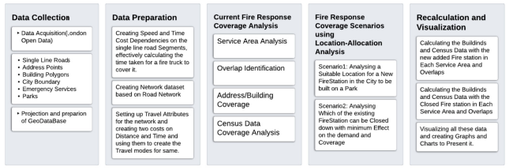
FIRE SERVICE COVERAGE STUDY : LONDON,ONTARIO

INTRODUCTION

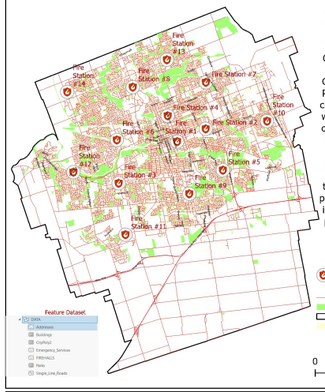
This Study is conducted on Fire Services in London,Ontario. With the city's population continuously growing, there is a pressing need to evaluate and optimize the spatial distribution of fire halls to maintain efficient emergency response times. The City of London currently operates fourteen fire halls, but with the anticipated population increase, an additional fire hall is essential to meet the increasing demand for emergency services. Conversely, budget constraints or strategic reallocations may necessitate the closure of one fire hall, requiring a thorough analysis to minimize the impact on service coverage.

This project leverages the Network Analyst extension tools in ArcGIS Pro to perform a comprehensive study on the existing fire service coverage and to explore two critical scenarios: identifying the optimal location for a new fire hall to enhance service coverage, and determining which existing fire hall could be closed with minimal impact on service efficiency. The objective is to optimize fire service response times and coverage, ensuring the safety and protection of the city's inhabitants.

METHODOLOGY AND WORKFLOW



DATA COLLECTION



In Data Collection, we gather Data like Buildings, City Boundary, Parks, Roads with Classifications, Address Points, Emergency Service Points from London Open Data Portal. Now with These Data we Create a Feature Dataset in our Geodatabase with UTM Zone 17N as the Projection to it and as the every Feature class here is in the Same Projection. Now we Extract the Fire Stations which are of our interest from Emergency Services by Selecting them from the attributes and export them into our database.
As we can see in the map we have the Fire halls highlighted and at a first look the the spread of Fire halls in the City is pretty good as per the Urban Settlements in the city as there not much of Address points or Buildings visible in the map in the Southern Part of the City.

DATA PREPARATION

ATTRIBUTE EDITING

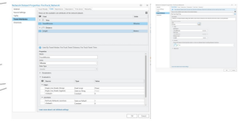
Now, for a Firetruck, shortest Travel Time is more Crucial than the Distance, a firetruck should be able to travel from the Forestation to the Accident Site in a very short time. so it should effectively take the shortest travel time route rather than shortest distance route.
For our Project Purpose we set the response time as 3.5 minutes of travel time to reach the site.
Now we should be able to indicate the costs and impedance on different roads in the city, we take the maximum speed limit on each type of road in the city and assign them accordingly, we create two fields of speed and time with long and double as the data type and to populate speed field take max speed limit because there is no restrictions for Firetrucks and also we are not Considering Impedance on 1-way or 2-way as they are exempted and also road junction wait times are also eliminated for the Fire trucks.
We make use of the below table to assign speed to each class of road in the attribute table using select by attributes tools and populating the speeds. Now we calculate the time as we have the length of the road and speed using the formula below for time calculation.
These would give us the time taken to travel on each road segment in the city at the specified speed limits.

Street Classification	Speed Limit (Km/h)
Airport Runway	40
Arterial	60
Collector	50
Local	40
Primary Collector	50
Private Road/Alley/Private Sanctioned Access	40
Ramp	60
Secondary Collector	50

Time attributes is based on the Speed Constraint attributes
[Street Segment Length] / 60) : [Speed] * 1000

NETWORK

Now after we have the Time for every Road in the city we would create a Network Dataset based on the Roads in our Feature Dataset and then we build the network to eliminate any Dirty areas.
Now we need to setup our Network to reflect the costs we have given through time for the Roads. Now we go to the Properties of the Network and indicate the costs for the time naming it appropriately and in evaluators through field script we indicate the time field for both along and against types. Now we go to setup the Travel modes for our network we create a new travel mode and naming it appropriately we indicate type as driving and cost impedance as the one we created in the costs with time field indicated and check the length and time costs.
in here we create distance modes to verify our network analysis also.



