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Assessment of Land-Use Impacts of Highways in Small Urban Areas

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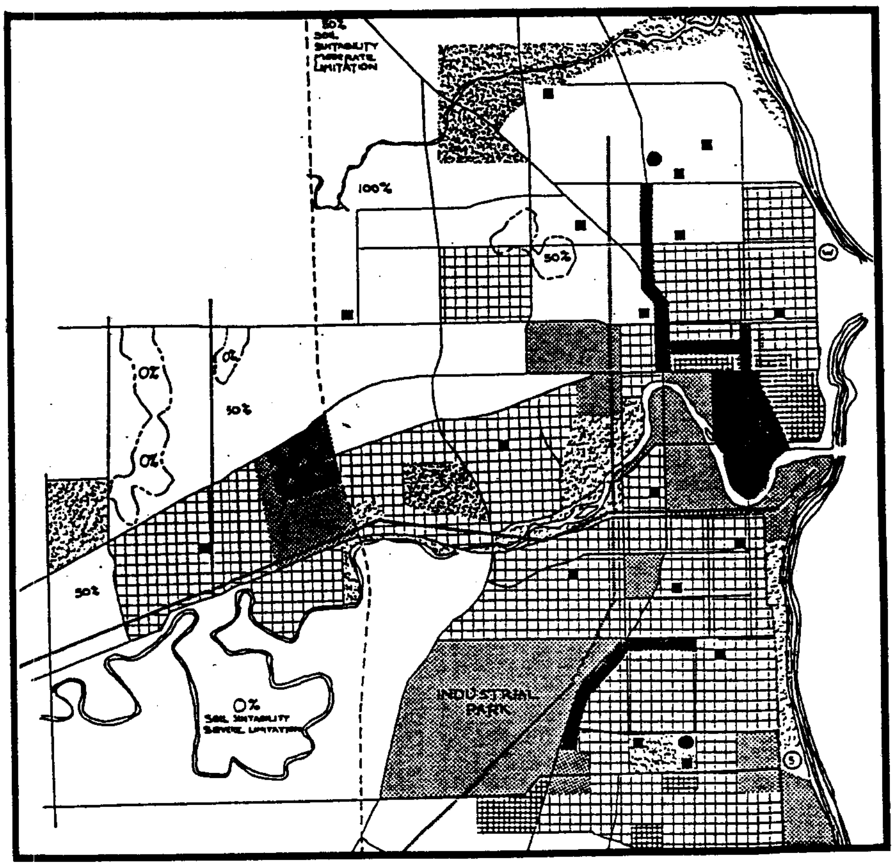

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Abstract

This report evaluates the applicability of existing techniques for assessing the secondary land-use impacts of highway projects in small communities in Wisconsin. Three promising existing techniques -- a structured expert panel evaluation, a Lowry land-use model, and a qualitative "checklist" approach -- were evaluated by applying them to case study projects in Wausau, Eau Claire, Sheboygan, and Wisconsin Rapids. The report summarizes the advantages and limitations of each approach for forecasting secondary land-use impacts of highways. This report was prepared under a grand from the Wisconsin Department of Transportation.

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1. INTRODUCTION

A potentially important impact of any highway project is its effect on the spatial distribution of urban development. This type of impact is often referred to as a secondary land-use impact, in order to distinguish it from changes in land-use that occur within the right-of-way of the highway. Secondary land-use impacts are not direct consequences of the project, but result from modifications in access to parcels of land and from modifications in travel time between various points in the urban area. Secondary land-use impacts have included regional shopping center developments, urban sprawl, and economic decline of central business districts. The reasons why highway projects cause impacts on land use have been well understood for at least two decades (Anas, 1984). However, existing techniques for assessing land-use impacts are directed toward large freeway and rail transit systems in major urban areas. Little prior effort has been devoted to formulating techniques that could be used for assessing impacts of highway projects in or near small communities -- the type of project that is now most often built.

The purpose of this study was to determine the applicability of existing techniques for assessing highway-related impacts in small communities. Various techniques were evaluated by applying them to one or more case study projects. The projects were completed between 10 and 20 years ago -- long enough so that any changes in the development pattern of the urban area would be readily apparent. As best as possible, the techniques were applied as they would have been at the time of the projects. The case study cities were Eau Claire, Sheboygan, Wausau, and Wisconsin Rapids. The projects were of two types: widening of an existing facilility (Eau Claire and Wisconsin Rapids) and a freeway bypass within a completely new right-of-way (Sheboygan and Wausau). These case study projects were selected, with the assistance of WisDOT's staff, because they are typical of the types of projects that would be constructed in Wisconsin in the foreseeable future.

Existing techniques were categorized as (1) assessment by experts, such as an expert panel or gaming-simulation, (2) computer simulations, (3) statistical models, or (4) qualitative assessment, such as a series of short questions, a checklist, or a cross-impact matrix. A representative technique was selected from each category. An attempt was made to adopt, intact, existing techniques. Substantial problems in doing so were encountered. Some techniques were specific to a particular location or to a particular type of project; application of other techniques required more time and/or effort than would be reasonable for most current projects. Therefore, extensive revision was performed to tailor the techniques to the specific problem of highway impact assessment in small cities. The final techniques were a multiple-round, structured expert panel that was derived primarily from the Delphi Method; a Lowry Model of the relationship between transportation and land use; an application of average levels of development; and two checklists.

Two types of validation were sought for each technique. The first validation was that the forecasts from the techniques should correspond to actual patterns of development since the project was built. The second validation, and just as important, was that the techniques should not require more effort than would be justified by the quality and usefulness of the results.

2. EXPERT PANEL EVALUATION

An expert panel was one of the techniques examined and evaluated for usefulness in predicting secondary land-use impacts of highways. A panel, consisting of individuals with backgrounds in different aspects of land use and forecasting, was assembled. This panel of experts was asked to adopt a 1965 frame of mind and to predict changes that had actually occurred over the past twenty years. To aid the panelists in developing such a frame of mind, a narrative of general societal conditions that existed in 1965 was read to them. They also received information regarding each of the two case study cities, as well as brief descriptions of the projects. The forecasting instrument consisted of a questionnaire to elicit evaluations of thirty-one features of community development and a map for each city. Each feature was rated as to whether an impact would take place, whether the impact was negative or positive, the magnitude of the impact and its importance. On the map, the panelists predicted the areas in which residential, retail, service and industrial impact would occur. The first round of this study was conducted in person while the second round was completed by mail. After the results from the second round were tabulated, they were submitted to a smaller panel in each of the cities for evaluation with respect to accuracy and usefulness.

This technique provides a contrast to other methods investigated in this overall study. An expert panel can handle intangible impacts, such as aesthetics, strength of government authority and attitudes of financial institutions, and extremely localized impacts, such as the development of a regional shopping center. These are not impacts that are easily assessed by mathematical models. In addition, an expert panel evaluation can assess intangible impacts with more comprehensive insight than can be accomplished with simple checklists. A structured expert panel appeared to have the following desirable characteristics: (1) expert knowledge and experienced intuition, (2) time efficiency, and (3) low cost.

Prominent Methods of Expert Panel Evaluation

Expert panel techniques include focus groups, gaming-simulations, and structured expert panels. These procedures have received considerable attention, both in the literature and in practice, because they are able to handle issues that are not easily quantifiable. It has been shown that human judgments from these methods can enhance the process of land-use forecasting.

Focus groups (Lovestock and Weinberg, 1984) allow a small number of participants (typically six to ten) to discuss a particular issue in an unstructured manner under the guidance of a skilled moderator. The early discussion is intended to be quite broad so that the participants will be put at ease and will be more comfortable while interacting. Through interaction more spontaneous and possibly more honest comments will be made. When the group is assembled it is necessary to allow for diversity as well as similarity. If too much contrast is present it may stifle discussion. The expertise of the moderator is the essential element in a successful group. It is the responsibility of this individual to maintain the direction of the group on the subject under consideration. This task requires a high level of skill. Clear, unambiguous interpretation of the results is rarely possible, because of the role of the moderator and the unstructured nature of this type of research. This technique would be useful at an exploratory stage but would not be suitable for detailed land-use forecasting. Therefore, this method was not considered appropriate for further investigation in this study.

Simulations are simplified representations of larger, more complex systems. Three different types can be identified: there are those that use computers exclusively (known as models); a combination of computer and human players; and human players only. Those simulations that just utilize humans to generate operations and calculate consequences are known as gaming-simulations (Greenblat, 1981).

Games have three features: (1) explicit rules about how a goal is to be achieved with certain resources, (2) players' psychological orientation that the goal is valueless in itself, (3) social consensus that the activity is inconsequential for the serious business of life (Inbar and Stoll, 1972). When games are used by decision makers in the real world the third feature is naturally violated.

There have been many games developed to assist planners. Three particular games have received considerable attention and illustrate the potential and weaknesses of such an approach. These are SIMSOC (Simulated Society), CLUG (Community Land Uses Game) and IMPASSE (the IMPact ASSEssment game).

SIMSOC (Gamson, 1972) is intended to be a cooperative learning experience. SIMSOC has many desirable features with which a simulated society can be constructed. Its main thrust is centered on social behavior. All components of this game involve the interaction of the participants as well as their personal, group and societal goals. While these elements must all be addressed during the planning and decision making process, they do not directly enhance the powers of prediction. There are no winners or losers, but some participants will do better than others. It is necessary for the players to take the objectives of the society seriously. When ambiguous situations arise there is a coordinator present to refer the question to a group in the society for clarification. The ideal method of running SIMSOC, according to the author, is a full weekend workshop. This game is designed for approximately 40 participants (maximum 60) using four small adjacent rooms.

CLUG (Feldt, 1972) attempts to predict how land will be used based on existing constraints. The players' objectives in this gaming-simulation are to buy and sell land, to construct commercial and residential property, to put industries into operation and to make a profit. CLUG most resembles a board game, complete with dice, markers and play money. It is able to stimulate the interactive elements of conflict and cooperation, as well as strategic thinking. CLUG is designed to include 9 to 25 players who participate in five to ten rounds of the basic game, plus additional experiments if appropriate. The game could easily occupy twenty hours or more of playing time. In this game there are some preestablished components, some left to chance (the roll of the dice) and others are open to negotiations and decision making.

Because of its simplicity, CLUG will not predict what will take place in the future, but will provide an arena for creating possible outcomes. Modifications can be made to better simulate different problems. An argument that can be posited against games such as CLUG is that results will be constrained and directed by the game's design. This is not necessarily undesirable if the limitation of the framework is clearly understood. CLUG can be valuable, but its chief virtue lies in education rather than prediction. Students of urban affairs or urban planning may be better able to anticipate real world problems after playing CLUG.

One game that may eventually prove useful in land-use forecasting is IMPASSE. It is called a game by its authors, but it is actually a combination of a focus group and a structured expert panel. IMPASSE asks participants to evaluate issues that are arranged like spokes on a wheel (Duke and Greenblat, 1979). There are actually two wheels used, each divided into 30 wedges permitting a like number of issues to be rated. Different components relating to the same issue can, thereby, be considered simultaneously. The smaller wheel is for evaluator's responses. They are measured against the ones made by the participants on the larger wheel. This game gives participants an opportunity to compare their opinions with those of an expert. The expert can then provide the reasoning that generated the stated conclusions. The purpose of IMPASSE is to stimulate discussion. If there is disagreement, the expert, through his/her reasoning, may be able to facilitate consensus.

The Delphi Method (Linstone and Turoff, 1975) is another structured expert panel technique that attempts to reach consensus through an iterative process. Delphi panels were first used to predict when events will take place. Rand Corporation has conducted several (Helmer, 1966). Some of the areas investigated included scientific breakthroughs, automation, space progress and future weapons systems.

For Delphi to attain the most reliable consensus of opinion held by a group of experts, intensive questionnaires with controlled feedback are used. After one round has been completed, the findings are tabulated and returned to the panelists. The panel monitoring team may choose to provide this information verbally or use a statistical technique to represent central tendency. Equipped with this additional information, participants may modify their original responses. The number of rounds is not prescribed, but generally three rounds are needed to gain consensus and show stability.

Delphi employs the services of several experts but interaction between them is discouraged. One of the most important features is that the panelists are unknown to each other. Anonymity is preserved by administering the questionnaire through the mail. With Delphi, a dominant personality or an individual with a particularly prestigious title would be unable to exert pressure, either consciously or unconsciously, on the other participating individuals.

The Delphi panel should consist of experts with varied backgrounds. In this way the forecast will benefit from the diversity of knowledgeable input. These experts are often individuals with many commitments; therefore, it is imperative to explain the expected amount of time that needs to be devoted to this activity. The time needed is not extraordinarily large, but individuals with full schedules need to be informed of the requirements.

Ervin (1977) applied the Delphi method to regional industrial land-use forecasting in Tennessee in the mid-seventies. This study was considered an "abbreviated" version, according to the author, since only two rounds were conducted and no effort was made to arrive at a stabilized consensus of opinion. However, it did provide useful information. Since this set of panels was conducted for several industries, it was discovered that the relative importance of the various factors would vary from one industry to another and location factors were important to some industries but of little significance to others.

More recently Cavalli-Sforza and Ortolano (1984) attempted to predict impacts of three alternative transportation projects in San Jose, California by using the Delphi method. Panelists were first asked to rate the importance of components of future scenarios with regard to transportation/land use interaction that may take place. In other words, panelists were asked: What components should be included for further evaluation? There was also an opportunity to rate the likelihood that alternative transportation plans would be implemented. The study team then formulated the alternative scenarios that were used in subsequent rounds. In later rounds, panelists rated the importance and likelihood of the components. They were also asked to forecast land use, commuting patterns and choice of transit mode for each transportation project for both 1990 and 2000. The impacted area was also divided into four zones. Panelists made separate predictions for each zone.

Regarding land use, specific forecasts were made with respect to expected population, number of single family units and multi-family units, and number of commercial and industrial employees for the two different years. The panelists were also provided with this information for 1970 and 1975 so that they would have knowledge of existing trends. Responses were summarized according to medians and interquartile ranges. As the rounds progressed there was evidence of a tightening of the range around the median. This convergence (agreement) was precisely what was sought. Stability was evidenced by the fact that there were smaller changes between Rounds II and III than there were between Rounds I and II.

The greatest difficulty experienced by Cavalli-Sforza and Ortolano was the amount of time needed to reach a successful conclusion. It took progressively greater periods of time to recover the questionnaires as the rounds advanced. The third round was completed eighteen months after the inception of the study. Monetary compensation is one means of counteracting the problem. Of course, the most desirable solution is to bring together a totally committed panel from the inception.

Long time delays will certainly present problems. The most troublesome feature of long time lags is the break with consistency and interest in the project. Regardless of the care taken in selecting panelists, there will be unforeseen events to contend with. If a study is undertaken during the traditional vacation season, there will be greater difficulties in retrieving the materials. It is necessary to carefully plan the time frame of the project and allow a realistic period to complete each phase.

Study Technique: Structured Expert Panel

For this study it was desirable to combine several positive aspects of the aforementioned techniques. An iterative questionnaire, like the Delphi Method, formed the basis for the overall structure. However, it was felt that the technique would benefit from the informal setting, the personal input, the immediate feedback, and the guidance of a moderator that are essential to focus groups. Because land use is a spatial issue, the structured expert panel would also benefit from a map, like the one in CLUG. But it was considered inappropriate to include the competitive element that is part of gaming-simulations such as SIMSOC. By drawing on these earlier methods, it was possible to develop a technique that could handle all the full range land-use impacts.

Panelists were asked to rate thirty-one features of community development that could change because of a highway project. These features are listed in Table 2.1. The questionnaire was based on a modification of the Leopold technique (Leopold, et al, 1971), which asks respondents to rate both the magnitude and importance of an impact. Both ratings used category scales with 0 signifying "no importance" or "no impact" and 10 signifying "extremely important" or "extremely large impact". An example set of scales is shown in Figure 2.1. Panelists were also asked to record the direction of the impact (larger or smaller). Panelists were specifically not asked questions regarding the desirability of the impact. When no impact was recorded, panel members were told to explain this response.

In addition, maps were provided for each of the case study cities, Sheboygan and Wisconsin Rapids, so the locations of residential, commercial, industrial and service impact could be identified. These maps, shown in Figures 2.2 and 2.3, represented the cities as they were in 1965. The features shown were the existing major road network, proposed changes, areas defined as industrial, concentration of workers, commercial, residential, open space and parks. The levels of soil suitability for septic tanks were defined. Also included were the locations of water and sewage plants, as well as schools, hospitals and shopping centers. The maps were not divided into zones. Color pencils were provided to be used by panelists for designating areas in which significant changes in land-use activity would take place. In addition, panelists were asked to show where a regional shopping center or a concentration of services might develop.

Since this study, in essence, was one of "predicting" events that have already come to pass, it was necessary to choose individuals that had little familiarity with the case study cities. The prospective panelists were asked to rate their familiarity with six cities (including the two case study cities). It was necessary to eliminate from the panel some otherwise highly qualified individuals on this basis. A thirteen member panel was recruited, consisting of five experts in technical aspects of highway planning from WisDOT, four university professors who specialize in community development, three community planners from separate agencies and one real estate developer.

The panelists were provided with a brief description of each

Noise Pollution

A) Impact occurs   Yes [ ]   No [ ]   (If No skip to E)

B) Direction of impact   Larger [ ]   Smaller [ ]

C) Magnitude   No Impact |_|_|_|_|_|_|_|_|_|_|_| Extremely Large Impact

D) Importance   No Importance |_|_|_|_|_|_|_|_|_|_|_| Extremely Important

E) Why do you feel there would be no impact?

____

____

Figure 2.1. Sample Question with Scales

Table 2.1

LIST OF COMMUNITY FEATURES

Employment in existing industrial park (e.g. manufacturing)
Industrial employment elsewhere within the study area
Employment in regional shopping centers
Employment in community shopping centers
Employment in neighborhood shopping centers
Retail employment in the CBD
Employment in hotel/motel services
Employment in repair and cleaning services
Employment in advertising, management, consulting and legal services
Amount of regional educational facilities--post-secondary (colleges & technical)
Amount of local schools
Amount of regional health care facilities
Amount of local health care facilities
Service employment in the CBD
Employment in restaurant and fast food establishments
Total population
Amount of unoccupied housing units
Ability of local government to control land use through traditional measures, e.g. zoning
Length of average trip to work in miles
Amount of ride sharing
Amount of intercity travel for work purposes
Overall congestion in the study area
Congestion in the area of highway project
Aesthetics of area surrounding the highway project
Amount of development in communities near but not part of the study area
Amount of development in areas with incomplete utility service
Willingness of financial institutions to lend money for further land development
Land values near project (i.e., within 1000 feet)
Land values in the remainder of the study area
Tax base
Utilization of existing parks

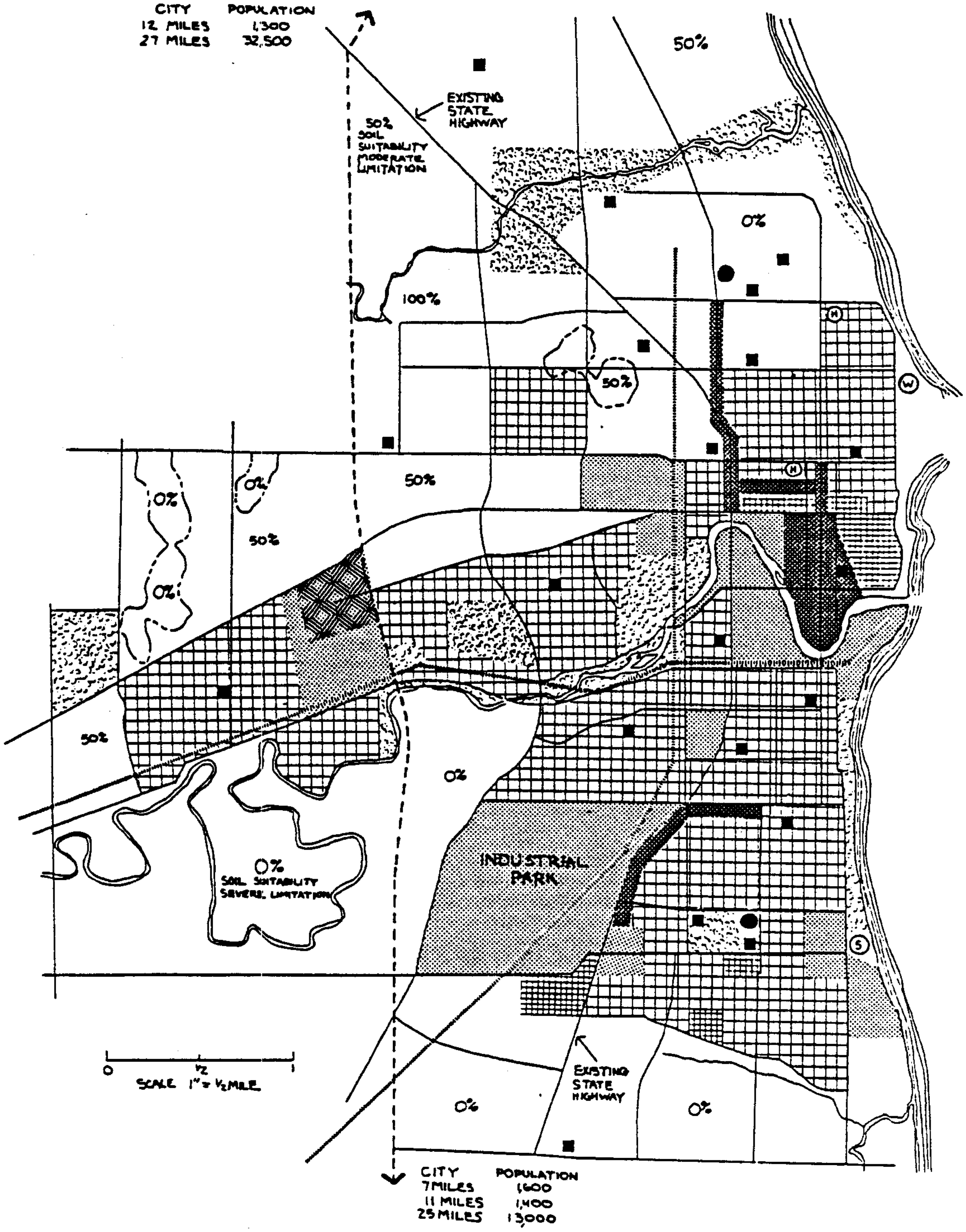


Figure 2.2. Map of Sheboygan

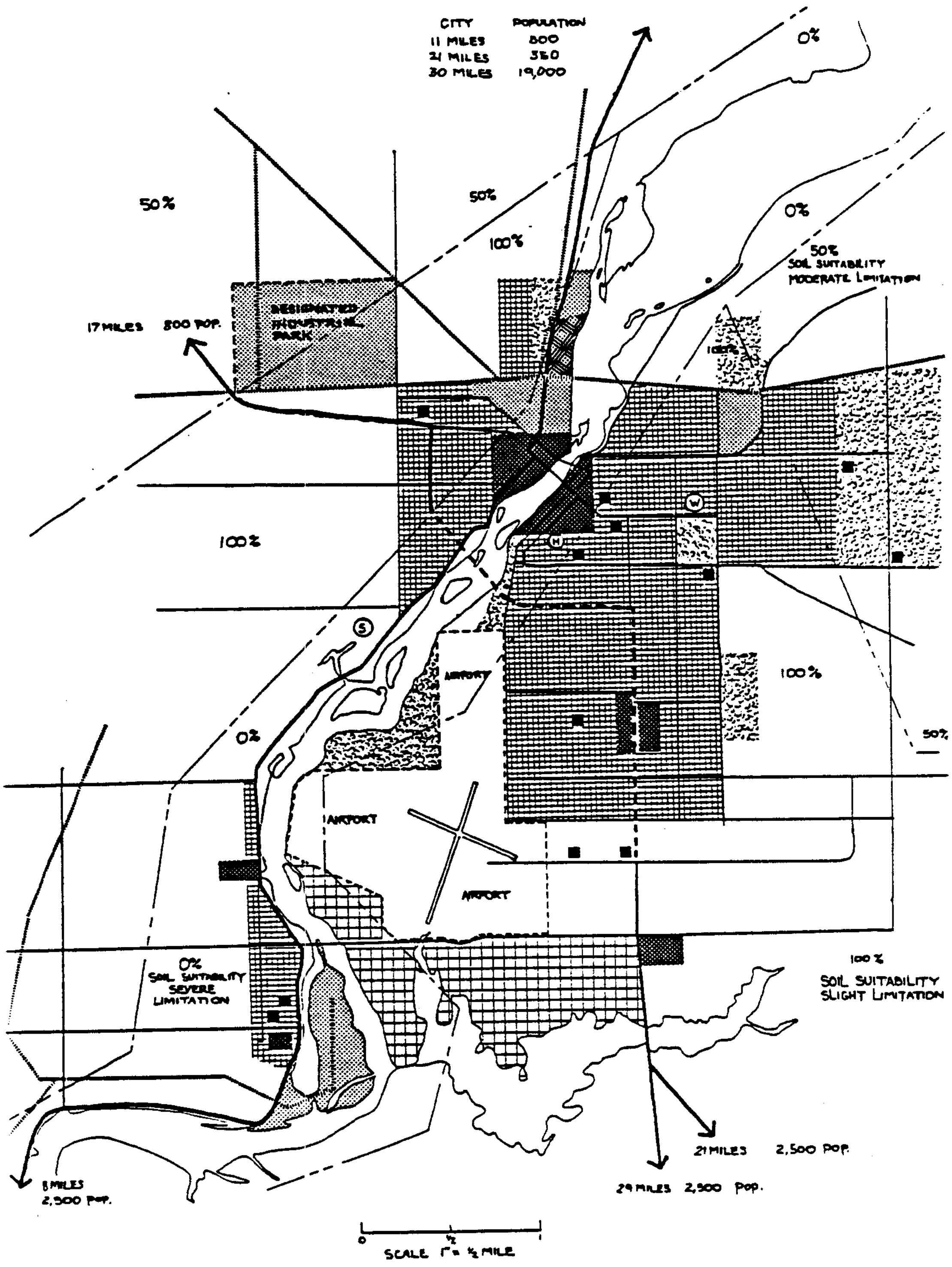


Figure 2.3. Map of Wisconsin Rapids.

city labeled only as "City A" and "City B". The descriptions contained information regarding size, government, economy and concentration of employment. The project for Sheboygan was a freeway bypass, just west of the central city. The project for Wisconsin Rapids consisted of two events: (1) widening portions of an existing two-lane rural highway that is a major link in the state highway system; and (2) adding a bridge across the Wisconsin River so that traffic on this highway could bypass the CBD.

