Duluth International Airport Zone 2.5 Analysis

This document is a supplement to the Airport Zoning Ordinance Analysis previously submitted to illustrate how the proposed Duluth International Airport Zone 2.5 balances safety and economic development. The JAZB and Airport staff work together with the local jurisdictions to implement land use policies that conform to Minnesota Statute Chapter 360.063 Airport Zoning, protect vulnerable populations, and enable compatible development near the Airport. The Minnesota Airport Zoning statute outlines four zones restricting development adjacent to airports:

- Clear Zone: Airport must control property in the Runway Protection Zone (RPZ) associated with the approach to the runway
- Zone A: There shall be no buildings in the approach zone adjacent to the RPZ
- Zone B: No land use of less than 3 acres should be found in an approach zone that extends outward from Zone A to a distance equal to one-third of the runway length
- Zone C: All land within the horizonal zone, subject to uses that do not interfere with airport electronic facilities

The purpose of the State's Airport Zoning statute is to ensure that the following elements are considered when allowing or denying land uses in the vicinity of the Airport:

- Location of vulnerable populations
- Availability of contiguous open spaces
- Land uses that surround the airport, create or cause interference, attract large assemblies of people, attract wildlife, cause interference with airport operations
- Airspace protection
- Social and economic costs of restricting land uses
- Accident rate compared to statistically significant sample
- Planned uses within the airport hazard area
- Any other information relevant to safety or the Airport

The JAZB sets zoning requirements for the properties surrounding the Airport and the communities have also established individual zoning or land use measures to help protect from incompatible uses. Zoning for the Canosia Township is administered through St. Louis County. Note that respecting the character of the surrounding community was emphasized in all stages of Custom Zone development. All nonconforming existing land uses would be permitted to remain. Land use regulations were assessed by working closely with the surrounding communities and an Ordinance was drafted that we believe appropriately balances the interests of all parties.

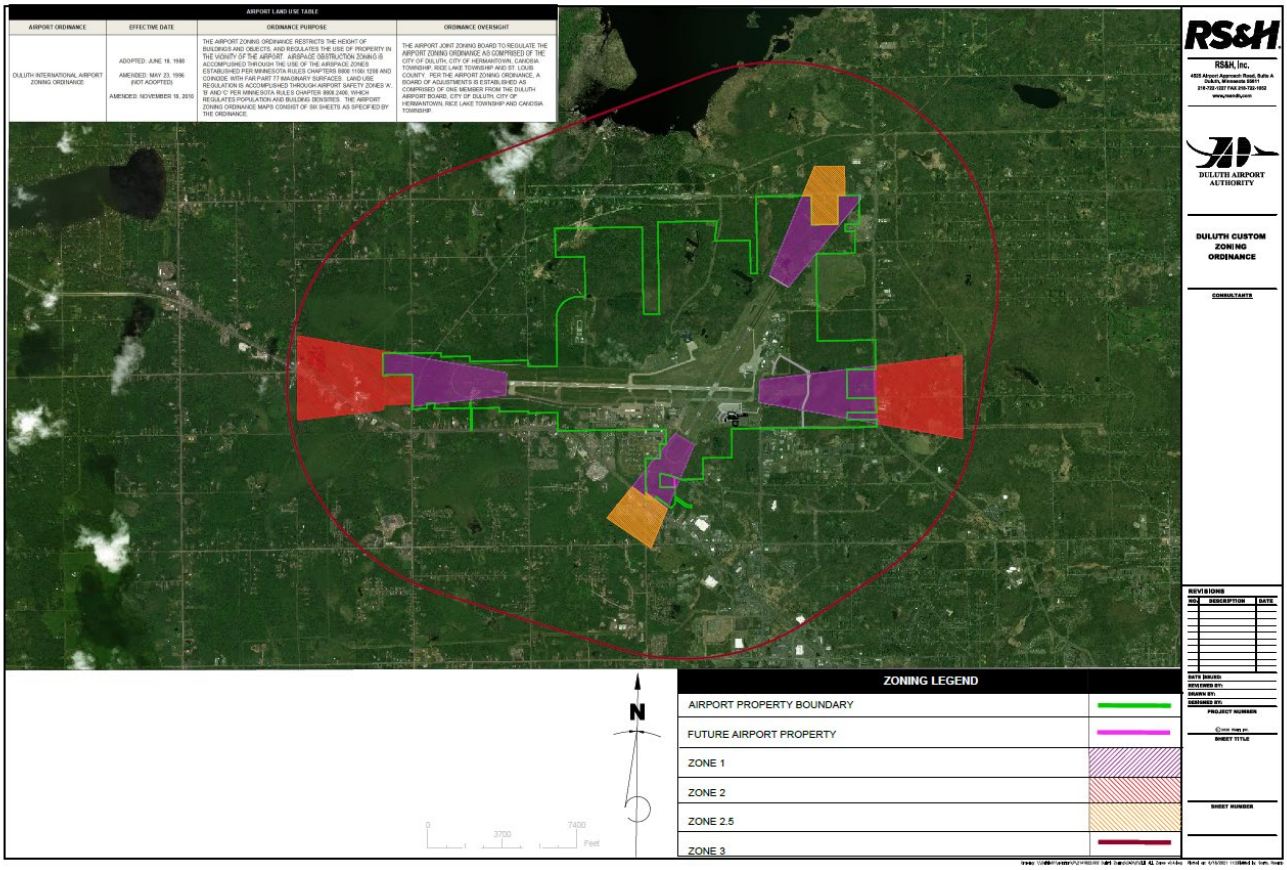
The analytical targets outlined in the Statute and summarized in the previous section were then translated to key metrics for integration into the revised Custom Airport Zones. In order to avoid confusion between the standard zones defined by the Statute in Figure 1 and the Custom Airport Zones

proposed by the JAZB, the proposed Custom Airport Zones are referred to as Zone 1, Zone 2, and Zone 3. Custom Zone 1 is roughly analogous to standard Zone A; Custom Zone 2 is roughly analogous to standard Zone B; and Custom Zone 3 is roughly analogous to standard Zone C. The JAZB is also proposing Custom Zone 2.5 which has less restrictions than Zone 2 and more restrictions than Zone 3. The following are key goals associated with the development of the new Custom Airport Zones:

- Existing land uses are not affected
- For future development:
  - Zone 1: In approach zones of a runway, shall not contain buildings
    - Approach surface = Imaginary surface longitudinally centered on extended centerline at each end of a runway
  - Zone 2: Extends outward from Zone 1, each use shall not be less than 2.5 acres and prohibits uses that attract/house crowds
    - Places of public assembly
    - Schools
    - Hospitals
  - Zone 2.5: Extends outward from Zone 1 on Runway 3-21 and prohibits
    - Schools
    - Hospitals
    - Childcare or daycare centers
    - State licensed residential care facilities and housing with service establishments serving 6 or fewer persons;
    - State licensed adult daycare facility serving 12 or fewer persons;
    - State licensed group family daycare facility serving 12 or fewer children;
  - Zone 3: Subject to uses that do not create or cause interference with airport operations
    - Electronic facilities
    - Make it difficult for pilots to distinguish airport lights
    - Glare

Based on the analysis, a Custom Airport Zone map was created, as shown in Figure 1.

Figure 1
Proposed Custom Zones



Source: RS&H, 2020

Zoning Standards in Duluth International Airport Zones

This section illustrates for each of the requirements in Minnesota Statute 360.0656 how the proposed Duluth International Airport Zones meet that requirement. Note that respecting the character of the surrounding community was emphasized in all stages of Custom Zone development. The Ordinance was written such that existing land uses would be permitted to remain.

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

> **-the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including: - the location of vulnerable populations, including schools, hospitals, and nursing homes, in the airport hazard area**

The locations of vulnerable populations and places of public assembly within vicinity of the Airport are shown Figure 2. There are no locations of vulnerable populations including nursing homes, schools, or hospitals within Zones 1, 2, or 2.5. There is one place of public assembly on the boundary of Zone 2 (Grace Lutheran Church) west of Runway 9 and is allowed to remain. Zone 2.5 is located on the southern end of Runway 3 and north of Runway 21. The following uses are prohibited in Zone 2.5:

- Childcare or daycare centers
- State licensed residential care facilities and housing with service establishments serving 6 or fewer persons;
- State licensed adult daycare facility serving 12 or fewer persons;
- State licensed group family daycare facility serving 12 or fewer children;
- Public or private hospital;
- Public or private school

Runway 3-21 currently serves as a crosswind runway that provides another option for pilots to land when winds do not favor Runway 9-27. Current zoning underlying Zone 2.5 at the south end is identified as Public, High Density Commercial, and Low Density Residential within the Hermantown Zoning District (see Figure 3). Zone 2.5 land at the north end is currently zoned as Rural Residential 1 District and Industrial Future Land Use within the Rice Lake Zoning District and Future Land Use. Future development in the Zone 2.5 area will prohibit development of uses that include places vulnerable populations such as daycares, hospitals, schools, and nursing homes.

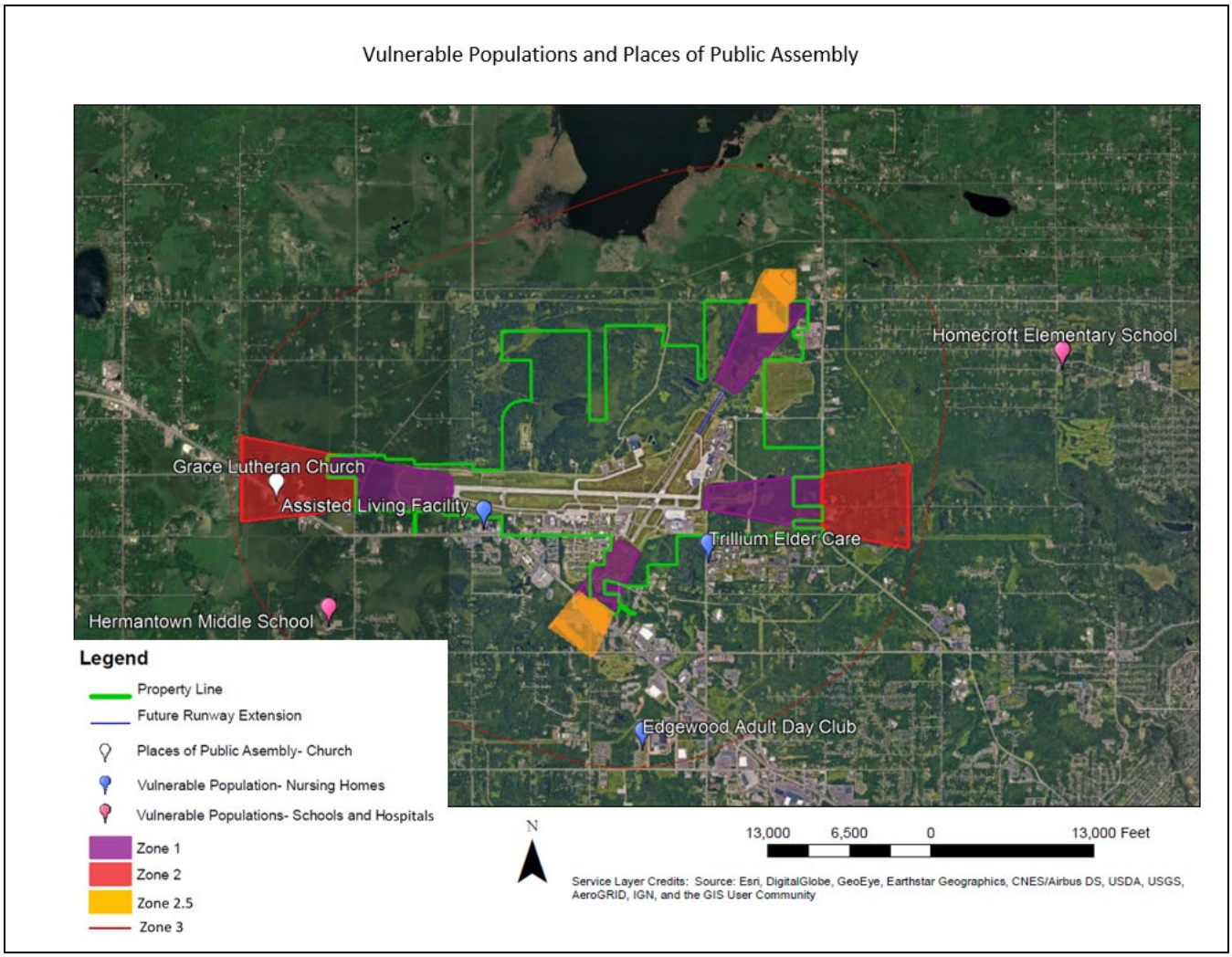
As previously discussed, Zone 2 is within the City of Hermantown Zoning District Industrial, C-1A Commercial, R-1 Residential, and Open Space districts. Per Section 520.01 Land Use Regulations for Hermantown, the Commercial Zoning District is intended to provide suitable areas within the community for the grouping and establishment of general retail sales, offices, professional buildings, and service businesses. It is intended to provide convenient retail facilities for the residents of Hermantown and the surrounding area. The City of Hermantown Residential R-1 Zoning District allows for one- and two-family residential dwellings (Section 505.01). The minimum lot area requirement for R-1 is 2.5 acres.

