Fire Station Location Study
Phase II

Sylvania Township Fire Department
Sylvania, Ohio

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This document describes the contents of the set of 13 slides prepared from an extended location study for the Sylvania Township Fire Department. This portion of the study was based on the assumption that one station in the current configuration of four stations must be closed. The study undertaken took into account four main criteria in evaluating the locational effectiveness of alternative solutions to a three-station township fire department:

Incidents reported by the Sylvania Township Fire Department to Lucas County EMS from 2000-2006—both fire and EMS. Roughly 80 percent of the incidents were EMS calls. While incidents will provide a useful description of demand for emergency services over the past five years, it does not necessarily represent an adequate description of potential future demand—particularly when significant growth in population and commercial development is taking place in the western portions of the township.

Square Footage of all structures within the township as a means to measure the potential for fire incidents. Both current square footage figures from the Lucas County Auditor and Projected square footage from the Sylvania Township Administrator were used in this analysis.

Total population from the 2000 Census and projected population figures were used as a means to evaluate service coverage for EMS services for residential calls. Each city block in the region was assigned a center point (*i.e*., a centroid) which was connected to the street network for analysis purposes

Simple ***geometric coverage*** based on adequate service to all points in the study area (*e.g*., parcel points, street intersections, block midpoint locations). One significant element of emergency location studies requires that every point in every location within a jurisdiction area must be served; station locations must consider any possible incident at any possible location at any time. As a result this locational criterion was included to assure equity in the delivery of service over all areas of the township and city.

Location effectiveness of all of the location solutions delivered in this report are based on a measure of aggregate response time between each station and all incident locations weighted on the basis of population, , incidents or structural square footage. This measure is described as follows:

$$Z = \sum_{j=1}^{m} \sum_{i=1}^{n} a_{ij} C_{ij} W_i$$

Where:

Z is the aggregate response time between every station in the system and every weighted point representing demand in the region—it is the sum of the combined products of the response time minutes times the measure of demand at every point (measures of demand are incidents, population and square footage). Thus the units are in minutes. ***The smaller the value of Z, the "closer" the set of stations to all of the members of the population within the region.***

C_{ij} is the travel time between each jth station and ith demand point in the region

W_i is the "weight" or measure of demand at each demand point.

a_{ij} is a "decision variable" or "partitioning variable" where $a_{ij} = 1$ if station j is closer to demand point i than any other station; otherwise set it to zero.

m & n are the number of stations and demand points in the system respectively.

Please note that the value of **Z** (as reported in aggregate minutes of response time) is reported on each slide as a comparative measure of accessibility according to the locational criteria specified above. These measures can then be used to compare the locational effectiveness of each solution.

Each street in the region was assigned a travel speed. All street segments crossing active railroad tracks at at-grade crossings were assigned a 15 minute travel penalty as a means to avoid assigning service across the tracks. The only exception to this rule was imposed for Monroe Street next to Station 1. The complications associated with assigning fire service out of Station 1 to the west led to the relaxation of this assumption. Having stated this, it is strongly recommended that no emergency facility should ever be located that close to active railroad tracks with at-grade crossings.

The same street network, city blocks and parcel database used for the first phase of the fire station location study in 2003 was used in the current study. All of the additional assumptions followed in that previous phase were also included in the present study. The results of this current study are summarized as follows.

Slide 1: CURRENT STATION LOCATIONS
Slide 1 shows the location of the current stations within the system. All demand points shown in the map are based on simple assignment of each demand point to their closest station. Again, assignment of demand points around Station 1 do not incorporate the 15 minute penalty across the adjacent railroad crossing. The values of Z for this solution among the three location criteria are listed as follows:

Incident Z:	44,644
Population Z:	162,368
Sq. ft. Z:	136,931,420

Slide 2: THREE STATION IDEAL SOLUTION—INCIDENT BASED
Slide 2 shows the optimal location solution for three new stations under the assumption that all existing stations were to be closed and three new stations were permitted to be opened elsewhere. The location criteria used in this evaluation was based on incidents between 2000-2004. These locations included Alexis and Whiteford, McCord and Central, and West Erie Street just east of Little Road. These locations are "idealized" in order to provide a benchmark for evaluating later solutions involving the closing of existing stations.

Slide 3: THREE STATION IDEAL SOLUTION—SQUARE FOOTAGE
Slide 3 shows the optimal location solution for three new stations under this same assumption that all existing stations were to be closed and three new stations were permitted to be opened elsewhere. In this case, however, the location criterion was based on year 2003 Square Footage. Interestingly, two of these ideal locations virtually coincided with current Stations 2 and 3. The third ideal location occupied the same location on Erie Street as its corresponding station location from Slide 2. Again, these locations are "idealized" in order to provide a benchmark for evaluating later solutions involving the closing of existing stations.

