.8	34
NBL	125	E	59.0	70	D	43.8	55
NBT	500+	B	10.6	168	A	8.1	85
SBT	500+	C	24.3	190	C	27.4	190
Airport Road at Delivery Rd		A	4.1		A	2.3	
EBT	465	A	3.4	46	A	2.6	45
WBT	500+	A	4.6	140	A	1.6	74
NBL	500+	B	20.0	7	C	21.0	8
NBR	50	B	16.0	8	B	18.0	10

[1] Queue Storage Length (ft) [2] Level of Service, based on vehicular delay thresholds [3] Delay in seconds per vehicle; [4] 95th percentile queue length (ft), based on SimTraffic Analysis

Source: WSP USA

2027 Conditions

The traffic volumes projected for the 2027 condition were analyzed using Synchro model and the results are provided in **Table 5.29**. The Table illustrates the overall intersection delay, delay by movement, and queue length by movement for the four signalized intersections evaluated in both the AM (7:45 AM to 8:45 AM) and PM (5:00 PM to 6:00 PM) peak hours under the 2027 traffic volume condition.

As noted in 2027, each of the studied intersections will operate at LOS C or better in both the AM and PM peak hour with the exception of the intersection of Airport Connector at Evans Road which will operate at LOS D during the PM peak-hour. At this intersection, the northbound approach (due to high through volumes) will operate at LOS F during the PM peak-hour. All other movements will continue to operate at acceptable conditions.

Synchro's SimTraffic simulation module was used to analyze queue lengths at the above intersections. This analysis shows that during the AM peak-hour, vehicle queues are accommodated at the signalized intersection. In the PM peak hour, however, the 95th percentile queue length at a number of movements exceeds capacity at the signalized intersections. As in Existing and 2022 conditions, however, there is sufficient capacity throughout the intersections to adjust signal timings to mitigate queue lengths.

The 2027 Synchro and SimTraffic outputs are included in **Appendix C.**

Table 5.29—2027 Synchro Level of Service, Delay, and Queue Lengths

		AM Peak			PM Peak		
Intersection / Movement	Queue Storage[1]	LOS[2]	Delay[3]	Queue Length[4]	LOS[2]	Delay[3]	Queue Length[4]
Airport Connector Rd at Evans Ave		A	9.2		D	39.7	
EBL	200	A	5.8	58	C	26.4	120
EBT	200	B	14.9	48	B	18.2	114
EBR	140	A	6.7	Free	C	31.4	181
WBL	50	B	16.3	31	B	16.0	70
WBR	300+	A	6.9	68	C	22.6	135
NBT	300+	B	12.8	93	F	89.0	279
Post Rd at Aviation Ave		B	10.2		B	20.0	
EBT	150	C	23.3	47	D	49.5	167
NBL	100	C	29.7	19	D	41.6	45
NBT	300+	B	11.5	190	B	19.6	262
SBL	110/170	C	28.5	64	D	49.1	188
SBT	175	A	5.2	117	A	9.2	166
Post Rd at Coronado Rd		C	22.1		C	30.2	
EBL	360	C	28.2	135	C	29.2	138
EBR	100	A	6.3	61	B	12.0	57
WBL	85	D	41.0	22	D	51.6	28
WBT	125	D	40.9	107	D	50.9	144
WBR	150	A	4.4	0	B	14.9	0
NBL	125	E	66.1	77	D	44.2	49
NBT	500+	B	10.9	150	A	8.2	58
SBT	500+	C	26.3	185	C	32.9	184
Airport Road at Delivery Rd		A	4.4		A	2.6	
EBT	465	A	3.5	66	A	3.0	80
WBT	500+	A	4.9	140	A	1.7	121
NBL	500+	C	20.5	13	C	21.0	15
NBR	50	B	16.0	9	B	20.0	15

[1] Queue Storage Length (ft) [2] Level of Service, based on vehicular delay thresholds [3] Delay in seconds per vehicle; [4] 95th percentile queue length (ft), based on SimTraffic Analysis

Source: WSP USA

2037 Conditions

The 2037 traffic volumes were analyzed using Synchro and the results are provided in **Table 5.30.** The table illustrates the overall intersection delay, delay by movement, and queue length by movement for the four signalized intersections evaluated in both the AM (7:45 to 8:45 AM) and PM (5:00 to 6:00 PM) peak-hours under the 2037 traffic volume condition.

By 2037, the operational analysis shows significant congestion will develop at the signalized intersections. The on-airport signalized intersection of Airport Connector Road at Evans Avenue will operate at an overall LOS F with numerous movements operating at LOS F and lengthy queues. By 2037, significant infrastructure improvements will be required at this intersection. Although the intersection of Post Road at Aviation Avenue will operate with acceptable delays, the number of queued vehicles will exceed available storage for most movements. Infrastructure improvements will be required at this location in order to reduce this congestion. Traffic signal timing adjustments will be required at the remaining intersections to ensure optimal operations and queue management.

The 2037 Synchro and SimTraffic outputs are included in **Appendix C.**

Table 5.30—2037 Synchro Level of Service, Delay, and Queue Lengths

		AM Peak			PM Peak		
Intersection / Movement	Queue Storage[1]	LOS[2]	Delay[3]	Queue Length[4]	LOS[2]	Delay[3]	Queue Length[4]
Airport Connector Rd at Evans Ave		A	9.7		F	124.1	
EBL	200	A	5.6	67	F	95.5	178
EBT	200	B	15.2	59	B	19.1	258
EBR	140	A	6.8	15	F	143.7	344
WBL	50	B	16.7	39	B	15.9	78
WBR	300+	A	6.8	72	C	31.8	148
NBT	300+	B	14.5	109	F	218.2	258
Post Rd at Aviation Ave		B	10.8		C	23.8	
EBT	150	C	25.8	61	D	51.3	166
NBL	100	C	32.2	20	D	41.6	30
NBT	300+	B	12.0	213	C	27.3	309
SBL	110/170	C	31.4	107	D	46.3	223
SBT	175	A	5.2	105	B	10.5	204
Post Rd at Coronado Rd		C	26.5		D	47.3	
EBL	360	C	30.6	141	C	30.6	143
EBR	100	A	8.6	56	B	12.3	56
WBL	85	D	45.2	21	E	57.7	51
WBT	125	D	44.7	108	E	57.7	162
WBR	150	A	7.4	0	B	15.0	063
NBL	125	F	88.0	81	D	46.4	57
NBT	500+	B	11.7	168	A	8.5	106
SBT	500+	C	32.5	187	E	59.7	190
Airport Road at Delivery Rd		A	5.1		A	3.5	
EBT	465	A	3.8	74	A	4.4	73
WBT	500+	A	5.9	162	A	2.0	164
NBL	500+	C	22.0	5	C	21.0	15
NBR	50	B	16.5	9	B	20.0	13

[1] Queue Storage Length (ft) [2] Level of Service, based on vehicular delay thresholds [3] Delay in seconds per vehicle; [4] 95th percentile queue length (ft), based on SimTraffic Analysis

Source: WSP USA

Curbside Occupancy Analysis

The Quick Analysis Tool for Airport Roadways (QATAR) was used to determine how densely occupied the departure and arrivals curbsides can be during periods of peak activity for 2018 existing conditions as well as 2022, 2027, and 2037 future conditions. The projected volumes for these conditions were based on the traffic forecasting discussed in Section 5.4.1.

Curbside volumes (and accompanying pass-through trips along the through or travel lanes) were projected to 2022, 2027, and 2037 using the traffic forecasting methodology discussed in Section 5.5.4.1. Growth rates were based on the expected number of flights arriving and departing in the target years. Analysis was re-run with the projected values for the AM and PM peaks, the results of which are described in **Table 5.31**, **Table 5.32**, and **Table 5.33** below.

In the 2022 PM Peak scenario, areas of the two lanes closest to the curbside drop to LOS E, while the travel (through) lanes along those sections drop to LOS B. This indicates that the congestion along the curbside will continue to worsen, and impact through lanes operations. However, the southernmost section of the curbside, the 375-foot area before the first crosswalk, remains unaffected with a Level of Service of A in all lanes.

In the 2027 PM Peak scenario, areas of the two lanes closest to the curbside drop to LOS F, while the travel lanes along those sections drop to LOS E. The southernmost curbside has its two most distant lanes drop to LOS B, likely as a result of congestion downstream. The presence of LOS F indicates a significant need for mitigation.

In the 2037 PM Peak scenario, all four lanes in sections between the crosswalks drop to LOS F. With nearly twice the volume in the PM peak, it's possible that the Arrivals Inner Curbside may be severely over capacity.

Each of the future conditions QATAR analyses assumed the same distribution of arriving vehicles along the curbside as was observed in existing conditions; because the tool is static (i.e., it does not re-distribute trips to areas of the curbside that are less occupied), the analysis results show the curb segments nearest the terminal doors experiencing greater congestion and occupancy as volumes increase. As noted, the southernmost section in this analysis remains at LOS B in its worst lane, and it is possible that drivers would adjust to increasing curbside demand by waiting further from the terminal doors.

