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AN ALGORITHM TO SITE DISTRICT POLICE STATIONS FOR THE CITY OF DENVER

by

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ABSTRACT

This thesis presents a project done for the City of Denver Police Department. The City of Denver will in the course of the next decade build 3 new district police stations. The purpose of this project was to develop a method to pick sites for these new stations.

The district police station in the City of Denver is used for a variety of purposes. The important points in siting a district station include access, egress, distance to patrol routes, and distance from arrest sites. Because of the inherently qualitative nature of access and egress, these issues are considered separately from distance.

A patrol officer has two types of vehicular trips which are affected by the location of the district station: shift trips and a certain class of minor arrests where the offender can be left at the district station. Because the city of Denver is divided in a rectangular street system, all distances must be measured rectangularly (as the car drives) instead of straight line (as the crow flies). To minimize the distance traveled to and from the district station the theoretically optimal location is the median of mass of the trips. In this study every trip is given a mass of one.

For cost valuation, a method is presented to assign costs to building at alternative sites based on distance from the optimal spot. Finally, access, egress, and political factors must be examined to choose a best feasible location.

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Chapter 1

INTRODUCTION

On March 16, 1988, *The Rocky Mountain News* reported,

> Denver will not hire a consultant to determine where to put new district police stations and instead will do the work itself. ...Although the $70,000 to pay for a consultant had been appropriated, Martinez told the general government committee he wouldn't ask for it.

The article states that the Police Department wants to replace district stations 1, 2, and 3 because they are "small, outdated and don't allow for decentralization of police services." The article goes on to say that the city council believes "the city has enough in-house expertise to analyze police station sites." Also the Police Department is in no hurry because "the city doesn't have any money to build any replacements right now anyway."

With the help of Professor David Fletcher, Colorado School of Mines, I was able to get in touch with Mr. Denny Weller, deputy manager of safety for the City of Denver. Mr. Weller said that indeed the article was correct in the part referring to the cancellation of consulting services, but that neither the Manager of Safety's office nor the Police Department possessed the expertise to site the new stations. Professor Fletcher arranged an initial interview with Mr. Weller for April 1, 1988.

Prior to the initial interview, I started a literature search to find applicable articles on the problem of single facility location within a given service area. While the literature is replete with articles on facility

location, most of the articles deal with multiple facility problems (see Patel 1979) or with straight line (as the crow flies) distance (see Ceverny 1980). The City of Denver is a rectangular grid with very specific routes possible, i.e., a police car must travel a rectangular path (the street system) to get anywhere. One article (Price and Turcotte 1986) dealt with the single facility location in a city, but the authors assumed away the rectangular travel aspect. The most applicable literature was the section in *Facilities Location* (Love, Morris, and Weslowsky 1988) on single facility location in rectangular grid systems.

Chapter 2
MEETINGS WITH DEPARTMENT OF SAFETY SUPERVISORS

2.1 Meeting with Deputy Manager of Safety

Professor Fletcher and I met with Mr. Weller at the Denver police headquarters on Cherokee Street. Mr. Weller explained that the police district stations in Districts 1, 2, and 3 range in age from 18 to 40 years. District 4 constructed a new station in 1987 and will not be moved. The reasons given for relocation of the other stations range from inadequate facilities to other uses for the present sites.

Mr. Weller discussed the general needs of a police district station: parking for police vehicles; parking for officers' personal vehicles; offices for district administration, detectives, and crime prevention personnel; changing room for officers going on or off shift; classrooms; and detention facilities. In addition the police department is trying to decentralize services and, as the decentralization progresses, more services will be transferred to the district stations. Asked about the services provided to citizens at the district stations, Mr. Weller said that walk-ins file accident or criminal reports and request information on courts, law, crime prevention, and street directions. The needs of on-duty officers at district stations are computer terminals, telephones, administrative information access, and inventories of official forms. Mr. Weller said that the general needs of a police station site were convenient public access, good access

to major arteries for patrol cars, and cheap or city-owned land. Mr. Weller arranged for Dr. Steve Brown to be our liaison for the duration of the project. Dr. Brown is director of statistics for the Department of Safety.

2.2 Meeting with Messrs. Weller and Brown

The first meeting with Dr. Brown, April 18, included Professor R. E. D. Woolsey, Colorado School of Mines, Denny Weller, and myself. Dr. Brown and Mr. Weller had previously discussed the problem of site selection with the district commanders and the chief of patrol. The project as outlined by Dr. Brown to us, based on his meeting with the police officers, was where to locate buildings without regard to availability of land (or buildings) and then attempt to find a site in the area with the highest scores on certain criteria. An alternative given was to determine what land was available and then rank each parcel on its usefulness based the criteria given.

2.2.1 Initial Selection Criteria

The initial criteria (in no specific rank or order) were the following:

1. Population demographics
2. Population growth
3. Physical barriers (e.g., railroads, rivers)
4. Access to roads or major thoroughfares
5. Distance from site to farthest precinct or boundary
6. Future RTD construction or developments
7. Traffic patterns

8. Availability of land
9. Land costs/ city's fiscal capacity
10. Land use (future development, elimination of parks police)
11. Geologic issues (toxic dumps/radon gas)
12. Community access to police district stations
13. Calls for service
    Incident location
    Incident nature
14. Workload parity

2.2.2 Establishing Goal of Study

Dr. Woolsey and I first tried to establish exactly what the police department wanted as a final product. Mr. Weller explained that the construction time frame was a big unknown. As funds become available the city will acquire the land and build the new stations. The changes in demographics and demographic trends, as well as new construction, improvements, and developments such as a light rail system, or new airport, could make any site selected today obsolete by the time the city is ready to build. Because of this uncertainty the assembled group decided that specific site selection would be inappropriate. What the police department needs is a method to select sites.

Dr. Woolsey explained the concept of Varignon frame (Love, Morris, and Weslowsky 1988, 27-28) to the assembled group. The explanation is this: Imagine a table in the same shape as a district. Mark the precinct outlines on the table. In the center of each precinct, drill a hole. Put a

round washer on the table and tie fishing line to the washer, as many lines as there are precincts. Run a line through each hole and tie as many weights to each line as there are calls for service in that precinct. Give the table a good shake and where the washer ends up is the best location to minimize distance to the calls for service. If one kind of call is more important, give it a correspondingly greater weight. The Safety Department people seemed to grasp this explanation very well and said that indeed this was a method they could sell to the police and to the City Council. It should be noted that the Varignon frame will minimize straight line distances from facility to demand points. The problem then lies with what has mass, how much mass, and where the holes should be drilled.

2.2.3 Specification of True Criteria

In dealing with what had mass and what did not, we decided to take a limiting approach. First we convinced Messrs. Weller and Brown that of the above issues, land use and geologic factors (numbers 10 and 11 section 2.2.1) were so site specific that they would not be included in the selection algorithm but would be considered after an optimal spot was located and specific surrounding sites were being considered. Item 14, workload parity, was deemed important in setting up district boundaries, but not in selection of sites. Traffic patterns (#7) are a good thought but the city really does not have any information on them nor does it plan to gather the data. Number 6, future RTD construction, is important but only in selecting a specific site, not in the general process.

Population demographics and population growth (#1 and #2) are important but even the city planning office projections have to be revised every 6 months. Also, the City and County of Denver is not allowed to expand except by special election and, except for the acquisition of property for the new airport, the assembled parties agreed that Denver will probably not change boundaries for a long time. Numbers 3 and 4 (physical barriers and access) will have to be taken into account as specific sites are considered, but, once again these have no place in the algorithm. Last, Mr. Weller agreed that land cost and availability of land (numbers 8 and 9) are important in specific site selection but could not be successfully incorporated into any sort of long-term algorithm. This leaves only criteria 5, 12, and 13 as relevant to the algorithm for site selection:

5. Distance from site to farthest precinct or boundary
12. Community access to police district stations
13. Calls for service
    - Incident location
    - Incident nature

2.2.4 Purpose

The City of Denver Police Department wants to build 3 new district police stations in the next several years. Population, demographics, demographic trends, and geographical features will change throughout those years. The purpose of this thesis is to devise a *method* for optimally siting district police stations for the City of Denver.

Chapter 3

FIELD WORK

3.1 Dispatch Room

The dispatch room for the police department is similar to an airport control tower. It is buzzing 24 hours a day, 365 days a year. Each district has a separate radio frequency and dispatcher. The dispatchers send the officers to calls, shuttle the officer information, and give the officer whatever assistance they can including whether a person or vehicle is wanted, if the officer can break for lunch or potty, or even if they can return to the station for shift change.