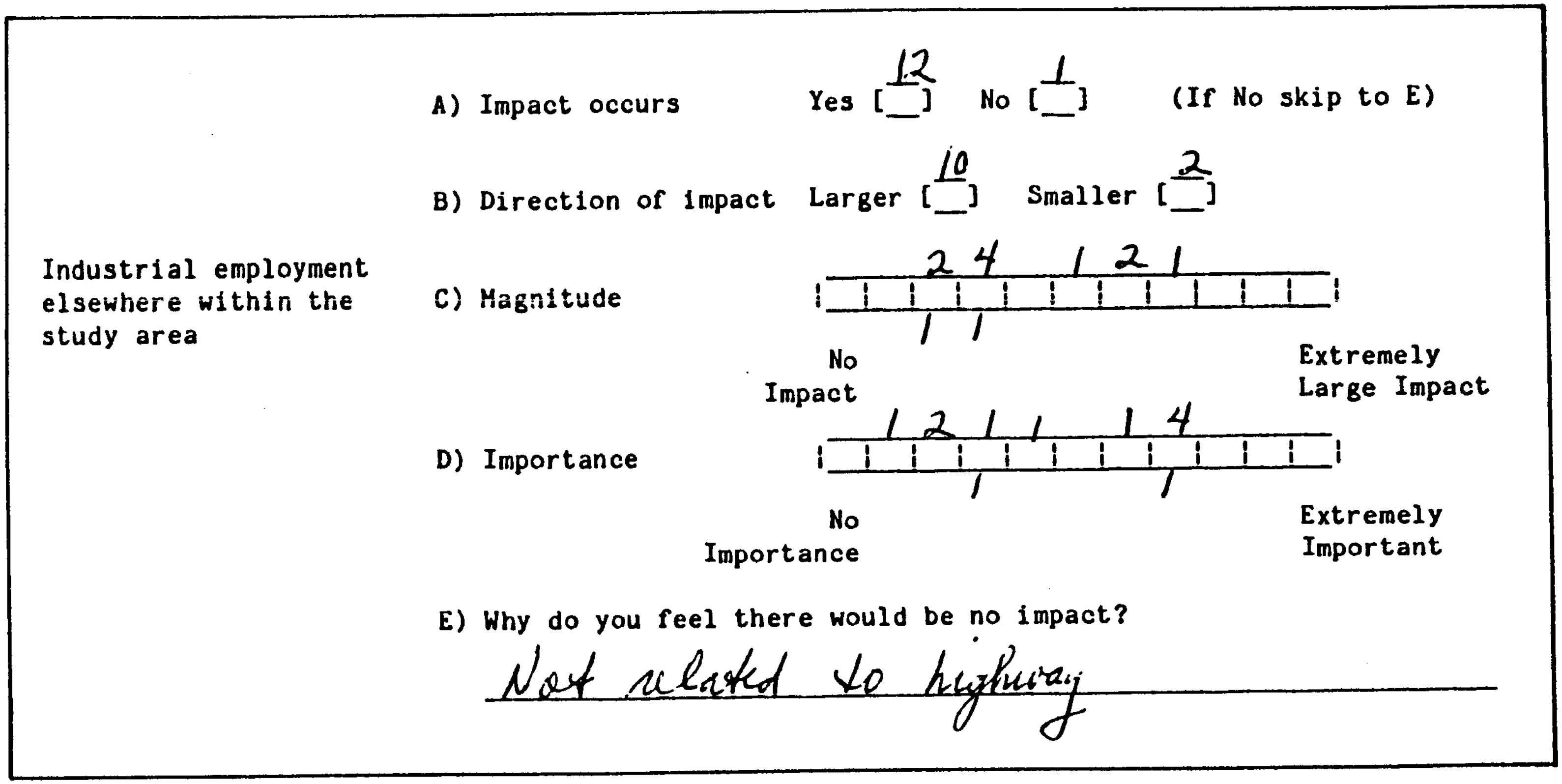
In the interest of expediting the first round, it was conducted in three sessions. Based on the location of panel members, one session took place in Madison, another group met in Milwaukee, and one individual completed the questionnaire for Round I in his Milwaukee office. These sessions were accomplished on three consecutive working days.

At this session panelists were read a narrative of societal conditions in 1965 and complete instructions for handling the features of community development questionnaire and the map (see Appendix A). A member of the study team was present to answer any questions, but the panelists were reminded not to interact with the other panelists. It was necessary to provide some clarification at each session, but the panelists were able to make their responses in an expedient manner.

First round responses were summarized for use in the second round. The responses for questions A, B, C and D for each feature were tallied on a questionnaire as indicated in Figure 2.4. If the panelist felt that the community feature would be larger as a result of the project, the magnitude or importance response was recorded above the appropriate box on the questionnaire. On the other hand, if the community feature was judged to be smaller as a result of the project, it was recorded below the box. The reasons for no impact, given in response to question E, were also recorded as shown in Figure 2.4. It was also necessary to provide a short addendum to the description of each city in response to questions raised by panelists at the time of the first round.

Composite maps for each land-use activity (Residential, Retail, Service, and Industrial) were developed from the information provided by Round I. In the first round panelists had one map on which they were to define the areas of impact for the different land-use activities. In the second round there were four maps provided for each city, one for each activity, showing how all the panelists evaluated the areas of impact. These maps are reproduced in Appendix B.

The second round, unlike the first, was conducted by mail. All the summaries compiled from Round I were mailed approximately two weeks after it took place. The following materials were provided for each city: general instructions, a features



Industrial employment elsewhere within the study area

A) Impact occurs — Yes [12] No [1] (If No skip to E)

B) Direction of impact — Larger [10] Smaller [2]

C) Magnitude — No Impact … Extremely Large Impact

D) Importance — No Importance … Extremely Important

E) Why do you feel there would be no impact?

Not related to highway

Figure 2.4. Example Compilation of Round I Responses

questionnaire with responses recorded; four maps showing the locations of impact on population, industry, retail, service (not retail); the original description of the city, an addendum to the description with information requested by the panelists in the first round. The addendum for Sheboygan included a map showing planned interchanges.

In Round II panelists were asked to respond to exactly the same questions as they had previously answered. This gave them an opportunity to reevaluate their answers given the collective responses of the whole panel. Each of the maps now provided zones that could be selected as areas of impact. Panelists again used the color pencils to designate where impacts would occur. However, they were asked to show areas of positive impact in one color and areas of negative impact in another color.

In Round II the features of community development responses were tabulated in the same way as they had been in Round I. These responses are summarized on Tables 2.2 and 2.3. The reasons for stating no impact are shown in Appendix C. Combined results of the map portion were produced by coloring zones to represent how many panelists said an impact would occur. Separate colors were chosen for: three to seven panelists saying a positive impact would occur in a zone; more than seven panelists saying a positive impact would occur in a zone; three to seven panelists saying a negative impact would occur in a zone, and more than seven panelists saying a negative impact would occur in a zone. The results in Round II displayed greater convergence and consensus than Round I, especially for Wisconsin Rapids.

Evaluation of the Forecasts

Since the panelists forecasted events that had already taken place, it was possible to evaluate the accuracy and usefulness of the technique. The results were presented for review to evaluation panels of local experts. These local experts were people who had actually observed the changes that took place, and thus would be in the best position to assess the forecasts.

Separate evaluation panels were recruited for Wisconsin Rapids and Sheboygan. Each panel was made up of four individuals who were active in city planning or highway engineering. All evaluation panel members had lived in their respective cities for at least twenty years and were well aware of the impacts that their city had experienced.

The Wisconsin Rapids evaluation panel found the forecasting panel to be most accurate in predicting service and industrial impacts. Both the forecasting and evaluation panels agreed on the location of retail impacts, but the evaluation panel rated the magnitude and importance of retail impacts more strongly than

Table 2.2

SUMMARY OF ROUND II RESPONSES--SHEBOYGAN

Statement	Number of No Impact	Number of Responses Positive Impact	Median Positive Magnitude	Median Positive Importance	Number of Responses Negative Impact	Median Negative Magnitude	Median Negative Importance
Employment in existing industrial park (e.g. manufacturing)	0	13	4	5	0	0	0
Industrial employment elsewhere within the study area	0	12	3	4	1	4	4
Employment in regional shopping centers	2	11	6	6	0	0	0
Employment in community shopping centers	2	4	4	3	7	3	4
Employment in neighborhood shopping centers	4	1	4	6	8	3	2
Retail employment in the CBD	0	0	0	0	13	6	7
Employment in hotel/motel services	0	13	6	5	0	0	0
Employment in repair and cleaning services	8	5	3	3	0	0	0
Employment in advertising, management, consulting and legal services	5	8	2	2	0	0	0
Amount of regional educational facilities--post-secondary (colleges & technical)	13	0	0	0	0	0	0
Amount of local schools	4	8	3	4	1	4	1
Amount of regional health care facilities	7	6	2	3	0	0	0
Amount of local health care facilities	7	6	2	2	0	0	0
Service employment in the CBD	2	0	0	0	11	5	5
Employment in restaurant and fast food establishments	0	13	4	5	0	0	0
Total population	6	7	2	2	0	0	0

Table 2.2

SUMMARY OF ROUND II RESPONSES--SHEBOYGAN (continued)

Statement	Number of No Impact	Number of Responses Positive Impact	Median Positive Magnitude	Median Positive Importance	Number of Responses Negative Impact	Median Negative Magnitude	Median Negative Importance
Amount of unoccupied housing units	5	6	3	3	2	3	3
Ability of local government to control land use through traditional measures, e.g. zoning	2	3	2	5	6	7	6
Length of average trip to work in miles	0	10	4	4	3	4	2
Amount of ride sharing	7	0	0	0	6	2	2
Amount of intercity travel for work purposes	0	13	4	3	0	0	0
Overall congestion in the study area	2	0	0	0	11	4	4
Congestion in the area of highway project	1	12	2	3	0	0	0
Aesthetics of area surrounding the highway project	0	8	2	2	5	3	4
Amount of development in communities near but not part ofthe study area	0	13	3	2	0	0	0
Amount of development in areas with incomplete utility service	0	13	2	3	0	0	0
Willingness of financial institutions to lend money for furtherland development	2	11	3	3	0	0	0
Land values near project (i.e., within 1000 feet)	0	13	7	7	0	0	0
Land values in the remainder of the study area	2	12	6	4	0	0	0
Tax base	5	8	3	3	0	0	0
Utilization of existing parks	10	3	2	2	0	0	0

Table 2.3

SUMMARY OF ROUND II RESPONSES--WISCONSIN RAPIDS (continued)

Statement	Number of No Impact	Number of Responses Positive Impact	Median Positive Magnitude	Median Positive Importance	Number of Responses Negative Impact	Median Negative Magnitude	Median Negative Importance
Amount of unoccupied housing units	7	5	2	1	1	3	3
Ability of local government to control land use through traditional measures, e.g. zoning	6	2	6	6	5	4	6
Length of average trip to work in miles	4	8	2	2	1	0	0
Amount of ride sharing	11	0	0	0	2	1	1
Amount of intercity travel for work purposes	3	10	2	2	0	0	0
Overall congestion in the study area	0	1	3	1	12	3	3
Congestion in the area of highway project	0	8	3	2	5	3	3
Aesthetics of area surrounding the highway project	0	8	2	2	4	5	3
Amount of development in communities near but not part ofthe study area	9	4	2	1	0	0	0
Amount of development in areas with incomplete utility service	6	7	3	3	0	0	0
Willingness of financial institutions to lend money for furtherland development	2	11	3	3	0	0	0
Land values near project (i.e., within 1000 feet)	0	12	5	5	1	5	5
Land values in the remainder of the study area	8	5	2	1	0	0	0
Tax base	1	12	3	3	0	0	0
Utilization of existing parks	10	3	2	2	0	0	0

Table 2.3

SUMMARY OF ROUND II RESPONSES--WISCONSIN RAPIDS

Statement	Number of No Impact	Number of Responses Positive Impact	Median Positive Magnitude	Median Positive Importance	Number of Responses Negative Impact	Median Negative Magnitude	Median Negative Importance
Employment in existing industrial park (e.g. manufacturing)	1	12	3	3	0	0	0
Industrial employment elsewhere within the study area	10	3	2	2	0	0	0
Employment in regional shopping centers	12	1	2	2	0	0	0
Employment in community shopping centers	2	11	2	2	0	0	0
Employment in neighborhood shopping centers	6	7	2	2	0	0	0
Retail employment in the CBD	0	0	0	0	13	3	3
Employment in hotel/motel services	5	8	2	2	0	0	0
Employment in repair and cleaning services	12	1	1	2	0	0	0
Employment in advertising, management, consulting and legal services	12	1	3	2	0	0	0
Amount of regional educational facilities--post-secondary (colleges & technical)	13	0	0	0	0	0	0
Amount of local schools	10	3	2	2	0	0	0
Amount of regional health care facilities	13	0	0	0	0	0	0
Amount of local health care facilities	13	0	0	0	0	0	0
Service employment in the CBD	2	0	0	0	11	1	1
Employment in restaurant and fast food establishments	1	12	2	2	0	0	0
Total population	12	1	3	3	0	0	0

the forecasting panel.

Overall, there was also agreement about population impacts. However, some disagreements about population impacts occurred because the study team did not provide complete enough information to the forecasting panel; neither the maps nor the narrative gave any information about high water tables present in some potential growth areas. Also, the study team did not inform the forecasting panel about a large parcel of land held by a local high school, which meant that the land was not available for residential development.

In Sheboygan the forecasting panel did not produce as strong a consensus as they had for Wisconsin Rapids. This made it more difficult to evaluate, but the Sheboygan evaluation panel agreed with most of the forecast. The closest agreement concerned the location of industrial activity. The forecasting panel was able to predict the development of a regional shopping center and to pinpoint its exact location. With only a few exceptions, there was agreement on the magnitude and importance of the thirty-one community features.

The evaluation panel in Sheboygan differed from the forecasting panel primarily in the map portion of the study. The location of retail (excluding the regional shopping center), service and residential areas were only partially accurate. Again, the errors were traced to insufficient information being given to the forecasting panel. For example, access to areas near freeway interchanges was not fully described. The evaluation panel disagreed with the forecasted level of employment in community and neighborhood shopping centers and in some services. As in Wisconsin Rapids, the Sheboygan evaluation panel felt that the magnitude and importance of negative impact on retail in the CBD were stronger than forecasted.

Overall, the forecasting panel slightly underestimated the impacts in Wisconsin Rapids and slightly overestimated them in Sheboygan. Inaccuracies resulted chiefly from incomplete information. This does not indicate a serious flaw in the procedure. In this study it was necessary to reconstruct data from a much earlier year, to be presented to a group of people who were unfamiliar with the cities. But when such an approach is implemented for a future project, the forecasting panel can include residents who would be much more informed about current conditions.

Both evaluation panels felt that the format of presenting maps and features of community development was useful. They had little trouble in understanding the forecasts, but tended to confuse measures of consensus as being measures of strength.

Discussion

A forecast using a structured expert panel can be conducted quickly and efficiently, providing insights that only human expertise can supply. This study was completed in less than two months, once the instrument was developed. A structured expert panel is also a relatively inexpensive undertaking. Participants do not require sizable monetary compensation, and there is no costly equipment. A wide range of issues can be addressed -- some quite intangible. A strong consensus can be reached on difficult subjects; consequently, the results can be interpreted as more dependable than those of a single expert.

The forecasts were reasonably accurate and a good measure of agreement was present. Where the forecasts diverged from actuality, the divergence could usually be attributed to inadequate information presented to the panel. This problem could easily be avoided in actual practice, since both more detail and respondents with greater knowledge of a particular city would be available. An ideal panel would consist of both local residents and outside experts. In addition, a limited amount of data could be collected between rounds if a strong need is indicated by the panelists.

The multiple-round format gave the panel a chance to request additional information, ask for clarification of information already provided, and to define their own zones for reporting impacts. In essence, the panel further refined the evaluation instrument as they completed the first round. A dynamic instrument is an important feature. It permits the panel to raise and evaluate issues that may have been overlooked by the study team and to discard issues it deems irrelevant.

It has been demonstrated that panelists are able to fully understand the development processes in cities the size of Sheboygan and Wisconsin Rapids. For small cities only a limited amount of information needs to be presented. Clearly, a panel could be overloaded with data when evaluating impacts in larger cities. However, it was not possible, from this study, to determine the maximum sized city that could be evaluated with a structured expert panel.

It would have been possible to ask the expert panel to make projections for a future year (e.g. 2010) but it would not have been possible to assess the accuracy of an expert panel for forecasting land-use impacts. By projecting the present from 1965, accuracy could be tested. This method of forecasting the present worked well and is recommended to others seeking to test forecasting techniques.

The first round of this study was conducted in group sessions to expedite the process. It would have been possible to conduct the entire procedure by mail, but long time delays would have resulted. The excessive time required to complete the San Jose study was considered problematical. If WisDOT were to use this technique, such a time line would negate the usefulness of the findings. Although anonymity was violated by conducting the first round in group sessions, panelists were instructed not to discuss their opinions with other panelists. There was no evidence that this method of conducting Round I biased the results.

The results of an expert panel forecast are not quantifiable in the same manner as those produced by a mathematical model, but that is not to say they are less reliable. Since we have been exposed to a vast array of sophisticated, computer-assisted techniques, it has become a natural tendency to rate these as most accurate. But a structured expert panel benefits from personal insight that would be difficult to incorporate into a mathematical model.

3. MATHEMATICAL MODELING OF LAND USE

A land-use model is a series of mathematical equations that forecast the distribution of activities (e.g., living, working, and shopping) across an urban area. By knowing where activities would occur, the amount of land devoted to each activity can be determined. Land-use models are used primarily to test the impact that a transportation policy, a transportation project, or a land-use policy would have on urban development. If the model suggests that an undesirable distribution of activities would result, then it is possible to introduce mitigation measures before the project or policy is implemented.

Land-use models were first used for planning transportation projects in the early 1960's. Interest in this type of forecasting remained strong for only about a decade. The reasons for the decline of land-use models as a forecasting tool are varied, but a major factor was unfulfilled expectations (Goldberg, 1984). The required huge expenditures of time and money for data collection and preparation were not justified by the limited amount of reliable information produced. (See Lee, 1974, for an extensive discussion of the limitations of these early models.) Nonetheless, research has continued on land-use models, and with recent advances in computer hardware many of the tactical pitfalls of previous efforts can now be largely avoided.

The land-use theory that has received the most favorable attention in the last ten years was originally formulated by Ira Lowry of the Rand Corporation (1964). Lowry's theory is appealing because it is conceptually straightforward, it is computationally tractable for large urban areas and it is based on sound, validated principles of transportation and urban economics. An extensive discussion of the Lowry Model is found in Appendix D (Chapter 4). Briefly, Lowry's theory states that people will attempt to locate their residences proximate to their workplaces and that services (including retail) will attempt to locate proximate to their markets, i.e., concentrations of population or other businesses. At the minimum, the Lowry Model will forecast the spatial distribution of population and employment in an urban area. Numerous small improvements have been added to Lowry's original model by other researchers in order to make it more computationally efficient, properly introduce the effects of traffic congestion, place the notion of "proximate" on a stronger theoretical base, and reduce the complexity of data preparation and calibration procedures.

A drawback to the Lowry Model is that the results can be difficult to interpret. It forecasts the end-state of development; in other words, the way in which the city would look at a distant future point in time. Since cities are always in transition and factors that affect development are always changing, forecasted impacts from the Lowry Model are generally larger and more focussed than would be seen in reality.

For this research project, a completely new version of the Lowry Model was written. It was implemented on a microcomputer (specifically an Apple II), generally following the outline of the Lowry Model as presented by Wilson (1974). More recent improvements to the Lowry Model were included. Also incorporated was a new method for handling agglomeration (i.e., the tendency for businesses to locate close to one another) in the service sector. The program is fully interactive, and it utilizes color graphics for data input and retrieval of results. Because of the memory limitations of the microcomputer, this particular version of the Lowry Model is only suitable for impact assessment in urban areas of less than 100,000 people or small sections of larger urban areas. The program is described in Appendix D.

The most serious open question about a land-use model for a small urban areas is whether it would be properly sensitive to highway projects of varying magnitude. In order to determine if the model results were reasonable, a comparative analysis was conducted on three cases studies: a complete bypass in Wausau, a partial bypass and widening in Wisconsin Rapids, and a widening in Eau Claire. These three projects span the range of projects likely to be constructed by WisDOT over the next 20 years. Since these three projects were completed 15 to 20 years ago, most developmental impacts would have had sufficient time to materialize. Networks and base year were prepared for each city. Then the Lowry Model was run both with and without the highway projects. Finally, forecasted development was qualitatively compared with actual development.

Implementation of a Lowry Model for Small Cities

There has been little prior experience with land-use models in small cities. As the Lowry Model was being implemented, it became apparent that certain assumptions of the model that worked well in large-city applications would work poorly in small-city applications. Consequently, additions to the model and modifications of data preparation procedures were instituted to better simulate urban development in small cities. The additions and modifications are described in the following paragraphs.

Service as a Basic Industry. The Lowry Model divides employment into two categories: basic and nonbasic. Basic industries derive their income from outside the study area and include such industrial sectors as manufacturing and national insurance headquarters. Lowry's theory states that basic industries will not move in response to a change in the transportation system, because it is unlikely that any such change could affect a basic industry's proximity to either its markets or raw materials. The locations of basic industries are inputs to the Lowry Model. Nonbasic industries, as defined in the Lowry Model, will relocate in response to a change in the transportation system. These industries are services (e.g., dry cleaners, department stores and accountants).

Unlike large cities, some small cities have considerably greater levels of service employment than are necessary to serve its own population (G. F. Mulligan, 1984). These additional employees are serving residents of even smaller cities and towns nearby, as well as agricultural areas, and these employees tend to be concentrated in industrial sectors that are either highly specialized or experience substantial economies of scale. For example, the U.S. Census reports that every hospital bed within Marathon County is located within the city of Wausau. Consequently, most hospital employees in Wausau are serving markets that are located outside of the Wausau urbanized area. According to Lowry's theory these excess hospital employees should be categorized as being basic.

When preparing the data for the three case study cities it was necessary to include many service employees in the basic totals. Table 3.1 illustrates how service employees were split into basic and nonbasic categories. The table shows county and city employment data for the three case studies cities that are within SMSA's: Eau Claire, Sheboygan, and Wausau. It can be seen that if the ratio of service employees to population remains constant across a county, then about 50 percent of all service employees are basic.

Agglomeration in Nonbasic Employment. It is a well known phenomenon that retail and service establishments tend to locate near each other and near the center of the metropolitan area. The original Lowry Model did not directly deal with agglomeration. Rather, Lowry allowed planners to set minimum employment levels in certain zones or to arbitrarily increase the "attractiveness" of the zones for service uses.

It became apparent during the preparation of case study data that agglomeration effects could be relatively large and that Lowry's procedure of simply setting minimum employment levels could distort estimates of impact. A procedure, described fully in Appendix D, was introduced into the Lowry Model to increase the likelihood that a service establishment would locate near the center of the metropolitan area and decrease the likelihood that one would locate in sparsely developed, fringe areas. A single, central-tendency parameter was introduced to control the degree of agglomeration that would be forecasted.

Brute Force Calibration of Trip Distribution Equations. Embedded within the Lowry Model are three trip distribution equations that are mathematically identical to those used for

Table 3.1

CALCULATION OF THE FRACTION OF SERVICE EMPLOYEES TO BE CATEGORIZED AS BASIC (1972)*

City	County Population	County Retail Employment	County Other Service Employment	County Ratio of Retail Employment to Population	County Ratio of Service Employment to Population
Eau Claire	114,936	7,147	1,514	Ø.Ø62	Ø.Ø13
Sheboygan	96,66Ø	5,7Ø5	1,495	Ø.Ø59	Ø.Ø15
Wausau	97,457	4,846	1,326	Ø.Ø5Ø	Ø.Ø14

City	City Population	Nonbasic Retail in City	Nonbasic Service in City	City Retail Employment	City Service Employment	Basic Retail in City	Basic Service in City
Eau Claire	44,619	2,775	588	4,89Ø	1,149	2,115	561
Sheboygan	48,484	2,862	75Ø	4,362	951	1,5ØØ	2Ø1
Wausau	32,8Ø6	1,631	466	3,275	879	1,644	433

*Source: City and County Databook

traffic forecasting. The trip distribution equations determine the spatial distribution of workers' residences in relation to their workplaces, the spatial distribution of business services (e.g., accountant, industrial laundries) in relation to other business, and the spatial distribution of personal services (e.g., grocery stores, theaters) in relation to residences. Each of the trip distribution equations has a parameter that needs to be calibrated for each new application. The standard method of calibration is explained in Appendix D. Usually, land-use models have separate calibration routines.

Because this particular model was intended for small city application, it was felt that better forecasts would result if the calibration routines were included as part of the model. A "hands-on" approach would then be practical. The model could be repeatedly run on base year data until a good fit to reality, both statistically and intuitively, is obtained.

Limitation on the Number of Zones, Links, and Nodes. Like traffic forecasting models, the Lowry Model represents areas of the city as zones, streets as links, and intersections as nodes. The size of the microcomputer dictates that there be at most 40 zones, 320 two-way links, and 200 nodes. To a person familiar with traffic forecasting, these limits would seem restrictive.

However, in land-use modeling compromises must always be made between the desire for small zones, so that computed travel times are most accurate, and the desire for large zones, so that data preparation costs are not excessive. It has been observed (Goldberg, 1984) that some of the first applications of land-use models were not successful because of the need for huge amounts of data. Additionally, forecasts for small zones have inherently more relative error than forecasts for large zones, so it is important to choose a zone size that keeps errors to tolerable levels.

Estimates of Peak-Hour Traffic Volumes. A highway improvement could stimulate so much development that unanticipated congestion could occur on certain links in the network. In order to test for this possibility, the model performs an all-or-nothing assignment for peak-hour traffic. If large traffic volumes are found, then speeds can be decreased on the affected links and the model can again be run.

Some land-use models automatically adjust for unanticipated congestion effects (Putman, 1974). The present implementation of the Lowry Model leaves this as a manual task, because it is likely that only a few links in small-city networks could have speeds that are adversely affected by a highway improvement.

Case Study Applications of the Land-Use Model

As in the expert panel evaluation, the case studies for the land-use model were twenty-year forecasts to 1985. Data for each city were prepared as they would have been in 1965. This data preparation process required some judgments as to how much planners could have known about the future locations of basic employers, the future condition of the highway system, and the future extent of land-use controls. These judgments were aided by planning reports that were written for each city in the late 1960's.

Model inputs were prepared according to the procedures described in Appendix D (Chapter 3). Within these procedures, two separate approaches were taken. The Eau Claire inputs were derived from a traffic network and set of traffic analysis zones that had been previously prepared by WisDOT. Links representing less important streets were removed and larger land-use zones were created by combining (on average, six) traffic analysis zones. The networks for Wausau and Wisconsin Rapids were developed from scratch, with the zones taken as portions of Census tracts. The two approaches to input data preparation resulted in networks of similar quality.

