The report of an Internship in Urban Planning as performed at the Tucson City Planning Department, Tucson, Arizona, June 4, 1975 - August 15, 1975

by

Nancy Anne Carlisle

An Internship Report Submitted to the
COMMITTEE ON URBAN PLANNING
In partial fulfillment of the Requirements
For the Degree of
MASTER OF SCIENCE
In the Graduate College
The University of Arizona

1976

Approved: ______________________ Date:
Director of Internship

STATEMENT BY AUTHOR

This internship report has been submitted in partial fulfillment of requirements for an advanced degree at the University of Arizona and is deposited in the University Library to be made available to anyone with an interest in the subject.

Brief quotations from this internship report are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department when in his judgement the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: ______________________

Chapter 1

An Overview of the Comprehensive Planning Process in Tucson

In the spring of 1972, the cities of Tucson and South Tucson, Pima County, Pima Association of Governments and the Tucson Area Transportation Planning Agency launched the Comprehensive Planning Process (C.P.P.) directed toward the creation of a 25 year development plan for eastern Pima County. As it was conceptualized, it would take nine steps.[1]

1. Identify the problems
2. Analysis
3. Determine community objectives
4. Establish priorities
5. Formulate alternatives (plans and policies)
6. Select plans and policies
7. Review, evaluation and adoption
8. Implimentation
9. Continuing review

The CPP was organized into four phases. In Phase 1 (March - July, 1972), city planners went to the people to find out what concerned them, to identify the scope and nature of the plan. Among the techniques used to evoke citizen response were slide shows presented at community meetings, followed by a questionnaire on Tucson's problems; a survey sent out in the monthly water bill. The result was a list of issues and alternatives for local policy.

In May, 1973, Phase II began, and potential solutions to the previously identified problems were discussed. Fourteen public meetings were held; presentations were made before numerous community groups and organizations. Further publicity for the process was brought about by discussion on local television and radio stations. Phase II ended with the compilation of lists of feasible, acceptable, and desirable solutions to Tucson's regional problems.

The presentation of a series of alternative solutions in the fall of 1973 marked the beginning of Phase III. These solutions were sifted out from the public's reactions the previous spring. In order to maximize feedback from the public on these alternatives, a tabloid, <u>Tell Tucson Where to Go</u>, was distributed; there was a series of eight television programs on the solutions, <u>Alternatives '73</u>; public meetings and presentations before additional community groups and organizations were held to insure the validity of the results, a community attitude survey was taken. The results of the third phase of citizen participation was "a clear picture of future direction for public policy in Eastern Pima County."[2]

Phase IV of the process began with the release of the CPP on March 7, 1975. The release of the document was followed by a series of eleven community meetings and forty-one meetings with organizations to introduce and explain the plan. The plan was met with much criticism in the community. Everyday for weeks following the release of the draft plan, headlines in the local papers announced accusations made by members of the business community that the planners and the plan were socialist and the plan would cause the economic destruction of Tucson.

It was evident that the planners could not completely substantiate all conclusions and policy statements put forth in the plan and if the planners wanted to attempt to "save" the plan it became clear that: first, clarification of future steps was necessary; second, there is a need to simplify, further define and rewrite the draft plan; and, third, further opportunities for public discussion and review must be provided.

The draft plan presented large amounts of factual material and lengthy explanations of suggested actions to establish a sufficient basis for community discussions. This resulted in a long and somewhat cumbersome document. It was decided that in order to promote a better understanding of the proposals presented in the draft plan, the existing document needed to be revised and separated into three concise sections. These sections would cover the broad categories of physical, economic and social planning and would be prepared as pre-hearing documents and released on a phased basis. Each of these documents would focus on key goals, policies and implementation strategies, and would be based on material presented in the draft plan, alternatives developed through community discussions and additional staff research.

The first pre-hearing document to be prepared is a physical development guide, primarily encompassing the Land use, Environment and Transportation elements of the first draft. The second document would deal with economic development and would focus on the pertinent issues and policies cited in the Economic and Human Resource element of the draft plan. Major portions of the Human Resource, Housing and Government elements would be included within a third document, the human resource development guide. Population growth issues are closely tied to topics presented in all three regional development guides.

Each of the development guides will emphasize those planning items required of cities and counties by state law. The development guides will also be designed to satisfy requirements for regional planning in federal programs. Although the three documents would be released in sequence, to facilitate community discussion and review, they would collectively constitute the Comprehensive Planning Process for Tucson.

In order to clarify the process by which the current draft will be reviewed, revised and brought to public hearing and adopted, a work program was set up which included the following steps.

Community forums were held to enable citizens, community groups, and organizations to present their ideas, suggestions and initial reactions concerning the draft plan to the planning director and CPP staff. The purpose of these forums was to enable citizens and groups to identify topics requiring further elaboration and in-depth exploration of the plan.

The community and organizational responses to the Comprehensive Plan draft, as well as input and discussions from the community forums will raise and highlight a number of major issues and topics. In order to facilitate public discussion of these topics a limited series of "Issues Papers" were planned to be published. Each of these brief issue papers - no longer than five pages - were planned to deal with a topic of major concern to Eastern Pima County residents and were planned to be distributed as widely as possible. These papers were planned to provide a basis for additional community discussion and serve as an intermediate step in preparing the pre-hearing drafts.

Review sessions will be held following publication of each pre-hearing development guide to explain, clarify and discuss content.

Revisions will be made prior to scheduling them for public hearing. The revisions will be based upon public input received in community review sessions.

Upon completion of public hearings and the preparation of findings by the aforementioned bodies, the development guides will be submitted to the Pima County Board of Supervisors and the Mayor and Councils of Tucson and South Tucson for final hearings, review and action.

Chapter 2

My responsibilities as an intern for the City of Tucson
Summer 1975

Amidst the controversy generated after the release of the draft plan, it became evident that there were many unanswered questions and unsubstantiated conclusions in the draft CPP. In an effort to "save" the plan, the planners scrambled to find answers to the citizens' questions.

One of the questions generated through citizen input at the community meetings was about the cost of the transportation alternative which was presented in the plan. The alternative presented in the transportation element of the plan included provisions for increasing bus service and decreasing reliance on the automobile by the following amounts:

Modes of transportation

	Car	Bus	Motorcycle	Walk	Bicycle
Present Transportation Alternative[3] (Associated with Sprawl)	84%	3%	2%	8%	3%
Proposed Transportation Alternative[4] (Associated with Contained Growth)	70%	12%	3%	10%	5%

As a result of this inquiry, as an intern I was given the task of researching the following question: Given as two polar extremes the present transportation system and the alternative presented in the plan, which is the most cost-effective way to meet Tucson's transportation needs to the year 2000? The information generated from this research was to be included in an issue paper relating to transportation alternatives.

This question was generated through citizen input at the community meetings concerning the draft CPP. My input fits into the CPP process as an analysis of alternatives in terms of one variable; cost. The parameters of my study were specifically laid out for me by a member of the planning staff. I was told to consider costs only, without regard for specifically who pays (public or private sector) or any of the revenue sources.

My research was supposed to cover three major topics; the cost of owning and operating an automobile under each alternative, the cost of building and maintaining the additional miles of road needed between now and 2000 under each alternative, and the capital and operating expenses of the bus system under each alternative. Other costs such as the cost of traffic law enforcement, accidents, time costs and environmental costs were mentioned as being relavent to the study but due to time constraints and the lack of available information were not considered.

The data used in the study was all from secondary sources. The costs were only calculated for cars and buses. Any costs relating to motorcycles, bicycles and walking were not considered. There were some problems in obtaining the data. The biggest problem was the fact that the projections which I used for the number of miles of road required between now and the year 2000 were in terms of neighborhood, collector, arterial streets, highways and freeways while the maintenance cost data was in terms of streets paved/curbs, paved/curbs/sidewalks, strip paving, multilane/divided/no curbs, multilane/divided/with curbs and four lane/not divided/curbs. Thus I had to convert all my data to common terms. To do this I had to make assumptions about the percentage of neighborhood, collector, arterial roads, etc. which were paved/curbs versus paved/curbs/sidewalks, etc. My assumptions in making the conversions were based on interviews with reliable members of the Department of Transportation. My calculations all involved tedious arithmetic. This specific problem is shown in Table VII - A, Appendix of the research.

Another problem involved the determination of the number of buses needed between now and the year 2000. I could find no data on this topic so a meeting of all knowledgeable transportation related people was called to agree on some figures for me to use. In theory this was a good idea, in reality the group agreed to let one person handle it and he gave me some figures but could not completely justify them. Since no one else had the time to help me or could help me without doing a little thinking coupled with the fact that I was not as persistant and demanding as I should have been, I used the data I was given and had to recalculate those figures for my second draft when the mistake was discovered and the research was taken more seriously. (Remember, I was an unpaid intern.)

The data came in bits and pieces from many sources, the validity of which was based on my own discretion. Many times I would come across contradictory sources. I got a second opinion and sometimes a third from someone knowledgeable in the field of transportation concerning all my data. I had the data obtained from interviews put in writing and I documented all sources in case there were any questions. The methodology which I used was briefly as follows: (see Appendix for more detail)

First of all I put forth some explicit assumptions to clarify and narrow the scope of the research. These included:

1. The study was to deal with costs, both public and private and exclude all revenue sources. It was assumed that

the citizens of Tucson pay for what they get in one way or another, either directly or indirectly.

2. The costs were figured on a per year basis, based on the yearly population projection, then summed to determine the total cost over the 25 year period. The population projections used were the five year projections from the comprehensive plan.[5]

3. The two alternative transportation systems assumed two alternative land use patterns. It was assumed that in Alternative 1, which is a continuation of the existing transportation system, that our land use pattern, characterized by peripheral expansion, will remain unchanged. The Alternative 2 transportation system is based on achieving a land use pattern in Tucson which is characterized by "contained growth" in which urban development will be restricted in outlying areas while promoting it within the existing metropolitan area.

4. In the study, it was assumed that gasoline will continue to be available and no new constraints will be imposed on the use of the private automobile. All costs were in 1975 dollars and no provisions were made for inflation.

This list only covers the major assumptions.

Next I dealt with each section considered in the study individually. The first section considered was the cost of car usership. All costs in this section were based on the population projections, the average trip length between now and 2000 (this varies by alternative), the average number of trips taken per person per day, the percentage of travel by car and passenger truck (this varies by alternative), the average car and passenger truck occupancy and the cost per mile to operate an automobile. I used this data to determine the yearly cost of vehicle miles traveled by automobile and summed this for the 25 year period to get the total. I divided each yearly total by the yearly population projection and summed these yearly figures to get the total cost per person. The factors which reflected the cost difference between alternatives were the average trip length and the percentage of person miles traveled by car and passenger truck.

An assumption which I had to make in this section is that all costs associated with the automobile are variable. This is not necessarily true (such as for car insurance and depreciation to some extent) but I could not think of any way to avoid it given the time constraints.

The next topic discussed was the cost of providing roads under each alternative. The added miles of road needed for the Tucson metropolitan region between 1975-2000 varies dramatically by transportation alternative. It is assumed with Alternative 1 that if we continue with our current transportation system, our current land use pattern, characterized by "leap frog" developments, will continue generating the need for additional roads for commuting purposes. It will also create a need for more neighborhood roads due to the fact that with this type of land use pattern, the neighborhoods tend to be fairly spread out. In comparison the Alternative 2 transportation system assumes a land development pattern characterized by continued infilling in the urban development area, along with development of activity centers. This land use pattern will provide the patronage for the expansion of the Alternative 2 transportation system.

