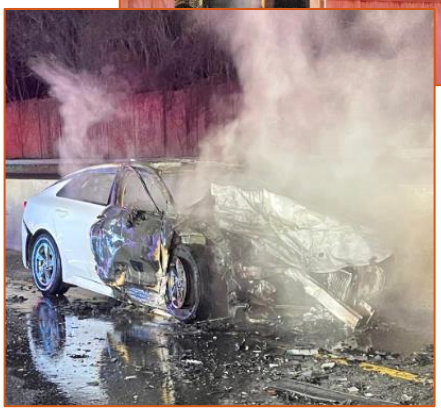
EVALUATING RISK IN MONTGOMERY COUNTY

An MCFRS Assessment of Community Risk

December 2022

Contents



Executive Summary

Risk is a concept used by the Montgomery County Fire and Rescue Service (MCFRS) to provide contextualized understanding to its mission to reduce harm and add value to our communities. Risk can be expressed as the product of threat (hazard), vulnerability (susceptibility), and consequence (magnitude) or R= T x V x C. The value of the expression is in its description of the relationship between the variables: in order to reduce risk, one must either reduce the threat, the vulnerability or the consequence, and as any one of those factors approaches zero, risk also approaches zero.

The concept of risk also includes the notion of vulnerability, where vulnerability is defined as the susceptibility of an entity to the adverse impact of exposure to hazards. According to the Federal Emergency Management Agency: *A community's social vulnerability score is proportional to a community's risk*[1]. Another way to think about vulnerability is as a lack of resilience. A community's resilience is inversely proportional to its risk. Social vulnerability is tightly coupled with prevailing notions of racial equity and social justice, in that the factors that predict social vulnerability also predict fire, injury, and other risk. This relationship drives the MCFRS notion that building community resilience is an important supporting strategy for racial equity as much as it is a strategy for reducing risk.

The risk remaining after reasonable controls and system capacity have been provided is called residual risk. Deciding what residual risk is "acceptable" is a political choice, but generally, it is, "...that level of risk which can be further lowered only by an increment in resource expenditure that is disproportionate in relation to the resulting decrement of risk..."[2].

In order to make "assessments" of risk, MCFRS started with the R = T x V x C framework but to facilitate calculations, we grouped the factors on the right side of the equation into two broad categories: mitigating factors (things that lower risk) and aggravating factors (things that increase risk). This led to a new formula: Risk = Aggravating Factors/Mitigating Factors [$R = R_{AF}/R_{MF}$]. With this modification, it is easier for us to make some normalized generalizations about risk across the County and in specific communities. The balance of this document details how MCFRS has applied the $R = R_{AF}/R_{MF}$ framework and how the results of that analysis are consistent with similar work done by the Red Cross, FEMA, the IAFF, and the CDC.

Historically, MCFRS has addressed risk at the hyper-local box area level (risk management zones). We must consider moving away from this level of focus and towards evaluating risk at the census tract level. If our efforts at reducing risk are based on increasing community resilience, and if shared community demographics inform resilience, it makes sense to evaluate risk at the level of shared demographics, e.g., the census tract. As MCFRS looks into the future, it hopes to leverage the notion of resilience as an antidote to vulnerability to reduce harm and add value in our communities. Considering risk in this way allows the emergence of opportunities to reduce risk *ex-ante*, where it is much cheaper to do and much more effective, than solely on the *ex-post* solution, emergency response.

[1] FEMA. (2022). Community Resilience. Retrieved from https://hazards.fema.gov/nri/community-resilience

[2] Manuele, F.A. (2010). Acceptable Risk. Retrieved from https://aeasseincludes.assp.org/professionalsafety/pastissues/055/05/F1Manuel_0510.pdf

Risk in Context

This document provides a contextualized understanding of risk as an idea applied by the Montgomery County Fire Rescue Service (MCFRS) as a framework to reduce harm and add value to our communities.

MCFRS treats risk as a state where an entity (*person or property*) is exposed to a hazard, where a hazard is something that can cause harm. Exposure to hazards is a natural part of the human condition. Not all risk can be eliminated. When considering the hazards that MCFRS protects against, it is not feasible, practically or economically, to bring risk to zero. The risk remaining after reasonable hazard controls and system capacity have been provided is called residual risk. Deciding what level of residual risk is "acceptable" is a political value and moral choice. Generally, acceptable risk is, "…that level of risk which can be further lowered only by an increment in resource expenditure that is disproportionate in relation to the resulting decrement of risk…".[3]

There are two prevailing risk frameworks. The first considers risk as the product of probability and severity: Risk = Probability x Severity [R = P x S]. The second frames risk as the product of threat, vulnerability, and consequence: Risk = Threat x Vulnerability x Consequence [R = T x V x C]. The frameworks are of value for defining the relationship between the variables.

The first framework is useful mostly because of its pragmatic simplicity. It expresses that in order to reduce risk, one must either reduce the probability that a given hazard exposure will cause harm or reduce the harm caused when the exposure happens. The second framework adds the notion of vulnerability. Vulnerability is the susceptibility of an entity to the adverse impacts of hazards. Another way to frame that idea is as the lack of capacity to absorb the "consequence" of hazard exposure and emerge intact. The ability to emerge intact can also be called resilience. In this way, vulnerability is the absence of resilience and by improving resilience, one can reduce vulnerability and therefore reduce risk. If we consider "threat" to be synonymous with "probability," and "consequence" to be synonymous with "severity," vulnerability becomes a major driver of risk.

It is also in this way that vulnerability is tightly coupled with prevailing notions of racial equity and social justice, in that there are pre-conditions, expressed as lack of resilience, that are co-morbid with considerations of social vulnerability in general. It is true that many of the same factors that make one socially vulnerable also makes them vulnerable to fires, injury, and accidental death. In that way, MCFRS sees the building of community resilience as an important supporting strategy for racial equity.

Racial Equity and Risk

The Montgomery County Executive and Council established racial equity as a central guiding principle and priority in 2019 for all government activities, with the signing of the Racial Equity and Social Justice Act, which, among other things, requires all County departments to develop and apply an equity framework, a frame of reference that enables each department to navigate the complexities of equity and develop the capacity to engage in a purposeful action, to everything it does. Montgomery County also joined the Government Alliance on Race and Equity (GARE) network, which recommends a three-pronged approach to systematically reduce and eliminate racial inequities in government.

[3] Manuele, F.A. (2010). Acceptable Risk. Retrieved from https://aeasseincludes.assp.org/professionalsafety/pastissues/055/05/F1Manuel_0510.pdf

Using the recommended GARE framework, and applying what GARE calls an equity lens to our work, MCFRS has started to have some important discussions and ask some critical questions: What end condition(s) are we seeking? What areas do we have the most influence over? What **processes** (owned by MCFRS) have statistically significant differentiation that can be attributed to race? What **outcomes** (that MCFRS has a role in) have statistically significant differentiation that can be attributed to race? We have only started to scratch the surface of responding to these questions, but we do know that the mission of the department is to improve public safety and minimize the impact of hazards, and we do that by improving community resilience.

The MCFRS Operational Doctrine states, in part: "Many of the people assisted by MCFRS personnel are in a vulnerable position; they are either unable to resolve the issue at hand for themselves or they are unable to advocate for themselves. In some cases, personnel will need to act as a gateway to other agencies and services. In other cases, personnel will need to be advocates for those who cannot advocate for themselves. Personnel must never lose sight of their role as public servants and the importance of advocacy to that role." Ergo, it is reasonable to use *vulnerability* as a surrogate for *equity*. Conducting this community risk assessment is an opportunity to identify and highlight the vulnerabilities to different hazards throughout the County. Recognizing that inequity and vulnerability are co-morbid, MCFRS can continue to support the advancement of racial equity by building sustainable community resilience: educating against harm, preparing against harm, limiting damages from harm, and assisting with recovery. Where we build resilience, we will reduce inequities.

Understanding Risk in the Community

Why is it important?

It is important is to establish the framework for how MCFRS approaches risk in order to enable an apples-to-apples comparison of the methodologies utilized to address risk in the community. Given the varying use of the word *risk* throughout daily life, it is too easy to conflate disparate notions, thereby confounding efforts to maximize value.

The MCFRS approach considers "community" at various levels; first, from a "whole of County" perspective, then also from the perspective of individual communities. Resource deployment, e.g., a specific ambulance, is important at the whole of County level in that it provides system-wide capacity. We send the closest unit regardless of its geo-based home. However, there are considerations for individual communities, especially with respect to ensuring racial equity and the idea that resources should be deployed, to the extent possible, to either reduce inequities or at the least, not create new inequities.

This represents a fundamental shift for MCFRS. We have historically considered risk using fire station box areas as the primary delimiter. This historical practice is problematic because box areas are artificial creations based on ancient technologies that could not provide a real time accounting for unit location and instead, based response order on a static imagining of space. Furthermore, box areas are based on station location, which was based solely on the judgement of the local fire and rescue departments and the availability of land at the time location decisions were made. The box area cannot define a community.

Census tracts generally have a population size between 1,200 and 8,000 people, with an optimum size of 4,000 people. A census tract usually covers a contiguous area; however, the spatial size of census tracts varies widely depending on the density of settlement. The census tract provides a more adequate definition of community because they benefit from a more consistent rule set for delineation, more consistent application over time, and, most importantly, because the measures of demographics leading to social vulnerability are tied to census tracts.

Risk assessment is more of a deliberative process than an analytical process. Ideas of probability and severity are highly dependent on context. The determination of community risk requires the application of contextual judgment. Further, the notion of probability implies *knowing*. For example, answering the question, "what is the probability that any one person in Montgomery County will be harmed by a hazardous material?" requires certain knowledge of future states, a knowledge that we cannot have. Despite the presence of inherent uncertainty, it is of value to have a codified approach to characterizing risk. Part of the core mission of MCFRS is to prevent exposure to risk and where that is not possible, to mitigate (or reduce) the impact of that risk. Though MCFRS cannot reduce any risk to zero, the department strives to:

- Prevent the realization of risk to the extent possible, primarily through education
- Reduce risk to the lowest reasonably achieved level
- Maximize mitigation via improved community resilience

Hazards

Probability & Severity

Those who live, work, and visit Montgomery County face several different hazards including, but not limited to:

- Fire (involving structures, vehicles, trains, aircraft, vegetation, other property)
- Illness, disease, bodily injury, and other medical conditions
- Transportation networks (e.g., highway, rail, air) and vehicles/trains using them
- Hazardous materials, including destructive/explosive devices and weapons of mass destruction (WMD)
- Terrorism and other acts of violence
- Natural/environmental hazards (e.g., thunderstorms, tornados, winter storms, floods, drought, temperature extremes)
- Drowning in bodies of water (rivers, streams, lakes, ponds) and swimming pools

How likely is it (or what are the chances) that an exposure to a given hazard will result in harm? And what is the severity of the relative impact of the harm caused by a given hazard? This is difficult to quantify, and dependent on many factors. The likelihood or probability of these hazards vary. For example, there is a low probability that on any given day, a train carrying hazardous materials would derail, leak, and produce a toxic vapor cloud within a densely populated area of Montgomery County, yet on that same day, there is a high probability there is a two-vehicle collision on the Outer Loop with non-life-threatening injuries. Likewise, the consequences of both events vary significantly. The consequences of the train derailment could impact tens of thousands of people, whereas the impact of the vehicle collision would be minor, in comparison. Thus, risk can be examined and compared subjectively in terms of categories, as presented in this risk matrix. Using a four-quadrant model, we can characterize the magnitude of risk using probability and consequences. The idea of vulnerability is embedded in "consequences."

Figure 1: Risk Matrix

Vulnerability

Vulnerability is a complex matter, but necessary to our understanding of risk in the sense that we acknowledge that risk not only depends on the severity of the hazard, or the number of people exposed, but is also a reflection of the susceptibility of people and assets to suffer loss and damage (their level of resilience). Some people experience higher levels of vulnerability than others. Vulnerable people/communities find it harder to recover or reconstruct their livelihoods following exposure to, or an experience of a hazard, thereby making them more vulnerable to the effects of subsequent hazard events. Consequently, we have to reduce vulnerability, or improve resilience, in order to reduce risk.

The causes of vulnerability, from the underlying drivers (e.g., socioeconomic processes) to the immediate conditions that present themselves (e.g., lower quality housing, market conditions), can be complex, but by identifying and tracking the causes, we can then identify the vulnerabilities that build pressure on certain communities and alleviate that pressure by taking measures to reduce vulnerability and increase resilience along the causal chain. It is imperative that we focus on understanding people's capacity to resist and recover from a hazard event, and enhancing the overall resilience of people and systems, and thereby reduce risk.

How MCFRS Assesses Risk

When MCFRS last conducted a community risk assessment (2017), planning staff considered the probability of an event causing injury/illness, property damage and/or business interruption (e.g., building fire, vehicle collision, hazardous material leak, winter storm), in combination with the consequences or severity of that event. A point scale was developed and assigned to each different factor, and a cumulative "risk score" total was derived for each risk management zone (RMZ), or box area. Based on the cumulative score, each RMZ was assigned a risk category for each type of hazard, similar to the risk matrix above.

Over the course of the last two years, as discussions about risk unfolded and planning personnel began preparing to update the Fire, Rescue, and Emergency Services Master Plan, it was obvious that the previous process to assess risk should be revised. However, given delays caused by the pandemic, deadlines for completion of certain tasks prior to the department's onsite accreditation review in 2023, and work surrounding the Master Plan, the decision was made to delay a large-scale revision to the assessment process, but begin with some modifications to the subjective mathematical approach used to determine the risk score.