Table 5.31—Arrivals Inner Curb QATAR Analysis Results

Segment / Condition	1	2	3	4	5	6	7	8	9
2018 AM	A/A A/A		A/A A/A		A/A A/A		A/A A/A		A/A A/A
2018 PM	A/A A/A		A/A D/D		A/A D/D		A/A D/D		A/A D/D
2022 AM	A/A A/A		A/A A/A		A/A A/A		A/A A/A		A/A A/A
2022 PM	A/A A/A		B/B E/E		B/B E/E		B/B E/E		B/B D/D
2027 AM	A/A A/A		A/A A/A		A/A A/A		A/A A/A		A/A A/A
2027 PM	B/B A/A		E/E F/F		E/E F/F		E/E F/F		C/C E/E
2037 AM	A/A A/A		A/A A/A		A/A A/A		A/A A/A		A/A A/A
2037 PM	B/B A/A		F/F F/F		F/F F/F		F/F F/F		C/C E/E

LOS listed from most distant lane from curb to closest lane to curb; Sections 2, 4, 6, and 8 represent crosswalks
Source: WSP USA

The QATAR analyses projected that Arrivals Outer Curbside operations will not drop below a Level of Service of A in any AM Peak scenario, as the number of flights arriving at T.F. Green Airport in the morning remains low. Similarly, the analysis results indicate that the Departures Curbside will remain operating at LOS A in each of the forecast PM Peak scenarios. However, the outer curb forecasting is likely the most volatile due to a number of factors including: Lyft's recent relocation to the outer curb from Lot D, the potential for other TNCs to shift to the outer curb in the near future, and the broader uncertainty of "New Mobility" options that may develop in the coming decades that could shift T.F. Green Airport travelers and employees from other modes. The current curb and lane allocation and sizing, particularly the short length and single lane for TNC operation, could cause delays beyond what the analysis is predicting.

Table 5.32—Arrivals Outer Curb QATAR Analysis Results

Segment / Condition	1	2	3	4
2018 AM	A/A/A	A/A/A		A/A/A
2018 PM	A/A/A	A/A/A		A/A/A
2022 AM	A/A/A	A/A/A		A/A/A
2022 PM	A/A/A	A/A/A		A/A/A
2027 AM	A/A/A	A/A/A		A/A/A
2027 PM	A/A/A	A/A/A		A/A/A
2037 AM	A/A/A	A/A/A		A/A/A
2037 PM	A/A/A	A/A/A		A/A/A

LOS listed from most distant lane from curb to closest lane to curb; Section 3 represent crosswalks
Source: WSP USA

According to the QATAR analyses, the Departures Curbside is projected to maintain an LOS of A across all its lanes in the 2022 AM scenario. In 2027, the two lanes closest to the curbside are projected to worsen to LOS B during the AM peak, driven by the approximately 50 percent increase in the number of curbside and circulating vehicles. In 2037, with approximately twice the projected volume as existing conditions, the southern half of the Departures Curbside remains at the same Level of Service as 2027, but the northern half drops to LOS C on the two inner lanes and LOS B on the two outer lanes during the AM peak hour. The congestion in the outer lanes is likely caused by vehicles triple-parking and impeding the flow of traffic, which often happens when lanes closer to the curbside are more occupied.

Field observations indicate that on average, vehicles on the arrivals level dwell much longer than on the departures level, which in effect increases the relative capacity of the departures level compared to the arrivals level.

Table 5.33—Departures Level QATAR Analysis Results

Segment / Condition	1	2
2018 AM	A/A/A/A	A/A/A/A
2018 PM	A/A/A/A	A/A/A/A
2022 AM	A/A/A/A	A/A/A/A
2022 PM	A/A/A/A	A/A/A/A
2027 AM	B/B/A/A	B/B/A/A
2027 PM	A/A/A/A	A/A/A/A
2037 AM	B/B/A/A	B/B/C/C
2037 PM	A/A/A/A	A/A/A/A

LOS listed from most distant lane from curb to closest lane to curb.
Source: WSP USA

For each of these analyses, it should be noted that the QATAR analysis is based on hourly volumes and does not account for "peak of the peak" fluctuations, and thus may not reflect the more intense, but brief congestion that occurs when multiple flights land in close succession. As noted, it is a static analysis, that does not take into account drivers' ability to react to changing conditions and occupancies, or patrons willingness to walk further to reach their destination.

Vissim Microsimulation Analysis

The Vissim simulation was updated to model the expected traffic operations during PAL 3, which corresponds to the 2037 AM and PM peak hour. Additional curbside analyses are included in the future conditions QATAR analyses, discussed below. Volumes for the Vissim model were increased per the methodology discussed in Section 5.4.1.1, with additional small refinements for visual purposes, given Vissim's stochastic nature.

Visual observation of the 2037 Vissim model illustrate that the departures and arrivals curbsides will become more congested as volumes increase, with the Departures most congested prior to early morning flights and the arrivals level most congested during the evening peak hour. During existing conditions data collection, significant circulating vehicle volumes were observed on all three curbsides. These volumes were increased at the same rates as the respective AM and PM curbside volumes.

The AM simulation indicates that the higher number of curbside and circulating vehicles will create queues at the end of the departures level, as vehicles must merge from effectively four lanes to two (and then one), as they exit to either Garage A or the ramp to ground level, as shown in **Figure 5.5**. **Figure 5.6** also illustrates 2037 Vissim operations. In addition to this visual confirmation, queueing data derived from the simulation indicates that the maximum queue length at the end of the departures level would reach a maximum length of approximately 350 feet, with an average length of approximately 60 feet. The 2037 AM peak hour Vissim simulation did not illustrate issues or congestion on the arrivals curbsides, as they are currently limited arriving flights in during the AM "Street Peak" and it was assumed that flight patterns would remain consistent.

Figure 5.5—2037 AM Vissim Simulation Model - Departures Level Queueing

Source: WSP USA

Figure 5.6—2037 AM Peak Hour Vissim Departures Operations

Source: WSP USA

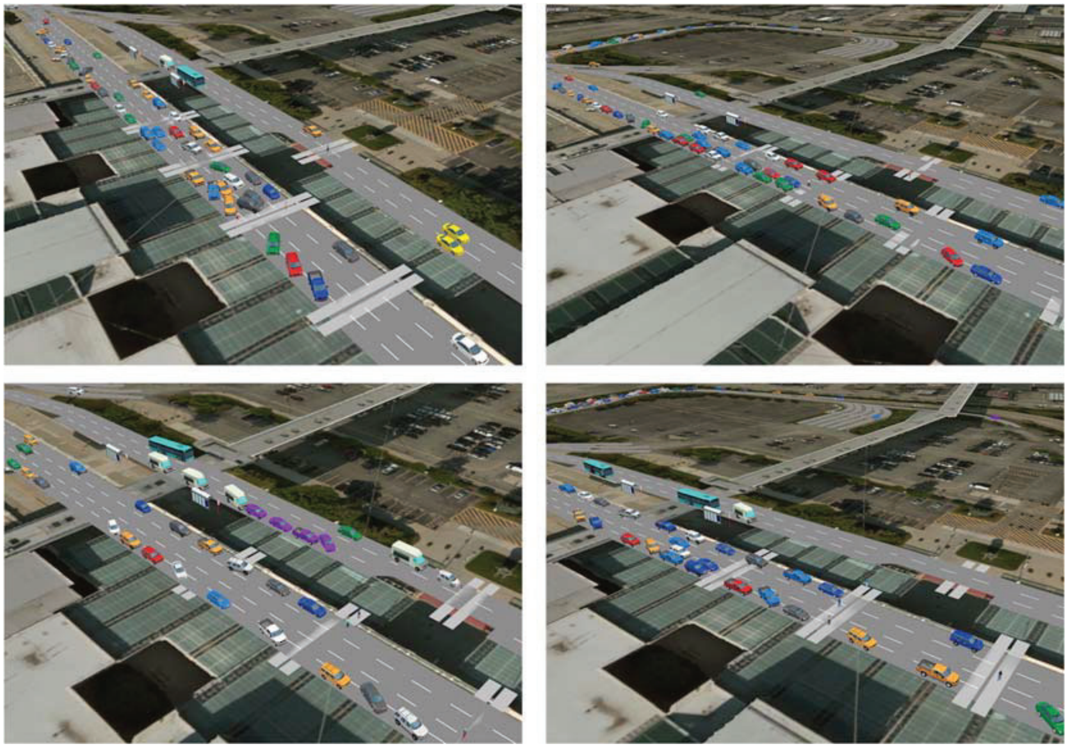
The 2037 PM peak hour Vissim simulation indicates that the volume entering the Airport Connector Road at Evans Road intersection will exceed its capacity, as nearly twice as many curbside and circulating vehicles are projected to pass through the intersection as compared to existing conditions. This not only delays vehicles (and those attempting to pick up passengers), but it in effect meters the number of vehicles that can reach the curbside in a given time period. This is illustrated in **Figure 5.7**.

Figure 5.7—2037 PM Vissim: Airport Connector Road at Evans Avenue Queues

Source: WSP USA

The simulation also projects the arrivals inner curbside to become more congested, as more vehicles attempt to access the curbside. Vissim allows drivers to "react" to model conditions, which causes more drivers to park along the curbside further from the terminal doors, as the areas closest to the terminal are occupied. During the June 2018 existing conditions observations, drivers picking up arriving passengers sought to park between columns 5 and 13; however, as the curbside becomes more congested, drivers will be forced to utilize more of the curbside and arriving passengers will be willing to walk further to reach the vehicle picking them up. **Figure 5.8** illustrates the arrivals inner and outer curbside congestion.