Slide 4: THREE STATION IDEAL SOLUTION—PREDICTED SQUARE FOOTAGE
Slide 4 represents an extension to the solution in Slide 3 still under this assumption that all existing stations were to be closed and three new stations were permitted to be opened elsewhere. In this case, however, the Square Footage figures were modified to include future projected square footage for western

portions of the township obtained from the Township Administrator. These projected results are described with the yellow circles. In this case there was no difference from the solution presented in Slide 3; the increased square footage did little to "pull" any station location westward. Again, these locations are "idealized" in order to provide a benchmark for evaluating later solutions involving the closing of existing stations.

Slide 5: THREE STATION IDEAL SOLUTION—POPULATION

Slide 5 shows the optimal location solution for three new stations under this same assumption that all existing stations were to be closed and three new stations were permitted to be opened elsewhere. In this case, the location criterion was based on year 2000 Total Population. In this case, station locations based on total population generally coincided with those locations based on incidents, except where one station moved from McCord and Central to McCord and Sylvania. The other two locations included Alexis and Whiteford, and West Erie Street just east of Little Road. Again, these locations are "idealized" in order to provide a benchmark for evaluating later solutions involving the closing of existing stations.

Slide 6: THREE STATION IDEAL SOLUTION—PREDICTED POPULATION

Slide 6 represents an extension to the solution in Slide 5 which is still under this assumption that all existing stations were to be closed and three new stations were permitted to be opened elsewhere. In this case, however, the Total Population figures were extended to include projected residential populations for western portions of the township obtained from the Township Administrator. These projected results are described with the yellow circles. In this case there was very little difference from the solution presented in Slide 5, except that the third station on Erie Street shifted several blocks west; the increased population did manage to "pull" that station location slightly westward. Again, these locations are "idealized" in order to provide a benchmark for evaluating later solutions involving the closing of existing stations.

Slide 7: THREE STATION IDEAL SOLUTION—SIMPLE UNWEIGHTED COVERAGE

Slide 7 shows the optimal location solution for three new stations under this same assumption that all existing stations were to be closed and three new stations were permitted to be opened elsewhere. In this case, however, the location criterion was based simply on the inclusion of all unweighted points in the study area. These points included every street intersection, major midblock point, and every parcel centroid in the region. Population and housing densities were not necessarily factored into this analysis. Interestingly again, two of these ideal locations virtually coincided with current Stations 2 and 3. The third ideal location shifted westward on Erie Street to the intersection of Erie and Centennial.

Again, it should be emphasized here that this location solution is based entirely on the optimal geometric coverage of the region; it thus suggests the most "equitable" solution because the maximum distance between all stations and the furthest users are minimized. However, this solution is not necessarily the most efficient because the westernmost station is pulled further away from the denser populations within the City of Sylvania and Sylvania Township. Again, these locations are "idealized" in order to provide a benchmark for evaluating later solutions involving the closing of existing stations.

Slide 8: THREE STATION IDEAL SOLUTION—COMPOSITE SOLUTION

Slide 8 shows a composite map of the ideal solutions based on the four locational criteria: incidents, square footage, population and simple point coverage. This maps shows a powerful trend with locational stability for current Stations 2 and 3. This suggests that these stations should not be closed. Furthermore, an "intermediate" station location on West Erie Street between Stations 1 and 4 appears to offer better coverage for the western portion of the township. This result suggests perhaps that a station constructed in the vicinity of Erie and Little Roads (***near this location, not directly at this location***) in combination with existing Stations 2 and 3 would provide the best pattern of coverage. See Slide 9 for a better view.

Slide 9: THREE STATION IDEAL SOLUTION

As suggested in the description for the previous slide, Slide 9 shows that a more idealized station configuration would include a new station constructed in the vicinity of Erie and Little Roads (***near this location, not directly at this location***), as well as a new station constructed at Whiteford and Alexis Roads. Station 2 could remain in its present location. Stations 1, 3 and 4 would need to close. Station locations are presented with the blue circles in Slide 9. This solution would yield the following accessibility measures:

Incident ***Z***:	46,003	(44,644)
Population ***Z***:	162,907	(162,368)
Sq. ft. ***Z***:	138,734,045	(136,931,420)

Values of Z for the existing set of four stations are shown in parentheses for purposes of comparison. Again, this is an idealized configuration used as a benchmark for comparison of the four location scenarios presented in Slides 10 through 13.

