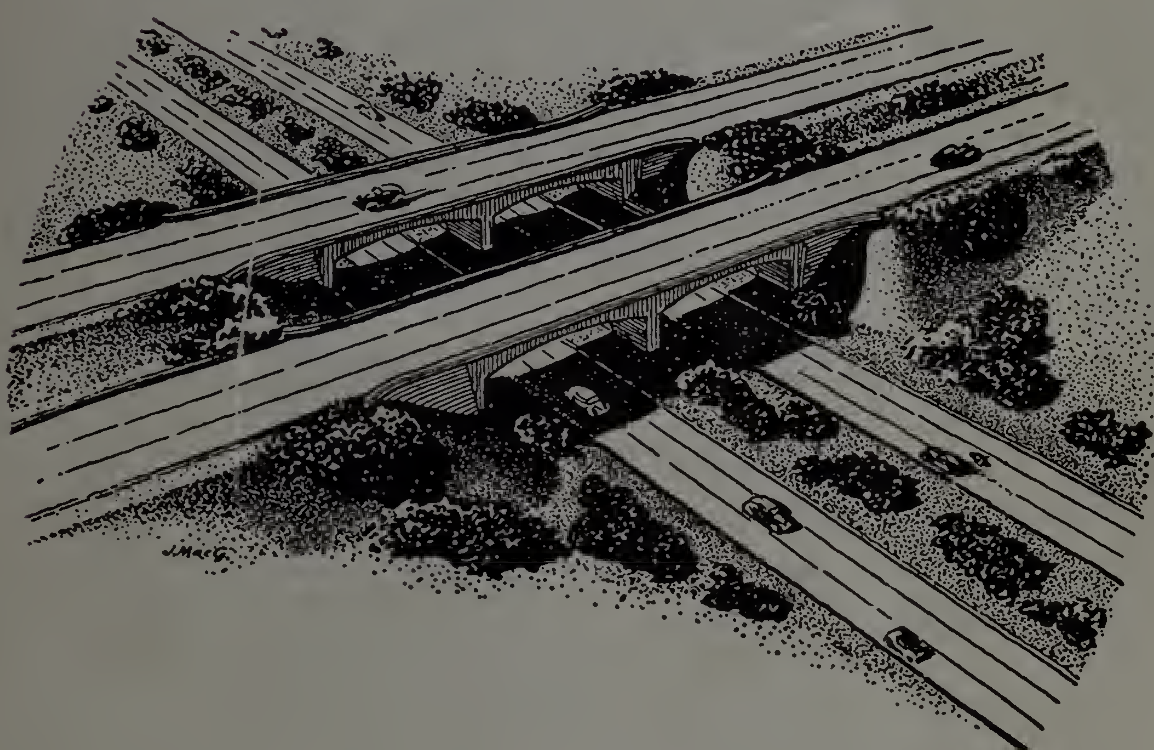
THE VALLEY HIGHWAY

A North-South Limited-Access Highway Through Denver



Report to CHAS. D. VAIL, *State Highway Engineer of Colorado*

By CROCKER AND RYAN, *Consulting Engineers*

93

Compliments of

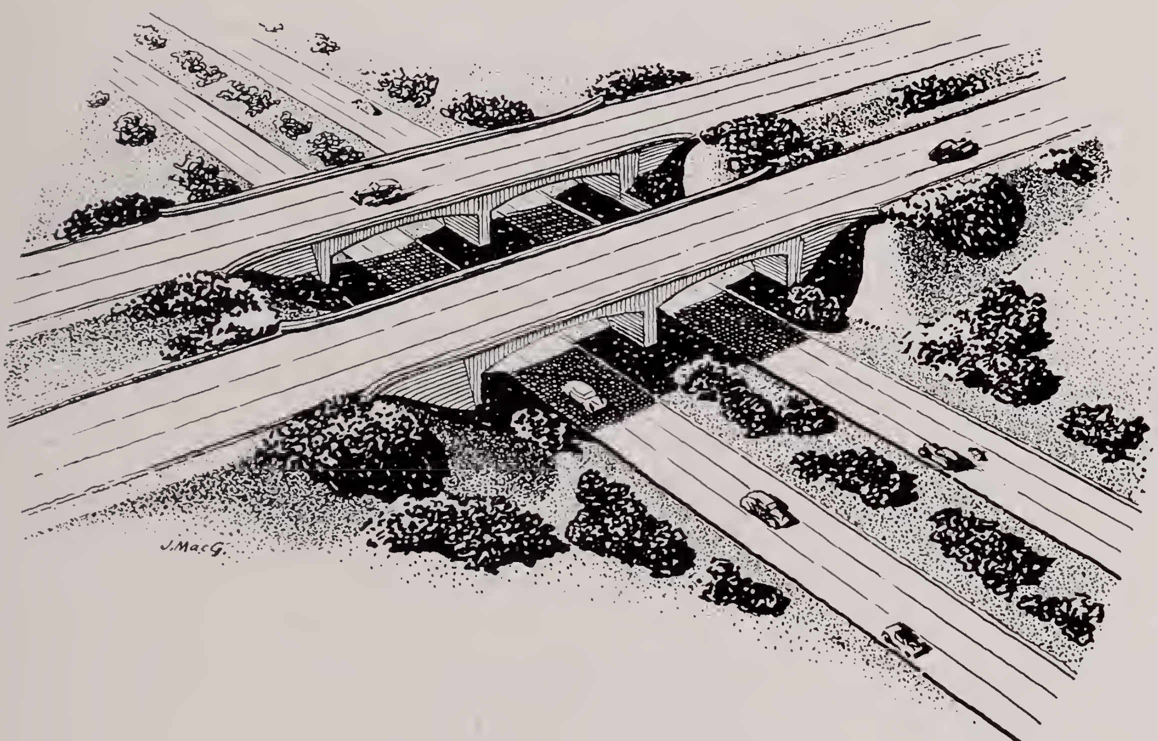
Denver Planning Commission

420 City and County Building

PRELIMINARY REPORT

on

A North-South Limited-Access Highway Through Denver



A report rendered to Charles D. Vail,
State Highway Engineer
of Colorado

Crocker and Ryan
Consulting Engineers

Denver, Colorado
December 9, 1944

HERBERT S. CROCKER
HON. M. AM. SOC. C. E.

ALFRED J. RYAN
M. AM. SOC. C. E.

CROCKER and RYAN
CIVIL ENGINEERS
FIRST NATIONAL BANK BUILDING
DENVER, COLORADO

Mr. Charles D. Vail
State Highway Engineer
State Office Building
Denver, Colorado

Dear Sir:

Under your instructions of September 9, 1944, we have studied the location and construction of a north-south limited-access highway extending through the city of Denver from the north city line near West 52nd Avenue and Acoma Street to University and Buchtel Boulevards. The traffic which the highway would carry is in part through traffic, in part city-entrance traffic and in part local traffic. We have taken all three classes into consideration.

As set out in the following report, we find, in brief:

that a high-speed, limited-access road through Denver from north to south is needed;

that its best location is along the Platte River valley and Buchtel Boulevard;

that a four-lane divided road, which with an added third lane in each direction will be adequate for all traffic requirements for many years, can be built on this location for $14,500,000, including right-of-way cost. The thoroughfare has a value largely in excess of its cost and thus is a profitable investment; and

that full development of the city entrance and terminal functions of the road will require the early construction of distributing facilities, most of which have already been contemplated by the city authorities.

Our conclusions and recommendations are stated more fully at the close of the report. Location maps, profiles, general design drawings and estimates of cost are contained in the report.

We have consulted the principal interested parties to obtain all pertinent facts and opinions bearing on the plan of the road and its service. Our discussions lead us to believe that the project which we outline fully satisfies all constructional and service requirements, with fairness to all the interests affected, and should prove of general benefit.

Very truly yours,

H S Crocker

December 9, 1944.

CROCKER and RYAN

Many agencies and individuals have aided the preparation of this report by contributing information and knowledge of local conditions. Officials of the city of Denver, the Colorado Highway Department and the U. S. Public Roads Administration gave especially valuable data and counsel. To these and others who assisted the work we desire to express our acknowledgment.

—Crocker and Ryan.

SMITH-BROOKS PRESS
DENVER

Report on
A North-South Limited-Access Highway
Through Denver

Contents

List of Illustrations

The Valley Highway, as seen from the north city line of Denver.

Report on
A North-South Limited-Access Highway
Through Denver

Presenting recommendations on the location and general plan of a highway link through Denver from north to south, together with its essential features of construction and an estimate of its cost.

I. INTRODUCTION

The Denver Project

Improvement of highway transportation facilities in the Denver area has long been needed and has been the subject of much study in recent years. State and city officials as well as the people of the region have been conscious of the injurious effects of traffic congestion on the roads approaching the city and on the heavily burdened city streets. The increase in transportation cost and the deterrent effect on traffic arising from accidents and delays are quite generally recognized.

Efforts to improve conditions began many years ago. They were concerned primarily with facilitating movement north and south, which is the direction of heaviest traffic, greatest extent of built-up area and maximum congestion, although east-west movement has also received much attention. However, demand has at all times increased faster than the improvement of facilities.

The question has now become of immediate urgency because of the decision of the state highway authorities and the federal Public Roads Administration to plan a highway of most modern type through the state from north to south for immediate post-war construction. The necessary extension of this highway through or around the Denver city area, which is designated as The Denver Project in the program of the state highway department, is the subject of this report, rendered under the instructions of Charles D. Vail, State Highway Engineer, of September 9, 1944.

The problem presented by this project owes its character to the topography and the economic complexion of the region. Colorado is divided into east and west halves by the abrupt front of the Rocky Mountains. To the east lie the Great Plains, a farming and stockraising region, while on the west is a broad mountain belt, a region of mining, lumbering, grazing and scattered agriculture, mainly irrigated. The principal line of travel in the state extends along the foot of the mountains. Of this important artery, which forms virtually the only north-south traffic route in the Colorado area, Denver is the central point and principal traffic objective.

Recent plans for a network of interregional highways covering the entire United States utilize the Cheyenne-Denver-Pueblo road as a major element, connecting the main east-west route passing through Cheyenne with parallel routes through the southern states, as may be seen from the network map of the western half of the country, Fig. 1. In the interregional system the Denver highway will provide the only north-south thoroughfare in an expanse of territory a thousand miles wide, stretching from the Missouri River to Great Salt Lake.

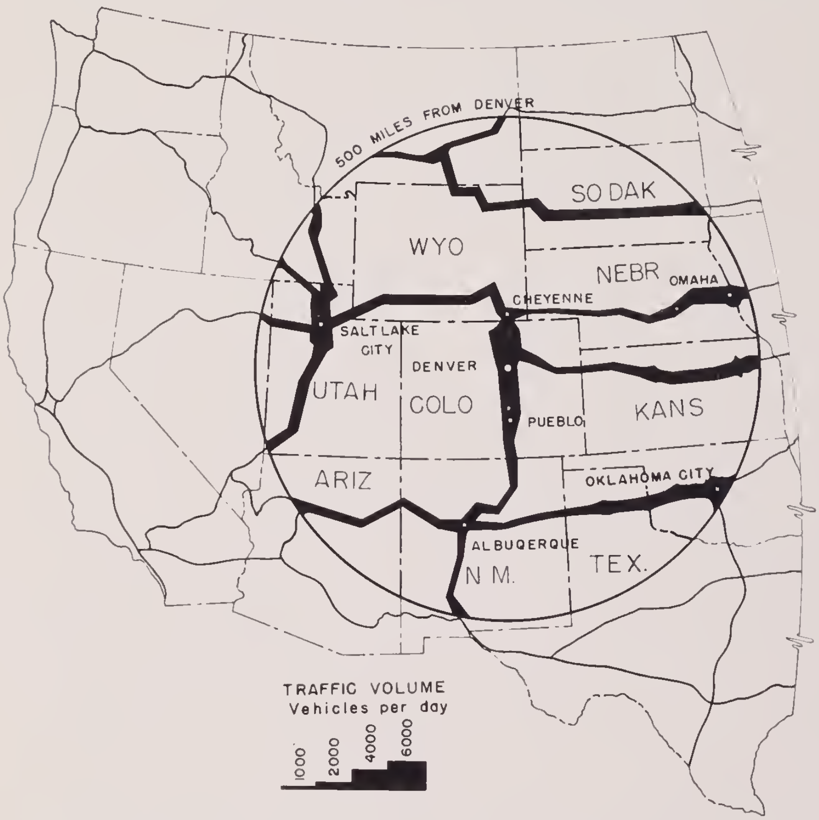


Fig. 1—*An interregional highway network of the West, as proposed by the National Interregional Highway Committee.*

The location of this essential connecting link along a route that for three-quarters of a century has been the principal line of travel in the region is determined by the factors that brought about the rise of Denver and its neighbor cities to north and south, from Cheyenne to Santa Fe. The meeting line of the agricultural and grazing lands of the Plains with the mining and forest regions of the Rocky Mountain belt was the original site of settlement, trade and travel; the course of development subsequent to pioneer days has consistently emphasized its significance as a communication route.

Like the existing road, a modern highway properly responsive to the demands of traffic must pass through the Denver city area, as this metropolitan center is the origin or objective of much of the transportation to be served. However, a transportation facility adequate for present and coming requirements obviously should be freed of the throttling effect of Denver's street traffic. This is not to be accomplished merely by widening an existing street or laying out a new street; instead, a traffic-way must be opened which will be independent of the cross-flow of city traffic and will serve as an artery of unimpeded transport while at the same time providing fully for distribution and reception of traffic destined to or from Denver.

It is clear, also, that a vital facility of this kind must be planned for enduring service. Its function is to carry not merely the traffic of today or of the next few years but that of the future, so far as it can be foreseen. Its plan should look ahead at least twenty-five years.

In that period of time the steady growth of the region is certain to bring about a great increase in traffic volume. The interrelation of the mountain-front communities and travel route with the productive and commercial activities of the western Great Plains and the eastern Rockies will cause future demands on the highway to be far beyond those of today. Not only here, but throughout the United States a large growth of highway traffic is looked for; the federal highway authorities have forecast a doubling of national road use within the next twenty years. Plans for the Denver thoroughfare should include provision for at least equal increase.

Together with providing for increased volume, the Denver Project highway should reduce the time and cost of transportation, through sustained speed of traffic movement. It should be so built, moreover, as to afford maximum road safety. Finally, its service necessarily requires that distribution and terminal facilities be provided for inbound and outbound traffic, inasmuch as such traffic constitutes by far the larger part of all the traffic which it will be called upon to carry. To serve these purposes it is essential that the thoroughfare be designed for free flow, elimination of conflicting traffic streams and left turns, an adequate number of lanes, appropriately located interchanges, and such details of alignment, width, profile and sight distance as conform to the full requirements of speed and safety of transportation.

It has been demonstrated by a quarter century's experience with attempts to overcome the limitations of the traditional two-lane road that these results can be obtained only by means of a highway of limited access, a freeway — a road separated from adjoining land and buildings and rendered independent of cross traffic by grade separations. Denver's own experience reveals the ineffectiveness of attempting to remedy traffic evils by mere road widening without effective protection of the road against roadside abuse. West Colfax Avenue, the route of U. S. Highways 6 and 40, was rebuilt to four-lane width a few years ago in order to relieve its obstructive and dangerous congestion, but nothing was done to avoid roadside intrusion. The result is that the value of the widening has largely been lost; in fact, the very first year of its service showed a ninefold increase in accidents.

Freeway construction has found extensive application within the last fifteen years. Two examples — from the New York suburban region and Detroit — are pictured by the photographic views Figs. 2 and 3. The Grand Central Parkway, upper view, illustrates how a four-lane freeway (at this

Long Island State Park Comm.

FIG. 2—*A metropolitan expressway; Grand Central Parkway, New York.*

Board of Wayne County Road Commissioners.

FIG. 3—*Davidson Highway, Detroit, depressed below cross traffic.*

point partly depressed) is separated from adjacent property by planted strips, bordered by land-service roads. The lower view, showing part of the Davidson Highway in Detroit, illustrates to larger scale how cross-traffic is carried across a freeway thoroughfare without interference.

Experience proves that a central separation between opposing traffic streams also is highly important, being little less essential than side segregation. Where the available right-of-way width permits, best practice provides a central separation wide enough to accommodate a screen of shrubbery and low trees, which makes travel safe by shading the headlight beams of vehicles moving in the opposite direction.

Another illustration of modern construction is presented by Fig. 10, page 14, a view on the Arroyo Seco freeway in the suburbs of Los Angeles. Construction at this point exemplifies the use of access ramps for interchange of traffic with a crossing artery, the ramps here being separated from the adjoining service road, by reason of topographical and property conditions.

Restriction of access to fixed points spaced some distance apart is an essential feature of freeway construction. The access facilities at these points should give free traffic connection to transverse thoroughfares without blocking or checking traffic on either roadway. Important intersections often require intricate arrangement of the connecting roadways in order to eliminate all left turns and thus remove traffic interference, as in the case of the series of loop roadways on the Southern State Parkway on Long Island, in New York, shown in Fig. 22, page 53, which is a view of the connection of the Parkway with Wellwood Avenue in the town of Pinelawn.

In general, freeway construction implies that all elements of layout and design be such as to assure continuous and rapid movement of vehicles without need for slowdowns or stops. We have based our plans for the Denver Project thoroughfare on construction of this type, and strongly recommend its adoption.

It goes without saying that in the design and construction of such a highway great care should be taken to avoid any detrimental effect on the community traversed. Unattractive or objectionable appearance that might depress property values and affect unfavorably the use of lands along the route should not be permitted. On the contrary a favorable effect on adjacent property should be sought through pleasing design and avoidance of all features that might have harmful influence.

Many communities have given full recognition to this element of freeway planning. The magnificent parkways that have been built in various metropolitan centers — New York, Detroit, St. Louis, Chicago, Los Angeles and others — are evidences of such endeavor, and their effect testifies to the human values inherent in proper esthetic planning of urban traffic arteries. The Denver Project thoroughfare is no less subject to the requirements that it shall enhance rather than detract from the value and attractiveness of the city.

Accomplishment of this purpose need not involve extravagant planning or large expenditure. It does, however, necessitate great care to attain pleasing simplicity of roadway and structures and to avoid obtrusive or objectionable effects. The planting which serves as traffic screen in the interests of safety should be also skillfully developed, in conjunction with any associated landscaping, to produce an esthetically satisfying result. Our general plans, while they do not include details of the esthetic development, contemplate full attention to it in construction.

The Denver Project thoroughfare is intended to serve as a link between state highway locations jointly determined upon by the Colorado Highway Department and the Public Roads Administration. On the north, the new state route is planned to reach the city line (52nd Avenue) at a point just west of Broadway, as indicated on the city map, Fig. 4. On the south, it is to enter along the left slope of Cherry Creek valley, near the location of the Colorado

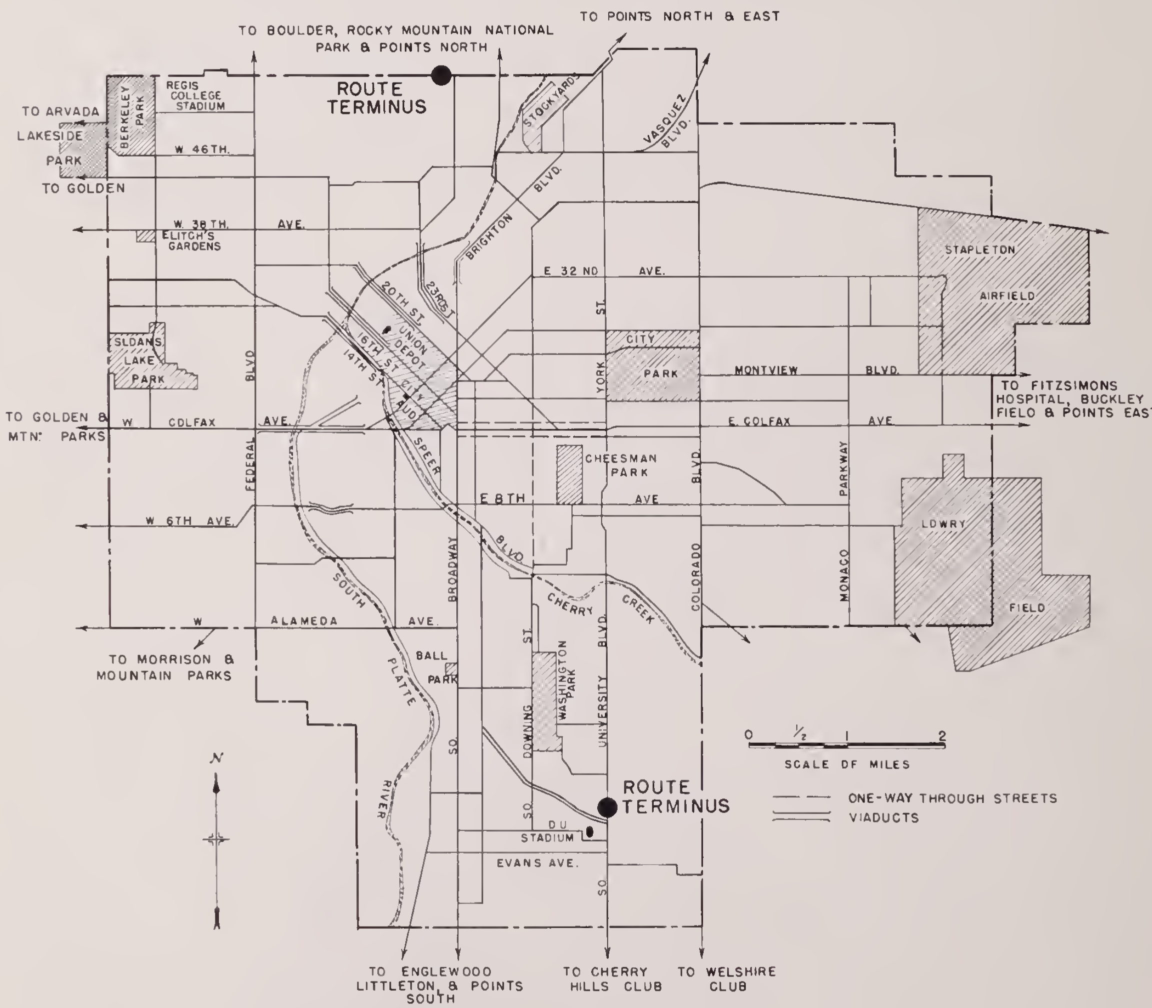


FIG. 4—*The street network of Denver, and the route termini of the proposed north-south thoroughfare.*

& Southern Ry. branch line on Buchtel Boulevard. Pending final location of the route at and near the city line, the intersection of Buchtel and University Boulevards has been designated as southern terminus of the city link.

We have carefully examined the Denver area to find the best location of the desired link, with a view to satisfying all traffic requirements and harmonizing all affected interests. The route which we recommend and show on our plans is the most direct practicable route and in our opinion assures the most favorable conditions for both through and terminal traffic. Further, it is the route of lowest overall cost and highest traffic value.

In proportioning the highway we have applied a conservative forecast of city growth and traffic requirements, by aid of the fullest information available. A general project plan has been drawn up to define the type of construction as well as the traffic interchanges and connections that in our judgment will best serve the purposes outlined, at minimum cost and with maximum economy in maintenance and operation.

General Character of the City Area

Situated at the extreme edge of the Great Plains, Denver lies on the banks of the South Platte River a short distance below its northeasterly emergence from the mountain valley in which it has its source. Westward for ten miles the ground rises on a continuous slope from the river to the scarp of the front range of the Rocky Mountains. At Denver the river takes a general course to the north, but with a sweeping westward bend through the city. The gently sloping upland plain within this bend and north of Cherry Creek, a tributary from the southeast, was the site of the original settlement of Denver — the Cherry Creek gold diggings — and today is occupied by the city's business and financial district. East and south of the latter as well as on the upland of the west bank are the residential districts.

The half-mile-wide South Platte valley is the most prominent topographical feature of the city area. Elsewhere the metropolitan region presents no important irregularities of ground surface, but rises rather smoothly from the low east bank and the somewhat more bluff-like west bank. The location of transportation routes is therefore little restricted by topography but is controlled mainly by occupancy and property use, developed transportation arteries, and probable directions of growth.

Nearly all of the valley bottom is occupied by railroad yards, shops and industries. Except for a few scattered industrial plants in other parts of the city it constitutes the industrial district, including in its northerly part also stockyards and packing houses and a large public produce market. Bordering the valley in the business district is the main warehouse and wholesale area. The location of these areas and of the residential districts is more fully defined by the property-use map, Fig. 5.

Much of the commercial highway traffic that enters the city, especially from the north, has the industrial, market and warehouse district as objective; a corresponding amount of traffic originates here. Intercity bus traffic also centers in the business district, where the various bus routes have their present terminals. Most of the private cars reaching the city, especially in the peak periods of Sundays and the summer resort season, come from or are destined to the residential districts.