New facilities containing vulnerable populations will not be developed in Zone 1, 2, or 2.5. Future development of properties containing vulnerable populations are acceptable in Zone 3. The existing community development patterns indicate that vulnerable populations are likely to cluster closer to the more developed areas of Duluth and in areas of higher density development. There are no existing development patterns that indicate higher density growth in the vicinity of the Airport is likely. This is due to the various Zoning Districts immediately surrounding the airport which include Open Space, Residential (R-1 and Rural Residential), Industrial, and Commercial uses.

The location of future or potential land uses containing vulnerable populations or the identification of areas where the development of land uses containing vulnerable populations would be most harmful to airport safety along Runway 3-21 will not be able to exist due to the creation of Zone 2.5. Land use restrictions in Zone 2 prevent the creation of land uses which contain vulnerable populations. Now, with the creation of Zone 2.5, there is a reasonable level of safety regarding vulnerable populations off the ends of Runways 3 and 21, much like Zone 2 provides for Zone 2.5, by adding land use restrictions that

improve public safety, especially when combined with existing mechanisms preventing the creation of other airport hazards for Runways 9 and 27.

Figure 2
Vulnerable Populations and Places of Public Assembly



Source: RS&H, 2020

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-the location of land uses that attract large assemblies of people in the airport hazard area

Chapter 360 of the Minnesota Statutes does not define what constitutes a “large assembly of people,” and, for the purposes of this analysis, this was defined to mean a location or facility that may attract a number and density of people in excess of what would typically be found in a retail establishment or residential area. “Large assembly” was interpreted to mean several hundred people collected in a dense

environment, such as what may be found during peak times at a church, concert venue, or indoor recreational facility.

The uses found within Zone 2.5 are within the Hermantown Commercial Zoning District which is intended to provide suitable areas within the community for the grouping and establishment of general retail sales, offices, professional buildings, and service businesses. This district is intended to provide convenient retail facilities for the residents of Hermantown and the surrounding area.

It is important to note that Chapter 360 of the Minnesota Statutes does not impact existing development. There are two existing land uses that may create a number or density of people. Marcus Lakes Cinema (movie theater) and Skyline Social and Games are located 0.77 miles southwest of Runway 3. Section 520.02 of the Hermantown Zoning Code outlines the uses allowed. The properties found within the proposed Zone 3 are described in Table 1.

Table 1
Land Uses That May Attract Large Numbers of People

Churches		
Name	Location	Zone
Gethsemane Covenant Church	0.94 miles southwest of Runway 9	Within Zone 3 and 2019 MnDOT Zoning Statute Zone B
Grace Lutheran Church	1.46 miles west of Runway 9	Within Zone 2 and 2019 MnDOT Zoning Statute Zone B
New Life Lutheran Church	1.16 miles southeast of Runway 3	Within Zone 3 and 2019 MnDOT Zoning Statute Zone C
Movie Theater		
Name	Location	Zone
Marcus Lakes Cinema	0.77 miles southwest of Runway 3	Within Zone 2.5 and 2019 MnDOT Zoning Statute Zone A
Bowling/Games Center		
Name	Location	Zone
Skyline Social & Games	0.73 miles southwest of Runway 3	Within Zone 2.5 and 2019 MnDOT Zoning Statute Zone A
Meeting/Event Centers		
Name	Location	Zone
AAD Shrine Meeting and Event Center	0.42 miles of south of Runway 9	Within Zone 3 and 2019 MnDOT Zoning Statute Zone C

Source: RS&H, 2020

The JAZB collaborates with the surrounding communities as part of the municipal review process to provide comments and feedback about the compatibility of any proposed conditional use development

in this area.

Future development of properties containing land uses that may attract large assemblies of people will not be developed in Zone 1. Future development of properties containing land uses that may attract large assemblies of people are unlikely to be developed in Zone 2.

Runway 9 end: Highway 53 crosses the Runway 9-27 extended centerline approximately 9,000 feet (1.7 miles) west of the threshold. This road is the only commercial corridor that intersects the extended centerline within the Airport Hazard Area and is therefore the only road on which a future facility that may attract large assemblies of people is likely to be proposed for development. Existing development in the area primarily consists of low-density commercial facilities such as small-scale industrial, consumer storage facilities, and automobile sales/repair facilities.

As distance from the Airport increases, the area takes on rural characteristics of low-density and large property sizes. Given the characteristics of the area and the increasingly rural environment as distance from the City of Duluth increases, it is reasonable to assume that future land uses will resemble existing land uses.

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-the social and economic costs of restricting land uses

Based on this discussion of balancing safety and economic development, the boundaries of Zone 2.5 were revised from the initial proposal. The JAZB set the final proposed boundaries of Zone 2.5 after consideration of all the all the custom zoning factors and with the goal of ensuring a reasonable level of safety, including consideration of the balance between safety and costs.

The purpose of custom zoning is to provide airports with flexibility to best balance the social and economic costs of zoning while providing a reasonable level of safety in a manner which considers the unique qualities of the airport. This takes into thought the economic costs of impeding new development, which has three primary impacts: the loss of potential tax revenue, the loss of employment opportunities, and the cost to the governmental agency to acquire property or development rights from the property owners.

Zone 2.5 balances these costs with airport safety by maintaining restrictions that would not encourage incompatible development due to the current objectives in the various plans that surround the Airport but still allow development that maintains safety without adding restrictions that socially and economically impact the residents of the communities near the airport. Land adjacent to Zone 2, off Runway 9, is within the Western Miller Trunk Highway Small Area Plan conducted by the City of Hermantown. The purpose of the study was to provide guidance for future planning development, redevelopment, transportation, infrastructure, and commerce within this corridor. State Trunk Highway 53, otherwise known as the Miller Trunk Highway, is a key transportation connection between downtown Duluth, Hermantown, and outlying northern residential communities. Zone 2.5 does not impact this area (see Figure 5) that contains 40 percent of the city's commercial and industrial zoned land. Commercial uses are mixed in function though most are locally or regionally owned retail and

service businesses. The study identified this area to be central to several development opportunities including corridor, office, industrial, and small business growth. In 2017, there were over 130 businesses located in the study area. Although Zone 2.5 does not impact this area, this reaffirms that acquiring commercial properties and forcing those businesses could disrupt long-established development patterns in the area that would ripple throughout the community.

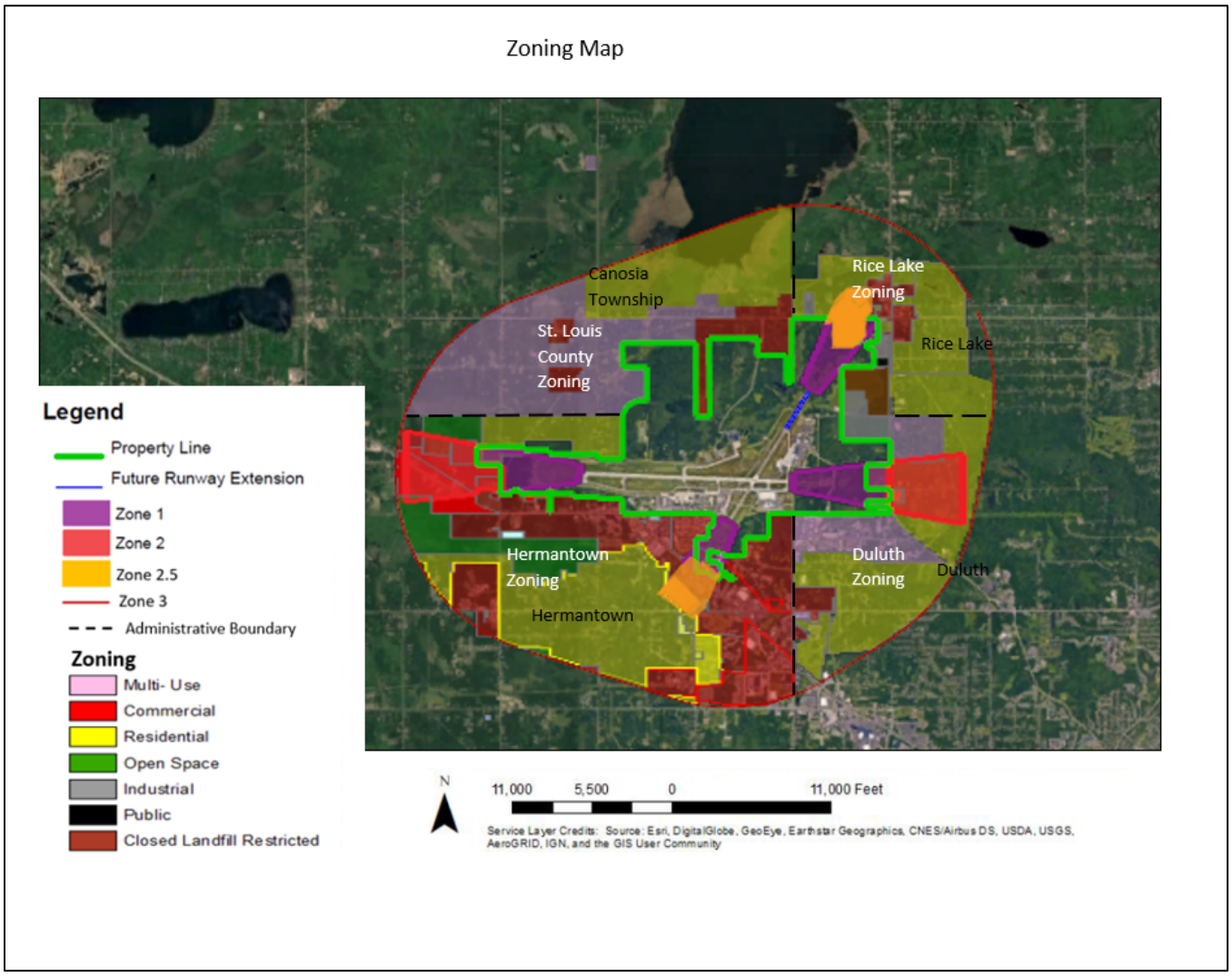
The custom zones balance these costs with airport safety by maintaining restrictions that would not encourage incompatible development due to the current objectives in the various Comprehensive Plans and Zoning Districts surround the Airport including the Western Miller Trunk Highway Small Area Plan.

