# DISCUSSION PAPER ON RTD'S REGIONAL ROLE IN PROVIDING PUBLIC TRANSPORTATION

SECOND DRAFT

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The legislation which created the RTD places practically no limitations on the role of the District. Rapid Transit is broadly defined in the act as the transportation of passengers only and their incidental baggage by means other than by chartered bus, sightseeing bus, taxi or any other motor vehicle not on an individual passenger fare-paying basis. The act specifically mentions school bus service as one of the types of service not prohibited by the broad definition. Restrictions on competing with other public systems do not appear as a limitation on the type of service but as guarantees against competition between RTD and other established transit systems.

Indeed, the power to acquire public and private systems suggests that the legislature did not intend to restrict RTD to a purely regional role but expected the District to develop and operate a comprehensive public transportation system.

While there do not appear to be any legal restrictions on RTD, there is a real and obvious limitation in terms of resources available to meet all of the needs, local and regional, for public transportation. The fact that some municipalities within the District own and operate transit systems requires that there be agreement on the respective roles of the two systems where they meet or overlap. Additionally, there are substantial differences between cities and communities with regard to needs and desires for public transportation and the willingness to provide funds for the support of local service.

This paper discusses some of the alternative ways in which service might be allocated and the responsibilities of the RTD and Muni Systems defined.

How should service be measured?

Basic to the concept of allocation of service is agreement on ways to measure service. In this regard, standards covering hours of operation, loading, maximum headways and stop spacing can be useful in providing at least a common understanding. With established standards, a discussion of a route includes an understanding that that route will be operated between known hours of the day with sufficient seats to accommodate the patronage or a maximum period between buses during the peak base, night and owl periods.

The development of standards requires a route classification system since standards vary by the function the route is intended to provide. Both the classification and the standards must be explicit, understandable and widely publicized.

While standards are extremely useful in describing service, they do not fully meet the need for measuring the amount of service.

Cost of service (particularly cost net of revenues) is another measure which can be used to describe service allocation. In negotiations and discussions with a given municipality or community, RTD can use cost as an indication of the effort which is being made to serve that community. However, there are many problems associated with cost and earnings allocations and these can lead to misunderstandings and to difficulties in administration of the service.

Coverage provided by the system is a commonly used measure of transit services. Either on a geographic or population basis, it describes the extent to which an area is served.

Both cost and coverage, while useful, tend to be second order measures which may mask transit deficiencies. An example is an area lying astride several heavily travelled routes radiating from downtown. Such an area appears to have good service, but it may be very difficult to travel by transit in directions other than to or from downtown.

Transit accessibility is a measure of the time and cost associated with travel to opportunities of various kinds. As such, it is more nearly a measure of the goodness of service as perceived by an individual user or by the residents of a particular community.

The same accessibility cannot be provided to all areas (if accessibility is measured in minutes of travel) for the simple reason that some areas are closer to opportunities than are others. Thus, a minutes-per-mile measure or a ratio of transit to auto accessibility might be more appropriate. Alternatively, the District could be divided into areas which recognize their spatial relationship to opportunities and different accessibility measures could be used for each district.

Functional Classification of Service

There are a number of recognized ways to classify transit service. The one proposed here attempts to cover the spectrum of services offered in more detail than is commonly used so that standards and guidelines can eventually be discussed for each.

1. Express. Express service is intended to serve long trips with few stops. Such service typically has a collection area with a number of stops, a delivery area with one or more stops, and a non-stop or limited-stop route between.

2. Arterial Local Service. This service radiates outward from CBD's and major activity centers, serving all types of trips but with intervening stops.

3. Cross County. This is a special type of service which, while it might serve one or more activity centers, provides relatively long connections for inter-city travel within the county.

4. Feeder. Feeder services are specialized routes centered on rapid transit stations and express bus route stops. They may serve local trips as well, but their principal purpose is to extend the market area of express and rapid transit routes.

5. Neighborhood. This fixed route service caters to short trips within a localized area, community or neighborhood. It may feed other services, but its feeder function is secondary to its local circulation function.

6. Collector-Distributor Service. This service is confined to high activity centers and serves very short trips. It may (and almost invariably will), serve a feeder function, but trips beginning and ending within the center are also served.

