ANALYSIS OF LOCATIONS OF EXISTING FIRE STATIONS IN ANKARA IN COMPARISON TO OPTIMIZED LOCATIONS

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By

Pelin Balcı

December, 2012

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

ANALYSIS OF LOCATIONS OF EXISTING FIRE STATIONS IN ANKARA IN COMPARISON TO OPTIMIZED LOCATIONS

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December, 2012

This thesis aims to evaluate the locations of the existing fire stations in the city of Ankara. Vertex restricted p-center problem is solved via set covering problem and optimal locations of fire stations are found. We evaluate the fire stations in two ways. The first study aims to locate the same number of fire stations with the existing case. We use an algorithm proposed by Tansel (2011) which solves a finite series of set covering problems to reach the optimal solution of the p-center problem. We use three approaches for the p-center solution which constitutes our first study. In the first approach, we optimally locate the fire stations while keeping their allocation sets the same as those of the existing stations.In the second approach, we locate the fire stations to minimize the maximum of the distances between demand nodes and their closest stations. In the last approach, we take the population of the nodes into account and solve a weighted p-center problem where the weights of demand nodes are defined by their composite populations. We also give a methodology to compute the composite population counts for nodes. In the second study, we locate a minimum number of fire stations while ensuring that each demand node is covered within a pre-determined upper bound on the service time (distance). The bounds are taken to be 4 minutes and 8 minutes in accordance with the internationally accepted norms. Optimally located fire stations are found for both time restrictions. There are two subcases for this study; one of them aims to locate the fire stations without considering the existing fire stations while the other one locates the new fire stations in addition to the existing fire stations. Optimal solutions for all the cases explained above are compared with the existing fire stations with regard to the maximum distances, populations, and covered regions. Assessments are made on existing fire stations by benchmarking their performances against optimal solutions obtained via p-center or covering solutions as outlined above. Geographical information systems

are used for obtaining the demographic data and presenting visual analysis.

Keywords: optimal locations, fire stations, p-center location, location covering.

ÖZET

ANKARA'DAKİ MEVCUT İTFAİYE YERLERİNİN OPTİMAL YERLER İLE KARŞILAŞTIRMALI ANALİZİ

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Bu tezin amacı, Ankara'daki mevcut itfaiye istasyonlarının yerleşimlerini değerlendirmektir. Düğüm kısıtlı p-merkez problemi, küme kaplama problemi yoluyla çözülmüş ve optimal lokasyonlar bulunmuştur. İtfaiye yerleşimleri için iki tip çalışma gerçekleştirilmiştir. Birinci çalışma mevcut durumla aynı sayıdaki itfaiye istasyonunun yerleştirilmesine dayanır. Önceden belirlenen sayıda itfaiye istasyonunun yerleşimi için Tansel (2011) tarafından önerilen algoritma kullanılmış ve sonlu sayıda küme kaplama problemi çözülerek optimal kaplama uzaklığı bulunmuştur. P-merkez problemini içeren bu çalışmada üç farklı yaklaşım kullanılmıştır. İlk durumda, mevcut durumdaki kaplama bölgeleriyle aynı kapsama bölgelerine sahip istasyon atamaları gerçekleştirilmiştir. İkinci durumda, talep noktalarıyla kendilerine en yakın itfaiye istasyonları arasındaki maksimum mesafe minimize edilecek şekilde istasyon atamaları yapılmıştır. Son durumda, populasyon da dahil edilmiştir ve talep noktalarına atanan ağırlıklar kullanılarak ağırlıklı p-merkez problemi çözülmüştür. Talep noktalarına ağırlıkların atanması için bir metod önerilmiştir. İkinci çalışmada, önceden belirlenen servis zamanı içerisinde talep noktalarının kapsanmasını sağlayacak minimum sayıda itfaiye istasyonu yerleştirilmiştir. Uluslarası kabul gören normları sağlayan 4 dakika ve 8 dakikalk zaman kısıtları sınır olarak alınmıştır. Her iki zaman kısıtı için atamalar yapılmıştır. Bu çalışmada mevcut itfaiye istasyonlarını göz önüne almadan atama yapan ve mevcut itfaiye istasyonlarına ek olarak yeni itfaiye istasyonlarını atayan iki farklı model çözülmüştür. Bulunan tüm optimal sonuçlar ile mevcut itfaiye istasyonları arasında, maksimum uzaklık, populasyon ve kapsanan bölgeler bazında kıyaslamalar yapılmıştır. Mevcut durumdaki itfaiye istasyonlarının performansları p-merkez ve lokasyon kapsama çözümleriyle elde edilen optimal sonuçlara göre kıyaslanarak değerlendirilmiştir. Demografik verilerin toplanması ve görsel açıdan analizlerin sunulmasında coğrafi bilgi sistemlerinden yararlanılmıştır.

Anahtar sözcükler: optimal yerleşim, itfaiye istasyonu, p-merkez yerleşimi, lokasyon kapsama.

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Chapter 1

Introduction

The p-center problem is a problem which locates p facilities on a network such that it minimizes the maximum of distances between demand points and their closest facilities. The objective function of the p-center problem is appropriate for emergency services. For locating police, ambulance or fire stations, the critical issue is reaching the place of incidence as soon as possible since the main objective is saving human life. The p-center problem involves locating one or more services in order to minimize the response time even in the worst case. The average time for meeting the demand may also be important; however, time to reach to a demand point in the worst case is more important than the average time to reach it. The p-center problem is closely related to the problem of finding the minimum number of facilities satisfying a predetermined upper bound on the maximum service distance. This problem is called the location covering problem.

In the literature, different types of p-center problems are considered according to the number of stations, weights, network types, locations of facilities, and the structure of demand points. If the number of facilities is one, then this problem is called *the 1-center problem* and if the number of facilities is more than one, then this type of problem is called *the p-center problem*. The network type may be a general network or a tree network. Demand points can be weighted or unweighted. These are called *the weighted* and *unweighted center problems*, respectively. Demands may occur only at vertices as discrete demand or along

edges as continuous demand. Facilities can be located at vertices or along edges. Problems solved for discrete locations are called *vertex restricted center problems* and problems solved for the continuous case are called *absolute center problems*. In this thesis, the vertex restricted p-center problem is used.

The literature is reviewed for the vertex restricted p-center problems. Daskin [1] solved the p-center problem by solving a series of maximal set covering problems for the vertex restricted case. Ilhan and Pınar [2] proposed a two-stage LP-IP formulation. Elloumi, Labbe, and Pochet [3] gave a new formulation for the vertex restricted p-center problem which was solved by solving a sequence of set covering problems. The algorithm used in this thesis is proposed by Tansel [4] and explained clearly in Çalık and Tansel's paper [5]. This approach is implicity used in Elloumi, Labbe, and Pochet's [3] paper.

The aim of this thesis is to evaluate the locations of fire stations in Ankara and make suggestions to the Fire Department about the locations and coverage areas of the fire stations. In the existing case, locations of fire stations and the regions assigned to them have been determined according to the distribution of population and road network of Ankara; the effectiveness of the existing locations is not known precisely. Also, the Fire Department only considers the average distances from the coverage areas to the fire stations. The main purpose of fire stations is fire fighting to save human life. That means, fire trucks should answer calls for fire immediately. The five steps, after receipt of an alarm, is given below [6]:

1. Dispatch time: Amount of time that it takes to receive and process an emergency call. This includes (1) receiving the call, (2) determining what the emergency is, (3) verifying where the emergency is located, (4) determining what resources are required to handle the call, and (5) notifying the units that are to respond.

2. Turnout time: The time from when units acknowledge notification of the emergency to the beginning point of response time.

3. Response time: The time that begins when units are en route to the emergency incident and ends when units arrive on the scene.

4. Access time: Amount of time required for the crew to move from where the apparatus stops to where the emergency exists. This can include moving to the interior or upper stories of a large building and dealing with any barriers in the access to that area.

5. Setup time: The amount of time required for fire department units to set up, connect hose lines, position ladders, and so on, and prepare to extinguish the fire.

This study focuses on the response time and we consider the maximum distance from a demand point to its closest fire station, since when we mentioned about saving human life we should know the maximum service distances. For this reason, instead of calculating the average distances, we focus on minimizing the maximum distances for all fire stations in Ankara. Fire stations are found via location covering and vertex restricted p-center problem and a comparison with the existing situation is made.

We evaluate the fire stations in four ways. Figure 1.1 shows the studies. In the existing case there are 14 fire stations and 3 of them are stable according to the decision of the Fire Department. That means, 11 fire stations should be evaluated. We solve set covering problem and locate the 11 fire stations such that the maximum distance from a demand point to its closest fire station be minimized. In the first study, the coverage areas of the existing fire stations are kept the same and for all these coverage areas the optimal locations of fire stations are found. In the second study, the same number of fire stations as the existing situation are assigned for two subcases. One of them assigns the facilities with regard to distances but the other considers the population additionally. Then, their coverage and optimal r values are compared with the existing situation. These studied shows us how these 11 fire stations can be located optimally. Moreover, average distances of all optimally located 11 fire stations are computed according to the total distance and total number of demand nodes they serve.

Then, the location covering problem is solved according to the time restrictions. For this study, NFPA (National Fire Protection Association) norms are used. NFPA is an international nonprofit organization that was established in 1896 in the USA. The company's mission is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. With a membership that includes more than 70,000 individuals from nearly 100 nations, NFPA is the world's leading advocate of fire prevention and an authoritative source on public safety. The website is *www.nfpa.org*. The time bounds represent the norms determined by NFPA. The time restrictions aims fire trucks arriving a demand point in 4 minutes or in 8 minutes.

In the third study, the locations and the coverages of the fire stations are determined according to 4-minute and 8-minute time restrictions. In the fourth study, under these time restrictions, addition of new fire stations to the existing fire stations is determined. The results are compared according to the existing case, and each region covered by the existing fire stations are analysed relative to optimal solutions. All solutions are displayed in the maps which are constituted with ArcGIS program (http://www.arcgis.com/about/). Also, there is a CD which includes all the maps as jpeg file.

There is an algorithm proposed by Tansel [4] for solving the weighted and the unweighted vertex restricted p-center problems and the problem about location of fire stations with the same coverage areas as the existing situation. This algorithm aims to solve a series of minimum set covering problem and find the optimal coverage distance. This algorithm is different from the algorithms proposed in the literature. It is such an algorithm that aims to find locations of a pre-determined number of fire stations by searching radius (r) values via a series of set covering problem solutions. If the solution for an r value is bigger than the pre-determined number of fire stations, then the r value is decreased and the problem is solved again. However, if the solution for an r value gives a smaller number of fire stations, then the r value is increased and the problem is solved again. Solving a series of minimum set covering problems finally gives the optimal r value for the pre-determined number of fire stations. The binary search technique is used to

search r values over a finite list of possible values. The same model is also used for solving the problem with a fixed r value that stands for the time bound on travel time. GAMS program is used for solving all of these problems. After the demand points are assigned to their closest facilities, the procedure is completed.

The solutions show us important results about the fire stations in Ankara. The maximum time can be decreased to one third of the existing case with the same number of fire stations. Moreover, the time restricted models show that the whole region can be covered in less minutes with less number of fire stations. The locations of additional fire stations demonstrate the places which are not covered efficiently in the existing cases. There are some suggestions to the Fire Department. They may decide to change the location of the existing fire stations or close them or keep them and open new ones according to our suggestions. We explain the coverage areas, location of optimal fire stations and the improvement clearly for all cases.

The rest of this thesis is organized as follows: Chapter 2 contains the literature review for the p-center problem. In chapter 3, we discuss the algorithm and the mathematical model. In chapter 4, the information related to data used is explained clearly. Chapter 5 gives information about the existing situation. Chapter 6 continues with the explanation of the location of fire stations for four different types of cases. Analyses of assignments of fire stations with the existing situation are presented in chapter 7. Chapter 8 gives the suggestions to Fire Department. Chapter 9 presents the conclusion of the thesis with a discussion of the results.

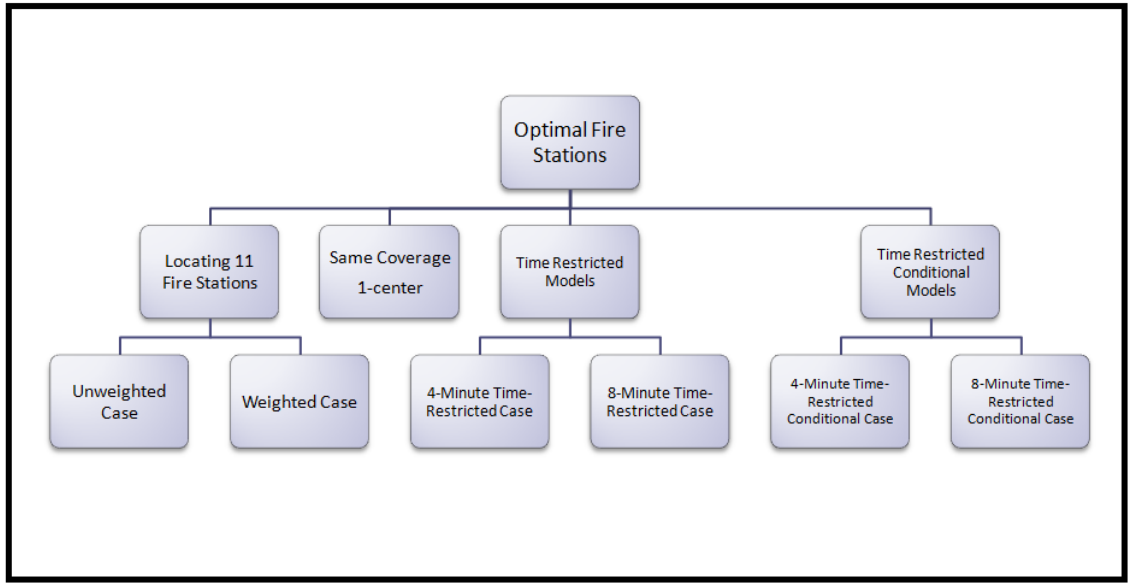

Figure 1.1: Locating Optimal Fire Stations

Chapter 2

Literature Review

Literature review is given in three sections: 1-center problems, p-center problems, and fire stations. The set covering based method which is used in this study constitutes the main area of the review. The review of the 1-center problem begins with Hakimi's seminal paper [7]. Then, some basic papers that consider different types of solution methods are given. The review of the p-center problems also starts with Hakimi's paper [7]. After the explanation of Kariv and Hakimi's [8] paper which is one of the most important papers about center problems, the papers which use set covering based methods for the p-center problems are mentioned. More detailed information can be found in [9] and [10]. Lastly, there is a literature review for emergency services. The papers examined mostly solve the location of station problems with covering problems.

2.1 Center Problems

Hakimi [7] analyzed two problems in this paper; the absolute median and the absolute center problem. While the objective of the absolute median problem is to minimize the summation of distances from the facility to all vertices, the objective of the absolute center problem is to minimize the maximum distance

from the facility to all vertices. Hakimi proved that there is always an absolute median of a graph at a vertex. However, the absolute center of a graph is not necessarily at a vertex. Hakimi found a method to solve the absolute center problem. In this method, all branches are investigated and the local optimal facility location at each branch is found. Let $G = (V, E)$ be an undirected finite network where $V = \{v_1, ...v_n\}$ is the vertex set and E consists of undirected edges (v_i, v_j) with $i, j \epsilon I = \{1, 2, ..., n\}$. If x is a point in edge (v_p, v_q), then the minimum distance from x to a vertex v_i can be written as:

$$d(v_i, x) \quad = \quad \min\{d(x, v_p) + d(v_p, v_i), d(x, v_q) + d(v_q, v_i)\}. \tag{2.1}$$

Then, these functions from x to v_i for all i is plotted on a graph. The curve of the function gives the maximum of the functions. This is a piecewise linear function. Minimum of this function gives the local optimal point at that branch. After applying the same procedure for each branch, the global solution can easily be found.

Hakimi [11] first introduced the p-center problem.

Kariv and Hakimi [8] examined 1-center and p-center problems and found dominating sets for a given radius r. They improved algorithms for weighted and unweighted cases. They showed that the p-center problems are NP-hard on general networks. However, there exists polynomial time algorithms for the p-center problem on tree networks.

Set Covering Based Methods for the P-Center Problem

Minieka [12] gave a procedure for the unweighted absolute p-center problem by solving a finite series of minimum set covering problems.

Christofides and Viola [13] presented an iterative algorithm for the absolute p-center problems on general networks. In order to find p centers, the first thing

to do is to find the set which contains all points on G such that the distance between these points and a vertex is at most r units. G^1 is defined for each vertex by finding these sets and regions. Minimal externally stable set of G^1 is found by solving a finite number of set covering problems. If the number of centers is greater than p, then r is increased and the algorithm is repeated until it reaches the p center. For the inverse case, r becomes a constant.

Garfinkel, Neebe, and Rao [14] gave an integer programming for the unweighted p-center problem. A binary search technique, combination of exact tests and heuristics were used. The first step of their algorithm is to determine the bottleneck values for r. Then, a set covering problem is solved to determine whether there exists a feasible solution. Lastly, the bottleneck value is updated according to the feasibility of the problem, until there exists a feasible solution with the smallest r value. In the paper there was a technique eliminating the bottleneck points in order to reduce the search space.

In p -center problems, the service is delivered from facilities to the demand points. Tamir [15] considered a different situation in which customers and servers move towards each other. Covering problems were used to solve the problem.

Ilhan and Pınar [2] proposed a two-phase LP-IP formulation and generated a method to check the feasibility of covering with p centers within a given radius. In the first phase the lower bounds are searched and in the second phase IP formulation is solved by using the lower bound found in the first stage.

Elloumi, Labbe, and Pochet [3] gave a new formulation to the general p-center problem based on solving set covering problems and it was compared with Daskin's [1, 16] formulation. The new formulation gives better lower bound values. The authors proved that a polynomial number of LPs can be solved to obtain the lower bound. They solved $O(log_2(NM))$ LPs where N is the number of clients and M is the number of potential sites. There were computational experiments and this is the first paper which extends the number of nodes up to 1817.

Çalık and Tansel [5] proposed a new IP formulation for the absolute and

vertex-restricted p-center problems. They proposed a polynomial time algorithm to find a lower bound for searching r values instead of using binary or bisection search. They solve the problems with up to 3038 nodes.

2.2 Fire Stations

Toregas et al. [17] defined a set covering problem for the location of minimum number of emergency service facilities that cover all regions. Church and Revelle [18] proposed a maximal set covering problem to locate emergency stations within a desired distance with a given number of fire stations such that the covered population is maximized. Locations of fire stations in rural areas were studied by Doeksen and Oehrtman [19]. The general transportation model was used for this problem. Hogg [20] used the set covering problem for locating a given number of fire stations in Bristol. Plane and Hendrick [21] conducted a research study about location of fire stations in Denver city. The study used the set covering problem as a solution method and aimed at minimizing the number of fire stations and maximizing the number of existing fire stations within the total number of fire stations.

The mathematical model proposed by Schilling et al. [22] assigned not only fire stations but also the equipments, such as fire trucks and manpower. This study was realized in Baltimore City with The Tandem Equipment Allocation Model which assumed that the demand points can be covered only once. Schreduder [23] made a study in Rotterdam Fire Station in order to locate the minimum number of fire stations and determine the covered points which were reached by a fire station in a predetermined time. The set covering problem with double coverage were used for the solution of the problem.

Marianov and Revelle [24] improved the maximum set covering problem with probabilistic constraints for fire protection. In this model, every region was covered with at least α joint reliability. Narasimhan, Pirkul, and Schilling [25] proposed a model for the capacitated facility siting problem with multiple levels of

backup coverage. The solution method was based on lagrange relaxation. This model differed from other covering models since the uncovered demand was forced to be assigned to a facility. Moreover, the objective function could measure the distance of the uncovered demand points which were assigned to a facility.

Badri, Mortagy, and Alsayed [26] proposed a multi criteria model which was different from general studies considering only travel distances and times. As well as considering these criteria, technical and political restrictions and cost were included in the study. A goal programming approach is used for location of fire stations in Dubai city.

A location model based on a fuzzy multi-objective approach was proposed by Tzeng and Chen [27]. In this study, the number of fire stations at Taipei's international airport was determined. Also, genetic algorithm and enumeration method were compared and it is found that genetic algorithm was more effective. The goals in this paper were siting minimum number of fire stations, using the resources of fire stations effectively, minimizing the maximum distance between the fire station and the accident sites. Although there is a similarity between Yang, Jones, and Yang's paper [28] and Tzeng and Chen's [27], Yang, Jones, and Yang focused on various fire risk categories of a given area. The distinguishable features were, separating the areas according to risk categories, introducing fuzzy models which helped to find minimum number of stations, choosing suitable chromosome format and embedding constraints into the fitness function of a genetic algorithm which dramatically reduced the complexity of the problem. Araz, Selim, and Ozkarahan [29] proposed a fuzzy multi-objective maximal covering location model. The model focused on the facility locations with limited vehicles. The quality of emergency service systems was considered as objectives in the model. The service level was reflected by the maximization of the population covered by one vehicle, maximization of the population with backup coverage and minimization of the total travel distance from locations at a distance bigger than a predetermined distance standard for all zones [29].

Geographic Information Systems (GIS) were improved to store, manipulate, analyze, and map geographical data. In the literature, GIS was used for location

problems. Dobson [30] utilized GIS for the power plant in northern Maryland in order to locate fire stations. Church [31] gave an information about usage of GIS while doing location analysis and determining optimal location sites for emergency services. Liu, Huang, and Chandramouli [32] presented an approach to determine the location of new fire stations in Singapore by using GIS and ANT (Ant Algorithm). The first goal was to measure the effectiveness and maximizing the coverage of the roads that were used for transportation of hazardous materials. Second goal was to cover all regions in 6 minutes. The last goal was to achieve reasonable distance among fire stations. Chevalier et al. [33] developed a decision support system for fire stations in Belgium. The main aim was to cover 90% of the area within a given time.

There is a method to locate new fire stations in Istanbul proposed by Çatay [34].The name of the 0-1 integer model is Maximal Set Covering Model based on Risk Factor. In this model, two or three types of stations are assigned to the regions in different risk groups. The model aims to cover the largest area with a predetermined number of stations.

A study about fire stations in İstanbul has been made in 2009 by Aktaş et al. [35]. An integer model is proposed which includes such constraints as, the types of fire stations, capacity of fire stations and probabilities of fires. By using one of GIS program ArcGIS, location of fire stations in each districts are found. The arrival time from the possible location of fire stations to other districts is accounted for with certain features of ArcGIS. The time matrix was used in the integer model. The time restriction is 5 minutes. It is found that 70 new fire stations is enough to cover the whole region. Also, the efficiency of the existing fire stations is found via ArcGIS.

In the literature, it is seen that as well as mathematical programming, different types of programs like GIS were used to locate fire stations. On the other hand, the models which have more than one goal were developed which can be seen in Tzeng and Chen's paper [27]. This study was pursued in a real area and different solutions were presented after analyzing the existing situation. For this reason, both set covering model and GIS system were used. Optimal solutions were found

for different types of criteria with minimum set covering model and solutions are visually analyzed with GIS system. In most studies, maximal covering models were considered, but this study aims to cover all the region in the predetermined area.

We locate the optimal fire stations by using the data of travel distances and population. Moreover, the assignments with different criteria were realized for one region and they were compared according to population, maximum and average distances.

Aktaş et al. [35] used the time restriction of 5 minutes which is the time limit given by İstanbul Fire Department. However, we used 4 minute and 8 minute time restrictions. These are international accepted norms. Lack of a study which demonstrates efficiency of existing fire stations in Ankara and optimally located fire stations shows the importance of this study.

Chapter 3

Mathematical Formulation and The Algorithm

This thesis aims to analyze and locate fire stations in Ankara. In the literature, many different solutions have been proposed for siting fire stations. However, in this study, a p-center problem is solved via the minimum set covering problem. The proposed algorithm aims to reach the solution by solving a finite series of minimum set covering problem. Firstly, some notations and definitions about the algorithm are defined; then, the explanation of the model and the algorithm is given.

3.1 Notations

- The index set $I = \{1, ..., n\}$ is the set of vertex indices.
- $N = (V, E)$ is an undirected finite network where $V = \{v_1, v_2, ..., v_n\}$ is the vertex set and E is the edge set. (v_i, v_j) represents an edge with end vertices v_i and v_j.
- $d(v_i, v_j)$ is the length of a shortest path between vertex v_i and vertex v_j.

- w_i is the weight of vertex i.
- $X = \{x_1, x_2..., x_p\}$ is the set of locations of p identical facilities.

3.2 Definition of the Radius

$D(X, v_i) = \min\{d(x_1, v_i), d(x_2, v_i), ..., d(x_p, v_i)\} = D(v_i, X)$ shows the distance from a vertex to its closest facility. The radius is the maximum of $D(X, v_i)$ for the unweighted case and the maximum of $w_i \times D(X, v_i)$ for the weighted case. In other words, the radius shows a weighted or unweighted maximum distance from a demand point to the closest facility to that demand point. Here, the computation of the candidate set for the optimal r value for the set covering problem will be explained. For the unweighted problem $d(v_i, v_j)$ is computed for each vertex v_j where $j = \{1, 2..., n\}$. After sorting these numbers in ascending order, the finite list of r values are at hand. For the weighted problem, the formulation becomes $w_i \times d(v_i, v_j)$ and the same procedure is repeated. The finite list of r values are shown as $R = \{r_1..., r_k..., r_t\}$. The optimal objective value of the p-center problem is shown as r_p^*.

3.3 The Set Covering Problem

The minimum set covering problem finds the minimum number of facilities under the constraint that all demand points should be covered. The minimum set covering problem that is used in the algorithm is defined in equation 3.1.

$$\begin{aligned} \min \quad & \sum_{j=1}^{n} x_j \\ s.t. \quad & \sum_{j=1}^{n} a_{ij} x_j \geq 1 \quad \forall\ i\ \epsilon\ I \\ & x_j \epsilon \{0,1\} \quad \forall\ j\ \epsilon\ I \end{aligned} \tag{3.1}$$

The variables in the model are

$$x_j = \begin{cases} 1, & \text{if vertex } V_j \text{ is selected as a location of fire station} \\ 0, & \text{otherwise} \qquad\qquad \forall j = 1, ..., n \end{cases} \tag{3.2}$$

and the parameters are

$$a_{ij} = \begin{cases} 1, & \text{if } w(i)d(v_i, v_j) \leq r \\ 0, & \text{otherwise} \qquad\qquad \forall i = 1, ..., n \end{cases} \tag{3.3}$$

where a_{ij} shows the coverage or noncoverage of a vertex v_i by a vertex v_j. Equation 3.3 gives the definition of a_{ij} for the weighted case. In the unweighted case, $w(i)$ in 3.3 is taken to be one for each i.

3.4 Algorithm for the P-Center Problem

Location covering problem is solved for fixed r value and the number of facilities is found based on this r value. In the set covering model, r_p^* is found for a fixed number of facilities. We use the binary search algorithm presented by Tansel

[4] to find a pre-determined number of facilities. The algorithm is also explained clearly in Çalık and Tansel's paper [5]. Let $q(r_k)$ represent the minimum objective value of the set covering problem for fixed r_k. The algorithm aims to find the minimum r value which gives the predetermined number of centers. Solving the p-center problem via the set covering problem is explained as follows:

0. Initially, take R to be the sorted list of r values; i.e. $R = \{r_1, ..., r_t\}$.

1. Perform a binary search over the list of r values. Let r_k be the middle r value in R.

2. Find a_{ij} matrix according to the selected r_k, then solve the set covering problem.

3. If $q(r_k) > p$, then $r_k < r_p^*$. That means that the selected r value should be increased. Delete from R all values in R that are less than or equal to r_k. If R is a singleton, go to step 5, otherwise go to step 1.

4. If $q(r_k) \leq p$, then $r_k \geq r_p^*$. That means, the selected r value should be decreased. Delete from R all r values in R that are greater than r_k. If R is a singleton, go to step 5, otherwise go to step 1.

5. Stop. If r_l is the last surviving value in R, then $r_p^* = r_l$. In the event the set covering solution has fewer centers than p, any $p - q(r_l)$ vertices can be added to the solution to obtain a p-center solution. Otherwise, $p = q(r_l)$ and the set covering solution gives the optimal locations of the p centers.

Chapter 4

Collection and Analysis of Data

Ankara is the capital city of Turkey with a population of 4,890,893 according to the 2011 census. The area of Ankara is 2.516 km^2. Ankara has 24 townships; Altındağ, Çankaya, Etimesgut, Gölbaşı, Keçiören, Mamak, Sincan, Yenimahalle, Akyurt, Ayaş, Bala, Beypazarı, Çamlıdere, Çubuk, Elmadağ, Evren, Güdül, Haymana, Kalecik, Kazan, Kızılcahamam, Nallıhan, Polatlı and Şereflikoçhisar. In this thesis, only the central townships which are located in the beltway, Altındağ, Çankaya, Etimesgut, Keçiören, Mamak, Sincan, Yenimahalle are considered. Solution steps of the problem are listed below:

- Construction of the network
- Finding all pairs of shortest paths
- Finding r values
- Determining the weights of vertices
- Solving the set covering problems

4.1 The Construction of the Network

The area which is inside the beltway of Ankara is examined. The network was constructed for the seven townships and the union of all main streets in the seven townships constituted the street network. Intersection points of main streets and additional points on the beltways are considered as demand points and potential facility locations. We site the points on the beltways a few kilometers apart. The roads between adjacent pairs of vertices constitute the edges of the network. There are 452 nodes and 1920 edges in the network so constructed. Figure 4.5 shows the formed map and also the existing situation in Ankara. After the map is formed, the length of each edge is found. Google Map program (http://maps.google.com/) is used for determining the lengths of edges. A small part of the length matrix is given in Table B.1. The total matrix is given in the CD attached to this thesis.

4.2 Finding All-Pairs Shortest Paths

Shortest path distances between all pairs of nodes are computed by Floyd-Warshall algorithm [36]. It is an efficient algorithm that runs in $O(n^3)$ time. Given a graph $G = (N, E)$ with n nodes, let $d^k[i, j]$ be the shortest path from node i to node j that uses only the nodes $1, 2, .., k-1$ as internal nodes. The algorithm first computes $d^1[i, j]$ for all node pairs i and j, and then computes $d^2[i, j]$ by using $d^1[i, j]$. This process is repeated until computing $d^{n+1}[i, j]$ that represents the actual shortest path distances, and then the algorithm terminates. Given $d^k[i, j]$, $d^{k+1}[i, j]$ is computed via;

$$d^{k+1}[i, j] = \min\{d^k[i, j], d^k[i, k] + d^k[k, j]\} \tag{4.1}$$

The formal statement of the Floyd-Warshall algorithm is;

```
begin
for all node pairs [i, j]ϵNxN do
   d[i, j] := ∞ and pred[i, j] := 0;
end for;
for all nodes iϵN do
   d[i, i] := 0;
end for;
for each arc (i, j)ϵA do
   d[i, j] := c_ij and pred[i, j] := i;
end for;
for each k := 1 to n do
   for each [i, j]ϵNxN do
      if d[i, j] > d[i, k] + d[k, j] then
         begin
         d[i, j] := d[i, k] + d[k, j];
         pred[i, j] := pred[k, j];
      end if;
   end for;
end for;
```

where pred[i,j] is the last node before node j in the tentative shortest path from node i to node j [36]. The algorithm uses the predecessor indices to keep track of the shortest paths. The algorithm is implemented in software R. The R code is given in the Appendix A. A small part of the shortest path matrix is given in Table B.2. The total matrix is given in the CD.

4.3 Obtaining the r Values

In this study, weighted and unweighted problem types are studied and r values are found for both of them. As stated in Chapter 3, the list of r values are computed

via the formulations; $w_i d(v_i, v_j)$ and $d(v_i, v_j)$ for weighted and unweighted cases, respectively. The calculations are filled out on Excel. These values are sorted in ascending order. For the weighted case, there are 166206 distinct r values and for the unweighted case there are 3922 r values. The r values which were used in the algorithm were chosen via a binary technique. The r values for the unweighted case is given in Tables B.3, B.4 and B.5.

4.4 Weights of Nodes

The population data of districts of Ankara are obtained from TÜİK (Türkiye İstatistik Kurumu) for the purpose of determining the weights of the vertices. The obtained data is for the year 2008. Nevertheless, the data is not enough to show the true population during daytime. The population density changes during daytime. It is not possible to gather population information for daytime. The population of critical places are obtained separately and added to the population data.

Public institutions, hospitals, shopping centers and industrial sites are the areas that are densely populated during daytime. Also, there are some other important spots where people visit frequently. Such spots include Ulus Train Station, Atatürk Forest Farm, Atatürk Cultural Center, the wholesale market, some big parks such as Kurtuluş Park, Gençlik Park, Seğmenler Park, Botanik Park, Bayındır Dam and some workplaces deployed in Kızılay and Ulus. Moreover, Ankara has 17 universities in it. Web sites are used to clarify how many people work in industrial sites and in public institutions. Additionally, the number of people who visit shopping centers, the central train station, Atatürk Forest Farm, Atatürk Cultural Center and big parks are investigated by learning the capacity of these places. Estimated daytime population is assigned to Kızılay and Ulus since there is no formal source of data that could give the number of workplaces in those places. Also, the number of beds in big hospitals as well as the number of doctors, nurses, care givers and administrative staffs are obtained. Only the big hospitals such as Hacettepe Hospital, İbni Sina Hospital, Numune

Hospital are taken into account, since it is easy to get information from internet for these places. Lastly, the number of personnel, students and instructors in the universities are obtained from their web sites. Actually, it is not possible to reach the exact numbers and the capacity information from the web sites. Estimated populations are used in this study. The total population including daytime population of the aforementioned places is found to be as 4117511.

The term *region* is used in this chapter for any undivided planar area which is bounded all around with the main streets in the map constructed. Hence, a region is a maximal portion of the plane contained in a cycle of main streets such that the cycle has no chord connecting some two vertices of the cycle. The term *district* is used for a small part of a township whose borders are determined by municipalities. Thus, a district is an administrative unit and has nothing to do with the street network of Ankara. A region in the sense we use the term may have more than one district in it and some of those districts may be partly contained in that region while remaining parts of a district may be contained in other neighboring regions. We count the population of each district as stated in the previous paragraph. Because the borders of regions and districts are, in general, different, we need to convert the population data of districts to population data of regions and then compute the population of each node from the regions it belongs to. Thus, each region is enumerated and the nodes around the regions are found. Also, the districts which are overlapped with the regions are determined. There are four cases in the computation of the populations of regions.

- A region may include only one district. The population of the district gives the population of the region.
- A region may include more than one district. Its population is found via sum of the populations of the districts included in that region.
- More than one region may constitute one district. The population of this district is divided in proportion to the areas of the regions that contain that district.
- More than one region may constitute more than one district. The sum of

the population of these districts are found. Then this total population is divided in proportion to the areas of the regions.

The formulation about the division according to the population is given in Equation 4.2

$$\frac{Area\ of\ the\ region}{Total\ area\ of\ the\ grouped\ region} \times Total\ population\ of\ the\ grouped\ region \quad (4.2)$$

This formulation gives the population of each region for cases 3 and 4. We use ArcGIS program to find the areas. The populations of the regions are found according to these four cases. Then, we need to find the population of the nodes by using the population data of regions. The population of a region is divided by the number of nodes around it. We can use the term *divided population* for this. If the node belongs to more than one region, then we need to count the divided population of those regions too. Then we sum all divided populations coming from the regions around the node. This gives the population of the node.

Here, there are four numerical examples related with these calculations.

1. First example of the situation about the regions and the districts is Region 253. It is demonstrated in Figure 4.1.

   Its location is in Çankaya Township. It includes only Naci Çakır District. Therefore, the population of Region 253 equals the population of Naci Çakır District. It is 10680. There are 3 nodes around that region, these are nodes 188, 265 and 266. Therefore the population of the region should be divided by 3. The divided population is 3560. Table 4.1 gives the information about this region and the population divided by the number of nodes in that region.

   Node 188 belong to Region 252, Region 253 and Region 255. We calculate the divided population of those regions too. These are, 6734, 3560, and

Region	District	Total population	Number of node	Divided population
Region 253	Naci Çakır	10680	3	3560

Table 4.1: Example 1; one region and one district

6090, respectively. The population of node 188 is the sum of the populations coming from these regions and it is 16384.

The regions around Node 265 are Regions 252, 253, and 254. The populations from these regions are 6734, 3560, and 2109. Their sum gives the population of node 265. It is 12403.

Node 266 belong to the regions 253, 254, and 255. The divided population of these regions are 3560, 2109, and 6090, respectively. The population of node 266 is found by summing these divided populations. It is 11759. Table 4.2 shows the population counts of these nodes.

Node	Region around the node	Population coming from the region	Population of the Node
Node 188	Region 252	6734	16384
	Region253	3560	
	Region 255	6090	
Node 265	Region 252	6734	12403
	Region 253	3560	
	Region 254	2109	
Node 266	Region 253	3560	11759
	Region 254	2109	
	Region 255	6090	

Table 4.2: Example 1; obtaining node population

2. The second example is Region 131. Its location is in Keçiören. This region includes more than one district in it, Çiçekli, Karargahtepe, and Basınevleri. Figure 4.2 gives a map of this region. The discrete red lines in the figure demonstrate the border lines between the districts.

   The total population of Region 131 equals the sum of the populations of Çiçekli, Karargahtepe, and Basınevleri Districts. The population of Region 131 is 43263. There are 5 nodes around the Region 131. These are the nodes 105, 106, 107, 115, and 124. That means, we need to divide the

total population by 5. The population that comes from Region 131 to these nodes is 8653. Table 4.3 demonstrates the population counts and divided population of Region 131.

Region	District	Population	Total population	Number of node	Divided Population
Region 131	Çiçekli	12501	43263	5	8653
	Karargahtepe	14036			
	Basınevleri	16275			

Table 4.3: Example 2; one region and more than one districts

These nodes belong to more than one region and after summing the population coming from other regions, the total population of the nodes are found. The method is the same as the method shown in Table 4.2.

3. In the third example, there are two regions which include only one district. Kent Koop District in Batıkent is divided into Regions 47 and 51. We need to divide the population of Kent Koop District in proportion to the areas of the regions. Figure 4.3. shows the regions.

   Table 4.4 shows the population counts of these regions. Area of Region 47 is 1.2 km^2 and area of Region 51 is 1.3 km^2. The ratios of the areas according to the total area are 0.48 and 0.52, respectively. Thus, multiplication of the total population with these ratios give the population of each region. These are 15308 and 16584 approximately.

Region	District	Population	Area	Total Area	Area/Total area	Population of the region	Number of node	Divided Population
Region 47	Kent koop	31893	1.2 km^2	2.5 km^2	0.48	15308.64	4	3827
Region 51			1.3 km^2		0.52	16584.36	5	3317

Table 4.4: Example 3; more than one regions and one district

Region 47 has 4 nodes around it and these are the nodes 42, 43, 45 and 46. Region 51 has 5 nodes and these are the nodes 45, 46, 49, 51, and 368. The divided populations are found as shown in Table 4.4. Therefore, the nodes 42, 43, 45 and 46 get 3827 people from Region 47 and the nodes 45, 46, 49, 51 and 368 get 3317 people from Region 51. These nodes belong to more than one region. Thus, the actual population of the nodes are found

by summing all the population coming from the other regions which cover them.

4. The last example shows the case where more than one region include more than one district. Region 137, Region 138 and Tepebaşı and Kalaba Districts which are located in Keçiören Township make a good example. As seen from Figure 4.4, some parts of Tepebaşı District belong to Region 137 and other parts of it belong to Region 138. The broken red line in Figure 4.4 shows the border line between Tepebaşı and Kalaba. It is not possible to account for the division of population of Tepebaşı District. The sum of Tepebaşı and Kalaba Districts constitutes the population of Region 137 and 138. The population of Region 137 and 138 is 39811. The areas of them are 0.6 km^2 and 0.8 km^2, respectively. They are divided by the total area and the ratios are found. Their multiplication with the total population gives the population of the regions. These are 17061 and 22749 approximately.

   Table 4.5 shows the population counts of Regions 137 and 138 and their divided populations.

Region	District	Population	Total population	Area	Total area	Area/Total area	Population of the region	Number of node	Divided Population
Region 137	Kalaba	13891	39811	0.6	1.4	0.428571429	17061.86	5	3412
Region 138	Tepebaşı	25920		0.8		0.571428571	22749.14	5	4550

Table 4.5: Example 4; more than one regions and more than one districts

   Region 137 has 5 nodes. These are nodes 116, 117, 122, 123, and 124. The population coming from Region 137 to these nodes is 3412. Also, Region 138 has 5 nodes. The population coming from Region 138 to nodes 75, 107, 123, 124, and 322 is 4550. These nodes belong to more than one region. After summing the whole population coming from the regions, population of each node is found.

According to these 4 examples, the population of each region and the population of each node are calculated. The calculation of the population of the regions are shown in Tables B.6 and B.7. The population for the nodes give the values of the weights w_i used in the weighted model.

Table B.8 gives a small part of the table which shows the regions and the nodes around them. This table is used for calculation of the number of nodes around a region. Table B.9 gives the regions, populations of the regions, the number of nodes around them and divided populations. The divided populations are written in Table B.10. The last column of Table B.10 shows the sum of the populations coming from the regions around a node. In other words, the sum of each row gives the population of each node. Table B.10 shows a small part of these calculations . Lastly, table B.11 represents the population of all nodes.

Assumptions:

The map used in this study covers the region in the beltway. However, there are some points in the southern part of Ankara which get service from Gölbaşı Fire Station. Since the area of Gölbaşı is not considered, these points should be eliminated from the study. Their locations are used for calculation of the travel distances and shortest paths, but they are not taken as demand nodes in our study. After subtracting the population already covered by Gölbaşı Fire Station, the considered population in Ankara is 4101167 people. The uncovered demand points are demonstrated with big blue cross sign in the maps. Another assumption is about the coverage of the existing fire stations in Ankara. The existing fire stations serve some points outside the beltways. Nevertheless, this thesis assumes that they only cover the regions inside the beltway. They will be analyzed in the next chapters according to this assumption. Lastly, considered roads are assumed to be undirected.

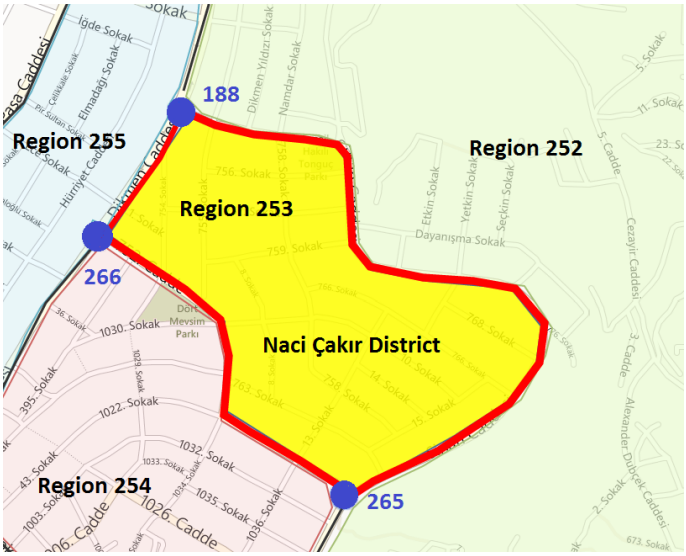

Figure 4.1: Region 253

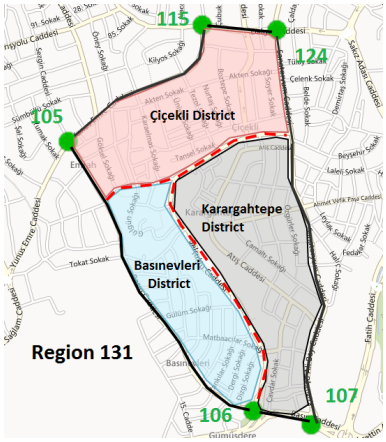

Figure 4.2: Region 131

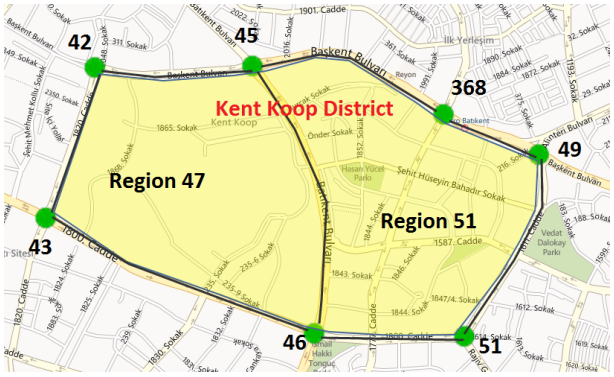

Figure 4.3: Region 47 and Region 51

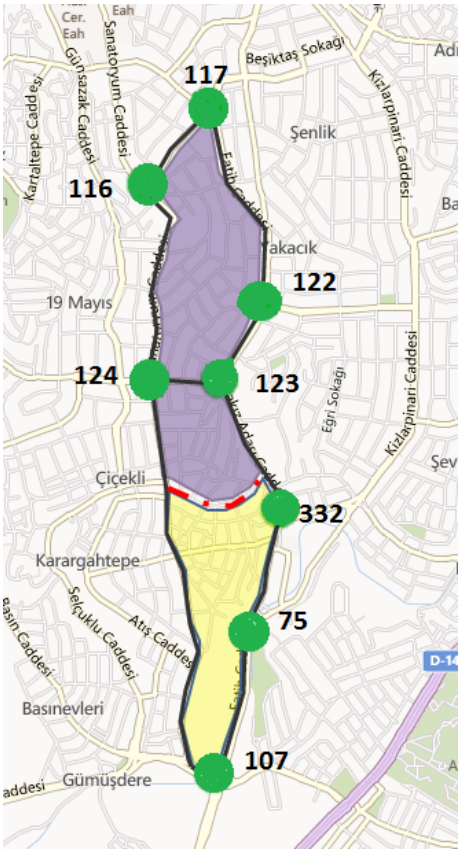

Figure 4.4: Region 137 and Region 138

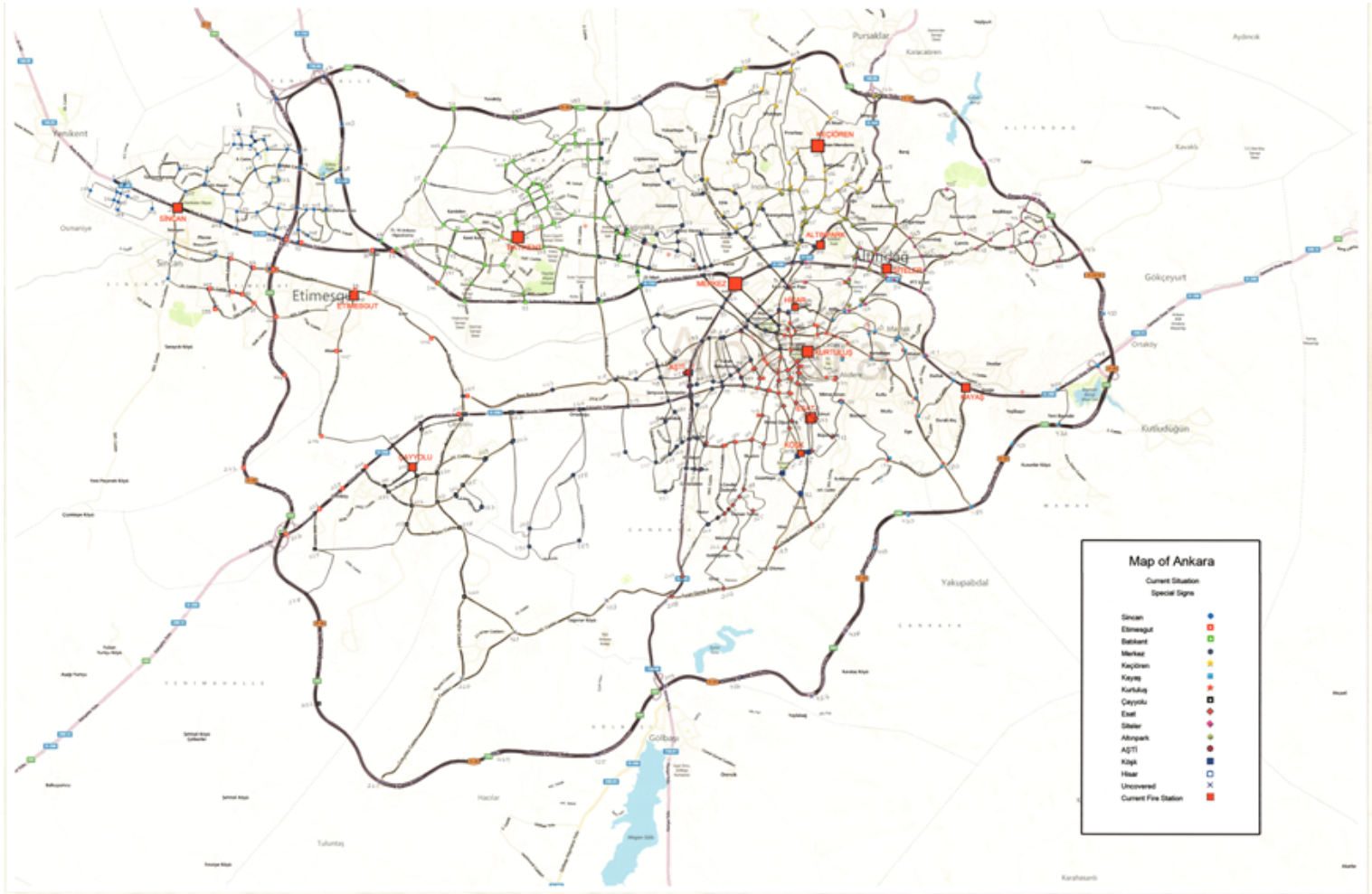

Figure 4.5: The street network of Ankara (restricted to main streets)

Chapter 5

The Existing Situation

In this chapter, the existing situation in Ankara is discussed and a detailed explanation is given. Figure 5.1 shows the map of the existing case. The fire stations are shown as red squares on the map. The demand points which are assigned to the fire stations are shown as different shapes and colours. Ankara has 14 fire stations in the considered regions. Their name, address, node number and the shape of the demand points assigned to them are listed below:

Fire Station	Address	Node Number	Shape of the Demand Points on the Map
Sincan Fire Station	Ayaş Street No: 9	Node 2	blue point
Etimesgut Fire Station	Inside Etimesgut Aski, Etimesgut	Node 40	red square
Batıkent Fire Station	Ostim Alınteri Boulevard No:22, Yenimahalle	Node 50	green square
Merkez Fire Station	Turgut Özal Boulevard No: 9 , Altındağ	Node 91	gray point
Keçiören Fire Station	Kızlarpınarı Street No: 90, Keçiören	Node 120	yellow star
Kayaş Fire Station	Samsun Yolu Yeşilöz District, Mamak	Node 149	light blue square
Kurtuluş Fire Station	Celal Bayar Bulvar No:11, Altındağ	Node 158	red star
Çayyolu Fire Station	Ankaralılar Street, Near Gendarmerie, Yenimahalle	Node 242	balck square
Esat Fire Station	Bülbül Deresi Street No:128, Çankaya	Node 274	pink diamond
Siteler Fire Station	Altınay Street No:62/A,Siteler	Node 322	purple diamond
Altınpark Fire Station	Inside Altınpark/Altındağ	Node 341	light green point
AŞTİ Fire Station	Inside AŞTİl / Yenimahalle	Node 254	claret red point
Köşk Fire Station	Inside Presidential Mansion, Çankaya	Node 271	dark blue square
Hisar Fire Station	İçhisar Ali Taşkın Street No:36, Altındağ	Node 297	white square

Table 5.1: Fire Stations in the Unweighted Model

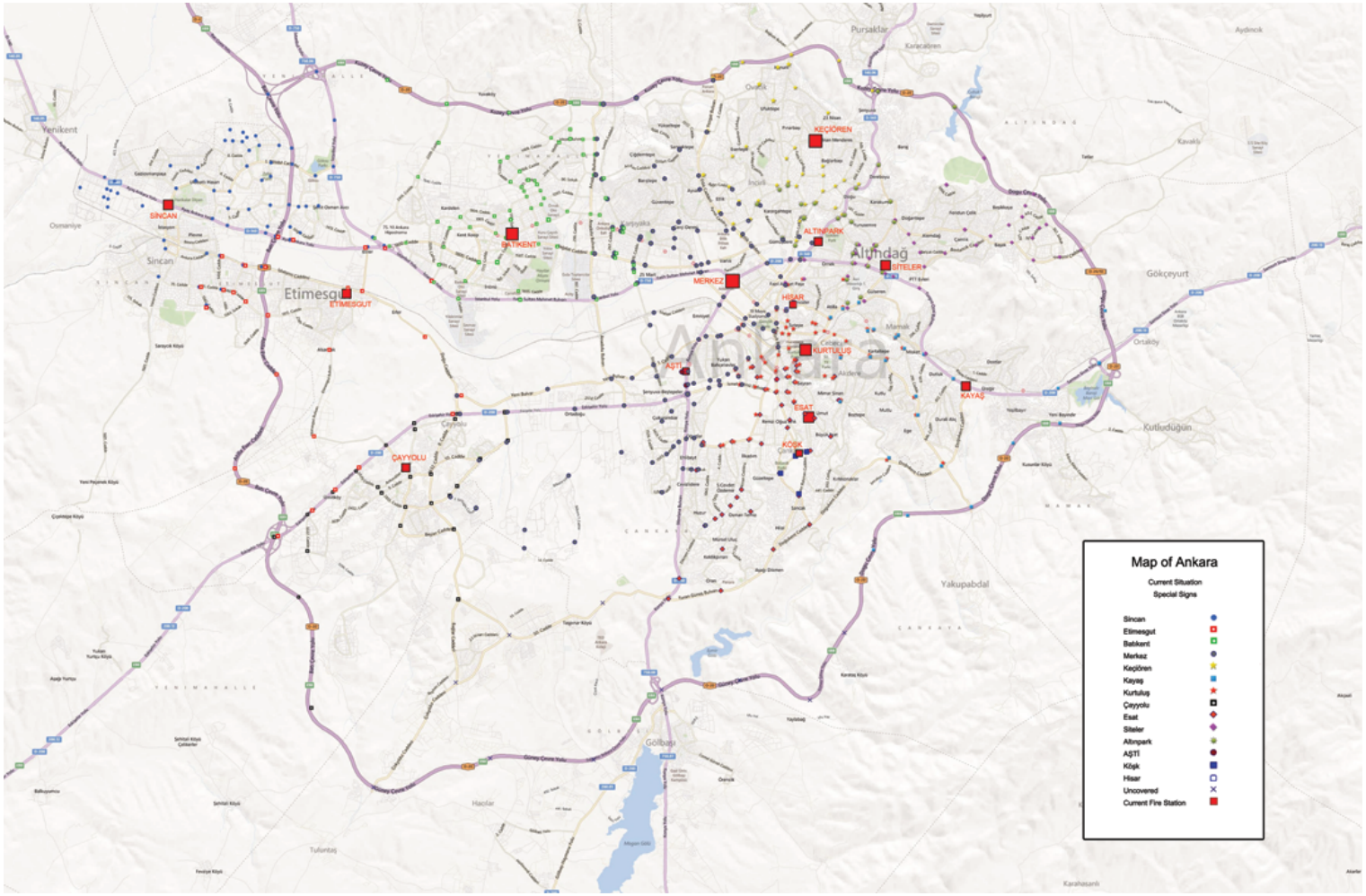

Figure 5.1: Fire stations and their assigned nodes in the existing situation

Three of the fire stations in the above list have a special situation. AŞTİ, Köşk and Hisar Fire Stations cover only the regions in which they are situated. AŞTİ is the bus station from where all the interurban buses take their passengers. The Köşk Fire Station is situated in the presidential mansion at Çankaya and the Hisar Fire Station is located at the Ankara Castle. The three stations and their covered nodes remain the same in our study with no change. These are dedicated fire stations that cover only their specially assigned nodes.

Merkez Fire Station is the main place which coordinates all of the fire stations, analyzes them and collects the data. According to the data gathered from Merkez Fire Station, the capacity of a fire station can be raised by raising the number of fire trucks in accordance with the regulations of fire stations in Ankara. The capacity issue is not relevant as the number of fire trucks can be increased at will depending on the population served. Hence, all fire stations can be considered as uncapacitated. Table 5.2 displays the number of fire trucks determined by the Fire Department according to the population.

Number of People	Types of trucks
0- 10.000	1 fire truck
10.000 - 25.000	1 emergency rescue vehicle 2 fire trucks 1 vehicle with stairs
25.000 - 50.000	1 emergency rescue vehicle 3 fire trucks 1 vehicle with stairs 1 double cabin pickup 1 service vehicle
50.000-100.000	1 emergency rescue vehicle 1 ambulance 4 fire trucks 1 vehicle with stairs 1 double cabin pickup 1 service vehicle
200.000-300.000	1 emergency rescue vehicle 1 multi purpose rescue vehicle 2 ambulances 8 fire trucks 2 vehicles with stairs 3 double cabin pickups 1 service vehicle
300.000-400.000	1 emergency rescue vehicle 2 multi purpose rescue vehicles 2 ambulances 10 fire trucks 3 vehicles with stairs 3 double cabin pickups 2 service vehicles
400.000-600.000	2 emergency rescue vehicles 2 multi purpose rescue vehicles 3 ambulances 14 fire trucks 4 vehicle with stairs 4 double cabin pickups 2 service vehicles
for each 150.000 people	1 fire truck
for each 400.000 people	1 vehicle with stairs, 1 ambulance, 1 multi purpose rescue vehicle
for each 500.000 people	1 emergency rescue vehicle, 1 double cabin pickup, 1 service vehicle

Table 5.2: Regulation of Fire Trucks

We gather the information of the coverage area of the existing fire stations from the Fire Department. In the existing situation a district can be covered by more than one fire station. Also, there is a study about average distances from a facility to demand points. However, there is not any knowledge about the maximum distance between the fire stations and covered demand points.

Excel tables and the constructed map are utilized while analyzing the existing situation. First, the nodes that are covered by the existing fire stations are found. The steps are:

- After the information about the districts covered by the existing fire stations is obtained, the regions which correspond to those districts are found.
- The node-region matrix is used which clarifies the relationship between nodes and regions. Then, the tables which demonstrate the regions and the nodes covered by existing fire stations are formed.
- Even if a fire station covers a region, it may not cover all points in that region because some of the points may belong to another district.If there is an uncovered node in a region, it is separated from this table.
- A matrix is formed which represents the relationship between nodes and existing stations. A small part of this matrix is given in Table C.1. The total matrix is given in the CD.

Second, the maximum distances from a fire station to covered demand points are analyzed.

- The shortest paths from the existing fire stations to covered nodes are formed.
- The maximum distances are found between each existing fire station and their assigned demand points by Tables C.2, C.3, C.4 and C.5

The third analysis is about the number of nodes covered by the existing fire stations.