The project in Wausau is a completely new section of U.S. Highway 51 that bypasses most of the city of Wausau. It is a freeway, with full access control and two lanes in each direction. The project can be seen on the drawing of the whole Wausau network, Figure 3.1. In this drawing nodes are labeled with an arbitrary two-letter designation; nodes that are black are centroids of zones. Starting from the very bottom of the drawing, nodes along the project are FF, FB, EE, DK, DM, DP, and HO. The central portion of the Wausau network is shown in greater detail in Figure 3.2. A total of nine interchanges (including three partial interchanges) were provided along the project.

The Wausau network and zone system span the whole urbanized area and immediately adjacent rural areas. Included are the villages of Brokaw and Rothschild, the cities of Wausau and Schofield, and portions of the towns of Texas, Wausau, Maine, Stettin, Rib Mountain, Weston, and Kronenwetter. Land area is represented by 40 zones. The population of the study area is approximately 56,000.

The project in Wisconsin Rapids is identical to the one evaluated by the expert panel. It constitutes a widening of the portion of State Trunk Highway 13 that follows 8th Street (between nodes FG, AF, EY, AK, AO, DI and EU on Figures 3.3 and 3.4), a new expressway (between nodes EU, AT, and FE on Figure 3.4) and a new bridge across the Wisconsin River (between nodes FE and CU on Figure 3.4).

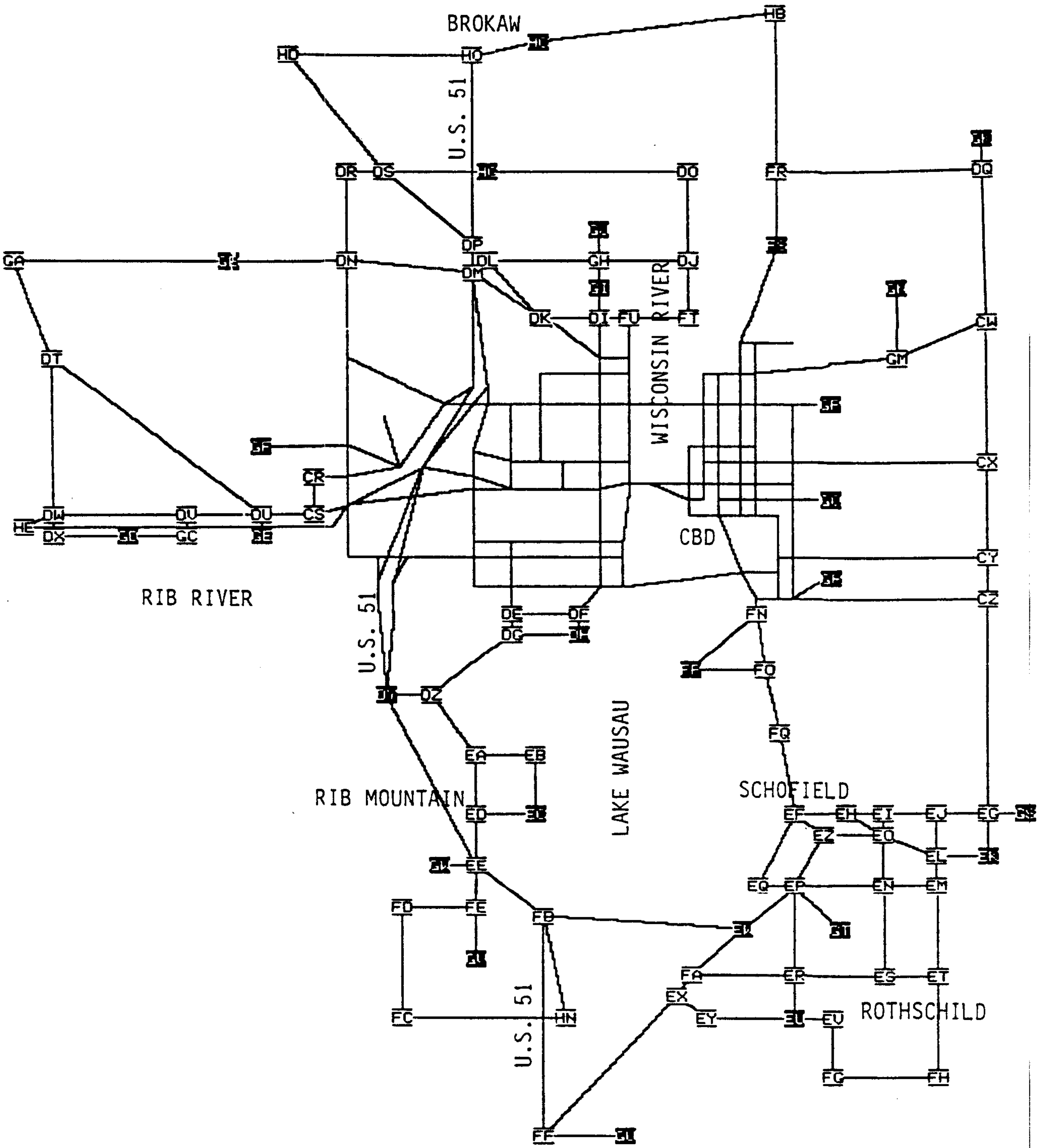


Figure 3.1. Network for Wausau Metropolitan Area

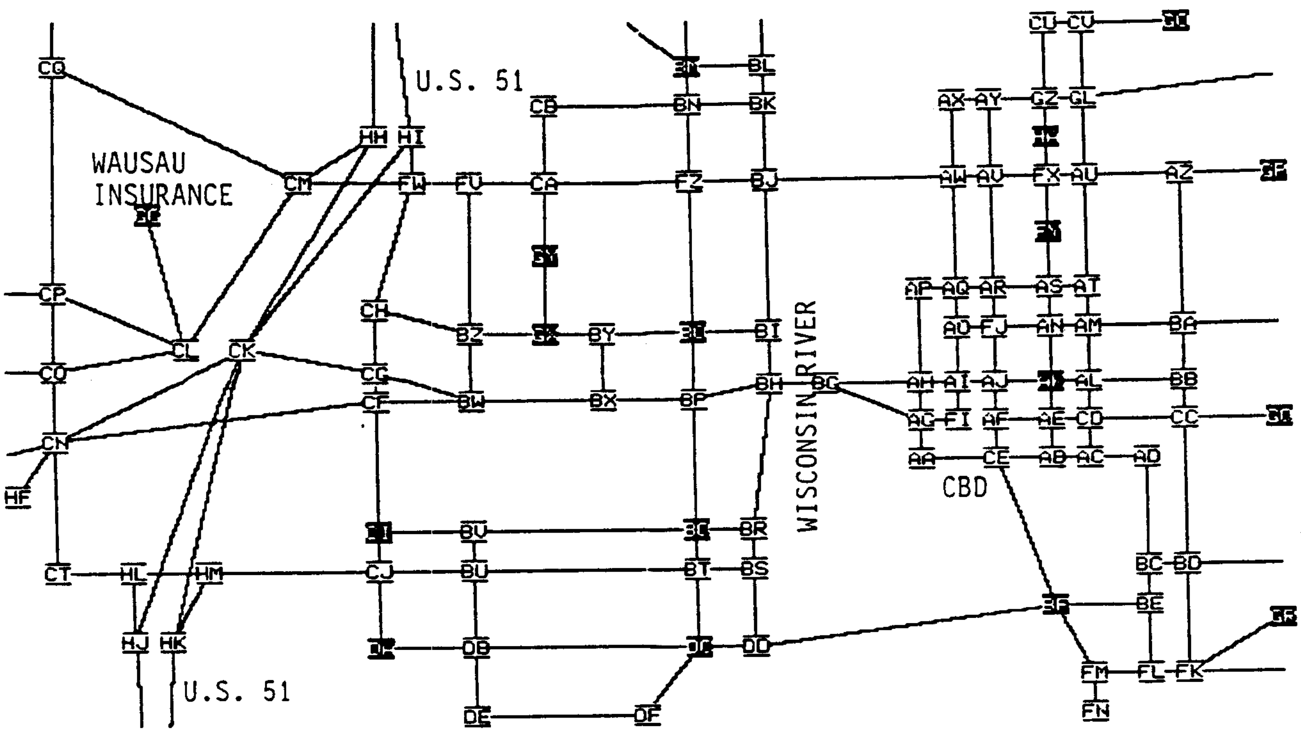


Figure 3.2. Detail Network for Central Wausau

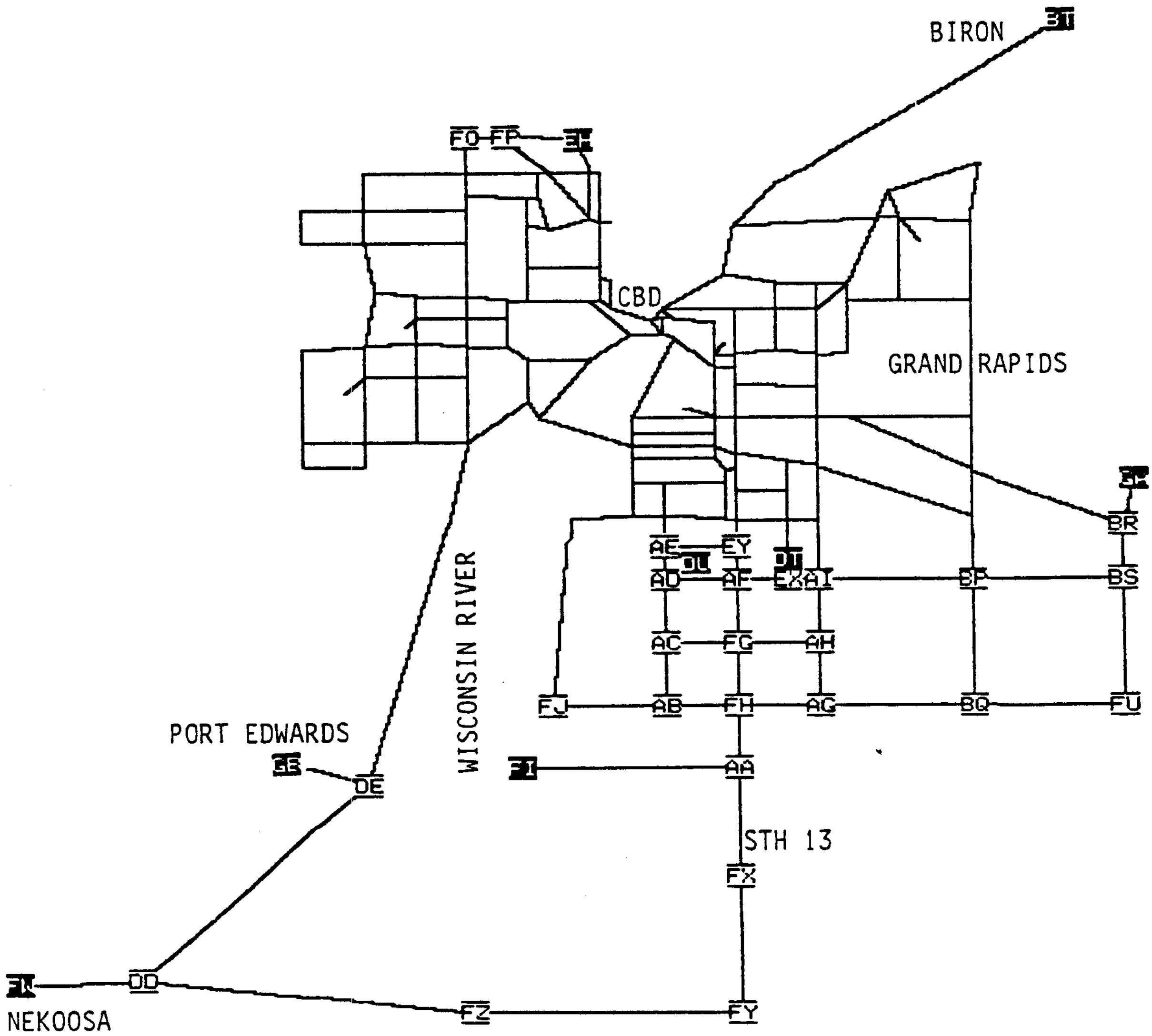


Figure 3.3. Network for Wisconsin Rapids Metropolitan Area

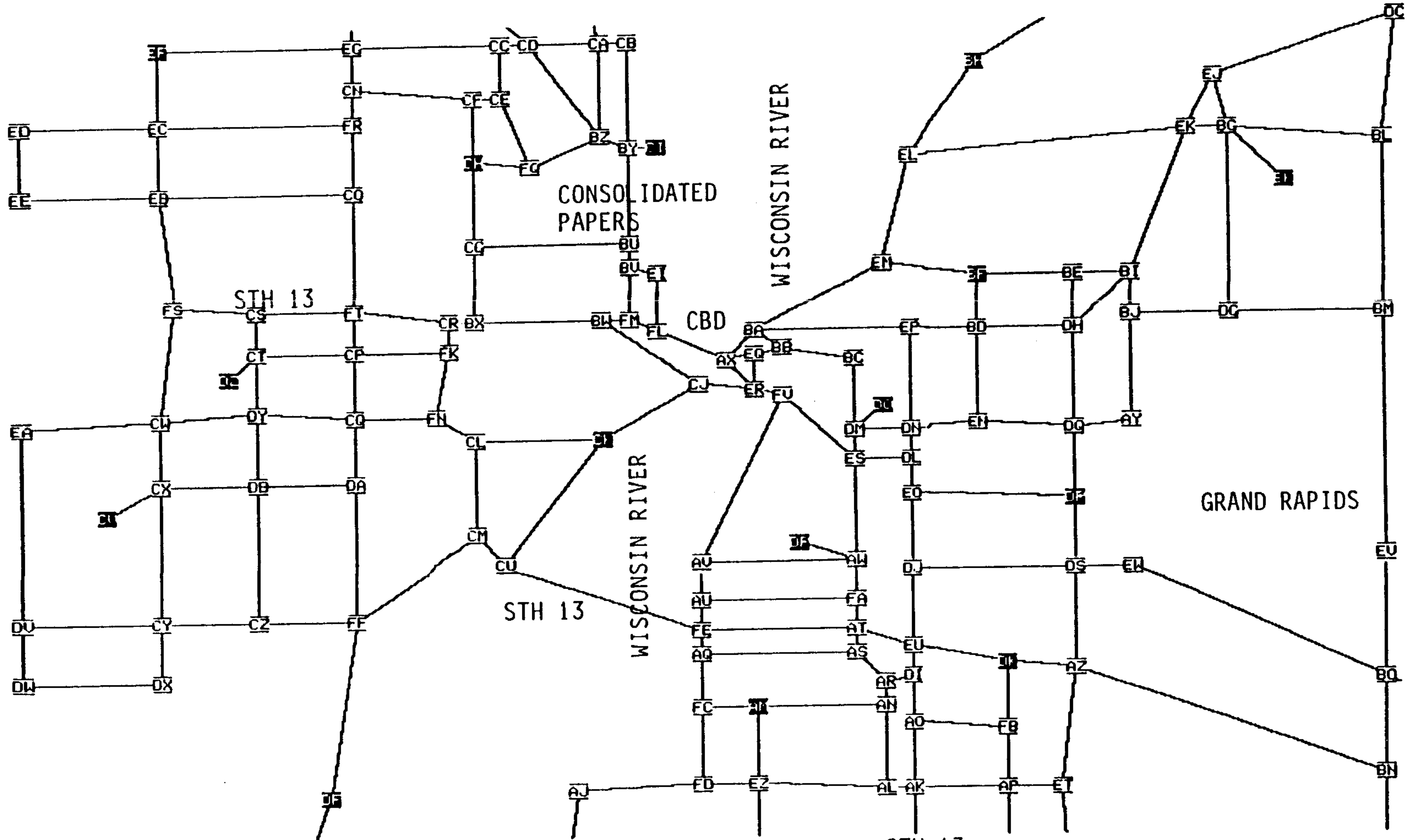


Figure 3.4. Detail Network for Wisconsin Rapids

The study area includes the city of Wisconsin Rapids and all adjacent urbanized areas and some adjacent rural areas. These areas are the villages of Biron, Grand Rapids, and Port Edwards, the city of Nekoosa, and portions of the towns of Port Edwards, Grand Rapids and Saratoga. This land area is represented by 23 zones. The population of the study area is approximately 32,000.

The project in Eau Claire is a six-lane expressway that was built on an existing two-lane section of U.S. Highway 12. The project is shown on Figure 3.5 between nodes CX, CW, CR, CI, CM, GD, and GE. Of all three projects, the upgrading of U.S. Highway 12 should have the least impact on land use. It does not provide additional access to land and it does not provide new paths for travelers. Impacts, if they were to occur, would be caused by increases in speeds along the project.

The Eau Claire study area is limited by the extent of the original WisDOT network. Included are the incorporated areas of Eau Claire, Altoona, and Chippewa Falls, and portions of towns of Hallie, Wheaton, Eagle Point, Lafayette, Union, Brunswick, Washington, and Seymour. This land area is represented by 34 zones. The population of the study area is now approximately 86,000, although the networks used for assessing the impact of the highway project assumed a growth in population to about 140,000.

Each of the three case study networks were prepared by separate individuals. Prior to network construction, agreement was reached about general principles. However, the means of preparing the data, the amount of detail in the network, and the assumptions about the future state of the city were left entirely to the discretion of the person responsible for the case study.

An example of the zonal data for Wausau is shown in Figure 3.7. The first column shows the arbitrary two-letter designation of the zone's centroid. The numerical data are the intrazonal trip time in minutes, the ratio of population to employment, the amount of land in square miles that could possibly be developed for residential uses, the amount of land in square miles that could possibly be developed for service (and retail) uses, basic employment, and automobile destination costs in cents (typically parking charges). Also shown in Figure 3.7 are statistics about the network, the two base multipliers, and automobile costs per minute (typically gasoline costs).

Calibration and Results

The land-use model has four parameters that need calibration -- three trip distribution parameters and the central tendency parameter. The standard method of calibrating the distribution parameters is explained fully in Appendix D. The method assures that parameters will be properly set when the average travel

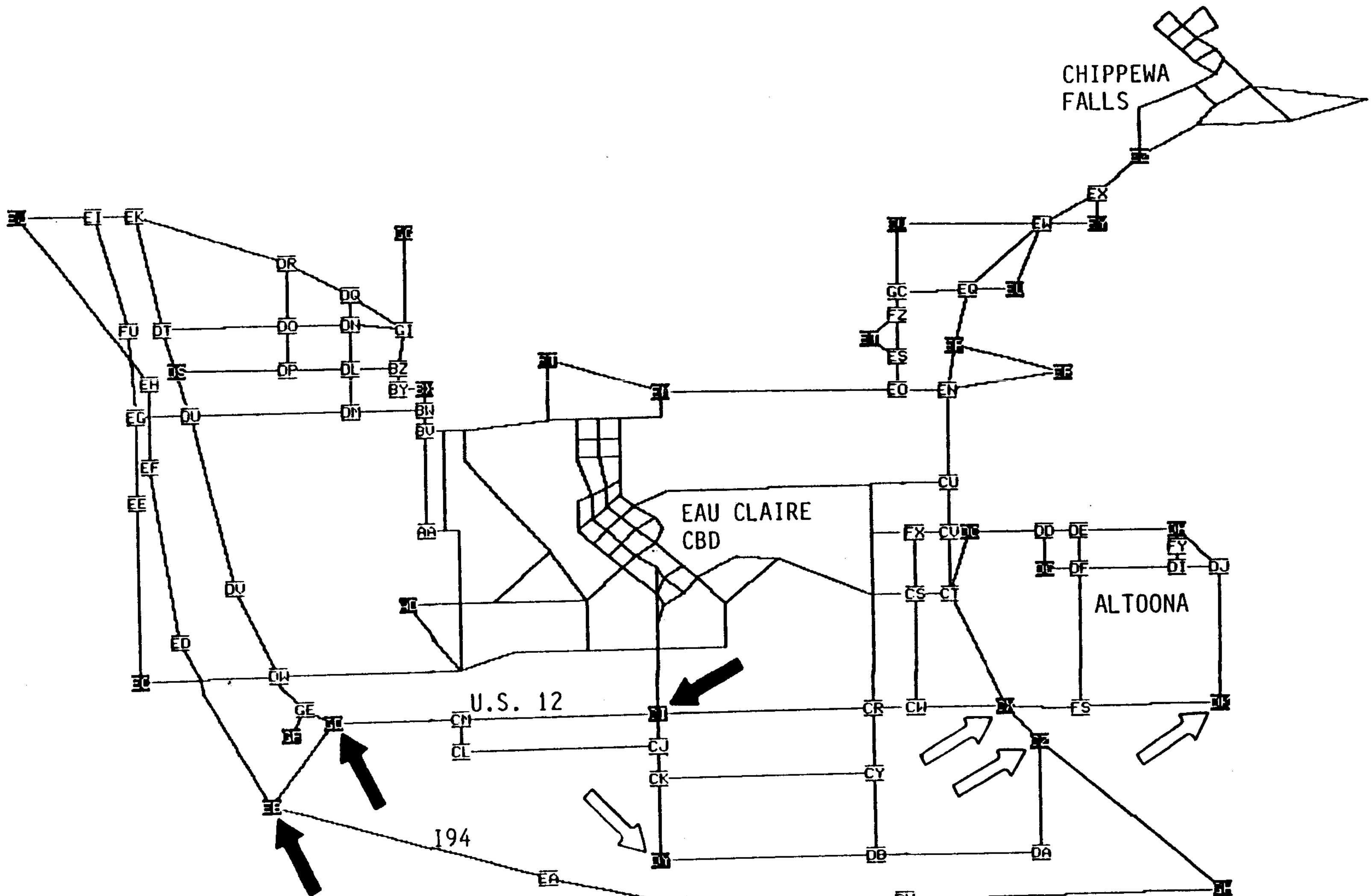


Figure 3.5. Network for the Eau Claire Metropolitan Area

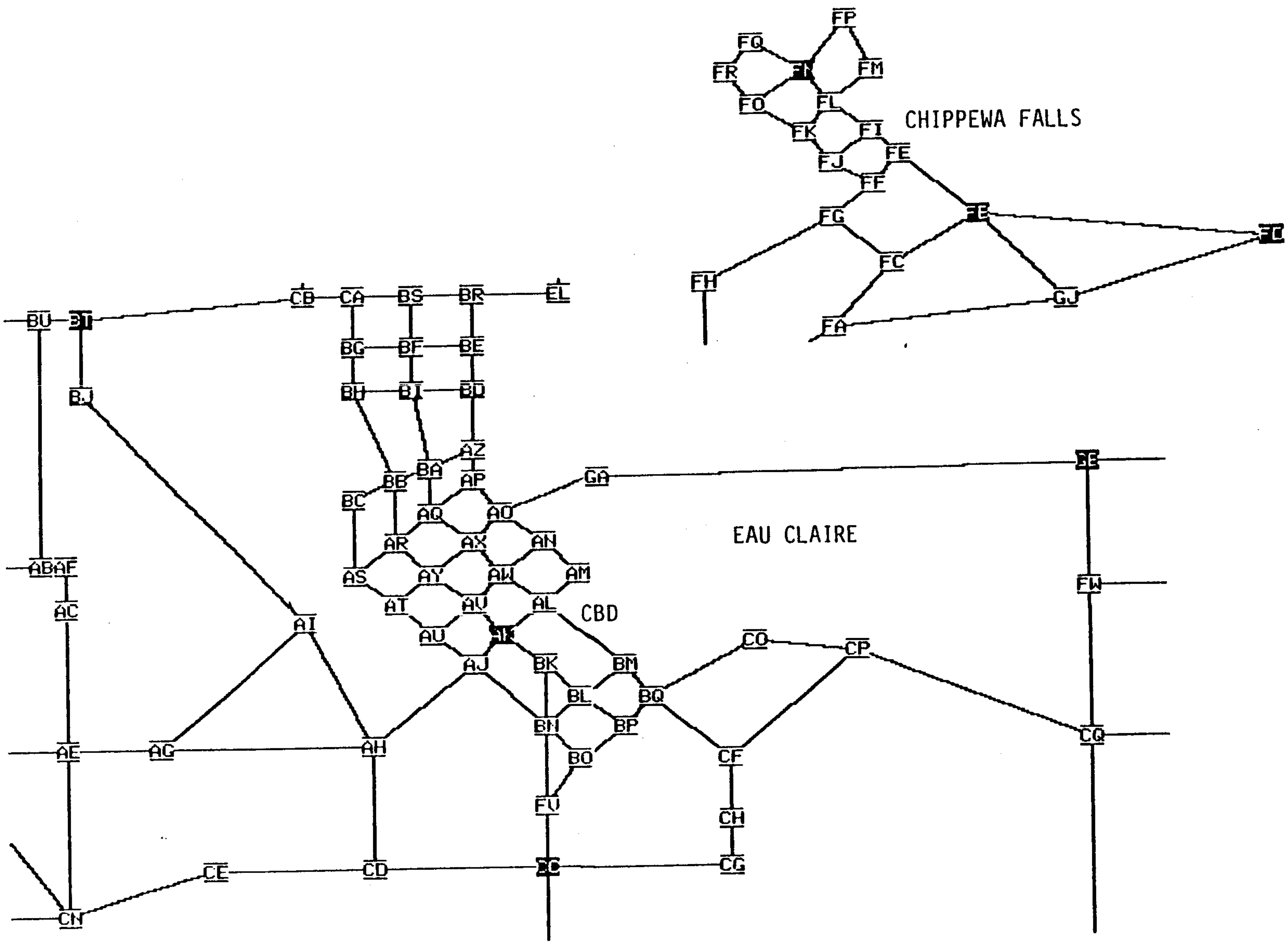


Figure 3.6. Detail Networks for Chippewa Falls and Central Eau Claire

WAUSAU 1985 NO GROWTH NULL
NUMBER OF NODES = 197
NUMBER OF LINKS = 299
RATIO OF SERVICE EMPLOYMENT TO TOTAL EMPLOYMENT = .1709
RATIO OF SERVICE EMPLOYMENT TO POPULATION = .082033
AUTOMOBILE COSTS PER MINUTE = 3

CENTROID INFORMATION

NODE	INTRAZONAL TRIP TIME	POPULATION/ EMPLOYMENT	DEVELOPABLE AREA	SERVICE AREA	BASIC EMPLOYMENT	AUTOMOBILE COST
AK	0.82	2.17	0.09	0.09	1819.00	0.00
BF	1.42	2.36	0.27	0.27	364.00	0.00
BM	1.50	2.08	0.80	0.80	1826.00	0.00
BO	0.17	2.17	0.08	0.08	315.00	0.00
BQ	0.62	2.15	0.10	0.10	65.00	0.00
CI	1.09	1.93	0.27	0.27	867.00	0.00
DA	1.12	1.93	0.34	0.34	4.00	0.00
DC	0.84	2.15	0.19	0.19	65.00	0.00
DH	1.43	2.15	0.46	0.46	800.00	0.00
DY	1.90	1.99	0.80	0.80	0.00	0.00
EC	2.05	1.99	0.94	0.94	0.00	0.00
EK	3.24	2.11	1.87	1.87	62.00	0.00
EU	1.69	2.23	0.64	0.64	1027.00	0.00
EW	2.31	2.19	0.59	0.59	944.00	0.00
FP	2.31	2.51	0.71	0.71	885.00	0.00
FS	1.34	2.25	0.52	0.52	0.00	0.00
FY	0.76	2.17	0.05	0.05	750.00	0.00
GB	2.92	2.18	0.50	0.50	0.00	0.00
GD	1.12	2.07	0.06	0.06	453.00	0.00
GE	1.14	2.07	0.03	0.03	132.00	0.00
GF	2.81	2.07	1.34	1.34	14.00	0.00
GG	1.16	2.07	0.12	0.12	3463.00	0.00
GI	1.37	2.08	0.63	0.63	416.00	0.00
GJ	1.40	2.08	0.58	0.58	21.00	0.00
GK	4.45	2.18	0.09	0.09	0.00	0.00
GN	2.94	2.25	0.54	0.54	0.00	0.00
GO	1.21	2.25	0.52	0.52	233.00	0.00
GP	1.48	2.27	0.33	0.33	0.00	0.00
GQ	1.40	2.36	0.35	0.35	475.00	0.00
GR	1.54	2.36	0.32	0.32	611.00	0.00
GS	4.74	2.17	0.05	0.05	0.00	0.00
GT	1.59	2.11	0.95	0.95	0.00	0.00
GU	4.74	2.23	1.00	1.00	560.00	0.00
GV	2.58	1.99	0.30	0.30	0.00	0.00
GW	2.14	1.99	0.61	0.61	0.00	0.00
GX	0.97	2.08	0.42	0.42	250.00	0.00
GY	0.87	2.08	0.27	0.27	15.00	0.00
HA	0.70	2.27	0.11	0.11	95.00	0.00
HC	1.00	2.18	0.10	0.10	580.00	0.00
HG	1.81	2.18	0.03	0.03	0.00	0.00

Figure 3.7. Example Zonal Data for Wausau

times predicted by the model match actual average travel times. Unfortunately, average trip times for these cities are not available for 1965, nor can they be reconstructed from existing sources of data.

