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Great Falls urbanized area travel demand forecasting

Ross Tervo
The University of Montana

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Great Falls Urbanized Area
Travel Demand Forecasting

by

Ross Tervo
B.S., Northern Michigan University, 1982

Presented in partial fulfillment of the requirements for a
Master of Science Degree in
Rural Town and Regional Planning

THE UNIVERSITY OF MONTANA

1992

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June 26, 1992
Date
Introduction

Traffic models are used to stimulate the flows of vehicular traffic on a street network. Such models can provide a variety of information that is useful to the urban planner. The consequences of making changes to the street network in terms of the amount of traffic diverted from one street to another can be estimated. Traffic model outputs of travel time, travel distances, and travel speed are useful for the environmental analysis of air pollution and energy consumption. The benefits of alternative street improvement projects can also be evaluated using the model, and the results used to establish a priority program of improvements. These beneficial uses describe only some of the possibilities for its practical application in urban planning environments.

Problem Statement

While the information provided by a traffic model is useful, the costs of developing one are high. This is especially true for smaller urban areas. Local planning staffs are unlikely to have the money, time, staffing or expertise to develop a traditional traffic model. The costs in terms of money and time to obtain results from a sophisticated model are simply prohibitive to most small planning offices.

A solution to budget and time constraints is to use a less sophisticated model that requires less input data. A computer model known as the Quick
Response System II (QRS II) contains a comprehensive set of default travel parameters that can be used if local studies are not available.\(^1\) By using the default travel parameters, the need for costly and time consuming studies of local travel characteristics is eliminated. The default travel characteristics are "borrowed" from studies performed in other cities, and thus saves the planner time and money in producing results.

QRS II embodies the idea that meaningful traffic forecasts can be produced from relatively little input data.\(^2\) The techniques used in the QRS II model began with the National Cooperative Highway Research Program's report number 187 (NCHRP 187) published in 1978.\(^3\) NCHRP 187 documents a set of manual techniques used to forecast travel demands. The QRS II computer program automates the manual techniques and allows the user to handle more complex problems.

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\(^1\) QRS II is a computer program that runs on IBM compatible microcomputers. This program is distributed by AJH Associates of Milwaukee, Wisconsin. Alan J. Horowitz, *The Quick Response System II Users Manual: Volume 2.3*, (Milwaukee: Center for Urban Transportation Studies, University of Wisconsin, 1989) pp. 1.1-1.2.

\(^2\) Ibid., p. 1.4.

The objective of this paper is to apply the quick response travel demand estimation technique using input data from Great Falls, Montana, and evaluate the validity of the results.

Methodology

Chapter One is devoted to the sources of information used to compile the input data for the traffic model. Also covered in Chapter One is discussion on how the study area is represented within the model. Chapters Two, Three and Four demonstrate how the complex problem of estimating traffic volumes on a street network is separated into three sequential steps: (1) trip generation, (2) trip distribution, and (3) trip assignment. Each of these steps is explained in detail. In Chapter Five the model is calibrated to increase the accuracy of the traffic volume estimates. In Chapter Six the ability of the model to produce useful traffic volume estimates is evaluated and recommendations are made on ways to improve their accuracy.
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Study Area

The City of Great Falls is located at the confluence of the Missouri and Sun Rivers in north central Montana (see Figure 1). It is the second largest metropolitan area in the state, with a 1990 population estimated at 55,097.\textsuperscript{4}

Great Falls initially developed as a major agricultural trade center due in part to the ease of shipping goods on the Missouri River to and from the eastern cities.\textsuperscript{5} In addition, hydroelectric power plants were developed before the turn of the century. This electricity attracted basic industry, including, metal smelters, refineries, wire mills, and flour mills. With the closure of the Anaconda Smelter in 1980, the smelting industry came to an end.\textsuperscript{6}

Agriculture is still an important component of the local economy. In the latter half of this century, the economy diversified and expanded to include the

\textsuperscript{4}U.S., Department of Commerce, Bureau of the Census, \textit{1990 Census of Population and Housing}.

\textsuperscript{5}Great Falls City Council, \textit{Master Land Use Plan}, (1959) p. 1.

\textsuperscript{6}Mountain West Research, Inc., \textit{Population, Employment, Dwelling Unit, Vehicle, and Student Enrollment Forecasts for the Great Falls Transportation Study Area 1980-2010}, (Great Falls, MT: City-County Planning Board, 1984) p. 6.
military, regional medical facilities, education, tourism, energy development, retail trade, and service industries.\(^7\)

Fig. 1. Study Area Location

The study area, for the purposes of this paper, is the City of Great Falls circa 1985 plus the area expected to become urbanized in the next 20 years. The study area includes the urban fringe of the city and occupies approximately 34,600 acres and contains a 1990 population estimated at 70,271.\(^8\) The study area is illustrated on Figure 2.

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\(^7\)Mountain West Research, Inc., p. 9.

\(^8\)Ibid. p. 15.
Figure 2.

In Pocket
Data Sources

In the inventory step, the needed data are gathered to operate the model. The inventory phase step performed to define and characterize three areas:

1) The existing major street network
2) The types and intensities of land uses which generate the traffic
3) The existing distribution of traffic on the street network

The data are entered into a "network file" or data base composed of two interrelated components: the input data about land use, which generates the vehicular traffic; and the input data about the physical attributes of the streets, which defines and characterizes the street network.

The inventory phase relied upon existing data whenever it was possible to do so. There are three documents of particular importance to this study which provided the bulk of the data used to construct the data base for the QRS II model. The three documents are:

1) A study entitled, "Population, Employment, Dwelling Unit, Vehicle, and Student Enrollment Forecasts For The Great Falls Transportation Study Area." 1980-2010"^9
2) The Great Falls Comprehensive Traffic Count Program"^10

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^9Ibid.

^10Great Falls City-County Planning Board, Great Falls Comprehensive Traffic County Program, (1989).
Characterization of Land Use Within the Zones

During the development of the Great Falls 1985 Plan Update (1985 Plan Update), the study area was divided into 140 traffic analysis zones (zones).\textsuperscript{12} These zones provided a framework for an inventory of the distribution of employment and dwelling units (homes) within the study area. This information is used by the model to estimate the type and number of vehicle trips generated within each of the 140 zones. Figure 2 illustrates the study area and the 140 traffic analysis zones. The study entitled, "Population, Employment, Dwelling Unit, Vehicle, and Student Enrollment Forecasts For the Great Falls Study Area: (Mountain West Study) was carried out to provide a data base for a different travel demand forecasting model known as PLANPAC/BACPAC which was used in the development of the 1985 Plan Update.\textsuperscript{13} This study contained an inventory of number of employees working and the number of homes in each of

\textsuperscript{11}Great Falls City-County Planning Board, \textit{Great Falls 1985 Transportation Plan Update}, (Great Falls, Montana: 1990).

\textsuperscript{12}A traffic analysis zone is a subdivision of the study area. It forms a discrete areal unit and is characterized by its size in square miles, the number of homes, and the number of jobs that it contains.

the zones. This study used a base year of 1985 and projected employment and homes in five year increments to the year 2010.

From this study 1989 values were interpolated and transformed into terms suitable for entry into the QRS II data base. The following variables were entered into the QRS II model to characterize the land use in each zone:

1) The area of the zone in square miles
2) The number of dwelling units in the zone
3) The number of retail employees who work in the zone
4) The number of non-retail employees who work in the zone

Modifications of the Land Use Data

The Mountain West Study was completed in 1985. Therefore, the interpolations of the 1989 conditions are, in fact, projections and not an inventory of the conditions as they existed in 1989. In light of this, the staff of the Great Falls City-County Planning Board identified four zones which had undergone land use changes between 1985 and 1989 that could not have been addressed within the Mountain West Study.

1) In Zone 22, the Paris Gibson Middle School opened; an increase of 85 employees
2) In Zone 38, Buttrey's Food Store closed; a decrease of 125 employees
3) In Zone 50, Malmstrom Air Force Base refueling mission activated; an increase of 700 employees

4) In Zone 129, Buttrey's Food Store closed; a decrease of 100 employees

Three more zones - 42, 49, 50 - were found for which the land use data from the inventory needed to be modified to produce acceptable results. See Figure 2 for the locations of these zones.

Zone 42, in the northwest portion of the study area, represents Giant Springs State Park. This park attracts tourists, campers, picnickers, and fishermen, whose travel would not be accounted for in the model. Therefore, the number of trips generated within the zone was based upon the traffic volume observed on Giant Springs Road rather than upon the land use data within the zone. The result was a three-fold increase in traffic moving to and from the zone. Zones 49 and 50 represent Malmstrom Air Force Base. Malmstrom functions much as a city by itself rather than as a large suburb of Great Falls. Its population lives, works, shops and recreates predominantly within the confines of the base. To account for the large number of trips that have both an origin and a destination within the base (intrazonal trips), the number of employees and homes were reduced from the numbers reported in the Mountain West Study. Employment was reduced from 4,500 to 750 to match the number
of civilian employees who work on the base. The number of homes was reduced from 2,316 to 1,175 at which point the traffic generated agreed with the known traffic volumes at the two access points to the base.

The data used to characterize each traffic analysis zone is summarized in Appendix A.

**Major Street Identification**

The street network entered in the model is a subset and approximation of the actual street network within the study area. The actual streets are spatially grouped into a network of links and nodes which may or may not (but usually does not) correspond one to one with the actual street network. When identifying the major routes, it is paramount to ascertain which streets currently carry relatively large volumes of traffic. The major street network used for this study was developed from scratch and is illustrated in Figure 3.

In 1976, The Montana Department of Highways classified the streets in Great Falls by the function or role that each particular street played in serving the flow of traffic. Each street can be classified based upon its role in

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providing travel mobility and access to property. This classification system used four major classes of streets: 1) interstate 2) principal arterial 3) minor arterial, and 4) collector. Streets below collector level, known as local streets, were not individually classified in this system.

Recognizing that the classification done in 1976 might not include all streets that should be a part of the major street network, the staff of the Great Falls City-County Planning Board identified local streets that carry relatively large volumes of traffic. Local streets that provided continuity within the network and local streets linking the study area to important outlying areas were included as part of the major street network.