Zone 2.5 does not place new burdens on property owners in the form of variance requirements including commercial uses and development. Social repercussions of relocation and displacement of existing homes and businesses to the community were also considered when creating Zone 2.5. The existing land uses found within Zone 2.5 are allowed to remain.

The social and economic costs of restricting land uses were determined when creating the appropriate boundaries for Zone 2.5. Based on its analysis of all the custom zoning factors (including those related to safety, and social and economic costs of restricting land uses), it was determined that no additional land use restrictions, including less-burdensome land use restrictions, were necessary outside the proposed zones to ensure a reasonable level of safety.

Zone 2.5 does not restrict future commercial development in an area that has existing commercial development (southwest of Runway 3). Doing so would have legal implications that could result in challenges to the zoning ordinance by property owners because it could be considered a public taking without just compensation. Acquiring commercial properties and forcing those businesses could disrupt long-established development patterns in the area that would ripple throughout the community. The JAZB worked very closely with the surrounding communities to arrive at the proposed configuration of the safety zones and drafted an Ordinance that the JAZB believes provides a reasonable level of safety while respecting the economic interests of each community. Other alternatives were considered during that process before arriving at the proposed configuration.

Figure 3
Zoning Map



Source: RS&H, 2020

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-the accident rate of the airport compared to a statistically significant sample, including an analysis of accident distribution based on the rate with a higher accident incidence

The Airport's low historical accident rate and the existing land use protections in place through the existing RPZs provide an acceptable level of safety for the community in the vicinity of the airport. Statistically, an aircraft could be expected to crash within the airport hazard area off one of the runway ends, but outside the RPZ, approximately once every 800 years. See the previously submitted Appendix.

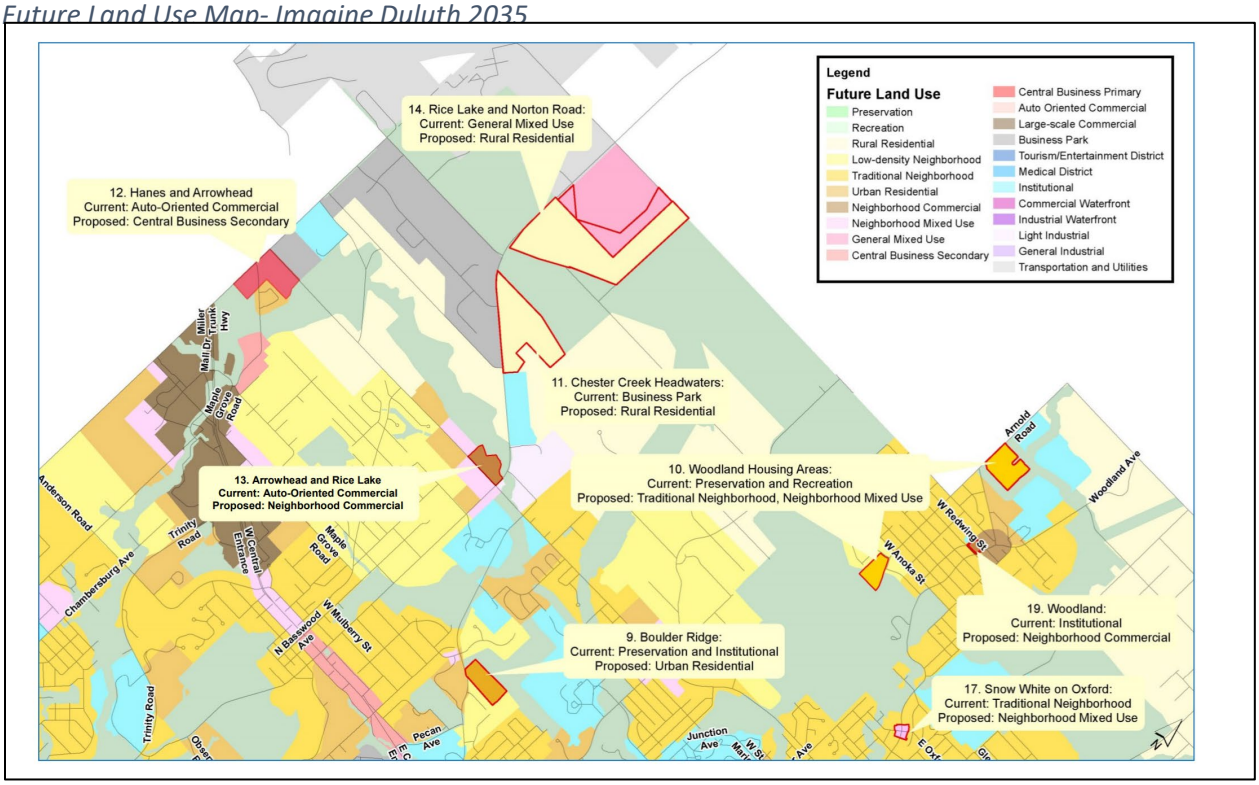
Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-the planned land uses within an airport hazard area, including any applicable platting, zoning, comprehensive plan, or transportation plan

The custom zones do not impact the existing municipal plans and reinforce the policies found within each plan. The analysis states that the custom zones are compatible with current comprehensive, zoning and/or transportation plans in the surrounding jurisdictions. Land use regulations created outside of airport zoning are subject to change at the discretion of the community. However, the custom zones and the addition of Zone 2.5 decrease incompatible uses that would negatively impact airport safety. Zone 2.5 provides the community a regulatory tool to prevent the creation of airport hazards.

Rice Lake and Canosia are rural residential communities consisting of mostly agricultural, conservation, large lot, and low-density land uses that require at least 2.5 acres per dwelling unit. Hermantown is a city experiencing growth in single-family and multi-family residential and commercial uses on varied lot sizes. The Imagine Duluth 2035 Comprehensive Plan evaluated the area of Rice Lake and Norton Area and identified this area as Site 14. This area is recognized as potentially dealing with development pressure. However, the Imagine Duluth 2035 Comprehensive Plan identified this area as pivotal for the preservation of the low intensity character and within the headwaters of Chester Creek resulting in Preservation and Low-Density Neighborhood Future Land Use categories (see Figure 4).

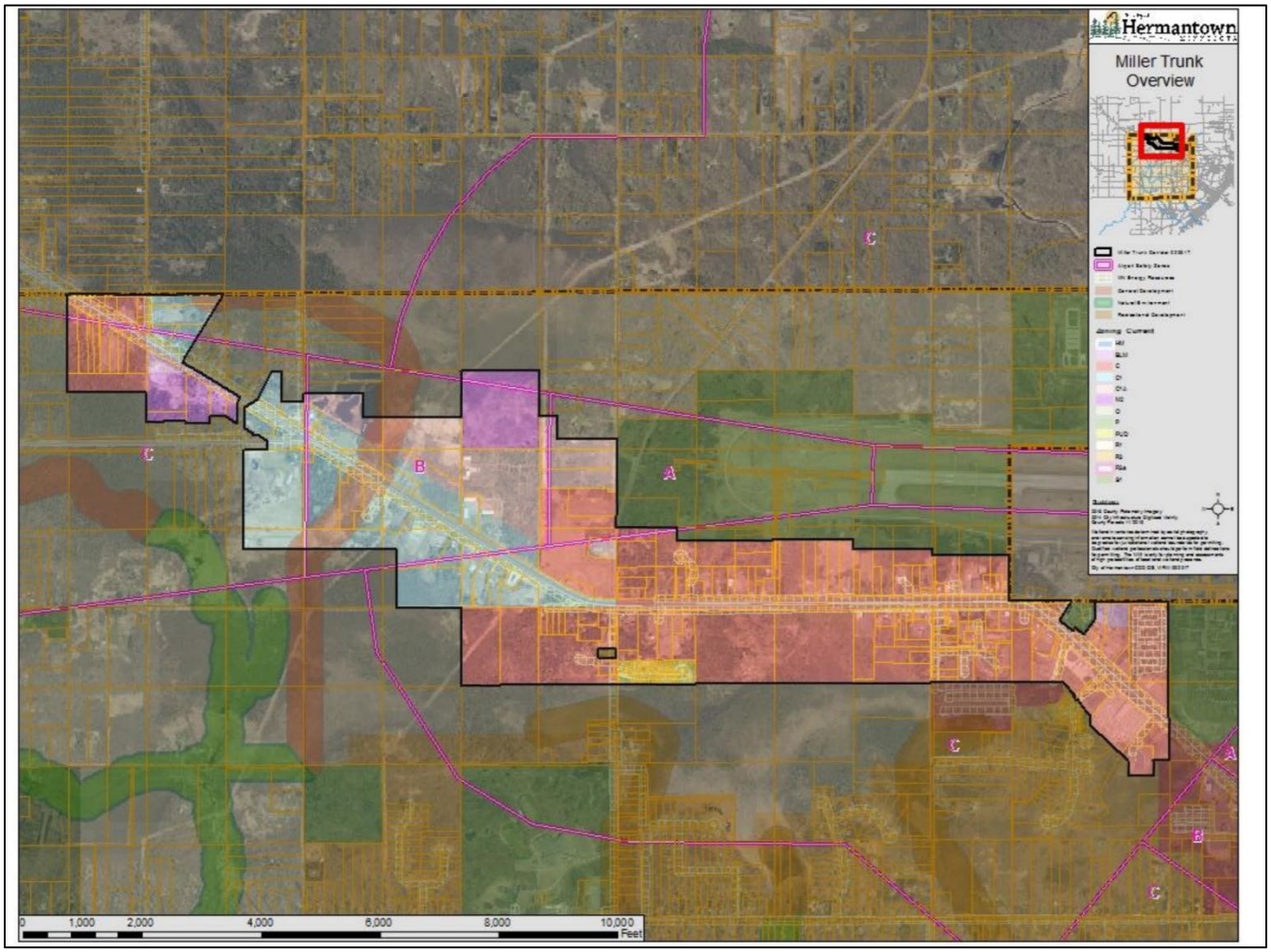
Figure 4
Future Land Use Map- Imagine Duluth 2035



Source: Imagine Duluth 2035 Land Use, 2018

As previously discussed, a portion of land adjacent to Zone 2, off Runway 9, is within the Western Miller Trunk Highway Small Area Plan (see Western Miller Trunk Highway Study Area figure) conducted by the City of Hermantown. The study area included commercial and industrial parcels along Miller Trunk Highway between R.J. Sport and Cycle and Seville Road on the west end of Hermantown. The stretch of area adjacent to Zone 2 along Miller Trunk Highway is zoned Commercial and Open Space to represent the low-density area of the highway and transition to rural areas. The study also recognized that much of the land within this study area that is zoned Commercial and subject to additional development regulations from the overlay zoning district. This area is also classified as Airport Safety Zone A and Zone B (now Custom Zone 1 and 2) within the Western Miller Trunk Highway Study Area. The plan specifically indicates that uses in the area require approval of the Airport Zoning administrator and JAZB. The Commercial Zoning District allows for more intense uses and is consistent with Airport standards.