Economic Development

Future as well as present traffic is influenced greatly by the commercial position of Denver. The city occupies a strategic site, at the junction of two great regions of primary resource production and at the point where the Continental Divide reaches its most easterly extent. It lies on the shortest route to the upper valley of the Colorado River, the gateway to the Rocky Mountain area and the regions to the west. From its early settlement it has

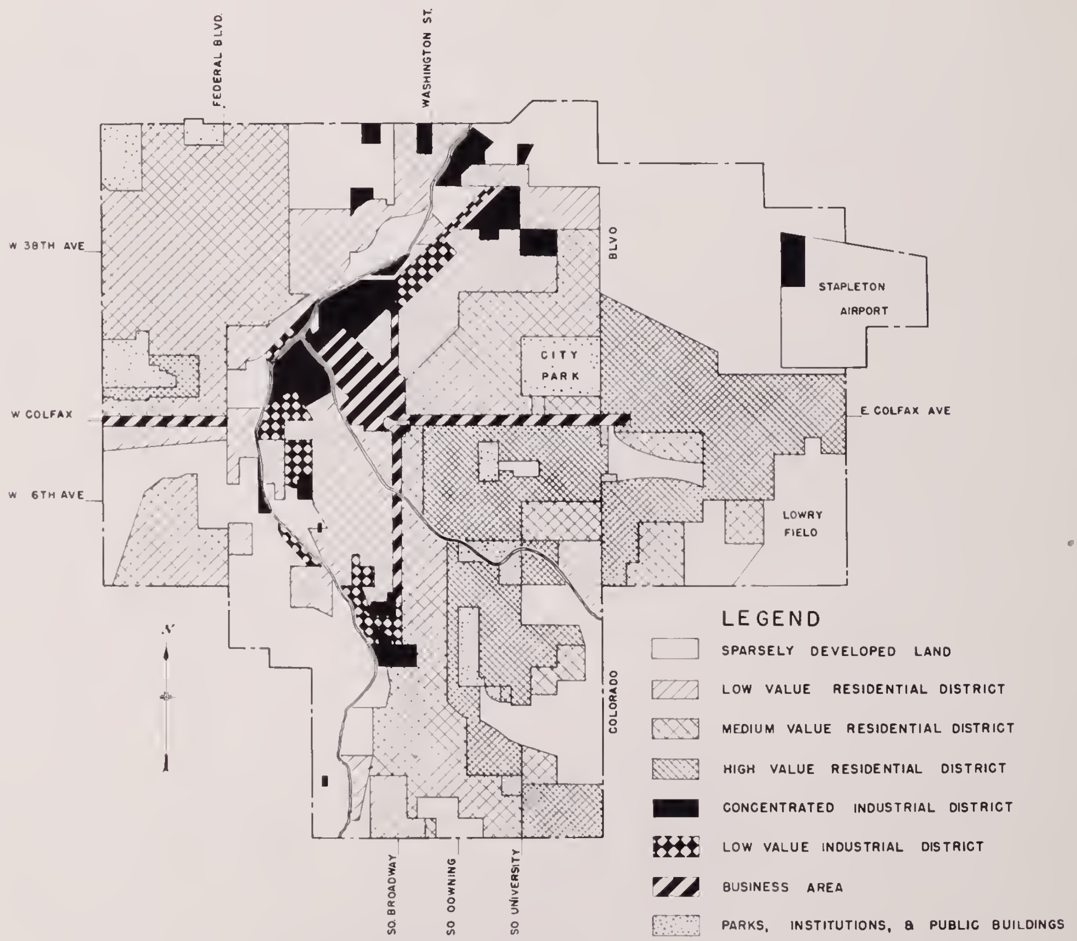


FIG. 5—*A map of property uses in Denver outlines the principal objective areas of traffic.*

been a natural focus of transportation, the objective point of trails, railways and modern highways.

Soon after the city's foundation as a placer mining settlement it became the commercial supply and financial center of an active mining region in the mountains to the west and of an agricultural region to the east and north. Although younger than several other western communities it gained a dominating position in trade and growth and during 85 years of existence has maintained this position. Today Denver is the metropolis of a region extending more than 500 miles in each direction, as may be seen from the population and trade data graphically recorded on the map, Fig. 6.

Because of its commercial and transportation importance the city is certain to remain a focal point of state and interregional traffic within the foreseeable future. In our judgment the forecast of traffic requirements of the coming twenty to twenty-five years should be based on rates of growth corresponding to those of the region of which Denver is the commercial capital.

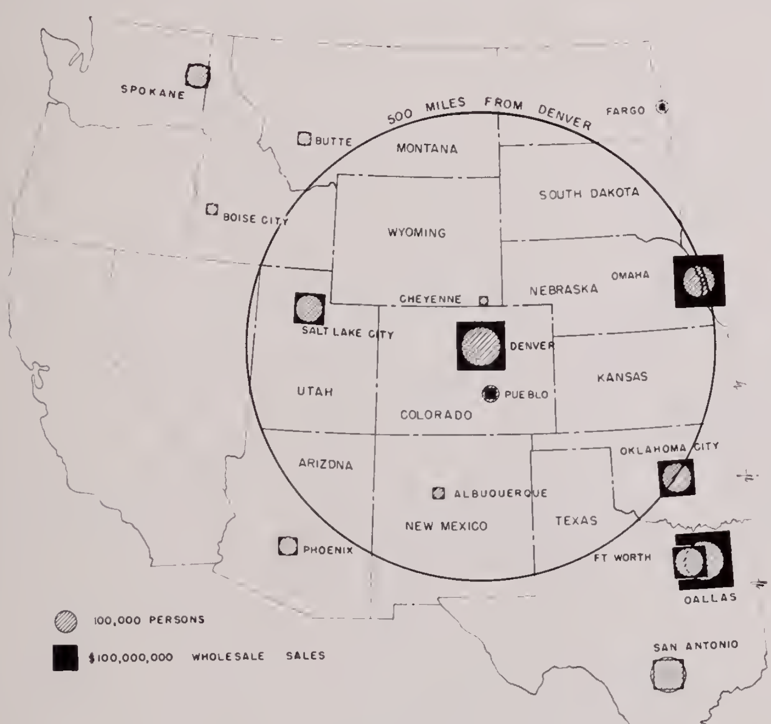


FIG. 6—*Denver's position as metropolis of the Plains and mountain area determines the traffic demands on its road system.*

While the growth of the city is a resultant mainly of the tributary mining and agricultural activities and its large wholesale trade and expanding manufactures, much traffic importance attaches also to tourist and resort activities. The climate of Denver early made the city known as a health resort and summer residence, and the city is further favored by occupying a central position in the extensive park, camping and hunting area extending from Rocky Mountain National Park southward through the Denver Mountain Park system to Pike's Peak and the Garden of the Gods. An estimate made some years ago that one in five of the private cars on Denver streets in summer belongs to a visitor suggests the traffic contribution made by health and recreation activities. As the region has many recreational resources yet undeveloped, the influence of this element is not believed likely to decrease.

Consistent growth is shown by the city's census record. Denver's rate of population increase has been in excess of the national and state rates (Fig. 7). Motor vehicle traffic here as elsewhere has increased much faster than the population; car mileage figures computed from gasoline consumption, as charted in Fig. 8, bring this relation to view. Data for the entire state agree closely with those of Denver, a fact which strengthens the conclusion that forecasts of the city's growth may safely be based on those of the surrounding region.

The Denver chart will be observed to show a sharp rise of vehicle mileage after 1939, attributable to traffic of the military establishments in and near Denver — Fort Logan, Lowry Field, Buckley Field, Fitzsimons Hospital, Denver Ordnance Plant and Rocky Mountain Arsenal. As it is probable that post-war traffic from these sources will be much reduced, our estimates of traffic growth have been based on the normal rate of increase, without regard to the wartime rise.

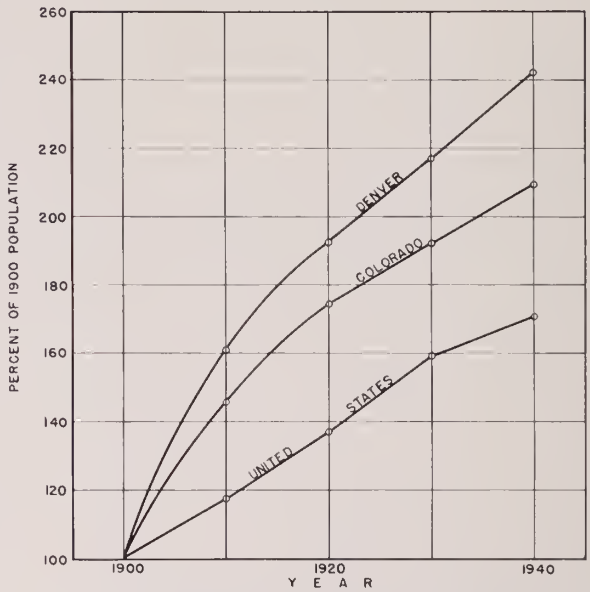


Fig. 7—*Population has grown faster in both Colorado and Denver than in the United States as a whole.*

Streets and Roads

Existing traffic arteries in the city area, indicated on the skeleton street map, Fig. 4, show less development in north-south than in east-west direction.

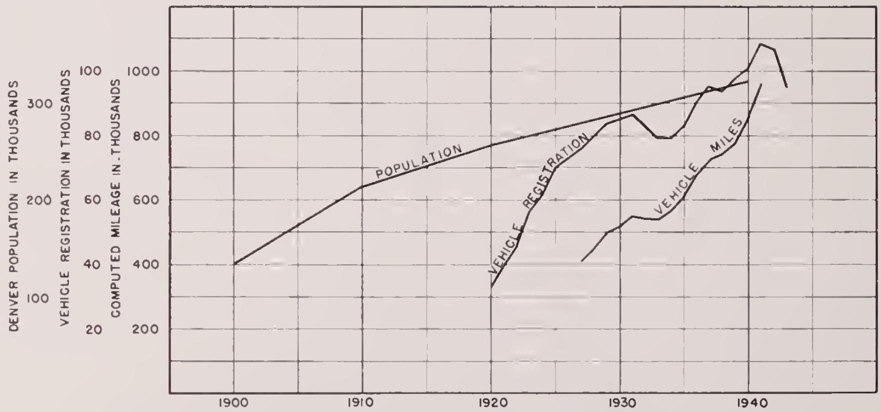


Fig. 8—*Car registrations and motor vehicle mileage are indicators of the growing highway problem of the Denver area.*

This may be attributed to the origin of the street system in relation to the river valley and to more rapid growth of the city parallel to the river than transversely.

In the original city, now the central business district, the streets were aligned along Cherry Creek and the river valley, in northwest and northeast directions; the remainder of the city was oriented on the cardinal points. The resulting dual street system combined with the narrowness of most of the streets — the prevailing width in the business district is 80 feet, in the residential 60 feet — is a factor of the inadequacy of the arterial street system. In north-south direction the city has virtually only two main traffic routes, Broadway (the only street 100 feet wide throughout its length) and Federal Boulevard. In east-west direction the obstacle of the river valley has been effectively overcome by the construction of half a dozen high-level viaducts and numerous low-level bridges.

Only three important diagonal streets are contained in the city network; Park Avenue, a survival of the early street layout; Speer Boulevard, developed along both banks of Cherry Creek some thirty years ago, and Buchtel Boulevard in the southern part of the city, constructed along a railroad right of way. As city transportation thus depends mainly on a rectangular network of narrow streets, it is not as efficient as it might be, and many efforts at traffic improvement have been made in the past quarter century. The roadways of a number of streets have been widened, and several streets have been restricted to one-way traffic. Only partial relief was afforded by these improvements, however.

The transportation service of the street system as a whole and of the proposed thoroughfare in particular is influenced in large degree by the existing road system that focuses at Denver. The arrangement of this system, shown diagrammatically by Fig. 9, emphasizes the extent to which incoming and outgoing traffic is concentrated within the city. The importance of the new thoroughfare for the accommodation of highway traffic approaching the city from points north and northeast and from the south is clearly apparent.

Today, as a result of the existing street conditions, north-south vehicle traffic into and through the city must merge and compete with a heavy volume of intracity traffic of streetcars, trucks and passenger vehicles crowded into two main streets, where it encounters a continuous sequence of crossing delays. Test runs have shown that transit through the city, even under traffic conditions considerably better than those of peak periods, consumes nearly an hour of time. Thus the city interposes a traffic obstacle measured by a time loss of fully one-half hour. It is the function of the proposed new thoroughfare to remove this obstacle.

A master plan of the city has been under study for fifteen years or more, but no plan has yet received general acceptance. Early completion and adoption of a city plan is believed to be especially urgent at this time, to serve as guide for post-war development. As the principal arterials are fully loaded at the peak hours, a master plan will undoubtedly include additional arterials in both directions, some of them perhaps including grade-separation structures at important intersections.

In the absence of an accepted city development plan, it is essential that the north-south thoroughfare now under study be so located and planned as not to restrict the appropriate choice of east-west routes. It should be flexibly adapted to whatever master plan may be adopted. As will be brought out farther on in this report, the major intersections on the recommended thoroughfare route are sufficiently well defined to coordinate the highway effectively with any probable plan.

Study of possible routes for the Denver Project and of the necessary distribution of traffic from the new highway indicates that some street improvements would be valuable auxiliaries of the Project highway. We suggest several specific improvements which appear to offer efficient means of distributing the traffic without adding to the load carried by the present streets. However, as the final selection of distributary routes is the responsibility of the city authorities and no doubt will be made in conformity with a general city plan, we wish to emphasize that the suggestions are in no way intended to limit the city's choice of traffic arteries to be improved. We advance them only for the purpose of pointing out the directions of traffic flow that in our opinion may be expected to develop.

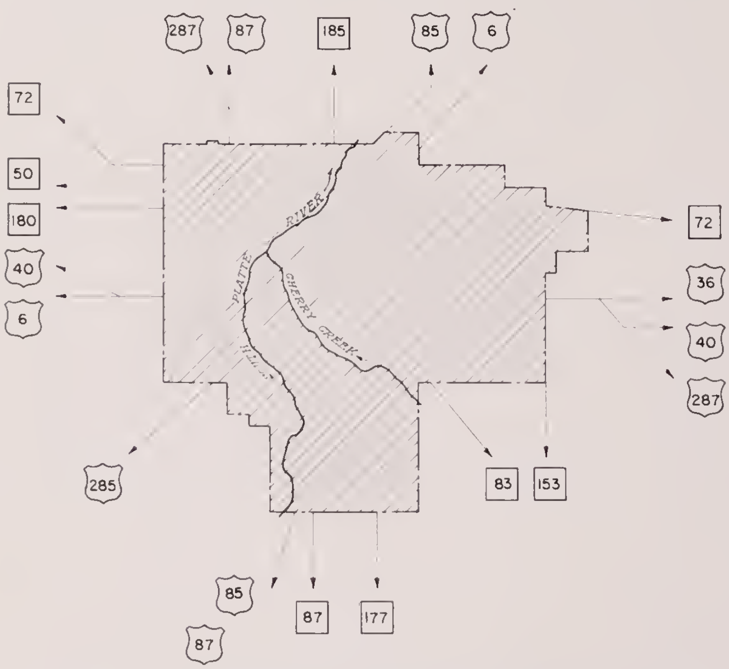


FIG. 9—*The main highways centering in Denver tend to concentrate traffic in north-south direction.*

II. HISTORY OF PROJECT

Origin and Authorization

For a number of years studies to improve the highways approaching Denver have been carried on by both the Colorado Highway Department and the Public Roads Administration. One result was the construction of extensive stretches of four-lane road, but the need for more radical improvement in the near future was recognized. Within the past two years the studies were accelerated by the necessity of developing definite plans for post-war resumption of highway improvement suspended at the outbreak of hostilities.

A foundation for this planning had been laid by two elaborate investigations of national highway needs, reported in "Toll Roads and Free Roads" (House Doc. 272, 76th Cong. 1st Sess., 1939) and "Interregional Highways" (House Doc. 379, 78th Cong. 2nd Sess., 1944), which showed that modernization of the country's roads requires the construction of a nation-wide system of trunk-line freeways. The interregional network developed by these investigations, shown in part by Fig 1, includes the Colorado mountain-front route as a main element of regional and interregional service.

At the time the present work was initiated it had been concluded, with the approval of Governor Vivian, that this north-south route should be given a primary place in the state's post-war highway plans, because of its urgency as a means of relieving the existing pressure of traffic as well as because of its interregional function. Surveys determined that the improvement should be a limited-access highway located on new alignment approaching Denver on the north along a line lying between the present U. S. Highway 87 and State 185, and on the south along the valley of Cherry Creek. This determination rendered it imperative that an efficient means of passing through the city be developed.

As the city section of the new highway is certain to affect numerous official and private interests, satisfactory location and general plan could be developed only after detailed consideration of its effect on these interests. The scope of the necessary investigations and conferences led to entrusting the responsibility of working out the general plan to the undersigned engineers.

The assignment has been carried out with the close cooperation of the authorities of the city of Denver, the State Highway Department and officials of the federal Public Roads Administration. These agencies have contributed many data and have aided the study by their experienced judgment. It should be understood, however, that they assume no responsibility for the recommendations made, which express the findings and conclusions of the undersigned alone.

California Department of Public Works.

Fig. 10—*Where Avenue 52 crosses the Arroyo Seco Freeway in Los Angeles, interchange traffic is handled by ramp connections.*

Even prior to initiation of the study, attention had been called to the importance of Market Street, in the center of the warehouse area, as the best location for a truck route of large capacity. The principal part of the highway freight traffic tributary to Denver, together with passenger traffic directed to the business district, could be carried to its destination quite directly by way of Market Street if adequate width were provided and suitable entrance connections built. Accordingly this line was suggested as the location of the midtown part of the new highway.

The practicability of carrying the main thoroughfare through Market Street has had our careful consideration. We are convinced that a traffic artery constructed along this route would be highly advantageous to the city, but, as discussed in the following chapter, we have concluded that such an artery would be most valuable as a terminal and distribution branch, rather than as part of the main thoroughfare. We believe that it is an effective auxiliary of the recommended thoroughfare, and that if practicable the city should proceed to build it in immediate conjunction therewith. The thoroughfare itself should, however, be kept distinct from this distributing route, in the interests of adequate traffic movement as well as cost.

The Colorado Freeway Act

Previous paragraphs have pointed out that the service requirements of the proposed north-south city thoroughfare can be met satisfactorily only by freeway construction. Fortunately an act of the State Legislature passed last year (approved April 20, 1943) makes provision for such construction. The act provides that the State Highway Advisory Board, with the approval of the Governor, may designate any portion of a state highway as a freeway

> "wherever, in its opinion, by reason of the volume and speed of traffic thereon, there is particular danger to the safety of the traveling public by collisions between vehicles proceeding in opposite directions thereon, or between vehicles at intersections of said state highway with other public highways or at approaches to said state highways from private property abutting thereon."

Where the freeway divides property held in one ownership, on demand of the land owner a road across the freeway must be provided at least once in each mile. Such connecting road must not be used for roadside business, however, and it may be discontinued when the divided tract is no longer held by one owner.

As the act was passed as an emergency act and took effect at once on passage, it is now in full force. It is believed to afford adequate legislative foundation for the planning and construction of the city trunk highway discussed in the present report, subject to satisfactory agreement between the city and state authorities.

Prior Plans for a North-South Thoroughfare

Development of improved north-south traffic facilities through Denver has been in progress for many years. Near the southerly end of the city parts of Santa Fe Drive were opened more than thirty years ago, and in increasing degree a large part of the traffic reaching the city from the Colorado Springs road sought an entrance along the river valley to by-pass Broadway.

Plans for a further river-valley artery, initiated by the city's Department of Parks and Improvements, reached an active stage in 1938, when a general project to construct a river-bank road (the Platte River Drive), was conceived and work was begun on engineering plans preparatory to applying for a grant by the Federal Public Works Administration. This project was discontinued, however, when the special improvement district which was to underwrite the construction cost was not organized.

According to the plan of that time, existing stretches of river-bank road were to be developed to greater capacity and extended along the river bank entirely through the city, from a point near the southern boundary to a connection with 38th Street near the north boundary of the city. The Platte River

Drive thus created was to form a complete traffic artery, wherever possible freed of cross traffic by grade separations.

After failure of the P.W.A. project, parts of the Drive were built by the city during 1939 and 1940 with aid of W.P.A. labor; a four-lane roadway in the southerly half of the city was built along the east river bank north to near the Colfax Avenue viaduct, and in the northerly part a river-bank road was opened from the Denargo Market northeast to 38th Avenue. Completion of the Drive by building the intermediate section through the railroad yard and industrial area was left for the future.

At the time the present study was begun the use of Platte River Drive as main highway link through the city received consideration, but it was concluded to be impracticable because of the high cost of overcoming the obstacles presented by existing occupancy in the valley, and because of its connection to North Washington Street, which for several miles north of the city could not be widened to freeway proportions at reasonable cost. Somewhat later, when the location of the entering highway line was fixed at Acoma Street, attention turned to routes farther west in the valley area, as well as to alternative routes through the city.

Detailed route studies were carried on by engineers of the Colorado Highway Department and the Denver district office of the Public Roads Administration, in conjunction with city officials, and a valley route was developed on the westerly side of the river throughout the north half of the city. The route was found to afford the advantages of a central location, direct access to markets, industrial area and business district, and minimum interference with existing improvements and city development. The route which we recommend follows closely this location. After examination of all alternative routes we conclude that it affords the best combination of transportation utility, economy and adaptability to development.

III. LOCATION OF THE NORTH-SOUTH THOROUGHFARE

Functions of the Thoroughfare

For efficient performance of the essential functions of the projected thoroughfare — to carry traffic from north and south through Denver expeditiously and safely and at the same time receive and deliver the Denver terminal traffic — its location must be appropriately chosen. Traffic survey data show that the larger part of all traffic near the Denver area originates in or is destined to the city; distribution to objective points within the city is therefore a controlling consideration. In addition, a large volume of intracity traffic that will be attracted to the new thoroughfare requires consideration.

As freight and passenger traffic in the main have different objective areas, their individual distribution requirements claim attention. Service to both classes can be simplified if it is found possible to segregate them within the city by providing separate distribution routes.

The major objective areas of traffic are well defined by the property-use map, Fig. 5. Commercial traffic largely originates or terminates in the market and warehouse district and in the manufacturing and railroad-yard areas of the valley bottom lands. Intercity bus traffic originates almost wholly in the business triangle. The latter also is the objective of a considerable volume of private-car traffic. However, the larger number of private cars on some roads, or as much as one-half to two-thirds of their peak traffic, comes from or goes to the residential districts. The population density map, Fig. 15, provides an index of the passenger traffic distribution.

The eastern, southern and western residential districts of the city are divided by the valleys of the South Platte River and Cherry Creek. Viaducts and bridges provide ample connection between the east and west districts. Cherry Creek is crossed by some 17 bridges that connect the south residential area with the city center, but the easterly part of the south side is somewhat isolated by the Cherry Creek depression, as there are only two crossings east of Downing Street, in a distance of more than two miles.

For most direct service to these several objective areas a central location of the city route presents obvious advantages. The two present central arteries therefore receive the bulk of the north-south traffic. Broadway is the main link between traffic north and northeast of the city and traffic south, while Federal Boulevard is the principal route from the communities of the more immediate mountain-front region north of Denver, including Fort Collins, Estes Park, Longmont and Boulder. These two streets carry a heavy traffic load and are closely built up, in large part with improvements of high value. To develop them into large-capacity freeways would involve prohibitive cost and serious interference with traffic and business.

Alternative Routes

As already pointed out, the topography of the Denver area places few restrictions on the location of a north-south route. For this reason directness of travel, access to the objective areas within the city, and the location of existing thoroughfares and improvements, constitute the principal governing considerations.

Through traffic could be carried past the city by by-pass routes or belt lines, and from these the traffic desiring to enter the city could reach its destination by way of radial entrance branches. This terminal traffic, however, would be much more effectively served by routes passing through the city itself, which would afford direct distribution by way of the existing street system or supplementary distribution arteries.

In view of the large proportion of terminal traffic the excess length of by-pass routes as well as their indirectness of distribution excludes such routes from present consideration. Similar reasons militate against routes passing through the outskirts of the city, as for example along or near Monaco Parkway in the eastern part of the city or Sheridan Boulevard in the westerly part. In consequence practical consideration of a route meeting the requirements of the Denver Project is limited to the area lying between Colorado Boulevard on the east and Federal Boulevard on the west (see Fig. 11). The lower right-of-way costs of an outlying route would be outweighed by the increase in vehicle operating cost and traffic disadvantage, to such extent that the economic justification of the project would be placed in question and might disappear.

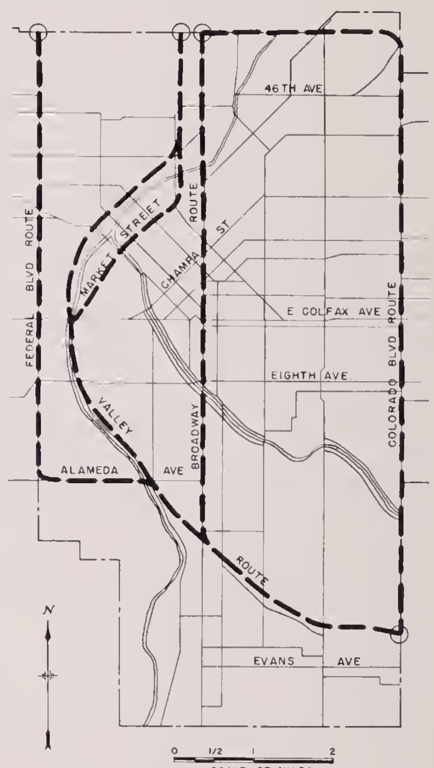


Fig. 11—*Possible alternative routes for the Denver Project thoroughfare.*

Colorado Boulevard, lying within three miles of the business district and at present serving as a north-south artery for private-car traffic, would provide a fairly direct route for the proposed freeway. As it extends through developed residential areas of relatively high character, construction of a trunk-line free-way would be costly in right-of-way acquisition. Traffic distribution to the east side and south side districts would be quite direct, especially if some residential streets were dedicated to arterial use, with suitable widening and other development. For adequate traffic distribution to the commercial and business districts and to the North Side, it would be necessary to build a branch route diverging from the main highway north of the city and entering along Broadway or the river valley, as well as a transverse route in the southern part of the city to connect Colorado Boulevard with Santa Fe Drive.

These conditions make the over-all cost of the Colorado Boulevard route relatively high. A more central location, if found practicable, would offer marked economies in directness of traffic handling.

An intermediate route could be carried through the city at one of a number of points between Colorado Boulevard and Broadway. Possible locations are (1) along University Boulevard; (2) diagonally from the 23rd Street viaduct through Park Avenue, Cheesman Park and Cherry Creek valley to a connection with University Boulevard or Colorado Boulevard; and (3) directly south through one of the residential blocks, such as that between Downing and Marion Streets. The route length along any of these locations would be somewhat shorter than that of the Colorado Boulevard route, and traffic distribution would be somewhat better and more direct. However, the cost of the right of way would be greatly increased, and the destruction of present city development would be of such serious proportions to make any of these locations highly objectionable and certain to be opposed by the city.

Broadway, the present main north-south highway through the city, offers the most direct location for a new through route. Its high development as a business street, its occupancy by streetcar lines and city traffic, and its essential relation to both business and residential districts as well as to city activities in general, combine to form a virtually insuperable objection to location of a large-capacity freeway along or adjacent to this thoroughfare. Rough estimates of the right-of-way cost that would be involved in freeway construction here indicate that the cost of the project might reach or exceed $55,000,000.