7. Demand-Responsive Service. This type of service, frequently called Dial-A-Bus, is dispatched and routed in response to calls from people wishing to make a trip. It can be used to provide service in areas which do not warrant fixed-route and schedule service.

8. Exurban Commuter Service. This is a special type of express service operating essentially non-stop between outlying very low-density residential areas and central area employment centers. A variation of this is subscription service which is included under this general category.

## STANDARDS

Formulation of guidelines and standards will continue into the future, drawing on the findings of pilot subarea studies, network analysis, and discussions with citizens, transit operators, and public officials. This paper is a beginning, using information based largely on industry standards and on experience in the Los Angeles area.

## Route Layout

The material under this general heading applies to fixed bus routes on conventional streets and does not apply directly to busways, reserved freeways lanes or demand-responsive service such as Dial-A-Bus.

Directness. Routes should be as direct as possible and involve a minimum of turning.

Transfers. Transfer points and areas should be established to facilitate transfers between different types of service, between different systems (e.g., RTD and the Munis) and between different modes (e.g., between inter-city bus or rail and RTD). Transfers from auto to bus are discussed separately under Park-Ride Facilities. Schedules of intersecting routes should be coordinated to reduce waiting time.

Spacing. Routes should be separated to achieve coverage consistent with the density of development, the socioeconomic characteristics of the population, the street patterns, and the types of trips to be served. Suggested spacings are shown in Table 1. Those spacing suggestions are based on walking distance and residential density. In fact, route spacing involves many considerations, not the least of which are available funds, historical precedent, and streets patterns. There are trade-offs between route spacing and the frequency of service on each route. Accordingly, while the spacings shown in Table 1 cannot be regarded as standards, they are useful guides to general system layout.

## Frequency of Service

Frequency of service is governed by two factors--policy and patronage. Policy governs the provision of a minimum level-of-service frequency for a route and usually will apply only during off-peak hours. Stated another way, some minimum amount of service should be provided or else a route should be discontinued. Policy determines what that

TABLE 1. SUGGESTED SPACING BASED ON POPULATION DENSITY AND FAMILY INCOME

| Family Income | | Persons Per Acre | | | |
|---|---|---|---|---|---|
| | | 40 Plus | 29-30 | 10-19 | 09 |
| Up to $5,000 | (15.9%) | .25[1] mile | .25[1] mile | .5 mile | .5 mile |
| $5,000 to $9,999 | (28.0%) | .25[1] | .25[1] | .5 | .5 |
| $10,000 to $14,999 | (27.7%) | .5 | .5 | .5 | (2) |
| Over $15,000 | (28.4%) | .5 | .5 | (2) | (2) |
| | 100.0 | | | | |

**Note:** (1) If streets are adequate reduced headways may be substituted for closer spacing.

**Note:** (2) Dial-A-Ride and Park-Ride lots should be considered in lieu of fixed route service.

**TABLE 2. POLICY HEADWAYS (Minimum level-of-service frequencies in minutes)**

| | Peak Hours | Base Hours | Evening | Owl[2] |
|---|---|---|---|---|
| Approximate Period Times | 7:00-9:00 a.m. 4:00-6:00 p.m. | 6:00-7:00 a.m. 9:00 a.m.-4:00 p.m. | 6:00-12:00 p.m. | 12:00-6:00 a.m. |
| Express Service[1] | 15 | 30 | 60[3] | 60 |
| Arterial Local Cross County Service | 30 | 30 | 60[3] | 60 |
| Feeder Service | 15 | 30 | 60[3] | 60 |
| Neighborhood Service | 30 | 30 | 60[3] | 60 |
| C-D Service | 15 | 15 | (6) | (6) |
| Exurban Commuter Service | (4) | | | |

[1]Express service, if run where local service also exists, may be determined by loading standards; however, it will not be operated so as to make local service too infrequent.

[2]Owl service may be operated on a skeleton route structure (at 60-minute minimum headway) so as to place all areas meeting the criteria for a 0.5-mile route spacing within one mile of service.

[3]30-minute service for all center city, low-income areas (i.e., income less than $10,000).

[4]By demand.

[5]Determined by connecting service.

minimum service should be. Suggested minimum levels are shown in Table 2. Often the actual headway operated on very low volume routes will be determined by the frequency that can be provided by one bus.