- The total number of nodes covered by each station is easily found by using the node-existing fire station table whose small part is given in Table C.1.

The last analysis is made for the total population for each fire station. In the existing situation, the nodes may belong to more than one fire station.

- How many times a node is covered by existing fire stations is found via node-existing fire station matrix. A small part of this matrix is given in Table C.1.
- It is assumed that the population of the node is distributed equally among the fire stations that cover that node.
- Therefore, the population of the node is divided by the number of fire stations. The procedure is repeated for all nodes. Table C.6 shows these values.
- The divided population of each node is written on the node-existing fire station matrix which gives the total number of people covered by the existing fire stations.

Table 5.3 indicates the general analysis of existing fire stations. As it is seen from the Table 5.3, Merkez Fire Station covers the maximum distance with 16.64 km. Also, the maximum population is covered by Merkez Fire Station with 845875 people.

Fire Station	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	Esat	Siteler	Altınpark	AŞTİ	Köşk	Hisar
Node Number	Node 2	Node 40	Node 50	Node 91	Node 120	Node 149	Node 158	Node 242	Node 274	Node 322	Node 341	Node 254	Node 271	Node 297
Maximum Distance	9.5	12.5	13.04	16.64	7.8	11.3	6.65	12.3	10.7	8.7	10.31	0.55	1.9	0.35
Number of nodes	66	30	71	130	40	26	70	28	47	41	35	3	5	2
Population	379711	221125	430856	845875	488537	262105	403125	110627	388844	346557	180754	10968	28968	3116

Table 5.3: Analysis of existing fire stations in terms of the maximum distance they serve, the number of nodes they serve, and the total population they serve

Chapter 6

Locating Fire Stations Optimally

The studies done for the location of fire stations is explained in this chapter. There are four types for locating fire stations.

- Locate 11 fire stations for unweighted and weighted cases.
- Locate 11 fire stations which have the same coverage area as existing fire stations.
- Locate fire stations under a service time restriction.
- Locate new fire stations in addition to the existing fire stations under a service time restriction.

In the first study, we assume that there are no fire stations in Ankara, then, we answer the question that if we were plan the locations of fire stations, where should these 11 fire stations be located to minimize the maximum service distance. The study is completed for weighted and unweighted cases. In the second study, we consider locating 11 fire stations without changing the coverage areas. Also, the average distances of the optimally located 11 fire stations and those of the existing situation are compared. The third study is made for fixed r values that satisfy predetermined time restrictions. The last study aims at locating the new

fire stations in Ankara in addition to the existing ones and re-allocate the regions between old and new fire stations according to the closest fire station criteria.

Here, the studies on Excel will be explained. After the solutions are found via GAMS, some studies are realized in Excel in order to gather more information. In the Excel tables given in the Appendix, the columns show the optimal fire stations and the rows show the demand points. We can find the covered nodes by the optimal fire stations, the population covered by each fire station, the total number of nodes covered by each fire station and the maximum distance that each fire station serves. First, demand points are assigned to their closest facilities. We use optimal a_{ij} and shortest path matrix for this calculation, since a_{ij} matrix gives us information about the distance values which are smaller than the optimal r value. After all demand points are assigned to a fire station, it is easy to see the maximum distance of a fire station and the total number of nodes covered by a fire station. Moreover, the population of each demand point is computed before. That gives us the population covered by each fire station. Actually, the distances from a demand point to more than one fire station can be equal. In other words, some demand points can be covered by more than one facility. If we encounter such a situation, we assign that demand point to the facility which has a smaller assigned population.

6.1 Locating 11 Fire Stations

There are 14 fire stations in Ankara. Since three of them are dedicated, 11 fire stations are sited optimally with minimum r value for weighted and unweighted cases. Because of the dedicated fire stations, the minimum set covering model is modified appropriately.

First, the locations of the 3 fire stations, Köşk, Hisar and AŞTİ, should not be changed by GAMS. Köşk Fire Station is represented with node 271, Hisar is represented with node 297 and AŞTİ is represented with node 254. Constraint 2, 3 and 4 are written for these fire stations. The other points represented as $x_j = 0$

where $j = 259, 260, 261, 421, 423, 424, 425, 426, 427, 428$ are the nodes which are not considered in this study. They belong to the region that is covered by Gölbaşi Fire Station. The first constraint forces each node to assign to a fire station. Dedicated fire stations, the points which get service from these constant fire stations and the points which belong to Gölbaşi district need not to be covered by a fire station. Therefore they are separated from the node set. Determination of a_{ij} is changed according to the consideration of populations of nodes. For the unweighted case, w_i is not used. The new minimum set covering problem is given in equation 6.1. GAMS code of this model is given in Appendix A.

$$\min \quad \sum_{j=1}^{n} x_j \tag{6.1}$$

$$s.t. \quad \sum_{j=1}^{n} a_{ij} x_j \geq 1 \quad \forall\, i \epsilon N / \{171, 172, 182, 184, 215, 253, 254, 259, 260, 261, 271, 296, 297, 421, 423, 424, 425, 426, 427, 428\}$$

$$x_{254} = 0$$

$$x_{271} = 0$$

$$x_{297} = 0$$

$$x_{259} = 0$$

$$x_{260} = 0$$

$$x_{261} = 0$$

$$x_{421} = 0$$

$$x_{423} = 0$$

$$x_{424} = 0$$

$$x_{425} = 0$$

$$x_{426} = 0$$

$$x_{427} = 0$$

$$x_{428} = 0$$

$$x_j \epsilon \{0, 1\}$$

where

$$a_{ij} = \begin{cases} 1, & \text{if } w_i \times d(v_i, v_j) \leq r \\ 0, & \text{otherwise} \end{cases} \qquad \forall i = 1...n$$

for the weighted case.

There is a coding to identify the fire stations found in the weighted and unweighted models.

- U represents the fire stations found in the unweighted minimum set covering model (U1, U2, ... ,U11)
- W represents the fire stations found in the weighted minimum set covering model (W1, W2, ...,W11).

6.1.1 The Unweighted Case

This case is investigated without considering node populations. The concern in this case is coverage of all people with minimum distance without considering the number of people located in a node. Therefore, this study gives better solutions according to the distances.

First of all, a middle r value, $r_{1962} = 19.76$ is chosen via binary technique from a list R consisting of 3922 elements. According to the formulation given above, the a_{ij} matrix is constructed. Using this matrix, a modified minimum set covering model (6.1) is coded in GAMS and is solved. The first run of GAMS gave 2 facilities as a solution which is smaller than 11. In order to increase the solution, the r values from r_{1963} to r_{3922} are deleted. Then, the algorithm is repeated for remaining r values. Other steps are given in the Table 6.1.

The 11th solution gives a minimum r value = 7 km with p = 11. GAMS program shows the optimal facility locations. The nodes; 39, 71, 126, 181, 201, 228, 235, 391, 401, 410, 437 are the optimal locations of fire stations for the unweighted case. The assignment of these fire stations which is necessary for

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	2	0.269	1963...3922
2	982	9.96	6	0.288	983...1962
3	492	5.06	20	0.213	1...492
4	752	7.52	10	0.28	493...738
5	616	6.3	14	0.336	493...616
6	678	6.92	13	0.344	617...678
7	709	7.23	11	0.316	710...738
8	694	7.08	11	0.215	695...709
9	687	7.01	11	0.21	688...694
10	683	6.97	12	0.208	679...683
11	686	7	11	0.276	687
12	685	6.99	12	0.199	684-685

Table 6.1: GAMS Solutions for unweighted minimum set covering model

analysing the maximum distance that each fire station services and the population that is covered by each station is made. The matrix which gives the maximum distance of each fire station is given in Tables D.1, D.2, D.3 and D.4. With these tables, the covered nodes can be seen where each node is assigned to only one fire station. Table B.11 is used to account for the total population served by each fire station.

The information about the maximum distances, covered population and the number of nodes served are given in Table 6.2.

Fire Stations	U2	U4	U6	U8	U9	U10	U11	U3	U1	U7	U5	AŞTİ	Köşk	Hisar
Node Number	39	71	126	181	201	228	235	391	401	410	437	254	271	297
Maximum Distance	6.58	6.97	6.88	6.9	6.9	7	6.7	6.95	6.7	6.7	6.75	0.55	1.9	0.35
Number of Node	33	41	107	12	66	26	8	47	51	24	17	3	5	2
Population	341384	351692	1205473	223438	576942	158410	65715	326726	272828	216814	272527	21935	57936	9347

Table 6.2: Results of unweighted 11 fire stations

6.1.2 The Weighted Case

This case considers population of each demand point. The procedure of obtaining the weights of nodes is given in Section 4.3. The r values are found via ordering the values obtained from multiplication of weights and shortest paths matrices. Also, the a_{ij} matrix is separately constructed from the weighted shortest path matrix for each given r value. The other steps are the same as the unweighted case. Table 6.3 displays the chosen r values, the number of facilities found by GAMS, and the deleted elements from the list of r values.

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	83104	9.205079	12	0.468	1...83104
2	124656	17.900025	5	0.377	124657...166206
3	103881	12.606345	9	0.329	103882...124656
4	93493	10.77523	10	0.292	93494...103881
5	88299	9.958564	11	0.2	88300...93493
6	85702	9.586674	12	0.312	83105...85702
7	87001	9.771952	12	0.298	85703...87001
8	87651	9.8653	11	0.201	87652...88299
9	87327	9.821388	12	0.3	87002...87327
10	87490	9.84425	11	0.3	87491...87651
11	87409	9.834183	11	0.199	87410...87490
12	87369	9.828216	11	0.309	87370...87409
13	87349	9.824345	11	0.198	87530...87369
14	87339	9.823382	12	0.199	87328...87339
15	87345	9.823868	12	0.198	87340...87345
16	87348	9.82425	11	0.297	87349
17	87347	9.82422	11	0.197	87348
18	87346	9.82396	11	0.197	

Table 6.3: GAMS solutions for weighted minimum set covering model

The last solution gives a minimum r value of 9.82396 with p = 11. Optimal facility locations of fire stations for the weighted case are; 13, 68, 109, 115, 173, 178, 209, 228, 245, 337, 440. Demand points are covered by more than one fire stations, but we assign each demand point to its closest facility. Tables E.1, E.2,

E.3 and E.4 display the shortest paths between optimally placed fire stations and covered nodes.

Table 6.4 shows the results of weighted case.

Here, the maximum distance is 12.3 km which is bigger than the maximum distance of the unweighted case. The reason is the consideration of populations of nodes. Nonetheless, this time the allocation of the population is better than the unweighted case. U8 fire station covers more than 1000000 people.

Fire Stations	W1	W2	W4	W5	W8	W7	W9	W10	W11	W6	W3	AŞTİ	Köşk	Hisar
Node Number	13	68	109	115	173	178	209	228	245	337	440	254	271	297
Maximum Distance	10.9	9.83	9.8	5.68	6.32	10.5	6.33	7	11.4	10.2	12.3	0.55	1.9	0.35
Number of Node	74	86	13	30	64	21	24	15	22	59	24	3	5	2
Population	537759	622699	167298	433042	505152	333762	276345	90317	159172	616278	270125	21935	57936	9347

Table 6.4: Results of weighted 11 fire stations

6.2 Locating Fire Stations Based on Their Existing Coverage Areas

In this section, fire stations are located with the same coverage areas as those of existing fire stations. For each coverage area, the optimal fire station is a 1-center solution with respect to demand nodes restricted to the coverage area under consideration and can be found either by enumerating over node locations or by solving a sequence of set covering problems with a restricted demand set. We use the latter approach as the set up for set covering based approach is already made available in GAMS from our p-center solution.

The set covering model used for this part is given below.

$$\min \quad \sum_{j=1}^{n} x_j \tag{6.3}$$

$$s.t. \quad \sum_{j=1}^{n} a_{ij} x_j \geq 1 \quad for \;\; i \;\; \epsilon \;\; I_{covered\ area}$$

$$x_{254} = 0$$

$$x_{271} = 0$$

$$x_{297} = 0$$

$$x_{259} = 0$$

$$x_{260} = 0$$

$$x_{261} = 0$$

$$x_{421} = 0$$

$$x_{423} = 0$$

$$x_{424} = 0$$

$$x_{425} = 0$$

$$x_{426} = 0$$

$$x_{427} = 0$$

$$x_{428} = 0$$

$$x_j \epsilon \{0, 1\}$$

where

$$a_{ij} = \begin{cases} 1, & \text{if } d(v_i, v_j) \leq r \\ 0, & \text{otherwise} \end{cases} \qquad \forall i = 1...n$$

and $I_{covered\ area}$ describes the nodes in the considered area. Here the gams solutions for the fire stations are given. The optimal solutions are shown by gray line.

This study shows us how to improve the existing situation by just changing the location of each fire station without changing its allocation set. Table 6.16

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.381	1963...3922
2	982	9.96	1	2.425	983...1962
3	492	5.06	2	0.29	1...492
4	738	7.52	2	0.294	493...738
5	861	8.75	1	0.186	862...982
6	800	8.14	1	0.19	801...861
7	770	7.84	1	0.196	771...800
8	755	7.69	1	0.205	756...770
9	747	7.61	1	0.193	748...755
10	743	7.57	1	0.209	744...747
11	741	7.55	1	0.206	742-743
12	740	7.54	2	0.191	739-740

Table 6.5: GAMS solutions for the region of Sincan Fire Station

shows the comparison of maximum distances of existing fire stations and new fire stations.

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.381	1963...3922
2	982	9.96	1	0.276	983...1962
3	492	5.06	4	0.182	1...492
4	738	7.52	2	0.184	493...738
5	861	8.75	2	0.186	862...982
6	922	9.36	2	0.259	862...922
7	953	9.67	2	0.213	923...953
8	968	9.82	1	0.189	969...982
9	961	9.75	1	0.303	962...968
10	957	9.71	1	0.202	958...961
11	955	9.69	2	0.307	953...955
12	956	9.7	1	0.232	

Table 6.6: GAMS solutions for the region of Etimesgut Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.381	1963...3922
2	982	9.96	1	0.276	983...1962
3	492	5.06	3	2.343	1...492
4	738	7.52	2	0.5	493...738
5	861	8.75	1	0.101	862...982
6	800	8.14	1	0.195	801...861
7	770	7.84	1	0.188	771...800
8	755	7.69	1	0.191	756...771
9	747	7.61	1	0.29	748...755
10	743	7.57	2	0.201	739...743
11	745	7.59	2	0.21	744-745
12	746	7.6	1		

Table 6.7: GAMS solutions for the region of Batıkent Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.256	1963...3922
2	982	9.96	1	0.1	983...1962
3	492	5.06	2	0.209	1...492
4	738	7.52	1	0.5	739...982
5	616	6.3	2	0.209	493...616
6	678	6.92	1	0.152	679...738
7	648	6.62	2	0.303	617...648
8	664	6.78	1	0.191	664...678
9	657	6.71	2	0.188	649...657
10	661	6.75	1	0.189	662...664
11	660	6.74	2	0.314	658...660

Table 6.8: GAMS solutions for the region of Keçiören Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.362	1963...3922
2	982	9.96	1	0.184	983...1962
3	492	5.06	2	0.182	1...492
4	738	7.52	1	0.207	739...982
5	616	6.3	2	0.231	493...616
6	678	6.92	1	0.164	679...738
7	648	6.62	1	0.185	649...678
8	633	6.47	1	2.482	634...648
9	625	6.39	2	0.202	617...625
10	630	6.44	1	0.207	631...633
11	628	6.42	1	0.185	629-630
12	627	6.41	1	0.189	628
13	626	6.4	1	0.193	

Table 6.9: GAMS solutions for the region of Altınpark Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.193	1963...3922
2	982	9.96	1	0.198	983...1962
3	492	5.06	2	0.128	1...492
4	738	7.52	1	0.239	739...982
5	616	6.3	2	0.203	493...616
6	678	6.92	2	0.198	617...678
7	709	7.23	1	0.206	710...738
8	694	7.08	2	0.187	679...694
9	702	7.16	2	0.291	695...702
10	706	7.2	1	0.202	707...709
11	705	7.19	1	0.175	706
12	704	7.18	1	0.321	
13	703	7.17	2	0.147	

Table 6.10: GAMS solutions for the region of Siteler Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.295	1963...3922
2	982	9.96	2	0.487	1...982
3	1473	14.87	1	0.289	1474...1962
4	1228	12.42	1	0.212	1229...1473
5	1106	11.2	1	0.206	1107...1228
6	1045	10.59	1	0.291	1046...1106
7	1014	10.28	2	0.187	983...1014
8	1030	10.44	2	0.308	1015...1030
9	1038	10.52	1	0.196	1039...1045
10	1035	10.49	2	0.209	1031...1035
11	1037	10.51	1	0.197	1038
12	1036	10.5	1	0.206	

Table 6.11: GAMS solutions for the region of Kayaş Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.193	1963...3922
2	982	9.96	1	0.145	983...1962
3	492	5.06	2	0.228	1...492
4	738	7.52	1	0.874	493...738
5	616	6.3	2	0.412	493...616
6	678	6.92	1	0.784	679...738
7	648	6.62	2	1.012	617...648
8	664	6.78	1	0.654	665...678
9	657	6.71	1	0.213	658...664
10	653	6.67	1	0.692	654...657
11	651	6.65	1	0.459	652-653
12	650	6.64	2	0.224	649-650

Table 6.12: GAMS solutions for the region of Kurtuluş Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.169	1963...3922
2	982	9.96	1	0.541	983...1962
3	492	5.06	2	0.632	1...492
4	738	7.52	1	0.165	739...982
5	616	6.3	2	0.532	493...616
6	678	6.92	2	0.219	617...678
7	709	7.23	1	0.265	710...738
8	694	7.08	2	0.356	679...694
9	702	7.16	1	0.352	703...709
10	699	7.13	1	0.7	700...703
11	697	7.11	1	0.21	698...699
12	696	7.1	1	0.163	697
13	695	7.09	2	0.392	

Table 6.13: GAMS solutions for the region of Esat Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.193	1963...3922
2	982	9.96	1	0.207	983...1962
3	492	5.06	3	0.309	1...492
4	738	7.52	2	0.265	493...738
5	861	8.75	2	0.185	739...861
6	922	9.36	2	0.244	923...982
7	892	9.06	1	0.356	893...922
8	877	8.91	1	0.147	878...892
9	870	8.84	1	0.452	871...877
10	866	8.8	1	0.125	867...870
11	864	8.78	2	0.286	862...864
12	865	8.79	2	0.233	

Table 6.14: GAMS solutions for the region of Çayyolu Fire Station

	Order	r value	Number of Facilities	Solution Time	Deleted r values from...to
1	1962	19.76	1	0.193	1963...3922
2	982	9.96	2	0.32	1...982
3	1473	14.87	1	0.547	1474...1962
4	1228	12.42	2	0.145	983...1228
5	1351	13.65	1	0.452	1352...1473
6	1290	13.04	2	0.36	1229...1290
7	1321	13.35	1	0.472	1322...1351
8	1306	13.2	2	0.245	1291...1306
9	1314	13.28	2	0.326	1307...1314
10	1318	13.32	1	0.214	1319...1321
11	1317	13.31	1	0.214	1318-1319
12	1316	13.3	1	0.54	1317
13	1315	13.29	2	0.423	

Table 6.15: GAMS solutions for the region of Merkez Fire Station

Coverage area of	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	Esat	Siteler	Altınpark
Maximum distance of existing fire stations	9.5	12.5	13.04	16.64	7.8	11.3	6.65	12.3	10.7	8.7	10.31
Maximum distance of new fire stations	7.55	9.7	7.6	13.3	6.75	10.5	6.65	8.8	7.1	7.18	6.4

Table 6.16: Results of the locations of the fire stations with the same coverage areas

6.3 Average Distances

Another criterion used for comparing the effectiveness of the existing fire stations and the new fire stations is the comparison of their induced average distances. In other words, the total distance that a fire station goes is found and this distance is divided by the total number of nodes covered. This gives the average distance of one fire station. Table 6.17 gives the average distances of the existing and optimally located fire stations found in the previous three subcases.

When the averages of 11 fire stations are investigated, it is seen that the unweighted and weighted cases give better solutions than the existing case on the averages. However, the grand average distance of the fixed allocation model is worse than the existing case. The unweighted case gives the best solution on the average distances.

Existing Case												Grand Average
Fire Stations	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	Esat	Siteler	Altınpark	
Node Number	2	40	50	91	120	149	158	242	274	322	341	
Total Distances	273.97	165.2	294.38	708.52	149.68	133.55	173.37	104.53	180.54	141.69	86.89	
Number of Nodes Covered	66	30	71	130	40	26	70	28	47	42	28	
Average Distance	4.15	5.51	4.15	5.45	3.74	5.14	2.48	3.73	3.84	3.37	3.10	4.06
Unweighted Case												Grand Average
Fire Stations	U2	U4	U6	U8	U9	U10	U11	U3	U1	U7	U5	
Node Number	39	71	126	181	201	228	235	391	401	410	437	
Total Distances	139.59	123.45	400.54	53.4	229.97	98.81	26.6	161.42	177.71	74.65	68.65	
Number of Nodes Covered	33	41	107	12	66	26	8	47	51	24	17	
Average Distance	4.23	3.01	3.74	4.45	3.48	3.80	3.33	3.43	3.48	3.11	4.04	3.64
Weighted Case												Grand Average
Fire Stations	W1	W2	W4	W5	W8	W7	W9	W10	W11	W6	W3	
Node Number	13	68	109	115	173	178	209	228	245	337	440	
Total Distances	375.94	409.27	38.3	76.92	252.28	99.4	104.04	48.4	86.15	243.03	114.85	
Number of Nodes Covered	74	86	13	30	64	21	24	15	22	59	24	
Average Distance	5.08	4.76	2.95	2.56	3.94	4.73	4.34	3.23	3.92	4.12	4.79	4.03
Same Coverage Case												Grand Average
Fire Stations	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	Esat	Siteler	Altınpark	
Node Number	11	445	47	213	113	178	158	239	187	330	128	
Total Distances	244.27	199.44	275.91	737.85	172.93	128.9	173.37	133.35	181.03	143.27	109.3	
Number of Nodes Covered	66	30	71	130	40	26	70	28	47	42	28	
Average Distance	3.70	6.65	3.89	5.68	4.32	4.96	2.48	4.76	3.85	3.41	3.90	4.32

Table 6.17: Average distances comparison

6.4 Location of Fire Stations with a Time Restriction

The aim of this part is locating fire stations as they comply with the norms of NFPA. There are three NFPA standards that contain time requirements that influence the delivery of fire and emergency medical services. These are:

- NFPA 1221, Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems;
- NFPA 1710, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments;
- NFPA 1720, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments. [6]

NFPA 1720 contains no time requirements for turnout and response times. According to NFPA 1221, after receipt of a call for assistance, the fire department will respond with a unit to that location, within four minutes, to % 90 of area served [6].

In this thesis, National Fire Protection Association 1710 Standard for the Organization and Deployment of Fire Suppression Operations is used. People who want to gain more information about this standard may look at the website [37]. The response time for fire department will be: Four minutes (240 seconds) or less for the arrival of the first arriving engine company at a fire suppression incident and/or eight minutes (480 seconds) or less for the deployment of a full first alarm assignment at a fire suppression incident [6]. In Ankara there is not any regulation about the first arrival. If there is an alarm, all fire trucks act together according to the fire type. Therefore, we solve the problems such that the fire trucks arrive the demand points in 4 minutes or in 8 minutes. In this part, both 4 minute and 8 minute arrival times are considered.

The speed of fire trucks may vary depending on congestion and traffic jam, road conditions or influence of snowfalling etc. The maximum speed of a fire truck is 80 km/h and in the center of the city the speed can decrease to 40 km/h. Thus the average speed is 60 km/h. These three speeds are used for computing r values.

- For 4 minutes 40 km/h $r_1 = 2.67km$
- For 4 minutes 60 km/h $r_2 = 4km$
- For 4 minutes 80 km/h $r_3 = 5.34km$
- For 8 minutes 40 km/h $r_4 = 5.34km$
- For 8 minutes 60 km/h $r_5 = 8km$
- For 8 minutes 80 km/h $r_6 = 10.67km$

Since there is no change with the stable fire stations, Köşk, Hisar and AŞTİ, the model used for locating 11 fire stations can also be used here. However, this time, the number of fire stations is not fixed. The number of fire stations and their locations can be found by solving the set covering model for fixed r values. The GAMS solutions are given in Table 6.18.

	Speed	r value	Number of Fire Stations	Solution Time
4 min	40km/h	2.67	55	0.655
	60km/h	4	26	0.348
	80km/h	5.34	18	0.673
8 min	40km/h	5.34	18	0.673
	60km/h	8	8	2.81
	80km/h	10.67	6	2.277

Table 6.18: GAMS solutions for locating fire stations with a time restriction

The speed of 40 km/h gives 55 fire stations for a 4-minute coverage and 18 fire stations for an 8-minute coverage. On the other hand the maximum speed of 80 km/h gives 18 and 6 fire stations, respectively, for 4-minute and 8-minute

coverages. These solutions lack some realism. The speed of 60 km/h gives 26 and 8 fire station for 4-minute and 8-minute coverages, respectively. Since 60 km/h speed is more acceptable, only the analysis of solution of this case will be given. While giving a name to the fire stations, two different coding is used for 4 minute and 8 minute time restricted models.

- "4T" represents the station found in 4 minute time restricted model (4T1, 4T2, ... 4T26)
- "8T" represents the station found in 8 minute time restricted model (8T1, 8T2, ...8T8)

The matrix given in Table F.1, F.2, F.3, F.4, F.5, F.6 represents the distances after assigning each demand point to one fire station. The covered demand points can be seen from these tables. The distance matrices for the 8 minute case are given in Tables F.7, F.8, F.9 and F.10. Population that are assigned to each fire station are found via Table B.11.

The results of the 4 min 60km/h location and 8 min 60 km/h location are given in the Tables 6.19 and 6.20.

Fire Stations	4T1	4T2	4T3	4T6	4T7	4T9	4T10	4T11	4T14	4T23	4T22	4T20	4T19	4T17	
Node Number	2	17	26	43	69	111	115	139	178	189	206	224	231	237	
Maximum Distance	3.79	3.6	3.98	3.87	3.9	3.65	3.7	3.78	3.7	2.5	3.2	3.6	3.9	2.7	
Total Number of Node	26	31	12	24	39	11	35	28	11	3	10	9	15	3	
Total Population	205742	133615	171925	175773	337451	165302	487286	329735	263555	44766	149419	56060	62678	30391	
Fire Stations	4T18	4T4	4T25	4T21	4T26	4T8	4T13	4T16	4T15	4T12	4T24	4T5	AŞTİ	Köşk	Hisar
Node Number	238	246	288	344	390	392	411	430	432	436	440	441	254	271	297
Maximum Distance	3.7	3.2	4	3.97	3.9	3.8	3.5	3	3.7	3.3	2.7	3.9	0.55	1.9	0.35
Total Number of Node	3	4	38	71	4	21	14	3	4	3	6	4	3	5	2
Total Population	9337	49636	298661	569611	42826	117900	106470	11029	32551	28285	117568	14377	21935	57936	9347

Table 6.19: Results of the 4 min-time-restricted model

Fire Stations	8T1	8T3	8T5	8T6	8T7	8T8	8T2	8T4	AŞTİ	Köşk	Hisar
Node Number	11	120	180	237	243	268	381	411	254	271	297
Maximum Distance	7.55	7.9	7.8	7.4	7.8	8	7.95	7.05	0.55	1.9	0.35
Number of Nodes Covered	72	74	30	8	29	113	82	24	3	5	2
Population Covered	524951	981481	529479	61493	185260	831784	668506	228995	21935	57936	9347

Table 6.20: Results of the 8 min-time-restricted model

6.5 Locating New Fire Stations in addition to Existing Ones

In this section, the new fire stations are located according to the 4-minute and 8-minute time restrictions while the existing fire stations are kept as active at their current locations. The three dedicated fire stations get 0 values for their x_j's as before. Also, the nodes 259, 260, 261, 421, 423, 424, 425, 426, 427, 428 are covered by the existing Gölbaşı Fire Station and they get 0 values for their x_j's. The existing fire stations are chosen automatically with the constraints $x_j = 1$ for $j = 2, 40, 50, 91, 120, 149, 158, 242, 274, 322, 341$. However, the covered demand points may change. The reorganized minimum set covering model is given in equation 6.3. GAMS code for this model is given in Appendix A.

$$\min \sum_{j=1}^{n} x_j \tag{6.3}$$

$$s.t. \sum_{j=1}^{n} a_{ij}x_j \geq 1 \quad \forall\, i\epsilon N/\{171, 172, 182, 184, 215, 253, 254, 259, 260, 261, 271, 296, 297, 421, 423, 424, 425, 426, 427, 428\}$$

$$x_{254} = 0$$

$$x_{271} = 0$$

$$x_{297} = 0$$

$$x_{259} = 0$$

$$x_{260} = 0$$

$$x_{261} = 0$$

$$x_{421} = 0$$

$$x_{423} = 0$$

$$x_{424} = 0$$

$$x_{425} = 0$$

$$x_{426} = 0$$

$$x_{427} = 0$$

$$x_{428} = 0$$

$$x_2 = 1$$

$$x_{40} = 1$$

$$x_{50} = 1$$

$$x_{91} = 1$$

$$x_{120} = 1$$

$$x_{149} = 1$$

$$x_{158} = 1$$

$$x_{242} = 1$$

$$x_{274} = 1$$

$$x_{322} = 1$$

$$x_{341} = 1$$

$$x_j\epsilon\{0, 1\} \quad \forall\, j$$

where

$$a_{ij} = \begin{cases} 1, & \text{if } d(v_i, v_j) \leq r \\ 0, & \text{otherwise} \end{cases} \qquad \forall i = 1...n$$

.

In order to name the new fire stations, the codes used are 4N and 8N for 4 minute and 8 minute time restrictions.

- "4N" represents the new fire stations for 4 minute time restricted model. (4N1, 4N2,...,4N23)
- "8N" represents the new fire stations for 8 minute time restricted model. (8N1,8N2,...,8N6)

GAMS solutions are given in Table 6.21.

	Speed	r value	Number of Fire Stations	Number of Additional Fire Stations	Solution Time
4 min	40km/sa	2.67	62	51	0.248
	60km/sa	4	34	23	0.288
	80km/sa	5.34	22	11	0.191
8 min	40km/sa	5.34	22	11	0.191
	60km/sa	8	17	6	0.268
	80km/sa	10.67	14	3	0.198

Table 6.21: GAMS solutions for locating additional fire stations with a time restriction

For the 4-minute coverage with a speed of 60km/h, there are 23 additional fire stations and for the 8-minute coverage with a speed of 60km/h there are 6 new fire stations. These two solutions are investigated with excel tables. The matrix representing the distance between a demand point and closest fire station are given in 14 parts since it is a very big matrix. Tables G.1, G.2, G.3, G.4, G.5, G.6, G.7, G.8, G.9, G.10, G.11, G.12, G.13, G.14 represent this matrix. Tables G.15, G.16, G.17, G.18, G.19, G.20, G.21 give the distances from fire stations found in 8 minute time restricted model to covered nodes. Assigned population are found via B.11 table.

Solutions for the two case are given in the Table 6.22 and 6.23.

Fire Stations	Sincan	4N1	4N2	Etimesgut	Batıkent	4N7	Merkez	4N9	Keçiçören	4N10	Kayaş	Kurtuluş	4N21	4N20	4N22	4N17	4N16	4N18	
Node Number	2	17	24	40	50	53	91	111	120	127	149	158	189	206	211	224	231	238	
Maximum Distance	3.79	3.6	3.68	3.63	3.74	3.4	4	4	2.75	3.3	3.7	2.93	2.5	3.2	3.93	3.6	3.9	3.9	
Number of Nodes	23	24	18	8	31	6	29	8	13	3	8	29	3	10	12	9	10	5	
Population	155160	98332	224211	56416	204908	65468	213140	106030	236636	43774	189942	141898	44766	149419	99903	56060	33039	28273	
Fire Stations	Çayyolu	4N3	Esat	4N23	4N19	Siteler	4N8	Altınpark	4N15	4N6	4N11	4N14	4N13	4N12	4N4	4N5	AŞTİ	Köşk	Hisar
Number of Node	242	247	274	288	317	322	340	341	390	395	417	430	431	433	441	442	254	271	297
Maximum Distance	3.6	3.9	2.91	4	3.4	3.05	4	3.65	3.9	3.8	3.75	3	2.1	2.4	3.1	3.9	0.55	1.9	0.35
Number of Nodes	7	3	15	34	17	22	10	18	4	21	15	3	2	3	2	7	3	5	2
Population	51483	39247	99172	265923	291636	258396	199598	205232	42826	204520	119215	11029	16474	14299	4528	40996	21935	57936	9347

Table 6.22: Results of 4 min-time-restricted model for additional fire stations

Fire Stations	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3
Node Number	2	34	40	50	76	91	120	149	158	181
Maximum Distance	7.3	7.3	6.78	5.25	7.35	7.45	7.9	7.9	4.13	5
Number of Ndes	50	16	24	52	24	55	27	11	45	6
Population	366455	108620	171906	414352	235160	449434	457034	181628	359850	66492
Fire Stations	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
Node Number	182	235	242	274	322	341	388	254	271	297
Maximum Distance	8	6.7	7.83	4.43	2.48	5.05	6.3	0.55	1.1	0.35
Number of Ndes	29	7	24	19	15	20	9	3	4	2
Population	364020	54022	130889	175092	169548	237129	94704	21935	33550	9347

Table 6.23: Results of 8 min-time-restricted model for additional fire stations

Chapter 7

Analysis

In this chapter, the existing fire stations will be evaluated in comparison to the optimal solutions. There are four types of assignment of fire stations in the optimal solutions; locating 11 fire stations which have the same coverage area as existing fire stations, locating 11 fire stations for weighted and unweighted cases, locating fire stations based on time restrictions, and locating new fire stations in addition to the existing fire stations based on time restrictions. For instance, while comparing an optimal solution with Sincan Fire Station, the considered area is the coverage of Sincan Fire Stations currently. Thus, all fire stations located in coverage of Sincan Fire Stations are evaluated. The coverage area of the existing fire station is almost the same with the coverage area of the optimal fire stations. If there is a difference between them, they will be explained in the analysis. The comparisons will be made according to the location of fire stations, covered nodes and population, average and maximum distances.

7.1 Analysis of 11 Fire Stations

In this section the fire stations found via weighted and unweighted minimum set covering models are analyzed with the existing fire stations. As stated in Chapter 6 U indicates the station found in unweighted minimum set covering model and

W indicates the station found in weighted minimum set covering model. The maps which demonstrate the fire stations and covered nodes are given in Figures 7.1 and 7.2 for the unweighted and weighted cases. The red circles show the optimal fire stations in the maps. The maximum distance in the unweighted case is 7 km and the maximum distance in the weighted case is 12.3 km.

The name of the station, its address, node number and the color of the assigned nodes to the fire station are listed in Table 7.1.

Fire Station	Address	Node Number	Shape of the Demand Points on the Map
U1	Yavuz Selim District, 10 Street, Etimesgut	Node 401	blue point
U2	Etiler District, İstasyon Street, Etimesgut	Node 39	red square
U3	İvedik Industrial Site, Yenimahalle Melih Gökçek Boulevard, 1368 Street.	Node 391	green square
U4	İstanbul and Çiftlik Street, 25 Mart District, Yenimahalle	Node 71	orange diamond
U5	Kanuni District, North Beltway, Keçiören	Node 437	pink point
U6	Babür and Ankara Streets, Ulubatlı Hasan and Plevne Districts, Altındağ	Node 126	yellow star
U7	Başak District, Yeniyol Street, Altındağ	Node 410	purple diamond
U8	East Beltway, Mamak	Node 181	light blue square
U9	Sokullu Mehmet Paşa District, Çetin Emeç Boulevard, Çankaya	Node 201	gray point
U10	Prof. Dr. Amet Taner Kşlalı District, Beyler Street, Yenimahalle	Node 228	black square
U11	Yaşamkent District, 3222 Street, Yenimahalle	Node 235	light green point

Table 7.1: Fire Stations in the Unweighted Model

The location of 11 fire stations via weighted p-center model is given in Table 7.2.

Fire Station	Address	Node Number	Shape on the Map
W1	Mareşal Çakmak District, Atatürk and 1466 Street, Sincan	Node 13	blue point
W2	Anadolu Boulevard İstanbul Street, Yenimahalle	Node 68	orange diamond
W3	Sancaktepe District, 1669 Street, Yenimahalle	Node 440	green square
W4	Kanuni District, North Beltway, Keçiören	Node 109	pink point
W5	19 Mays and Çiçekli Districts, Dalgıç and Yunus Emre Streets, Keçiören	Node 115	yellow star
W6	Hasköy District, Felek Street, Altındağ	Node 337	purple diamond
W7	Ege District, Nato Yolu Street, Mamak	Node 178	black point with cross
W8	Büyükesat District, Vedat Dalokay Street, Çankaya	Node 173	light blue square
W9	Konya Street, Turan Güneş Boulevard, Çankaya	Node209	gray point
W10	Prof. Dr. Ahmet Taner Kışlalı District Beyler Street, Yenimahalle	Node 228	black square
W11	Koru District, Eskişehir Street, Yenimahalle	Node 245	light green point

Table 7.2: Fire Stations in the Weighted Model

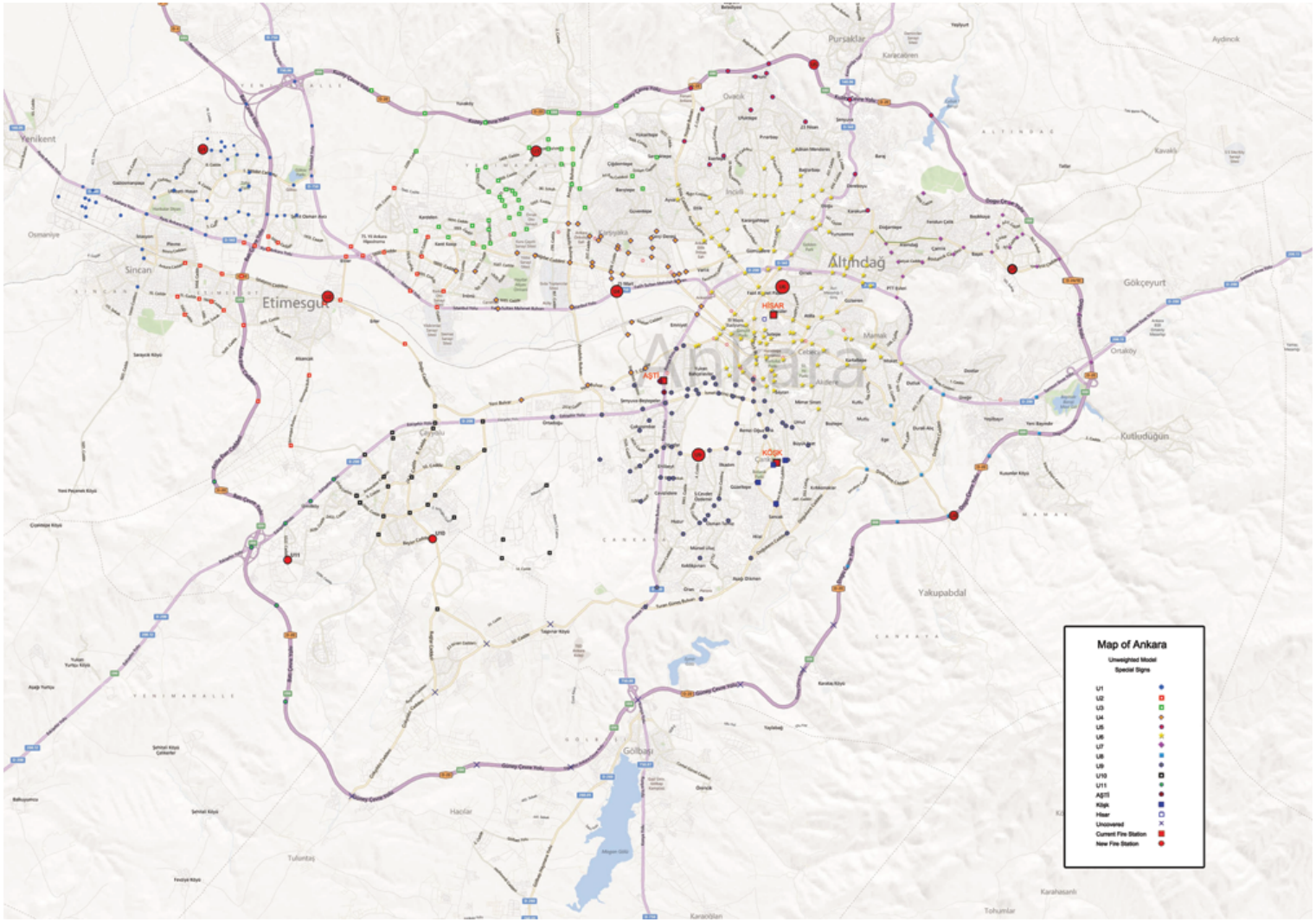

Figure 7.1: Fire stations and their assigned nodes in the unweighted model

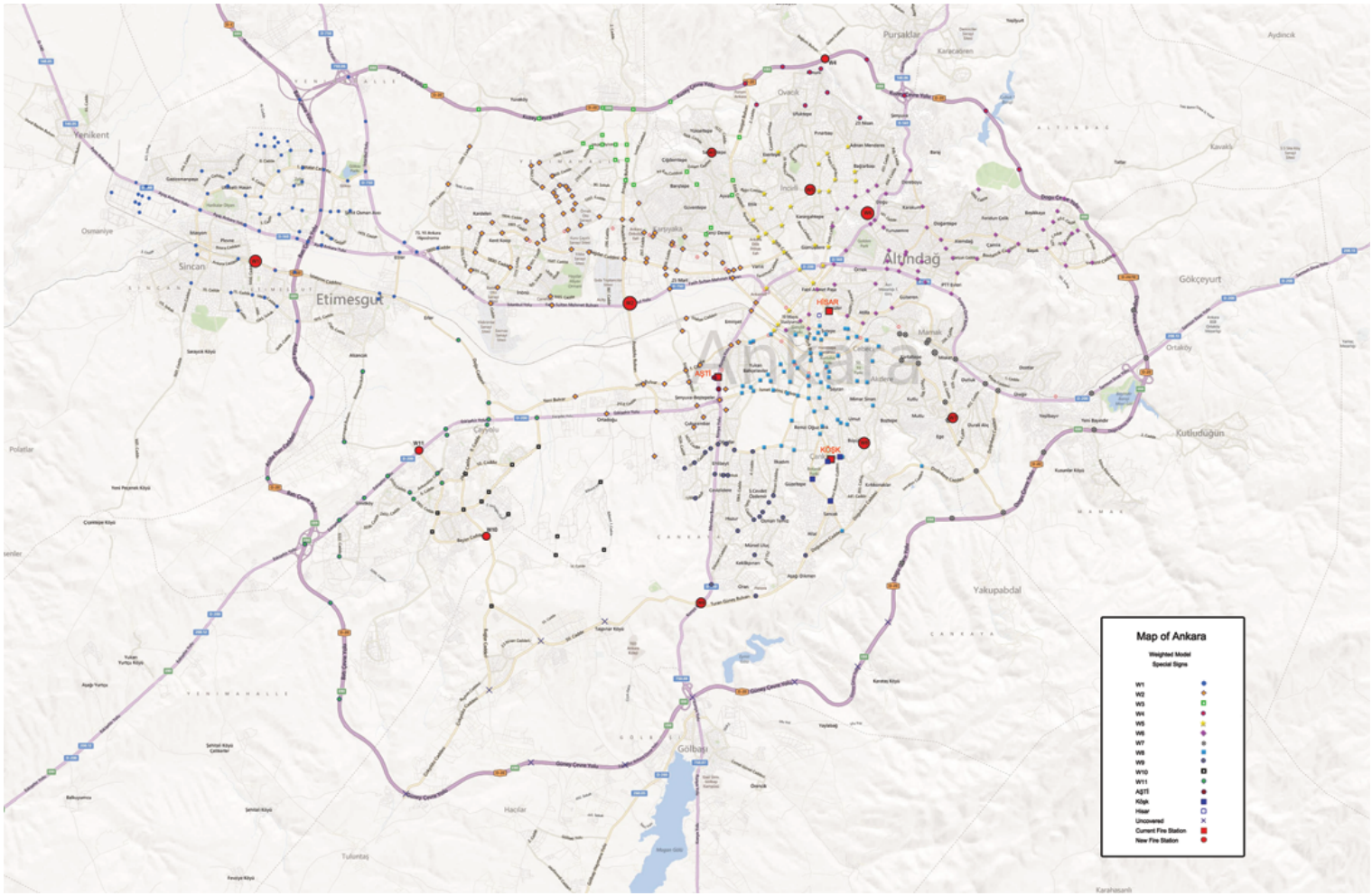

Figure 7.2: Fire stations and their assigned nodes in the weighted model

7.1.1 Comparison with Sincan Fire Station

The information about Sincan Fire Station is given in the Table 7.3.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average
Existing	Sincan	Sincan	Node 2	9.5 km	66	380884	4.15 km
Unweighted	U1	Etimesgut	Node 401	6.7 km	51	272828	3.48 km
Weighted	W1	Sincan	Node13	10.9 km	74	537759	5.08 km

Table 7.3: Comparison with Sincan Fire Station

In the existing situation, Sincan Fire station covers the districts around Sincan township. Sincan and Etimesgut Fire stations have common districts on the border of Etimesgut. Sincan Fire Station is located in the İstasyon Street, almost in the middle of the region in which the population is dense. However, it has to serve the points far away from its location. It serves 66 nodes in the map and 380884 people. The maximum distance it covers is 9.5 km. That means, it takes 9.5 minutes with 60km/h speed to reach the farthest place for this station. The average distance is 4.15 km. In the map, the covered nodes are marked with small blue points.

The unweighted p-center location model assigns the Fire Station U1 in Yavuz Selim District which is north side of İstasyon Street. There are not so many differences between the existing fire station in terms of covered regions. It does not serve the points located in Etimesgut and some farther points in Sincan. It serves 51 nodes and they are represented by the same small blue points in the map. The different 14 nodes from the existing situation are the nodes which are covered by Sincan and other fire stations jointly. This situation makes the maximum distance of Sincan Fire station longer. In our siting the maximum distance becomes 6.7 km and the maximum arrival time is 6.7 minutes. For the average distances, the unweighted case gives the best solution.

In the weighted location model, the fire station nearby Sincan is located at Mareşal Çakmak District which is south side of İstasyon Street. This station, W1, covers both Sincan and Etimesgut townships. That means there is no station nearby the existing Etimesgut Fire Station. This station covers almost all nodes covered by the existing Etimesgut Fire Station. It is not expected to find

minimum distances in the weighted case, due to the fact that this case considers the population information. This time, the maximum distance is 10.9 km. This distance has the maximum time decreased to 10.9 minutes with 60km/h speed. Also, it serves 74 points in the map which are demonstrated with small blue points.

7.1.2 Comparison with Etimesgut Fire Station

Table 7.4 shows the information about the Etimesgut Fire Station.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average
Existing	Etimesgut	Etimesgut	Node 40	12.5 km	30	221125	5.51 km
Unweighted	U2	Etimesgut	Node 39	6.58 km	33	341384	4.23 km

Table 7.4: Comparison with Etimesgut Fire Station

In the existing situation Etimesgut Fire Station serves the points in Etimesgut. There are 29 points which are served from this station. They are indicated with red square shapes with a small white point in the middle. Some of them get also service from Çayyolu and Sincan Fire Stations. The common points makes the covered area larger. The maximum distance is 12.5 km. This fire station reaches the farthest place within 12.5 minutes. The average distance is 5.51 km.

The unweighted model sites the Fire Station U2 near the existing Etimesgut Fire Station. There are 200 m between them. This station covers more nodes than the existing fire stations. There are 33 nodes which are served from this station. In the map, the red square nodes are represented these covered nodes. Nevertheless, the maximum distance is almost half of the existing case, 6.5 km. This makes the maximum time to decrease to 6.5 minutes. It serves some districts in Batıkent and not serve the points in the Çayyolu and Ümitköy districts. That means, even if the location of the fire station will not be changed from the existing situation, the assigned points should be reviewed. Then, more efficient solutions may be gained. The existing case is worse than the optimal case on the averages.

There is no fire station located in this region in the weighted model.

7.1.3 Comparison with Batıkent Fire Station

Table 7.5 shows the quantitative values of Batıkent Fire Station.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average Distance
Existing	Batıkent	Yenimahalle	Node 50	13.04 km	71	430856	4.15 km
Unweighted	U3	İvedik Industrial Site	Node 391	6.95 km	47	326726	3.43 km
Weighted	W2	Yenimahalle	Node 68	9.83 km	86	622699	4.76 km

Table 7.5: Comparison with Batıkent Fire Station

In the existing case, Batıkent Fire Station covers the districts in Batıkent İvedik Industrial Site and some points from Demetevler District. It serves 430856 people. 71 nodes on the map are served by this station. Their shapes are green squares with small white points in them. East side of the Anadolu Boluevard is also served by Merkez Fire Station and some points on the west side are covered by Etimesgut Fire Station. The maximum distance is 13.04 km and the maximum service time is 13.04 minutes. The average distance is 4.15 km.

The mentioned area are covered by three fire stations in the unweighted model. Here, the Fire Station U3, located in node 391, is investigated which covers the biggest area. The fire station is located at İvedik Industrial Site which is an important location with regard to fires. The Fire Station U3 covers the same nodes with the existing situation except the nodes in the districts GİMAT, Uğur Mumcu, Macunköy and Demetevler. On the other hand, it covers the nodes which are in Yenimahalle township located west side of Keçiören Township and thereabouts Karşıyaka District. U3 covers 47 nodes. The maximum distance is 6.95 km and the maximum time with speed of 60km/h is 6.95 minutes. The average distance is 3.43 km. The covered nodes are symbolized by green squares with small white points in them. Remaining areas begin from Hipodrom to GİMAT. The area between Hipodrom and Gersan Industrial Site is covered by the Fire Station U2 which is located in Etimesgut. Moreover, the remaining area is covered by the Fire Station U4 in 25 Mart District. Because the main service area of U2 and W4 fire stations are different, their information is not given in Table 7.3. The unweighted case has the minimum average distance among all.

In the weighted model, the biggest area of Batıkent is covered by the Fire

Station W2 located at the intersection of Anadolu Boulevard and İstanbul Street. The nodes getting service from W2 are indicated with orange diamond. This fire station covers the nodes such as in Batıkent, Çukurambar, ODTÜ, Atatürk Orman Çiftliği, Demetevler and Ankamall . Although it covers larger areas, the maximum distance is smaller than the existing situation with 9.83 km. 86 nodes in the map get service from this station. The average distance also increases, it is 4.76 km. Accordingly, it services more people than the existing situation. Fire Station W2 does not cover the nodes in İvedik Industrial Site. There exists another fire station, W3, which covers them. The nodes that are covered by W3 are represented with green squares with small white points in them.

7.1.4 Comparison with Keçiören Fire Station

The comparison for Keçiören region is given in Table 7.6.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average
Existing	Keçiören	Keçiören	Node 120	7.8 km	40	488537	3.74 km
Unweighted	U5	Keçiören	Node 437	6.75 km	17	272527	4.04 km
	U6	Altındağ.	Node 126	6.88 km	107	1205473	3.74 km
Weighted	W4	Keçiören	Node 109	9.8 km	13	167298	2.95 km
	W5	Keçiören	Node 115	5.68 km	30	433042	2.56 km

Table 7.6: Comparison with Keçiören Fire Station

It is hard to make a comparison for Keçiören region compared to the other regions. As it is seen from the maps, the region covered by Keçiören Fire Station currently is covered by different fire stations in the optimal solutions. The yellow stars display the nodes of Keçiören Fire Station. The borders of the serviced area is the North Beltway, Etlik Street, Yozgat Boulevard, and above Turgut Özal Boulevard. There are common regions with Altınpark and Merkez Fire Stations. The maximum distance is 7.8 km and there are 40 nodes that are covered by this fire station. The maximum distance is 7.8 km and the average distance is 3.74 km.

There are 2 fire stations assigned for this area in the unweighted model. The Fire Station U5 locates at the North Beltway, at Node 437. U5 covers the districts south side of the North Beltway. The maximum distance is 6.75 km, the maximum time is 6.75 minutes and the average distance is 3.74 km. The nodes of U5 are

symbolized by pink points. The other fire station, U6, is located in Altındağ township in Ulubatlı Hasan District at Node 126. The covered nodes can be seen with yellow stars on the map. It covers the remaining districts in Keçiören as well as the districts in Altındağ and some districts in Çankaya. The farthest point for this station locates in Altndağ township in Misket District in Mamak. Therefore, comparison about the maximum distances does not give an accurate idea.

The weighted model also gives 2 fire stations for the considered area. The fire station located at the North Beltway at Node 109, named as W4, services the districts under the North Beltway and also the points within Baraj Street. The maximum distance is 9.8 km, the maximum time is 9.8 minutes and the average distance is 2.95 km. The pink points show the covered nodes by the Fire Station W4. On the other hand, the Fire Station W5 at node 115 located at 19 Mayıs District in Keçiören, services the remaining districts in Keçiören. Also, the districts on the south until Ulus are covered by this fire station. The maximum distance is 5.8 km. The arrival time to the farthest point for the Fire Station W5 is 5.8 minutes. The average distance is 2.56 km. Seeing that the area represents similarity between the existing coverage area, the number of nodes can be compared.

7.1.5 Comparison with Altınpark and Siteler Fire Stations

The values about Altınpark and Siteler Fire Stations are given in Table 7.7.

	Name of The Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average Distances
Existing	Altınpark	Altındağ	Node 341	10.31 km	35	212967	3.10 km
	Siteler	Siteler	Node 322	8.7 km	41	314344	3.37
Unweighted	U6	Altındağ	Node 126	6.88 km	107	1205473	3.74 km
	U7	Altındağ	Node 410	6.7 km	24	216814	3.11 km
Weighted	W6	Altındağ	Node 337	10.2 km	59	616278	4.12 km

Table 7.7: Comparison with Altınpark and Siteler Fire Stations

As Altınpark and Siteler Fire Stations service adjacent places, comparison will be made jointly. Siteler Fire Station is located in Siteler where furnishers and workshops are mostly located. This place is important in terms of fires. As well as Siteler, this station covers the districts in Mamak and some districts under Turgut

Özal Boulevard such as Gülseren, Örnek, and Plevne. The maximum distance is 7.85 km. 41 nodes get service from this station which are indicated with purple diamond on the map. Altınpark Fire Station is located in Altınpark. It includes some districts south side of Keçiören, Altındağ, Baraj Street and some districts in Mamak. It has common districts with Keçiören and Siteler Fire Stations. The maximum distance is 12.01 km. 35 nodes get service from this station which have light green point shapes. The maximum times are 7.85 minutes and 12.01 minutes respectively. On the other hand, the average distances are 3.10 km and 3.37 km.

In the unweighted model, there exists a fire station at node 410 located at Başak District in Mamak, named U7. It covers the nodes in Mamak. The maximum distance is 6.7 km; that means, the maximum arrival time is 6.7 minutes with 60 km/h speed. The average distance is 3.11 km. The covered nodes are symbolized by purple diamond. The other fire station, U6, which is also considered for Keçiören Fire Station is located at node 126 in Altındağ township. It covers the regions at Siteler, some districts under Turgut Özal Boulevard and also south side of Keçiören. The area which gives the maximum distance covered by this fire station is unrelated with the considered area. The nodes with yellow stars are served by U6. On the other hand, Baraj Street which is covered by Altınpark Fire Station is covered by Fire Station U5.

In the weighted model, the considered area is covered by only one fire station. It is located in Hasköy District in Altındağ and it is named as W6. Its location is near the existing Altınpark Fire Station. It does not cover so many districts in Keçiören and Baraj Street. Yet, it covers the districts until Ulus. The maximum distance is 10.2 km and the maximum arrival time is 10.2 minutes. The average distance is bigger than the existing case, 4.12 km.

The most critical path for the existing case is Baraj Street. Without this area, the maximum distance can be decreased as it is seen in optimal solutions.

7.1.6 Comparison with Kayaş Fire Station

The relevant information about Kayaş Fire station is given in Table 7.8.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average Distance
Existing	Kayaş	Mamak	Node 149	11.3 km	26	262105	5.14 km
Unweighted	U8	Kayaş	Node 181	6.9 km	12	223438	4.45 km
Weighted	W7	Mamak	Node 178	10.5 km	21	333762	4.73 km

Table 7.8: Comparison with Kayaş Fire Station

Kayaş Fire Station locates on 19 Mayıs Boulevard. It covers the districts from Bayındır Dam to Mamak. It has common districts with Kurtuluş Fire Station. 26 nodes and 26205 people get service from this station. The maximum distance from the fire station to these points is 11.3 km. Therefore, the arrival time to the farthest point is 11.3 minutes. The average distance is 5.14 km. The covered nodes can be seen as light blue squares.

The unweighted model assigns a fire station, U8, on the East Beltway. This station covers less nodes compared to Kayaş Fire Station. Even though the number of nodes covered decreases to 12 nodes, the covered population is still more than 240000 people. The reason is that the uncovered nodes which are covered in the existing situation are the common nodes with other fire stations. The maximum distance is almost half of the existing situation, 6.3 km. Also, the time decreases to half of the existing case with 6.3 minutes. Also, the average distance is smaller than the average distance of existing case, it is 4.45 km . The shape of the nodes are the same as existing case.

The fire station, W7, is located at Natoyolu Street and near Ege District in the weighted case. Its coverage area represents much more similarity with the existing fire station than the unweighted case. Like Kayaş Fire Station, it covers some districts in Mamak and also districts around Bayındır Dam. The maximum distance is 10.5 km and the maximum time is 10.5 minutes. The average distance is 4.73 km. However, this station covers many more people compared to the existing fire station. Since, in the existing situation, some nodes are covered by more than one fire station and have divided population. The shape of the nodes in the weighted case are black cross in a circle.

7.1.7 Comparison with Çayyolu Fire Station

The whole information about Çayyolu Fire Station is given in Table 7.9.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average Distance
Existing	Çayyolu	Yenimahalle	Node 242	12.3 km	28	110627	3.73 km
Unweighted	U10	Çayyolu	Node 228	7 km	26	158410	3.80 km
	U11	Yenimahalle	Node 235	6.7 km	8	65715	3.33 km
Weighted	W10	Yenimahalle	Node 228	7 km	15	90317	3.23 km
	W11	Yenimahalle	Node 245	11.4 km	22	159172	3.92 km

Table 7.9: Comparison with Çayyolu Fire Station

Çayyolu Fire Station is located on Ankaralılar Street in Çayyolu and covers the districts on the west side of Hacettepe Kampüs Street and Saltoğlu Boulevard and mostly under Eskişehir Street. The maximum distance is 12.3 km. It arrives at the farthest point within 12.3 minutes with 60km/h speed. the average distance is 3.73 km. Here, some districts get service from Merkez and Etimesgut Fire Stations additionally.

