Appendix E. Annual Service Volume

Annual Service Volume (ASV) is a metric commonly used to identify deficiencies in airfield capacity. Once the ASV has been calculated and compared to the forecasts of future demand, capital improvement needs, and operational capacity enhancements can be determined.

Airfield capacity is defined in Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5060-5, *Airport Capacity and Delay*, as the maximum number of aircraft operations that a given airport configuration can accommodate during a given time interval of continuous demand. This derived level of capacity is affected by several factors including: weather conditions, number of runways and their configuration, the placement of exit taxiways and their configuration, the number of touch-and-go operations, and the types of aircraft utilizing a facility. This section estimates and evaluates the following airfield capacity metrics:

- **Hourly Capacity of Runways.** The maximum number of aircraft operations that can occur at an airport in an hour, given specified weather conditions.
- **Annual Service Volume.** An estimate of an airport's annual capacity that accounts for runway use, aircraft mix, weather conditions, and other factors that would be encountered over the course of a year. The ASV also assumes an acceptable level of aircraft delay as described in FAA AC 150/5060-5, which is used in this analysis.

Runway Capacity Factors

There are several factors that can affect hourly capacity. These factors are described in the following sections:

- **Weather Conditions (Ceiling and Visibility)**
- **Runway Use Configuration**
- **Aircraft Mix Index**
- **Peak Hour**
- **Percent Arrivals and Percent Touch-and-Go Operations**
- **Exit Taxiway Locations**
- **Peak Hour Airfield Capacity.**

Weather Conditions (Ceiling and Visibility)

Adverse weather conditions impact capacity by increasing the separation distances needed between aircraft on arrival. Aircraft operate under two primary weather categories: Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). VFR conditions exist when the cloud ceiling is 1,000 feet or greater above ground level (AGL) and visibility is at least three statute miles. IFR weather conditions prevail when the cloud ceiling is 500 feet AGL, or greater, but less than 1,000 feet, and visibility is less than three statute miles. In general, any weather conditions below VFR minimums are considered IFR weather conditions. The ability of aircraft to operate during IFR conditions is often solely dependent on the lowest available instrument approach minimums at an airport. The lowest minimums at PUB are a 200-foot AGL cloud ceiling and ½-mile visibility that correspond to the Instrument Landing System (ILS) approach to Runway 8R. During VFR and IFR conditions, the required separation distances between aircraft vary. In general, greater separation is required under IFR than VFR.

Information from PUB was retrieved from the Automated Surface Observing System (ASOS) located on the field. The frequency of adverse weather occurrences is an important consideration as it influences the weighted capacity (C_w) variable used in the final capacity calculation presented near the end of this section. More frequent occurrences of IFR weather reduces capacity as greater aircraft spacing is required. Based on its geographic location, PUB tends to experience clear days and the observed conditions for VFR and IFR conditions from 2015 through 2019 show that IFR conditions occurred an average of only 3.4 percent of the time. This information is presented in **TABLE 1**.

TABLE 1 **Occurrences per Year by Percentage**

	2015	2016	2017	2018	2019	AVERAGE
IFR OCCURANCE	3.8%	2.1%	3.5%	3.4%	4.0%	3.4%

SOURCE: PUB ASOS, 2015-2019.

Runway Use Configuration

Runway use configuration refers to the number, location, and orientation of runways. It also refers to the type and direction of operations as well as the flight rules in effect at any given time. The number, placement, and orientation of runways at an airport can affect capacity. For example, runways that intersect each other can affect the overall capacity of an airport since simultaneous use of the runways cannot occur. Likewise, parallel runways allow for simultaneous aircraft operations to occur that can increase the overall capacity of an airport. AC 150/5060-5 includes a variety of runway use configuration diagrams. The AC advises selecting the configuration that best represents airport use during the specified hour. PUB has three runways, one of which intersects with the other two. Runway 8R/26L is the longest runway at PUB at 10,498 feet long and parallel to Runway 8L/26R, which is 4,690 feet in length. Finally, Runway 17/35, having a north-south orientation and intersecting the other two runways, is 8,310 feet long.