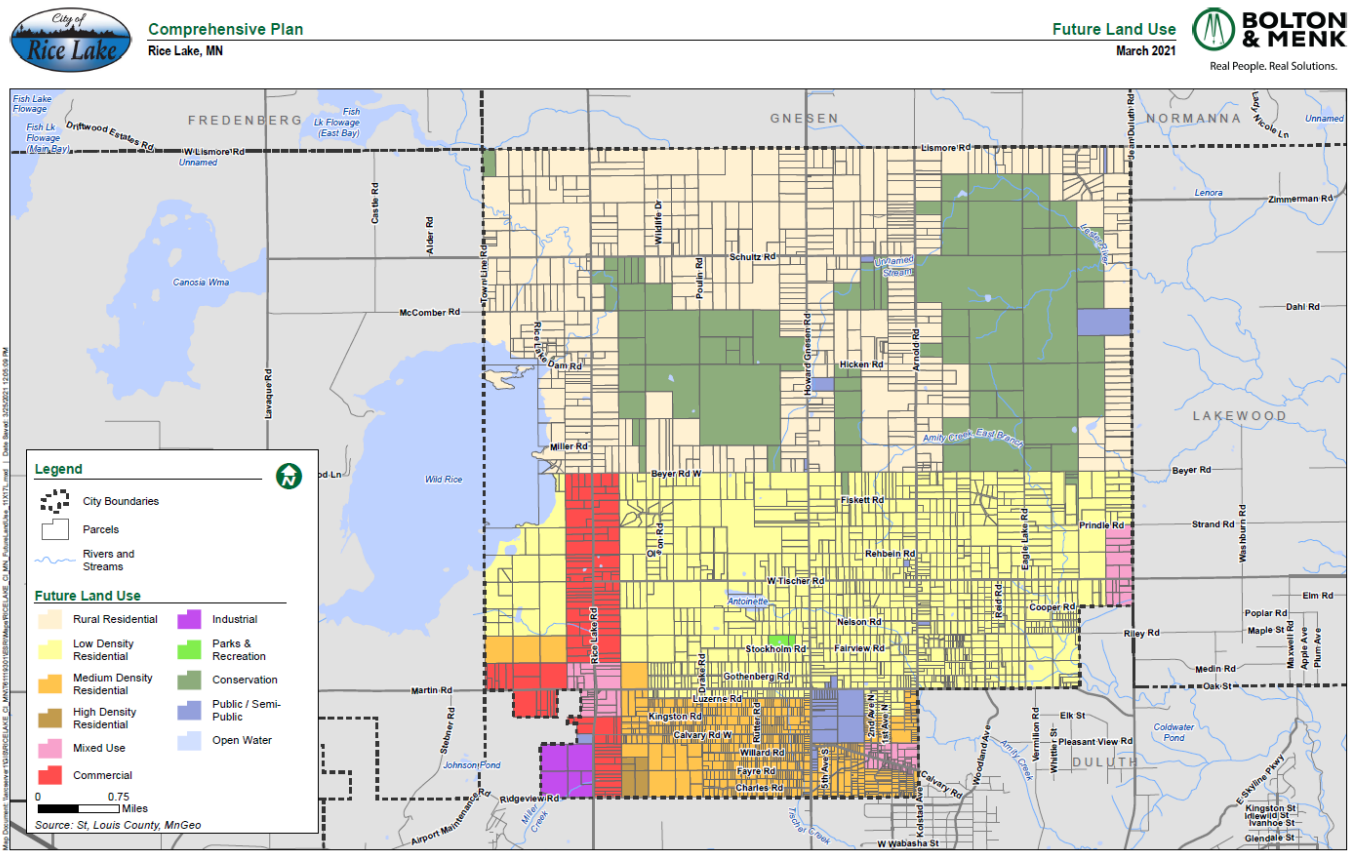
Figure 5
Western Miller Trunk Highway Study Area



Source: City of Hermantown, Western Miller Trunk Highway Small Area Plan, 2017

The City of Rice Lake Comprehensive Plan also recognizes the importance of preserving the safety of regional air carrier service and identifies this as goal with objectives specifically focusing on the coordination with the Airport Authority to protect the Airport from encroachment of incompatible uses. The Future Land Use Map (see Rice Lake Future Land Use Map figure) created in March 2021, identifies the area west of Runway 21 as Commercial Future Land Use category. The goal of identifying this area is to support the development of regional and local transportation options but to also preserve the safety of the Airport including addressing federal and state standards when planning the design of any object related to or affecting navigable space as specified in the Rice Lake Comprehensive Plan. Therefore, the plans mentioned above recognize the existence of the Airport and coordination required to develop in the area in order to protect the Airport from incompatible land uses.

Figure 6
Rice Lake Future Land Use Map



Source: City of Rice Lake Comprehensive Plan, 2021.

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-the location of wildlife attractants in the airport hazard area

Land uses that attract wildlife in the vicinity of the Airport include open water and wetland areas. No other traditional wildlife attractants, such as wastewater treatment facilities and waste transfer stations are located in the vicinity of the area or in Zones 1 and 2. The former Rice Lake Landfill east of the extended runway centerline was closed and capped in 2003 and should not serve as a wildlife attractant. A small portion of Wild Lake Reservoir is located within Zone 3 approximately 2 miles away from Runway 21.

- Runway 3 end: No properties of interest were found in this area. Based on existing development patterns, no additional development of wildlife attractants is likely in this area.

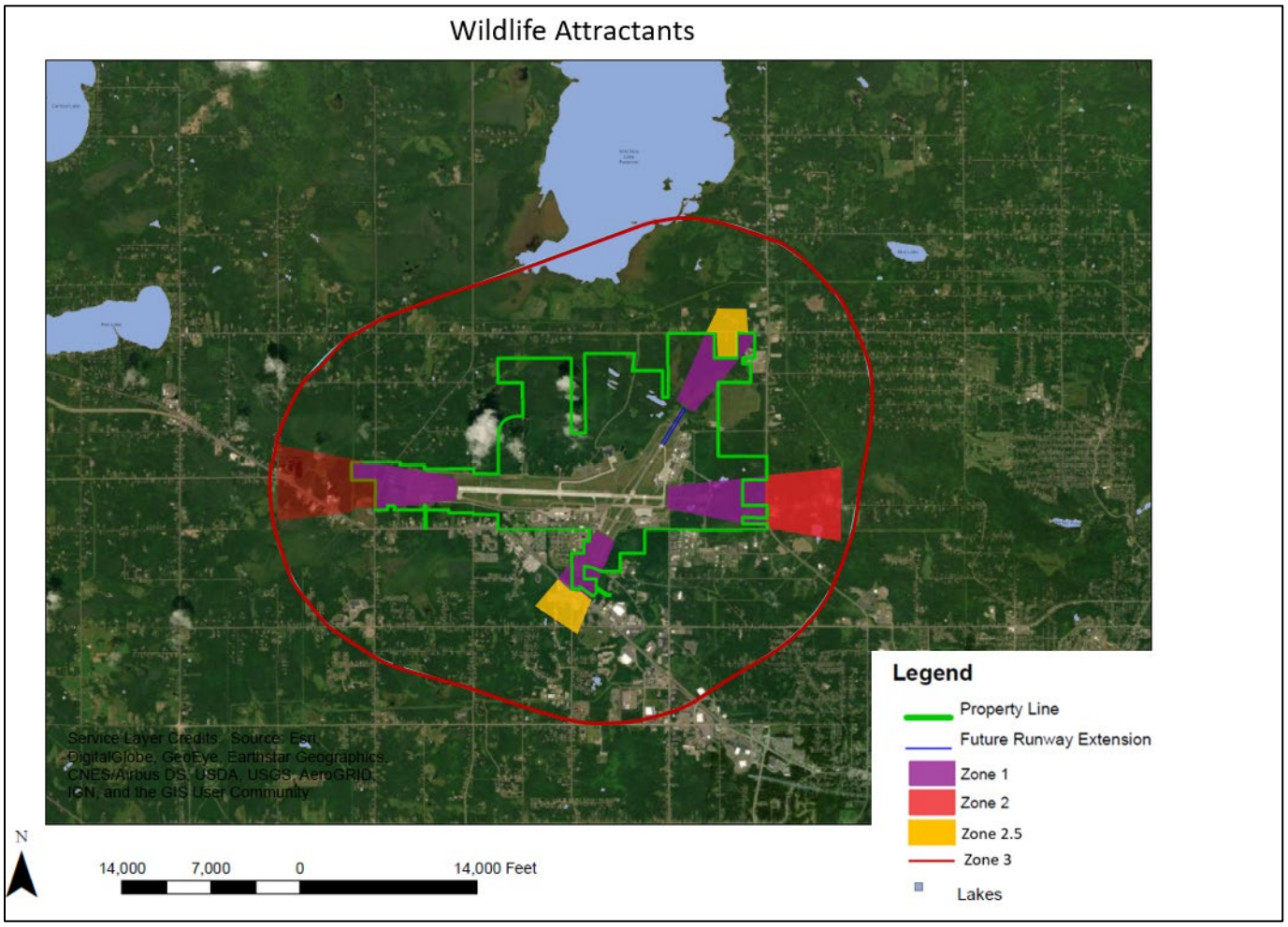
- Runway 9 end: No properties of interest were found in this area with the exception of a borrow pit that sometimes retains water located approximately 8,500 feet (1.6 miles) west of the runway threshold. Based on existing development patterns, no additional development of wildlife attractants is likely in this area.

- Runway 21 end: The former Rice Lake Landfill east of the extended runway centerline was closed and capped in 2003 and should not serve as a wildlife attractant. Based on existing development patterns, no additional development of wildlife attractants is likely in this area.

- Runway 27 end: Three small ponds of approximately 2 acres each currently exist within a half mile of the runway threshold and on either side of the extended runway centerline. Based on existing development patterns, no additional development of wildlife attractants is likely in this area.

Based on existing development patterns (see Figure 7), no additional development of wildlife attractants is likely to develop in this area. Wildlife attractant areas are shown below. Zone 2.5 provides a reasonable level of safety regarding the prevention of the creation of wildlife attractants by precluding the establishment of new wildlife attractants in the foreseeable future.

Figure 7
Wildlife Attractants



Source: RS&H, 2020

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-the availability of contiguous open spaces in the airport hazard area

Contiguous open spaces are valuable in the vicinity of an airport as they give the pilot of a disabled aircraft options to land in a place that have the greatest potential to minimize damage and contain the accident site. Contiguous open spaces adjacent to runway ends in the vicinity of the Airport are provided by the following land uses in the zoning districts below:

- Land guided Open Space in the City of Hermantown and St. Louis County
- Land guided as Open Space and Residential (required to be a minimum of 2.5 acres) in the City of Hermantown
- Open water

Per Section 545.01 Land Use Regulations for Hermantown, the Open Space district is intended to preserve those areas of the community which have limited development potential due to their location, accessibility, natural features, or unique characteristics. They are normally areas of unsuitable soils, low marsh/wetlands, bedrock, or steep topography. Uses within these areas, due to specific unsuitable conditions, will include agriculture, forestry, and recreation. The minimum lot area requirement is 5 acres. Research shows that in more than 95 percent of aircraft accidents the pilot has some measure of control of the aircraft well into the ground impact sequence. For that reason, open contiguous parcels adjacent to the airport are desirable – particularly along the extended runway centerline. A pilot experiencing fuel exhaustion or mechanical failure can then steer toward the open parcels to complete an off-airport landing.