The unweighted model assigns two fire stations for the considered area. The first one is U10 which is located at Beyler Street. It covers the nodes around Çayyolu and Ümit Districts and also Hacettepe and Bilkent Universities. The covered maximum distance is 7 km and the average distance is 3.80 km. The covered nodes are marked as black squares with white points in them. The remaining points in Yaşamkent and Ümitköy are covered by another fire station, U11. U11 is located in Yaşamkent District and it covers the nodes on the Eskişehir Street and the West Beltway. The covered nodes are shown as light green points. The maximum distance of this fire station is 6.7 km and the average distance is 3.33 km. The maximum times are 7 minutes and 6.7 minutes, respectively.

The weighted model also assigns two fire stations and one of them is located at exactly the same node as the fire station found in the unweighted model. The name of the fire station is W10 and it is located on Beyler Street. The maximum distance is 7 km and the average distance is 3.23 km. Nonetheless, this time it serves 15 nodes. As it is seen from the map, the nodes around Eskişehir Street are not covered. The covered points are marked as black squares with white points in them. The other fire station, W11, is located in Eskişehir Street near Ankaralılar Street. The districts in Ümitköy, Yaşamkent, the nodes on the West Beltway,

and also some points from Etimesgut are covered by this station. The maximum distance is 11.4 km. Therefore, the maximum arrival time is 11.4 minutes. The average distance is 3.92 km.

7.1.8 Comparison with Kurtuluş and Esat Fire Stations

Table 7.10 gives total information about Kurtuluş and Esat Fire Stations.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average Distance
Existing	Kurtuluş	Altındağ	Node 158	6.65 km	70	403125	2.48 km
	Esat	Çankaya	Node 274	10.7 km	47	388844	3.84 km
Unweighted	U6	Altındağ	Node 126	6.88 km	107	1205473	3.74 km
	U9	Çankaya	Node 201	6.9 km	66	576942	3.48 km
Weighted	W8	Çankaya	Node 173	6.32 km	64	505152	3.94 km
	W9	Çankaya	Node 209	6.33 km	24	276345	4.34 km

Table 7.10: Comparison with Kurtuluş and Esat Fire Stations

As the covered areas of Kurtuluş and Esat Fire Stations are close to each other, they are evaluated together. Kurtuluş Fire Station is located near Kurtuluş Park. It covers the districts around Bahçelievler, Hacettepe Hospital, Devlet Districts and the districts among them. Its maximum distance is 6.65 km, its average distance is 2.48 km and it covers 403125 people within 70 nodes. Esat Fire Station locates on Bülbül Deresi Street in Çankaya. It covers the districts from Kurtuluş to Oran in Çankaya. The maximum distance that the fire station has to service is 10.7 km. The average distance is 3.84 km. It services 388844 people within 47 nodes. It takes 10.7 minutes to reach the farthest point.

In the unweighted model, there are two fire stations for this area. The first one, U9, is located under Devlet District and covers the regions similar to Esat Fire Station. In addition, it covers Balgat, 100. Yıl, Çukurambar, Çiğdem, and ODTÜ. Though it covers more districts than Esat Fire Station, the maximum distance for this station is only 6.9 km. Thus, the maximum arrival time becomes 6.9 minutes. The average distance is 3.48 km. There are 66 marked nodes and more than 570000 people. These marked nodes can be seen with gray points. The other points are covered by the fire station, U6, which is also investigated for Keçiören, Siteler and Altınpark fire stations. In the mentioned area, around Kurtuluş, Maltepe, Ulus are covered by this fire station. They are marked as

yellow stars. The maximum distance and population it covers are unrelated with the covered area of Kurtuluş and Esat Fire Stations.

The weighted model assigns two fire stations on those places. One of them, W8, locates at Büyükesat District. The nodes getting service from the Fire Station U8 are represented as light blue squares. It covers many similar points with Kurtuluş Fire Station. Additionally, it covers some districts on the east side of Devlet District in Çankaya. The maximum distance is 6.32 km and the maximum time is 6.32 minutes. The average distance is 3.94 km. There are more than 500000 people in 64 nodes getting service from this station. The remaining points which are covered by Esat Fire Station in the existing situation are covered by the other fire station, W9. Its location is on the intersection of Konya Street and Turan Güneş Boulevard. In addition to the east side of Konya Street, it covers Çiğdem District. The maximum distance of this station is 6.33 km. Here, 276345 people in the 24 nodes are covered. The average distance is 4.34 km. The gray points on the map are allocated to this fire station.

7.1.9 Comparison with Merkez Fire Station

Table 7.11 gives the information about Merkez Fire Station.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered	Average Distances
Existing	Merkez	Yenimahalle	Node 91	16.64 km	130	845875	5.45 km
Unweighted	U3	Yenimahalle	Node 391	6.95 km	47	326726	3.43 km
	U4	Yenimahalle	Node 71	6.97 km	41	351692	3.01 km
	U9	Çankaya	Node 201	6.9 km	66	576942	3.48 km
Weighted	W2	Yenimahalle	Node 68	9.83 km	86	622699	4.76 km
	W3	Yenimahalle	Node 440	12.3 km	24	270125	4.79 km
	W9	Çankaya	Node 209	6.33 km	24	276345	4.34 km

Table 7.11: Comparison with Merkez Fire Station

Merkez Fire Station is the fire station which covers the largest area compared to the other stations. The regions under the North Beltway between the Yozgat Boulevard and Anadolu Boulevard, Bahçelievler, Atatürk Orman Çiftliği, ODTÜ, Hacettepe and Bilkent Universities, Balgat, Çiğdem and some points in Çayyolu. This station spreads over large distances. The gray nodes on the map are covered by Merkez Fire Station. The maximum distance along these regions is 16.64 km, the average distance is 5.45 km and there are 845875 people in 130 nodes who

get service from this station. It takes 16.64 minutes to reach the farthest point for this station.

In the unweighted model, three fire stations are assigned for the considered area. The districts under the North Beltway are covered by the Fire Station U3 siting in İvedik Industrial Site. The area which includes Atatürk Orman Çiftliği, GİMAT, Karşıyaka and 25 Mart are covered by the Fire Station U4 at node 71 which is in İstanbul Street. The remaining places including ODTÜ, Balgat, Çiğdem and some point around Devlet District are covered by the Fire Station U9. Its location is under Devlet District.

Similar to the unweighted model, weighted model also assigns three fire station for the mentioned area. The regions under the North Beltway are covered by the Fire Station W3 which is located in Sancaktepe District. The regions including Atatürk Orman Çiftliği, GİMAT, Karşıyaka and 25 Mart, Beştepeler, Ankamall, ODTÜ and Çukurambar are covered by the Fire Station W2 which is located at the intersection of Fatih Sultan Mehmet Boulevard and Anadolu Boulevard. The remaining points around Balgat and Çiğdem Districts are covered by the Fire Station W9 located on the intersection of Konya Street and Turan Güneş Boulevard.

These optimal fire stations do not cover the regions of coverage area of the existing Merkez Fire Station. The regions mentioned are related with the coverage area but there are more districts that they cover. Therefore, comparison of the maximum distances with the existing fire stations is not appropriate for this situation.

7.2 Locating Fire Stations with the Same Coverage Region

In this section, fire stations which have the same coverage area as the existing fire stations are optimally located. Even if the coverage area does not change, the maximum distances can be decreased up to 5.44 km. The maximum distance of this case is 13.3 km. That means, a fire station can reach a place in a shorter time. Figure 7.3 shows the locations of these new fire stations. The red diamonds show the optimally located fire stations in the map.

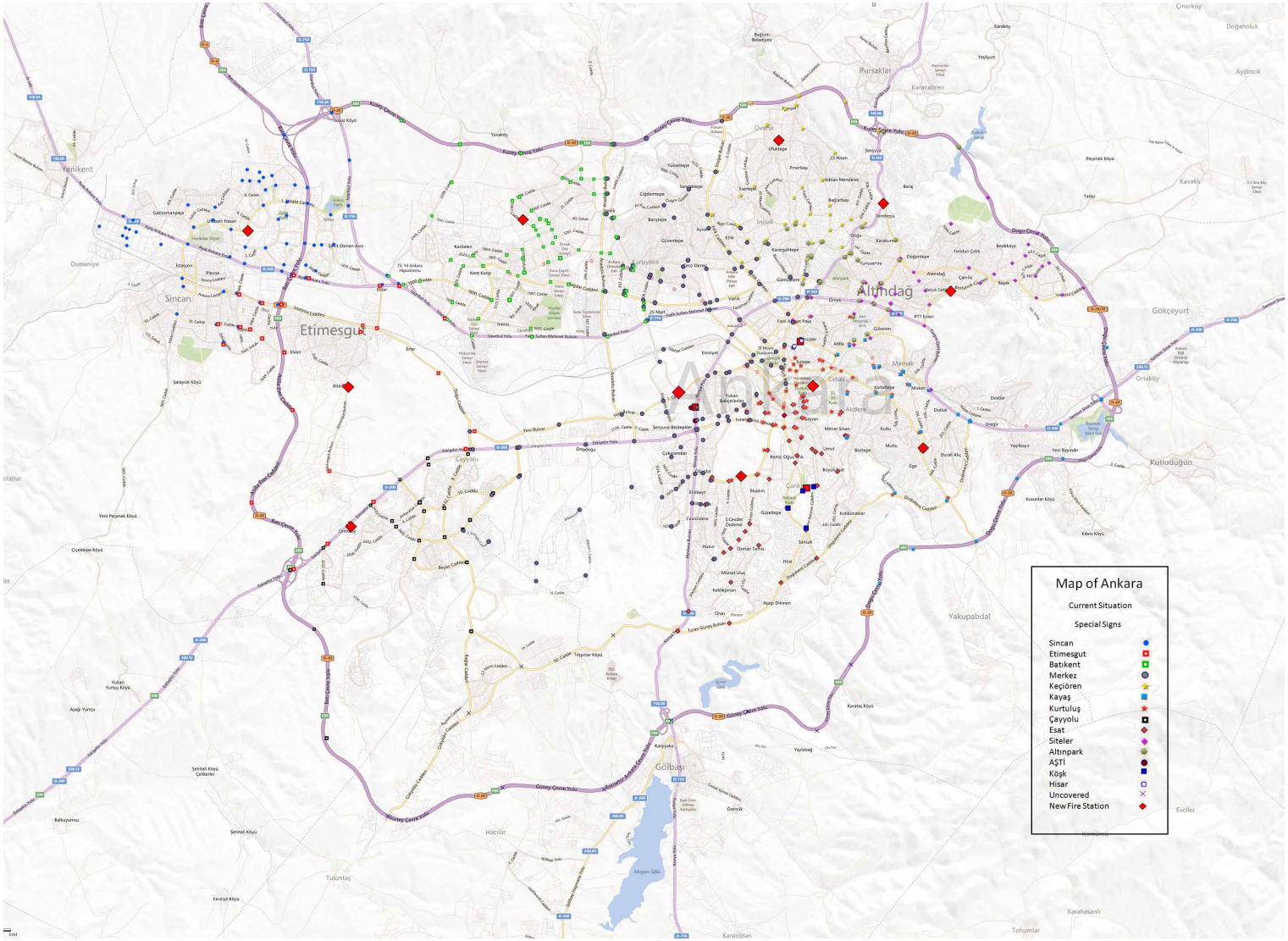

Figure 7.3: New fire stations with the same coverage area as the existing ones

7.2.1 Comparison of Sincan Region

	Node Number	Address	Maximum Distance	Average Distance
Sincan Fire Station	Node 2	Ayaş Street No: 9 Sincan	9.5 km	4.15 km
New Sincan Fire Station	Node 11	Ulubatl Hasan District, Dumlupınar 30 Ağustos Street, Sincan	7.55 km	3.70 km

Table 7.12: Comparison of new and existing Sincan Fire Stations

The new Sincan Fire Station is close to the existing one. It is located on the north side of Harikalar Diyarı. This change makes the maximum distance 7.55 km. There is a reduction of 1.95 km. Also, the average distance decreases from 4.15 km to 3.70 km.

7.2.2 Comparison of Etimesgut Region

	Node Number	Address	Maximum Distance	Average Distance
Etimesgut Fire Station	Node 40	Inside Etimesgut Aski, Etimesgut	12.5 km	5.51 km
New Etimesgut Fire Station	Node 445	Alsancak District, Etimesgut Boulevard, Etimesgut	9.7 km	6.65 km

Table 7.13: Comparison of new and existing Etimesgut Fire Stations

The new and the existing Etimesgut Fire Stations are on the same boulevard, however the new one locates on the south side of the existing one. Since this fire station also covers the regions around Eskişehir Street, the new one locates near Eskişehir Street and the maximum distance decreases from 12.5 km to 9.7 km. However, there is an increase on the average distance.

7.2.3 Comparison of Batıkent Region

	Node Number	Address	Maximum Distance	Average Distance
Batıkent Fire Station	Node 50	Ostim Alınteri Boulevard No:22, Yenimahalle	13.04 km	4.15 km
New Batıkent Fire Station	Node 47	İvedik Industrial Site 1467 Street Yenimahalle	7.6 km	3.89 km

Table 7.14: Comparison of new and existing Batıkent Fire Stations

The new Batıkent Fire Station locates in the middle of the coverage area. This change makes the maximum distance to decrease to half of the maximum distance of the existing case. Also, the average distance of the new Batıkent Fire Station is smaller than the existing one.

7.2.4 Comparison of Keçiören Region

	Node Number	Address	Maximum Distance	Average Distance
Keçiören Fire Station	Node 120	Kızlarpınarı Street No: 90, Keçiören	7.8 km	3.74 km
New Keçiören Fire Station	Node 113	Ufuktepe District, Gaziler Street, Keçiören	6.75 km	4.32 km

Table 7.15: Comparison of new and existing Batıkent Fire Stations

The new Keçiören Fire Station locates in Ufuktepe District which is closer to the North Beltway. The maximum distance decreases from 7.8 km to 6.74 km with this change. However the average distance is better in the existing case.

7.2.5 Comparison of Altınpark Region

	Node Number	Address	Maximum Distance	Average Distance
Altınpark Fire Station	Node 341	Inside Altınpark/Altındağ	10.31 km	3.10 km
New Altınpark Fire Station	Node 128	Dereboyu District, İrfan Başţuğ Street, Altındağ	6.4 km	3.90 km

Table 7.16: Comparison of new and existing Altınpark Fire Stations

The new and existing Altınpark Fire Stations are on the same street, İrfan Başţuğ Street. The new one locates on the north and is close to Baraj District which is the farthest place for existing Altınpark Fire Station. There is a reduction of 3.91 km in the maximum distance. The average distances are 3.10 km in the existing case and 3.90 km in the new case.

7.2.6 Comparison of Siteler Region

	Node Number	Address	Maximum Distance	Average Distance
Siteler Fire Station	Node 322	Altınay Street No:62/A,Siteler	8.7 km	3.37 km
New Siteler Fire Station	Node 330	Battalgazi District, Bostancık Street	7.18 km	3.41 km

Table 7.17: Comparison of new and existing Siteler Fire Stations

Siteler Fire Station locates in the industrial site and the new Siteler Fire Station locates on the north-west of this place in Battalgazi District. The maximum distance decreases from 8.7 km to 7.21 km. There is not significant change on the averages.

7.2.7 Comparison of Kayaş Region

	Node Number	Address	Maximum Distance	Average Distance
Kayaş Fire Station	Node 149	Samsun Yolu Yeşilöz District, Mamak	11.3 km	5.14 km
New Kayaş Fire Station	Node 178	Durali Alıç District, Natoyolu Street, Mamak	10.5 km	4.96 km

Table 7.18: Comparison of new and existing Kayaş Fire Stations

The existing and new fire stations are located in Yeşilöz and Durali Alıç Districts, respectively, and they are adjacent to each other. The change in the maximum distance is 0.8 km. The average distances are almost the same.

7.2.8 Comparison of Çayyolu Region

	Node Number	Address	Maximum Distance	Average Distance
Çayyolu Fire Station	Node 242	Ankaralılar Street, Near Gendarmerie, Yenimahalle	12.3 km	3.73 km
New Çayyolu Fire Station	Node 239	Ümitköy District, Eskişehir Street Yenimahalle	8.8 km	4.56 km

Table 7.19: Comparison of new and existing Çayyolu Fire Stations

The location of the new Çayyolu Fire Station is close to the new settlements. The maximum distance is decreased from 12.3 km to 9.37 km. However, the average distance in the existing case is better than the new case.

7.2.9 Comparison of Kurtuluş Region

	Node Number	Address	Maximum Distance	Average Distance
Kurtuluş Fire Station	Node 158	Celal Bayar Bulvar No:11, Altındağ	6.65 km	2.48 km
New Kurtuluş Fire Station	Node 158	Celal Bayar Bulvar No:11, Altındağ	6.65 km	2.48 km

Table 7.20: Comparison of new and existing Kurtuluş Fire Stations

According to the GAMS solution, the existing Kurtuluş Fire Station locates in the optimal node. The place of Kurtuluş Fire Station does not need to be changed. The maximum distance of this fire station is 6.65 km and the average distance is 2.48 km.

7.2.10 Comparison of Esat Region

	Node Number	Address	Maximum Distance	Average Distance
Esat Fire Station	Node 274	Bülbül Deresi Street No:128, Çankaya	10.7 km	3.84 km
New Esat Fire Station	Node 187	Sokullu Mehmet Paş District, Çetin Emeç Boulevard, Çankaya	7.1 km	3.85 km

Table 7.21: Comparison of new and existing Esat Fire Stations

The new Esat Fire Station locates on the south side of Devlet District and this place covers all the regions in less time. The maximum distance decreases from 10.7 km to 7.1 km. The average distances are almost the same in the new and the existing cases.

7.2.11 Comparison of Merkez Region

	Node Number	Address	Maximum Distance	Average Distance
Merkez Fire Station	Node 91	Turgut Özal Boulevard No: 9 , Altındağ	16.64 km	5.45 km
New Merkez Fire Station	Node 213	Beştepeler District, Alparslan Türkeş Street Yenimahalle	13.3 km	5.68 km

Table 7.22: Comparison of new and existing Merkez Fire Stations

Merkez Fire Station covers the largest area among all the fire stations. If this fire station locates in Beştepeler rather than Akköprü it covers the region in less time. The maximum distance of this new fire station is 13.29 km. The average distance is better in the existing case.

7.3 Analysis of the Time Restricted Model

In this part, the locations of fire stations found via time restricted model and their coverage will be explained in detail, and the comparison with the existing locations of fire stations will be given. For a 4-minute time restriction, 26 fire stations are located excluding the fixed fire stations, AŞTİ, Köşk, and Hisar. For an 8-minute time restriction, only 8 fire stations are enough to cover all regions. The comparisons will be made at the same time for 4-minute and 8-minute time restricted models according to the coverage regions of existing fire stations. While giving a name to the fire stations, two different codings are used for 4 minute and

8 minute time restricted models. The codes of the fire stations as mentioned in Chapter 6 are $4T$ and $8T$ which represent the fire stations found in 4 minute and 8 minute time restricted models respectively. Figures 7.4 and 7.5 represent the maps constructed for these two cases. The red circles show the optimally located fire stations in the maps.

The name of the fire stations located in 4 minute and 8 minute time restricted models, their nodes, information of their address and the shapes of their covered nodes are listed below.

Fire Station	Address	Node Number	Shape of the Demand Points on the Map
4T1	Harikalar Diyarı, Ayaş Ankara Street, Sincan	Node 2	blue point
4T2	Göksu District, West Beltway, 1. TBMM Street, Etimesgut	Node 17	light pink diamond
4T3	Ayyıldız District, West Beltway, 1817 Street, Etimesgut	Node 26	red square with white point
4T4	Bağlıca District, Etimesgut Boulevard, Etimesgut	Node 246	black cross in a circle
4T5	North Beltway, Batıkent, Yenimahalle	Node 441	red spiral
4T6	Batı Sitesi District, 1800 Street, Batıkent, Yenimahalle	Node 43	green square
4T7	Mehmet Akif Ersoy District, Vatan Street, Yenimahalle	Node 69	orange diamond
4T8	İvedik Industrial Site District, 36 Street, Yenimahalle	Node 392	green square with white point
4T9	Kanuni District, Bağlum Street, Keçiören	Node 111	pink point
4T10	19 Mayıs District, Dalgıç Street, Keçiören	Node 115	yellow star
4T11	Yunus Emre District, Yıldız Street, Altındağ	Node 139	light blue square
4T12	Baraj District, Altındağ	Node 436	black spiral
4T13	Başak District, Yeniyol Street, Altındağ.	Node 411	light purple diamond
4T14	Ege District, Natoyolu Street, Mamak	Node 178	light blue square
4T15	Yeni Bayındır District, East Beltway, Mamak	Node 432	red leaf
4T16	East Beltway, Çankaya	Node 430	black point
4T17	Yaşamkent District, West Beltway, Eskişehir Street, Yenimahalle	Node 237	light green point
4T18	Yaşamkent District, West Beltway, Yenimahalle	Node 238	purple point
4T19	Prof. Dr. Ahmet Taner Kışlalı District, Saltoğlu Boulevard, Yenimahalle	Node 231	white diamond
4T20	Yeni Boulevard, Etimesgut	Node 224	black square with white point
4T21	Kurtuluş Park, Kurtuluş, Çankaya	Node 344	gray point
4T22	Karapınar District, Dikmen Street, Çankaya	Node 206	sea green point
4T23	Yukarı Dikmen District, Doğukent Street, Çankaya	Node 189	yellow point
4T24	Sancaktepe District, Mehtap Street, Yenimahalle	Node 440	black flag
4T25	Çukurambar District, 1423 Street, Çankaya	Node 288	light purple square
4T26	Hacettepe Beytepe Campus, Çankaya	Node 390	red-white point

Table 7.23: Fire stations in the 4 minute time restricted model

Fire Station	Address	Node Number	Shape of the Demand Points on the Map
8T1	Güzelkent District, Şapka Devrimi Street, Sincan	Node 11	blue point
8T2	İvedik Indsutrial Site, 21 Street, Ivedik Yenimahalle	Node 381	orange diamond
8T3	Uyanış District, Kızlarpınarı Street, Keçiören	Node 120	yellow star
8T4	Başak District, Yeniyol Street, Altındağ.	Node 411	light purple diamond
8T5	Duralı Alıç District, Natoyolu Street, Mamak	Node 180	red star
8T6	Yaşamkent District, West Beltway, Eskişehir Street, Yenimahalle	Node 237	light green point
8T7	Prof. Dr. Ahmet Taner Kışlalı District, 8 Street, Yenimahalle	Node 243	black square with white point
8T8	Oğuzlar District, Çetin Emeç Boulevard, Çankaya	Node 268	gray point

Table 7.24: Fire stations in the 8 minute time restricted model

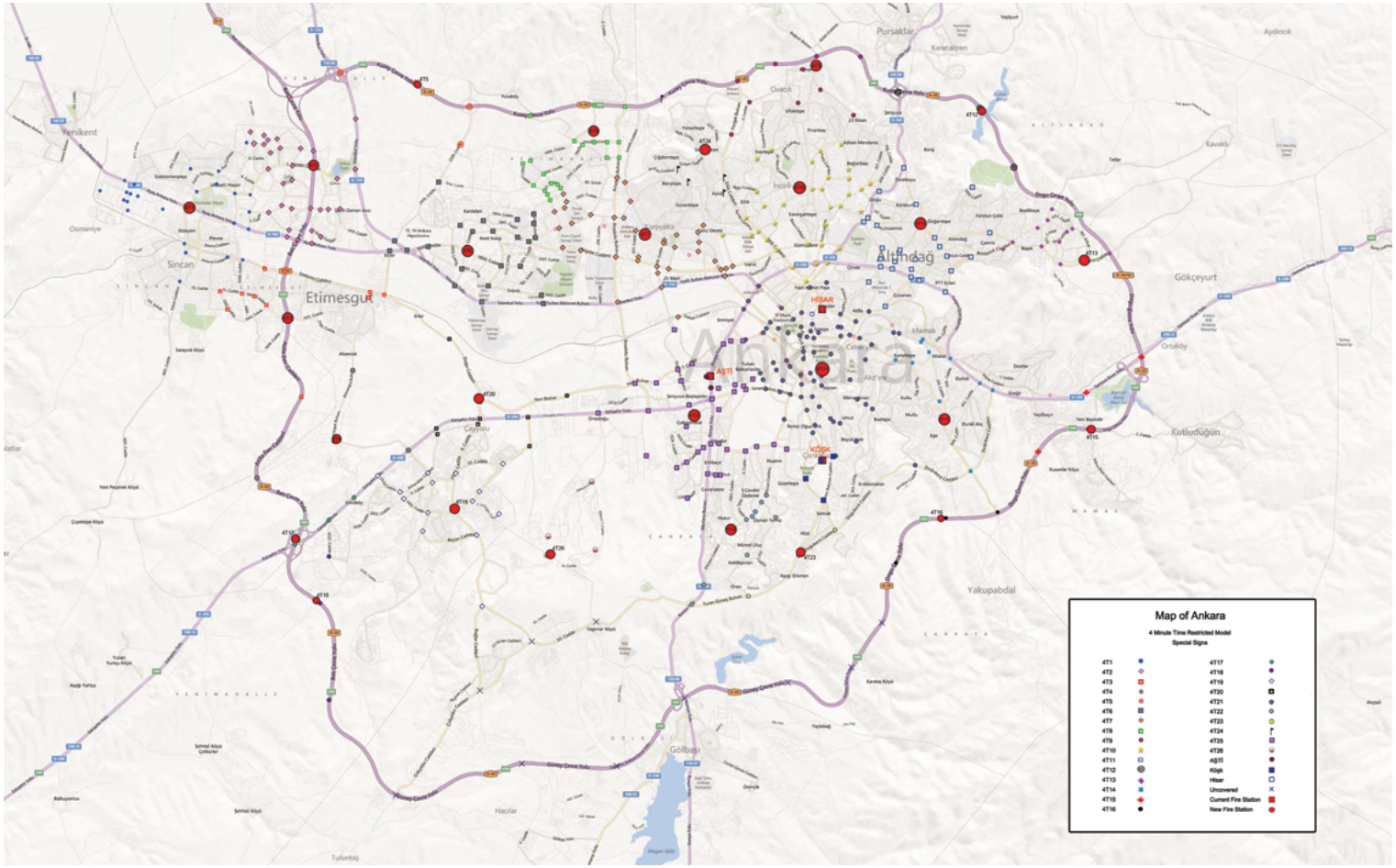

Figure 7.4: Fire stations and their assigned nodes in the 4-minute time-restricted model

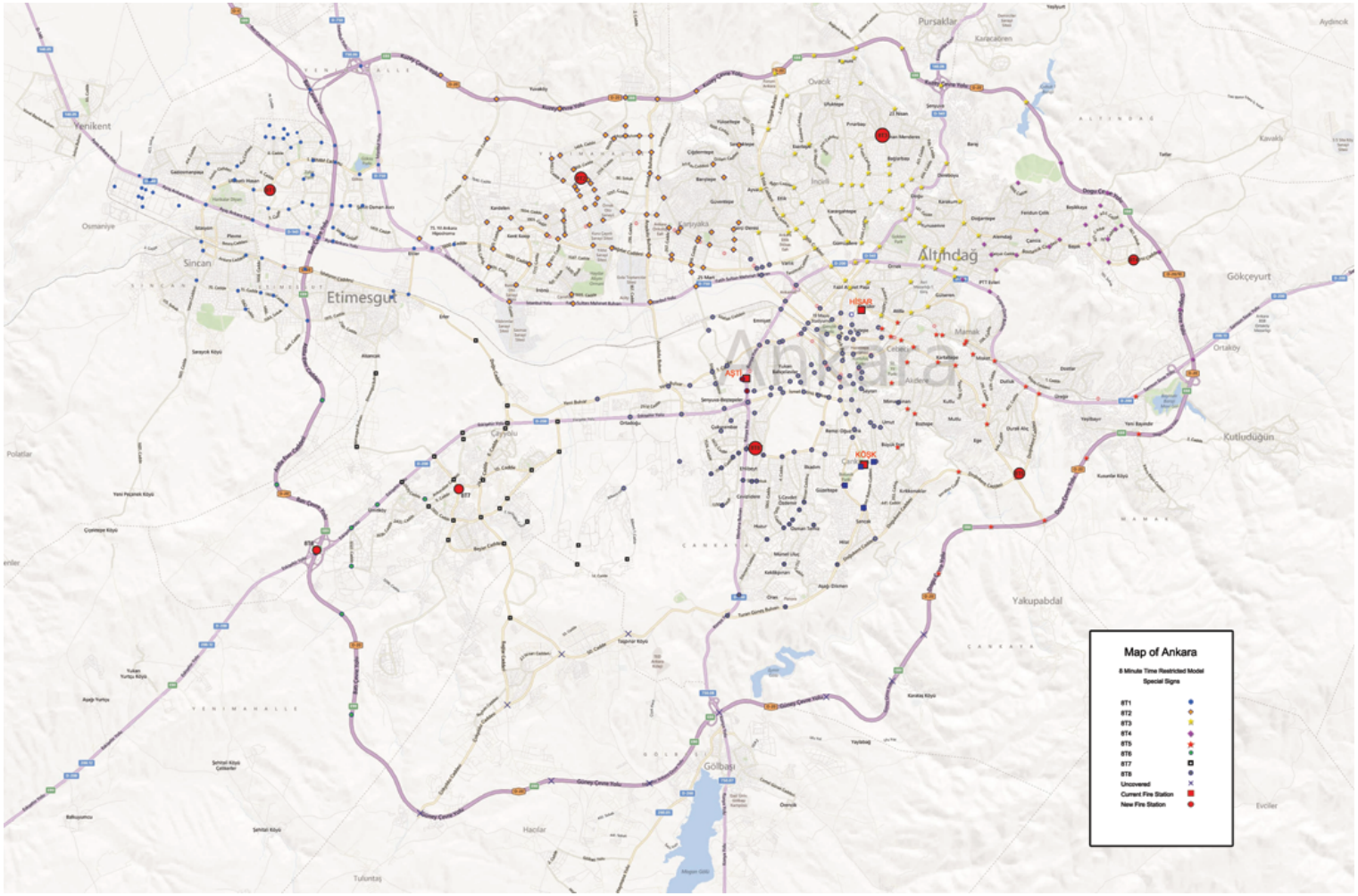

Figure 7.5: Fire stations and their assigned nodes in the 8-minute time-restricted model

7.3.1 Comparison with Sincan Fire Station

As stated before, the existing Sincan Fire Station services the area within 9.5 km. The relevant information about the fire stations with Sincan region are given in Table 7.25.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Sincan	Sincan	Node 2	9.5 km	66	379711
4 min	4T1	Sincan	Node 2	3.79 km	26	205742
	4T2	Etimesgut	Node 17	3.6 km	31	133615
8 min	8T1	Sincan	Node 11	7.55 km	72	524951

Table 7.25: Comparison with Sincan Fire Station

The 4-minute time-restricted model assigns a fire station at exactly the same node, Node 2, as the existing Sincan Fire Station. It does not cover the regions around Eryaman and Etimesgut. The name of this station is 4T1 and it covers 26 nodes and more than 205000 people within a 3.79 km radius. The blue points represent the nodes which belong to the coverage region of 4T1 Fire Station. The second fire station, named 4T2, is assigned at node 17, on the West Beltway in Eryaman. Fire Station 4T2 covers the regions around Eryaman and some other regions above İstasyon Street. 4T2 covers more than 130000 people and the maximum distance is 3.6 km. The shape of its nodes are light pink diamond. These two stations cover almost all areas that are covered by the existing Sincan Fire Station.

In the 8-minute time restricted model, there is one fire station, 8T1, assigned for the considered area. 8T1 is located in Ulubatlı Hasan District which is close to Harikalar Diyarı. This fire station covers the regions around Sincan and Eryaman, but, it does not cover the districts around Alsancak. The mentioned areas are demonstrated with the blue points on the map. The maximum distance is 7.55 km and there are more than 500000 people getting service from this station.

7.3.2 Comparison with Etimesgut Fire Station

The information about Etimesgut and Fire Stations 4T3 and 4T4 are given in Table 7.26.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Etimesgut	Etimesgut	Node 40	12.5 km	30	221125
4 min	4T3	Etimesgut	Node 26	3.98 km	12	171925
	4T4	Etimesgut	Node 246	3.2 km	4	49636

Table 7.26: Comparison with Etimesgut Fire Station

The Fire Station 4T3 assigned around Etimesgut is located on Atilla Eser Street, which is a location at the continuation of the West Beltway. Compared with the existing Etimesgut Fire Station, 4T3 is located in the region where population is dense. 4T3 covers the regions beginning from under İstasyon Street to Bağlıca District. About 170000 people get service from Fire Station 4T3. The maximum coverage distance is 3.98 km. The covered points are shown as red squares with white points. For Bağlıca District, there is another fire station, 4T4, located at node 246. The maximum distance here is 3.2 km. It serves about 50000 people. The shape of the covered nodes is black crosses in circles. The points on the Eskişehir Street are covered by three different fire stations and they will be analysed later.

In the 8 minute time restricted model there is no specific fire station around Etimesgut. The points which are close to Sincan are covered by fire station 4T1. The regions around Bağlıca are covered by the fire station sited in Çayyolu and it will be analysed later.

7.3.3 Comparison with Batıkent Fire Station

The information about Batıkent and the optimal fire stations are given in Table 7.27.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Batıkent	Yenimahalle	Node 50	13.04 km	71	430856
4 min	4T5	Yenimahalle	Node 441	3.9 km	4	14377
	4T6	Yenimahalle	Node 43	3.87 km	24	175773
	4T7	Yenimahalle	Node 69	3.9 km	39	337451
	4T8	Yenimahalle	Node 392	3.8 km	21	117900
8 min	8T2	Yenimahalle	Node 381	7.95 km	82	668506

Table 7.27: Comparison with Batıkent Fire Station

The regions covered by Batıkent Fire Station are covered by four different fire stations in the 4-minute time restricted model. The districts around Susuz Village

are covered by a fire station, 4T5, which is sited at node 441 on the North Beltway. It serves 4 nodes and about 14000 people. The maximum distance it serves is 3.9km. The red spirals represent the nodes covered by Fire Station 4T5. Another fire station, 4T6, is located in Batı Sitesi District. Fire Station 4T6 covers the districts from Hipodrom to İvedik Industrial Site. It covers about 175000 people within a 3.75 km radius. The nodes that 4T6 covers are marked with green squares. The places including Örnek Oto Industry, G˙IMAT, Demetevler are covered by a fire station located at node 69, in Mehmet Akif Ersoy District near Demetevler. The name of this station is 4T7. The maximum distance it serves is 3.9 km. About 300000 people get service from Fire Station 4T7. The orange diamonds on the map are these covered points. The last fire station here, 4T8, is sited in İvedik Industrial Site, near the North Beltway. It covers more than 100000 people within a maximum distance of 2.9 km. The shape of these nodes is green square with white point in it.

In the 8-minute time restricted model only one fire station is assigned for the considered region covered by the existing Batıkent Fire Station. It is named as 8T2. As seen from the map, the orange diamonds represent the nodes which belong to the coverage region of 8T2. Actually, it covers more districts than Batıkent Fire Station. For example, the points located around east side of Anadolu Boulevard are not covered by Batıkent Fire Station. Therefore, 8T2 Fire Station serves approximately 200000 more people. However, the maximum distance that 8T2 goes is almost half of the maximum distance of Batıkent Fire Station. The location of the 8T2 Fire Station is more central than Batıkent.

7.3.4 Comparison with Keçiören Fire Station

The quantitative values of the fire stations around Keçiören are given in Table 7.28.

The regions covered by Keçiören Fire Station are covered by two fire stations in the 4-minute time restricted model. One of them, 4T9, is sited around Kanuni District which is close to the North Beltway. It covers 11 nodes and more than

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Keçiören	Keçiören	Node 120	7.8 km	40	488537
4 min	4T9	Keçiören	Node 111	3.65 km	11	165302
	4T10	Keçiören	Node 115	3.7 km	35	487286
8 min	8T3	Keçiören	Node 120	7.9 km	74	981481

Table 7.28: Comparison with Keçiören Fire Station

160000 people in 3.65 km radius. The shape of these nodes is a pink point. The districts which are located up to Ziraat District under Turgut Özal Boulevard are covered by the Fire Station 4T10. Its location is around 19 Mayıs District. More than 480000 people are covered by 4T10 Fire Station and its maximum distance is 3.7 km. The maximum distances of 4T9 and 4T10 Fire Stations are approximately half of Keçiören Fire Station.

The 8-minute time restricted model assigns a fire station in Keçiören at exactly the same node as Keçiören Fire Station. It is named as 8T3. Despite the fact that Fire Station 8T3 covers more points and almost twice as many population as that covered by Keçiören Fire Station, the maximum distances of them are almost the same. 8T3 covers some of the districts in Altındağ. That means in the existing situation Keçiören Fire Station can be assigned more districts without increasing its maximum coverage distance.

7.3.5 Comparison with Altındağ and Siteler Fire Stations

Table 7.29 gives the information about the fire stations around Altındağ.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Siteler	Siteler	Node 322	8.7 km	41	346557
	Altınpark	Altındağ	Node 341	10.31 km	35	180754
4 min	4T10	Keçiören	Node 115	3.7 km	35	487286
	4T11	Altındağ	Node 139	3.78 km	28	329735
	4T12	Altındağ	Node 436	3.3 km	3	28285
	4T13	Altındağ	Node 411	3.5 km	14	106470
8 min	8T3	Keçiören	Node 120	7.9 km	74	981481
	8T4	Altındağ	Node 411	7.05 km	24	228995

Table 7.29: Comparison with Altındağ and Siteler Fire Stations

The regions around Çiçekli, Şevkat, Basınevleri belong to the coverage region of the Fire Station 4T10 in the 4-minute time-restricted model. Here, the regions

on the east side of İrfan Başţuğ Street are investigated. There are two fire stations assigned for these regions. The first one is located on the border of Yunus Emre and Doğantepe Districts. The name of 4T11 is given to this station. The covered nodes are marked as light blue squares on the map. It covers the regions including Siteler, some districts under Turgut Özal Boulevard, and the districts until Karapürçek. More than 320000 people get service from this station. The maximum distance of 4T11 Fire Station is only 3.78 km. It is such a small value compared to the Altınpark Fire Station which has 10.31 km radius. The reason is that 4T11 does not cover Baraj District which is covered by Altınpark Fire Station in the existing situation. There is another fire station, 4T12, for Baraj District. It is assigned exactly on Baraj District on the North Beltway. There are three nodes which are covered by Fire Station 4T12. Nevertheless, the maximum distance of this station is 3.3 km. In order to cover every region in 4 minutes, it is necessary to assign such facilities for the farther points. The covered nodes of Fire Station 4T12 are shown as black spirals on the map. The districts which are located east side of Bostancık and Karapürçek Street are covered by another fire station. Its location is on Yeniyol Street, near the East Beltway. The station, called 4T13, covers 14 nodes and more than 100000 people. It has a radius of 3.5 km. The shape of the covered nodes is purple diamond.

In the 8 minute time restricted model, there are two fire stations for the considered region. 8T3 Fire Station, which is analysed for Keçiören, covers some points around Altındağ. It serves almost all points which Altınpark Fire Station serves. The nodes are represented by yellow stars. The other fire station, 8T4, locates at exactly the same node where 4T13 is assigned. As distinct from 4T13, 8T4 covers the districts such as PTT Evleri, Feridun Çelik, Çamlık and Alemdağ. Furthermore, its coverage extends until Bayındındır Dam. It serves more than 220000 people within a radius of 7.5 km. The shape of the nodes which are covered by 8T4 is purple diamond.

7.3.6 Comparison with Kayaş Fire Station

The information about fire stations around Kayaş is given in Table 7.30.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Kayaş	Mamak	Node 149	11.3 km	26	262105
4 min	4T14	Mamak	Node 178	3.7 km	11	263555
	4T15	Mamak	Node 432	3.7 km	4	32551
	4T16	Çankaya	Node 430	3 km	3	11029
8 min	8T5	Mamak	Node 180	7.8 km	30	529479

Table 7.30: Comparison with Kayaş Fire Station

There are three fire stations which are assigned for the region of Kayaş Fire Station in the 4-minute time-restricted model. Some nodes on the west side of Kartaltepe District are covered by another fire station which will be analysed later. The first station, 4T14, locates on Natoyolu Street near Ege District. 4T14 covers the districts around Durali Alıç, Misket, Dutluk and Kartaltepe Districts. The maximum distance of Fire Station 4T14 is 3.7 km and it covers more than 260000 people. The shape of the nodes is light blue square. For Bayındır Dam, Fire Station 4T15 is assigned. It covers 4 nodes and about 30000 people in this region. The maximum distance it serves is 3.7 km. The red leaves on the map are the nodes which are covered by the Fire Station 4T15. The fire station, 4T16, assigned on the East Beltway covers the nodes on the East Beltway. There are three nodes, the black points, which are covered by 4T16. The maximum distance is 3 km.

In the 8-minute time-restricted model, a fire station is assigned at the intersection of Doğukent Street and Natoyolu Street. It is called 8T5. It covers the same nodes as Kayaş Fire Station. Because their locations are different, the maximum distances are different. There are only 3.2 km distance between the two fire stations and a few points covered are different. Yet, these small changes have the maximum distance of Kayaş Fire Station decreased from 11.3 km to 7.8 km. That means small changes may have big effects on life-saving.

7.3.7 Comparison with Çayyolu Fire Station

Table 7.31 shows the information about the fire stations around Çayyolu.

The 4-minute time-restricted model assigns four fire stations for Çayyolu region. Fire Stations 4T17 and 4T18 are located at Yaşamkent District covers

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Çayyolu	Yenimahalle	Node 242	12.3 km	28	110627
4 min	4T17	Yeniahalle	Node 237	2.7 km	3	30391
	4T18	Yenimahalle	Node 238	3.7 km	3	9337
	4T19	Yenimahalle	Node 231	3.9 km	15	62678
	4T20	Etimesgut	Node 224	3.6 km	9	56060
	4T26	Çankaya	Node 390	3.9 km	4	42826
8 min	8T6	Yenimahalle	Node 237	7.4 km	8	61493
	8T7	Yenimahalle	Node 243	7.8 km	29	185260

Table 7.31: Comparison with Çayyolu Fire Station

six nodes and about 40000 people in this region. Their maximum distances are 2.7 km and 3.7 km, respectively. The shape of the nodes of 4T17 is light green points and the shape of the nodes of 4T18 is purple points. The districts around Prof. Dr. Ahmet Taner Kışlalı, Ümit, Koru and Çayyolu Districts are covered by Fire Station, 4T19, located at Saltoğlu Boulevard. It covers about 60000 people and the maximum distance of this station is 3.9 km.The nodes belonging to the coverage region of 4T19 are shown as white diamonds. The other nodes around Eskişehir Street are covered by another fire station, 4T20. Its location is on Yeni Boulevard and it maximum distance is 3.6 km. The black squares with white point in them represent the nodes which are covered by 4T20. Bilkent and Hacettepe Universities are covered by another fire station, 4T26. Its location is Hacettepe Beytepe Campus. The maximum distance of this station is 3.9 km and it covers about 40000 people. The shape of the nodes is red-white points.

The 8-minute time-restricted model assigns two fire stations for the considered region. One of them locates at the same node as Fire Station 4T17's node. Now, this station is called 8T6 and it covers more than 60000 people with 7.4 km radius. The covered area includes Bağlıca and Yaşamkent. Since this area is bigger, the maximum distance is as twice as the Fire Station 4T17. The light green nodes are covered by this station. The other fire station, 8T7, sites on the 8th Street. In addition to the coverage region of Çayyolu Fire Station, 8T7 covers the districts around Alsancak, Bilkent and Hacettepe Universities. The maximum distance of this station is 7.8 km and it covers more than 180000 people. The black squares with white point belong to the coverage region of the Fire Station 8T7.

7.3.8 Comparison with Kurtuluş and Esat Fire Stations

Table 7.32 shows the quantitative values about Kurtuluş, Esat, and optimal fire stations.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Kurtuluş	Altındağ	Node 158	6.65 km	70	403125
	Esat	Çankaya	Node 274	10.7 km	47	388844
4 min	4T21	Çankaya	Node 344	3.97 km	71	569611
	4T22	Çankaya	Node 206	3.2 km	10	149419
8 min	8T8	Çankaya	Node 268	8 km	113	831784

Table 7.32: Comparison with Kurtuluş and Esat Fire Stations

In the 4-minute time-restricted model, the regions which are covered by Kurtuluş and Esat Fire Stations are covered to a large extent by three fire stations. One of them is located near Kurtuluş Park and is called 4T21. Its location is close to the existing Kurtuluş Fire Station. It covers around 570000 people. As well as central districts such as Kurtuluş, Cebeci, Kızılay, Ulus, it also covers the districts up to Presidential Mansion. The covered area is similar to the coverage area of the Kurtuluş Fire Station. However, Kurtuluş Fire Station also serves some points in Devlet District and Mamak. Besides the difference about the location of the station, the difference about the covered nodes result in a change in a maximum distances. The maximum distance of 4T21 is 3.97 km. The shape of the covered nodes by 4T21 is gray points. The regions from about Oran District to Öveçler District are covered by another fire station, 4T22. 4T22 is located in Karapınar District. It covers less points compared to Esat Fire Station and their locations are quite different. The maximum distance of this station is 3.2 km and it covers about 150000 people. The sea green points represent the covered nodes by 4T22. Around Yukarı Dikmen, Aşağı Dikmen, Birlik Districts get service from the Fire Station 4T23. It serves three nodes in the map which have yellow point shape.

The 8-minute time-restricted model assigns a facility on Çetin Emeç Boulevard. It is called 8T8. Its coverage area is larger than the considered region here. Besides the points around right side of Konya Street, it covers Çiğdem, Balgat, ODTÜ, Çiftlik and the districts above Ulus. The maximum distance is 8 km and this fire station covers more than 830000 people which is bigger than the sum of

existing Kurtuluş and Esat Fire Stations. The gray points are the covered points by 8T8.

7.3.9 Comparison with Merkez Fire Station

The information about the fire stations is given in Table 7.33.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Merkez	Yenimahalle	91	16.64	130	845875
4 min	4T7	Yenimahalle	69	3.9	39	337451
	4T24	Yenimahalle	440	2.7	6	117568
	4T25	Çankaya	288	4	38	298661
8 min	8T8	Çankaya	268	8	113	831784
	8T2	Yenimahalle	Node 381	7.95 km	82	668506

Table 7.33: Comparison with Merkez Fire Station

The coverage of Merkez Fire Station is very large and its region is covered by so many different fire stations in the optimal models. As it is not possible investigating all the nodes one by one, the information of the fire stations which cover the regions in general will be given.

The region covered by the existing Merkez Fire Station which is under the North Beltway and between Anadolu Boulevard and Yozgat Boulevard are covered by two fire stations in the 4-minute time-restricted model. The first one is sited in Sancaktepe District, called 4T24. It covers more than 115000 people in this region. The nodes around this region are approximately 9 km away from Merkez Fire Station. Fire Station 4T24 covers these nodes within 2.7 km radius. They are represented as black flags on the map. The other fire station, 4T7, is assigned to Mehmet Akif Ersoy District. This station is also analysed for Batıkent District. It covers a portion of Çiftlik region and the districts above Fatih Sultan Mehmet Boulevard. The maximum distance of 4T7 is 3.9 km and it covers more than 330000 people here. The orange diamonds are covered by 4T7 Fire Station. The other fire station locates in Çukurambar District. It is called 4T25. The endpoints 4T25 Fire Station covers are ODTÜ, until below Cevizlidere, Çiftlik and Devlet District. The shape of these nodes is light purple square. It covers about 400000 people within 4 km radius. 4T21 and 4T22 fire stations also cover some points. However, they are not investigated here, since these are so small in

number.

There are two fire stations assigned in the 8 minute time restricted model for the coverage area of Merkez Fire Station. On of them, 8T8, is also investigated for Kurtuluş and Esat Fire Stations, seeing that it covers most of the points in their regions. Its coverage area includes ODTÜ, Çiftlik, Varlık, Kurtuluş Park, Mimar Sinan, Birlik and Oran Districts. Similar to the Merkez Fire Station, it covers about 800000 people, however the maximum distance of 8T8 Fire Station is half of the Merkez Fire Station, it is only 8 km. The other fire station, 8T2, is mentioned for the coverage area of Batıkent Fire Station. It covers the regions above İstanbul Street such as Güventepe, Sancaktepe and Çiğiltepe Districts which are covered by the existing Merkez Fire Station. 8T2 covers whole Batıkent region which is not considered here, and its maximum distance is related to this field.

7.4 Analysis of the Time Restricted Conditional Model for Placing Additional Fire Stations

The conditional model is established to determine the new fire stations conditional on the existing fire stations so that they cover all regions in a specific time. The regions are covered in 4 minutes by 23 new fire stations in addition to the existing fire stations. The necessary number of new fire stations is 6 in the 8-minute coverage. The name of fire stations beginning with *4N* and *8N* represent fire stations found in the 4- minute and 8-minute time restricted conditional models, respectively. The maps for the two cases are given in Figures 7.6 and 7.7. In these maps, the new fire stations are shown as orange circles and the existing ones are shown as red squares.

The name of the new stations, their addresses, and shapes of their covered nodes are given in Tables 7.34 and Table 7.35.

Here, the location of new fire stations as well as their coverage area and changed covered area of existing fire stations will be examined. Numerical results

Fire Station	Address	Node Number	Shape of the Demand Points on the Map
4N1	Göksu Districts, 1st TBMM Street and West Beltway, Etimesgut	Node 17	light pink daimond
4N2	İstasyon Street and West Beltway, Etimesgut	Node 24	black cross in circle
4N3	Bağlıca District, Atilla Eser Street, Etimesgut	Node 247	light blue squares
4N4	North Beltway, Batıkent Yenimahalle	Node 441	white point
4N5	2209 Street, Batıkent Yenimahalle	Node 442	light pink point
4N6	Anadolu Boulevard, 21 Street İvedik Yenimahalle	Node 395	red spiral
4N7	Fatih Sultan Mehmet Boulevard, Batıkent, Yenimahalle	Node 53	orange diamond
4N8	Yayla District, Yozgat Boulevard, 2nd Street, Keçiören	Node 340	black plus
4N9	Kanuni District, Bağlum Street, Keçiören	Node 111	pink point
4N10	Baraj District, İrfan Baştuğ Street, North Beltway, Altındağ	Node 127	dark green point
4N11	Beşikkaya District, Karapürçek Street, Altındağ	Node 417	black flag
4N12	Kızılca District, East Beltway, Mamak	Node 433	green triangle
4N13	Yeşilbayır District, East Beltway, Mamak	Node 431	light blue diamond
4N14	Yukarı İmrahor District, East Beltway, Mamak	Node 430	brown diamond
4N15	Şehit Mustafa Tayyarcan Street, Beytepe, Çankaya	Node 390	green star
4N16	Prof. Dr. Ahmet Taner Kışlalı District, Saltoğlu Boulevard, Yenimahalle	Node 231	pink-blue point
4N17	Yeni Boulevard and Etimesgut Street, Etimesgut	Node 224	white diamond
4N18	Yaşamkent District, West Beltway, Yenimahalle	Node 238	light gren point
4N19	Ertuğrulgazi District, Münzeviler Street, Çankaya	Node 317	black point
4N20	Karapınar District, Dikmen Street, Çankaya	Node 206	red-white point
4N21	Hilal District, Doğukent Street, Çankaya	Node 189	yellow point
4N22	Gazi District, Silahtar Street, Yenimahalle	Node 211	purple square
4N23	Çukurambar District, 1423 Street, Çankaya	Node 288	brown square

Table 7.34: New fire stations in the 4 minute time restricted model

Fire Station	Address	Node Number	Shape of the Demand Points on the Map
8N1	North Beltway, 2209 Street, Batıkent, Yenimahalle	Node 34	white point
8N2	Hacılar District, Orhan Kemal Street, Altındağ	Node 76	black point
8N3	Intersection of Natoyolu Street and East Beltway, Mamak	Node 181	black cross in a circle
8N4	Bilkent Street, Bilkent, Çankaya	Node 388	orange diamond
8N5	Yaşamkent District, 3222 Street, Yenimahalle	Node 235	light green point
8N6	Sancak District, Turan Güneş Boulevard, Çankaya	Node 182	green square

Table 7.35: New fire stations in the 8 minute time restricted model

will be given in the tables.

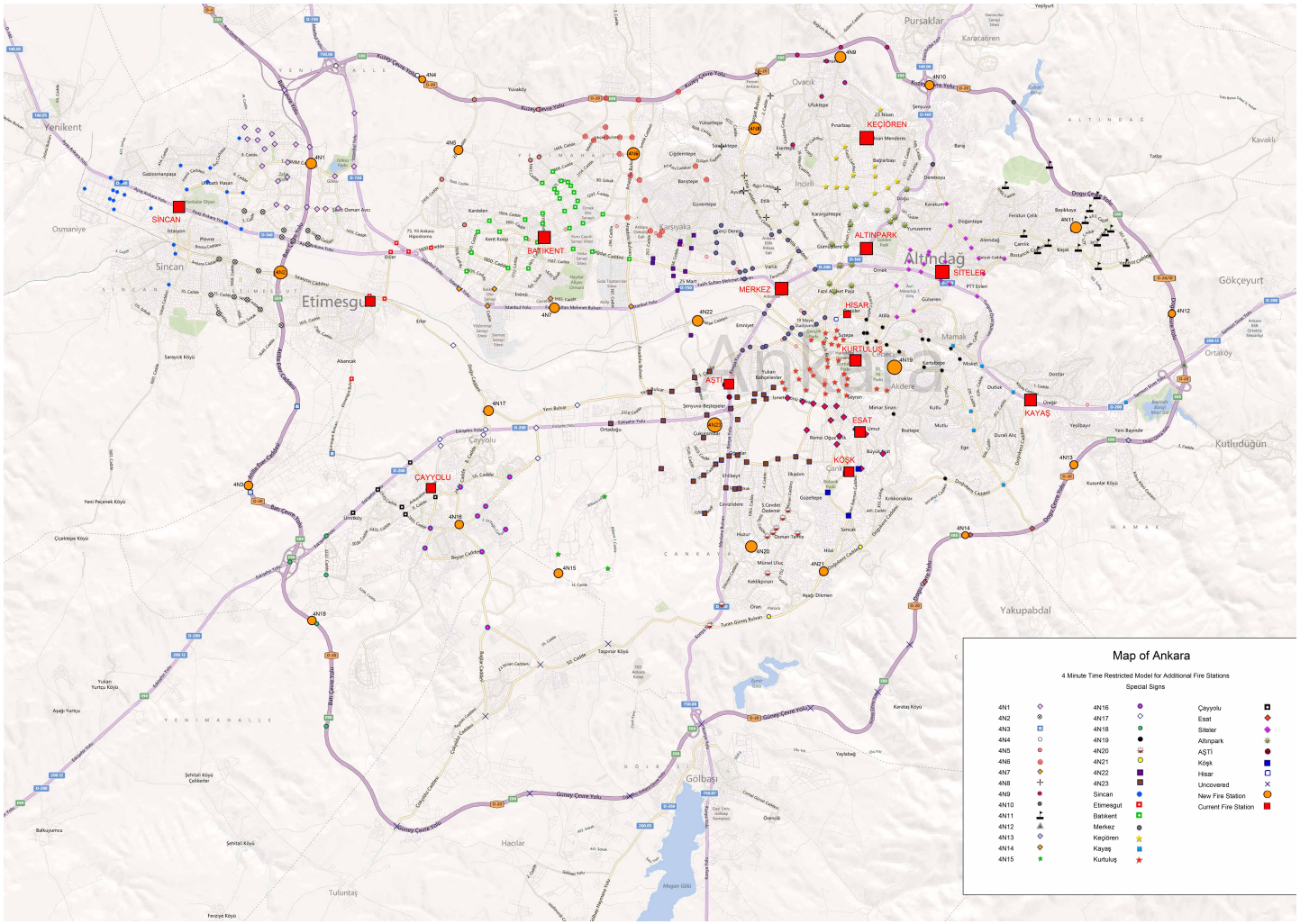

Figure 7.6: Additional and existing fire stations and their assigned nodes in the 4-minute time-restricted conditional model

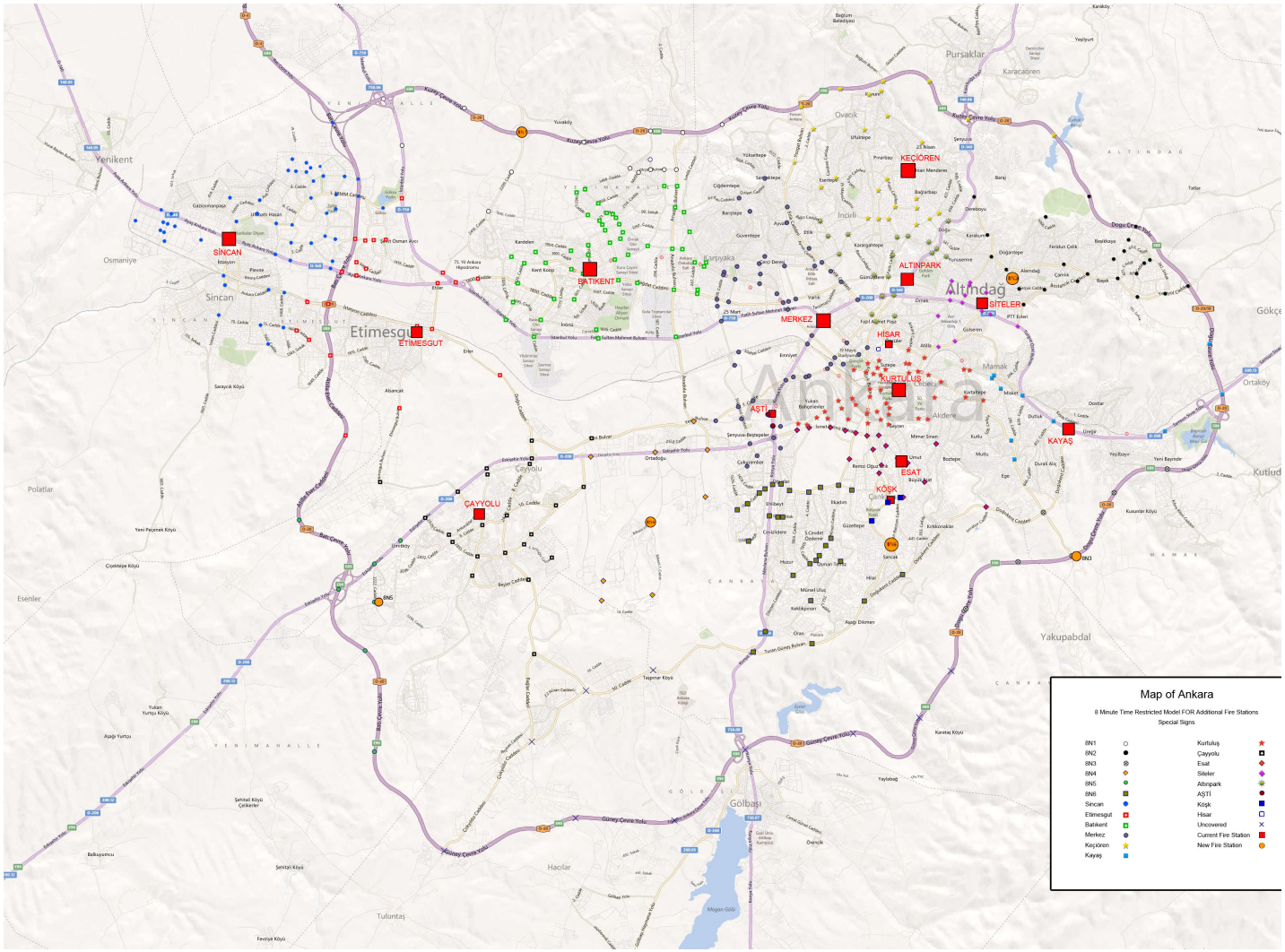

Figure 7.7: New and existing fire stations and their assigned nodes in the 8-minute time-restricted conditional model

7.4.1 Comparison with Sincan Fire Station

Table 7.36 gives the information about existing situation as well as the changed situation and the new fire stations.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Sincan	Sincan	Node 2	9.5 km	66	379711
4 min	4N1	Etimesgut	Node 17	3.6 km	24	98332
	Sincan	Sincan	Node 2	3.79 km	23	155160
8 min	Sincan	Sincan	Node 2	7.3 km	50	366455

Table 7.36: Comparison with Sincan Fire Station

The coverage area of Sincan Fire Station is changed with the 4-minute time-restricted conditional model. It covers the regions including Sincan Industrial Site, Harikalar Diyarı and the regions around Plevne and Yeni Cimşit Districts. The blue points represent the points that belong to the coverage region of Sincan Fire Station. The maximum distance decreases from 9.5 km to 3.79 km. Also, the population covered decreases by half. Another fire station, 4N1, is located at the intersection of 1st TBMM Street and the West Beltway. Şeyh Şamil, Göksu and Altay Districts are covered by Fire Station 4N1. It covers around 100000 people within 3.6 km radius. Light pink diamonds are covered by this station.