Aircraft tend to operate in one of two configurations at PUB. Ideally, both parallel runways would be used for continuous operations and are the designated calm wind runways by the PUB Airport Traffic Control Tower (ATCT). However, the Canadian Aviation Education (CAE)-Doss aircraft and other aircraft used for flight training purposes at PUB are small and have limited crosswind tolerances, so Runway 17/35 is used when crosswind conditions necessitate. Coordination with local ATCT personnel indicates that use of Runway 17/35 is not common, and the runway is typically only used approximately five percent of the time. Coordination with the ATCT also indicated that use of all three runways at the same time is not common. Each of these configurations are also used in either VFR or IFR conditions and result in four configurations that are listed below. The configurations are also shown by percent used in **TABLE 2**.

- **VFR Runways 8R/26L and 8L/26R**
- **VFR Runway 17/35**
- **IFR Runways 8R/26L and 8L/26R**
- **IFR Runway 17/35.**

TABLE 2 Runway Configuration Uses by Percentage

RUNWAY USED	VFR	IFR
8R/26L AND 8L/26R	91.8%	3.2%
17/35	4.8%	0.2%

SOURCE: PUB ATCT.

Aircraft Mix Index

The aircraft mix index is based on the percentage of operations conducted by four different categories of aircraft (A, B, C, and D). Aircraft class definitions used to calculate the mix index are based on a combination of maximum certified takeoff weight, number of engines, and wake turbulence classification. Wake turbulence classification is based on aircraft wake vortices, which are the air turbulence trails behind aircraft created by their movement through the air. Heavier and larger aircraft create more significant and potentially more hazardous wake vortices, which are of greater concern for aircraft on arrival. To mitigate the hazards of wake vortices, aircraft are spaced according to differences in approach airspeed as well as weight. In general, aircraft departures are spaced two minutes apart for larger aircraft and at least three minutes for the largest aircraft (AC 90-23G, *Aircraft Wake Turbulence*). Airfield capacity can significantly increase or decrease depending on the approach speeds, aircraft weights, wake turbulence classification, and the separation needed between aircraft to mitigate for wake turbulence.

To better understand the effect aircraft mix has on runway configuration and capacity, FAA AC 150/5060-5 uses different aircraft classifications than FAA AC 150/5300-13A, *Airport Design*. When referring to the aircraft mix index categories, the categories laid out in **TABLE 3** coincide with the criteria used in AC 150/5060-5.

TABLE 3 Aircraft Mix Index

CLASS	MAXIMUM TAKEOFF WEIGHT (POUNDS)	AIRCRAFT TYPE	WAKE TURBULANCE FACTOR
A	12,500 or less	Small Single-Engine	Small
B	12,500 or less	Small Multi-Engine	Small
C	12,500 – 300,000	Large	Large
D	300,000 or more	Heavy	Heavy

SOURCE: FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*.

Baseline 2019 operations data presented in **Chapter B – Aviation Activity Forecasts** is used in the airfield capacity calculations and further examined via the FAA operations data from the Traffic Flow Management System Counts (TFMSC) database. TFMSC collects information for aircraft flying under IFR flight plans and captured by FAA en route computers.

AC 150/5060-5 defines the aircraft mix index as the percent of Class C aircraft plus three times the percent of Class D aircraft, or %(C+3D), and A and B aircraft are not included in this formula. While Class D aircraft use the Airport on occasion, they are not expected to be a significant presence during the twenty-year planning period. However, Class C aircraft are a common presence at PUB, the most frequent of which is the CRJ 200 with 1,830 operations in 2019. While this is a significant amount of operations there were a total of 217,424 total operations and small, single engine training aircraft conducted a total of 191,339 operations in 2019. Therefore, the total number of operations by Class C aircraft, including the CRJ 200, and other air carriers and business jets is approximately one percent of total operations. Therefore, the fleet mix index is set at one percent.