The added miles of roads needed under each alternative had been projected in the Booz, Hamilton, and Allen study, Cost/Revenue Analysis. I calculated the cost per mile to build roads and multiplied by the number of miles of roads built per year. Since the added miles of roads needed between now and the year 2000 was not on a per year basis in the Booz, Hamilton and Allen study, I had to make an assumption on what percentage of roads would be built per year. My assumption was that the percentage of roads built every five years would be proportionate to the five year population projections presented in the CPP. This probably is not realistic but since there is no accurate way to predict realistically when the roads will be built, I based this assumption on how things ought to be. This assumption does not affect the cost difference between alternatives, it only affects the total road maintenance costs (the more roads built in earlier years, the greater the total road maintenance costs each year thereafter).

The cost of road maintenance was based on the cummulative mileage of roads built yearly. Therefore it is assumed that these roads are built yearly.

The road maintenance costs considered include the cost of asphalt maintenance, sealcoating, overlay, street sweeping, sign, signal, street lighting and median maintenance. The cost of maintenance was assumed to remain constant by road types between alternatives. The maintenance costs were figured per mile for each road type and then multiplied by the commulative road requirements to obtain the yearly road maintenance cost.

The final subsection considered the capital and operating expenses of the bus system under each alternative. To do this first, the total number of buses needed under each alternative was calculated. This was multiplied by the cost/bus and amortized over a twenty year period. The operating expenses per mile per bus was known and this was multiplied by the number of buses times the miles traveled per year to determine the cost to operate a bus per year. All costs for each alternative were then summed on an aggregate and per person basis and presented in the conclusion.

My methodology was based on that used by the De Leuw, Cather consulting firm in their study, Santa Clara Rapid Transit Development Project, 1974. It was assumed in this study that the cost of transportation includes both public and private costs and total transportation costs can be reduced only if the savings in private ownership and operating costs are greater than the additional expenditures on the public transportation system. The Santa Clara study also considered time savings, social, environmental, energy and land use impacts and the distribution of the impacts and figured these costs for six rapid transit alternatives.

Ideally the study in Tucson should have considered more factors and should have been done to determine the best combination of transportation modes for Tucson before the draft plan was released (rather than supplying the date to justify the alternative after it has been decided upon). The study is bias from the standpoint that it does not consider the negative aspects of the bus system such as waiting time or inconvenience at times. These factors are not easily quantifiable so they were not considered. Their consideration would provide for a more objective study.

The study was originally done as a technical report to suppliment the proposed issue paper on transportation costs. The issue paper idea was scrapped so the research is now planned to be a supplimentary technical report to the physical development guide, which is in preparation. At one point it was thought that it could also be used to defeat one of the "anti-planning" and "anti-busing" candidates running in the city council primary. Theoretically, by using this research in this manner, the planners would be encroaching on the systems of voting, political representation and the diverse pressure of the political system. The role of the planner is theoretically supportive rather than partisan. In this situation the planners seemed to be looking out for the well-being of the planning staff and their own ideas of what ought to be. The staff being well informed and keenly aware of municipal needs would have a better chance of getting their plans implimented if the city council was made up of members who supported the planning staff and realized its importance. Nevertheless this was a definate encroachment of the political process.

The study is planned to be used as stated and will also be given to the mayor and council as an information source to answer one of the questions left unanswered by the draft CPP.

I enjoyed my internship and think that it was a valuable learning experience and gave me some insight into the planning process.

I was put in a position in which I had to deal with persons in high positions. I had the opportunity to attend public hearings and meetings. I wrote an entire document on my own and most importantly from my own point of view. I gained some work experience and self confidence. Pertaining to my internship, Professional Methods and Advanced Geographic Techniques were the most applicable classes.

Chapter 3
The Big Picture

Tucson is Arizona's sole island of liberalism in an otherwise conservative state. It is one of the fastest growing communities in the United States, attracting people because of its mild climate, Southwestern charm and recreational opportunities. It is a community which supports many divergent ideas and values ranging from one end of the political spectrum to the other. The release of the draft CPP made this very evident. The reaction to the CPP ranged from complete support to calling the planning staff "socialists" and drawing analogies between Hitler and the planning staff. There does not seem to be any real consensus on specific goals for Tucson, although through the outcome of the November 1975 city council election, Tucson voters seemed to express the view that a plan for their community was desired.

The Tucson Comprehensive Planning Process was unique to say the least. Rarely have so many new ideas been so intricately woven together into a political fabric of policy making, rarely have the issues and outcome of a city council election been so heavily influenced by a plan or a planning process. The Tucson experience was not just another effort of a dull and dreary planning department.

The CPP was set up in a rational and comprehensive framework. It was composed of nine steps to achieve a desired end-state. The steps included identifying problems, analysis, determination of community objectives, establish priorities, formulate alternatives, select plans and policies, review-evaluation-adoption, implementation and continued review. The philosophy of the process was to rely upon citizen participation to create a "peoples' plan" which would have the public support necessary to insure adoption and implementation.

> When the people take part in the formulation of a plan from the beginning, it can truly be said that it is "their plan." Not only will the plan face a better chance for adoption, it will also have a real opportunity to be implemented. A plan without public support is not worth the paper it is printed on, because it will never stimulate action.[6]

The CPP planned to go beyond physical plans or comprehensive plans and decided to deal with specific problems and their causes, resulting in policies and policy guidelines and action programs.

It is evident from the outcome of the planners' overwhelming effort that it did not succeed in realizing its objective. What went wrong? The remainder of this chapter is my interpretation of what went wrong.

I see the role of the planner in a local planning department theoretically as an active advisor to the mayor and council, participating in the decision-making process by being able to give the politicians detailed information on alternative courses of action to achieve desired goals. Planners should be able to say to the politicians if you do such and such then such and such will result. Ideally the politicians will solicit advice regarding alternative courses of action to take and ideally they will listen to the planners' responses and recommendations.

I believe that a planner can also take a more active roll and initiate ideas and push for their implemtnation. This must be done discreetly or it could cause problems. The best way to accomplish this is by working with citizen groups which support the cause being pushed for. The citizens in Tucson are very active in community affairs and always seem willing to support a cause they believe in. Planners must work <u>with</u> groups of people, listen and understand their needs and desired rather than merely talking at them. Of course the role the planner plays will depend to a large degree on the planner's individual philosophy about the relationahip of man to society and more importantly how that "view" squares with the community for which he works.

As I see it the planners in Tucson have overstepped their traditional role. Rather than merely prescribing policy to the decision making body, the planning staff has usurped the function of the political process. Policy making is and always has been a very political process. It is the resolution of conflict among groups with divergent interests. Policy is formulated as a result of competition among goals rather than by intellectual and deliberate choice. Policy making is a generator as well as a product of conflict, evolving through a process of "social weighing" that rarely can be comprehensively planned.[7]

I can only speculate on the reasons why the planners took the course of action that they did. Given the fact that certain council members were more concerned with development than planning combined with the fact that there was not good rapport between the city council and the planning staff, the planning staff could have thought that since policy making was the outcome of controvery, if they created such an all encompassing document as they did, it would force the divergent interest groups to confront each other on the issues and get the ball rolling towards a comprehensive plan.

I believe this idea was coupled with the fact that the planners believed that they were articulating policy representative of many interests in Tucson. They even stated in the introduction of the plan, "A plan without public support is not worth the paper it is printed on."[8] I do not think they would have made a statement like that if they did not believe that the draft CPP was representative.

Besides overstepping the traditional planning role, the CPP's methodology was sloppy in terms of citizen participation, goal formulation, and analysis of alternatives.

The citizen participation aspect of the process was fragmented and the questionnaires used to obtain the citizen input were biased therefore the input was not representative.

In each phase of the process the planners sought citizen participation in terms of surveys or meetings and then would disappear into the planning department at City Hall to analyze the results for up to almost a year at one point then the responses would reappear in a new form for citizen review. Thus the process appeared as a series of unrelated incidents instead of steps towards a goal.

Given the high mobility of residents and the national political upheaval that has occured over the last three years (including Watergate, the energy crisis and increasing distrust of government and big business), the validity of public input at the beginning of the process may have little resembalance to public attitudes a year or more hence.[9] I think some type of "pulse-taking function"[10] should have been encorporated into the process to monitor changing attitudes in the community. I think an on-going citizens committee was needed in this case to act as a liaison between the planning staff and community to constantly be scanning the community for changing attitudes and report to the planning staff periodically. In this way the members of the committee would be citizens actively involved in the process rather than the planners merely eliciting responses from a group of people and labeling it participation. I would like to think participation means active involvement.

Concerning the bias of the questions, I can give an example:

> Question 12, Water Bill survey:
>
> Tucson's growth should not be curtailed but rather planned and directed to protect both the economy and the environment.[11]
>
> agree
>
> disagree

In this two-part question, a "disagree" answer can imply disagreement with the first part (growth <u>should</u> be curtailed) or with the second part (should <u>not</u> be planned and directed). Thus the same answer could have two quite different interpretations.[12] The bias I see is that these questions and answer's interpretations are up to the planning staff's discretion.

The next major problem with the planning process is the goals are nonoperationalizeable. As I was taught in UP 310, <u>Professional Methods</u>, goals must be specified in terms of what needs are to be served as well as whose needs are to be served.[13] These goals must be put into specific, quantitative form with defined standards of performance. Indices and scales can then be used to represent the difference between reality and the standard necessary to achieve the desired result. The CPP seemed to ignore the idea of creating specific quantifiable goal statements, for example, goal 2-Land Use Element is stated as follows:

> To achieve and maintain a high quality of urban development and to promote the necessary revitilization of urban areas.[14]

They set no criteria to define high quality or necessary revitilization or which urban areas. These types of vague, overly broad goals lead to confusion and misrepresentation.

The analysis of policy alternatives to achieve desired goals was nonexistant. It seems to me that with policy planning the planning staff must be able to analyze the problems systematically, identifying the causes of the problems and developing policies and programs to deal with the problems. This seems to necessitate identifying trade-offs among competing goals. In the CPP what were the trade-offs among equity-environmental excellence or efficiency to achieve the specified policy? Which of these goals was weighted most heavily in each case? Whose decision was this based on? None of these questions were dealt with.

The idea that many of the decisions in the plan were subjective was hinted at by a statement in the CPP Introduction.

> The method by which the four alternative physical plans discussed in Phase III of

> the CPP were narrowed down into one integrated plan for the region was basically simple. It involved three main criteria: the attitudes, values and desires of the people in the region as assesed by the numerous citizen participation activities during the process; the comparative economic costs of the four alternative plans, and; CPP staff professional recommendations.[15]

Since I believe the citizen participation was fragmented and biased, I do not see any way the staff could have avoided subjectivity.

In reality the choice of alternative means is dictated by the possibilities evolving from political interaction rather than from deliberative, a priori design and analysis.

Thus I see the combination of these factors led to the problems associated with the CPP.

I see the overall goal of the plan: To improve the quality of life for all residents of Eastern Pima County by pursuing three objectives in all public action; equity, efficiency and environmental excellence,[16] as a normative rather than operatioal-izeable end state and I think the time frame (25 years) is too long to plan for. I think the plan is too long and full of controversal information for adoption.

The planners will have a second chance though, with the three development guides, which they are now preparing. I think the planning staff learned much about citizen participation after the release of the first draft and are going to do a better job of encorporating it into the development guides. In the first section of the physical development guide released, a page was allocated to answering questions that could not be worked into the text. Also the issue papers and technical reports which will be incorporated into the development guides answer the questions the first draft left unanswered.

The impact of the release of the draft CPP has not been all bad. The citizens of Tucson have been educated about planning due to the fact that the controversy has occupied such a central place in the media. The community now seems to be very much aware of the issues and problems facing Tucson relating to planning. I think this was part of the stradegy behind the plan ... to present ideas and generate conflict. I think the methodology of the plan was sloppy but the plan has been effective in getting people involved in creating a "people's plan." Awareness of the problems is definately the first step towards solutions and Tucson is now aware of it's problems.

The planning students at the University of Arizona also have the advantage of watching and participating in the CPP, seeing the planning process in action, being able to analyze it and learn from its mistakes. After all...