The author’s criteria used to establish the existing major street network for the 1989 base year are as follows:

1) Streets on the federal-aid system were included as part of the major street network.

2) Streets classified as interstate, principal arterial, minor arterial, or collector in the Montana Department of Highways’ 1976 study were included as part of the existing major street network.

3) Local streets needed to provide continuity within the federal-aid system or local streets which carry a relatively large volume of traffic within the study area were included as part of the major street network.
**Major Street Characterization**

Data were collected to characterize the major street network in terms relevant to the needs of the computer model. Of importance to the model is the length of each street and the speed at which an automobile could travel along the street. The attributes used to characterize the street network are:

1) Whether the street is a one or two-way route
2) The actual travel speed
3) Intersections with turn prohibitions

The 1985 Plan Update provided information concerning the operational characteristics of the street network. Of particular importance was the study of travel speed and travel delays contained in the 1985 Plan Update. The 1985 Plan Update provided actual travel speeds for the majority of the street major network. Those streets not covered under the speed and delay study were relegated to the default speed of 20 mph with the exception of Interstate 15. Those links were given a speed of 55 mph.

A mix of travel times and speeds can be entered as variables to characterize a given link (street segment). In this study, travel speed was used on the streets that composed the major street network, and travel time was used on the local streets that provided access between the major street network and the zones.
Local streets provide access between the major street network and the land uses within the city. The majority of these streets are not represented in the model but are aggregated into a few connecting links, called centroid connectors or zone connectors, running from the center of the zone to the major street network (see Figure 3 for illustration of the centroid connectors). In general, the zone connectors were representative of the distance that would be traveled on local streets when driving from the center of the zone to the major street network. The travel time was calculated for each of the connecting links assuming a travel speed of 15 mph.

In addition to the attributes of length and travel time, the connecting links were given the attribute of terminal time. Terminal time accounts for the congestion experienced at the end of the trip such as the time it takes to walk from the home, office, or classroom to where the automobile is parked, or to find a parking place and walk to the final destination. Terminal time is the additional time it takes to travel door-to-door over and above the over-the-road travel time actually spent traveling in the automobile. A motorist going to the central business district could expect to spend time searching for a parking space and then walking several blocks to the final destination. The same motorist returning home could expect to park in close proximity to the home either in the driveway or at the curb. The amount of terminal time in the former case would be relatively long and would make up large portion of the
total time that it takes to complete a trip in a city the size of Great Falls. In the latter case, the terminal time would amount to roughly a minute or two.

To represent the differences that could be expected in terminal times at various locations within the city, each of the zones was relegated to one of three terminal time classes:

1) central business district
2) central city
3) suburb

Central business district zones were given a terminal time of four minutes, central city zones a time of three minutes, and suburban zones a terminal time of one minute.¹⁷

Travel speed and terminal time are used to derive the relative differences in travel time between each possible combination of zone pairs. From this the route having the shortest travel time between zones could be identified and a travel door-to-door time matrix be constructed. This matrix contains the time it takes to travel between each pair of zones.

Two turn prohibitions were identified within the study area which were entered into the model. These turn prohibitions preclude specific turning movements at the two intersections. One prohibition prevents a east-bound to

¹⁷Sosslau, p. 39.
west-bound left turn at the intersection of 3rd Street Northwest and Smelter Avenue. The second prevents a west-bound to south-bound left turn at the intersection of Central Avenue West and 3rd Street Southwest.

**Existing Distribution of Traffic**

The Montana Department of Highways, in cooperation with the Great Falls City-Council Planning Board, maintains an extensive traffic counting program within Great Falls known as the Great Falls Comprehensive Traffic Count Program. The traffic count program provides valuable information about past and present levels of use on the street network. The traffic counts identify which routes carry the heaviest volumes and also reveal growth trends. With this information, the major routes of travel can be readily identified.

The traffic count program monitors 223 locations on the major street network as it has been defined here. Twenty-four additional counts were made specifically to gather traffic volume information at locations not covered by the formal traffic count program. All but 3 of the 247 counts were recorded by pneumatic traffic count machines for a minimum of 48 hours. The counts were seasonally adjusted to represent annual average daily traffic.

Twenty-one of the traffic count locations formed a cordon around the study area (see Figure 3). Traffic entering and leaving the study area at these locations was recorded and attached to what is known as an "external station." The "external station" provides a means to represent traffic moving in and out of
the study area on the 21 streets and highways. The 247 observed traffic volumes and their locations are listed in Appendix B.

**Representation of the Study Area Within the Model**

The study area street network is represented spatially as a scale drawing composed of five types of nodes and four types of links. Nodes define the point of origin and destination for the 140 zones and the 21 external stations. Links define the paths of travel both between the zones and external stations. Each node and link is given attributes which further define their role within the network. This network is illustrated in a link and node format in Figure 3.

Links are used to represent the streets. A separate link is used to represent one-way streets, two-way streets, as well as the connections between the zones and the major street network. Each link has the attributes of length and travel speed with the exception of the zone connectors which use travel time rather than speed.

Nodes are used to tie the links together to represent the spatial configuration of the street network. The nodes form points of intersection between the links and provide a means to represent curves and the detailed geometry of highway interchanges.

Nodes are also used to represent the zones and the external stations. The zone is represented by a centroid. The centroid is the origin and destination of all trips moving to and from the zone and contains all attributes used to
characterize the zone. All of the land use information needed by the model for each zone has been collapsed to a single point, the centroid. The centroids are assigned the attributes of zone area, employment, and homes. In effect, centroids define the geographic distribution of employment and homes within the study area.

Five types of nodes and four types of links were used to describe the 140 traffic analysis zones and the street network that serves them. These node and link types are described in the QRS II user's manual and are defined as follows:¹⁸

NODE TYPES

1) Intersections Without Penalties
   Tie links together to form streets and points of access from the centroids to the major street network.

2) Intersections With Penalties
   Tie links together to form intersections and can be used to control the movement of traffic through the intersections.

3) Centroids
   Represent the center of activity within the traffic analysis zones. The centroid is the origin and the destination of all trips going to or coming from a zone.

4) Special generator centroids
   Used when the amount of traffic generated within the zone must be tightly controlled. These centroids represent zones that have special characteristics which could not adequately be represented by the trip generation and distribution portions of the model.

¹⁸Horowitz, p. 3.1-3.9.
5) External stations
Points of access into the study area on major streets. External stations are like centroids in that they produce and attract traffic.

LINK TYPES

1) Two-way street
A street on which traffic can move in both directions.

2) One-way street
A street segment on which traffic can move in a single direction.

3) Two-way street/(No Left Turn)
A street segment on which traffic moves in both directions but left turns are prohibited at both types of intersections.

4) Centroid (zone) connectors
Connectors to attach the zone centroids, special generator centroids, and external stations to the major street network.

Conclusion

The inventory phase is used to gather the data needed to operate the travel demand forecasting model. Where possible, the information was obtained from existing studies and planning documents. Information was gathered to characterize three aspects of the study area:

1) The distribution of homes and employment by place of work

2) The spatial configuration and operational characteristics of the street network

3) The existing distribution of vehicular traffic
The information from items two and three above is entered into a network file which is a graphic representation of the study area drawn to scale in a link and node format. Each zone is represented by a centroid. The centroids geographically define the distribution of housing and employment in the study area. Links are used to represent the streets and provide the paths of travel between the zones and the external stations.
CHAPTER 2

TRIP GENERATION

Trip generation is the prediction of the total number of trips that will be made over a given period of time within the study area. In this instance, the prediction was made for a 24-hour period.

For the purpose of trip generation analysis, the study area was divided into zones to tie together information about land use, transportation, and economic activities, and to tie this information to a spatial location. In this process it is assumed that the number and type of trips generated within the zone is a function of the type and intensity of the land use. For example, a major retail shopping center (on a per unit area basis) would be expected to generate more traffic than would a small residential area or a hospital.

The estimation process focuses on zonal trip ends rather than on complete trips. As described by Meyer, "Trip ends are classified as being either a production (defined as the home end of a home-based trip or the origin of a non home-based trip) or an attraction (the non home end of a home-based trip or the destination of a non home-based trip)."\(^19\) A completed trip has both a production and attraction end. Separate models are used to predict trip

\(^{19}\)Meyer, p. 246.
productions and trip attractions. Furthermore, estimates are made in terms of person trips which are later converted into automobile trips.

Not only does the type of land use determine the intensity of trip interchange, it also determines the type or purpose of the trip. Stores attract shopping trips, places of employment attract work trips, and so on. In this model, three trip purposes are used that fit into two basic categories: those trips which either begin or end at the home (home-based), and all other trips (non home-based). The three trip purposes used are defined as follows:

1) Home-based work (HBW) trip - A trip, for the purpose of work, with one end at the residence of the trip maker.

2) Home-based non-work (HBNW) trip - A trip, for the purpose of shopping, or for a social-recreational purpose or for any purpose other than work, with one end at the residence of the trip maker.

3) Non home-based (NHB) trip - A trip that takes place between two points, neither or which is the home end of the trip maker.\(^{20}\)

The daily number of person trip end productions generated by each home was estimated using the rate of 14.1\(^{21}\) The total number of daily person trip productions within the zone would be the average rate of production (14.1)

\(^{20}\)Sosslau, p. 228.