The patronage-based frequency, normally applicable only during peak periods, is determined by loading standards used by the transit industry for many years. These are usually expressed as a percentage of the number of seats. Thus, a load factor of 100 implies that seats exactly equal passengers whereas a load factor of 150 implies that there is one standee for every two seats.

Loading standards are usually applied at the maximum load point which, in turn, is usually near the destination of most passengers (for example, a central business district, a large employment center or major transfer point).

A more desirable form for expressing the standard is in terms of time spent standing. Admittedly, travel time spent standing is more difficult to measure than loads past a point, but it does more properly describe the quality of service.

Some measure of an acceptable limit on travel time spent standing can be obtained by examining walking times in urban areas. Studies in New York found that approximately 85 percent of all persons walked no more than five minutes for purposes such as from their place of work to transit stations, lunch, shopping, and parking. Although distance walked varied considerably by age and sex, when time spent walking was calculated based on actual walking speed, the times for all ages and sexes were remarkably similar. A survey of transit riders in the Cincinnati region showed a similar average walking duration; half the bus passengers walked no more than a block at each end of their bus ride.

The relationship between time spent walking and time spent standing in a vehicle is not well documented, but other studies of human characteristics and behavior support the conclusion that standing for more than

five or ten minutes is uncomfortable for most persons. In any case, the vehicle ride immediately follows a walk to the stop or station and a wait for the vehicle. Thus, the proposed standard for patronage-based frequency of service is that service which results in a maximum of five minutes travel time as a standee on a bus (or ten minutes as a standee on a rapid transit car.) (The justification for the longer standee time on a rapid transit car is based on the relative number of stops and starts and the fact that rapid transit cars are designed to better accommodate standees.)

Because the relationship between the load factor and travel time spent standing varies by type of service, different standards are recommended for different types of service. For example, an express service such as commuter routes from the San Fernando Valley to downtown Los Angeles should provide seats for all passengers since a standee would have to stand 30 minutes or more.

Even though travel time standing is the preferred standard, for most types of service, load factors cannot be entirely discarded. For example, the use of standee time alone on the downtown mini-bus (where most trips are less than five minutes) would suggest that any load factor would be acceptable. Obviously, this is not the case; there should be a limit to the number of standees to control crowding. Load factors also have the virtue of being easy to measure and to apply in scheduling. Thus, Table 3 shows suggested standards for load factors at maximum load points and at the five-minute ride duration point.

## Reliability

On-time performance directly affects the number of standees and their average waiting time. Thus, early and late vehicles make it more difficult to meet seating standards. Most systems allow a larger percentage of early and late arrivals on routes with frequent service, on the assumption that there is less inconvenience to passengers when one bus

TABLE 3. PEAK-PERIOD LOADING STANDARDS[1]

| | Load Factor[2] | |
|---|---|---|
| | At Maximum Load Point | At Five-Minute Point[3] |
| Express Service | 100 | 100 |
| Local Service | 125 | 100 |
| Feeder Service | 150 | 100 |
| Neighborhood Service | 125 | 100 |
| Crosstown Service | 125 | 100 |
| CBD Service | 150 | N.A. |
| Exurban Commuter Service | 100 | 100 |

[1] These standards are for vehicles having generally maximum seating density.

[2] Load Factor is defined as the ratio of passengers to seats.

[3] The five-minute point is five minutes travel time from the major destination point served by the route.

is early or late out of 10 to 20 buses per hour than if one of only four or five buses per hour is early or late. In fact, the reverse is probably true, since both waiting time and standee travel are affected on the higher-volume routes, but only waiting time on low-volume routes.

On-time performance usually is measured at "time points"--a number of carefully selected points along routes, used to schedule and supervise service.

While early arrival of a bus is considered highly objectionable at boarding and transfer points, it can be very desirable at an alighting point, as in the case of express buses to downtown. Thus, the application of on-time performance standards must recognize that there are exceptions. Suggested schedule adherence tolerances are zero minutes early to two minutes late. Any vehicle within that tolerance is considered to be "on time." The suggested standard is that each scheduled trip is within tolerance at time points 90 percent of the time.

Related to schedule adherence and an important factor in reliability of service are delayed or missed trips. Trips may be missed for any of a variety of causes--accidents, illness, or vehicle failure. Vehicle failure can be partly controlled by preventive maintenance and replacement of older buses. It can be measured by the number of road calls due to equipment failure. Road calls for this reason should be held to a maximum of one call per 10,000 vehicle-miles.