" 'Trying things out' and 'watching how they go' occupy a central place in the intellectual tradition and practice of planners."[17]

FOOTNOTES

1. The City of Tucson, The Comprehensive Plan. Introduction, p. 6. (1975)

2. Ibid, p. 7.

3. Ibid, Transportation, p. 3.

4. Ibid, Transportation, p. 26. (The projected non-auto trips for the year 2000 = 30.2%. This was broken down by transportation mode by Rich Corbett, P.A.G.T.P.P.)

5. Ibid, Population, p. 22.

6. Ibid, Introduction, p. 5.

7. Rondinelli, Dennin A. "Urban Planning as Policy Analysis: Management of Urban Change," Journal of the American Institute of Planners, 39,(January, 1973) p. 14.

8. The City of Tucson, The Comprehensive Plan. Introduction, p. 5. (1975)

9. Rich, Jackie, "A Funny Thing Happened on the Way to the Comprehensive Plan." Unpublished paper, (1975)

10. Meyerson, Martin. "Building thr Middle Range Bridge." Journal of the American Institute of Planners. Volume 22, No. 2, (1956)

11. League of Women Voters, Correspondence with Councilman Kennedy, May 12, 1974.

12. Ibid.

13. Krueckeburg and Silvers. Urban Planning Analysis: Methods and Models. John Wiley and Sons, N.Y. 1974, p. 8.

14. The City of Tucson, The Comprehensive Plan, Land Use, p. 15. (1975)

15. Ibid, Introduction, p. 7.

16. Ibid, Introduction, p. 8.

17. Mandelbaum, Seymour J. "On not doing one's best: The uses and problems of experimentation in planning." Journal of the American Institute of Planners, Volume 41, (May 1975) p. 184.

APPENDIX

A COST COMPARISON OF TWO ALTERNATIVE TRANSPORTATION SYSTEMS FOR TUCSON

Prepared by
Nancy Carlisle, Intern,
for the City of Tucson
Planning Department
under the supervision
of Jerry Swanson

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

In response to the Transportation Element of the first draft of the Comprehensive Plan, the following question has arisen: which is the most cost effective way to meet Tucson's transportation needs to the year 2000?

Since the people of Tucson must pay for their transportation system in one way or another, the question this paper is concerned with is what the cost will be to provide adequate transportation regardless if it is financed through public or private means.

In this study a cost comparison of two polar transportation alternatives are presented. One alternative is that bus ridership will remain at a constant level of 3% of all daily person trips to the year 2000. This is compared to the alternative presented in the Transportation Element of the plan in which bus ridership increases to 12% by the year 2000.

The purpose of this study is to determine which alternative is less costly to the citizens of Tucson. The cost factors considered in this study include: the cost of owning and operating an automobile; constructing and maintaining roads; and financing and operating a bus system.

CONCLUSIONS

Based on the findings of this study, it is financially adventageous for the citizens of Tucson to support the Alternative 2 transportation system as opposed to Alternative 1. The Alternative 2 transportation system, as presented in the Comprehensive Plan, calls for expanding the present bus system to accommodate 12% of all daily person trips by the year 2000 while Alternative 1 provides for keeping the bus system operating at its present capacity of 3% of all daily person trips. By increasing bus ridership to 12%, the citizens of Tucson can save in terms of both public and private costs. The public cost savings include the cost of constructing less additional miles of road and maintaining less additional miles of road between now and 2000, as compared to Alternative 1. The private cost savings are in terms of gasoline, car maintenance and parking. The private cost savings will only accrue to those who actually use the bus system while the savings in public costs will accrue to all Tucsonans. The total savings are substanital. In the aggregate Tucsonans can save $2,800,000,000 in terms of public and private costs. This equals a savings of $4,106 per person over the next 25 years. These savings are more than enough to offset the additional capital and operating costs of expanding the bus system, which equals $278,238,525 in the aggregate or $454 per person. All costs are presented in the following two tables.

This finding is consistant with studies done in other communities. In Santa Clara County, California,[1] if a 30% ridership objective can be realized on the proposed rapid transit system, 280-300 million can be saved in highway construction, auto ownership and operating cost to county residents. This is a greater savings by 110-160 million than is needed to finance the rapid transit system.

A study done by the Institute of Urban and Regional Research at the University of Iowa, Iowa City[2] concludes that when factors including owning and operating a car, cost of highways, parking, the environment, capital and operating costs of a bus system are considered, a passenger trip of 8 miles by car cost $1.80 while the same trip costs $.90 by bus, (assuming 1.6 persons/vehicle for the car and 20-30% occupancy on the bus).

---

[1] De Leuw, Cather consulting firm, Santa Clara Rapid Transit Development Project, 1974.

[2] Lee, Douglass B. Jr., Costs of Urban and Suburban Transportation Modes. The Institute of Urban and Regional Research, University of Iowa, Iowa City, April, 1975.

TABLE A

COST (AGGREGATE)

	Alternative 1 (dollars)	Alternative 2 (dollars)	Difference (dollars)
Car Usership:	9,201,729,064	7,143,674,591	2,058,054,473
Road Construction:			
Neighborhood	583,200,000	414,900,000	168,300,000
Collector	103,350,000	30,740,000	72,610,000
Arterial	276,000,000	70,000,000	206,000,000
Non-divided hwys.	94,500,000	-0-	94,500,000
Divided highways	91,000,000	29,050,000	6,950,000
Freeways	177,500,000	45,000,000	132,500,000
Subtotal	1,325,550,000	589,690,000	735,860,000
Road Maintenance:			
Neighborhood	106,693,000	75,844,600	30,849,000
Collector	19,914,000	5,512,000	14,402,000
Arterial	49,008,100	12,124,900	36,883,200
Non-divided hwys.	6,021,400	-0-	6,021,400
Divided highways	7,086,400	2,104,420	4,981,980
Freeways	6,597,500	2,001,000	4,596,500
Subtotal	195,321,000	97,586,920	97,734,080
Savings in these categories with Alternative 2			2,891,648,553
Bus System:			
Capital costs	22,093,200	71,064,400	48,971,200
Operating expenses	125,304,725	354,572,050	229,267,325
Subtotal	147,397,925	425,636,450	278,238,525
Savings in this category with Alternative 1			278,238,525
Net Savings - Alternative 2			2,613,410,028

TABLE B

COST (PER PERSON)

	Alternative 1 (dollars)	Alternative 2 (dollars)	Difference (dollars)
Car Usership	14,700	11,973	2,727
Road Construction:			
Neighborhood	971	691	280
Collector	175	25	150
Arterial	461	115	346
Non-divided hyws.	155	-0-	155
Divided highways	152	45	107
Freeways	292	94	198
Subtotal	2,206	970	1,236
Road Maintenance:			
Neighborhood	162	115	47
Collector	31	7	24
Arterial	76	18	58
Non-divided hwys.	7.8	-0-	7.8
Divided highways	9.2	2	7.2
Freeways	6.1	1.8	4.3
Subtotal	292.1	143.8	148.3
Savings in these categories with Alternative 2			4,106.3
Bus System:			
Capital costs	26	118	92
Operating expenses	200	562	362
Subtotal	226	680	454
Savings in this category with Alternative 1			454
Net Savings (Alternative 2)			3652.3

METHODOLOGY

1. The two alternative modal splits being compared in this study in terms of cost are as follows:

Percent of travel by the following means of transportation for the year 2000

	Car	Bus	Motorcycle	Walking	Bicycle	Total
Modal Split 1 [1] (referred to as Alternative 1)	84%	3%	2%	8%	3%	100%
Modal Split 2 [2] (referred to as Alternative 2)	70%	12%	3%	10%	5%	100%

Alternative 1 is the existing transportation system in Tucson. Alternative 2 is suggested for implementation by the year 2000 in the Transportation Element of the Comprehen - sive Plan. This study deals only with the costs relating to car and bus travel.

2. The population projections between now and the year 2000 used in this study are based on the population projections in The Comprehensive Plan[3]. The five year projections are as follows:

1975	457,104
1980	513,688
1985	567,720
1990	617,891
1995	702,703
2000	752,165

Between the five year projections, population is assumed to increase at equal increments.

----

1 The Comprehensive Plan, Transportation p.3.

2 The projected non-auto trips - 2000 of 30.2% is found on p. 26 Transportation, The Comprehensive Plan. This was broken dwon by Mode by Rich Corbett, PAGTPP.

3 CPP Population Projections, The Comprehensive Plan, p.22 Population Growth.

3. The study area is the Tucson metropolitan region.

4. All costs are in 1975 dollars. No provisions are made for inflation.

5. The study compared only quantifiable impacts, the apparent dollar cost. This includes the cost of owning and operating a car, building and maintaining roads, financing the bus system. Other costs and benefits such as time cost[1] or savings, or environmental effects were not considered.

6. There are a few other quantifiable costs that would vary with the transportation alternatives which could not be considered in this study due to either lack of available information or time constraints. These include costs such as the cost of policing the streets and the cost of accidents and hospital costs.

7. This study was concerned only with costs. It is assumed that in one way or another the money to finance roads, highways and buses in Tucson comes from the citizens of Tucson, whether directly or indirectly through taxes. This study was not concerned with the revenue sources, only the costs. It is very difficult to make assumptions about revenue sources over a 25 year period because they vary yearly.

---

[1] This was considered in a study by J.T. Wenders, "Cost of Urban Transportation", Arizona Review, June-July 1974.

GENERAL ASSUMPTIONS

1. The continuation of gasoline availability is assumed and it is assumed that no new constraints will be imposed on the use of the private automobile.

2. The two alternative transportation systems assume two alternative land use patterns. Alternative 1 which is a continuation of existing travel modes assumes our land development patterns will remain unchanged, characterized by "Peripheral Expansion". The Mode 2 transportation alternative is based on achieving a land use pattern in Tucson characterized by "Contained Growth" in which urban development will be restricted in outlying areas while promoting it within the existing metropolitan area.

3. The bus system is assumed to operate 18 hours per day.

4. The buses are assumed to travel at a speed of 20 m.p.h.

5. Bus occupancy is assumed to be 25%.

6. All costs associated with car usership are assumed to be variable.

7. The road specifications remained constant for both alternatives.

GLOSSARY OF TERMS

Arterial road	The class of streets serving major movement of traffic not served by freeway.
Collector road	A street which collects and distributes traffic between higher type arterial highways and less important streets or directly to traffic movement and access to abutting properties equally important.
Freeway	A divided arterial highway designed for the safe, unimpeded movement of large volumes of traffic, with full control of access and grade separation at intersections.
Highway system	Network of streets which carry the automotive vehicles throughout local, arterial, ramp and freeway type facilities.
Local or neighborhood street	A street intended only to provide access to abutting properties.
Mode	A means of type of travel such as auto driver, auto passenger, transit, bicycle, or walk.
Seat mile	One seat going one mile.
Vehicle mile of travel (VMT)	One vehicle traveling one mile or two vehicles traveling one half mile each and so on.

COST OF CAR USERSHIP - ALTERNATIVE 1 vs ALTERNATIVE 2

This section presents a cost comparison of car usership between Alternative 1 and 2. Alternative 1 holds car usership constant to the year 2000 at its present level of accommodating 84% of all daily person trips. This is compared to Alternative 2 in which car usership is decreased from its present level to accommodating 70% of all daily person trips by the year 2000 as suggested in the Transportation Element of The Comprehensive Plan.

All the calculations associated with these alternatives are presented in detail in Tables I and II.

The calculations to determine the cost associated with Alternative 1 versus Alternative 2 are based on the yearly vehicle miles traveled under each alternative, multiplied by the cost per mile. The vehicle miles traveled by car and passenger truck were based on an average trip length, an average number of trips per day per person and an average car and passenger truck occupancy. The cost difference between alternatives is substantial.