Figure 5.8—2037 PM Vissim: Arrivals Inner and Outer Curbside Congestion



Source: WSP USA

Queue data was also collected as part of the 2037 PM Simulation, as shown in **Table 5.34** on the following page. The Table illustrates the significant queues projected to occur at the intersection as well as along the arrivals inner curb. These queues build not only due to the increased vehicular volume, but also the increased interaction with pedestrians, as pedestrian volumes are projected to increase, which will create more frequent vehicle-pedestrian conflicts along both curbsides. Vissim outputs both the average queue length throughout the analysis period as well as the maximum queue length recorded.

Table 5.34—2037 PM Peak Hour Vissim Queue Lengths

Approach	Avg. Queue		Max Queue	
	(ft)	# of Veh	(ft)	# of Veh
Evans Avenue at Signal	313	14	422	19
Airport Connector at Signal	292	13	424	19
Airport Connector Road at Signal	354	14	762	35
Outer Curb at Stop Sign	8	1	126	6
End of Inner Curb	142	6	657	30

Source: WSP USA

Parking Analysis

Based on the forecast projections, if existing mode splits for air passengers remain constant, the parking facilities will be able to accommodate the demand for the 2022 forecast condition. At that passenger level, based on consistent mode choice, it is anticipated that Lot E will remain at only 40 percent occupancy, Garage A and Lot D will be between 50 and 60 percent occupied, and Garage B will approach 80 percent occupancy. Based on recent industry trends as well as changes locally that may affect mode share, however, the parking demand rate may not remain consistent in the future. Regardless, at this level, airport patrons can still find parking relatively easily.

Once the forecasted air traffic levels for 2027 and 2037 are reached, however, the onsite parking will begin to be constrained. Prior to reaching the 2027 forecast year, Garage B will reach its capacity causing demand to shift to other facilities, but continue to be served on the site. At this level, additional wayfinding signage identifying whether a certain parking facility has spaces available will ensure that the public does not have to circulate unnecessarily. Other options could include valet parking in certain facilities to increase capacity.

By 2037, if existing mode choices continue, Garages A and B as well as Lot D will reach capacity and the demand for Lot E will increase significantly based on spillover from the other facilities. At this level of parking demand, additional facilities are required.

5.4.3 Ground Transportation Facility Requirements

The existing ground transportation facilities were reviewed, data collected, and analyses to assess how each of the facilities and modes of transportation were operating. The potential opportunities for improvement were identified and are categorized by facility type below.

Roadway Facilities

The roadway facilities and their associated operations were assessed to evaluate existing conditions and identify opportunities for improvement. This assessment included operations along the airport's adjacent external roadways as well as internal circulation and operations. Many of the findings and opportunities for improvement center on driver information and signage, as existing geometries and alignments force drivers to make quick decisions at several locations throughout the airport. More redundant and visible information, through signage and markings would help drivers process information, make decisions, and safely navigate the airport. The potential improvements include better speed limit signage, increased sight distance, and better wayfinding and directional signage.

Signal Timing

As discussed in Section 2.3.3, each of the signalized intersections studied is currently operating at an acceptable level of service. However, a more detailed evaluation shows that if traffic volumes increase, some of the left-turn queues could extend to block the through movement. This is especially likely on for the eastbound and southbound left movements at the Post Road at Aviation Avenue intersection as well as the westbound movement exiting the airport at the Post Road at Coronado Road intersection, as shown in previous **Table 5.29**.

These queue lengths should be periodically monitored through field observation toward adjusting signal split times and cycle length to ensure optimal operation and to mitigate long queue lengths. As indicated, delays and queuing can likely be controlled through 2027 with traffic signal timing and phasing changes with the exception of the intersection of the Airport Connector Road at Evans Avenue which may require infrastructure investments in addition to signal timing changes at that time.

Speed Limit Signage & Sight Distance

During data collection, the team identified multiple locations that presented potential sight distance issues, as well as conditions that forced drivers to quickly react before an oncoming decision point. Related to the sight distance concerns, the team found a lack of speed limit signage, or signage that was difficult to see at key locations.

There are 15 mph speed limit signs on the departures level and at the entry to the arrivals curbside. However, the existing speed limit signs on the arrivals level are small and placed amidst other information at a decision point as shown in **Figure 5.9**, which can overload drivers' ability to process the information presented.

An opportunity for improvement would be to place additional column or overhead mounted speed limit signage further downstream along the arrivals level to reinforce the speed limit.

Figure 5.9—Existing Conditions Arrivals Inner Curb Speed Limit Signage

Source: WSP USA

The team also noted that there is currently no speed limit signage on the Airport Connector Road. Signage should be placed along the roadway to either enforce a universal 15-mph airport-wide speed limit or to define a different speed limit on this facility.

Defining driver speeds is critical at this location, as measurements showed limited sight distance. **Figure 5.10** illustrates that drivers have only 149 feet of sight distance when entering the curve in the Airport Connector Road. This available sight distance is just less than the required distance for vehicles traveling 25 mph (155 feet), per industry standards.[2]

[2] *A Policy on Geometric Design of Highways and Streets 6th Edition*, 2011 (American Association of State Highway and Transportation Officials).

Figure 5.10—Airport Connector Road Sight Distance and Lane Change Distance

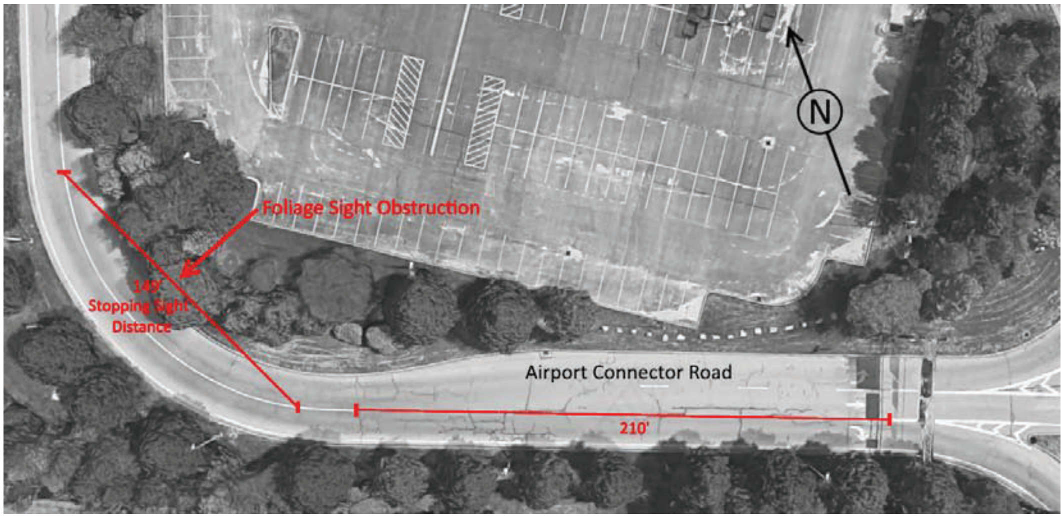


Photo Source: Google Maps and WSP USA

Removing and/or trimming the trees and foliage along the curve would provide additional sight distance and improve safety and driver certainty along the curve. Installing a speed limit sign (maximum of 25 mph) on the Airport Connector Road would also provide appropriate guidance to circulating drivers. Increasing the curve radius or slight realignment would also improve the sight distance.

In the future, increasing traffic volumes are likely to exacerbate sight distance issues, as queues on the approach to the Airport Connector Road at Evans Avenue signal will extend to the limits of existing sight distance, which would present safety issues for drivers traveling in excess of 25 mph.

Directional and Informational Signage

During observations, the team also found that directional and informational signage could be improved to better inform drivers and facilitate decision making. This was specifically noted on the approaches to and at the Airport Connector Road at Evans Road intersection as well as other locations within the airport roadway force drivers to make quick decisions. During data collection, several drivers approaching the intersection were "confused," and stopped to ask for directions. Observers also noted that vehicles proceeded with uncertainty when choosing between Lot D, the arrivals' outer curbside, and arrivals inner curbside paths. Adding signage and pavement markings at the following locations would help reduce confusion and the number of wrong turns and present an opportunity for improvement.

Post Road at Aviation Avenue Signalized Intersection

The Airport entrance from Post Road is not prominent and drivers have a hard time identifying the entrance to the airport. Establishing a sense of place with larger signage and providing a clear view into the airport would better establish the access point to travelers. Access points are also dependent an efficient internal roadway circulation system between those points and the terminal. They depend on each other to function effectively.

Airport Connector Road at Evans Road Signalized Intersection

Vehicles approaching the signalized intersection from the Airport Connector Road enter the intersection approach after a sharp turn with limited sight distance, as discussed in the previous section. Drivers then have approximately 210 feet to read signage to confirm which way to turn and change lanes if necessary, as shown in previous **Figure 5.10**. Just before the curve, signage directs drivers heading to the arrivals, parking, and Post Road to turn left, as shown in **Figure 5.11;** however, there is no signage informing drivers destined for I-95 to keep right.