A location along the Platte River valley bottoms or slopes presents topographic conditions fully as favorable as those of any other route. By reason of the fact that the river makes a bend to the west in the city area, the route length of a valley location is somewhat greater than that of a direct route through Broadway or a location not far east of Broadway, but the increase would not be of critical importance. On the east bank of the river, railroad and industrial occupancy and prospective future development for similar uses block the development of a satisfactory route for the type of highway demanded by the present project. The west slope of the valley is not thus restricted, and a favorable route has been found practicable in this region. It would pass through low-value property and would encounter only minor railroad interference. In the vicinity of Colfax Avenue it could cross to the east bank and follow the present River Drive and the line of the Colorado & Southern Ry. branch along Buchtel Boulevard to the southern terminus of the project.

This location has the important advantage of affording direct connection to all important viaducts and bridges and thus providing a multiplicity of short access routes to the business district. Excellent distribution of traffic to the north and south sides is available by way of existing thoroughfares and streets, while the east side residential district could be reached effectively and conveniently by way of 46th Avenue and Colorado Boulevard, especially if these streets were improved for more effective distribution service. Perhaps equally important is the fact that because of the nature of the location a freeway on the valley location indicated would in no way erect a barrier to cross traffic.

Federal Boulevard, located along the brow of the west slope of the river valley and forming part of a present through highway to the north, also presents the advantage of direct connection to the east side of the river by the valley viaducts. A location here has many of the favorable features of a valley route; on the other hand its increased length, high right-of-way costs and property damages, and extensive interference with communication during construction, make it definitely inferior. Comparison with the valley route indicates a construction cost several million dollars higher and a traffic value materially lower.

Controlling Considerations of Route Selection

In comparing alternative locations, the essential features of an ideal location for a high-capacity thoroughfare of the kind contemplated by the Denver Project require consideration. They include the following:

(a) Short length between terminal points and between these termini and the objective areas within the city.

(b) Short and direct distribution to the traffic objective areas, with a minimum of construction or improvement of these routes.

(c) Favorable physical and property conditions at interchange points.

(d) Harmony with the general city plan and the natural development of city and vicinity.

(e) Adaptation to inclusion in a comprehensive arterial or throughway system in the city.

(f) Topography and soil conditions favoring easy and economical construction.

(g) Adaptability to future increase of capacity, either of the whole route or of critical sections, if rendered necessary by growth of traffic.

(h) Minimum interference with existing improvements, the city's current business activities, and prospective property uses.

(i) Low right-of-way cost.

(j) Favorable influence on values and growth of the city area traversed.

(k) Minimum over-all cost, taking account of construction, maintenance and operating costs.

Recommended Route

Applying these criteria to the routes above suggested, we find that a valley location is outstandingly superior. All others either are more costly by reason of existing occupancy and property uses, or they do not afford equally efficient traffic service, or they involve an extent of disruption of city business and established city districts that renders them unacceptable at the present time.

The valley route proves on detailed study to satisfy all the criteria of desirable route selection. The service as well as the cost factors are strongly in its favor. It is markedly superior to alternative routes in respect to distribution, as its central location gives most direct access to the objective points of traffic and facilitates interchange with transverse thoroughfares. Its physical conditions result in low right-of-way cost and economical construction, and its directness assures low operating cost.

Valley-Market Street Alternate

An attractive variant of a route following the valley throughout is presented by a location that would extend along the valley for part of its length and pass through the heart of the commercial district in the central portion of the city by way of Market Street and its southward prolongation, Walnut Street. The numerous desirable traffic features of such a location merit study. We have therefore considered the construction requirements and service features of a Valley-Market Street combination route (indicated in Fig. 11) in some detail.

Market and Walnut Streets are 80-foot streets fully built up with warehouse, market and other commercial buildings and in part carrying a railroad track. At the north, connection can be made with the Broadway viaduct by diverging eastward into Larimer Street; thence, by way of the Broadway viaduct extended in a straight line northward, the route would join the valley location near 43rd Avenue. Thus the highway entering from the north would lead directly into the commercial center of the city, and would rejoin the valley location at the southerly end of Walnut Street, in the center of a somewhat congested market, railroad yard and industrial area. Adoption of this route as main line of the freeway through the city center would render unnecessary the construction of 2.6 miles of the valley route, from 43rd Avenue south to near 14th Avenue.

Business use of Market and Walnut Streets and their location between the Denver Union Station and the main part of the city obviously preclude construction of the freeway on the surface; elevated or viaduct construction would have to be resorted to. Further, to provide the width required for the freeway a half-block depth of property now occupied by warehouse buildings would have to be acquired. Both conditions make this route costly, and adequate traffic connections to the business district and to the Union Station area would add to the cost. Part of this cost would be saved, however, if a plan for some time contemplated by the city, to open up a wide thoroughfare through Market Street for commercial and warehouse service, were carried out prior to construction of the suggested freeway. In such case little additional right of way would need to be acquired for the freeway, and the construction cost would become the major item to be considered.

It is evident, however, that use of Market Street as a freeway location would materially restrict the ease of communication between the Union Station commercial area lying to the west and the business district lying to the east. Because of this effect as well as the reduced facility of passenger traffic distribution, we are convinced that it would be highly disadvantageous to the city to locate the main trunk of the freeway along Market and Walnut Streets. We believe that its advantages of direct access to the distribution area of part of the traffic would be more than neutralized by the reduced convenience to the bulk of the entering and departing traffic and by the interference with vital commercial traffic. Nevertheless we have made a comparative estimate of cost and traffic value of the full valley route and the Valley-Market Street variant.

The Market Street route from 43rd Avenue to a point near 14th Avenue would cost approximately $7,800,000, if Market Street were previously developed as a thoroughfare by the city. At the same time, elimination of that part of the valley route between the points just mentioned would save a cost of $3,600,000. Thus the Market Street combination would represent an additional first cost of upwards of $4,000,000. As partial offset, reduction in time and distance of freight traffic distribution, mainly by eliminating travel over the viaducts between west and east sides of the valley, would reduce the operating cost of transportation by an amount approaching $100,000 per year. Even with this saving a balance of investment value approaching $2,000,000 would remain in favor of the full valley route, and it has the decisive advantage of avoiding the traffic interferences which the Market Street freeway would cause by erecting a mild form of Chinese Wall between the business district and the Union Station area.

The ramps necessary to provide connections — as a minimum to 14th, 17th, 20th and 23rd Streets — would make this barrier a great deal more realistic than the natural psychological obstacle normally created by the erection of an elevated roadway. The access ramps would also occupy large areas of the dockways proposed by the city, thereby materially decreasing the benefits anticipated. These disadvantages, together with the interference to free flow of traffic which would result from large volumes of truck turning movements on steep ramps, are compelling arguments against this alternate.

The superiority of the valley route over the Valley-Market Street alternate appears sufficiently clear to confirm its selection as best route. Comparative estimates show even more marked advantages over other alternative routes. Stated in figures, the cost advantage of the valley route is apparent from the following:

ROUTE	COST, INCLUDING RIGHT OF WAY AND CONSTRUCTION
Colorado Boulevard	$18,500,000
Broadway	55,000,000*
Valley	14,500,000
Valley-Market Street	19,000,000*

Advantages of the Valley Route

The valley location, shown by Fig. 12, has the additional advantage that the physical conditions of the line adapt it to the highest standards of design. Except at isolated points it is free from restrictions on right-of-way width, and throughout it presents no difficulties in obtaining the easy curvature and grades essential to expressway service at interchanges as well as on the main route.

Because of its location the route affords most direct connection with the railroad passenger terminal and freight yards and with the city transportation systems. The airport is easily reached from the north by way of the 46th Avenue interchange and distribution route, and from the south by way of Monaco Parkway or Colorado Boulevard.

Assessed land values along the route average $1,250 an acre. This is about half the values along the Colorado Boulevard route. The value of existing improvements is moderate. The region traversed by the route permits of adequate esthetic development of the highway, and through such development the proposed highway would tend to improve property uses and enhance city values in its vicinity.

Relation of Valley Location to City Plan

The valley location is characterized by the fact that it utilizes a natural route, taking advantage of topography and improvement factors in most efficient manner for the purpose in view. It is devoid of any Chinese-Wall effect, by reason of its relation to the river and railroad area. Because of these

*Does not include damage payments for depreciation of adjoining property. The Valley-Market Street estimate is based on prior construction of the Market-Walnut Street improvement by the city, including side service roads on Walnut Street. The city project would involve an estimated expenditure of $6,000,000.

favorable factors and the availability of the existing valley viaducts as direct entrances to the business and commercial districts and the civic center, as well as because it intersects all existing and probable east-west thoroughfares at points well adapted to traffic interchange, it represents the main trunk or backbone of an ultimate city thoroughfare network.

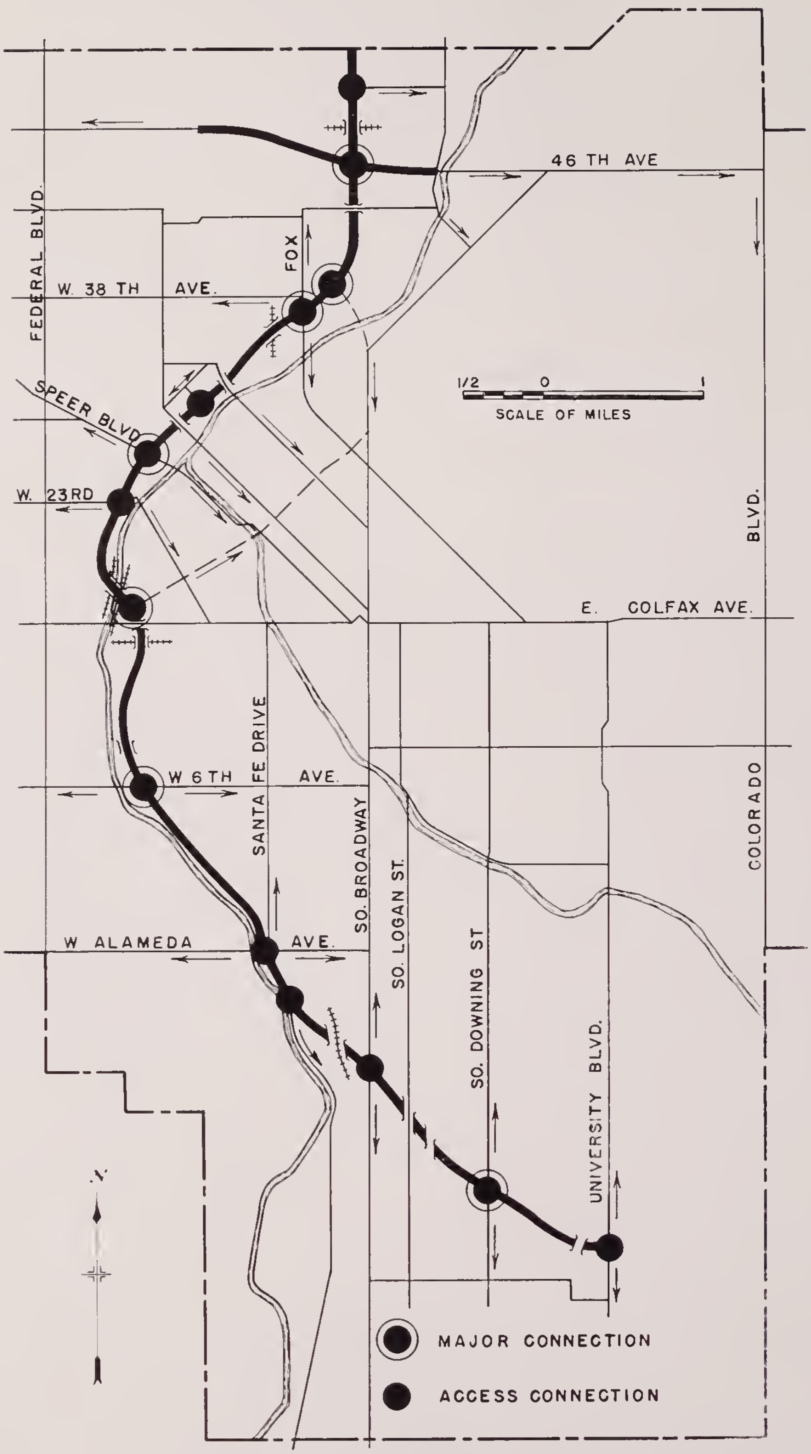


Fig. 12—*A river valley location is found to be cheapest and best.*

Regardless of whether such a network is to be partly or wholly of limited-access type, the valley location is flexibly adapted to any probable plan. Two generalized plans, which represent arbitrary combinations of thoroughfare routes that have been considered by city and highway officials, are outlined in Figs. 13 and 14. It appears from these sketch maps that the valley route coordinates naturally with all transverse routes and results in a net work providing complete distribution and through-traffic service.

We wish to emphasize that neither of the plans shown in Figs. 13 and 14 represents an official choice of routes, although all the routes shown have had extended and favorable consideration.

The possibility should be kept in view that further development of city and through traffic may at some later period justify the construction of additional north-south thoroughfares to supplement the valley trunk. Such a thoroughfare might, for example, be developed along Colorado Boulevard. We believe, however, that this is a matter for future consideration, and that any additional thoroughfare would be secondary or auxiliary to the Valley Highway here recommended. The latter appears likely to be at all times the key north-south highway through the city. It should be recognized as the initial element of the future system.

FIG. 13—*Illustrating how the Valley Highway coordinates with a possible future thoroughfare system.*

FIG. 14—*Equally good coordination is obtained with an alternative thoroughfare system.*

Route of the Valley Highway

Specifically described, the Valley Highway route extends south from the city line at 52nd Avenue along the block between Acoma and Bannock Streets, using these streets so far as possible as service roads for the territory adjoining to either side. Thence south and southwesterly it crosses 38th Avenue at Fox Street and continues southwesterly, passing under the 20th Street viaduct and along Central Avenue to an undercrossing of the 16th Street and 14th Street viaduct approaches. From 14th Street it curves to the south along the west bank of the river near Zuni Street, and then crosses to the east bank near 17th Avenue. Here it passes the westerly end of the market and freight district adjoining Walnut Street, and for a short distance traverses an industrial and low-value dwelling district.

South of Walnut Street the route curves somewhat westward to the Platte River Drive along the east bank of the river, and swinging gradually southeastward near Eighth Avenue it crosses Alameda Avenue at Garden Park and parallels the Santa Fe and Colorado & Southern tracks to a crossing under three railway tracks near Exposition Avenue. Thence it parallels the Falcon branch line of the Colorado & Southern Ry. to an undercrossing of Broadway and connects with Buchtel Boulevard, continuing southeast along the latter to the terminus at University Boulevard. The route so developed is 9¼ miles long between termini.

In its general course the Valley Highway has been designed as a surface road, locally depressed or elevated as made necessary by topographical and intersection conditions. It crosses and generally connects with all the valley viaducts and all major east-west arterials, for direct distribution of traffic to the principal objective areas as well as to all focal points of city activities and assembly. The Highway circles the principal railroad lines, yards and shops, and requires only minor track changes to facilitate such detail location as is most favorable to efficient operation.

Where the Highway crosses main thoroughfares, suitable traffic interchanges with non-crossing connections have been designed. The major interchanges proposed are at 46th Avenue, 38th Avenue (with connections also to Fox Street and to Broadway), 14th Street, Walnut Street, Sixth Avenue, Downing Street, and University Boulevard. Ramp connections are contemplated at 18th Street (for connection to the 20th Street and 16th Street viaducts), Alameda Avenue, Santa Fe Drive, and Broadway. Access is provided at 50th Avenue. Under or over-crossings are planned at a number of points to accommodate non-interchange cross traffic.

Distributing Routes

The importance of traffic distribution from the Valley Highway, in view of the terminal character of roughly three-fourths the total traffic carried, calls for thorough consideration of the routes by which this distribution may best be accomplished.

Traffic directed to the residential areas west of the river and on the south side can be reached satisfactorily by existing streets. Widening of South Downing Street from the line of the Valley Highway north to Cherry Creek is recommended as a desirable auxiliary improvement by the city.

Traffic coming from the north to the east side residential area can by-pass the built-up section of the city advantageously by following a route along 46th Avenue and Colorado Boulevard. Improvement of this route by some revision of alignment and pavement widening would convert it into a distribution artery, and such improvement should be carried out by city or state authorities as soon as possible. Traffic coming from the south has direct access to Colorado Boulevard, University Boulevard and Downing Street, and, especially if Downing Street is widened as above recommended, requires no auxiliary work beyond local improvement.

More extensive provision is necessary to assure efficient freight distribution. The city's proposed Market Street improvement, already discussed in connection with the question of route location, would form a natural distribution artery. Construction of this improvement is believed to be an essential auxiliary to the Valley Highway project, but as it is inherently a city facility rather than part of the state or federal highway system it should be undertaken by the city.

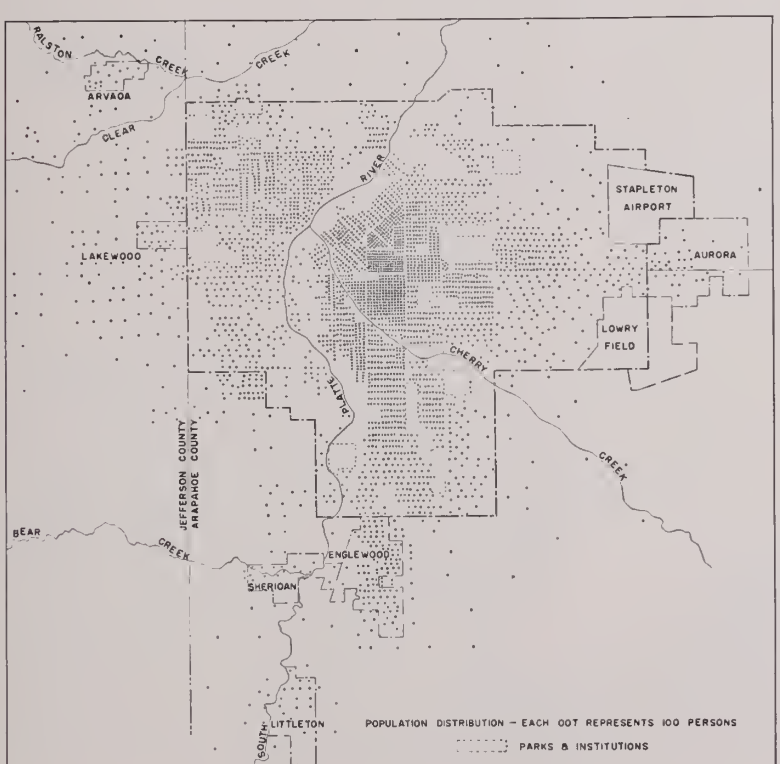


FIG. 15—*As traffic follows population, the distribution of population in Denver indicates where much of the passenger traffic originates.*

Market Street Improvement

General plans for the Market Street improvement have been prepared by the Denver Planning Commission in preliminary form. The plan Fig. 16 and the sketch Fig. 17 indicate the general nature of the arrangement of the street as suggested by the Commission. In addition to reconstruction

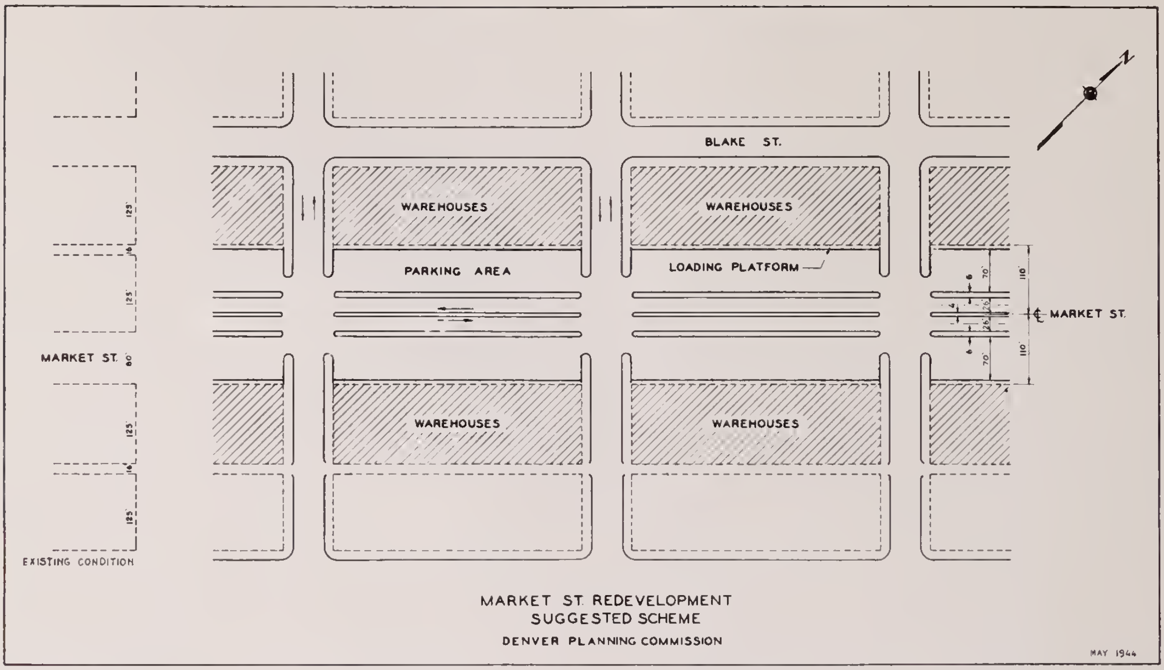


FIG. 16—*A freight distribution artery in Market Street has been planned by the city authorities to relieve serious truck congestion which has limited efficient property use.*

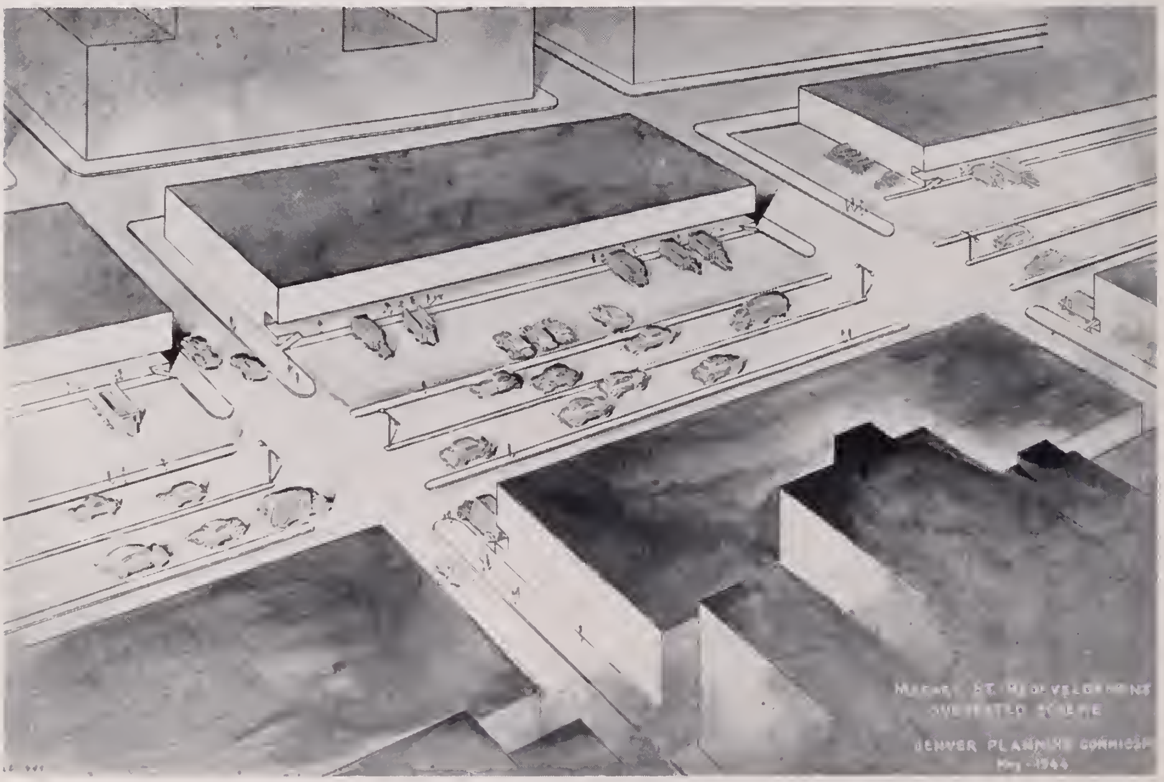


FIG. 17—*The city's proposed Market Street improvement would provide wide loading zones for trucks.*

of Market Street as shown, major improvement of its southwestward extension, Walnut Street, from Speer Boulevard to the Valley Highway is essential.

Present connection to Market Street from the roads entering the city at the north is made by way of Broadway, from which either Market or Larimer Street can be entered by vehicles to reach the wholesale and warehouse area directly, although subject at times to serious congestion or even blocking of traffic. However, cars approaching on Federal Boulevard must follow a more indirect route, over Fox Street and the 23rd Street viaduct. To give adequate access from the north to the market area by way of the Valley Highway, the Broadway viaduct requires to be extended to an interchange on the Highway at 31st Street. The necessary connection has been included in the general plans attached to this report.

At the southerly end of the market and warehouse area Walnut Street requires to be connected with the Valley Highway by an interchange permitting free flow of traffic to north or to south. Our general plans and estimates include such an interchange. They do not include construction of the Market-Walnut Street improvement or extension of the Broadway viaduct.

Lacking the Market-Walnut Street development, distribution of commercial traffic to the market and warehouse district would be considerably less direct, and the full transportation economy of the Valley Highway would not be realized. It is strongly recommended that the city in its own interest undertake construction of the improvement at the time the Valley Highway project is carried out or earlier.

IV. TRAFFIC DATA

Initial Traffic at City Line

For forecasting the service requirements of the proposed thoroughfare, basic data on traffic are available in traffic determinations made by the State Highway Department from counts and an origin-and-destination survey conducted in July and August 1939. In interpreting and applying these data we have been guided by observation of vehicle movement and knowledge of local travel habits.

The year 1939 is a representative pre-war year. A sharp increase of vehicle movement attendant on defense and war activities beginning about 1940 is apparent in the Denver vehicle mileage data charted in Fig. 8, but this is regarded as a temporary phenomenon, and the traffic requirements of the future have been estimated without regard to the increase. The influence of gasoline rationing, which began in the latter part of 1942, is also eliminated by basing the forecasts on 1939 data.