	Aggregate Cost of Car Usership Between 1975-2000	Cost of Car Usership Per Person Between 1975-2000
Alternative 1	9,201,729,060	14,700
Alternative 2	7,143,674,591	11,973
Difference	2,058,054,473	2,727

Considering all the factors presented in this study, the greatest difference presented in Alternative 2 can come from decreasing car usership 14%. This finding is consistant with a study done on financing a public transportation system in Santa Clara County, California[2]. The study concluded that the major potential for the reduction in the total cost of transportation comes from a reduction in private transportation.

---

[1] The Comprehensive Plan, Transportation Element, p.26.

[2] DeLeuw, Cather consulting firm. Santa Clara County Rapid Transit Development Project, p. II-4, 1974.

Road Requirements - Alternative 1 vs. Alternative 2

The added miles of road needed to maintain current mobility levels for the Tucson metropolitan region between now and the year 2000 varies dramatically by transportation alternative. If we continue with our current transportation system (Alternative 1), our current land use pattern, characterized by a "leap frog" pattern of development, will continue generating the need for additional roads for commuting purposes. It will also create a need for more neighborhood roads because under this type of land use pattern the neighborhoods tend to be more "spread out."

In comparison, Alternative 2 assumes a land development pattern characterized by continued infilling in the urban development area, along with the development of activity centers. This will provide the patronage for the expansion of the Alternative 2 transportation system. This alternative will require substantially fewer miles of roadways.

Table III and IV present a comparison of the total and per year road requirements under each alternative. The road requirements under the (Alternative 2) Contained Growth alternative are 1,651 miles less than under the (Alternative 1) Peripheral Expansion alternative.[1]

To figure the total cost of the various road types under each alternative, the cost per mile for each road type was multiplied by the number of miles of road required under each alternative. The cost of providing bridges and culverts were not included in the road requirements. A bridge costs 200-400 thousand dollars and a culvert costs 50-100 thousand dollars[2] and it is assumed that under Alternative 1, the Tucson metropolitan area needs about 11 bridges. There are no accurate projections concerning the number of bridges and culverts needed under Alternative 2 so neither figures were included.

The specifications of the roads under both alternatives remained constant. In actuality, under Alternative 2 the roads possibly could have been narrower. Due to decreased car usership, the demand on the roads would be less. This would have caused the cost difference between alternatives to be even greater.

Based on the calculations presented in Table III and IV, the difference in cost by alternative is as follows:

---

[1] Booz, Allen and Hamilton. Cost/Revenue Analysis, July, 1974 p.30.

[2] Allen, John, Department of Transportation, City of Tucson.

	Aggregate Cost for All New Roads Between 1975-2000	Cost Per Individual For All New Roads Between 1975-2000
Alternative 1	$1,325,550,000	$2,206
Alternative 2	589,690,000	970
Difference	735,860,000	1,236

Road Maintenance Costs Alternative I vs Alternative II

The amount of money spent on maintaining the added road mileage required over the next 25 years is dependent upon the mileage of the various types of road built between 1975 and 2000. It is assumed that the road requirements presented in Tables III and IV are built because the maintenance costs are based on the road requirements by year. The cost of maintenance remains constant by road types between alternatives.

The maintenance costs include the cost of asphalt maintenance, sealcoating, overlay, street sweeping, sign, signal, street lighting, and median maintenance.

Tables VII-a and VII-b present a detailed analysis of how the yearly maintenance figures for all types of roads were determined. All maintenance cost figures are presented in Tables V and VI.

The conclusions of this section are obvious. Since Alternative 1 provides for the construction of more miles of roads than Alternative 2 the yearly maintenance costs associated with Alternative 1 are significantly higher also.

The cost difference between Alternatives are as follows:

	Aggregate Cost of Road Maintenance Between 1975-2000	Cost Per Individial For Road Maintenance Between 1975-2000
Alternative 1	$195,321,000	$292.10
Alternative 2	97,586,920	143.80
Difference	97,734,080	148.30

Bus System - Alternative 1 vs Alternative 2

The number of buses needed for each alternative is based on the projected year 2000 daily person trips of 2,600,000.[1] Alternative 1 assumes 3% of all daily person trips will be made by bus between now and 2000 while Alternative 2 assumes that 12% of all daily person trips will be made by bus between now and 2000. The following table presents a comparison of the number of buses needed and costs under each alternative.

	Alternative 1	Alternative 2
Number of buses to be purchased	337	942
Costs (aggregate)		
Capital	22,093,220	71,064,400
Operating	125,304,725	354,572,050
Total	147,397,925	425,636,450
Costs (per person)		
Capital	26	118
Operating	200	562
	226	680

The number of buses needed to meet the Alternative 1 demand of 3% and Alternative 2 demand of 12% of all daily person trips equals 145 and 577 buses respectively. In order to acquire this many buses over the 25 year period replacement of buses must also be considered. A bus must be replaced every 10 years. When this is taken into consideration the number of buses to be purchased by Alternative increases dramatically to 337 (Alternative 1) and 942 (Alternative 2).

It must be stressed that the number of buses needed will vary greatly depending on the length and type of bus route. For this reason, it must be assumed that the length and type of bus route will remain similar to the present operating structure.

The calculation to determine the number of needed under each alternative is shown in footnotes to Table VIII and IX.

The capital costs for the alternative bus system equal the number of buses needed at cost per bus of 68,200.[2] The total operating expenses equal the number of buses acquired each year under each alternative (-15% spare[3]) x the cost per mile to operate a bus (91¢[4]) x the number of miles traveled per year (50,000[5]).

The added cost of the Alternative 2 bus system equals $278,238,525 in the aggregate or $454 dollars per person. This is the only category in this study in which Alternative 1 shows a cost savings.

----

1 The Comprehensive Plan, Transportation Element, p. 23.

2 John Allen, Department of Transportation. The cost includes $65,000 per bus plus $1,200/bus for a fare and $2,000 /bus for a radio.

3 Marty Nizlek, Department of Transportation.

4 Mayor and Council Communication, Amendment of Transit Management Contract with Tucson Transit Corp., June 23, 1975.

5 Estimate from bus manufacturer.

TABLE I Car Usership - Alternative 1

1 Year	2 Population (1)	3 Average trip length (2)	4 Trips per day per person(3)	5 Total Avg. daily person miles [Column 3x4x2]	6 No. of days per Year	7 Total Avg.Yearly person miles [Column 5x6]
1975	457,104	5.03	3.15	7,222,243	365	2,636,118,768
1976	468,421	5.03	3.15	7,401,052	365	2,701,383,907
1977	479,738	5.03	3.15	7,579,860	365	2,766,649,046
1978	491,054	5.03	3.15	7,758,653	365	2,831,908,418
1979	502,371	5.03	3.15	7,937,462	365	2,897,173,557
1980	513,688	5.03	3.15	8,116,270	365	2,962,438,696
1981	524,494	5.03	3.15	8,287,005	365	3,024,756,898
1982	535,301	5.03	3.15	8,457,756	365	3,087,080,867
1983	546,107	5.03	3.15	8,628,491	365	3,149,399,069
1984	556,914	5.03	3.15	8,799,241	365	3,211,723,038
1985	567,720	5.03	3.15	8,969,976	365	3,274,041,240
1986	577,754	5.03	3.15	9,128,513	365	3,331,907,318
1987	587,788	5.03	3.15	9,287,050	365	3,389,773,396
1988	597,823	5.03	3.15	9,445,603	365	3,447,645,241
1989	607,857	5.03	3.15	9,604,141	365	3,505,511,319
1990	617,891	5.03	3.15	9,762,678	365	3,563,377,397
1991	634,853	5.03	3.15	10,030,677	365	3,661,197,251
1992	651,815	5.03	3.15	10,298,677	365	3,759,017,105
1993	668,778	5.03	3.15	10,566,692	365	3,856,842,726
1994	685,741	5.03	3.15	10,834,708	365	3,054,668,347
1995	702,703	5.03	3.15	11,102,707	365	4,052,488,201
1996	712,595	5.03	3.15	11,259,001	365	4,109,535,365
1997	722,488	5.03	3.15	11,415,310	365	4,166,588,296
1998	732,380	5.03	3.15	11,571,604	365	4,223,635,460
1999	742,273	5.03	3.15	11,727,913	365	4,280,688,391
2000	752,165	5.03	3.15	11,884,207	365	4,337,735,555

---

[1]CPP Population Projections, The Comprehensive Plan. pg.22, Population Growth. (between the 5 year intervals, the population was assumed to increase in equal increments)

[2]The Comprehensive Plan, pg.22, Transportation (this is the average of the 73 avg. trip length of 4.38 miles and the forecast based on existing trends of 5.69 miles for year 2000).

[3]The Comprehensive Plan, pg.22, Transportation. (The average of the 1973 trips per person per day and the projection for the year 2000.

TABLE I Car Usership- Aleternative 1 (Cont'd)

8 % Person miles by Cars and Passenger Trucks(4)	9 Person mile by car and Passenger Trucks	10 Car and truck Occupancy (5)	11 Yearly VMT by car and passenger truck [Column 9÷ Column 10]	12 Yearly Cost of VMT by car and Passenger Truck (dollars) [Col. 11x.145](6)	13 Yearly Cost To The Individual [Col. 12÷2]
95%	2,504,312,830	1.35	1,855,046,541	268,981,748	588
95%	2,566,314,712	1.35	1,900,973,861	275,641,210	588
95%	2,628,316,594	1.35	1,946,901,181	282,300,671	588
95%	2,690,312,977	1.35	1,992,824,427	288,959,542	588
95%	2,752,314,879	1.35	2,038,751,762	295,619,005	588
95%	2,814,316,761	1.35	2,084,679,082	302,278,467	588
95%	2,873,519,053	1.35	2,128,532,632	308,637,232	588
95%	2,932,726,824	1.35	2,172,390,240	314,996,585	588
95%	2,991,929,116	1.35	2,216,243,790	321,355,350	588
95%	3,051,136,886	1.35	2,260,101,397	327,714,703	588
95%	3,110,339,178	1.35	2,303,954,947	334,073,467	588
95%	3,165,311,952	1.35	2,344,675,520	339,977,950	588
95%	3,220,284,726	1.35	2,385,396,093	345,882,433	588
95%	3,275,262,979	1.35	2,426,120,725	351,787,505	588
95%	3,330,235,753	1.35	2,466,841,299	357,691,988	588
95%	3,385,208,527	1.35	2,507,561,872	363,596,471	588
95%	3,478,137,388	1.35	2,576,398,065	373,577,719	588
95%	3,568,216,250	1.35	2,643,123,148	383,252,856	588
95%	3,664,000,589	1.35	2,714,074,510	393,540,804	588
95%	3,756,934,930	1.35	2,782,914,763	403,522,641	588
95%	3,849,863,791	1.35	2,851,750,956	413,503,889	588
95%	3,904,058,597	1.35	2,891,895,257	419,324,812	588
95%	3,958,258,881	1.35	2,932,043,616	425,146,324	588
95%	4,012,453,687	1.35	2,972,187,916	430,967,248	588
95%	4,066,653,971	1.35	3,012,336,275	436,788,760	588
95%	4,120,848,777	1.35	3,052,480,576	442,609,684	588
TOTAL				9,201,729,064	14,700

[4] Yearly person miles consist of miles traveled by car, transit, and motorcycle. The % of miles traveled by transit (3.5%) and motorcycle(2%) were subtracted out. The 3.5% and 2% figure were taken from pg.3 Transportation, The Comprehensive Plan.

[5] The average of the existing car occupancy of 1.2, pg.8 Transportation, The Comprehensive Plan and the projection of 1.5 persons/car for 2000, Rich Corbett, PAGTPP.

[6] U.S. Department of Transportation Federal Highway Administrative Statistics 1975. The figure used was the cost/mile for an intermediate car. The 14.5¢ includes 4.2¢/mile for depreciation, 3.4%/mile for maintenance, accessories, parts and tires, 5.3¢mile for gas and oil (excluding taxes) and 1.6¢ for insurance. 1.5¢/mile for state and federal taxes was not included to avoid double counting because a portion of that money goes towards road construction.