Accidents

Reliability of service is directly related to motor vehicle accidents. Generally speaking, even a minor accident will involve 20 to 30 minutes delay for accident reporting and securing the names and addresses of witnesses and involved parties. Serious accidents involving personal injuries to passengers, pedestrians, or motorists take a coach out of service for longer periods. Based upon examinations of performance

within the transit industry in the United States, traffic accidents for buses should not exceed about 75 per million vehicle-miles operated. Passenger accidents should not exceed approximately 7 per million passengers carried.

## Stop Spacing

The spacing of stops is of vital importance to system operation and to system attractiveness. The more opportunities there are to board and transfer, the easier it is for people to use the system. Offsetting this, however, is the fact that travel time increases with the number of stops. The objective is to find a balance between ease of access and quality of service as expressed by speed or travel time.

Bus Stop Spacing. Bus stops should be located near intersections. In normal residential areas, stop spacing should be between 700 and 1,500 feet for route spacings up to 2,000 feet. Spacing of bus stops in commerical and industrial areas should not be controlled by an arbitrary standard, but by the location of patron concentrations. The confluence of routes in CBD's often results in larger bus volumes than can be accommodated at a single stop, even if space is allowed for two to three buses (three being a reasonable maximum for a single stop). The necessity to allocate a limited number of routes to a stop may prevent achieving desired stop spacing.

## Passenger Amenities

This category encompasses all facilities and equipment that may be encountered by a passenger making a trip.

Transit Vehicles. Buses should be of superior contemporary design with adequate heating and air-conditioning. Seats should be cushioned, and lighting should be designed to allow reading by seated passengers but to minimize glare so that passengers can look out of the vehicle

at night. Vehicle performance, riding comfort, quietness, and emission standards should conform to the most advanced production specifications available at the time of vehicle purchase. Vehicles should be kept clean and in good repair inside and out.

Bus Stop Shelters. Shelters are needed to provide year-round comfort for waiting passengers under conditions of heat, wind, rain or cold. Shelters should be sized according to passenger volumes and should be provided if possible and needed at all stops meeting a standard.

Shelters should be sheathed with transparent material, at least from below seated eye level upward to permit clear vision in all directions. They should be designed to protect patrons from rain and wind and should be lighted by nearby street lighting or self-contained lights. Seating should be provided in each shelter, unless available space prevents provision of a shelter of adequate size.

Transit Rights-of-Way. Rights-of-way traversed by transit vehicles should be kept free of litter and defacement. Where rights-of-way are not transit-owned, appropriate agreements should be made with those responsible to ensure that adequate standards of cleanliness and appearance are maintained.

Information Services

Transit stations and passenger shelters should be supplied with posted route maps and timetables for the routes served. A system map should be displayed in at least one location in each station or shelter. Bus stops should be identified by route markers, which include (at a minimum) a system logo or functional identification, and the identification of all routes serving that stop which would correspond to the information displayed in the destination sign on the front of the bus.

Vehicles should contain a posted map of the route being operated, and public route timetables and maps should be available.

For each route, there should be a public timetable and map showing corssing and paralleling streets within a quarter-mile of the route and indicating major activity centers, landmarks, and street address numbering. Intersection transit routes should be marked, with summary schedule information given. Fare information should be provided.

Telephone information should be available 24 hours a day and should be operated to a high standard of competence and courtesy, including provision of adequate switchboard capacity so that callers seldom get a busy signal.

Promotional efforts should have the objective of providing households near transit service with system and route maps, route timetables, and any specific information requested regarding system use. Promotional material should identify probable destinations from each neighborhood and show how to reach those destinations. Short courses explaining the transit system and how to use it should be offered in schools, at various age levels, and via public news media.

Route and schedule information should be published in all major newspapers, preferably in a form easily saved by the reader, at least three times each year and particularly at those times when there are substantial changes in schedules.

Security Program

Transit system users and employees should be safe from acts of violence, and property of the system should be secure from vandalism and theft. To provide this security, each transit system should have an aggressive security program consisting of the following:

- Surveillance of stations, yards, parking areas, buses and stops
- Provision of emergency communication equipment to police

- Maintenance of records showing the location, frequency, and nature of incidents
- Standards for security by type of incident
- Liaison with police agencies

Law enforcement should be by sworn officers accountable to the policy agency responsible for law enforcement in the area. Surveillance and communications systems should be the primary responsibility of the transit agency.