Peak Hour

The number of peak hour operations can affect the total annual capacity of an airport. Due to the separation needed between aircraft, periods of congestion limit the number of aircraft that can land and takeoff on a runway. Based on the information in **Chapter B – Aviation Activity Forecasts**, October is determined to be the peak month with 9.6 percent of the annual operations. As this is a 31-day peak month, the peak month operations can be divided by 31 to determine the average daily operations during October. Finally, 11 percent of the peak month average day operations are believed to occur during the peak hour. This process can be used for both the base year, 2019 and for the end of the master planning period, 2040, to determine the peak hour as shown in **TABLE 4**.

TABLE 4 Peak Period Aircraft Operations, 2019

YEAR	ANNUAL	PEAK MONTH	AVERAGE DAY OF THE PEAK MONTH	PEAK HOUR/AVERAGE DAY RATIO	AVERAGE PEAK HOUR
2019	217,424	20,873	673	11%	74
2040	440,713	42,308	1,365	11%	150

SOURCE: FAA TAF, Mead and Hunt Forecast.

Percent Arrivals and Touch-and-Go Operations

Percent arrivals is the ratio of arrivals to total operations. In general, aircraft on final approach are given priority over departures, which increases percentage of arrivals during peak periods, thus reducing the ASV. Percent arrivals are computed as follows:

$$Percent\ Arrivals = \frac{A + 0.5(T)}{A + D + T}\ x\ 100$$

A = Number of arriving aircraft in the hour
D = Number of departing aircraft in the hour
T = Number of touch-and-go operations in the hour

In the section above, the current peak aircraft operations were determined to be an average of 74 peak hour operations during October during the peak month average day. The TFMSC database does not track touch-and-go operations. Given the strong presence of local flight training at PUB, a large percentage of touch and go operations are known to occur. Therefore, the touch and go operations are considered to represent 25 percent of total operations at PUB. For these 74 peak operations, it is estimated that 28 were arriving aircraft, 28 departing aircraft and 18 aircraft were conducting touch-and-go operations. Arriving and departing aircraft were determined based on the assumption that for every arriving aircraft, there was also a departing aircraft. Based on the formula above, as well as touch-and-go estimates, the percent arrivals during the peak hour is 50 percent.

Exit Taxiway Locations

In some cases, exit taxiway locations providing access to a parallel taxiway can affect capacity. Optimally located exit taxiways provide aircraft multiple options to exit the runway safely as soon as their speed decreases sufficiently. Permitting aircraft to quickly exit the runway via additional exits can reduce runway occupancy times and make the runway available for other aircraft, thus increasing total capacity. While Runway 8R/26L and 8L/26R have numerous taxiway exits relative to their size, Runway 17/35 has limited opportunities for aircraft to exit the runway. Due to the lack a parallel taxiway, the north half of Runway 17/35 only has a turnaround opportunity at the Runway 17 threshold, so aircraft that cannot exit at Taxiways A or B must continue taxiing down the entire length of the runway when landing to Runway 35. This increases runway occupancy time and reduces overall airfield capacity as other aircraft are not able to land efficiently. **TABLE 5** provides the relative location of each runway's exit taxiways.

TABLE 5 Exit Taxiway Locations

RUNWAY	TAXIWAY AND DISTANCE FROM LANDING THRESHOLD									
Runway 8R/26L										
Runway End	**A1**	**A2**	**A4/B4**	**A5**	**A7/B7**	**A8**	**A9**	**A10**	**A11**	**A12**
8R	50’	1,950’	3,200’	4,255’	4,700’	5,700’	7,000’	8,450’	10,100’	10,450’
26L	10,450’	8,550’	7,300’	6,245’	5,800’	4,800’	3,500’	2,050’	400’	50’

	TAXIWAY AND DISTANCE FROM LANDING THRESHOLD							
Runway 17/35					**Runway 8L/26R**			
Runway End	**C1**	**A**	**B**	**C5**	**Runway End**	**B1**	**B3**	**B7**
17	8,300’	6,900’	5,100’	200’	8L	0’	2,600’	4,650’
35	0’	1,450’	2,800’	8,100’	26R	4,650’	2,100’	0’

SOURCE: Mead and Hunt.
NOTES: Exit taxiway must be separated by at least 750 feet to count as separate exits for the capacity analysis. Therefore, Taxiways A11 and A12 on Runway 8R/26L are counted as one exit and Taxiway A11 is omitted from the analysis but shown here for reference.