3.1.1 Dispatch Procedure

The system used in the dispatch room is fairly simple. An operator takes the call from the citizen. The call can come in on either 911 or the regular phone lines. The operator assesses if police, fire, or ambulance service is needed. If police service is required, the operator then writes up the request on a tan (non-emergency) or pink (emergency) card and puts the card on a conveyor to the desired district dispatcher. The dispatcher then determines by personal knowledge if the call is indeed in his district. If the call is not in his district, he sends it to the district he thinks it is in or sends it back to the operators if the request for service is not in Denver. When the call for service is properly routed, the dispatcher then determines which precinct the request came from and

whether that patrol car is available. If available, the dispatcher sends the precinct car to answer the call. If not available, he will send an available car from a close precinct or save the request for such time as the precinct car is available. In the event that no nearby cars are available and the call is important, the dispatcher may ask for any available cars. When a special situation arises, such as a hold-up in progress or an officer needing help the dispatcher can put the request over all the districts' radio channels and request help from any available officers, or even ask for officers from areas outside of Denver.

3.1.2 Location of Officers

Each time an officer responds to a dispatched radio call, the patrolman tells the dispatcher when he is "code 6" (at the location) although he may in fact be several blocks from the address of the call. The dispatcher writes down the officer's location as that stated on the dispatch card. The dispatch card is then put in a slot assigned to that patrol car for the dispatcher's assistance. Often the complainant gives an incorrect address. Also, the officer never parks directly in front of the site where the assistance is requested. These two facts together add up to the dispatcher almost never knowing exactly where the officer is unless he is eating lunch. To compound the problem, when a patrolman finishes his on-site portion of the call, he may drive several blocks to park and finish his paperwork on the call. As soon as the officer pronounces himself in-service (finished with this call), he begins to patrol

again. The dispatcher puts the call for service card on the conveyor to be filed.

When an officer is patrolling he is a semi-autonomous unit. He uses the radio to request assistance or information. The patrolman does not give his location to the dispatcher unless he is going to leave the car.

3.2 Office of Asset Management

Due to the economic constraints on the city, i.e., they do not have enough money, the police would prefer to build on city owned land. The Office of Asset Management is charged with maintaining records of city-owned property. I spoke with Marilee Utter (Utter, 1988) regarding maps of city-owned property. Ms. Utter replied that her office is not even sure how much property the city owns. She said that she thinks her office has about 98% of the city-owned property on computer file but that is only a guess. I asked her if she had maps of the property that they think they own, she said she did not but that they could sort the files in the computer database. She went on to explain that they could sort by square footage and/or by zoning but that there is some problem in those types of sorts because the city owns many rights-of-ways which are long and narrow (say 10 feet by 5,000 feet) and that any sort keyed on area would pick out these parcels as well as parcels which are more conducive to a police station (say 100 feet by 500 feet).

3.3 Ride-alongs

It was decided that one of the most important tasks for this study was for the investigator to go with the officers on patrol and find out how they actually use the district station, what is important to them and their jobs about the location of the district station, and what is good and bad about the present locations of the district stations.

To do a comprehensive study of all the actions required of a police officer would require accompanying the officer from the first day of Police Academy through the first year on the job. That amount of time and effort was not available. It was decided to do ride-alongs and interviews in each of the districts, covering all shifts and all days of the week. Each district was investigated with three ride-alongs, each on a different day. There were more ride-alongs on the night shift (1800 hours to 0200 hours) because night shift has the highest call density and the higher call density allows more experience in less time.

3.3.1 District 1

District 1 station is located at 2195 Decatur Street encompassing the northwest quadrant of Denver. Adjacent to the District 1 station is the Police Protective Association building and a large park.

3.3.1.1 Reasons for Replacement

The District 1 station is 3 blocks north of Mile High Stadium. The proximity to Mile High and McNichols Arena means that whenever a large spectator event takes place at either of the two complexes, the

District 1 station is almost inaccessible to officers coming on duty because of traffic problems. The juxtaposition of the station to Mile High, compounded by the parking problems at Mile High, make the District 1 land an ideal site for a parking lot. The station is on sloping ground, suffers from foundation problems, and with every heavy rain the basement floods. Finally, the facilities are inadequate for current operations.

3.3.1.2 Positive Points of Present Location

The officers I spoke to indicated that, except for sports complex traffic problems, the location of the district 1 station is good. The officers mentioned specifically access to the station when going to work, access to patrol areas, central location, and side street location (this cuts down on harassment and vandalism). The desk officer indicated that the station is convenient for walk-in traffic and that its being next to a park gives citizens a protected area for family outings.

3.3.1.3 Negative Aspects of Present Location

As stated before, the negative aspect of the location is the problem in access during events at the sports complex. The officers have some minor problems getting to and from the station while in patrol cars but these are minimal compared to those of getting to or from work while in their personal cars.

3.3.1.4 Officers' Desired Location Specifics

The positive consideration mentioned most frequently by the officers, except for the traffic problems, was convenience to their homes or access

to their homes. As with most employees, officers consider time spent commuting in their cars as wasted time and would like to minimize travel.

The desk officer pointed out that there is some walk-in traffic, but, except after events at the sports complex, it is relatively light. No break-down exists on how many persons walk to the station and how many drive. The desk officer's main concern for the station location relative to the walk-ins is ease of access. Any location that gives officers good access from their homes will also give the public good access.

3.3.2 District 2

The District 2 station is at 3555 Colorado Boulevard. District 2 encompasses northeast Denver including Montbello and the proposed new international airport. During the time the study was conducted a substation opened in Montbello.

3.3.2.1 Reasons for Replacement

The District 2 station is located on Colorado Boulevard, bounded by a church on the north, houses on the west, the street on the east, and a convenience store on the south. The parking facilities are insufficient for employee cars and patrol cars and additional parking space is unattainable. Additionally the facilities are too small for the number of officers assigned there, as evidenced by the lack of locker space, the number of officers that must park their personal vehicles on the street, and the overcrowding of the detectives' office area. The opening of the Montbello

substation has relieved many of the overcrowding problems, but the expected growth from the new airport could bring these problems forward again.

3.3.2.2 Positive Points of Present Location

The location on Colorado Boulevard gives the police high visibility, adding a little convenience to travelers looking for directions. A main thoroughfare increases the officer's perception of easy access to the precinct.

3.3.2.3 Negative Points of Present Location

Although the thought is that a police station discourages crime in the area, the high visibility of the District 2 station did not deter a "crack" house from opening 3 blocks away, nor did it prevent the robbery of the convenience store and the fast food restaurant 2 blocks away. The high visibility location also promotes vandalism of the station, patrol cars, and employee cars.

3.3.2.4 Officers' Desired Location Specifics

Once again the officers want a location convenient to home, both in distance and access.

3.3.3 District 3

The District 3 station, located at 1625 South University Boulevard, covers southeast Denver including the Denver Technological Center. This very large district covers some of the wealthiest areas of Denver.

3.3.3.1 Reasons for Replacement

The district has grown considerably since its inception. The present facilities are too small for the number of officers now assigned there. The police department is presently adding a modular building behind the station to add room for the officers, and will increase the number of parking spaces.

3.3.3.2 Positive Points of Present Location

The district 3 station is located just 2 blocks from Interstate 25. This location allows quick access to the southern precincts by way of I-25. The area between the station and the interstate is undeveloped. Behind the station is a very large park. These areas with no housing give the officers a large buffer against their noise becoming a problem to area residents.

3.3.3.3 Negative Points of Present Location

This is generally a well-sited station. The officers expressed no negative feelings about the location. One drawback is proximity to some local residents, and as with all the stations, this one is noisy at all hours. Another problem is that a park borders two sides of the station, limiting the number of streets an officer can use to get into and out of the station.

3.3.3.4 Officers' Desired Location Specifics

The officers would like a more isolated location to prevent noise problems and to cut down on vandalism.

3.3.4 District 4

District 4 station is located at 2100 South Clay Street. This station is less than two years old and will not be replaced in the foreseeable future. This is the dream station for the police officers. The station has 4 holding cells, large lockers, racquet ball court, weight room, and protected parking.

3.3.4.1 Positive Points of Present Location

The officers in District 4 think the present location is fairly good. They cite the ease of access to Federal Boulevard and several cross streets which give them good access to their patrol routes. The officers mostly want to talk about what is good or bad about the station and, as with all districts, the officers have given very little thought to what is good or bad about the location.