Table 2 Car Usership - Alternative 2

1. Year	2. Population (1)	3. Average trip length (2)	4. Trips per day per person (3)	5. Total avg. daily person miles (column 3x4x2)	6. Number of days per year	7. Total yearly average person miles (column 5x6)
1975	457,104	4.29	3.15	6,170,904	365	2,252,379,960
1976	468,421	4.29	3.15	6,323,683	365	2,308,144,295
1977	479,738	4.29	3.15	6,476,463	365	2,363,908,995
1978	491,054	4.29	3.15	6,629,229	365	2,419,668,585
1979	502,371	4.29	3.15	6,782,009	365	2,475,433,285
1980	513,688	4.29	3.15	6,934,788	365	2,531,197,620
1981	524,494	4.29	3.15	7,080,669	365	2,584,444,185
1982	535,301	4.29	3.15	7,226,564	365	2,637,695,860
1983	546,107	4.29	3.15	7,372,445	365	2,690,942,425
1984	556,914	4.29	3.15	7,518,339	365	2,744,193,735
1985	567,720	4.29	3.15	7,664,220	365	2,797,440,300
1986	577,754	4.29	3.15	7,799,679	365	2,846,882,835
1987	587,788	4.29	3.15	7,935,138	365	2,896,325,370
1988	597,823	4.29	3.15	8,070,611	365	2,945,773,015
1989	607,857	4.29	3.15	8,206,069	365	2,996,215,185
1990	617,891	4.29	3.15	8,341,529	365	3,044,658,085
1991	634,853	4.29	3.15	8,570,516	365	3,128,238,340
1992	651,815	4.29	3.15	8,799,503	365	3,211,818,595
1993	668,778	4.29	3.15	9,028,503	365	3,295,403,595
1994	685,741	4.29	3.15	9,257,504	365	3,378,988,960
1995	702,703	4.29	3.15	9,486,491	365	3,462,569,215
1996	712,595	4.29	3.15	9,620,033	365	3,511,312,045
1997	722,488	4.29	3.15	9,753,588	365	3,560,059,620
1998	732,380	4.29	3.15	9,887,130	365	3,608,802,450
1999	742,273	4.29	3.15	10,020,685	365	3,657,550,025
2000	752,165	4.29	3.15	10,154,277	365	3,706,311,105

---

1 CPP Population Projections, The Comprehensive Plan. Page 22 population growth. (Between the 5 year intervals, the population was assumed to increase in equal incraments.)

2 The Comprehensive Plan. Page 22 transportation. (This is the average of the 1973 average trip length of 4.38 miles and the average trip length assumed for the year 2000 of 4.2 miles.)

3 The Comprehensive Plan. Page 22 transportation. (The average of the 1973 trips per person per day and the Projection for the year 2000.

Car Usership - Alternative 2 (Cont'd)

8. % person miles by car and passenger truck (4)	9. person miles by car and passenger trucks	10. car and truck occupancy (5)	11. yearly VMT by car and passenger truck (column 9 ÷ 10)	12. cost of VMT by car and passenger truck (dollars) (column x .145) (6)	13. cost of the individual (column 11 ÷ column 2)
95%	2,139,760,962	1.35	1,585,088,120	229,826,177	503
94%	2,174.271,926	1.35	1,610,571,797	233,532,911	499
94%	2,212,618,819	1.35	1,638,976,903	237,651,651	495
93%	2,250,291,784	1.35	1,666,882,803	241,698,006	492
92%	2,287,300,355	1.35	1,694,296,559	245,673,001	489
92%	2,321,108,218	1.35	1,719,339,421	249,304,216	485
91%	2,354,428,653	1.35	1,744,021,224	252,883,077	482
90%	2,387,114,753	1.35	1,768,233,150	256,393,807	478
90%	2,416,466,298	1.35	1,789,975,036	259,546,380	475
89%	2,450,565,005	1.35	1,815,233,337	263,208,834	473
89%	2,478,532,106	1.35	1,835,949,708	266,212,708	469
88%	2,502,410,012	1.35	1,853,637,046	268,777,372	465
87%	2,531,388,373	1.35	1,875,102,499	271,889,862	462
87%	2,553,985,204	1.35	1,891,840,982	274,316,929	459
86%	2,578,880,274	1.35	1,910,281,684	276,990,844	456
86%	2,603,182,662	1.35	1,928,283,453	279,601,101	452
85%	2,652,746,112	1.35	1,964,977,120	284,921,68	449
84%	2,704,351,257	1.35	2,003,223,153	290,467,357	446
84%	2,754,957,405	1.35	2,040,709,189	295,902,832	442
83%	2,801,181,848	1.35	2,074,949,517	300,867,680	439
82%	2,849,694,464	1.35	2,110,884,788	306,078,294	436
81%	2,868,390,810	1.35	2,124,733,933	308,086,420	432
81%	2,883,648,292	1.35	2,136,035,772	309,725,187	429
80%	2,901,477,170	1.35	2,149,242.348	311,640,140	426
80%	2,918,724.920	1.35	2,162,018,459	313,492,677	422
80%	2,931,692,084	1.35	2,171,623,766	314,885,446	418
Total				7,143,674,591	11,973

Savings (Mode 2 over Mode 1) 2,058,054,473 2,727

---

[4]In 1974, trips by car and passenger trucks were 95% of all person trips. Transportation page 3, The Comprehensive Plan. One of the assumptions of mode 2 of car usership is that car usership will decrease 14% by the year 2000. The percentages of car usership is assumed to decrease at equal increments until the low point of 79% of VMT by car and passenger truck is reached. This low point was established by solving for x in the ratio x/95 + 70/84.

[5]The average of the existing car occupancy of 1.2, pg. 8, transportation, The Comprehensive Plan and the projection of 1.5 persons/car for 2000, Rich Corbett, PAGTPP.

[6]U.S. Department of Transportation Federal Highway Administrative Statistics 1975. (See footnote 5 of table I for a detailed explanation.)

TABLE-III Road Requirements- Alternative 1

YEAR	NEIGHBORHOOD ROADS			COLLECTOR ROADS			ARTERIAL ROADS		
	Miles of roads needed (1)	Capital cost (dollars) (2)	Cost to individual (dollars) (3)	Miles of road needed	Capital cost (dollars) (4)	Cost to individual (dollars)	miles of roads needed	Capital costs (dollars) (5)	Cost to the individual (dollars)
1975									
1976	123	22,140,000	47	15	3,975,000	8	13	10,400,000	22
1977	123	22,140,000	46	15	3,975,000	8	13	10,400,000	22
1978	123	22,140,000	45	15	3,975,000	8	13	10,400,000	21
1979	123	22,140,000	44	15	3,975,000	8	13	10,400,000	21
1980	123	22,140,000	43	15	3,975,000	8	13	10,400,000	20
1981	117	21,060,000	40	14	3,710,000	7	12	9,600,000	18
1982	117	21,060,000	39	14	3,710,000	7	12	9,600,000	18
1983	117	21,060,000	38	14	3,710,000	7	12	9,600,000	18
1984	117	21,060,000	38	14	3,710,000	7	12	9,600,000	17
1985	117	21,060,000	37	14	3,710,000	7	12	9,600,000	17
1986	110	19,800,000	34	13	3,445,000	6	12	9,600,000	17
1987	110	19,800,000	34	13	3,445,000	6	12	9,600,000	16
1988	110	19,800,000	33	13	3,445,000	6	12	9,600,000	16
1989	110	19,800,000	33	13	3,445,000	6	12	9,600,000	16
1990	110	33,840,000	32	13	3,445,000	6	12	9,600,000	16
1991	188	33,840,000	53	23	6,095,000	10	20	16,000,000	25
1992	188	33,840,000	52	23	6,095,000	9	20	16,000,000	24
1993	188	33,840,000	51	23	6,095,000	9	20	16,000,000	24
1994	188	33,840,000	49	23	6,095,000	9	20	16,000,000	23
1995	188	33,840,000	48	23	6,095,000	9	20	16,000,000	23
1996	110	19,800,000	28	13	3,445,000	5	12	9,600,000	14
1997	110	19,800,000	27	13	3,445,000	5	12	9,600,000	14
1998	110	19,800,000	27	13	3,445,000	5	12	9,600,000	13
1999	110	19,800,000	27	13	3,445,000	5	12	9,600,000	13
2000	110	19,800,000	26	13	3,445,000	5	12	9,600,000	13
TOTAL	3244	583,200,000	971	394	103,350,000	175	343	276,000,000	461

TABLE III (cont.) Road Requirements-Alternative 2

YEAR	NON-DIVIDED HIGHWAYS			DIVIDED HIGHWAYS			FREEWAYS		
	Miles of road needed	Capital Cost (dollars) (6)	Cost to individual (dollars)	Miles of road needed	Capital Cost (dollars) (7)	Cost to individual (dollars)	miles of roads needed	Capital Cost (dollars) (8)	Cost to the individual (dollars)
1975									
1976	4	3,600,000	7	2.5	3,500,000	8	1.4	7,000,000	14
1977	4	3,600,000	7	2.5	3,500,000	8	1.4	7,000,000	14
1978	4	3,600,000	7	2.5	3,500,000	8	1.4	7,000,000	14
1979	4	3,600,000	7	2.5	3,500,000	7	1.4	7,000,000	14
1980	4	3,600,000	7	2.5	3,500,000	7	1.4	7,000,000	14
1981	4	3,600,000	7	2.3	3,220,000	6	1.3	6,500,000	13
1982	4	3,600,000	7	2.3	3,220,000	6	1.3	6,500,000	12
1983	4	3,600,000	7	2.3	3,220,000	6	1.3	6,500,000	12
1984	4	3,600,000	7	2.3	3,220,000	6	1.3	6,500,000	12
1985	4	3,600,000	7	2.3	3,220,000	6	1.3	6,500,000	11
1986	3.5	3,150,000	5	2.2	3,080,000	5	1.2	6,000,000	10
1987	3.5	3,150,000	5	2.2	3,080,000	5	1.2	6,000,000	10
1988	3.5	3,150,000	5	2.2	3,080,000	5	1.2	6,000,000	10
1989	3.5	3,150,000	5	2.2	3,080,000	5	1.2	6,000,000	10
1990	3.5	3,150,000	5	2.2	3,080,000	5	1.2	6,000,000	10
1991	6	5,400,000	8	3.8	5,320,000	8	2.0	10,000,000	15
1992	6	5,400,000	8	3.8	5,320,000	8	2.0	10,000,000	15
1993	6	5,400,000	8	3.8	5,320,000	8	2.0	10,000,000	15
1994	6	5,400,000	8	3.8	5,320,000	8	2.0	10,000,000	15
1995	6	5,400,000	7	3.8	5,320,000	7	2.0	10,000,000	15
1996	3.5	3,150,000	5	2.2	3,080,000	4	1.2	6,000,000	7
1997	3.5	3,150,000	4	2.2	3,080,000	4	1.2	6,000,000	7
1998	3.5	3,150,000	4	2.2	3,080,000	4	1.2	6,000,000	7
1999	3.5	3,150,000	4	2.2	3,080,000	4	1.2	6,000,000	8
2000	3.5	3,150,000	4	2.2	3,080,000	4	1.2	6,000,000	8
TOTAL	103	94,500,000	155	65	91,000,000	152	36	177,500,000	292

Table III Footnotes

---

[1]Booz, Allen and Hamilton, Cost/Revenue Analysis, July 1974, page 30. On page 30 of this study, the total amount of neighborhood, collector and arterial roads, divided, nondivided highways and freeways needed between now and 2000 are found. The roads are assumed to be built in proportion to the population increases stated on page 22, Population, The Comprehensive Plan.

*[2]John Allen, Dept. of Transportation. Neighborhood roads are assumed to cost 180,000/mile.

[3]The cost to the individual is figured by dividing the capital costs by the population projection for that year.