Peak Hour Airfield Capacity

Determining the peak hour airfield capacity provides a method to determine how many aircraft operations an airfield accommodates during the busiest time of day. Peak hour airfield capacity is calculated using the guidelines in AC 150/5060-5 under both VFR and IFR conditions. It is calculated as follows:

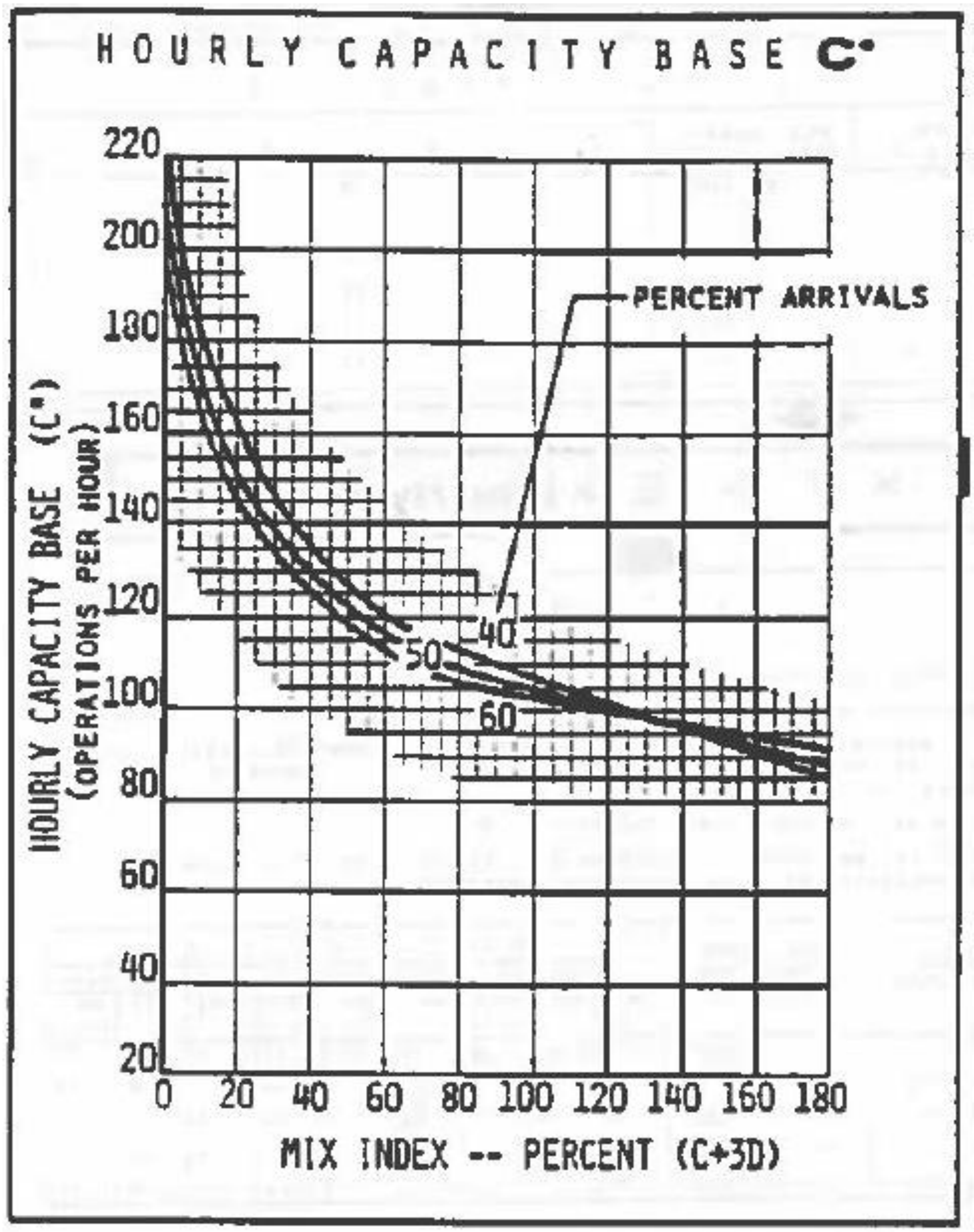
$$Hourly\ Capacity = C^{*} x\ T\ x\ E$$

C = Hourly capacity base*
T = Touch-and-go factor
E = Exit factor