3.3.4.2 Negative Points of Present Location

The officers had no specific complaints about the present location.

Chapter 4
MODEL SELECTION

4.1 Rectangular Distances

Denver is set up on a north-south, east-west grid system except for the downtown area. A police car usually cannot travel in a straight line between any two points in the city. The cars must travel along the grid of streets which means the cars must travel in rectangular paths.

The Denver downtown is rotated about 45° to the west of North. Generally this is believed to have been done to assist in solar snow removal. While this rotation decreases the perfect applicability of rectangular distances to the problem under study, the downtown area is small enough to make the problems associated with the rotation diminish. In addition the city is considering opening a downtown police district which would contain all of the rotated streets.

4.2 Factors for Site Selection Model

The objective function for the site selection is to maximize officer time on patrol. As one lieutenant said, "Cops are blind when they are out of their precinct." The objective for the study then is to maximize the officer's time in his precinct.

There are several reasons for an officer to be away from his precinct on a nonproductive official trip. By nonproductive I mean a trip that subtracts directly from the time a police officer spends protecting the

public. One reason might be taking the car in for radio repair, another might be taking a felon in for booking at the downtown facility. The officer on patrol has two types of countable nonproductive trips that relate directly to the location of the district station. Type one is a trip getting on or off shift. Type two is a trip taking an offender to the district station holding cells. By no stretch of the imagination are these the only reasons the officer goes back to the station, but they are the only regularly occurring recorded trips which impact station location. If the police department keeps detectives in the district stations, then the detectives' trips to and from investigation sites are also nonproductive trips.

4.2.1 Type 1 Nonproductive Trips

The officers report to the district station to start and end shifts. At the start of shift the officers attend a roll call and inspection. The officers then take their assigned patrol cars and proceed to their patrol area. The time spent traveling to their patrol area is nonproductive time. At the end of shift the officers must travel back to the district station from their patrol area, again, nonproductive travel time.

If the city decides to house the detectives permanently in the district police stations, then a detective's travel to and from sites of investigation would be considered the same as trips on and off shift. This is because a detective is not really doing very much productive work while driving. Most of a detective's productive work is done at a crime site or at a witness location or at his desk.

4.2.2 Type 2 Nonproductive Trips

Most arrestees must be taken to the central jail for processing. Only in certain misdemeanors involving adults can offenders be taken to the district station holding cells. If the misdemeanor involves evidence, the evidence must be delivered personally by the arresting officer to the downtown property room, in which case the officer would probably personally deliver the offender as well. All drunk driving offenders must be taken downtown for testing, and all persons arrested on outstanding warrants must be taken downtown to be identified against the warrant. These specifications leave only a small percentage of the total arrests in which the location of the district station influences nonproductive travel time.

If the city decides to house detectives at the district station permanently, then the detectives may have some arrests which could be delivered to the district station. These too would have to be included in the decision to locate a new district station.

4.3 Type of Problem

The primal problem as stated in section 4.2 is to maximize the officer's time on patrol. The problem stated as the dual is to minimize police travel time by placement of the district station. This is a facilities location problem of where to locate a single facility with regard to rectangular distances. This is a straightforward problem (see Love, Morris, and Weslowsky, 1988) with the slight twist that some of the product (nonproductive trips) can be delivered by an existing warehouse (the

downtown jail). The method to compensate for the downtown facility is quite simple. If an officer has an offender who can be taken to either the district station or the downtown facility, the officer will, in theory and in practice, take the person to whichever is closer. The method then is to construct a line which is equal travel distance from the district station and the downtown facility. Any holding-cell type arrests on the downtown side of this line are not counted as nonproductive trips in calculating the position of the district station.

4.4 Median Equals Minimum

According to Love, Morris, and Weslowsky (1988), in a single-facility rectangular location problem, the optimal location is at or in the median of mass in the coordinate system. Appendix A contains a proof of the optimality of the median.

Chapter 5
ALGORITHM

5.1 Language of Algorithm

The algorithm given as a final product to the Manager of Safety's office will be in an unscientific, nonintellectual form (see appendix B). This is to allow for the possibility that the personnel associated with the project might move on to other jobs. Consequently new employees must be able to understand and use the algorithm if it is to be useful in the future.

5.2 Method

The algorithm, in facilities location vernacular, is as follows:

1. Identify demand for product and mark the demand location on a map of the service area.
2. Calculate total demand for the service area.
3. Find the intersection of east-west and north-south medians of demand.
4. If the intersection is not significantly different from the previous intersection, stop, this is the optimal spot, else continue.
5. Construct a line connecting the intersection and the downtown facility.
6. Mark the midpoint of the connecting line.

7. Construct an equal rectangular distance line through the midpoint.
8. Repeat this procedure disregarding all type 2 demand (see section 4.2.2) on the downtown side of the equidistance line.

Chapter 6
CONSIDERATIONS FOR SPECIFIC SITE SELECTION

6.1 Optimal Location

After locating the optimal spot on the map, the realities of the non-mathematical world must be considered. The optimal spot may be in the middle of a highway, the middle of a lake, or on top of a 25-story office building. The optimal spot is a place to start looking for the optimal location. The optimal location is the specific plot of land that is feasible in the world of political, economic, and geographic constraints and is fairly well located, relative to the optimal spot.

6.2 Factors in Specific Location Selection

As stated in section 2.2.1 the Office of the Manager of Safety originally presented 14 criteria for what was important in picking a location for a police station. The number of criteria that could or should be incorporated into a mathematical model was cut to 3 as explained in section 2.2.3. The remaining factors are going to have to be considered in the transition from optimal spot to optimal location.

The first criteria to be looked at in selecting the optimal location is availability of land. The City of Denver would, of course, prefer to build on land it already owns; however, that land must be available for occupancy for the 30-year expected life of the police station. If the city plans

to build a new baseball stadium on the land 10 years hence, that land would obviously be unavailable for a district station. If appropriate land is not owned, the city would prefer cheap land.

When considering land owned by the city, the concept of opportunity cost must be included. City owned land can have a variety of uses and each use has a value to the public. If the selected land is being used as a park, the city must consider the value a park has to the public and how the park may benefit or suffer due to the construction of a police station. A worst case valuation of opportunity cost of the land selected could be the replacement cost for the land.

The next criteria would be size and configuration of parcels of land available. A police station takes up more than an acre of land and to consider any thing under 50,000 square feet, or with a breadth of less than 100 feet, would be ludicrous.

The next criteria must be access. Good access is essential to efficient functioning. Included in good access is multiple access, meaning that the police station would not be isolated if a couple of streets were removed from service. Good access allows an officer to get to work from home and to get home from work. Good access allows the citizens to come to the police station for whatever services they might need. Access is essential to a police station to allow officers to get to their patrol routes quickly and efficiently. Last, good access is critical in the event of a disaster such as flood or tornado. If there were only one or two routes connecting a district station to its district, then a disaster could

conceivably eliminate all access for the police and eliminate the police from providing emergency and relief services.

Included in the access issue is the criteria of future construction or development. When looking at a potential site, the future of the surrounding area must be considered as well. If the city is going to build another baseball stadium 2 blocks from the possible location the planners must consider which streets will be removed and what traffic congestion will result. The city does not want to recreate the problems it already has.

Referring to section 2.2.1, criteria 1 and 2 will be considered through the use of the algorithm for specific spot selection. The population demographics and growth will be reflected in the data used for demand in the system. This will not give a true representation of trends but, as stated earlier, Denver is relatively stagnant in its growth and change. If the city devises a method to accurately forecast these factors, and a method to relate them to the duties of a police officer, then the statistician who has accomplished this feat can come up with the demand figures and feed them into the algorithm instead of actual data.

Those who implement the algorithm will eventually determine a set of locations that are at least feasible. Each parcel of land will be at a different distance and angle from the optimal spot. The mathematical difference from optimality will need to be calculated and considered for each plot. This calculation will be expressed in layman's terms in a separate report to the Manager of Safety's ffice (see appendix B).