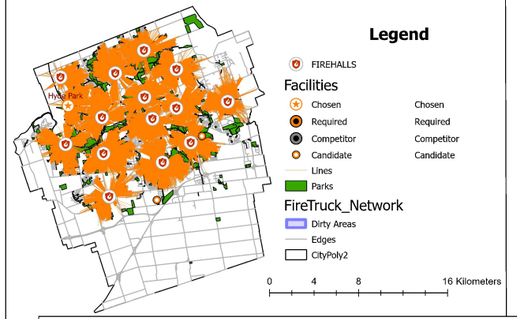
SCENARIO 1

In the Scenario1 we explore the possibility of adding a new additional Fire Station in the City and Proposing a suitable location for Maximum Coverage of the Demand in the City and while maintaining Response Time efficiency.
To do this Analysis we make use of the Location-Allocation Analysis in Network Analysis and use our Existing Fire Stations as the facilities and Address points in the City as Demand Points, while making the existing Fire Stations as required we add three more Suitable Locations on parks as parks are a public land can be easily be converted into a Fire Station. These Points are placed strategically outside the current service areas and nearer to more address points. Now we run the Analysis by keeping the No. of Facilities as 15 so as existing 14 are made required it is forced to select one of the three new candidates.

Now, this will result in one of the candidates being Chosen and it also draws the demand lines for each Fire Station.

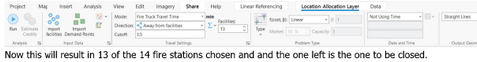
In our Analysis as we can see in the map it has Chosen the point in the north western part of the city which also cover a good amount of address points within the cutoff response time of 3.5 minutes.

In here the system has chosen a new fire Station built on Hyde Park would give City a better Fire Response Coverage than the existing Situation.

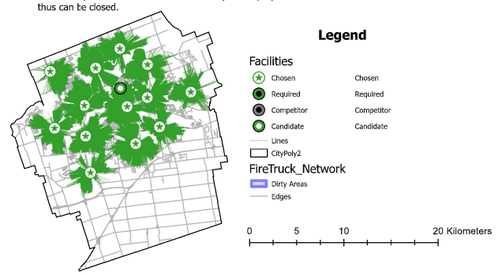


SCENARIO 2

In the Scenario2 we explore the possibility of removing an existing Fire Station in the City might be due to budget Constraints, we try to propose which Fire Station can be Closed with minimal effect on the current Fire Response Coverage.
To do this Analysis we make use of the Location-Allocation Analysis in Network Analysis and use our Existing Fire Stations æ the facilities and Address points in the City as Demand Points, we run the tools while keeping the facilities no 13 as it is forced to choose 13 of the 14 Fire Stations.



Now this will result in 13 of the 14 fire stations chosen and and the one left is the one to be closed.
in our Analysis as we can see the below map it has proposed that Fire Station #4 has least demand and thus can be closed.



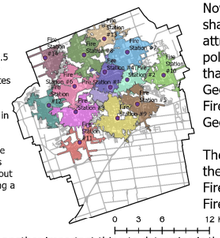
Buildings and Census Data Analysis Scenario -2

Now similarly using Spatial join we get the counts of Buildings in each service area and each overlap.
By using apportion Polygon and Summarizing it we get the Census Data in each Service Area and Overlap. these counts in Scenario2are as follows:

Current Fire Response Coverage Analysis

Service Area

In here we analyze the Current situation in the city.
By our previously determining fire response time of 3.5 minutes, we see how much area in the city can a fire truck cover in each fire station can cover in 3.5 minutes time along our network with our predefined costs impedances along the network.
To determine these we use the Service Area Analysis in network analysis on our network.
In here we import the existing fire station points as facilities and give the cutoff as minutes on time mode and travel away from facilities, with these parameters we can run the service area analysis tools and it will out put as the polygons around our Fire Stations indicating a 3.5 min Travel Time.



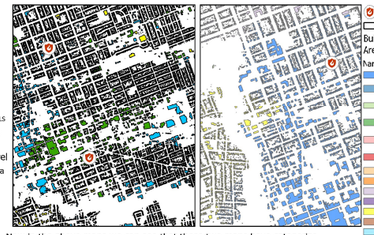
Now, just by looking at the shape area field in the attribute table for the polygons created we can see that FireStation14 covers least Geographical Area and the Fire Station 1 Covers the most Geographical Area among all.

These two fire stations have the following area :
FireStation14 : 8722237.5
FireStation1 : 20470787.5

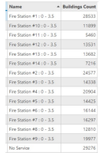
Buildings Analysis

Now we want to Count no of buildings in each scenario ideally we want to count buildings in each Overlap and also buildings served by each Fire Station. To get these we can make use of Spatial Join tool to join Buildings spatially to our desired Polygons and we use largest Overlap as the Match Option.

In first we join the service area polygons with buildings Spatially to give the buildings count in each service area. Then we repeat the same steps for overlaps to give the Buildings Count each Overlap.