## LEVEL OF SERVICE

The analysis of service quality and quantity provided by existing and proposed transit services for the SCRTD area should attempt to develop various methods of describing service provided by these systems. The service standards above deal with coverage of the area by transit routes, frequency of service, capacity in relation to demand, and other measures of service quality and quantity. Although these standards are valuable and usable, they do not fully describe the service provided since they do not tell how well each part of the area is connected to the other parts. Thus, in looking at a particular part of the region, one might conclude that it has good transit service on the basis of coverage and frequency when in fact very few parts of the region can be reached in a reasonable time at reasonable cost.

The need for level-of-service guidelines has long been recognized, but there is no generally accepted yardstick for that purpose. Functions of level-of-service guidelines were described earlier in this paper. SCRTD's intention is to develop a method whereby the amount of service to be operated can be equitably distributed, given a possible level of expenditure. To function in this way, the method must have these characteristics:

- It must be demonstrably rational, based upon clear concepts, and as direct and realistic as possible.

- It must be derived from measurements that are easily obtained and updated.
- It must perform realiably over a wide range of need and service levels.

Level-of-service guidelines must relate an adequate description of transit service to an equally adequate description of transit users and the trips for which they may use transit. While the guidelines will have to describe transit service in a composite manner, the measurement of service can be understood by considering its components, as defined by four concepts:

1. Coverage. Within a geographic area (neighborhood, subarea, or traffic zone) where existing or potential transit users live, the proximity of the population to each transit route (stops or stations) can be measured or forecasted.
2. Linkage. The potential destinations to which each transit route provides access can be described.
3. Frequency. The amount of service on each route, in terms of frequency or headway by time of day and day of week, can be described.
4. Speed. Measurements or estimates can be made to determine vehicle running time or speed on each route.

The combination of data expressing these four concepts will provide an overall quantitative expression of the level of service provided by existing or postulated routes within each geographic area being considered.

The description of transit users and their trips may be based on these or other concepts:

5. Family income. Census data and forecasting methods are adequate to describe family income, which is closely correlated with the degree of transit dependence within families.
6. Population density. This easily described statistic tends to correlate inversely with the net cost (total operating cost less fares) of providing transit service. As density drops, net cost rises.

7. Accessibility by automobile. The adequacy of transit service is related to how well it performs relative to alternative means of transportation--it should be in as strongly competitive a position as possible.

8. When a trip is made. Those who use transit by choice do so mainly to travel to work. Where transit dependence is high, on the other hand, most or all trip purposes must be served by public transportation. Each of these trip purposes characteristically occurs during certain hours of the day or days of the week. Because transit service also varies by time of day and day of the week, it is necessary to know when the travel demand occurs.

9. Activity levels at desintations. Transit accessibility to any location is made significant by the amount of activity (i.e., potential for satisfying the purpose of a trip) at that location. For example, if work trips are being considered, the amount of employment at a potential destination must be known in order to weigh the value of providing good access to that destination.

As an alternative to the use of factors such as income and population density to describe transit users, it may be possible to substitute their transit trip rate. This would be a relatively direct, practical approach although it is influenced by the level of service provided; its use will be investigated.

Integrating measures derived from the four service concepts above with those resulting from the five user and trip concepts produces, in effect, accessibility indices. For each geographic unit or area studied, the accessibility provided by transit to the major destinations for each of five trip purposes will be studied. The five purposes, which vary in transit significance according to user characteristics of that geographic unit, are:

- Employment
- Shopping
- Education
- Health Care
- Recreation

The intention is not only to create competent level-of-service measures in this way, but also to determine minimum acceptable levels.

Development of level-of-service measures begins by describing transportation desires from a personal rather than a regional point of view since an individual will judge a transit system by how well it serves his travel desires. Thus, the process may begin by dividing travel desires into four broad categories, based on the findings from several studies of transit-dependent populations. The four categories might be

- Travel to work
- Travel to shopping
- Travel to health care facilities
- Travel to educational, cultural, recreational and social opportunities

The measures of goodness for an individual would then be the time and cost associated with travel to the various opportunities for jobs, shopping, health, and education/recreation in the region. The primary problem is to find a way to express this type of measure. The approach may be to calculate the weighted average travel time from every zone to the opportunities in the four broad categories, using a transit network and the LARTS traffic analysis zones. The method for doing this is relatively straightforward, but it will first be necessary to define what constitutes an opportunity and, second, to identify the locations where they exist.