In the 8-minute time-restricted conditional model, there is not any new fire station around Sincan. The only change is about the coverage area of the existing Sincan Fire Station. It does not cover the regions around Altay District any more. On the other hand, the common coverage area with Etimesgut Fire Station is separated. Selçuk District is covered by Sincan Fire Station while Topçu District is covered by Etimesgut Fire Station. The maximum distance of Sincan Fire Station is 7.3 km and the number of covered people is close to the existing situation.

7.4.2 Comparison with Etimesgut Fire Station

The information about these fire stations around Etimesgut is given in Table 7.37.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Etimesgut	Etimesgut	Node 40	12.5 km	30	221125
4 min	4N2	Etimesgut	Node 24	3.68 km	18	224211
	4N3	Etimesgut	Node 247	3.9 km	3	39247
	Etimesgut	Etimesgut	Node 40	3.63 km	8	56416
8 min	Etimesgut	Etimesgut	Node 40	6.78 km	24	171906

Table 7.37: Comparison with Etimesgut Fire Station

For Etimesgut, three fire stations can be investigated which placed in the 4-minute time-restricted conditional model. The coverage of Etimesgut Fire Station is restricted with 8 node and it now covers around 56000 people within 3.63 km maximum distance. The other parts are now covered by the new fire stations. One of them, 4N2, is placed at the intersection of İstasyon Street and the West Beltway. It covers Piyade, Topçu Districts, and some parts of Eryaman Districts. These are shown as black crosses in circles in the map. The maximum distance of Fire Station 4N2 is 3.68 km and it covers more than 220000 people. Bağlıca District is covered by another fire station, 4N3. It is located on Atilla Eser Street and it covers three nodes with 3.9 km radius. The shapes of the covered nodes are seen as light blue squares.

The 8-minute time-restricted conditional model does not assign a new fire station for this region. In the new situation, it does not cover the points around Eskişehir Street which has the maximum distance decreased from 12.5 km to 6.78 km. Furthermore, Altay, Şehit Osman Avcı, and Şeker districts are covered in the new situation which are not covered in the existing case.

7.4.3 Comparison with Batıkent Fire Station

The information about the fire stations around Batıkent is given in Table 7.38.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Batıkent	Batıkent	Node 50	13.04 km	71	430856
4 min	4N4	Yenimahalle	Node 441	3.1 km	2	4528
	4N5	Yenimahalle	Node 442	3.9 km	7	40996
	4N6	Yenimahalle	Node 395	3.8 km	21	204520
	4N7	Yenimahalle	Node 53	3.4 km	6	65468
	Batıkent	Batıkent	Node 50	3.74 km	31	204908
8 min	8N1	Yenimahalle	Node 34	7.3 km	16	108620
	Batıkent	Batıkent	Node 50	5.25 km	52	414352

Table 7.38: Comparison with Batıkent Fire Station

4 new fire stations and the existing Batıkent Fire Station cover the regions around Batıkent in the 4-minute time-restricted conditional model. The first new station is located on the North Beltway and covers the two nodes, marked as white points, on that street. It is called 4N4 and it covers around 40000 people with 3.1 km radius. The second one is placed on 2209 Street where population is still not very dense. It is called 4N5 and it covers around 40000 people with 3.9 km maximum distance. The shape of the covered nodes is light pink points. It covers the new residential areas on the north side of Kardelen District and the districts around the North Beltway. The third new fire station, 4N6, is located at Anadolu Boulevard. 4N6 covers the districts around İvedik Industrial Site, Özevler, Aşağı Yahyalar, Karşıyaka Graveyard, and the regions around Çiğiltepe, Sancaktepe and Güventepe Districts. The maximum distance of 4N6 is 3.8 km and it covers around 200000 people. The fourth fire station, 4N7, is located on Fatih Sultan Mehmet Boulevard near Carrefour Supermarket. It covers the industrial sites around İstanbul Street. The shape of the covered nodes is orange diamond. The maximum distance of Fire Station 4N7 is 3.4 km. The coverage area of Batıkent Fire Station changes with these new fire stations. It covers the west side of Anadolu Boulevard, the districts around Batıkent and some points around İvedik Industrial Site. The maximum distance of this station is now 3.74 km. The facilities established for the farther regions from the existing fire stations improve the efficiency.

The 8-minute time-restricted conditional model assigns one new fire station for the considered area. It is called 8N1. It covers the regions around the North Beltway, the new residential areas on the north side of Kardelen District and a part of İvedik Industrial Site. The white points represent the covered nodes by 8N1. The maximum distance of this fire station is 7.3 km and around 100000 people get service from this station. On the other hand, Batıkent Fire Station does not serve the nodes covered by 8N1 and the points around Hipodrom. When the points away from the existing Batıkent Fire Station are removed from the coverage area, the maximum distance decreases from 13.04km to 5.25km.

7.4.4 Comparison with Keçiören Fire Station

The information about the fire stations in Keçiören is given in Table 7.39.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Keçiören	Keçiören	Node 120	7.8 km	40	488537
4 min	4N8	Keçiören	Node 340	4 km	10	199598
	4N9	Keçiören	Node 111	4 km	8	106030
	Keçiören	Keçiören	Node 120	2.75 km	13	236636
8 min	Keçiören	Keçiören	Node 120	7.9 km	27	457034

Table 7.39: Comparison with Keçiören Fire Station

There are three fire stations to evaluate in the 4-minute time-restricted conditional model for the vicinity of Keçiören which is currently covered by the Keçiören Fire Station. Two new fire stations are enough to cover this region in 4 minutes. The first one, 4N8, is sited on Yozgat Boulevard. It covers the regions around Etlik, Ayvalı, Yayla and a portion of Ovacık Districts. It covers approximately 200000 people and the maximum distance of this station is 4 km. The second new fire station, 4N9, exists in Kanuni District, on the south of the North Beltway. It covers the area beginning from the North Beltway to Esertepe District. The maximum distance of 4N9 is 4 km and it covers around 100000 people there. The pink points represent the covered nodes by Fire Station 4N9. The remaining area is covered by the existing Keçiören Fire Station. The common regions covered by both Keçiören and Altınpark Fire Stations are no longer covered by Keçiören Fire Station in this new case. Therefore, the maximum distance decreases to 2.75 km and the covered population is half of the existing case.

There is not any new fire station in the 8-minute time-restricted model. Also, the covered area does not change so much. While the common region with Altınpark Fire Station is not covered, Baraj District is covered in the new case. This change does not effect the maximum distance highly, the increase is just from 7.8 km to 7.9 km.

7.4.5 Comparison with Altınpark and Siteler Fire Station

The information about the fire stations around Altındağ is given in Table 7.40.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Siteler	Siteler	Node 322	8.7 km	41	346557
	Altınpark	Altındağ	Node 341	10.31 km	35	180754
4 min	4N10	Altındağ	Node 127	3.3 km	3	43774
	4N11	Altındağ	Node 417	3.75 km	15	119215
	Siteler	Siteler	Node 322	3.05 km	22	258396
	Altınpark	Altındağ	Node 341	3.65 km	18	205232
8 min	8N2	Altındağ	Node 76	7.35 km	24	235160
	Siteler	Siteler	Node 322	2.48 km	15	169548
	Altınpark	Altındağ	Node 341	5.05 km	20	237129

Table 7.40: Comparison with Altınpark and Siteler Fire Station

The 4-minute time-restricted conditional model assigns two new fire stations in addition to the existing fire stations. One of them is placed at the Baraj District. It is called Fire Station 4N10. The maximum distance of Fire Station 4N10 is 3.3 km. It only covers the Baraj District. The three green points on the map represent the nodes covered by 4N10. The next fire station, 4N11, is sited in Beşikkaya District. It covers the districts beginning from Alemdağ and Doğantepe to the East Beltway. The maximum distance of Fire Station 4N11 is 3.75 km. It covers around 120000 people. The black flags on the map are the nodes getting service from Fire Station 4N11. Siteler Fire Station covers Ulubey, Hacılar, a portion of Yunus Emre District, Siteler and a few points on the south side of the Turgut Özal Boulevard. The maximum distance decreases to 3.05 km. Most of the area covered by the existing situation is now covered by Fire Station 4N11. The covered area by Altınpark Fire Station also decreases with this new situation. It does not cover Baraj Districts, some points in Keçiören and the points on the west side of Plevne and Örnek Districts. This change has the maximum distance reduced to 3.65 km. In the existing case the population of these nodes are shared by different existing fire stations. Yet in 4-minute time-restricted case their whole population are covered by only one fire station. The rise on the population is caused by this difference.

In the 8-minute time-restricted conditional model, there is one new fire station, 8N2. The coverage of this new fire station resembles Fire Station 4N11. 8N2 covers the part of the districts Hacılar, Ulubey, Yıldıztepe, Karakum, Zülfazıl and the districts on the west side of these districts up to the West Beltway. The maximum distance of Fire Station 8N2 is 7.35 km. The black points on the map are covered by this fire station. Altınpark Fire Station covers the districts among

Emrah Çicekli, Hasköy, and Fazıl Ahmet Paşa Districts. The maximum distance of Altınpark Fire Station is 5.05 km in this new case. Since many nodes are covered by only one fire station, the population increases. Siteler Fire Station only covers Siteler and regions around Çalışkanlar District. The maximum distance of Siteler Fire Station is only 2.48 km.

7.4.6 Comparison with Kayaş Fire Station

The information about the fire stations is given in Table 7.41.

	Name of the Station	Location	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Kayaş	Mamak	Node 149	11.3 km	26	262105
4 min	4N12	Mamak	Node 433	2.4 km	3	14299
	4N13	Mamak	Node 431	2.1 km	2	16474
	4N14	Mamak	Node 430	3 km	3	11029
	Kayaş	Mamak	Node 149	3.7 km	8	189942
8 min	8N3	Mamak	Node 181	5 km	6	66492
	Kayaş	Mamak	Node 149	7.9 km	11	181628

Table 7.41: Comparison with Kayaş Fire Station

There are five fire stations examined around Kayaş in the 4-minute time-restricted conditional model. The first one, 4N12 is placed in Kızılca Districts and it covers three nodes around the East Beltway. The maximum distance of 4N12 is 2.4 km. There is a green triangle on the map which belongs to this fire station. The second fire station, 4N13, is again placed on the East Beltway in Yeşilbayır District. The coverage area of 4N13 is restricted with the East Beltway. Therefore, the total population covered is under 20000 people. The maximum distance of 4N13 Fire Station is 2.1 km. The light blue diamonds represent the nodes covered by 4N13 Fire Station. The third fire station exists on the East Beltway, on the south side of Yukarı İmrahor District. The covered nodes are marked as brown diamonds. It has 3 km maximum distance. As a result, the covered area of Kayaş Fire Station is changed. It covers around Dutluk, Duralı Alıç, Dostlar and Ege Districts. The maximum distance decreases from 11.3 km to 3.7 km. The fire stations on the beltway have the maximum distance decreased.

For the 8-minute time-restricted conditional model, one new fire station is enough to cover the regions covered by existing Kayaş Fire Stations. This station

is placed at the intersection of Natoyolu Street and the East Beltway. It is called 8N3 and it covers around 60000 people. The covered nodes are represented by black crosses in circles and the maximum distance to those nodes is 5 km. It covers a part of Duralı Alıç, Yeni Bayındır, and Yeşil Bayır Districts. The coverage area of Kayaş Fire Station changes with this model. Regions around Misket, Dutluk, Duralı Alıç, Dostlar Districts, and Kızılcaköy get service from Kayaş Fire Station in this new case. The maximum distance is 7.9 km and the covered population decreases.

7.4.7 Comparison with Çayyolu Fire Station

The quantitative values about the fire stations are given in Table 7.42.

	Name of the Station	Loacation	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Çayyolu	Yenimahalle	Node 242	12.3 km	28	110627
4 min	4N16	Yenimahalle	Node 231	3.9 km	10	33039
	4N17	Etimesgut	Node 224	3.6 km	9	56060
	4N18	Yenimahalle	Node 238	3.9 km	5	28273
	Çayyolu	Yenimahalle	Node 242	3.6 km	7	51483
8 min	8N5	Yenimahalle	Node 235	6.7 km	7	54022
	Çayyolu	Yenimahalle	Node 242	7.83 km	24	130889

Table 7.42: Comparison with Çayyolu Fire Station

Three new fire stations and Çayyolu Fire Station cover the regions covered by Çayyolu Fire Station currently. The first one exists in Prof. Dr. Ahmet Taner Kışlalı District and it is called 4N16 Fire Station. The shape of the nodes is pink-blue points. Fire Station 4N16 covers Prof. Dr. Ahmet Taner Kışlalı District, Angora Evleri, and Çayyolu District. The covered population of 4N16 is about 30000 people. The second fire station, 4N17, exists at the intersection of Yeni Boulevard and Etimesgut Street. The shape of the nodes covered by this fire station is white diamond. It covers the regions around Eskişehir Street as well as the region located up to half of the Etimesgut Street. The total population which get service from 4N17 is approximately 56000 people and the maximum distance is 3.6 km. The third fire station, 4N18, is placed in Yaşamkent District and it covers the nodes around the West Beltway. The nodes can be seen as light green points on the map. The maximum distance of 4N18 is 3.9 km. In this situation, the remaining area assigned to Çayyolu Fire Station is very small. However, the

region it covers is the densest region in the considered area. It covers 7 nodes but still half of the population compared to the existing situation. The maximum distance becomes 3.6 km.

The 8-minute time-restricted conditional model assigns one new fire station for the considered area. The fire station, 8N5, is located in Yaşamkent District. The shape of the nodes is light green points and the maximum distance of 8N5 is 6.7 km. The remaining areas including Prof. Dr. Ahmet Taner Kışlalı, Çayyolu, Ümit District, Koru, Konutkent Districts, and Angora Evleri are covered by Çayyolu Fire Station. The maximum distance is 7.83 km. It covers less points compared to the existing situation. Since there are not any nodes jointly covered by other fire stations, the covered population increases.

7.4.8 Comparison with Kurtuluş and Esat Fire Stations

Total information about the fire stations is given in Table 7.43.

	Name of the Station	Loacation	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Kurtuluş	Altındağ	Node 158	6.65 km	70	403125
	Esat	Çankaya	Node 274	10.7 km	47	388844
4 min	4N19	Çankaya	Node 317	3.4 km	17	291636
	4N20	Çankaya	Node 206	3.2 km	10	149419
	4N21	Çankaya	Node 189	2.5 km	3	44766
	Kurtuluş	Altındağ	Node 158	2.93 km	29	141898
	Esat	Çankaya	Node 274	2.91 km	15	99172
8 min	8N6	Çankaya	Node 182	8 km	29	364020
	Kurtuluş	Altındağ	Node 158	4.13 km	45	359850
	Esat	Çankaya	Node 274	4.43 km	19	175092

Table 7.43: Comparison with Kurtuluş and Esat Fire Station

There are three new fire stations for the regions covered by Esat and Kurtuluş Fire Stations currently. One of them, 4N19, exists in Ertuğrulgazi District. It covers the regions around Cebeci Military Cemetery, Şükriye, Mehtap, Çağlayan, Aşık Veysel, Türközü, Kazım Orbay Districts up to Orta İmrahor District. The maximum distance of this station is 3.4 km. It covers the population close to 300000. The shapes of these nodes are black points. The other fire station, 4N20, is located in Karapınar District. It covers the districts from around Oran to S.Cevdet Özdemir District and covers close to 150000 people within 3.2 km radius. Red-white points represent the nodes getting service from Fire Station

4N20. Hilal, Yukarı Dikmen, Aşağı Dikmen Districts are covered by another fire station, 4N21. Its location is in Hilal District. It covers 3 nodes and close to 50000 people. The maximum distance of this station is 2.5 km. The coverage area of Esat Fire Station decreases with Fire Stations 4N20 and 4N21. Gaziosmanpaşa, Remzi Oğuz Arıkan, Büyükesat, Esatoğlu and part of Devlet Districts are covered by Esat Fire Station. Its maximum distance decreases to 2.91 km. The region from Oran to Devlet District is important with regard to the population. Esat Fire Station can not reach these regions currently in 4 minutes. On the other hand, the Kurtuluş Fire Station covers a smaller region compared to the existing case. Maltepe, Anıttepe, Eti, Kurtuluş, Kızılay, Seyran, Şehit Cengiz Topel and the hospitals in Sıhhiye, such as Hacettepe and İbni Sina Hospitals, are covered. The maximum distance is 2.93 km. The population covered is a quarter of the population covered in the existing case.

The 8-minute time-restricted conditional model assigns only one new fire station for the considered region and it is located at node 182. This node is covered by Köşk Fire Station currently, however while constructing the models, these nodes are allowed to be locations of new fire stations. This fire station, 8N6, is located at the beginning of Turan Güneş Boulevard. It covers the districts from Çiğdem, Aşağı Öveçler, Harbiye, Aziziye to Oran District on the south and to Birlik District on the east. The maximum distance of 8N6 is 8 km. It covers about 360000 people. The green squares represent the nodes covered by Fire Station 8N6. On the other hand, Esat Fire Station covers the regions around Devlet, Aşıkpaşa, Büyükesat, and Orta İmrahor. The maximum distance of Esat Fire Station is 4.43 km and it covers half of the population it covers currently. Kurtuluş Fire Station covers less nodes compared to the existing case. This time, Devlet, Remzi Oğuz, Arıkan and Esatoğlu Districts are not covered. There is not so much difference for the other regions. There is a 2 km decrease in the maximum distance. It becomes 4.13 km in the new case.

7.4.9 Comparison with Merkez Fire Station

Table 7.44 gives the information about Merkez Fire Station.

	Name of the Station	Loacation	Node Number	Maximum Distance	Number of Nodes Covered	Population Covered
Existing	Merkez	Yenimahalle	Node 91	16.64 km	130	845875
4 min	4N6	Yenimahalle	Node 395	3.8 km	21	204520
	4N8	Keçiören	Node 340	4 km	10	199598
	4N15	Çankaya	Node 390	3.9 km	4	42826
	4N22	Yenimahalle	Node 211	3.93 km	12	99903
	4N23	Çankaya	Node 288	4 km	34	265923
	Merkez	Yenimahalle	Node 91	4 km	29	213140
8 min	8N4	Çankaya	Node 388	6.3 km	9	94704
	8N6	Yenimahalle	Node 182	8 km	29	364020
	Merkez	Yenimahalle	Node 91	7.45 km	55	449434

Table 7.44: Comparison with Merkez Fire Station

There are five new fire stations in the 4-minute time-restricted conditional model for the regions covered by Merkez Fire Station currently. Three of them are located on north side of Fatih Sultan Mehmet Boulevard. 4N6 Fire Station, which is also investigated for Batıkent Fire Station, covers the regions around Çiğdemtepe, Barıştepe, Kayalar, İvedik, Güventepe, Özevler, Mehmet Akif Ersoy Districts. The maximum distance is 3.8 km and it covers more than 200000 people. The red spirals represent the covered nodes by Fire Station 4N6. Fire Station 4N8 covers Sancaktepe and Ayvalı Districts in the considered region. The maximum distance of 4N8 is not related with a demand point in the considered area. The plus signs represent the nodes which belong to the coverage region of Fire Station 4N8. There is another fire station, 4N22, in Çiftlik region at Gazi District. The covered nodes by this fire station are represented as purple squares. It covers the districts around Mehmet Akif Ersoy, Demetgül, Gazi, 25 Mart, and Çamlıca Districts. It covers around 100000 people within a 3.93 km radius. Another new fire station, 4N23, is located in Çukurambar District. It covers the regions up to ODTÜ on the west, Beştepeler on the north, Devlet on the east and Cevizlidere on the south. The maximum distance of 4N23 is 4km. It covers more than 260000 people. The last one is located on Beytepe Köyü Street (also called Şehit Mustafa Tayyarcan Street). It is called 4N15. Hacettepe and Bilkent Universities are covered by this fire station. The maximum distance of 4N15 Fire Station is 3.9 km and approximately 40000 people get service from this fire station. The coverage area of Merkez Fire Station is decreased by these new fire stations. Only the regions around Ulus, Maltepe, Akköprü and Ragıp Tüzün Districts are covered. The maximum distance of Merkez Fire Station is 4km. It covers a quarter of the population compared to the existing case.

The 8-minute time-restricted conditional model assigns a new fire station only in Bilkent for the considered area. It is located on Bilkent Street and it is called Fire Station 8N4. It covers the regions around ODTÜ, Bilkent and Hacettepe Universities. The maximum distance of this station is 6.3 km and it covers approximatey 100000 people here. The covered nodes can be seen as orange diamonds on the map. The nodes around Devlet, Çukurambar, 100. Yl, Çiğdem, Oğuzlar, and Ehlibeyt Districts are covered by a new Fire Station 8N6. The shapes of the nodes are green squares. The coverage area of 8N6 extents up to Oran District; however these regions are not considered here. The regions between Ulus and Bahçelievler are jointly covered by Merkez, Kurtuluş and Esat Fire Stations. However, in this case Merkez Fire Station does not cover them anymore. In this case, Merkez Fire Station covers the regions around Sancaktepe, Barıştepe, Güventepe, Ayvalık, 25 Mart, Varlık, Akköpü, Ulus, Gazi, Beştepeler, Balgat, Çukurambar and part of Yukarı Bahçelievler Districts. The maximum distance reduces to 7.45 km and it covers half of the population that is covered by Merkez Fire Station currently.

Chapter 8

General Evaluation

In this thesis, the locations of optimal fire stations are investigated for four different cases. In chapter 7, a detailed analysis including the comparison of the optimal and the existing fire stations is presented. For making the comparison, first, the coverage areas of the existing fire stations are found. Then, the optimal fire stations which are located in these coverage areas are determined. After that, the locations and the coverage areas of the optimal and the existing fire stations are compared. In this chapter, the results are summarized and some suggestions are presented.

The fire stations are evaluated by two types of studies. The first study aims to locate 11 fire stations optimally. In the existing case, 11 fire stations are located according to the necessities, population, and road network. However, today, we do not know whether their locations are good. Locating 11 fire stations optimally shows that how these fire stations can be sited optimally. The studies are: locating 11 fire stations without considering the population, locating 11 fire stations with regard to the population and locating 11 fire stations with the same coverage areas as the existing cases. Table 8.1 shows the information about the existing and optimal cases.

Table 8.1 shows that, the weighted case and the same coverage case does not

	Number of Fire Stations	Maximum Distance
Existing Case	11	16.64 km
Unweighted Case	11	7 km
Weighted Case	11	12.3 km
Same Coverage	11	13.3 km

Table 8.1: Locating 11 fire stations

give a significant improvement on the maximum distances. However, the fire stations in the unweighted case can reach the farthest point in 7 minutes with the speed of 60 km/h. This maximum distance is better than the international norms with 8 km. Therefore, it can be considered by the Fire Department.

The second study aims to site the fire stations complying with the international norms. In this study, the number of fire stations is not fixed. There are 2 cases for this study, the first one aims to locate the fire stations according to the 4-minute and 8-minute time restrictions without considering the existing fire stations. The second one aims to locate new fire stations in addition to the existing ones according to the same time restrictions. Table 8.2 shows us the information about these studies.

	Total Number of Fire Stations	Number of New Fire Stations	Maximum Distance
4-minute Time Restricted Case	26		4 km
8-minute Time Restricted Case	8		8 km
4-minute Time Restricted Conditional Case	34	23	4 km
8-minute Time Restricted Conditional Case	17	6	8 km

Table 8.2: Locating fire stations according to the time restrictions

According to the 4-minute time-restricted model, 26 new fire stations are needed. If the Fire Department uses the results of this case, then the resources

of the existing 11 fire stations should be transferred to the new fire stations and there should be new resources for the remaining 15 fire stations. When we consider the 4-minute time-restricted conditional model, 23 new fire stations are needed in addition to the existing ones. Locating 26 new fire stations is clearly more superior to locating 23 new fire stations in addition to the 11 existing ones, as the latter case requires personnel and equipment for a total of 34 fire stations while the former case achieves the same coverage with equipment and personnel needed only for 26 fire stations. The expenses for new building are essentially the same (26 versus 23). These two cases may be considered for further regulations, since they need so many fire trucks and firemen.

On the other hand, the 8-minute time restricted case needs 8 fire stations. If the Fire Department uses the results of this model, the existing resources can easily be transferred to the new fire stations. Except the expense of the new buildings, there is not any cost for the Fire Department for applying this case.

In the 8-minute time-restricted conditional model, 6 new fire stations are needed in addition to the 11 existing ones. It is still an acceptable solution for the Fire Department. However, new personnel and equipment should be found for the 6 new stations in addition to the equipment and personnel of the 11 existing stations. Clearly, opening 8 new fire stations is a much better solution than opening 6 new stations in addition to the 11 existing ones as they both achieve the same level of coverage but the former requires personnel and equipment for 8 fire stations while the latter requires equipment and personnel for 17 fire stations (6 new + 11 existing).

We recommend the Fire Department the 8-minute time-restricted case. The 8-minute time-restricted model is analyzed with respect to the coverage minutes. Then we reach these results: 93.66 % of the nodes are covered in 7 minutes, 79.18 % of the nodes are covered in 6 minutes, 60.63% of the nodes are covered in 5 minutes, and 46.38 % of the nodes are covered in 4 minutes in this model. Although the unweighted p-center model covers the regions within 7 minutes with 11 new fire stations, the 8-minute time-restricted model can reach 93.66 % of the coverage regions in 7 minutes with 8 new fire stations. Another analysis for the

8-minute time-restricted model is made. We obtained that whether a node is covered by more than one fire stations. We analyze this for 8-minute, 7-minute and 6-minute coverages in the 8-minute time-restricted model. The information is given in Table 8.3.

	Number of nodes covered by 1 fire station	Number of nodes covered by 2 fire stations	Number of nodes covered by 3 fire stations
8-minute coverage	327	98	17
7-minute coverage	368	44	2
6-minute coverage	336	14	0

Table 8.3: Number of nodes covered by one or more than one fire stations for different time coverages

As it is seen from Table 8.3, 98 nodes are covered by 2 fire stations and 17 nodes are covered by 3 fire stations in 8 minutes. Also, 44 fire stations are covered by 2 fire stations in 7 minutes in this model.

Here, we summarize all the solutions. In the first study, the locations of fire stations are examined while their coverage areas remain the same. The 11 optimal locations of fire stations are compared with the 11 existing fire stations with regard to the maximum distances. The most important change observed is in Batıkent Fire Station. The maximum distance decreases from 13.4 km to 7.6 km. That means the departure time of a fire truck to the farthest place decreases 5 minutes in Batıkent Fire Station. The maximum distances of other fire stations also decrease between 1 km and 3 km. Actually, in these results, the four optimal locations, Merkez, Etimesgut, Kayaş and Çayyolu, still reach the farthest place in more than 8 minutes with a speed of 60 km/h. This does not agree with the standard times determined by NFPA and used in this thesis and in other related studies. The only good news is the existing Kurtuluş Fire Station is placed at the optimal node.

In the second study, the number of fire station is kept constant and the model is run without considering the existing coverage areas. The optimal 11 fire stations are found according to the unweighted and the weighted cases. Here, as well as the optimal locations of fire stations, the coverage areas are evaluated. In the existing

situation, the fire stations are placed at the most densely populated locations. Nevertheless, the maximum distance of the fire stations increases due to serving some far points. This situation leads the existing fire stations not to serve every region with the same quality. When we look at the whole map, it is easily seen that the coverage areas are determined based on the municipal boundaries in the existing case. In other words, fire stations bring service to places that are only in the municipal boundaries and this is the greatest mistake.

There are some important points about the weighted and the unweighted cases. When we look at the optimal fire station located in Etimesgut, its location and coverage area is similar to the existing Etimesgut Fire Station. Nevertheless the maximum distance in the optimal case is half of the maximum distance of existing case. If the coverage area of this fire station is reviewed, approximatley 6-minute reduction can be obtained in the worst case coverage.

Another important fire station is Merkez Fire Station since it covers the largest area among all fire stations in the existing situation and has the maximum distance. Its coverage area should be reviewed. Especially, the region between the North Beltway and Fatih sultan Mehmet Boulevard around Batıkent or the districts around 25 Mart or Çamlıca are covered by different fire stations. Moreover, the existing Merkez Fire Station serves up to Çayyolu Districts which is far away from its location. They should be covered by different fire stations. Çayyolu and its surrounding districts are important in regards to the population growth.

Baraj District is also an important area with regard to the forests around it. It is covered by the existing Altınpark Fire Station. However, both unweighted and weighted cases assign this region to a fire station which is located on the north side of Keçiören. Especially, in the unweighted case, the location of the fire station decreases the maximum distances reached in the Altınpark region.

The studies point out the importance of siting the fire stations which minimize the maximum distances. We see that it is possible to cover people in less time by using the same resources, i.e. 11 fire stations. In the unweighted case, a fire station aims to reach a place in a short time regardless of population. However, in the weighted model, population plays an important role. As a result, the

unweighted model gives better solutions compared to the weighted model with regard to maximum and average distances. The maximum distances are 7 km and 11.4 km, respectively, for the unweighted and the weighted cases. Both of these maximum distances are smaller than the existing case which is 16.64 km. In the weighted case, allocation of people is better than the unweighted case. Actually, there is not any capacity constraint for the Fire Department but the results of the weighted case can be considered for an equitable workload. According to the existing regulations in Ankara, the equipment and firemen of a fire station is increased according to the population growth as specified in Table 5.2. However, beginning to fight a fire on time is an important point as well as including enough equipment.

Here, we summarize the studies about time restricted models. The third study aims to locate the fire stations such that they cover all regions in 4-minute and 8-minute radii. The fourth study aims to locate additional fire stations to the existing ones with the time restriction of 4-minute and 8-minute. 8 minute time restricted models are discussed first.

According to the 8-minute time-restricted model, location of Keçiören Fire Station remains the same. It can cover a larger region and can reach the coverage area of Altınpark Fire Station in 8 minutes. With this change, there is no need for Altınpark and Siteler Fire Stations any more. However, the regions around Feridun Çelik, Başak and Beşikkaya needs a fire station. In the 8-minute time-restricted conditional model, the existing ones are still on hand but these regions, Feridun Çelik, Başak, and Beşikkaya, also need a fire station. We can say, the coverage area of Keçiören can be changed and with one more fire station these regions can be covered or the existing ones can be retained and one more fire station can be opened.

If the location of the existing Batıkent Fire Station is changed, it can cover more regions within 8 minutes. However, if the Fire Department does not want to change the location, then the coverage should be changed and a new fire station should be opened for the regions around Susuz Village and Ovacık.

According to the 8-minute time restricted model, the regions under Turgut

Özal Boulevard which is currently covered by the existing Merkez, Kurtuluş and Esat Fire Stations can now be covered by two fire stations. Well positioned two fire stations can reach these regions in 8 minutes. The remaining area above Turgut Özal Boulevard covered currently by the existing Merkez Fire Station can be covered by another fire station. If closing the existing fire stations is not possible, then the 8-minute time-restricted conditional model can be used. First, the coverage area of Esat Fire Station should be reviewed. Since it does not reach the places among Devlet and Oran Districts in a short time, a new fire station should be opened for these regions. Secondly, the coverage area of Merkez Fire Station should be restricted to the regions around Çukurambar and Bahçelievler Districts and the east side of Anadolu Boulevard . Also the regions around ODTÜ needs a new fire station in this case.

The coverage area of the existing Çayyolu Fire Station is separated into two parts in both models. The existing Çayyolu Fire Station can remain in the same place, but its coverage area should be decreased. There should be a new fire station around Yaşamkent District which has a growing population.

The 8-minute time-restricted model shows us an important case. For the coverage of all places in 8 minutes, only 8 fire stations is enough. However, when the existing fire stations are preserved, the number of fire stations goes up to 17 in total. The Fire Department can consider to change the location of fire stations instead of establishing new ones.

Applying the locations and coverage of fire stations in the 4-minute models need so many regulations in Ankara. The 4-minute time restriction is important for leading forces; however, leading forces are not used in the existing case. In order to catch the standards, this issue should also be considered. The map prepared for the new facilities and the map which does not consider the existing facilities can be a reference for long-term planning of the Fire Department.

Table 8.4 shows the improvement on the nodes. The distance from a node to the fire station is recorded for the existing cases and the optimal solutions. Then the difference between them are counted and the improvement on the nodes and the total improvement are given. The net change gives the difference between the

total distance in the optimal case and the existing case. As it is seen from the table, the fire trucks in the optimal solutions go less distances except the solution for the location of 11 fire stations with the same coverage area as the existing case(same coverage). The 4-minute time-restricted conditional model gives the maximum decrease. It is more than 1000 km. In the unweighted, weighted, 4-minute time-restricted, and 8-minute time-restricted models the deteriorated and the improved nodes are almost the same. In the fixed allocation model more nodes are deteriorated. However, in the conditional models, no node is deteriorated. The maximum decrease shows us the maximum of the difference between the existing and optimal cases on the distance from a node to its closest fire station. It is approximately 14 km for all optimal solutions, except the same coverage model. The maximum increase on the distance from a node to its closest fire station is seen in 8-minute time-restricted model, it is 6.98 km. Again, the conditional models do not make this distance to increase. All information is given in Table 8.4.

Cases	Total km Saved	The km Saved per Fire Station	Total Increase	Total Decrease	Maximum Decrease	Maximum Increase	The Improved Number of Nodes	The Stable Number of Nodes	The Deteriorated Number of Nodes
Unweighted	-375.21 km	34.11 km	405 km	-780.21 km	-14.77 km	6.3 km	240	11	201
Weighted	-81.42 km	7.4 km	529.52 km	-610.94 km	-14.77 km	5.14 km	211	10	221
Same Coverage	52.77 km	-4.8 km	485.06 km	-432.29 km	-5.49 km	5.24 km	189	44	199
4-minute	-997.91 km	34.8 km	122.64 km	-1120.55 km	-15.97 km	3.94 km	311	37	104
8-minute	-113.88 km	14.2 km	542.63 km	-656.51 km	-13.97 km	6.98 km	206	47	199
4-minute conditional	-1109.07 km	32.6 km	0 km	-1109.07 km	-15.97 km	0 km	309	143	0
8-minute conditional	-560.39 km	33 km	0 km	-560.39 km	-13.62 km	0 km	226	226	0

Table 8.4: General Improvement

Chapter 9

Conclusion

This thesis aims to evaluate the locations of existing fire stations and proposes new locations and coverage of the fire stations in Ankara. The primary purpose of having fire stations is saving people's lives. Therefore, it is important to reach the farthest point in a short time. In the existing case, only average distances are considered and there is not any studies about the maximum distances. For the location of fire stations, the vertex restricted p-center problem is solved via a minimum set covering model to minimize the maximum distance from a fire station to its farthest demand point. The problem is solved for two cases: The first one aims to locate a specific number of fire stations, while the other one aims to locate the fire stations within a fixed r value. An algorithm is presented for the first type of problem.

In the literature different types of set covering problems are used and maximal set covering problems are studied mostly. Also, multi objective models and GIS systems are used to locate fire stations. Here, the minimum set covering model is used to cover the whole region and the aim is to minimize the maximum distance of all fire stations.

The first step is forming the network of Ankara and obtaining data about distances and population. These are explained in Chapter 4. In light of these data, three types of assignments are made. The first type of problem aims to locate

11 fire stations which is equal to the number of fire stations in the existing case. The problem is solved for the weighted and unweighted cases. Both of them give better solutions and show important results about locations and coverage of fire stations. The existing situation is evaluated according to these optimal solutions and some suggestions are presented. The average distances of the existing, the unweighted and the weighted cases are found with the fire statistics collected in 2010 and 2011. The comparison of them also shows the importance of locating facilities to minimize the maximum distance.

The next two problems aim to reach national standards. According to NFPA Standards 1710, leading forces need to arrive at the event place in 4 minutes and the whole team need to arrive in 8 minutes. Thus, fire stations are located so that they reach the farthest point in 4 minute and 8 minute time bounds. In the first study, existing fire stations are not considered. It is seen that, 26 fire stations are required for a 4-minute coverage while only 8 fire stations are enough for an 8-minute coverage. Their locations and coverages are compared with the existing situation. Lastly, the location of new fire stations are investigated for 4-minute and 8-minute coverages. This study also changes the coverage of existing fire stations. Regional analysis and maps for all studies are presented in Chapter 7 and in the Appendix. To sum up, it is important to use optimal solutions for Fire Department in order to preserve resources, provide better quality service and save people's lives.

Here, possible future works are explained. In this thesis, the considered area is inside the beltways and some districts of Sincan township. It is known that the existing fire stations serve some small districts and villages outside the beltways of Ankara. Therefore, a new map can be constructed by adding these nodes and more efficient solutions can be obtained. There are other issues about townships. As stated before, Ankara has 24 townships, but only 7 of them are considered in this thesis. A study including all townships is required for the fire department. Moreover, only the main streets are considered in the construction of the map. The system which includes all the streets and their directions will change the shortest paths and give more accurate solutions. Moreover, it is assumed that the fire trucks move with constant speed of 60 km/h. These cases are changeable

according to the traffic jam, road conditions, seasons, maintenance and repair works on the roads, school periods, rush hours in the day. By considering these situations, the location of fire stations can be found in different places. On the other hand, the weighted model considers population of the nodes with the data that belong to 2008. For future studies, actual data is needed. Furthermore, some important points such as hospitals, schools and universities should be weighted. This study does not restrict the location of fire stations in the models. Yet, it is necessary to specify the appropriate regions in reality. This requires a comprehensive study with both municipalities and fire departments.

The maps are constructed in online ArcGIS program. They are not shared with the public. Thus, people who want to reach the software of these maps can contact us by e-mail: barbaros@bilkent.edu.tr or balci.pelin@gmail.com.

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Appendix A

Codes

R Code for Shortest Paths

```
wd = C:/Users/Pelin/Desktop
rm(list=ls())
d = read.table(C : /Users/Pelin/Desktop/lengthmatrix.csv, sep =
; , header = TRUE, strip.white = TRUE)
lengthmatrix < −as.matrix(d)
n < −ncol(lengthmatrix
for (iter in 1:n) do
  for (i in 1:n) do
    for (j in 1:n) do
      for (k in 1:n) do
        lengthmatrix[i, j] = min(lengthmatrix[i, j], lengthmatrix[i, k] +
        lengthmatrix[k, j])
      end for
    end for
  end for
end for
```

GAMS Code for Locating Fire Stations

Sets

i **demand** /1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452/

subseti(i)/1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65,

66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 173, 174, 175, 176, 177, 178, 179, 180, 181, 183, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 255, 256, 257, 258, 262, 263, 264, 265, 266, 267, 268, 269, 270, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 422, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452/

alias (i,j);

Table $a(i,j)$ **matrix**

Parameter $a(i,j)$ **define distance smaller than r;**

Variables
$x(j)$ **define facility**
q **total facility;**

Binary variable $x(j)$;

Equations

obj **define objective function**
cons **define each demand covered by a facility**
facil1 **define assigned facilities**
facil2 **define assigned facilities**
facil3 **define assigned facilities**
facil4 **define uncovered point**
facil5 **define uncovered point**
facil6 **define uncovered point**
facil7 **define uncovered point**
facil8 **define uncovered point**
facil9 **define uncovered point**
facil10 **define uncovered point**
facil11 **define uncovered point**
facil12 **define uncovered point**
facil13 **define uncovered point;**

obj .. $q = e = \mathbf{sum}(j, x(j))$;
cons $(subseti(i))$ .. $\mathbf{sum}(j, a(i,j) * x(j)) = g = 1$;
facil1.. x('254') =e= 0;
facil2.. x('271') =e= 0;
facil3.. x('297') =e= 0;
facil4.. x('259') =e= 0;
facil5.. x('260') =e= 0;
facil6.. x('261') =e= 0;
facil7.. x('421') =e= 0;
facil8.. x('423') =e= 0;
facil9.. x('424') =e= 0;

facil10.. x('425') =e= 0;
facil11.. x('426') =e= 0;
facil12.. x('427') =e= 0;
facil13.. x('428') =e= 0;

Model firestation /all/ ;

Solve firestation using mip minimizing q ;

display 'resorceused:' ,firestation.Resusd, '';

option optcr = 0;

GAMS Code for Locating Additional Fire Stations

Sets

i **demand** /1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452/ subseti(i)/1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58,

59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 173, 174, 175, 176, 177, 178, 179, 180, 181, 183, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 255, 256, 257, 258, 262, 263, 264, 265, 266, 267, 268, 269, 270, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 422, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452/

alias (i,j);

Table a(i,j) **matrix**

Parameter a(i,j) **define distance smaller than r;**

Variables
x(j) **define facility**
q **total facility;**

Binary variable x(j);

Equations

obj **define objective function**
cons **define each demand covered by a facility**
facil1 **define assigned facilities**
facil2 **define assigned facilities**
facil3 **define assigned facilities**
facil4 **define uncovered point**
facil5 **define uncovered point**
facil6 **define uncovered point**
facil7 **define uncovered point**
facil8 **define uncovered point**
facil9 **define uncovered point**
facil10 **define uncovered point**
facil11 **define uncovered point**
facil12 **define uncovered point**
facil13 **define uncovered point**
facil14 **define current station**
facil15 **define current station**
facil16 **define current station**
facil17 **define current station**
facil18 **define current station**
facil19 **define current station**
facil20 **define current station**
facil21 **define current station**
facil22 **define current station**
facil23 **define current station**
facil24 **define current station;**

obj .. $q = e = \mathbf{sum}(j, x(j))$;

cons($subseti(i)$)..$\mathbf{sum}(j, a(i,j) * x(j)) = g = 1$;

facil1.. x('254') =e= 0;

facil2.. x('271') =e= 0;

facil3.. x('297') =e= 0;

facil4.. x('259') =e= 0;

facil5.. x('260') =e= 0;

facil6.. x('261') =e= 0;

facil7.. x('421') =e= 0;

facil8.. x('423') =e= 0;

facil9.. x('424') =e= 0;

facil10.. x('425') =e= 0;

facil11.. x('426') =e= 0;

facil12.. x('427') =e= 0;

facil13.. x('428') =e= 0;

facil14.. x('2') =e= 1;

facil15.. x('40') =e= 1;

facil16.. x('50') =e= 1;

facil17.. x('91') =e= 1;

facil18.. x('120') =e= 1;

facil19.. x('149') =e= 1;

facil20.. x('158') =e= 1;

facil21.. x('242') =e= 1;

facil22.. x('274') =e= 1;

facil23.. x('322') =e= 1;

facil24.. x('341') =e= 1;

Model additionalstations /all/ ;

Solve additionalstations using mip minimizing q ;

display 'resorceused:' ,additionalstations.Resusd, '';

option optcr = 0;

Appendix B

Collection of Data

	Node1	Node2	Node3	Node4	Node5	Node6	Node7	Node8	Node9	Node10	Node11	Node12	Node13	Node14	Node15	Node16	Node17	Node18	Node19	Node20	Node21	Node22	Node23	Node24	Node25
Node1	0																								
Node2		0	1																						
Node3		1	0	0.35																					
Node4			0.35	0	1.1																				
Node5				1.1	0																				
Node6						0	0.45																		
Node7						0.45	0	0.85																	
Node8							0.85	0			0.5														
Node9									0	0.65															
Node10									0.65	0	1.2							0.75							
Node11								0.5		1.2	0														
Node12												0													
Node13													0	1.2								1.1			
Node14													1.2	0									0.5		
Node15															0	2.2									
Node16															2.2	0	0.55								
Node17																0.55	0			1.5					
Node18										0.75								0	0.9						
Node19																		0.9	0						
Node20																	1.5			0	1.3				
Node21																				1.3	0			1.3	
Node22													1.1									0	1.1	0.75	
Node23														0.5								1.1	0		0.5
Node24																					1.3	0.75		0	
Node25																							0.5		0
Node26																								1.8	0.9
Node27															2.2										
Node28																	1								
Node29																									
Node30																				0.3					
Node31																									
Node32																									
Node33																					0.45				
Node34																									
Node35																									
Node36																									
Node37																									
Node38																									
Node39																								2.8	
Node40																									

Table B.1: A portion of the length matrix

	Node1	Node2	Node3	Node4	Node5	Node6	Node7	Node8	Node9	Node10	Node11	Node12	Node13	Node14	Node15	Node16	Node17	Node18	Node19	Node20	Node21	Node22	Node23	Node24	Node25
Node1	0	2.55	3.55	3.9	5	4.35	3.9	4.75	6.3	6.45	5.25	5.25	5.6	6.8	9.85	7.65	8.05	7.2	7.1	8.22	7.1	6.7	7.3	7.45	7.8
Node2	2.55	0	1	1.35	2.45	1.8	1.35	2.2	3.75	3.9	2.7	2.7	3.05	4.25	7.3	5.1	5.5	4.65	4.55	5.67	4.55	4.15	4.75	4.9	5.25
Node3	3.55	1	0	0.35	1.45	2.8	2.35	3.2	4.75	4.9	3.7	3.7	2.05	3.25	8.3	6.1	6.5	5.65	5.55	6.5	5.2	3.15	3.75	3.9	4.25
Node4	3.9	1.35	0.35	0	1.1	3.15	2.7	3.55	5.1	5.25	4.05	4.05	2.15	3.23	8.65	6.45	6.85	6	5.9	6.6	5.3	3.25	3.73	4	4.23
Node5	5	2.45	1.45	1.1	0	4.25	3.8	4.65	6.2	6.35	5.15	5.15	3.25	2.13	9.75	7.55	7.95	7.1	7	7.08	5.78	3.73	2.63	4.48	3.13
Node6	4.35	1.8	2.8	3.15	4.25	0	0.45	1.3	1.95	2.6	1.8	3.25	4.85	6.05	5.5	3.3	3.85	3.35	3.8	4.92	4.5	5.95	6.55	5.8	7.05
Node7	3.9	1.35	2.35	2.7	3.8	0.45	0	0.85	2.4	2.55	1.35	2.8	4.4	5.6	5.95	3.75	4.15	3.3	3.35	4.47	4.05	5.5	6.1	5.35	6.6
Node8	4.75	2.2	3.2	3.55	4.65	1.3	0.85	0	2.35	1.7	0.5	1.95	5.25	6.45	5.85	3.65	3.3	2.45	2.5	3.62	3.2	5.25	6.35	4.5	6.85
Node9	6.3	3.75	4.75	5.1	6.2	1.95	2.4	2.35	0	0.65	1.85	3.3	6.8	7.62	3.55	1.35	1.9	1.4	2.3	3.4	3.97	6.02	7.12	5.27	7.62
Node10	6.45	3.9	4.9	5.25	6.35	2.6	2.55	1.7	0.65	0	1.2	2.65	6.47	6.97	4.15	1.95	1.6	0.75	1.65	2.77	3.32	5.37	6.47	4.62	6.97
Node11	5.25	2.7	3.7	4.05	5.15	1.8	1.35	0.5	1.85	1.2	0	1.45	5.75	6.35	5.35	3.15	2.8	1.95	2	3.12	2.7	4.75	5.85	4	6.35
Node12	5.25	2.7	3.7	4.05	5.15	3.25	2.8	1.95	3.3	2.65	1.45	0	5	5.5	6.8	4.6	4.25	2.75	1.85	2.97	1.85	3.9	5	3.15	5.5
Node13	5.6	3.05	2.05	2.15	3.25	4.85	4.4	5.25	6.8	6.47	5.75	5	0	1.2	8.7	6.5	5.95	5.72	4.82	4.45	3.15	1.1	1.7	1.85	2.2
Node14	6.8	4.25	3.25	3.23	2.13	6.05	5.6	6.45	7.62	6.97	6.35	5.5	1.2	0	9.2	7	6.45	6.22	5.32	4.95	3.65	1.6	0.5	2.35	1
Node15	9.85	7.3	8.3	8.65	9.75	5.5	5.95	5.85	3.55	4.15	5.35	6.8	8.7	9.2	0	2.2	2.75	4.35	5.25	4.25	5.55	7.6	8.7	6.85	9.2
Node16	7.65	5.1	6.1	6.45	7.55	3.3	3.75	3.65	1.35	1.95	3.15	4.6	6.5	7	2.2	0	0.55	2.15	3.05	2.05	3.35	5.4	6.5	4.65	7
Node17	8.05	5.5	6.5	6.85	7.95	3.85	4.15	3.3	1.9	1.6	2.8	4.25	5.95	6.45	2.75	0.55	0	1.8	2.62	1.5	2.8	4.85	5.95	4.1	6.45
Node18	7.2	4.65	5.65	6	7.1	3.35	3.3	2.45	1.4	0.75	1.95	2.75	5.72	6.22	4.35	2.15	1.8	0	0.9	2.02	2.57	4.62	5.72	3.87	6.22
Node19	7.1	4.55	5.55	5.9	7	3.8	3.35	2.5	2.3	1.65	2	1.85	4.82	5.32	5.25	3.05	2.62	0.9	0	1.12	1.67	3.72	4.82	2.97	5.32
Node20	8.22	5.67	6.5	6.6	7.08	4.92	4.47	3.62	3.4	2.77	3.12	2.97	4.45	4.95	4.25	2.05	1.5	2.02	1.12	0	1.3	3.35	4.45	2.6	4.95
Node21	7.1	4.55	5.2	5.3	5.78	4.5	4.05	3.2	3.97	3.32	2.7	1.85	3.15	3.65	5.55	3.35	2.8	2.57	1.67	1.3	0	2.05	3.15	1.3	3.65
Node22	6.7	4.15	3.15	3.25	3.73	5.95	5.5	5.25	6.02	5.37	4.75	3.9	1.1	1.6	7.6	5.4	4.85	4.62	3.72	3.35	2.05	0	1.1	0.75	1.6
Node23	7.3	4.75	3.75	3.73	2.63	6.55	6.1	6.35	7.12	6.47	5.85	5	1.7	0.5	8.7	6.5	5.95	5.72	4.82	4.45	3.15	1.1	0	1.85	0.5
Node24	7.45	4.9	3.9	4	4.48	5.8	5.35	4.5	5.27	4.62	4	3.15	1.85	2.35	6.85	4.65	4.1	3.87	2.97	2.6	1.3	0.75	1.85	0	2.35
Node25	7.8	5.25	4.25	4.23	3.13	7.05	6.6	6.85	7.62	6.97	6.35	5.5	2.2	1	9.2	7	6.45	6.22	5.32	4.95	3.65	1.6	0.5	2.35	0
Node26	8.7	6.15	5.15	5.13	4.03	7.6	7.15	6.3	7.07	6.42	5.8	4.95	3.1	1.9	8.65	6.45	5.9	5.67	4.77	4.4	3.1	2.5	1.4	1.8	0.9
Node27	12.05	9.5	10.5	10.85	11.95	7.7	8.15	8.05	5.75	6.35	7.55	9	10.9	11.4	2.2	4.4	4.95	6.55	7.45	6.45	7.75	9.8	10.9	9.05	11.4
Node28	9.05	6.5	7.5	7.85	8.95	4.85	5.15	4.3	2.9	2.6	3.8	5.12	6.6	7.1	3.75	1.55	1	2.8	3.27	2.15	3.45	5.5	6.6	4.75	7.1
Node29	9.65	7.1	8.1	8.45	9.55	5.45	5.75	4.9	3.5	3.2	4.4	5.72	7.2	7.7	4.35	2.15	1.6	3.4	3.87	2.75	4.05	6.1	7.2	5.35	7.7
Node30	8.52	5.97	6.8	6.9	7.38	5.22	4.77	3.92	3.7	3.07	3.42	3.27	4.75	5.25	4.55	2.35	1.8	2.32	1.42	0.3	1.6	3.65	4.75	2.9	5.25
Node31	9.27	6.72	7.55	7.65	8.13	5.95	5.52	4.67	4	3.7	4.17	4.02	5.5	6	4.85	2.65	2.1	3.07	2.17	1.05	2.35	4.4	5.5	3.65	6
Node32	7.9	5.35	6	6.1	6.58	5.3	4.85	4	4.77	4.12	3.5	2.65	3.95	4.45	5.85	3.65	3.1	3.37	2.47	1.6	0.8	2.85	3.95	2.1	4.45
Node33	7.55	5	5.65	5.75	6.23	4.95	4.5	3.65	4.42	3.77	3.15	2.3	3.6	4.1	6	3.8	3.25	3.02	2.12	1.75	0.45	2.5	3.6	1.75	4.1
Node34	17.35	14.8	15.45	15.55	16.03	13.1	13.55	13.45	11.15	11.75	12.95	12.1	13.4	13.9	7.6	9.8	10.35	11.95	11.92	11.55	10.25	12.3	13.4	11.55	13.28
Node35	14.25	11.7	12.35	12.45	12.93	11.25	11.2	10.35	9.3	9	9.85	9	10.3	10.8	10.15	7.95	7.4	9.2	8.82	8.45	7.15	9.2	10.3	8.45	10.18
Node36	11.75	9.2	9.85	9.95	10.43	8.75	8.7	7.85	6.8	6.5	7.35	6.5	7.8	8.3	7.65	5.45	4.9	6.7	6.32	5.95	4.65	6.7	7.8	5.95	7.68
Node37	11.2	8.65	9.3	9.4	9.88	8.6	8.15	7.3	7.35	7.05	6.8	5.95	7.25	7.75	8.2	6	5.45	6.67	5.77	5.4	4.1	6.15	7.25	5.4	7.13
Node38	10.55	8	8.65	8.75	9.23	7.95	7.5	6.65	7.42	6.77	6.15	5.3	6.6	7.1	8.85	6.65	6.1	6.02	5.12	4.75	3.45	5.5	6.6	4.75	6.48
Node39	10.25	7.7	6.7	6.8	7.28	8.6	8.15	7.3	8.07	7.42	6.8	5.95	4.65	5.15	9.65	7.45	6.9	6.67	5.77	5.4	4.1	3.55	4.65	2.8	4.38
Node40	10.43	7.88	6.88	6.98	7.33	8.78	8.33	7.48	8.25	7.6	6.98	6.13	4.83	5.2	9.83	7.63	7.08	6.85	5.95	5.58	4.28	3.73	4.7	2.98	4.2