Instead, average trip times were taken from a national study of trip lengths that was performed in the mid-1960's (Alan M. Voorhees and Associates, 1968). This study found that over-the-network average home-to-work time could be predicted by this equation:

$$t = 0.98 \ P^{0.19} \quad ,$$

where P is the urban area population. This same study found that service trips lengths were unrelated to the size of the urban area. The average service trip time over the eleven cities with populations less than 300,000 was 7.3 minutes. These average trip times were used to perform separate calibrations for each case study city.

Not unexpectedly, little data existed to calibrate the central tendency parameter. The parameter was roughly and conservatively set for Wausau by visually matching the predicted distribution of service with distribution found in the Wausau Comprehensive Plan that was prepared in 1965. This same value for the central tendency parameter was then adopted for Wisconsin Rapids and Eau Claire.

The effect of the central tendency parameter on the distribution of nonbasic services is illustrated in Figure 3.8. This figure compares the nonbasic service distribution as predicted by the normal Lowry Model (without any agglomeration) with the distribution predicted with agglomeration. The dots indicate the effect of the agglomeration on the various zones. A large black dot shows that the zone benefited from agglomeration effects. A large white dot shows that agglomeration tends to reduce the amount of service activity in the zone. Figure 3.8 illustrates relative effects; a centrally located zone can greatly benefit from agglomeration but the total service employment can still be quite small.

Positive agglomeration effects are strongest in zones between the Wisconsin River and the U.S. Highway 51 bypass -- part of the city that has recently seen strong growth in retail and other service activities. Negative agglomeration effects are found at fringe areas and most urbanized areas that are east of the Wisconsin River. It is especially interesting that the model states that Wausau central business district does not benefit from agglomeration. Nonetheless, a regional shopping mall has recently been built there, clearly demonstrating the difficulty of predicting, with a mathematical model, the actions of

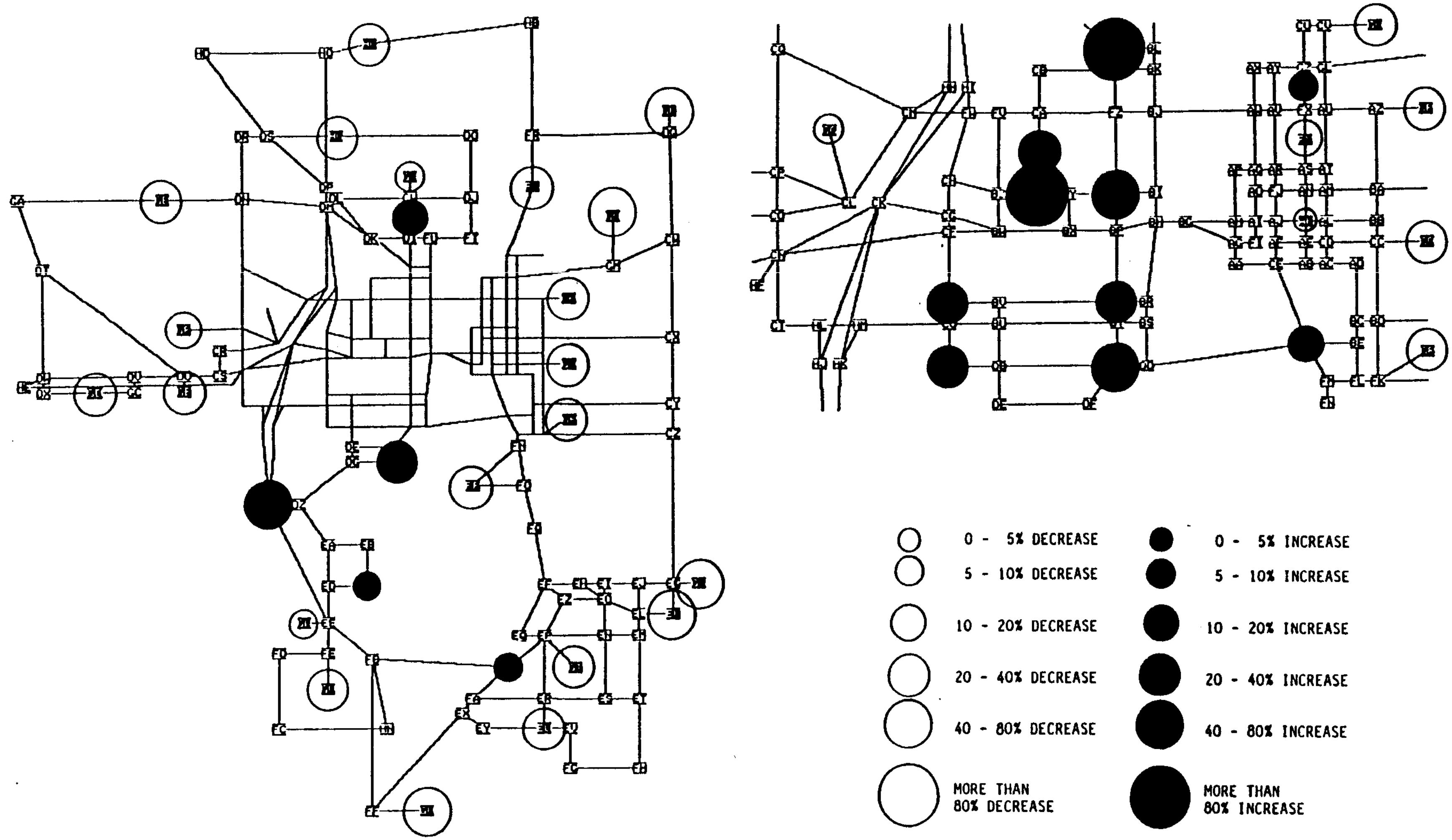


Figure 3.8. Forecasted Effect of Agglomeration of Nonbasic Services in Wausau

dedicated civic leaders to stem the decline of an important part of their city.

The model was run twice for each case study city -- once with the project and once without the project. Otherwise the data for both runs in a single city were identical, permitting the impact of the project, in isolation from extraneous events, to be clearly seen.

Figure 3.9 shows a typical result from one of the runs -- the no-build alternative in Wausau. The results include the population, total employment, and the number of peak-hour intrazonal trips for each zone. Nonbasic service employment may be found by subtracting basic employment (Figure 3.7) from total employment. Results also include peak-hour volumes on each link in each direction (not shown in Figure 3.9).

The maps in Figures 3.10 to 3.13 summarize the forecasted impacts of the highway projects with respect to population and nonbasic service employment in Wausau and Wisconsin Rapids. Black dots show zones that are positively impacted by the project; white dots show negatively impacted zones. The size of the dots are based on percentage difference between two model runs. Consequently, some larger dots, which have been placed on zones with small levels of activity, represent a change of only a few people or employees. The forecasted impacts in Eau Claire are generally quite small, so summary maps are not provided for this city. Instead, the zones that have moderately positive impacts (10 to 25 percent increase in nonbasic service) are shown with black arrows on Figure 3.5; zones with slightly positive impacts (5 to 10 percent increase in nonbasic service) are shown with white arrows. Significant negative impacts are not forecasted for any zone in Eau Claire.

A quick inspection of the five maps reveals that the projects differed markedly in the size and distribution of forecasted impact. The results confirm intuition that the Wausau project would have the largest impact; the Eau Claire project would have a minimal impact. Furthermore, the forecasted impacts are much more localized in Eau Claire than in either Wausau or Wisconsin Rapids.

Although not shown in the maps, because they show changes rather than absolute levels of population and employment, the model indicated that all three cities would have experienced additional sprawl even without the highway project. This sprawl is due to the residual effects of earlier highway projects and land developments. Residual sprawl is not relevant to the evaluation of the three case-study highway projects. However, it is a complicating factor when trying to assess whether the forecasted impacts actually happened.

In Wausau, the model states that the project will have

WAUSAU 1985 NO GROWTH NULL RESULTS
NUMBER OF CENTROIDS = 40
NUMBER OF LINKS = 299
TOTAL EMPLOYMENT = 26182.2
TOTAL POPULATION = 56034.3
TOTAL SERVICE EMPLOYMENT = 9071.2
WORK-TO-HOME AVERAGE COST = 10.76
WORK-TO-SERVICE AVERAGE COST = 9.68
HOME-TO-SERVICE AVERAGE COST = 9.71

CENTROID INFORMATION

NODE	POPULATION	EMPLOYMENT	INTRAZONAL
AK	307.0	1898.4	14.6
BF	879.8	682.8	44.2
BM	2841.0	2834.7	416.2
BO	188.7	430.7	4.1
BQ	321.4	210.1	6.8
CI	963.1	1133.7	53.0
DA	1240.5	332.8	59.0
DC	634.6	333.8	23.5
DH	1911.0	1228.0	144.5
DY	2738.7	369.6	182.7
EC	2559.5	266.9	152.6
EK	4085.2	542.5	568.1
EU	1617.8	1228.8	200.5
EW	1531.4	1157.7	155.1
FP	2834.0	1177.4	235.3
FS	2006.5	197.8	98.8
FY	198.7	787.9	4.3
GB	1739.3	132.6	41.8
GD	179.8	466.0	7.8
GE	106.7	140.7	1.0
GF	5329.6	619.5	529.8
GG	444.5	3536.7	45.9
GI	2717.4	897.7	220.8
GJ	2361.7	309.7	121.5
GK	135.8	6.7	0.2
GN	1416.4	90.5	32.1
GO	2090.6	466.4	133.2
GP	1412.3	185.2	50.8
GQ	1488.4	661.9	71.4
GR	1256.1	755.8	61.5
GS	92.0	8.9	0.2
GT	2288.8	322.6	261.2
GU	1525.5	674.8	141.7
GV	454.2	28.0	3.9
GW	1210.7	92.1	32.1
GX	1326.0	777.2	93.7
GY	812.7	378.6	37.9
HA	403.5	209.8	9.7
HC	280.9	599.5	20.5
HG	102.5	7.7	0.2

Figure 3.9. Example Model Results for Wausau

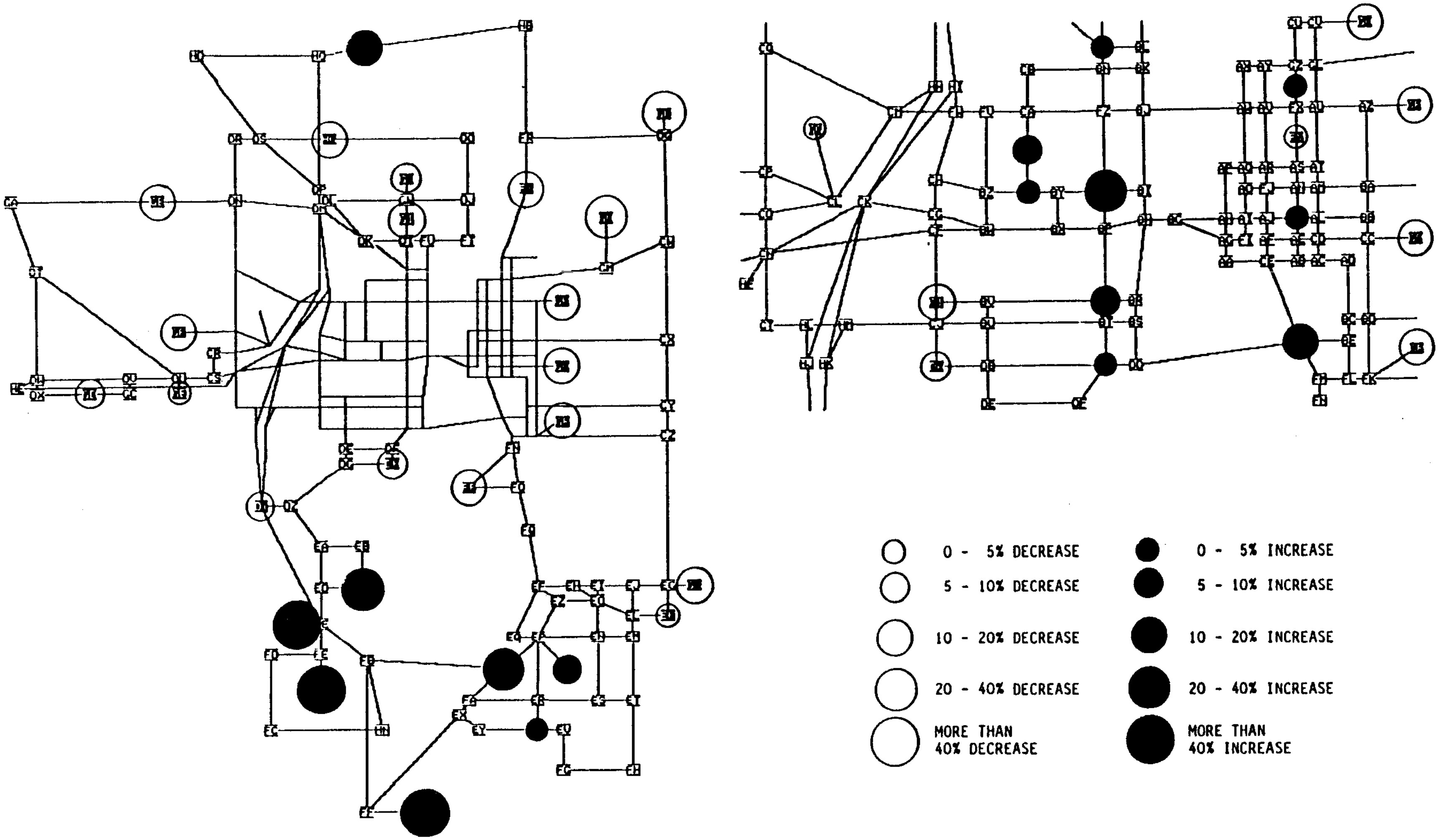


Figure 3.1Ø. Forecasted Impact of Highway Project on Population Distribution in Wausau

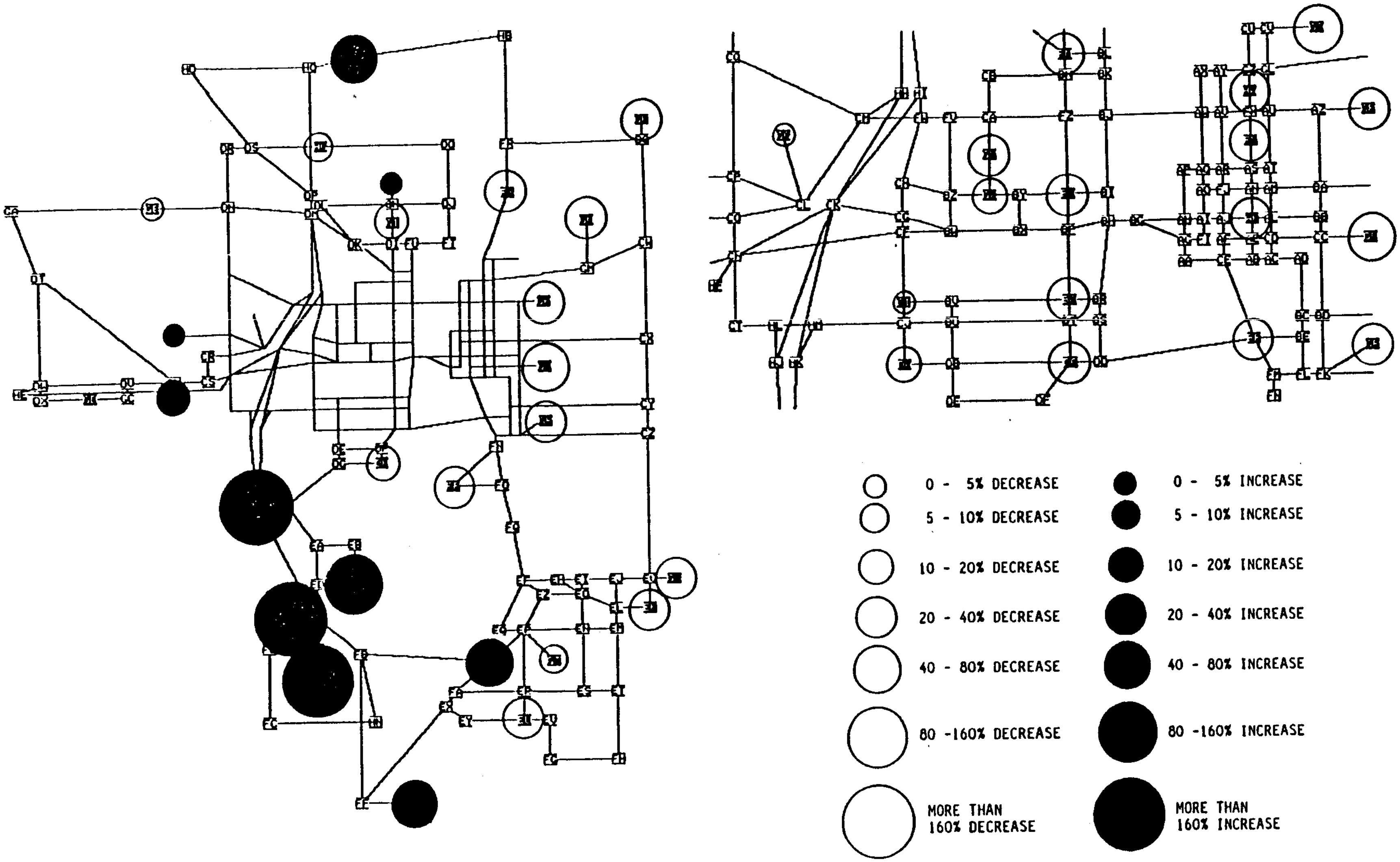


Figure 3.11. Forecasted Impact of Highway Project on Service Distribution in Wausau

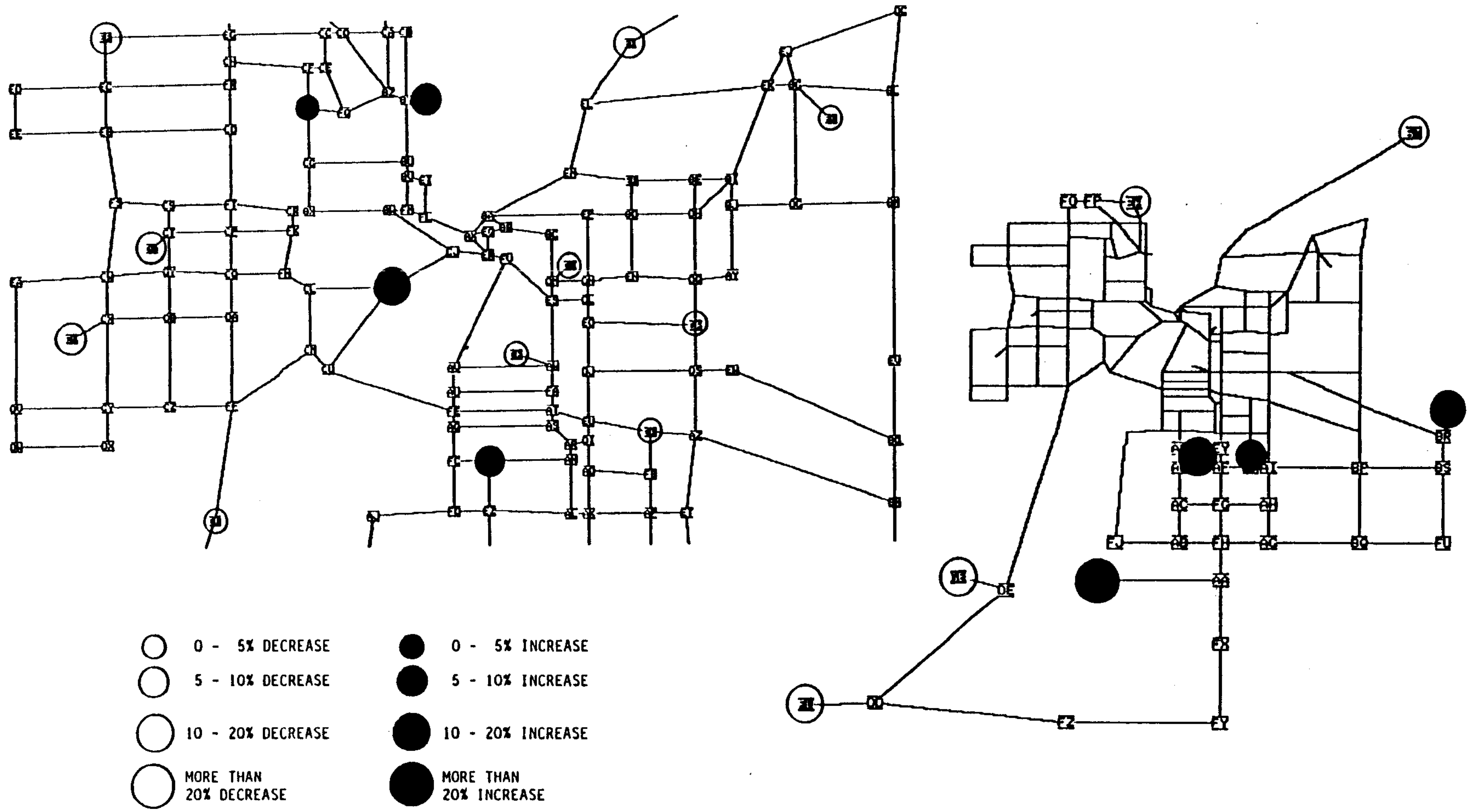


Figure 3.12. Forecasted Impact of Highway Project on Population Distribution in Wisconsin Rapids

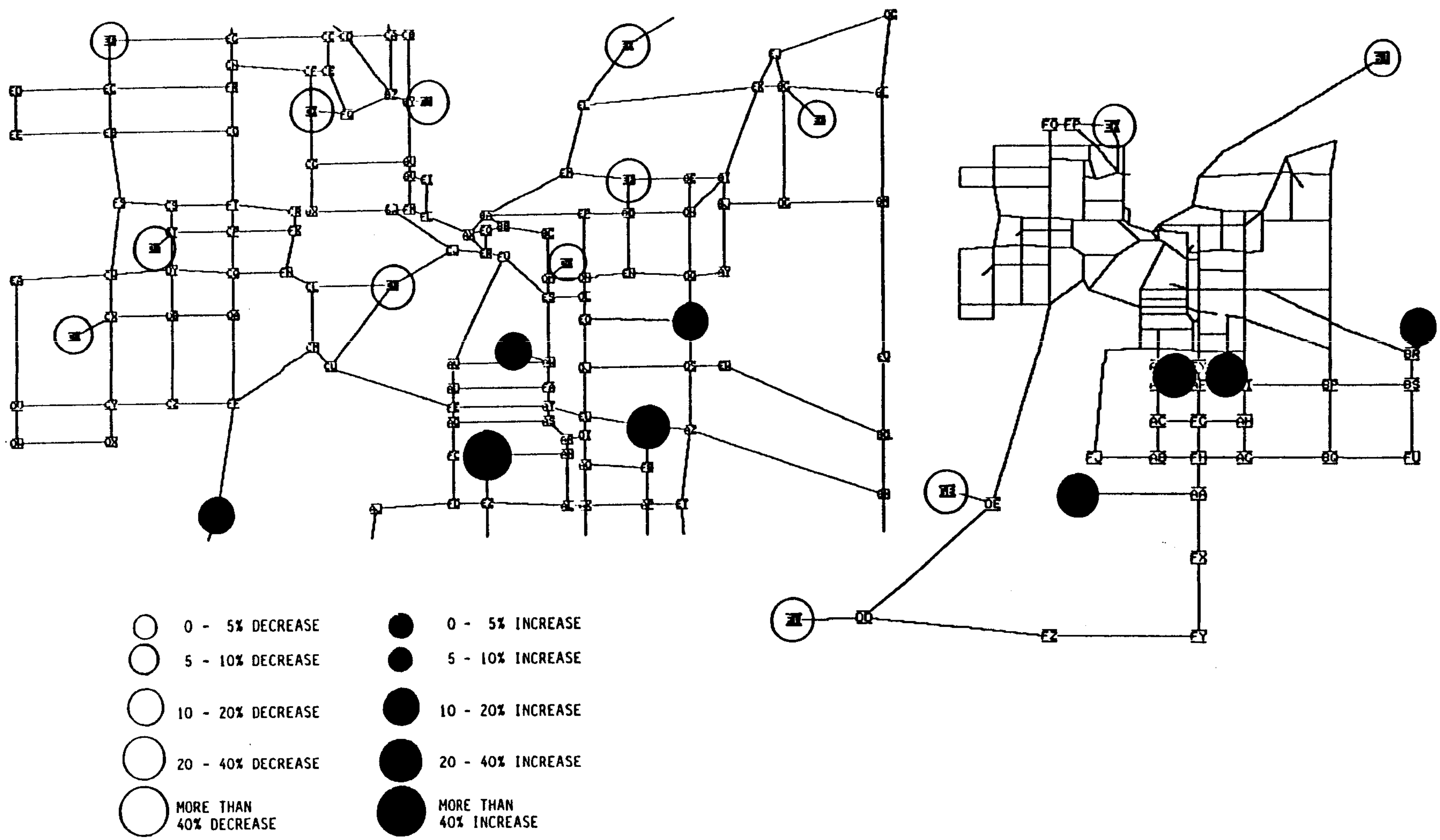


Figure 3.13. Forecasted Impact of Highway Project on Service Distribution in Wisconsin Rapids

moderate population impact throughout the study area. Small population increase are forecasted for the central areas of the city of Wausau and in Brokaw. Substantial population increases would occur in the most southern portions of the study area -- as much as a 73 percent increase in the town of Rib Mountain. Of course, losses in population would occur elsewhere, particularly in the most western and most eastern sections of the city of Wausau.