Slide 10: THREE STATION IDEAL SOLUTION—CLOSE STATION 1

A more realistic scenario than that portrayed in Slide 9 would be to close one of the four current stations and keep the remaining three in operation. These final four slides show each of these potential location schemes. The first of these is to close Station 1 and keep Stations 2, 3 and 4 in operation. The following accessibility measures show the relative efficiency of this solution in comparison to the benchmark figures for the ideal solution (from Slide 9) and the current station configuration (from Slide 1):

	Scenario 1	Ideal Arrangement	Current Four Station Arrangement
Incident Z:	49,864	46,003	44,644
Population Z:	175,677	162,907	162,368
Sq. ft. Z:	150,234,919	138,734,045	136,931,420

This solution represents an 11% increase in incident-based aggregate response time relative to the current four station arrangement. This compares to an 8% increase with respect to population and 10% with respect to square footage measures. In comparison to the ideal three-station arrangement, this solution represents an 8% aggregate response time increase in all three categories: incident-based, population, and square footage. This arrangement is not as equitable or efficient as the current arrangement, but it is the most efficient of the four scenarios presented here.

Slide 11: THREE STATION IDEAL SOLUTION—CLOSE STATION 2

Slide 11 Shows Scenario 2: Close Station 2. The following accessibility measures show the relative efficiency of this solution in comparison to the benchmark figures for the ideal solution (from Slide 9) and the current station configuration (from Slide 1):

	Scenario 2	Ideal Arrangement	Current Four Station Arrangement
Incident Z:	55,170	46,003	44,644
Population Z:	201,790	162,907	162,368
Sq. ft. Z:	175,232,604	138,734,045	136,931,420

This solution represents a 24% increase in incident-based aggregate response time relative to the current four station arrangement. It also compares to a 24% increase with respect to population and 28% with respect to square footage measures. In comparison to the ideal three-station arrangement, this solution represents an 19%, 24%, and 26% aggregate response time increase in all three respective categories: incident-based, population, and square footage. As a result, this solution is significantly less efficient than that of Scenario 1.

Slide 12: THREE STATION IDEAL SOLUTION—CLOSE STATION 3
Slide 12 Shows Scenario 3: Close Station 3. The following accessibility measures show the relative efficiency of this solution in comparison to the benchmark figures for the ideal solution (from Slide 9) and the current station configuration (from Slide 1):

	Scenario 2	Ideal Arrangement	Current Four Station Arrangement
Incident Z:	50,819	46,003	44,644
Population Z:	182,798	162,907	162,368
Sq. ft. Z:	151,933,294	138,734,045	136,931,420

This solution represents a 14% increase in incident-based aggregate response time relative to the current four station arrangement. It also compares to a 13% increase with respect to population and 11% with respect to square footage measures. In comparison to the ideal three-station arrangement, this solution represents an 10%, 12%, and 10% aggregate response time increase in all three respective categories: incident-based, population, and square footage. As a result, this solution is significantly more efficient than Scenario 2, but still somewhat less efficient than that of Scenario 1.

Slide 13: THREE STATION IDEAL SOLUTION—CLOSE STATION 4
Slide 13 Shows Scenario 4: Close Station 4. The following accessibility measures show the relative efficiency of this solution in comparison to the benchmark figures for the ideal solution (from Slide 9) and the current station configuration (from Slide 1):

	Scenario 2	Ideal Arrangement	Current Four Station Arrangement
Incident Z:	48,952	46,003	44,644
Population Z:	188,177	162,907	162,368
Sq. ft. Z:	158,308,726	138,734,045	136,931,420

This solution represents a 10% increase in incident-based aggregate response time relative to the current four station arrangement. It also compares to a 16% increase with respect to population and 16% with respect to square footage measures. In comparison to the ideal three-station arrangement, this solution represents an 6%, 16%, and 15% aggregate response time increase in all three respective categories: incident-based, population, and square footage. It should be emphasized, however, that the only improvement over Scenario 1 lies in improving accessibility based on past incidents. However, projected data show that increasing population densities projected for the western portions of the township will lead to more incidents in the future. The current distribution of incidents do not show this pattern. Thus, this solution produced somewhat misleading results; it is still not as efficient as the solution in Scenario 1.

RECOMMENDATIONS

These findings show that Station 1 should be closed if such a decision had to be made in the Sylvania Township Fire Department. Station 1 has significant physical deficiencies, it is next to an at-grade railroad crossing, and its closing would affect not affect accessibility as much as closing any of the other existing stations. In addition, maximum response times for the remaining stations do push the envelope at the 8-minute maximum. However, the conservative drive time estimates in this study tend to overestimate response times in less developed areas. Thus the 8 minute standard will be preserved for the time being. However, as traffic volumes increase in the western portions of the township, then drive time studies should be undertaken to assure adequate protection.