Table B.2: A portion of the shortest path matrix

Ordered R Values																						
0	0.8	1.47	2.13	2.79	3.45	4.11	4.77	5.43	6.09	6.75	7.41	8.07	8.73	9.39	10.05	10.71	11.37	12.03	12.69	13.35	14.01	14.67	15.33
0.03	0.81	1.48	2.14	2.8	3.46	4.12	4.78	5.44	6.1	6.76	7.42	8.08	8.74	9.4	10.06	10.72	11.38	12.04	12.7	13.36	14.02	14.68	15.34
0.08	0.82	1.49	2.15	2.81	3.47	4.13	4.79	5.45	6.11	6.77	7.43	8.09	8.75	9.41	10.07	10.73	11.39	12.05	12.71	13.37	14.03	14.69	15.35
0.1	0.83	1.5	2.16	2.82	3.48	4.14	4.8	5.46	6.12	6.78	7.44	8.1	8.76	9.42	10.08	10.74	11.4	12.06	12.72	13.38	14.04	14.7	15.36
0.11	0.84	1.51	2.17	2.83	3.49	4.15	4.81	5.47	6.13	6.79	7.45	8.11	8.77	9.43	10.09	10.75	11.41	12.07	12.73	13.39	14.05	14.71	15.37
0.12	0.85	1.52	2.18	2.84	3.5	4.16	4.82	5.48	6.14	6.8	7.46	8.12	8.78	9.44	10.1	10.76	11.42	12.08	12.74	13.4	14.06	14.72	15.38
0.13	0.86	1.53	2.19	2.85	3.51	4.17	4.83	5.49	6.15	6.81	7.47	8.13	8.79	9.45	10.11	10.77	11.43	12.09	12.75	13.41	14.07	14.73	15.39
0.14	0.87	1.54	2.2	2.86	3.52	4.18	4.84	5.5	6.16	6.82	7.48	8.14	8.8	9.46	10.12	10.78	11.44	12.1	12.76	13.42	14.08	14.74	15.4
0.15	0.88	1.55	2.21	2.87	3.53	4.19	4.85	5.51	6.17	6.83	7.49	8.15	8.81	9.47	10.13	10.79	11.45	12.11	12.77	13.43	14.09	14.75	15.41
0.16	0.89	1.56	2.22	2.88	3.54	4.2	4.86	5.52	6.18	6.84	7.5	8.16	8.82	9.48	10.14	10.8	11.46	12.12	12.78	13.44	14.1	14.76	15.42
0.18	0.9	1.57	2.23	2.89	3.55	4.21	4.87	5.53	6.19	6.85	7.51	8.17	8.83	9.49	10.15	10.81	11.47	12.13	12.79	13.45	14.11	14.77	15.43
0.19	0.91	1.58	2.24	2.9	3.56	4.22	4.88	5.54	6.2	6.86	7.52	8.18	8.84	9.5	10.16	10.82	11.48	12.14	12.8	13.46	14.12	14.78	15.44
0.2	0.92	1.59	2.25	2.91	3.57	4.23	4.89	5.55	6.21	6.87	7.53	8.19	8.85	9.51	10.17	10.83	11.49	12.15	12.81	13.47	14.13	14.79	15.45
0.21	0.93	1.6	2.26	2.92	3.58	4.24	4.9	5.56	6.22	6.88	7.54	8.2	8.86	9.52	10.18	10.84	11.5	12.16	12.82	13.48	14.14	14.8	15.46
0.22	0.94	1.61	2.27	2.93	3.59	4.25	4.91	5.57	6.23	6.89	7.55	8.21	8.87	9.53	10.19	10.85	11.51	12.17	12.83	13.49	14.15	14.81	15.47
0.23	0.95	1.62	2.28	2.94	3.6	4.26	4.92	5.58	6.24	6.9	7.56	8.22	8.88	9.54	10.2	10.86	11.52	12.18	12.84	13.5	14.16	14.82	15.48
0.24	0.96	1.63	2.29	2.95	3.61	4.27	4.93	5.59	6.25	6.91	7.57	8.23	8.89	9.55	10.21	10.87	11.53	12.19	12.85	13.51	14.17	14.83	15.49
0.25	0.97	1.64	2.3	2.96	3.62	4.28	4.94	5.6	6.26	6.92	7.58	8.24	8.9	9.56	10.22	10.88	11.54	12.2	12.86	13.52	14.18	14.84	15.5
0.26	0.98	1.65	2.31	2.97	3.63	4.29	4.95	5.61	6.27	6.93	7.59	8.25	8.91	9.57	10.23	10.89	11.55	12.21	12.87	13.53	14.19	14.85	15.51
0.27	0.99	1.66	2.32	2.98	3.64	4.3	4.96	5.62	6.28	6.94	7.6	8.26	8.92	9.58	10.24	10.9	11.56	12.22	12.88	13.54	14.2	14.86	15.52
0.28	1	1.67	2.33	2.99	3.65	4.31	4.97	5.63	6.29	6.95	7.61	8.27	8.93	9.59	10.25	10.91	11.57	12.23	12.89	13.55	14.21	14.87	15.53
0.29	1.01	1.68	2.34	3	3.66	4.32	4.98	5.64	6.3	6.96	7.62	8.28	8.94	9.6	10.26	10.92	11.58	12.24	12.9	13.56	14.22	14.88	15.54
0.3	1.02	1.69	2.35	3.01	3.67	4.33	4.99	5.65	6.31	6.97	7.63	8.29	8.95	9.61	10.27	10.93	11.59	12.25	12.91	13.57	14.23	14.89	15.55
0.32	1.03	1.7	2.36	3.02	3.68	4.34	5	5.66	6.32	6.98	7.64	8.3	8.96	9.62	10.28	10.94	11.6	12.26	12.92	13.58	14.24	14.9	15.56
0.35	1.04	1.71	2.37	3.03	3.69	4.35	5.01	5.67	6.33	6.99	7.65	8.31	8.97	9.63	10.29	10.95	11.61	12.27	12.93	13.59	14.25	14.91	15.57
0.37	1.05	1.72	2.38	3.04	3.7	4.36	5.02	5.68	6.34	7	7.66	8.32	8.98	9.64	10.3	10.96	11.62	12.28	12.94	13.6	14.26	14.92	15.58
0.38	1.06	1.73	2.39	3.05	3.71	4.37	5.03	5.69	6.35	7.01	7.67	8.33	8.99	9.65	10.31	10.97	11.63	12.29	12.95	13.61	14.27	14.93	15.59
0.39	1.08	1.74	2.4	3.06	3.72	4.38	5.04	5.7	6.36	7.02	7.68	8.34	9	9.66	10.32	10.98	11.64	12.3	12.96	13.62	14.28	14.94	15.6
0.4	1.09	1.75	2.41	3.07	3.73	4.39	5.05	5.71	6.37	7.03	7.69	8.35	9.01	9.67	10.33	10.99	11.65	12.31	12.97	13.63	14.29	14.95	15.61
0.41	1.1	1.76	2.42	3.08	3.74	4.4	5.06	5.72	6.38	7.04	7.7	8.36	9.02	9.68	10.34	11	11.66	12.32	12.98	13.64	14.3	14.96	15.62
0.42	1.11	1.77	2.43	3.09	3.75	4.41	5.07	5.73	6.39	7.05	7.71	8.37	9.03	9.69	10.35	11.01	11.67	12.33	12.99	13.65	14.31	14.97	15.63
0.43	1.12	1.78	2.44	3.1	3.76	4.42	5.08	5.74	6.4	7.06	7.72	8.38	9.04	9.7	10.36	11.02	11.68	12.34	13	13.66	14.32	14.98	15.64
0.44	1.13	1.79	2.45	3.11	3.77	4.43	5.09	5.75	6.41	7.07	7.73	8.39	9.05	9.71	10.37	11.03	11.69	12.35	13.01	13.67	14.33	14.99	15.65
0.45	1.14	1.8	2.46	3.12	3.78	4.44	5.1	5.76	6.42	7.08	7.74	8.4	9.06	9.72	10.38	11.04	11.7	12.36	13.02	13.68	14.34	15	15.66
0.46	1.15	1.81	2.47	3.13	3.79	4.45	5.11	5.77	6.43	7.09	7.75	8.41	9.07	9.73	10.39	11.05	11.71	12.37	13.03	13.69	14.35	15.01	15.67
0.47	1.16	1.82	2.48	3.14	3.8	4.46	5.12	5.78	6.44	7.1	7.76	8.42	9.08	9.74	10.4	11.06	11.72	12.38	13.04	13.7	14.36	15.02	15.68
0.49	1.17	1.83	2.49	3.15	3.81	4.47	5.13	5.79	6.45	7.11	7.77	8.43	9.09	9.75	10.41	11.07	11.73	12.39	13.05	13.71	14.37	15.03	15.69
0.5	1.18	1.84	2.5	3.16	3.82	4.48	5.14	5.8	6.46	7.12	7.78	8.44	9.1	9.76	10.42	11.08	11.74	12.4	13.06	13.72	14.38	15.04	15.7
0.51	1.19	1.85	2.51	3.17	3.83	4.49	5.15	5.81	6.47	7.13	7.79	8.45	9.11	9.77	10.43	11.09	11.75	12.41	13.07	13.73	14.39	15.05	15.71
0.52	1.2	1.86	2.52	3.18	3.84	4.5	5.16	5.82	6.48	7.14	7.8	8.46	9.12	9.78	10.44	11.1	11.76	12.42	13.08	13.74	14.4	15.06	15.72
0.53	1.21	1.87	2.53	3.19	3.85	4.51	5.17	5.83	6.49	7.15	7.81	8.47	9.13	9.79	10.45	11.11	11.77	12.43	13.09	13.75	14.41	15.07	15.73
0.55	1.22	1.88	2.54	3.2	3.86	4.52	5.18	5.84	6.5	7.16	7.82	8.48	9.14	9.8	10.46	11.12	11.78	12.44	13.1	13.76	14.42	15.08	15.74
0.56	1.23	1.89	2.55	3.21	3.87	4.53	5.19	5.85	6.51	7.17	7.83	8.49	9.15	9.81	10.47	11.13	11.79	12.45	13.11	13.77	14.43	15.09	15.75
0.57	1.24	1.9	2.56	3.22	3.88	4.54	5.2	5.86	6.52	7.18	7.84	8.5	9.16	9.82	10.48	11.14	11.8	12.46	13.12	13.78	14.44	15.1	15.76
0.58	1.25	1.91	2.57	3.23	3.89	4.55	5.21	5.87	6.53	7.19	7.85	8.51	9.17	9.83	10.49	11.15	11.81	12.47	13.13	13.79	14.45	15.11	15.77
0.59	1.26	1.92	2.58	3.24	3.9	4.56	5.22	5.88	6.54	7.2	7.86	8.52	9.18	9.84	10.5	11.16	11.82	12.48	13.14	13.8	14.46	15.12	15.78
0.6	1.27	1.93	2.59	3.25	3.91	4.57	5.23	5.89	6.55	7.21	7.87	8.53	9.19	9.85	10.51	11.17	11.83	12.49	13.15	13.81	14.47	15.13	15.79
0.61	1.28	1.94	2.6	3.26	3.92	4.58	5.24	5.9	6.56	7.22	7.88	8.54	9.2	9.86	10.52	11.18	11.84	12.5	13.16	13.82	14.48	15.14	15.8
0.62	1.29	1.95	2.61	3.27	3.93	4.59	5.25	5.91	6.57	7.23	7.89	8.55	9.21	9.87	10.53	11.19	11.85	12.51	13.17	13.83	14.49	15.15	15.81
0.63	1.3	1.96	2.62	3.28	3.94	4.6	5.26	5.92	6.58	7.24	7.9	8.56	9.22	9.88	10.54	11.2	11.86	12.52	13.18	13.84	14.5	15.16	15.82
0.64	1.31	1.97	2.63	3.29	3.95	4.61	5.27	5.93	6.59	7.25	7.91	8.57	9.23	9.89	10.55	11.21	11.87	12.53	13.19	13.85	14.51	15.17	15.83
0.65	1.32	1.98	2.64	3.3	3.96	4.62	5.28	5.94	6.6	7.26	7.92	8.58	9.24	9.9	10.56	11.22	11.88	12.54	13.2	13.86	14.52	15.18	15.84
0.66	1.33	1.99	2.65	3.31	3.97	4.63	5.29	5.95	6.61	7.27	7.93	8.59	9.25	9.91	10.57	11.23	11.89	12.55	13.21	13.87	14.53	15.19	15.85
0.67	1.34	2	2.66	3.32	3.98	4.64	5.3	5.96	6.62	7.28	7.94	8.6	9.26	9.92	10.58	11.24	11.9	12.56	13.22	13.88	14.54	15.2	15.86
0.68	1.35	2.01	2.67	3.33	3.99	4.65	5.31	5.97	6.63	7.29	7.95	8.61	9.27	9.93	10.59	11.25	11.91	12.57	13.23	13.89	14.55	15.21	15.87
0.69	1.36	2.02	2.68	3.34	4	4.66	5.32	5.98	6.64	7.3	7.96	8.62	9.28	9.94	10.6	11.26	11.92	12.58	13.24	13.9	14.56	15.22	15.88
0.7	1.37	2.03	2.69	3.35	4.01	4.67	5.33	5.99	6.65	7.31	7.97	8.63	9.29	9.95	10.61	11.27	11.93	12.59	13.25	13.91	14.57	15.23	15.89
0.71	1.38	2.04	2.7	3.36	4.02	4.68	5.34	6	6.66	7.32	7.98	8.64	9.3	9.96	10.62	11.28	11.94	12.6	13.26	13.92	14.58	15.24	15.9
0.72	1.39	2.05	2.71	3.37	4.03	4.69	5.35	6.01	6.67	7.33	7.99	8.65	9.31	9.97	10.63	11.29	11.95	12.61	13.27	13.93	14.59	15.25	15.91
0.73	1.4	2.06	2.72	3.38	4.04	4.7	5.36	6.02	6.68	7.34	8	8.66	9.32	9.98	10.64	11.3	11.96	12.62	13.28	13.94	14.6	15.26	15.92
0.74	1.41	2.07	2.73	3.39	4.05	4.71	5.37	6.03	6.69	7.35	8.01	8.67	9.33	9.99	10.65	11.31	11.97	12.63	13.29	13.95	14.61	15.27	15.93
0.75	1.42	2.08	2.74	3.4	4.06	4.72	5.38	6.04	6.7	7.36	8.02	8.68	9.34	10	10.66	11.32	11.98	12.64	13.3	13.96	14.62	15.28	15.94
0.76	1.43	2.09	2.75	3.41	4.07	4.73	5.39	6.05	6.71	7.37	8.03	8.69	9.35	10.01	10.67	11.33	11.99	12.65	13.31	13.97	14.63	15.29	15.95
0.77	1.44	2.1	2.76	3.42	4.08	4.74	5.4	6.06	6.72	7.38	8.04	8.7	9.36	10.02	10.68	11.34	12	12.66	13.32	13.98	14.64	15.3	15.96
0.78	1.45	2.11	2.77	3.43	4.09	4.75	5.41	6.07	6.73	7.39	8.05	8.71	9.37	10.03	10.69	11.35	12.01	12.67	13.33	13.99	14.65	15.31	15.97
0.79	1.46	2.12	2.78	3.44	4.1	4.76	5.42	6.08	6.74	7.4	8.06	8.72	9.38	10.04	10.7	11.36	12.02	12.68	13.34	14	14.66	15.32	15.98

Table B.3: Ordered R values for the unweighted case-1

Ordered R Values																							
15.99	16.65	17.31	17.97	18.63	19.29	19.95	20.61	21.27	21.93	22.59	23.25	23.91	22.59	23.25	23.91	24.57	25.23	25.89	26.55	27.21	27.87	28.53	29.19	29.85
16	16.66	17.32	17.98	18.64	19.3	19.96	20.62	21.28	21.94	22.6	23.26	23.92	22.6	23.26	23.92	24.58	25.24	25.9	26.56	27.22	27.88	28.54	29.2	29.86
16.01	16.67	17.33	17.99	18.65	19.31	19.97	20.63	21.29	21.95	22.61	23.27	23.93	22.61	23.27	23.93	24.59	25.25	25.91	26.57	27.23	27.89	28.55	29.21	29.87
16.02	16.68	17.34	18	18.66	19.32	19.98	20.64	21.3	21.96	22.62	23.28	23.94	22.62	23.28	23.94	24.6	25.26	25.92	26.58	27.24	27.9	28.56	29.22	29.88
16.03	16.69	17.35	18.01	18.67	19.33	19.99	20.65	21.31	21.97	22.63	23.29	23.95	22.63	23.29	23.95	24.61	25.27	25.93	26.59	27.25	27.91	28.57	29.23	29.9
16.04	16.7	17.36	18.02	18.68	19.34	20	20.66	21.32	21.98	22.64	23.3	23.96	22.64	23.3	23.96	24.62	25.28	25.94	26.6	27.26	27.92	28.58	29.24	29.91
16.05	16.71	17.37	18.03	18.69	19.35	20.01	20.67	21.33	21.99	22.65	23.31	23.97	22.65	23.31	23.97	24.63	25.29	25.95	26.61	27.27	27.93	28.59	29.25	29.92
16.06	16.72	17.38	18.04	18.7	19.36	20.02	20.68	21.34	22	22.66	23.32	23.98	22.66	23.32	23.98	24.64	25.3	25.96	26.62	27.28	27.94	28.6	29.26	29.93
16.07	16.73	17.39	18.05	18.71	19.37	20.03	20.69	21.35	22.01	22.67	23.33	23.99	22.67	23.33	23.99	24.65	25.31	25.97	26.63	27.29	27.95	28.61	29.27	29.94
16.08	16.74	17.4	18.06	18.72	19.38	20.04	20.7	21.36	22.02	22.68	23.34	24	22.68	23.34	24	24.66	25.32	25.98	26.64	27.3	27.96	28.62	29.28	29.95
16.09	16.75	17.41	18.07	18.73	19.39	20.05	20.71	21.37	22.03	22.69	23.35	24.01	22.69	23.35	24.01	24.67	25.33	25.99	26.65	27.31	27.97	28.63	29.29	29.96
16.1	16.76	17.42	18.08	18.74	19.4	20.06	20.72	21.38	22.04	22.7	23.36	24.02	22.7	23.36	24.02	24.68	25.34	26	26.66	27.32	27.98	28.64	29.3	29.97
16.11	16.77	17.43	18.09	18.75	19.41	20.07	20.73	21.39	22.05	22.71	23.37	24.03	22.71	23.37	24.03	24.69	25.35	26.01	26.67	27.33	27.99	28.65	29.31	29.98
16.12	16.78	17.44	18.1	18.76	19.42	20.08	20.74	21.4	22.06	22.72	23.38	24.04	22.72	23.38	24.04	24.7	25.36	26.02	26.68	27.34	28	28.66	29.32	29.99
16.13	16.79	17.45	18.11	18.77	19.43	20.09	20.75	21.41	22.07	22.73	23.39	24.05	22.73	23.39	24.05	24.71	25.37	26.03	26.69	27.35	28.01	28.67	29.33	30
16.14	16.8	17.46	18.12	18.78	19.44	20.1	20.76	21.42	22.08	22.74	23.4	24.06	22.74	23.4	24.06	24.72	25.38	26.04	26.7	27.36	28.02	28.68	29.34	30.01
16.15	16.81	17.47	18.13	18.79	19.45	20.11	20.77	21.43	22.09	22.75	23.41	24.07	22.75	23.41	24.07	24.73	25.39	26.05	26.71	27.37	28.03	28.69	29.35	30.02
16.16	16.82	17.48	18.14	18.8	19.46	20.12	20.78	21.44	22.1	22.76	23.42	24.08	22.76	23.42	24.08	24.74	25.4	26.06	26.72	27.38	28.04	28.7	29.36	30.03
16.17	16.83	17.49	18.15	18.81	19.47	20.13	20.79	21.45	22.11	22.77	23.43	24.09	22.77	23.43	24.09	24.75	25.41	26.07	26.73	27.39	28.05	28.71	29.37	30.04
16.18	16.84	17.5	18.16	18.82	19.48	20.14	20.8	21.46	22.12	22.78	23.44	24.1	22.78	23.44	24.1	24.76	25.42	26.08	26.74	27.4	28.06	28.72	29.38	30.05
16.19	16.85	17.51	18.17	18.83	19.49	20.15	20.81	21.47	22.13	22.79	23.45	24.11	22.79	23.45	24.11	24.77	25.43	26.09	26.75	27.41	28.07	28.73	29.39	30.06
16.2	16.86	17.52	18.18	18.84	19.5	20.16	20.82	21.48	22.14	22.8	23.46	24.12	22.8	23.46	24.12	24.78	25.44	26.1	26.76	27.42	28.08	28.74	29.4	30.07
16.21	16.87	17.53	18.19	18.85	19.51	20.17	20.83	21.49	22.15	22.81	23.47	24.13	22.81	23.47	24.13	24.79	25.45	26.11	26.77	27.43	28.09	28.75	29.41	30.08
16.22	16.88	17.54	18.2	18.86	19.52	20.18	20.84	21.5	22.16	22.82	23.48	24.14	22.82	23.48	24.14	24.8	25.46	26.12	26.78	27.44	28.1	28.76	29.42	30.09
16.23	16.89	17.55	18.21	18.87	19.53	20.19	20.85	21.51	22.17	22.83	23.49	24.15	22.83	23.49	24.15	24.81	25.47	26.13	26.79	27.45	28.11	28.77	29.43	30.1
16.24	16.9	17.56	18.22	18.88	19.54	20.2	20.86	21.52	22.18	22.84	23.5	24.16	22.84	23.5	24.16	24.82	25.48	26.14	26.8	27.46	28.12	28.78	29.44	30.11
16.25	16.91	17.57	18.23	18.89	19.55	20.21	20.87	21.53	22.19	22.85	23.51	24.17	22.85	23.51	24.17	24.83	25.49	26.15	26.81	27.47	28.13	28.79	29.45	30.12
16.26	16.92	17.58	18.24	18.9	19.56	20.22	20.88	21.54	22.2	22.86	23.52	24.18	22.86	23.52	24.18	24.84	25.5	26.16	26.82	27.48	28.14	28.8	29.46	30.13
16.27	16.93	17.59	18.25	18.91	19.57	20.23	20.89	21.55	22.21	22.87	23.53	24.19	22.87	23.53	24.19	24.85	25.51	26.17	26.83	27.49	28.15	28.81	29.47	30.14
16.28	16.94	17.6	18.26	18.92	19.58	20.24	20.9	21.56	22.22	22.88	23.54	24.2	22.88	23.54	24.2	24.86	25.52	26.18	26.84	27.5	28.16	28.82	29.48	30.15
16.29	16.95	17.61	18.27	18.93	19.59	20.25	20.91	21.57	22.23	22.89	23.55	24.21	22.89	23.55	24.21	24.87	25.53	26.19	26.85	27.51	28.17	28.83	29.49	30.16
16.3	16.96	17.62	18.28	18.94	19.6	20.26	20.92	21.58	22.24	22.9	23.56	24.22	22.9	23.56	24.22	24.88	25.54	26.2	26.86	27.52	28.18	28.84	29.5	30.17
16.31	16.97	17.63	18.29	18.95	19.61	20.27	20.93	21.59	22.25	22.91	23.57	24.23	22.91	23.57	24.23	24.89	25.55	26.21	26.87	27.53	28.19	28.85	29.51	30.18
16.32	16.98	17.64	18.3	18.96	19.62	20.28	20.94	21.6	22.26	22.92	23.58	24.24	22.92	23.58	24.24	24.9	25.56	26.22	26.88	27.54	28.2	28.86	29.52	30.19
16.33	16.99	17.65	18.31	18.97	19.63	20.29	20.95	21.61	22.27	22.93	23.59	24.25	22.93	23.59	24.25	24.91	25.57	26.23	26.89	27.55	28.21	28.87	29.53	30.2
16.34	17	17.66	18.32	18.98	19.64	20.3	20.96	21.62	22.28	22.94	23.6	24.26	22.94	23.6	24.26	24.92	25.58	26.24	26.9	27.56	28.22	28.88	29.54	30.21
16.35	17.01	17.67	18.33	18.99	19.65	20.31	20.97	21.63	22.29	22.95	23.61	24.27	22.95	23.61	24.27	24.93	25.59	26.25	26.91	27.57	28.23	28.89	29.55	30.22
16.36	17.02	17.68	18.34	19	19.66	20.32	20.98	21.64	22.3	22.96	23.62	24.28	22.96	23.62	24.28	24.94	25.6	26.26	26.92	27.58	28.24	28.9	29.56	30.23
16.37	17.03	17.69	18.35	19.01	19.67	20.33	20.99	21.65	22.31	22.97	23.63	24.29	22.97	23.63	24.29	24.95	25.61	26.27	26.93	27.59	28.25	28.91	29.57	30.24
16.38	17.04	17.7	18.36	19.02	19.68	20.34	21	21.66	22.32	22.98	23.64	24.3	22.98	23.64	24.3	24.96	25.62	26.28	26.94	27.6	28.26	28.92	29.58	30.25
16.39	17.05	17.71	18.37	19.03	19.69	20.35	21.01	21.67	22.33	22.99	23.65	24.31	22.99	23.65	24.31	24.97	25.63	26.29	26.95	27.61	28.27	28.93	29.59	30.26
16.4	17.06	17.72	18.38	19.04	19.7	20.36	21.02	21.68	22.34	23	23.66	24.32	23	23.66	24.32	24.98	25.64	26.3	26.96	27.62	28.28	28.94	29.6	30.27
16.41	17.07	17.73	18.39	19.05	19.71	20.37	21.03	21.69	22.35	23.01	23.67	24.33	23.01	23.67	24.33	24.99	25.65	26.31	26.97	27.63	28.29	28.95	29.61	30.28
16.42	17.08	17.74	18.4	19.06	19.72	20.38	21.04	21.7	22.36	23.02	23.68	24.34	23.02	23.68	24.34	25	25.66	26.32	26.98	27.64	28.3	28.96	29.62	30.29
16.43	17.09	17.75	18.41	19.07	19.73	20.39	21.05	21.71	22.37	23.03	23.69	24.35	23.03	23.69	24.35	25.01	25.67	26.33	26.99	27.65	28.31	28.97	29.63	30.3
16.44	17.1	17.76	18.42	19.08	19.74	20.4	21.06	21.72	22.38	23.04	23.7	24.36	23.04	23.7	24.36	25.02	25.68	26.34	27	27.66	28.32	28.98	29.64	30.31
16.45	17.11	17.77	18.43	19.09	19.75	20.41	21.07	21.73	22.39	23.05	23.71	24.37	23.05	23.71	24.37	25.03	25.69	26.35	27.01	27.67	28.33	28.99	29.65	30.32
16.46	17.12	17.78	18.44	19.1	19.76	20.42	21.08	21.74	22.4	23.06	23.72	24.38	23.06	23.72	24.38	25.04	25.7	26.36	27.02	27.68	28.34	29	29.66	30.33
16.47	17.13	17.79	18.45	19.11	19.77	20.43	21.09	21.75	22.41	23.07	23.73	24.39	23.07	23.73	24.39	25.05	25.71	26.37	27.03	27.69	28.35	29.01	29.67	30.34
16.48	17.14	17.8	18.46	19.12	19.78	20.44	21.1	21.76	22.42	23.08	23.74	24.4	23.08	23.74	24.4	25.06	25.72	26.38	27.04	27.7	28.36	29.02	29.68	30.35
16.49	17.15	17.81	18.47	19.13	19.79	20.45	21.11	21.77	22.43	23.09	23.75	24.41	23.09	23.75	24.41	25.07	25.73	26.39	27.05	27.71	28.37	29.03	29.69	30.36
16.5	17.16	17.82	18.48	19.14	19.8	20.46	21.12	21.78	22.44	23.1	23.76	24.42	23.1	23.76	24.42	25.08	25.74	26.4	27.06	27.72	28.38	29.04	29.7	30.37
16.51	17.17	17.83	18.49	19.15	19.81	20.47	21.13	21.79	22.45	23.11	23.77	24.43	23.11	23.77	24.43	25.09	25.75	26.41	27.07	27.73	28.39	29.05	29.71	30.38
16.52	17.18	17.84	18.5	19.16	19.82	20.48	21.14	21.8	22.46	23.12	23.78	24.44	23.12	23.78	24.44	25.1	25.76	26.42	27.08	27.74	28.4	29.06	29.72	30.39
16.53	17.19	17.85	18.51	19.17	19.83	20.49	21.15	21.81	22.47	23.13	23.79	24.45	23.13	23.79	24.45	25.11	25.77	26.43	27.09	27.75	28.41	29.07	29.73	30.4
16.54	17.2	17.86	18.52	19.18	19.84	20.5	21.16	21.82	22.48	23.14	23.8	24.46	23.14	23.8	24.46	25.12	25.78	26.44	27.1	27.76	28.42	29.08	29.74	30.41
16.55	17.21	17.87	18.53	19.19	19.85	20.51	21.17	21.83	22.49	23.15	23.81	24.47	23.15	23.81	24.47	25.13	25.79	26.45	27.11	27.77	28.43	29.09	29.75	30.42
16.56	17.22	17.88	18.54	19.2	19.86	20.52	21.18	21.84	22.5	23.16	23.82	24.48	23.16	23.82	24.48	25.14	25.8	26.46	27.12	27.78	28.44	29.1	29.76	30.43
16.57	17.23	17.89	18.55	19.21	19.87	20.53	21.19	21.85	22.51	23.17	23.83	24.49	23.17	23.83	24.49	25.15	25.81	26.47	27.13	27.79	28.45	29.11	29.77	30.44
16.58	17.24	17.9	18.56	19.22	19.88	20.54	21.2	21.86	22.52	23.18	23.84	24.5	23.18	23.84	24.5	25.16	25.82	26.48	27.14	27.8	28.46	29.12	29.78	30.45
16.59	17.25	17.91	18.57	19.23	19.89	20.55	21.21	21.87	22.53	23.19	23.85	24.51	23.19	23.85	24.51	25.17	25.83	26.49	27.15	27.81	28.47	29.13	29.79	30.46
16.6	17.26	17.92	18.58	19.24	19.9	20.56	21.22	21.88	22.54	23.2	23.86	24.52	23.2	23.86	24.52	25.18	25.84	26.5	27.16	27.82	28.48	29.14	29.8	30.47
16.61	17.27	17.93	18.59	19.25	19.91	20.57	21.23	21.89	22.55	23.21	23.87	24.53	23.21	23.87	24.53	25.19	25.85	26.51	27.17	27.83	28.49	29.15	29.81	30.48
16.62	17.28	17.94	18.6	19.26	19.92	20.58	21.24	21.9	22.56	23.22	23.88	24.54	23.22	23.88	24.54	25.2	25.86	26.52	27.18	27.84	28.5	29.16	29.82	30.49
16.63	17.29	17.95	18.61	19.27	19.93	20.59	21.25	21.91	22.57	23.23	23.89	24.55	23.23	23.89	24.55	25.21	25.87	26.53	27.19	27.85	28.51	29.17	29.83	30.5
16.64	17.3	17.96	18.62	19.28	19.94	20.6	21.26	21.92	22.58	23.24	23.9	24.56	23.24	23.9	24.56	25.22	25.88	26.54	27.2	27.86	28.52	29.18	29.84	30.51

Table B.4: Ordered R values for the unweighted case-2

Ordered R Values																				
30.52	30.93	31.34	31.76	32.18	32.61	33.04	33.49	33.92	34.37	34.83	35.32	35.81	36.28	36.79	37.3	37.87	38.45	39.15	39.83	40.74	42.6
30.53	30.94	31.35	31.77	32.19	32.62	33.05	33.5	33.93	34.38	34.85	35.33	35.83	36.29	36.8	37.31	37.88	38.46	39.18	39.87	40.75	42.83
30.54	30.95	31.36	31.78	32.2	32.63	33.06	33.51	33.94	34.4	34.86	35.34	35.84	36.3	36.81	37.32	37.9	38.47	39.2	39.9	40.76	42.88
30.55	30.96	31.37	31.79	32.22	32.64	33.07	33.52	33.95	34.41	34.87	35.35	35.85	36.33	36.82	37.33	37.91	38.48	39.21	39.91	40.82	43.06
30.56	30.97	31.38	31.8	32.23	32.65	33.08	33.53	33.96	34.42	34.88	35.37	35.87	36.35	36.83	37.37	37.93	38.49	39.23	39.93	40.83	43.11
30.57	30.98	31.4	31.81	32.24	32.66	33.09	33.54	33.97	34.43	34.89	35.38	35.88	36.36	36.84	37.38	37.95	38.51	39.26	39.95	40.85	43.14
30.58	30.99	31.41	31.82	32.25	32.67	33.1	33.55	33.98	34.45	34.9	35.4	35.89	36.37	36.85	37.39	37.97	38.52	39.28	39.97	40.87	43.22
30.59	31	31.42	31.83	32.26	32.68	33.11	33.56	33.99	34.46	34.92	35.42	35.9	36.38	36.86	37.4	37.98	38.53	39.3	39.98	40.89	43.23
30.6	31.01	31.43	31.84	32.27	32.7	33.12	33.57	34	34.47	34.93	35.43	35.91	36.4	36.87	37.41	37.99	38.55	39.31	39.99	40.9	43.24
30.61	31.02	31.44	31.85	32.28	32.71	33.13	33.58	34.01	34.48	34.94	35.44	35.92	36.41	36.89	37.42	38	38.56	39.32	40	40.93	43.28
30.62	31.03	31.45	31.86	32.29	32.72	33.14	33.59	34.03	34.49	34.95	35.45	35.93	36.42	36.9	37.43	38.02	38.58	39.33	40.03	40.96	43.39
30.63	31.04	31.46	31.87	32.3	32.73	33.15	33.6	34.04	34.5	34.96	35.46	35.94	36.44	36.91	37.44	38.03	38.59	39.34	40.05	41.04	43.51
30.64	31.05	31.47	31.88	32.31	32.74	33.16	33.61	34.05	34.51	34.97	35.47	35.95	36.45	36.92	37.45	38.04	38.6	39.35	40.06	41.1	43.69
30.65	31.06	31.48	31.89	32.32	32.75	33.17	33.62	34.06	34.52	34.98	35.48	35.96	36.46	36.93	37.47	38.05	38.62	39.38	40.1	41.15	43.75
30.66	31.07	31.49	31.9	32.33	32.76	33.18	33.63	34.07	34.53	34.99	35.5	35.97	36.47	36.94	37.48	38.06	38.63	39.39	40.13	41.16	44.03
30.67	31.08	31.5	31.91	32.34	32.77	33.19	33.64	34.08	34.54	35	35.51	35.98	36.48	36.97	37.49	38.07	38.64	39.4	40.14	41.2	44.14
30.68	31.09	31.51	31.92	32.35	32.78	33.2	33.65	34.09	34.55	35.01	35.52	36	36.5	36.98	37.5	38.08	38.67	39.41	40.15	41.25	44.16
30.69	31.1	31.52	31.93	32.36	32.79	33.21	33.66	34.1	34.56	35.02	35.53	36.01	36.52	36.99	37.51	38.09	38.68	39.43	40.21	41.3	44.2
30.7	31.11	31.53	31.94	32.37	32.8	33.22	33.67	34.11	34.57	35.03	35.55	36.02	36.53	37	37.52	38.1	38.72	39.44	40.23	41.31	44.31
30.71	31.12	31.54	31.95	32.38	32.81	33.23	33.68	34.12	34.58	35.04	35.56	36.03	36.54	37.01	37.53	38.11	38.73	39.49	40.25	41.34	44.43
30.72	31.13	31.55	31.96	32.39	32.82	33.24	33.69	34.13	34.59	35.05	35.57	36.06	36.55	37.02	37.54	38.12	38.75	39.5	40.26	41.45	44.44
30.73	31.14	31.56	31.97	32.4	32.83	33.25	33.7	34.14	34.6	35.07	35.58	36.07	36.56	37.03	37.57	38.13	38.76	39.52	40.28	41.48	44.52
30.74	31.15	31.57	31.98	32.41	32.84	33.27	33.71	34.15	34.62	35.08	35.6	36.08	36.57	37.04	37.58	38.14	38.77	39.53	40.3	41.56	44.61
30.75	31.16	31.58	31.99	32.42	32.85	33.28	33.72	34.17	34.63	35.1	35.61	36.09	36.58	37.06	37.6	38.15	38.81	39.54	40.32	41.58	45.36
30.76	31.17	31.59	32	32.43	32.86	33.3	33.73	34.18	34.64	35.11	35.62	36.1	36.59	37.07	37.61	38.2	38.82	39.55	40.33	41.6	45.44
30.77	31.18	31.6	32.01	32.44	32.87	33.31	33.74	34.2	34.65	35.12	35.63	36.11	36.6	37.08	37.62	38.21	38.84	39.57	40.35	41.65	
30.78	31.19	31.61	32.02	32.45	32.88	33.32	33.75	34.21	34.67	35.13	35.64	36.12	36.62	37.09	37.63	38.22	38.85	39.58	40.36	41.66	
30.79	31.2	31.62	32.03	32.46	32.89	33.33	33.76	34.22	34.68	35.14	35.65	36.13	36.63	37.1	37.65	38.24	38.86	39.61	40.38	41.68	
30.8	31.21	31.63	32.04	32.47	32.9	33.34	33.77	34.23	34.7	35.15	35.66	36.14	36.65	37.12	37.66	38.25	38.88	39.63	40.41	41.73	
30.81	31.22	31.64	32.05	32.48	32.91	33.35	33.78	34.24	34.71	35.17	35.67	36.15	36.66	37.13	37.67	38.26	38.9	39.64	40.42	41.84	
30.82	31.23	31.65	32.06	32.49	32.92	33.36	33.8	34.25	34.72	35.18	35.68	36.16	36.67	37.17	37.68	38.28	38.93	39.67	40.43	41.85	
30.83	31.24	31.66	32.07	32.5	32.93	33.37	33.81	34.26	34.73	35.2	35.69	36.17	36.68	37.19	37.7	38.3	38.94	39.68	40.48	41.86	
30.84	31.25	31.67	32.08	32.51	32.94	33.38	33.82	34.27	34.74	35.21	35.72	36.18	36.69	37.2	37.72	38.32	38.95	39.69	40.53	41.9	
30.85	31.26	31.68	32.09	32.52	32.95	33.4	33.83	34.28	34.75	35.22	35.73	36.19	36.7	37.21	37.74	38.33	38.98	39.73	40.54	42.01	
30.86	31.27	31.69	32.1	32.53	32.97	33.41	33.85	34.3	34.76	35.23	35.74	36.2	36.71	37.23	37.75	38.35	39	39.74	40.55	42.08	
30.87	31.28	31.7	32.11	32.54	32.98	33.42	33.86	34.31	34.77	35.25	35.75	36.21	36.72	37.24	37.77	38.36	39.01	39.76	40.58	42.09	
30.88	31.29	31.71	32.12	32.55	32.99	33.43	33.87	34.32	34.78	35.26	35.76	36.22	36.73	37.25	37.79	38.38	39.03	39.77	40.62	42.13	
30.89	31.3	31.72	32.13	32.56	33	33.44	33.88	34.33	34.79	35.27	35.77	36.23	36.74	37.26	37.82	38.4	39.06	39.78	40.65	42.17	
30.9	31.31	31.73	32.14	32.58	33.01	33.45	33.89	34.34	34.8	35.28	35.78	36.24	36.75	37.27	37.83	38.41	39.08	39.79	40.68	42.3	
30.91	31.32	31.74	32.15	32.59	33.02	33.47	33.9	34.35	34.81	35.3	35.79	36.25	36.77	37.28	37.84	38.42	39.1	39.8	40.7	42.31	
30.92	31.33	31.75	32.17	32.6	33.03	33.48	33.91	34.36	34.82	35.31	35.8	36.27	36.78	37.29	37.85	38.43	39.13	39.81	40.73	42.4	

Table B.5: Ordered R values for the unweighted case-3

Regions	Total Population	Area of Region	Total Area	Area of Region/Total Area	Population of Region
105	19296	2.3	3.4	0.676470588	13053.17647
114		0.1		0.029411765	567.5294118
115		1		0.294117647	5675.294118
124	3109				
125	59016				
126	38140	1.1	4.2	0.261904762	9989.047619
274		2.5		0.595238095	22702.38095
123		0.4		0.095238095	3632.380952
127		0.2		0.047619048	1816.190476
128	10140				
275	34457				
132	218714	2.2	11	0.2	43742.8
133		2.9		0.263636364	57660.96364
134		1.5		0.136363636	29824.63636
135		3.3		0.3	65614.2
136		1.1		0.1	21871.4
131	43263				
137	39811	0.6	1.4	0.428571429	17061.85714
138		0.8		0.571428571	22749.14286
139	21300				
140	22752	1.4	1.8	0.777777778	17696
130		0.4		0.222222222	5056
129	1462				
98	271047	6.1	23.55	0.259023355	70207.50318
99		0.7		0.029723992	8056.598726
100		3.9		0.165605096	44886.76433
101		0.5		0.021231423	5754.713376
58		0.1		0.004246285	1150.942675
107		0.05		0.002123142	575.4713376
108		1.1		0.04670913	12660.36943
109		3.2		0.135881104	36830.16561
110		0.2		0.008492569	2301.88535
111		0.3		0.012738854	3452.828025
112		0.4		0.016985138	4603.770701
118		0.3		0.012738854	3452.828025
119		0.3		0.012738854	3452.828025
280		6.4		0.271762208	73660.33121
144	91145				
145	700				
143	17000				
142	8000				
141	14835				
147	14810				
149	22356	0.7	1.6	0.4375	9780.75
148		0.9		0.5625	12575.25

Regions	Total Population	Area of Region	Total Area	Area of Region/Total Area	Population of Region
150	39261	2	2.3	0.869565217	34140
151		0.2		0.086956522	3414
152		0.1		0.043478261	1707
157	20967	0.8	1.3	0.615384615	12902.76923
153		0.3		0.230769231	4838.538462
154		0.2		0.153846154	3225.692308
159	9655				
160	91398	0.4	1.3	0.307692308	28122.46154
155		0.7		0.53846153 8	49214.30769
156		0.2		0.153846154	14061.23077
162	28617	0.2	2.1	0.095238095	2725.428571
161		1.9		0.904761905	25891.57143
146	74672	18.9	21.5	0.879069767	65641.89767
158		2.6		0.120930233	9030.102326
163	49976	0.5	4.3	0.11627907	5811.162791
164		0.6		0.139534884	6973.395349
165		0.4		0.093023256	4648.930233
166		1.2		0.27969767	13946.7907
167		0.4		0.093023256	4648.930233
168		1.2		0.27969767	13946.7907
122	15284				
1	43874	2.1	4.6	0.456521739	20029.43478
2		0.8		0.173913043	7630.26087
3		1.7		0.369565217	16214.30435
4	23923	2	2.6	0.769230769	18402.30769
5		0.2		0.076923077	1840.230769
6		0.2		0.076923077	1840.230769
7		0.2		0.076923077	1840.230769
9	59643	0.7	6.6	0.106060606	6325.772727
10		0.4		0.060606061	3614.727273
11		0.5		0.075757576	4518.409091
12		0.6		0.090909091	5422.090909
13		1.4		0.212121212	12651.54545
14		0.9		0.136363636	8133.136364
15		0.7		0.106060606	6325.772727
16		0.5		0.075757576	4518.409091
17		0.9		0.136363636	8133.136364
19	20000	0.7	1.46	0.479452055	9589.041096
20		0.03		0.020547945	410.9589041
21		0.7		0.479452055	9589.041096
25		0.03		0.020547945	410.9589041
8	17769				
18	15360				
30	27604	6.7	9.6	0.697916667	19265.29167
31		1.4		0.145833333	4025.583333
33		0.5		0.052083333	1437.708333
34		0.6		0.0625	1725.25
35		0.4		0.041666667	1150.166667
32	15313				

Regions	Total Population	Area of Region	Total Area	Area of Region/Total Area	Population of Region
22	57580				
23	139063	0.6	5.6	0.107142857	14899.60714
24		2.7		0.482142857	67048.23214
26		1.1		0.196428571	27315.94643
28		1.2		0.214285714	29799.21429
27	19762				
29	26628				
36	6698				
37	105447	3.5	28.7	0.12195122	12859.39024
38		12.2		0.425087108	44824.16028
77		13		0.452961672	47763.44948
41	7100				
43	19237				
44	15646	0.8	1.8	0.444444444	6953.777778
45		1		0.555555556	8692.222222
47	31893	1.2	2.5	0.48	15308.64
51		1.3		0.52	16584.36
48	16377				
52	19275				
55	22029				
46	51039	0.4	17.7	0.02259887	1153.423729
49		0.8		0.04519774	2306.847458
50		0.5		0.028248588	1441.779661
42		6.7		0.378531073	19319.84746
281		3.6		0.203389831	10380.81356
282		5.7		0.322033898	16436.28814
56	130903	0.6	15.3	0.039215686	5133.45098
57		2.5		0.163398693	21389.37908
59		0.5		0.032679739	4277.875817
60		1.5		0.098039216	12833.62745
61		0.6		0.039215686	5133.45098
62		0.4		0.026143791	3422.300654
63		0.3		0.019607843	2566.72549
64		2		0.130718954	17111.50327
65		0.2		0.013071895	1711.150327
66		0.1		0.006535948	855.5751634
67		0.2		0.013071895	1711.150327
68		1.4		0.091503268	11978.05229
69		0.5		0.032679739	4277.875817
70		1.1		0.071895425	9411.326797
71		0.2		0.013071895	1711.150327
72		0.3		0.019607843	2566.72549
73		1.2		0.078431373	10266.90196
74		1.4		0.091503268	11978.05229
75		0.3		0.019607843	2566.72549
102	5023				
103	77836	0.3	1.2	0.25	19459
104		0.7		0.583333333	45404.33333

Table B.6: Calculation of populations of regions-1

Regions	Total Population	Area of Region	Total Area	Area of Region /Total Area	Population of Region
113		0.2		0.167	12972.667
40	4525				
39	25506				
80	1509	1.7	2.7	0.630	950.111
81		1		0.370	558.889
84	41222	0.4	9.9	0.040	1665.535
85		0.6		0.061	2498.303
79		8.9		0.899	37058.162
86	5304	1.1	3	0.367	1944.800
89		1.9		0.633	3359.200
82	30426	0.4	6.3	0.063	1931.810
83		2.2		0.349	10624.952
88		3.7		0.587	17869.238
78	12539	4.9	46.7	0.105	1315.655
92		40.2		0.861	10793.743
87		1.6		0.034	429.602
90	1650	0.5	7.6	0.066	108.553
91		7.1		0.934	1541.447
95	56660	7.9	9.9	0.798	45213.535
96		2		0.202	11446.465
263	56157	2.1	5.4	0.389	21838.833
264		0.6		0.111	6239.667
265		0.4		0.074	4159.778
266		0.1		0.019	1039.944
267		0.8		0.148	8319.556
278		1.4		0.259	14559.222
260	39451				
261	52728	3.6	4.5	0.800	42182.400
254		0.9		0.200	10545.600
252	60602				
255	30449				
257	67267	2.4	3.9	0.615	41395.077
256		1.5		0.385	25871.923
250	16949				
194	16521	1	1.6	0.625	10325.625
195		0.3		0.188	3097.688
196		0.3		0.188	3097.688
193	1953	4	4.2	0.952	1860.000
223		0.2		0.048	93.000
189	4073				
222	14317	0.6	0.8	0.750	10737.750
221		0.2		0.250	3579.250
191	5600	0.2	0.6	0.333	1866.667
192		0.4		0.667	3733.333
215	3685	0.2	0.7	0.286	1052.857
216		0.5		0.714	2632.143
217	1241				
190	3349				
184	53263	0.4	2.6	0.154	8194.308
185		0.7		0.269	14340.038
186		0.6		0.231	12291.462
187		0.6		0.231	12291.462
188		0.3		0.115	6145.731
247	7375	1	1.6	0.625	4609.375
246		0.6		0.375	2765.625
198	46568	0.5	2.8	0.179	8315.714
199		0.9		0.321	14968.286
200		1.4		0.500	23284.000
201	4148				
203	1413				
202	3789				
244	10390	0.1	0.9	0.111	1154.444
245		0.8		0.889	9235.556
197	1200				
213	341				
214	128				
212	1960	0.3	0.5	0.600	1176.000
262		0.2		0.400	784.000
218	1172				
204	6974				
205	12238				
207	6252				
208	10854				
243	6023				
242	77563				
251	12527				
258	3351	0.3	1.2	0.250	837.750
259		0.9		0.750	2513.250
206	44985				
209	31110				
241	144226				
237	14464				
248	47439				
239	60587	2.3	3.2	0.719	43546.906
240		0.9		0.281	17040.094
238	17550				
236	12481				
249	48822				
169	52776				
235	24352				
170	26709				
171	24881				
172	8241				
173	28042				
178	10085	0.2	0.5	0.400	4034.000
179		0.3		0.600	6051.000
174	19779				
175	18348				
176	3267				
177	20772	0.7	0.8	0.875	18175.500
225		0.1		0.125	2596.500
219	6500				
224	2500				
220	2000				
226	21000				
211	57085				
210					
232	5433	0.2	0.3	0.667	3622.000
234		0.1		0.333	1811.000
231	9115				
227	995	0.2	0.45	0.444	442.222
228		0.1		0.222	221.111
229		0.05		0.111	110.556
230		0.1		0.222	221.111
180	30000				
181	5000				
182	3000				
183	9603				
121	8000				
117	10308				
76	7195				
269	6068				
268	28000				
270	8828				
106	8316	5.8	9.3	0.624	5186.323
116		3.5		0.376	3129.677
273	350				
272	15000				
271	1000				
233	5661				
253	10680				
120	3300				
53	2000				
54	57500				
93	30250				
94	5662				
97	17500				
276	1500				
277	1200				
279	600				

Table B.7: Calculation of populations of regions-2

region1	region 2	region3	region4	region5	region6	region7	region8	region9	region1	region11	region12	region13	region14	region15	region16	region17	region18	region19	region2	region21	region22	region23	region24	region25	region26	region27	region28	region29	region3	region31
Node1																														
Node2		Node2																			Node2									
																					Node3	Node3								
																						Node4	Node4							
																							Node5		Node5					
	Node6		Node6																											
	Node7	Node7	Node7																											
		Node8	Node8														Node8													
			Node9			Node9		Node9																						
			Node1					Node1		Node1		Node1																		
			Node11									Node11					Node11													
																Node12	Node12				Node12									
																					Node13		Node13			Node13				
																							Node14			Node14	Node14			
																													Node15	
									Node16																				Node16	
									Node17		Node17																		Node17	Node17
										Node18		Node18	Node18																	
												Node19	Node19		Node19															
													Node2	Node2																Node2
											Node21			Node21							Node21									
																					Node22					Node22		Node22		
																					Node23					Node23	Node23	Node23		
																					Node24							Node24		
																											Node25	Node25		
																												Node26		
																													Node27	
																													Node28	Node28
																													Node29	
																														Node3
																														Node31

Table B.8: A small part of region-node matrix: The regions and the nodes belong to the regions

Region	Population of region	Number of node	Population of region/number of node	Region	Population of region	Number of node	Population of region/number of node	Region	Population of region	Number of node	Population of region/number of node	Region	Population of region	Number of node	Population of region/number of node	Region	Population of region	Number of node	Population of region/number of node
1	20029.43	5	4006	67	1711.15	4	428	133	57660.96	5	11532	199	14968.29	5	2994	265	4159.78	5	832
2	7630.26	4	1908	68	11978.05	7	1711	134	29824.64	6	4971	200	23284.00	4	5821	266	1039.94	3	347
3	16214.30	5	3243	69	4277.88	3	1426	135	65614.20	6	10936	201	4148.00	4	1037	267	8319.56	5	1664
4	18402.31	9	2045	70	9411.33	4	2353	136	21871.40	5	4374	202	3789.00	4	947	268	28000.00	6	4667
5	1840.23	3	613	71	1711.15	4	428	137	17061.86	5	3412	203	1413.00	8	177	269	6068.00	5	1214
6	1840.23	5	368	72	2566.73	4	642	138	22749.14	5	4550	204	6974.00	4	1744	270	8828.00	5	1766
7	1840.23	4	460	73	10266.90	6	1711	139	21300.00	6	3550	205	12238.00	4	3060	271	1000.00	3	333
8	17769.00	4	4442	74	11978.05	4	2995	140	17696.00	7	2528	206	44985.00	6	7498	272	15000.00	6	2500
9	6325.77	5	1265	75	2566.73	3	856	141	14835.00	4	3709	207	6252.00	4	1563	273	350.00	3	117
10	3614.73	4	904	76	7195.00	7	1028	142	8000.00	4	2000	208	10854.00	3	3618	274	22702.38	7	3243
11	4518.41	4	1130	77	47763.45	7	6823	143	17000.00	5	3400	209	31110.00	7	4444	275	34457.00	4	8614
12	5422.09	4	1356	78	1315.66	4	329	144	91145.00	7	13021	210	41516.36	6	6919	276	1500.00	3	500
13	12651.55	6	2109	79	37058.16	8	4632	145	700.00	6	117	211	15568.64	5	3114	277	1200.00	3	400
14	8133.14	5	1627	80	950.11	4	238	146	65641.90	13	5049	212	1176.00	5	235	278	14559.22	7	2080
15	6325.77	5	1265	81	558.89	4	140	147	14810.00	6	2468	213	341.00	4	85	279	600.00	3	200
16	4518.41	4	1130	82	1931.81	4	483	148	12575.25	3	4192	214	128.00	3	43	280	73660.33	8	9208
17	8133.14	5	1627	83	10624.95	5	2125	149	9780.75	6	1630	215	1052.86	3	351	281	10380.81	4	2595
18	15360.00	5	3072	84	1665.54	4	416	150	34140.00	6	5690	216	2632.14	5	526	282	16436.29	6	2739
19	9589.04	3	3196	85	2498.30	3	833	151	3414.00	4	854	217	1241.00	4	310				
20	410.96	4	103	86	1944.80	4	486	152	1707.00	4	427	218	1172.00	4	293				
21	9589.04	3	3196	87	429.60	4	107	153	4838.54	4	1210	219	6500.00	3	2167				
22	57580.00	10	5758	88	17869.24	6	2978	154	3225.69	4	806	220	2000.00	5	400				
23	14899.61	3	4967	89	3359.20	5	672	155	49214.31	5	9843	221	3579.25	4	895				
24	67048.23	6	11175	90	108.55	3	36	156	14061.23	3	4687	222	10737.75	4	2684				
25	410.96	4	103	91	1541.45	9	171	157	12902.77	5	2581	223	93.00	4	23				
26	27315.95	3	9105	92	10793.74	8	1349	158	9030.10	5	1806	224	2500.00	5	500				
27	19762.00	4	4941	93	30250.00	15	2017	159	9655.00	4	2414	225	2596.50	3	866				
28	29799.21	5	5960	94	5662.00	8	708	160	28122.46	3	9374	226	21000.00	4	5250				
29	26628.00	5	5326	95	45213.54	4	11303	161	25891.57	6	4315	227	442.22	5	88				
30	19265.29	7	2752	96	11446.46	3	3815	162	2725.43	3	908	228	221.11	4	55				
31	4025.58	6	671	97	17500.00	4	4375	163	5811.16	4	1453	229	110.56	3	37				
32	15313.00	9	1701	98	70207.50	5	14042	164	6973.40	5	1395	230	221.11	4	55				
33	1437.71	3	479	99	8056.60	5	1611	165	4648.93	3	1550	231	9115.00	6	1519				
34	1725.25	4	431	100	44886.76	8	5611	166	13946.79	5	2789	232	3622.00	5	724				
35	1150.17	5	230	101	5754.71	5	1151	167	4648.93	4	1162	233	5661.00	5	1132				
36	6698.00	6	1116	102	5023.00	6	837	168	13946.79	5	2789	234	1811.00	3	604				
37	12859.39	4	3215	103	19459.00	3	6486	169	52776.00	14	3770	235	24352.00	5	4870				
38	44824.16	6	7471	104	45404.33	5	9081	170	26709.00	6	4452	236	12481.00	4	3120				
39	25506.00	8	3188	105	13053.18	6	2176	171	24881.00	6	4147	237	14464.00	3	4821				
40	4525.00	11	411	106	5186.32	7	741	172	8241.00	6	1374	238	17550.00	6	2925				
41	7100.00	8	888	107	575.47	3	192	173	28042.00	5	5608	239	43546.91	6	7258				
42	19319.85	9	2147	108	12660.37	5	2532	174	19779.00	5	3956	240	17040.09	3	5680				
43	19237.00	7	2748	109	36830.17	9	4092	175	18348.00	4	4587	241	144226.00	8	18028				
44	6953.78	3	2318	110	2301.89	3	767	176	3267.00	4	817	242	77563.00	7	11080				
45	8692.22	4	2173	111	3452.83	3	1151	177	18175.50	5	3635	243	6023.00	4	1506				
46	1153.42	4	288	112	4603.77	5	921	178	4034.00	4	1009	244	1154.44	4	289				
47	15308.64	4	3827	113	12972.67	4	3243	179	6051.00	3	2017	245	9235.56	5	1847				
48	16377.00	6	2730	114	567.53	3	189	180	30000.00	4	7500	246	2765.63	3	922				
49	2306.85	4	577	115	5675.29	5	1135	181	5000.00	4	1250	247	4609.38	5	922				
50	1441.78	6	240	116	3129.68	5	626	182	3000.00	4	750	248	47439.00	4	11860				
51	16584.36	5	3317	117	10308.00	5	2062	183	9603.00	7	1372	249	48822.00	6	8137				
52	19275.00	4	4819	118	3452.83	3	1151	184	8194.31	4	2049	250	16949.00	3	5650				
53	2000.00	4	500	119	3452.83	3	1151	185	14340.04	4	3585	251	12527.00	13	964				
54	57500.00	5	11500	120	3300.00	6	550	186	12291.46	4	3073	252	60602.00	9	6734				
55	22029.00	5	4406	121	8000.00	3	2667	187	12291.46	3	4097	253	10680.00	3	3560				
56	5133.45	4	1283	122	15284.00	7	2183	188	6145.73	4	1536	254	10545.60	5	2109				
57	21389.38	7	3056	123	3632.38	5	726	189	4073.00	4	1018	255	30449.00	5	6090				
58	1150.94	4	288	124	3109.00	7	444	190	3349.00	11	304	256	25871.92	5	5174				
59	4277.88	4	1069	125	59016.00	5	11803	191	1866.67	4	467	257	41395.08	5	8279				
60	12833.63	4	3208	126	9989.05	4	2497	192	3733.33	5	747	258	837.75	4	209				
61	5133.45	4	1283	127	1816.19	3	605	193	1860.00	9	207	259	2513.25	4	628				
62	3422.30	4	856	128	10140.00	5	2028	194	10325.63	7	1475	260	39451.00	5	7890				
63	2566.73	5	513	129	1462.00	5	292	195	3097.69	3	1033	261	42182.40	7	6026				
64	17111.50	8	2139	130	5056.00	4	1264	196	3097.69	4	774	262	784.00	3	261				
65	1711.15	4	428	131	43263.00	5	8653	197	1200.00	6	200	263	21838.83	5	4368				
66	855.58	5	171	132	43742.80	3	14581	198	8315.71	3	2772	264	6239.67	3	2080				

Table B.9: Divided population of regions: The population coming from a region to a node

	region1	region 2	region3	region4	region5	region6	region7	region8	region9	region10	region11	region12	region13	region14	region15	region16	region17	region18	region19	region20	region21	region22	region23	region24	region25	region26	region27	region28	region29	region30	region31	...	Sum
Node1	4006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	4006
Node2	4006	0	3243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5758	0	0	0	0	0	0	0	0	0	...	13007
Node3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5758	4967	0	0	0	0	0	0	0	0	...	10725
Node4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4967	11175	0	0	0	0	0	0	0	...	16142
Node5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11175	0	9105	0	0	0	0	0	...	20280
Node6	0	1908	0	2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	3953
Node7	0	1908	3243	2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	7196
Node8	0	0	3243	2045	0	0	0	0	0	0	0	0	0	0	0	0	0	3072	0	0	0	0	0	0	0	0	0	0	0	0	0	...	8360
Node9	0	0	0	2045	0	0	460	0	1265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	3770
Node10	0	0	0	2045	0	0	0	0	1265	0	1130	0	2109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	6549
Node11	0	0	0	2045	0	0	0	0	0	0	0	0	2109	0	0	0	0	3072	0	0	0	0	0	0	0	0	0	0	0	0	0	...	7226
Node12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1627	3072	0	0	0	5758	0	0	0	0	0	0	0	0	0	...	10457
Node13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5758	0	11175	0	0	4941	0	0	0	0	...	21874
Node14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11175	0	0	4941	5960	0	0	0	...	22076
Node15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2752	0	...	2752
Node16	0	0	0	0	0	0	0	0	0	904	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2752	0	...	3656
Node17	0	0	0	0	0	0	0	0	0	904	0	1356	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2752	671	...	5683
Node18	0	0	0	0	0	0	0	0	0	0	1130	0	2109	1627	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	4866
Node19	0	0	0	0	0	0	0	0	0	0	0	0	2109	1627	0	1130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	4866
Node20	0	0	0	0	0	0	0	0	0	0	0	0	0	1627	1265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	671	...	3793
Node21	0	0	0	0	0	0	0	0	0	0	0	1356	0	0	1265	0	0	0	0	0	0	5758	0	0	0	0	0	0	0	0	0	...	9725
Node22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5758	0	0	0	0	4941	0	5326	0	0	...	16025
Node23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4941	5960	5326	0	0	...	16227
Node24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5758	0	0	0	0	0	0	5326	0	0	...	15415
Node25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5960	5326	0	0	...	11286
Node26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5326	0	0	...	16012
Node27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2752	0	...	3640
Node28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2752	671	...	5124
Node29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2752	0	...	5341
Node30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	671	...	1332
Node31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	671	...	2851

Table B.10: A small part of the matrix which shows the count of population of the nodes by using divided population of the regions