The 1965 Comprehensive Plan for the Wausau urbanized area predicted a 30 percent increase in basic employment by 1985 -- a mere 1.5 percent growth per year. An additional run of the model was performed in order to determine the impact of the highway along with this assumed growth. The additional basic employment was distributed to the industrial park (then newly designated), existing major industrial areas, and planned industrial areas near Schofield and Rothschild. When this scenario was run, many zones were forecasted to increase greatly in population, but only one zone declined in population. From this exercise it can be concluded that the impact of the highway had negative aspects, only because the planned economic growth failed to materialize.

The model stated that the distribution of nonbasic service employment in Wausau was also strongly affected by the highway project. Central and western areas were said to decline; growth was concentrated in Rib Mountain and Rothschild in the southern-most portion of the study area.

The model results in Wisconsin Rapids (Figures 3.12 and 3.13) were surprisingly similar to those from the expert panel. (It is useful to note that the individual responsible for preparing the Wisconsin Rapids network was not involved in any way with the expert panel.) Small population increases were said to have occurred in Grand Rapids, and in the southern and near-western portions of the city of Wisconsin Rapids. The model indicated that even smaller population declines should have occurred elsewhere.

The most interesting impacts relate to nonbasic service. Figure 3.13 shows that only eight zones would have experienced an increase in nonbasic service employment. Six of the eight zones are immediately adjacent to the project, east of the Wisconsin River. The exceptions are one zone in the southern part of Wisconsin Rapids and the zone for Grand Rapids. The largest forecasted increase is 40 percent, just south of the expressway portion of the project (zone AM).

As mentioned earlier, the model showed little impact in Eau Claire. Two zones in the southwestern portion of the study area (GD and EB) have a significant increase in nonbasic service employment (24 percent and 18 percent, respectively). Otherwise the impacts were small and localized along the extent of the project. The largest population increases were forecasted for zones GD, EB and DG; these zones were expected to increase by only about 7 percent.

Evaluation of Results and Discussion

Qualitative evaluations of the accuracy of the forecasts were performed. The evaluation was based on site visits, interviews with citizens and local officials, and topographic maps from the U.S. Geological Survey. The topographic maps were particularly helpful because they clearly showed the extent of new development. Maps for two points in time (1963 and 1978 in Wausau; 1963 and 1984 in Wisconsin Rapids; and 1972 and 1982 in Eau Claire) were compared.

Overall, it appears that the model performed very well, but it is difficult to sort impacts from these particular projects from the impacts of other highway projects, other land developments and land-use policy. Causality can never be proven. The strongest conclusion that can be reached is that the simulated cities and the actual cities are behaving roughly in the same way.

Wausau's pattern of development closely follows the forecast from the model. There are still confounding factors, such as the relocation of Wausau Insurance, the partial completion of the bypass for State Trunk Highway 29, increase in occupancy of the industrial park, and the downtown mall. Many of the impacts from these developments can be identified from the base run (null alternative, Figure 3.9) of the model. Actual growth is evident between U.S. Highway 51 and the Wisconsin River, in Rib Mountain, in Schofield and in Rothschild -- areas that the model said would be positively impacted. It is not possible to confirm the moderate growth that was predicted for the area just south of the CBD.

In Wisconsin Rapids, the model correctly predicted all areas of population growth, with the exception of the two small zones just north of the central business district (CH and CI). One local official remarked that residential development in these areas was inhibited because they were undesirably close to the Consolidated Papers Mill. The impact on nonbasic service was also located properly. The most serious error of the model, like the expert panel, was in under-predicting the amount of retail development along 8th Street (the portion of the project that widened State Trunk Highway 13 from two to four lanes.) Some of this under-prediction could be explained by the step in the data preparation process that fixed the locations of all basic services. Some of these basic services have voluntarily chosen to locate on 8th Street; other basic services were forced to move from their original locations because of extensive land purchases by Consolidated Papers.

Eau Claire has experienced considerable expansion of the urban area since 1972. Development has occurred in nearly all directions, although it is concentrated near major highways. It would be impossible to determine from existing data sources whether the widening of U.S. Highway 12 had any impact on land use. Indeed, there was sufficient growth in the areas where the model indicated that there would be growth, but there was growth in many other places, too. The model predicted such small impacts, that they can only be considered to be a ripple on a sea of other urban developments.

The most serious open question about modeling land use has been answered: it is possible to build a model that properly represents the impacts of highway projects in small cities. However, the fact that the forecasts are for an undefined time in the distant future can make interpretation of the results somewhat difficult. Urban development is a slow process. As seen in these case studies, there will always be unpredictable, intervening events that cause deviations from the forecast.

Land-use modeling would be a practical aspect of a full-scale environmental assessment. The amount of effort is of the same order of magnitude as required for an air pollution model or a noise pollution model. The computer program, which includes extensive interactive features, greatly facilitates the preparation of data.

The limited size of the model (e.g., 40 zones) is not a handicap. In practice such a limit could be a blessing. It places an upper bound on the amount of input data while keeping areas of zones appropriately large.

The validation method of forecasting the present was less successful for the Lowry Model than it was for the expert panel. The case study projects were selected because they occurred at a certain time in cities of a certain size. Availability of base year data was not a consideration; and in fact, very little base year data could be obtained. The lack of base year data had little effect on the evaluation of the expert panel, because the panel's subjective forecasts could be compared to a second panel's subjective judgments of what actually happened. The objective forecasts of the Lowry could not be weighed against equally objective measures of changes in urban development.

Compared to the expert panel, the land-use model produces forecasts with less texture but with greater quantification. The more precise results from the model would be especially useful when comparing several different alignments or access control strategies. The Wisconsin Rapids case study demonstrated that the two techniques are complementary. If used together they can yield a careful, comprehensive assessment of land-use impacts of highway projects.

4. QUICK RESPONSE METHODS

Expert panels and mathematical models require more cost and time than are justified for some smaller projects. Smaller projects may require only a cursory evaluation to establish that negative land-use impacts would be minimal. Three different evaluation techniques are presented here: average development factors for service employment; a detailed checklist; and a short checklist.

These techniques do not call for the same level of testing as either the Lowry Model or the structured expert panel, because the quality of results depends as much on the skill of the person performing the assessment as it does on the method itself. Instead, examples are provided on how the techniques may be applied in actual practice. These examples illustrate the time and data requirements and the extent of reliable information that may be generated. Service development factors were calculated for each of the four case study cities, and the detailed checklist was applied to Eau Claire -- the only case study that had minimal negative impacts.

Service Development Factors

Previous studies (e.g., Chui, et al, 1983; Khasnabis and Babcock, 1978) have attempted to produce statistical models of land-use impacts in the immediate vicinity of a highway project. A review of these studies was performed, and it was determined that the models were not transferable to other localities. The overall fits to data were not particularly strong, there was no underlying theory, and location-specific variables were included. Nonetheless, the results of these studies did suggest that very simple statistical techniques, such as taking averages, could help forecast the amount of development that might occur because of a highway project.

Toward that end, "service development factors" have been calculated for each of the four case study cities. These service development factors are shown in Tables 4.1 to 4.4. The service development factors do not constitute a complete technique. Rather, they are helpful in determining if the results from the more elaborate techniques are reasonable, in refining the results of a Lowry Model, and in doing rough estimates of impact to see if further analysis is warranted.

Separate factors are listed for six standard industrial categories of services. The four tables show the number of service employees as a ratio of population, land area, total

Table 4.1

EMPLOYEE PER POPULATION
FOR SELECTED SERVICE CATEGORIES

	Eau Claire	Sheboygan	Wausau	Wisconsin Rapids
Transportation, Communications, Electric, Gas and Sanitary Service	0.0390	0.0186	0.0487	0.0380
Wholesale Trade	0.0307	0.0135	0.0423	0.0300
Retail Trade	0.1490	0.1085	0.1073	0.1411
Finance, Insurance and Real Estate	0.0210	0.0272	0.0288	0.0208
Services	0.1650	0.1353	0.1871	0.1152
Public Administration	0.0263	0.0372	0.0424	0.0622

Table 4.2

EMPLOYEE PER TOTAL EMPLOYMENT
FOR SELECTED SERVICE CATEGORIES

	Eau Claire	Sheboygan	Wausau	Wisconsin Rapids
Transportation, Communications, Electric, Gas and Sanitary Service	0.0703	0.0339	0.0623	0.0569
Wholesale Trade	0.0554	0.0245	0.0542	0.0450
Retail Trade	0.2687	0.1975	0.1373	0.2117
Finance, Insurance and Real Estate	0.0378	0.0495	0.0368	0.0313
Services	0.2975	0.2463	0.2394	0.1729
Public Administration	0.0475	0.0676	0.0542	0.0933

Table 4.3

EMPLOYEES PER SQUARE MILE
FOR SELECTED SERVICE CATEGORIES

	Eau Claire	Sheboygan	Wausau	Wisconsin Rapids
Transportation, Communications, Electric, Gas and Sanitary Service	91	88	125	60
Wholesale Trade	72	63	109	47
Retail Trade	347	512	276	223
Finance, Insurance and Real Estate	49	128	74	33
Services	385	638	482	182
Public Administration	61	175	109	98

Table 4.4

EMPLOYEE PER VEHICLE MILES TRAVELED
FOR SELECTED SERVICE CATEGORIES

	Eau Claire	Sheboygan	Wausau	Wisconsin Rapids
Transportation, Communications, Electric, Gas and Sanitary Service	0.0026	0.0023	0.0044	0.0026
Wholesale Trade	0.0021	0.0017	0.0038	0.0020
Retail Trade	0.0101	0.0136	0.0097	0.0095
Finance, Insurance and Real Estate	0.0014	0.0034	0.0026	0.0014
Services	0.0111	0.0169	0.0169	0.0078
Public Administration	0.0018	0.0047	0.0038	0.0042

employment, and vehicle-miles-traveled (VMT). Only data from the principal city in each study area were used to develop these service development factors. Vehicle-miles-traveled was limited to major arterials, excluding freeways.

Simple economic base theory states that employment in most service categories is proportional to population, so the factors from Table 4.1 are preferred. If a population forecast for a given area is not available, then total employment (Table 4.2) or land area (Table 4.3) could be used instead, with the understanding that these two variables are proxies for population. Use of these first three sets of service development factors ignores the possibility of agglomeration and does not explicitly incorporate accessibility effects.

Many transportation professionals have an intriguing but unconfirmed belief that service development is related to the amount of traffic on a road. A major study of development along Texas highways (Chui, et al, 1983) tried and failed to confirm such a relationship. Clearly, services would prefer to be readily accessible, to be near other services, to be near concentrations of population, to be central to their market areas. Zoning boards prefer services to be in places that are less desirable for residential use, such as along busy arterials. These preferences would tend to place services along arterial streets with high traffic volumes. Even though the relationship between traffic volumes and development is fuzzy at best, arterial VMT does appear to be a good indicator of the the amount of development that would occur in fully developed corridor within an urbanized area. Table 4.4 lists the appropriate service development factors. One use of these particular factors is to approximate an intrazonal distribution of nonbasic service employment as forecasted by a Lowry Model.

Checklists

In evaluating secondary land-use impacts of highway projects, the most fundamental approach is to use a checklist. The advantage of a checklist is to assure that an analysis of impacts will be complete, even though the analysis may not have great depth. Checklists can be as simple as a list of potential impacts. More elaborate checklists could require ratings of impacts, verbal descriptions of the environmental setting, or verbal descriptions of the potential impacts. The principal use of a checklist in assessing land-use impacts of highway projects is to uncover, at a modest cost, signifcant negative impacts. If a checklist evaluation indicates that significant negative impacts are possible, then one of the more sophisticated evaluation techniques also should be applied.

The list of 31 community features (Table 2.1), which was part of the expert panel questionnaire, is one form of checklist.

It could be used to ensure that nothing important has been overlooked, or it can be used to rate the importances and magnitudes of impacts.

The two other checklists presented in this section are the "detailed checklist" and the "short checklist". The detailed checklist requires short descriptions of all aspects of the project and urban area that could possibly lead to a negative impact. The short checklist is intended for minor projects, which are not expected to have significant impacts.

The detailed checklist consists of an overall summary and seven broad categories of possible land-use impacts, including impacts on the location or amount of industrial, commercial, and residential developments. The checklist items are reproduced in Figures 4.1 and 4.2. The categories and questions included in the checklist provide a framework that is based on traditional urban location theory and on experience gained from applying the structured expert panel and the Lowry Model. A suggested procedure for utilizing the detailed checklist is found in Appendix E. For a comprehensive example of how the checklist should be completed, see the Eau Claire case study presented in Appendix F.

Figures 4.3 and 4.4 are excerpted from the Eau Claire evaluation (Appendix F) and illustrate the extent of discussion that is considered appropriate. This excerpt is from the section of the checklist dealing with potential commercial development. It is seen that some calculations are required, but the analyst is encouraged to draw upon any existing socioeconomic projections. Occasionally, maps and charts are necessary to further explain the impact.

The expectation is that very little original data collection would be required to complete the checklist. The procedures have been designed so that existing sources (Census data, land-use planning reports, state-wide economic data, transit development plans, etc.) could be tapped. It would take between one and three person-weeks to complete the checklist, depending on the nature of the project and the availability of data.

The short checklist is shown in Figures 4.5 and 4.6. Like the detailed checklist, the short checklist requires verbal descriptions of possible impacts. It is intended for initial screening for a negative impact or for documenting the sometimes obvious conclusion that negative impacts will not occur. The short checklist provides a level of analysis that is comparable to the Environmental Screening Worksheets presently used by WisDOT.

1. Summary description of the major secondary land use impacts identified in this analysis

2. Description of existing constraints on development

3.1. Spatial distribution of existing industrial activity

- 3.1.a. Industrial employment data
- 3.1.b. Projections of manufacturing employment
- 3.1.c. Identification of existing areas zoned for industrial activity
- 3.1.d. Identification of major employers

3.2. Evaluate Project impact on the spatial distribution of industrial activity

- 3.2.a. Travel time accessibility
- 3.2.b. Project impact on accessibility from industrial zones to freeway, transfer depots, CBD
- 3.2.c. Project impact on accessibility to major highway interchanges
- 3.2.d. Project impact on industrial location decisions
- 3.2.e. Likelihood of industrial rezoning because of Project

4.1. Spatial distribution of existing commercial activity

- 4.1.a. Commercial employment data
- 4.1.b. Projections of commercial employment
- 4.1.c. Identification of areas zoned for commercial activity

4.2. How the Project will affect spatial distribution of commercial activities

- 4.2.a. Project impact on travel time accessibility to commercial zones

Figure 4.1. Outline of Detailed Checklist: Part I

4.2.b. Project impact on consumer visibility of commercial business activity

4.2.c. Project impact on the commercial trade area

4.2.d. Existing regional shopping centers

4.2.e. Project impact on consumer accessibility to an interstate highway interchange

4.2.f. Project impact on commercial activities in the CBD

5.1. Spatial distribution of existing residential locations

5.1.a. Population data and projections

5.1.b. Identification of existing areas zoned for residential location

5.1.c. Identification of residential densities

5.2. How the Project will affect the spatial distribution of residential location and densities

5.2.a. Project impact on travel time accessibility for residential activity

5.2.b. Likelihood of Project to result in residential rezoning

5.2.c. Likelihood of Project to contribute to a deterioration in community/neighborhood qualities or a decline in community residential values

6. Project impact on agricultural activity within 10 miles of the Project

7. Project impact on land values

8. Project impact on commuting patterns and mass transportation

9. Project impact on public land-use or public services

Figure 4.2. Outline of Detailed Checklist: Part II

4.2.a. Project impact on travel time accessibility to commercial zones

As shown in 3.2.a., the project will reduce driving times along Clairemont Avenue from Highway 53 to the Chippewa River from 7.8 to 5.3 minutes -- a reduction of 32 percent.

The reductions in travel time along Clairemont Avenue also contribute to increases in accessibility between commercial zones at either end of the project and the central business district.

Accessibility to the I-94 interchange is relatively unaffected by the project. However, some reduction in congestion will likely result because of the project.

The project is not likely to lead to any significant increases in the population that will be within a 30 minutes driving time of the commercial zones. Figure F.5 shows the accessibility contours from the project. These contours are essentially unchanged by the project.

Figure 4.3. Excerpt from the Eau Claire Evaluation

TRAVEL TIME FROM PROJECT (IN MINUTES)

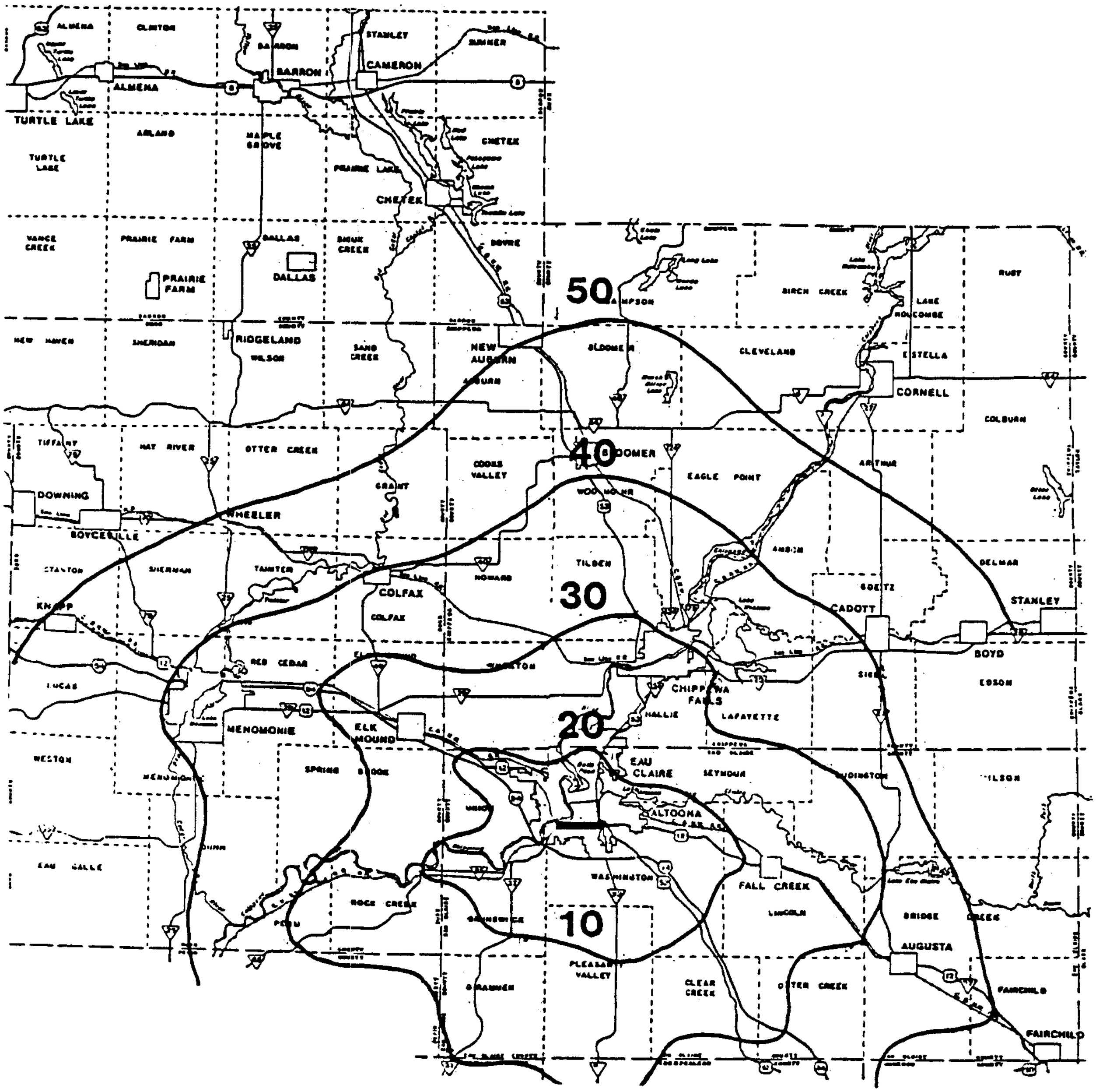


Figure 4.4. Travel Time Contours from Project Center

1. Summary description of existing land use for project and surrounding areas: (summarize answers to 2(a), 3(a), 4(a); include land use maps if available.)

2. Describe briefly existing constraints on development within 10 miles of the project.

3. a) Describe briefly the spatial distribution of existing industrial employment in any urbanized areas within 10 miles of the project.

   b) Estimate how the proposed action (project) will affect (or change) the conditions described in 2(a).

4. a) Describe briefly the spatial distribution of existing commercial activity in any urbanized areas within 10 miles of the project.

   b) Estimate how the proposed action (project) will affect (or change) the conditions described in 3(a).

Figure 4.5. Short Checklist: Part I

5. a) Describe briefly the spatial distribution of existing <u>residential location</u> in any urbanized areas within 10 miles of the project.

   b) Estimate how the proposed action (project) will affect (or change) the conditions described in 4(a).

6. Is a land use change or secondary development expected to occur that will affect <u>agricultural activity</u> within 10 miles of the project?

7. Describe changes in <u>land values</u> that will occur because of or in anticipation of this project.

8. Describe any expected changes to <u>commuting patterns and mass transit</u> in any urbanized areas within 10 miles of the project.

9. Estimate how the proposed action (project) will affect (or change) any <u>public land use or public services</u>.

Figure 4.6. Short Checklist: Part II

Discussion

Forecasting with a statistical model implies that the project and the impacted area are average in all respects, except in terms of the few independent variables within the model. Because of the lack of underlying theory, a model that was developed at a distant location (e.g., Texas or North Carolina) probably would perform poorly. Developing a new statistical model from scratch requires considerable time and effort; no guarantees can be given that the resulting model would dependably forecast anything. On the other hand, simple averages that are well grounded in theory can be easily determined and applied. Simple averages can also be used to further refine the results of more sophisticated forecasting techniques, such as the Lowry Model.

Three versions of checklists have been presented in this report. Checklists inherently constrain the depth and range of the assessment, so they are ideal as screening devices for possible negative impacts. There is still the possibility that a project would have an unusual impact that is not included in the checklist, or that an impact would go undetected because the checklist did not suggest that more extensive analysis is needed. The quality of the results from a checklist depends on the expertise and judgment of the analyst.

5. CONCLUSIONS AND RECOMMENDATIONS

The potential impact of a highway project can be so complex that more than one technique may be necessary. Each technique for assessing the land-use impacts of a highway project has both strengths and weaknesses. Major trends in urban development can be identified by a Lowry Model, but localized impacts are better addressed by an expert panel. On the other hand, it would be a mistake to expect a Lowry Model to forecast localized impacts by making zones very small, and it would be an equally serious mistake to expect an expert panel to judge the relative impacts of two alternatives that differ only in the speed of traffic. The Wisconsin Rapids case study demonstrates that the expert panel and the Lowry Model are compatible techniques, which together produce a complete picture of future urban development.

The four case studies illustrate that land-use impacts from highway projects can vary greatly in both quantity and quality. Simple, general rules for determining the magnitude of impacts are not available. Without extensive analyses, similar to those presented in this report, forecasts of impacts would be quite shallow and may be unreliable.

The Eau Claire case study shows that a seemingly large project can have a relatively small impact. It would be advantageous if the techniques could be applied in an ascending order of complexity -- simple checklist, detailed checklist, Lowry Model, and expert panel. If an earlier technique demonstrates that the impact will be inconsequential, then the later, more complicated, techniques can be foregone.

It may be possible to develop guidelines for categorically excluding certain projects from land-use impact assessment. For example, projects that do not significantly change travel times and do not significantly affect access to land or other transportation facilities will not cause a secondary land-use impact. Four case studies are not a sufficient number to permit determination of such guidelines, but projects with minimal impacts would be easier to identify as more field experience is gained with these techniques.

An important feature of an assessment technique is the ability to help build a consensus about the proposed project. The expert panel and the Lowry Model are the best in that regard. Both can be treated as independent viewpoints. The panel can be made up of disinterested individuals, and the Lowry Model is inherently impartial. People can differ on the interpretation of the forecasts, but a common ground for discussion would be established.

Some of these techniques, expecially the Lowry Model and the structured expert panel, produce results that are far too complicated for a lay audience. Some interested citizens may wish to see the complete analysis, but most citizens and community leaders would be better served by a digest. WisDOT should work toward developing a method of presenting land-use assessments that is concise, fair and accurate.

None of these techniques are unreasonably difficult to execute. Neither the costs nor time requirements are excessive, considering the potential that exists for learning more about the desirablity of the project and incorporating mitigation measures in project plans.

All of the techniques, however, require some technical expertise. It is recommended that at least two people be involved in a land-use impact assessment: one person who is well versed in the theory and practice of land-use forecasting; and a second person who is familiar with both the project and the city. Training of both district and central office personnel is required to assure that such expertise is available at the time of project design.

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APPENDIX A

Instruction Materials for Round I

INSTRUCTIONS AS READ TO ROUND I PANELISTS:

You are participating in the first round of an expert panel evaluation of land use changes in small cities due to transportation developments. The primary purpose of this research project is to test the applicability of a technique. Thus, we are asking you to "predict" changes that have already occurred. Our particular transportation projects were initiated 15 to 20 years ago. Thus, we want you to adopt a frame of mind of an expert from 1965. In order to help you do this, here is a short reminder of the way things were in 1965.