The hourly capacity base (C*) is based on performance curves developed for the specific runway use configuration. As shown in **FIGURE 1** and **FIGURE 2**, C* is calculated by identifying aircraft mix index and percent arrivals, which are one percent and 50 percent, respectively. Using these inputs, C* is shown below for each configuration displayed in **FIGURE 1** through **FIGURE 4**.

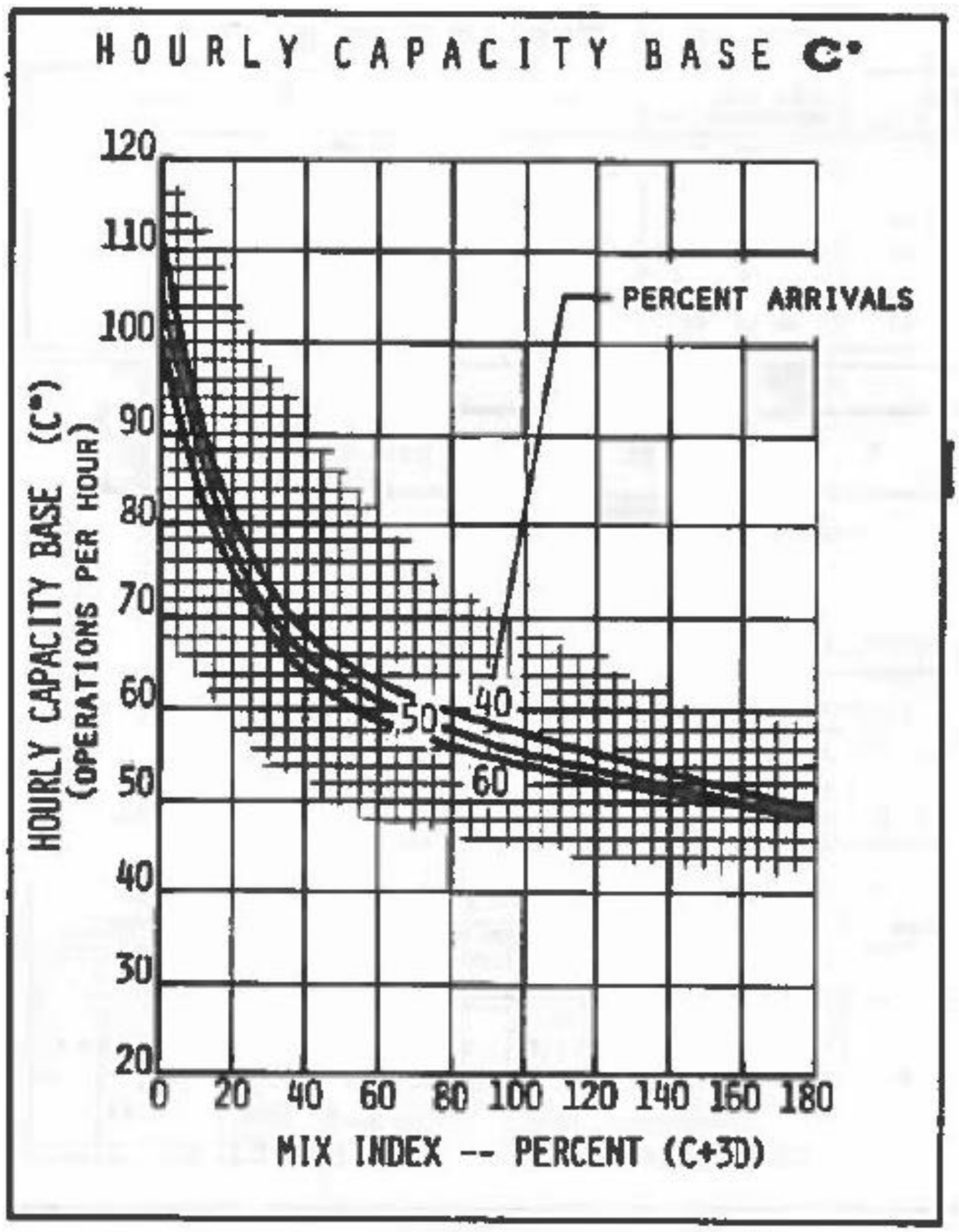
- **Configuration 1:** VFR Runways 8R/26L and 8L/26R = 200
- **Configuration 2:** VFR Runway 17/35 = 102
- **Configuration 3:** IFR Runways 8R/26L and 8L/26R = 60
- **Configuration 4:** IFR Runway 17/35 = 60.