In the formulation of level-of-service measures and guidelines based on the concepts described above, attention will have to be given to the prospects for a wide range of transit service types, including local, express, and exclusive right-of-way fixed-route, fixed-schedule service (conventional bus and rapid transit), divertible-path routes (limited deviation from a fixed route provided for by means of radio dispatching), dial-a-ride, and subscription type or specially-scheduled service. The provision of park-ride and kiss-ride facilities is a related service feature

to be considered. Some of these service types justify charging premium fares, the effect of which also must be taken into account.

Level-of-service guidelines will help to define the relevance of such conceptual types of service as well as the appropriate amount of service on each by permitting description of all service types on a common basis. Once this is done, the guidelines will permit definition of the amount of service to be operated within each geographic area subject to operating fund constraints.

The service allocation process is not an end in itself but a means to an end. In very simple terms, the process is a method of distributing the total budget--subsidy plus revenues--over the area to achieve a purpose. The method used to achieve one purpose will be different from that of another purpose and therefore, the place to begin is with the purpose.

For that, we can look to what others have said and done. Following are some typical general statements gleaned from reports, conversations, and public statements about the purpose of public transportation.

Increase Urban Mobility

Such a broad goal is not very helpful. It leaves unanswered the questions of: by how much? For whom? For what kinds of trips? The answers to those questions are partially provided by the "transit dependent" purpose usually stated something like:

> "Provide transportation for those who have no reasonable alternative."

This is usually expanded by defining transit dependents as those who do not own cars, those who cannot drive an automobile and those members of car owning families who wish to make a trip at a time when a family car is not available to them. This purpose statement still leaves unanswered the question of how much service to provide to the transit dependent group since under the broadest definition there are people dependent on transit at all times and all places in the metropolitan area. Also, those people have desires to travel ranging from essential to frivolous in purpose and some of the desired trips could be adjusted in time or combined with other trips while some must be made within rather narrow time limits.

Others see the goal of public transport as being to provide an alternative to travel by private automobile. Those who advocate this goal do so for a variety of reasons ranging from giving people a choice of mode to reducing air pollution or reducing energy consumption. Studies of the extent to which transit can reduce air pollution or energy consumption in the Los Angeles area suggest that the contribution would be small even with a vastly expanded and improved transit system.

The goal which has been implicit in most planning has been to serve the greatest number of trips. This goal generates the greatest revenue, thereby increasing the amount of service which can be provided. Strict adherence could, however, mean that some individuals might receive no service whatever because they live in areas which produce very few transit trips. In recognition of that possibility, others propose that transit service should be so distributed that the costs are roughly equal to the contribution from each area. The problems of defining areas and determining costs are many and complex. But more seriously, there is no assurance that the amounts of money available would provide enough service in low density areas to be of any practical value. On the other hand, there is no assurance that amounts allocated to the various areas of the region would be signivicantly different under that method than under a method designed to provide the means of achieving one of the objectives. To fully answer that question, it would be necessary to test a number of alternatives.

However, even without developing system alternatives, we can perform some very simple tests to see where a policy of providing fixed route service to all areas of the county might lead. A proposed standard for local and cross county service calls for routes on half mile spacing with half hour headways through the day and one hour headways at night, with service beginning at 6:00 a.m. and ending at 10:00 p.m.

The costs of such service were estimated using $20.00 per revenue hour and converted to cost per capita per year. When cost per capita is plotted against population density, it can be seen that at densities above 20,000 persons per square mile, the cost is in the range of $3.00 to $6.00 and at densities below 10,000 persons per square mile, the costs rise abruptly to about $50.00 at 2,000 to 3,000 persons per square mile (see Figure 1).

Since the average density for the urbanized area is slightly more than 5,000 per square mile, it can be seen that many parts of the urban area would fall in the low density areas with high per-capita cost.

This suggests that either a lower standard or less expensive type of service may be needed to serve such areas.

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# COST OF SERVICE $ PER PERSON