6.3 Determination of Weighted Badness of Location

The method for calculating the weighted badness is as follows:

1. Using a map with all demand for product marked, put a point on the map corresponding to the proposed location and a point corresponding to the optimal spot as determined with the method of section 5.2.
2. Draw a connecting line between the proposed location and the downtown facility. Mark the midpoint of this line.
3. Draw a rectangular equidistance line through the midpoint.
4. Remove all type-two demands from the map on the downtown side of the equidistance line.
5. Calculate the demand for product east of the proposed site, subtract the demand west of the proposed site.
6. Multiply the absolute value of the difference by the east-west distance of the proposed site from the optimal spot.
7. Repeat steps 5 and 6 for the north-south direction.
8. Add the two numbers, the result is the weighted badness for the proposed location.

6.4 Factors to Consider for Specific Location

The following list is a summary of the factors that must be considered in the selection of a specific location.

1. Availability of land
2. Cost of land
3. Size and configuration of lot
4. Access and physical barriers
5. Future construction on or around the location
6. Weighted badness of available sites

Chapter 7
SITE SELECTION FOR DISTRICT 2

7.1 Data Collection

At a preimplementation meeting with Messrs Weller and Brown, the decision was made to do the algorithm demonstration on data from district 2. The author spent 2 days at the district 2 station going through a week of officer log sheets. The dates of data are October 29 to November 4. During those seven days there were 42 shift trips in each of the 17 precincts and a total of 95 arrest trips.

District 2 officers are presently housed in two locations, the district station on Colorado Blvd. and a substation in Montbello. The Montbello substation is responsible for all 240 precincts. In the demonstrations of the method, this separation of officers is accounted for by not using the 240 precincts' data in calculating the optimal location for the district 2 station.

7.2 Assumptions

Because of the variability of an officer's location at the beginning or end of a shift, the assumption is made that all shift trips are made to or from the middle of the officer's precinct. This massing of trips at one location will tend to make the middle of a precinct the most likely place for a station to be located.

7.3 Initial Try

The initial run through done for Dr. Woolsey for district 2 produced a first iteration location for a new district 2 station at the corner of Martin Luther King Blvd. and Williams Street. After removal of arrest trips, which were closer to the downtown facility (a total of 90 trips), the new median was determined to be less than 1 block northeast. This means that for the data used, the new district 2 station should be located in precinct 225 near the corner of MLK and Williams.

7.4 Presentation Working Session

The final working session presentation was made on December 15. The participants included Dr. Woolsey, Dr. Brown, Mr. Weller, and myself. The session was arranged as a prepresentation work session by the clients. As the session progressed it became apparent that the main purpose of this session was to change certain language in the report so that it would be viewed more as a technical document than as a political potato. I must report, however, that the two gentlemen from the city also had several valid complaints about language use and change in those passages has improved the readability of the report considerably. They pointed out that several of my statements were flippant and a couple were indefensible in light of the facts.

The first of the items to be addressed by the safety employees was in section 2.1 of the report (attached as appendix B). In the version presented December 15 the report mentioned that officers would like a location close to their homes to minimize commuting time. This section was

removed so that the group reading the report would not think that the algorithm considered officers' commuting time. Section 2.1.2 of the report ended with the words "... that civilian access can be both a blessing and a curse." This was softened. Mr. Weller objected to the line, "Police actually discourage use of the police stations by the public." He was emphatic that I not say that in the final group presentation.

Section 2.3 originally ended with the sentence "A police station cut off from the district it serves by the severing of one or two streets could cost civilians their lives and officials their jobs." Removal of this sentence was requested because it appeared to be a veiled threat or a restatement of the obvious. "Locations to Avoid," section 2.4.1, was changed considerably to reduce the ominous tone of the original. Phrases such as "would not put up with a police station" were changed to "may have difficulty tolerating ..." Generally the changes requested made little difference in the actual report. The one deletion that materially altered the report was the officers' request for a location convenient to their homes.

7.5 Final Presentation

The final presentation of the report was on December 19 at the Cherokee Street offices of the manager of safety. Present were Steve Brown of the Office of Policy Analysis; Denny Weller, deputy manager of safety; Cliff Stanley, deputy chief of police; Robert Cantwell, chief of patrol; Derek Brown of the Office of Asset Management, Dr. Woolsey, and myself.

Chief Cantwell, Chief Stanley, and Derek Brown had not previously seen the report in any form. The presentation was geared to their knowledge base. The meat of the presentation, the site selection algorithm, piqued the interest of the group. The concept and construction of the equidistance line was a sticking point which took a few extra minutes of explanation. When Chief Cantwell began asking about the location of the new district 4 station relative to this method and said "I knew it was too far away, now I have a way to prove it," we knew we had acceptance of the method. The final approval came when Chief Cantwell tried to carry all the presentation materials back to his office and had to ask Mr. Weller if he could come back in a few minutes because he did not have enough arms to carry everything at one time.

7.6 Conclusions

Police provide a vital service for the public good. Proper location of police facilities can increase the total value to the citizens at no increase in cost to the providers. As such, the application of operations research techniques and common sense to public services provides a win-win situation for public officials and the public.

The siting of new district police stations for the City of Denver is a good example of how operations research can be used to enhance public services at minimum cost. With study of only a few factors, the City of Denver will be able to site new district stations in an efficient and cost effective manner.

The factors which enter in to the siting decision, location, access, egress, visibility, cost, and alternative use are easily studied. The only factors which need be quantitatively defined are officer travel distance and cost of the site. Because an officer responds to requests for service from his patrol car, the officer travel distance is limited to two types of trips. The trips which are important in station location are trips on or off shift, and trips to deliver offenders to the district station.

Presently, officers on patrol do not use the district station for many activities during their shift. This leads to a theoretically optimal location which is in large part dependant on the shift trip locations. As more services and functions are shifted from the downtown facility to the district stations, the theoretical locations of the district stations will tend to shift toward the district's busier precincts.

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Appendix A

PROOF OF MEDIAN EQUAL TO MINIMUM IN RECTANGULAR LOCATION PROBLEM

Paraphrased entirely from *Facilities Location: Models and Methods* by Love, Morris, and Weslowsky, pages 18 to 21. Published in 1988 by North-Holland in New York.

A.1
Terms

W = Weight of Event

L = Rectangular distance from event to District Station

(L_x, L_y) = Location of new District Station

(a_{ix}, a_{iy}) = Location of an individual mass

A.2
Objective Function

MINIMIZE $WL = \sum_{i=1}^{n} w_i(|L_x - a_{ix}| + |L_y - a_{iy}|)$

This is separable to

$\text{Min}\, WL = \text{Min}\, WL_x + \text{Min}\, WL_y$

where

$WL_x = \sum_{i=1}^{n} w_i |L_x - a_{ix}|$

and

$WL_y = \sum_{i=1}^{n} w_i |L_y - a_{iy}|$

A.3
Proof of Convexity

Plot $w_i|L_x - a_{ix}|$ with $w_i > 0$ against L_x. This will easily demonstrate that the function is convex. Since the summation of convex functions is a convex function, WL is convex.

A.4
Reordering

For ease of analysis, renumber the a_{ix} and a_{iy} such that $a_{(1)x} < a_{(2)x} < \ldots < a_{(n)x}$. There will now be $n_{(x)}$ coordinates with $n_{(x)} \leq n$. This is because some of the terms will combine. For example, $a_{(6)x} = a_{(8)x} = 9$ with $w_{(6)} = 7$ and $w_{(8)} = 3$. The terms $7|L_x - 9|$ and $3|L_x - 9|$ can be combined to yield $10|L_x - 9|$. This ordering and combination gives a strictly increasing sequence with possibly fewer terms.

The single axis problem now becomes

Minimize $W_x(L_{(x)}) = \sum_{(i)=1_{(x)}}^{n} w_{(i)} |L_x - a_{(i)x}|$.

A.5
First Derivative

The single axis derivative becomes

$$W'_x(L_{(x)}) = -\sum_{(i)=1}^{n_{(x)}} w_{(i)} \qquad \text{for } L_{(x)} < a_{(1)x}$$

$$W'_x(L_{(x)}) = \sum_{(i)=1}^{t} w_{(i)} - \sum_{(i)=t+1}^{n_{(x)}} w_{(i)} \qquad \text{for } a_{(t)x} < L_{(x)} < a_{(t+1)x}$$

$$W'_x(L_{(x)}) = \sum_{(i)=1}^{n_{(x)}} W_{(i)} \qquad \text{for } L_{(x)} > a_{(n_{(x)})x}$$

This indicates that the slope of $W_x(L_{(x)})$ is a continuous piecewise-linear function with points of discontinuity at the locations of mass for the first derivatives.