\(^{21}\)Ibid., p. 9.
times the number of homes within the zone. This total was then allocated to three household trip purposes based upon the following percentages:\textsuperscript{22}

1) Home-based work trips 16%
2) Home-based non-work trips 61%
3) Non home-based trips 23%

Person trip attractions represent the number of trips that will be potentially attracted to a particular zone. Trip attractions are predominantly determined by the amount of employment within the zone, although the number of homes plays a minor role in instances of non home-based and home-based work trips. Zones that contain a large amount of employment, particularly retail employment, will attract more trips compared to those with relatively little employment. A separate formula is used to calculate trip attractions for each of the three trip purposes. The trip attraction formulas for each of the three trip purposes are as follows:

1) \textit{HBW Trip Attractions} = [1.7(Analysis Area Total Employment)]

2) \textit{HBNW Trip Attractions} = [10(Zonal Retail Employment) + 0.5(Zonal Non-Retail Employment) + (Zonal Dwelling Units)]

\textsuperscript{22}\textit{Ibid.}, p. 15.
3) NHB Trip Attractions = [2.0(Zonal Retail Employment) + 2.5(Zonal Non-Retail Employment) + (Zonal Dwelling Units)]

Before being assigned to specific routes of the major street network, the person trips for each trip purpose are converted into vehicle trips. The person trips are divided by a vehicle occupancy parameter to arrive at vehicle trips. The vehicle occupancy parameters are used as follows:

1) home-base work 1.38
2) home-base non-work 1.82
3) non home-based 1.43

It is assumed each home will produce and each employee will attract trips at the same rate irrespective of its location in the study area. Trip generation rates are the same for each zone but the number of trips varies according to the amount of employment and the number of homes. The trip rates are aggregate in nature because the trip-making behavior of an individual or an individual household is, for all practical purposes, unpredictable. This is true for a variety of reasons. One household selected at random might include elderly retired people who no longer drive. One the other hand, a second household could be composed of a large wealthy family with several children of driving age, each

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23 Ibid., p. 15.

24 Ibid., p. 90.
having their own automobile. Such a household would generate more automobile trips than an average or typical household. To reduce this variation in trip making, average rates are used for the study area. The study area therefore represents a grouping of individual motorists. According to Meyer, such groupings "tend to exhibit common tendencies and behave in similar ways...statistical regularities emerge which are sufficiently strong, stable, and theoretically reasonable to be useful in the prediction of travel demand."  

Conclusion

Trip generation is performed to estimate the zonal trip end productions and attractions. Zonal trip ends are derived from the number of homes, the number of retail employees, and the number of non-retail employees within the zone. Separate estimates were made for each of the three trip purposes using the suggested parameters from the model. Trip end productions are a function of the number of homes and trip end attractions are a function of the amount of type of employment in the zone.

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CHAPTER 3

TRIP DISTRIBUTION

Internal Trips

QRS II uses a gravity model to distribute trips and create a matrix of the number of trip interchanges between the zones. Trip distribution adds the spatial dimension to the forecasting process in that it estimates the number of trips that will be exchanged between various points (zone centroids) within the study area. In the trip distribution step, zonal trip productions are linked to trip attractions to form complete trips.

The gravity model is a model of spatial interaction based on an analogy to

![Diagram showing trip distribution between zones]

Fig. 4 Trip distribution links trip end productions and attractions to form complete trips between zones.
Newton's law of gravitational pull. This law states that the gravitational force between two bodies is directly proportional to the product of the masses and inversely proportional to the distance between them. The gravity model used in QRS II substitutes the trip generating potential of the zones for the mass term and substitutes an inverse exponential function of travel time between zones for the distance term. The gravity model is based upon the hypothesis that the trips produced at an origin and attracted to a destination are directly proportional to the trip production at the origin, the total trip attraction at the destination, and an inverse function of the distance between them.

Zonal trip attractions and trip productions estimated in the trip generation step are analogous to the mass term in Newton's law. Zones with large amounts of employment and many homes would offer a great likelihood of satisfying the purpose of a given trip and would be more attractive to motorists. Zones that are large in terms of trip generation produce more trips, are more attractive to motorists and exert a stronger pull as if having a larger mass in Newtonian terms.

Newton's law states that as the distance between two bodies is increased, the force of attraction decreases. In estimating the number of trips exchanged


27 Federal Highway Administration, p. 118.
between zones, the door-to-door travel time is substituted for the straight-line
distance. The door-to-door travel time is the time that it would take to drive
between the zones plus the terminal time at both the production and attraction
end of the trip. The door-to-door travel time is a measure of the accessibility
between the zones. As this accessibility is decreased, the number of trips
exchanged would be expected to decrease as well.

The gravity model equation used to distribute trips is as follows:

\[ T_{ijk} = P_{ik} B_{jk}^s f_k(t_{ij}) / B_{jk}^s f_k(t_{ij}) \]

Where:

- \( T_{ijk} \) = Trips produced in zone i attracted to zone j for purpose k
- \( P_{ik} \) = Trips produced in zone i for purpose k
- \( B_{jk}^s \) = Attractions in zone j for purpose k for the s iteration
- \( f_k(t_{ij}) \) = A friction factor that is a function of travel time between
  zones i and j for purpose k. In this instance an exponential
  functional form was used and is defined as \( f_k(t_{ij}) = \exp(-a_k t_{ij}) \).  

The gravity model, using the trip productions and attractions generated in
the preceding trip generation step, the door-to-door travel times, and the above
equation, creates a matrix of zonal trip interchanges which make up a trip table.
A trip table is the estimated distribution of trip interchanges between the zones
within the study area. A separate trip table is produced for each of the three
trip purposes. An example of a three-zone trip table is shown in Table 1.

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28 Horowitz, p. 4.6-4.7.
The reason for making separate trip distribution estimates for each trip purpose is that trip length has been shown to vary depending upon the trip purpose.²⁹ Basically, motorists are willing to travel further to satisfy more essential trips such as the journey to work as compared to less essential trips such as convenience shopping. To best represent the differences in trip motorists’ willingness to make trips for three different trip purposes, a separate travel time function, the $f_k$ found in the gravity model equation, is used for each. This allows the trip lengths for each trip purpose to be estimated with more accuracy than if a single travel time function is used for all three trip purposes.

The travel time function for each of the three trip purposes is represented by a user specified trip distribution parameter. By changing the value of the parameter it is possible to indirectly control the average trip length. An iterative process is used where the model provides estimated average trip lengths and is subsequently adjusted by changing the value of the parameter until the estimated

<table>
<thead>
<tr>
<th>Origin Zone</th>
<th>Destination Zone</th>
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</tbody>
</table>

²⁹Meyer, p. 22.
trip lengths were within one-half minute of those observed in a study of the Great Falls metropolitan area completed in 1969. Separate trip distribution parameters are used for each of the three trip purposes. The average trip lengths as determined by this study and as estimated by the model are compared in Table 2.

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>1969 Study</th>
<th>QRSII Model</th>
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<tr>
<td>HBW</td>
<td>11.77</td>
<td>11.33</td>
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<tr>
<td>HBNW</td>
<td>9.62</td>
<td>9.91</td>
</tr>
<tr>
<td>NHB</td>
<td>10.17</td>
<td>10.02</td>
</tr>
</tbody>
</table>

Trip length affects the volume of traffic as measured at the 247 traffic count locations. Trips that are relatively long will pass through greater numbers of count locations compared to the same number of shorter trips. Longer trips will, in effect, put higher estimated volumes on the street network. As a preliminary check of the trip lengths and the number of trips estimated in the trip generation step, the totals of the 247 observed and estimated volumes were compared. Less than a two percent difference was found indicating the total

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trips estimated by the model compared favorably with the observed volumes. The Federal Highway Administration suggests less that a five percent difference be obtained for this measurement.  

External Trips

External trips are those trips having one or both ends outside the study area.  

Trips with one end outside the study area are known as external-to-internal or internal-to-external trips. Trips with both ends outside of the study area (passing through the study area) are known as external-to-external trips.  

Two techniques were used to distribute the external trips. External-to-internal trips and internal-to-external trips were distributed between the 21 external stations and the 140 traffic analysis zones by the aforementioned trip distribution model. External-to-external trips were distributed between the seven external stations having the largest observed traffic volumes using a manual distribution technique.  

The QRS II model does not directly provide a means to represent external-to-external trips, so a manual estimate was used which was then added

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into the non-home based trip table. The seven external stations accounted for 84% of the total traffic passing through all 22 external stations. It was assumed that 29% of the trips were external-to-external trips.  

The trips were distributed between the seven external stations under the assumption that trips attracted to a given station would be proportional to the traffic volume observed at that station. The matrix of external-to-external person trips exchanged between the seven external stations is illustrated in Table 3.

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</table>

Table 3
External Station Trip Table

33Great Falls City-County Planning Board, *Great Falls 1985 Transportation Plan Update*, Task II, Sub-task E., Section 5, p. 1.
Conclusion

The purpose of the trip distribution step was to estimate the number of trip interchanges that will take place between the 140 zones and the 21 external stations that compose the study area. A gravity model was used to distribute the trips based upon the relative attractiveness and accessibility of the zones. Separate travel time functions were used to represent each of the three trip purposes based on average trip lengths observed in 1969. The distribution model produced three trip tables containing the estimated trip interchanges between the zones. Trips passing through the study area were distributed between the seven largest external stations manually.
CHAPTER 4

NETWORK ASSIGNMENT

Network assignment is the process of estimating the route or path motorists will choose in traveling between zones. The assignment technique used is based on the assumption that motorists will select the routes having the shortest travel time. This assignment technique known as an all-or-nothing assignment, assumes that all motorists will invariably choose the path of minimum travel time.\(^{34}\)

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\(^{34}\)Peter R. Stopher, p. 203.
The number of trips exchanged between zones, estimated by the generation and distribution steps, are assigned by the model to the minimum time path. All trips between a given zone pair are assigned to the same path. The process is repeated until the trip interchanges between all possible combinations of zones for each of the three trip purposes have been accumulated and assigned to their respective minimum time paths on the major street network. The accumulated 24-hour volumes are the desired end product of the forecasting process.

Conclusion

The assignment step is the last step of the three step process of trip generation, trip distribution, and network assignment. Network assignment is the estimation of the routes or paths that motorists would choose in traveling over the street network to reach their destinations. It is based on the idea that motorists will take the route having the shortest travel time. All motorists traveling between a given zone pair were assigned to the route having the minimum travel time.
CHAPTER 5

NETWORK FILE CALIBRATION

The data base containing zonal land use data and a description of the street network is known as a network file. The network file is calibrated so that the estimated traffic volumes match the observed traffic volumes from the traffic count program. The model is run to provide an initial traffic assignment. This assignment is then examined, and the network file is modified to influence the subsequent assignment. This process was repeated four times.

From the comparison of the total estimated trips with the observed trips, it was known that on a study area-wide basis, the model was providing reasonable estimates of the twenty-four hour traffic volumes. However, this simple comparison did not provide insights into how this volume was being assigned (distributed) across the street network. The network file calibration process identifies specific streets that are being underassigned or overassigned and redistributes the traffic volumes to more closely match the distribution of observed volumes. Where observed volumes were not available an interpolation was made between the observed volumes.