The proposed custom zoning ordinance requires a minimum parcel size of 2.5 acres in Zone 2, as well as the presence of at least one undeveloped open space of at least 2.5 acres. The intent of this requirement is to ensure very low-density development so as to give pilots options in the case of a forced landing, thereby increasing the safety of people on the ground. This strategy provides ample area for a pilot of a stricken airplane to guide it away from population on the ground.

For example, a Cessna 172 – the most popular general aviation aircraft ever manufactured – requires approximately 600 feet for a controlled landing to a full stop on grass.

- Runway 3 end: Except for a stretch of commercial properties along Highway 53 south of the Airport, the primary development in this area is low-density residential with lot sizes in excess of 1 acre, as well as several undeveloped parcels of greater than 15 acres (though ownership may vary). Most of the undeveloped land and much of the residential property is wooded.

- Runway 9 end: Except for the low-density rural commercial land uses along Highway 53, Zone 2 off the end of Runway 9-27 west of the Airport is primarily agricultural and complies with the intent to maintain contiguous open areas. Some of the undeveloped land is wooded, but most is either small scrub vegetation or open fields.

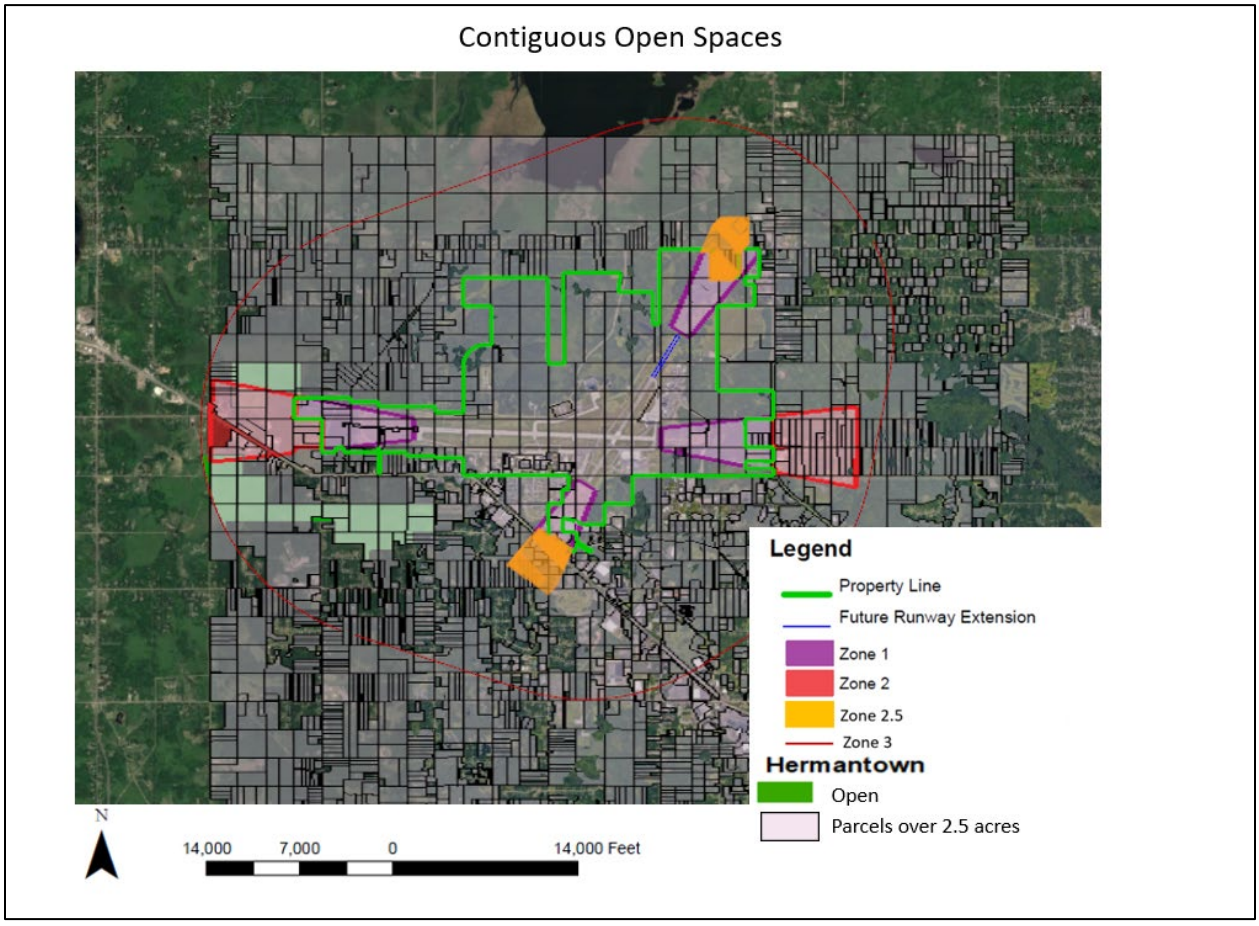
- Runway 21 end: Two roadways, Martin Road and Rice Lake Road serve properties off the north end of Runway 3-21. Development along both of these roads is limited to low-density rural commercial and residential properties. The majority of the land in this area is undeveloped and forested, although some areas of open field and scrub vegetation exist on either side of the approach corridor.

- Runway 27 end: Rice Lake Road intersects the extended runway centerline approximately 5,500 feet (1 mile) east of the threshold. Development along this road and throughout the area is limited to low-density rural commercial and residential properties. The majority of the land in this area is undeveloped and forested, although some areas of open field and scrub vegetation exist on either side of the approach corridor.

The rural atmosphere surrounding the Airport will maintain sufficient buffer for the pilot of a malfunctioning airport to steer clear of structures.

In addition to these open space areas, there are large bands of low-density residential development surrounding the airport that is zoned to require at least 2.5 acres per dwelling unit. This type of low-density development provides additional swaths of open space not available in more densely developed areas. This meets the requirement of contiguous open spaces within the Airport Hazard Area. In addition, the map below depicts the Residential and Open Space Zoning Districts and parcels that are a minimum of 2.5 acres. The Airport is surrounded by properties over 2.5 acres as seen in Figure 8 and includes those parcels within Zone 2.5.

Figure 8
Contiguous Open Spaces



Source: RS&H, 2020

Requirement : *Analyze the location of the airport, the surrounding land uses, and the character of neighborhoods in the vicinity of the airport, including:*

-analyze the accident rate at the airport compared to a statistically significant sample, including an analysis of accident distribution based on the rate with a higher accident incidence

In the 20 years from January 2000-December 2019, there have been two civil aviation accidents within DLH's Airport environment that rose to the level of accident as defined by the National Transportation

Safety Board. Both were general aviation accidents. One (January 2008) involved a poor landing of a general aviation aircraft that resulted in a broken nose gear. The accident was contained within the runway safety area of Runway 9-27.

The other (July 2000) involved a spatial disorientation loss of control after an instrument departure in fog from Runway 9 and a resulting crash in a wooded area approximately 1.8 miles north-northeast of the departure end of the runway. The NTSB report does not specify the exact location, but analysis from aerial imagery suggests ground impact was within the standard Zone C and proposed custom Zone 3.

These two events represent an accident rate of 0.158 per 100,000 operations over the 20-year period. By comparison, the accident rate for all US air carriers during the same interval was 0.187 per 100,000 operations. The 28th Joseph T Nall Report, published in October 2019, found that over a 10-year period from January 2007 through December 2016, there were a total of 4,749 non-commercial general aviation airplane accidents in the US that occurred either on landing or on takeoff/initial climb. FAA's Traffic Flow Management System Counts found that over the same period there were approximately 70.7 million general aviation operations. Together, these data put the accident rate in the airport environment for all US general aviation at approximately 6.717 per 100,000 operations – far higher than the rate exhibited at the Airport.

The small sample size of local aviation accidents requires examination of a broader universe of airports to determine potential accident site distribution. One key study was the 2008 ACRP Report 3, Analysis of Aircraft Overruns and Undershoots for Runway Safety Areas, which examined landing undershoots, landing overruns and takeoff overruns to identify the location and extent of hazardous areas near the runway ends. ARCP Report 3 looked at 459 air carrier accidents and incidents in the vicinity of the airport to determine the value of Runway Safety Areas. Data for the study was compiled from the National Transportation Safety Board, FAA, NASA's Aviation Safety Reporting System, Canada's Transportation Safety Board, the United Kingdom's Air Accident Investigation Branch and France's Bureau d'Enquêtes et d'Analyses.

In the course of the analysis, the research team developed a series of risk models that created a probability distribution for the point of first impact for landing undershoots and the final stopping location for landing and takeoff overruns. Although the purpose of ACRP Report 3 was to analyze Runway Safety Areas, an intermediary step involved creating probability formulas for each of the three accident/incident scenarios that reflected the real-world probability of an accident aircraft's position relative to the threshold and the extended runway centerline. This analysis included only landing undershoots, landing overruns, and takeoff overruns. Runway loss-of-control accidents were not considered, as they occur independently of the location of the runway ends and typically remain on airport property.

The study created probability formulas that show the distribution of landing undershoots, landing overruns, and departure overruns based on longitudinal distance from the threshold and lateral distance from the extended centerline. Those probability formulas gave the following distances in which the probability of containing the accident would be 80 percent, 90 percent, and 95 percent.

Table 2
Accident Containment Probability

	80% Probability	90% Probability	95% Probability
Landing Undershoot			
Distance from Threshold (ft)	671	1,170	1,764
Distance from Centerline (ft)	49	136	286
Landing Overrun			
Distance from Threshold (ft)	552	803	1,057
Distance from Centerline (ft)	70	145	249
Departure Overrun			
Distance from Threshold (ft)	994	1,392	1,782
Distance from Centerline (ft)	129	287	500

Source: ACRP 3, Table 10 and Table 11 Raw Data

As evident from Table 2, there is a greater than 95 percent probability that a runway-area accident would be contained within an area between the runway threshold and a point 1,782 from the threshold, and within 500 feet of the runway extended centerlines. This area fits wholly within the Runway Protection Zone of each runway, and all RPZs are contained wholly within Airport property.

The Airport's low historical accident rate and the existing land use protections in place through the existing RPZs provide an acceptable level of safety for the community in the vicinity of the airport. Statistically, an aircraft could be expected to crash within the airport hazard area off one of the runway ends but outside the RPZ approximately once every 800 years.

APPENDIX-

Airport Area Safety Analysis

1 BACKGROUND

This study examined the rationale for establishing airport land use classifications based on the geolocation of aviation accidents. A primary consideration of airport development is ensuring that the community surrounding the airport contains land uses that are compatible with aviation activity.

This analysis examined current and historical studies of aircraft accident locations that were designed to identify the risk to uninvolved public in the airport area due to an aircraft accident. The purpose of the analysis was to identify ways to determine acceptable land uses near the airport in an effort to assess state and local zoning ordinances with respect to predicted risk.

A variety of studies and datasets were examined to determine the likely spread of accidents near an airport. It was the intention of this study to identify areas surrounding the Duluth International Airport and identify areas where the risk to the uninvolved public may be elevated due to the potential for accidents involving fixed-wing aircraft.

There are several key limitations involved in a study of general aviation aircraft accidents, which are described throughout this Appendix. Those limitations include the lack of authoritative flight activity data that would allow accident rates to be calculated and the inconsistent documentation created as a result of the accident investigations. In addition, a relatively low number of accidents occur near the airport, but outside of the runway environment. Combined, these factors mean that statistical analysis of aviation accident locations should be approached with caution, particularly as the accident sample size shrinks even further during the segmentation of near-airport areas.