Instead of a cumulative score based on likelihood and impact, the Planning Section considered risk to be the quotient of the sum of a series of risk or aggravating factors (the conditions that increase vulnerabilities, whether physical, functional, or systemic) divided by the sum of mitigating factors (the physical characteristics present, and the actions taken by the department to reduce vulnerability). Mathematically, it looks like this:

Risk = aggravating factors/mitigating factors [$R = R_{AF} / R_{MF}$]

This mathematical formula is not perfect or without limitations, but it does provide a methodology for normalizing risk considerations across a diverse range of local circumstances. MCFRS still assigned a subjective range of points to each aggravating and mitigating factor for each hazard category the department has a role in preventing and mitigating: structure fires, emergency medical services, hazardous materials, technical rescue, water/ice rescue, bombings/explosions, aircraft rescue/firefighting, and brush/wildland fires.

MCFRS still used the box areas as the designated risk management zones, but we recognize the limitations of using so many small geographical areas. There are 840 random, unique box areas. There are no consistent characteristics (e.g., size/area), so when extrapolating demographic data at this level, the numbers are often so small that some box areas receive no points for certain aggravating factors.

Data representing the population and pertinent factors was obtained from the 2020 U.S. Census.

Response times were based on a five-year analysis of computer-aided dispatch (CAD) timestamps at the 90th percentile for urban and rural density zones (FY18-FY22). First-arriving unit (FAU) times measure the time from when the call was received by the Emergency Communications Center until the first unit arrived on scene. Effective response force (ERF) times measure the time from when the call was received by the ECC until the minimum number of apparatus and fire/rescue personnel reach a specific emergency incident. For any category in which there were no incidents in a box area and therefore no response times, a single point was assessed for a mitigating factor.

Once the risk quotient was determined for each risk management zone, the score was further categorized to define risk as low, medium, high, or special. The closer the risk quotient is to zero, the lower the risk in that box. Box areas with risk quotients that fall at the upper range of the score (furthest from zero) for the respective hazard types are classified as special risk. The mathematical change in the "formula" to assign a score and categorize risk caused some changes to the risk maps, which are presented by hazard category on the following pages. The most significant changes occurred within the structure fires and emergency medical services categories, and an attempt was made to explain the differences between the 2017 and 2022 assessments.

It is also important to note that the categorization of a box area with a risk level should not be confused with the risk classifications assigned to every incident during the initial dispatch of the call. There could still be a high- or special-risk incident within a box area classified as a low or moderate risk zone.

To view the box areas in more detail, visit the interactive map. The map opens with structure fire risk displayed, but users can modify the layers under the content heading on the left. To see how points were assigned to the various factors, view the complete risk scoring matrix. For questions about this process, the scoring, or the maps, please contact the Planning & Accreditation Section.

Hazard: Structure fires

Aggravating Factors	Description
Incident frequency	Number of dispatched reported structure fires, moderate risk fire incidents, and low risk fire incidents reported in box areas (RMZs), which suggests likelihood of future incidents and greater impact on the department's ability to provide ongoing services to the remaining areas of a community.
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ). The higher the population density, the higher the likelihood of a fire incident occurring, and the consequences could be greater.
Percentage of Black/African American population	Percent of estimated population within the box area (calculated on a percentage of the census block) who are black/African American. Research indicates that black/African American people are disproportionately victims of injury/death caused by fire.
Percentage of population 65 years or older	Percent of estimated population within the box area (calculated on a percentage of the census block) who are 65 years old or older. Research indicates that seniors are disproportionately victims of injury/death caused by fire.
Percentage of population 4 years old or younger	Percent of estimated population within the box area (calculated on a percentage of the census block) who are 4 years old or younger.
Number of households/ facilities with one (1) or more persons with a disability	The presence of at least one person with a disability elevates the risk related to fire. Visual and hearing disabilities can affect a person's ability to react and respond to an emergency. Those with mobility issues could have difficulty escaping a dangerous environment.
Non-English-speaking residents	Measure of how well the population within a box area speaks English. Language and cultural norms may result in a delay of calling 911 and challenges communicating the emergency.
Median household income	Median household income within the box area (calculated on a percentage of the census block). Those living below the median could be living in an environment characterized by overcrowding, unsafe heat sources, older homes, etc. People living below the median income level may have less means to maintain the safety of their home.
Number of high-rise buildings	Fires in high-rise buildings present greater challenges to responders and have higher potential to impact multiple families and businesses.

Mitigating Factors	Description
90th percentile first arriving engine total response time to all reported fire full assignment structure fires within each box area (RMZ)	A measure of how quickly the first engine arrives and can get water on the fire.
90th percentile total response time for the ERF in dispatched reported fire full assignment structure fires in ***hydranted*** box areas (RMZs)	A measure of how quickly the full complement of apparatus arrives onscene in hydranted areas and takes steps to mitigate the incident.

Mitigating Factors	Description
90th percentile total response time for the ERF in dispatched reported fire full assignment structure fires in ***non-hydranted*** box areas (RMZs)	A measure of how quickly the full complement of apparatus arrives onscene in non-hydranted areas and takes steps to mitigate the incident.
Predominant residential zoned housing stock within a box area (RMZ) is sprinklered	Generally, the risk/impact of fire is reduced by the presence of sprinklers. An RMZ is considered sprinklered if at least 50% of the residential housing stock includes single family homes built in 2005 or later and/or garden apartments and townhouses built in 1989 or later.
Hydranted v non-hydranted	Generally, it is easier to mitigate a structure fire where there is a readily available water supply (hydrants).

The final risk map for structure fires looks much different this year than in the past, when there were more boxes (risk management zones, or RMZ) designated as high and special risk. This is largely attributed to the change in calculating the risk score and the use of box areas as RMZs.

Two aggravating factors that were used previously were not used: total structure fire loss (in dollars) and the percentage of the population without a high school diploma.

There are several new aggravating factors considered this year, including the percentage of black/African Americans; the percentage of children 4 and under; households/facilities with disabilities; and non-English speaking residents. Each of these factors have been shown to be more prone to injury or death due to fire.

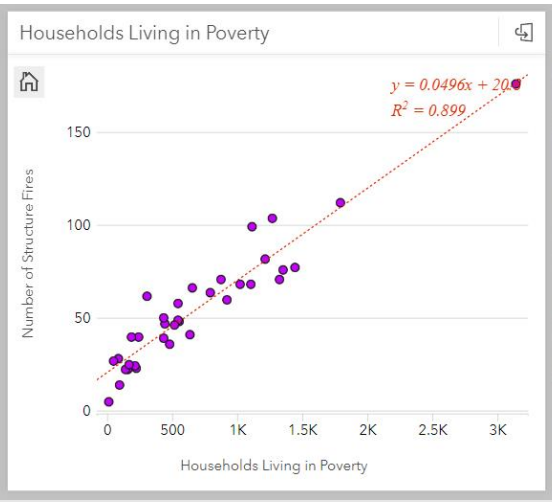
The International Association of Fire Fighters (IAFF) Headquarters recently provided technical assistance to MCFRS[4], performing regression analysis for fire and emergency medical incidents. This statistical process identifies a relationship between independent and dependent variables. The output of the regression model indicates that the independent variables used in the model accurately predict the dependent variable. R-Squared (R^2) is a statistical measure in a regression model that determines the proportion of variance in the dependent variable that can be explained by the independent variables. The output of the regression model determines if the independent variables used in the model accurately predict the dependent variable. An R^2 closer to 1 signifies a model where the independent variables accurately predict the dependent variable. For structure fires, the IAFF found several variables associated with the risk of fire; the strongest predictors were people living below the poverty line, households with minimum one person with a disability, multi-family residential structures, people with an education attainment of less than a high school diploma, and population 65 or older.

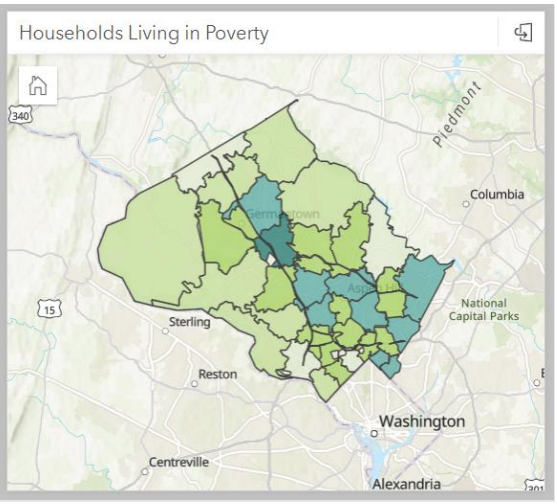
Overall, the IAFF calculated the R^2 for structure fires to be 0.95, which indicates a high confidence that the independent variables influence the dependent variable. Risk levels were divided into four tiers, 1 to 4, with tier 1 having the least risk and tier 4 having the most. The images on the next few pages highlight each of the independent variables, as well as the overall risk for the entire County.

[4] International Association of Fire Fighters (2022). Montgomery County Risk Assessment.

Households Living in Poverty

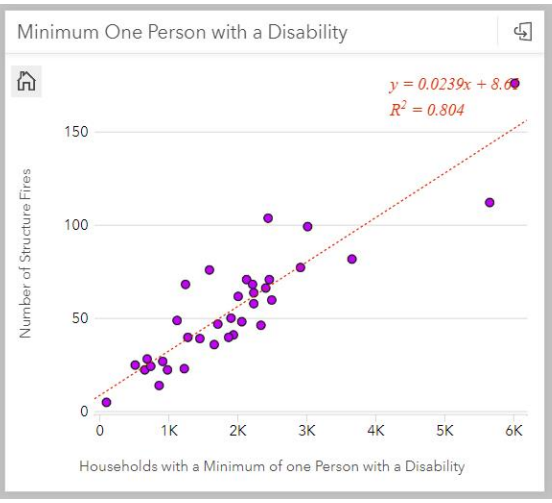
Those living below the poverty line could have factors associated with an elevated fire risk. These factors include overcrowding, unsafe heating sources, rental-occupied homes, vacant homes, and older homes. These people also may have less means to maintain the safety and maintenances of their home.

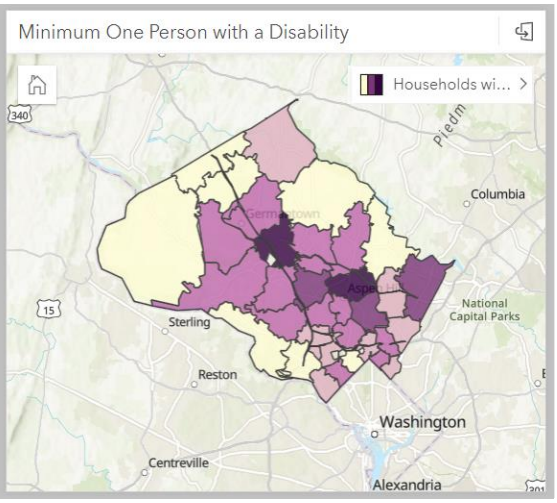




Households with Minimum One Person with a Disability

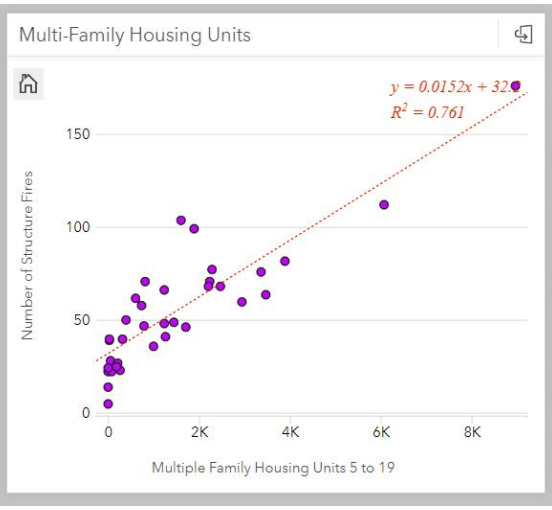
Households with person with a disability have factors associated with an elevated fire risk. Visual and hearing disabilities can affect a person's ability to react and respond to an emergency. Those with mobility issues could have difficulty escaping a dangerous environment.

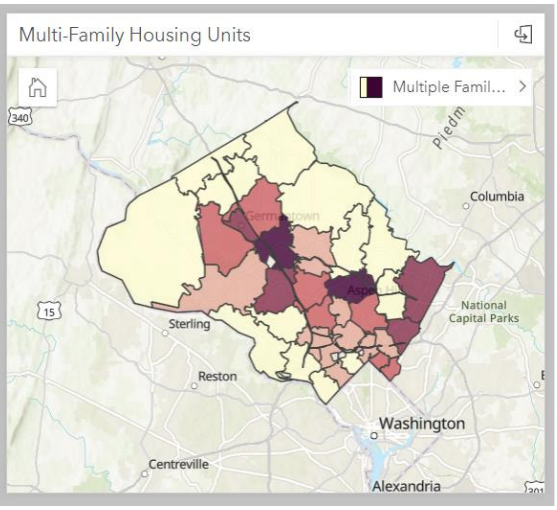




Multi-Family Housing Units

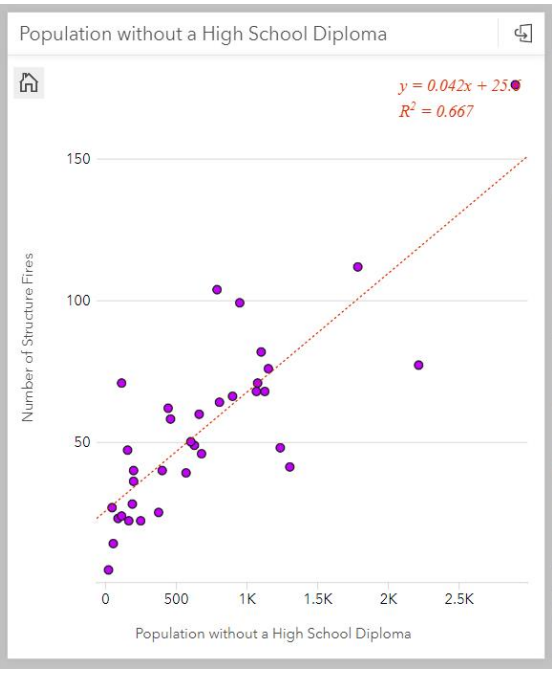
Multi-family housing includes apartments, town houses, row houses, and condominiums which are high-occupancy buildings. These buildings are usually maintained by a landlord or property manager who may neglect appliance upkeep and fail to ensure smoke alarms functions.