Node	Population	Node	Population	Node	Population	Node	Population	Node	Population	Node	Population	Node	Population
1	4006	67	17569	133	10938	199	1986	265	12403	331	17351	397	1518
2	13007	68	14828	134	11194	200	8442	266	11759	332	8600	398	3299
3	10725	69	17006	135	9477	201	13660	267	17853	333	10659	399	15065
4	16142	70	12094	136	9973	202	10170	268	3086	334	18421	400	26240
5	20280	71	4678	137	11319	203	5146	269	3282	335	17489	401	2658
6	3953	72	6629	138	6275	204	13373	270	2812	336	20795	402	981
7	7196	73	7012	139	16096	205	19479	271	2969	337	8237	403	368
8	8360	74	6418	140	7517	206	22195	272	12875	338	9109	404	5270
9	3770	75	7578	141	18065	207	13724	273	12064	339	8290	405	7468
10	6549	76	8535	142	23895	208	9715	274	6599	340	26289	406	2873
11	7226	77	10470	143	9538	209	15933	275	3880	341	9482	407	6167
12	10457	78	12235	144	10817	210	12615	276	4981	342	3084	408	2611
13	21874	79	31600	145	11170	211	3867	277	4992	343	10735	409	1581
14	22076	80	7350	146	7838	212	3358	278	4793	344	9238	410	8109
15	2752	81	5793	147	6559	213	4383	279	4182	345	10545	411	9348
16	3656	82	7305	148	3970	214	2957	280	939	346	4006	412	5734
17	5683	83	6611	149	23767	215	6433	281	2161	347	3196	413	5346
18	4866	84	3884	150	22888	216	12260	282	1055	348	3299	414	6740
19	4866	85	14486	151	15480	217	2288	283	1209	349	206	415	9000
20	3793	86	23779	152	7072	218	3394	284	540	350	3299	416	7606
21	9725	87	26578	153	11942	219	8627	285	10529	351	206	417	7897
22	16025	88	17543	154	14105	220	18163	286	7474	352	3299	418	8168
23	16227	89	11837	155	13525	221	5586	287	4576	353	3196	419	5973
24	15415	90	5368	156	19353	222	7426	288	2843	354	5914	420	3766
25	11286	91	13600	157	12385	223	15309	289	7627	355	9157	421	3125
26	16012	92	5293	158	15242	224	4627	290	9625	356	4022	422	1349
27	3640	93	5248	159	1509	225	7677	291	2607	357	4022	423	2725
28	5124	94	7650	160	5836	226	14452	292	6150	358	8650	424	708
29	5341	95	17635	161	6519	227	2748	293	3067	359	4866	425	708
30	1332	96	14161	162	5854	228	3644	294	10251	360	7967	426	964
31	2851	97	15656	163	1028	229	3821	295	5406	361	3299	427	964
32	2362	98	4582	164	5367	230	6261	296	2424	362	4113	428	964
33	3047	99	11992	165	4169	231	1436	297	6923	363	8049	429	964
34	3627	100	5053	166	3750	232	6058	298	1662	364	5183	430	964
35	8378	101	3183	167	5201	233	6088	299	235	365	3243	431	8137
36	5337	102	10495	168	9015	234	5881	300	3206	366	3012	432	8337
37	7033	103	14490	169	4805	235	6310	301	10849	367	2964	433	3770
38	3228	104	14354	170	6943	236	11784	302	2298	368	4134	434	5049
39	7519	105	13924	171	2044	237	7152	303	3375	369	7239	435	6855
40	13874	106	10973	172	14138	238	1678	304	8247	370	5314	436	5049
41	4715	107	17287	173	20084	239	11455	305	2460	371	7221	437	117
42	6863	108	13571	174	13505	240	11693	306	28894	372	8830	438	444
43	11623	109	561	175	41050	241	5286	307	3500	373	8745	439	23250
44	3641	110	16947	176	30072	242	2919	308	16404	374	4790	440	25782
45	8009	111	16468	177	30966	243	3860	309	8474	375	5860	441	888
46	14693	112	11053	178	37146	244	3811	310	7050	376	2379	442	6222
47	6596	113	31084	179	5380	245	10389	311	12804	377	6518	443	3640
48	3944	114	29356	180	38989	246	17482	312	8450	378	3850	444	7471
49	9246	115	31448	181	9101	247	14294	313	6010	379	5918	445	7471
50	2806	116	19319	182	24386	248	12073	314	7315	380	2746	446	411
51	12542	117	18722	183	17694	249	21900	315	4134	381	2310	447	1439
52	21225	118	24074	184	14399	250	6808	316	8599	382	4021	448	6385
53	12411	119	14689	185	18321	251	5734	317	27293	383	2738	449	8714
54	8515	120	28331	186	15803	252	2168	318	10915	384	2746	450	12107
55	3080	121	11324	187	11471	253	7020	319	33891	385	879	451	4097
56	3721	122	11336	188	16384	254	8482	320	15863	386	879	452	5334
57	7333	123	11512	189	13348	255	2082	321	18982	387	207		
58	18962	124	21586	190	3926	256	2815	322	16546	388	10207		
59	5348	125	10287	191	10078	257	1480	323	25422	389	6392		
60	10919	126	14151	192	8030	258	19664	324	3297	390	6563		
61	6264	127	18187	193	11272	259	1672	325	17011	391	4492		
62	13814	128	20538	194	3325	260	2457	326	6971	392	5134		
63	16430	129	6626	195	5937	261	2057	327	2912	393	4706		
64	7643	130	9848	196	6962	262	14869	328	8403	394	11561		
65	8373	131	8174	197	5938	263	13309	329	6801	395	10706		
66	3599	132	13099	198	1258	264	10202	330	8993	396	4064		

Table B.11: Final node populations

Appendix C

Existing Fire Stations

	Sincan 2	Etimesgut 40	Batıkent 50	Merkez 91	Keçiören 120	Kayaş 149	Kurtuluş 158	Çayyolu 242	AŞTİ 254	Köşk 271	Esat 274	Hisar 297	Siteler 322	Altınpark 341
Node1	Node1													
Node2	Node2													
Node3	Node3													
Node4	Node4													
Node5	Node5													
Node6	Node6													
Node7	Node7													
Node8	Node8													
Node9	Node9													
Node10	Node10													
Node11	Node11													
Node12	Node12													
Node13	Node13	Node13												
Node14	Node14	Node14												
Node15	Node15													
Node16	Node16													
Node17	Node17													
Node18	Node18													
Node19	Node19													
Node20	Node20													
Node21	Node21	Node21												
Node22	Node22	Node22												
Node23		Node23												
Node24	Node24	Node24												
Node25		Node25												
Node26		Node26												
Node27	Node27													
Node28	Node28													
Node29	Node29													
Node30	Node30													
Node31	Node31													
Node32	Node32													
Node33	Node33	Node33												
Node34			Node34											
Node35			Node35											
Node36	Node36		Node36											
Node37	Node37	Node37	Node37											
Node38	Node38	Node38												
Node39		Node39												
Node40		Node40												
Node41		Node41												
Node42			Node42											
Node43			Node43											
Node44			Node44											
Node45			Node45											
Node46			Node46											
Node47			Node47											
Node48			Node48											
Node49			Node49											
Node50			Node50											
Node51			Node51											
Node52			Node52											
Node53			Node53											
Node54			Node54											
Node55			Node55											
Node56			Node56											
Node57			Node57											
Node58			Node58											
Node59			Node59											
Node60			Node60	Node60										
Node61			Node61											
Node62			Node62	Node62										
Node63			Node63	Node63										
Node64			Node64											
Node65			Node65	Node65										
Node66			Node66											

Table C.1: A portion of existing fire stations and their assigned nodes

	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	AŞTİ	Köşk	Esat	Hisar	Siteler	Altınpark
	2	40	50	91	120	149	158	242	254	271	274	297	322	341
Node1	2.55	0	0	0	0	0	0	0	0	0	0	0	0	0
Node2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node4	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node5	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node6	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Node7	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node8	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node9	3.75	0	0	0	0	0	0	0	0	0	0	0	0	0
Node10	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Node11	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node12	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node13	3.05	4.83	0	0	0	0	0	0	0	0	0	0	0	0
Node14	4.25	5.2	0	0	0	0	0	0	0	0	0	0	0	0
Node15	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node16	5.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node17	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node18	4.65	0	0	0	0	0	0	0	0	0	0	0	0	0
Node19	4.55	0	0	0	0	0	0	0	0	0	0	0	0	0
Node20	5.67	0	0	0	0	0	0	0	0	0	0	0	0	0
Node21	4.55	4.28	0	0	0	0	0	0	0	0	0	0	0	0
Node22	4.15	3.73	0	0	0	0	0	0	0	0	0	0	0	0
Node23	0	4.7	0	0	0	0	0	0	0	0	0	0	0	0
Node24	4.9	2.98	0	0	0	0	0	0	0	0	0	0	0	0
Node25	0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
Node26	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0
Node27	9.5	0	13.04	0	0	0	0	0	0	0	0	0	0	0
Node28	6.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node29	7.1	0	9.74	0	0	0	0	0	0	0	0	0	0	0
Node30	5.97	0	0	0	0	0	0	0	0	0	0	0	0	0
Node31	6.72	0	0	0	0	0	0	0	0	0	0	0	0	0
Node32	5.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node33	5	4.73	0	0	0	0	0	0	0	0	0	0	0	0
Node34	0	0	7.64	0	0	0	0	0	0	0	0	0	0	0
Node35	0	0	4.54	0	0	0	0	0	0	0	0	0	0	0
Node36	9.2	0	6.44	0	0	0	0	0	0	0	0	0	0	0
Node37	8.65	2.93	5.89	0	0	0	0	0	0	0	0	0	0	0
Node38	8	2.28	0	0	0	0	0	0	0	0	0	0	0	0
Node39	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0
Node40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node41	0	0.68	0	0	0	0	0	0	0	0	0	0	0	0
Node42	0	0	2.29	0	0	0	0	0	0	0	0	0	0	0
Node43	0	0	2.99	0	0	0	0	0	0	0	0	0	0	0
Node44	0	0	3.54	0	0	0	0	0	0	0	0	0	0	0
Node45	0	0	1.59	0	0	0	0	0	0	0	0	0	0	0
Node46	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0
Node47	0	0	2.92	0	0	0	0	0	0	0	0	0	0	0
Node48	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Node49	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0
Node50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node51	0	0	1.19	0	0	0	0	0	0	0	0	0	0	0
Node52	0	0	2.59	0	0	0	0	0	0	0	0	0	0	0
Node53	0	0	2.86	0	0	0	0	0	0	0	0	0	0	0
Node54	0	0	5.35	0	0	0	0	0	0	0	0	0	0	0
Node55	0	0	2.36	0	0	0	0	0	0	0	0	0	0	0
Node56	0	0	2.12	0	0	0	0	0	0	0	0	0	0	0
Node57	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0
Node58	0	0	2.19	0	0	0	0	0	0	0	0	0	0	0
Node59	0	0	5.25	0	0	0	0	0	0	0	0	0	0	0
Node60	0	0	7.55	10.6	0	0	0	0	0	0	0	0	0	0
Node61	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0
Node62	0	0	4.5	7.55	0	0	0	0	0	0	0	0	0	0
Node63	0	0	4.75	7.2	0	0	0	0	0	0	0	0	0	0
Node64	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Node65	0	0	3.95	6.4	0	0	0	0	0	0	0	0	0	0
Node66	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0

	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	AŞTİ	Köşk	Esat	Hisar	Siteler	Altınpark
	2	40	50	91	120	149	158	242	254	271	274	297	322	341
Node67	0	0	3.49	5.55	0	0	0	0	0	0	0	0	0	0
Node68	0	0	5.09	5.6	0	0	0	0	0	0	0	0	0	0
Node69	0	0	4.4	5.2	0	0	0	0	0	0	0	0	0	0
Node70	0	0	4.29	4.75	0	0	0	0	0	0	0	0	0	0
Node71	0	0	5.84	3.9	0	0	0	0	0	0	0	0	0	0
Node72	0	0	0	3.65	0	0	0	0	0	0	0	0	0	0
Node73	0	0	0	4.45	0	0	0	0	0	0	0	0	0	0
Node74	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Node75	0	0	0	0	3.25	0	0	0	0	0	0	0	0	1.4
Node76	0	0	0	0	0	0	0	0	0	0	0	0	1.85	0
Node77	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Node78	0	0	0	6.1	0	0	0	0	0	0	0	0	0	0
Node79	0	0	0	5.65	6.84	0	0	0	0	0	0	0	0	0
Node80	0	0	0	5.45	0	0	0	0	0	0	0	0	0	0
Node81	0	0	0	3.35	0	0	0	0	0	0	0	0	0	0
Node82	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0
Node83	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0
Node84	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0
Node85	0	0	0	9.55	7.8	0	0	0	0	0	0	0	0	0
Node86	0	0	0	0	6.35	0	0	0	0	0	0	0	0	0
Node87	0	0	0	0	5.14	0	0	0	0	0	0	0	0	0
Node88	0	0	0	5.35	5.44	0	0	0	0	0	0	0	0	0
Node89	0	0	0	3.95	5.34	0	0	0	0	0	0	0	0	0
Node90	0	0	0	3.55	0	0	0	0	0	0	0	0	0	0
Node91	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node92	0	0	0	0.65	0	0	0	0	0	0	0	0	0	0
Node93	0	0	0	0.94	0	0	0	0	0	0	0	0	0	0
Node94	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0
Node95	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0
Node96	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0
Node97	0	0	0	2.4	0	0	3.22	0	0	0	0	0	4.33	0
Node98	0	0	0	2.3	0	0	0	0	0	0	0	0	0	0
Node99	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0
Node100	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0
Node101	0	0	0	3.2	4.79	0	0	0	0	0	0	0	0	0
Node102	0	0	0	3.3	4.69	0	0	0	0	0	0	0	0	0
Node103	0	0	0	3.95	4.04	0	0	0	0	0	0	0	0	0
Node104	0	0	0	4.75	4.84	0	0	0	0	0	0	0	0	0
Node105	0	0	0	4.7	3.29	0	0	0	0	0	0	0	0	2.9
Node106	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0
Node107	0	0	0	3	3.95	0	0	0	0	0	0	0	0	0.7
Node108	0	0	0	2.65	0	0	0	0	0	0	0	0	3.33	0.7
Node109	0	0	0	0	4.6	0	0	0	0	0	0	0	0	0
Node110	0	0	0	0	4.55	0	0	0	0	0	0	0	0	0
Node111	0	0	0	0	4.15	0	0	0	0	0	0	0	0	0
Node112	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
Node113	0	0	0	0	5.24	0	0	0	0	0	0	0	0	0
Node114	0	0	0	0	4.54	0	0	0	0	0	0	0	0	0
Node115	0	0	0	0	2.34	0	0	0	0	0	0	0	0	2.84
Node116	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0
Node117	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0
Node118	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0
Node119	0	0	5.04	4	0	0	0	0	0	0	0	0	0	0
Node120	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node121	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0
Node122	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0
Node123	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0
Node124	0	0	0	0	2.2	0	0	0	0	0	0	0	0	2.7
Node125	0	0	0	0	2.35	0	0	0	0	0	0	0	0	2.3
Node126	0	0	0	0	0	0	3.87	0	0	0	0	0	4.93	0
Node127	0	0	0	0	4.6	0	0	0	0	0	0	0	0	7.01
Node128	0	0	0	0	0	0	0	0	0	0	0	0	0	4.11
Node129	0	0	0	0	0	0	0	0	0	0	0	0	0	1.51
Node130	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Node131	0	0	0	0	0	0	0	0	0	0	0	0	1.6	2.5
Node132	0	0	0	0	0	0	0	0	0	0	0	0	1.33	2.7

Table C.2: Distances from existing fire stations to their assigned nodes-1

	Sincan 2	Etimesgut 40	Batıkent 50	Merkez 91	Keçiören 120	Kayaş 149	Kurtuluş 158	Çayyolu 242	AŞTİ 254	Köşk 271	Esat 274	Hisar 297	Siteler 322	Altınpark 341
Node133	0	0	0	0	0	0	3.3	0	0	0	0	0	2.33	3.7
Node134	0	0	0	0	0	0	2.38	0	0	0	0	0	0	0
Node135	0	0	0	0	0	6.75	2.55	0	0	0	0	0	2.48	4.45
Node136	0	0	0	0	0	5.9	0	0	0	0	0	0	1.63	5.2
Node137	0	0	0	0	0	0	0	0	0	0	0	0	0.23	3.8
Node138	0	0	0	0	0	0	0	0	0	0	0	0	1	3.15
Node139	0	0	0	0	0	0	0	0	0	0	0	0	2.15	3.56
Node140	0	0	0	0	0	0	0	0	0	0	0	0	0	4.46
Node141	0	0	0	0	0	0	0	0	0	0	0	0	1.68	0
Node142	0	0	0	0	0	0	0	0	0	0	0	0	1.75	0
Node143	0	0	0	0	0	0	0	0	0	0	0	0	3.95	0
Node144	0	0	0	0	0	0	0	0	0	0	0	0	4.35	0
Node145	0	0	0	0	0	0	0	0	0	0	0	0	3.85	0
Node146	0	0	0	0	0	0	0	0	0	0	0	0	6.3	0
Node147	0	0	0	0	0	0	0	0	0	0	0	0	7.85	0
Node148	0	0	0	0	0	5.5	0	0	0	0	0	0	0	0
Node149	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node150	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0
Node151	0	0	0	0	0	2	0	0	0	0	0	0	4.28	0
Node152	0	0	0	0	0	3.7	3.7	0	0	0	0	0	0	0
Node153	0	0	0	0	0	4.9	2.5	0	0	0	0	0	0	0
Node154	0	0	0	0	0	6.85	1.85	0	0	0	0	0	0	0
Node155	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0
Node156	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0
Node157	0	0	0	0	0	0	1.75	0	0	0	0	0	0	0
Node158	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node159	0	0	0	2	0	0	1.84	0	0	0	0	0	0	0
Node160	0	0	0	2.35	0	0	1.55	0	0	0	0	0	0	0
Node161	0	0	0	2.95	0	0	0.95	0	0	0	0	0	0	0
Node162	0	0	0	0	0	0	0.55	0	0	0	2.1	0	0	0
Node163	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0
Node164	0	0	0	2.15	0	0	2.71	0	0	0	0	0	0	0
Node165	0	0	0	3.35	0	0	2.38	0	0	0	0	0	0	0
Node166	0	0	0	0	0	0	2.2	0	0	0	1.91	0	0	0
Node167	0	0	0	0	0	0	2	0	0	0	1.51	0	0	0
Node168	0	0	0	0	0	0	0	0	0	0	2.01	0	0	0
Node169	0	0	0	0	0	0	2.3	0	0	0	0.81	0	0	0
Node170	0	0	0	0	0	0	0	0	0	0	2.68	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0.2	1.68	0	0	0
Node172	0	0	0	0	0	0	0	0	0	0.1	1.38	0	0	0
Node173	0	0	0	0	0	0	0	0	0	0	1.33	0	0	0
Node174	0	0	0	0	0	0	2.4	0	0	0	3.48	0	0	0
Node175	0	0	0	0	0	7.2	2.95	0	0	0	2.93	0	0	0
Node176	0	0	0	0	0	5.7	4.45	0	0	0	0	0	0	0
Node177	0	0	0	0	0	3.3	5.75	0	0	0	0	0	0	0
Node178	0	0	0	0	0	2.6	6.45	0	0	0	0	0	0	0
Node179	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0
Node180	0	0	0	0	0	3.5	6.65	0	0	0	0	0	0	0
Node181	0	0	0	0	0	6.3	0	0	0	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	1.9	3.18	0	0	0
Node183	0	0	0	0	0	0	0	0	0	0	4.48	0	0	0
Node184	0	0	0	0	0	0	0	0	0	1.1	2.58	0	0	0
Node185	0	0	0	0	0	0	0	0	0	0	4.11	0	0	0
Node186	0	0	0	0	0	0	4.2	0	0	0	3.91	0	0	0
Node187	0	0	0	0	0	0	4.9	0	0	0	4.61	0	0	0
Node188	0	0	0	0	0	0	0	0	0	0	6.31	0	0	0
Node189	0	0	0	0	0	0	0	0	0	0	5.58	0	0	0
Node190	0	0	0	2.95	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	3.07	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	2.62	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	2.44	0	0	0	0	0	0	0	0	0	0
Node194	0	0	0	3.95	0	0	2.93	0	0	0	0	0	0	0
Node195	0	0	0	4.35	0	0	0	0	0	0	0	0	0	0
Node196	0	0	0	4.32	0	0	0	0	0	0	0	0	0	0
Node197	0	0	0	4.14	0	0	0	0	0	0	0	0	0	0
Node198	0	0	0	4.48	0	0	3	0	0	0	0	0	0	0
Node199	0	0	0	5.28	0	0	3.8	0	0	0	0	0	0	0

	Sincan 2	Etimesgut 40	Batıkent 50	Merkez 91	Keçiören 120	Kayaş 149	Kurtuluş 158	Çayyolu 242	AŞTİ 254	Köşk 271	Esat 274	Hisar 297	Siteler 322	Altınpark 341
Node200	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0
Node201	0	0	0	0	0	0	5.35	0	0	0	5.06	0	0	0
Node202	0	0	0	6.07	0	0	5.95	0	0	0	5.66	0	0	0
Node203	0	0	0	5.99	0	0	0	0	0	0	0	0	0	0
Node204	0	0	0	0	0	0	0	0	0	0	7.16	0	0	0
Node205	0	0	0	0	0	0	0	0	0	0	7.55	0	0	0
Node206	0	0	0	10.12	0	0	0	0	0	0	8.3	0	0	0
Node207	0	0	0	0	0	0	0	0	0	0	8.08	0	0	0
Node208	0	0	0	0	0	0	0	0	0	0	10.18	0	0	0
Node209	0	0	0	0	0	0	0	0	0	0	10.7	0	0	0
Node210	0	0	0	7.09	0	0	0	0	0	0	0	0	0	0
Node211	0	0	0	3.54	0	0	0	0	0	0	0	0	0	0
Node212	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0
Node213	0	0	0	3.74	0	0	0	0	0	0	0	0	0	0
Node214	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0
Node215	0	0	0	3.99	0	0	0	0	0.55	0	0	0	0	0
Node216	0	0	0	5.09	0	0	0	0	0	0	0	0	0	0
Node217	0	0	0	5.24	0	0	0	0	0	0	0	0	0	0
Node218	0	0	0	5.89	0	0	0	0	0	0	0	0	0	0
Node219	0	0	0	6.69	0	0	0	0	0	0	0	0	0	0
Node220	0	0	0	8.49	0	0	0	0	0	0	0	0	0	0
Node221	0	0	0	0	0	0	0	0	3.45	0	0	0	0	0
Node222	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0
Node223	0	0	0	11.09	0	0	0	0	5.4	0	0	0	0	0
Node224	0	6.38	0	12.09	0	0	0	0	0	0	0	0	0	0
Node225	0	6.98	0	12.69	0	0	0	0	3.63	0	0	0	0	0
Node226	0	0	0	11.94	0	0	0	0	4.55	0	0	0	0	0
Node227	0	0	0	0	0	0	0	0	2.9	0	0	0	0	0
Node228	0	0	0	0	0	0	0	0	3.55	0	0	0	0	0
Node229	0	0	0	13.14	0	0	0	0	3.35	0	0	0	0	0
Node230	0	0	0	0	0	0	0	0	1.55	0	0	0	0	0
Node231	0	0	0	15.97	0	0	0	0	2.35	0	0	0	0	0
Node232	0	0	0	0	0	0	0	0	1.35	0	0	0	0	0
Node233	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Node234	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0
Node235	0	0	0	0	0	0	0	0	6.2	0	0	0	0	0
Node236	0	12.5	0	0	0	0	0	0	4.7	0	0	0	0	0
Node237	0	12.3	0	0	0	0	0	0	6.3	0	0	0	0	0
Node238	0	0	0	0	0	0	0	0	8.6	0	0	0	0	0
Node239	0	11.4	0	0	0	0	0	0	3.6	0	0	0	0	0
Node240	0	10.2	0	0	0	0	0	0	2.4	0	0	0	0	0
Node241	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0
Node242	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node243	0	0	0	0	0	0	0	0	0.35	0	0	0	0	0
Node244	0	8.68	0	0	0	0	0	0	2.8	0	0	0	0	0
Node245	0	8.7	0	0	0	0	0	0	1.4	0	0	0	0	0
Node246	0	5.6	0	0	0	0	0	0	0	0	0	0	0	0
Node247	0	8.8	0	0	0	0	0	0	0	0	0	0	0	0
Node248	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node249	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node250	3.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node251	0	0	7.15	0	0	0	0	0	0	0	0	0	0	0
Node252	0	0	0	0	0	0	2.21	0	0	0	2.76	0	0	0
Node253	0	0	0	3.94	0	0	0	0	0.5	0	0	0	0	0
Node254	0	0	0	3.44	0	0	0	0	0	0	0	0	0	0
Node255	0	0	0	0	0	0	1.71	0	0	0	0	0	0	0
Node256	0	0	0	1.99	0	0	2.55	0	0	0	0	0	0	0
Node257	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0
Node258	0	0	0	14.09	0	0	0	0	0	0	0	0	0	0
Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node262	0	0	0	0	0	0	0	0	0	0	9.25	0	0	0
Node263	0	0	0	0	0	0	0	0	0	0	7.35	0	0	0
Node264	0	0	0	6.97	0	0	0	0	0	0	0	0	0	0
Node265	0	0	0	0	0	0	0	0	0	0	7.56	0	0	0
Node266	0	0	0	0	0	0	0	0	0	0	6.71	0	0	0

Table C.3: Distances from existing fire stations to their assigned nodes-2

	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	AŞTİ	Köşk	Esat	Hisar	Siteler	Altınpark		Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	AŞTİ	Köşk	Esat	Hisar	Siteler	Altınpark
	2	40	50	91	120	149	158	242	254	271	274	297	322	341		2	40	50	91	120	149	158	242	254	271	274	297	322	341
Node267	0	0	0	7.07	0	0	0	0	0	0	6.66	0	0	0	Node334	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0
Node268	0	0	0	5.77	0	0	0	0	0	0	0	0	0	0	Node335	0	0	0	0	3.25	0	0	0	0	0	0	0	0	2.71
Node269	0	0	0	4.47	0	0	0	0	0	0	0	0	0	0	Node336	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Node270	0	0	0	5.14	0	0	0	0	0	0	0	0	0	0	Node337	0	0	0	0	3.15	0	0	0	0	0	0	0	0	1.91
Node271	0	0	0	0	0	0	0	0	0	0	1.48	0	0	0	Node338	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0
Node272	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	Node339	0	0	0	0	0	0	0	0	0	0	0	0	0	1.86
Node273	0	0	0	0	0	0	0	0	0	0	0.23	0	0	0	Node340	0	0	0	7.55	7.45	0	0	0	0	0	0	0	0	0
Node274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Node341	0	0	0	3.35	0	0	0	0	0	0	0	0	0	0
Node275	0	0	0	0	0	0	0	0	0	0	0.16	0	0	0	Node342	0	0	0	0	0	0	0	0	0	0	1.51	0	0	0
Node276	0	0	0	0	0	0	1.25	0	0	0	1.4	0	0	0	Node343	0	0	0	0	0	0	0.9	0	0	0	1.75	0	0	0
Node277	0	0	0	6.42	0	0	0	0	0	0	0	0	0	0	Node344	0	0	0	0	0	0	0.7	0	0	0	1.95	0	0	0
Node278	0	0	0	0	0	0	2.1	0	0	0	3.16	0	0	0	Node345	0	0	0	7.02	0	0	0	0	0	0	0	0	0	0
Node279	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	Node346	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node280	0	0	0	0	0	0	1.16	0	0	0	0	0	0	0	Node347	3.71	0	0	0	0	0	0	0	0	0	0	0	0	0
Node281	0	0	0	0	0	0	1.9	0	0	0	1.21	0	0	0	Node348	2.51	0	0	0	0	0	0	0	0	0	0	0	0	0
Node282	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	Node349	2.38	0	0	0	0	0	0	0	0	0	0	0	0	0
Node283	0	0	0	0	0	0	1.3	0	0	0	1.81	0	0	0	Node350	2.49	0	0	0	0	0	0	0	0	0	0	0	0	0
Node284	0	0	0	0	0	0	1	0	0	0	2.11	0	0	0	Node351	2.66	0	0	0	0	0	0	0	0	0	0	0	0	0
Node285	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	Node352	2.78	0	0	0	0	0	0	0	0	0	0	0	0	0
Node286	0	0	0	4.62	0	0	0	0	0	0	0	0	0	0	Node353	3.79	0	0	0	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	6.02	0	0	0	0	0	0	0	0	0	0	Node354	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0
Node288	0	0	0	5.49	0	0	0	0	0	0	0	0	0	0	Node355	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0
Node289	0	0	0	5.89	0	0	0	0	0	0	0	0	0	0	Node356	4.77	0	0	0	0	0	0	0	0	0	0	0	0	0
Node290	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	Node357	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0
Node291	0	0	0	0	0	0	0	0	0	0	0	0	0.88	3.15	Node358	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node292	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	Node359	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	Node360	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node294	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	Node361	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0
Node295	0	0	0	2.05	0	0	2.27	0	0	0	0	0	0	0	Node362	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node296	0	0	0	2.35	0	0	1.97	0	0	0	0	0.35	0	0	Node363	0	0	2.89	0	0	0	0	0	0	0	0	0	0	0
Node297	0	0	0	2.7	0	0	2.32	0	0	0	0	0	0	0	Node364	0	0	3.04	0	0	0	0	0	0	0	0	0	0	0
Node298	0	0	0	0	0	0	1.57	0	0	0	0	0	0	0	Node365	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Node299	0	0	0	0	0	0	1.34	0	0	0	0	0	0	0	Node366	0	0	2.14	0	0	0	0	0	0	0	0	0	0	0
Node300	0	0	0	0	0	0	1.35	0	0	0	0	0	0	0	Node367	0	0	1.29	0	0	0	0	0	0	0	0	0	0	0
Node301	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	Node368	0	0	0.59	0	0	0	0	0	0	0	0	0	0	0
Node302	0	0	0	0	0	0	1.36	0	0	0	0	0	0	0	Node369	0	0	5.19	0	0	0	0	0	0	0	0	0	0	0
Node303	0	0	0	0	0	0	1.93	0	0	0	0	0	0	0	Node370	0	4.63	4.29	0	0	0	0	0	0	0	0	0	0	0
Node304	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	Node371	0	0	3.74	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	0	0	0	0	1.85	0	0	0	0	0	0	0	Node372	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	0	0	0	5.35	3.05	0	0	0	0	0	0	0	Node373	0	0	1.49	0	0	0	0	0	0	0	0	0	0	0
Node307	0	0	5.34	4.1	0	0	0	0	0	0	0	0	0	0	Node374	0	0	1.87	0	0	0	0	0	0	0	0	0	0	0
Node308	0	0	4.42	4.88	0	0	0	0	0	0	0	0	0	0	Node375	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Node309	0	0	4.05	5.55	0	0	0	0	0	0	0	0	0	0	Node376	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Node310	0	0	4.5	5.2	0	0	0	0	0	0	0	0	0	0	Node377	0	0	3.65	0	0	0	0	0	0	0	0	0	0	0
Node311	0	0	0	4.45	0	0	0	0	0	0	0	0	0	0	Node378	0	0	5.4	0	0	0	0	0	0	0	0	0	0	0
Node312	0	0	0	4.35	0	0	0	0	0	0	0	0	0	0	Node379	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Node313	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	Node380	0	0	2.32	0	0	0	0	0	0	0	0	0	0	0
Node314	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	Node381	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0
Node315	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	Node382	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0
Node316	0	0	0	0	0	3.4	4	0	0	0	0	0	4.13	0	Node383	0	0	2.54	0	0	0	0	0	0	0	0	0	0	0
Node317	0	0	0	0	0	6.85	2.35	0	0	0	0	0	0	0	Node384	0	0	2.18	0	0	0	0	0	0	0	0	0	0	0
Node318	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	Node385	0	0	0	14.94	0	0	0	4.05	0	0	0	0	0	0
Node319	0	0	0	0	0	4.65	3.75	0	0	0	0	0	0	0	Node386	0	0	0	15.64	0	0	0	3.35	0	0	0	0	0	0
Node320	0	0	0	0	0	4.1	4.1	0	0	0	0	0	0	0	Node387	0	0	0	16.64	0	0	0	5.35	0	0	0	0	0	0
Node321	0	0	0	0	0	0	0	0	0	0	0	0	0.98	0	Node388	0	0	0	11.19	0	0	0	0	0	0	0	0	0	0
Node322	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Node389	0	0	0	16.59	0	0	0	0	0	0	0	0	0	0
Node323	0	0	0	0	0	0	0	0	0	0	0	0	0.35	0	Node390	0	0	0	15.09	0	0	0	0	0	0	0	0	0	0
Node324	0	0	0	0	0	0	0	0	0	0	0	0	0.65	0	Node391	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Node325	0	0	0	0	0	0	0	0	0	0	0	0	1.35	0	Node392	0	0	5.8	0	0	0	0	0	0	0	0	0	0	0
Node326	0	0	0	0	0	0	0	0	0	0	0	0	1.2	2.9	Node393	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Node327	0	0	0	6.22	0	0	0	0	0	0	0	0	0	0	Node394	0	0	5.95	9	0	0	0	0	0	0	0	0	0	0
Node328	0	0	0	0	0	0	0	0	0	0	0	0	1.1	3.06	Node395	0	0	5.25	8.3	0	0	0	0	0	0	0	0	0	0
Node329	0	0	0	0	0	0	0	0	0	0	0	0	1.55	0	Node396	0	0	5.85	0	0	0	0	0	0	0	0	0	0	0
Node330	0	0	0	0	0	0	0	0	0	0	0	0	2.25	0	Node397	0	0	0	4.18	0	0	2.7	0	0	0	0	0	0	0
Node331	0	0	0	6.7	0	0	0	0	0	0	0	0	0	0	Node398	2.96	0	0	0	0	0	0	0	0	0	0	0	0	0
Node332	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	Node399	4.45	6.2	0	0	0	0	0	0	0	0	0	0	0	0
Node333	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	Node400	3.85	5.93	0	0	0	0	0	0	0	0	0	0	0	0

Table C.4: Distances from existing fire stations to their assigned nodes-3

	Sincan	Etimesgut	Batıkent	Merkez	Keçiören	Kayaş	Kurtuluş	Çayyolu	AŞTİ	Köşk	Esat	Hisar	Siteler	Altınpark
	2	40	50	91	120	149	158	242	254	271	274	297	322	341
Node401	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Node402	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Node403	4.17	0	0	0	0	0	0	0	0	0	0	0	0	0
Node404	3.82	0	0	0	0	0	0	0	0	0	0	0	0	0
Node405	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0
Node406	3.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node407	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node408	5.75	0	0	0	0	0	0	0	0	0	0	0	0	0
Node409	6.27	0	0	0	0	0	0	0	0	0	0	0	0	0
Node410	0	0	0	0	0	0	0	0	0	0	0	0	5.95	0
Node411	0	0	0	0	0	0	0	0	0	0	0	0	6.75	0
Node412	0	0	0	0	0	0	0	0	0	0	0	0	5.65	0
Node413	0	0	0	0	0	0	0	0	0	0	0	0	6.15	0
Node414	0	0	0	0	0	0	0	0	0	0	0	0	6.4	0
Node415	0	0	0	0	0	0	0	0	0	0	0	0	5.9	0
Node416	0	0	0	0	0	0	0	0	0	0	0	0	5.45	0
Node417	0	0	0	0	0	0	0	0	0	0	0	0	5.1	0
Node418	0	0	0	0	0	0	0	0	0	0	0	0	5.05	0
Node419	0	0	0	0	0	0	3.2	0	0	0	2.91	0	0	0
Node420	0	0	0	0	0	0	0	6.25	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	0	12.3	0	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	0	0	11.3	0	0	0	0	0	0	0	0
Node430	0	0	0	0	0	8.3	0	0	0	0	0	0	0	0
Node431	0	0	0	0	0	7.7	0	0	0	0	0	0	0	0
Node432	0	0	0	0	0	5.6	0	0	0	0	0	0	0	0
Node433	0	0	0	0	0	7.9	0	0	0	0	0	0	0	0
Node434	0	0	0	0	0	0	0	0	0	0	0	0	8.7	0
Node435	0	0	0	0	0	0	0	0	0	0	0	0	4.95	0
Node436	0	0	0	0	0	0	0	0	0	0	0	0	0	10.31
Node437	0	0	0	0	6.3	0	0	0	0	0	0	0	0	0
Node438	0	0	0	0	6.2	0	0	0	0	0	0	0	0	0
Node439	0	0	0	10.15	0	0	0	0	0	0	0	0	0	0
Node440	0	0	0	7.45	0	0	0	0	0	0	0	0	0	0
Node441	0	0	9.94	0	0	0	0	0	0	0	0	0	0	0
Node442	0	0	6.04	0	0	0	0	0	0	0	0	0	0	0
Node443	9.1	0	11.74	0	0	0	0	0	0	0	0	0	0	0
Node444	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0
Node445	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
Node446	0	3.68	0	0	0	0	0	0	0	0	0	0	0	0
Node447	0	0	0	8.49	0	0	0	0	0	0	0	0	0	0
Node448	0	0	0	8.49	0	0	0	0	0	0	0	0	0	0
Node449	0	0	0	4.49	0	0	0	0	0	0	0	0	0	0
Node450	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0
Node451	0	0	0	8.62	0	0	0	0	0	0	0	0	0	0
Node452	0	0	3.92	0	0	0	0	0	0	0	0	0	0	0
max	9.5	12.5	13.04	16.64	7.8	11.3	6.65	12.3	0.55	1.9	10.7	0.35	8.7	10.31

Table C.5: Distances from existing fire stations to their assigned nodes-4

Node	Population	Number of Fire Station	Divided Population	Node	Population	Number of Fire Station	Divided Population	Node	Population	Number of Fire Station	Divided Population	Node	Population	Number of Fire Station	Divided Population	Node	Population	Number of Fire Station	Divided Population	Node	Population	Number of Fire Station	Divided Population	Node	Population	Number of Fire Station	Divided Population
1	4006	1	4006	67	17569	2	8785	133	10938	3	3646	199	1986	2	993	257	1480	1	1480	323	25422	1	25422	389	6392	1	6392
2	13007	1	13007	68	14828	2	7414	134	11194	1	11194	200	8442	1	8442	258	19664	1	19664	324	3297	1	3297	390	6563	1	6563
3	10725	1	10725	69	17006	2	8503	135	9477	4	2369	201	13660	2	6830	259	1672	0	0	325	17011	1	17011	391	4492	1	4492
4	16142	1	16142	70	12094	2	6047	136	9973	3	3324	202	10170	3	3390	260	2457	0	0	326	6971	2	3486	392	5134	1	5134
5	20280	1	20280	71	4678	2	2339	137	11319	2	5660	203	5146	1	5146	261	2057	0	0	327	2912	1	2912	393	4706	1	4706
6	3953	1	3953	72	6629	1	6629	138	6275	2	3138	204	13373	1	13373	262	14869	1	14869	328	8403	2	4202	394	11561	2	5781
7	7196	1	7196	73	7012	1	7012	139	16096	2	8048	205	19479	1	19479	263	13309	1	13309	329	6801	1	6801	395	10706	2	5353
8	8360	1	8360	74	6418	1	6418	140	7517	1	7517	206	22195	2	11098	264	10202	1	10202	330	8993	1	8993	396	4064	1	4064
9	3770	1	3770	75	7578	2	3789	141	18065	1	18065	207	13724	1	13724	265	12403	1	12403	331	17351	1	17351	397	1518	2	759
10	6549	1	6549	76	8535	1	8535	142	23895	1	23895	208	9715	1	9715	266	11759	1	11759	332	8600	1	8600	398	3299	1	3299
11	7226	1	7226	77	10470	1	10470	143	9538	1	9538	209	15933	1	15933	267	17853	2	8927	333	10659	1	10659	399	15065	2	7533
12	10457	1	10457	78	12235	1	12235	144	10817	1	10817	210	12615	1	12615	268	3086	1	3086	334	18421	1	18421	400	26240	2	13120
13	21874	2	10937	79	31600	2	15800	145	11170	1	11170	211	3867	1	3867	269	3282	1	3282	335	17489	2	8745	401	2658	1	2658
14	22076	2	11038	80	7350	1	7350	146	7838	1	7838	212	3358	1	3358	270	2812	1	2812	336	20795	1	20795	402	981	1	981
15	2752	1	2752	81	5793	1	5793	147	6559	1	6559	213	4383	1	4383	271	2969	2	1485	337	8237	2	4119	403	368	1	368
16	3656	1	3656	82	7305	1	7305	148	3970	1	3970	214	2957	1	2957	272	12875	1	12875	338	9109	1	9109	404	5270	1	5270
17	5683	1	5683	83	6611	1	6611	149	23767	1	23767	215	6433	2	3217	273	12064	1	12064	339	8290	1	8290	405	7468	1	7468
18	4866	1	4866	84	3884	1	3884	150	22888	1	22888	216	12260	1	12260	274	6599	1	6599	340	26289	2	13145	406	2873	1	2873
19	4866	1	4866	85	14486	2	7243	151	15480	2	7740	217	2288	1	2288	275	3880	1	3880	341	9482	2	4741	407	6167	1	6167
20	3793	1	3793	86	23779	1	23779	152	7072	2	3536	218	3394	1	3394	276	4981	2	2491	342	3084	1	3084	408	2611	1	2611
21	9725	2	4863	87	26578	1	26578	153	11942	2	5971	219	8627	1	8627	277	4992	1	4992	343	10735	2	5368	409	1581	1	1581
22	16025	2	8013	88	17543	2	8772	154	14105	2	7053	220	18163	1	18163	278	4793	2	2397	344	9238	2	4619	410	8109	1	8109
23	16227	1	16227	89	11837	2	5919	155	13525	1	13525	221	5586	1	5586	279	4182	1	4182	345	10545	1	10545	411	9348	1	9348
24	15415	2	7708	90	5368	1	5368	156	19353	1	19353	222	7426	1	7426	280	939	1	939	346	4006	1	4006	412	5734	1	5734
25	11286	1	11286	91	13600	1	13600	157	12385	1	12385	223	15309	2	7655	281	2161	2	1081	347	3196	1	3196	413	5346	1	5346
26	16012	1	16012	92	5293	1	5293	158	15242	1	15242	224	4627	2	2314	282	1055	1	1055	348	3299	1	3299	414	6740	1	6740
27	3640	1	3640	93	5248	1	5248	159	1509	2	755	225	7677	3	2559	283	1209	2	605	349	206	1	206	415	9000	1	9000
28	5124	1	5124	94	7650	1	7650	160	5836	2	2918	226	14452	2	7226	284	540	2	270	350	3299	1	3299	416	7606	1	7606
29	5341	1	5341	95	17635	1	17635	161	6519	2	3260	227	2748	1	2748	285	10529	1	10529	351	206	1	206	417	7897	1	7897
30	1332	1	1332	96	14161	1	14161	162	5854	2	2927	228	3644	1	3644	286	7474	1	7474	352	3299	1	3299	418	8168	1	8168
31	2851	1	2851	97	15656	3	5219	163	1028	1	1028	229	3821	2	1911	287	4576	1	4576	353	3196	1	3196	419	5973	2	2987
32	2362	1	2362	98	4582	1	4582	164	5367	2	2684	230	6261	1	6261	288	2843	1	2843	354	5914	1	5914	420	3766	1	3766
33	3047	2	1524	99	11992	1	11992	165	4169	2	2085	231	1436	2	718	289	7627	1	7627	355	9157	1	9157	421	3125	0	0
34	3627	1	3627	100	5053	1	5053	166	3750	2	1875	232	6058	1	6058	290	9625	1	9625	356	4022	1	4022	422	1349	1	1349
35	8378	1	8378	101	3183	2	1592	167	5201	2	2601	233	6088	1	6088	291	2607	2	1304	357	4022	1	4022	423	2725	0	0
36	5337	2	2669	102	10495	2	5248	168	9015	1	9015	234	5881	1	5881	292	6150	1	6150	358	8650	1	8650	424	708	0	0
37	7033	3	2344	103	14490	2	7245	169	4805	2	2403	235	6310	1	6310	293	3067	1	3067	359	4866	1	4866	425	708	0	0
38	3228	2	1614	104	14354	2	7177	170	6943	1	6943	236	11784	2	5892	294	10251	1	10251	360	7967	1	7967	426	964	0	0
39	7519	1	7519	105	13924	3	4641	171	2044	2	1022	237	7152	2	3576	295	5406	2	2703	361	3299	1	3299	427	964	0	0
40	13874	1	13874	106	10973	1	10973	172	14138	2	7069	238	1678	1	1678	296	2424	3	808	362	4113	1	4113	428	964	0	0
41	4715	1	4715	107	17287	3	5762	173	20084	1	20084	239	11455	2	5728	297	6923	3	2308	363	8049	1	8049	429	964	1	964
42	6863	1	6863	108	13571	3	4524	174	13505	2	6753	240	11693	2	5847	298	1662	1	1662	364	5183	1	5183	430	964	1	964
43	11623	1	11623	109	561	1	561	175	41050	3	13683	241	5286	1	5286	299	235	1	235	365	3243	1	3243	431	8137	1	8137
44	3641	1	3641	110	16947	1	16947	176	30072	2	15036	242	2919	1	2919	300	3206	1	3206	366	3012	1	3012	432	8337	1	8337
45	8009	1	8009	111	16468	1	16468	177	30966	2	15483	243	3860	1	3860	301	10849	1	10849	367	2964	1	2964	433	3770	1	3770
46	14693	1	14693	112	11053	1	11053	178	37146	2	18573	244	3811	2	1906	302	2298	1	2298	368	4134	1	4134	434	5049	1	5049
47	6596	1	6596	113	31084	1	31084	179	5380	1	5380	245	10389	2	5195	303	3375	1	3375	369	7239	1	7239	435	6855	1	6855
48	3944	1	3944	114	29356	1	29356	180	38989	2	19495	246	17482	1	17482	304	8247	1	8247	370	5314	2	2657	436	5049	1	5049
49	9246	1	9246	115	31448	2	15724	181	9101	1	9101	247	14294	1	14294	305	2460	1	2460	371	7221	1	7221	437	117	1	117
50	2806	1	2806	116	19319	1	19319	182	24386	2	12193	248	12073	1	12073	306	28894	2	14447	372	8830	1	8830	438	444	1	444
51	12542	1	12542	117	18722	1	18722	183	17694	1	17694	249	21900	1	21900	307	3500	2	1750	373	8745	1	8745	439	23250	1	23250
52	21225	1	21225	118	24074	1	24074	184	14399	2	7200	250	6808	1	6808	308	16404	2	8202	374	4790	1	4790	440	25782	1	25782
53	12411	1	12411	119	14689	2	7345	185	18321	1	18321	251	5734	1	5734	309	8474	2	4237	375	5860	1	5860	441	888	1	888
54	8515	1	8515	120	28331	1	28331	186	15803	2	7902	252	2168	2	1084	310	7050	2	3525	376	2379	1	2379	442	6222	1	6222
55	3080	1	3080	121	11324	1	11324	187	11471	2	5736	253	7020	2	3510	311	12804	1	12804	377	6518	1	6518	443	3640	1	3640
56	3721	1	3721	122	11336	1	11336	188	16384	1	16384	254	8482	2	4241	312	8450	1	8450	378	3850	1	3850	444	7471	1	7471
57	7333	1	7333	123	11512	1	11512	189	13348	1	13348	255	2082	1	2082	313	6010	1	6010	379	5918	1	5918	445	7471	1	7471
58	18962	1	18962	124	21586	2	10793	190	3926	1	3926	256	2815	2	1408	314	7315	1	7315	380	2746	1	2746	446	411	1	411
59	5348	1	5348	125	10287	2	5144	191	10078	1	10078	257	1480	1	1480	315	4134	1	4134	381	2310	1	2310	447	1439	1	1439
60	10919	2	5460	126	14151	2	7076	192	8030	1	8030	258	19664	1	19664	316	8599	3	2866	382	4021	1	4021	448	6385	1	6385
61	6264	1	6264	127	18187	2	9094	193	11272	1	11272	259	1672	0	0	317	27293	2	13647	383	2738	1	2738	449	8714	1	8714
62	13814	2	6907	128	20538	1	20538	194	3325	2	1663	260	2457	0	0	318	10915	1	10915	384	2746	1	2746	450	12107	1	12107
63	16430	2	8215	129	6626	1	6626	195	5937	1	5937	261	2057	0	0	319	33891	2	16946	385	879	2	440	451	4097	1	4097
64	7643	1	7643	130	9848	1	9848	196	6962	1	6962	262	14869	1	14869	320	15863	2	7932	386	879	2	440	452	5334	1	5334
65	8373	2	4187	131	8174	2	4087	197	5938	1	5938	263	13309	1	13309	321	18982	1	18982	387	207	2	104				
66	3599	1	3599	132	13099	2	6550	198	1258	2	629	264	10202	1	10202	322	16546	1	16546	388	10207	1	10207				

Table C.6: Divided population according to the fire stations

Appendix D

Tables of Unweighted Assignment of Fire Stations

Node	U2 39	U4 71	U6 126	U8 181	U9 201	U10 228	U11 235	U3 391	U1 401	U7 410	U5 437	AŞTİ 254	Köşk 271	Hisar 297	Node	U2 39	U4 71	U6 126	U8 181	U9 201	U10 228	U11 235	U3 391	U1 401	U7 410	U5 437	AŞTİ 254	Köşk 271	Hisar 297
Node1	0	0	0	0	0	0	0	0	5.35	0	0	0	0	0	Node67	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0
Node2	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	Node68	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0
Node3	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	Node69	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
Node4	0	0	0	0	0	0	0	0	4.15	0	0	0	0	0	Node70	0	1.55	0	0	0	0	0	0	0	0	0	0	0	0
Node5	0	0	0	0	0	0	0	0	5.25	0	0	0	0	0	Node72	0	0.95	0	0	0	0	0	0	0	0	0	0	0	0
Node6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	Node73	0	1.73	0	0	0	0	0	0	0	0	0	0	0	0
Node7	0	0	0	0	0	0	0	0	1.45	0	0	0	0	0	Node74	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0
Node8	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	Node75	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Node9	0	0	0	0	0	0	0	0	0.95	0	0	0	0	0	Node76	0	0	0	0	0	0	0	0	0	5.1	0	0	0	0
Node10	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	Node77	0	3.73	0	0	0	0	0	0	0	0	0	0	0	0
Node11	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	Node78	0	0	0	0	0	0	0	5.55	0	0	0	0	0	0
Node12	0	0	0	0	0	0	0	0	4.25	0	0	0	0	0	Node79	0	0	5.7	0	0	0	0	0	0	0	0	0	0	0
Node13	4.65	0	0	0	0	0	0	0	0	0	0	0	0	0	Node80	0	0	5.5	0	0	0	0	0	0	0	0	0	0	0
Node14	5.15	0	0	0	0	0	0	0	0	0	0	0	0	0	Node81	0	4.25	0	0	0	0	0	0	0	0	0	0	0	0
Node15	0	0	0	0	0	0	0	0	4.5	0	0	0	0	0	Node82	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0
Node16	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	Node83	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
Node17	0	0	0	0	0	0	0	0	2.85	0	0	0	0	0	Node84	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0
Node18	0	0	0	0	0	0	0	0	2.35	0	0	0	0	0	Node85	0	0	0	0	0	0	0	0	0	0	4.9	0	0	0
Node19	0	0	0	0	0	0	0	0	3.25	0	0	0	0	0	Node86	0	0	0	0	0	0	0	0	0	0	4.35	0	0	0
Node20	0	0	0	0	0	0	0	0	4.35	0	0	0	0	0	Node87	0	0	0	0	0	0	0	0	0	0	6.75	0	0	0
Node21	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	Node88	0	0	5.4	0	0	0	0	0	0	0	0	0	0	0
Node22	3.55	0	0	0	0	0	0	0	0	0	0	0	0	0	Node89	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Node23	4.65	0	0	0	0	0	0	0	0	0	0	0	0	0	Node90	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0
Node24	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	Node91	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0
Node25	4.38	0	0	0	0	0	0	0	0	0	0	0	0	0	Node92	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
Node26	3.48	0	0	0	0	0	0	0	0	0	0	0	0	0	Node93	0	3.89	0	0	0	0	0	0	0	0	0	0	0	0
Node27	0	0	0	0	0	0	0	0	6.7	0	0	0	0	0	Node94	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0
Node28	0	0	0	0	0	0	0	0	3.85	0	0	0	0	0	Node95	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0
Node29	0	0	0	0	0	0	0	0	4.45	0	0	0	0	0	Node96	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0
Node30	0	0	0	0	0	0	0	0	4.65	0	0	0	0	0	Node97	0	0	0.65	0	0	0	0	0	0	0	0	0	0	0
Node31	0	0	0	0	0	0	0	0	4.95	0	0	0	0	0	Node98	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Node32	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	Node99	0	0	1.55	0	0	0	0	0	0	0	0	0	0	0
Node33	4.55	0	0	0	0	0	0	0	0	0	0	0	0	0	Node100	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0
Node34	0	0	0	0	0	0	0	4.45	0	0	0	0	0	0	Node101	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0
Node35	5.8	0	0	0	0	0	0	0	0	0	0	0	0	0	Node102	0	0	3.35	0	0	0	0	0	0	0	0	0	0	0
Node36	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	Node103	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Node37	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	Node104	0	0	4.8	0	0	0	0	0	0	0	0	0	0	0
Node38	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	Node105	0	0	4.5	0	0	0	0	0	0	0	0	0	0	0
Node40	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	Node106	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0
Node41	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	Node107	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0
Node42	6.35	0	0	0	0	0	0	0	0	0	0	0	0	0	Node108	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0
Node43	5.65	0	0	0	0	0	0	0	0	0	0	0	0	0	Node109	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0
Node44	5.65	0	0	0	0	0	0	0	0	0	0	0	0	0	Node110	0	0	0	0	0	0	0	0	0	0	2.55	0	0	0
Node45	0	0	0	0	0	0	0	6.35	0	0	0	0	0	0	Node111	0	0	0	0	0	0	0	0	0	0	2.15	0	0	0
Node46	0	6.97	0	0	0	0	0	0	0	0	0	0	0	0	Node112	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0
Node47	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	Node113	0	0	0	0	0	0	0	0	0	0	4.55	0	0	0
Node48	0	0	0	0	0	0	0	3	0	0	0	0	0	0	Node114	0	0	0	0	0	0	0	0	0	0	6.15	0	0	0
Node49	0	0	0	0	0	0	0	5.19	0	0	0	0	0	0	Node115	0	0	4.44	0	0	0	0	0	0	0	0	0	0	0
Node50	0	0	0	0	0	0	0	5	0	0	0	0	0	0	Node116	0	0	5.4	0	0	0	0	0	0	0	0	0	0	0
Node51	0	6.17	0	0	0	0	0	0	0	0	0	0	0	0	Node117	0	0	5.9	0	0	0	0	0	0	0	0	0	0	0
Node52	0	4.77	0	0	0	0	0	0	0	0	0	0	0	0	Node118	0	0	0	0	0	0	0	0	0	0	4.8	0	0	0
Node53	0	4.5	0	0	0	0	0	0	0	0	0	0	0	0	Node119	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0
Node54	0	0	0	0	0	0	0	0.35	0	0	0	0	0	0	Node120	0	0	6.25	0	0	0	0	0	0	0	0	0	0	0
Node55	0	0	0	0	0	0	0	2.99	0	0	0	0	0	0	Node121	0	0	4.95	0	0	0	0	0	0	0	0	0	0	0
Node56	0	0	0	0	0	0	0	3.23	0	0	0	0	0	0	Node122	0	0	4.8	0	0	0	0	0	0	0	0	0	0	0
Node57	0	0	0	0	0	0	0	4.14	0	0	0	0	0	0	Node123	0	0	4.35	0	0	0	0	0	0	0	0	0	0	0
Node58	0	3.65	0	0	0	0	0	0	0	0	0	0	0	0	Node124	0	0	4.3	0	0	0	0	0	0	0	0	0	0	0
Node59	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	Node125	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0
Node60	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0	Node127	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0
Node61	0	0	0	0	0	0	0	4.23	0	0	0	0	0	0	Node128	0	0	0	0	0	0	0	0	0	0	5.1	0	0	0
Node62	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	Node129	0	0	3.86	0	0	0	0	0	0	0	0	0	0	0
Node63	0	0	0	0	0	0	0	2.85	0	0	0	0	0	0	Node130	0	0	3.65	0	0	0	0	0	0	0	0	0	0	0
Node64	0	3.8	0	0	0	0	0	0	0	0	0	0	0	0	Node131	0	0	4.3	0	0	0	0	0	0	0	0	0	0	0
Node65	0	0	0	0	0	0	0	3.65	0	0	0	0	0	0	Node132	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0
66	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	Node133	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0