2 STUDY APPROACH

This study assesses the relative risk to the public of aviation operations, particularly in respect to the location of areas of higher risk that may be associated with extended runway centerlines or airport traffic patterns to and from Duluth International Airport (DLH).

By focusing on the risk to the uninvolved public, this study will not consider risk associated with accidents that can reasonably be expected to be contained within the confines of the runway safety area (such as hard landings or runway loss of control), or those associated with en-route operations (such as controlled flight into terrain or fuel mismanagement). This limitation leaves takeoff/initial climb and descent/approach as the phases of flight of interest when assessing near-airport risk exposure and removes most accidents from consideration. For example, National Transportation Safety Board (NTSB) recorded 10,673 accidents involving non-commercial fixed-wing general aviation aircraft from 2009 through 2018, of which only 16.2% occurred during the takeoff/initial climb and descent/approach phases of flight, according to the Air Safety Institute's Nall Report[1].

The Nall Report cites NTSB statistics show that in the most recent decade studied, non-commercial fixed-wing general aviation aircraft suffer an average of 178.2 accidents per year nationwide in the takeoff/initial climb and descent/approach phases of flight. The data includes operations from more than 13,000 airports, and so the likelihood of such an accident at any one airport is small.

[1] 30th Joseph T. Nall Report, Air Safety Institute, 2020, retrieved from https://www.aopa.org/training-and-safety/air-safety-institute/accident-analysis/joseph-t-nall-report

Table 1
Non-Commercial Fixed Wing Aircraft Accidents

Year	Total Accidents	Takeoff/ Climb	Approach/ Descent	Combined	% of Total Accidents
2009	1,180	151	44	195	16.5%
2010	1,160	135	46	181	15.6%
2011	1,185	146	57	203	17.1%
2012	1,155	145	52	197	17.1%
2013	964	119	32	151	15.7%
2014	969	115	46	161	16.6%
2015	975	108	44	152	15.6%
2016	1,050	123	39	162	15.4%
2017	1,002	113	44	157	15.7%
2018	1,033	111	58	169	16.4%
Total	**10,673**	**1,266**	**462**	**1,728**	**16.2%**

Source: 30th Joseph T. Nall Report, Air Safety Institute, 2020

While the potential for injury to the uninvolved public located in near-airport areas appears to be small, historically it has been a key component in determining compatible land uses and therefore should be given due consideration.

The factors to be analyzed are 1) the risk associated with each specific runway end and 2) identifying a distribution of likely locations on the ground, as may be determined by the geolocations of historical accidents.

There have been multiple attempts to develop statistical analyses of the locations of aircraft accidents in relation to airport infrastructure. Although all are limited by small data sets, a common theme appears throughout: risk is concentrated along the runway centerlines, and generally decreases as distance increases from the centerline at the threshold.

The most comprehensive to date has been the Airport Cooperative Research Program (ACRP) Report 3, Analysis of Aircraft Overruns and Undershoots for Runway Safety Areas, a 2008 study that examined landing undershoots, landing overruns, and takeoff overruns to identify the location and extent of hazardous areas near the runway ends.

ARCP Report 3 looked at 459 air carrier accidents and incidents in the vicinity of the airport to determine the value of Runway Safety Areas. Data for the study was compiled from the National Transportation Safety Board, FAA, NASA's Aviation Safety Reporting System, Canada's Transportation Safety Board, the United Kingdom's Air Accident Investigation Branch and France's Bureau d'Enquêtes et d'Analyses.

In the course of the analysis, the research team developed a series of risk models that created a probability distribution for the point of first impact for landing undershoots and the final stopping location for landing and takeoff overruns. Although the purpose of ACRP Report 3 was to analyze Runway Safety Areas, an intermediary step involved creating mathematical formulas for each of the three accident/incident scenarios that reflected the real-world probability of an accident aircraft's position relative to the threshold and the extended runway centerline.

The analysis included only landing undershoots, landing overruns, and takeoff overruns. Runway loss-of-control accidents were not considered, as they occur independently of the location of the runway ends and typically remain on airport property.

Three sets of complementary cumulative probability distribution (CCPD) models were developed. When multiplied by the frequency of events, a complementary cumulative frequency distribution (CCFD) is obtained, which can quantify the likelihood of an incident exceeding a given distance from the runway end or centerline.

2.1 LANDING OVERRUNS

Researchers used 257 accidents/incidents that involved landing overruns. The locations of the final stopping points of the aircraft can be described by two formulas, one for longitudinal distance from the runway end and one for lateral distance from the extended runway centerline.

The longitudinal distribution model is:

$P\{Location > x\} = e^{-ax^n}$ where:

- $P\{Location > x\}$ is the probability that distance of the overrun past the runway end will be greater than x.
- x is the given distance beyond the runway end.
- a and n are regression coefficients. For landing overruns, a = 0.003871 and n = 0.955175. The resulting R^2 value is 99.8%.

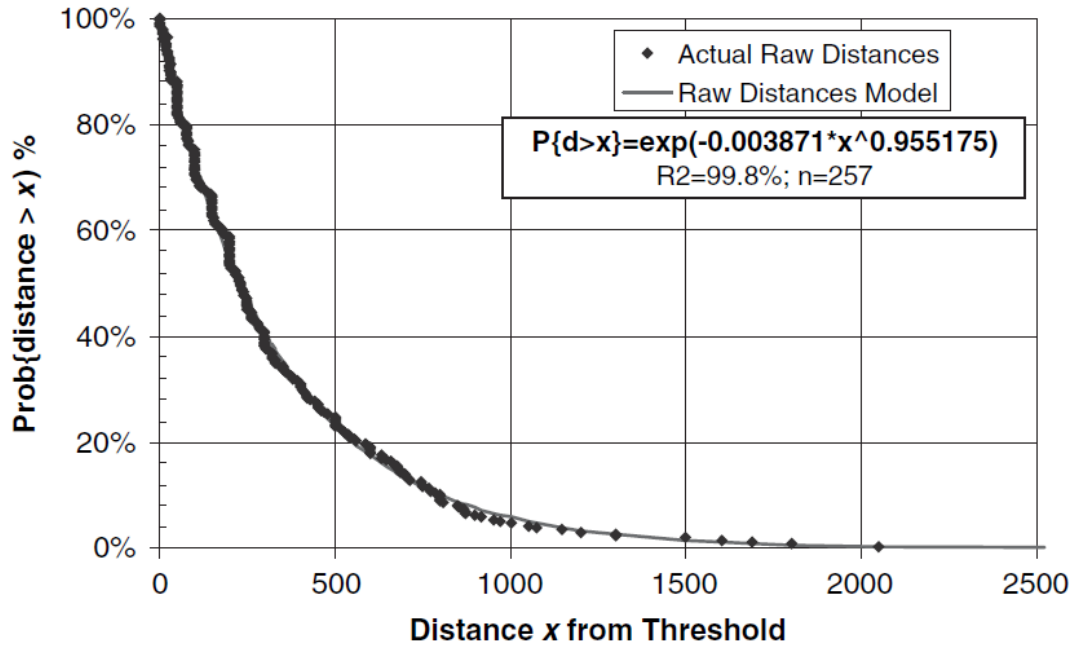
The lateral distribution model is:

$P\{Location > y\} = e^{-by^m}$ where:

- $P\{Location > y\}$ is the probability that distance of the lateral deviation from the runway centerline will be greater than y.
- y is the given distance from the extended runway centerline. Note that lateral R^2 factors will tend to be lower because distance from threshold is often not reported if the location is within the extended lateral limits of the runway.
- b and m are regression coefficients. For landing overruns, b = 0.20174 and m = 0.489009. The resulting R^2 value is 94.7%.

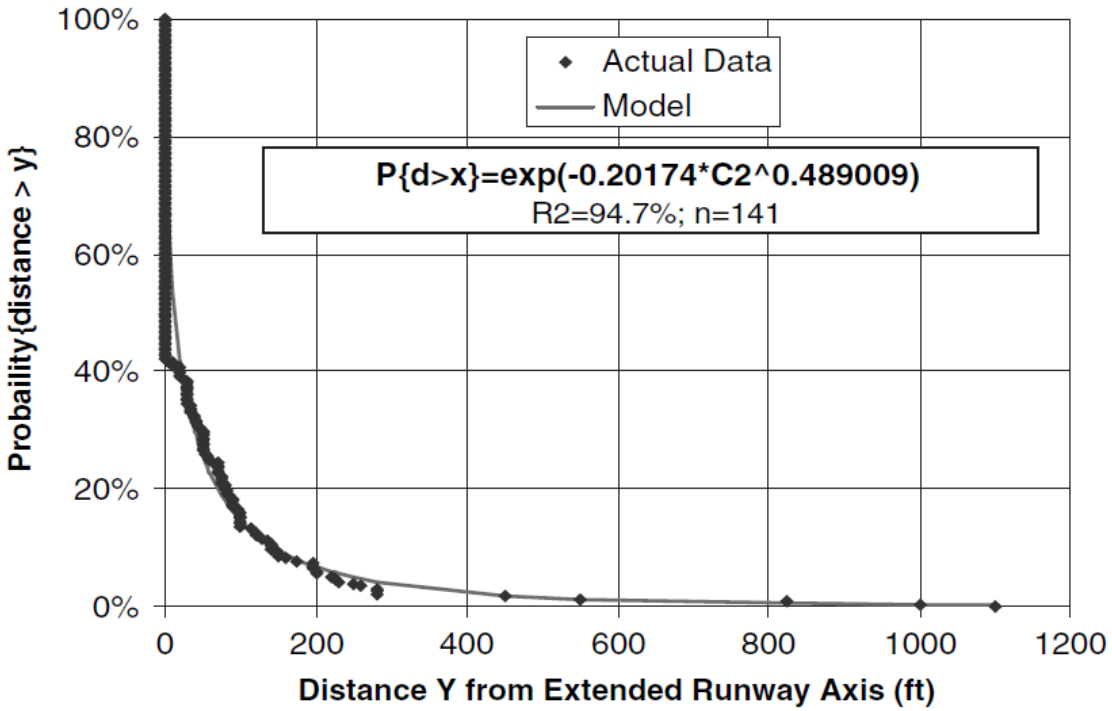
Figure 1 shows the distance distribution from the runway end for the 257 accidents/incidents studied that involved landing overruns and **Figure 2** shows the distance distribution from the extended runway center line for the 141 accidents/incidents for which data was available.

Figure 1
Raw Distances Model for Landing Overruns



Source: ACRP Report 3, page 30

Figure 2
Raw Lateral Distances Model for Runway Overruns



Source: ACRP Report 3, page 31

2.2 LANDING UNDERSHOOTS

Researchers used 82 accidents/incidents that involved landing undershoots. The locations of the initial impact points of the aircraft can be described by two formulas, one for longitudinal distance from the runway threshold and one for lateral distance from the extended runway centerline.