A.6
Conditions for a Minimum

Suppose:

$$\sum_{i=1}^{t-1} W_{(i)} - \sum_{i=t}^{n_{(x)}} W_{(i)} < 0$$

and

$$\sum_{i=1}^{t} W_{(i)} - \sum_{i=t+1}^{n_{(x)}} W_{(i)} \geq 0$$

are satisfied at some t^*. If the second condition is met as a strict equality then $L_x^* = a_{(t^*)x}$. If the second condition is met as an inequality then L^*_x is an element of $[a_{(t^*)}, a_{(t^*+1)}x]$. We can rewrite the minimum conditions as

$$\sum_{(i)=1}^{t-1} W_{(i)} + \sum_{(i)=1}^{t-1} W_{(i)} - \sum_{(i)=1}^{n_{(x)}} W_{(i)} < 0$$

and

$$\sum_{(i)=1}^{t} W_{(i)} + \sum_{(i)=1}^{t} W_{(i)} - \sum_{(i)=1}^{t} W_{(i)} - \sum_{(i)=t+1}^{n_{(x)}} W_{(i)} \geq 0$$

If we let

$$C = \sum_{(i)=1}^{n_{(x)}} W_{(i)}$$

The minimum conditions then become

$$-C + 2\sum_{(i)=1}^{t-1} W_{(i)} < 0$$

and

$$-C + 2\sum_{(i)=1}^{t} W_{(i)} \geq 0$$

These are easily seen to represent the conditions for the median of the

weights in the x and the y directions.

Appendix B

REPORT TO MANAGER OF SAFETY

A Method to Determine the Best Location for New District Police Stations

Prepared for The Manager of Safety's Office
The City of Denver

Prepared by
Craig A. Graham and
Dr. R. E. D. Woolsey

with the assistance of

Dr. Robert Patrick and
Dr. Dennis Tenney

December 19, 1988

B.1 Executive Summary

The City of Denver is divided into 4 police districts. The station facilities in districts 1, 2, and 3 are inadequate. The city will replace them as the funds become available.

This study devises a method for selecting the best locations to build future district stations. The authors recognize that the method must not be tied to the situation as it now exists in Denver, but rather must be a general purpose method that will allow for the change that must surely happen.

The authors spent over 3 weeks riding in patrol cars, talking to dispatchers, and listening to patrolmen, detectives, sergeants, lieutenants, and captains tell about the ideal location for a police station. The upshot of this is that police personnel that work in the district stations do not care where a police station is, so long as it is convenient to their homes.

A good location would be

Convenient to officers and the public
On city-owned or cheap land
Accessible by multiple routes and streets
Separated from residential property
Situated in the district to minimize unproductive driving time.

The method presented here is a routine to try to minimize the work involved in finding the best location for a district police station. First, the user finds the spot that minimizes on-patrol travel time. Second, the user pinpoints available land around that spot. Third, the user evaluates which of the available locations is best in light of the other selection criteria.

To use the method presented here, the user must be able to add, subtract, divide by two, draw a straight-line, tell east from west and north from south, put pins in a map and take pins out of a map. There <u>are</u> simple solutions for complex problems.

B.2 Factors Involved in Station Location

This section deals with what is important in picking a location for a station and why.

B.2.1 Convenient Access

A district station must be conveniently located. It must be accessible for officers and the public. Luckily any location that is good for officers will also be good for the public.

B.2.1.1 Officer Access

The one factor every officer mentioned in good station location was convenience to transport arteries. An officer, like the rest of us, views commuting time as wasted time. If a district station is built far away from major transportation arteries, this would increase travel time and would result in increased employee dissatisfaction and turnover.

B.2.1.2 Civilian Access

The department must consider public access to a new station whenever a site is chosen. The police department must remember that civilian access must be a consideration.

B.2.1.2.1 Good Points

The police department wants to be as convenient to the public as possible. Easy access promotes good civilian relations with the department and encourages more civilian use of the district facilities. Increased civilian use in turn promotes good civilian relations with the officer on the street. However, it has been the experience of the authors that civilians actually use the station very little. In the 21 days we spent in and around the district police stations we saw a maximum of 2 members of the public at one time in a district station. Typically a station would get about 2 civilians an hour coming in to pick up or fill out forms or to ask directions.

B.2.1.2.2 Bad Points

One of the officers' major concerns about a location is that it not invite vandalism to their personal vehicles. The other concern is that the station not be put where the civilian population is openly hostile.

B.2.1.3 Detectives' Access

The detectives work in an unpredictable pattern. The majority of their work is done on a telephone or at the downtown facility. Because of the number of trips a detective must make to the Cherokee street facility a District station should have good access to downtown.

B.2.1.4 Conclusions on Access

The district 4 station seemed to have the best location and configuration of all the district stations. The station fronts on a main street (Evans) and is close to a major artery (Federal) but the station and its parking facilities are on a relatively untraveled side street. This provides good access to the officers and the public but minimizes the possibility of drive-by harassment and vandalism.

B.2.2 Land Acquisition

The city would obviously like to keep down the cost of any police facility. The police would prefer that the dollars spent on a facility go towards the building and equipment rather than on land and a view. These two factors together mean that the ideal situation would be if the selected property was already owned by the city.

B.2.2.1 City-Owned Land

The City of Denver has difficulty determining what property it presently owns. If asked about a specific site the city can find out whether it owns it, but the city does not have a complete inventory of the property it owns. Consequently when looking for prospective sites for a station, the city officials will have to do considerable investigative work to find out what is available.

B.2.2.2 Privately Held Land

If no suitable city-owned sites are available, the city will have to consider purchasing land. Should this happen, the city must be aware of what the acquisition will do to local property values. Adjacent or close retail-property prices will go up, adjacent or close residential-property prices will go down.

B.2.3 Multiple Corridor Access

Police do more than catch bad guys, they also provide assistance in emergencies. In the case of a major disaster, either natural or man-made, the police must be able to get to and from their base of operations, which in Denver is the district station.

The district 3 station appears to be in a tenuous position relative to multiple corridor access. It has exits on only 2 sides and that seems risky. While the location near a park is good for other reasons, a lack of multiple corridor access should be avoided if possible.

The idea of being next to an interstate is appealing because of fast access to other parts of the district, but an interstate is as unpassable as a river or a canal if the bridge or viaduct goes out.

B.2.4 Residential Dilemma

No one wants a police station next door, everyone wants a police station two blocks away. While this may be true of the average neighborhood, it is not necessarily true in all situations.

B.2.4.1 Locations to Avoid

Police stations are noisy: doors slamming, sirens wailing, crooks (and officers) yelling. Police stations are also awake 24 hours a day with the lights on, cars coming and going, and people wandering in and out. Many residential neighborhoods may have difficulty tolerating a police station for a neighbor. The official opposition to locating a police station in a residential location will be in direct

proportion to the neighborhood's ability to influence their city council representative. The selected location should, if possible, be away from any residential area where the residents can see or hear.

B.2.4.2 Locations to Consider

Near a senior citizen's home is a good location for a police station. The residents would appreciate the added sense of security the police would add. Also the seniors could be a great asset in community relations and youth help programs. Special care would have to be taken to diminish the noise problems associated with a police station.

B.2.5 Maximizing Officer Productivity

A district station should be located to minimize an officer's unproductive on-patrol travel time. Basically, the time an officer spends out of his sector is unproductive because, as one lieutenant said, "When they are out of their sector they are blind." There are two countable types of trips which reduce an officer's productivity in which the location of the district station is a factor. The first type is a shift change trip; the second type is a trip to the district station to drop off offenders at the holding cells. Of course, there are many other reasons why an officer may go to the district station, but these trips are unpredictable and infrequent.

B.2.5.1 Shift Change Trips

The Denver Police work 3 eight-hour shifts. Ordinarily a car is assigned to a precinct and until one shift comes in, the other shift cannot go out. This means that the time an officer spends going from and coming to the district station is time the streets of the precinct are less patrolled and some cars are not able to respond to calls. Correct location of the station will minimize the time lost by officers in shift change.

The city officials making the decision of where to locate a new police station should recognize an uncertainty here. When considering

shift change trips, is the officer assumed to be in his precinct ready for action when: he is at just at the border of his precinct or when he is in the middle of his precinct.

B.2.5.2 Holding Cell Trips

Certain types of detainees may be taken to the district station holding cells and left for the scout car. The number of persons that can be left at the district station holding cells less than the number that must be taken to the downtown facility. Persons picked up on a felony charge, warrant, or D.U.I. and all juveniles must be taken to the downtown facility. Any person picked up with evidence or property will be taken downtown. Also, any person who is picked up closer to the downtown station than to the district station will be taken downtown.