Link Level Calibration

The link level calibrations relied on changes in travel time to influence the distribution of traffic and were targeted at those links having the largest
deviations from the observed volumes. Link level calibrations were held to four estimation cycles to limit what could become an endless process of small incremental improvements to the traffic assignments. Changes to the street network used to influence the distribution of traffic consisted of the following:

1) Changing the travel speed on a link or a series of links

2) Using time penalties to penalize specific movements through intersections

3) Addition, deletion, or movement of zone connectors

All three of the above changes to the street network description alter the travel time between the traffic analysis zones. Increasing the travel speed on a link or series of links reduces the travel time. This in turn increases the likelihood that the link would carry a larger volume of traffic because it would be more likely to be on the minimum time path between a great number of zones. The converse is also true, an increase in travel time would likely reduce the traffic volume.

Time penalties given to specific movements through intersections can affect the distribution of traffic. The addition of a time penalty increases the travel time and so decreases the estimated traffic volume utilizing the intersection.

The location of the zone connectors also affected the distribution of traffic. The zone connector attaches the zone centroid to the street network,
allowing the traffic generated within the zone to access the major street network. Routes (a series of links) which carry too low a volume of traffic were brought closer to a desired volume by the addition or movement of the zone connectors which increased the flow of traffic. Likewise, the deletion of zone connectors would lower the volume as an alternate route would be used to access the zone. Changes in the number and location of the zone connectors alters the distances and therefore the travel time between the zones.

A second factor came into play when changes were made to the network description during calibration. Trip distribution as influenced by making changes in travel time. As a result, trip interchanges were redistributed based on the relative accessibility of the zones. Trip interchange between zones having an increased accessibility to one another will exchange a larger number of trips. Trip interchange between zones having an increased accessibility to one another will exchange a larger number of trips. Trip interchange between zones having a relative decrease in accessibility would be likely to exchange fewer trips.

Manipulation of the number and location of the zone connectors were used in the first two calibration runs. This technique provided coarse adjustments to the estimated traffic volumes as it had a pronounced effect on the street network (links) adjacent to the zone. If a route did not have access to the
zone centroid via a connecting link, it could not carry the traffic generated by the zone.

A fifteen second turn penalty was given to all left turns at the signalized intersections on the major street network. The penalty served two purposes. Firstly, it represents the delay that a motorist experiences in waiting for the oncoming traffic to clear prior to completing the turn. Secondly, the time penalty eliminated the possibility of the model assigning zig-zag routes across the study area.

The adjustment of link speeds was the predominant method of influencing the distribution of traffic on the street network. The changes were usually on the order of one to five miles per hour and were directed at those routes or route segments having the largest amount of departure.

An exception to the use of modest link speed changes was the four bridges crossing the Missouri River. The initial volume estimates were quite high and the speeds had to be lowered to less than ten miles per hour to reduce the volume on each bridge. Perhaps the Missouri creates a psychological barrier of sorts in the minds of the motorists and this limits trip interchange across the bridges. For whatever reasons, the assumptions implicit in the trip distribution (gravity) model were unable to account for this aspect of human behavior. This phenomenon was also observed during a 1961 traffic modeling effort. As reported by Small, et al., "During the 1961 study, it was found that a two
minute time penalty was needed on each of the bridges...to produce the best results." \(^{35}\)
CHAPTER 6

EVALUATION

The calibrated model using data representative of the study area in its current condition provides an estimate of the vehicle usage on the street network. The estimate is compared to observed volumes at 247 locations within the study area. The comparison provides a means to evaluate the accuracy of the estimates and validate the performance of the model.

The traffic assignments produced by the model are intended to provide reasonable estimates of the link volumes. If they are to be useful in determining future needs the traffic assignments must be accurate enough to discern the number of lanes needed to carry the traffic. Therefore the assignments should not cause a difference of one lane due to the inaccuracies of the estimation process.36

Figure 6 illustrates the allowable percent RMS error for the assignments and is based on the assumption that the estimated volumes should not deviate more than one highway lane from what is actually needed for design purposes.37 An examination of Figure 6 shows the acceptable error is higher


Fig. 6. Allowable percent error for a given traffic volume.

on low-volume streets and lower on high-volume streets. This is because large percent RMS errors on low-volume streets are of little importance as they do not affect the number of lanes needed to carry the traffic. A two-lane street can just as easily carry 2000 vehicles per day as 200 and a ten-fold increase has little influence on the design of the street.

Figure 6 defines the acceptable level of accuracy for the estimated daily traffic volumes. The observed traffic volumes were split into nine volume classes. The average of the observed volumes in each class were used to located the allowable percent error. The allowable percent error provided the threshold in deeming the estimated volumes in each class as being acceptable or
unacceptable. The volume classes and respective allowable percent error appear in Table 4.

<table>
<thead>
<tr>
<th>Volume Class (in 1000's)</th>
<th>Allowable Percent Error</th>
<th>%RMSE Model Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>57</td>
<td>49</td>
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<td>5 - 10</td>
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<td>20 - 25</td>
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<td>40 - 45</td>
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</tbody>
</table>

To provide a comparable measure of error in the estimated volumes the root-mean-square-error (RMSE) and the percent root-mean-square-error (%RMSE) statistics were calculated for the nine volume classes. The RMSE measures the deviation between the distribution of observed and estimated volumes and the %RMSE measures the relation between the average observed volume and RMSE as the percentage difference. The equations for the RMSE and the %RMSE are as follows:

$$\text{RMSE} = \sqrt{\frac{\sum(O_i - E_j)^2}{n}}$$

$$\%\text{RMSE} = \frac{(\text{RMSE}/O) \times 100}{1}$$
where:

\[ O_i = \text{number of observed trips on link } i \]
\[ E_i = \text{number of estimated trips on link } i \]
\[ N = \text{number of links on which comparisons are made} \]
\[ O = \text{the average number of observed trips} \]

The %RMSE is compared to the allowable percent error to judge the accuracy of the estimated traffic volumes. Table 4 compares the allowable percent RMS error and the %RMSE from the model’s estimate for the nine volume classes.

The final model run did, in fact, reduce the %RMSE below the allowable percent error for each volume class. This demonstrates that the model given the limitations of the input data was able to estimate daily traffic volumes with sufficient accuracy to be useful.

Sources of Error

Errors in the forecasts stem either from the relationships within the model itself, from the quality of the input data or from some combination of the two. William Alonso refers to the error inherent in the design of the model as specification error and the error in data measurement as measurement error.\(^{38}\)

Specification error is inherent in any modeling process and results from the

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simplification of the complex phenomena being modeled. The simplification may leave out important relationships or not exactly represent the phenomenon using the relationships as defined in the model. Measurement error stems from the inaccuracies inherent in data collection. The inaccuracies are due to errors in reporting, rounding, aggregation, and having to use estimates rather than actual counts.

The traffic volume estimates are the end result of the trip generation, trip distribution and trip assignment steps, each having its own specification and measurement error. It is possible that the errors from each sub-model are cumulative and do not simply cancel one another out. As the entire model is validated on the results of its end product the traffic volume estimates, it is next to impossible to isolate exactly where in the process the errors originate.

Measurement Error

The amount of measurement error is dependent on the quality of the input data used as explanatory variables and this to a large degree determines the accuracy of the traffic estimates. The quality of the zonal distribution of homes and employment used in this study is hard to judge for three reasons. First, little information was provided by the source document on the sources, methods and assumptions used in allocating the amounts of employment and housing to each zone. Secondly, the splitting of employment into retail and non-retail employment was based on the judgement of the local planning staff.
And finally, the 1989 condition in terms of housing and employment were based on projections made in 1985, opening the possibility that changes have occurred which have not been accounted for in the four year projection.

**Specification Error**

Any modeling effort is based on assumptions made at each step of the process. In the trip generation step, households were represented by an average rate of trip production which cannot account for the variation in trip making between households which certainly exist.\(^{39}\)

Furthermore, the assumption is made that this average rate of trip production reflects the true average rate of the study area which is not known.

The simplification of the street network into a network of links and nodes representing only the major streets is responsible for some of the error in the estimates. All trips exchanged between zones must travel on the major street network as defined in the model. In reality, some of the travel between adjacent zones is likely to occur on the local streets not represented in the street network. Also, the loading of traffic onto the street network is crudely represented by the limited number of zone connectors, where in fact, the loading is more gradual from the numerous lesser streets not included in the network.

Each link basically had two attributes, length and speed. This simplification did not include such factors as the vehicular capacity of the links and the presence of traffic control devices (other than some crude measure of their effects on link travel speed).

The assignment technique also introduces error into the estimates of traffic volume. The assumption that a motorist will always choose the route having the minimum travel time cannot account for recreational trips along a scenic but circuitous route. In addition, the assumption is made that motorists always have knowledge of the route having the minimum travel time and further assumes that these routes have been accurately represented by the link speeds in the model. It is possible for trip exchanges between certain zones that the route having the shortest travel time is not included in the model’s street network.

The quick response technique assumes that observations of the travel relationships in other cities are useful in forecasting travel demand and are transferable between cities of similar size. In so far as these averaged conditions represent the particular are under study, the model should prove to be adequate, if carefully applied. Users should be aware of the limitations endemic to modeling efforts, as noted by Meyer:

Cities vary in structure and composition and hence in trip-making characteristics; thus "typical" data and models may prove to be very untypical of local conditions and relationships. Aggregations and abstraction always have implicit within them the danger of oversimplification, of
ignoring or obscuring important interactions and relationships. And, perhaps most important, considerable judgement and experience are often required in order to evaluate issues such as the ones just raised, implying that potential exists for these techniques to be seriously misused by people who do not fully understand their underlying assumptions and limitations.\textsuperscript{40}

**Error in Observed Traffic Volumes**

The observed traffic volumes are an approximation of the true traffic volumes and are likely to contain a significant amount of error.\textsuperscript{41} Local events such as auto accidents or street closures could alter the flow of traffic on the days that a particular traffic count was taken. Human error could bias the count through improper counter placement and in tabulation of data. Traffic volumes also fluctuate by the day of week as well as seasonally, further complicating the estimation of the true average daily condition.