FIGURE 1 **Configuration 1: VFR Runways 8R/26L and 8L/26R**



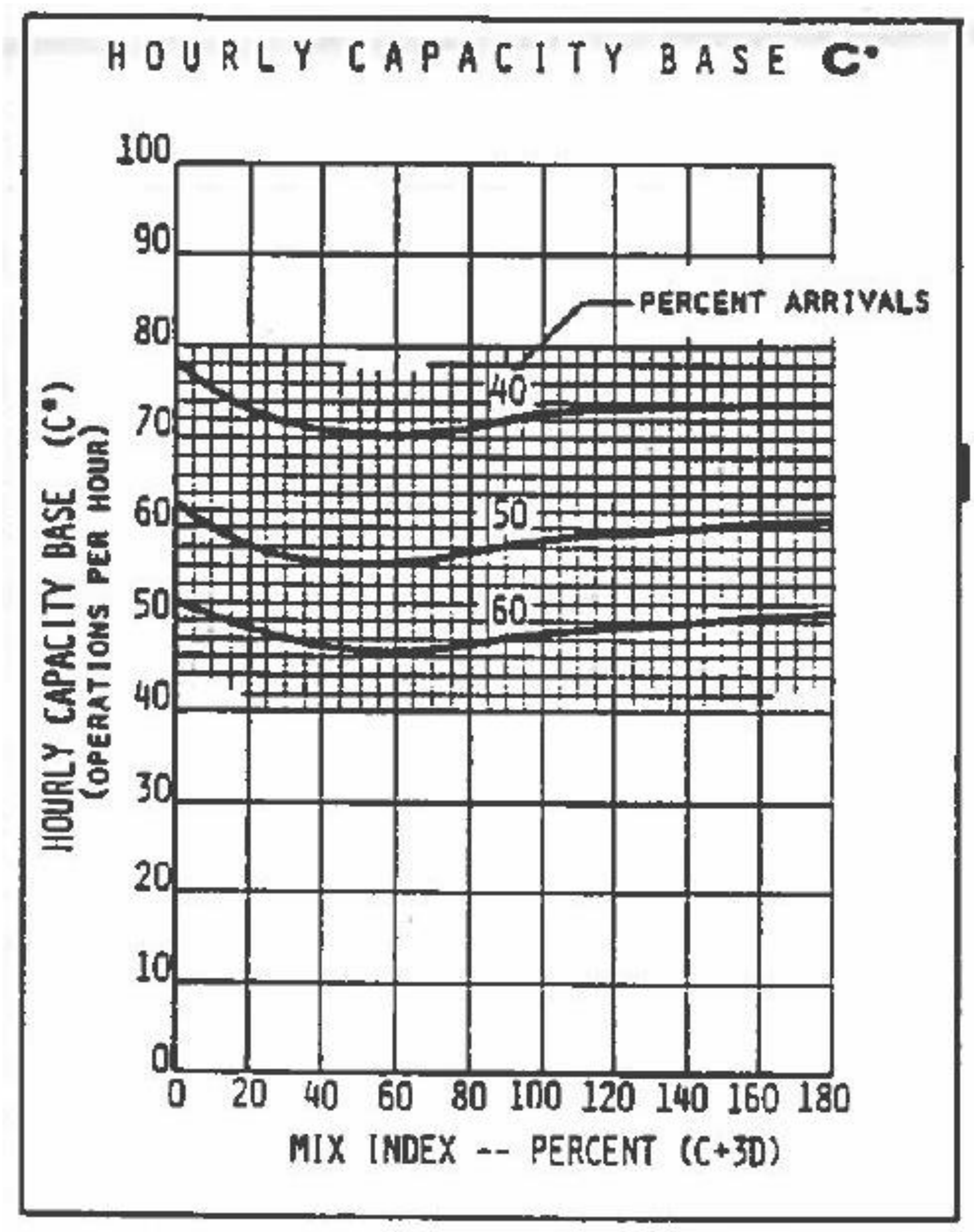
SOURCE: AC 150/5060-5, *Airport Capacity and Delay*, Figure 3-3.