B.3 Procedure to Pick a Starting Point

This section will describe how to pick the best point for a district station without regards to access, cost, availability, and political or geographical realities.

B.3.1 Get Some Supplies

The first thing to do is to get a map of the district, the bigger the better. Next get several boxes of pins, some red and some blue. A yardstick will be very helpful. The last items needed are a pencil and an eraser.

B.3.2 Meaning of Pins

Each pin will represent a trip from the officer's location to the station, or from the officer's precinct to the station, or from the station to the officer's precinct. A red pin will represent a one-way shift change trip, a blue pin will represent a trip to the district station holding cells or back to the patrol area after dropping off a detainee at the district station holding cells.

B.3.2.1 Red Pins

A red pin indicates that an officer went on shift or an officer went off shift. This is not a perfect world and this is not a perfect method. A perfect method would cost about the same as the budget of the police department, so some assumptions have to be made. The first assumption is that an officer always starts the day by going from the district station to his precinct. We must for lack of information neglect the fact that sometimes the officer responds to a call in another precinct or drops in for a cup of coffee. The second assumption is that at the end of the shift the officer returns from his precinct to the district station. We neglect the fact that sometimes the officer is at the jail or in another precinct at the end of his shift. As the department increases its database on calls for service, the actual locations at start and end of shift may be used.

B.3.2.2 Blue Pins

A blue pin represents a trip to or from the district station holding cells. Actually it represents a trip that could have been made to or from the district station holding cells. The idea is that we will start by assuming that anybody that can be taken to the district station holding cells will be taken to the district station holding cells. Don't worry that the downtown jail is only one block from where the offender was taken into custody. This will be taken into account later. A blue pin is put in the map where the offender was put in the car to represent the trip to the station. Another blue pin is put in the same spot to represent the trip back from the station.

B.3.3 Decide on Time Frame

You can recreate any amount of time you want from a week to 5 years but remember that each precinct is going to have at least 6 pins per day for each day used. The red pins might be assigned a value of 6, the blue pins a value of 2 to cut down on the number of pins.

B.3.4 Middle of Pins

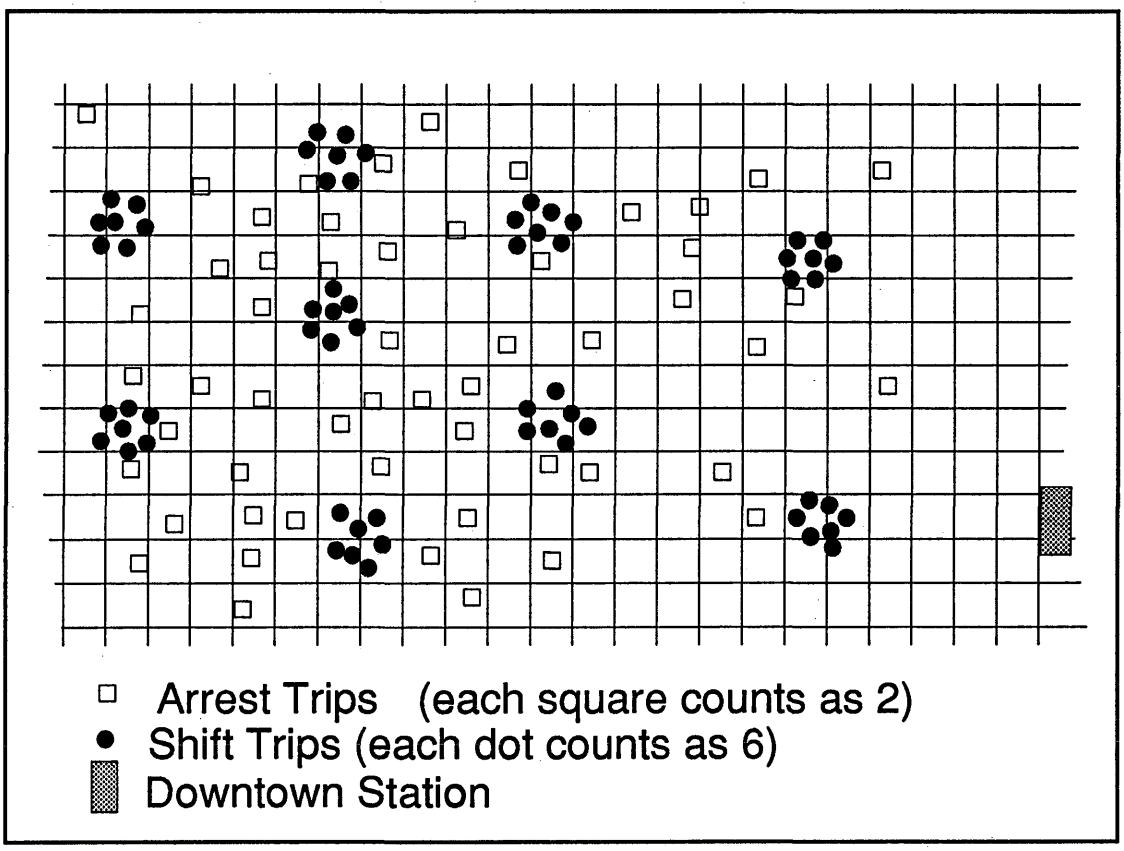
When the method says "middle of pins," the procedure is this: Take the total number of pins, say 19. Divide that number by 2, giving 9 1/2 . The middle of the pins is 10 (9 1/2 + 1/2) because there are 9 pins above it and 9 pins below it. If the number of pins is even, say 20, then the middle of the pins is anywhere between 10 and 11 (20 ÷ 2 and 20 ÷ 2 + 1).

B.3.5 Method to Locate the Ideal Spot

1	Put all locations of relevant calls on the district map (shift trips use red pins, arrest trips use blue pins). Adjust the map so that north is up.
2	Count all pins in the district. If you assigned a value of 6 to the red pins count each red pin as 6, if you have assigned a value of 2 to the blue pins count each blue pin as 2.
3	Starting at the northern boundary of the district, count pins to the south until the middle of the pins is found. Draw an east-west line through this point. This is a middle of the pins' line.
4	Starting at the western border of the precinct, count pins to the east until the middle of the pins is found. Draw a north-south line through this point. This is a middle of the pins' line.
5	Compare the intersection of the old middle of the pins' lines to the new intersection, if these intersections are within one block of each other stop, this is the ideal spot, else continue. If you stop do not throw away the map or take out the pins, you will use it again later.
6	Draw a box with the intersection of the MOPs lines and the downtown station as opposite corners.
7	Draw a line from the intersection of middle of the pins' lines to the downtown jail. Mark the midpoint of this line.
8a	If the connecting line leans to the right at the top: Starting at the midpoint count 1 block to the right and 1 block down, put a point there. Draw a line connecting the point and the midpoint, extend this line all the way across the box.
8b	If the connecting line leans to the left at the top: Starting at the midpoint count 1 block to the left and 1 block down, put a point there. Draw a line connecting the point and the midpoint, extend this line all the way across the box.
8c	If the connecting line is straight up and down or straight across: Draw a line perpendicular to the connecting line through its midpoint, extend this line all the way across the district.
9	If the line across the box ends at the north and south line, extend the lines due north and south all the way across the district. If the line across the box ends at the east and west lines, extend the lines due east and west across the district.
10	Take out all blue pins on the downtown side of the line through the midpoint.
11	Go to 2

B.3.6 Diagrams of Example Procedure

Steps 1 and 2: put calls on map and count pins in district.