Separate counts of traffic passing through the city and bound into or out of the city, for all of the main entering routes, showed that at the city line through traffic constitutes about 18 percent of the total. Vehicle movement at the north boundary of the city is several times that at the south boundary; the figures for through traffic are more nearly equal, while city terminal traffic from the north is about five times that from the south. Counts some distance outside the city, when combined to represent an average day typical of July and August 1939, showed the following numbers of vehicles per day:

	AT NORTH BOUNDARY	AT SOUTH BOUNDARY
Through traffic	2,816	1,400
Terminal traffic	13,972	2,774
Total	16,158	4,174

From the results of these counts the State Highway Department has estimated the average daily traffic for 1940 on the individual entering roads at the city line as follows:

AT NORTH CITY LINE		AT SOUTH CITY LINE	
Sheridan Boulevard	1,000	Santa Fe Drive	7,000
Federal Boulevard	6,500	Broadway	2,300
North Washington Street	3,500	University Boulevard (Suburban)	1,500
Brighton Boulevard	6,100		
Vasquez Boulevard (U. S. 6)	3,400		

A complete chart of average annual traffic tributary to Denver, in terms of vehicles per day on the several roads, is reproduced in Plate A, page 32.

Traffic that may be expected to transfer in whole or in part to the proposed Valley Highway includes mainly that which now follows Federal Boulevard and North Washington Street; minor amounts may be drawn from other roads entering the city on the north. It is believed that the through traffic on all north-south roads will make use of the Highway as a means of saving in time of transit through the city. Terminal traffic on Brighton Boulevard and U. S. Highway 6, however, would be likely to follow the present entrance routes.

The probable diversions to the Valley Highway on the north are estimated to include all of the through traffic, half the terminal traffic on Federal Boulevard, and all of that on North Washington Street. The probable traffic at the north city line as thus estimated is 8,500 cars daily average for 1940. At the south line the full traffic of the Colorado Springs highway is tributary to the new route, in addition to much of the local traffic that now follows Broadway or Santa Fe Drive. East of Broadway, however, diversion to the new route will be greatly reduced, as a large share of the present traffic is likely to continue using the existing Colorado Springs highway in preference to diverting to the Cherry Creek location. The traffic at University Boulevard is estimated at 3,500 vehicles per day.

Data on the distribution of motor vehicle traffic throughout the year are given by the monthly records of gasoline sales, available for both Colorado and Denver over a period of years to the end of 1941. The distribution, which is closely alike for city and state for various years, shows a peak in August at 125% of the annual average. Vehicle movement within the month as shown by the 1939 traffic census reaches a maximum one-day traffic of 150% of the month's average. Taken together, these data indicate that the traffic on the peak day of the year may approach twice the daily average for the year. The traffic of the peak hour has been estimated from traffic observations of the Public Roads Administration at one-eighth of the daily total. The peak hour may thus approach six times the average of the year.

Initial traffic on the Valley Highway as deduced from these data is estimated at a peak of 2,000 cars per hour at the north city line, 600 cars per hour at the south city line and 1,000 cars per hour north of Santa Fe Drive. These figures are regarded as a conservative basis of traffic estimates for proportioning the capacity of the Valley Highway. However, in view of the anticipated growth of traffic as discussed below, provision should be made for increasing the capacity well beyond the initial requirements.

Traffic Composition

Denver entrance traffic was found in the 1939 survey to include at different points from 13 to 20% of commercial vehicles. Similar figures obtained in prior traffic counts and observations by the Civil Works Administration in the business district of the city showed somewhat higher figures, commercial vehicles reaching 22% of the total traffic; this greater ratio is accounted for by the concentration of commercial business downtown. A ratio of 15 to 20% appears to be characteristic of the Denver area traffic over the past decade, but because of the trend toward increased proportion of commercial traffic a ratio of at least 20% truck traffic should be used in estimating future traffic demands.

Within-City Additions

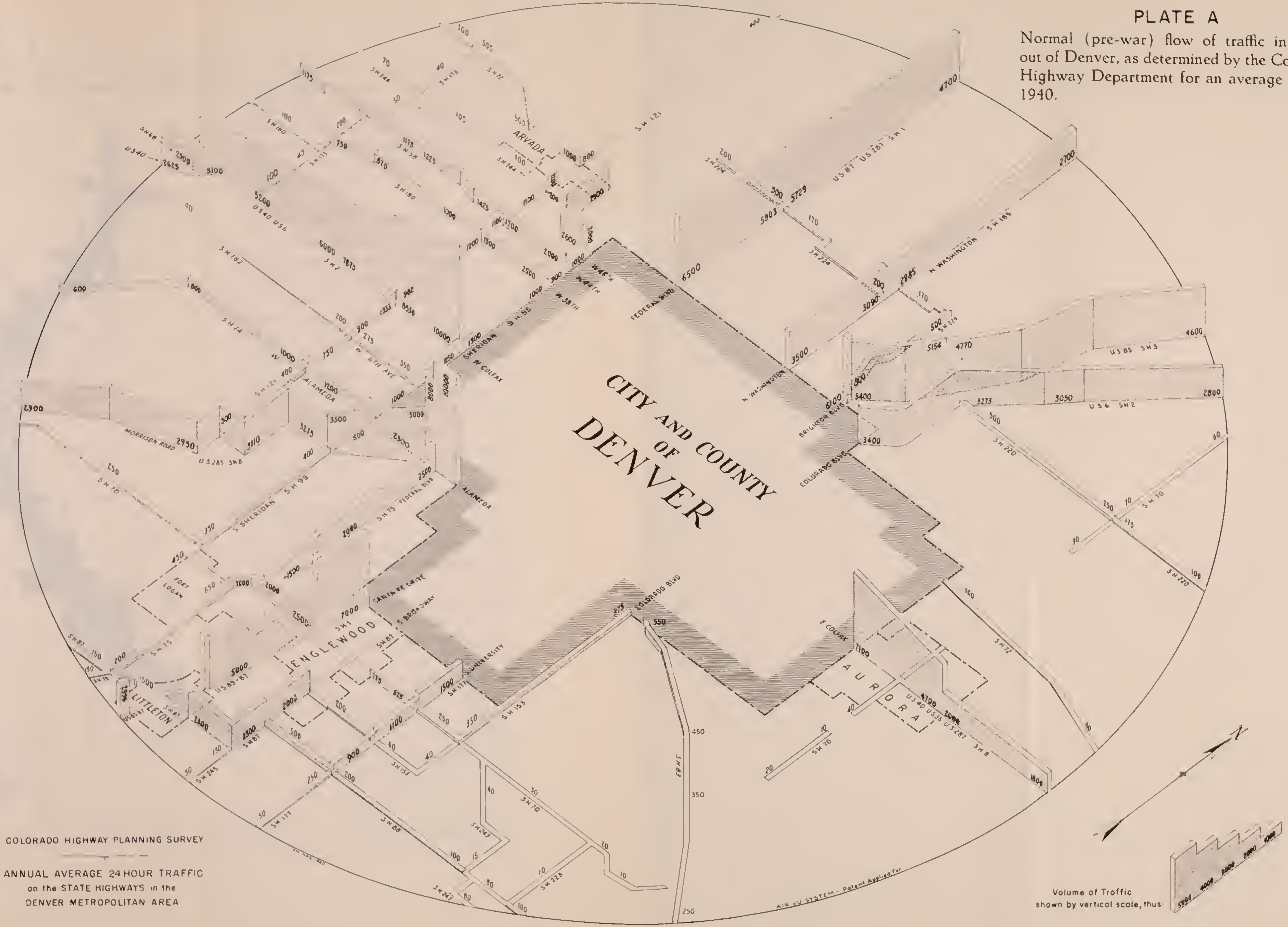
All city thoroughfares show a heavy increase of traffic between the city line and midtown. The generalized traffic flow diagram on the main arteries reproduced in Plate B, page 34, from a chart of the State Highway Department representing average week-day conditions for 1940 estimated from one-day counts, reveals a consistent increase of traffic in the passage through the city, in the ratio of more than 3:1. Such increase must be expected to occur also on the Valley Highway.

The arterial traffic added within the city includes both inbound or outbound vehicles and those moving wholly within the city. As the former usually follow a zigzag course between their city terminal and the open road, they enter a thoroughfare at some point within the city and continue for part of its length, in the same manner as strictly local traffic. Traffic counts therefore throw no light on the relative effect of the two contributions to traffic flow. However, as the outlying thoroughfares receive the smallest within-city additions and the inner thoroughfares the largest additions, it is clear that a new central artery is likely to receive the maximum inflow of traffic from both sources. This condition warrants the conclusion that the Valley Highway will experience a traffic multiplication of three to fourfold between its northerly terminus and the midtown area. (It deserves to be noted that by reason of this condition a new north-south highway located in the central part of the city will be of much greater assistance to traffic flow than one located farther out.)

As a check on the amount of within-city addition just deduced, three traffic engineers independently estimated the traffic additions to be expected at the interchanges of the Valley Highway, where it crosses transverse city arteries. Each was thoroughly familiar with city conditions and directions of travel, and used this knowledge in estimating from the known volume of normal cross-flow the probable number of turning movements in each direction at each of the interchanges of the Valley Highway. From these he estimated the net addition to or deduction from the movement on the highway itself. The three independent results agreed closely, showing important differences at one or two points only. They placed the traffic on the central section of the highway, directly opposite the city's business district, at 18,000 vehicles daily, as the average for the year.

PLATE A

Normal (pre-war) flow of traffic into and out of Denver, as determined by the Colorado Highway Department for an average day of 1940.



COLORADO HIGHWAY PLANNING SURVEY

ANNUAL AVERAGE 24 HOUR TRAFFIC on the STATE HIGHWAYS in the DENVER METROPOLITAN AREA

These figures represent a multiplication of three to four from north terminus to city center, thus agreeing closely with the ratio actually found on city thoroughfares. The averages of the three independent estimates have therefore been adopted as basis of design of the Valley Highway. The resulting flow diagram is shown in Fig. 18.

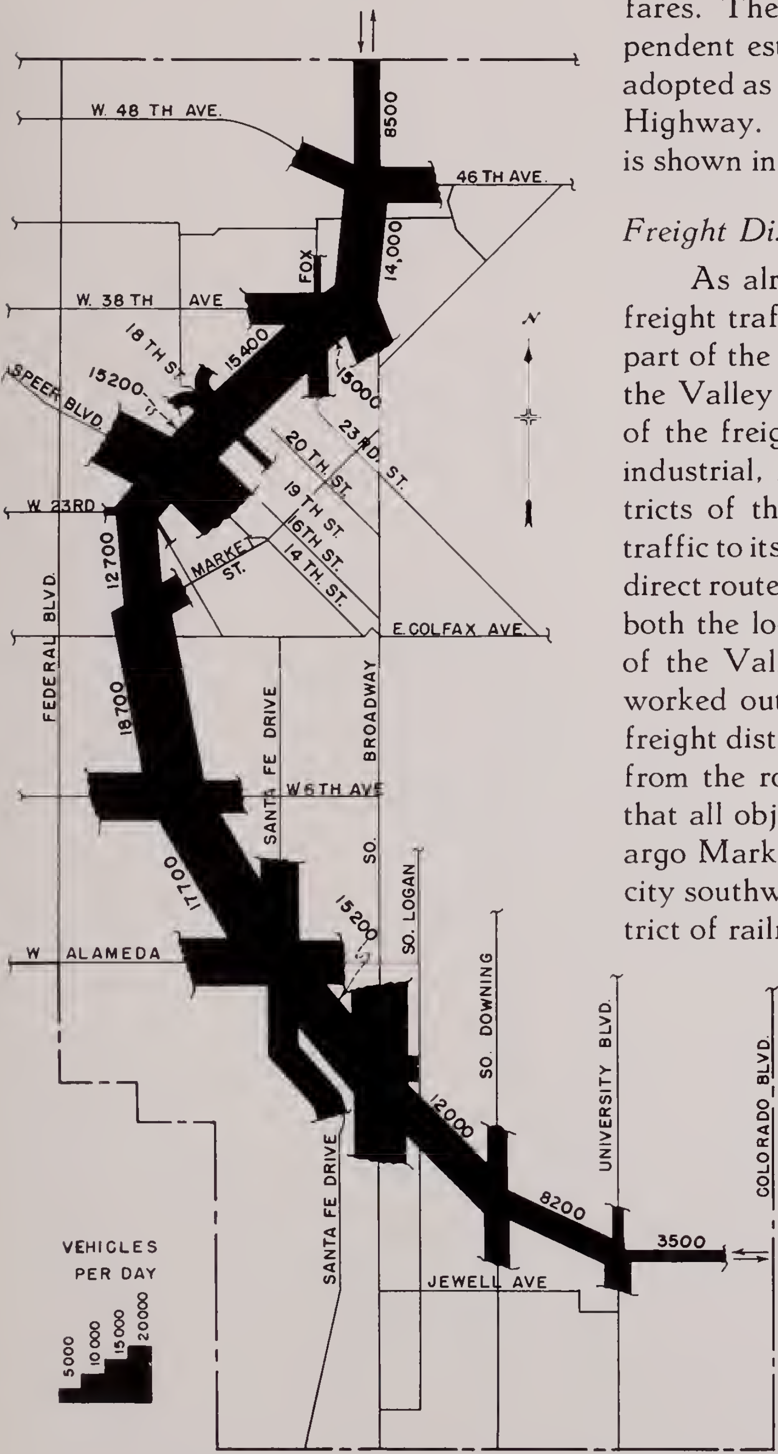


Fig. 18—*Flow chart of the initial traffic on the Valley Highway as forecast from traffic counts.*

Freight Distribution Requirements

As already stated, commercial or freight traffic constitutes an important part of the total traffic to be carried by the Valley Highway. The larger part of the freight traffic is directed to the industrial, market and warehouse districts of the city. Distribution of this traffic to its objective points by the most direct routes being obviously important, both the location and the general plan of the Valley Highway have been so worked out as to provide for efficient freight distribution. It will be observed from the route plan shown in Fig. 12 that all objective areas, from the Denargo Market near the north end of the city southward through the central district of railroad yards, warehouses and industrial plants to the southern extension of the industrial district, are reached quite directly through interchanges and existing transverse thoroughfares. In addition, the proposed Market-Walnut Street freight distributing route and the extended Broadway viaduct as described in the preceding chapter are believed to be essential features in developing the new highway to maximum service value. Similarly, the proposed passenger distribution route by way of East 46th Avenue and Colorado Boulevard is considered a necessary service auxiliary.

A survey of origin and destination of intracity traffic is now being carried out by the State Highway Department. This is expected to add valuable detail data on traffic distribution, which may show that the general plan here presented requires modification in some minor features, especially as to adequate interchange and distribution. Existing data, however, make the general traffic conditions within the city sufficiently clear to warrant the belief that the main features of the plan represent an adequate and economical solution of the problem.

Growth Trends and Future Traffic

In the preceding paragraphs the initial or "present" traffic requirements of the Valley Highway have been considered. In order to anticipate also the requirements of the near future the history of traffic growth in the Denver area and in the state of Colorado as a whole must be studied. It is found that this growth closely parallels that in the country at large. Attention has already been drawn to the rate of increase of car registrations, fuel consumption and total car mileage for Denver as charted in Fig. 8; a similar chart for the state of Colorado would present an almost identical picture. It is important to observe that the number of cars registered has consistently increased more rapidly than population, and that fuel consumption in turn has increased more rapidly than registrations. These factors together with progressive improvement in the fuel efficiency of motor vehicles have caused traffic mileage to grow several times as rapidly as population.

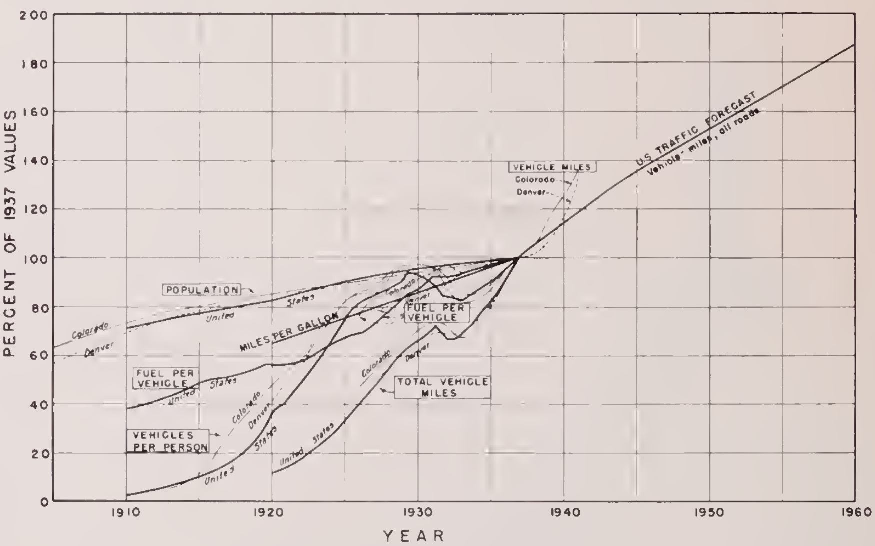
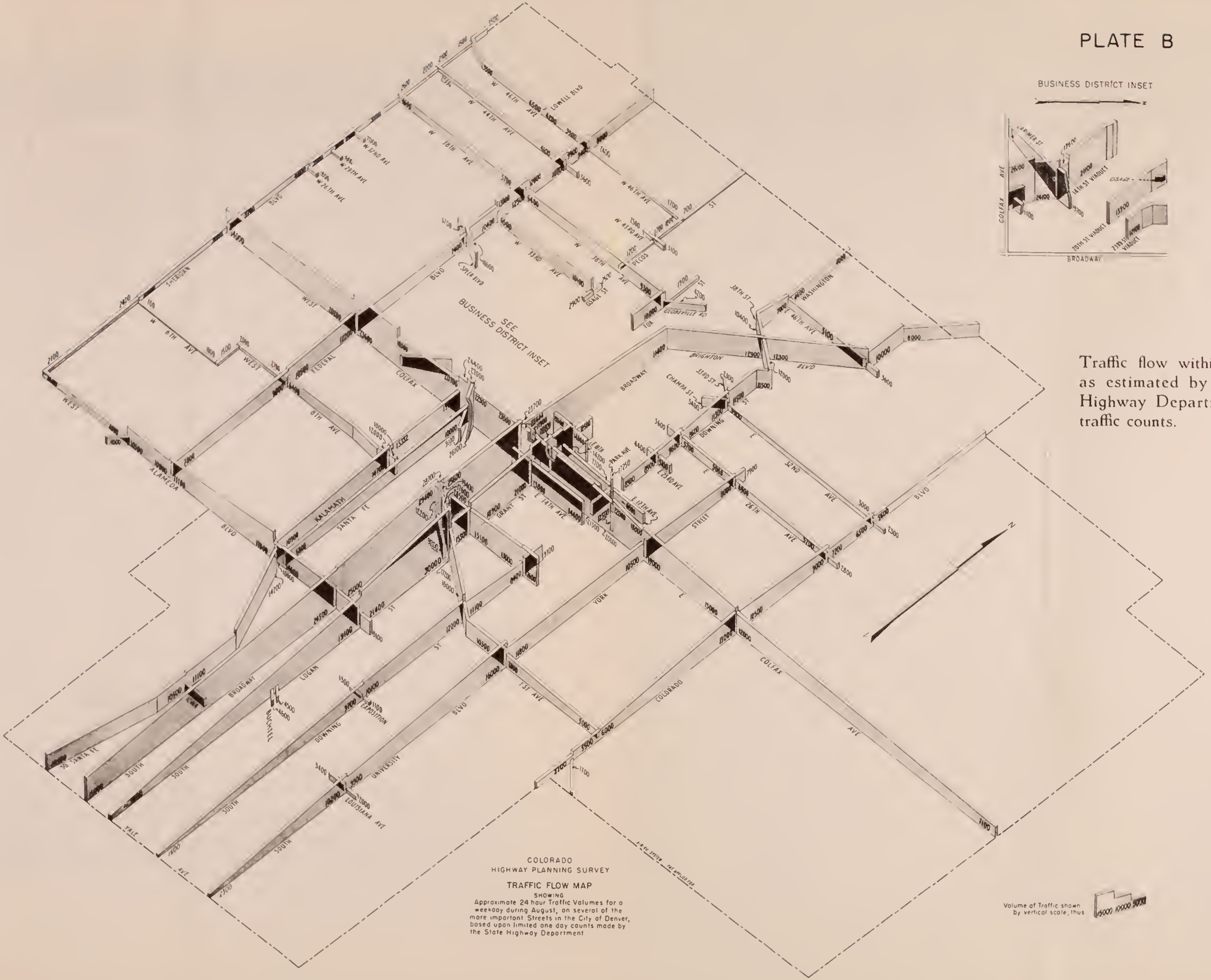


FIG. 19—*The Public Roads Administration forecasts a doubling of traffic in the next 20 years. Traffic in the Denver area is likely to increase even more rapidly.*

Such a rate of increase cannot be expected to maintain itself indefinitely; but, while mileage growth is bound to flatten off as car ownership and intensity of vehicle use approach the saturation point, it does not appear that the increase will be much checked within the next twenty years or more. A study of traffic growth trends carried out recently by the Public Roads Administration ("Toll

PLATE B



Traffic flow within the city as estimated by the State Highway Department from traffic counts.

Roads and Free Roads," 1939) led to the forecast that the total vehicle mileage on all roads of the United States will double by 1960. In view of the similarity of past growth, it is probable that at least equal traffic increase will take place in the Denver region.

The national forecast chart is reproduced in Fig. 19, on which the past growth in the Denver and Colorado areas has been added in light lines. The three sets of traffic-growth records are similar, and if independently projected they would lead to forecasts of roughly equal magnitude. However, the fact that the population of Colorado has grown somewhat more rapidly than that of the United States as a whole, and that Denver in turn has grown somewhat faster than the state, makes it probable that the increase of traffic on the Valley Highway will be proportionately greater than the national traffic increase.

The forecast line shown in Fig. 19 represents the expected traffic growth on all roads of the United States, including farm roads as well as main thoroughfares. Main highways are expected to experience more rapid increase of traffic than local roads, by reason of the trend toward longer trip mileages and resulting concentration of traffic on the major roads. Arteries of specially high type, such as limited-access roads adapted to free flow of traffic at high speed, are considered to be subject to still further increase of volume. Because of these considerations the national forecast, which predicts a 1960 traffic equal to 180% of the pre-war traffic, does not fully represent the future traffic on the interregional highway system. It has been concluded that for this network the 1960 traffic is more correctly estimated as 200 to 220% of the 1937 traffic volume. We believe that adequate design of the Valley Highway should take into account the possibility that 1960 traffic may be as high as 230 to 250% of the initial traffic, and that provision for such increase by preparing for future expansion of the roadway capacity is desirable.

We have therefore designed the roadways of the Valley Highway to receive an additional lane when traffic demands justify its construction. By the time the demands of north-south traffic exceed the capacity of three lanes in each direction it will be desirable to build an additional freeway. Lane efficiency drops off sharply beyond three lanes, and expansion of the Valley Highway beyond this width is not recommended.

Public Transportation

Many intercity buses operating north, northeast and south from the city will be able to reduce their trip times materially by using the new highway, and may be expected to route their regular runs accordingly. The probable volume of these bus movements cannot be estimated satisfactorily from present information, but relative to the total traffic on the highway it will not be sufficiently large to influence the provision of roadway capacity. Both the initial design and the provision for expansion are considered adequate to allow for the maximum intercity bus traffic to be anticipated.

Buses bound south serve a number of communities lying between Denver and Colorado Springs, and for this reason will probably continue to follow the present highway through Palmer Lake instead of using the new Cherry Creek route. Depending on the location of their Denver terminal, however, many of them would be likely to travel by way of the Valley Highway as far as the Santa Fe Drive ramp. Buses bound northeast to Greeley and lower Platte River valley points, as well as eastbound buses going by way of U. S. Highway 6, may be expected to use Brighton and Vasquez Boulevards as points of exit from the city and thus would not add to the Valley Highway traffic. With these exceptions the full volume of intercity bus movement should be considered as an addition to traffic on the new highway.

Construction of a central bus terminal is understood to have had consideration, to replace the present individual terminals located at various points in the business district. If such a terminal should be built along a direct entrance to the Valley Highway, virtually all intercity buses might use the new route as their city approach. In that event the necessary accommodation of passengers may render it desirable to arrange loading and unloading bays along the highway. Such facilities can readily be constructed when needed.

Congestion and Traffic Accidents

Present congestion on the highways both of Colorado and of Denver is responsible for a relatively high accident rate, as revealed by the record of fatalities and injuries in traffic accidents covering the years 1929 to 1943:

	COLORADO	DENVER
1929	......	2,209
1930	......	1,977
1931	......	1,924
1932	......	1,621
1933	......	1,480
1934	......	1,556
1935	......	1,534
1936	3,671	1,373
1937	3,989	1,500
1938	3,803	1,435
1939	3,867	1,501
1940	3,784	1,274
1941	......	1,567
1942	......	1,214
1943	2,261	1,152

A gradual decline is shown after the early 30's, but the principal decrease in accidents has taken place subsequent to 1939. Reduction in car registrations and car mileage after 1941 (see table below) accounts for part of the decrease in accidents; the reduced traffic congestion consequent on rationing may also be a factor, however.

MOTOR VEHICLE REGISTRATIONS AND ESTIMATED CAR MILEAGES FOR COLORADO AND DENVER

YEAR	M. V. REGISTRATION		ESTIMATED CAR MILEAGE MILLIONS	
	COLORADO	DENVER	COLORADO	DENVER
1930	308,509	84,709	1,840	600
31	308,458	86,273	1,876	635
32	285,860	83,183	1,620	615
33	266,491	79,305	1,640	610
34	274,231	79,270	1,720	635
1935	284,578	82,848	1,830	675
36	316,144	90,130	2,072	745
37	337,217	95,229	2,218	795
38	332,774	93,936	2,255	805
39	343,446	97,430	2,354	835
1940	352,110	100,410	2,481	915
41	367,768	108,364	2,658	1,025
42	363,260	107,171	2,370	950
43	347,434	94,705	1,910	765

It appears that the Denver accident figures normally are higher in proportion to population than the state figures. This fact no doubt results from the street congestion within the city. For like reason, accidents are concentrated along the major thoroughfares (see map of 1943 Denver traffic accidents, Fig. 20). Broadway and Colfax Avenue show much the largest number per unit of length as well as the greatest concentration of intersection accidents. In the light of this condition it may be anticipated that diversion of part of the north-south traffic from the present streets to the Valley Highway will significantly reduce the number of accidents. Quantitative estimate of such reduction is for the present impossible, however, because of the lack of sufficiently comprehensive data.