*[4]John Allen, Dept. of Transportation
Two lane road = $180,000/mile
Four lane (no median) = $350,000/mile
(Collector streets in Tucson were assumed to be either two or four lane. The cost of these two types of roads were averaged to get the figure $265,000 which was used for the cost/mile of a collector road)

*[5]John Allen, Dept. of Transportation

Four lane (no median) road	$350,000
Four lane (no median) road	$900,000
Five lane (no median) road	$750,000
Six lane (median) road	$1,200,000

(All 4 of these types of roads can be arterials.) The figure 800,000 which is the average of these 4 roads types was used as the cost/mile of a collector road.

[6]Lindsey, Dean, Planning Survey Group, Arizona Department of Transportation. In 1973 dollars a 4 lane non-divided 48 foot wide highway was estimated to cost $780,000 This excludes cost of right of way and utilities. This figure was updated to 900,000 in 1975 dollars by using the June 27 construction index value of 7.1 for 73-74, Engineering News Record, July 4, 1974, page 28 and the June 12 construction index value of 10.1 for 74-75 Engineering News Record, July 19,1975,pg.169

[7]Lindsey, Dean, Planning Survey Group, Arizona Dept. of Transportation. For a 4 lane divided highway, consisting of two 38 foot roadways, the cost is estimated at $1,200,000 per mile in 73 dollars. This figure was updated to $1,400,000 in 75 dollars as above. (see footnote 6)

[8]Lindsey, Dean, Planning Survey Group, Arizona Dept. of Transportation. In 1974 dollars an urban freeway consisting of two lanes in each direction is estimated to cost 4.5 million dollars. This excludes the cost of right of way, interchanges, and utilities. This figure was updated to $5,000,000 in 75 dollars by using the 74-75 construction index value of 10.1, Engineering News Record, July 19,1975, page 169.

*(All road costs are exclusive of design, inspection fees and right of way costs)

TABLE IV Road Requirements - Alternative 2

YEAR	NEIGHBORHOOD ROADS Miles of road needed (1)	Capital Costs (dollars) (2)	Cost to individual (dollars) (3)	COLLECTOR ROADS Miles of road needed	Capital Costs (Dollars) (4)	Cost to Individual (dollars)	ARTERIAL ROADS Miles of road needed	Capital Costs (dollars) (5)	Cost to individual (dollars)
1975							3	2,400,000	5
1976	88	15,840,000	34	4	1,060,000	2	3	2,400,000	5
1977	88	15,840,000	33	4	1,060,000	2	3	2,400,000	5
1988	88	15,840,000	32	4	1,060,000	2	3	2,400,000	5
1979	88	15,840,000	32	4	1,060,000	2	3	2,400,000	5
1980	88	15,840,000	31	4	1,060,000	2	3	2,400,000	5
1981	83	14,940,000	28	4	1,060,000	2	3	2,400,000	4
1982	83	14,940,000	28	4	1,060,000	2	3	2,400,000	4
1983	83	14,940,000	27	4	1,060,000	2	3	2,400,000	4
1984	83	14,940,000	27	4	1,060,000	2	3	2,400,000	4
1985	83	14,940,000	26	4	1,060,000	2	3	2,400,000	4
1986	78	14,040,000	24	4	1,060,000	2	3	2,400,000	4
1987	78	14,040,000	24	4	1,060,000	2	3	2,400,000	4
1988	78	14,040,000	23	4	1,060,000	2	3	2,400,000	4
1989	78	14,040,000	23	4	1,060,000	2	3	2,400,000	4
1990	78	14,040,000	23	4	1,060,000	2	3	2,400,000	4
1991	134	24,120,000	38	6	1,590,000	3	5	4,000,000	6
1992	134	24,120,000	37	6	1,590,000	2	5	4,000,000	6
1993	134	24,120,000	36	6	1,590,000	2	5	4,000,000	6
1994	134	24,120,000	35	6	1,590,000	2	5	4,000,000	6
1995	134	24,120,000	34	6	1,590,000	2	5	4,000,000	6
1996	78	14,140,000	20	4	1,060,000	1	3	2,400,000	3
1997	78	14,140,000	19	4	1,060,000	1	3	2,400,000	3
1998	78	14,140,000	19	4	1,060,000	1	3	2,400,000	3
1999	78	14,140,000	19	4	1,060,000	1	3	2,400,000	3
2000	78	14,140,000	19	4	1,060,000	1	3	2,400,000	3
TOTAL	2,306	414,900,000	691	109	30,740,000	25	85	70,000,000	115

TABLE IV (cont.) Road Requirements - Alternative 2

YEAR	NON-DIVIDED HIGHWAYS Miles of road needed	Capital cost (dollars)	Cost to the individual (dollars)	Miles of road needed	Capital Cost (dollars) (6)	Cost to the individual (dollars)	Miles of road needed	Capital Cost (dollars) (7)	Cost to the individual (dollars)
1975									
1976	0			.8	1,120,000		.4	2,000,000	4
1977	0			.8	1,120,000	2	.4	2,000,000	4
1978	0			.8	1,120,000	2	.4	2,000,000	4
1979	0			.8	1,120,000	2	.4	2,000,000	4
1980	0			.8	1,120,000	2	.4	2,000,000	4
1981	0			.75	1,050,000	2	.4	2,000,000	4
1982	0			.75	1,050,000	2	.4	2,000,000	4
1983	0			.75	1,050,000	2	.4	2,000,000	4
1984	0			.75	1,050,000	2	.4	2,000,000	4
1985	0			.75	1,050,000	2	.4	2,000,000	4
1986	0			.7	980,000	2	.4	2,000,000	4
1987	0			.7	980,000	2	.4	2,000,000	3
1988	0			.7	980,000	2	.4	2,000,000	3
1989	0			.7	980,000	1	.4	2,000,000	3
1990	0			.7	980,000	1	.4	2,000,000	3
1991	0			1.2	1,680,000	3	.6	3,000,000	5
1992	0			1.2	1,680,000	3	.6	3,000,000	5
1993	0			1.2	1,680,000	2	.6	3,000,000	5
1994	0			1.2	1,680,000	2	.6	3,000,000	4
1995	0			1.2	1,680,000	2	.6	3,000,000	4
1996	0			.7	980,000	1	.4	2,000,000	3
1997	0			.7	980,000	1	.4	2,000,000	3
1998	0			.7	980,000	1	.4	2,000,000	3
1999	0			.7	980,000	1	.4	2,000,000	3
2000	0			.7	980,000	1	.4	2,000,000	3
TOTAL	0			21	29,050,000	45	11	45,000,000	94

Table IV Footnotes

---

[1]Booz, Allen and Hamilton, Cost/Revenue Analysis. July, 1974, page 30. On page 30 of this study, the total amount of neighborhood, collector and arterial roads, divided, non-divided highways and freeways needed between now and 2000 are found. The roads are assumed to be built in proportion to population increases stated on page 22, Population, The Comprehensive Plan.

* [2]John Allen, Department of Transportation. Neighborhood roads cost $180,000/mile.

[3]The cost to the individual is figured by dividing the capital costs by the population projection for that year.

* [4]John Allen, Department of Transportation
Two lane road = $180,000/mile
Four lane (no median) road=$350,000/mile
(collector streets in Tucson were assumed to be either 2 or 4 lane. The figure 265,000 which was used as the cost of a collector road was the average cost of these two road types)

* [5]John Allen, Department of Transportation

Four lane (no median)	road	350,000
Four lane (median)	road	900,000
Five lane (no median)	road	750,000
Six lane (median)	road	1,200,000

(all 4 of these types of roads can be arterials. The figure 800,000 which is the average of these 4 road types was used as the cost/mile of an arterial road.)

[6]Lindsey, Dean, Planning Survey Group, Arizona Dept. of Transportation. For a four lane divided highway, consisting of two 38 foot roadways, is estimated at 1,200,000 per mile in 73 dollars. This does not include costs of right of way or utilities. This cost was updated to 1975 dollars by using the June 27 construction index value of 7.1 for 73-74, Engineering News Record, July 4, 1974, page 28 and the June 12 construction index value of 10.1 for 74-74, Engineering News Record, July 19,1975, page 169.

[7]Lindsey, Dean, Planning Survey Group, Arizona Dept. of Transportation. In 74 dollars an urban freeway consisting of two lanes in each direction is estimated to cost 4.5 million dollars. This excludes cost of right of way, interchanges, utilities. This figure was updated to 5,000,000 in 75 dollars by using the 74-75 construction index value of 10.1, Engineering News Record, July 19,1975, page 169.

*(All road costs are exclusive of design, inspection fees and right of way costs)

TABLE-V Road Maintenance Costs - Alternative 1

YEAR	NEIGHBORHOOD ROADS			COLLECTOR ROADS			ARTERIAL ROADS		
	Total miles of roads (1)	Mainten-ance cost (dollars) (2)	Cost to individual (dollars) (3)	Total miles of roads	Mainten-ance cost (dollars) (4)	Cost to individual (dollars)	Total miles of roads	Mainten-ance cost (dollars) (5)	Cost to individual (dollars)
1975									
1976	123	319,800	1	15	60,000	0	13	146,900	0
1977	247	642,200	1	30	120,000	0	26	293,800	1
1978	370	962,000	2	45	180,000	0	39	440,700	1
1979	493	1,281,800	3	60	240,000	0	52	587,600	1
1980	616	1,601,600	3	75	300,000	1	65	734,500	1
1981	733	1,905,800	4	89	356,000	1	77	870,100	2
1982	850	2,210,000	4	103	412,000	1	90	1,017,000	2
1983	967	2,514,200	5	117	468,000	1	102	1,152,600	2
1984	1083	2,815,800	5	132	526,000	1	115	1,299,500	2
1985	1200	3,120,000	6	146	584,000	1	127	1,435,100	3
1986	1311	3,408,600	6	159	636,000	1	139	1,570,700	3
1987	1421	3,694,600	6	173	692,000	1	150	1,695,000	3
1988	1531	3,980,600	7	186	744,000	1	162	1,830,600	3
1989	1641	4,266,600	7	199	796,000	1	174	1,966,200	3
1990	1752	4,555,200	7	213	852,000	1	185	2,090,500	3
1991	1940	5,044,000	7	236	944,000	2	205	2,316,500	4
1992	2128	5,532,800	8	258	1,032,000	2	225	2,542,500	4
1993	2316	6,021,600	9	281	1,124,000	2	245	2,768,500	4
1994	2504	6,510,400	9	304	1,216,000	2	265	2,994,500	4
1995	2693	7,001,800	10	327	1,308,000	2	283	3,197,900	5
1996	2803	7,287,800	10	340	1,360,000	2	296	3,344,800	5
1997	2913	7,573,800	10	354	1,416,000	2	308	3,480,400	5
1998	3023	7,859,800	10	362	1,448,000	2	320	3,616,000	5
1999	3134	8,148,400	11	381	1,524,000	2	331	3,740,300	5
2000	3244	8,434,400	11	394	1,576,000	2	343	3,875,900	5
TOTAL		106,693,600	162		19,914,000	31		49,008,100	76

TABLE V Road Maintenance Cost - Alternative 1 (Cont'd)