Figure 5.11—Airport Connector Road Signage with No I-95 Reference

Source: WSP USA

Potential improvements include:

- Adding a reference to I-95 on the existing sign and repeating the sign and information on the left side of the road OR removing the existing sign and installing an overhead gantry signage that includes the existing information as well as directions to I-95
- Adding a pavement marking with "TO I-95" and the appropriate interstate shield in the right lane

Once drivers arrive at the intersection, drivers enter the left lane and select from multiple similar paths to access Lot D, the outer arrivals outer curb, and arrivals inner curb. To clarify drivers' arriving from the Airport Connector Road approach, the following improvements should be considered:

- Installing post mounted or cantilevered signage to the left of the entry to Lot D, at the location shown in **Figure 5.12** to provide visibility to vehicles arriving from the Airport Connector Road and I-95.
- Adding Garage C to the existing signage

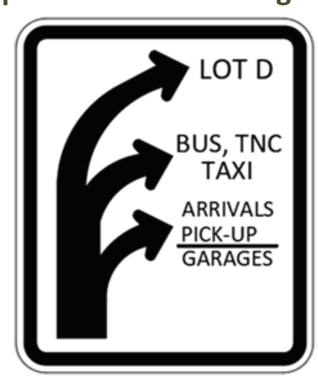
Figure 5.12—Proposed Airport Connector Road at Evans Road Sign Locations

Photo Source: Google Earth and WSP USA

Field observations also identified a need for improved signage on the Evans Road approach. Potential solutions to address this include:

- Installing signage on the departures level bridge to provide guidance for how to access the inner curbside, outer curbside, and Lot D (see **Figure 5.12** for sign location, **Figure 5.13** for sign example)
  - Adding an additional "DO NOT ENTER" sign on the barrier between the northbound and southbound access to/from I-95 to clarify routing
  - Adding dashed pavement markings from the solid yellow line at Evans Road to the solid yellow line on the access to Airport Connector (to I-95) to more safely delineate the left-turn and guide drivers to the correct side of the barrier

Figure 5.13: Potential Evans Road Approach Directional Signage



Improving signage to better inform drivers and improve traffic flow rates will become increasingly critical as traffic volumes, which will increase delays and queue lengths. The Vissim analysis and Synchro analysis results in Section 5.4.2 illustrate how operations are projected to worsen. A detailed wayfinding system should be incorporated in the infrastructure improvements the Synchro has indicated will be required in future conditions.

Airport Connector Road at Garages

During data collection, the team also noted driver hesitancy as they exited the arrivals curbsides and approached the exit to Post Road. As drivers exit the arrivals inner and outer curbside areas and exit Garages A and B and the Red Beam Garage, they encounter the sign shown in **Figure 5.14**. Updating these signs to read "Exit to Post Road" and "Exit to 95" presents an opportunity to add clarity for drivers. This will become especially important as volumes – especially circulating vehicles – continue to increase.

Figure 5.14—Airport Connector Road at Post Road / Coronado Road Signage

Source: WSP USA

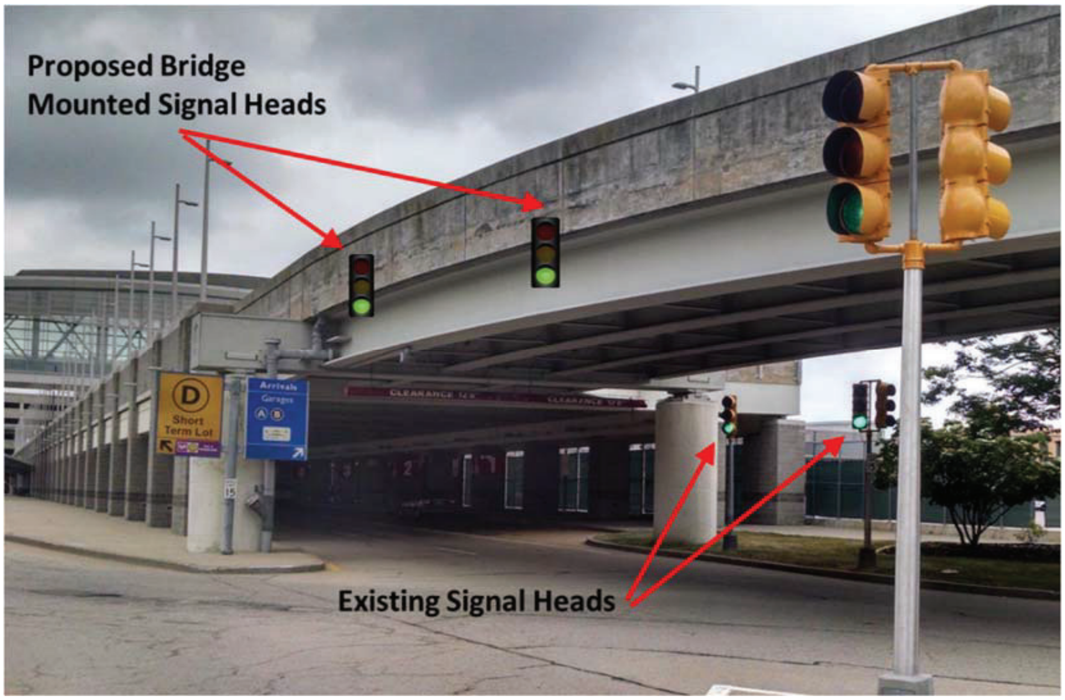
Signal Visibility

While observing the operations of the Airport Connector Road at Evans Road intersection, the team noted several drivers who proceeded with caution and uncertainty. Multiple team members noted that they did not see the far set of signal heads when turning left from the Airport Connector Road approach. The pole mounted signal heads can become lost in the shadows cast by the departures level bridge, and their location to the right of the travel path for vehicles turning left onto the outer curb or into Lot D, may cause driver expectancy issues.

Improving the visibility of the signal heads at this intersection is an opportunity to improve operations, safety, and improve driver clarity and meet industry standards for compliance. The visibility will become more important as volumes increase, when maintaining high traffic flow rates it has a greater impact on queues and delays.

Relocating the existing pole mounted signal heads to the departures level bridge would improve visibility and better align with drivers' field of vision for all potential movements from the existing left-turn stop bar. **Figure 5.15** identifies both the current signal head locations and the location of the proposed bridge mounted signal heads.

Figure 5.15—Current and Proposed Signal Heads at Airport Connector Road Left Turn at Evans Road



Source: WSP USA

In addition, it was found that the signals on the approach from the Airport Connector (from I-95) are not in compliance with the Manual on Uniform Traffic Control Devices (MUTCD), as it states:

> "if both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach are post-mounted, they shall both be on the far side of the intersection, **one on the right and one of the left of the approach lanes.**"

The signal head placement for this approach of the Airport Connector are not in compliance. They are all post mounted and located to the right of the approach lane. The team recommends evaluating whether the signal head that is currently post mounted on the median island could be mounted on the bridge beam immediately downstream of the stop bar. This placement would require ensuring that the vertical clearance meets MUTCD standards and that there are no structural issues mounting the signal heads to the bridge.

To further improve visibility at *all* signals, 5" back plates should be considered when installing new or replacement signal heads at the intersection.

Other Intersection Upgrades

The aforementioned signage, pavement marking and signal modifications would provide clarity at the intersection of Airport Connector Road at Evans Road intersection, however the large number of decision making points will remain. Additional modifications to separate decision points could be considered including a separate connection in advance of the traffic signal from Evans Road to the Arrivals level inner curb or a separate connection in advance of the signal on the Airport Connector Road into Lot D. Alternately, the entire entrance into Lot D could be moved further along the Arrivals level outer curb. Each of the potential changes would reduce the number of options at the signalized intersection. At this time, the short-term improvements identified should be implemented and alternatives developed to resolve these issues as well as the congestion anticipated in the future analysis. The additional study should incorporate the recent relocation of TNC vehicles to the arrivals level outer curbside, and the impact that these existing volumes (and projected future volumes) have on arrivals operations.

Curbside Facilities

The curbside assessment and analysis included data collection at multiple times over multiple days, a Vissim simulation analysis to model curbside operations, and a curbside capacity analysis using the Quick Analysis Tool for Airport Roadways (QATAR).

The field observations indicated that the curbside lanes could become congested during the busiest peaks of activity during the evening and late night along the arrivals inner curb. Airport officers and staff were observed on the arrivals and departures levels directing traffic and limit vehicles' curbside dwell times. Their presence ensured that vehicles did not dwell for excessive periods of time, which kept curbside operations orderly and efficient. Officers and staff also helped answer wayfinding questions, which mitigated confusion and unnecessary vehicular and pedestrian circulation. During observations, the most congested periods were found to be when there were no officers or staff present, as vehicles tended to dwell longer.

The existing conditions QATAR analysis found that the curbside segments nearest the terminal doors operated worse than other segments, at Level of Service D along the arrivals inner curbside during the PM peak hour, but were not over capacity. However, future conditions analyses indicate that curbside operations will worsen to LOS E (2022) and F

(2027, 2037) based on increased volumes. As noted in the QATAR discussion, this analysis assumed vehicles would be distributed along the curbside in future years at the same rate they were observed in June of 2018. Because of this, there is still available curb space along those curb segments more distant from the terminal doors.