Estimated Traffic Value of Valley Highway

In attempting to estimate the value of the project for comparison with its cost, an appraisal may be based on the fact that the Valley Highway will cheapen transportation and increase its range by carrying traffic into and through the city in less time than at present.

The time of transit through the city from north to south over existing streets, as measured in several test runs under different conditions, ranges from 35 minutes to 1 hour. By way of the Valley Highway the same distance would be covered in 12 to 15 minutes. Runs between various points within the city over present routes, compared with partly observed and partly calculated times of transit between the same points by way of the Valley Highway, provide a basis for a comparison of benefits with costs. Other factors used in this comparison include the cost saving corresponding to one mile of distance and one minute of time for both passenger cars and trucks, the total traffic, the percentage of trucks, and the economic life of the various features of the project. Computations for savings were made in the following manner:

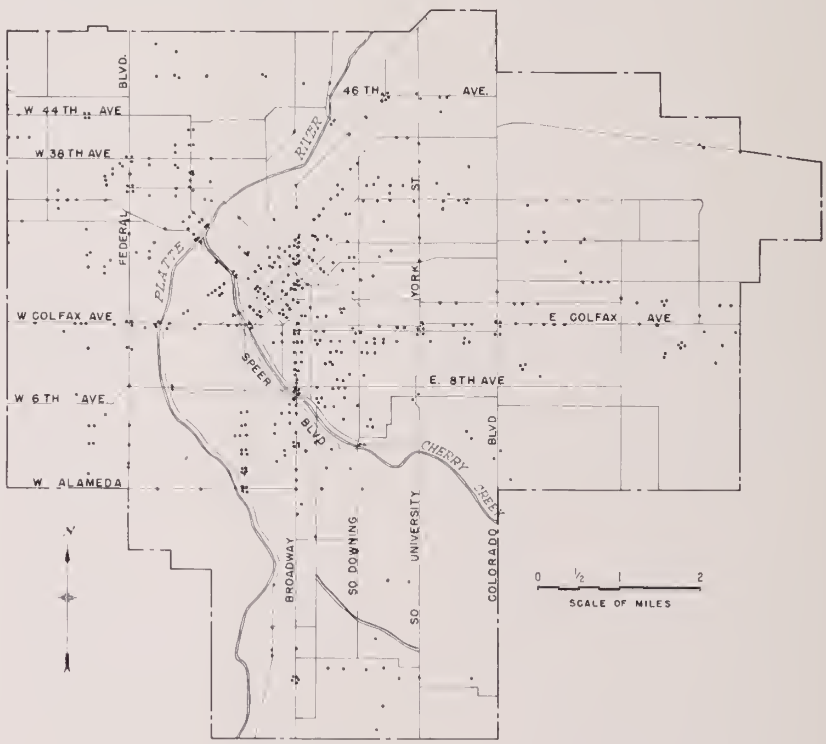


Fig. 20—*Police records for 1943 show that traffic accidents concentrate along the congested thoroughfares.*

For passenger cars the mileage-cost saving was computed by taking account of operating expense only, excluding depreciation, interest, insurance and taxes. On this basis it was found that the average passenger car will save 2 1/2 cents for every mile of reduced distance. The value of saving one minute of time for passenger cars was based on the direct benefit to business travelers and the approximate value of time saving to individuals as shown by present travel habits. For instance, the average man who drives to work in Denver rather than use tramway facilities spends about three-quarters of a cent per minute for time saving and convenience. Driving habits of Denver drivers indicate that on the average the extra distance that they will travel to save time and obtain convenience costs them about one cent per minute. The estimated value of one minute of saving to a business man varies from one cent to three cents. Because of the approximations involved in this type of determination, a value of one-half cent per minute for time saving has been adopted.

For trucks the saving per mile was also based on operating costs only, and the low cost of five cents per mile was adopted. The value of saving one minute of truck time, including the driver's time and fixed charges such as depreciation, interest, insurance, etc., was placed at 2 1/2 cents per minute.

All of these values are admittedly low, but for the purpose of benefit estimates the use of such figures will give a minimum estimate, which when compared with maximum estimate of cost will assure a conservative result.

In determining the number of cars which will benefit by use of this highway, three bases have been considered: (1) We could approximate the average number of cars which will use the project throughout its economic life. If this were done, the cost of the project would necessarily include the cost of the additional paving required to provide six lanes from 31st Street on the north to the South Broadway connection on the south. We estimate that the volume of traffic derived from this assumption would be approximately 145 percent of the traffic shown in Fig. 18. (2) The initial volume of traffic shown in Fig. 18, which was determined from 1939 traffic data and which we assume will be the traffic condition approximately two years after the war is over, could be taken as the basis of benefit appraisal. This, however, would not represent ultimate use of the facilities provided. (3) A third basis, and the one adopted, is to assume a volume of traffic which could be accommodated by the facilities provided in the initial construction — namely, four lanes throughout. It is estimated that this volume of traffic will be reached within five years after the completion of the project, and it represents a volume 15 percent greater than that shown in Fig. 18.

The method of determining the savings resulting from the use of the proposed highway is indicated by the three examples given below.

Trip 1

	PRESENT ROUTES	VALLEY HIGHWAY ROUTE
From:	University & Buchtel Blvds.	University & Buchtel Blvds.
To:	North city limits	North city limits
Via:	University Blvd., Speer Blvd., Broadway, and No. Washington	Valley Route
Distance:	9.1 mi.	9.3 mi.
Time:	35 min.	14 min.

BENEFIT OF VALLEY ROUTE:

Distance saved —0.2 mi. (negative saving)

Time saved 21 min.

Passenger cars:

—0.2	x	0.025	or	—0.005
21.0	x	0.005	or	0.105
Saving,				$0.10 per car per trip.

Trucks:

—0.02	x	0.05	or	—0.010
21.0	x	0.025	or	0.525
Saving,				$0.515 per truck per trip.

Trip 2

	PRESENT ROUTES	VALLEY HIGHWAY ROUTE
From:	Speer Blvd. and Platte St.	Speer Blvd. & Valley Route
To:	Ohio and Broadway	Ohio and Broadway
Via:	Speer Blvd., Broadway	Valley Route
Distance:	4.4 mi.	4.4 mi.
Time:	22 min.	6.6 min.

BENEFIT OF VALLEY ROUTE:

Passenger cars $0.07 per car per trip.
Trucks $0.385 per truck per trip.

Trip 3

From:	16th and Arapahoe Streets	16th and Arapahoe Streets
To:	North city limits	North city limits
Via:	Arapahoe, Broadway, North Washington	Valley Route
Distance:	3.6 mi.	3.6 mi.
Time:	14.3 min.	6.5 min.

BENEFIT OF VALLEY ROUTE:

Passenger cars $0.039 per car per trip.
Trucks $0.195 per car per trip.

Computations for the entire route in the above manner and using the volume of traffic indicated on Fig. 18 (initial traffic) show an annual benefit of $1,234,000. For the traffic equal to the capacity of the initial construction, the adopted basis defined above, the annual benefit will therefore be 1.15 times $1,234,000, or $1,419,000.

The annual cost of the Highway was determined by amortizing the total cost of the project at 3 percent interest, the economic life of the pavement being assumed to be 20 years and that of all other features (except those replaced in normal maintenance) 40 years, in consideration of possible obsolescence rather than physical wearing out. The cost of operating and maintaining the Highway was taken as $75,000 per year, including policing, road maintenance and care of landscaping. The total annual cost, including operation, maintenance and amortization, was thus found to be $753,000.

Comparing annual benefits with annual cost, the benefit ratio is found to be $1,419,000 divided by $753,000, or 1.88. If the full annual savings were to be used in defraying annual costs, it would take approximately 13 years to pay for the entire project.

As a matter of interest it may be added that the ratio of benefit to costs obtained by using the other two bases of traffic volume is: for the first basis 2.41, and for the second basis 1.64.

V. GENERAL DESIGN STANDARDS

Service Requirements

Efficient service on a modern highway of free-flow type requires that the construction meet a number of essential service requirements. The principal ones may be stated as follows:

Free flow: Traffic on the highway should be free from interruption by slowdowns, stops and bottlenecks.

Speed: High average speed should be regularly attainable.

Capacity: No congestion should occur at any point even under peak conditions of main or interchange traffic.

Safety: Road hazards should be eliminated as fully as experience makes possible.

Access and distribution: Free-flow interchange facilities providing for non-interfering movement on or off the highway should be provided at all major intersections. Less complete access facilities may be required at intermediate points, where left turns on the secondary road are permissible.

Parallel and cross traffic: Traffic alongside the highway should be accommodated by service roads, for adequate access to adjoining property. Cross traffic at points with sufficient volume of transverse movement should be taken care of by underpasses or overpasses.

Terminal and service facilities: Off-highway provision should be made for emergency stops, service needs and such terminal facilities (for example, bus loading stations) as conditions may justify.

Provision for expansion: Plan and design should facilitate future increase of traffic capacity, within reasonable limits.

An urban section of such a highway should in addition meet the special requirements imposed by its relation to the present and future city. It should conform in location and design to the existing city conditions and the probable directions and types of growth. It should be in harmony with the city's master thoroughfare plan, or, if no such plan has been formulated, with any probable future plan. Finally, it should enhance rather than depress property values and have a favorable influence on the city's development.

General Design

The Valley Highway, which has been planned throughout in conformity with these requirements, is designed to be a dual highway segregated from adjoining property, accessible only at special access or interchange points, and with opposing and conflicting traffic fully separated. Its two 2-lane roadways, which are in effect distinct highways independent as to alignment and grade, are divided by a median strip 44 feet wide, unbroken by connecting passages. Wide right of way, enclosed by fencing, protects the highway from lateral trespass, and planting in the median and side strips serves to screen the two roadways from each other and from outside property, minimizing glare interference and noise transmission. The wide median strip allows space for adding a third lane in each direction when required; it is to be built on the inner side of the initial roadways, leaving an ultimate median strip 20 feet wide. Full lighting of the highway is planned, in the interests of traffic safety and free flow.

Basic elements of design in general accord with the service requirements above indicated have been establishd by the Public Roads Administration and the Interregional Highway Committee. These standards have been adopted as fundamental to the general plan of the Valley Highway presented in this report. A design speed of 50 miles per hour controls the design.

The principal requirements of the authorities mentioned, applicable to the Valley Highway, fix the limit of curvature of the alignment for 50-mile design speed at 9°, and the desired maximum at 7°. The sight distance permissible is 400 feet. Maximum gradients have been specified only in terms of type of country traversed. As the nature of the terrain through which the Valley Highway passes is not controlling as to grades, we have adopted limits at structures and crossings consistent with efficient traffic movement, especially with a view to enabling heavy trucks to maintain speed on up-grades.

Alignment and sight distances of the Valley Highway are well within the limits specified. Our general preliminary plans embody a maximum curvature of 5°, spiraled (where more than 2°), and a minimum sight distance of 500 feet or more (reduced to 450 feet at only one point). Both maximum curvature and minimum sight distance occur at the passage under the Colfax-Larimer viaduct. Grades on the main highway have been limited to 4%, and the maximum grade is less than 500 feet long. The up-ramps of interchanges have a maximum grade of 4%, down-ramps 6%; the curves of these ramps have a minimum radius of 100 feet where speed-change lanes are used, elsewhere 140 feet.

Adequate side and vertical clearances are provided for in the plans. Where the Valley Highway underpasses bridges, the minimum horizontal clearance distance from edge of pavement to any part of the structure is fixed at 4 feet, but faces of abutments are set outside the roadway shoulder, or 13 feet from edge of pavement. Additional clearance width has been allowed where necessary to maintain the required sight distance or to prevent a cramped appearance of the structure openings. Vertical clearance in underpasses is 16 feet minimum at edge of pavement and 14 1/2 feet at edge of roadway shoulder (Colorado State Highway standard).

Where the Valley Highway overpasses railroad tracks, the lowest portion of the structure is kept 23 feet above top of rail, and the faces of piers and abutments have a minimum horizontal clearance of 10 feet from center line of track. Over main streets and highways passing under the Valley Highway the vertical clearance is fixed at 16 feet, over minor streets at 14 feet.

All structures are designed for adequate loadings: Cooper's E-72 loading for structures carrying railway tracks, and the loadings of the 1941 specifications of the American Association of State Highway Officials for street and highway structures.

No service stations or concessions are contemplated, and it is recommended that they be excluded from the Highway. Also, safety and freedom of traffic are believed to demand that no utility structures above ground be permitted other than the lighting standards necessary for illumination of the Highway.

Roadway and Pavement

A lane width of 12 ft. is used throughout on the main highway, without additional widening on curves. A speed-change lane is added outside the outer lane at the approach to an exit or an interchange. The roadways are superelevated on curves by the full amount required to compensate for centrifugal effect. A 3-foot curb strip of pavement with non-mountable curb adjoins the inner edge of the pavement, while a 5-foot lip gutter borders the outer edge.

Outside the gutter, a 5-foot strip of the shoulder is consolidated to form with the gutter a refuge space 10 feet wide for the use of disabled vehicles. No other parking facilities are included in our plans. Should off-road parking facilities be found desirable for accommodation of local traffic, it is recommended that they be provided by the city on land outside the right of way.

The median strip is drained toward the center, while the roadways are drained toward the outside except where superelevation turns the drainage toward the inner curb. The median strip and the right of way outside the refuge strip are to be grassed, as far as the planting areas; a sprinkler system is provided for maintenance of grass and shrubbery.

Concrete pavement with bituminous wearing surface has been adopted for the main roadway. The subgrade is to be reinforced with selected material to distribute the roadway loads, and a sand cushion is to be placed over this reinforcement as bed for the concrete slab. Where speed-change lanes diverge from the roadway, they are to be built of concrete without added wearing surface, in order to give a color difference as a guide to traffic. Bridge decks are to have the same type of pavement as the remainder of the roadway.

Ramp roadways at interchanges and access points will be 16 to 20 feet wide, superelevated for 30-mile speed. They are to have bituminous surfacing.

Appurtenances

On the approaches to bridges and at points where the roadway embankment slopes are steeper than 1 on 4, which is the case wherever the embankment is more than 10 feet high, a guard rail is to be placed outside the shoulders. The entire right of way is planned to be fenced.

For lighting the roadway, standards spaced 225 feet are to have fixtures 28 feet above the roadway.

To guide traffic, thorough informational and directional signing is believed to be essential. Our estimate includes an allowance for the cost of signing, but no details of the signing are shown. Location and type of signs should be in conformity with Colorado and federal standard practice.

Interchanges

Estimates of traffic flow at interchanges, based on all data available at present, indicate that single-lane transfers will be adequate at all points. The origin-and-destination survey now in progress is expected to give important information to define the volume of interchange movements more precisely. Should the results indicate that certain of the turning movements call for larger capacity, provision therefor can readily be made in the development of the detail plans.

Service Roads

Service roads are provided alongside the Valley Highway wherever existing streets are not available to give needed access to property alongside. They are to have a bituminous roadway 24 feet wide, curbed on both sides, and on the land side a concrete sidewalk integral with the curb.

VI. PRELIMINARY PLANS

General plans developed in accordance with the standards and design elements set forth in the preceding chapter are presented on the appended Plates 1 to 18. Typical cross sections are shown on Plate 1, while the plan of the highway is shown on Plates 3 to 12, in divisions indicated by the index map Plate 2. Details of alignment and profile are given by Plates 13 to 18.

Detail Location of the Valley Highway

The controlling features of detail location of the Valley Highway may be stated briefly as follows:

The line enters the city from the north at 52nd Avenue midway between Bannock and Acoma Streets; the location here was chosen to maintain these two streets for use as service roads. South to 43rd Avenue the area occupied by the highway contains no improvements, and a line due south assured an excellent profile with minimum grades. As explained later, at 50th Avenue access entrances are necessary; at 48th Avenue an overpass structure crosses the street and a railroad track.

After traversing an interchange at 46th Avenue the line of the highway curves to the west, to cross 38th Avenue and Fox street as well as the tracks of the Denver & Salt Lake and the Colorado & Southern railways. Local conditions made it necessary to hold the crossing of the railway lines as far north as practicable while keeping the highway sufficiently far east of the subway which carries 38th Avenue under the railroad tracks to give space for the important interchange at Fox Street and 38th Avenue. As located, the line of the highway meets these conditions with minimum curvature.

This part of the line is also controlled by the fact that freight traffic accommodation requires a connection southeastward to the Broadway viaduct, which must be extended for the purpose. Study of various methods of coordinating the connections to Broadway, 38th Avenue and Fox Street led to the conclusion that it is undesirable to combine the three connections in a single interchange, especially as the available area is restricted. The adopted solution provides for a future connection with Broadway near 31st Street, to be built when the city reconstructs the viaduct in connection with the Market Street improvement. A single interchange connecting the Highway with 38th Avenue and Fox Street is practicable, however, and is part of the initial project construction. The position of this interchange, which was determined by the available ground space, the 38th Avenue underpass and a 78-inch sanitary sewer, controlled the location of the Highway here.

Near 36th Avenue, where the two railway tracks are crossed, comparative study of an underpass and an overpass led to adoption of the latter, as an underpass would have given rise to drainage problems calling for a permanent pumping plant. Adoption of an overpass required holding the line well to the north, since south of this point the tracks spread in two directions, the Denver & Salt Lake line diverging to the west while a new yard connection of the Colorado & Southern diverges to the east. The alignment adopted assures a curvature north of the overpass within the limits of the design standards and requires the minimum length of structure.

From 36th Avenue to 32nd Avenue an alignment parallel to the Denver & Salt Lake tracks was adopted, as it involves minimum interference with improvements, has low right-of-way cost, and provides a satisfactory longitudinal profile. The line passes under the 20th Street viaduct at the intersection of 32nd Avenue and Navajo Street, where the viaduct bents have such spacing as to allow passage of the highway without viaduct reconstruction.

From the 20th Street to the 14th Street viaduct the alignment is controlled by the structures at the 18th and 15th Street undercrossings and the space requirement for the 14th Street interchange. The highway is here depressed below the ground surface, passing under 18th Street, where ramp connections are to be provided as means of distributing traffic to the 20th Street and 16th Street viaducts. The crossing under the 16th Street viaduct is made at a point immediately adjacent to the northwest abutment, which location permits of most economical reconstruction of the viaduct structure at this point. Along the section to 16th Street, Central Avenue and Platte Street will serve as side service roads.

After underpassing 15th Street, provision for a major interchange to connect with Speer Boulevard and the 14th Street viaduct is necessary. City plans for improvement of North Speer Boulevard influenced the location. Extension of North Speer Boulevard in direct alignment to reach a straightened 14th Street viaduct is contemplated, together with widening the boulevard for adequate accommodation of the relatively heavy traffic. Straightening the irregularly aligned north end of the 14th Street viaduct would be carried out at the same time. By such improvement the existing hazardous connection between the boulevard and the 14th Street viaduct would be eliminated. For temporary service, pending the construction of this improvement, a modified interchange with ramp connections would be constructed as part of the highway project (Plate 12).

The alignment of the Valley Highway between the 14th Street interchange and West 21st Avenue was determined by topography and existing improvements. A large hill west of Alcott Street, extending from 23rd to 21st Avenue, made it desirable to keep the highway alignment as far east as possible without interfering with existing industrial improvements, while maintenance of a moderate grade on the 23rd Avenue connection made it desirable to keep as far west as possible. Construction requirements also entered the case, as much fill material is required for that part of the highway north of 20th Street; the adopted location, running in cut between 20th Street and 23rd Avenue, provides a large amount of the required fill.

Much detail study was given to the location from 21st Avenue to 12th Avenue. Lines on the west as well as the east sides of the South Platte River were examined. A west side location from 19th Avenue south, passing under the Colfax Avenue viaduct between Clay and Bryant Streets, crossing the Denver & Intermountain railway tracks near West Howard Place, and bridging the South Platte River at West Tenth Avenue, involved substantial additional cost in providing an interchange connection with Walnut Street, and had the further disadvantage of carrying traffic too far west of the valley areas in which a large volume of traffic originates. The east side line was therefore concluded to be considerably better.

A further extension of the west-side location was also studied, to avoid some disadvantageous features of the Tenth Avenue river crossing. This extension proceeded south near Bryant Street to Sixth Avenue, and thence southeastward through the intersection of Pecos Street and West Byers Place; it crossed the river near the line of Virginia Avenue and joined the adopted location near the Denver & Rio Grande Western undercrossing.

This location had the advantage of making unnecessary any change in the Colorado & Southern Ry. trackage near Sixth Avenue, as the Sixth Avenue interchange would lie west of the river. Further, it did not require abandonment of the Colorado & Southern bridge at Fourth Avenue and its replacement by a new bridge farther north. The cost of the Valley Highway on this line would have been materially less than on the line previously discussed (crossing the river at Tenth Avenue), but would have been greater than the cost of the adopted line and in addition would have increased the route length by 1/4 mile. These disadvantages, together with the less efficient traffic service of the west side location, decided in favor of the east side line, shown by our plans.

The adopted line crosses the river near 17th Avenue. Just east of the river its location was controlled by property occupancy and the Colfax-Larimer viaduct. From First Street to the river, north of Colfax Avenue, the area is fully occupied by industries and railway tracks, and it was therefore imperative to locate the highway line northeast of First Street. In view of the necessity for a connection to Walnut Street as a freight distributing artery, it was important to keep the line far enough from First Street to assure a satisfactory grade of Walnut Street from the surface at First Street to the highway overcrossing. These considerations, in connection with the restrictions imposed by the necessity of underpassing the Colfax-Larimer viaduct, fixed the best location at about Second Street. The profile of the highway in this section is complicated by the crossing over the Platte River and the railroad tracks alongside, the crossing under the viaduct, and just south of the latter a crossing over the Denver &

Intermountain Ry.; short lengths of 4% grade had to be used. The alignment adopted affords the most favorable grades as well as the best adaptation to ground conditions.

From West 14th Avenue south the highway alignment swings west toward the river to avoid industrial and school developments. From Ninth Avenue to Third Avenue the alignment was determined by the space required for a major interchange at Sixth Avenue. Railroad trackage east of the highway location forced the interchange as close to the river as possible, but some track relocation cannot be avoided.

South of Third Avenue to Cedar Avenue the highway extends along the river bank, which assures low right-of-way costs and a good alignment and profile, at the expense of a track relocation. This relocation, however, eliminates the need for two railroad crossings.

At Alameda Avenue it is necessary to pass between the existing subway under the railroad tracks on the east and the river on the west, and at the same time provide a traffic connection. These restrictions fixed the highway location here. Just beyond Alameda Avenue, Santa Fe Drive is crossed by an overpass. Because of property restrictions, the Alameda connection is made on the north side only, and the south connections are made to Santa Fe Drive. The alternate location on the west side of the river to Virginia Avenue, mentioned just above, was studied primarily to give better conditions at these interchanges, but it was rejected because of higher cost and increased route length and the traffic disadvantage arising from the psychological barrier effect of the river.

Between South Santa Fe Drive and Kentucky Avenue the location is controlled by industrial development. Depressed construction was found more economical than viaduct construction. The alignment shown involves a minimum of disturbance of industrial facilities. The highway underpasses the parallel lines of the Denver & Rio Grande, the Santa Fe and the Colorado & Southern, and then underpasses Broadway. Study of locations farther to the south, to cross Broadway near Mississippi Avenue, showed that high property costs would be incurred, and the adopted alignment was found to be most economical.

From Pearl Street to University Boulevard, existing improvements placed the location north of the Colorado & Southern branch line. Topographic conditions together with the necessary provision for interchanges at Downing Street and University Boulevard dictated the detail of the alignment.

Highway Design

Construction in accordance with the typical sections shown by Plate 1 is maintained consistently throughout the length of the line except for modification at structures, which however involves no reduction in clearances. Side planting is omitted at a few points of restricted right-of-way width, and the median strip of the roadway is omitted at overpasses; the latter comprise two parallel single bridges carrying roadways spaced the same as on the remainder of the line, the width of the median strip being left open.

The two roadways are not everywhere at the same level, but are fitted to the side slope of the ground where such arrangement was found economical. In the preliminary plans they have been spaced a uniform distance apart, although closer study of property adjustments in connection with the development of detail designs may indicate that variation of spacing is advantageous.

The highway design shown by the cross sections conforms to all requirements of free traffic movement and full safety, together with favorable effect on the adjoining city regions through good esthetic effect. The Valley Highway is, in effect, a long, narrow park extending through the center of the city.

It will be noted from the typical cross sections that a 10-foot shoulder strip along either side of the highway is maintained throughout (except on overpass bridges). This shoulder strip, which provides an emergency standing area for disabled vehicles, is to have a hard earth surface formed by extending the subgrade reinforcement of the roadway out over the shoulders and graveling the surface. Except where the roadway fill exceeds 10 feet in height, no guard rail protection is thought necessary.

Landscaping is planned as an integral element of the highway construction. The median strip is to be grassed for a width of 10 feet along the roadway curb, while the area within these strips would be planted with shrubbery and possibly low trees in such manner as to serve as screen between the opposing roadways to eliminate or reduce the glare of oncoming headlights and also damp out noise transmission. Similar planting is to be applied outside the roadways, to form a screen and a protection against trespass between the highway and adjoining property.

A full sprinkler system to facilitate the necessary irrigation of grass and planted areas has been included in our estimate of cost. Details of its location and construction remain to be worked out in the detail design of the highway.

Location of the lighting standards is indicated by a typical detail on the cross section sheet. As previously stated, these standards are intended to be spaced about 225 feet apart. Details of the lighting system are to be developed in the later detail design.

Interchanges

Traffic interchanges will be required at all crossings of major city thoroughfares. Present traffic flow on these thoroughfares affords a sufficient basis for preliminary estimate of the required movements, and from these it has been concluded that no single interchange movement will require more than a single lane width. Should restudy of interchange volumes from the results of the origin-and-destination survey of city traffic now in progress indicate the need for increased capacity at certain interchange loops or ramps, the plans can readily be modified to suit.

Various types of traffic interchange were considered. Some types are shown diagrammatically by the sketch drawing Fig. 21.

Interchanges which eliminate left turns and provide grade separation at crossings fall into four general groups. The first and most simple of these is the simple ramp connection. This type of connection is dependent upon the possibility of making left turns on one of the intersecting highways, and is generally used at the intersection of a major and minor highway. Left turns are eliminated on the major highway only.