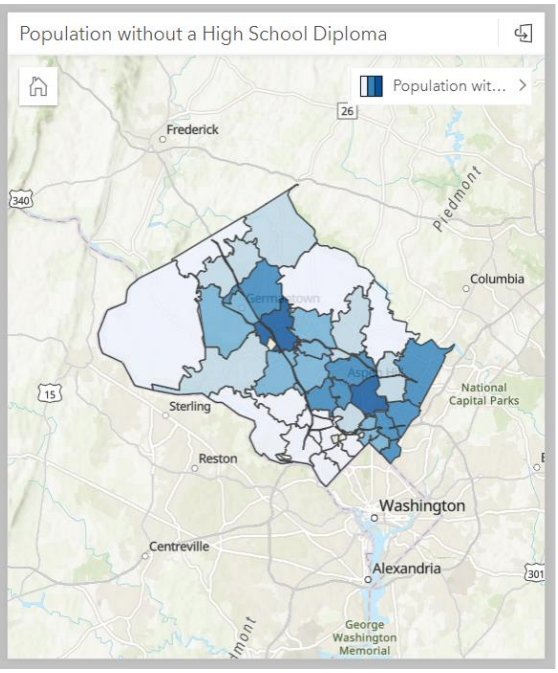




Population without a High School Diploma

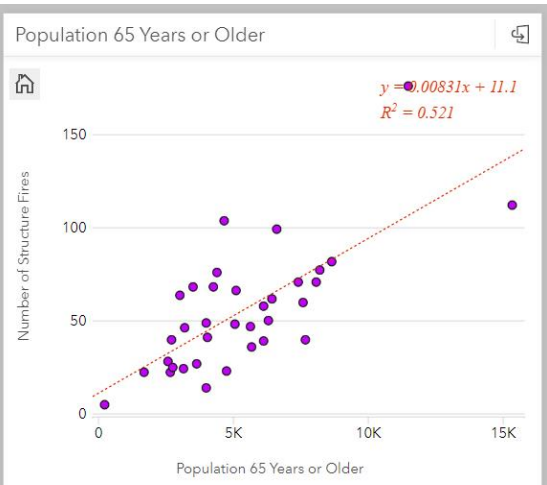
Individuals who have not completed high school are also more likely to live below the poverty line. These two socioeconomic factors create a feedback loop of increased risk due to potential crowding, unaffordability of home maintenance and/or neglectful landlords, and a lack of access to fire safety resources. Low literacy levels and/or language barriers may also hinder a person's ability to read instruction manuals and warning labels to ensure cooking and heating devices are operated safely.

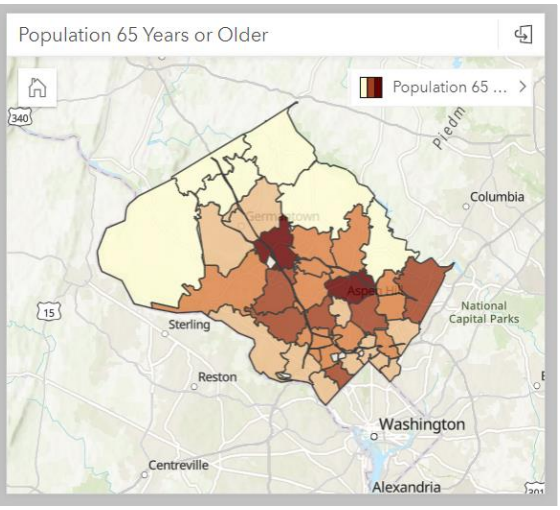


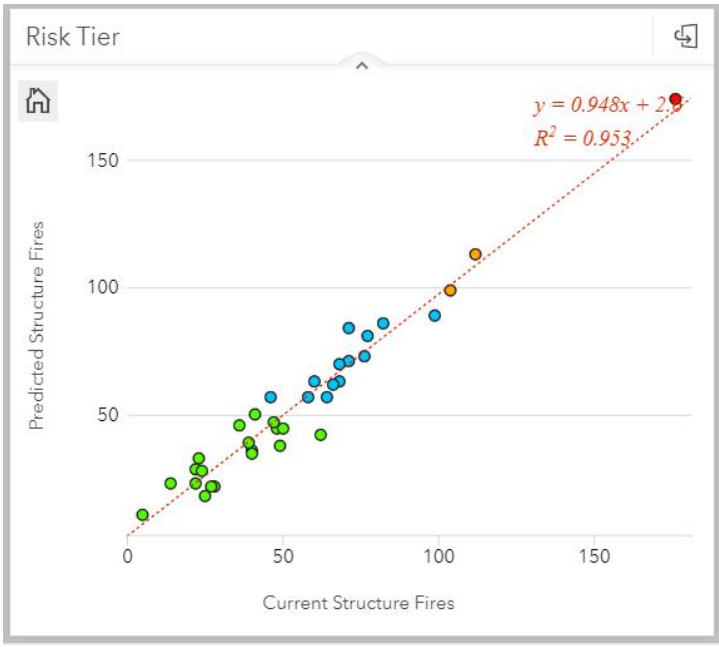


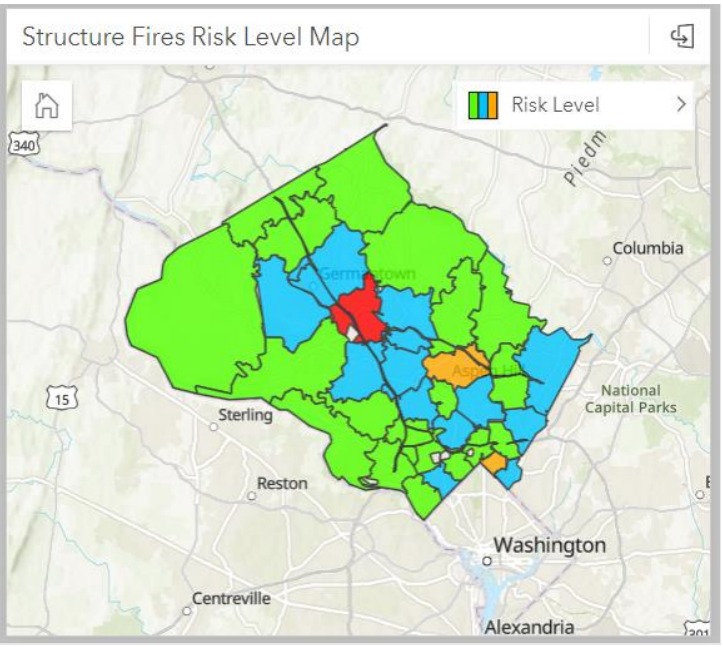
Population 65 Years or Older

Old age has considerable effects on the physical and cognitive abilities of an individual to practices fire prevention measures. This group may have issues evacuating and fire extinguishing can be difficult or impossible.







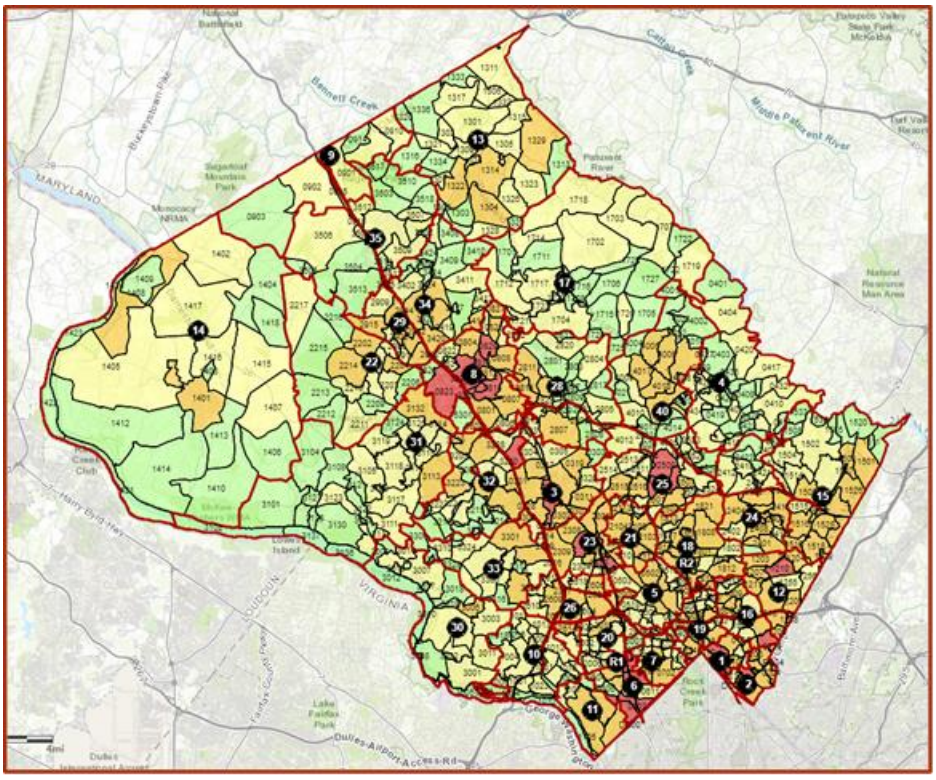


Although the IAFF used the percentage of the population without a high school diploma as an independent variable, internal discussion within the Planning Section did not feel that was as significant an issue for Montgomery County, as 91.2% of the population 25 years of age or older, are at least high school graduates, so we dropped this factor from our assessment this year.

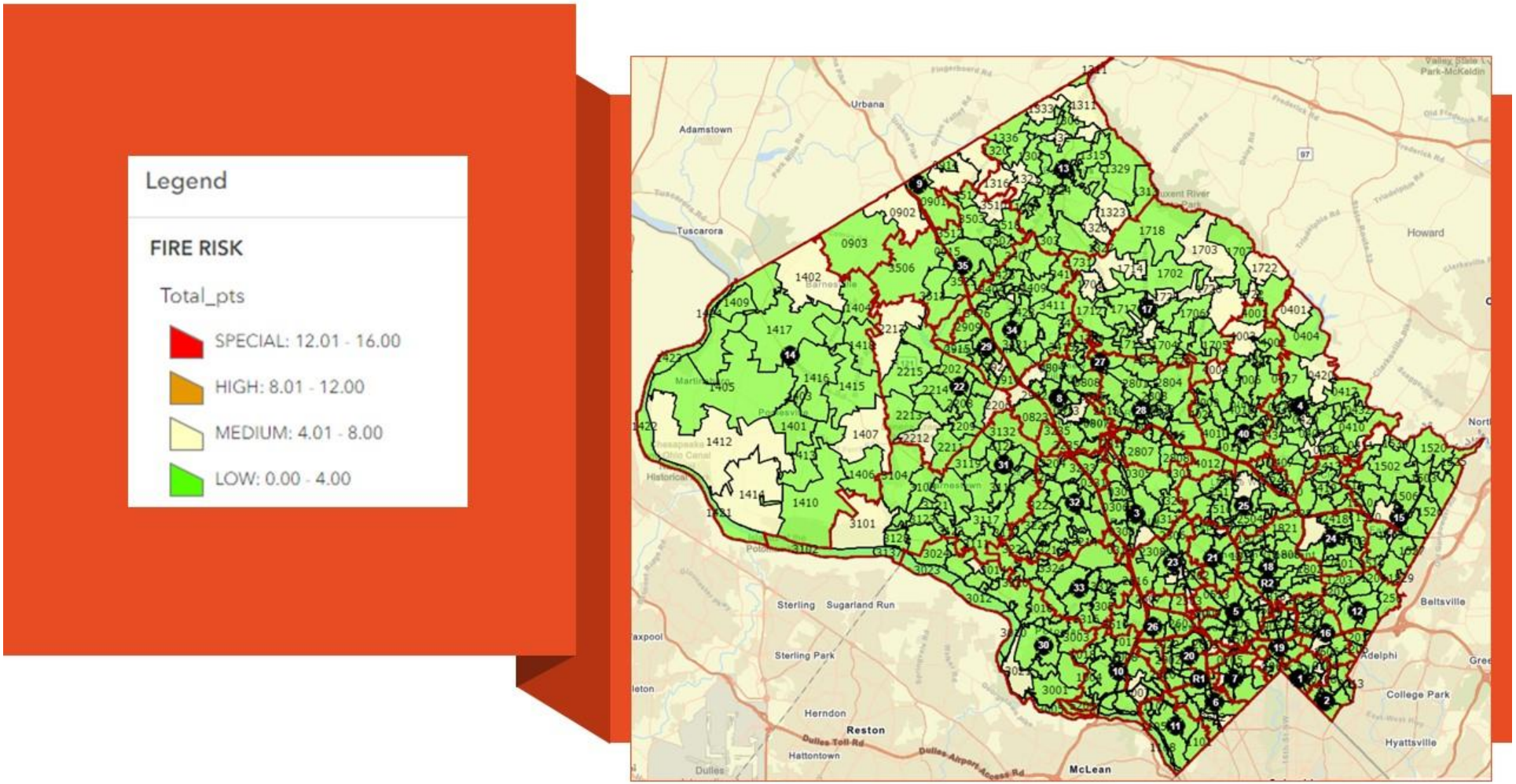
It should also be noted that IAFF conducted their analysis at the station response area, rather than the box area; thus, there are many more distinctive and obvious risk areas in their final assessment than in the analysis conducted internally, which used box areas. As mentioned previously, because there are so many box areas, with varying degrees of aggravating factors present, the risk may be "washed out" or it may be overemphasized, as you will see in some of the special operations categories, presented later in this report.