**Recommendations**

The simplest way to improve the accuracy of the estimates would be to continue with the calibration of the network by adjusting link speeds, zone connectors and the use of turn penalties. In each of the four calibration runs the accuracy of the estimates was improved. It seems safe to assume that further adjustments to the network would add to the accuracy of the estimates.

\textsuperscript{40}Meyer, p. 243.

\textsuperscript{41}Ismart, p. 40.
To custom tailor the relationships represented within the model to a particular study area, a limited survey of trip characteristics of the homes could be performed. The survey should look at trip generation rates by trip purpose and automobile occupancy to refine the trip generation parameters in the model.

The technique used to distribute trips having one or both ends outside of the study area (external trips) should be improved. A road side interview to determine the origin and destination, trip purpose, and the number of occupants would provide the information needed to more accurately represent the external trips.

Shopping centers, large hospitals, airports, office complexes, schools, and colleges may have trip generation rates that differ significantly from those used to estimate zonal trip ends. Such unique land use types are known as special generators. The special generators could be identified and their rates of trip generation be based upon observations of vehicle movements or alternately a more refined estimation technique be used. Doing this would improve the accuracy of the assignments in proximity to these special generators.

There is a relationship between the traffic analysis zones, the street network input into the model, and the resultant traffic assignments. To improve the assignments within the central business district, the zones in this area should be subdivided into smaller units. The smaller zones would smooth the loading of the vehicle trips onto the numerous routes of the street network within the
central business district. The street network could be used to define the zone boundaries and the larger parking lots be used as the locations for the zone centroids.

The network file could benefit from the redefinition of some of the zone boundaries, particularly along 2nd Avenue North, 1st Avenue North, and Central Avenue in the east-central portion of the study area. These zone boundary changes would correspond to changes made to the major street network subsequent to the 1985 Plan Update. For the most part, the zone structure was borrowed in its entirety from the Mountain West Study and was not specifically developed for entry into QRS II. The major street network could serve as a guide to relocate the zone boundaries.

Conclusion

The quick response technique embodied in the QRS II software is proven to be able to estimate 24-hour traffic volumes with a reasonable degree of accuracy within the Great Falls study area. Given that little collection of new data was needed compared to more traditional forecasting techniques, the quick response approach shows promise in providing useful travel demand estimates at a reduced cost in both time and money.

Simplified forecasting techniques have the potential to be responsive to a broad range of transportation issues that could not be addressed using more sophisticated traditional techniques due to time and monetary constraints.
Simplified techniques can be used to estimate the traffic impacts of a new shopping center on adjacent streets, the traffic volume diverted from an existing street onto a parallel facility, or to evaluate the effectiveness of alternate improvement schemes across an entire network of streets.

Small cities having limited technical expertise could benefit from less-sophisticated techniques in that they are easier to learn. By making the forecasting process less technical and more understandable, greater participation in the planning process could be expected by nonprofessionals. Active participation on the part of elected local officials and interested public should reduce the resistance to the highway improvements recommended by the planning process. Rather it would aid in their implementation.

Beyond understanding the techniques used in travel demand forecasting the model serves as an educational tool. By going through the process a better understanding of the interaction between land use and transportation can be gained.
Bibliography


Great Falls City-County Planning Board. Great Falls Comprehensive Traffic Count Program. 1989.


### APPENDIX A

**Zonal Distribution of Employment and Dwelling Units**

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<th>Zone Number</th>
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## APPENDIX B
Comparison of Observed and Estimated Twenty-Four Hour Volumes