Table D.1: Distances from unweighted fire stations to their assigned nodes-1

	U2	U4	U6	U8	U9	U10	U11	U3	U1	U7	U5	AŞTİ	Köşk	Hisar		U2	U4	U6	U8	U9	U10	U11	U3	U1	U7	U5	AŞTİ	Köşk	Hisar
Node	39	71	126	181	201	228	235	391	401	410	437	254	271	297	Node	39	71	126	181	201	228	235	391	401	410	437	254	271	297
Node134	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	Node199	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Node135	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0	Node200	0	0	0	0	2.38	0	0	0	0	0	0	0	0	0
Node136	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	Node202	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0
Node137	0	0	4.7	0	0	0	0	0	0	0	0	0	0	0	Node203	0	0	0	0	1.17	0	0	0	0	0	0	0	0	0
Node138	0	0	4.65	0	0	0	0	0	0	0	0	0	0	0	Node204	0	0	0	0	3.09	0	0	0	0	0	0	0	0	0
Node139	0	0	5.91	0	0	0	0	0	0	0	0	0	0	0	Node205	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0
Node140	0	0	0	0	0	0	0	0	0	0	6.5	0	0	0	Node206	0	0	0	0	3.45	0	0	0	0	0	0	0	0	0
Node141	0	0	0	0	0	0	0	0	0	5.55	0	0	0	0	Node207	0	0	0	0	6.9	0	0	0	0	0	0	0	0	0
Node142	0	0	0	0	0	0	0	0	0	4.7	0	0	0	0	Node208	0	0	0	0	6.65	0	0	0	0	0	0	0	0	0
Node143	0	0	0	0	0	0	0	0	0	2	0	0	0	0	Node209	0	0	0	0	5.85	0	0	0	0	0	0	0	0	0
Node144	0	0	0	0	0	0	0	0	0	2.35	0	0	0	0	Node210	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Node145	0	0	0	0	0	0	0	0	0	3.35	0	0	0	0	Node211	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0
Node146	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	Node212	0	2.25	0	0	0	0	0	0	0	0	0	0	0	0
Node147	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	Node213	0	3.95	0	0	0	0	0	0	0	0	0	0	0	0
Node148	0	0	0	0	0	0	0	0	0	6.7	0	0	0	0	Node214	0	3.85	0	0	0	0	0	0	0	0	0	0	0	0
Node149	0	0	0	6.3	0	0	0	0	0	0	0	0	0	0	Node215	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0
Node150	0	0	0	6.8	0	0	0	0	0	0	0	0	0	0	Node216	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0
Node151	0	0	6.88	0	0	0	0	0	0	0	0	0	0	0	Node217	0	0	0	0	4.6	0	0	0	0	0	0	0	0	0
Node152	0	0	5.18	0	0	0	0	0	0	0	0	0	0	0	Node218	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0
Node153	0	0	3.98	0	0	0	0	0	0	0	0	0	0	0	Node219	0	0	0	0	4.4	0	0	0	0	0	0	0	0	0
Node154	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	Node220	0	0	0	0	6.2	0	0	0	0	0	0	0	0	0
Node155	0	0	2.38	0	0	0	0	0	0	0	0	0	0	0	Node221	0	0	0	0	0	4.3	0	0	0	0	0	0	0	0
Node156	0	0	2.68	0	0	0	0	0	0	0	0	0	0	0	Node222	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
Node157	0	0	3.23	0	0	0	0	0	0	0	0	0	0	0	Node223	0	0	0	0	0	6.25	0	0	0	0	0	0	0	0
Node158	0	0	3.87	0	0	0	0	0	0	0	0	0	0	0	Node224	0	0	0	0	0	5.08	0	0	0	0	0	0	0	0
Node159	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	Node225	0	0	0	0	0	4.48	0	0	0	0	0	0	0	0
Node160	0	0	2.55	0	0	0	0	0	0	0	0	0	0	0	Node226	0	0	0	0	0	5.4	0	0	0	0	0	0	0	0
Node161	0	0	3.15	0	0	0	0	0	0	0	0	0	0	0	Node227	0	0	0	0	0	5.7	0	0	0	0	0	0	0	0
Node162	0	0	3.82	0	0	0	0	0	0	0	0	0	0	0	Node229	0	0	0	0	0	4.2	0	0	0	0	0	0	0	0
Node163	0	0	0	0	4.05	0	0	0	0	0	0	0	0	0	Node230	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0
Node164	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0	Node231	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0
Node165	0	0	4.4	0	0	0	0	0	0	0	0	0	0	0	Node232	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0
Node166	0	0	0	0	3.15	0	0	0	0	0	0	0	0	0	Node233	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0
Node167	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0	Node234	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0
Node168	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	Node236	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0
Node169	0	0	0	0	4.25	0	0	0	0	0	0	0	0	0	Node237	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0
Node170	0	0	0	0	4.55	0	0	0	0	0	0	0	0	0	Node238	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	Node239	0	0	0	0	0	0	2.7	0	0	0	0	0	0	0
Node172	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	Node240	0	0	0	0	0	0	3.9	0	0	0	0	0	0	0
Node173	0	0	0	0	6.08	0	0	0	0	0	0	0	0	0	Node241	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0
Node174	0	0	5.67	0	0	0	0	0	0	0	0	0	0	0	Node242	0	0	0	0	0	3.55	0	0	0	0	0	0	0	0
Node175	0	0	5.73	0	0	0	0	0	0	0	0	0	0	0	Node243	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0
Node176	0	0	0	5	0	0	0	0	0	0	0	0	0	0	Node244	0	0	0	0	0	5.9	0	0	0	0	0	0	0	0
Node177	0	0	0	5.7	0	0	0	0	0	0	0	0	0	0	Node245	0	0	0	0	0	4.95	0	0	0	0	0	0	0	0
Node178	0	0	0	5	0	0	0	0	0	0	0	0	0	0	Node246	5.78	0	0	0	0	0	0	0	0	0	0	0	0	0
Node179	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0	Node247	0	0	0	0	0	0	6.7	0	0	0	0	0	0	0
Node180	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	Node248	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	0	0	1.9	0	0	Node249	5.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node183	0	0	0	0	5.7	0	0	0	0	0	0	0	0	0	Node250	0	0	0	0	0	0	0	0	3.6	0	0	0	0	0
Node184	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	Node251	0	0	0	0	0	0	0	2.15	0	0	0	0	0	0
Node185	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	Node252	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Node186	0	0	0	0	1.15	0	0	0	0	0	0	0	0	0	Node253	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Node187	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0	Node255	0	0	3.91	0	0	0	0	0	0	0	0	0	0	0
Node188	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0	Node256	0	0	3.04	0	0	0	0	0	0	0	0	0	0	0
Node189	0	0	0	0	6.8	0	0	0	0	0	0	0	0	0	Node257	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0
Node190	0	0	4	0	0	0	0	0	0	0	0	0	0	0	Node258	0	0	0	0	0	4.1	0	0	0	0	0	0	0	0
Node191	0	0	4.2	0	0	0	0	0	0	0	0	0	0	0	Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	0	4.41	0	0	0	0	0	0	0	0	0	Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	0	4.23	0	0	0	0	0	0	0	0	0	Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node194	0	0	0	0	4.33	0	0	0	0	0	0	0	0	0	Node262	0	0	0	0	4.8	0	0	0	0	0	0	0	0	0
Node195	0	0	0	0	4.39	0	0	0	0	0	0	0	0	0	Node263	0	0	0	0	2.9	0	0	0	0	0	0	0	0	0
Node196	0	0	0	0	3.59	0	0	0	0	0	0	0	0	0	Node264	0	0	0	0	1.76	0	0	0	0	0	0	0	0	0
Node197	0	0	0	0	2.99	0	0	0	0	0	0	0	0	0	Node265	0	0	0	0	4.39	0	0	0	0	0	0	0	0	0
Node198	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0	Node266	0	0	0	0	3.54	0	0	0	0	0	0	0	0	0

Table D.2: Distances from unweighted fire stations to their assigned nodes-2

	U2	U4	U6	U8	U9	U10	U11	U3	U1	U7	U5	AŞTİ	Köşk	Hisar		U2	U4	U6	U8	U9	U10	U11	U3	U1	U7	U5	AŞTİ	Köşk	Hisar
Node	39	71	126	181	201	228	235	391	401	410	437	254	271	297	Node	39	71	126	181	201	228	235	391	401	410	437	254	271	297
Node267	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	Node334	0	0	5.3	0	0	0	0	0	0	0	0	0	0	0
Node268	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	Node335	0	0	5.06	0	0	0	0	0	0	0	0	0	0	0
Node269	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	Node336	0	0	5.25	0	0	0	0	0	0	0	0	0	0	0
Node270	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	Node337	0	0	4.26	0	0	0	0	0	0	0	0	0	0	0
Node272	0	0	0	0	4.58	0	0	0	0	0	0	0	0	0	Node338	0	0	4.9	0	0	0	0	0	0	0	0	0	0	0
Node273	0	0	0	0	5.29	0	0	0	0	0	0	0	0	0	Node339	0	0	4.21	0	0	0	0	0	0	0	0	0	0	0
Node274	0	0	0	0	5.06	0	0	0	0	0	0	0	0	0	Node340	0	0	0	0	0	0	0	0	0	0	5.45	0	0	0
Node275	0	0	0	0	4.9	0	0	0	0	0	0	0	0	0	Node341	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0
Node276	0	0	4.52	0	0	0	0	0	0	0	0	0	0	0	Node342	0	0	0	0	4.75	0	0	0	0	0	0	0	0	0
Node277	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	Node343	0	0	4.17	0	0	0	0	0	0	0	0	0	0	0
Node278	0	0	4.3	0	0	0	0	0	0	0	0	0	0	0	Node344	0	0	3.97	0	0	0	0	0	0	0	0	0	0	0
Node279	0	0	3.8	0	0	0	0	0	0	0	0	0	0	0	Node345	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0
Node280	0	0	3.36	0	0	0	0	0	0	0	0	0	0	0	Node346	0	0	0	0	0	0	0	0	4.9	0	0	0	0	0
Node281	0	0	0	0	3.85	0	0	0	0	0	0	0	0	0	Node347	0	0	0	0	0	0	0	0	6.51	0	0	0	0	0
Node282	0	0	0	0	3.95	0	0	0	0	0	0	0	0	0	Node348	0	0	0	0	0	0	0	0	5.31	0	0	0	0	0
Node283	0	0	4.26	0	0	0	0	0	0	0	0	0	0	0	Node349	0	0	0	0	0	0	0	0	5.18	0	0	0	0	0
Node284	0	0	3.96	0	0	0	0	0	0	0	0	0	0	0	Node350	0	0	0	0	0	0	0	0	5.29	0	0	0	0	0
Node285	0	0	3.27	0	0	0	0	0	0	0	0	0	0	0	Node351	0	0	0	0	0	0	0	0	5.46	0	0	0	0	0
Node286	0	0	0	0	3.89	0	0	0	0	0	0	0	0	0	Node352	0	0	0	0	0	0	0	0	5.58	0	0	0	0	0
Node287	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	Node353	0	0	0	0	0	0	0	0	6.59	0	0	0	0	0
Node288	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	Node354	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Node289	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0	Node355	0	0	0	0	0	0	0	0	2.15	0	0	0	0	0
Node290	0	0	5.27	0	0	0	0	0	0	0	0	0	0	0	Node356	0	0	0	0	0	0	0	0	3.47	0	0	0	0	0
Node291	0	0	4.05	0	0	0	0	0	0	0	0	0	0	0	Node357	0	0	0	0	0	0	0	0	4.37	0	0	0	0	0
Node292	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0	Node358	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	2.95	0	0	0	0	0	0	0	0	0	0	0	Node359	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0
Node294	0	0	2	0	0	0	0	0	0	0	0	0	0	0	Node360	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0
Node295	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0	Node361	0	0	0	0	0	0	0	0	2.45	0	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35	Node362	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0
Node298	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0	Node363	6.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node299	0	0	2.53	0	0	0	0	0	0	0	0	0	0	0	Node364	0	0	0	0	0	0	0	0	6.95	0	0	0	0	0
Node300	0	0	2.76	0	0	0	0	0	0	0	0	0	0	0	Node365	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Node301	0	0	2.77	0	0	0	0	0	0	0	0	0	0	0	Node366	0	0	0	0	0	0	0	0	6.05	0	0	0	0	0
Node302	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0	Node367	0	0	0	0	0	0	0	0	4.65	0	0	0	0	0
Node303	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0	Node368	0	0	0	0	0	0	0	0	5.35	0	0	0	0	0
Node304	0	0	2.32	0	0	0	0	0	0	0	0	0	0	0	Node369	3.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	2.03	0	0	0	0	0	0	0	0	0	0	0	Node370	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	4.53	0	0	0	0	0	0	0	0	0	0	0	Node371	4.95	0	0	0	0	0	0	0	0	0	0	0	0	0
Node307	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	Node372	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0
Node308	0	1.68	0	0	0	0	0	0	0	0	0	0	0	0	Node373	0	4.35	0	0	0	0	0	0	0	0	0	0	0	0
Node309	0	2.75	0	0	0	0	0	0	0	0	0	0	0	0	Node374	0	0	0	0	0	0	0	3.48	0	0	0	0	0	0
Node310	0	2.48	0	0	0	0	0	0	0	0	0	0	0	0	Node375	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0
Node311	0	1.65	0	0	0	0	0	0	0	0	0	0	0	0	Node376	0	0	0	0	0	0	0	4.5	0	0	0	0	0	0
Node312	0	2.43	0	0	0	0	0	0	0	0	0	0	0	0	Node377	0	0	0	0	0	0	0	2.65	0	0	0	0	0	0
Node313	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	Node378	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
Node314	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0	Node379	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Node315	0	2.75	0	0	0	0	0	0	0	0	0	0	0	0	Node380	0	0	0	0	0	0	0	2.68	0	0	0	0	0	0
Node316	0	0	5.48	0	0	0	0	0	0	0	0	0	0	0	Node381	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0
Node317	0	0	3.83	0	0	0	0	0	0	0	0	0	0	0	Node382	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0
Node318	0	0	3.78	0	0	0	0	0	0	0	0	0	0	0	Node383	0	0	0	0	0	0	0	2.81	0	0	0	0	0	0
Node319	0	0	5.23	0	0	0	0	0	0	0	0	0	0	0	Node384	0	0	0	0	0	0	0	2.82	0	0	0	0	0	0
Node320	0	0	5.58	0	0	0	0	0	0	0	0	0	0	0	Node385	0	0	0	0	0	2.9	0	0	0	0	0	0	0	0
Node321	0	0	5.45	0	0	0	0	0	0	0	0	0	0	0	Node386	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0
Node322	0	0	4.93	0	0	0	0	0	0	0	0	0	0	0	Node387	0	0	0	0	0	4.2	0	0	0	0	0	0	0	0
Node323	0	0	5.28	0	0	0	0	0	0	0	0	0	0	0	Node388	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Node324	0	0	4.3	0	0	0	0	0	0	0	0	0	0	0	Node389	0	0	0	0	0	4.6	0	0	0	0	0	0	0	0
Node325	0	0	0	0	0	0	0	0	0	4.6	0	0	0	0	Node390	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0
Node326	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	Node392	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0
Node327	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	Node393	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Node328	0	0	4.75	0	0	0	0	0	0	0	0	0	0	0	Node394	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0
Node329	0	0	0	0	0	0	0	0	0	5.6	0	0	0	0	Node395	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0
Node330	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	Node396	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0
Node331	0	0	0	0	0	0	0	4.95	0	0	0	0	0	0	Node397	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0
Node332	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	Node398	0	0	0	0	0	0	0	0	5.76	0	0	0	0	0
Node333	0	0	4.4	0	0	0	0	0	0	0	0	0	0	0	Node399	6.38	0	0	0	0	0	0	0	0	0	0	0	0	0

Table D.3: Distances from unweighted fire stations to their assigned nodes-3

Node	U2 39	U4 71	U6 126	U8 181	U9 201	U10 228	U11 235	U3 391	U1 401	U7 410	U5 437	AŞTİ 254	Köşk 271	Hisar 297
Node400	5.88	0	0	0	0	0	0	0	0	0	0	0	0	0
Node402	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0
Node403	0	0	0	0	0	0	0	0	1.37	0	0	0	0	0
Node404	0	0	0	0	0	0	0	0	1.02	0	0	0	0	0
Node405	0	0	0	0	0	0	0	0	0.45	0	0	0	0	0
Node406	0	0	0	0	0	0	0	0	0.65	0	0	0	0	0
Node407	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0
Node408	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node409	0	0	0	0	0	0	0	0	4.95	0	0	0	0	0
Node411	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0
Node412	0	0	0	0	0	0	0	0	0	0.85	0	0	0	0
Node413	0	0	0	0	0	0	0	0	0	1.35	0	0	0	0
Node414	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0
Node415	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0
Node416	0	0	0	0	0	0	0	0	0	1.95	0	0	0	0
Node417	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0
Node418	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0
Node419	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0
Node420	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	6.1	0	0	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Node430	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Node431	0	0	0	2.9	0	0	0	0	0	0	0	0	0	0
Node432	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Node433	0	0	0	0	0	0	0	0	0	4.3	0	0	0	0
Node434	0	0	0	0	0	0	0	0	0	5.2	0	0	0	0
Node435	0	0	0	0	0	0	0	0	0	5.35	0	0	0	0
Node436	0	0	0	0	0	0	0	0	0	0	5.5	0	0	0
Node438	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0
Node439	0	0	0	0	0	0	0	4.3	0	0	0	0	0	0
Node440	0	0	0	0	0	0	0	6.35	0	0	0	0	0	0
Node441	0	0	0	0	0	0	0	6.75	0	0	0	0	0	0
Node442	0	0	0	0	0	0	0	5.65	0	0	0	0	0	0
Node443	0	0	0	0	0	0	0	0	6.45	0	0	0	0	0
Node444	6.58	0	0	0	0	0	0	0	0	0	0	0	0	0
Node445	2.98	0	0	0	0	0	0	0	0	0	0	0	0	0
Node446	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node447	0	6.7	0	0	0	0	0	0	0	0	0	0	0	0
Node448	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0
Node449	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0
Node450	0	0	0	6.9	0	0	0	0	0	0	0	0	0	0
Node451	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
Node452	0	0	0	0	0	0	0	2.95	0	0	0	0	0	0
max	6.58	6.97	6.88	6.9	6.9	7	6.7	6.95	6.7	6.7	6.75	0.55	1.9	0.35

Table D.4: Distances from unweighted fire stations to their assigned nodes-4

Appendix E

Tables of Weighted Assignment of Fire Stations

	w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar		w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar
Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297	Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297
Node1	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	Node67	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0
Node2	3.05	0	0	0	0	0	0	0	0	0	0	0	0	0	Node69	0	3.38	0	0	0	0	0	0	0	0	0	0	0	0
Node3	2.05	0	0	0	0	0	0	0	0	0	0	0	0	0	Node70	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
Node4	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	Node71	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0
Node5	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0	Node72	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0
Node6	4.85	0	0	0	0	0	0	0	0	0	0	0	0	0	Node73	0	3.43	0	0	0	0	0	0	0	0	0	0	0	0
Node7	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	Node74	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0
Node8	5.25	0	0	0	0	0	0	0	0	0	0	0	0	0	Node75	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0
Node9	6.8	0	0	0	0	0	0	0	0	0	0	0	0	0	Node76	0	0	0	0	0	0	0	0	0	3.55	0	0	0	0
Node10	6.47	0	0	0	0	0	0	0	0	0	0	0	0	0	Node77	0	0	0	0	0	0	0	0	0	0	4.1	0	0	0
Node11	5.75	0	0	0	0	0	0	0	0	0	0	0	0	0	Node78	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Node12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	Node79	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0
Node14	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	Node80	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0
Node15	8.7	0	0	0	0	0	0	0	0	0	0	0	0	0	Node81	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0
Node16	6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	Node82	0	4.75	0	0	0	0	0	0	0	0	0	0	0	0
Node17	5.95	0	0	0	0	0	0	0	0	0	0	0	0	0	Node83	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0
Node18	5.72	0	0	0	0	0	0	0	0	0	0	0	0	0	Node84	0	4.75	0	0	0	0	0	0	0	0	0	0	0	0
Node19	4.82	0	0	0	0	0	0	0	0	0	0	0	0	0	Node85	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0
Node20	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0	Node86	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0
Node21	3.15	0	0	0	0	0	0	0	0	0	0	0	0	0	Node87	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0
Node22	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	Node88	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0
Node23	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	Node89	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Node24	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0	Node90	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0
Node25	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	Node91	0	0	0	5.14	0	0	0	0	0	0	0	0	0	0
Node26	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	Node92	0	5.3	0	0	0	0	0	0	0	0	0	0	0	0
Node27	10.9	0	0	0	0	0	0	0	0	0	0	0	0	0	Node93	0	5.59	0	0	0	0	0	0	0	0	0	0	0	0
Node28	6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	Node94	0	0	0	5.44	0	0	0	0	0	0	0	0	0	0
Node29	7.2	0	0	0	0	0	0	0	0	0	0	0	0	0	Node95	0	0	0	4.84	0	0	0	0	0	0	0	0	0	0
Node30	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0	Node96	0	0	0	3.54	0	0	0	0	0	0	0	0	0	0
Node31	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	Node97	0	0	0	0	0	0	0	0	0	3.61	0	0	0	0
Node32	3.95	0	0	0	0	0	0	0	0	0	0	0	0	0	Node98	0	0	0	2.84	0	0	0	0	0	0	0	0	0	0
Node33	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	Node99	0	0	0	3.64	0	0	0	0	0	0	0	0	0	0
Node34	0	0	0	0	0	0	0	0	0	0	10	0	0	0	Node100	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0
Node35	0	9.25	0	0	0	0	0	0	0	0	0	0	0	0	Node101	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0
Node36	7.8	0	0	0	0	0	0	0	0	0	0	0	0	0	Node102	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0
Node37	7.25	0	0	0	0	0	0	0	0	0	0	0	0	0	Node103	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0
Node38	6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	Node104	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0
Node39	4.65	0	0	0	0	0	0	0	0	0	0	0	0	0	Node105	0	0	0	0.95	0	0	0	0	0	0	0	0	0	0
Node40	4.83	0	0	0	0	0	0	0	0	0	0	0	0	0	Node106	0	0	0	2.54	0	0	0	0	0	0	0	0	0	0
Node41	5.15	0	0	0	0	0	0	0	0	0	0	0	0	0	Node107	0	0	0	2.14	0	0	0	0	0	0	0	0	0	0
Node42	0	7	0	0	0	0	0	0	0	0	0	0	0	0	Node108	0	0	0	0	0	0	0	0	0	2.61	0	0	0	0
Node43	0	6.67	0	0	0	0	0	0	0	0	0	0	0	0	Node110	0	0	0.85	0	0	0	0	0	0	0	0	0	0	0
Node44	0	5	0	0	0	0	0	0	0	0	0	0	0	0	Node111	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0
Node45	0	6.3	0	0	0	0	0	0	0	0	0	0	0	0	Node112	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Node46	0	5.27	0	0	0	0	0	0	0	0	0	0	0	0	Node113	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0
Node47	0	6.57	0	0	0	0	0	0	0	0	0	0	0	0	Node114	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0
Node48	0	5.65	0	0	0	0	0	0	0	0	0	0	0	0	Node116	0	0	0	1.24	0	0	0	0	0	0	0	0	0	0
Node49	0	4.9	0	0	0	0	0	0	0	0	0	0	0	0	Node117	0	0	0	1.74	0	0	0	0	0	0	0	0	0	0
Node50	0	5.09	0	0	0	0	0	0	0	0	0	0	0	0	Node118	0	0	3.1	0	0	0	0	0	0	0	0	0	0	0
Node51	0	4.47	0	0	0	0	0	0	0	0	0	0	0	0	Node119	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0
Node52	0	3.07	0	0	0	0	0	0	0	0	0	0	0	0	Node120	0	0	0	2.34	0	0	0	0	0	0	0	0	0	0
Node53	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	Node121	0	0	0	1.69	0	0	0	0	0	0	0	0	0	0
Node54	0	0	0	0	0	0	0	0	0	0	6.7	0	0	0	Node122	0	0	0	0.89	0	0	0	0	0	0	0	0	0	0
Node55	0	5.19	0	0	0	0	0	0	0	0	0	0	0	0	Node123	0	0	0	0.44	0	0	0	0	0	0	0	0	0	0
Node56	0	4.95	0	0	0	0	0	0	0	0	0	0	0	0	Node124	0	0	0	0.14	0	0	0	0	0	0	0	0	0	0
Node57	0	4.7	0	0	0	0	0	0	0	0	0	0	0	0	Node125	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0
Node58	0	2.9	0	0	0	0	0	0	0	0	0	0	0	0	Node126	0	0	0	0	0	0	0	0	0	4.26	0	0	0	0
Node59	0	0	0	0	0	0	0	0	0	0	4.85	0	0	0	Node127	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0
Node60	0	0	0	0	0	0	0	0	0	0	4.1	0	0	0	Node128	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Node61	0	3.95	0	0	0	0	0	0	0	0	0	0	0	0	Node129	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
Node62	0	0	0	0	0	0	0	0	0	0	3.85	0	0	0	Node130	0	0	0	0	0	0	0	0	0	0.61	0	0	0	0
Node63	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	Node131	0	0	0	0	0	0	0	0	0	1.81	0	0	0	0
Node64	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	Node132	0	0	0	0	0	0	0	0	0	2.51	0	0	0	0
Node65	0	4.05	0	0	0	0	0	0	0	0	0	0	0	0	Node133	0	0	0	0	0	0	0	0	0	3.51	0	0	0	0
Node66	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	Node134	0	0	0	0	0	0	0	0	0	5.51	0	0	0	0

Table E.1: Distances from weighted fire stations to their assigned nodes-1

	w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar		w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar
Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297	Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297
Node135	0	0	0	0	0	0	0	0	0	4.26	0	0	0	0	Node202	0	0	0	0	0	0	5.6	0	0	0	0	0	0	0
Node136	0	0	0	0	0	0	0	0	0	4.68	0	0	0	0	Node203	0	0	0	0	0	0	5.3	0	0	0	0	0	0	0
Node137	0	0	0	0	0	0	0	0	0	3.28	0	0	0	0	Node204	0	0	0	0	0	0	3.54	0	0	0	0	0	0	0
Node138	0	0	0	0	0	0	0	0	0	2.05	0	0	0	0	Node205	0	0	0	0	0	0	3.15	0	0	0	0	0	0	0
Node139	0	0	0	0	0	0	0	0	0	2.45	0	0	0	0	Node206	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0
Node140	0	0	0	0	0	0	0	0	0	3.35	0	0	0	0	Node207	0	0	0	0	0	0	2.9	0	0	0	0	0	0	0
Node141	0	0	0	0	0	0	0	0	0	4.73	0	0	0	0	Node208	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0
Node142	0	0	0	0	0	0	0	0	0	4.1	0	0	0	0	Node210	0	0	0	0	0	0	4.2	0	0	0	0	0	0	0
Node143	0	0	0	0	0	0	0	0	0	6.3	0	0	0	0	Node211	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0
Node144	0	0	0	0	0	0	0	0	0	6.55	0	0	0	0	Node212	0	3.95	0	0	0	0	0	0	0	0	0	0	0	0
Node145	0	0	0	0	0	0	0	0	0	5.55	0	0	0	0	Node213	0	4.55	0	0	0	0	0	0	0	0	0	0	0	0
Node146	0	0	0	0	0	0	0	0	0	8.5	0	0	0	0	Node214	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Node147	0	0	0	0	0	0	0	0	0	10.2	0	0	0	0	Node215	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0
Node148	0	0	0	0	0	8.1	0	0	0	0	0	0	0	0	Node216	0	4.85	0	0	0	0	0	0	0	0	0	0	0	0
Node149	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	Node217	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0
Node150	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	Node218	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
Node151	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	Node219	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
Node152	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	Node220	0	5.4	0	0	0	0	0	0	0	0	0	0	0	0
Node153	0	0	0	0	0	4.6	0	0	0	0	0	0	0	0	Node221	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Node154	0	0	0	0	0	0	0	0	0	4.96	0	0	0	0	Node222	0	4.5	0	0	0	0	0	0	0	0	0	0	0	0
Node155	0	0	0	0	4.95	0	0	0	0	0	0	0	0	0	Node223	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Node156	0	0	0	0	4.65	0	0	0	0	0	0	0	0	0	Node224	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0
Node157	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	Node225	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0
Node158	0	0	0	0	3.98	0	0	0	0	0	0	0	0	0	Node226	0	0	0	0	0	0	0	5.4	0	0	0	0	0	0
Node159	0	0	0	0	0	0	0	0	0	5.16	0	0	0	0	Node227	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0
Node160	0	0	0	0	4.85	0	0	0	0	0	0	0	0	0	Node229	0	0	0	0	0	0	0	4.2	0	0	0	0	0	0
Node161	0	0	0	0	4.25	0	0	0	0	0	0	0	0	0	Node230	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0
Node162	0	0	0	0	3.43	0	0	0	0	0	0	0	0	0	Node231	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0
Node163	0	0	0	0	3.54	0	0	0	0	0	0	0	0	0	Node232	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0
Node164	0	0	0	0	5.77	0	0	0	0	0	0	0	0	0	Node233	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0
Node165	0	0	0	0	4.77	0	0	0	0	0	0	0	0	0	Node234	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Node166	0	0	0	0	3.24	0	0	0	0	0	0	0	0	0	Node235	0	0	0	0	0	0	0	0	5.4	0	0	0	0	0
Node167	0	0	0	0	2.84	0	0	0	0	0	0	0	0	0	Node236	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0
Node168	0	0	0	0	3.34	0	0	0	0	0	0	0	0	0	Node237	0	0	0	0	0	0	0	0	5.4	0	0	0	0	0
Node169	0	0	0	0	2.14	0	0	0	0	0	0	0	0	0	Node238	0	0	0	0	0	0	0	0	7.7	0	0	0	0	0
Node170	0	0	0	0	2.88	0	0	0	0	0	0	0	0	0	Node239	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	Node240	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0
Node172	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	Node241	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0
Node174	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	Node242	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0
Node175	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	Node243	0	0	0	0	0	0	0	0	1.75	0	0	0	0	0
Node176	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	Node244	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0
Node177	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	Node246	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0
Node179	0	4.35	0	0	0	0	0	0	0	0	0	0	0	0	Node247	0	0	0	0	0	0	0	0	6.3	0	0	0	0	0
Node180	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	Node248	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0
Node181	0	0	0	0	0	5	0	0	0	0	0	0	0	0	Node249	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	0	0	1.9	0	0	Node250	5.05	0	0	0	0	0	0	0	0	0	0	0	0	0
Node183	0	0	0	0	4.68	0	0	0	0	0	0	0	0	0	Node251	0	0	0	0	0	0	0	0	0	0	7.7	0	0	0
Node184	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	Node252	0	0	0	0	4.09	0	0	0	0	0	0	0	0	0
Node185	0	0	0	0	4.48	0	0	0	0	0	0	0	0	0	Node253	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Node186	0	0	0	0	4.93	0	0	0	0	0	0	0	0	0	Node255	0	0	0	0	4.04	0	0	0	0	0	0	0	0	0
Node187	0	0	0	0	5.63	0	0	0	0	0	0	0	0	0	Node256	0	0	0	5.68	0	0	0	0	0	0	0	0	0	0
Node188	0	0	0	0	0	0	4.39	0	0	0	0	0	0	0	Node257	0	0	0	0	3.64	0	0	0	0	0	0	0	0	0
Node189	0	0	0	0	0	0	5.4	0	0	0	0	0	0	0	Node258	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0
Node190	0	0	0	0	6.12	0	0	0	0	0	0	0	0	0	Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	0	6.32	0	0	0	0	0	0	0	0	0	Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node192	0	6.03	0	0	0	0	0	0	0	0	0	0	0	0	Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node193	0	5.85	0	0	0	0	0	0	0	0	0	0	0	0	Node262	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Node194	0	0	0	0	4.72	0	0	0	0	0	0	0	0	0	Node263	0	0	0	0	0	0	0	3.35	0	0	0	0	0	0
Node195	0	0	0	0	5.12	0	0	0	0	0	0	0	0	0	Node264	0	0	0	0	0	0	0	4.44	0	0	0	0	0	0
Node196	0	0	0	0	5.92	0	0	0	0	0	0	0	0	0	Node265	0	0	0	0	0	0	0	4.84	0	0	0	0	0	0
Node197	0	5.76	0	0	0	0	0	0	0	0	0	0	0	0	Node266	0	0	0	0	0	0	0	3.99	0	0	0	0	0	0
Node198	0	0	0	0	4.19	0	0	0	0	0	0	0	0	0	Node267	0	0	0	0	0	0	4.6	0	0	0	0	0	0	0
Node199	0	0	0	0	4.99	0	0	0	0	0	0	0	0	0	Node268	0	0	0	0	0	0	5.57	0	0	0	0	0	0	0
Node200	0	5.65	0	0	0	0	0	0	0	0	0	0	0	0	Node269	0	5.83	0	0	0	0	0	0	0	0	0	0	0	0
Node201	0	0	0	0	0	0	5.85	0	0	0	0	0	0	0	Node270	0	0	0	0	5.34	0	0	0	0	0	0	0	0	0

Table E.2: Distances from weighted fire stations to their assigned nodes-2

	w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar		w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar
Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297	Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297
Node272	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	Node339	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0
Node273	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	Node340	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0
Node274	0	0	0	0	1.33	0	0	0	0	0	0	0	0	0	Node341	0	0	0	0	0	0	0	0	0	1.91	0	0	0	0
Node275	0	0	0	0	1.49	0	0	0	0	0	0	0	0	0	Node342	0	0	0	0	2.84	0	0	0	0	0	0	0	0	0
Node276	0	0	0	0	2.73	0	0	0	0	0	0	0	0	0	Node343	0	0	0	0	3.08	0	0	0	0	0	0	0	0	0
Node277	0	0	0	0	0	0	5.73	0	0	0	0	0	0	0	Node344	0	0	0	0	3.28	0	0	0	0	0	0	0	0	0
Node278	0	0	0	0	4.49	0	0	0	0	0	0	0	0	0	Node345	0	0	0	0	0	0	6.33	0	0	0	0	0	0	0
Node279	0	0	0	0	4.27	0	0	0	0	0	0	0	0	0	Node346	5.15	0	0	0	0	0	0	0	0	0	0	0	0	0
Node280	0	0	0	0	4.04	0	0	0	0	0	0	0	0	0	Node347	6.76	0	0	0	0	0	0	0	0	0	0	0	0	0
Node281	0	0	0	0	2.54	0	0	0	0	0	0	0	0	0	Node348	5.56	0	0	0	0	0	0	0	0	0	0	0	0	0
Node282	0	0	0	0	3.24	0	0	0	0	0	0	0	0	0	Node349	5.43	0	0	0	0	0	0	0	0	0	0	0	0	0
Node283	0	0	0	0	3.14	0	0	0	0	0	0	0	0	0	Node350	5.54	0	0	0	0	0	0	0	0	0	0	0	0	0
Node284	0	0	0	0	3.44	0	0	0	0	0	0	0	0	0	Node351	5.71	0	0	0	0	0	0	0	0	0	0	0	0	0
Node285	0	0	0	0	3.98	0	0	0	0	0	0	0	0	0	Node352	5.83	0	0	0	0	0	0	0	0	0	0	0	0	0
Node286	0	0	0	0	5.62	0	0	0	0	0	0	0	0	0	Node353	6.84	0	0	0	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	0	0	0	5.33	0	0	0	0	0	0	0	Node354	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node288	0	5.25	0	0	0	0	0	0	0	0	0	0	0	0	Node355	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node289	0	5.65	0	0	0	0	0	0	0	0	0	0	0	0	Node356	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node290	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	Node357	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node291	0	0	0	0	0	0	0	0	0	2.65	0	0	0	0	Node358	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node292	0	0	0	0	0	0	0	0	0	5.56	0	0	0	0	Node359	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	0	5.25	0	0	0	0	0	0	0	0	0	Node360	6.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Node294	0	0	0	0	0	0	0	0	0	4.96	0	0	0	0	Node361	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Node295	0	0	0	0	0	0	0	0	0	4.61	0	0	0	0	Node362	6.07	0	0	0	0	0	0	0	0	0	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35	Node363	0	5.17	0	0	0	0	0	0	0	0	0	0	0	0
Node298	0	0	0	0	4.95	0	0	0	0	0	0	0	0	0	Node364	0	7.75	0	0	0	0	0	0	0	0	0	0	0	0
Node299	0	0	0	0	4.72	0	0	0	0	0	0	0	0	0	Node365	0	6.09	0	0	0	0	0	0	0	0	0	0	0	0
Node300	0	0	0	0	4.73	0	0	0	0	0	0	0	0	0	Node366	0	6.85	0	0	0	0	0	0	0	0	0	0	0	0
Node301	0	0	0	0	4.48	0	0	0	0	0	0	0	0	0	Node367	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Node302	0	0	0	0	4.74	0	0	0	0	0	0	0	0	0	Node368	0	5.3	0	0	0	0	0	0	0	0	0	0	0	0
Node303	0	0	0	0	5.38	0	0	0	0	0	0	0	0	0	Node369	7.95	0	0	0	0	0	0	0	0	0	0	0	0	0
Node304	0	0	0	0	5.35	0	0	0	0	0	0	0	0	0	Node370	0	6.2	0	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	0	0	5.3	0	0	0	0	0	0	0	0	0	Node371	0	6.75	0	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	Node372	0	4.55	0	0	0	0	0	0	0	0	0	0	0	0
Node307	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	Node373	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
Node308	0	2.53	0	0	0	0	0	0	0	0	0	0	0	0	Node374	0	5.2	0	0	0	0	0	0	0	0	0	0	0	0
Node309	0	3.63	0	0	0	0	0	0	0	0	0	0	0	0	Node375	0	5.15	0	0	0	0	0	0	0	0	0	0	0	0
Node310	0	3.48	0	0	0	0	0	0	0	0	0	0	0	0	Node376	0	5.59	0	0	0	0	0	0	0	0	0	0	0	0
Node311	0	3.35	0	0	0	0	0	0	0	0	0	0	0	0	Node377	0	6.83	0	0	0	0	0	0	0	0	0	0	0	0
Node312	0	4.13	0	0	0	0	0	0	0	0	0	0	0	0	Node378	0	0	0	0	0	0	0	0	0	0	5.95	0	0	0
Node313	0	0	0	0	0	0	0	0	0	0	4.5	0	0	0	Node379	0	6.18	0	0	0	0	0	0	0	0	0	0	0	0
Node314	0	4.75	0	0	0	0	0	0	0	0	0	0	0	0	Node380	0	5.97	0	0	0	0	0	0	0	0	0	0	0	0
Node315	0	4.45	0	0	0	0	0	0	0	0	0	0	0	0	Node381	0	5.78	0	0	0	0	0	0	0	0	0	0	0	0
Node316	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	Node382	0	5.48	0	0	0	0	0	0	0	0	0	0	0	0
Node317	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	Node383	0	5.37	0	0	0	0	0	0	0	0	0	0	0	0
Node318	0	0	0	0	0	4.4	0	0	0	0	0	0	0	0	Node384	0	5.83	0	0	0	0	0	0	0	0	0	0	0	0
Node319	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0	Node385	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0
Node320	0	0	0	0	0	3	0	0	0	0	0	0	0	0	Node386	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0
Node321	0	0	0	0	0	0	0	0	0	4.03	0	0	0	0	Node387	0	0	0	0	0	0	0	4.2	0	0	0	0	0	0
Node322	0	0	0	0	0	0	0	0	0	3.05	0	0	0	0	Node388	0	0	0	0	0	0	0	7	0	0	0	0	0	0
Node323	0	0	0	0	0	0	0	0	0	2.7	0	0	0	0	Node389	0	0	0	0	0	0	0	4.6	0	0	0	0	0	0
Node324	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	Node390	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0
Node325	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	Node391	0	0	0	0	0	0	0	0	0	0	6.35	0	0	0
Node326	0	0	0	0	0	0	0	0	0	2.21	0	0	0	0	Node392	0	0	0	0	0	0	0	0	0	0	6.4	0	0	0
Node327	0	0	0	0	0	0	5.53	0	0	0	0	0	0	0	Node393	0	0	0	0	0	0	0	0	0	0	5.2	0	0	0
Node328	0	0	0	0	0	0	0	0	0	1.95	0	0	0	0	Node394	0	0	0	0	0	0	0	0	0	0	5.3	0	0	0
Node329	0	0	0	0	0	0	0	0	0	3.05	0	0	0	0	Node395	0	0	0	0	0	0	0	0	0	0	4.6	0	0	0
Node330	0	0	0	0	0	0	0	0	0	4.6	0	0	0	0	Node396	0	0	0	0	0	0	0	0	0	0	5.45	0	0	0
Node331	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	Node397	0	0	0	0	4.49	0	0	0	0	0	0	0	0	0
Node332	0	0	0	0	0	0	0	0	0	1.15	0	0	0	0	Node398	6.01	0	0	0	0	0	0	0	0	0	0	0	0	0
Node333	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	Node399	2.53	0	0	0	0	0	0	0	0	0	0	0	0	0
Node334	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	Node400	1.93	0	0	0	0	0	0	0	0	0	0	0	0	0
Node335	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	Node401	5.85	0	0	0	0	0	0	0	0	0	0	0	0	0
Node336	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	Node402	6.95	0	0	0	0	0	0	0	0	0	0	0	0	0
Node338	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	Node403	7.22	0	0	0	0	0	0	0	0	0	0	0	0	0

Table E.3: Distances from weighted fire stations to their assigned nodes-3

	w1	w2	w4	w5	w8	w7	w9	w10	w11	w6	w3	AŞTİ	Köşk	Hisar
Node	13	68	109	115	173	178	209	228	245	337	440	254	271	297
Node404	6.87	0	0	0	0	0	0	0	0	0	0	0	0	0
Node405	6.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node406	6.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node407	7.15	0	0	0	0	0	0	0	0	0	0	0	0	0
Node408	4.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node409	5.05	0	0	0	0	0	0	0	0	0	0	0	0	0
Node410	0	0	0	0	0	0	0	0	0	8.3	0	0	0	0
Node411	0	0	0	0	0	0	0	0	0	9.1	0	0	0	0
Node412	0	0	0	0	0	0	0	0	0	8	0	0	0	0
Node413	0	0	0	0	0	0	0	0	0	8.45	0	0	0	0
Node414	0	0	0	0	0	0	0	0	0	8.7	0	0	0	0
Node415	0	0	0	0	0	0	0	0	0	8.1	0	0	0	0
Node416	0	0	0	0	0	0	0	0	0	7.65	0	0	0	0
Node417	0	0	0	0	0	0	0	0	0	7.3	0	0	0	0
Node418	0	0	0	0	0	0	0	0	0	7.4	0	0	0	0
Node419	0	0	0	0	4.24	0	0	0	0	0	0	0	0	0
Node420	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	0	0	11.4	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	0	0	10	0	0	0	0	0	0	0	0
Node430	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Node431	0	0	0	0	0	7.9	0	0	0	0	0	0	0	0
Node432	0	0	0	0	0	8.2	0	0	0	0	0	0	0	0
Node433	0	0	0	0	0	10.5	0	0	0	0	0	0	0	0
Node434	0	0	9.8	0	0	0	0	0	0	0	0	0	0	0
Node435	0	0	0	0	0	0	0	0	0	5.25	0	0	0	0
Node436	0	0	7.2	0	0	0	0	0	0	0	0	0	0	0
Node437	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0
Node438	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Node439	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0
Node441	0	0	0	0	0	0	0	0	0	0	12.3	0	0	0
Node442	0	9.83	0	0	0	0	0	0	0	0	0	0	0	0
Node443	9.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node444	6.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node445	0	0	0	0	0	0	0	0	5.9	0	0	0	0	0
Node446	0	0	0	0	0	0	0	0	6.4	0	0	0	0	0
Node447	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Node448	0	5.4	0	0	0	0	0	0	0	0	0	0	0	0
Node449	0	3.95	0	0	0	0	0	0	0	0	0	0	0	0
Node450	0	0	0	0	0	6.3	0	0	0	0	0	0	0	0
Node451	0	0	0	0	0	0	5.8	0	0	0	0	0	0	0
Node452	0	7.13	0	0	0	0	0	0	0	0	0	0	0	0
max	10.9	9.83	9.8	5.68	6.32	10.5	6.33	7	11.4	10.2	12.3	0.55	1.9	0.35

Table E.4: Distances from weighted fire stations to their assigned nodes-4

Appendix F

Tables of Time Restricted Models

Tables for 4-Minute Coverage

	4T12	4T217	4T326	4T643	4T769	4T9111	4T10115	4T11139	4T14178	4T23189	4T22206	4T20224	4T19231	4T17237	4T18238	4T4246	4T25288	4T21344	4T26390	4T8392	4T13411	4T16430	4T15432	4T12436	4T24440	4T5441	AŞTİ254	Köşk271	Hisar297
Node1	2.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node4	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node5	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node6	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node7	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node8	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node9	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node10	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node11	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node12	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node13	3.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node14	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node15	0	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node16	0	0.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node18	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node19	0	2.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node20	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node21	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node22	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node23	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node24	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node25	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.1	0	0	0
Node28	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node29	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node30	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node31	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node32	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node33	0	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	0	0	0
Node35	0	0	0	2.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node36	0	0	0	3.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node37	0	0	0	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node38	0	0	0	3.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node39	0	0	3.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node40	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node41	0	0	3.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node42	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node44	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node45	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node46	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0
Node48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0
Node49	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node50	0	0	0	2.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node51	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node52	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node53	0	0	0	3.87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0
Node55	0	0	0	0	3.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node56	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node57	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node58	0	0	0	0	3.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0
Node60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	0	0
Node61	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node62	0	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node63	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node64	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node65	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node66	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table F.1: 4-minute time-restricted model: Distances between fire stations and their assigned nodes-1

	4T1 2	4T2 17	4T3 26	4T6 43	4T7 69	4T9 111	4T10 115	4T11 139	4T14 178	4T23 189	4T22 206	4T20 224	4T19 231	4T17 237	4T18 238	4T4 246	4T25 288	4T21 344	4T26 390	4T8 392	4T13 411	4T16 430	4T15 432	4T12 436	4T24 440	4T5 441	AŞTİ 254	Köşk 271	Hisar 297
Node67	0	0	0	0	1.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node68	0	0	0	0	3.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node70	0	0	0	0	0.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node71	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node72	0	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node73	0	0	0	0	0.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node74	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node75	0	0	0	0	0	0	1.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node76	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node77	0	0	0	0	2.83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Node79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0
Node80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0
Node81	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node82	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node83	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node84	0	0	0	0	3.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node85	0	0	0	0	0	3.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node86	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node87	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node88	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node89	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node90	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.94	0	0	0	0	0	0	0	0	0	0	0
Node92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.75	0	0	0	0	0	0	0	0	0	0	0
Node93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.75	0	0	0	0	0	0	0	0	0	0	0
Node94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0
Node95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.74	0	0	0	0	0	0	0	0	0	0	0
Node96	0	0	0	0	0	0	3.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.32	0	0	0	0	0	0	0	0	0	0	0
Node98	0	0	0	0	0	0	2.84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node99	0	0	0	0	0	0	3.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node100	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node101	0	0	0	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node102	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node103	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node104	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node105	0	0	0	0	0	0	0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node106	0	0	0	0	0	0	2.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node107	0	0	0	0	0	0	2.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node108	0	0	0	0	0	0	3.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node109	0	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node110	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node112	0	0	0	0	0	0.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node113	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node114	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node116	0	0	0	0	0	0	1.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node117	0	0	0	0	0	0	1.74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node118	0	0	0	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node119	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node120	0	0	0	0	0	0	2.34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node121	0	0	0	0	0	0	1.69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node122	0	0	0	0	0	0	0.89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node123	0	0	0	0	0	0	0.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node124	0	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node125	0	0	0	0	0	0	1.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.97	0	0	0	0	0	0	0	0	0	0	0
Node127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0
Node128	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node129	0	0	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node130	0	0	0	0	0	0	0	2.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node131	0	0	0	0	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node132	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node133	0	0	0	0	0	0	0	3.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table F.2: 4-minute time-restricted model: Distances between fire stations and their assigned nodes-2

	4T1	4T2	4T3	4T6	4T7	4T9	4T10	4T11	4T14	4T23	4T22	4T20	4T19	4T17	4T18	4T4	4T25	4T21	4T26	4T8	4T13	4T16	4T15	4T12	4T24	4T5	AŞTİ	Köşk	Hisar
	2	17	26	43	69	111	115	139	178	189	206	224	231	237	238	246	288	344	390	392	411	430	432	436	440	441	254	271	297
Node134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.71	0	0	0	0	0	0	0	0	0	0	0
Node135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0
Node136	0	0	0	0	0	0	0	3.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node137	0	0	0	0	0	0	0	2.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node138	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node140	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node141	0	0	0	0	0	0	0	2.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node142	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0
Node144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.15	0	0	0	0	0	0	0	0
Node145	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0
Node147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0
Node148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0
Node149	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node150	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node151	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node152	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0
Node154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.55	0	0	0	0	0	0	0	0	0	0	0
Node155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0
Node156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0
Node157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0	0
Node158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0
Node159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.94	0	0	0	0	0	0	0	0	0	0	0
Node160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0
Node161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.05	0	0	0	0	0	0	0	0	0	0	0
Node162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0	0	0	0	0	0	0	0	0	0	0
Node163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0
Node164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.81	0	0	0	0	0	0	0	0	0	0	0
Node165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.41	0	0	0	0	0	0	0	0	0	0	0
Node166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0
Node167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Node168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0
Node169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0
Node170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.95	0	0	0	0	0	0	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
Node172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Node173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.28	0	0	0	0	0	0	0	0	0	0	0
Node174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0
Node175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0	0
Node176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.75	0	0	0	0	0	0	0	0	0	0	0
Node177	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node179	0	0	0	0	3.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node180	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0
Node183	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0
Node185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Node186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0	0	0	0
Node187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0	0
Node188	0	0	0	0	0	0	0	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.61	0	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.68	0	0	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.23	0	0	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0
Node194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.96	0	0	0	0	0	0	0	0	0	0	0
Node195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.21	0	0	0	0	0	0	0	0	0	0	0	0
Node196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.41	0	0	0	0	0	0	0	0	0	0	0	0
Node197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.81	0	0	0	0	0	0	0	0	0	0	0	0
Node198	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0	0	0
Node199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
Node200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0

Table F.3: 4-minute time-restricted model: Distances between fire stations and their assigned nodes-3

	4T1 2	4T2 17	4T3 26	4T6 43	4T7 69	4T9 111	4T10 115	4T11 139	4T14 178	4T23 189	4T22 206	4T20 224	4T19 231	4T17 237	4T18 238	4T4 246	4T25 288	4T21 344	4T26 390	4T8 392	4T13 411	4T16 430	4T15 432	4T12 436	4T24 440	4T5 441	AŞTİ 254	Köşk 271	Hisar 297
Node201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0
Node202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0
Node203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.23	0	0	0	0	0	0	0	0	0	0	0	0
Node204	0	0	0	0	0	0	0	0	0	0	1.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node205	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node207	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node208	0	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node209	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	0	0	0	0	0	0	0	0	0	0	0	0
Node211	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0
Node213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0	0	0
Node214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0
Node215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0	0
Node216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Node217	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0
Node218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0	0
Node219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Node220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0	0	0	0
Node221	0	0	0	0	0	0	0	0	0	0	0	0.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node222	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node223	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node225	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node226	0	0	0	0	0	0	0	0	0	0	0	3.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node227	0	0	0	0	0	0	0	0	0	0	0	2.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node228	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node229	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node230	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node232	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node233	0	0	0	0	0	0	0	0	0	0	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node234	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node236	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node239	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node240	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node241	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node242	0	0	0	0	0	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node243	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node244	0	0	0	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node247	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node248	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node249	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node250	3.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0
Node252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0
Node253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Node255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0
Node256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0
Node257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0
Node258	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node262	0	0	0	0	0	0	0	0	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node263	0	0	0	0	0	0	0	0	0	0	0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.57	0	0	0	0	0	0	0	0	0	0	0	0
Node265	0	0	0	0	0	0	0	0	0	0	2.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node266	0	0	0	0	0	0	0	0	0	0	1.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.73	0	0	0	0	0	0	0	0	0	0	0	0
Node268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0
Node269	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.38	0	0	0	0	0	0	0	0	0	0	0	0
Node270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0	0
Node272	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0

Table F.4: 4-minute time-restricted model: Distances between fire stations and their assigned nodes-4

	4T1	4T2	4T3	4T6	4T7	4T9	4T10	4T11	4T14	4T23	4T22	4T20	4T19	4T17	4T18	4T4	4T25	4T21	4T26	4T8	4T13	4T16	4T15	4T12	4T24	4T5	AŞTİ	Köşk	Hisar
	2	17	26	43	69	111	115	139	178	189	206	224	231	237	238	246	288	344	390	392	411	430	432	436	440	441	254	271	297
Node273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.18	0	0	0	0	0	0	0	0	0	0	0
Node274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0
Node275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.11	0	0	0	0	0	0	0	0	0	0	0
Node276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0	0	0	0	0	0	0	0	0	0
Node277	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0
Node278	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.13	0	0	0	0	0	0	0	0	0	0	0
Node279	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.63	0	0	0	0	0	0	0	0	0	0	0
Node280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
Node281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0
Node282	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
Node283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0
Node284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0
Node285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0
Node286	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.71	0	0	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0
Node289	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0
Node290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0
Node291	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node292	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0
Node294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.24	0	0	0	0	0	0	0	0	0	0	0
Node295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.37	0	0	0	0	0	0	0	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35
Node298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.67	0	0	0	0	0	0	0	0	0	0	0
Node299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.44	0	0	0	0	0	0	0	0	0	0	0
Node300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.45	0	0	0	0	0	0	0	0	0	0	0
Node301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
Node302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.46	0	0	0	0	0	0	0	0	0	0	0
Node303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.26	0	0	0	0	0	0	0	0	0	0	0
Node304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.34	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node307	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node308	0	0	0	0	0.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node309	0	0	0	0	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node310	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node311	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node312	0	0	0	0	1.53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node313	0	0	0	0	2.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node314	0	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node315	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node316	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node317	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0
Node318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Node319	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node320	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node321	0	0	0	0	0	0	0	3.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node322	0	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node323	0	0	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node324	0	0	0	0	0	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node325	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node326	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0
Node328	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node329	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node330	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0
Node332	0	0	0	0	0	0	1.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node333	0	0	0	0	0	0	2.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node334	0	0	0	0	0	0	2.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node335	0	0	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node336	0	0	0	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node337	0	0	0	0	0	0	2.34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node338	0	0	0	0	0	0	2.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table F.5: 4-minute time-restricted model: Distances between fire stations and their assigned nodes-5

	4T1 2	4T2 17	4T3 26	4T6 43	4T7 69	4T9 111	4T10 115	4T11 139	4T14 178	4T23 189	4T22 206	4T20 224	4T19 231	4T17 237	4T18 238	4T4 246	4T25 288	4T21 344	4T26 390	4T8 392	4T13 411	4T16 430	4T15 432	4T12 436	4T24 440	4T5 441	AŞTİ 254	Köşk 271	Hisar 297
Node406	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node407	0	1.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node408	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node409	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0
Node412	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.65	0	0	0	0	0	0	0	0	0
Node413	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0
Node414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0
Node415	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Node416	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0
Node417	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0
Node418	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0
Node419	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0
Node420	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Node431	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0
Node433	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0
Node434	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0
Node435	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node437	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node438	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node439	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0
Node442	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	0	0	0
Node443	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node444	0	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Node446	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node447	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0
Node449	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0
Node450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0
Node451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0
Node452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0
max	3.79	3.6	3.98	3.87	3.9	3.65	3.7	3.78	3.7	2.5	3.2	3.6	3.9	2.7	3.7	3.2	4	3.97	3.9	3.8	3.5	3	3.7	3.3	2.7	3.9	0.55	1.9	0.35

Table F.6: 4-minute time-restricted model: Distances between fire stations and their assigned nodes-6

Tables for 8-Minute Coverages

	8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297		8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297
Node1	5.25	0	0	0	0	0	0	0	0	0	0	Node68	0	0	0	0	0	0	5.78	0	0	0	0
Node2	2.7	0	0	0	0	0	0	0	0	0	0	Node69	0	0	0	0	0	0	4.08	0	0	0	0
Node3	3.7	0	0	0	0	0	0	0	0	0	0	Node70	0	0	0	0	0	0	4.96	0	0	0	0
Node4	4.05	0	0	0	0	0	0	0	0	0	0	Node71	0	0	0	0	0	0	6.48	0	0	0	0
Node5	5.15	0	0	0	0	0	0	0	0	0	0	Node72	0	0	0	0	0	0	6.03	0	0	0	0
Node6	1.8	0	0	0	0	0	0	0	0	0	0	Node73	0	0	0	0	0	0	4.91	0	0	0	0
Node7	1.35	0	0	0	0	0	0	0	0	0	0	Node74	0	0	0	0	0	0	5.28	0	0	0	0
Node8	0.5	0	0	0	0	0	0	0	0	0	0	Node75	0	3.25	0	0	0	0	0	0	0	0	0
Node9	1.85	0	0	0	0	0	0	0	0	0	0	Node76	0	0	0	0	0	0	0	5.9	0	0	0
Node10	1.2	0	0	0	0	0	0	0	0	0	0	Node77	0	0	0	0	0	0	6.91	0	0	0	0
Node12	1.45	0	0	0	0	0	0	0	0	0	0	Node78	0	0	0	0	0	0	6.95	0	0	0	0
Node13	5.75	0	0	0	0	0	0	0	0	0	0	Node79	0	6.84	0	0	0	0	0	0	0	0	0
Node14	6.35	0	0	0	0	0	0	0	0	0	0	Node80	0	6.84	0	0	0	0	0	0	0	0	0
Node15	5.35	0	0	0	0	0	0	0	0	0	0	Node81	0	6.04	0	0	0	0	0	0	0	0	0
Node16	3.15	0	0	0	0	0	0	0	0	0	0	Node82	0	0	0	0	0	6.97	0	0	0	0	0
Node17	2.8	0	0	0	0	0	0	0	0	0	0	Node83	0	0	0	0	0	6.32	0	0	0	0	0
Node18	1.95	0	0	0	0	0	0	0	0	0	0	Node84	0	0	0	0	0	6.97	0	0	0	0	0
Node19	2	0	0	0	0	0	0	0	0	0	0	Node85	0	7.8	0	0	0	0	0	0	0	0	0
Node20	3.12	0	0	0	0	0	0	0	0	0	0	Node86	0	6.35	0	0	0	0	0	0	0	0	0
Node21	2.7	0	0	0	0	0	0	0	0	0	0	Node87	0	5.14	0	0	0	0	0	0	0	0	0
Node22	4.75	0	0	0	0	0	0	0	0	0	0	Node88	0	5.44	0	0	0	0	0	0	0	0	0
Node23	5.85	0	0	0	0	0	0	0	0	0	0	Node89	0	5.34	0	0	0	0	0	0	0	0	0
Node24	4	0	0	0	0	0	0	0	0	0	0	Node90	0	4.94	0	0	0	0	0	0	0	0	0
Node25	6.35	0	0	0	0	0	0	0	0	0	0	Node91	0	0	0	0	0	5.77	0	0	0	0	0
Node26	5.8	0	0	0	0	0	0	0	0	0	0	Node92	0	0	0	0	0	5.12	0	0	0	0	0
Node27	7.55	0	0	0	0	0	0	0	0	0	0	Node93	0	0	0	0	0	4.83	0	0	0	0	0
Node28	3.8	0	0	0	0	0	0	0	0	0	0	Node94	0	0	0	0	0	5.36	0	0	0	0	0
Node29	4.4	0	0	0	0	0	0	0	0	0	0	Node95	0	0	0	0	0	5.96	0	0	0	0	0
Node30	3.42	0	0	0	0	0	0	0	0	0	0	Node96	0	5.35	0	0	0	0	0	0	0	0	0
Node31	4.17	0	0	0	0	0	0	0	0	0	0	Node97	0	5.6	0	0	0	0	0	0	0	0	0
Node32	3.5	0	0	0	0	0	0	0	0	0	0	Node98	0	4.65	0	0	0	0	0	0	0	0	0
Node33	3.15	0	0	0	0	0	0	0	0	0	0	Node99	0	5.45	0	0	0	0	0	0	0	0	0
Node34	0	0	0	0	0	0	5.65	0	0	0	0	Node100	0	5.64	0	0	0	0	0	0	0	0	0
Node35	0	0	0	0	0	0	4.48	0	0	0	0	Node101	0	4.79	0	0	0	0	0	0	0	0	0
Node36	0	0	0	0	0	0	6.98	0	0	0	0	Node102	0	4.69	0	0	0	0	0	0	0	0	0
Node37	6.8	0	0	0	0	0	0	0	0	0	0	Node103	0	4.04	0	0	0	0	0	0	0	0	0
Node38	6.15	0	0	0	0	0	0	0	0	0	0	Node104	0	4.84	0	0	0	0	0	0	0	0	0
Node39	6.8	0	0	0	0	0	0	0	0	0	0	Node105	0	3.29	0	0	0	0	0	0	0	0	0
Node40	6.98	0	0	0	0	0	0	0	0	0	0	Node106	0	4.35	0	0	0	0	0	0	0	0	0
Node41	7.3	0	0	0	0	0	0	0	0	0	0	Node107	0	3.95	0	0	0	0	0	0	0	0	0
Node42	0	0	0	0	0	0	4.65	0	0	0	0	Node108	0	5	0	0	0	0	0	0	0	0	0
Node43	0	0	0	0	0	0	5.35	0	0	0	0	Node109	0	4.6	0	0	0	0	0	0	0	0	0
Node44	0	0	0	0	0	0	6.14	0	0	0	0	Node110	0	4.55	0	0	0	0	0	0	0	0	0
Node45	0	0	0	0	0	0	3.95	0	0	0	0	Node111	0	4.15	0	0	0	0	0	0	0	0	0
Node46	0	0	0	0	0	0	4.59	0	0	0	0	Node112	0	3.6	0	0	0	0	0	0	0	0	0
Node47	0	0	0	0	0	0	0.88	0	0	0	0	Node113	0	5.24	0	0	0	0	0	0	0	0	0
Node48	0	0	0	0	0	0	0.6	0	0	0	0	Node114	0	4.54	0	0	0	0	0	0	0	0	0
Node49	0	0	0	0	0	0	2.79	0	0	0	0	Node115	0	2.34	0	0	0	0	0	0	0	0	0
Node50	0	0	0	0	0	0	2.6	0	0	0	0	Node116	0	1.1	0	0	0	0	0	0	0	0	0
Node51	0	0	0	0	0	0	3.79	0	0	0	0	Node117	0	0.6	0	0	0	0	0	0	0	0	0
Node52	0	0	0	0	0	0	5.19	0	0	0	0	Node118	0	1.5	0	0	0	0	0	0	0	0	0
Node53	0	0	0	0	0	0	5.46	0	0	0	0	Node119	0	0	0	0	0	0	5.68	0	0	0	0
Node54	0	0	0	0	0	0	2.75	0	0	0	0	Node121	0	1.3	0	0	0	0	0	0	0	0	0
Node55	0	0	0	0	0	0	0.59	0	0	0	0	Node122	0	1.9	0	0	0	0	0	0	0	0	0
Node56	0	0	0	0	0	0	0.83	0	0	0	0	Node123	0	2.35	0	0	0	0	0	0	0	0	0
Node57	0	0	0	0	0	0	1.74	0	0	0	0	Node124	0	2.2	0	0	0	0	0	0	0	0	0
Node58	0	0	0	0	0	0	3.35	0	0	0	0	Node125	0	2.35	0	0	0	0	0	0	0	0	0
Node59	0	0	0	0	0	0	2.9	0	0	0	0	Node126	0	6.25	0	0	0	0	0	0	0	0	0
Node60	0	0	0	0	0	0	5.3	0	0	0	0	Node127	0	4.6	0	0	0	0	0	0	0	0	0
Node61	0	0	0	0	0	0	1.83	0	0	0	0	Node128	0	4.65	0	0	0	0	0	0	0	0	0
Node62	0	0	0	0	0	0	3.9	0	0	0	0	Node129	0	3.55	0	0	0	0	0	0	0	0	0
Node63	0	0	0	0	0	0	4.25	0	0	0	0	Node130	0	3.76	0	0	0	0	0	0	0	0	0
Node64	0	0	0	0	0	0	2.68	0	0	0	0	Node131	0	4.96	0	0	0	0	0	0	0	0	0
Node65	0	0	0	0	0	0	3.63	0	0	0	0	Node132	0	5.66	0	0	0	0	0	0	0	0	0
Node66	0	0	0	0	0	0	2.98	0	0	0	0	Node133	0	6.66	0	0	0	0	0	0	0	0	0
Node67	0	0	0	0	0	0	4.18	0	0	0	0	Node134	0	7.5	0	0	0	0	0	0	0	0	0