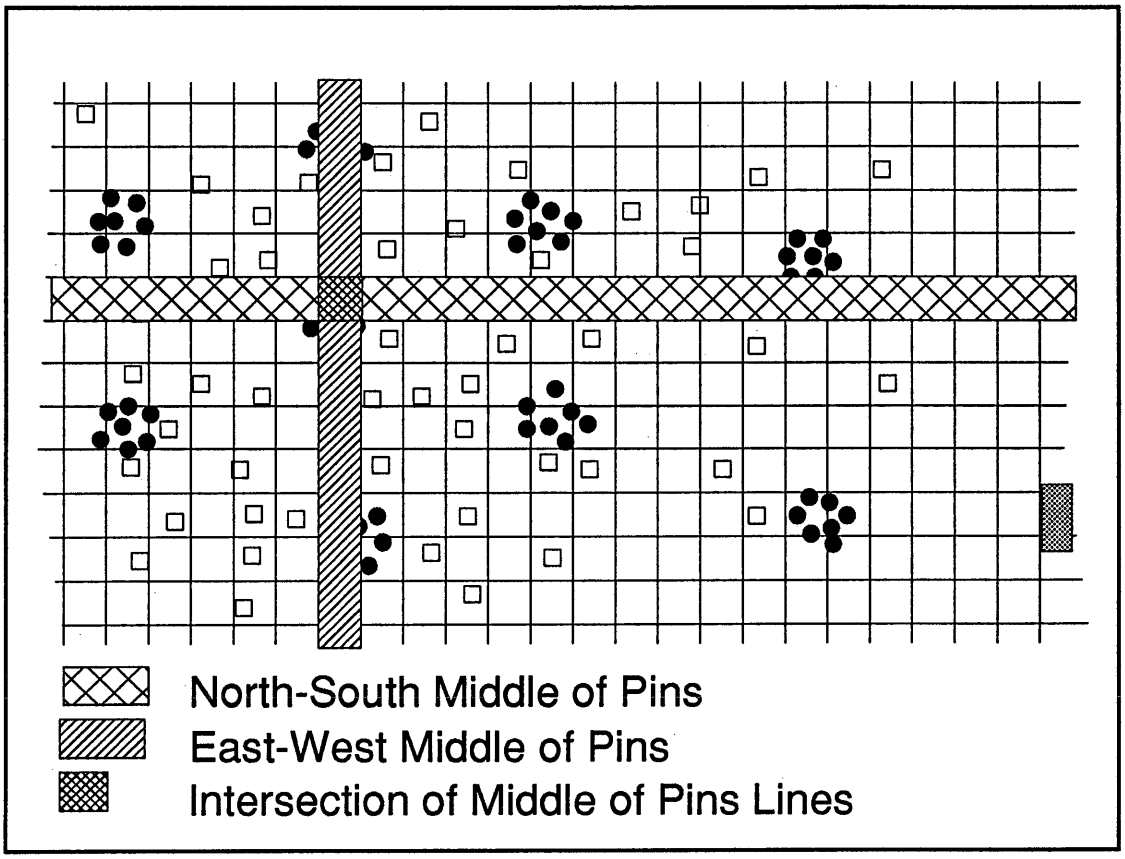


Suppose this is a map of the district with the downtown jail located on the southeastern corner. The small squares represent the arrests which can be taken to the district holding cells (blue pins, each square counts as two one-way trips). The black circles represent the shift trips to and from the precincts (red pins, each circle counts as 6 one-way trips). The total count is:

Trip Type	Count	Multiplier	Total
Arrest	54	2	108
Shift	63	6	378
			486

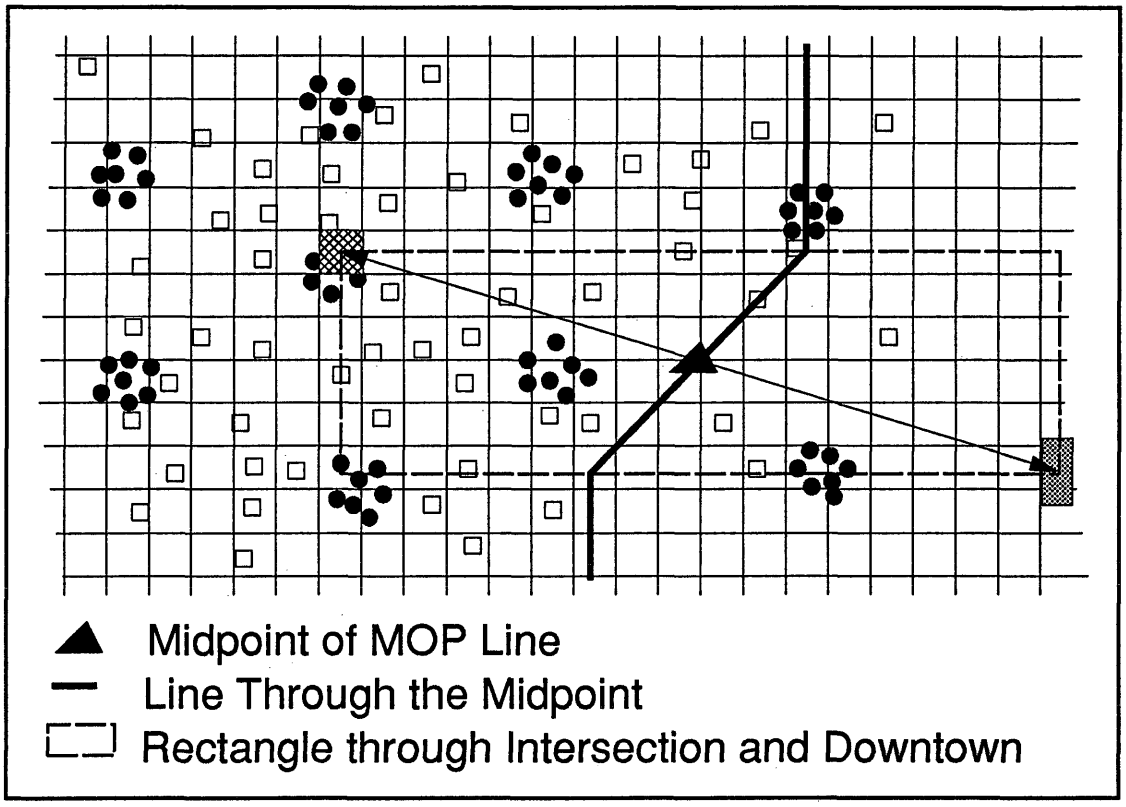
The middle of the pins is 243 to 244.

Steps 3, 4, and 5: find north-south middle of pins, find east-west middle of pins, find intersection of middle of pins lines.



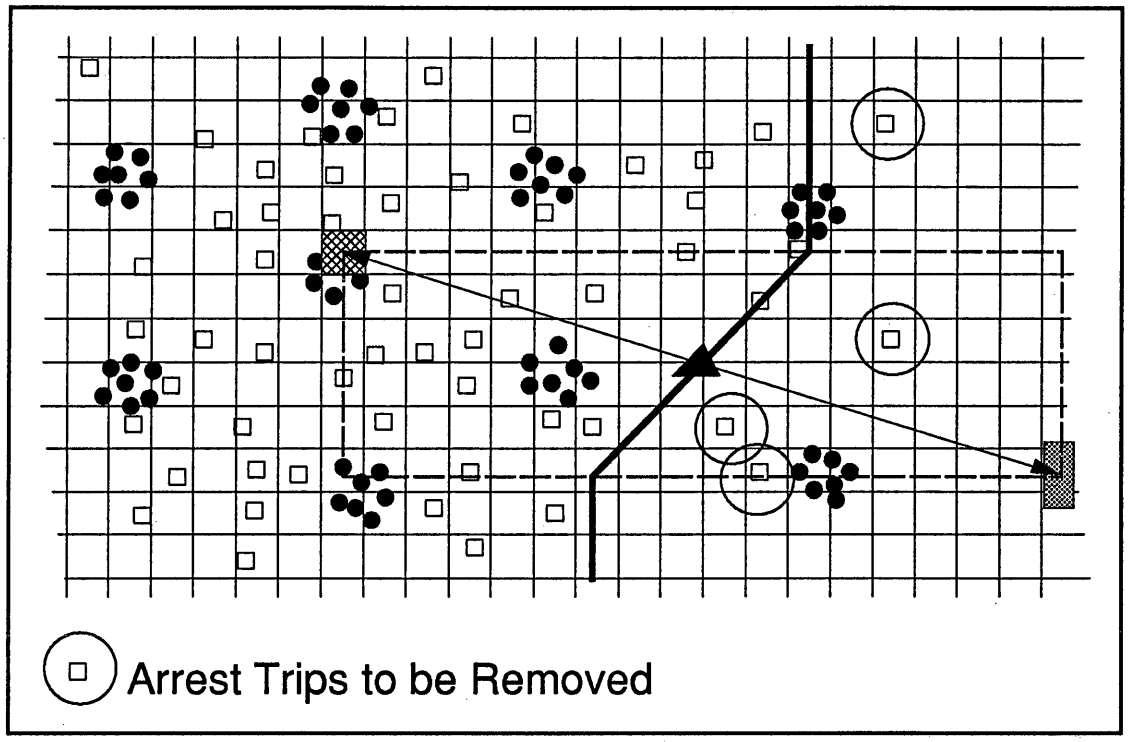
Counting from the northern boundary we find that the north-south MOP line is in the fifth block south. Counting from the western boundary the seventh block is the east-west middle of the pins. The intersection of the two MOP lines is marked. Because this is the first time through the steps we have no comparison of intersections to make.