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<th>Percent Variation</th>
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<td>1 On Watson Coulee Rd., approximately 1.6 miles north of N.W. Bypass</td>
<td>57</td>
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<td>2 On 26th St. S. at the southern study area boundary</td>
<td>81</td>
<td>82</td>
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<td>3 On Flood Rd., just north of 45th Ave. S.W.</td>
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<td>4 On county road, just north of intersection with Watson Coulee Rd.</td>
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<td>5 On 6th St. N.W., ¼ mile north of Skyline Dr.</td>
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<td>6 On unnamed road running from 13th St. S. along a line common to Sec. 30-31, T20N, R4E</td>
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<td>8 On Lower Sun River Rd., ¼ mile northwest of 4th W. Hill Dr.</td>
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<td>11 On Fox Farm R. at southern study area boundary</td>
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<td>18 On Giant Springs Rd, approx. 1.75 miles NE of River Dr.</td>
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</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---------------</td>
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</tr>
<tr>
<td>38 On unnamed road east of Lower River Rd. in Sec. 36, T20N., R3E</td>
<td>812</td>
<td>828</td>
<td>2.0</td>
</tr>
<tr>
<td>39 On Riverview Dr., between 8th St. N.E. and 5th St. N.E.</td>
<td>873</td>
<td>566</td>
<td>35.1</td>
</tr>
<tr>
<td>40 On 33rd Ave. S., between 18th &amp; 19th Sts. S.</td>
<td>880</td>
<td>1695</td>
<td>92.6</td>
</tr>
<tr>
<td>41 On Central Ave. W., just east of 34th St. N.W.</td>
<td>938</td>
<td>1576</td>
<td>68.0</td>
</tr>
<tr>
<td>42 On 26th St. S., just south of 24th Ave. S.</td>
<td>1018</td>
<td>1690</td>
<td>66.0</td>
</tr>
<tr>
<td>43 On Bootlegger Trail at northern study area boundary</td>
<td>1049</td>
<td>1110</td>
<td>5.8</td>
</tr>
<tr>
<td>44 On Giant Springs Rd., just north of River Dr.</td>
<td>1097</td>
<td>1172</td>
<td>6.8</td>
</tr>
<tr>
<td>45 On 34th St. N.W., just south of Vaughn Rd.</td>
<td>1165</td>
<td>1230</td>
<td>5.5</td>
</tr>
<tr>
<td>46 On Lower River Rd., just north of Jct. FAS 459</td>
<td>1260</td>
<td>1158</td>
<td>8.1</td>
</tr>
<tr>
<td>47 On 17th Ave. S., between 16th &amp; 17th Sts. S.</td>
<td>1317</td>
<td>1179</td>
<td>10.5</td>
</tr>
<tr>
<td>48 On Tri-Hil Frontage Rd. at western study area boundary</td>
<td>1353</td>
<td>1433</td>
<td>5.9</td>
</tr>
<tr>
<td>49 On Fox Farm Rd., just north of 45th Ave. S.W.</td>
<td>1362</td>
<td>724</td>
<td>46.9</td>
</tr>
<tr>
<td>50 On Lower Sun River Rd., just east of I-15</td>
<td>1443</td>
<td>393</td>
<td>72.8</td>
</tr>
<tr>
<td>51 On 4th Ave. S.W., between 6th &amp; 4th Sts. S.W.</td>
<td>1464</td>
<td>2021</td>
<td>38.1</td>
</tr>
<tr>
<td>52 On 14th St. S.W., just south of 13th Ave. S.W.</td>
<td>1474</td>
<td>3266</td>
<td>121.6</td>
</tr>
<tr>
<td>53 On 14th Ave. N.W., just west of 3rd St. N.W.</td>
<td>1476</td>
<td>2371</td>
<td>60.6</td>
</tr>
<tr>
<td>54 On 36th Ave. N.E., just west of Bootlegger Trail</td>
<td>1519</td>
<td>874</td>
<td>42.5</td>
</tr>
<tr>
<td>55 On 14th St. S.W., just south of I-315 Spur</td>
<td>1537</td>
<td>1808</td>
<td>17.7</td>
</tr>
<tr>
<td>56 On Lower River Rd., 1½ miles south of 10th Ave. S.</td>
<td>1629</td>
<td>1268</td>
<td>22.2</td>
</tr>
<tr>
<td>57 On 13th Ave. S., between 5th &amp; 7th St. S.</td>
<td>1756</td>
<td>3653</td>
<td>108.0</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>--------------</td>
<td>---------------</td>
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</tr>
<tr>
<td>58 On Wire Mill Rd., just east of 15th St. N.</td>
<td>1780</td>
<td>4272</td>
<td>140.0</td>
</tr>
<tr>
<td>59 On Park Garden Rd., just W. of Fox Farm Rd.</td>
<td>1787</td>
<td>1923</td>
<td>7.6</td>
</tr>
<tr>
<td>60 On 6th St. N., just south of River Dr.</td>
<td>1793</td>
<td>786</td>
<td>56.2</td>
</tr>
<tr>
<td>61 On 18th Ave. S.W., between 11th St. S.W. &amp; Treasure State Dr.</td>
<td>1898</td>
<td>786</td>
<td>58.6</td>
</tr>
<tr>
<td>62 On Smelter Ave., just east of 15th St. N.</td>
<td>1899</td>
<td>2391</td>
<td>25.9</td>
</tr>
<tr>
<td>63 On 20th St. S.W., just north of 1st Ave. S.W.</td>
<td>1908</td>
<td>960</td>
<td>49.7</td>
</tr>
<tr>
<td>64 On 4th St. N.E., just north of Smelter Ave.</td>
<td>1913</td>
<td>2719</td>
<td>42.1</td>
</tr>
<tr>
<td>65 On 8th Ave. N., between 34th St. N. &amp; 36th St. N.</td>
<td>1960</td>
<td>1841</td>
<td>6.1</td>
</tr>
<tr>
<td>66 On 13th St. S., 1 mile south of 33rd Ave. S.</td>
<td>1990</td>
<td>2047</td>
<td>2.8</td>
</tr>
<tr>
<td>67 On 25th Ave. N.E., just west of 17th St. N.</td>
<td>2000</td>
<td>653</td>
<td>67.4</td>
</tr>
<tr>
<td>68 On Upper River Rd., just south of 19th Ave. S.</td>
<td>2021</td>
<td>1373</td>
<td>32.1</td>
</tr>
<tr>
<td>69 On 6th St. N., just north of 2nd Ave. N.</td>
<td>2033</td>
<td>3086</td>
<td>51.6</td>
</tr>
<tr>
<td>70 On 13th St. S., 1/4 mile south of 33rd Ave. S.</td>
<td>2053</td>
<td>3225</td>
<td>57.1</td>
</tr>
<tr>
<td>71 On River Dr., just north of 1st Ave. N.</td>
<td>2110</td>
<td>1187</td>
<td>43.7</td>
</tr>
<tr>
<td>72 On Vaughn Road, just east of Jct. N.W. Bypass</td>
<td>2245</td>
<td>3439</td>
<td>53.2</td>
</tr>
<tr>
<td>73 On 8th Ave. N., between 7th &amp; 8th Sts. N.</td>
<td>2265</td>
<td>5808</td>
<td>156.4</td>
</tr>
<tr>
<td>74 On 13th St. S., just S. of 24th Ave. S.</td>
<td>2272</td>
<td>2494</td>
<td>9.8</td>
</tr>
<tr>
<td>75 On 9th St. S., just N. of 17th Ave. S.</td>
<td>2275</td>
<td>1704</td>
<td>25.1</td>
</tr>
<tr>
<td>76 On Lower River Road, just south of 10th Ave. S.</td>
<td>2298</td>
<td>2294</td>
<td>0.2</td>
</tr>
<tr>
<td>77 On Bootlegger Trail, just south of 36th Ave. N.E.</td>
<td>2360</td>
<td>2038</td>
<td>13.7</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>78 On 1st Ave. S., between 11th &amp; 12 Sts. S.</td>
<td>2368</td>
<td>1531</td>
<td>35.4</td>
</tr>
<tr>
<td>79 On 3rd St. S.W., just S. of Central Ave. W.</td>
<td>2477</td>
<td>1800</td>
<td>27.3</td>
</tr>
<tr>
<td>80 On Vaughn Road, just west of I-15 Interchange (Emerson Junction)</td>
<td>2536</td>
<td>2660</td>
<td>4.9</td>
</tr>
<tr>
<td>81 On 5th St. N., just north of 2nd Ave. N.</td>
<td>2561</td>
<td>2444</td>
<td>4.6</td>
</tr>
<tr>
<td>82 On US 87, just NE of Jct Bootlegger Trail on 2-lane</td>
<td>2640</td>
<td>2775</td>
<td>5.1</td>
</tr>
<tr>
<td>83 On 3rd Ave. S., just east of 38th St.</td>
<td>2660</td>
<td>2915</td>
<td>9.6</td>
</tr>
<tr>
<td>84 On 38th St. N., just south of North Star Blvd.</td>
<td>2741</td>
<td>3605</td>
<td>31.5</td>
</tr>
<tr>
<td>85 On Upper River Rd. (E. River St.), just south of River Dr. Loop</td>
<td>2751</td>
<td>1133</td>
<td>58.8</td>
</tr>
<tr>
<td>86 On 8th St. N.E., just north of Smelter Ave.</td>
<td>2795</td>
<td>2948</td>
<td>5.5</td>
</tr>
<tr>
<td>87 On Wire Mill Rd., just west of 15th St. N.</td>
<td>2800</td>
<td>2035</td>
<td>27.3</td>
</tr>
<tr>
<td>88 On 8th Ave. N., between 30th &amp; 31st Sts. N.</td>
<td>2827</td>
<td>2539</td>
<td>10.2</td>
</tr>
<tr>
<td>89 On Watson Coulee Rd., just south of Northwest Bypass</td>
<td>2852</td>
<td>654</td>
<td>77.1</td>
</tr>
<tr>
<td>90 On 10th St. N., just southwest of Jct. 15th St. N.</td>
<td>2864</td>
<td>2634</td>
<td>8.0</td>
</tr>
<tr>
<td>91 On 5th St. S., between 1st &amp; 2nd Aves. N.</td>
<td>2889</td>
<td>600</td>
<td>79.2</td>
</tr>
<tr>
<td>92 On 16th Ave. N.W., just east of 6th St. N.W.</td>
<td>2901</td>
<td>1633</td>
<td>43.7</td>
</tr>
<tr>
<td>93 On 6th St. N., between 1st &amp; 2nd Aves. N.</td>
<td>2932</td>
<td>3624</td>
<td>23.6</td>
</tr>
<tr>
<td>94 On Division Rd., just north of 16th Ave. N.W.</td>
<td>2939</td>
<td>2630</td>
<td>10.5</td>
</tr>
<tr>
<td>95 On 6th St. N.E., just north of Smelter Ave.</td>
<td>2995</td>
<td>1579</td>
<td>47.3</td>
</tr>
<tr>
<td>96 On Park Dr., just west of 5th St. N.</td>
<td>3009</td>
<td>3719</td>
<td>23.6</td>
</tr>
<tr>
<td>97 On Park Dr., just west of 5th St. N.</td>
<td>3010</td>
<td>2086</td>
<td>30.7</td>
</tr>
<tr>
<td>98 On 32nd St. S., between Central Ave. &amp; 1st Ave. S.</td>
<td>3016</td>
<td>3820</td>
<td>26.7</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>99 On 3rd Ave. S., just east of 46th St. S.</td>
<td>3045</td>
<td>1496</td>
<td>50.9</td>
</tr>
<tr>
<td>100 On 13th St. S., between 22nd &amp; 23rd Aves. S.</td>
<td>3217</td>
<td>2749</td>
<td>14.6</td>
</tr>
<tr>
<td>101 On 25th Ave NE, between 10th St. N. &amp; 15th St. N.</td>
<td>3224</td>
<td>4113</td>