YEAR	NON-DIVIDED HIGHWAYS			DIVIDED HIGHWAYS			FREEWAYS		
	Total miles of road	Capital costs (dollars) (6)	Cost to the individual (approx.) dollars (7)	Total miles of road	Capital costs (dollars) (8)	Cost to the individual (approx.) dollars	Total miles of road	Capital costs (dollars) (9)	Cost to the individual (approx.) dollars
1975		--							
1976	4	18,400	0	3	25,800	0	1.4	20,300	0
1977	8	36,800	0	5	43,000	0	2.7	39,150	0
1978	12	55,200	0	8	68,800	0	4.1	59,450	0
1979	16	73,600	0	10	86,000	.2	5.5	79,750	0
1980	20	92,000	.2	12	103,200	.2	6.8	98,600	.2
1981	23	105,800	.2	15	129,000	.2	8.1	117.450	.2
1982	27	124,200	.2	17	146,200	.2	9.4	136,300	.2
1983	31	142,600	.2	19	163,400	.2	10.7	155,150	.2
1984	34	156,400	.2	22	189,200	.3	12	174,000	.2
1985	38	174,800	.3	24	206,400	.3	13.3	192,850	.2
1986	42	193,200	.3	26	223,600	.3	14.5	210,250	.3
1987	45	207,000	.3	29	249,400	.3	15.7	227,650	.3
1988	49	225,400	.3	31	266,600	.5	17	246,500	.3
1989	52	239,200	.3	33	283,800	.5	18.2	263,900	.3
1990	56	257,600	.3	35	301,000	.5	19.4	281,300	.5
1991	62	285,200	.5	39	335,400	.5	21.5	311,750	.5
1992	68	312,800	.5	43	369,800	.5	23.6	342,200	.5
1993	74	340,400	.5	46	395,600	.5	25.7	372,650	.5
1994	80	368,000	.5	50	430,000	.5	27.8	403,100	.5
1995	86	395,600	.5	54	464,400	.5	30	435,000	.6
1996	90	414,000	.5	56	481,600	.6	31.1	450,950	.6
1997	93	427,800	.5	58	498,800	.6	32.3	468,350	.7
1998	96	441,600	.5	61	524,600	.6	33.5	485,750	.7
1999	100	460,000	.5	63	541,800	.6	34.7	503,150	.7
2000	103	473,800	.5	65	559,000	.6	36	522,000	.7
TOTAL		6,021,400	7.8		7,086,400	9.2		6,597,500	6.1

TABLE-VI Road Maintenance Costs - Alternative 2

YEAR	NEIGHBORHOOD ROADS			COLLECTOR ROADS			ARTERIAL ROADS		
	Miles of road needed (1)	Maintenance cost (dollars) (2)	Cost to individual (dollars) (3)	Miles of road needed	Maintenance cost (dollars) (4)	Cost to individual (dollars)	Miles of road needed	Maintenance cost (dollars) (5)	Cost to individual (dollars)
1975									
1976	88	228,800	0	4	16,000	0	3	33,900	0
1977	175	455,000	1	8	32,000	0	6	67,800	0
1978	263	683,800	1	12	48,000	0	10	113,000	0
1979	351	912,600	2	17	68,000	0	13	146,900	0
1980	438	1,138,800	2	21	84,000	0	16	180,800	0
1981	521	1,354,600	3	25	100,000	0	19	214,700	0
1982	604	1,570,400	3	29	116,000	0	22	248,600	0
1983	687	1,786,200	3	32	128,000	0	25	282,500	1
1984	770	2,002,000	4	36	144,000	0	28	316,400	1
1985	853	2,217,800	4	40	160,000	0	31	350,300	1
1986	932	2,423,200	4	44	176,000	0	34	384,200	1
1987	1010	2,626,000	4	48	192,000	0	37	418,100	1
1988	1088	2,828,800	5	51	204,000	0	40	452,000	1
1989	1167	3,034,200	5	55	220,000	0	43	485,900	1
1990	1245	3,237,000	5	59	236,000	0	46	519,800	1
1991	1379	3,585,400	6	65	260,000	0	51	576,300	1
1992	1513	3,933,800	6	72	288,000	0	56	632,800	1
1993	1647	4,282,200	6	78	312,000	0	61	689,300	1
1994	1780	4,628,000	7	84	336,000	1	66	745,800	1
1995	1914	4,976,400	7	90	360,000	1	71	802,300	1
1996	1992	5,179,200	7	94	376,000	1	73	824,900	1
1997	2071	5,384,600	7	98	392,000	1	76	858,800	1
1998	2149	5,587,400	7	102	408,000	1	79	892,700	1
1999	2228	5,792,800	8	105	420,000	1	82	926,600	1
2000	2306	5,995,600	8	109	436,000	1	85	960,500	1
TOTAL		75,844,600	115		5,512,000	7		12,124,900	18

TABLE VI Road Maintenance Cost - Alternative 2 (Cont'd)

YEAR	NON-DIVIDED HIGHWAYS			DIVIDED HIGHWAYS			FREEWAYS		
	Miles of road needed	Capital costs (dollars) (6)	Cost to the indiv. (approx. dollars) (7)	Miles of road needed	Capital costs (dollars) (8)	Cost to the indiv. (approx. dollars)	Miles of road needed	Capital costs (dollars) (9)	Cost to the indiv. (approx. dollars)
1975	0								
1976	0			.8	6,880	0	.4	5,800	0
1977	0			1.6	13,760	0	.8	11,600	0
1978	0			2.4	20,640	0	1.2	17,400	0
1979	0			3.2	27,520	0	1.6	23,200	0
1980	0			4.0	34,400	0	2.0	29,000	0
1981	0			4.7	40,420	0	2.4	34,800	0
1982	0			5.5	47,300	0	2.8	40,600	0
1983	0			6.3	54,180	0	3.2	46,400	0
1984	0			7.0	60,200	0	3.6	52,200	0
1985	0			7.8	67,080	0	4.0	58,000	0
1986	0			8.5	73,100	0	4.4	63,800	0
1987	0			9.2	79,120	0	4.8	69,600	0
1988	0			9.9	85,140	0	5.2	75,400	0
1989	0			10.6	91,160	0	5.6	81,200	0
1990	0			11.3	97,180	0	6.0	87,000	0
1991	0			12.6	108,360	.2	6.6	87,000	0
1992	0			13.8	118,680	.2	7.2	104,400	.2
1993	0			15.0	129,000	.2	7.8	113,100	.2
1994	0			16.2	139,320	.2	8.4	121,800	.2
1995	0			17.4	149,640	.2	9.0	130,500	.2
1996	0			18.1	155,660	.2	9.4	136,300	.2
1997	0			18.9	162,540	.2	9.8	142,100	.2
1998	0			19.6	168,560	.2	10.2	147,900	.2
1999	0			20.3	174,580	.2	10.6	153,700	.2
2000	0	0	0	21	180,600	.2	11	159,500	.2
TOTAL					2,104,420	2		2,001,000	1.8

TABLE V & VI

[1] See footnote 1, Table III. Maintenance costs are based on the total amount of roads needed per year so the added amount of roads needed each year are added to the total from the previous year. (Which are assumed to have been built).

[2] See Table VII-a for a complete explanation of yearly maintenance costs for neighborhood roads. The yearly maintenance cost was approximately $2500 per mile.

[3] The cost to the individual is figured by dividing the capital costs by the population projection for that year.

[4] See Table VII-a for a complete explanation of yearly maintenance costs for collector roads. The yearly maintenance cost was approximately $000 per mile.

[5] See Table VII-a for a complete explanation of yearly costs for arterial roads. The yearly maintenance cost was approximately $11,300 per mile.

[6] The cost/mile for non-divided highway maintenance per year equals approximately $4600. See Table VII-b for complete explanation.

[7] To obtain the cost to the individual, the yearly maintenance cost was divided by the population.

[8] The cost/mile for divided highway maintenance per year equals approximately $8600. For explanation, refer to Table VII-b.

[9] The cost/mile for interstate maintenance equals approximately $14,500. For exp lanation, refer to Table VII-b.

TABLE VII-A

Calculation of Road Maintenance Cost for
Neighborhood, Collector and Arterial Roads

Existing Road Mileage by Road Type[1]

paved with curbs (2 lane)	515.78 miles
paved with curbs and sidealks (2 land)	241.56 miles
strip paving (2 land)	219.60 miles
multiple lane divided without curbs (I-10, I-19)	25.16 miles
multiple lane divided with curbs (4 lane divided, 5 lane, 6 land divided)	37.23 miles
four lane not divided with curbs	63.58 miles

Cost of Sealcoat, Overlay, Sweeping, Asphalt Maintenance by Road Type[2]

	Paved/Curbs	Paved/Sideqalks/Curbs	Strip Paving
Sealcost	206,239	121,816	110,740
Overlay	-0-	-0-	579,000
Sweeping	188,000	88,000	80,000
Asphalt	376,000	176.000	160,000
Total	824,239	385,816	929,740
÷ No. of miles	518.78	241.56	219.69
Cost/Mile	1,588.80	1,597.18	4,232.05

	Multilane/Divided/ No Curbs	Multilane/Dividend/ With Curbs	4/lane/Not Divided/Curbs
Sealcoat	11,074	16,611	33,222
Overlay	-0-	-0-	-0-
Sweeping	8,000	12,000	24,000
Asphalt	16,000	24,000	48,000
Total	35,174	52,611	105,222
÷ No. of miles	25.16	37.23	63.58
Cost/Mile	1,394.14	1,413.13	1,654.95

(Assume that all paved with curbs, ½ paved with curbs and sidewalks, and 1/3 strip paving are neighborhood roads. Assume ½ of paved with curbs and sidewalks, 1/3 strip paving, ½ four lane not divided with curbs are collector roads. Assume 1/3 strip paving, all multiple lane divided with curbs and ½ four lane not divided with curbs are arterial. The multiple lane divided without curbs are highways.)

---

[1] The mileage allocated to the various street types was received from the Division of Engineering of the Department of Transportation, City of Tucson.

[2] Mr. Berg, Division of Street Maintenance, City of Tucson.

TABLE VII - A(contd.)

Neighborhood Road Maintenance Costs

1588.80	X	515.78	=	824,239	
1597.18	X	120.78	=	192,907	
4232.05	X	73.23	=	309,913	
TOTAL				1,327,059	÷ 709.79 = 1869.65 cost/mile

Cost/mile for street signs (3)	473
Cost/mile for street signals(4)	0
Cost/mile for street lights(5)	293.7
TOTAL maintenance cost/mile	2636.35 ≐ 2600

Collector Roads Maintenance Costs

120.78	X	1597.18	=	192,907	
73.23	X	4232.05	=	309,913	
31.79	X	1654.95	=	52,610.8	
				555,430	÷ 225.8 = 2459.8 cost/mile

Cost/mile for street signs	473
Cost/mile for street signals	832
Cost/mile for street lights	248
	4012.8 ≐ 4000.

Arterial Roads Maintenance Costs

73.23	X	4232.05	=	309,913	
37.23	X	1413.13	=	52,610.8	
31.79	X	1654.95	=	52,610.8	
				415,134.6	÷ 142.25 = 2918.3 cost/mile

Cost/mile for street signs	473
Cost/mile for street signals	3,963.6
Cost/mile for street lights	394
Cost/mile for median maintenance (6)	3,600
	11,348.9 ≐ 11,300

---

[3]Tucson Revised City Budget for 1974-75. Cost was 522,230 to maintain street names and signs. (this amount was divided equally among the three street types)

[4]Tucson Revised City Budget for 74-75. The cost was 751,769 to maintain traffic signals. It was assumed that approximately 25% of this is spent on collector streets and 75% is spent on arterial streets. Marvin Nordall, Electric Shop, Traffic Engineering, Dept. of Transportation, City of Tucson.

[5]Tucson Revised City Budget for 74-75 Cost was 320,710 to maintain street lights. It was assumed that approximately 65% of this is spent on neighborhood streets and 35% is spent on collector and arterial streets. Marvin Nordall, Electric Shop, Traffic Engineering, Dept. of Transportation, City of Tucson.

[6]Laura Nichols, Dept. of Parks and Recreation, City of Tucson. Median island maintenance costs from July 74- May 75 totaled 235,584.67 .

