

## **Project 1. Fire safety: Distances to nearest fire hydrants**

**Background and Motivation.** Fire departments comprise one of the three essential emergency response services to a community, the others being police and emergency medical. Some communities assign the emergency medical responsibilities to their fire department. In this project, students will collect data on one aspect of fire departments – their spatially distributed fire hydrants, so essential in providing water to fight fires. The key issue for the students: examining the distances from homes and other residences to the nearest fire hydrant. A running hypothesis is this: the larger this distance, the longer it will take for the fire fighters to be able to start fighting the fire with water from the hydrant. The students can examine the validity of this hypothesis with Internet research and with (hopefully) an eventual meeting with their local fire department!

**Student Activities.** The data to be collected will be the “distance” between sampled residences and their closest fire hydrants. As soon as the Student Team is assembled, the first task is for each member of the team to locate the fire hydrant closest to his/her home and then to measure the distance between the two. The most natural measure of distance is the shortest path along public street(s) between the hydrant and the residence. This is the path that the fire fighters will use to lay down the fire hose. A simple way to measure the length of this path is by human steps, with the student taking measured steps along this path, counting steps and then multiplying that number by the average length of a step. This may take some practice for the student to walk in such a controlled way – each step having roughly the same length. If this distance is great (rare!), then the student can ask a parent to drive him/her along the street(s) in the shortest path, and to use the vehicle’s odometer to measure the distance. We recommend that the unit of distance be feet or meters. If a vehicle’s odometer is used, a rescaling is needed to convert to feet or meters.

There is a second measure of distance, the “radial distance” between the residence and the closest hydrant. To measure this, the student needs a good resolution map of the community. The teacher can assist in locating and acquiring such a map for the team. On that map, she/he locates the closest hydrant to her/his residence, and uses a ruler to measure the radial or “straight-line” distance. The student must then rescale that measurement using the map scaling number to arrive at the estimated number of radial feet or meters between the hydrant and the residence. This is why radial distance is important: Some Internet apps provide on digital maps the locations of fire hydrants in various communities throughout the US; they show distances from any given point to the closest, 2<sup>nd</sup> closest, 3<sup>rd</sup> closest, etc. fire hydrant by displaying concentric circles – thus, they are showing radial distances. The students should seek to become comfortable knowing the approximate magnitude of percentage error between on-street and radial distances. That’s a type of discovery exercise. The radial distance will always be less than or equal to the distance measured along the streets. Why?

We are now at the point where the “real project” begins! The team seeks to create two histograms of the distances between each of 60 “random” residences in the community and the closest fire hydrant to that sampled residence. Each of the four team members will be responsible for gathering the required data on 15 random residences. We suggest in collecting

the street data that students work in teams of two. In the end, two histograms are needed since we want both on-street shortest path distances and radial straight-line distances.

This task poses at least two problems for the students: (1) How do we select “random” residences; (2) How can each student locate closest fire hydrants in parts of the community she/he may not be familiar with? The teacher should have conversations with the students about each question. There are various ways to select random residences. A fun way is to post an expendable map of the community onto a flat corkboard and then to throw darts at the map! There should be no intention of accuracy, with the dart thrower almost like being blindfolded. That process would get us 60 random locations. Another is to use “random numbers” from Excel and obtain locations on the map with two random numbers, one scaled for north-to-south distances, and the other for west-to-east. Let the students decide and design the details.

The second question relates to how to locate 60 fire hydrants. There are two ways we suggest: (1) contacting your local fire department and asking for a map showing the hydrant locations, or (2) using one of several Internet “apps” that claim to have such locations nation-wide (e.g., AnyFinder <https://anyfinder.info>). (We have not verified the accuracy and completeness of the databases for these apps.) If neither of these methods works, a student can always go to each of his/her 15 locations and ask local residents about the location of “their” fire hydrant. We speculate that some would know the answer and some would not. But eventually the answer would be found. Challenges are part of these projects!

Students eventually obtain their two histograms, one for on-street shortest-path distances and the other for radial distance, and on each histogram, they mark the mean (average), median, mode and the two 5% tail boundaries. They discuss the distances between the two 5% tail boundaries, exploring such topics as equity of fire coverage and safety. They also compare the radial distances to the on-street shortest path distances. The on-street distances will be greater, but by how much? This will be a student research finding! An issue is, “Can the radial distances be used as a good proxy for on-street distances, perhaps using a scaling correction factor?” If so, it is a lot easier and faster to use a map and measure only radial distances!

Finally, the students would ideally visit the local fire department to present their findings and to have an open discussion with the fire-fighting professionals. Issues that could be discussed, in addition to the students’ project, are those mentioned in the suggested web sites. They could also ask if there is a need to add or relocate any fire hydrants. How do they react when there is new construction in a part of the community?

The project ends with the formal presentation at the Final Event and submission of a final report.

**Potentially useful web sites:**

**The Evolution of the Fire Hydrant**

<https://www.terminalcity-acsc.com/blog/evolution-fire-hydrant/>

**The critical function of water in fighting fire risk**

<https://www.verisk.com/insurance/visualize/the-critical-function-of-water-in-fighting-fire-risk/>

**Fire chiefs stress crucial role of nearby hydrants**

<https://stoughton.wickedlocal.com/news/20200125/fire-chiefs-stress-crucial-role-of-nearby-hydrants>