Vissim was used to visualize how future conditions, which illustrated that vehicles would likely be more evenly distributed along the arrivals inner curbside. However, Vissim still shows significant curbside congestion and operational issues, which are exacerbated by the increase in circulating vehicles.

The QATAR analysis projects the arrivals level outer curb to operate well in existing and future conditions; however, there are a number of factors related to TNC usage and New Mobility options that could impact curbside usage in this area and thus impact curbside operations.

To address the existing congestion, it is recommended that officers are present during the busiest periods of curbside activity on both the departures and arrivals levels. During one peak period of data collection when officers were not present, vehicles were recorded dwelling at the curbside for longer periods (as long as 15+ minutes).

Another near-term improvement would be to install overhead signage along the arrivals level to assist officers and staff by reinforcing lane assignments. **Figure 5.16** on the following page illustrates Austin Bergstrom International Airport's arrivals area, which has similar lane usage to T.F. Green's arrivals curbside and shows how overhead signage and arrows can help guide drivers into the appropriate lanes. The overhead signage could be reinforced with pavement markings communicating the same messaging.

To better evaluate projected volume increases, it would be beneficial to implement the short-term recommendations listed above and then re-analyze curbside to assess future operations with increased volumes but reduced dwell times. Reducing circulating volumes through better wayfinding, an improved or relocated cell phone waiting facility, and potential changes in facility access would improve merging at the end of the curbside.

Figure 5.16—Overhead Lane Assignment Signage (Austin Bergstrom Airport)

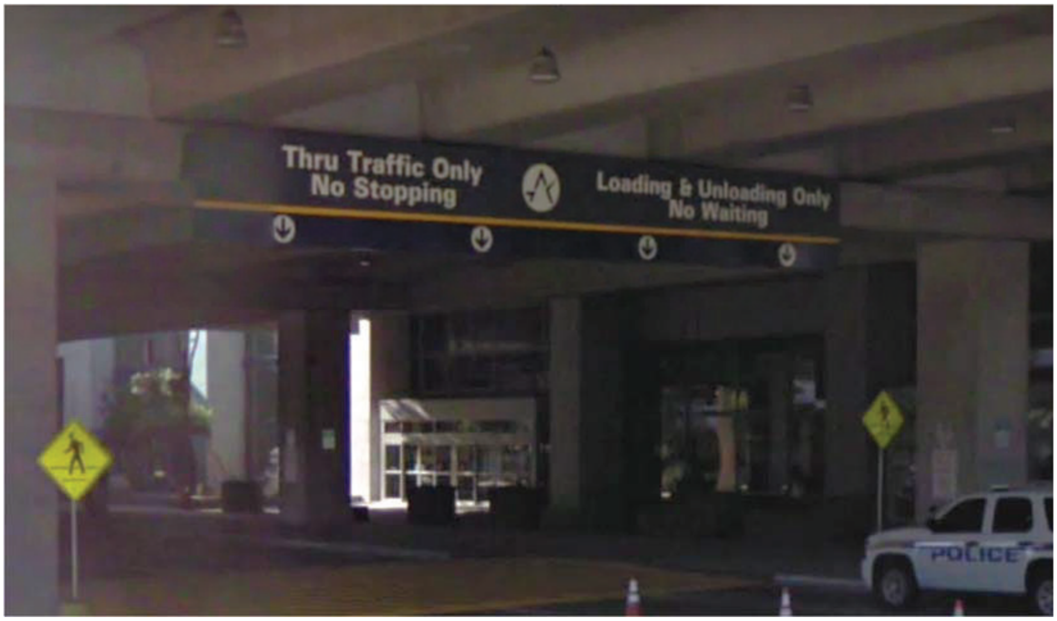


Photo Source: Google Maps and WSP USA

During data collection, several drivers asked team members where along the curb passengers arriving from a given airline would exit the terminal facility. Adding overhead signage at the beginning of the arrivals curbside that reinforces the *entire* arrivals curbside is the pick-up area for *all* arriving passengers would give drivers clarity.

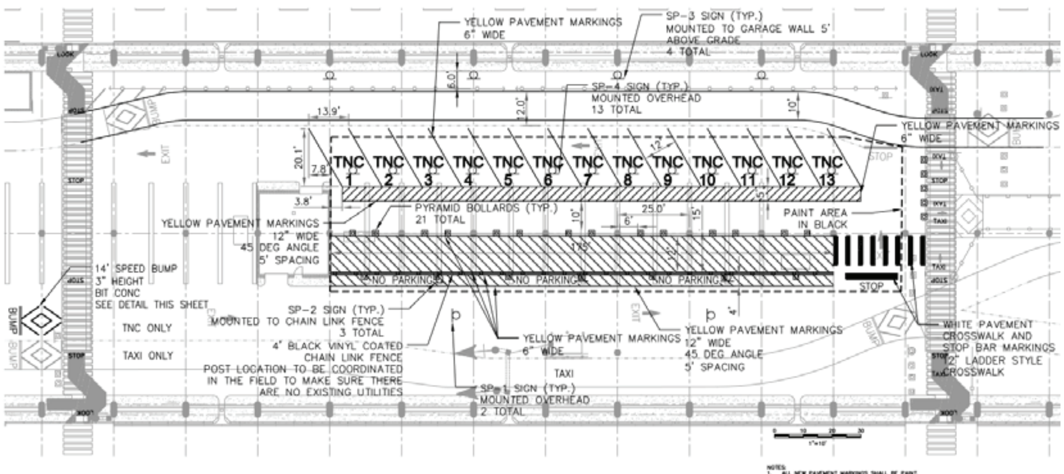
TNC/Taxi Facilities

As indicated above, during initial field visits, the TNC pickup area was located within Lot D and served only Lyft drivers. Those drivers indicated challenges with the operation as they would not read eligible for a pickup in the Lyft system if they were parked in the official Lyft waiting area. Since that time, Uber pickups are now occurring within Garage C and the Lyft operation has been relocated to the Arrivals outer curbside. Although the relocation of the Lyft operation likely corrects the system problem for drivers, trends indicate that the market share of TNC operations is increasing rapidly.

Although the Arrivals outer curb was previously underutilized, it is likely that the relocation of Lyft trips will result in congestion on the outer curb as both airport traffic in general and mode share of TNC increases. The airport is planning to modify the outer curb area to reduce the size of the waiting area for pedestrians and add an additional lane for traffic. Although that will increase the capacity of this outer curb area, it will do so at the expense of vehicles double parking which potentially creates a hazard where passengers walk between vehicles to access a vehicle in the second lane. Now that the Lyft operations have moved to the curbside, and Uber is in Garage C, observations of their demand should be collected again in order to quantify demand as well as operations in the new configuration.

Other airports have experimented with both curbside and lot pickups for TNCs. Once updated TNC demand is determined, proper allocation of curb space and/or parking lot concepts can be developed. Local airports have implemented in lot solutions for TNCs that either create a new "curbside" type lane where curbside is in high demand or reduce conflicts between vehicles by providing one way pull through circulation serving very high numbers of TNCs in a limited area. **Figure 5.17** shows the Terminal B TNC lot with pull-through circulation at Boston Logan Airport.

Figure 5.17—Existing Logan Terminal B TNC Lot



Parking Facilities

Parking facility occupancy was assessed based on the data provided for June 19, 2018. Facility access and use were also evaluated.

Occupancy

The assessment found that none of the facilities' occupancy exceeded 60 percent during any of the 24 hours analyzed (Garage C / Red Beam Garage was not analyzed, as it is not owned by RIAC).

Section 5.4.2 discusses the projected increase in parking usage at the airport, which indicates that by 2027, Garage B will have reached capacity on a typical day, and that by 2037, Garages A and B and Lot D will have reached capacity. Lot E is projected to still have capacity; however, it is in the least desirable location of each of the current facilities. Based on this analysis, alternatives to provide additional parking supply should be investigated.

Access

The access and signage to each facility was also assessed. During data collection, some drivers stopped to ask for directions to Garage C, as signage was missing on Airport Connector Road at Evans Avenue. Ensuring that proper advance signage to each parking facility is provided would improve drivers' decision making regardless of garage ownership.

The pedestrian access to each facility was also assessed. Although there is a pedestrian path to each facility, there are opportunities to improve and enhance the wayfinding and safety to Garages A, B, and C, as well as to Lot E. Additional discussion and opportunities for improvement for pedestrians follows later in this section.

Use

Lot D is the most proximate parking facility to the airport terminal and is also adjacent to Post Road. Thus, there is an opportunity to utilize portions of Lot D for other purposes, such as pedestrian access to Post Road, as well as for a value-add opportunity to monetize short-term uses, such as pick-up and drop-off activities and businesses. If any changes in use reduce parking capacity, these changes will need to be made in consideration with the total parking needs.

Cell Phone Lot

Based on the hourly volumes and curbside data collected, there are a significant number of vehicles that pass through (but do not stop along) the departures and arrivals curbside areas. This additional traffic adds to congestion for entering and exiting vehicles dwelling along each curbside, as well as additional pedestrian and vehicular conflicts. These volumes are projected to increase in future conditions, which will further exacerbate operations.