Table F.7: 8-minute time-restricted model: Distances between fire stations and their assigned nodes-1

	8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297		8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297
Node135	0	7.41	0	0	0	0	0	0	0	0	0	Node202	0	0	0	0	0	0.3	0	0	0	0	0
Node136	0	7.83	0	0	0	0	0	0	0	0	0	Node203	0	0	0	0	0	0.27	0	0	0	0	0
Node137	0	6.43	0	0	0	0	0	0	0	0	0	Node204	0	0	0	0	0	3.99	0	0	0	0	0
Node138	0	5.2	0	0	0	0	0	0	0	0	0	Node205	0	0	0	0	0	3.6	0	0	0	0	0
Node139	0	5.6	0	0	0	0	0	0	0	0	0	Node206	0	0	0	0	0	4.35	0	0	0	0	0
Node140	0	6.05	0	0	0	0	0	0	0	0	0	Node207	0	0	0	0	0	7.8	0	0	0	0	0
Node141	0	0	0	0	0	0	0	6.35	0	0	0	Node208	0	0	0	0	0	6.37	0	0	0	0	0
Node142	0	0	0	0	0	0	0	5.5	0	0	0	Node209	0	0	0	0	0	5.57	0	0	0	0	0
Node143	0	0	0	0	0	0	0	2.8	0	0	0	Node210	0	0	0	0	0	1.37	0	0	0	0	0
Node144	0	0	0	0	0	0	0	3.15	0	0	0	Node211	0	0	0	0	0	5.55	0	0	0	0	0
Node145	0	0	0	0	0	0	0	4.15	0	0	0	Node212	0	0	0	0	0	4.8	0	0	0	0	0
Node146	0	0	0	0	0	0	0	3.4	0	0	0	Node213	0	0	0	0	0	3.75	0	0	0	0	0
Node147	0	0	0	0	0	0	0	1.1	0	0	0	Node214	0	0	0	0	0	3.2	0	0	0	0	0
Node148	0	0	0	0	0	0	0	5.9	0	0	0	Node215	0	0	0	0	0	0	0	0	0.55	0	0
Node149	0	0	3.5	0	0	0	0	0	0	0	0	Node216	0	0	0	0	0	1.9	0	0	0	0	0
Node150	0	0	4	0	0	0	0	0	0	0	0	Node217	0	0	0	0	0	3.7	0	0	0	0	0
Node151	0	0	5.5	0	0	0	0	0	0	0	0	Node218	0	0	0	0	0	4.35	0	0	0	0	0
Node152	0	0	5.6	0	0	0	0	0	0	0	0	Node219	0	0	0	0	0	3.5	0	0	0	0	0
Node153	0	0	6.8	0	0	0	0	0	0	0	0	Node220	0	0	0	0	0	5.3	0	0	0	0	0
Node154	0	0	7.4	0	0	0	0	0	0	0	0	Node221	0	0	0	0	3.1	0	0	0	0	0	0
Node155	0	0	7.05	0	0	0	0	0	0	0	0	Node222	0	0	0	0	0	6.72	0	0	0	0	0
Node156	0	0	6.75	0	0	0	0	0	0	0	0	Node223	0	0	0	0	5.05	0	0	0	0	0	0
Node157	0	0	6.2	0	0	0	0	0	0	0	0	Node224	0	0	0	0	3.88	0	0	0	0	0	0
Node158	0	0	0	0	0	6.25	0	0	0	0	0	Node225	0	0	0	0	3.28	0	0	0	0	0	0
Node159	0	0	0	0	0	6.45	0	0	0	0	0	Node226	0	0	0	0	4.2	0	0	0	0	0	0
Node160	0	0	0	0	0	6.1	0	0	0	0	0	Node227	0	0	0	0	3.25	0	0	0	0	0	0
Node161	0	0	0	0	0	5.5	0	0	0	0	0	Node228	0	0	0	0	3.2	0	0	0	0	0	0
Node162	0	0	0	0	0	5.7	0	0	0	0	0	Node229	0	0	0	0	3	0	0	0	0	0	0
Node163	0	0	0	0	0	4.95	0	0	0	0	0	Node230	0	0	0	0	1.2	0	0	0	0	0	0
Node164	0	0	0	0	0	4.96	0	0	0	0	0	Node231	0	0	0	0	2	0	0	0	0	0	0
Node165	0	0	0	0	0	4.49	0	0	0	0	0	Node232	0	0	0	0	1	0	0	0	0	0	0
Node166	0	0	0	0	0	4.05	0	0	0	0	0	Node233	0	0	0	0	1.65	0	0	0	0	0	0
Node167	0	0	0	0	0	4.45	0	0	0	0	0	Node234	0	0	0	0	1.3	0	0	0	0	0	0
Node168	0	0	0	0	0	4.6	0	0	0	0	0	Node235	0	0	0	3.2	0	0	0	0	0	0	0
Node169	0	0	0	0	0	5.15	0	0	0	0	0	Node236	0	0	0	1.6	0	0	0	0	0	0	0
Node170	0	0	0	0	0	5.45	0	0	0	0	0	Node238	0	0	0	2.3	0	0	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0.2	0	Node239	0	0	0	2.7	0	0	0	0	0	0	0
Node172	0	0	0	0	0	0	0	0	0	0.1	0	Node240	0	0	0	0	2.75	0	0	0	0	0	0
Node173	0	0	5.3	0	0	0	0	0	0	0	0	Node241	0	0	0	0	1.55	0	0	0	0	0	0
Node174	0	0	4.25	0	0	0	0	0	0	0	0	Node242	0	0	0	0	0.35	0	0	0	0	0	0
Node175	0	0	3.7	0	0	0	0	0	0	0	0	Node244	0	0	0	0	3.15	0	0	0	0	0	0
Node176	0	0	2.2	0	0	0	0	0	0	0	0	Node245	0	0	0	0	1.75	0	0	0	0	0	0
Node177	0	0	2.9	0	0	0	0	0	0	0	0	Node246	0	0	0	0	4.85	0	0	0	0	0	0
Node178	0	0	2.2	0	0	0	0	0	0	0	0	Node247	0	0	0	3.5	0	0	0	0	0	0	0
Node179	0	0	0	0	0	6.57	0	0	0	0	0	Node248	1.6	0	0	0	0	0	0	0	0	0	0
Node181	0	0	2.8	0	0	0	0	0	0	0	0	Node249	5.3	0	0	0	0	0	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	1.9	0	Node250	0.8	0	0	0	0	0	0	0	0	0	0
Node183	0	0	0	0	0	6.6	0	0	0	0	0	Node251	0	0	0	0	0	0	4.55	0	0	0	0
Node184	0	0	0	0	0	0	0	0	0	1.1	0	Node252	0	0	0	0	0	4.45	0	0	0	0	0
Node185	0	0	0	0	0	2.5	0	0	0	0	0	Node253	0	0	0	0	0	0	0	0	0.5	0	0
Node186	0	0	0	0	0	2.05	0	0	0	0	0	Node255	0	0	0	0	0	4.95	0	0	0	0	0
Node187	0	0	0	0	0	1.35	0	0	0	0	0	Node256	0	0	0	0	0	5.12	0	0	0	0	0
Node188	0	0	0	0	0	4.45	0	0	0	0	0	Node257	0	0	0	0	0	4	0	0	0	0	0
Node189	0	0	0	0	0	7.7	0	0	0	0	0	Node258	0	0	0	0	7.3	0	0	0	0	0	0
Node190	0	0	0	0	0	4.16	0	0	0	0	0	Node259	0	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	0	0	3.96	0	0	0	0	0	Node260	0	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	0	0	3.51	0	0	0	0	0	Node261	0	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	0	0	3.33	0	0	0	0	0	Node262	0	0	0	0	0	5.7	0	0	0	0	0
Node194	0	0	0	0	0	3.89	0	0	0	0	0	Node263	0	0	0	0	0	3.8	0	0	0	0	0
Node195	0	0	0	0	0	3.49	0	0	0	0	0	Node264	0	0	0	0	0	1.2	0	0	0	0	0
Node196	0	0	0	0	0	2.69	0	0	0	0	0	Node265	0	0	0	0	0	5.29	0	0	0	0	0
Node197	0	0	0	0	0	2.09	0	0	0	0	0	Node266	0	0	0	0	0	4.44	0	0	0	0	0
Node198	0	0	0	0	0	3.45	0	0	0	0	0	Node267	0	0	0	0	0	1.3	0	0	0	0	0
Node199	0	0	0	0	0	2.65	0	0	0	0	0	Node269	0	0	0	0	0	1.3	0	0	0	0	0
Node200	0	0	0	0	0	1.48	0	0	0	0	0	Node270	0	0	0	0	0	2.3	0	0	0	0	0
Node201	0	0	0	0	0	0.9	0	0	0	0	0	Node272	0	0	0	0	0	5.48	0	0	0	0	0

Table F.8: 8-minute time-restricted model: Distances between fire stations and their assigned nodes-2

	8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297		8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297
Node273	0	0	0	0	0	6.19	0	0	0	0	0	Node342	0	0	0	0	0	5.65	0	0	0	0	0
Node274	0	0	0	0	0	5.96	0	0	0	0	0	Node343	0	0	0	0	0	6.05	0	0	0	0	0
Node275	0	0	0	0	0	5.8	0	0	0	0	0	Node344	0	0	0	0	0	5.85	0	0	0	0	0
Node276	0	0	0	0	0	6.4	0	0	0	0	0	Node345	0	0	0	0	0	1.3	0	0	0	0	0
Node277	0	0	0	0	0	0.7	0	0	0	0	0	Node346	4.8	0	0	0	0	0	0	0	0	0	0
Node278	0	0	0	0	0	4.35	0	0	0	0	0	Node347	6.41	0	0	0	0	0	0	0	0	0	0
Node279	0	0	0	0	0	4.85	0	0	0	0	0	Node348	5.21	0	0	0	0	0	0	0	0	0	0
Node280	0	0	0	0	0	5.5	0	0	0	0	0	Node349	5.08	0	0	0	0	0	0	0	0	0	0
Node281	0	0	0	0	0	4.75	0	0	0	0	0	Node350	5.19	0	0	0	0	0	0	0	0	0	0
Node282	0	0	0	0	0	4.85	0	0	0	0	0	Node351	5.36	0	0	0	0	0	0	0	0	0	0
Node283	0	0	0	0	0	5.3	0	0	0	0	0	Node352	5.48	0	0	0	0	0	0	0	0	0	0
Node284	0	0	0	0	0	5.25	0	0	0	0	0	Node353	6.49	0	0	0	0	0	0	0	0	0	0
Node285	0	0	0	0	0	5.85	0	0	0	0	0	Node354	2.8	0	0	0	0	0	0	0	0	0	0
Node286	0	0	0	0	0	2.99	0	0	0	0	0	Node355	2.05	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	0	0	0.3	0	0	0	0	0	Node356	2.22	0	0	0	0	0	0	0	0	0	0
Node288	0	0	0	0	0	1.5	0	0	0	0	0	Node357	2.15	0	0	0	0	0	0	0	0	0	0
Node289	0	0	0	0	0	1.7	0	0	0	0	0	Node358	2.35	0	0	0	0	0	0	0	0	0	0
Node290	0	0	5.35	0	0	0	0	0	0	0	0	Node359	1.35	0	0	0	0	0	0	0	0	0	0
Node291	0	5.8	0	0	0	0	0	0	0	0	0	Node360	2.75	0	0	0	0	0	0	0	0	0	0
Node292	0	0	0	0	0	5.56	0	0	0	0	0	Node361	2.05	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	0	0	5.96	0	0	0	0	0	Node362	2.3	0	0	0	0	0	0	0	0	0	0
Node294	0	0	0	0	0	6.16	0	0	0	0	0	Node363	0	0	0	0	0	0	5.49	0	0	0	0
Node295	0	0	0	0	0	6.51	0	0	0	0	0	Node364	0	0	0	0	0	0	4.55	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0.35	Node365	0	0	0	0	0	0	1.6	0	0	0	0
Node298	0	0	0	0	0	6.78	0	0	0	0	0	Node366	0	0	0	0	0	0	3.65	0	0	0	0
Node299	0	0	0	0	0	6.55	0	0	0	0	0	Node367	0	0	0	0	0	0	2.25	0	0	0	0
Node300	0	0	0	0	0	6.32	0	0	0	0	0	Node368	0	0	0	0	0	0	2.95	0	0	0	0
Node301	0	0	0	0	0	6.35	0	0	0	0	0	Node369	7.5	0	0	0	0	0	0	0	0	0	0
Node302	0	0	0	0	0	6.61	0	0	0	0	0	Node370	0	0	0	0	0	0	6.65	0	0	0	0
Node303	0	0	0	0	0	7.41	0	0	0	0	0	Node371	0	0	0	0	0	0	6.1	0	0	0	0
Node304	0	0	0	0	0	7.3	0	0	0	0	0	Node372	0	0	0	0	0	0	1.7	0	0	0	0
Node305	0	0	7.4	0	0	0	0	0	0	0	0	Node373	0	0	0	0	0	0	2.65	0	0	0	0
Node306	0	0	5.6	0	0	0	0	0	0	0	0	Node374	0	0	0	0	0	0	1.08	0	0	0	0
Node307	0	0	0	0	0	0	5.98	0	0	0	0	Node375	0	0	0	0	0	0	1.1	0	0	0	0
Node308	0	0	0	0	0	0	4.83	0	0	0	0	Node376	0	0	0	0	0	0	2.1	0	0	0	0
Node309	0	0	0	0	0	0	3.73	0	0	0	0	Node377	0	0	0	0	0	0	1.05	0	0	0	0
Node310	0	0	0	0	0	0	4.18	0	0	0	0	Node378	0	0	0	0	0	0	2.8	0	0	0	0
Node311	0	0	0	0	0	0	4.83	0	0	0	0	Node379	0	0	0	0	0	0	0.4	0	0	0	0
Node312	0	0	0	0	0	0	5.61	0	0	0	0	Node380	0	0	0	0	0	0	0.28	0	0	0	0
Node313	0	0	0	0	0	0	6.71	0	0	0	0	Node382	0	0	0	0	0	0	0.3	0	0	0	0
Node314	0	0	0	0	0	0	6.53	0	0	0	0	Node383	0	0	0	0	0	0	0.41	0	0	0	0
Node315	0	0	0	0	0	0	6.23	0	0	0	0	Node384	0	0	0	0	0	0	0.42	0	0	0	0
Node316	0	0	5.9	0	0	0	0	0	0	0	0	Node385	0	0	0	0	3.7	0	0	0	0	0	0
Node317	0	0	5.6	0	0	0	0	0	0	0	0	Node386	0	0	0	0	3	0	0	0	0	0	0
Node318	0	0	6.6	0	0	0	0	0	0	0	0	Node387	0	0	0	0	5	0	0	0	0	0	0
Node319	0	0	4.9	0	0	0	0	0	0	0	0	Node388	0	0	0	0	0	8	0	0	0	0	0
Node320	0	0	5.2	0	0	0	0	0	0	0	0	Node389	0	0	0	0	7.8	0	0	0	0	0	0
Node321	0	0	0	0	0	0	0	7.05	0	0	0	Node390	0	0	0	0	6.3	0	0	0	0	0	0
Node322	0	6.2	0	0	0	0	0	0	0	0	0	Node391	0	0	0	0	0	0	2.4	0	0	0	0
Node323	0	5.85	0	0	0	0	0	0	0	0	0	Node392	0	0	0	0	0	0	3.2	0	0	0	0
Node324	0	5.55	0	0	0	0	0	0	0	0	0	Node393	0	0	0	0	0	0	4.4	0	0	0	0
Node325	0	0	0	0	0	0	0	5.4	0	0	0	Node394	0	0	0	0	0	0	3.7	0	0	0	0
Node326	0	5.36	0	0	0	0	0	0	0	0	0	Node395	0	0	0	0	0	0	3.3	0	0	0	0
Node327	0	0	0	0	0	0.5	0	0	0	0	0	Node396	0	0	0	0	0	0	3.3	0	0	0	0
Node328	0	5.1	0	0	0	0	0	0	0	0	0	Node397	0	0	0	0	0	3.75	0	0	0	0	0
Node329	0	6.2	0	0	0	0	0	0	0	0	0	Node398	5.66	0	0	0	0	0	0	0	0	0	0
Node330	0	0	0	0	0	0	0	4.5	0	0	0	Node399	7.15	0	0	0	0	0	0	0	0	0	0
Node331	0	0	0	0	0	0	6.35	0	0	0	0	Node400	6.55	0	0	0	0	0	0	0	0	0	0
Node332	0	2.7	0	0	0	0	0	0	0	0	0	Node401	2.8	0	0	0	0	0	0	0	0	0	0
Node333	0	1.85	0	0	0	0	0	0	0	0	0	Node402	3.05	0	0	0	0	0	0	0	0	0	0
Node334	0	2.75	0	0	0	0	0	0	0	0	0	Node403	2.87	0	0	0	0	0	0	0	0	0	0
Node335	0	3.25	0	0	0	0	0	0	0	0	0	Node404	2.52	0	0	0	0	0	0	0	0	0	0
Node336	0	1	0	0	0	0	0	0	0	0	0	Node405	2.35	0	0	0	0	0	0	0	0	0	0
Node337	0	3.15	0	0	0	0	0	0	0	0	0	Node406	2.15	0	0	0	0	0	0	0	0	0	0
Node338	0	2.35	0	0	0	0	0	0	0	0	0	Node407	2.2	0	0	0	0	0	0	0	0	0	0
Node339	0	3.9	0	0	0	0	0	0	0	0	0	Node408	3.9	0	0	0	0	0	0	0	0	0	0
Node340	0	7.45	0	0	0	0	0	0	0	0	0	Node409	3.72	0	0	0	0	0	0	0	0	0	0
Node341	0	4.65	0	0	0	0	0	0	0	0	0	Node410	0	0	0	0	0	0	0	0.8	0	0	0

Table F.9: 8-minute time-restricted model: Distances between fire stations and their assigned nodes-3

	8T1 11	8T3 120	8T5 180	8T6 237	8T7 243	8T8 268	8T2 381	8T4 411	AŞTİ 254	Köşk 271	Hisar 297
Node412	0	0	0	0	0	0	0	1.65	0	0	0
Node413	0	0	0	0	0	0	0	2.15	0	0	0
Node414	0	0	0	0	0	0	0	1.9	0	0	0
Node415	0	0	0	0	0	0	0	3	0	0	0
Node416	0	0	0	0	0	0	0	2.75	0	0	0
Node417	0	0	0	0	0	0	0	2.4	0	0	0
Node418	0	0	0	0	0	0	0	1.7	0	0	0
Node419	0	0	0	0	0	3.05	0	0	0	0	0
Node420	0	0	0	0	5.9	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	6	0	0	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	7.8	0	0	0	0	0	0	0	0
Node430	0	0	4.8	0	0	0	0	0	0	0	0
Node431	0	0	5.7	0	0	0	0	0	0	0	0
Node432	0	0	7.8	0	0	0	0	0	0	0	0
Node433	0	0	0	0	0	0	0	3.5	0	0	0
Node434	0	0	0	0	0	0	0	5.8	0	0	0
Node435	0	0	0	0	0	0	0	6.15	0	0	0
Node436	0	7.9	0	0	0	0	0	0	0	0	0
Node437	0	6.3	0	0	0	0	0	0	0	0	0
Node438	0	6.2	0	0	0	0	0	0	0	0	0
Node439	0	0	0	0	0	0	6.7	0	0	0	0
Node440	0	0	0	0	0	0	7.75	0	0	0	0
Node441	0	0	0	0	0	0	7.95	0	0	0	0
Node442	0	0	0	0	0	0	4.05	0	0	0	0
Node443	6.4	0	0	0	0	0	0	0	0	0	0
Node444	0	0	0	7.4	0	0	0	0	0	0	0
Node445	0	0	0	0	7.65	0	0	0	0	0	0
Node446	0	0	0	0	6.58	0	0	0	0	0	0
Node447	0	0	0	0	0	6.95	0	0	0	0	0
Node448	0	0	0	0	0	2.9	0	0	0	0	0
Node449	0	0	0	0	0	2.8	0	0	0	0	0
Node450	0	0	7.2	0	0	0	0	0	0	0	0
Node451	0	0	0	0	0	2.9	0	0	0	0	0
Node452	0	0	0	0	0	0	1.35	0	0	0	0
max	7.55	7.9	7.8	7.4	7.8	8	7.95	7.05	0.55	1.9	0.35

Table F.10: 8-minute time-restricted model: Distances between fire stations and their assigned nodes-4

Appendix G

Tables of Time Restricted Models for Additional Fire Stations

Tables for 4-Minute Coverage

	Sincan	4N1	4N2	Etimesgut	Batıkent	4N7	Merkez	4N9	Keçiören	4N10	Kayaş	Kurtuluş	4N21	4N20	4N22	4N17	4N16	4N18
	2	17	24	40	50	53	91	111	120	127	149	158	189	206	211	224	231	238
Node1	2.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node4	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node5	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node6	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node7	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node8	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node9	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node10	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node11	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node12	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node13	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node14	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node15	0	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node16	0	0.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node18	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node19	0	2.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node20	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node21	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node22	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node23	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node25	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node26	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node28	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node29	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node30	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node31	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node32	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node33	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node36	0	0	0	3.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node37	0	0	0	2.93	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node38	0	0	0	2.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node39	0	0	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node41	0	0	0	0.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node42	0	0	0	0	2.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Node43	0	0	0	0	2.99	0	0	0	0	0	0	0	0	0	0	0	0	0
Node44	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0
Node45	0	0	0	0	1.59	0	0	0	0	0	0	0	0	0	0	0	0	0
Node46	0	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0	0	0
Node47	0	0	0	0	2.92	0	0	0	0	0	0	0	0	0	0	0	0	0
Node48	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node49	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0
Node51	0	0	0	0	1.19	0	0	0	0	0	0	0	0	0	0	0	0	0
Node52	0	0	0	0	0	0.27	0	0	0	0	0	0	0	0	0	0	0	0
Node54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node55	0	0	0	0	2.36	0	0	0	0	0	0	0	0	0	0	0	0	0
Node56	0	0	0	0	2.12	0	0	0	0	0	0	0	0	0	0	0	0	0
Node57	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0
Node58	0	0	0	0	2.19	0	0	0	0	0	0	0	0	0	0	0	0	0
Node59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node61	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0
Node62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node67	0	0	0	0	3.49	0	0	0	0	0	0	0	0	0	0	0	0	0
Node68	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
Node69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.05	0	0	0
Node71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0
Node72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.45	0	0	0

Table G.1: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 1-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTİ 254	Köşk 271	Hisar 297
Node1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0
Node28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0
Node35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0
Node36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node54	0	0	0	0	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0
Node55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node59	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Node60	0	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	0	0
Node61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node62	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0
Node63	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0
Node64	0	0	0	0	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0
Node65	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0
Node66	0	0	0	0	0	0	0	0	0	2.55	0	0	0	0	0	0	0	0	0
Node67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node69	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0
Node70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.2: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 1-2

	Sincan 2	4N1 17	4N2 24	Etimesgut 40	Batıkent 50	4N7 53	Merkez 91	4N9 111	Keçiören 120	4N10 127	Kayaş 149	Kurtuluş 158	4N21 189	4N20 206	4N22 211	4N17 224	4N16 231	4N18 238
Node73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.23	0	0	0
Node74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0
Node75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node77	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Node78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node81	0	0	0	0	0	0	3.35	0	0	0	0	0	0	0	0	0	0	0
Node82	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0
Node83	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0
Node84	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0
Node85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node90	0	0	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0	0	0
Node92	0	0	0	0	0	0	0.65	0	0	0	0	0	0	0	0	0	0	0
Node93	0	0	0	0	0	0	0.94	0	0	0	0	0	0	0	0	0	0	0
Node94	0	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0
Node95	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
Node96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node99	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0
Node100	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0
Node101	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0
Node102	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0
Node103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node109	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0	0
Node110	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0
Node112	0	0	0	0	0	0	0	0.55	0	0	0	0	0	0	0	0	0	0
Node113	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0
Node114	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Node115	0	0	0	0	0	0	0	0	2.34	0	0	0	0	0	0	0	0	0
Node116	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0
Node117	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0
Node118	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0
Node119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	0	0	0
Node121	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0
Node122	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0
Node123	0	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0
Node124	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0
Node125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node128	0	0	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0	0	0
Node129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.3: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 2-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTİ 254	Köşk 271	Hisar 297
Node73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node75	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0
Node76	0	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0
Node77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node78	0	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0
Node79	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0
Node80	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0
Node81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node85	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Node86	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0
Node87	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Node88	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0
Node89	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
Node90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node96	0	0	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0
Node97	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0
Node98	0	0	0	0	0	0	0	1.05	0	0	0	0	0	0	0	0	0	0	0
Node99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node103	0	0	0	0	0	0	0	3.65	0	0	0	0	0	0	0	0	0	0	0
Node104	0	0	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0
Node105	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0	0	0	0	0	0
Node106	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0
Node107	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0
Node108	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0
Node109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node125	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0
Node126	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0
Node128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node129	0	0	0	0	0	0	0	1.51	0	0	0	0	0	0	0	0	0	0	0
Node130	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0
Node131	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node132	0	0	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0	0	0
Node133	0	0	0	0	0	2.33	0	0	0	0	0	0	0	0	0	0	0	0	0
Node134	0	0	0	0	2.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node135	0	0	0	0	0	2.48	0	0	0	0	0	0	0	0	0	0	0	0	0
Node136	0	0	0	0	0	1.63	0	0	0	0	0	0	0	0	0	0	0	0	0
Node137	0	0	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0	0
Node138	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node139	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0
Node140	0	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0	0
Node141	0	0	0	0	0	1.68	0	0	0	0	0	0	0	0	0	0	0	0	0
Node142	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.4: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 2-2

	Sincan	4N1	4N2	Etimesgut	Batıkent	4N7	Merkez	4N9	Keçiören	4N10	Kayaş	Kurtuluş	4N21	4N20	4N22	4N17	4N16	4N18
	2	17	24	40	50	53	91	111	120	127	149	158	189	206	211	224	231	238
Node143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node150	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
Node151	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Node152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node159	0	0	0	0	0	0	0	0	0	0	0	1.84	0	0	0	0	0	0
Node160	0	0	0	0	0	0	0	0	0	0	0	1.55	0	0	0	0	0	0
Node161	0	0	0	0	0	0	0	0	0	0	0	0.95	0	0	0	0	0	0
Node162	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0	0	0	0	0
Node163	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0
Node164	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0
Node165	0	0	0	0	0	0	0	0	0	0	0	2.38	0	0	0	0	0	0
Node166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node174	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0
Node175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node177	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0
Node178	0	0	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0
Node179	0	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0
Node180	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0
Node181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node183	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0
Node184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node188	0	0	0	0	0	0	0	0	0	0	0	0	0	1.99	0	0	0	0
Node190	0	0	0	0	0	0	2.95	0	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	0	0	0	3.07	0	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	0	0	0	2.62	0	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	0	0	0	2.44	0	0	0	0	0	0	0	0	0	0	0
Node194	0	0	0	0	0	0	0	0	0	0	0	2.93	0	0	0	0	0	0
Node195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node198	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node204	0	0	0	0	0	0	0	0	0	0	0	0	0	1.14	0	0	0	0
Node205	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0
Node207	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0
Node208	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0
Node209	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0
Node210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0
Node213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.5: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 3-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTİ 254	Köşk 271	Hisar 297
Node143	0	0	0	0	0	0	0	0	0	0	1.15	0	0	0	0	0	0	0	0
Node144	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0
Node145	0	0	0	0	0	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0
Node146	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0
Node147	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0
Node148	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0
Node150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node152	0	0	0	0	3.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node153	0	0	0	0	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node154	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node155	0	0	0	0	1.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node156	0	0	0	0	1.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node157	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node166	0	0	1.91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node167	0	0	1.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node168	0	0	2.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node169	0	0	0.81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node170	0	0	2.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
Node172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Node173	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node175	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node176	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node179	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node181	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Node182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0
Node183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0
Node185	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node186	0	0	0	3.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node187	0	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node195	0	0	0	3.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node196	0	0	0	2.41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node197	0	0	0	1.81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node198	0	0	2.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node199	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node200	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node201	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node202	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node203	0	0	0	1.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node205	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node209	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node210	0	0	0	2.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node213	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.6: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 3-2

	Sincan	4N1	4N2	Etimesgut	Batıkent	4N7	Merkez	4N9	Keçiören	4N10	Kayaş	Kurtuluş	4N21	4N20	4N22	4N17	4N16	4N18
	2	17	24	40	50	53	91	111	120	127	149	158	189	206	211	224	231	238
Node214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node217	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.78	0	0
Node222	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0
Node223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0
Node225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0
Node226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.35	0	0
Node227	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.18	0	0
Node228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0
Node229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Node230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0
Node232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Node233	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.65	0
Node234	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4
Node236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9
Node237	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3
Node239	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node244	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	0	0
Node245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node246	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node248	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node249	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node250	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node252	0	0	0	0	0	0	0	0	0	0	0	2.21	0	0	0	0	0	0
Node253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node255	0	0	0	0	0	0	0	0	0	0	0	1.71	0	0	0	0	0	0
Node256	0	0	0	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0
Node257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node258	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node262	0	0	0	0	0	0	0	0	0	0	0	0	0	2.85	0	0	0	0
Node263	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0	0	0	0
Node264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node265	0	0	0	0	0	0	0	0	0	0	0	0	0	2.44	0	0	0	0
Node266	0	0	0	0	0	0	0	0	0	0	0	0	0	1.59	0	0	0	0
Node267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node269	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node272	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node276	0	0	0	0	0	0	0	0	0	0	0	1.25	0	0	0	0	0	0
Node277	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node278	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0
Node279	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0
Node280	0	0	0	0	0	0	0	0	0	0	0	1.16	0	0	0	0	0	0
Node281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node282	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0
Node283	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0
Node284	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Node285	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0
Node286	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.7: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 4-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTİ 254	Köşk 271	Hisar 297
Node214	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0
Node216	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node217	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node218	0	0	0	2.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node219	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node220	0	0	0	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node227	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node233	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node234	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node237	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node239	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node240	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node241	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node243	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node244	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node245	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node246	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node248	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	0	0
Node252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Node255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node257	0	0	2.31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node258	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node262	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node264	0	0	0	2.57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node266	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node267	0	0	0	2.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node268	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node269	0	0	0	1.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node270	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node272	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node273	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node275	0	0	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node277	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node278	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node279	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node281	0	0	1.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node282	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node286	0	0	0	2.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.8: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 4-2

	Sincan 2	4N1 17	4N2 24	Etimesgut 40	Batıkent 50	4N7 53	Merkez 91	4N9 111	Keçiören 120	4N10 127	Kayaş 149	Kurtuluş 158	4N21 189	4N20 206	4N22 211	4N17 224	4N16 231	4N18 238
Node289	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node290	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0
Node291	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node292	0	0	0	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	0	0	0	0	0	0	0	0	1.95	0	0	0	0	0	0
Node294	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0
Node295	0	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node298	0	0	0	0	0	0	0	0	0	0	0	1.57	0	0	0	0	0	0
Node299	0	0	0	0	0	0	0	0	0	0	0	1.34	0	0	0	0	0	0
Node300	0	0	0	0	0	0	0	0	0	0	0	1.35	0	0	0	0	0	0
Node301	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0
Node302	0	0	0	0	0	0	0	0	0	0	0	1.36	0	0	0	0	0	0
Node303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node307	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Node308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.18	0	0	0
Node309	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.15	0	0	0
Node312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.93	0	0	0
Node313	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0
Node314	0	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0
Node315	0	0	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0
Node316	0	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0
Node318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node319	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node323	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node329	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node333	0	0	0	0	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0
Node334	0	0	0	0	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0
Node335	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node336	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Node337	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node338	0	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0
Node339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node342	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node343	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0
Node344	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0
Node345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node346	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node347	3.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node348	2.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node349	2.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node350	2.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node351	2.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node352	2.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node353	3.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node354	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node355	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node356	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node357	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node358	0	0	1.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node359	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.9: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 5-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTİ 254	Köşk 271	Hisar 297
Node289	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node291	0	0	0	0	0	0.88	0	0	0	0	0	0	0	0	0	0	0	0	0
Node292	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35
Node298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node303	0	0	0	0	1.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node304	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node307	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node309	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0
Node310	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0
Node311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node313	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node314	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node318	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node319	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node320	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node321	0	0	0	0	0	0.98	0	0	0	0	0	0	0	0	0	0	0	0	0
Node323	0	0	0	0	0	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node324	0	0	0	0	0	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0
Node325	0	0	0	0	0	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node326	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node327	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node328	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node329	0	0	0	0	0	1.55	0	0	0	0	0	0	0	0	0	0	0	0	0
Node330	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0
Node331	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0
Node332	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Node333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node334	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node335	0	0	0	0	0	0	0	2.71	0	0	0	0	0	0	0	0	0	0	0
Node336	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node337	0	0	0	0	0	0	0	1.91	0	0	0	0	0	0	0	0	0	0	0
Node338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node339	0	0	0	0	0	0	0	1.86	0	0	0	0	0	0	0	0	0	0	0
Node342	0	0	1.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node343	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node345	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node347	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node349	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node352	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node353	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node354	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node355	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node356	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node357	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node359	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.10: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 5-2

	Sincan 2	4N1 17	4N2 24	Etimesgut 40	Batıkent 50	4N7 53	Merkez 91	4N9 111	Keçiören 120	4N10 127	Kayaş 149	Kurtuluş 158	4N21 189	4N20 206	4N22 211	4N17 224	4N16 231	4N18 238
Node360	0	0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node361	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node362	0	1.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node363	0	0	0	0	0	2.37	0	0	0	0	0	0	0	0	0	0	0	0
Node364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node365	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node366	0	0	0	0	2.14	0	0	0	0	0	0	0	0	0	0	0	0	0
Node367	0	0	0	0	1.29	0	0	0	0	0	0	0	0	0	0	0	0	0
Node368	0	0	0	0	0.59	0	0	0	0	0	0	0	0	0	0	0	0	0
Node369	0	0	0	3.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node370	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
Node371	0	0	0	0	3.74	0	0	0	0	0	0	0	0	0	0	0	0	0
Node372	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node373	0	0	0	0	1.49	0	0	0	0	0	0	0	0	0	0	0	0	0
Node374	0	0	0	0	1.87	0	0	0	0	0	0	0	0	0	0	0	0	0
Node375	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node376	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node377	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node378	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node379	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node380	0	0	0	0	2.32	0	0	0	0	0	0	0	0	0	0	0	0	0
Node381	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node382	0	0	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0	0
Node383	0	0	0	0	2.54	0	0	0	0	0	0	0	0	0	0	0	0	0
Node384	0	0	0	0	2.18	0	0	0	0	0	0	0	0	0	0	0	0	0
Node385	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0
Node386	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Node387	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Node388	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node389	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node391	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node392	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node393	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node394	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node396	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node397	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0
Node398	2.96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node399	0	0	3.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node400	0	0	3.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node401	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node402	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node403	0	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node404	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node405	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node406	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node407	0	1.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node408	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.11: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 6-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTİ 254	Köşk 271	Hisar 297
Node360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node362	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node363	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Node365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node366	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node369	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node373	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node374	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node376	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node377	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Node378	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0
Node379	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node381	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node383	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node385	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node386	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node387	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node388	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0
Node389	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0
Node391	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0
Node392	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0
Node393	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0
Node394	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0
Node396	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Node397	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node398	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node399	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node401	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node402	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node404	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node406	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node408	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.12: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 6-2

	Sincan	4N1	4N2	Etimesgut	Batıkent	4N7	Merkez	4N9	Keçiören	4N10	Kayaş	Kurtuluş	4N21	4N20	4N22	4N17	4N16	4N18
	2	17	24	40	50	53	91	111	120	127	149	158	189	206	211	224	231	238
Node409	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node411	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node412	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node413	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node415	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node416	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node418	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node419	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node434	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node435	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node436	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0
Node437	0	0	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0
Node438	0	0	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0
Node439	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node443	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node444	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node445	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0
Node447	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0
Node448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node449	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node450	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0
Node451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.13: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 7-1

	Çayyolu 242	4N3 247	Esat 274	4N23 288	4N19 317	Siteler 322	4N8 340	Altınpark 341	4N15 390	4N6 395	4N11 417	4N14 430	4N13 431	4N12 433	4N4 441	4N5 442	AŞTI 254	Köşk 271	Hisar 297
Node409	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node410	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0
Node411	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0
Node412	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0
Node413	0	0	0	0	0	0	0	0	0	0	1.15	0	0	0	0	0	0	0	0
Node414	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0
Node415	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0
Node416	0	0	0	0	0	0	0	0	0	0	0.35	0	0	0	0	0	0	0	0
Node418	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0
Node419	0	0	2.91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Node432	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0
Node434	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0
Node435	0	0	0	0	0	0	0	0	0	0	3.75	0	0	0	0	0	0	0	0
Node436	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node438	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node439	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0
Node440	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0
Node443	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node444	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node446	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node447	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node448	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node449	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node451	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0

Table G.14: 4-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes 7-2

Tables for 8 Minutes

	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
	2	34	40	50	76	91	120	149	158	181	182	235	242	274	322	341	388	254	271	297
Node1	2.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node4	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node5	2.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node6	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node7	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node8	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node9	3.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node10	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node11	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node12	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node13	3.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node14	4.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node15	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node16	5.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node17	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node18	4.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node19	4.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node20	0	0	5.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node21	0	0	4.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node22	0	0	3.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node23	0	0	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node24	0	0	2.98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node25	0	0	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node26	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node27	0	5.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node28	6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node29	0	0	6.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node30	0	0	5.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node31	0	0	6.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node32	0	0	5.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node33	0	0	4.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node35	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node36	0	0	3.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node37	0	0	2.93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node38	0	0	2.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node39	0	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node41	0	0	0.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node42	0	0	0	2.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node43	0	0	0	2.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node44	0	0	0	3.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node45	0	0	0	1.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node46	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node47	0	0	0	2.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node48	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node49	0	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node51	0	0	0	1.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node52	0	0	0	2.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node53	0	0	0	2.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node54	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node55	0	0	0	2.36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node56	0	0	0	2.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node57	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node58	0	0	0	2.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node59	0	0	0	5.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node60	0	5.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node61	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node62	0	0	0	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node63	0	0	0	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node64	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node65	0	0	0	3.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node66	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node67	0	0	0	3.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node68	0	0	0	5.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.15: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-1

	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
	2	34	40	50	76	91	120	149	158	181	182	235	242	274	322	341	388	254	271	297
Node69	0	0	0	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node70	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node71	0	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node72	0	0	0	0	0	3.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node73	0	0	0	0	0	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node74	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0
Node77	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node78	0	0	0	0	0	6.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node79	0	0	0	0	0	5.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node80	0	0	0	0	0	5.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node81	0	0	0	0	0	3.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node82	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node83	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node84	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node85	0	0	0	0	0	0	7.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Node86	0	0	0	0	0	0	6.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node87	0	0	0	0	0	0	5.14	0	0	0	0	0	0	0	0	0	0	0	0	0
Node88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.05	0	0	0	0
Node89	0	0	0	0	0	3.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node90	0	0	0	0	0	3.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node92	0	0	0	0	0	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node93	0	0	0	0	0	0.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node94	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node95	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.75	0	0	0	0
Node97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0
Node98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.05	0	0	0	0
Node99	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node100	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node101	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node102	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.65	0	0	0	0
Node104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.45	0	0	0	0
Node105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.9	0	0	0	0
Node106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0
Node107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0
Node108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0
Node109	0	0	0	0	0	0	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node110	0	0	0	0	0	0	4.55	0	0	0	0	0	0	0	0	0	0	0	0	0
Node111	0	0	0	0	0	0	4.15	0	0	0	0	0	0	0	0	0	0	0	0	0
Node112	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node113	0	0	0	0	0	0	5.24	0	0	0	0	0	0	0	0	0	0	0	0	0
Node114	0	0	0	0	0	0	4.54	0	0	0	0	0	0	0	0	0	0	0	0	0
Node115	0	0	0	0	0	0	2.34	0	0	0	0	0	0	0	0	0	0	0	0	0
Node116	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node117	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node118	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Node119	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node121	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node122	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Node123	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node124	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	0	0	0	0
Node126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.35	0	0	0	0
Node127	0	0	0	0	0	0	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Node128	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.51	0	0	0	0
Node130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0
Node131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0
Node132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.33	0	0	0	0	0
Node133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.33	0	0	0	0	0
Node134	0	0	0	0	0	0	0	0	2.38	0	0	0	0	0	0	0	0	0	0	0
Node135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.48	0	0	0	0	0
Node136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.63	0	0	0	0	0
Node137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23	0	0	0	0	0

Table G.16: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-2

	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
	2	34	40	50	76	91	120	149	158	181	182	235	242	274	322	341	388	254	271	297
Node138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Node139	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node140	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.68	0	0	0	0	0
Node142	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node143	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node144	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node145	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node146	0	0	0	0	4.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node147	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node148	0	0	0	0	0	0	0	5.5	0	0	0	0	0	0	0	0	0	0	0	0
Node150	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Node151	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Node152	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0
Node153	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0
Node154	0	0	0	0	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0
Node155	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0
Node156	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
Node157	0	0	0	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0
Node159	0	0	0	0	0	0	0	0	1.84	0	0	0	0	0	0	0	0	0	0	0
Node160	0	0	0	0	0	0	0	0	1.55	0	0	0	0	0	0	0	0	0	0	0
Node161	0	0	0	0	0	0	0	0	0.95	0	0	0	0	0	0	0	0	0	0	0
Node162	0	0	0	0	0	0	0	0	0.55	0	0	0	0	0	0	0	0	0	0	0
Node163	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0
Node164	0	0	0	0	0	2.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node165	0	0	0	0	0	0	0	0	2.38	0	0	0	0	0	0	0	0	0	0	0
Node166	0	0	0	0	0	0	0	0	0	0	0	0	0	1.91	0	0	0	0	0	0
Node167	0	0	0	0	0	0	0	0	0	0	0	0	0	1.51	0	0	0	0	0	0
Node168	0	0	0	0	0	0	0	0	0	0	0	0	0	2.01	0	0	0	0	0	0
Node169	0	0	0	0	0	0	0	0	0	0	0	0	0	0.81	0	0	0	0	0	0
Node170	0	0	0	0	0	0	0	0	0	0	0	0	0	2.68	0	0	0	0	0	0
Node171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
Node172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Node173	0	0	0	0	0	0	0	0	0	0	0	0	0	1.33	0	0	0	0	0	0
Node174	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0
Node175	0	0	0	0	0	0	0	0	0	0	0	0	0	2.93	0	0	0	0	0	0
Node176	0	0	0	0	0	0	0	0	0	0	0	0	0	4.43	0	0	0	0	0	0
Node177	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0
Node178	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0	0
Node179	0	0	0	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node180	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0	0
Node183	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0
Node184	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	1.1	0
Node185	0	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0	0	0
Node186	0	0	0	0	0	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0
Node187	0	0	0	0	0	0	0	0	0	0	3.95	0	0	0	0	0	0	0	0	0
Node188	0	0	0	0	0	0	0	0	0	0	5.65	0	0	0	0	0	0	0	0	0
Node189	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0
Node190	0	0	0	0	0	2.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node191	0	0	0	0	0	3.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node192	0	0	0	0	0	2.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node193	0	0	0	0	0	2.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node194	0	0	0	0	0	0	0	0	2.93	0	0	0	0	0	0	0	0	0	0	0
Node195	0	0	0	0	0	0	0	0	3.33	0	0	0	0	0	0	0	0	0	0	0
Node196	0	0	0	0	0	0	0	0	4.13	0	0	0	0	0	0	0	0	0	0	0
Node197	0	0	0	0	0	4.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node198	0	0	0	0	0	0	0	0	0	0	0	0	0	2.86	0	0	0	0	0	0
Node199	0	0	0	0	0	0	0	0	0	0	0	0	0	3.66	0	0	0	0	0	0
Node200	0	0	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node201	0	0	0	0	0	0	0	0	0	0	4.4	0	0	0	0	0	0	0	0	0
Node202	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Node203	0	0	0	0	0	0	0	0	0	0	5.57	0	0	0	0	0	0	0	0	0
Node204	0	0	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0	0	0	0	0
Node205	0	0	0	0	0	0	0	0	0	0	6.89	0	0	0	0	0	0	0	0	0
Node206	0	0	0	0	0	0	0	0	0	0	7.64	0	0	0	0	0	0	0	0	0
Node207	0	0	0	0	0	0	0	0	0	0	4.9	0	0	0	0	0	0	0	0	0

Table G.17: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-3

	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
	2	34	40	50	76	91	120	149	158	181	182	235	242	274	322	341	388	254	271	297
Node208	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Node209	0	0	0	0	0	0	0	0	0	0	7.8	0	0	0	0	0	0	0	0	0
Node210	0	0	0	0	0	0	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0
Node211	0	0	0	0	0	3.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node212	0	0	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node213	0	0	0	0	0	3.74	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node214	0	0	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.55	0	0
Node216	0	0	0	0	0	5.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node217	0	0	0	0	0	5.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.7	0	0	0
Node219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	0	0	0
Node220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0
Node221	0	0	0	0	0	0	0	0	0	0	0	0	3.45	0	0	0	0	0	0	0
Node222	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3	0	0	0
Node224	0	0	0	0	0	0	0	0	0	0	0	0	4.23	0	0	0	0	0	0	0
Node225	0	0	0	0	0	0	0	0	0	0	0	0	3.63	0	0	0	0	0	0	0
Node226	0	0	0	0	0	0	0	0	0	0	0	0	4.55	0	0	0	0	0	0	0
Node227	0	0	0	0	0	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0	0
Node228	0	0	0	0	0	0	0	0	0	0	0	0	3.55	0	0	0	0	0	0	0
Node229	0	0	0	0	0	0	0	0	0	0	0	0	3.35	0	0	0	0	0	0	0
Node230	0	0	0	0	0	0	0	0	0	0	0	0	1.55	0	0	0	0	0	0	0
Node231	0	0	0	0	0	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0
Node232	0	0	0	0	0	0	0	0	0	0	0	0	1.35	0	0	0	0	0	0	0
Node233	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Node234	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0
Node236	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0
Node237	0	0	0	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0	0
Node238	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0
Node239	0	0	0	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0
Node240	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0
Node241	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0
Node243	0	0	0	0	0	0	0	0	0	0	0	0	0.35	0	0	0	0	0	0	0
Node244	0	0	0	0	0	0	0	0	0	0	0	0	2.8	0	0	0	0	0	0	0
Node245	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0
Node246	0	0	0	0	0	0	0	0	0	0	0	0	4.5	0	0	0	0	0	0	0
Node247	0	0	0	0	0	0	0	0	0	0	0	6.7	0	0	0	0	0	0	0	0
Node248	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node249	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node250	3.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node251	0	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node252	0	0	0	0	0	0	0	0	2.21	0	0	0	0	0	0	0	0	0	0	0
Node253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Node255	0	0	0	0	0	0	0	0	1.71	0	0	0	0	0	0	0	0	0	0	0
Node256	0	0	0	0	0	1.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node257	0	0	0	0	0	0	0	0	0	0	0	0	0	2.31	0	0	0	0	0	0
Node258	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.9	0	0	0
Node259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node262	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Node263	0	0	0	0	0	0	0	0	0	0	6.69	0	0	0	0	0	0	0	0	0
Node264	0	0	0	0	0	0	0	0	0	0	6.16	0	0	0	0	0	0	0	0	0
Node265	0	0	0	0	0	0	0	0	0	0	6.9	0	0	0	0	0	0	0	0	0
Node266	0	0	0	0	0	0	0	0	0	0	6.05	0	0	0	0	0	0	0	0	0
Node267	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
Node268	0	0	0	0	0	0	0	0	0	0	5.3	0	0	0	0	0	0	0	0	0
Node269	0	0	0	0	0	4.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node270	0	0	0	0	0	0	0	0	0	0	0	0	0	4.01	0	0	0	0	0	0
Node272	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0
Node273	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23	0	0	0	0	0	0
Node275	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0	0	0
Node276	0	0	0	0	0	0	0	0	1.25	0	0	0	0	0	0	0	0	0	0	0
Node277	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
Node278	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0

Table G.18: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-4

	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
	2	34	40	50	76	91	120	149	158	181	182	235	242	274	322	341	388	254	271	297
Node279	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Node280	0	0	0	0	0	0	0	0	1.16	0	0	0	0	0	0	0	0	0	0	0
Node281	0	0	0	0	0	0	0	0	0	0	0	0	0	1.21	0	0	0	0	0	0
Node282	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Node283	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0
Node284	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Node285	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0
Node286	0	0	0	0	0	0	0	0	3.83	0	0	0	0	0	0	0	0	0	0	0
Node287	0	0	0	0	0	0	0	0	0	0	5.6	0	0	0	0	0	0	0	0	0
Node288	0	0	0	0	0	5.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node289	0	0	0	0	0	5.89	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node290	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0
Node291	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.88	0	0	0	0	0
Node292	0	0	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node293	0	0	0	0	0	0	0	0	1.95	0	0	0	0	0	0	0	0	0	0	0
Node294	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node295	0	0	0	0	0	2.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35
Node298	0	0	0	0	0	0	0	0	1.57	0	0	0	0	0	0	0	0	0	0	0
Node299	0	0	0	0	0	0	0	0	1.34	0	0	0	0	0	0	0	0	0	0	0
Node300	0	0	0	0	0	0	0	0	1.35	0	0	0	0	0	0	0	0	0	0	0
Node301	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0
Node302	0	0	0	0	0	0	0	0	1.36	0	0	0	0	0	0	0	0	0	0	0
Node303	0	0	0	0	0	0	0	0	1.93	0	0	0	0	0	0	0	0	0	0	0
Node304	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0
Node305	0	0	0	0	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0
Node306	0	0	0	0	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0
Node307	0	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node308	0	0	0	4.42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node309	0	0	0	4.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node310	0	0	0	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node311	0	0	0	0	0	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node312	0	0	0	0	0	4.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node313	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node314	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node315	0	0	0	0	0	3.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node316	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
Node317	0	0	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0
Node318	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0
Node319	0	0	0	0	0	0	0	0	3.75	0	0	0	0	0	0	0	0	0	0	0
Node320	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0
Node321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.98	0	0	0	0	0
Node323	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35	0	0	0	0	0
Node324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.65	0	0	0	0	0
Node325	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0
Node327	0	0	0	0	0	0	0	0	0	0	5.8	0	0	0	0	0	0	0	0	0
Node328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0
Node329	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node330	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node331	0	0	0	0	0	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Node333	0	0	0	0	0	0	1.85	0	0	0	0	0	0	0	0	0	0	0	0	0
Node334	0	0	0	0	0	0	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0
Node335	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.71	0	0	0	0
Node336	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Node337	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.91	0	0	0	0
Node338	0	0	0	0	0	0	2.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Node339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.86	0	0	0	0
Node340	0	0	0	0	0	0	7.45	0	0	0	0	0	0	0	0	0	0	0	0	0
Node342	0	0	0	0	0	0	0	0	0	0	0	0	0	1.51	0	0	0	0	0	0
Node343	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0
Node344	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0
Node345	0	0	0	0	0	0	0	0	0	0	6.6	0	0	0	0	0	0	0	0	0
Node346	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node347	3.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.19: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-5

	Sincan	8N1	Etimesgut	Batıkent	8N2	Merkez	Keçiören	Kayaş	Kurtuluş	8N3	8N6	8N5	Çayyolu	Esat	Siteler	Altınpark	8N4	AŞTİ	Köşk	Hisar
	2	34	40	50	76	91	120	149	158	181	182	235	242	274	322	341	388	254	271	297
Node348	2.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node349	2.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node350	2.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node351	2.66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node352	2.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node353	3.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node354	2.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node355	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node356	4.77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node357	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node358	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node359	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node360	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node361	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node362	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node363	0	0	0	2.89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node364	0	0	0	3.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node365	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node366	0	0	0	2.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node367	0	0	0	1.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node368	0	0	0	0.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node369	0	0	3.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node370	0	0	0	4.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node371	0	0	0	3.74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node372	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node373	0	0	0	1.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node374	0	0	0	1.87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node375	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node376	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node377	0	0	0	3.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node378	0	4.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node379	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node380	0	0	0	2.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node381	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node382	0	0	0	2.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node383	0	0	0	2.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node384	0	0	0	2.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node385	0	0	0	0	0	0	0	0	0	0	0	0	4.05	0	0	0	0	0	0	0
Node386	0	0	0	0	0	0	0	0	0	0	0	0	3.35	0	0	0	0	0	0	0
Node387	0	0	0	0	0	0	0	0	0	0	0	0	5.35	0	0	0	0	0	0	0
Node389	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.4	0	0	0
Node390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	0	0
Node391	0	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node392	0	4.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node393	0	4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node394	0	5.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node395	0	0	0	5.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node396	0	5.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node397	0	0	0	0	0	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0
Node398	2.96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node399	4.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node400	3.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node401	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node402	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node403	4.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node404	3.82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node405	3.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node406	3.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node407	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node408	0	0	5.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node409	0	0	6.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node410	0	0	0	0	5.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node411	0	0	0	0	5.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node412	0	0	0	0	4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node413	0	0	0	0	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node414	0	0	0	0	5.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table G.20: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-6

	Sincan 2	8N1 34	Etimesgut 40	Batıkent 50	8N2 76	Merkez 91	Keçiören 120	Kayaş 149	Kurtuluş 158	8N3 181	8N6 182	8N5 235	Çayyolu 242	Esat 274	Siteler 322	Altınpark 341	8N4 388	AŞTİ 254	Köşk 271	Hisar 297
Node415	0	0	0	0	4.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node416	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node417	0	0	0	0	3.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node418	0	0	0	0	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node419	0	0	0	0	0	0	0	0	0	0	0	0	0	2.91	0	0	0	0	0	0
Node420	0	0	0	0	0	0	0	0	0	0	0	0	6.25	0	0	0	0	0	0	0
Node421	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node422	0	0	0	0	0	0	0	0	0	0	0	6.1	0	0	0	0	0	0	0	0
Node423	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node424	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node429	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Node430	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Node431	0	0	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0	0	0	0	0
Node432	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Node433	0	0	0	0	0	0	0	7.9	0	0	0	0	0	0	0	0	0	0	0	0
Node434	0	0	0	0	7.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node435	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node436	0	0	0	0	0	0	7.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Node437	0	0	0	0	0	0	6.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Node438	0	0	0	0	0	0	6.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Node439	0	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node440	0	0	0	0	0	7.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node441	0	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node442	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node443	0	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node444	0	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node445	0	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node446	0	0	3.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node447	0	0	0	0	0	0	0	0	0	0	0	0	7.83	0	0	0	0	0	0	0
Node448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.3	0	0	0
Node449	0	0	0	0	0	4.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Node450	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0
Node451	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
Node452	0	0	0	3.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
max	7.3	7.3	6.78	5.25	7.35	7.45	7.9	7.9	4.13	5	8	6.7	7.83	4.43	2.48	5.05	6.3	0.55	1.1	0.35

Table G.21: 8-minute time-restricted model for additional fire stations: Distances between fire stations and their assigned nodes-7