The longitudinal distribution model is:

$P\{Location > x\} = e^{-ax^n}$ where:

- $P\{Location > x\}$ is the probability that distance of the initial impact point prior to the runway threshold will be greater than x
- x is the given distance prior to the runway threshold
- a and n are regression coefficients. For landing undershoots, a = 0.024445 and n = 0.643232. The resulting R^2 value is 98.5%

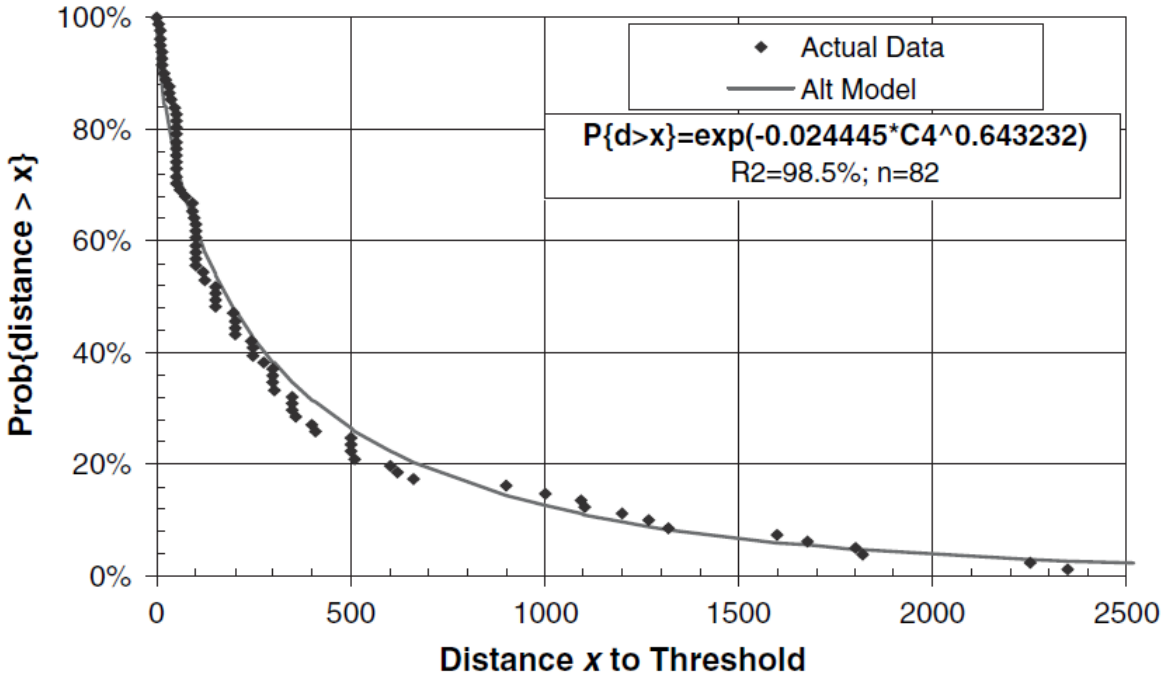
The lateral distribution model is:

$P\{Location > y\} = e^{-by^m}$ where:

- $P\{Location > y\}$ is the probability that distance of the lateral deviation from the runway centerline will be greater than y
- y is the given distance from the extended runway centerline. Note that lateral R^2 factors will tend to be lower because distance from threshold is often not reported if the location is within the extended lateral limits of the runway.
- b and m are regression coefficients. For landing undershoots, b = 0.409268 and m = 0.643232. The resulting R^2 value is 92.0%.

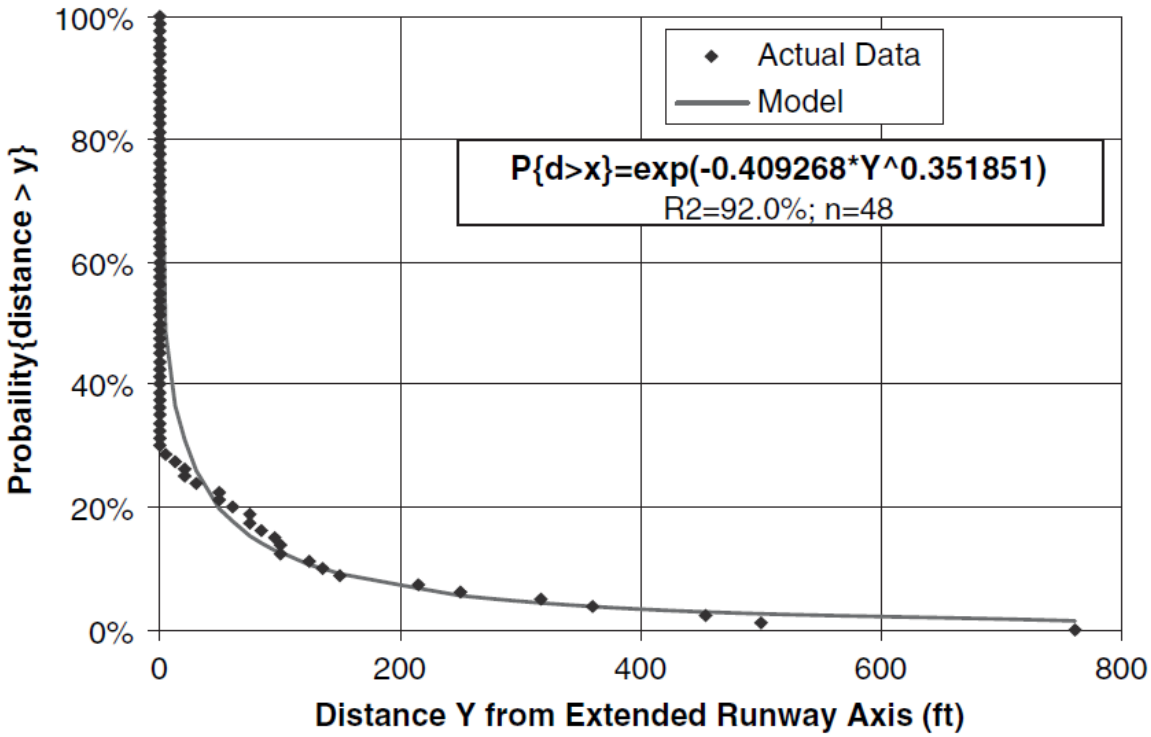
Figure 3 shows the distance distribution from the runway threshold for the 82 accidents/incidents studied that involved landing undershoots and **Figure 4** shows the distance distribution from the extended runway center line for the 48 accidents/incidents for which data was available.

Figure 3
Raw Distances Model for Landing Undershoots



Source: ACRP Report 3, page 32

Figure 4
Raw Lateral Distances Model for Landing Undershoots



Source: ACRP Report 3, page 32

2.3 TAKEOFF OVERRUNS

Researchers used 76 accidents/incidents that involved takeoff overruns. The locations of the final stopping points of the aircraft can be described by two formulas, one for longitudinal distance from the runway threshold and one for lateral distance from the extended runway centerline.

The longitudinal distribution model is:

$P\{Location > x\} = e^{-ax^n}$ where:

- $P\{Location > x\}$ is the probability that distance of the overrun past the runway end will be greater than x
- x is the given distance beyond the runway end
- a and n are regression coefficients. For takeoff overruns, a = 0.001033 and n = 1.065025. The resulting R^2 value is 99.0%

The lateral distribution model is:

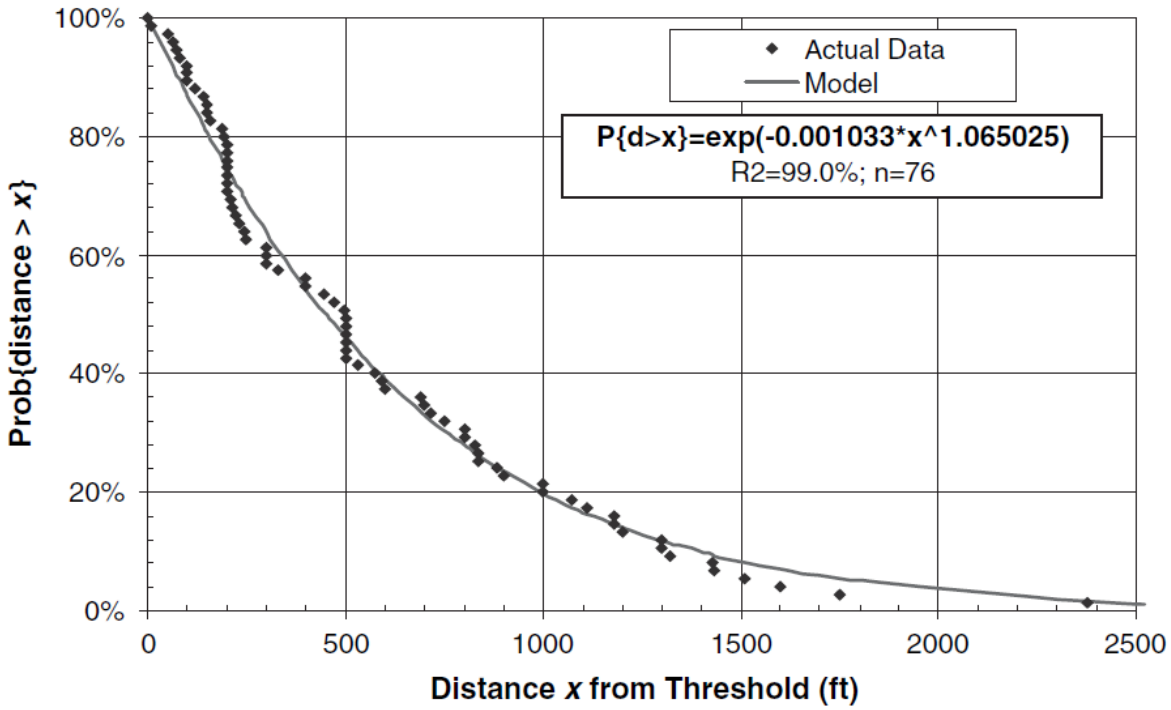
$P\{Location > y\} = e^{-by^m}$ where:

- $P\{Location > y\}$ is the probability that distance of the lateral deviation from the runway centerline will be greater than y
- y is the given distance from the extended runway centerline. Note that lateral R^2 factors will tend to be lower because distance from threshold is often not reported if the location is within the extended lateral limits of the runway.
- b and m are regression coefficients. For landing undershoots, b = 0.182098 and m = 0.448346. The resulting R^2 value is 95.6%.

Figure 5 shows the distance distribution from the runway end for the 76 accidents/incidents studied that involved takeoff overruns and Figure 6 shows the distance distribution from the extended runway center line for the 44 accidents/incidents for which data was available.

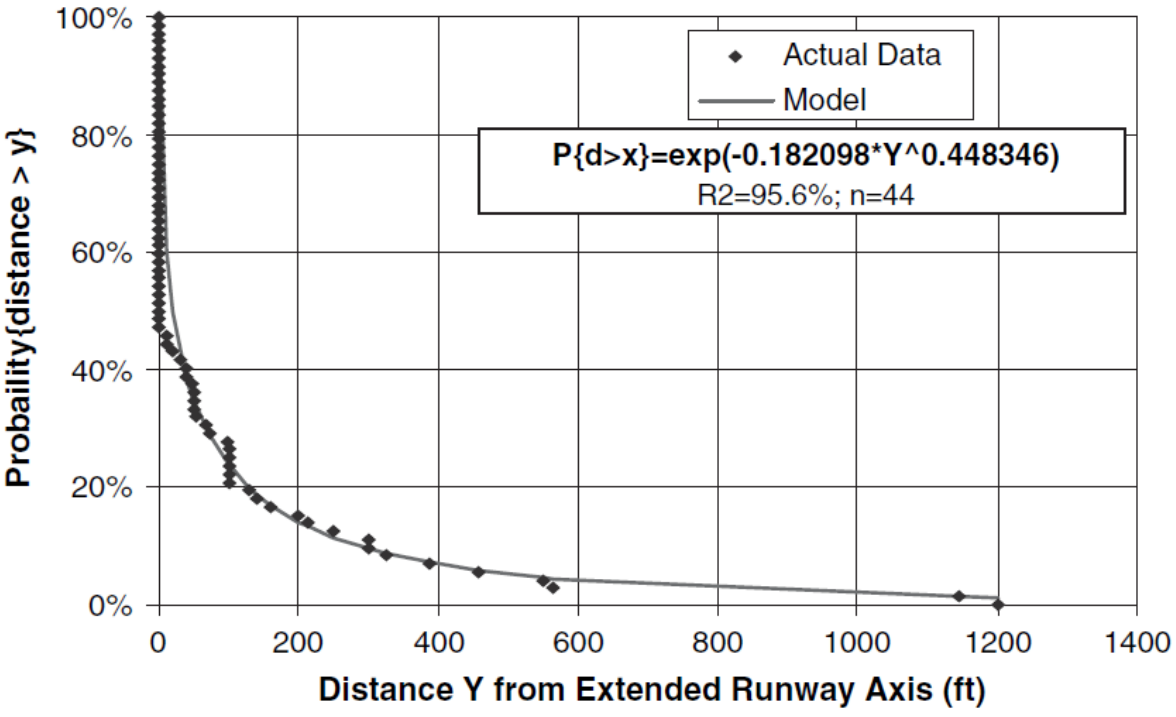
Table 2 shows a summary of all of the models presented in this section.