Directly observing the Cell Phone Lot was not included in the scope of this effort; however, enhancing and promoting the Cell Phone Lot would improve operations by reducing the number of circulating drivers, safety, and air quality. Potential improvement opportunities include placing additional or improved signage directing drivers to the Cell Phone Lot at the following locations (also shown in **Figure 5.18**)**:**

- Signage on the I-95 off-ramp to Route 1 (Post Road), indicating which direction to turn to access the Cell Phone Lot
- Replace and upgrade the existing signage along Post Road with a well-lit and larger and higher-mounted sign that has greater reflectivity and fonts and coloring that are consistent with other T.F. Green lettering.

Figure 5.18—Cell Phone Lot; Existing and Proposed Signage

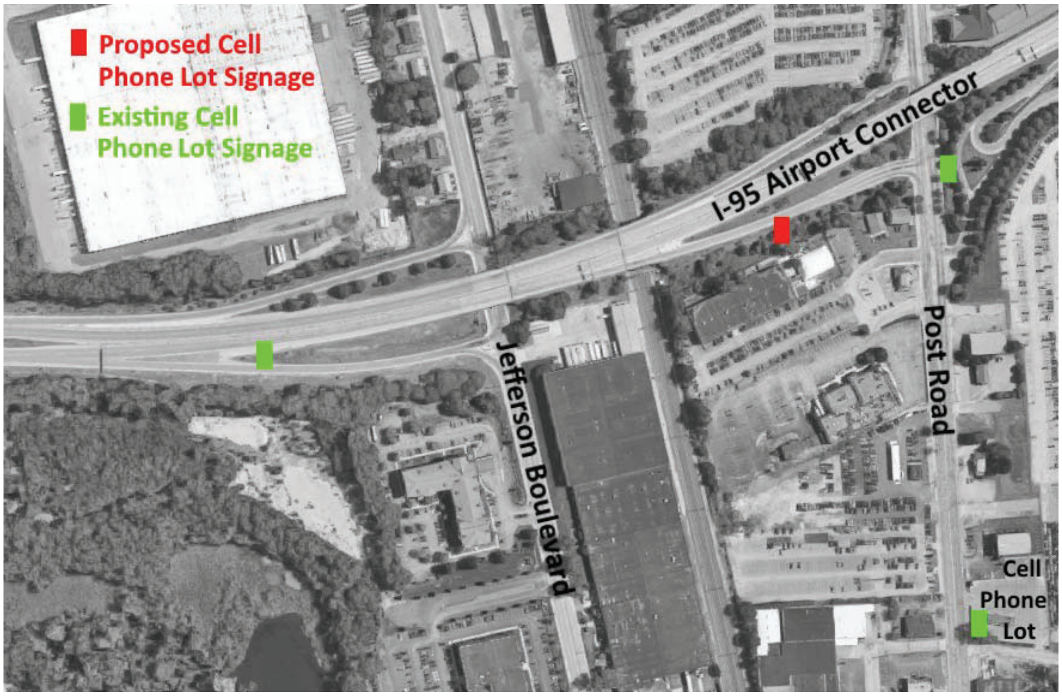


Photo Source: Google Earth and WSP USA

Potential amenities to enhance the Cell Phone Lot include free Wi-Fi and free electric vehicle charging stations, as well as vending machines.

Rail Facilities

The Interlink walkway combined with the proximity of the T.F. Green Rail Station provide airport travelers and employees near seamless access to and from the rail station and commuter rail line to the airport.

As discussed in Section 2.3.1, there are currently 10 northbound and southbound MBTA trains per day that connect the airport to Providence and Boston to the north, and Wickford Junction to the south. Currently, the last weekday northbound train to Boston departs T.F. Green Airport Station at 9:07 p.m., which means passengers on many of the later arriving flights are not served. In addition, Amtrak currently does not serve the station.

Opportunities to improve rail service to the airport include:

- Coordinating with the MBTA to add later northbound service to serve greater numbers of later arriving passengers
- Coordinating with Amtrak to add T.F. Green Station as a stop on the Northeast Corridor rail line that currently provides service from Boston to Washington D.C.

If RIAC coordinates with the MBTA or other rail providers to provide additional service, it is recommended that this be done with an eye toward future flight schedules to ensure that additional rail capacity properly meets future demand.

Bus Facilities and Operations

Currently, the local RIPTA bus routes and regional Peter Pan service provides airport travelers and employees connectivity to/from Providence, Pawtucket, the Galilee area beaches and Block Island Ferry, the Wakefield Mall, and Kingston.

Given the buses' relatively infrequent service, an opportunity for improvement would be to provide dynamic signage inside the terminal to inform passengers when buses have arrived (or are about to arrive). This could be achieved by coordinating with the transit providers and predictive scheduling algorithms as well as employing real-time vehicle locator software. Not only would this improve passenger comfort during inclement weather, but it might also increase spending inside the airport.

As passenger loads increase and airport operations increase and demographics change, additional studies could be undertaken to ensure that existing RIPTA and other bus services adequately serve travelers and airport area employees, both in terms of service area, service frequency, and scheduling (early enough or late enough to serve shift employees). If additional onsite remote or offsite parking is contemplated to accommodate future parking demand, the corresponding bus or shuttle accommodation will be needed.

Pedestrian Access and Access

The team walked and observed the existing pedestrian facilities, including path to Lot E, the route through Garages A, B, and C, and along the curbside crosswalks to outer curbs and Lot D.

Crosswalks

Observations showed that pedestrians typically had safe passage on the crosswalks across the arrivals inner and outer level curbsides, although there were a few instances where drivers were observed driving aggressively at higher speeds.

One way to potential improve the safety of pedestrians crossing from the outer curb to the terminal would be to add mirrors to make pedestrians more visible to drivers in the lane adjacent to the outer curbside. This will become more critical in the future as traffic volumes increase, vehicular-pedestrian conflicts become more frequent, and more vehicles use the outermost lane, where risk of conflict is greatest.

Garage and Post Road Access

Currently, pedestrians desiring to access Garage B, Garage C (Red Beam Garage), or Post Road from the terminal must walk along the terminal to Garage A and then follow a circuitous route through the garages and across multiple entry and exit lanes. Although there is wayfinding signage and the garages offer protection from the elements, the path is circuitous, and the garages may present an unwelcoming environment. During site visits, numerous pedestrians were noted with luggage walking to the garages in the roadway instead of following the circuitous route.

Evaluating the feasibility for an exterior pedestrian pathway to Garage B and the Red Beam Garage offers an opportunity to define pedestrian access more clearly and improve pedestrian comfort.

In the meantime, adding lighting at deficient locations along the existing path, coloring the pavement along the path - especially where it crosses vehicular paths - to enhance wayfinding, and ensuring that parked vehicles do not limit progress along the route, especially along the route to the hotel could improve conditions.

Pedestrian Access to Lot E

There is currently a sidewalk leading from the terminal to Lot E along Evans Road. Based on field observations, the current path is not obvious for those exiting the terminal. Additional signage for those wishing to walk instead of waiting for the Lot E shuttle would improve pedestrian accessibility.

Pedestrian Access to Adjacent Land Uses

Currently, there is limited connectivity to/from the airport to Post Road and destinations such as the Hampton Inn, as pedestrians must travel to connect to/from Post Road, and these connections may not be obvious or be perceived as safe by all. Going forward, as the area around the airport develops, more (and enhanced) pedestrian connectivity would better connect T.F. Green Airport to the community, which could benefit the airport and adjacent conference centers, restaurants, and other airport-related land uses.

Arrivals Curbside Signage

Along the arrivals level, several arriving passengers asked those collecting data where the TNC and Taxi stands were located, despite the presence of some TNC signage. Many drivers also asked data collectors where a given airline arrived along the curbside; thus, it could beneficial to reinforce that *all* airlines' arriving passengers arrive at the same curbside through additional overhead signage placed where vehicles enter the arrivals level.