The most significant contributing factor to the reduction of structure fire risk levels in our 2022 assessment is the use of response times, the consideration of hydranted versus non-hydranted box areas, and the presence of sprinklers as mitigating factors of structure fires.

In the future, as MCFRS builds upon this model, we will consider additional aggravating factors, which may include adding the high school graduate factor back in, or assessing points for critical infrastructure and key resources (CI/KR). It is also necessary that we work to improve our ability to calculate property values, so as to attempt a quantitative measure of risk impact. Accounting for property value was discussed during this process, but there is such a limited data set related to property value; we would have only been able to account for the lot/structure of residential properties, which would not have included apartment buildings, commercial, or industrial properties, etc. And we must also work to integrate our community risk reduction activities as a mitigating factor if we wish to be thorough in this process. Every year, MCFRS distributes and installs hundreds of smoke alarms, conducts home safety inspections, and educates the community on fire safety and prevention. These activities are an important component to reducing vulnerability throughout our communities.



2017 Structure Fire Risk Map.



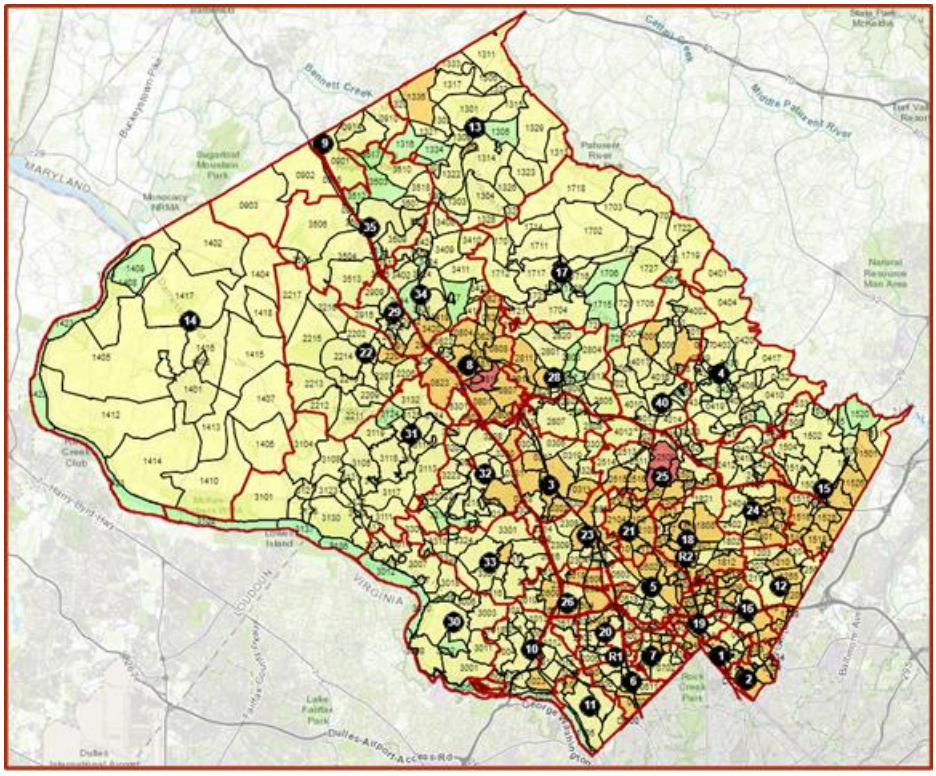
Structure Fire Risk Map, 2022; Planning & Accreditation Section.
Created with ArcGIS Pro.

Hazard: Emergency Medical Services

Aggravating Factors	Description
Incident frequency	Number of dispatched BLS, ALS1, & ALS2 incidents in box areas (RMZs), which has an impact on the department's ability to provide ongoing services to the remaining areas of a community.
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ). The higher the population density, the more demanding the stress is on the system if there was an incident with a high volume of victims/patients.
Percentage of BIPOC population	Percent of estimated population within the box area (calculated on a percentage of the census block) who are not white. Research indicates that non-white people experience health disparities (e.g., black people have a lower life expectancy than white people).
Percentage of population 65 years or older	Percent of estimated population within the box area (calculated on a percentage of the census block) who are 65 years of age or older. Aging increases the risk of chronic disease, and as people age, they are more likely to experience several conditions at the same time.
Percentage of population 4 years old or younger	Percent of estimated population within the box area (calculated on a percentage of the census block) who are 4 years old or younger. Infant/child mortality rates for this age group are high.
Non-English-speaking residents	Measure of how well the population within a box area speaks English. Language and cultural norms may result in a delay of calling 911 and challenges communicating the emergency.
Median household income	Median household income within the box area (calculated on a percentage of the census block). Research indicates that those with higher incomes generally have a better overall health condition and lower health risks, while lower income people/families generally have more exposure to health risk factors (e.g., food availability/quality, healthcare, etc.)
Number of assisted living and skilled nursing facilities within a box area (RMZ)	Assessed points for facilities in box areas (RMZs) that tend to have high call volume.

Mitigating Factors	Description
First arriving unit (paramedic) total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the first unit arrives.
Total response time for ALS2 ERF at the 90th percentile in urban and rural density zones	A measure of how quickly the full complement of apparatus arrives onscene and takes steps to mitigate the incident.

Like the risk scores for structure fires, there were different results this year in the scores and map for emergency medical services due to the calculation change. Again, the factor accounting for no high school graduate was eliminated, and three new aggravating factors were added: the percentage of black, indigenous, and people of color (BIPOC); the percentage of children 4 years of age and younger; and the percentage of non-English speaking residents.



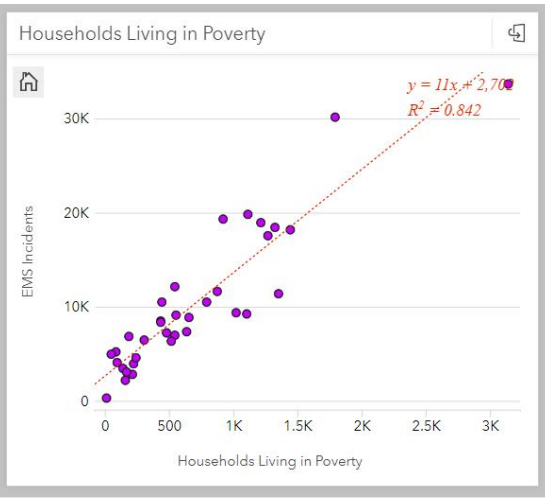
2017 Emergency Medical Risk Map.

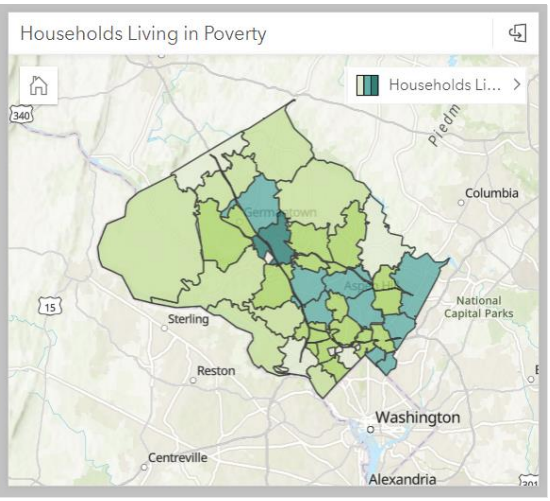
The assessment conducted by the IAFF[5] identified four independent variables associated with the risk of EMS incidents: the number of households living below the poverty level, number of households with one or more members having a disability, number of people below five years old, and the number of people 65 years or older. The images on the following pages highlight each of the independent variables, as well as the overall risk for the entire County, which calculated to 0.95 in the IAFF regression analysis.

[5] [5] International Association of Fire Fighters (2022). Montgomery County Risk Assessment.

Households Living in Poverty

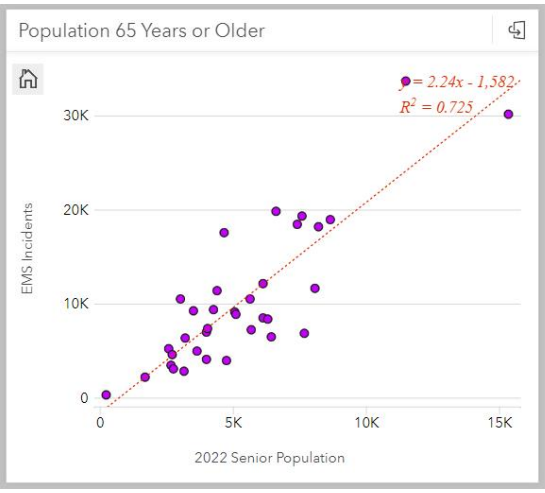
Those living below the poverty line often cannot afford requirements for good health such as quality food, regular health care visits, and the out-of-pocket costs of seeking health care. Unhealthy practices lead to a higher risk for medical complications resulting in an increase in EMS demand.

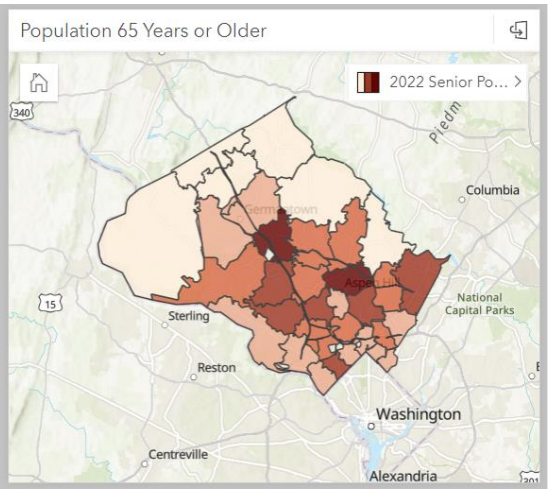




Population 65 Years or Older

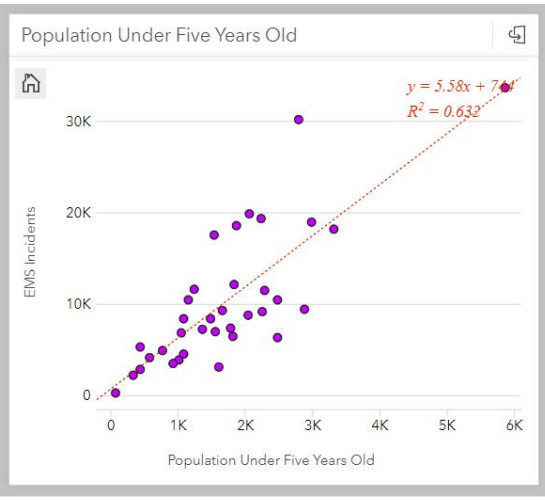
People aged 65 and older tends to place an increased demand on emergency medical resources due to greater incidence of illness, disease, and injury.

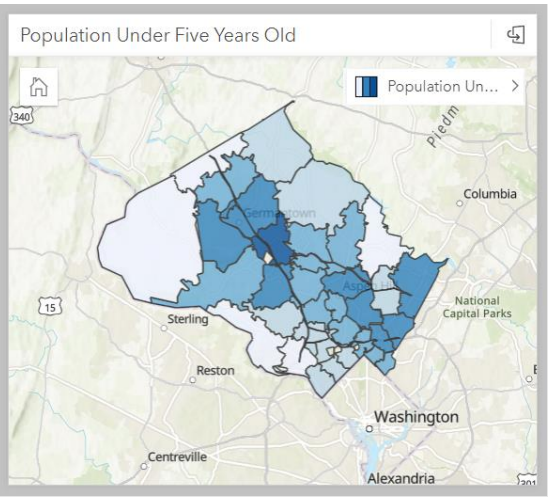


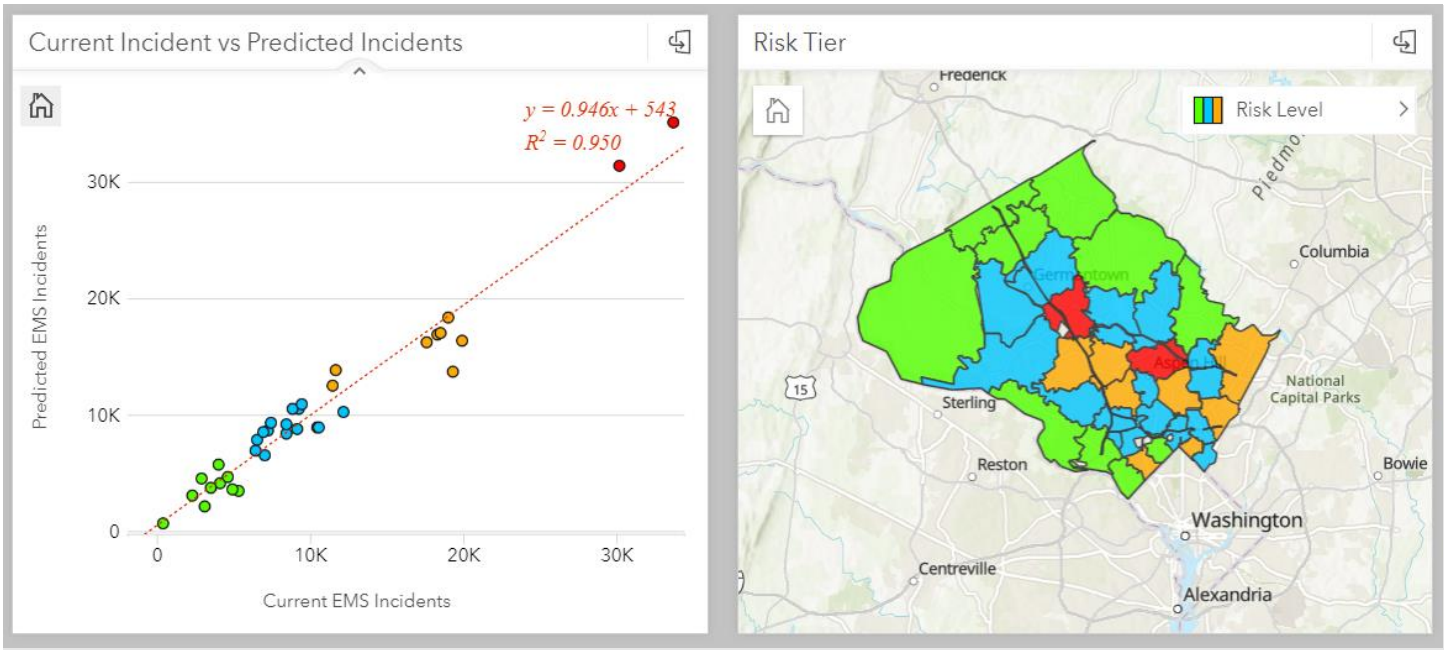


Population Under Five Years Old

People under five years old place an increased demand on emergency medical resources due to relying on others to care for illness or injuries.