TABLE VII- B

Cost of Road Maintenance on the State Highway System in the Tucson Area

Existing Mileage[1]

15.48 Miles of Interstate (I-10, I-19)
5.19 Miles of Divided State Highway (St. 86, U.S. 89, not including B-10 because no cost figures were given)
8.92 Miles of Undivided State Highways (St. 86, U.S. 89)

Cost of Street Maintenance per year per mile[2] (including asphalt maintenance, overlay, sweeping, sealcoating)

Interstates	Divided St. Highways	Non-Divided State Highways
$10,399	$1,697	$1,481

Cost of Street Signal Maintenance per year[3]

	Material	Vehicle	Labor
Cleaning and Relamping	$1920	$1600	$4800
Signal Control	2400	4800	7200
Traffic Signal Replacement	8000	2400	3780
	$12,320	$8,800	$15,780

Total (from above)	$36,900	
	+ 1,600	(electrical check)
	+ 2,600	(pole replacement)
	$41,100	total yearly signal maintenance cost for all three types of road. (Assume there are no signals on interstates, and an equal number on divided and non-divided state highways.)

Cost of Street Lighting and Sign Maintenance per year[4]

	Material	Vehicle	Labor
Signs	378	130	1800
Knockdowns	4800	480	1800
Pole Painting	166	166	950
Cleaning and Relamping	910	1400	1950
	$6,254	$2,176	$6,500

$14,930 total yearly street sign and lighting maintenance for all three types of road. (Assumed that the per mile cost of all three road types are equal)

Table VII-B

Median Maintenance Cost per mile[5]

$3,600/mile

Cost/Mile for all types of Maintenance

	Interstates	Divided Highways	Non-Divided Highways
Street Maintenance	10,399	1,589	1,205
Signal Maintenance	0	2,912	2,912
Street Lights and Sign Maintenance	504	504	504
Median Maintenance	3,600	3,600	0
	$14,503=	$8,605=	$4,621=
	14,500	8,600	4,600

[1]Webster, Thomas, Planning Survey Group, Arizona Department of Transportation

[2]Webster, Thomas, Planning Sudy Group, Arizona Department of Transportation, (Annual maintenance expenditures on the state highway system in the Tucson are from 7/1/74 to 4/30/75 prorated to one year, the data was developed from the ADOT PECOS system).

[3]Lessard, Buz, Arizona Department of Highways.

[4]Lessard, Buz, Arizona Department of Highways.

[5]Nichols, Laura, Department of Parks and Recreation, City of Tucson Median island maintenance costs from July 74 - May 75 totaled $235,584.67.

TABLE VIII

Bus System - Alternative 1

	Capital Costs		Operating Expenses	
Year	Total Yearly Capital Costs (dollars)[a]	Total Yearly Costs per person (dollars)[b]	Total Yearly Operating Exp. (dollars)[c]	Total Yearly Operating Exp. per person (dollars)[d]
1975	750,200	1	4,254,250	8
1976	818,400	1	4,292,925	8
1977	818,400	1	4,331,600	8
1978	818,400	1	4,368,000	8
1979	818,400	1	4,408,950	8
1980	818,400	1	4,447,625	8
1981	818,400	1	4,486,300	8
1982	818,400	1	4,524,975	8
1983	818,400	1	4,563,650	8
1984	886,600	1	4,602,325	8
1985	866,600	1	4,641,000	8
1986	866,600	1	4,679,675	8
1987	866,600	1	4,718,350	8
1988	866,600	1	4,757,025	8
1989	866,600	1	4,795,700	8
1990	886,600	1	4,834,375	8
1991	954,800	1	4,911,725	8
1992	954,800	1	4,989,075	8
1993	954,800	1	5,066,425	7
1994	954,800	1	5,143,775	7
1995	954,800	1	5,221,125	7
1996	954,800	1	5,298,475	7
1997	954,800	1	5,373,825	7
1998	954,800	1	5,453,175	7
1999	954,800	1	5,530,525	7
2000	954,800	1	5,607,875	7
Total	22,093,200	26	125,304,725	200

---

[a] A 45 passenger bus costs $60-65,000. For this study the high figure is used, plus $1200 per bus for a fare box and $2000 per bus for a radio. Total cost of an average bus equals $68,200. (John Allen, Department of Transportation). As of 1975, the City of Tucson had acquired 110 buses. To meet the year 2000 demand to accommodate 3% of all daily person trips, the City of Tucson must acquire and maintain a fleet of 145 buses (this includes 15% spare buses) by the year 2000. It is assumed that the buses will be acquired at equal increments yearly.

TABLE VIII Footnotes (cont'd)

Procedure to calculate the buses needed to meet projected 2000 demand.

	2,600,000 projected 2000 daily person trips	
x .03	78,000	# of trips taken by bus
x 4 (average bus trip length)	312,000	passenger miles/day
x 4 (assume 25% occupancy)	1,248,000	seat miles traveled/day
÷45 (number of seats per bus)	27,733	bus miles per day
÷360 (at 20 mph/18 hour day each bus travels 360 miles per day)	77	buses
x 1.63 (peak hour/average hr. ratio)	126	buses needed
+ 15% of 126	19	spare buses needed
	145	total buses number to accommodate demand

In order to acquire a fleet of 145 buses by 2000, the City must purchase 337 buses over the 25 year period due to the fact that a bus has a life expectancy of 10 years. To acquire 145 buses over the 25 year period, 1 or 2 buses must be added to the fleet yearly plus 11 or 12 must be replaced yearly (it is assumed that the existing fleet of 110 buses will be retired at equal increments yearly.)

[b] The cost per year was divided by the population projection for that year.

[c] Operating costs of a bus equals 91 cents per mile. (Mayor and Council Communication, Amendment of Transit Management Contract with the Tucson Transit Corp., June 23, 1975). According to the bus manufacturer, a bus is expected to go 50,000 miles/year. The yearly operating costs were calculated assuming 85% (to account for the fact that 15% of the buses are spare) of the buses accumulated each year will go 50,000 miles per year at a cost of 91¢/mile.

[d] Cost per year was divided by population per year.

TABLE IX

Bus System Alternative 2

Year	Capital Costs: Total Yearly Capital Costs (dollars)[a]	Capital Costs: Total Yearly Capital Costs per person (dollars)[b]	Operating Costs: Total Yearly Operating Exp. (dollars)[c]	Operating Costs: Total Yearly Operating Exp. per person (dollars)[d]
1975	1,977,800	4	4,950,400	10
1976	1,977,800	4	5,646,500	11
1977	1,977,800	4	6,342,700	11
1978	1,977,800	4	7,038,850	14
1979	1,977,800	4	7,735,000	15
1980	1,977,800	4	8,431,150	16
1981	1,977,800	4	9,127,000	17
1982	1,977,800	4	9,823,450	18
1983	1,977,800	4	10,519,600	19
1984	1,977,800	4	11,215,750	20
1985	3,205,400	6	11,911,900	21
1986	3,205,400	6	12,608,050	22
1987	3,205,400	6	13,304,200	23
1988	3,205,400	5	14,000,350	24
1989	3,205,400	5	14,696,500	24
1990	3,205,400	5	15,392,650	25
1991	3,205,400	5	16,088,800	25
1992	3,205,400	5	16,784,950	26
1993	3,205,400	5	17,481,100	26
1994	3,205,400	5	18,177,250	27
1995	3,205,400	5	18,873,400	27
1996	3,205,400	4	19,569,550	27
1997	3,205,400	4	20,265,700	28
1998	3,205,400	4	20,961,850	28
1999	3,205,400	4	21,658,000	29
2000	3,205,400	4	21,967,400	29
Total	71,064,400	118	354,572,050	562

[a] A 45 passenger bus costs $60-65,000, for the purposes of this study the high figure is used, plus $1200 per bus for a fare box and $2000 per bus for a radio. Total cost of an average bus equals $68,200. (John Allen, Department of Transportation). As of 1975, the City of Tucson had acquired 110 buses. To meet the year 2000 demand to accommodate 12% of all daily person trips, the City of Tucson must acquire and maintain a fleet of 571 buses. It is assumed that the buses will be acquired at equal increments yearly.

Procedure to calculate the additional buses needed.

		2,600,000	projected year 2000 daily person trips
x	.12	312,000	# of trips taken on bus
x	4 (average bus trip length)	1,248,000	passenger miles/day
x	4 (assume 25% occupancy)	4,992,000	seat miles traveled per day.
÷	45 (number of seats per bus)	110,933	bus miles/day
÷	360 (at 20 mph, 18 hours/day a bus travels 360 miles)	308	buses
x	1.63 (peak hour/average hour ratio)	502	buses needed
+	15% of 502	75	spare buses needed
		577	total buses needed to accommodate demand

In order to acquire a fleet of 578 buses by 2000, the City of Tucson must purchase 942 buses over the 25 year period. The fleet must be increased by 18 buses per year plus replace 10 year old buses (the life expectancy of a bus equals 10 years). In the next 10 years, 11 buses must be replaced per year, in the following years 29 buses must be replaced yearly.

b The cost per year was divided by the population projection for each year.

c Operating costs of a bus equal 91 cents per mile (Mayor and Council Communication, Amendment of Transit Management Contract with Tucson Transit Corp. June 23, 1975). According to the bus manufacturer a bus is expected to go 50,000 miles per year. The yearly operating costs were calculated by assuming 85% (to account for the fact that 15% of all buses are spare) of the buses accumulated each year will travel 50,000 miles per year at a cost of 91¢ per mile.

d Cost per year was divided by the population projection for the year.

BIBLIOGRAPHY

1. Allen, John, Department of Transportation, City of Tucson. (Information received was on various cost figures - roads, buses, etc.)

2. Mr. Berg, Division of Street Maintenance, City of Tucson (cost for various types of street maintenance).

3. Booz, Allen and Hamilton, Cost/Revenue Analysis - Four Alternative Plan for Growth. Development Research Associates Division, Booz, Allen and Hamilton, July 1974.

4. ________________, The Comprehensive Plan, Population Growth Element, Tucson, 1975.

5. ________________, The Comprehensive Plan, Transportation Element, Tucson, 1975.

6. Corbett, Rich, PAFTPP (clarification of various points in the Transportation Element of the Comprehensive Plan).

7. ________________, The Cost of Sprawl. Real Estate Research Corp., April 1974.

8. DeLeuw, Cather Consulting Firm. Alternate Modes Study. (unpublished study) 1975.

9. DeLeuw, Cather Consulting Firm. Santa Clara Rapid Transit Development Project, 1974.

10. Division of Engineering of the Department of Transportation, City of Tucson (existing mileage in Tucson by road type).

11. ________________, "Construction Index". Engineering News Record. July 4, 1975, p.28.

12. ________________, "Construction Index". Engineering News Record. July 19, 1975, p.169.

13. Lee, Douglass B., Jr. Costs of Urban and Suburban Transportation Modes. The Institute of Urban and Regional Research, University of Iowa, Iowa City, April 1975.

14. Lessard, Buz. Arizona Department of Highways (per year costs of signals and lighting on highways).

15. Lindsey, Dean. Planning Survey Group, Arizona Department of Transportation (cost of highway, freeway construction).

16. Mayor and Council Communication, Amendment of Transit Management Contract with Tucson Transit Corp., June 23, 1975. (revenue and cost of a bus/mile)

17. Nichols, Laura, Department of Parks and Recreation, City of Tucson, (per year median maintenance costs).

18. Nizlek, Marty, Department of Transportation (calculation of number of buses needed).

19. Nordall, Marvin, Electric Shop, Traffic Division of Transportation, City of Tucson (percent of money spent for maintenance of street signals and lights on the various type of road).

20. , Tucson Revised City Budget, 1974-75 (yearly maintenance cost of street signs, lights, signals).

21. Webster, Thomas, Planning Study Group, Arizona Department of Transportation Planning Division (annual maintenance expenditures on the state highway system in the Tucson area from 7-1-74 to 4-30-75 prorated to one year. The data was developed from the ADOT PECOS system).

22. Wenders, J.T. "Cost of Urban Transportation". Arizona Review, June-July 1974.

23. White, William H., Maintenance Supervisor, District 2, Maintenance Section, Arizona Department of Transportation (cost per year of sign maintenance on highways).

24. U.S. Department of Transportation, Federal Highway Administration, Cost of Operating an Automobile, 1975.