NINETEEN SIXTY-FIVE NARRATIVE

Transportation project planning normally requires projections for a future date--generally 10 or 20 years from now. Here we are asking you to imagine yourself in 1965 and then to predict what two cities would be like, in your opinion, in 1985. Do you remember what you were doing in 1965?

LBJ was president, and you may recall he had won the '64 election with more than 61% of the popular vote--the greatest majority of any president. Not only did he receive a stunning majority, but 69% of those eligible participated in the election. In Wisconsin the participation rate was almost 62%. He was extremely well liked and his optimistic attitude helped him maintain the support of the nation. There were only slight misgivings aroused when he asked for more troops for Vietnam in July 1965. The war in Vietnam had wide popular support, at that time, even though very few people actually knew where Vietnam was. On June 30th there were 2,655,389 military personnel on active duty.

Leaders like Bobby Kennedy and Martin Luther King, Jr. were still alive. We had not experienced the devastation of the race riots yet to come, although a major riot took place in the Watts suburb of Los Angeles in 1965. Urban violence continued and Protests mounted throughout this period. Not all blacks were able to adopt the nonviolent posture of Martin Luther King, Jr. There was bitterness and anger.

The world was changing, industry was changing, and attitudes were in need of adaptation. There were many low-skilled workers that needed to be retrained for the jobs of the 60's and beyond. It was not possible just to formally educate children. It was necessary to provide educational opportunities to all of those in need of them. The bright hope that JFK brought at the beginning of the decade had started to diminish.

About this time we saw the emergence of the "love and peace" generation. The '65 song by Bacharach and David proclaimed "What the World Needs Now is Love, Sweet Love." The Beatles had their first hit in 1963, "She Loves You." We started to see a widening of the "generation gap." The "Free Speech Movement" had begun at the University of California--Berkeley. Their leaders became extremely mistrustful of anyone over the age of 30. Singers like Joan Baez, Pete Seeger, Bob Dylan, and Judy Collins popularized songs of protest.

The Great Society provided many programs to low income individuals, both black and white, not the least of these being Medicare, Medicaid, and food stamps. Urban transit had not yet become a national issue.

In 1965 the Dow-Jones Industrial Average reached the 1000 mark for the first time. The GNP was $681.2 billion. A real growth rate in GNP of 6.3% was experienced that year. There were 74,455,000 members in the civilian labor force. Unemployment stood at only 4.5%. The average earnings of a full time employee was $5,710. Retail prices were somewhat different than they are now. Here is a small sampling: pork chops $.97/lb., milk $1.05/gal., coffee $.83/lb. The enclosed shopping mall did not yet exist in smaller cities, but it had been introduced in the largest cities.

Over 90 million motor vehicles were registered in the U.S.--almost 2 million of them in Wisconsin. Nationally there were over 908,722 miles of Federal highway; approximately 17,433 miles had been completed in 1965. The number of households with telephone service was 94 million or 91%. It cost $1.40 to call NYC from Chicago for 3 minutes. While only 5% of the households owned color TVs, 94% had black and white sets. First class postage was priced at $.05 then.

At this point the women's movement was just gaining strength. Betty Friedan had written The Feminine Mystique in 1963. Also, a 1965 Harvard Business Review article reported that 41% of those interviewed looked at female executives with disfavor and only 35% were actually in favor of female executives.

In 1965 Ed White floated in space outside of the Gemini 4 capsule.

Mainframe computers were in use by the government, universities, and large businesses. These computers were of the IBM 360 vintage (some 7094s and 1620s were still in use), something quite different than what we experience today.

We now recognize that 1965 was a pivotal year of social change. The optimism of the 1950s and early 1960s was being replaced by frustration and turmoil in the late 1960s and 1970s. When evaluating impacts due to these highway improvements, you should try to remember the prevailing beliefs of this era that the government was the primary agent for positive urban development.

This is the first of three rounds of evaluation. Subsequent rounds will be handled primarily by mail. When this round is completed, the study team will compile the results. If your responses are unusual or particularly interesting, you will be contacted for clarification. A summary of the first round will be prepared, selected new data will be assembled, and a new questionnaire will be produced. You will be sent all of this material. You will then have the opportunity to modify your answers from the first round. We want you to return this information to us as soon as possible. A third round, like the second, will be conducted if the study team feels that new information may prompt members of the panel to modify their second round responses.

Since this is an iterative process, please feel free to recommend changes to the questionnaire for rounds two and three. The complete panel has about 12 members. Your individual responses will be kept confidential. IT IS EXTREMELY IMPORTANT THAT YOU REFRAIN FROM DISCUSSING ANY OF YOUR RESPONSES WITH OTHER MEMBERS OF THE PANEL UNTIL THE FINAL ROUND IS COMPLETED.

You will be evaluating the land use changes in two separate cities, denoted here as City A and City B. The relevant materials for each city are contained in separate envelopes. Contained in the envelopes are descriptions of transportation projects that occurred between 1965 and 1970, maps of the cities, and a set of questions about features of community development. Additional instructions on how to answer the various questions are included in the envelope.

Please carefully read the instructions for completing the map and the instructions for answering the questions about features of community development. You may deal with the map first or the features first or perform both tasks simultaneously. However, please complete all the materials for City A before progressing to City B. Members of the study team are present to answer questions about the process of filling out the materials or to clarify the meaning of data presented to you. They are not able to provide any additional data or interpretation. If you desire additional information on subsequent rounds, you may indicate that at the end of the features questionnaire.

Please take the materials out of envelope A and we will briefly go through the layout.

COMMUNITY FEATURES INSTRUCTIONS

The purpose of this questionnaire is to learn your opinion of how the highway improvement affects thirty-one features of community development. There are five questions (A through E) for each feature. Question A asks if the community feature is impacted by the highway improvement. If there is no impact, skip immediately to Question E and explain why you think no impact will occur. Question B asks whether the feature will get bigger or smaller. We are not seeking your opinion as to whether the impact is good or bad. For Question C you should rate the magnitude (or relative size) of the impact. Place an "X" in the box that best represents the importance of the impact. An example set of questions for one community feature, noise pollution, is shown below.

Noise Pollution

A) Impact occurs Yes [X] No [ ] (If No skip to E)

B) Direction of impact Larger [X] Smaller [ ]

C) Magnitude No Impact [| | X | | | | | | |] Extremely Large Impact

D) Importance No Importance [| | | | | | | X | | |] Extremely Important

E) Why do you feel there would be no impact?

____

____

You can see that a respondent has already answered these questions. The respondent felt that an impact would occur (A) and that there would be more noise (B). The amount of increase in noise was considered to be small (C), but the importance was considered to be large (D) because this respondent felt that any increase in noise should be taken quite seriously.

Unless otherwise stated, you should assume that the features of community development apply to the whole urban area. A few features pertain only to small portions of the urban area, such as the Central Business District (CBD) or land near the highway project.

If you would like additional information for subsequent rounds, you may indicate this at the end of the questionnaire.

CASE STUDY A

The case study area consists of a central city, one satellite community to the west and surrounding rural areas. The central city is 10.2 square miles in size and stands on the shoreline of a lake. The population (in 1965) of the whole study area is approximately 50,000.

This study area enjoys a diversified economy and there is only a single concentration of employment in one establishment in the area. There are 3,900 employees located at that firm. The median family income in the city is $10,000. The housing stock is mature and single family home ownership is predominant. There is some multifamily rental property available near the CBD. The central city supplies water and sewer service. Any construction beyond the city limits is dependent on importing such services or installing septic tanks and wells where feasible.

The central city is also the county seat. The central city elects a mayor and a common council consisting of aldermen representing districts. This area has a well developed road system.

Proposed Project

The existing state highway passes near the central business district. The proposed project is a bypass, just west of the central city. This bypass is to be undertaken in two stages. The first stage (to be completed in 1968) consists of a two-lane rural highway. In 1972, a parallel roadway will be added in order to bring the facility up to freeway standards.

CASE STUDY B

This urban area is divided by a river that runs from the northeast through the city to the southwest. In fact, the Central Business District is on both sides of the river. Urbanized land area is approximately 15 square miles. The 1965 population of the whole study area is 28,000.

The public water systems of the communities are generally adequate. Central water and sewer services are available within currently developed areas. Water and sewer are not yet available to the undeveloped areas. Because of the soil conditions the area east of the central city is suitable for residential development, only. The presence of a large industrial plant, just north of the CBD, seems to be inhibiting residential development to the northwest. The housing stock is mature. There is a heavy concentration in a single industry engaging 30% of the work force. The location of highest employment is identified on the map. The central city is the county seat. City government lacks strong leadership in land use control, zoning and building codes. Variances are readily granted. The central city has a history of incorporating adjacent, fully developed areas upon petition.

Proposed Project

The existing road is a two-lane rural highway. The road is a major link in the state highway system. Traffic now flows through the CBD. Work consists of reconstructing the portions of the road and adding a bridge across the river. The north-south portion of the road will include two, 12-foot travel lanes in each direction separated by a 16-foot blacktop bituminous capped crossover type median with left turn lanes provided at intersections. A new 5 foot wide sidewalk will also be constructed. The east-west portion of the road (as it approaches the bridge) is an expressway. Traffic will bypass the CBD, but will still go through less intensively developed areas.