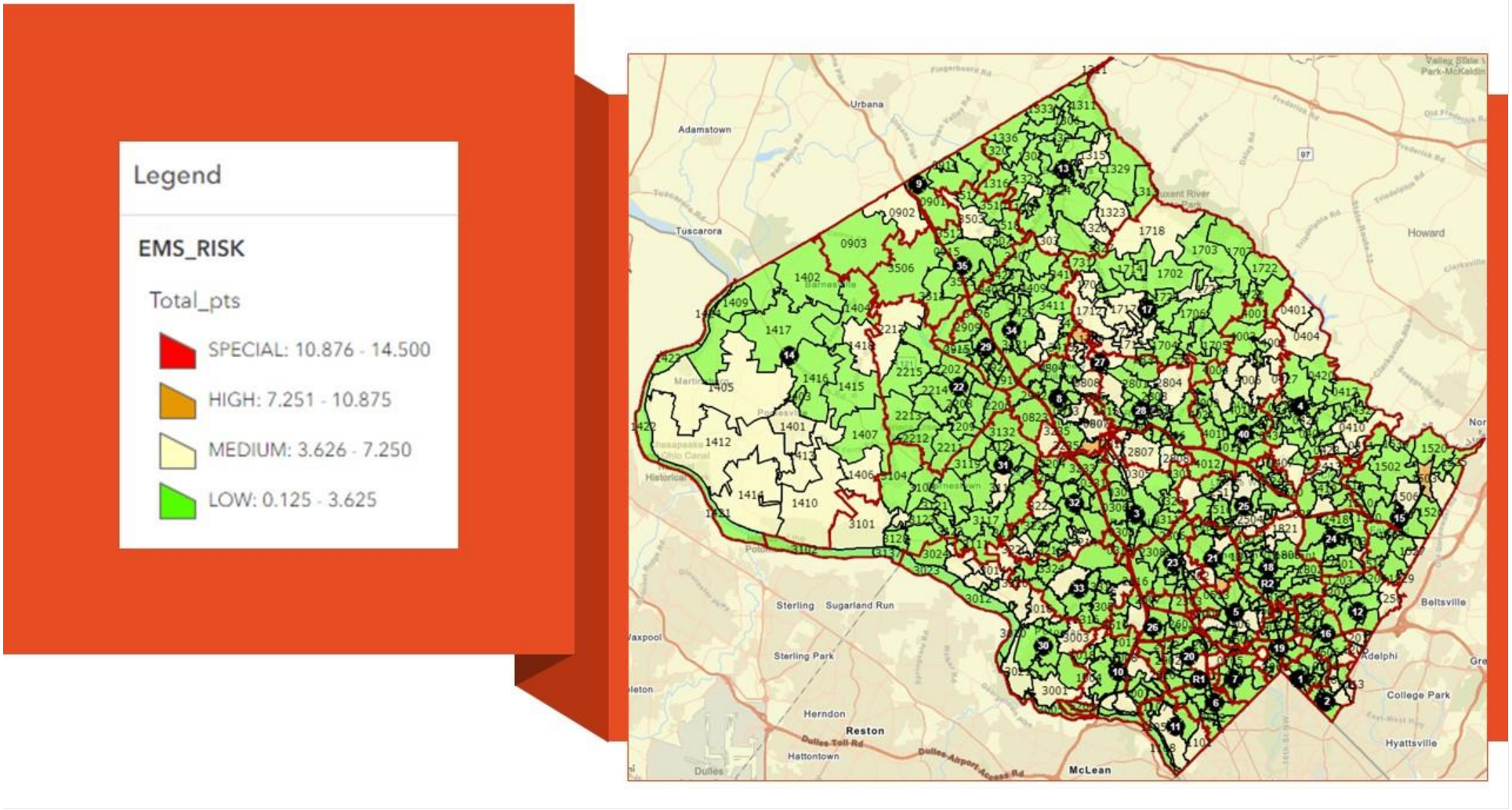






The R^2 scores for each of the independent variables in this part of the assessment are not as high as the independent variables in the structure fire analysis. Emergency medical incidents comprise approximately 80% of MCFRS' workload, so a considerable amount of time was spent talking about the aggravating factors in this category. While there are some similarities between the independent variables in the IAFF assessment and the aggravating factors in the 2022 assessment, there are still opportunities to expand the notion of risk as it relates to emergency medical services. This hazard category is more complex than the others, as we are generally assessing risk at a community level, but this risk in particular, occurs at the individual level. Furthermore, there are numerous health disparities and social determinants of health that we have barely begun to address in this assessment

Notably, the IAFF analysis highlighting station areas 8 and 25 as Tier 4 risk (highest level) echoes the 2017 MCFRS assessment, which classified several boxes in each of those station areas as special risk. In the 2022 assessment, there are no special risk boxes, and there are a lot more green/low risk boxes than before. The contributing factor to this change is the consideration of first arriving unit and effective response force times as mitigating measures to emergency medical incidents.



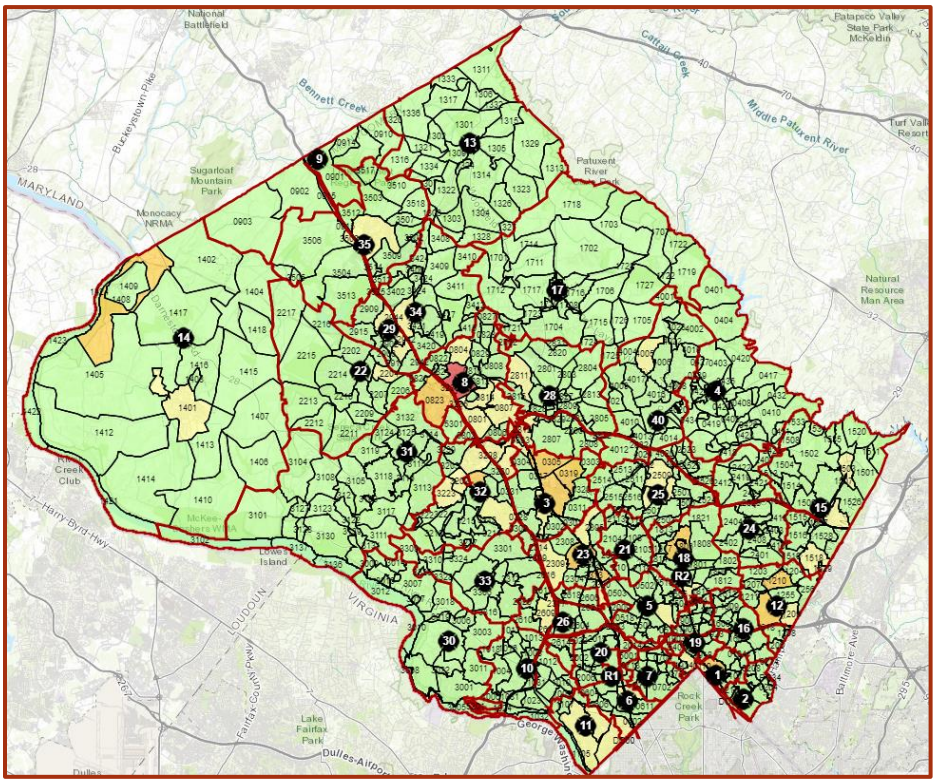
Emergency Medical Risk Map, 2022; Planning & Accreditation Section. Created with ArcGIS Pro.

Hazard: Hazardous Materials

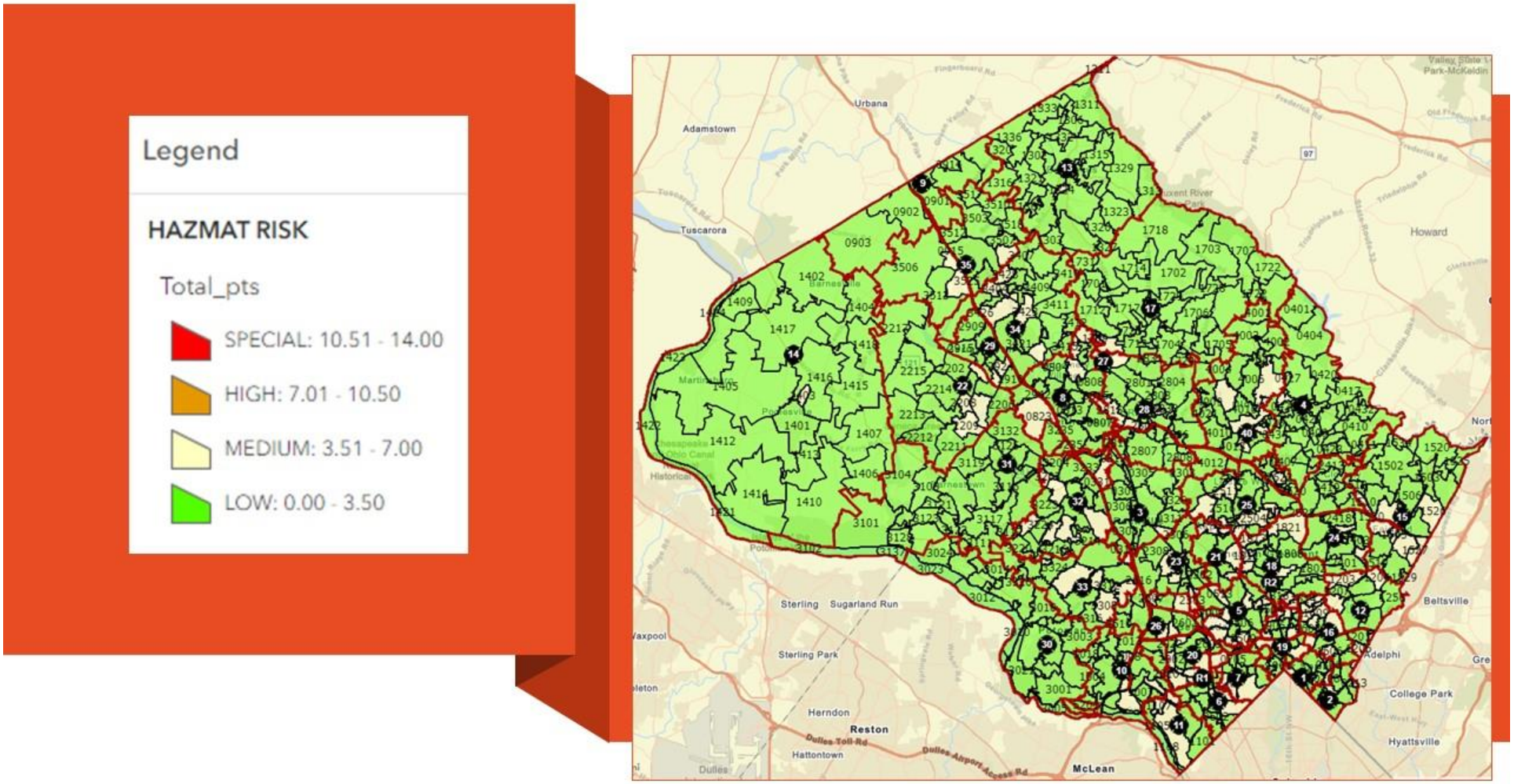
Aggravating Factors	Description
Incident frequency	Number of dispatched hazmat call types in each box (RMZ), which has an impact on the department's ability to provide ongoing services to the remaining areas of a community.
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ).
Highways	Assessed points for box areas (RMZs) that have highways.
Railroads	Assessed points for box areas (RMZs) that have railroads.
Pipelines	Assessed points for box areas (RMZs) that have pipelines.
SARA Title 3 facilities	Total # of SARA Title 3 facilities within box areas (RMZs).

Mitigating Factors	Description
First arriving unit total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the first unit arrives.

Population density is now included as an aggravating factor for hazardous materials emergencies. A serious hazardous materials incident in a densely populated area could result in a high number of victims (depending on the hazardous material involved). The consideration of response times as a mitigating factor is what changed the risk scores/classifications throughout the County this year.