FIGURE 2 **Configuration 2: VFR Runway 17/35**



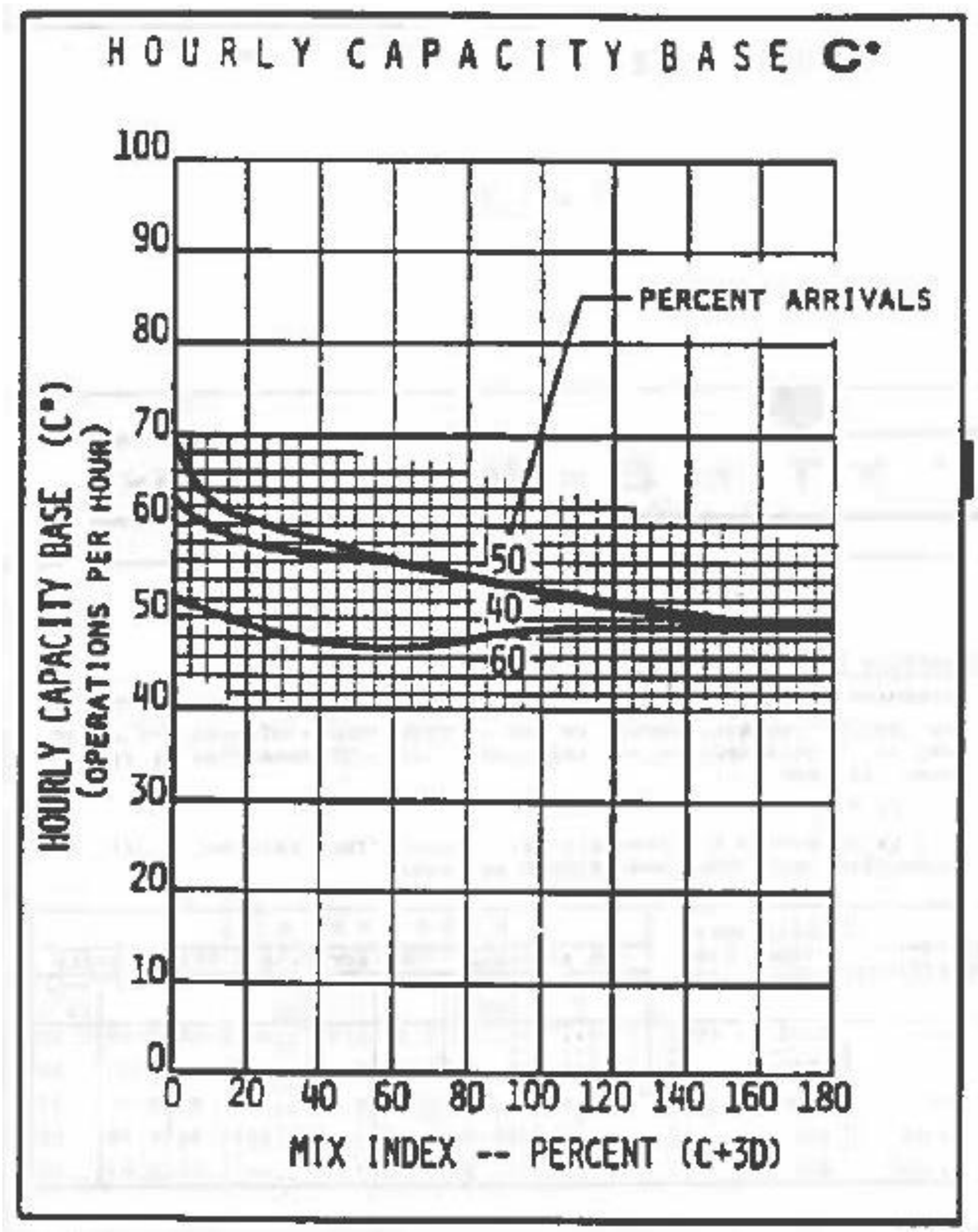
SOURCE: AC 150/5060-5, Airport Capacity and Delay, Figure 3-3.