Figure 5
Raw Distances Model for Takeoff Overruns



Source: ACRP Report 3, page 34

Figure 6
Raw Lateral Distances Model for Takeoff Overruns



Source: ACRP Report 3, page 34

Table 2
Summary of Location Models

Type of Accident	Model	R^2	# of Points
Landing Overrun Longitudinal	$P\{d>x\} = e^{-0.003871\ x^{0.955175}}$	99.8%	257
Landing Overrun Lateral	$P\{d>x\} = e^{-0.20174\ y^{0.489009}}$	94.7%	141
Landing Undershoot Longitudinal	$P\{d>x\} = e^{-0.024445\ x^{0.643232}}$	98.5%	82
Landing Undershoot Lateral	$P\{d>x\} = e^{-0.409268\ y^{0.351851}}$	92.0%	48
Takeoff Overrun Longitudinal	$P\{d>x\} = e^{-0.001033\ x^{1.065025}}$	99.0%	76
Takeoff Overrun Lateral	$P\{d>x\} = e^{-0.182098\ y^{0.406544}}$	95.6%	44

Source: ACRP Report 3, page 35-36

Determining the risk to the public that may be associated with Zones 1, 2, and 3 required applying the probability models shown in **Table 2** to the statistical historical accident distribution and existing and forecast operations at DLH to get a probability that an accident would occur at any given runway end that would extend into each of the custom zones. This accident probability was then applied to FAA's Safety Risk Matrices to determine the acceptability of the calculated probability.

3 ANALYTICAL RESULTS

The formulas in **Table 2** were used to create a distance from the runway end/threshold that would have a, 80%, 90% and 95% chance of containing the wreckage should an accident or incident occur. The results of the calculations are shown in **Table 3**.

Table 3
Distances Required to Contain Accident/Incident

	80% Probability	90% Probability	95% Probability
Landing Undershoot			
Distance from threshold	671 feet	1,170 feet	1,764 feet
Distance from centerline	49 feet	136 feet	286 feet
Landing Overrun			
Distance from runway end	552 feet	803 feet	1,057 feet
Distance from centerline	70 feet	145 feet	249 feet
Departure Overrun			
Distance from runway end	994 feet	1,392 feet	1,782 feet
Distance from centerline	129 feet	287 feet	500 feet

Source: ACRP Report 3, RS&H 2020

Recall, however, that the probabilities discussed above are the probabilities of an accident that has happened at the runway end will occur outside the stated distance. The ACRP analysis determined that, during a 24-year period that included more than 200 million commercial flights, only 459 accidents and incidents occurred in the runway environment that left the Runway Safety Area, which means that in the unlikely event of an aircraft incident, the probability of an aircraft leaving the runway safety area equals $459 \div 200{,}000{,}000 = 2.3 \times 10^{-6}$.

Duluth International Airport hosts approximately 62,000 operations annually, excluding traffic impacts associated with the Covid-19 pandemic. Statistically speaking, that would mean that the

number of accidents/incidents at DLH leaving the runway safety area would be 62,000 x (2.3×10^{-6}) = 0.14 per year.

A recent study of traffic at DLH by the consulting firm Landrum & Brown concluded that approximately 69% of traffic uses Runway 9-27 and 31% uses Runway 3-12. Therefore, the number of accidents/incidents anticipated to leave the runway safety area would be:

- 0.098 per year on Runway 9-27
- 0.044 per year on Runway 3-21.

As the curves in **Figures 1-6** showed, the probability of accident/incident occurrence drops dramatically as distance from the runway increases. Therefore, the risk that an accident/incident would leave the proposed Zone 1 area was calculated using the probabilities and distances shown in **Table 3**.

For Runway 9-27, the distances shown in the 95% column are contained within airport property and are within Zone 1. For Runway 3-21, the distances contained within the 80% column are contained within airport property and are within Zone 1. That is, 5% of the accidents/incidents that left the Runway Safety Area could be expected to be outside of Zone 1 for Runway 9-27 operations and 20% of the accidents/incidents that left the Runway Safety Area could be expected to be outside of Zone 1 for Runway 3-21.

Applying these percentages to the numbers of flights per year shown in the bullets above:

- 0.098 x 0.05 = 0.0049 per year, or **1 every 203.7 years for Runway 9-27**
- 0.044 x 0.20 = 0.0088 per year, or **1 every 113.4 years for Runway 3-21**

4 RISK ASSESSMENT

Some assessment of the realistic effect of the land use model must be made, to ensure the public is adequately protected without unnecessarily restricting private property rights or having the airport or other government entity investing excessively in acquiring land or easements.

Determining the acceptability of different levels of risk as consistently and objectively as possible is the basis for Safety Risk Management (SRM) processes put into place by FAA in its various safety management systems (SMS) programs. SRM is used internally by FAA's Air Traffic Organization (ATO) to assess the impacts of changes to the National Airspace System due to revisions of operational procedures as well as introduction of new equipment. FAA's Airports line of business uses SRM to identify and manage potential hazards associated with changes to airport design standards, airfield construction projects, and modification of standards applications. FAA has required airlines, maintenance shops, flight schools, and many airports to adopt SRM methodologies.

The FAA's SMS initiatives all have common goals: identifying potential hazards, developing ways to control those hazards, predicting the worst credible outcome if the hazard results in an accident, and determining the likelihood of that worst credible outcome occurring. FAA Order 8040.4B aligns the requirements of the various FAA programs.

FAA's SMS protocols require risk assessments to measure both worst credible outcome (severity) and probability (likelihood). The measure of severity is that death or injury will occur or significant property damage. The potential for fatalities generally leads to a severity ranking of either Hazardous or Catastrophic. Order 8040.4B defines the two terms as follows:

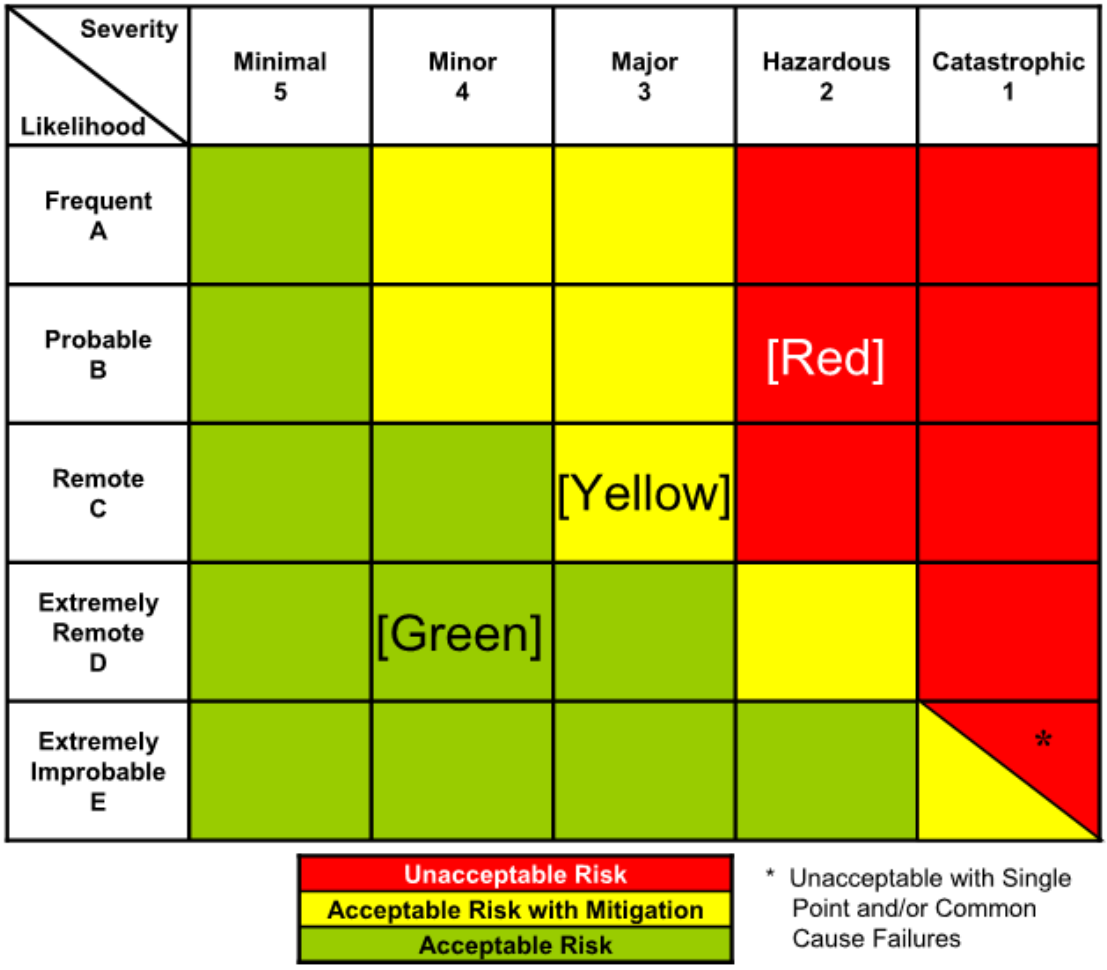
- Hazardous: Multiple serious injuries; fatal injury to a relatively small number of persons (one or two); or hull loss without fatalities
- Catastrophic: Multiple fatalities (or fatality to all on board) usually with the loss of aircraft/vehicle

For assessing likelihood, the methodology includes using quantitative data when possible, and using qualitative assessments when data is not available. Determining likelihood can be made through either subjective or statistical means. The following definitions apply:

- Unlikely to occur, but not impossible
- Expected to occur less than once every 10 years

With probabilities of an accident/incident occurring outside of Zone 1 determined to be 1 in every 203.7 years for Runway 9-27 and 1 in every 113.4 years for Runway 3-21, the standard for Extremely improbable is met. The results are then plotted on a risk matrix (see **Figure 7**) and the risk is identified as low (acceptable), medium (possibly acceptable), and high (not acceptable).

Figure 7
FAA Risk Matrix



Source: FAA Order 8040.4B

Based on the risk matrix, a severity of Hazardous or Catastrophic and a likelihood of Extremely Remote lead to an acceptable outcome.

From the standpoint of SRM, then, the risk of multiple serious injuries or fatalities due to an aircraft accident/incident occurring outside of Zone 1 appears to be acceptable under the existing definitions of Zone 1 for all four runway ends at DLH.