<td>27.6</td>
</tr>
<tr>
<td>102 On 13th Ave. S.W. just E. of 14th St. S.W.</td>
<td>3314</td>
<td>3572</td>
<td>7.8</td>
</tr>
<tr>
<td>103 On 31st St. S.W., between Airport Interchange and Tri-Hil Frontage Rd.</td>
<td>3366</td>
<td>3978</td>
<td>18.2</td>
</tr>
<tr>
<td>104 On River Dr., just west of 10th St. N.</td>
<td>3378</td>
<td>1851</td>
<td>45.2</td>
</tr>
<tr>
<td>105 On Division Rd., between 21st Ave. N.W. &amp; 23rd Ave. N.E.</td>
<td>3484</td>
<td>1561</td>
<td>55.2</td>
</tr>
<tr>
<td>106 On 9th St. N.W., between 4th &amp; 5th Aves. N.W.</td>
<td>3520</td>
<td>1684</td>
<td>52.2</td>
</tr>
<tr>
<td>107 On 2nd Ave. S., between 11th &amp; 12th Sts. S.</td>
<td>3522</td>
<td>2365</td>
<td>32.9</td>
</tr>
<tr>
<td>108 On 17th Ave. S., east of 9th St. S.</td>
<td>3545</td>
<td>2186</td>
<td>38.3</td>
</tr>
<tr>
<td>109 On Central Ave. W., just west of 20th St. S.W.</td>
<td>3550</td>
<td>1484</td>
<td>58.2</td>
</tr>
<tr>
<td>110 On 25th Ave. N.E., just west of 10th St. N.</td>
<td>3561</td>
<td>3731</td>
<td>4.8</td>
</tr>
<tr>
<td>111 On 6th St. S., just north of 10th Ave. S.</td>
<td>3579</td>
<td>3640</td>
<td>1.7</td>
</tr>
<tr>
<td>112 On 1st Ave. N., just west of 37th St. N.</td>
<td>3586</td>
<td>2450</td>
<td>31.7</td>
</tr>
<tr>
<td>113 On 15th St. N., just north of 25th Ave. N.E.</td>
<td>3610</td>
<td>2076</td>
<td>42.5</td>
</tr>
<tr>
<td>114 On 5th St. N., just north of Central Ave.</td>
<td>3658</td>
<td>683</td>
<td>81.3</td>
</tr>
<tr>
<td>115 On 5th St. S., just north of 10th Ave. S.</td>
<td>3697</td>
<td>6076</td>
<td>64.3</td>
</tr>
<tr>
<td>116 On Park Dr., between 3rd &amp; 4th Aves. N.</td>
<td>3703</td>
<td>2355</td>
<td>36.4</td>
</tr>
<tr>
<td>117 On 32nd St. S., just north of 10th Ave. S.</td>
<td>3811</td>
<td>3810</td>
<td>0.0</td>
</tr>
<tr>
<td>118 On 26th St. S., just south of 1st Ave. S.</td>
<td>3855</td>
<td>5246</td>
<td>36.1</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
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<td>---------------</td>
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</tr>
<tr>
<td>119 On 25th St. S., between 4th &amp; 5th Aves. N.</td>
<td>3860</td>
<td>2711</td>
<td>29.8</td>
</tr>
<tr>
<td>120 On 8th Ave. N., between 23rd &amp; 24th Sts. N.</td>
<td>3900</td>
<td>4139</td>
<td>6.1</td>
</tr>
<tr>
<td>121 On Central Ave., between 35th &amp; 35th Sts. S.</td>
<td>3931</td>
<td>3261</td>
<td>17.0</td>
</tr>
<tr>
<td>122 On Airport Drive, just north of N. Frontage Rd.</td>
<td>3937</td>
<td>3665</td>
<td>6.9</td>
</tr>
<tr>
<td>123 On 2nd Ave. S., between 4th &amp; 5th Sts. S.</td>
<td>3996</td>
<td>3717</td>
<td>7.0</td>
</tr>
<tr>
<td>124 On 38th St. S., just north of 10th Ave. S.</td>
<td>4018</td>
<td>4501</td>
<td>12.0</td>
</tr>
<tr>
<td>125 On 6th St. S., between 3rd &amp; 4th Aves. S.</td>
<td>4019</td>
<td>3984</td>
<td>0.9</td>
</tr>
<tr>
<td>126 On 13th Ave. S., between 16th &amp; 17th Sts. S.</td>
<td>4035</td>
<td>4905</td>
<td>21.6</td>
</tr>
<tr>
<td>127 On 8th St. N.E., between 26th &amp; 27th Aves. N.E.</td>
<td>4110</td>
<td>5793</td>
<td>40.9</td>
</tr>
<tr>
<td>128 On River Dr., just east of 10th St. N.</td>
<td>4253</td>
<td>3887</td>
<td>8.6</td>
</tr>
<tr>
<td>129 On 26th St. S., just north of 10th Ave. S.</td>
<td>4255</td>
<td>5620</td>
<td>32.1</td>
</tr>
<tr>
<td>130 On 10th St. N., just north of Smelter Ave.</td>
<td>4260</td>
<td>4992</td>
<td>7.9</td>
</tr>
<tr>
<td>131 On River Dr., just south of 1st Ave. N.</td>
<td>4274</td>
<td>5368</td>
<td>25.6</td>
</tr>
<tr>
<td>132 On 6th St. N.W., just south of 16th Ave. N.W.</td>
<td>4290</td>
<td>5111</td>
<td>19.1</td>
</tr>
<tr>
<td>133 On north entry road to MAFB, just east of 57th St.</td>
<td>4295</td>
<td>3621</td>
<td>15.7</td>
</tr>
<tr>
<td>134 On River Dr. Loop, just east of River Dr.</td>
<td>4310</td>
<td>4890</td>
<td>13.5</td>
</tr>
<tr>
<td>135 On 6th St. N., just north of Central Ave.</td>
<td>4334</td>
<td>2587</td>
<td>40.3</td>
</tr>
<tr>
<td>136 On I-15, just S.W. of Gore Hill Interchange</td>
<td>4380</td>
<td>4535</td>
<td>3.5</td>
</tr>
<tr>
<td>137 On 25th St. N., just south of River Dr.</td>
<td>4541</td>
<td>5593</td>
<td>23.2</td>
</tr>
<tr>
<td>138 On 14th St. N., at BN tracks, just north of 8th Ave. N.</td>
<td>4580</td>
<td>6307</td>
<td>37.7</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>-------------------------</td>
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</tr>
<tr>
<td>139 On 57th St., just north of 2nd Ave. N.</td>
<td>4601</td>
<td>2325</td>
<td>49.5</td>
</tr>
<tr>
<td>140 On Vaughn Road, just north of Central Ave. W.</td>
<td>4612</td>
<td>4093</td>
<td>11.3</td>
</tr>
<tr>
<td>141 On 8th Ave. N., between 16th &amp; 17th Sts. N.</td>
<td>4839</td>
<td>4816</td>
<td>0.5</td>
</tr>
<tr>
<td>142 On 8th Ave. N., between 16th &amp; 17th Sts. N.</td>
<td>4890</td>
<td>3625</td>
<td>25.9</td>
</tr>
<tr>
<td>143 On I-15, 1 mile N.W. of Central Ave. W. Interchange</td>
<td>4910</td>
<td>5581</td>
<td>13.7</td>
</tr>
<tr>
<td>144 On Fox Farm Rd., just south of Garden Rd.</td>
<td>4919</td>
<td>2358</td>
<td>52.1</td>
</tr>
<tr>
<td>145 On 23rd St. S., just S. of 10th Ave. S.</td>
<td>4959</td>
<td>179</td>
<td>96.4</td>
</tr>
<tr>
<td>146 On 8th Ave. N., just west of 14th St. N.</td>
<td>5006</td>
<td>3731</td>
<td>25.5</td>
</tr>
<tr>
<td>147 On 25th St. S., just south of 1st Ave. S.</td>
<td>5013</td>
<td>5999</td>
<td>19.7</td>
</tr>
<tr>
<td>148 On Central Ave. W., just west of I-15 Interchange</td>
<td>5063</td>
<td>5782</td>
<td>14.2</td>
</tr>
<tr>
<td>149 On Smelter Ave., just east of 10th St. N.</td>
<td>5084</td>
<td>4426</td>
<td>12.9</td>
</tr>
<tr>
<td>150 On River Dr., 3/4 mile north of 2nd Ave. N.</td>
<td>5101</td>
<td>4963</td>
<td>2.7</td>
</tr>
<tr>
<td>151 On 4th St. S., just south of 10th Ave. S.</td>
<td>5214</td>
<td>4733</td>
<td>9.2</td>
</tr>
<tr>
<td>152 On 38th St. N., just north of 2nd Ave. N.</td>
<td>5259</td>
<td>2995</td>
<td>43.0</td>
</tr>
<tr>
<td>153 On 1st Ave. N., just west of 25th N.</td>
<td>5275</td>
<td>4077</td>
<td>22.7</td>
</tr>
<tr>
<td>154 On 1st Ave. N., just east of 26th St. N.</td>
<td>5370</td>
<td>6180</td>
<td>13.7</td>
</tr>
<tr>
<td>155 On Vaughn Road, just east of I-15 Interchange (Emerson Jct.)</td>
<td>5508</td>
<td>4081</td>
<td>25.9</td>
</tr>
<tr>
<td>156 On River Dr. Loop, just south of 10th Ave. S.</td>
<td>5519</td>
<td>3471</td>
<td>37.1</td>
</tr>
<tr>
<td>157 On 2nd Ave. N., just west of 25th St. N.</td>
<td>5616</td>
<td>5710</td>
<td>1.7</td>
</tr>
<tr>
<td>158 On N.W. Bypass, just west of Watson Coulee Rd.</td>
<td>5690</td>
<td>5147</td>
<td>9.6</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
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<tr>
<td>159 On 15th St. N., at BN tracks, just north of 8th Ave. N.</td>
<td>5770</td>
<td>5646</td>
<td>2.2</td>
</tr>
<tr>
<td>160 On U.S. 87/89, just east of 57th St.</td>
<td>5777</td>
<td>5901</td>
<td>2.2</td>
</tr>
<tr>
<td>161 On 2nd Ave. N., just west of 14th St. N.</td>
<td>6012</td>
<td>8545</td>
<td>42.1</td>
</tr>
<tr>
<td>162 On 25th St. S., just north of 10th Ave. S.</td>
<td>6031</td>
<td>6005</td>
<td>0.4</td>
</tr>
<tr>
<td>163 On 9th St. N., just south of River Drive</td>
<td>6054</td>
<td>6841</td>
<td>13.0</td>
</tr>
<tr>
<td>164 On Vaughn Road, ¼ mile east of 34th St. N.W.</td>
<td>6127</td>
<td>5004</td>
<td>18.3</td>
</tr>
<tr>
<td>165 On 2nd Ave. N., just west of 5th St. N.</td>
<td>6248</td>
<td>8605</td>
<td>37.7</td>
</tr>
<tr>
<td>166 On 2nd Ave. N., between 52nd St. &amp; 57th St.</td>
<td>6457</td>
<td>5401</td>
<td>16.3</td>
</tr>
<tr>
<td>167 On River Dr., just east of 38th St. N.</td>
<td>6492</td>
<td>7511</td>
<td>15.7</td>
</tr>
<tr>
<td>168 On I-15, between 10th Ave. S. and Central Ave. W. Interchanges</td>
<td>6520</td>
<td>6133</td>
<td>5.9</td>
</tr>
<tr>
<td>169 On 9th St. S., just south of 10th Ave. S.</td>
<td>6624</td>
<td>7101</td>
<td>7.2</td>
</tr>
<tr>
<td>170 On North River Road, just east of 10th St. N.</td>
<td>6668</td>
<td>4815</td>
<td>27.8</td>
</tr>
<tr>
<td>171 On 15th St. S., just south of 1st Ave. N.</td>
<td>6680</td>
<td>6321</td>
<td>5.4</td>
</tr>
<tr>
<td>172 On Central Ave., between 3rd &amp; 4th Sts. S.</td>
<td>6712</td>
<td>10918</td>
<td>62.7</td>
</tr>
<tr>
<td>173 On 2nd Ave. N., just east of 6th St. N.</td>
<td>6747</td>
<td>6219</td>
<td>7.8</td>
</tr>
<tr>
<td>174 On River Dr., just N. of Warden Bridge</td>
<td>6756</td>
<td>5368</td>
<td>20.5</td>
</tr>
<tr>
<td>175 On 1st Ave. N., just east of 15th St. N.</td>
<td>6772</td>
<td>4427</td>
<td>34.6</td>
</tr>
<tr>
<td>176 On 6th St. N.W., just south of 4th Ave. N.W.</td>
<td>6778</td>
<td>6011</td>
<td>11.3</td>
</tr>
<tr>