Now in the above maps we can see that these two maps have categorize the buildings into Service Areas and Overlap Areas. The count for both are then summarized to get the count at each level. The Counts are as below :



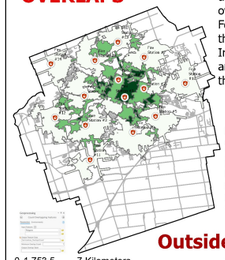
Name	Buildings Count
Fire Station #1 : 0 - 3.5	28531
Fire Station #10 : 0 - 3.5	11899
Fire Station #11 : 0 - 3.5	5460
Fire Station #12 : 0 - 3.5	13531
Fire Station #13 : 0 - 3.5	10682
Fire Station #14 : 0 - 3.5	7216
Fire Station #2 : 0 - 3.5	24577
Fire Station #3 : 0 - 3.5	14308
Fire Station #4 : 0 - 3.5	23964
Fire Station #5 : 0 - 3.5	14423
Fire Station #6 : 0 - 3.5	18144
Fire Station #7 : 0 - 3.5	16297
Fire Station #8 : 0 - 3.5	12810
Fire Station #9 : 0 - 3.5	19857
No Service	29276

Buildings Covered by each Fire Station

Service Area Coverage	Buildings Count
0	30317
1	115264
2	34406
3	11098

Buildings Count by Overlaps

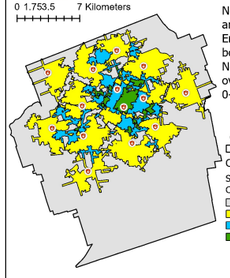
OVERLAPS



Now another important thing to determine is the overlaps of these Service Area Polygons with each other. To determine the overlaps in here we make use of the Count Overlapping Features Geo processing tool. In here we input the polygons of the service area to count the overlap on them.
In here we can see that in London City we can see that there are 3 levels of overlaps in city and most of them are around the center part of the City.

From the Attribute table we can infer that we have 11 areas which are served by 3 Fire Stations and 25 Areas which are served by 2 Fire Stations in the city.

Outside Service Area

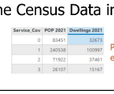


Now we want to separate the area which are outside of the service areas of the fire stations in the city. for this we make utilize of the Erase tools, here we erase the Service Area Polygons from city boundary Polygon to get the No Service Area.
Now for better visualization and easy handling we union the both overlaps layer and No Service Area layer. This has overlaps from 0-3 counts where 0 indicating No service.

Census Data Analysis

Similarly to calculate the Census Data we can use Download the DA files with population counts from statistics Canada website then we join it with DA file with boundary and then by select by location with our City boundary we get the Population and dwellings Data for our City boundary at DA level.

Now to get the Census Data for our desired Polygons we use the tool Apportion Polygon to calculate the approximate Census data. At first we we apportion the City DA layer with Service Area Polygons which will give us the census Data served by each Fire Station. then by doing the same with Overlaps layer we get the Census Data in each Layer. the Counts for them are as follows:



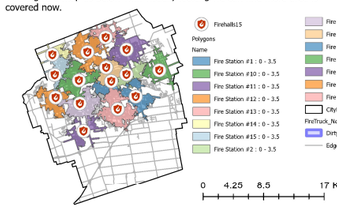
Service_Cov	POP 2021	Dwellings 2021
0	83451	32675
1	240538	103997
2	71922	31461
3	26107	15147

Population and Dwellings in each Overlap

Population and Dwellings served by each Fire Station

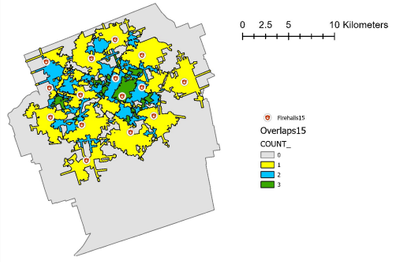
Service Area Analysis - Scenario1

Now we have 15 Fire halls now we do the same steps as above to get similar Statistics with 15 Firehalls in the City. in First we create the Service Areas for each of the Fire Stations as we did for existing firehalls the result would give a map as below with visually looking we can find more area is covered now.



OVERLAPS - SCENARIO1

Similarly we do the Overlaps for Service Area Polygons with the help of Count Overlapping Features Tool and it would output overlaps in them as we can see in the below map although the no of overlapping areas has certainly increase but maximum overlaps has not crossed 3.
Now Similarly we use erase tool to fin d out the No Coverage Area and union these two get a combined overlap file with the No Coverage Area as 0 Service Level.