5.4.4 Summary of Ground Transportation Requirements

Figure 5.19—Summary of Ground Transportation Requirements

	Existing	Baseline	PAL 1	PAL 2	PAL 3
Year	2017	2017	2022	2027	2037
Annual Enplanements	1,969,966	1,969,966	2,553,530	2,997,929	3,715,999
Peak Hour Enplanements	708	708	917	1,077	1,335
Peak hour Domestic Arrivals	1,092	1,092	1,415	1,662	2,060
Peak hour International Arrivals	252	252	299	354	488
Departures Curbside					
Number of lanes	4	4	4	4	4
Level of Service (AM)	A	A	A	A-B	A-C
Level of Service (PM)	A	A	A	A	A
Length of curbside (feet)	530	530	530	530	530
Volume AM Peak	458	458	593	697	864
Volume PM Peak	198	198	256	301	373
Arrivals Inner Curbside (private vehicles)					
Number of lanes	4	4	4	4	4
Level of Service (AM)	A	A	A	A	A
Level of Service (PM)	A-D	A-D	A-E	B-F	B-F
Length of curbside (feet)	665	665	665	665	665
Volume AM Peak	22	22	28	33	41
Volume PM Peak	512	512	663	779	965
Arrivals Outer Curbside (Bus, Shuttle)					
Number of lanes	3	3	3	3	3
Level of Service (AM)	A	A	A	A	A
Level of Service (PM)	A	A	A	A	A
Length of curbside (feet)	240	240	240	240	240
Volume AM Peak	14	14	15	18	21
Volume PM Peak	28	28	30	35	43
Arrivals Outer Curbside (Lyft, TNCs)					
Number of lanes	3	3	3	3	3
Level of Service (AM)	A	A	A	A	A
Level of Service (PM)	A	A	A	A	A
Length of curbside (feet)	100	100	100	100	100
Volume AM Peak	92	92	102	116	140
Volume PM Peak	78	78	145	167	203
Arrivals Outer Curbside (Taxis)					
Number of lanes	3	3	3	3	3
Level of Service (AM)	A	A	A	A	A
Level of Service (PM)	A	A	A	A	A
Length of curbside (feet)	130	130	130	130	130
Volume AM Peak	3	3	3	4	5
Volume PM Peak	25	25	28	31	38
Parking (spaces)					
Garage A (1,500)	600	600	900	1,110	1,500
Garage B (740)	444	444	622	666	740
Short-term Lot D (529)	238	238	333	440	529
Long-term Lot E (4,358)	1,395	1,395	1,743	1,952	2,092
Employee	Not Available				
Cell Phone Lot	Not Available				
Intersections (Level of Service)					
Airport Conector and Evans Road (AM)	A	A	A	A	A
Airport Conector and Evans Road (PM)	B	B	B	D	F
Post Road and Aviation Avenue (AM)	A	A	A	B	B
Post Road and Aviation Avenue (PM)	B	B	B	B	C
Post Road and Coronado Road (AM)	B	B	C	C	C
Post Road and Coronado Road (PM)	C	C	C	C	D
Airport Road and Delivery Road (AM)	A	A	A	A	A
Airport Road and Delivery Road (PM)	A	A	A	A	A
Other					
MBTA trains per day to Boston	10	10	10	10	10
MBTA trains per day to Wickford Junction	10	10	10	10	10
Bus	Not Available				
Pedestrian	Not Available				

Legend	
(green)	= No expected issues
(yellow)	= Issues possible
(orange)	= Issues expected

5.5 General Aviation

The facility requirements for the general aviation facilities were determined based on their exclusivity for both based and transient activities using the forecasted GA annual operations and existing and forecasted based aircraft fleet mix. The forecasted annual GA operations established the peak month and design day/hour operations, which was used to estimate the required common space needed for GA pilots and passengers within the planning period. Likewise, the existing and forecasted based aircraft fleet mix provided requirements for hangar and apron storage within the planning period.

5.5.1 Corporate/Business Tenant Facility Requirements

Since the use of these types of facilities is determined based on the leasing of an area that is generally hangar and apron space with office and automobile parking, the determination of future requirements is primarily driven through conversations with the existing tenants as well as any information that is available from RIAC about prospective tenants.

Through interviews conducted with key tenants named above, several common findings regarding the space currently allocated for exclusive GA use at PVD emerged and is summarized as follows:

- Hangar capacity for two of the tenants (CVS and Textron) is a concern. Textron indicates that their hangar capacity is adequate today, but should an additional aircraft be added to their fleet, it will not fit in the existing hangar. Additionally, CVS states that their existing hangar capacity is already constrained, as they currently have four aircraft stored in a hangar that was designed to accommodate only two aircraft. They are considering adding a helicopter to their fleet, but at this time are not certain where to store it.
- Apron space for both tenants is mostly adequate during their normal operations, but space becomes limited during peak periods of activity. However, cooperation between the two entities for coordinating sharing of the apron has worked out well to date.
- Both CVS and Textron commented on the underutilization of the hangar adjacent to the old terminal building and the apron area and old terminal building itself. If the old terminal building, its apron, and hangar were able to be more efficiently utilized, some capacity issues could be alleviated.
- Finally, it was also mentioned that the existing airfield electrical vault may not be located in the most ideal location. They suggested that if it could be relocated elsewhere, the area could better serve the needs of the GA tenants/users.

For RIAC to provide exclusive GA facility use to future corporate or business entities at PVD throughout the planning horizon, the above items as well as on-going discussions between some of these tenants should be factored in to provide a minimum of the total area these facilities include from a hangar, office, apron and auto parking footprint.

5.5.2 Flight Training Facility Requirements

A summary of Horizon's existing and future facility requirements described below in **Table 5.35** are driven through conversations with Horizon, as well as any information that was available from RIAC about prospective tenants. Currently, there are no indications of a new entrant into flight training services at PVD, but if there was, accommodation for space is usually factored into the FBO facilities discussed in the next section.

Table 5.35—Existing and Future Flight Training Facilities

Horizon	Existing (SF)	Future (SF)	Total (SF)
Hangar Area[1]	7,200	10,000	17,200
Apron Area	24,000	0	24,000

Note. 1 Includes office and student flight planning areas.
Total information on SF not available at the time of this report.
Source: RIAC, August Stakeholder and September 2018; complied by C&S Engineers, Inc., 2018.

Horizon management indicates that their operations are steady, and they hope to continue an upward increase in operations assuming additional hangar and apron capacity can be achieved in the near future. As noted in Section 2.4.2, due to some constraints in their existing hangar facility, Horizon recently constructed a 7,200 square foot hangar adjacent to their existing facility that was operational starting January 2020. Management believes the additional hangar will meet their aircraft storage needs over the 20-year planning horizon; however, additional apron area is still desired. Horizon also stated they would be adding charter operations to their business model starting in September 2018. No other facility related needs are anticipated at this time.

5.5.3 FBO Demand/Capacity and Facility Requirements

Northstar indicates that their busiest peak periods occur during the fall and winter, usually coinciding with football season. Because of their lack of available apron space directly adjacent to their facility, they often have to park the larger corporate or large charter aircraft (Boeing 747s) on the apron in front of the old terminal building. Should RIAC add additional apron in this area within the planning period, Northstar would be highly interested in leasing the vast majority of it.

Other notable concerns or constraints brought forward by Northstar during stakeholder interviews related to their GA operations include the existing fuel and deicing/glycol facilities. In general, the fueling operation is constrained by inadequate and outdated equipment (motor fuel pump) and its susceptibility to power outages, amongst other things. Likewise, the existing location of the glycol facility hinders the efficient use and maneuverability of the apron and surrounding area. It was suggested that its relocation to another area of the airfield would be supported. Facility requirements for Northstar for their GA common-space, hangar, and apron needs are discussed in more detail in the subsequent paragraphs.

Common Space Requirements

At most GA facilities, common space includes any non-exclusive areas that are accessible to the public (e.g., lobby/waiting areas, restrooms, meeting rooms, etc.), and is usually associated with the FBO(s). Therefore, only the estimated common space associated with Northstar's facility was calculated for each of the PALs. Using FAA activity data for GA itinerant operations for the calendar year 2017, peak month activity was determined for 2017 and throughout the PALs. The peak month activity data also provided an estimate of the design day and hour operations[3]. Ultimately, the estimated amount of pilots and passengers expected to use the FBO facility during an average day within the peak month was determined to be five for each of the PALs.[4] Using an average of 150 square feet per pilot/passenger produces a space requirement of 750 square feet; this was determined to be the minimum amount of common space Northstar should anticipate to provide GA itinerant users of their facility over the course of the 20-year planning horizon. The existing common space area is adequate for the planning period.

Hangar and Apron Requirements

Analysis of the GA itinerant operations data also determined that Northstar can expect at a minimum three itinerant aircraft during an average day during the peak month that would require parking apron (or hangar parking) over the course of the 20-year planning horizon. Based on the types of itinerant aircraft Northstar accommodates today, it was assumed that approximately 9,000 square feet of apron per aircraft is required for parking purposes. Should all three of the projected itinerant aircraft need apron parking concurrently, one can infer that a minimum of 27,000 square feet of apron would be required. This should be able to be accommodated in their existing airside area of 35,000 square feet, but not during peak periods.

Additionally, using the same itinerant aircraft parking needs described above, an estimated 20,000 square feet of conventional hangar would likely meet demand over the planning

[3] The design hour is the estimate of the peak hour of the average day of the busiest month in terms of operations.

[4] Multiplying the design hour by the industry standard of 2.5 will then determine the peak hour pilot and passenger throughput.

period. However, this also assumes that additional apron will be constructed for use by Northstar.

5.6 Support Facilities and Equipment

Support facilities and equipment at PVD encompass most of the remaining facilities on the airport with this section serving as a catch all for the master plan effort. Two specific areas: air cargo and fuel supply and storage are called out as focus areas in the scope, therefore have their own subsections, followed by the other support areas known to an airport or brought to the attention of the master plan effort. As a result, this section will address those needs for each type:

- Cargo Facilities
- Fuel Supply and Storage
- Other Facilities and Equipment

5.6.1 Cargo Facilities

Air cargo at PVD comes in two forms; Integrated Cargo (All Cargo), and Belly Cargo. Integrated cargo is cargo transported by carriers like FedEx and UPS that exclusively transport cargo. Belly cargo refers to cargo that is transported by commercial air carriers under the main deck of the airplane. As indicated in Section 4, Forecasts of Demand, air cargo is expected to grow to 99.3 million pounds by PAL 3. This is an approximate doubling of cargo activity from existing (2017) air cargo levels. Integrated cargo is projected to grow to 97.5 million pounds or 48.8 tons; and belly cargo is projected to grow to 1.8 million pounds or 900 tons by PAL 3. PVD trends continue to show integrated cargo capturing 98 percent of the cargo activity at the Airport.