APPENDIX B

Areas of Impact from Rounds I and II

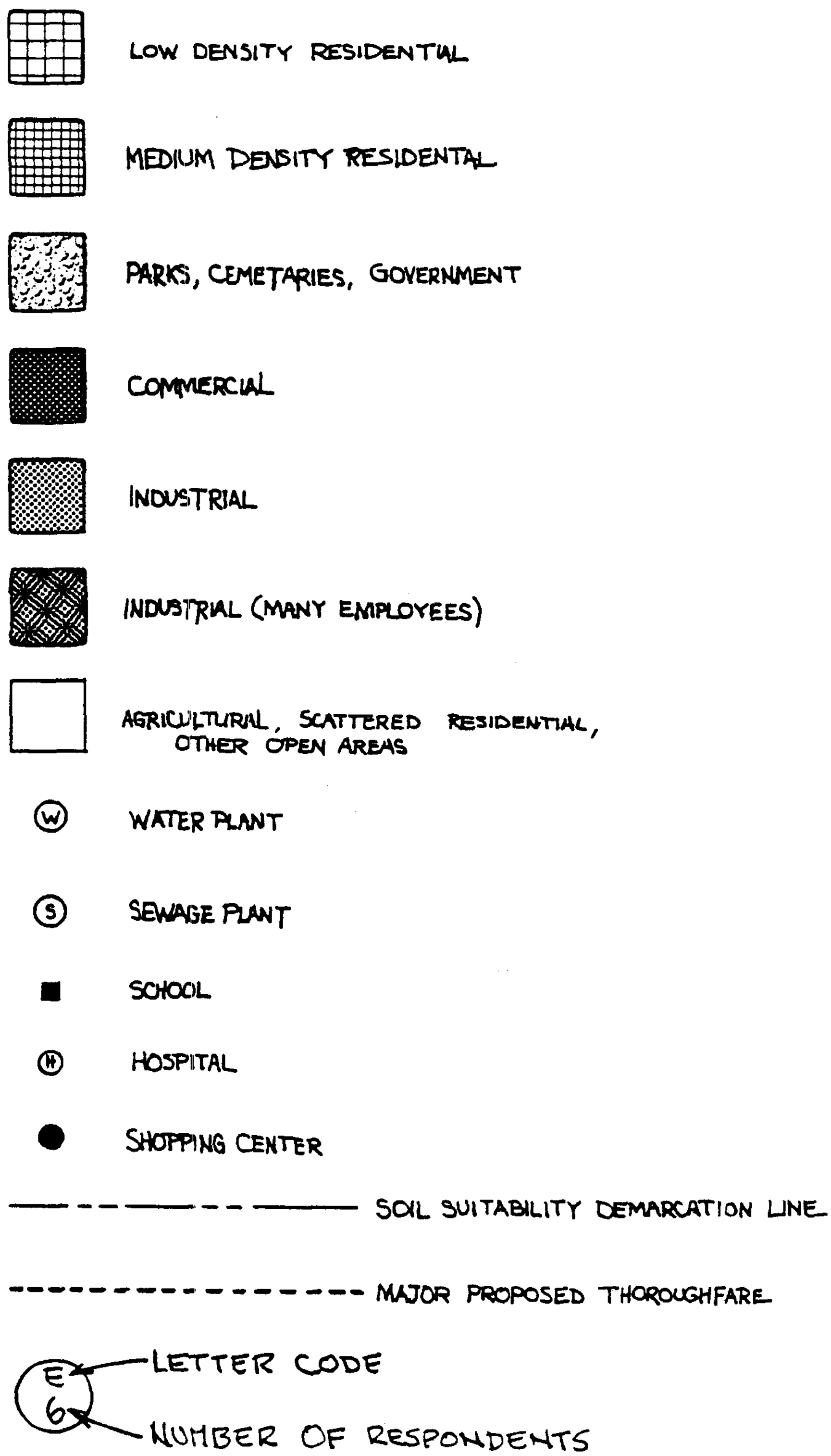

Figure B.1. Key to the Maps

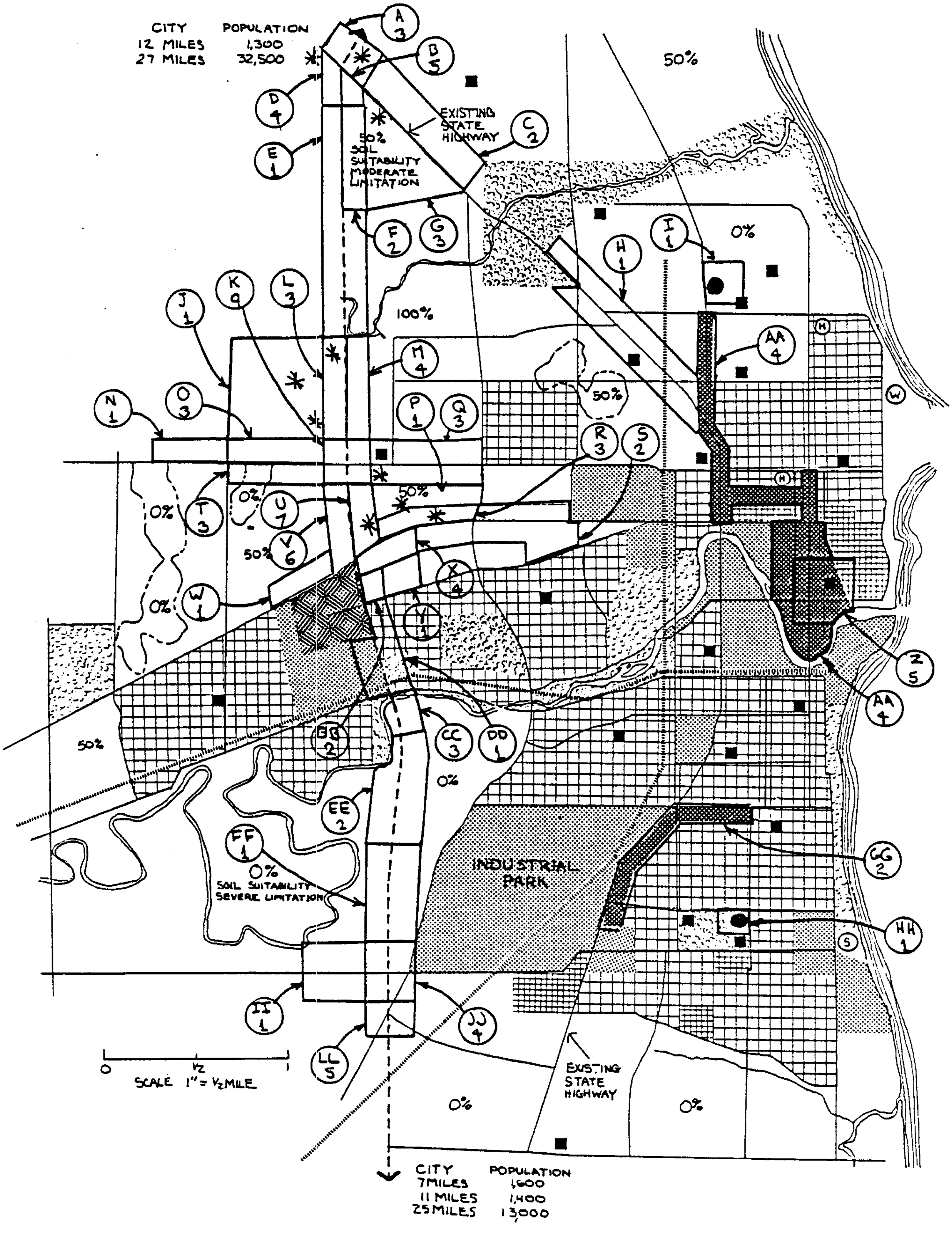

Figure B.2. Areas of Retail Impact in Sheboygan

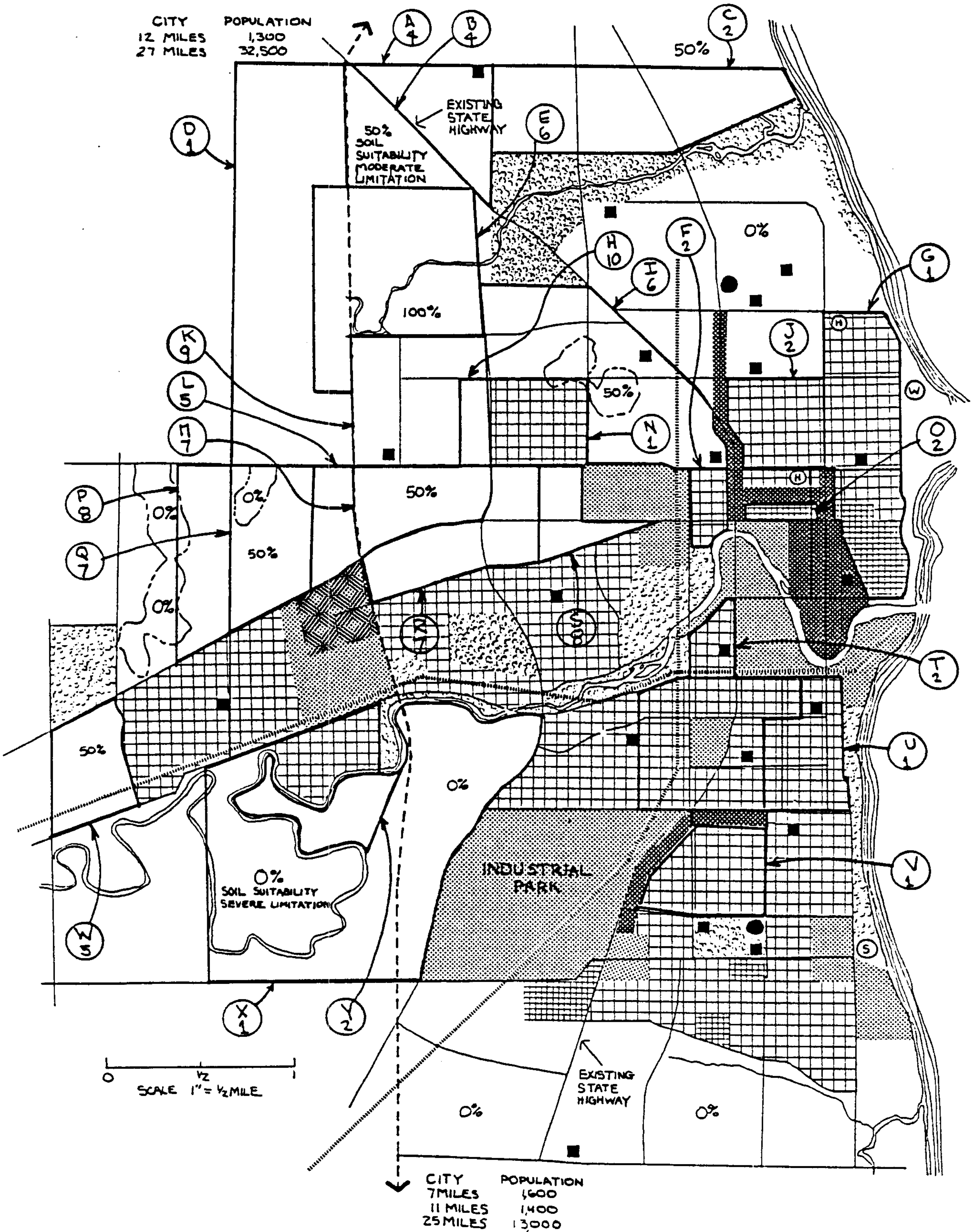

Figure B.3. Areas of Residential Impact in Sheboygan

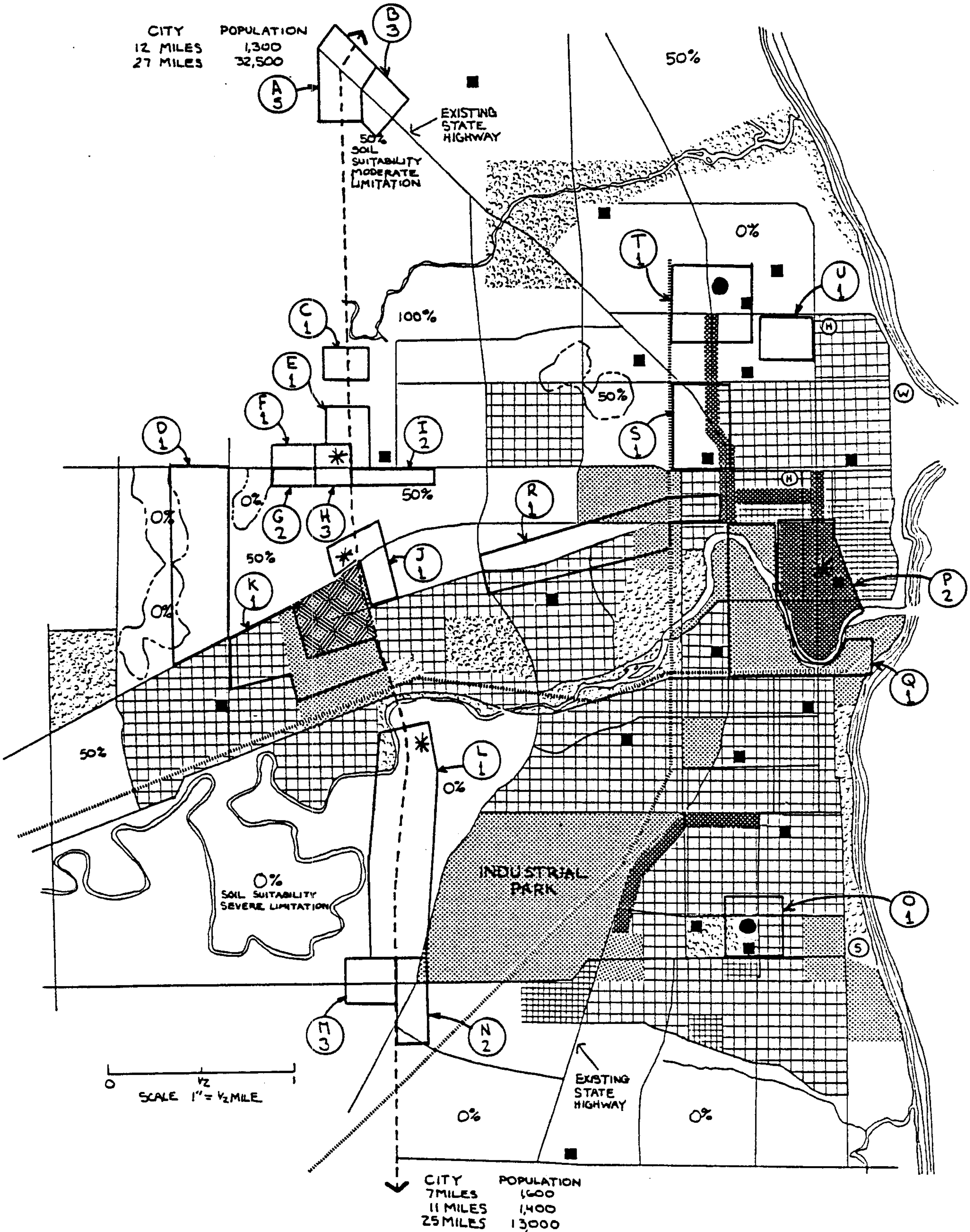

Figure B.4. Areas of Service Impact in Sheboygan

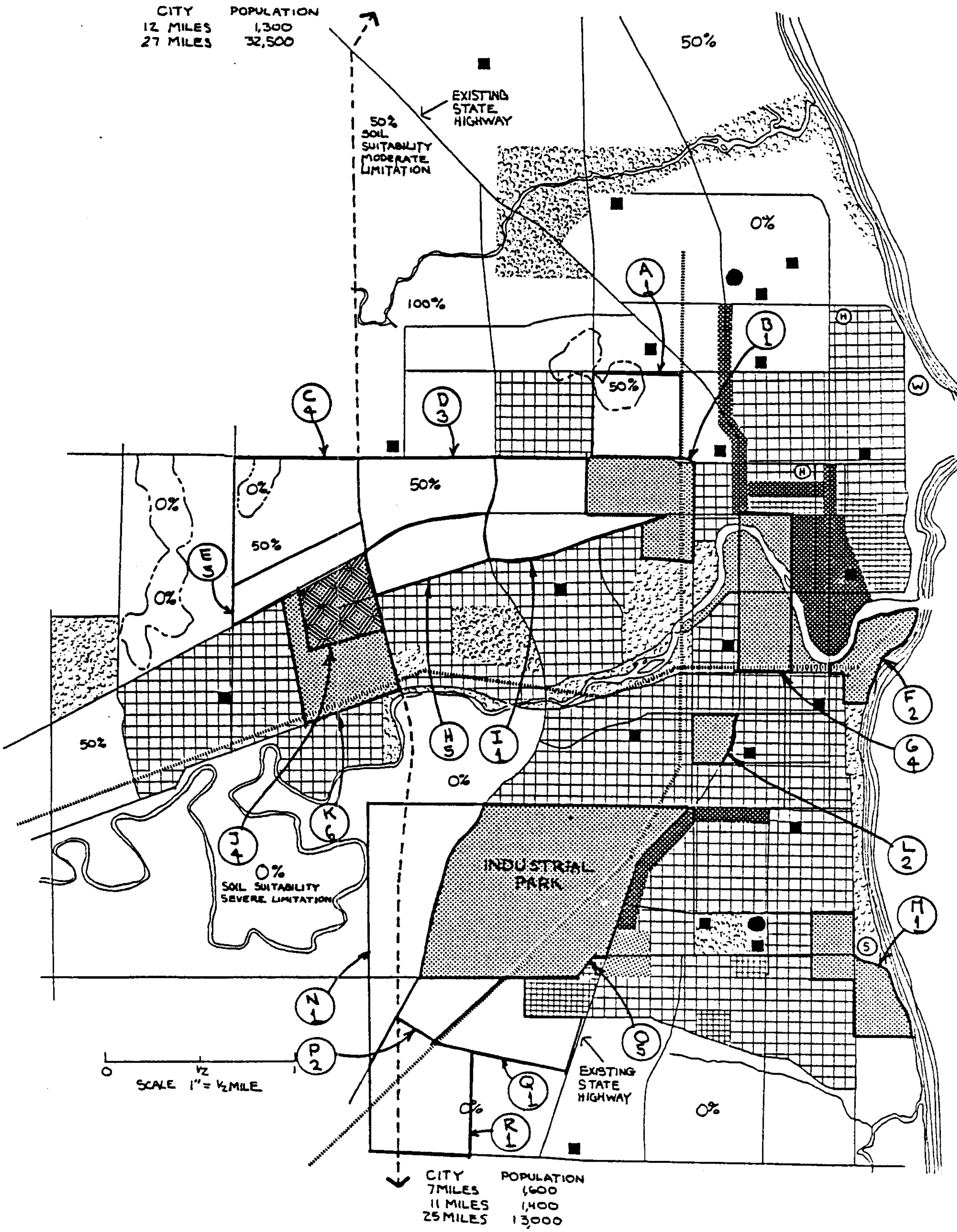

Figure B.5. Areas of Industrial Impact in Sheboygan

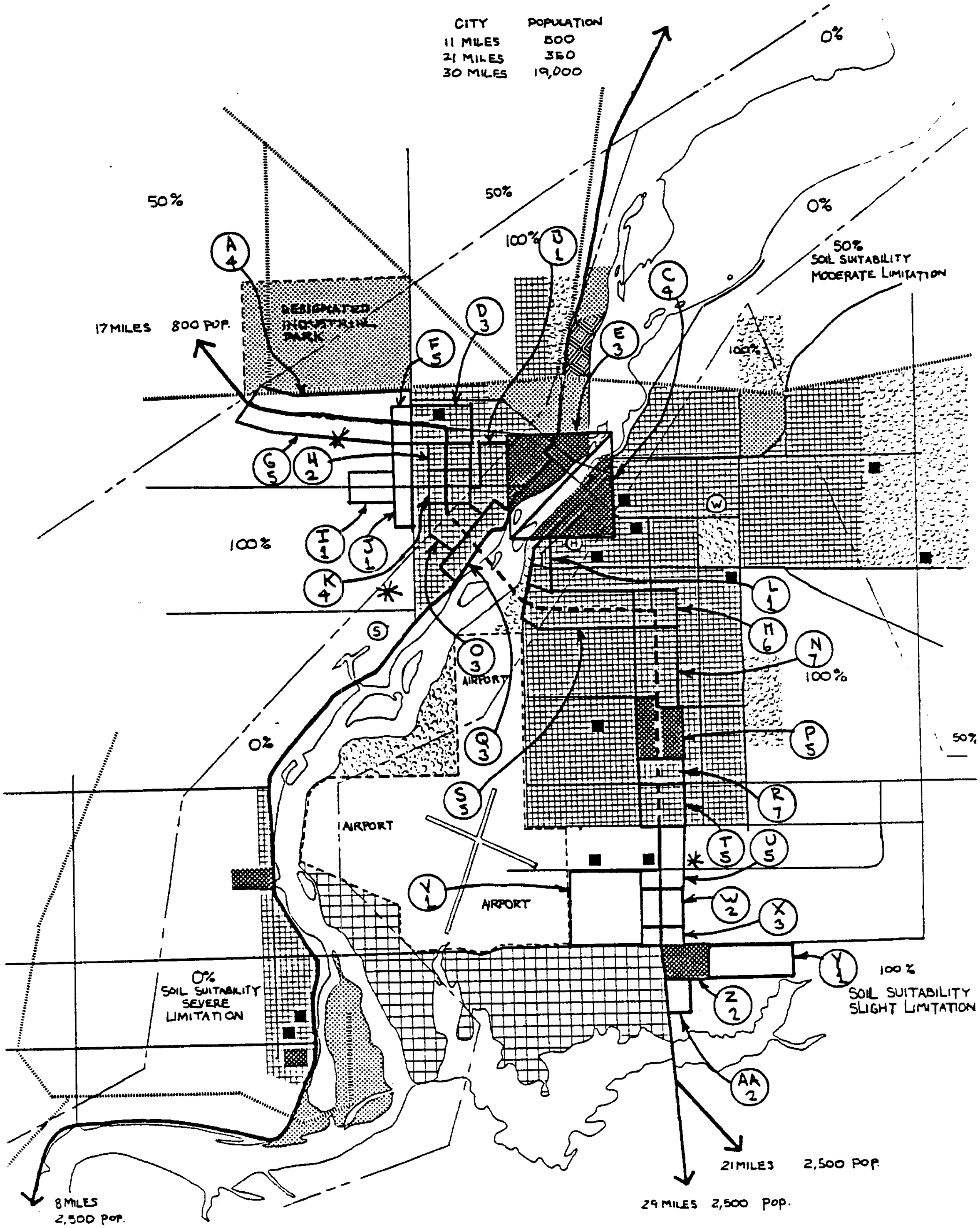

Figure B.6. Areas of Retail Impact in Wisconsin Rapids

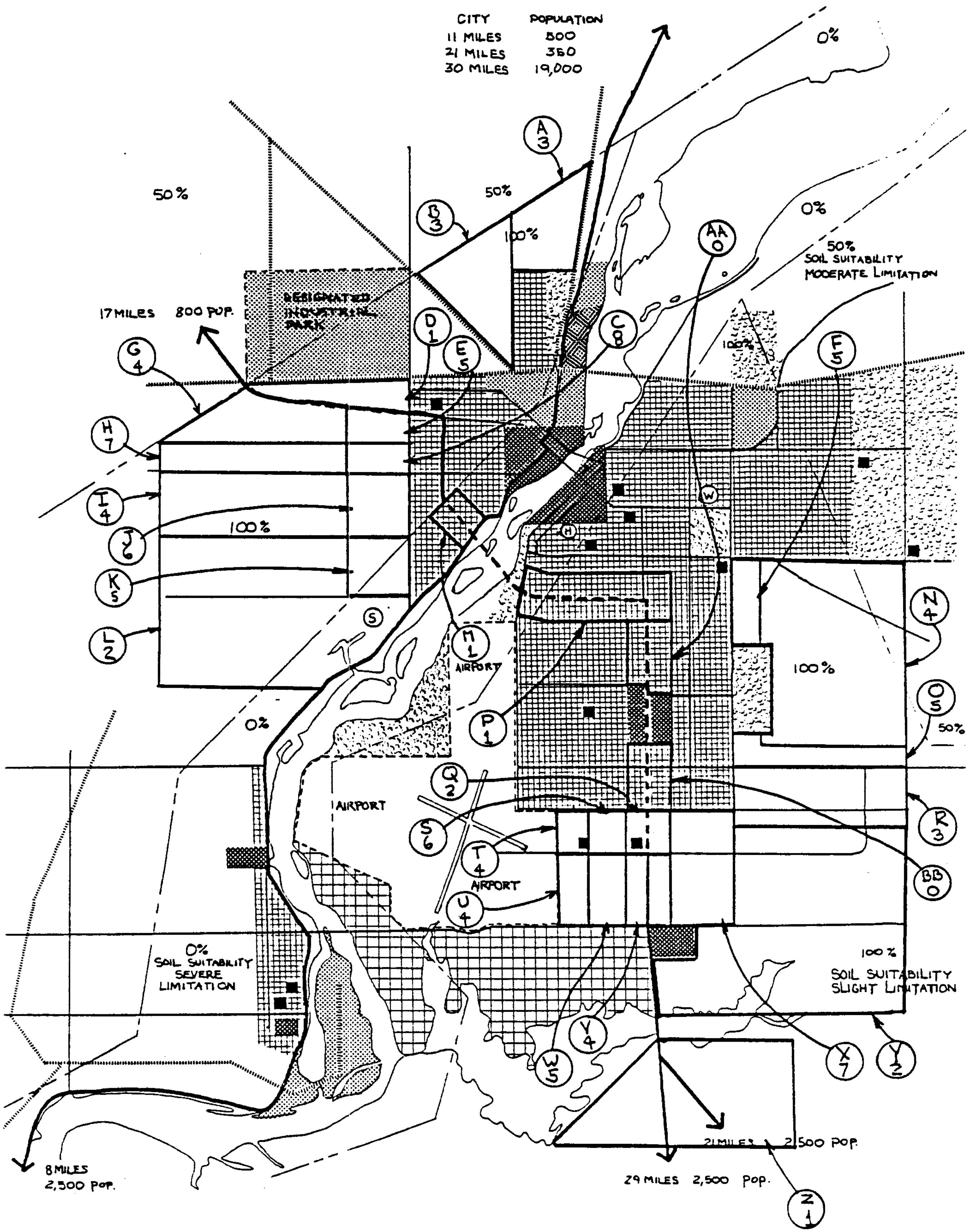

Figure B.7. Areas of Residential Impact in Wisconsin Rapids

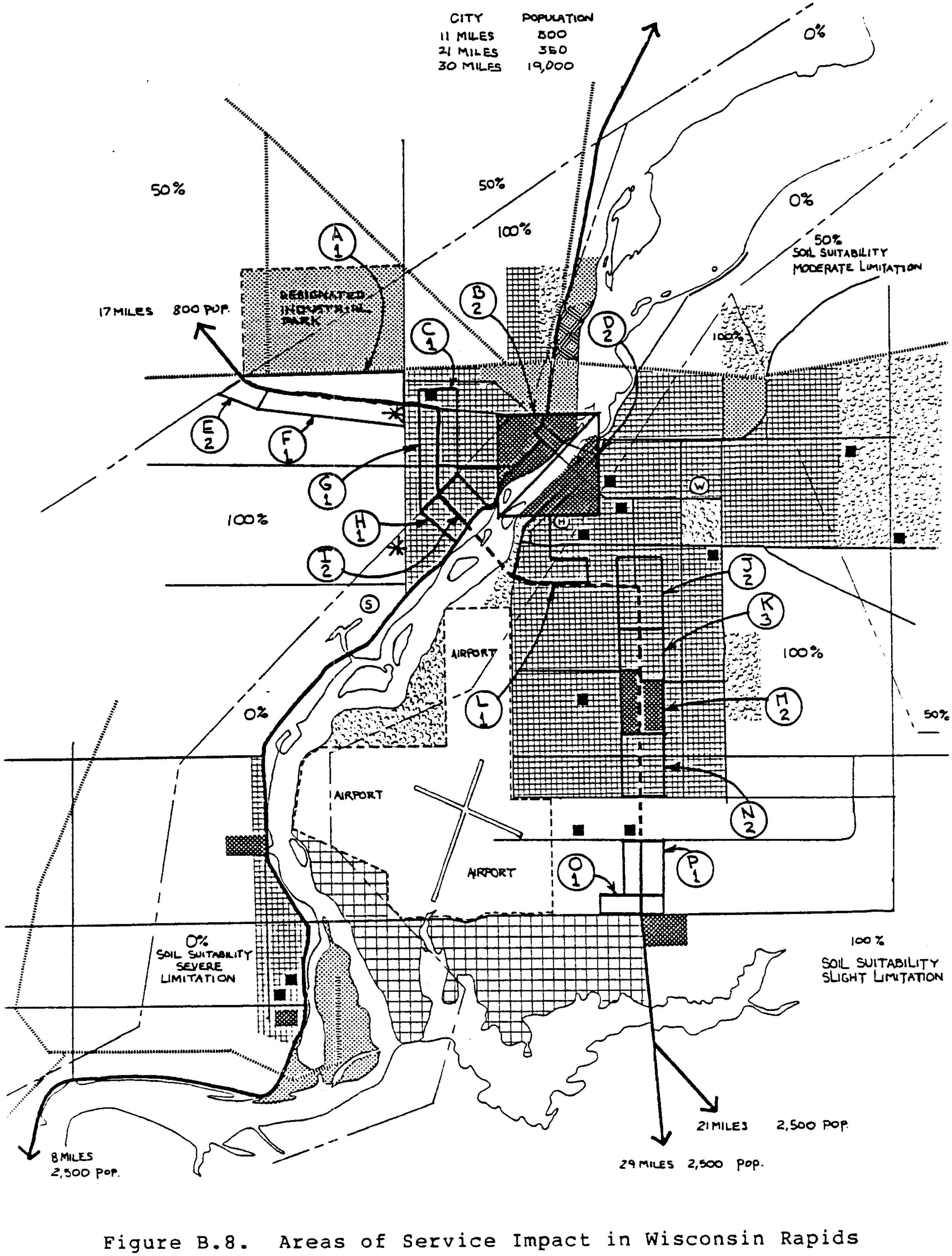

Figure B.8. Areas of Service Impact in Wisconsin Rapids

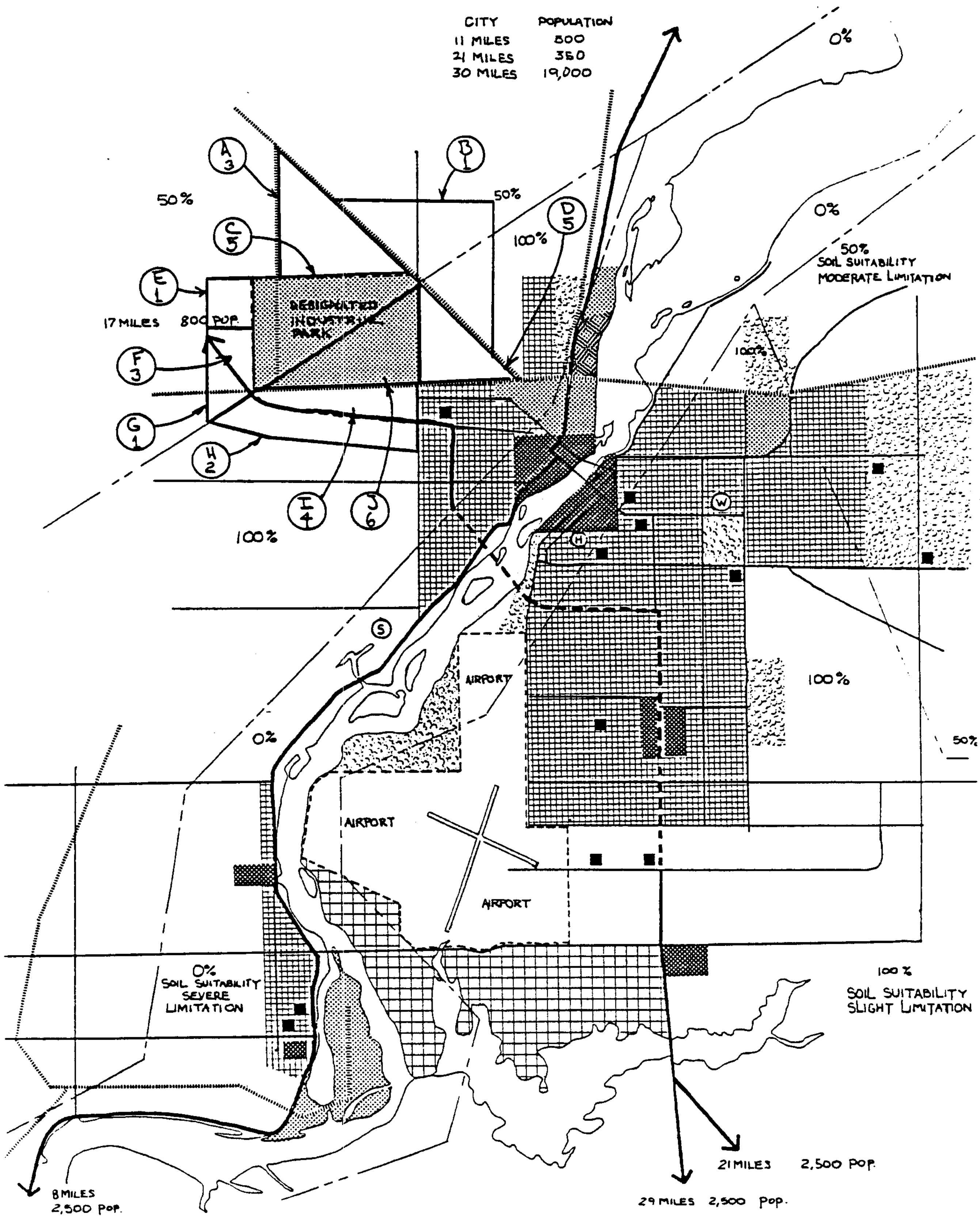

Figure B.9. Areas of Industrial Impact in Wisconsin Rapids

Table B.1

SUMMARY OF ROUND II RESPONSES TO MAP PORTION OF QUESTIONNAIRE

	Positive Areas		Negative Areas	
	3 to 7 Panelists	More than 7 Panelists	3 to 7 Panelists	More than 7 Panelists
Sheboygan				
Retail Impacts	C,E,F,K,R,S,W,X,JJ,LL	A,B,D,U,V	GG	Z,AA
Service Impacts	F,J,N	A,B,M	P	---
Residential Impacts	A,B,E,L,P,R,S	H,K,M,Q	---	---
Industrial Impacts	C,D,E,J	K,O	G,L,M	---
Wisconsin Rapids				
Retail Impacts	A,G,K,O,P,S,R,T,U,W,X,Z	M,N	---	C,E
Service Impacts	F,J,K,M,N,O,P	---	B,D	---
Residential Impacts	F,G,I,N,O,Q,R,T,U,V	C,E,H,J,K,W,X	AA,BB	M,P
Industrial Impacts	A,C,D,E,G,H,J	F,I	---	---

APPENDIX C

Reasons for No Impact on Community Features

Table C.1

REASONS FOR NO IMPACT FOR SHEBOYGAN

Statement	Reason
Employment in existing industrial park (e.g. manufacturing)	All yes
Industrial employment elsewhere within the study area	All yes
Employment in regional shopping centers	Too small for regional
Employment in community shopping centers	Distant labor pool will not be tapped--only location affect
Employment in neighborhood shopping centers	Traditional habits won't change
Retail employment in the CBD	All yes
Employment in hotel/motel services	All yes
Employment in repair and cleaning services	Not related to highway
Employment in advertising, management, consulting and legal services	Related to economy, not highway
Amount of regional educational facilities--post-secondary (colleges & technical)	Independent
Amount of local schools	Population not affected
Amount of regional health care facilities	Independent
Amount of local health care facilities	Location, not amount
Service employment in the CBD	Independent
Employment in restaurant and fast food establishments	All yes
Total population	Unrelated
Amount of unoccupied housing units	No connection

Table C.1

REASONS FOR NO IMPACT FOR SHEBOYGAN (continued)

Statement	Reason
Ability of local government to control land use through traditional measures, e.g. zoning	Road has nothing to do with ability
Length of average trip to work in miles	All yes
Amount of ride sharing	Fuel inexpensive in 1965
Amount of intercity travel for work purposes	All yes
Overall congestion in the study area	More mobility
Congestion in the area of highway project	Solve in short run; long run congestion will return
Aesthetics of area surrounding the highway project	All yes
Amount of development in communities near but not part of the study area	All yes
Amount of development in areas with incomplete utility service	All yes
Willingness of financial institutions to lend money for further land development	Too esoteric
Land values near project (i.e., within 1000 feet)	All yes
Land values in the remainder of the study area	No connection
Tax base	All yes
Utilization of existing parks	No relationship

Table C.2

REASONS FOR NO IMPACT FOR WISCONSIN RAPIDS

Statement	Reason
Employment in existing industrial park (e.g. manufacturing)	Nonsignificant change in access
Industrial employment elsewhere within the study area	Not sensitive to highway project
Employment in regional shopping centers	Too small for regional
Employment in community shopping centers	Perhaps location, not size
Employment in neighborhood shopping centers	Habits won't change
Retail employment in the CBD	All yes
Employment in hotel/motel services	No relationship
Employment in repair and cleaning services	Independent of highway
Employment in advertising, management, consulting and legal services	Unrelated to highway
Amount of regional educational facilities--post-secondary (colleges & technical)	No relationship
Amount of local schools	Not enough population change
Amount of regional health care facilities	Independent
Amount of local health care facilities	Independent
Service employment in the CBD	No relationship
Employment in restaurant and fast food establishments	Population and income not affected
Total population	Independent--project too small
Amount of unoccupied housing units	Independent--access improvement too small

Table C.2

REASONS FOR NO IMPACT FOR WISCONSIN RAPIDS (continued)

Statement	Reason
Ability of local government to control land use through traditional measures, e.g. zoning	Power exists, but no change
Length of average trip to work in miles	Not significant
Amount of ride sharing	Economy was not an issue in 1965
Amount of intercity travel for work purposes	No relationship--not a large enough population change
Overall congestion in the study area	All yes
Congestion in the area of highway project	All yes
Aesthetics of area surrounding the highway project	All yes
Amount of development in communities near but not part of the study area	Not regional
Amount of development in areas with incomplete utility service	Not related to highway
Willingness of financial institutions to lend money for further land development	Not significant
Land values near project (i.e., within 1000 feet)	All yes
Land values in the remainder of the study area	Independent--localized--not significant
Tax base	Plus and minus will offset
Utilization of existing parks	Not related

APPENDIX D

Documentation of the Lowry Model

HIGHWAY LAND-USE FORECASTING MODEL

REFERENCE MANUAL

Alan J. Horowitz

Center for Urban Transportation Studies
University of Wisconsin -- Milwaukee

July 31, 1985

NOTICE

The software described in this manual and the manual itself are made available without warranties, either expressed or implied, with respect to their quality, performance, merchantability, or fitness for any particular purpose. This software and manual are made available "as is." In no event will the University of Wisconsin or its employees be liable for direct, indirect, incidental, or consequential damages resulting from any defect in the software or manual.

Portions of this program were compiled with TASC by Microsoft, Inc.

HLFM contains a high-speed operating system called Diversi-DOS (tm), which is licensed for use with HLFM only. To legally use Diversi-DOS with other programs, you may send $30 directly to: DSR Inc., 5848 Crampton Ct., Rockford, IL 61111. You will receive a Diversi-DOS utility disk with documentation.

ACKNOWLEDGEMENTS

The Highway Land-Use Forecasting Model was developed under a contract with the Wisconsin Department of Transportation. The contract was administered through the Transportation Policy Studies Institute of the University of Wisconsin -- Extension.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Welcome to the Highway Land-Use Forecasting Model. This program is designed to help you identify the likely developmental impacts on small urban areas owing to improvements in the highway system. HLFM draws its steps from traditional traffic theory and from urban economic theory. If you are already familiar with land-use and traffic forecasting, then you should find HLFM exceptionally easy to use. However, if land-use forecasting is new to you, then you should pay particular attention to this manual. In it you will find everything you need to know for generating a high quality forecast.

Land-use forecasting is not predicting the future. No one, even with the most powerful computer, can do that. All HLFM can do is to take available data and interpret it in a manner that shows the magnitude and location of impacts on population and employment, if almost everything else remains the same. We can only make transportation and urban development decisions on the basis of facts at hand. HLFM is a tool for improving those decisions.

HLFM produces a very long-term forecast. It tells us where city development is ultimately heading. Obviously, unanticipated events or attempts at mitigating impacts can redirect development along some other path. But, HLFM will let us know what is going to happen if nothing interferes with existing transportation and development processes. Because HLFM reveals fundamental trends, it can be used for medium-range planning, too.

Although HLFM runs on a small microcomputer, it is a sophisticated model. HLFM will produce very useful information if good common sense is exercised, and if care is taken when preparing the data and when performing the necessary calibration step.

Using HLFM

As you follow through the example problems, you will see that HLFM wants specific information from you. It is best to first assume that everything HLFM wants is necessary. As you become more familiar with land-use forecasting in your own city, you may be able to take shortcuts.

If you can remember when using a computer meant hours of coding and keypunching, you will find HLFM a pleasure. HLFM capitalizes on those features of the Apple II+/e/c that help remove the pain of giving the computer information. HLFM is made up of a sketch pad; on it, the highways being considered and their surrounding areas are drawn. In addition, several work sheets prompt you for required information; they then do the necessary calculations. Chapter 2 will show you how to use the various features of HLFM, and Chapter 3 talks about how HLFM can be used to analyze highway impacts. Chapter 4 explains the inner workings of HLFM. Although some of the discussion in Chapter 4 is highly technical, you are encouraged to read it -- so that you won't consider HLFM a mysterious black box.

System Requirements

To run HLFM you will need, at the minimum, an Apple II+/e/c with one disk drive. An Apple II+ requires a 16K RAM board. Drawing the network on the sketch pad is facilitated if game paddles or a mouse are installed. A joystick will do the same thing, but control is less precise. A color monitor (or a color television with an RF modulator) will make the sketch pad both more convenient and more enjoyable to look at over long periods of time. If a printer with dot addressable graphics (for example, the Epson FX-80) and a Grappler (or similar) graphics interface are available, then HLFM will print pictures of the network. A second disk drive will permit more convenient storage of data. If you can equip your Apple IIe with an extended 80 column card, then HLFM can greatly decrease its need to retrieve information from disk.

If you plan to use the Apple II+/e/c for more than just HLFM, then you should read one of the many introductions to the BASIC language. You need not know how to program in BASIC to use HLFM, but a little knowledge of how the computer works will make the whole process less intimidating. By the way, HLFM is written in Applesoft BASIC, but many portions have been converted to machine language and cannot be easily modified. This manual only discusses the features of the Apple II+/e/c that are essential for running HLFM.

Getting Started

HLFM normally uses only the first disk drive that is installed on the Apple II+/e/c. If there are two disk drives, start by using the one that is marked "1". If there are more than two disk drives, you must make sure you use the first drive that connects to "slot 6". If the disk drives are not properly marked, then you can either ask someone who knows or try HLFM in all the drives -- only one will work properly. When inserting the disk make sure that the Apple II+/e/c is turned off; the switch is in the rear of the Apple II+/e/c near the left corner. Open the little door and insert the disk into the drive, with the disk's label up and toward you. It should slide in with little force. If it shows some resistance, then check the drive for obstructions, such as another disk. After the disk is fully inserted, close the door. Turning the Apple II+/e/c on again will automatically load HLFM. When it is not in the computer, treat the disk with tender loving care. Always store it in the paper envelope. Don't "flex" it, "flop" it, expose it to magnetism or heat, or touch the brown surface.

After the Apple II+/e/c is switched on, the disk drive will run for a couple of seconds and the screen will display a title and a question about which part of HLFM you wish to access. Also listed is the default graphics input device (paddles, mouse, or keyboard). You can initiate HLFM with this graphics input device by hitting "H" and then <return>. The <return> button is a very important item. It tells HLFM to start processing the information that you have just typed on the screen. HLFM requires that the <return> button be pressed every time you have answered a question.

Entering "U" from this display will take you to a series of utilities for printing input data and results. They are discussed in Chapter 2. Entering "Q" will cause you to leave HLFM.