<td>177 On 14th St. N., just north of 2nd Ave. N.</td>
<td>6840</td>
<td>5230</td>
<td>23.5</td>
</tr>
<tr>
<td>178 On 38th St. S., just north of Central Ave.</td>
<td>6911</td>
<td>6279</td>
<td>9.1</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
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</tr>
<tr>
<td>179 On 13th Ave. S.W., just west of 6th St. S.W.</td>
<td>6928</td>
<td>5232</td>
<td>24.5</td>
</tr>
<tr>
<td>180 On Smelter Ave., just west of 4th St. N.E.</td>
<td>6983</td>
<td>4859</td>
<td>30.4</td>
</tr>
<tr>
<td>181 On N.W. Bypass, just west of 14th St. N.W.</td>
<td>7041</td>
<td>5726</td>
<td>18.7</td>
</tr>
<tr>
<td>182 On 15th St. N., just south of 25th Ave. N.E.</td>
<td>7110</td>
<td>5537</td>
<td>22.1</td>
</tr>
<tr>
<td>183 On 2nd St. S., just south of 2nd Ave. S.</td>
<td>7128</td>
<td>8101</td>
<td>13.6</td>
</tr>
<tr>
<td>184 On 2nd Ave. N., just west of 38th St. N.</td>
<td>7151</td>
<td>6134</td>
<td>14.2</td>
</tr>
<tr>
<td>185 On 2nd Ave. N., just east of 26th St. N.</td>
<td>7263</td>
<td>7059</td>
<td>2.8</td>
</tr>
<tr>
<td>186 On 20th St. S., just south of 10th Ave. S.</td>
<td>7316</td>
<td>4959</td>
<td>32.2</td>
</tr>
<tr>
<td>187 On 15th St. S., just north of 10th Ave. S.</td>
<td>7340</td>
<td>8922</td>
<td>21.6</td>
</tr>
<tr>
<td>188 On Central Ave., between 11th &amp; 12th Sts. S.</td>
<td>7456</td>
<td>6595</td>
<td>11.6</td>
</tr>
<tr>
<td>189 On 14th St. S., just south of 1st Ave. N.</td>
<td>7530</td>
<td>10387</td>
<td>37.9</td>
</tr>
<tr>
<td>190 On I-15, just N.W. of Emerson Junction Interchange</td>
<td>7560</td>
<td>7580</td>
<td>0.3</td>
</tr>
<tr>
<td>191 On 15th St. N., just north of 2nd Ave. N.</td>
<td>7640</td>
<td>6466</td>
<td>15.4</td>
</tr>
<tr>
<td>192 On River Dr., just east of Jct. Giant Springs Rd.</td>
<td>7717</td>
<td>8496</td>
<td>10.1</td>
</tr>
<tr>
<td>193 On 2nd Ave. N., just east of 15th St. N.</td>
<td>7800</td>
<td>8295</td>
<td>6.3</td>
</tr>
<tr>
<td>194 On Fox Farm Rd., just north of 25th Ave. S.W.</td>
<td>7837</td>
<td>4209</td>
<td>46.3</td>
</tr>
<tr>
<td>195 On 26th St. S., just south of 10th Ave. S.</td>
<td>7908</td>
<td>13094</td>
<td>65.6</td>
</tr>
<tr>
<td>196 On Central Ave., between 21st &amp; 22nd Sts. S.</td>
<td>8158</td>
<td>5074</td>
<td>37.8</td>
</tr>
<tr>
<td>197 On 2nd Ave. N., just east of 38th St. N.</td>
<td>8501</td>
<td>9565</td>
<td>12.5</td>
</tr>
<tr>
<td>198 On Central Ave. W., just east of I-15 Interchange</td>
<td>8583</td>
<td>7805</td>
<td>9.1</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
<td>Estimated ADT</td>
<td>Percent Variation</td>
</tr>
<tr>
<td>-------------------------</td>
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<td>---------------</td>
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</tr>
<tr>
<td>199 On 9th St. N., between 3rd &amp; 4th Aves. N.</td>
<td>8602</td>
<td>6962</td>
<td>19.1</td>
</tr>
<tr>
<td>200 On Park Dr., between Central Ave. and 1st Ave. S.</td>
<td>8810</td>
<td>5356</td>
<td>39.2</td>
</tr>
<tr>
<td>201 On River Dr., just west of Jct. Giant Springs Rd.</td>
<td>8931</td>
<td>8986</td>
<td>0.6</td>
</tr>
<tr>
<td>202 On 1st Ave. N., just west of 5th St. N.</td>
<td>9171</td>
<td>10142</td>
<td>10.6</td>
</tr>
<tr>
<td>203 On 57th St., just north of 10th Ave. S.</td>
<td>9215</td>
<td>9217</td>
<td>0.0</td>
</tr>
<tr>
<td>204 On 1st Ave. N., just west of 14th St. N.</td>
<td>9580</td>
<td>9979</td>
<td>4.2</td>
</tr>
<tr>
<td>205 On 9th St. S., between Central Ave. &amp; 1st Ave. S.</td>
<td>9659</td>
<td>10752</td>
<td>11.3</td>
</tr>
<tr>
<td>206 On 9th St. S., between 8th &amp; 9th Aves. S.</td>
<td>9719</td>
<td>8834</td>
<td>9.1</td>
</tr>
<tr>
<td>207 On 10th St. N., at north end of 10th St. N. Bridge</td>
<td>9798</td>
<td>10113</td>
<td>3.2</td>
</tr>
<tr>
<td>208 On 14th St. S., just north of 10th Ave. S.</td>
<td>10130</td>
<td>10254</td>
<td>1.2</td>
</tr>
<tr>
<td>209 On 1st Ave. N., just east of 6th St. N.</td>
<td>10240</td>
<td>9022</td>
<td>11.9</td>
</tr>
<tr>
<td>210 On I-15, just N.E. of Gore Hill Interchange</td>
<td>10390</td>
<td>11705</td>
<td>12.7</td>
</tr>
<tr>
<td>211 On 15th St. N., just south of River Dr.</td>
<td>10460</td>
<td>10861</td>
<td>3.8</td>
</tr>
<tr>
<td>212 On 6th St. S.W., just south of Central Ave.</td>
<td>10683</td>
<td>14493</td>
<td>35.7</td>
</tr>
<tr>
<td>213 On River Dr., ½ mile west of 25th St. N.</td>
<td>10713</td>
<td>10247</td>
<td>4.4</td>
</tr>
<tr>
<td>214 On 57th St., just south of 2nd Ave. N.</td>
<td>11256</td>
<td>9055</td>
<td>19.6</td>
</tr>
<tr>
<td>215 On Central Ave. W., between 12th &amp; 13th Sts. S.W.</td>
<td>11312</td>
<td>9373</td>
<td>17.1</td>
</tr>
<tr>
<td>216 On I-315, between Fox Farm Rd. &amp; 10th Ave. S. Interchange</td>
<td>11460</td>
<td>12928</td>
<td>12.8</td>
</tr>
<tr>
<td>217 On 13th St. S., just south of 10 Ave. S.</td>
<td>11508</td>
<td>12995</td>
<td>12.9</td>
</tr>
<tr>
<td>218 On 15th St. N., just north of N. River Rd.</td>
<td>11660</td>
<td>10710</td>
<td>8.1</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
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<td>Percent Variation</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
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</tr>
<tr>
<td>219 On 10th Ave. S., just west of 57th St.</td>
<td>11776</td>
<td>11721</td>
<td>0.5</td>
</tr>
<tr>
<td>220 On 2nd Ave. N., just east of 57th St.</td>
<td>12019</td>
<td>10293</td>
<td>14.4</td>
</tr>
<tr>
<td>221 On 6th St. S.W., at south end of Sun River Bridge</td>
<td>12750</td>
<td>13481</td>
<td>5.7</td>
</tr>
<tr>
<td>222 On 6th St. S.W., between Russell Ave. &amp; BNRR underpass</td>
<td>13832</td>
<td>14369</td>
<td>9.0</td>
</tr>
<tr>
<td>223 On 3rd St. N.W., just S.W. of Jct. Smelter Ave.</td>
<td>13435</td>
<td>14567</td>
<td>8.4</td>
</tr>
<tr>
<td>224 On N.W. Bypass, just west of 3rd St. N.W.</td>
<td>13871</td>
<td>13354</td>
<td>3.7</td>
</tr>
<tr>
<td>225 On 3rd. St. N.W., just south of N.W. Bypass</td>
<td>14454</td>
<td>16722</td>
<td>15.7</td>
</tr>
<tr>
<td>226 On 10th St. N., between N. River Rd. &amp; Smelter Ave.</td>
<td>14631</td>
<td>14928</td>
<td>2.0</td>
</tr>
<tr>
<td>227 On Fox Farm Rd., just south of 10th Ave. S.</td>
<td>15020</td>
<td>15416</td>
<td>2.6</td>
</tr>
<tr>
<td>228 On 3rd. St. N.W., just north of Central Ave. W.</td>
<td>15459</td>
<td>18862</td>
<td>22.0</td>
</tr>
<tr>
<td>229 On Central Ave. W., just east of 6th St. N.W.</td>
<td>15975</td>
<td>19693</td>
<td>23.3</td>
</tr>
<tr>
<td>230 On Northwest Bypass, between 6th &amp; 9th Sts. S.W.</td>
<td>15994</td>
<td>13548</td>
<td>15.3</td>
</tr>
<tr>
<td>231 On Central Ave. W., just west of 6th St. N.W.</td>
<td>16113</td>
<td>12619</td>
<td>21.7</td>
</tr>
<tr>
<td>232 On 15th St. N. Bridge, just north of River Dr.</td>
<td>16520</td>
<td>15526</td>
<td>6.0</td>
</tr>
<tr>
<td>233 On 3rd St. N.W., just north of N.W. Bypass</td>
<td>17705</td>
<td>16130</td>
<td>8.9</td>
</tr>
<tr>
<td>234 On Smelter Ave., just west of Jct. 10th St. N.</td>
<td>17779</td>
<td>17724</td>
<td>0.3</td>
</tr>
<tr>
<td>235 On Smelter Ave., just west of 6th St. N.E.</td>
<td>17941</td>
<td>17205</td>
<td>4.1</td>
</tr>
<tr>
<td>236 On 10th Ave. S., just east of 38th St.</td>
<td>22251</td>
<td>24753</td>
<td>11.2</td>
</tr>
<tr>
<td>237 On 1st Ave. N., just east of River Dr.</td>
<td>22645</td>
<td>22528</td>
<td>0.5</td>
</tr>
<tr>
<td>238 On 1st Ave. N., at west end of 1st Ave. N. Bridge</td>
<td>22981</td>
<td>25030</td>
<td>8.9</td>
</tr>
<tr>
<td>239 On 10th Ave. S. on Warden Bridge</td>
<td>24681</td>
<td>23860</td>
<td>3.3</td>
</tr>
<tr>
<td>Traffic Count Locations</td>
<td>Observed ADT</td>
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<tr>
<td>-------------------------</td>
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<tr>
<td>240 On 10th Ave. S., just west of 38th St.</td>
<td>26696</td>
<td>26064</td>
<td>2.4</td>
</tr>
<tr>
<td>241 On 10th Ave. S., just west of 5th St. S.</td>
<td>27010</td>
<td>27887</td>
<td>3.2</td>
</tr>
<tr>
<td>242 On 10th Ave. S., just east of 6th St. S.</td>
<td>27020</td>
<td>27742</td>
<td>2.7</td>
</tr>
<tr>
<td>243 On 10th Ave. S., just east of 26th St.</td>
<td>27520</td>
<td>29181</td>
<td>6.0</td>
</tr>
<tr>
<td>244 On 10th Ave. S., between 9th &amp; 10th Sts.</td>
<td>32770</td>
<td>30685</td>
<td>6.4</td>
</tr>
<tr>
<td>245 On 10th Ave. S., just west of 25th St.</td>
<td>33350</td>
<td>39732</td>
<td>19.1</td>
</tr>
<tr>
<td>246 On 10th Ave. S., just west of 14th St.</td>
<td>34570</td>
<td>30938</td>
<td>10.5</td>
</tr>
<tr>
<td>247 On 10th Ave. S., just east of 15th St.</td>
<td>40950</td>
<td>41497</td>
<td>1.3</td>
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