FIGURE 3 Configuration 3: IFR Runways 8R/26L and 8L/26R



SOURCE: AC 150/5060-5, *Airport Capacity and Delay*, Figure 3-3.

FIGURE 4 **Configuration 4: IFR Runway 17/35**



SOURCE: AC 150/5060-5, *Airport Capacity and Delay*, Figure 3-3.

The touch-and-go factor (T) is determined based on the aircraft mix index (1 percent) and percent touch-and-go (50 percent). A table in AC 150/5060-5 specific to the runway use configuration identifies T based on pairing these two factors. With PUB's current runway use configuration, T equals 1.2 in VFR conditions and one in IFR conditions. The exit factor (E) is determined by several factors including aircraft mix index, percent arrivals, and the average number of exits located in the appropriate exit range separated by at least 750 feet. Based on the number of exit taxiways, E is 1.0 for the parallel runways and 0.86 for Runway 17/35. Lastly, using C*, T, and E described above, the hourly capacities of PUB are as follows:

- **Configuration 1:** VFR Runways 8R/26L and 8L/26R
  - *C* x T x E* = 200 x 1.2 x 1.0 = 240.0 operations.
- **Configuration 2:** VFR Runway 17/35
  - *C* x T x E* = 102 x 1.2 x 0.86 = 105.3 operations.
- **Configuration 3:** IFR Runways 8R/26L and 8L/26R
  - *C* x T x E* = 60 x 1.0 x 1.0 = 60.0 operations.
- **Configuration 4:** IFR Runway 17/35
  - *C* x T x E* = 60 x 1 x 0.86 = 51.6 operations.

Annual Service Volume Calculation

ASV provides an estimate of an airport's annual practical capacity. It accounts for differences in runway use, aircraft mix, weather conditions, pattern of demand (peaking), and other factors that impact an airport. When calculating the ASV, three variables are considered: weighted hourly capacity (C_w), the ratio of annual demand to average daily demand during the peak month (D), and the ratio of average daily demand to average peak hour demand during the peak month (H).

The weighted hourly capacity blends several inputs to be used in the final determination of an airport's annual capacity. Both the IFR and VFR hourly capacities are used, as well as the percentage of IFR and VFR weather. Using the weighted hourly capacity formula found in AC 150/5060-5, C_w at PUB is 157.28 operations.

The Daily Demand Ratio (D) is the ratio of annual demand to average daily demand during the peak month. Using 2019 operational levels identified in **Chapter B – Aviation Activity Forecasts**, this ratio is calculated as follows:

D = Annual Demand/Peak Month Average Daily Demand
D = 217,424/673
D = 323.07

The Hourly Demand Ratio (H) is the ratio of the peak month average daily demand to average peak hour demand during the peak month. This ratio is calculated using 2019 operational levels as shown below:

H = Peak Month Average Daily Demand/Peak Hour Demand
H = 673/74
H = 9.09

Lastly, the ASV is calculated below. Due to rounding shown for simplicity during the narrative process, the number shown does match exactly.

$ASV = C_W \times D \times H$
ASV = 157.28 x 323.07 x 9.09
ASV = 462,108

Since AC 150/5060-5 does not provide clear guidance for estimating change in ASV over time, a typical airfield capacity analysis fixes ASV at a given number (such as 462,108 operations) throughout the planning period, instead of fluctuating with operational demand. Consequently, with an existing ASV of 462,108 and a 2019 number of 217,424 total operations, PUB is currently assumed to be operating at approximately 47.1 percent of its annual capacity.