2017 Hazardous Materials Risk Map.



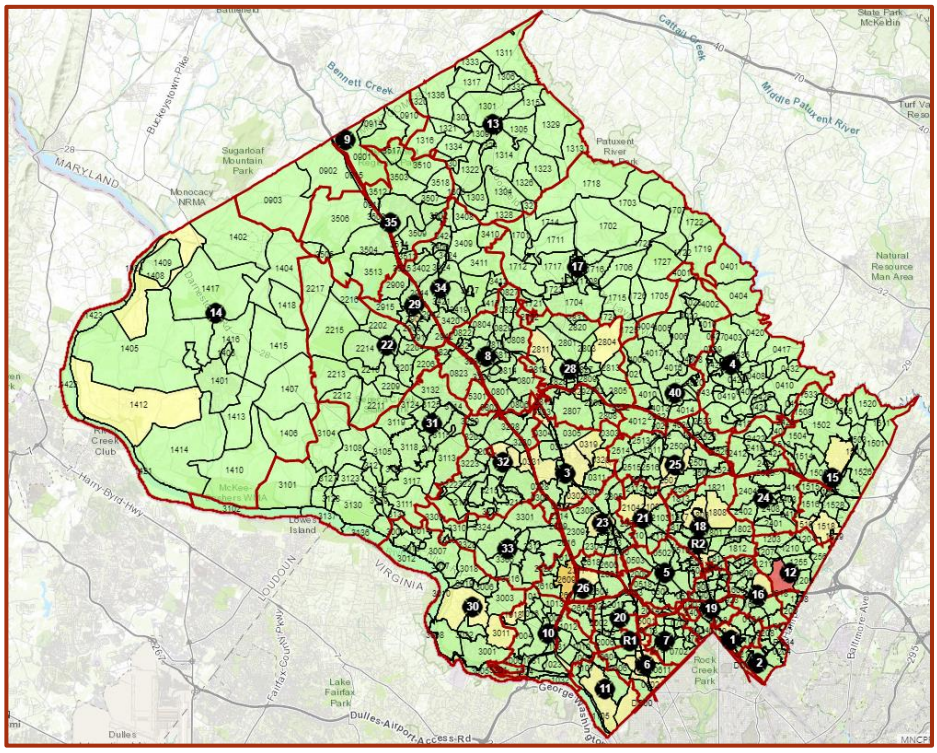
Hazardous Materials Risk Map, 2022; Planning & Accreditation Section. Created with ArcGIS Pro.

Hazard: Technical Rescue

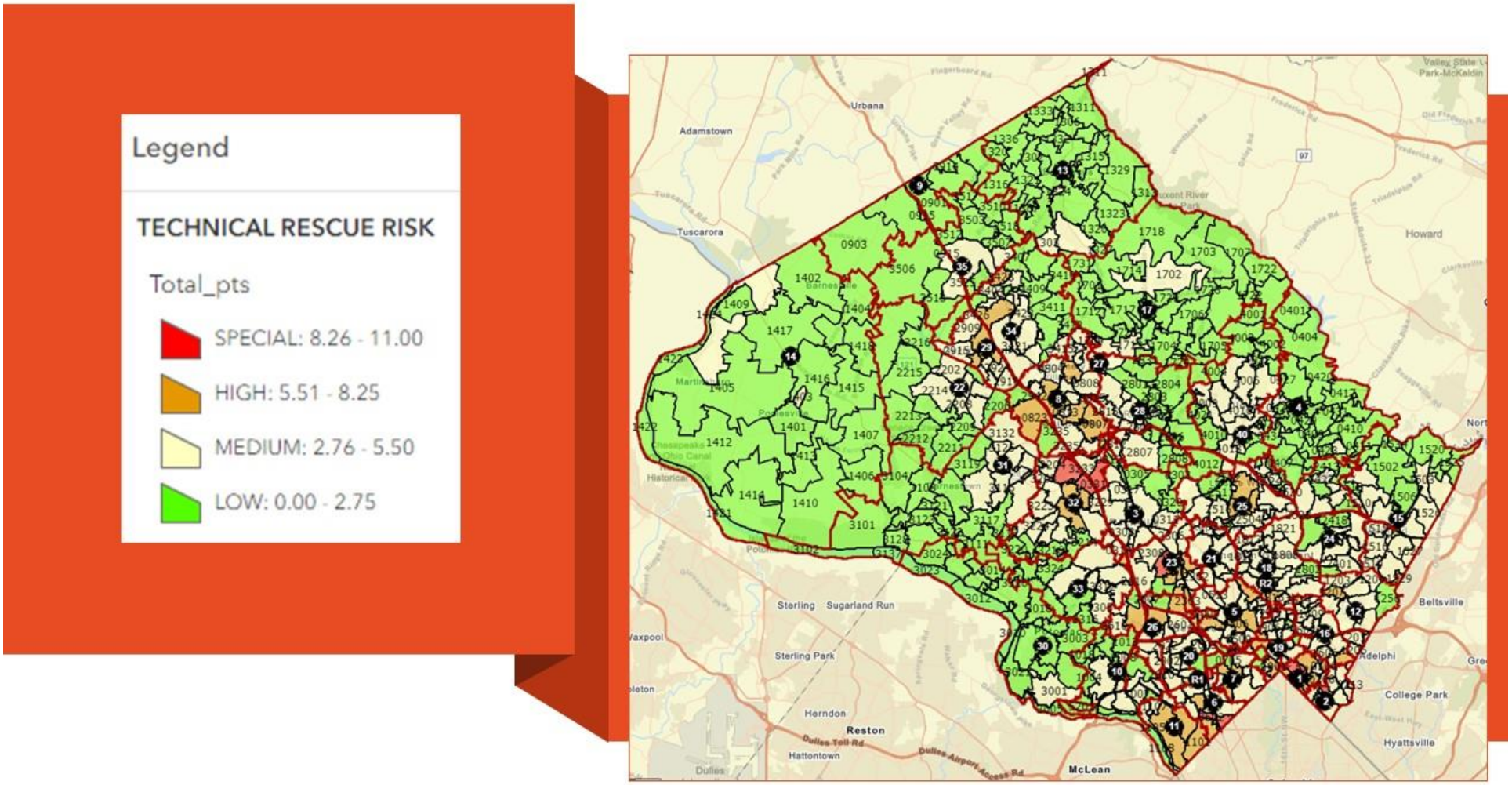
Aggravating Factors	Description
Incident frequency	Total # of technical rescue incidents dispatched in each box (RMZ).
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ). The higher the population density, the more demanding the stress is on the system if there was an incident with a high volume of victims/patients.
Number of high-rise buildings	Buildings which, if collapse/entrapment occurred, would demand greater resources and/or extended operations.

Mitigating Factors	Description
First arriving unit total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the first unit arrives.

The last time risk was evaluated for technical rescue, it was based only on incident frequency, which is not that high. This time, the process accounted for population density and the number of high-rise buildings, where there is greater potential for collapse and entrapment that would require an extended operational period to resolve. Those changes resulted in a more diverse map this year than in 2017. And this particular hazard highlights the issue with using box areas and incident frequency as a predictor of risk. In 2017, box 1202 (red in the 2017 map) was classified as special risk due to three incidents occurring in the previous five years. In the five years prior to this year's assessment, there have been no incidents, and now the box is classified as medium risk.



2017 Technical Rescue Risk Map.



Technical Rescue Risk Map, 2022; Planning & Accreditation Section. Created with ArcGIS Pro.

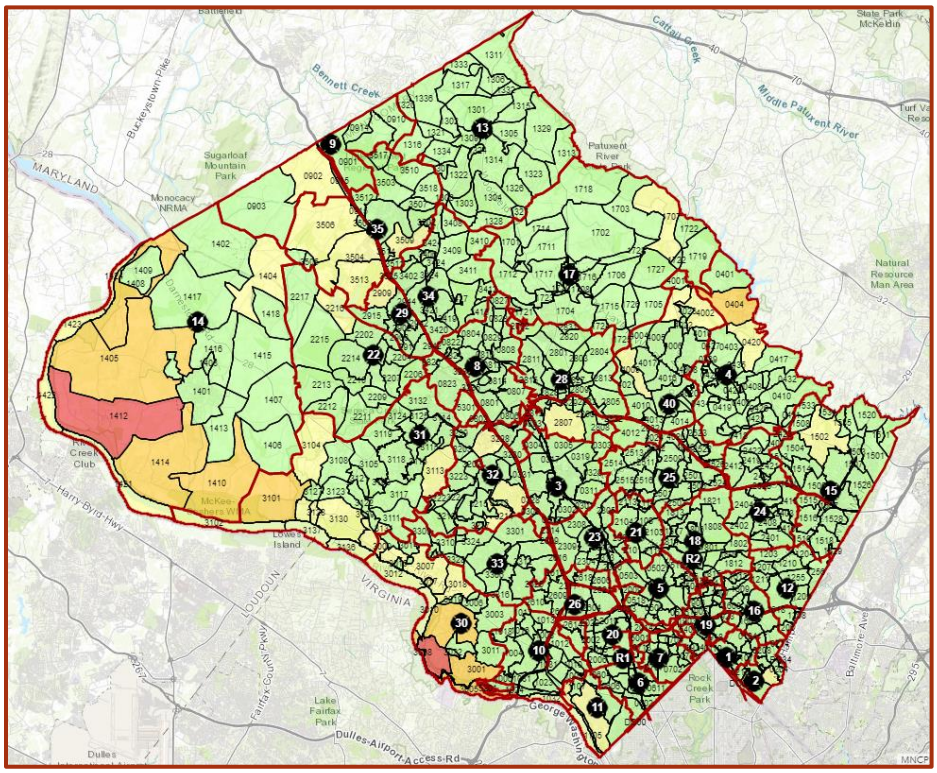
Hazard: Water/Ice Rescue

Aggravating Factors	Description
Incident frequency	Total # of dispatched water/ice rescue incidents dispatched in each box area (RMZ)
Large bodies of water	Accounts for the presence of the Potomac River, Blackhills & Clopper Lakes, Rocky Gorge, and Triadelphia Reservoirs within box areas (RMZs)
Ponds	Accounts for the # of ponds within a box area (RMZ)
Intersections prone to flooding	Accounts for specific intersections within the box areas (RMZs) prone to periodic flooding

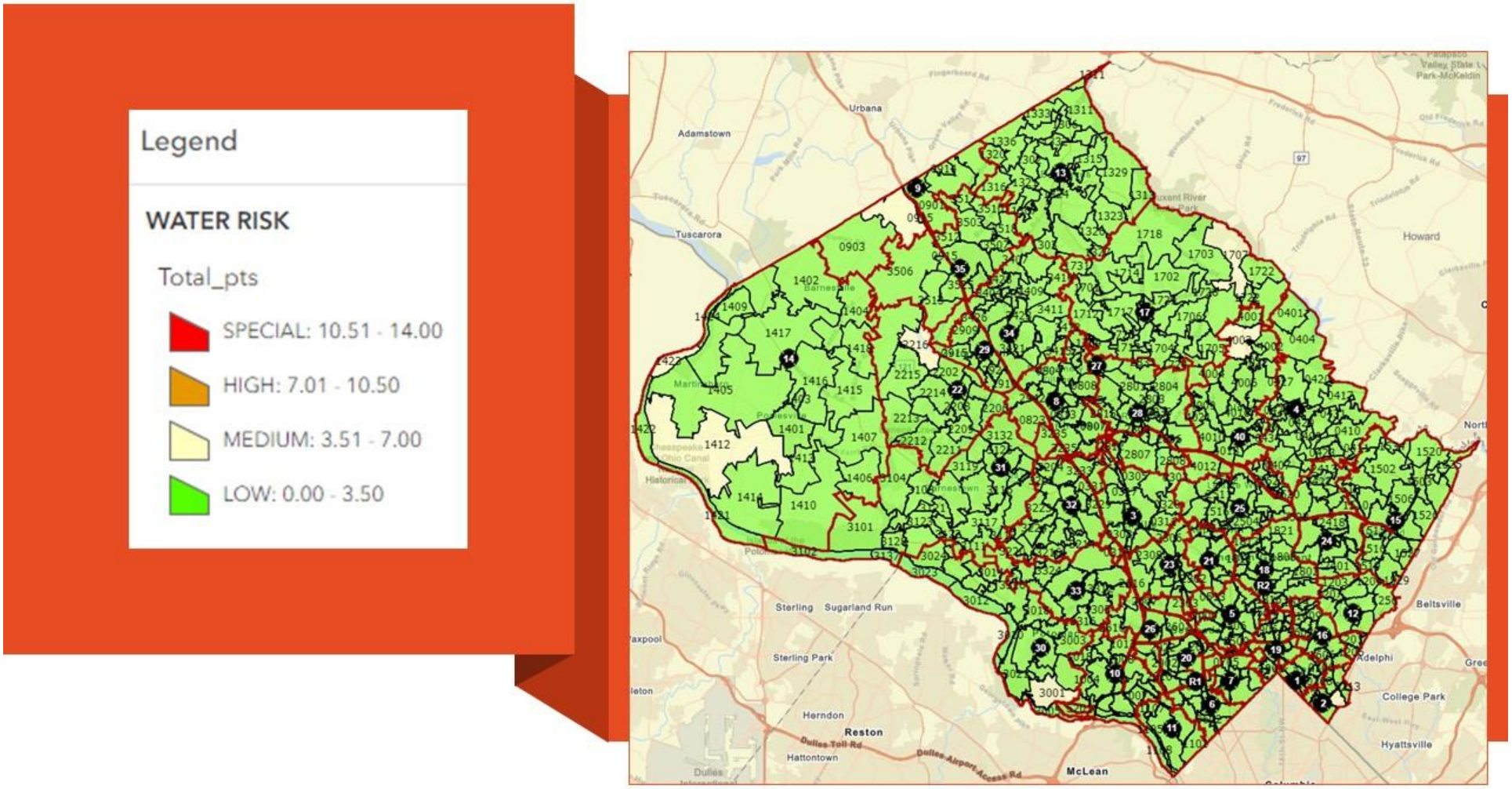
Mitigating Factors	Description
First arriving unit total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the first unit arrives.