The second type of interchange is the rotary intersection. In its basic form no structures are required, and traffic interference is prevented by causing all vehicles to travel on the circle. The basic or one-level type of rotary is not satisfactory for other than a moderately low volume of traffic. The fact that all traffic must travel on a circle not only causes confusion but presents an obstacle to through traffic. For traffic of large volume it is necessary to run the major highway directly through the rotary, providing grade separations between the circle and the through route. This type of construction is known as a bridged rotary. A through route may be provided also for the minor highway, if required. The principal advantage of a bridged rotary is that when turning movements are high they can be accommodated by the use of additional lanes on the structures. Its principal disadvantage is the number and cost of the grade separation structures.

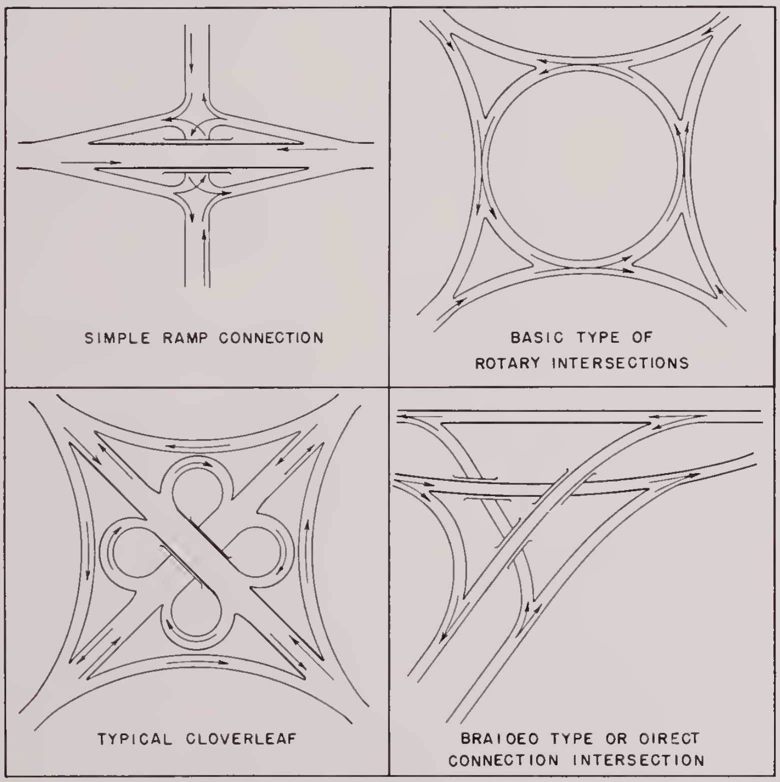


Fig. 21—*Some types of traffic interchange, represented diagrammatically.*

The more common type of interchange is the one known as the cloverleaf. This type of construction makes possible the elimination of left turns on both highways with the use of only one structure. For this reason it is usually the least expensive type of interchange for two major highways. For effective operation all ramps should consist of a single lane only and because of this the intensity of turning movements that can be accommodated is limited.

For extremely busy intersections with large volumes of turning movement, it may be necessary to use the braided type or direct-connection intersection. This type of intersection has the advantage of providing adequate facilities for any reasonable amount of turning movement. It also has the second advantage of allowing people who wish to turn to the left to do so directly rather than making an initial turn to the right. This direct left turn is made without crossing the traffic flow from the other direction. This type of intersection is extremely expensive since it requires not less than three structures for a junction as shown in the figure and usually requires eight structures for an intersection of main highways. Because of the expense this type of intersection can not be justified except in the case of volumes of through traffic and turning movement which are very much in excess of any which will be encountered in the Rocky Mountain area.

Following the Highway from north to south, access provision or traffic interchange is required at the points indicated below:

At 50th Avenue access is provided to serve the adjacent Burlington shops and a somewhat compact residential area lying between Broadway and Washington Street. One type studied comprised an overpass at West Burlington Place, directly in front of the shop entrance, with ramp connections to the Valley Highway. Later, railroad realignment at and south of 48th Avenue made it necessary to provide an overpass of 48th Avenue and a relocated railroad connecting track, and with this construction it became possible to eliminate the Burlington Place overpass and to provide simple stop entrances at 50th Avenue, where the Highway is at street grade, to function in connection with this overpass. By developing Bannock Street on the west side of the Highway as a service road from 48th Avenue to the shop entrance, full service to the shops is assured.

At 46th Avenue an interchange of high type, eliminating all left turns on both highways, is imperative because 46th Avenue east of the Highway and 48th Avenue west of the Highway will undoubtedly be developed as a major east-west thoroughfare. After full consideration a cloverleaf type of interchange was adopted as the most suitable, for the reason that it provides adequate facility for all turning movements, is simplest from the standpoint of the vehicle operator with the possible exception of a simplified direct-connection interchange, and contains only one structure and no more ramp construction than other types. It is also cheaper in construction than any type giving equivalent service.

Improvement of 46th Avenue east of the Highway and the connection from the interchange to 48th Avenue west of the Highway are included as an integral part of the Valley Highway project (see Plate 11). A closely built-up community lying east of the Valley Highway will be divided by the approach along 46th Avenue, and it is therefore necessary to provide side service roads from Leaf Court east to Washington Street, a pedestrian underpass at Lincoln Street and a pedestrian overpass at Pennsylvania Street. From this approach, 46th Avenue is carried under the Valley Highway with sufficient clearance width to allow space for speed-change lanes, thus assuring maximum capacity and rate of flow of traffic. An overpass has been used as grade separation structure where 48th Avenue crosses the Colorado & Southern and Denver & Salt Lake tracks, as more economical than an underpass and free from ground-water difficulties. It is assumed that, in accordance with preliminary discussions with railroad officials, the Colorado & Southern tracks will be lowered 8 feet in this vicinity, to the level of the Salt Lake tracks; the change will assure easier grades on the 48th Avenue approach and reduce the length of the overcrossing structure; it may also provide additional borrow for use in the highway.

Construction of the 46th-48th Avenue approach sections is planned to be identical with that of the Valley Highway itself, except for reduction of the median strip to 24 feet width.

South of the 46th Avenue interchange the Valley Highway is to be crossed by an overpass at 44th Avenue, for communication between the residential area west of the highway and the residential and business area east of the highway. No access to the Valley Highway is to be provided here. Because of the facilities afforded by this overpass, the present Globeville road which now serves this area can be abandoned, its traffic being rerouted by way of Fox Street and 44th Avenue.

Major traffic connections next are required at the future Broadway extension in the vicinity of 31st Street, and at 38th Avenue and Fox Street. Original plans for a joint interchange proved to be unsatisfactory, in part because of the necessity for free movement from 38th Avenue south on Fox Street, the need for access to the Valley Highway from both thoroughfares, and the turning movements into Broadway, all of which overtaxed the limitations of grade and available space. Other possibilities involved either a grade crossing of 38th Avenue immediately west of the Highway route or extensive retaining wall construction and objectionable traffic conditions with short sight distance. The plan shown, which separates the Broadway interchange from the 38th Avenue-Fox Street interchange, was adopted as the best means of overcoming these objections. It gives easy and safe movement of traffic in all directions and is cheaper in construction. It eliminates the necessity of virtually abandoning use of the present 23rd Street viaduct as a distribution route into the business district of the city. Finally, as the time when the new Broadway viaduct will be built is indefinite, the unsatisfactory expedient of building a temporary and incomplete interchange is avoided.

Picture by Fairchild Aerial Surveys, Inc.

FIG. 22—*Looped roadways are used to provide free traffic flow at the connection between Wellwood Avenue and Southern State Parkway at Pinelawn, New York.*

The plan as drawn contemplates building the 38th Avenue-Fox Street interchange in ultimate form, as a modified cloverleaf, and building the trumpet-type Broadway interchange when the new viaduct is constructed. Against these marked advantages, the adopted arrangement makes it necessary for traffic destined from 38th Avenue into Broadway to pass through loops and travel along the Valley Highway for a short distance. In order to facilitate such movement, the speed-change lanes on the two ramps are carried continuously along the Highway between the two interchanges.

Full traffic distribution to the east side of the river makes it desirable to utilize all of the valley viaducts as branches of the Valley Highway. This would imply connection to the 20th Street and 16th Street viaducts; connection to these viaducts has therefore had extended study. Direct connections to these viaducts would involve very costly construction and almost inevitably would involve the use of left turns on the viaducts themselves. A connection of equal directness and traffic value has been worked out by providing ramp interchanges to the Valley Highway at 18th Street, from which both viaducts can be reached with only a small amount of added travel distance. This arrangement, embodied in our plans, eliminates left turns on the viaducts, though requiring some such turns on the city streets.

The interchange plan in this vicinity is influenced also by the fact that both the 16th and 20th Street viaducts are now rather fully taxed by direct traffic between the residential area west of the Highway and the downtown district, and provision of interchanges of high type would tend to overload them. Partly because of traffic conditions it is believed that the logical place for traffic on the Highway to enter the business district is at 14th Street if approaching from the south, and Broadway (31st Street) if approaching from the north.

At 15th Street a non-access crossing is included in our plans. The requirements of traffic on 15th Street are believed to render interchange provision unnecessary.

Speer Boulevard, of which the 14th Street viaduct is the connecting link across the valley, appears certain to be developed into a limited-access highway in the relatively near future. For this reason a full cloverleaf interchange at its intersection with the Valley Highway has been given thorough study, and the design shown on the general plans has been developed. Until the North Speer Boulevard improvement is made, however, a temporary interchange will be required (Plate 12). As Speer Boulevard is a major traffic artery, and as the part extending from the east bank of the river to Zuni Street is now on irregular alignment, which is highly unsatisfactory as to both traffic efficiency and safety, the improvement when carried out should logically include realignment of the westerly part of the viaduct and that part of the boulevard extending to Zuni Street. Our plan shows the ultimate cloverleaf interchange so placed as to conform to this realignment.

The Speer Boulevard interchange may be ranked as a key point of the Valley Highway because of the large volume of interchange traffic likely to develop here. Much of the passenger traffic on the Valley Highway from both north and south will find its best route to the city center over this interchange, and the fact that the 14th Street viaduct connects two densely populated areas and passes close to the retail business district will add to the traffic.

Access to the Valley Highway is believed to be required also at 23rd Street. It would accommodate the residential area west of the Highway which now travels by way of 23rd Street and the existing ramp along Water Street to the 14th Street viaduct as a means of reaching the business district, and also will give access to the commercial area east of the Highway, including the Colorado & Southern roundhouse, repair shop and yards. Simple ramp construction is believed satisfactory for this access.

FIG. 23—*Sketch of the projected 46th Avenue cloverleaf of the Valley Highway, seen looking northeast; at the right is the connection to East 46th Avenue, at the left curve to join 48th Avenue.*

Highly important interchange movements are required to be accommodated at the Second Street junction with the proposed Market Street improvement. Even prior to construction of the improvement much market traffic will be certain to enter and leave the highway at this point, in view of the active commercial business centering along Walnut, Market and adjoining streets. Occupancy conditions in this vicinity are unusually restrictive, however, and in order not to exceed the desired limits of grade and curvature a modified ramp interchange must be used. While not as free-moving as might be desired, it furnishes the best solution under the conditions of the location, and is believed to meet the requirements of traffic satisfactorily.

In the development plans of the city the construction of a limited-access highway in the vicinity of 12th Avenue has had frequent consideration. Should such a thoroughfare be constructed, it would call for an efficient interchange with the Valley Highway. The possibility of such construction has been considered in determining the highway location, and a cloverleaf interchange could be built without encountering major difficulties. However, because of the many questions connected with this potential future development such an interchange is not shown on our plans.

Eighth Avenue seems likely to remain for a long time an important thoroughfare for local east-west traffic. A non-access intersection is therefore provided, the Highway overpassing Eighth Avenue. It should be remarked, however, that if the Valley Highway is built prior to construction of the Sixth Avenue thoroughfare and river bridge mentioned in the next paragraph, entrance ramps to the Highway should be provided at Eighth Avenue to serve traffic bound for the West Sixth Avenue freeway by way of the existing river bridge at Eighth Avenue.

In all plans for city thoroughfare development a limited-access highway on West Sixth Avenue is included. West of Federal Boulevard such a freeway is already in existence, having been built two years ago as a main traffic-way to the Denver Ordnance Plant, five miles west. Extension of this freeway eastward across the river should not be long deferred, and a major traffic interchange with the Valley Highway appears an indispensable requisite. The cloverleaf type of interchange is best adapted to conditions at this point, for reasons identical with those given in connection with the 46th Avenue interchange.

Track relocation required to provide space for the cloverleaf and for an adjacent section of the Valley Highway is mentioned farther on, as is also the proposed construction program, under which the building of the interchange would be deferred until such time as the Sixth Avenue improvement is carried out.

The Valley Highway crosses Alameda Avenue and Santa Fe Drive near their intersections. It is not probable that either of these streets will be developed into a limited-access thoroughfare. On the other hand, both of them provide important traffic connections, and interchange provision is therefore essential. Space limitations as well as the expected direction of the principal traffic movements dictated adoption of ramp interchanges, as shown on the plans. While the limitations of available space somewhat complicate the ramp arrangement, relatively free interchange with both streets is rendered possible.

Because of the trends of industrial and commercial development outlined in previous sections of this report, Broadway will undoubtedly never be developed as a limited-access thoroughfare. Ramp connections as shown will assure fully adequate service under these conditions. A large volume of interchange movement must be anticipated here, but because of the convergence of Broadway and the Valley Highway left turns will be virtually absent, and free flow is obtained by the connections planned. However, it is not expected that Broadway traffic at this point will at any time be so heavy as to make left turns objectionable, and this was in fact the primary reason for adopting ramp connections in place of an interchange of higher type, which would have been considerably more expensive. The ramp grades here are somewhat heavier than at other interchanges and access ramps, because of the proximity of the railroad bridges where the Valley Highway underpasses the lines leading south out of Denver. Nevertheless the grades are well within the limits accepted as permissible on major highway connections, and should present no traffic obstacle.

In the area east of Broadway, Logan Street is a thoroughfare carrying an important amount of north-south traffic, while Pearl Street, two blocks to the east, is the principal street-railway route to the extensive residential area south of Buchtel Boulevard and east of Broadway. It is not believed desirable to add to the Logan Street traffic by interchange with the Valley Highway, and in view of the provision of adequate interchange facilities at Downing Street, a few blocks to the east, as well as the access facilities at Broadway, a short distance to the west, no traffic connections have been planned at Logan Street. However, both Logan Street and Pearl Street are to be carried across the Highway on bridges. In addition, Pearl Street from Mississippi Avenue to Louisiana Avenue is to be widened as part of the project in order to provide additional traffic width outside the streetcar tracks and take care of the important Louisiana Avenue traffic.

City development indicates that it will be necessary in the relatively near future to develop Downing Street north of the Valley Highway into some form of limited-access thoroughfare. South of the Highway such construction is less probable. A traffic connection at Downing Street is believed essential, primarily as a means of access to the Valley Highway but also to utilize Downing Street as a distribution route into the large residential area extending northward to Cherry Creek.

In order to provide adequate access, and because space conditions virtually preclude use of a cloverleaf, a two-bridge rotary interchange has been designed for this point. This interchange, although involving two structures, appears necessary because of the heavy interchange movement expected. The design provides easy turning movement and satisfies all the principal traffic require-

FIG. 24—*Proposed interchanges at 38th Avenue and Fox Street, and at the westerly end of the proposed new Broadway viaduct.*

ments, with the disadvantage of moderate inconvenience to through traffic along Downing Street, which is expected to be relatively insignificant in amount.

University Boulevard, the terminal point of the Denver Project, will probably never be developed on a limited-access basis, in view of the small amount of occupied territory to the south and the certainty that a major interchange will be required at Colorado Boulevard, the next thoroughfare to the east. Nevertheless University Boulevard is relatively important for local north-south traffic, largely drawn from the residential, estate and country club region a short distance south. Further, being the nearest thoroughfare to the Denver University stadium, it is subject to the chance of carrying the highest temporary traffic peaks that are to be expected anywhere in the city.

The conditions stated are believed to require provision for access at University Boulevard and also for non-intersection crossing of the stadium traffic. A ramped interchange is therefore planned at University Boulevard, which street is to be carried over the Valley Highway, and additional direct connection from the stadium parking area across the Highway to Race Street is provided to facilitate the flow of traffic peaks into University Boulevard.

Structures

Development of general designs for the structures of the Valley Highway has been worked out with regard to both economy and satisfactory appearance, in addition to the primary requisites of strength and permanence. All interchange structures are planned to be of rigid-frame construction of concrete, while the river bridge and the bridges carrying the main-line railroad tracks over the Highway have been designed as steel plate-girder structures on concrete substructures. All have been designed for a loading corresponding to most advanced modern traffic conditions.

As already stated, the bridges which carry the Valley Highway over streets or railway tracks are planned to be dual, consisting of two parallel bridges each carrying a one-direction roadway, including any speed-change lanes that reach or traverse the bridge. The space between the parallel bridges would be left open. Underpass bridges are single structures.

A plain form of design has been adopted, devoid of special architectural organization or ornament, in the belief that the simplicity of such construction and its direct expression of function will have full esthetic value. Nevertheless, in the course of detail design fuller consideration will undoubtedly be given to the esthetic possibilities and requirements of these structures.

In view of the snow conditions likely to prevail in the Denver region in winter, open railings are believed to be necessary to prevent accumulation of snow in storms. For this purpose as well as in the interests of economy and simplicity, a simple open metal railing is suggested. This feature however requires fuller study in the course of detail design, in connection with the general consideration of esthetic development of the bridges.

Appurtenances

Included in our general plans and estimates are those essential appurtenances necessary either to supplement and protect the main construction or to assure effective service and safety.

FIG. 25—*How the Downing Street rotary will appear. The branch line of the Colorado & Southern along Buchtel Boulevard is at the right-hand edge of the highway right of way. Downing Street to the left of the Valley Highway is shown as it will be when widened.*

Drainage is to be taken care of by a main drain pipe carried longitudinally along the center line of the median strip. Drainage of the median strip itself is toward catch basins along the center line, while the roadways have a drainage slope outward to a shallow lip gutter along their outer edge. Catchbasins and transverse drains connect this gutter with the central drain line. At suitable intervals transverse outfall drains will take the discharge from the central drain pipe to city sewers or to the river.

Guard rails at all hazardous points of the embankment (where the side slopes are steeper than 4:1) and at the approaches to bridges are included in our estimate. Detail designs have not been prepared; the type of guard rail adopted should conform to the current practice of the Colorado Highway Department for high-speed roads.

A complete lighting system is considered essential to safe and efficient traffic service of the Valley Highway. The type of lighting fixture, intensity of illumination and related features require to be developed in connection with the preparation of detail designs.

Full direction, information and safety signing is an indispensable requirement, and the cost of signing has accordingly been included in our estimate. Type and position of signs should have thorough study in the final design stage, with due attention to advance signing on both the main highway and interchange thoroughfares.

To preserve the essential character of the Valley Highway as a sustained speed thoroughfare, speed zones or related restrictions must be avoided. At the time of inception of the project full agreement should be reached between the federal, state and city authorities that no speed restrictions below 50 miles per hour are at any time to be imposed. In connection with such agreement, also, care should be taken to exclude permanently all utility structures above ground, except the lighting standards for illumination of the Highway. Similar safety considerations counsel exclusion of all city bus traffic, except for use of the Highway as a no-stop express section.

No concessions should be tolerated on the Highway, the prohibition to include service stations. Parking areas considered desirable for the convenience of traffic using the Highway should be a city responsibility, and their location and layout should be such as in the opinion of the state highway authorities will be consistent with unrestricted operation of the Highway.

Special Construction

Few special construction problems are presented by the Valley Highway project. Three points are believed to require present mention, however.

Foundation conditions are in general excellent. East of the river valley, as well as in the river bottom and on most of the west slope, the subsoil is principally sand and gravel, with occasional interleaved clay or shale strata, but part of the route passes through an area where foundations will be in clay. Present information indicates that most of the clay encountered will be compact and will have high bearing capacity. The possibility of encountering some areas of softer consistency must be kept in view, however, and some additional cost of foundations

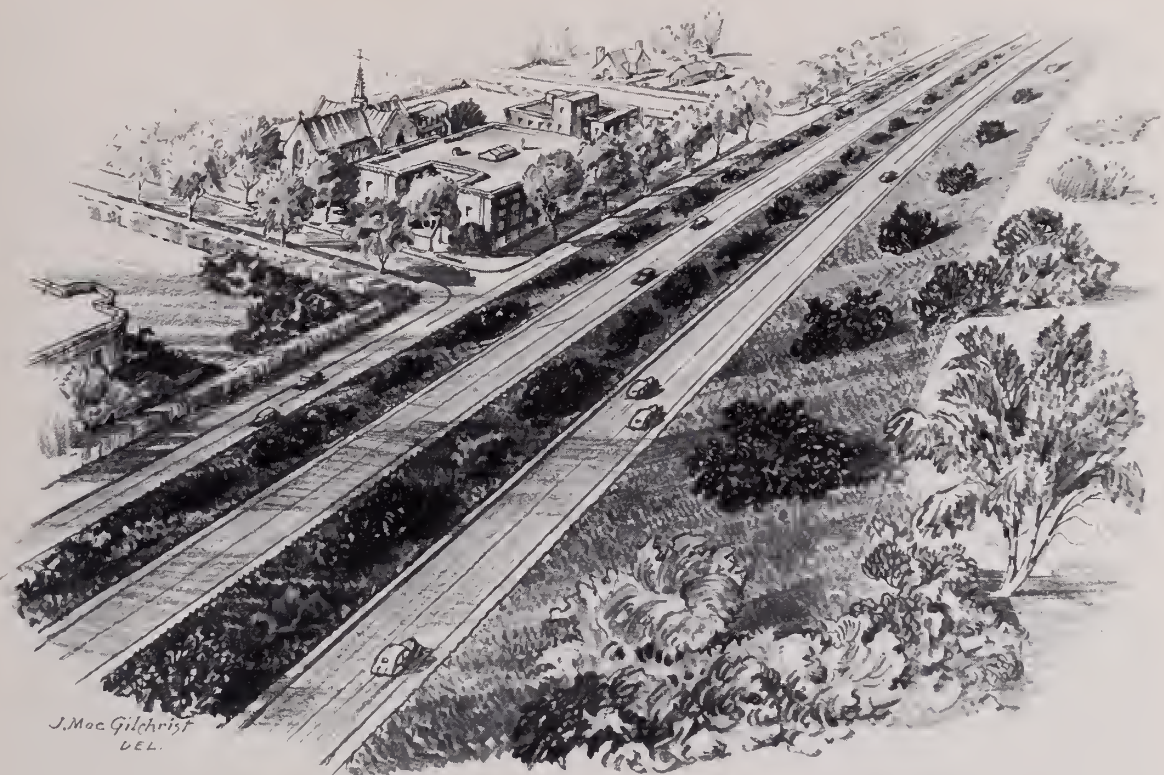


Fig. 26—*The Valley Highway as seen by the artist: Dual roadways separated by a landscaped median strip and bordered by service roads where adjoining property requires.*

may be entailed in dealing with these conditions. Allowance has been made in our cost estimate for such additional construction expense.

The northern and central parts of the Valley Highway include a volume of embankment largely exceeding the volume of excavation and therefore requiring extensive borrow. It is believed that undeveloped areas along the northern half of the highway afford opportunity for desirable grading that would provide much of the needed fill material. To determine the best and cheapest source of required borrow will require more extended surveys, however, and we have estimated the construction cost of the project on the assumption that it will be necessary to pay for enough borrow material to provide the full excess of embankment over excavation, except for the amount obtainable from the contemplated railroad changes.

South of 23rd Street the location of the Valley Highway crosses an old claypit area of considerable extent, now utilized as a city rubbish dump. The possibility is foreseen that the high embankment required in this region will impose a greater load on the dump than it can carry within tolerable settlement limits. In order to obtain a solid foundation it may be necessary to excavate most or all of the dump material now in place within the embankment limits, and our estimates include the necessary cost of this work. Should such excavation

FIG. 27—*At the southern terminus of the Denver Project, the Valley Highway is to have ramp connections to University Boulevard, which crosses the sketch near the top. A few blocks to the west, a bridge across the Highway would handle traffic concentrations coming from the parking area of Denver University's stadium.*

have to be carried out, the excavated dump fill might suitably be deposited along the embankment slopes, outside their normal section. Fill so used would be covered with earth to a smooth surface satisfactorily adapted to grassing or planting.

Stage Construction

Reference has previously been made to the dependence of full traffic service of the Valley Highway on three associated improvements: the 31st Street connection to the Broadway viaduct; the 14th Street-Speer Boulevard improvement; and the extension of West Sixth Avenue across the river. Should any or all of these associated improvements be deferred until after completion of the Valley Highway, the project would necessarily be built in two or more stages.

The initial stage, carried out prior to completion of any one of the three improvements, would include at the north Broadway intersection as well as at Sixth Avenue the simple completion of the highway embankment and roadways as though no connecting or diverging route were contemplated. The Broadway trumpet connection would therefore remain to be built as an independent second-stage operation, with reconstruction of the outer lane of the Valley Highway to connect with the diverging lane into the viaduct. At Sixth Avenue the bridge structure necessary to carry the future Sixth Avenue highway across the Valley Highway would also be built in the second stage, together with the cloverleaf embankments and interchange lanes.

The 14th Street-Speer Boulevard connection involves a somewhat different treatment; an efficient temporary interchange (Plate 12) must here be provided, since the traffic connection here is one of the most important of the entire project. Reconstruction of the initial interchange into a full cloverleaf (Plate 5) after construction of the Speer Boulevard and 14th Street viaduct rectification would cost about $150,000.

The cost estimate presented on a later page represents the full cost of completing the Valley Highway with connections to the North Broadway viaduct, to Speer Boulevard and the 14th Street viaduct, and to Sixth Avenue, in the final condition of these city improvements. The estimated deduction from the ultimate cost for these deferred items is stated separately to show the cost of the initial stage of the project.

Trackage Changes

In order to give a favorable alignment and profile and make efficient interchange structures practicable, several track changes have been found to be desirable. They have been discussed in detail with officials of the railroad companies concerned, and tentative agreement has been reached. The two major changes are indicated in Fig. 28. In general terms the desired track changes are:

> At 48th Avenue, the tracks of the Colorado & Southern Ry. extending north near Galapago Street present difficulties in carrying the 48th Avenue approach across the railroad. These tracks should be lowered at least to the grade of the adjoining Denver & Salt Lake tracks, or about eight feet. In this same region, the Colorado & Southern's Denver West Side line at Cherokee Street and the Chicago, Burlington & Quincy's Lyons line at Delaware Street are to be replaced by a new track along 48th Avenue; this will be crossed by the overpass of the Valley Highway over 48th Avenue. As industrial traffic westward on 48th Avenue to the Chicago, Burlington & Quincy main

tracks is thus provided for, the avenue is to be closed at the railroad to eliminate the present dangerous grade crossing. The changes indicated will reduce the grade on the 48th Avenue approach from 6% to about 4%, and will eliminate two underpass structures.