Buildings and Census Data Analysis

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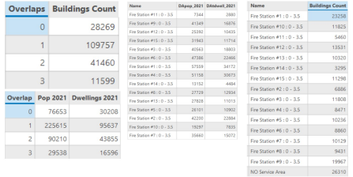
By using apportion Polygon and Summarizing it we get the Census Data in each Service Area and Overlap. these counts are as follows:

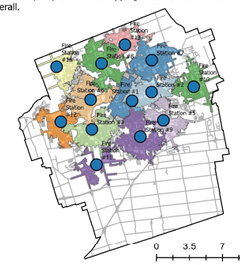
Overlaps	Buildings Count
0	28269
1	109757
2	41460
3	11599

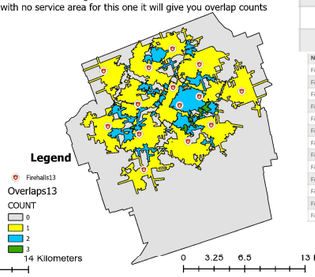
Overlap	Pop 2021	Dwellings 2021
0	76653	30208
1	225615	95637
2	90210	43855
3	29538	16596



SERVICE AREA and OVERLAPS - SCENARIO 2

The Service area for the 13 Fire Stations is created through Service Area analysis tool same as previous.
as we can see visually there a lesser area coverage in this scenario than the existing 14 fire halls service area and also we do the Overlaps by Count Overlapping Feature Tool and union this with no service area for this one it will give you overlap counts overall.





Service_Cov	Buildings Count
0	32175
1	123850
2	32432
3	2628

Name	DApop_2021	DAdwell_2021
Fire Station #11 : 0 - 3.5	7344	2880
Fire Station #9 : 0 - 3.5	41349	16876
Fire Station #12 : 0 - 3.5	25392	10435
Fire Station #3 : 0 - 3.5	40563	18803
Fire Station #6 : 0 - 3.5	47306	22466
Fire Station #1 : 0 - 3.5	57559	34172
Fire Station #14 : 0 - 3.5	13152	4484
Fire Station #8 : 0 - 3.5	27729	12934
Fire Station #13 : 0 - 3.5	27828	11013
Fire Station #5 : 0 - 3.5	26101	10902
Fire Station #2 : 0 - 3.5	42200	22064
Fire Station #10 : 0 - 3.5	19297	7835
Fire Station #7 : 0 - 3.5	35660	15072

Name	COUNT_Join_Count
Fire Station #1 : 0 - 3.5	23258
Fire Station #10 : 0 - 3.5	11825
Fire Station #11 : 0 - 3.5	5460
Fire Station #12 : 0 - 3.5	13531
Fire Station #13 : 0 - 3.5	10320
Fire Station #14 : 0 - 3.5	3295
Fire Station #15 : 0 - 3.5	11290
Fire Station #2 : 0 - 3.5	6886
Fire Station #3 : 0 - 3.5	11808
Fire Station #4 : 0 - 3.5	8471
Fire Station #5 : 0 - 3.5	10236
Fire Station #6 : 0 - 3.5	8865
Fire Station #7 : 0 - 3.5	10129
Fire Station #8 : 0 - 3.5	9431
Fire Station #9 : 0 - 3.5	19967
No Service Area	26319

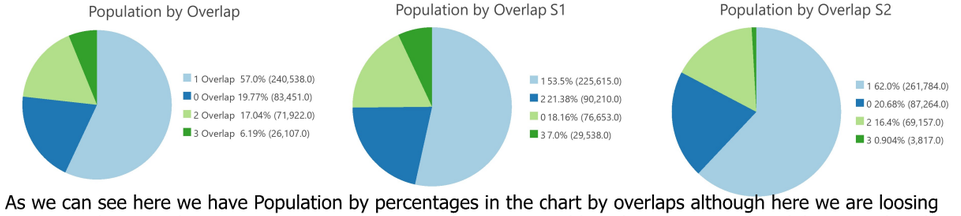
COUNT_	SUM_DApop_2021	SUM_DAtdwell_2021
0	87264	34583
1	261784	114569
2	69157	35266
3	3817	1883

RESULTS AND DISCUSSION

Buildings

As we can see with all the analysis, the current situation in London city on basis of Fire response Coverage doesn't look bad as the No coverage buildings are 29276 which are 15% of the total buildings it indicates that 85% of the buildings are covered in 3.5 response time. if the response time is more than 4 Minutes then it would probably cover 90% of the buildings in the city. Now in Scenario1 we can see that these buildings with no service come down to 28269 this comes to 87% buildings being covered which is a good improvement. while in Scenario2 the no Coverage Buildings increase to 31031 which is only 84% down 1% from current scenario which is not bad at face value.

Population



As we can see here we have Population by percentages in the chart by overlaps although here we are loosing more population in the coverage area in scenario 2 than we are adding them in scenario1 while we analyzed it through buildings data the differences were not this stark as they are here in population. so we could say closing a fire station would have a larger impact than it looks from outside

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