There were no changes to the factors in this year's assessment of water/ice-related incidents, but the 2022 map shows fewer medium, high, or special risk boxes than the 2017 map conveyed. This is due largely to the reconfiguration of the scoring for the individual aggravating factors, particularly the presence of ponds. The 2017 numerical rating scale for ponds allocated up to four points depending on the number of ponds in a box area, whereas this year, only one point was allocated for up to 20 ponds in a box and two points for more than 20 ponds.

Internally, there was concern that box areas that encompass the Potomac River were not categorized as high or special risk due to the volume of calls related to the river, as well as the conditions that rescue personnel face in a water-related incident. But the purpose of this exercise is not to categorize the risk of individual incidents, which personnel do every time they receive a call and arrive on scene. The purpose of this assessment was to categorize the risk associated with the box areas. The consideration of response times as a mitigating factor to risk has "improved" the risk classification (lowered the score/ranking) in water/ice incidents and a few of the other hazards, which is a potential indicator that MCFRS has put the right resources in the appropriate places.



2017 Water/Ice Risk Map.



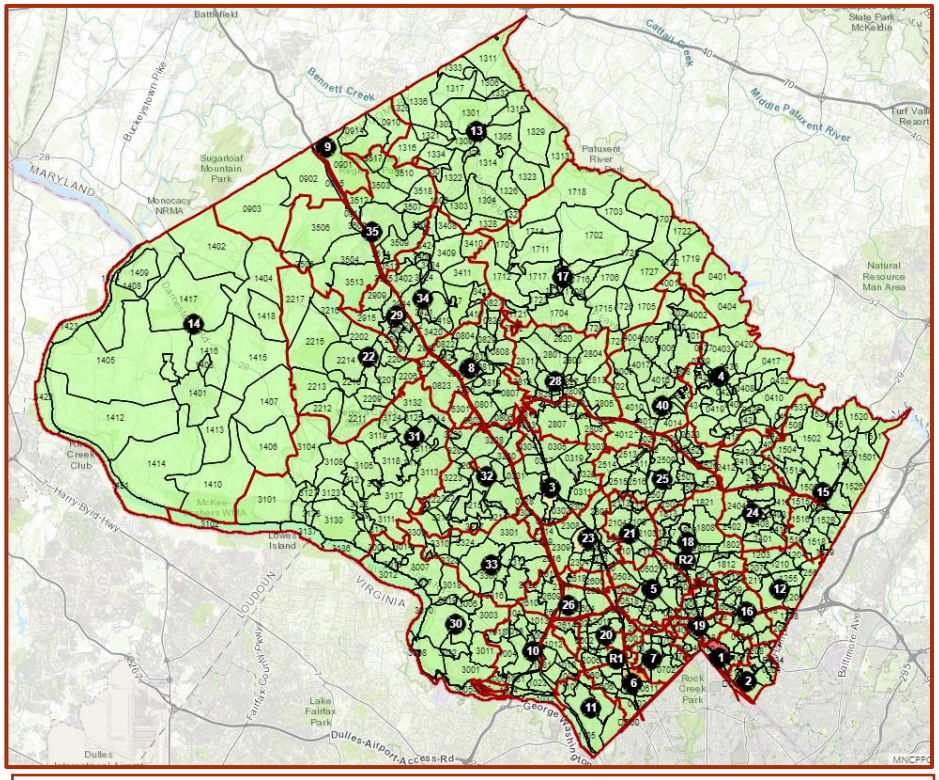
Water/Ice Risk Map, 2022; Planning & Accreditation Section.
Created with ArcGIS Pro.

Hazard: Bombings/Explosions

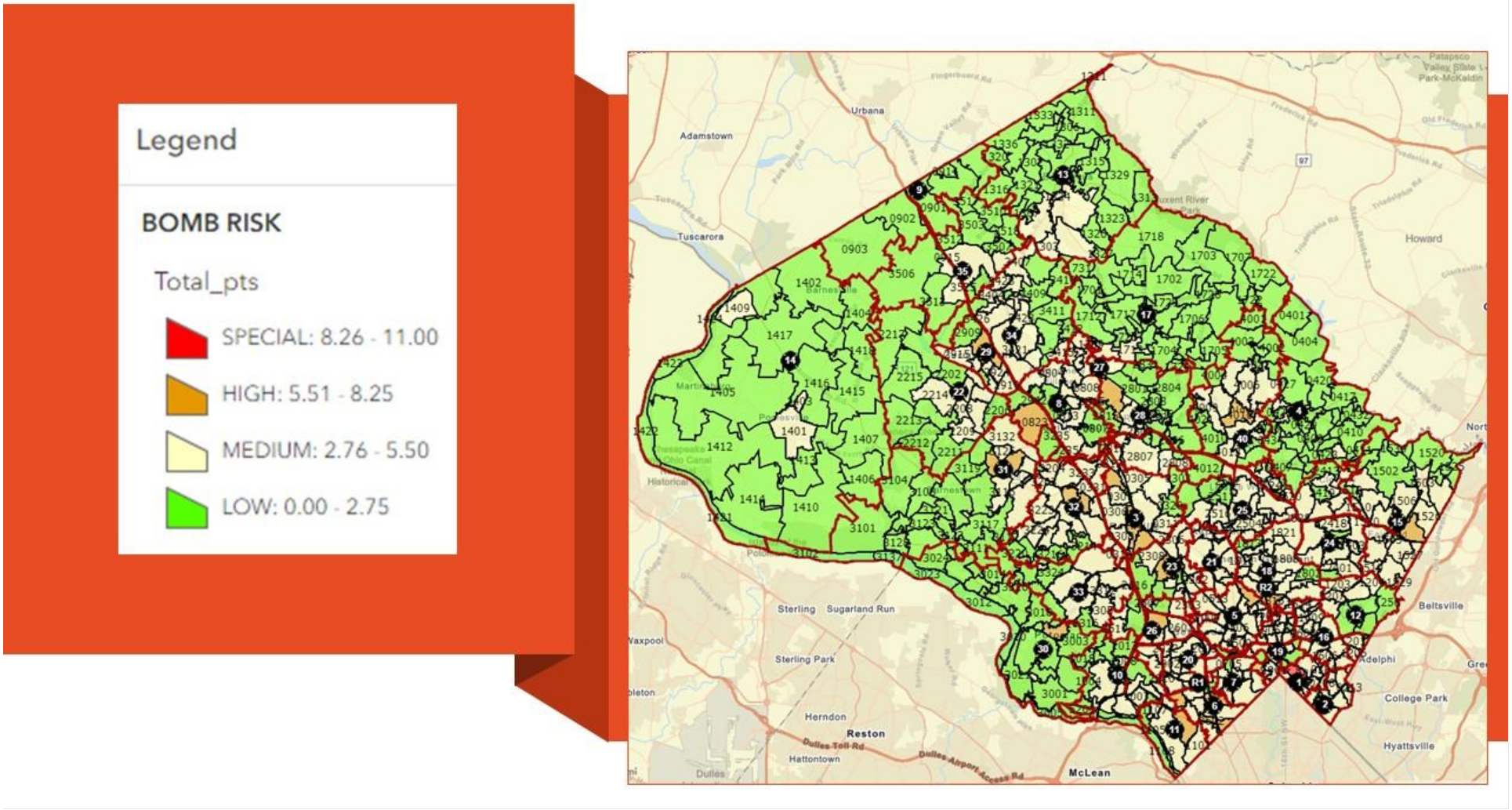
Aggravating Factors	Description
Incident frequency	Total # of dispatched bomb squad incidents where at least one unit arrived in station response areas.
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ). The higher the population density, the more demanding the stress is on the system if there was an incident with a high volume of victims/patients.
Total number of critical infrastructure/key resources (CI/KR) present in a box area (RMZ)	Assets within Montgomery County that are essential to safety, security, and public health, economic vitality, and way of life.

Mitigating Factors	Description
First arriving unit total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the first unit arrives.

In the last risk assessment, incident frequency was the only factor assessed for the risk of bombing/explosion. This year, we considered population density, as an explosion of any sort will have a more significant impact in a densely populated urban area than in a rural area. The location of critical infrastructure and key resources (CI/KR) was also added to the formula, as these locations could be potential targets for nefarious activity and have considerable repercussions in terms of loss of life, loss of vital systems, such as electrical grids and transportation networks, and financial/economic impact. These changes produced a more diverse map this year, with all four distinct risk categories appearing throughout the County.



2017 Bomb/Explosion Risk Map.



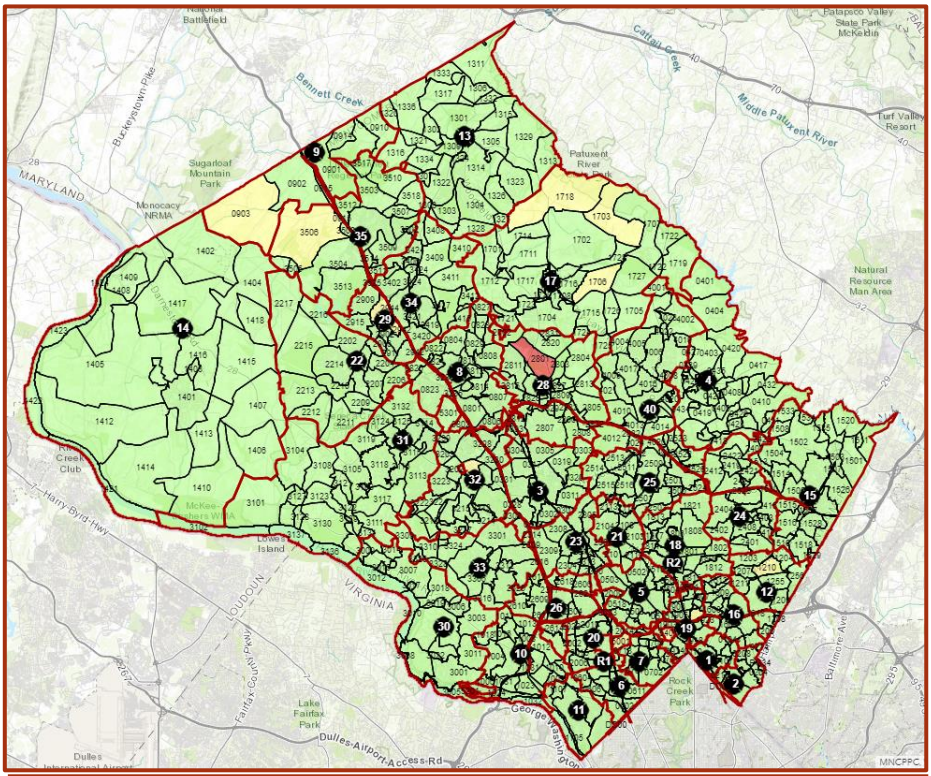
Bomb/Explosion Risk Map, 2022; Planning & Accreditation Section. Created with ArcGIS Pro.

Hazard: Aircraft Rescue/Firefighting

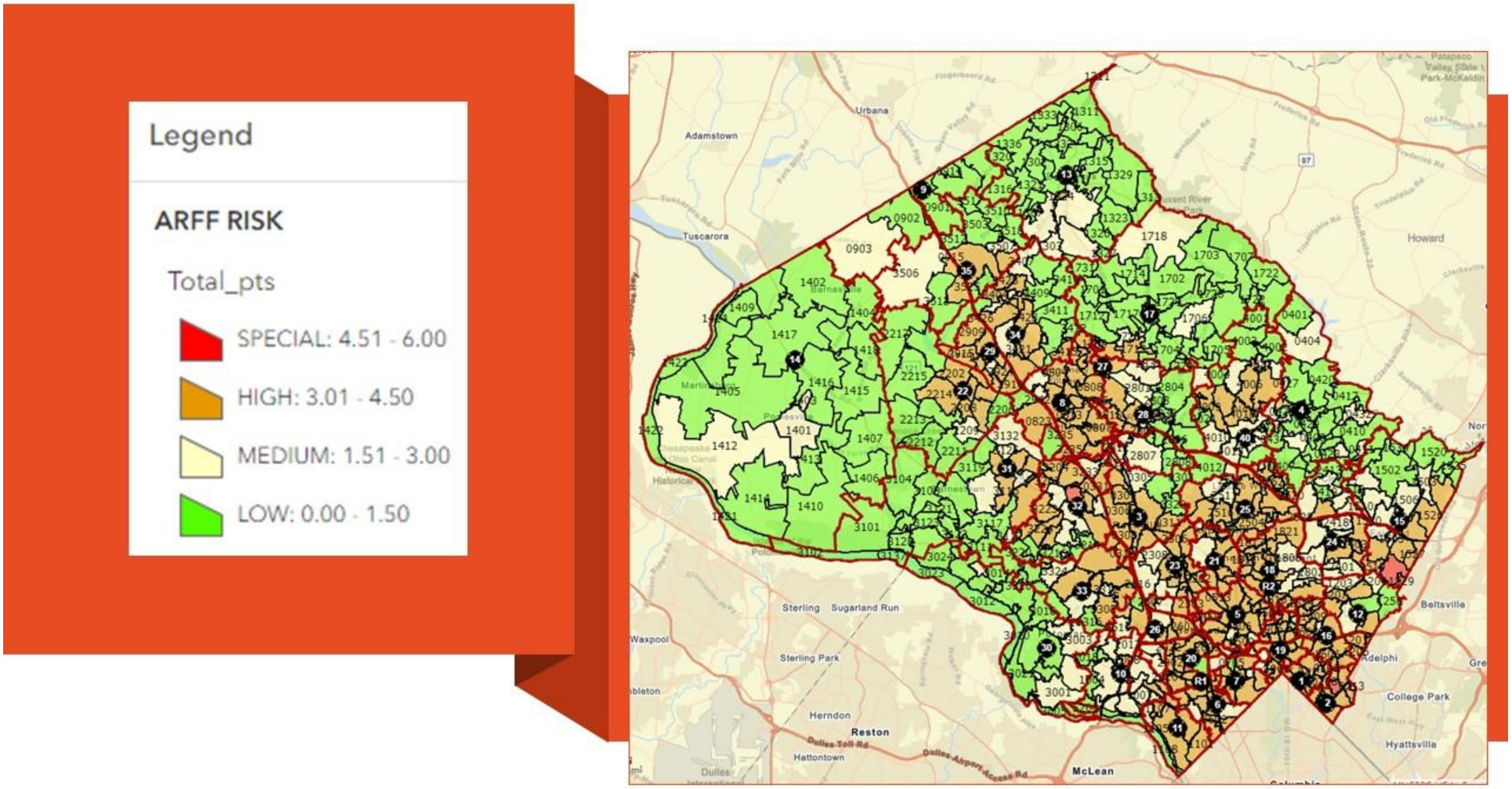
Aggravating Factors	Description
Incident frequency	# of dispatched aircraft emergency incidents in each box (RMZ).
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ). Generally, an aircraft incident in a densely populated area will have a greater impact (on the victims and the County, as a whole) than an incident in a rural, less densely populated area.
Airparks/airfields	Box areas (RMZs) that encompass Montgomery Airpark and Davis Airfield
Helipads	Box areas (RMZs) that encompass known helipads
Private airstrips	Box areas (RMZs) that encompass known private airstrips

Mitigating Factors	Description
ERF total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the full complement of apparatus arrives onscene.