This section analyzes estimated requirements for the Airport's air cargo facilities under the anticipated growth in air-cargo activity. This includes requirements for forecasted cargo quantities using both integrated and belly cargo using industry standard ratios from ACRP Report 143, *Guidebook for Air Cargo Facility Planning and Development*. The assumptions used from this report for determining the total integrated cargo requirements include:

- Warehouse – 0.92 tons of cargo per square foot
- Aircraft Apron – 0.19 tons of cargo per square foot
- GSE Storage – 0.57 tons of cargo per square foot

With limited information available about the current cargo operations at PVD, the total requirements needed to accommodate the forecasted levels of cargo activity are important to the alternatives analysis to ensure the total requirement needed is considered. Integrated cargo requirements are presented in **Table 5.36**.

Table 5.36—Industry Ratio Integrated Cargo Requirements

Design Standards	Existing	Baseline	PAL 1	PAL 2	PAL 3
Warehouse (SF)	36,374	23,098	30,217	36,196	52,989
Aircraft Apron (SF)	276,787	111,842	146,316	175,263	256,579
GSE Storage (SF)	N/A	37,281	48,772	58,421	85,526
Total	**313,161**	**172,221**	**225,305**	**269,880**	**395,094**

Source: C&S Engineers, Inc.

Using the industry ratio analysis shown in the table above, it indicates that additional cargo facilities are sufficient until PAL 3. While no direct input was provided by UPS or FedEx, information from RIAC on existing cargo tenants, as well as potential new entrants would require additional cargo facilities sooner than PAL 3. Recently, RIAC has received proposals to develop cargo facilities with an ultimate build-out of 1.2 million square feet of apron space and 500,000 square feet of warehouse space, but they have not yet materialized. In addition, it should be noted that the existing integrated cargo area on the north side of PVD is constrained from an operational standpoint and does not have anywhere to expand.

The same analysis was completed for airline belly cargo. The assumptions used from the ACRP report for determining the total airline belly cargo requirements include:

- Warehouse – 0.64 tons of cargo per square foot
- GSE Storage – 0.36 tons of cargo per square foot

With limited information available about the current belly cargo operations the total requirements needed to accommodate the forecasted levels of activity are important to the alternatives analysis to ensure the total requirement needed is considered. Airline belly cargo requirements are presented in **Table 5.37**.

Table 5.37—Industry Ratio Airline Belly Cargo Requirements

Design Standards	Existing	Baseline	PAL 1	PAL 2	PAL 3
Warehouse (SF)	18,000	781	938	1,094	1,406
GSE Storage (SF)		1,389	1,667	1,944	2,500
Total	**18,000**	**2,170**	**2,605**	**3,038**	**3,906**

Source: C&S Engineers, Inc.

The existing area is adequate to accommodate the airline belly cargo need. The airlines did not report any existing GSE maintenance space issues, but considering the location, any conflicting alternatives should accommodate at least the footprint of the existing area which is approximately 50,000 square feet.

5.6.2 Fuel Supply and Storage

Fuel supply and storage is primarily through the central fuel farm. This central fuel farm serves the fuel needs of the airlines. Independent fuel tanks serving corporate and FBO needs are not evaluated under these facility requirements and are assumed adequate given recent discussions with those tenants during the course of this master plan update. As noted in the inventory, Northstar manages the fuel farm on behalf of the airline consortium and delivers it to the aircraft on demand.

The last master plan completed an analysis of the fuel supply and storage that identified an existing capacity deficit with the 250,000 gallons of capacity. Based on inventory information provided by RIAC, the capacity of the fuel farm remains the same at the time of this report. There are operational considerations, like more frequent fuel deliveries, that can overcome the shortage identified, but that ultimately becomes limited. As a result, this effort updated the fuel storage requirements for Jet A at PVD. The main update to this allows for assessing the new peak month average day operations (PMAD) forecasted, as well as aircraft fleet mix changes that account for assumptions regarding the gallons per peak month average day operation. See **Table 5.38.**

Table 5.38—Jet A Fuel Storage Requirements

	Existing	Baseline	PAL 1	PAL 2	PAL 3
Forecasted PMAD Operations	N/A	151	177	183	201
Historical Gallons per PMAD Operation	635	635	635	635	635
PMAD Demand (2-yr avg)	96,096	96,096	112,619	116,261	127,615
3-Day Storage Requirements	288,288	288,288	337,857	348,783	382,845
Surplus/(Deficit)	**(38,288)**	**(87,857)**	**(38,288)**	**(98,783)**	**(132,845)**

Source: C&S Engineers, Inc.. 2016/2017 historical fuel activity from Northstar, September 2018.

The above analysis confirms that there continues to be a fuel storage shortage, albeit less than previously identified. It should be further noted that the FBO provided the following input for consideration:

- Fueling in general is a constraint.
  - There is only one motor fuel pump that pumps slow and can cause waiting lines.

- Some issues with fuel farm being down during power outages.
- PVD has come close to running out of fuel when roads are shut down to truck traffic during winter storms and fuel deliveries cannot make it to the Airport.

- There have been constraints with the Providence Fuel Terminal. In the winter only one loading rack is used for Jet A and home heating oil which can cause delays.

5.6.3 Other Facilities and Equipment

Aircraft Rescue and Fire Fighting (ARFF) Requirements

Emergency response services to all individuals, aircraft, and facilities on airport property at PVD is the responsibility of the ARFF department located on the northeast side of the airfield. In accordance with the airport index classifications found in 14 CFR Part 139, *Certification and Operations: Land Airports Serving Certain Air Carriers, Subpart D – Operations*, PVD currently meets requirements under Index C. Requirements within this index are based on an average of five or more daily departures of air carrier aircraft at least 126 feet, but less than 159 feet, in length. According to the PVD's *Airport Certification Manual (ACM)*, the longest air carrier aircraft that is currently using the Airport is a Boeing 757-200.

Based on the projected commercial aircraft fleet mix as discussed in Section 4, Forecasts of Demand, no change in PVD's ARFF index is anticipated. However, should operations by certain commercial aircraft known to operate at the Airport, such as the Boeing 767-300 or 747-400, increase to more than five daily departures, an increase in the ARFF index would be required. These aircraft have lengths of 180 feet and 231 feet respectively, and therefore are categorized into a higher ARFF index. RIAC should continue to coordinate with the airlines and monitor the departure schedules of these types of aircraft throughout the planning horizon to ensure compliance with Part 139 requirements continue to be met.

It should also be noted that if an increase to ARFF Index D or E is required, the PVD ARFF department already have the equipment and extinguishing agents required as a part of their current fleet according to a recent inventory performed by RIAC personnel and review of the current ACM.

The existing ARFF station is located on the east side of the airfield. The building is old and not up to existing ARFF design standards. In addition, the current location does present some challenges to ARFF personnel for responses in the terminal building. Often they will position some staff in the terminal building, but with limited areas for them to park their response vehicle on the ramp near active aircraft at the gates. A new location for an updated ARFF facility should be considered in subsequent alternatives analysis.

Deicing Facility Requirements

During the inventory based on interviews with airport staff, it was determined that deicing areas are limited with no secondary areas for anti-ice and de-ice. Development options should consider alternatives to tie into the glycol treatment system, along with the use of any Remain Overnight (RON) apron alternatives. While considering these alternatives, it should be noted that the current storm water discharge permit, under dry weather deicing requires active vacuum pick up and cannot use the glycol treatment system.

Maintenance Facility Requirements

The airfield maintenance facility is located in the northeast quadrant of PVD. No information on the facility was provided as part of the inventory for this master plan, but through conversations with RIAC staff, the following information was obtained about the current facility and the operational needs of the maintenance department as it pertains to their needs.

The current facility became operational in late 2008, but is very tight as the original design was scaled back because of cost. About 80-90 percent of equipment fits indoors with limited supply storage areas. Space between equipment is used, but complicates truck maneuvering inside of the building.

Some staff we talked to though that the existing building area had footings designed for an expansion to the south, and there is land and area for expansion near the existing building.

Based on maintenance department input, they believe there is the potential need for 30 percent more building space. Currently, small equipment is stored in other buildings (one bay in cargo; the north ramp Eng. 8 building; and the old Avis area), but these areas are scheduled for demolition. In addition, maintenance could use cold storage for ancillary equipment, and some other equipment like mowers are kept outdoors during winter months when not in use.

The Airport Certification Manual (ACM) and Snow Removal Plan at the time of this master plan does not include the new Runway 5 extension in the calculation of priority surfaces to be cleared. And while this master plan did not calculate Snow Removal Equipment (SRE) needs, it was noted that PVD probably has about twice the SRE recommended by the FAA Advisory Circular. The condition and replacement of this equipment should also be factored into future capital programming.

Other Support Areas

During discussions with RIAC during the development of the facility requirements, other issues at PVD were noted and summarized here for awareness and context as the alternatives to address the facility requirements are developed. These include:

- Airfield electrical challenges with certain systems being on the wrong circuits that impacts the ability to turn off or shut down sections of the airfield lighting when needed.
- Very limited utility information was available during the development of this report.