At 38th Avenue, the proposed Buckwheat track of the Chicago, Burlington & Quincy to the 31st Street yard should be shifted in alignment to reduce the cost of the overcrossing of the Highway over the track. Fox Street would be lowered 5 feet where

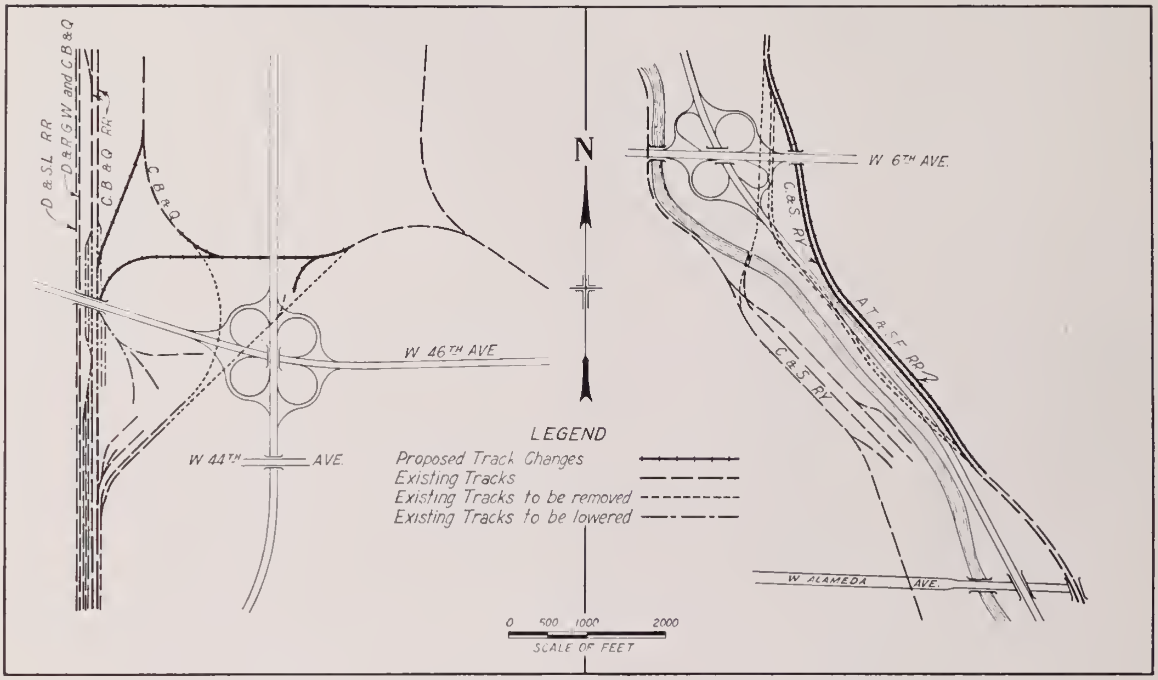


FIG. 28—*Two major railroad track changes proposed to simplify construction of the Valley Highway.*

the proposed track is to be carried over it. The Denver & Salt Lake track should be moved directly alongside the Colorado & Southern track.

South of Colfax Avenue the Falcon branch of the Colorado & Southern and the main line of the Santa Fe should be shifted eastward between West Seventh Avenue and West Bayaud Avenue, a length of about 6400 feet, by a maximum amount of 400 feet.

The Colorado & Southern bridge across the South Platte River at West Fourth Avenue, together with its connecting spur thence north to West Seventh Avenue, should be removed, and a new bridge built near West 16th Avenue to connect the Denver West Side line with the Seventh Street yard.

Industry tracks of the Colorado & Southern north of the 20th Street viaduct, from Lipan to Navajo Streets, should be removed.

VII. RIGHT OF WAY

Ample right-of-way width is essential to protect the highway from encroachment and trespass as well as to minimize objectionable effects of the highway traffic on adjoining property. It is therefore recommended that a width of 300 feet be acquired throughout, except at a few points where it is undesirable to disturb existing property uses. The width stated will give adequate opportunity

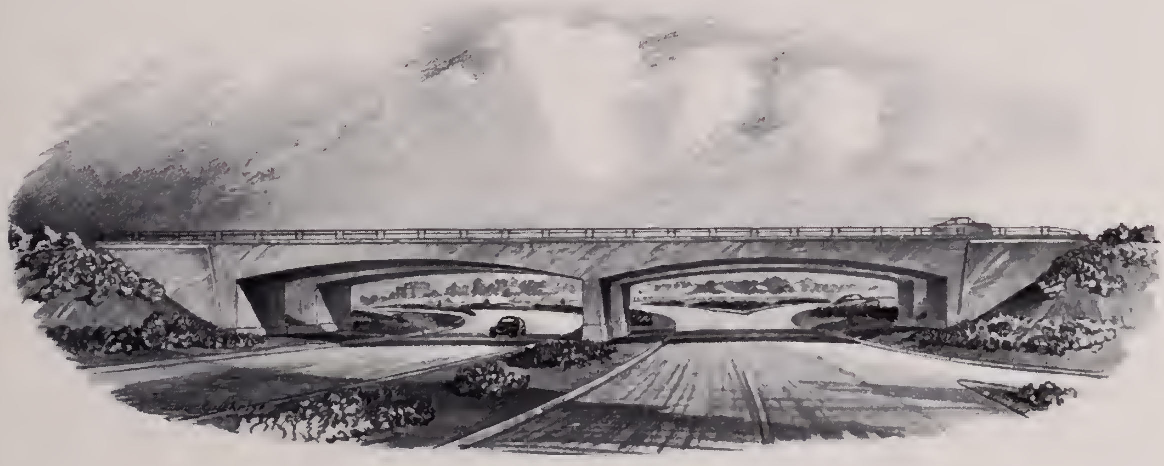


Fig. 29—*A typical Valley Highway bridge.*

for landscaping. In general no excess land acquisition is provided for by our preliminary plans and estimates.

The points at which the right of way is restricted to less than 300 feet are, principally, in the vicinity of West Tenth Avenue, West Third Avenue, Ellsworth Avenue, and near the crossing of Broadway in the vicinity of Kentucky Avenue. The right-of-way width and adjacent conditions at these points will be understood from the general plans of the route, Plates 3 to 12.

The total area of right of way required, including parts of public streets and other city property, totals 595 acres, or excluding streets 485 acres. These areas cover also the necessary right of way for service roads and street relocations, such as those at and near South Logan Street.

Of the total required right-of-way area, 451 acres represents the land required for the Highway and service roads, while 144 acres is the additional land needed at interchanges. The latter item includes the land required for the future interchanges at the west end of the proposed new Broadway viaduct and at West Sixth Avenue, which should be purchased at the same time as the other right of way.

The intent of the general design is that the full right-of-way area, including roadway slopes, shall be maintained in finished condition by grassing or planting, and that no part of the Valley Highway shall remain bare or in other respects disfiguring to the region traversed. The recommended irrigation system included in our plans and estimates is to be built of sufficient capacity to permit of satisfactory maintenance of the grass and planted areas.

To exclude small children, as well as animals, whose access to the roadway might be dangerous, it is proposed that the right of way be fenced. Our estimates provide for the cost of this protection.

VIII. COST OF THE VALLEY HIGHWAY

The construction cost of the complete project, as determined by careful estimates, will be $12,500,000. The initial construction, before building the interchanges at North Broadway and Sixth Avenue and the final interchange at North Speer Boulevard, would cost $1,100,000 less. To these costs must be added the expenditure necessary for purchase of the right of way. This expenditure can not be determined with accuracy in advance, but according to the best information available the market value of the land and improvements that must be taken for the project approaches $2,300,000. As some of the land involved is owned by the city, the actual right-of-way cost may be reduced below $2,000,000. Adopting the latter figure, and assuming that the full area of land required for the complete project is to be purchased at the time of initial construction, the initial and ultimate project costs are:

COST OF COMPLETE PROJECT

Not Including Third Lane

	INITIAL (before construction of ultimate interchanges at North Broadway, North Speer Blvd. and Sixth Ave.)	ULTIMATE (after completion of the deferred interchanges)
Right of way	$ 2,000,000	$ 2,000,000
Construction	11,400,000	12,500,000
Total Cost	$13,400,000	$14,500,000

These costs are believed to represent closely the required expenditure to carry out the project, at present prices of materials and current wage rates. It is assumed that construction efficiency would be rather higher than can be attained today, by virtue of more advanced equipment and possibly also some increase in labor performance.

A fuller statement of the construction cost, with principal items segregated, is as follows:

CONSTRUCTION COST OF VALLEY HIGHWAY

Grading	$ 2,395,000
Drainage	550,000
Structures	4,387,000
Paving, including service roads	2,655,000

Appurtenances		
Guard rail	$ 68,000	
Fencing	50,000	
Signing	10,000	
Irrigation system	164,000	
Lighting	113,000	405,000
Railroad and sewer changes		378,000
Landscaping		74,000
Engineering and contingencies, 15%		1,626,000
Construction Cost of Complete Project		$12,470,000
Deduct for deferred interchanges		
North Broadway	$695,000	
North Speer Boulevard	151,000	
Sixth Avenue*	242,000	1,088,000
Construction Cost of Initial Project		$11,382,000

*Deferring the construction of the Sixth Avenue interchange will necessitate construction of ramps at Eighth Avenue. The deferred cost of the interchange, $341,000, has therefore been reduced by this amount.

IX. CONCLUSIONS AND RECOMMENDATIONS

Having studied the conditions that control a limited-access highway extending north and south through Denver, and having considered its service requirements and the several possible routes, we conclude and recommend as follows:

1. A through highway of limited-access type adapted to sustained high speed is a desirable and necessary traffic improvement and will reduce the cost of transportation by an amount roughly twice the full annual cost of the improvement including amortization. The savings realized would pay for the entire cost of the project in 15 years.
2. The Valley route is best, as (a) being the shortest practicable route, (b) easily accessible from both sides of the South Platte river, (c) involving least disturbance of existing industries and avoiding the confusion that would result from leading them to seek new locations, (d) affording an economical right of way, (e) lowest in construction cost of all the routes studied, and (f) adaptable to any master plan that the city may adopt. It gives the maximum traffic value per dollar of expenditure.
3. The Valley Highway should be a four-lane road of dual-roadway construction, segregated from adjoining property, provided with adequate interchange facilities at transverse arteries, and of highest known type for safety, speed, capacity and esthetic value, as shown on the plans submitted herewith.
4. Space should be provided for a third lane in each direction to take care of the increase in traffic certain to develop.
5. The estimated cost of initial construction, exclusive of real estate, is $11,400,000, and with completion of three deferred interchanges $12,500,000.
6. The construction program can be made sufficiently flexible to meet reasonable financial limitations and provide for post-war employment needs.
7. In order to avoid delay in meeting the post-war employment conditions, the final plans, specifications and estimates should be prepared immediately.
8. An agreement should be executed with the city to comply with the terms of the Colorado Freeway Act, and specifically to provide (a) that no concessions be allowed on the right of way, and that no utilities be allowed on the Valley Highway without consent of the State Highway Department, (b) that city buses be excluded from the Highway,

(c) that access restriction and the necessary street closures be assured, (d) that lighting and maintenance of the Highway be provided for, (e) that the city will police the Highway, and (f) that traffic control shall be subject to approval by the State Highway Department, that no control shall impede the undisturbed flow of traffic, and that in no case shall a speed limit below 50 miles per hour be imposed.

9. For full development of the service of the Valley Highway to city-entrance traffic, distribution routes must be provided auxiliary to the highway itself. The city has in contemplation various improvements which will be of value for this purpose.

We offer the following additional suggestion in the interests of expeditious and efficient prosecution of the improvement:

The northerly half of the project, from the north city line to about Tenth Avenue and Zuni Street, should be undertaken as the first post-war construction. It will provide for the most urgent traffic needs, in view of the preponderance of traffic from the north and the fact that the valley viaducts and most important transverse thoroughfares are located in this part of the route. The construction cost of this section, excluding the deferred construction of the North Broadway interchange and completion of the final interchange at North Speer Boulevard, is estimated at $6,200,000. The probable right-of-way cost is believed to be less than $800,000.

In closing, we desire to express our conviction that too much emphasis can not be placed on the need for adoption of a master plan by the city of Denver, which may serve to coordinate all future arteries of traffic.

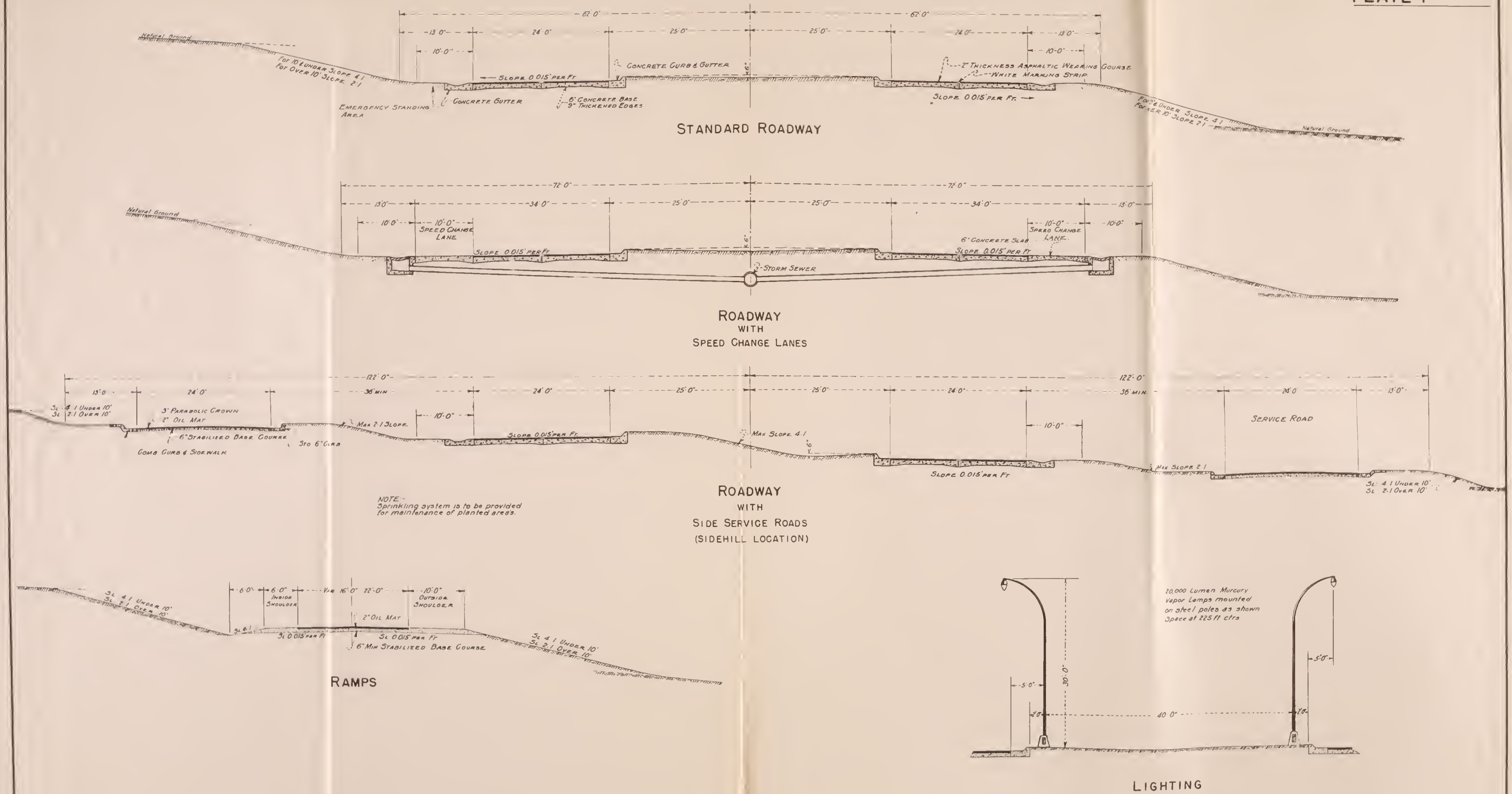
CROCKER and RYAN

Herbert S. Crocker

Alfred J. Ryan

Denver, Colorado
December 9, 1944.

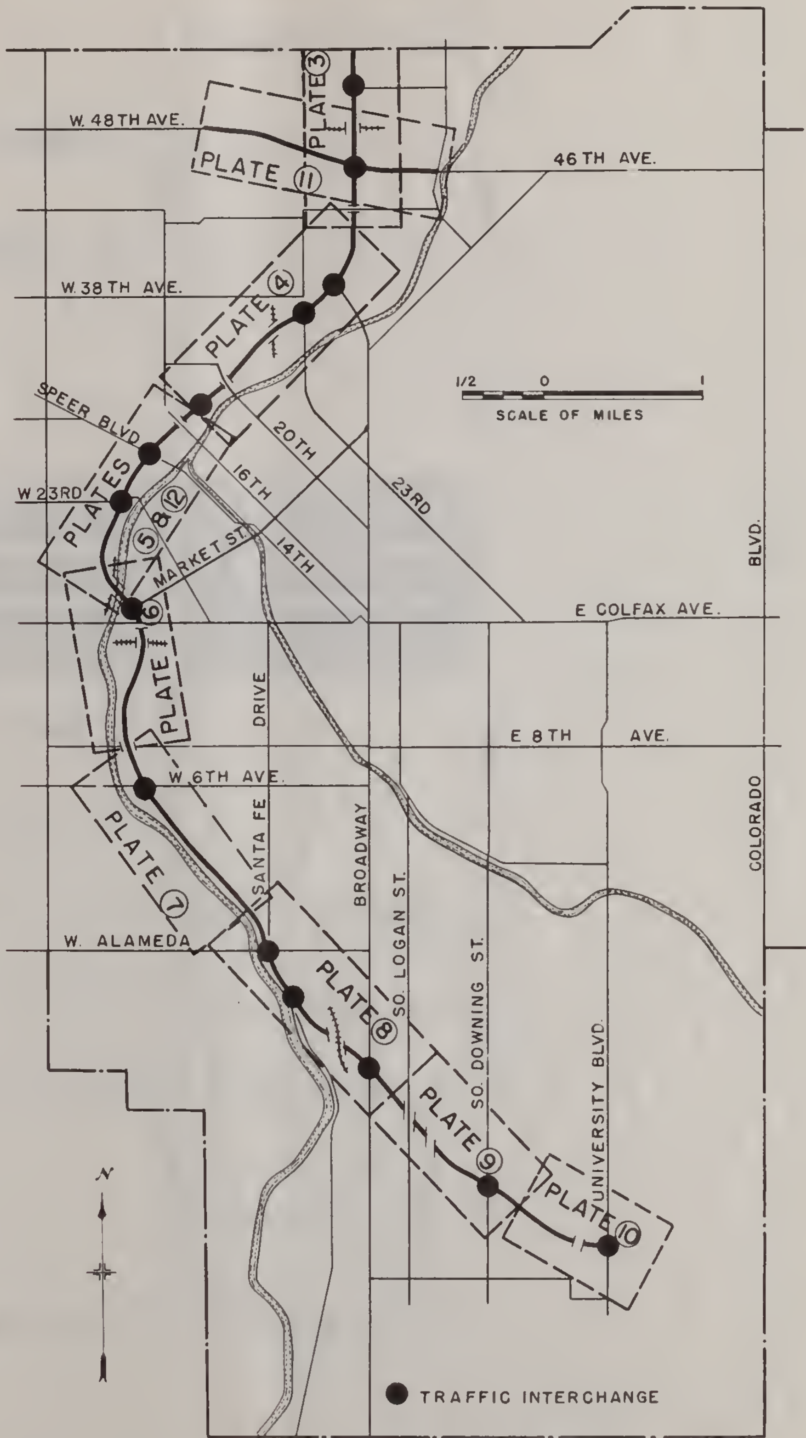
PLATE I



TYPICAL SECTIONS

SCALE 0 2 4 6 8 10 20 FEET

PLATE 2



INDEX MAP

PLATE 3

52ND AVE. TO 43RD AVE.

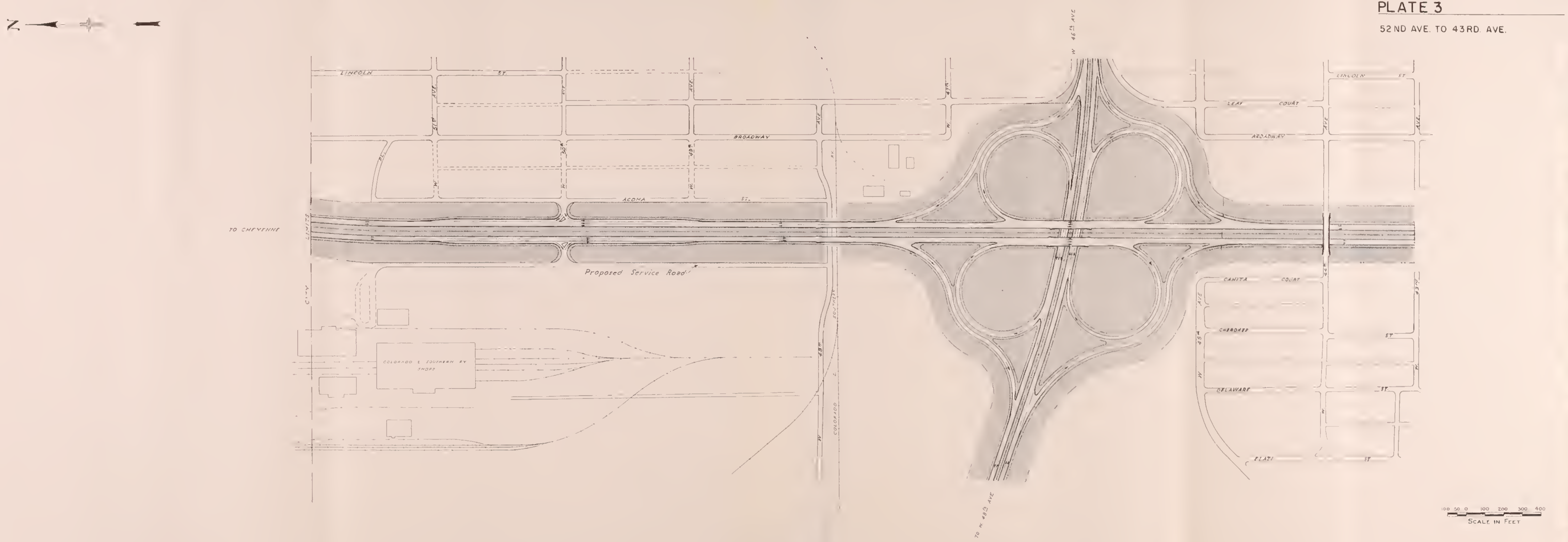


PLATE 4

43RD AVE. TO 17TH ST.

PLATE 5

17TH. ST. TO PLATTE RIVER

CROSSING NEAR W. 17TH AVE.

PLATE 6

PLATTE RIVER CROSSING NEAR
W.17TH. AVE TO W.8TH. AVE.

PLATE 7

W. 8TH. AVE. TO W. BAYAUD AVE.

PLATE 8

W. BAYAUD AVE. TO SO. LOGAN ST

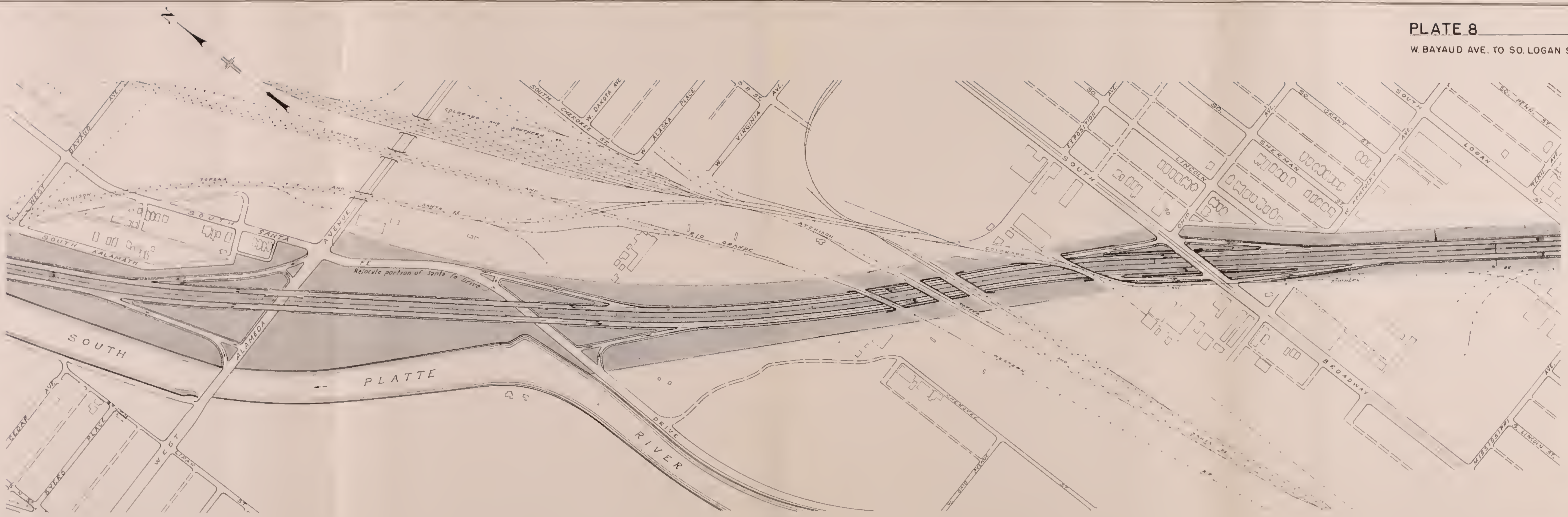


PLATE 9

SO LOGAN ST. TO SO FRANKLIN ST.