This diagram illustrates steps 6, 7, 8, and 9: draw the box, draw the line from downtown to intersection, draw the equidistant line through the box, extend the equidistant line through the district.



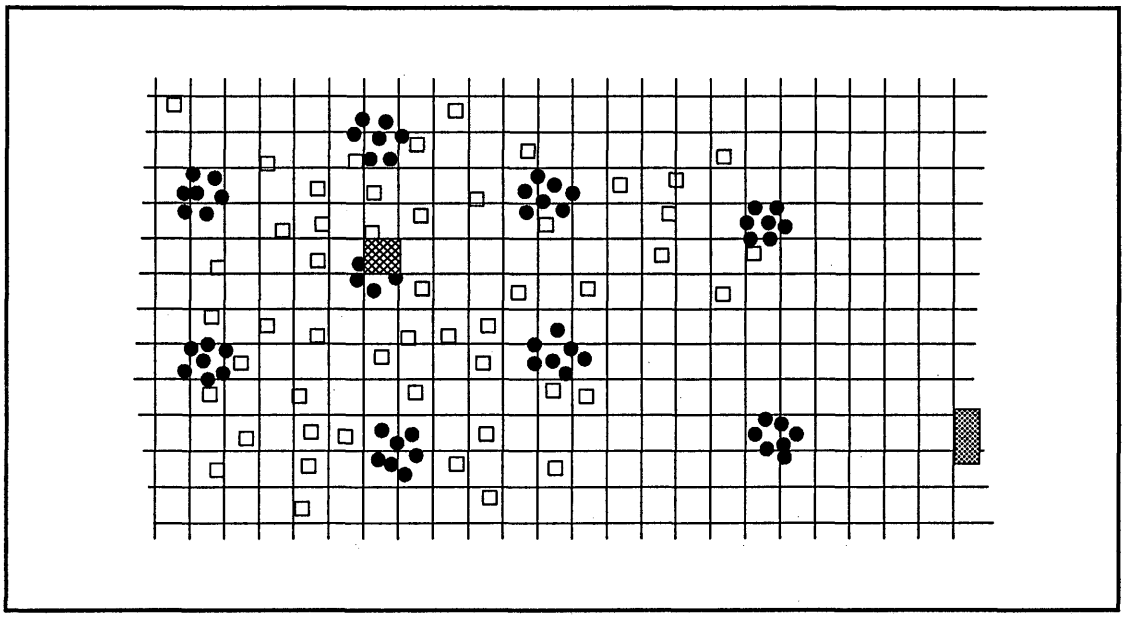
First draw the box with the intersection and the downtown station as opposite corners. Draw a line connecting the downtown station and the intersection. The midpoint of this line is marked with a triangle. The heavy black line is the line which marks the equal travel distance between the intersection and the downtown station.

This is step 10, take out the blue pins on the downtown side of the equal travel distance line.



The arrest trips on the downtown side of the equal travel line are circled. They will be removed.

Step 11, ready to start the method over from step 2.



B.4 Locating Suitable Property

The starting point is just that, a starting point. The starting point is probably in a lake or at the bottom of a gravel pit or in the most expensive residential area in the district. Now the city officials must locate the suitable property that is close.

B.4.1 How Near

This is an administrative decision that will depend on what is available at the time the process is done. At the time of this writing, the City of Denver owns around 10,000 pieces of property. Hopefully several suitable pieces of property can be found within 1/2 mile of the starting point. If there is no suitable property in that range, move farther from the optimal spot. Remember that increased distance from the optimal spot increases unproductive on-patrol travel time for the police.

B.4.2 What is Suitable

The property ideally would have all the features discussed in sections B.2.1 to B.2.4, but this is a world of compromise and the city officials choosing the location must weigh these factors when deciding what is a suitable location.

B.5 How Close to the Starting Point

Once several suitable pieces of property are located they can be compared to each other relative to the starting point.

B.5.1 Method to Compare Closeness to Starting Point

1.Put all locations of relevant calls on the district map (shift trips use red pins, arrest trips use blue pins). Turn the map so north is up.

2.Mark the ideal station site and the proposed station site on the map.

3.Draw a line between the proposed site and the downtown jail.

4.Mark the midpoint of this line.

5a If the connecting line leans to the right at the top:
Starting at the midpoint count 1 block to the right and 1 block down, put a point there. Draw a line connecting the point and the midpoint, extend this line all the way across the box.

5b If the connecting line leans to the left at the top:
Starting at the midpoint count 1 block to the left and 1 block down, put a point there. Draw a line connecting the point and the midpoint, extend this line all the way across the box.

5c If the connecting line is straight up and down or straight across:
Draw a line perpendicular to the connecting line through its midpoint, extend this line all the way across the district. This is the equal travel distance line.

6 If the line across the box ends at the north and south line, extend the lines due north and south all the way across the district. If the line across the box ends at the east and west lines, extend the lines due east and west across the district. This is the equal travel distance line.

7.Take out all blue pins on the downtown side of the equal travel distance line.

8.Count the number of pins east of the proposed site, west of the proposed site, north of the proposed site, and south of the proposed site. If red pins count as 6 or blue pins count as 2, don't forget this.

9a.If the proposed site is east of the ideal site subtract the number of pins to the east from the number of pins to the west. Multiply this number by the actual miles the proposed site is east of the ideal site

9b.If the proposed site is west of the ideal site subtract the number of pins to the west from the number of pins to the east. Multiply this number by the actual miles the proposed site is west of the ideal site

10a.If the proposed site is north of the ideal site subtract the number of pins to the north from the number of pins to the south. Multiply this number by the actual miles the proposed site is north of the ideal site

10b.If the proposed site is south of the ideal site subtract the number of pins to the south from the number of pins to the north. Multiply this number by the actual miles the proposed site is south of the ideal site

11.Add the number from step 9 to the number of step 10. The total is the extra distance traveled by the officers if this location is selected.

B.5.2 Method to Calculate Value of Location

The number calculated in B.5.1 above gives a value of officer-miles or car-miles for the time period used. This number by itself is not very useful, to be useful the number must be converted into dollars and cents.

To convert the value of car-miles or officer-miles into dollars you only need one thing, the cost of an officer in a car.

Quick and Dirty Method to Calculate the Cost of an Officer Hour:

1. Count the total number of department employees, call this total workers.
2. Count the number of administrative personnel, call this admin.
3. Count the number of technicians who do not interact with the public, call this techs.
4. Take total workers subtract admin and techs, call this worker bees.
5. Divide total department budget by worker bees, call this cost/bee.
6. Divide cost/bee by hours worked per year (no, this is not 2000), this is the hourly cost for an worker bee.

Method to Calculate the Cost of Not Building at the Ideal Spot:

1. Take the number of officer-miles calculated in B.5.1 above
2. Multiply this by the hourly cost per worker bee
3. Multiply this by the average number of officers in a car
4. Divide this number by 30 (figure an officer averages 30 miles per hour on the city streets)
5. This is not a real number, but it does give a good indication of the real number.

This number is good for comparing locations around the ideal spot. . This is not a sufficiently accurate estimate to justify spending an extra 1/2 million dollars to acquire a site. More work would have to be done on the cost per officer hour, and on the average officer travel speed for true cost justification.

B.6 Conclusion

This report should serve as a guide for determining where to put a new district station in the City of Denver. The *Method to Locate the Ideal Spot* and the *Method to Compare Closeness to Starting Point* are mathematically optimal methods, every other method described here is subject to interpretation and subjective evaluation.

B.7 General Method

1. Assemble data on appropriate calls

2. Use *Method to Locate the Ideal Spot* (section B.3.5)

3. Locate available property near ideal spot

4. Evaluate available property for suitability based on:
   - Price
   - Convenience
   - Access
   - Residential Conflicts

5. Evaluate available land on travel cost using:
   - *Method to Compare Closeness to Starting Point* (section B.5.1)
   - *Quick and Dirty Method to Calculate the Cost of an Officer Hour* (section B.5.2)
   - *Method to Calculate the Cost of Not building at the Ideal Spot* (section B.5.2)

6. Consider all the information and pick a spot.