There are 12 airports/heliports within Montgomery County, and six private airstrips. Furthermore, Montgomery County is in an area serviced by three national airports; there is no shortage of air traffic within Montgomery County, and there have been notable aircraft-related incidents in the past. There were no changes to the factors used in the risk calculation for this category, although more points were assessed on boxes that encompassed air/heliports during the last assessment, while only one point was assessed for each location this year. That still resulted in several special risk areas noted on this map, and it is those box areas (RMZs) that are both densely populated and have an airport or heliport.



2017 ARFF Risk Map.



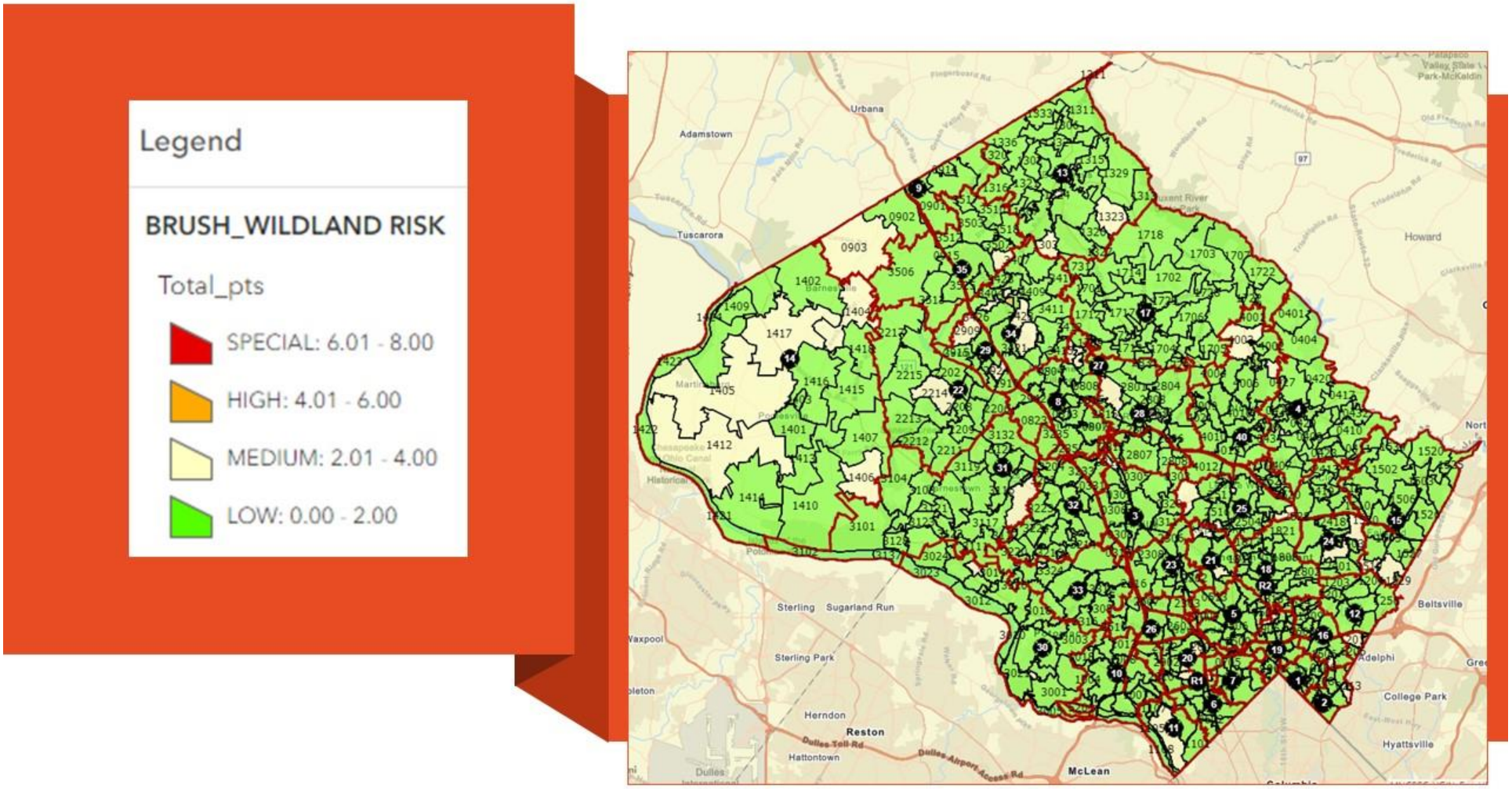
Aircraft Rescue Risk Map, 2022; Planning & Accreditation Section. Created with ArcGIS Pro.

Hazard: Brush/Wildland Fires

Aggravating Factors	Description
Incident frequency	Total # of documented brushfires (situation found) in each box area (RMZ)
Population/square mile	Estimated population density within the box area calculated on a percentage of the census block that falls within the box area (RMZ). Generally, a brush/wildland fire in a densely populated area will have a greater impact than an incident in a less densely populated area.
Agricultural Reserve OR parks/recreation areas	Box areas (RMZs) that consist of at least 50% of agricultural reserve/wooded land OR contain parks/recreation areas totaling 200 acres or more.

Mitigating Factors	Description
First arriving engine total response time at the 90th percentile in urban and rural density zones	A measure of how quickly the first engine arrives.
Hydranted v non-hydranted	Generally, it is easier to mitigate a fire when there is a readily available water supply (hydrants).

This is the first time this hazard category has been evaluated, so it is still a work in progress, as we did not want to exaggerate the risk by using the same factors that were used for structure fires. The process accounted for agricultural reserve area, where the average person would likely think of a brush/wildland fire occurring. However, most of the brush/wildland incidents in 2021 occurred within the urban density zones of the County, so we also accounted for large acreage of parks and recreation land. However, the shortcomings associated with using box areas to score risk are evident in this category; consider box 3405 (Germantown). There haven't been any brush/wildland incidents in at least the last five years in this box area. However, because of the small size of the box and the population density, the presence of the agricultural reserve, and being a non-hydranted area, the calculated risk score is *high*. The same box area, assessed for structure fire risk, is only *medium*.

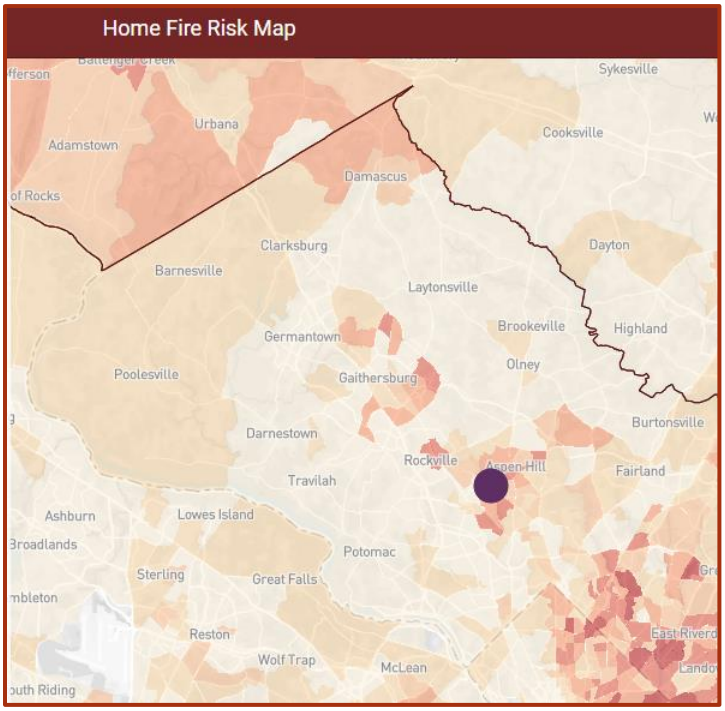


Brush/Wildland Fire Risk Map, 2022; Planning & Accreditation Section. Created with ArcGIS Pro.

Future Considerations

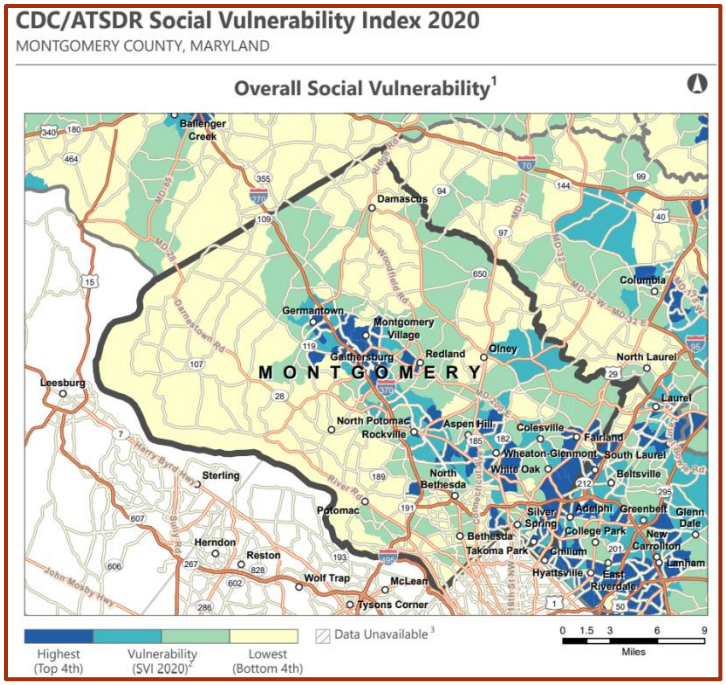
Although a lot of time has been allocated to completing the community risk assessment, there is much more we can do. At the very least, stations may use this information to conduct education and outreach to those most vulnerable to specific hazards. MCFRS also utilizes the Community Risk Assessment Insight Generator (CRAIG) 1300, which allows station personnel to get a comprehensive overview of their response area and its hazards based on the most currently available American Community Survey (ACS) data. This NFPA 1300-based tool offers greater insight into station response areas than this risk assessment, featuring many more factors that contribute to specific hazards.

Ideally, our community risk assessment should consider some of these additional factors. However, using the box areas as our defined risk management zones becomes cumbersome mathematically when more factors are examined, and more subjectivity is introduced to the process in terms of scoring. The goal is to remove as much subjectivity from the process as possible and create quantifiable metrics that identify those most vulnerable. One step we should take is redefining what a risk management zone is, something larger than a box area. The logical approach is to use census tracts, which would make extrapolation of the aggravating factors easier to do and less ambiguous. This would also allow us to consider risk levels in coordination with the 56 Equity Focus Areas identified by the Montgomery Planning Department. Census tracts are also used by a number of other tools that future assessments may be able to draw upon to improve the understanding of risk throughout the County.



For example, the American Red Cross developed a Home Fire Risk Map (left) that predicts aggregate neighborhood home fire risk based on the likelihood that homes within a census tract lack functioning smoke alarms; the prevalence of home fires in a census tract over a five year period; and the increased likelihood that a home fire could result in injury or death; an updated version of this project is expected this year.

The Geospatial Research, Analysis, and Services Program (GRASP) created and maintains databases to help planners and public health officials identify and map communities that will most likely need support before, during, and after a hazardous event. Using census tracts, this tool ranks each one on 16 social factors and creates a social vulnerability index (right).



FEMA recently deployed the Resilience Analysis and Planning Tool (RAPT), which contains over 100 pre-loaded data layers and analytical tools to support emergency management outreach, planning, mitigation, response and recovery. This tool calculates a community resilience index based on 22 indicators applied at the census tract level and includes other factors of interest, such as the percentage of the population without health insurance, single family households, and percentage of owner-occupied housing. It also offers infrastructure indicators, as well as hazard and risk indicators that would allow us to consider the effect of climate (e.g., floods, extreme temperatures) on Montgomery County communities.

This is just a sample of additional tools that are available and would give us a more robust examination of risk in Montgomery County, but there is some technical work that needs to occur before we can redefine the risk management zones. Subsequently, we need to work on revising and creating performance measures and indicators that allow us to evaluate our processes and outcomes. Going forward, MCFRS should continue to build upon and use the framework of risk, vulnerability, equity, and resilience to inform decision-making, particularly as it relates to policy, budgeting, and resource allocation/deployment, while also being mindful that there are limits on our ability to influence risk. The department must work within the inherent limitations of allocated resources to maximize the impact on mitigation. This framework will contribute to increased coherence among all MCFRS divisions, allowing us to better plan and prioritize risk and vulnerabilities, allocate and deploy resources based on identified needs, and ensure a sustainable model of service delivery that improves resilience, and therefore, outcomes.