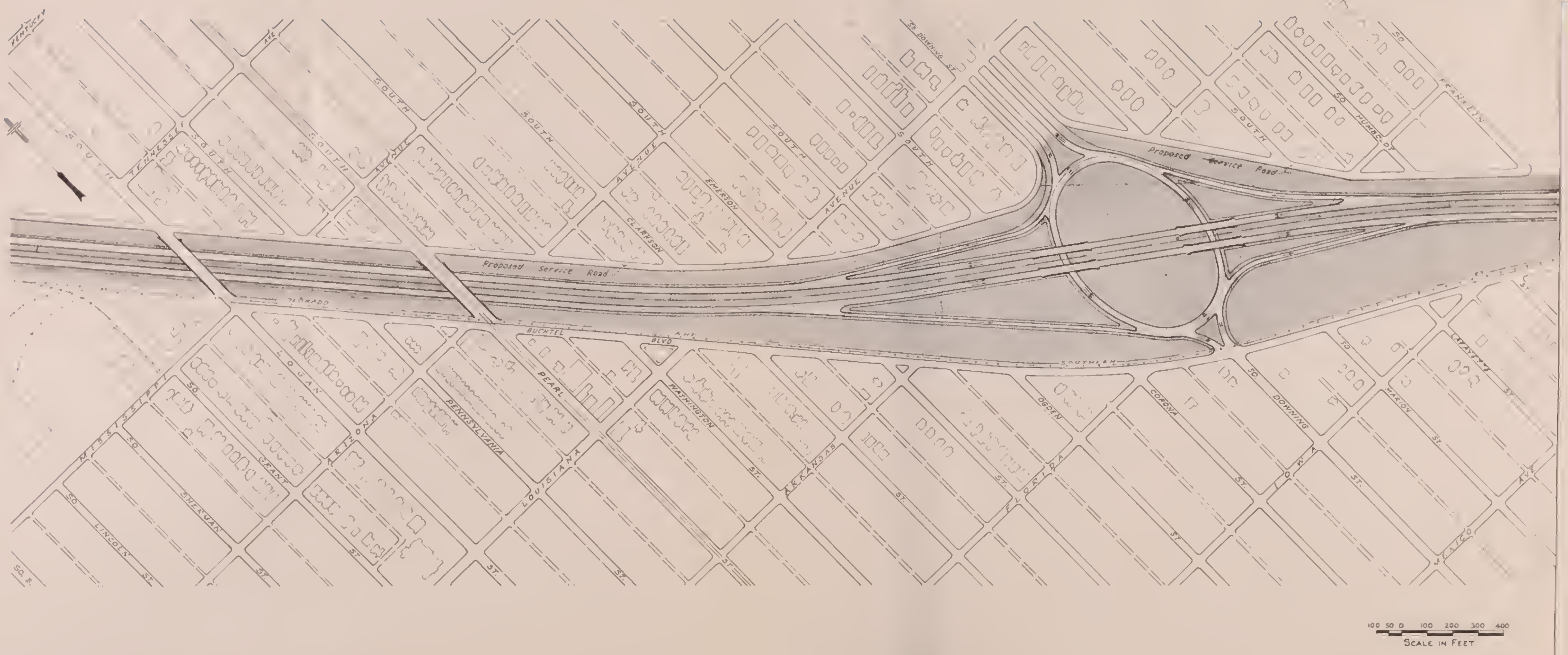


PLATE 10

SO FRANKLIN ST. TO SO. UNIVERSITY BLVD.

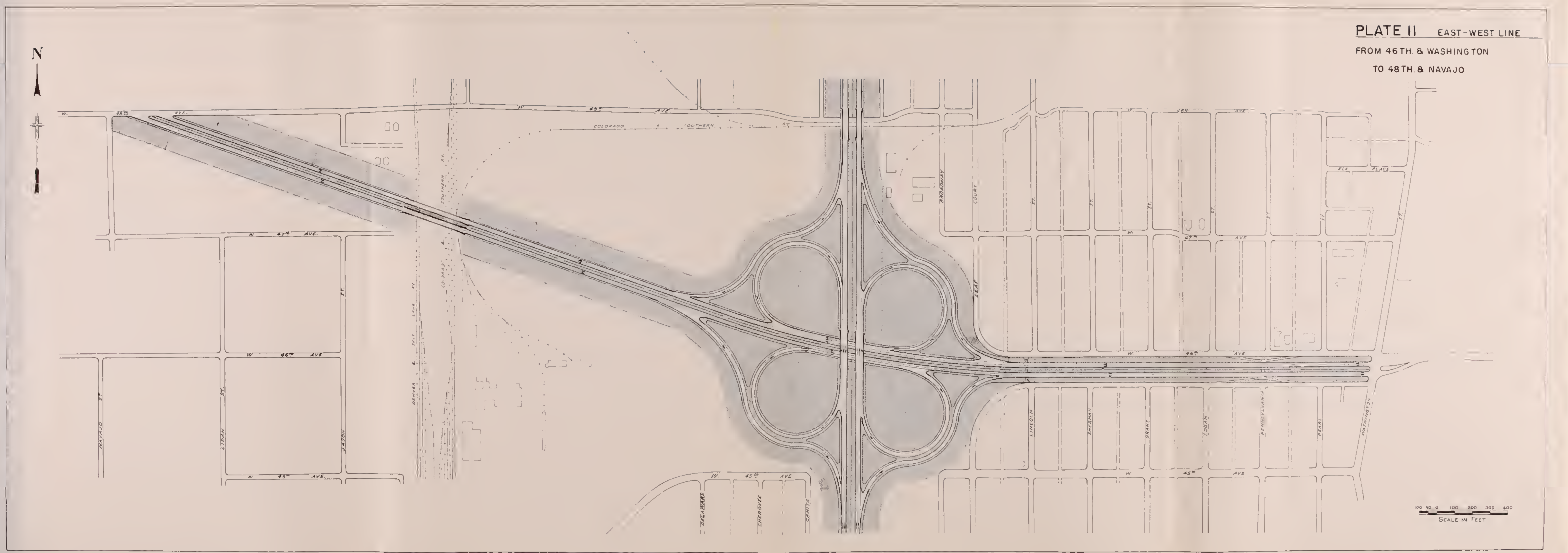


PLATE II EAST-WEST LINE
FROM 46TH & WASHINGTON
TO 48TH & NAVAJO

PLATE 12

17 TH. ST. TO PLATTE RIVER

CROSSING NEAR W 17 TH. AVE.

INITIAL CONSTRUCTION AT SPEER-BLVD.

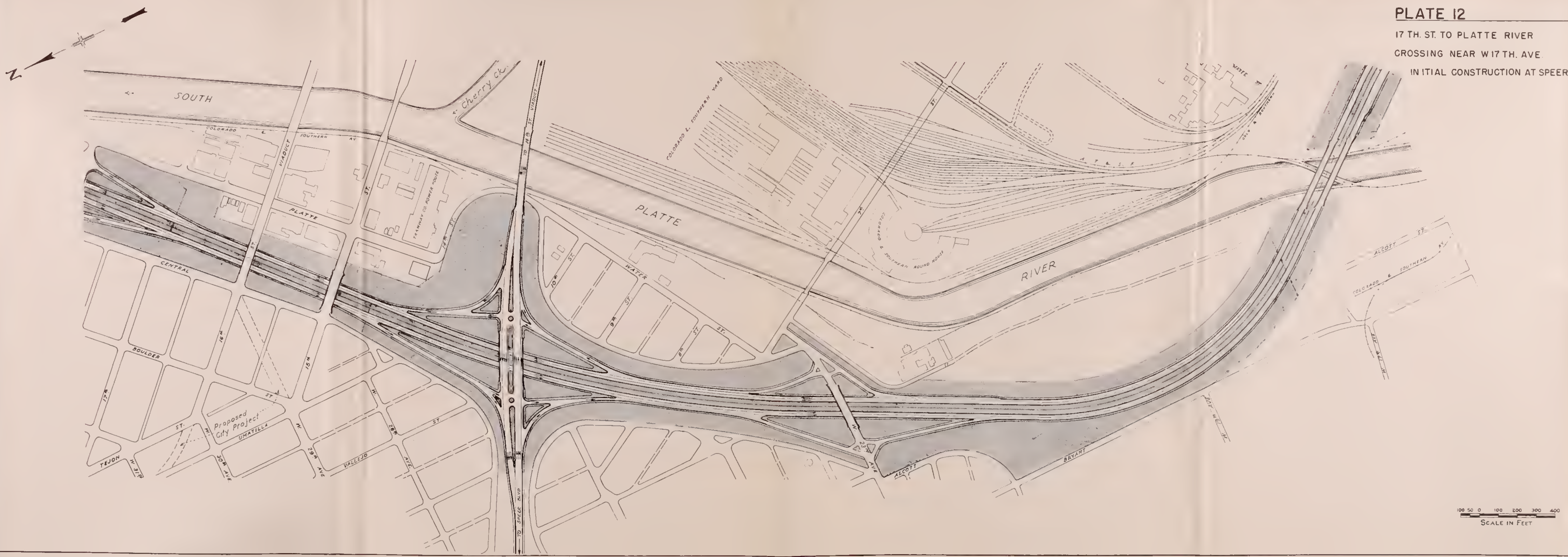
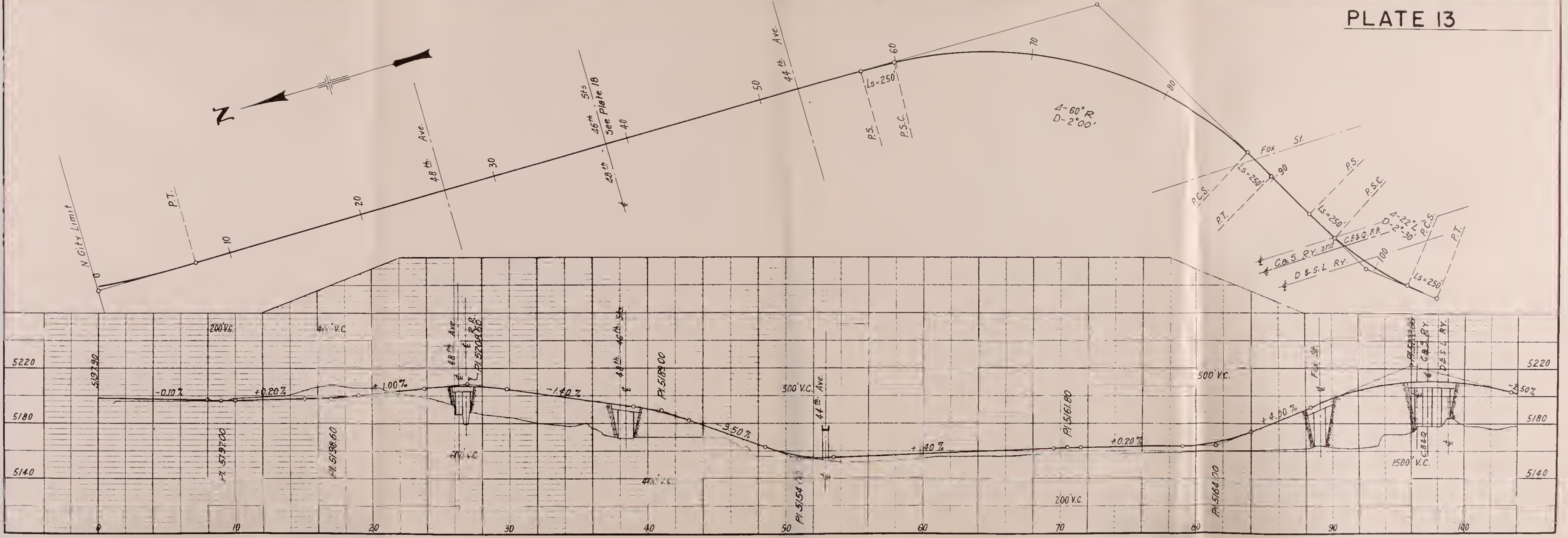


PLATE 13



N. City Limit
P.T.
48th Ave.
46th Sts
See Plate 18
44th Ave.
Ls=250'
P.S.
P.S.C.
Δ-60° R
D-2°00'
Fox St.
P.C.S.
Δ-22° L
D-2°30'
C.&S. RY. and C.B.&Q. RR.
D.&S.L. RY.
200' V.C.
400' V.C.
500' V.C.
1500' V.C.
-0.10%
+0.20%
+1.00%
-1.40%
-3.50%
+.40%
+0.20%
+4.00%
-3.50%
P.I. 5197.00
P.I. 5198.60
P.I. 5208.60
P.I. 5189.00
P.I. 5154
P.I. 5161.80
P.I. 5164.00
5220
5180
5140

PLATE 14

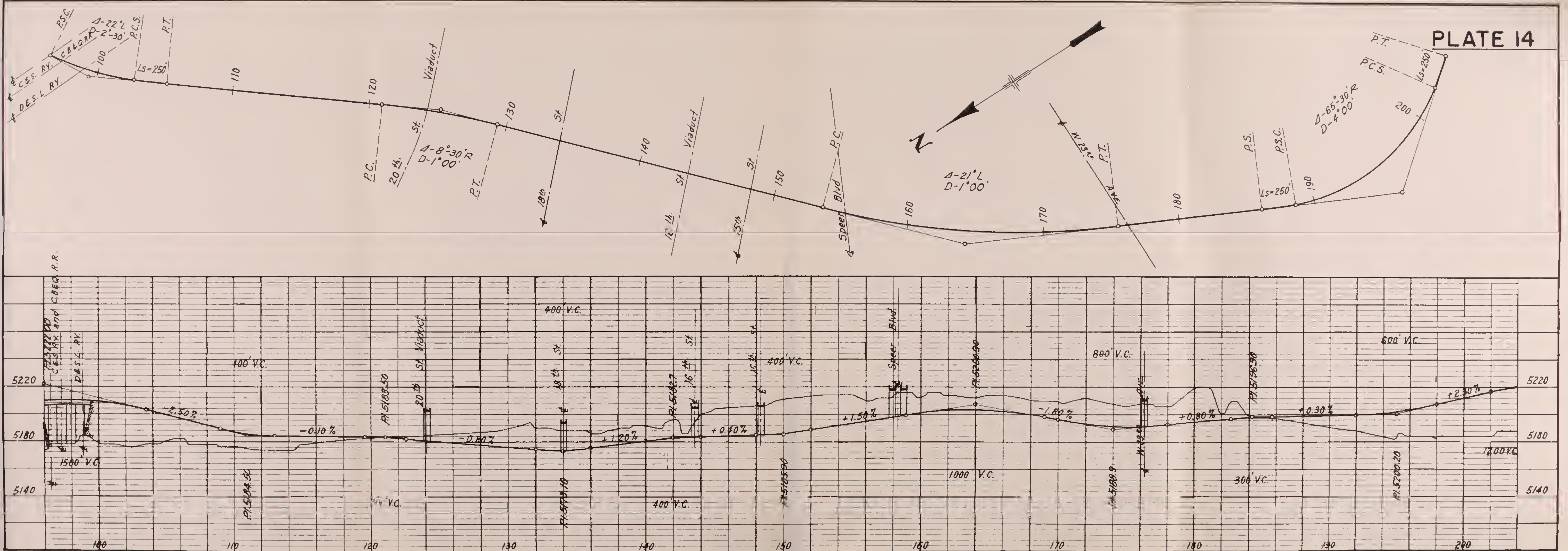
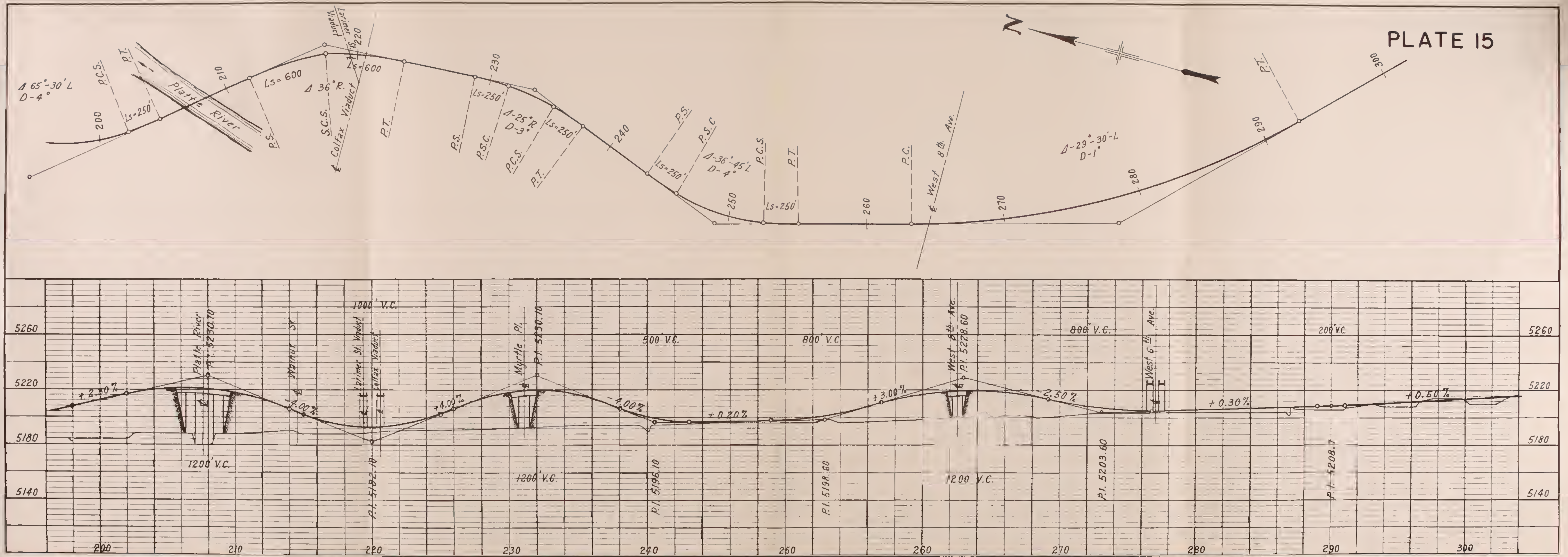

P.S.C.
Δ-22°L
D-2°-30'
P.C.S.
P.T.
C.B.&Q.R.R.
C.&S. RY.
D.&S.L. RY.
Ls=250
Viaduct
Δ-8°-30'R
D-1°00'
P.C.
20 th. St.
P.T.
18 th. St.
16 th. St.
15 th. St.
Speer Blvd.
Δ-21°L
D-1°00'
W. 23rd Ave.
P.S.
P.S.C.
Δ-65°-30'R
D-4°00'
N
400' V.C.
1500' V.C.
-2.50%
-0.10%
-0.80%
+1.20%
+0.40%
+1.50%
-1.80%
+0.80%
+0.30%
+2.30%
1000' V.C.
800' V.C.
300' V.C.
600' V.C.
1200' V.C.
5220
5180
5140
100
110
120
130
140
150
160
170
180
190
200

PLATE 15



Platte River
Colfax Viaduct
Larimer St. Viaduct
West 8th Ave.
Δ 65°-30' L
D-4°
Δ 36° R.
Δ-25° R
D-3°
Δ-36°-45' L
D-4°
Δ-29°-30'-L
D-1°
Ls=600
Ls=250
1000' V.C.
500' V.C.
800' V.C.
200' V.C.
1200' V.C.
Walnut St.
Myrtle Pl.
West 6th Ave.
P.I. 5230.10
P.I. 5228.60
P.I. 5182.10
P.I. 5196.10
P.I. 5198.60
P.I. 5203.60
P.I. 5208.7
+2.50%
-4.00%
+4.00%
+0.20%
+3.00%
-2.50%
+0.30%
+0.60%
5260
5220
5180
5140

PLATE 16

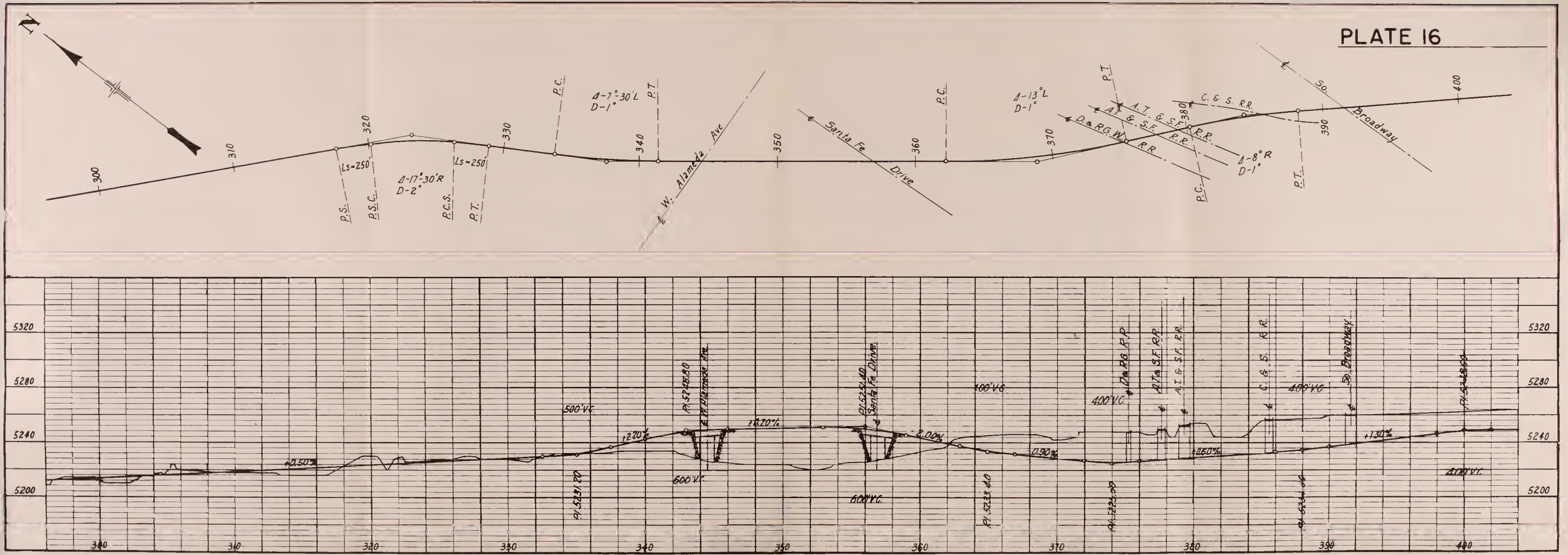
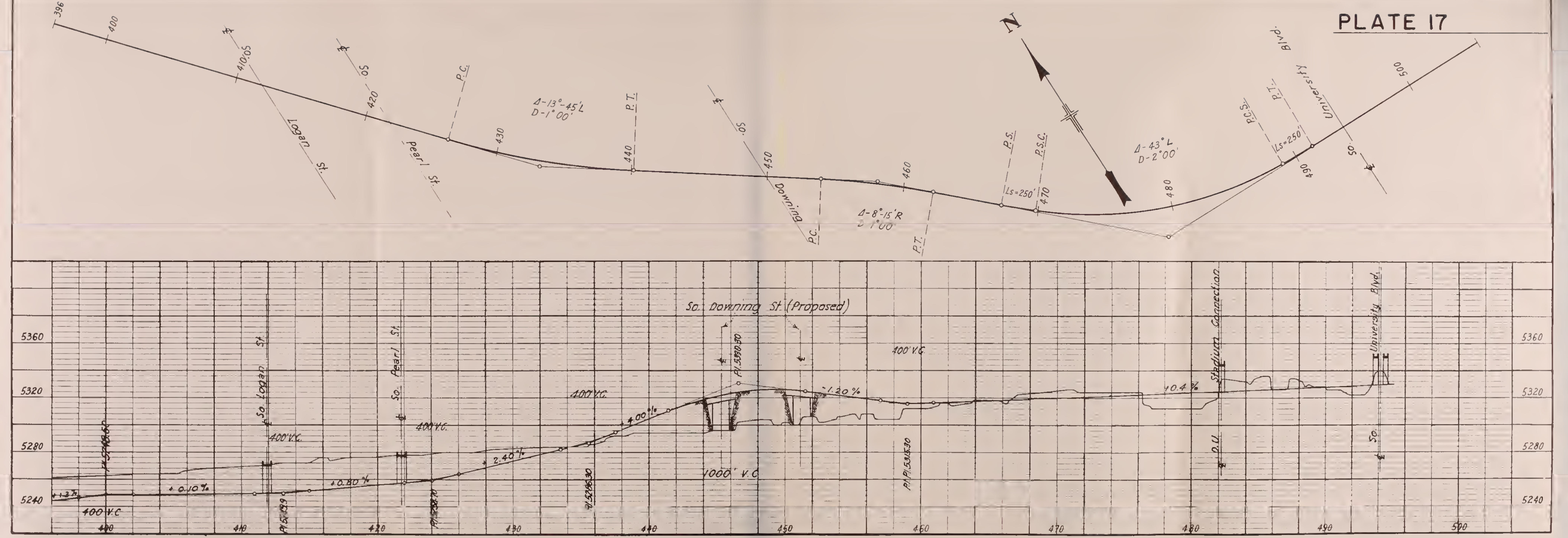

N
P.S.
P.S.C.
Ls=250
Δ-17°-30'R
D-2°
P.C.S.
P.T.
P.C.
Δ-7°-30'L
D-1°
W. Alameda Ave
Santa Fe Drive
Δ-13°L
D-1°
D.& R.G.W. R.R.
A.T. & S.F. R.R.
C. & S. R.R.
Δ-8°R
D-1°
So. Broadway
300
310
320
330
340
350
360
370
380
390
400
5320
5280
5240
5200
+0.50%
+2.20%
+0.20%
-2.00%
-0.90%
+0.60%
+1.30%
500' V.C.
600' V.C.
400' V.C.
P.I. 5231.20
P.I. 5249.80
P.I. 5251.40
P.I. 5233.40
Santa Fe Drive
D.& R.G. R.R.
A.T.& S.F. R.R.
A.T. & S.F. R.R.
C. & S. R.R.
So. Broadway

PLATE 17



N
Logan St.
Pearl St.
Downing
University Blvd.
Δ-13°-45'L
D-1°00'
Δ-8°-15'R
D-1°00'
Δ-43°L
D-2°00'
P.C.
P.T.
P.S.
P.S.C.
P.C.S.
Ls=250'
So. Downing St. (Proposed)
So. Logan St.
So. Pearl St.
Stadium Connection
So. University Blvd.
400' V.C.
1000' V.C.
+0.10%
+0.80%
+2.40%
+4.00%
-1.20%
+0.4%
5360
5320
5280
5240
400
410
420
430
440
450
460
470
480
490
500