It is also possible to use a different graphics input device with HLFM, but HLFM must be properly reconfigured. Reconfiguration requires running programs that rewrite portions of HLFM. To do this, enter "M" (if you are converting to a mouse) or "P" (if you are converting to paddles) or "K" (if you are converting to keyboard). The disk drive will then run for about a minute, and HLFM will be restarted with the new option installed.

Once you have entered "H", a major portion of HLFM will be automatically loaded into the Apple II+/e/c. This process will take a few seconds. You will know that everything is working properly if the display shows a title and a very long question about previously created data files. At this point the computer is ready for you to start using HLFM.

It is a good idea to make a backup copy of the HLFM disk for yourself. To copy HLFM, use the program "COPYA", which is supplied on the "DOS 3.3 System Master" disk, or any other convenient disk copying utility.

If You Have Questions

If, after reading this manual, you still have questions about how HLFM operates or if you have problems getting HLFM to work properly, then you may get help by calling the Center for Urban Transportation Studies. Our phone number is (414)

963-5787. We are especially interested in hearing from you if you have used HLFM in a novel way or if you have suggestions on how HLFM can be improved.

CHAPTER 2

OPERATING THE HIGHWAY LAND-USE FORECASTING MODEL

HLFM is interactive. That is, it asks you questions, and you answer them. Sometimes it asks for a number, other times it asks for permission to take certain action. HLFM generally needs to know many things, so it's best to familiarize yourself with the types of questions it will ask before you start to forecast land-use in your city. In the following pages, the various features of HLFM are described. By following the step-by-step instructions you will get a good hands-on feel of how the program operates.

The Grand Tour

You can see most of the inner workings of HLFM by loading a simple example called "FINCHBURG". Follow the instructions in the "Getting Started" section of Chapter 1. If you have done this properly you should see that HLFM is asking you to "Enter file name or 'N' for new network, ...". At this point HLFM allows you to do a variety of things. Right now, however, just enter a test network. Type "FINCHBURG" and hit the <return> button. If you make a mistake, HLFM will tell you so and let you try again. (FINCHBURG is on the "Master" disk that should now be in drive 1. If this copy of HLFM has been used by someone else, then the default data drive could have been reset to "D2". If so, change the default to "D1" by entering a "1" before entering the file name.)

The display soon shows the sketch pad and a small highway network. The network is made up of red squares, called nodes, and lines, called links. The links can be thought of as streets and the nodes can be thought of as intersections. The purpose of the sketch pad is to allow you to draw your highway network, add to it, and delete from it. Working the sketch pad requires moving the four arrows in the margins of the sketch pad so that they point to different places on the screen. The arrows are used to locate nodes, connect the nodes with links, and to perform other functions that will be described later. The arrows can be moved by using the keyboard, mouse or paddles. If you have previously selected the paddle option, then the top and bottom arrows can be moved by turning the "0" paddle. The right and left arrows can be moved by turning the "1" paddle. With the mouse option, the arrows will move in response to movement of the mouse across a flat surface.

Moving the arrows with the keyboard is less convenient but usually more precise. With the keyboard option, it is best to imagine that the arrows point to an invisible dot on the screen. If you want the invisible dot to rise, press the "I" key (or up-arrow key). Pressing the "M" (or down-arrow) will lower the invisible dot. Pressing the "J" (or left-arrow) and "K" (or right-arrow) will move the invisible dot left and right, respectively. Holding the "rept" key down while pressing these letters on the Apple II+ will cause the arrows to move faster. On the Apple IIe/c fast movement can be achieved by simply holding down the appropriate key. Try not to hit any other keys while moving the arrows. When the sketch pad is first displayed, each press of a letter will move the arrows a fixed distance on the screen, i.e. 4 "pixels". A pixel is the width of a link. Pressing any number from "1" to "9" or ":" will change that distance (from 1 to 10 "pixels"). Pressing the "0" key does nothing. You can point to any spot on the sketch pad by pressing these numbers and letters or arrows.

On the right hand side of the screen is a strip of symbols. These symbols represent the sketch pad menu. They allow you to connect nodes (the vertical line), add nodes (the square), print the sketch pad ("1"), shift and rotate the network ("2"), delete nodes and links ("D"), initiate a new network ("N"), or continue to the next step in HLFM ("C"). You will have a chance to modify FINCHBURG in a few minutes. For now, move the arrows so that they point to the "C". Press the button on paddle "1" or the mouse button or <return> if you are using the keyboard option. If you have trouble moving the arrows all the way to the right using the keys, try reducing the spacing by first pressing "1".

At this point the network is redrawn without the menu and three of the four arrows. The paddles are of no use here; HLFM expects you to enter data at this stage. However, on this grand tour of HLFM you won't be entering anything, just viewing what is already there. The arrow is pointing to a link, and at the bottom of the screen is the request: "Enter 1-way (1), 2-way (2), reverse (R), continue (C), or skip <cr>". At this point HLFM needs to know if automobiles can run both ways or one-way on the street represented by that link.

All information about this link has already been given to HLFM, so you can move to the next link by simply hitting the <return> button. Continue to hit <return> until the arrow points to the right-most, vertical link on the screen. It looks different from all the others. The hash mark in the middle of the link indicates that it has been designated as being one-way. Also, one of the nodes connected to the link has a hash mark, too. This is the origin node for the link. That is, all automobiles traveling on this link leave that node, but do not come back.

At this time, enter "R" for "reverse". Notice that you have gone backwards to the previous link. Enter "R" a few more times to see what happens, then hit <return> several times until the arrow disappears.

You will notice that one of the nodes has turned a frosted blue from its original red color. If you are using a monochrome monitor, the node will look like a Roman numeral three. At the bottom of the screen, HLFM is requesting, "Enter network node (N), zonal centroid (Z), reverse (R), continue (C) or skip <cr>". Since all node information has already been given to HLFM, this node can be skipped. You can do that by simply hitting <return>. Hit <return> a few more times until HLFM asks you about the "service to total ratio". Notice that all the nodes turned from red to frosted blue to some other color. The nodes that are still red are "network nodes" or simply intersections. The nodes that are orange are "zonal centroids", which represent areas of the city.

If you need to change the service employees to total employees ratio, or the service employees to population ratio, or the automobile costs per minute, you could do it now. However, they have already been fixed, so hit <return> several more times until the display doesn't change any more. HLFM is now making a rather complicated request: "Enter modify (M), view (V), new (N), save (S), quit (Q), execute (E), reverse (R) or data (D)". At this stage it might be useful to see all the data that you have skipped when you hit <return>. Press "V" and hit <return> again.

An arrow reappears and the travel time for the first link is displayed. Continue to hit <return> until the arrow disappears and the display below the network becomes crowded with words and numbers.

The information below the display refers to the frosted blue node. Shown are the intrazonal travel time, the amount of land that could possibly be developed for residential use, the amount of land that could possibly be developed for service use, the basic employment, the ratio of population to employment, and the average cost (in cents) of taking an automobile to this place. These numbers were generated by a process that will be described later. You can continue to display the data for the remaining nodes by hitting <return> until the service to total ratio, the service to population ratio and the automobile costs per minute are shown. Hitting <return> once more gets you back to the question about modifying, viewing, saving, quitting, etc. This time you should enter "E" and then "C" to calculate the employment and population in each zone.

After the disk drive stops running, HLFM displays the "Model Parameter Page I" and says, "Enter choice or 'C' to continue or 'P' to see more parameters." It's not a good idea to tamper with the model parameters unless you are sure you know what you are doing. Any change made in model parameters becomes permanent. So for now, enter "C" and hit <return>. HLFM does its heavy calculations at this time. For the network you have been displaying the calculations take about 3 minutes. But a typical 150-node network takes about 30 minutes to finish. HLFM produces three summary answers: total population, total employment, and total service employment. Also displayed are average travel costs for various trip purposes. These travel costs are used for calibrating HLFM.

The population and employment estimates for each zone can be seen by entering a "V" and then a "C" when prompted for a line number at the "Land-Use Results Display". Only the centroids are shown. The numbers at the bottom of the screen refer to the node that is highlighted (or colored frosted blue). These numbers represent estimates of the population, employment, service employment and intrazonal trips for this zone. You can advance through the centroids by hitting <return> and you can go back to a previous centroid by hitting "R". Hitting "C" will terminate this step and return you to the summary page.

Link loads can be viewed by entering "L" and then a "C" when prompted for a line number on the "Link Load Display". When viewing each link, the "A" node turns frosted blue to differentiate the direction of the load. These link loads could be for a single hour or for the whole day, depending on the trip rates that have been entered on the Model Parameter Pages.

If you wish to take a break, now is a good time. Progress to the question about viewing, modifying, etc., by hitting <return> a few times. Then tell the computer that you do not want to try again by entering "Q". If you say "M", the whole process will start over.

Up to this point, you have seen only a small part of HLFM. However, some of the procedures that you went through apply to other parts of HLFM, as well. For instance, you can almost always ignore a question by simply hitting <return>. HLFM will take no action -- leaving everything as it was. Also, by entering "C" for continue, you will almost always progress to the next major step in HLFM. Again, HLFM takes no action about things that are skipped. Entering "C" is especially helpful when editing a few items in a particularly large network. HLFM will not accept a <return> or "C" in only one instance: entering the beginning node of a newly designated one-way link. The ability to skip questions permits both piecemeal data entry and quick modification of a previously defined network. By entering "R" at any point, HLFM reverses itself by one step. If you have overshot the data item you wanted to change, "R" will allow you to get back to it. (The big exception to these rules is the "five-function calculator" discussed later in this chapter; a <return> or a "C" or an "R" response will be interpreted as a zero.) With the "C", "R", and plain <return> you will be able to quickly edit data that has already been entered, as well as give HLFM new data.

Using the Sketch Pad

The sketch pad allows you to define, in a way HLFM can understand, how the roads are interconnected. As mentioned previously, a highway network can be represented by "nodes" and "links". A "node" can be thought of as a single important intersection. Ideally, every intersection should be explicitly shown, but this is impractical. Instead, nodes are usually separated by about 1/8 mile to 2 miles. Chapter 3 provides some guidance on how to effectively define nodes.

All nodes must connect to at least one "link". Links represent the streets in your city. A link must have a node at both ends. Together, nodes and links form a network that can be displayed and edited using the sketch pad.

In order to see how the sketch pad works, you should load HLFM in the manner described in Chapter 1. When HLFM asks for the name of a data file, just enter "N" to display a blank sketch pad.

The first step is to select an option from the menu. To do this, just point to the desired symbol with your arrows and press the button on the "1" paddle or press the mouse button or press <return>. Since you cannot add links to the network until nodes are first plotted, point the arrows at the square dot and press the button. You will know that you have done this correctly when the Apple makes a noise and a second square dot appears in the upper right corner of the screen. Move the arrows to a point in the work area and press the button. You have plotted your first node. Now plot a few more nodes at other places in the work area. You need not go back to the menu as long as you are only plotting nodes.

Now add some links. First, point your arrows at the vertical line (first symbol) and press the button. If you have done this correctly, the square dot in the upper right hand corner will change to a line. Then select one node to start the linking process. Point your arrows at it and press the button. It may take some practice to be able to consistently hit the node on the first try. If you have indeed hit the node, it will turn blue (on a color monitor) and it will chirp. This is now the first node in the link. Move the arrows to another node and again press the button. A line will appear between the two nodes, the first node will have regained its original color and the second node will have turned blue. The blue node is always the first node in the next link to be drawn. You can continue with this process until all the nodes have been connected. If you are not using a color monitor, you must keep a mental note of which node was last hit.

When using the keyboard to move the arrows, there is a faster way to enter the node plotting mode or link plotting mode. Pressing "H" will immediately place you into the node plotting mode. Pressing "L" will immediately place you into the link plotting mode. The other functions can only be reached from the menu.

If you have put enough nodes on the screen, connecting them in this fashion produces a drawing that more closely resembles a cat's cradle than a highway network. Usually, each street looks like a separate line, and all the nodes on each street are connected separately from nodes on other street. You can begin connecting up a new street by going back to the menu and reselecting the vertical line or by simply pressing "L". Then a new starting node can be chosen and the process repeated. There is one restriction: HLFM will not let you select the blue node to be the next starting node for a link. If you attempt to select a blue node as the first node in a sequence of links, HLFM will not respond. This restriction will probably cause some minor aggravation, but it is necessary to prevent the possibility of connecting a node with itself.

Nodes and links can be deleted by returning to the menu and selecting "D". After you have done this, point the arrows at one of your expendable nodes and press the button. The node and all of its connecting links disappear. HLFM has marked the node and links for deletion at the next time the network is saved. In effect, HLFM will forget that the node had ever existed (once the network is saved to disk). Deleting a node from a very large network can take a few seconds, so be patient. By using the three sketch pad functions discussed so far, it is possible to edit an existing network or develop a new one from scratch.

If your Apple II+/e/c has a Grappler (or similar) graphics printer interface, you can print a copy of the sketch pad. If you select the "1" from the sketch pad menu, the "Sketch Pad Options I" page will be displayed. Selecting a "1" from this menu will ask a "Grappler" graphics interface to print a small picture of the sketch pad. If you select the "2" from the menu, the resulting picture will be double size. You should not select either the "1" or "2" without having the proper hardware -- it may hang the system and you could lose some valuable data.

The third menu item on the "Sketch Pad Options I" page will tell HLFM to send a string of characters to the printer interface. The string of characters is of your choosing. It could be used to label drawings of the sketch pad produced by menu items "1" or "2", although that is not its intended purpose. Menu item "3" will allow other types of graphics interfaces to dump a picture of the sketch pad. Graphics interfaces usually require that a string of characters, starting with a "control I", be sent to it for a graphics dump to occur. An invisible "control I" is produced when the <control> key and the "I" key are pressed at the same time. Thus, when you are prompted for "something", enter the appropriate character string as specified by your graphics interface manual. (You may need to know that the sketch pad resides on high resolution graphics page 1.)

Apples have trouble accepting some special characters, especially the comma. If it is necessary to include one of the troublesome characters in the string that is sent to the printer interface, just enclose the string in quotation marks. The string will be faithfully (without the quotation marks) transmitted to the printer interface.

Networks need not be limited by the size of the sketch pad. It is possible to shift the network up, down, right or left, thereby opening new areas in which to draw. The sketch pad can be thought of as a window, with the drawing of the sketch pad being movable relative to that window. Networks can also be rotated through 90 degrees. Consequently, networks can be as large as necessary to maintain scale.

The shifting and rotating functions can be accessed by selecting "2" from the sketch pad menu. This action will display the "Sketch Pad Option II" page. There are six choices on this menu. The first choice will rotate the network counter-clockwise through 90 degrees. This choice can be repeated, so the network can assume four different orientations. The next four choices handle the shifting. After you have selected one of these choices, HLFM will prompt for a distance. The unit of distance is a pixel (the width of a link). The sketch pad is about 230 pixels wide by about 160 pixels high. Be careful when entering the distance. If you accidentally specify a large distance you could hide the network by shifting it completely off the screen, making it difficult to find again. After you have completed all necessary shifts and rotations, enter "C" to leave "Sketch Pad Options II" page.

A similar set of shifting and rotating functions is provided at the time that population and employment estimates at each zone are displayed.

There is a sixth item on the "Sketch Pad Options I" page that doesn't have anything to do with shifting. It is the "undelete" function. If this menu item is selected, the very last deleted node will be restored. (Remember, HLFM just marks nodes and links for deletion at the next time the network is saved, but HLFM doesn't actually destroy them.) Repeatedly exercising this function will restore every deleted node and link. Sometimes, a node is restored, but the display remains unchanged. This happens because the position of the deleted node had been previously shifted to outside the sketch pad. The restored node can be observed when the network is shifted back to the position that existed when the node was deleted.

Networks that HLFM saves do not contain deleted nodes. Consequently, it is not possible to restore nodes and links that were deleted in a previous session.

Obviously, HLFM cannot display nodes that are outside the boundaries of the sketch pad. Links that are cut by the edges of the sketch pad are not shown, either. However, nodes within the sketch pad that are attached to these cut links are colored white (or solid on a monochrome monitor). The white nodes make it easy to see which portions of the network have not been plotted.

Networks can be of nearly any size, but HLFM will function best if most of the important parts of the network can be displayed at one time. There is one limit that relates to the length of links: because of the way links must be plotted, their lengths cannot be bigger than the width of the sketch pad.

If at least one node is not displayed, a plus sign will appear in the upper, left corner of the sketch pad. HLFM also alerts you to the number of unplotted nodes and links when you continue from the sketch pad. HLFM does not give data prompts for nodes and links that are off the sketch pad. Therefore, it is essential that you be aware of what has not been plotted, so that nodes and links are not mistakenly skipped.

To erase the currently displayed network, select "N" (for "new") from the menu. This will take you to the question about data files. Entering an "N" will clear the sketch pad and allow you to draw a new network. If you had selected "N" from the sketch pad menu by mistake, don't despair. Entering "C" at the question about data files will take you back to the sketch pad with your old network intact.

To leave the sketch pad, select "C" (for "continue").

Careful placement of nodes and links can produce a better looking network, as well as one that is easier to edit. It is also useful if the network on the sketch pad looks somewhat like a map of your city and is roughly to scale. A scale map makes it much easier to enter data and to spot errors.

HLFM allows plotting of up to 200 nodes and 320 links. At most 40 of these nodes may be designated as centroids. Unfortunately, deleted nodes and links are counted in this total. However, deleted nodes and links are always cleaned from the network when it is saved. So if you need to use all 200 nodes but have deleted some, you should save your data and restart. This procedure frees the deleted nodes for further use. Three methods of saving your data are discussed later in this chapter.

If you are familiar with other highway forecasting procedures, you know that there is usually a limit on the number of links that can be connected to a single node. HLFM does not impose such a limitation.

Example Networks. Examples of real networks are found on the "Master" disk and on the "Utilities" disk. WAUSAU is on the "Master" disk residing in drive 1. Get to the questions about data files and enter "WAUSAU". (Of course, make sure that the default data drive has been set to "D1".)

Wait for the network to load. This network uses 193 nodes, about a fifth of which represent areas of the city; the others simply represent intersections. If you have a color monitor, the centroids can be better seen by continuing to the data input step ("C") and hitting <return> many times until all the nodes have changed to their final color.

WAUSAU would be a large network for an urban area of 60,000 people. You should avoid using all 200 nodes simply because they are available. Too much detail increases data preparation time and greatly slows the calculations, but may not help the accuracy of estimates.

Entering a Small Network

Defining a whole new network requires both the sketch pad and the subsequent data input step. You are now familiar with operation of the sketch pad, so this section will concentrate on giving HLFM your data. First you need a network to play with. Clear the sketch pad ("N" on the sketch pad menu and then "N" at the question about old files) and draw the simple network that is illustrated in Figure 2.1. You won't be able to label the nodes on the screen the way they are labeled in the figure; however, you will soon be designating nodes A, B, C and D to be network nodes and nodes E, F and G to be zonal centroids. Links 1 and 8 are centroid connectors and links 2 through 7 are regular streets. Once you are satisfied that the network looks correct, select "C" from the menu in order to continue to the next step.

At the data input step, you need to describe the nodes and links to HLFM. Your data for the links are:

Link 1 -- Direction is two-way.
Travel time equals 8 minutes.

Link 2 -- Direction is one-way, B to A.
Travel time equals 5.2 minutes.

Link 3 -- Direction is two-way.
Travel time equals 10 minutes.

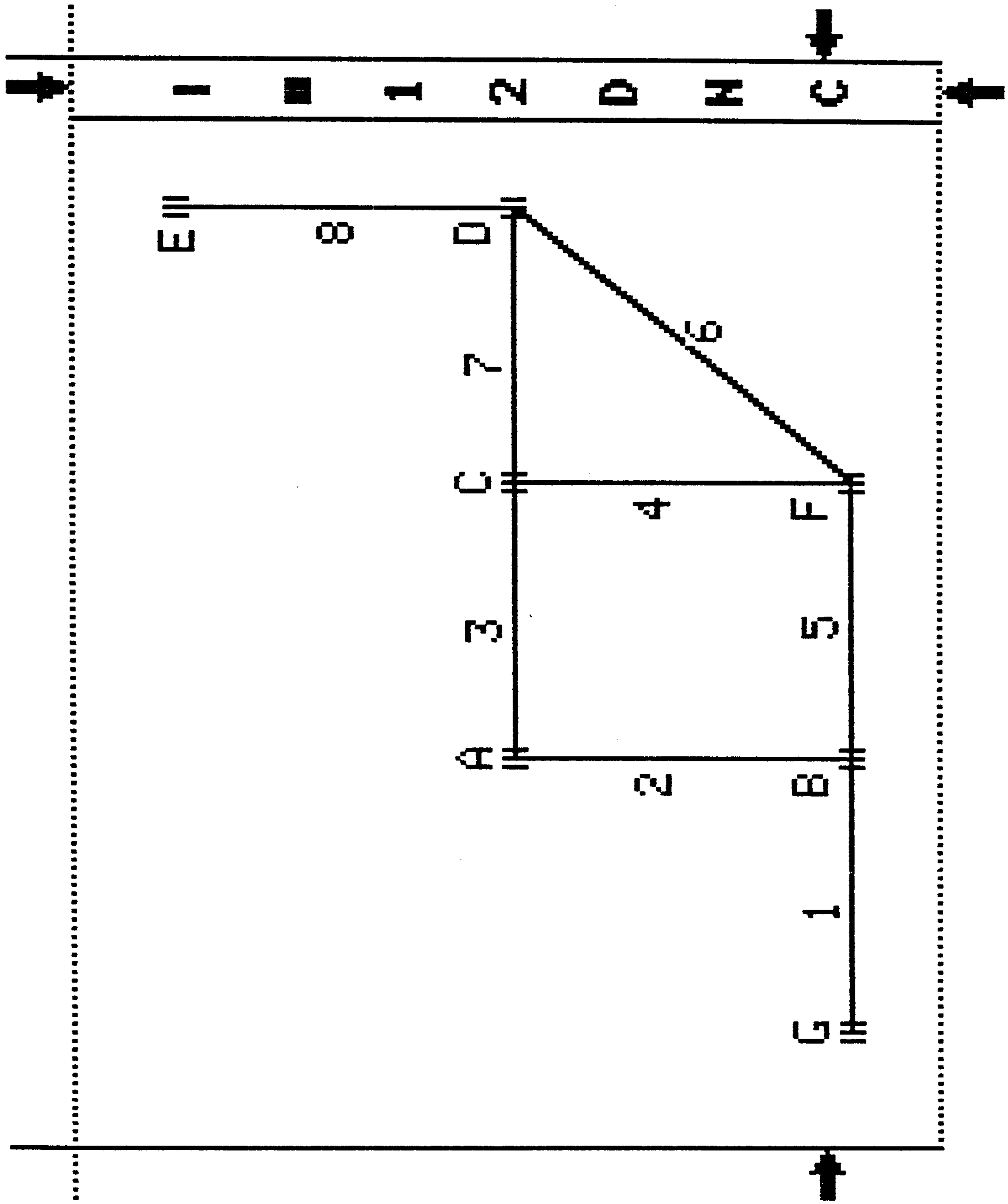

Figure 2.1. An Example Seven Node Network

Link 4 -- Direction is two-way.
Travel time equals 5.6 minutes.

Link 5 -- Direction is two-way.
Travel time equals 10.4 minutes.

Link 6 -- Direction is two-way.
Travel time equals 9 minutes.

Link 7 -- Direction is one-way, C to D.
Travel time equals 3 minutes.

Link 8 -- Direction is two-way.
Travel time equals 3.6 minutes.

Nodes A, B, C and D are network nodes and do not require data entry. Here are the data for the three centroids.

Node E -- Intrazonal time equals 3.5 minutes.
Population to employment ratio equals 2.3.
Basic employment equals 250 employees.
Net developable area equals 1.6 square miles.
Service developable area equals 1.6 square miles.
Automobile destination costs equals 0 cents.

Node F -- Intrazonal time equals 2.6 minutes.
Population to employment ratio equals 2.1.
Basic employment equals 720 employees.
Net developable area equals 1.2 square miles.
Service developable area equals 1.2 square miles.
Automobile destination costs equals 50 cents.

Node G -- Intrazonal time equals 3.1 minutes.
Population to employment ratio equals 2.4.
Basic employment equals 15 employees.
Net developable area equals 1.9 square miles.
Service developable area equals 0.9 square miles.
Automobile destination costs equals 0 cents.

The following whole network information should be entered.

Ratio of service employment to total employment equals 0.15.
Ratio of service employment to population equals 0.10.
Automobile costs per minute of travel equals 3 cents per minute.

One-way links may be specified by entering "1" for the link designation request. HLFM will respond by turning one node frosted blue and asking you if it is the origin node for the link. HLFM requires a yes "Y" or no "N" response to this question in order to fix the direction of travel. This is the only question in the data input step that HLFM won't let you skip by hitting <return>.

The order in which HLFM displays the links and nodes for data entry is the order in which they were originally created on the sketch pad. To be able to enter numerical data about links and nodes, the question about the type of link or node must be answered. Then you will be prompted for each piece of numerical data.

Enter the data by answering all the questions. Numbers can be entered as whole numbers (e. g., "134") or as decimal fractions (e. g., "-1.34") or in scientific notation (e. g., "1.34E3"). If you make a mistake; don't worry, you'll have a chance to correct it later. After you have finished, view the data to make sure you have entered it properly.

Changing the network is relatively easy. You can add nodes and links by drawing them on the sketch pad. Changing numbers is only slightly more difficult, if you keep in mind that hitting <return> without entering a number causes HLFM to advance, leaving everything as it was, while entering an "R" causes HLFM to back up one step. If you are changing link data, then you must answer at least the question about the link designation. Otherwise, HLFM will skip the link. If you are changing data for a node, then you must answer at least the question about the node designation. Otherwise, HLFM will skip the node.

It is often inconvenient to redesignate the links and nodes just so their numerical data can be edited. For this purpose it is easier to enter the wild card designation, "X". If an "X" is entered, the previous designation will be left as it was, and HLFM will let you change the numerical data. It is helpful to keep in mind the default data conditions for links and nodes. All numerical data is initially set to zero. Links are two-way. Nodes are network nodes.

After you have viewed your data, you can modify anything by entering "D" or "M" when HLFM gives you a chance. Entering an "M" will take you to the sketch pad. Entering a "D" will take you back to the first link for data input. Right now, change the basic employment for node "G" to 150, and fix anything else that may have been entered improperly.

When editing a large network, repeatedly hitting <return> to skip nodes and links can be slow and boring. There are two ways to speed up the process. First, holding the "rept" key down at the same time that the <return> key is pressed on the Apple II+ will speed things up considerably. Second, entering "C" anywhere will cause HLFM to continue to its next major step. The distance HLFM jumps when it encounters a "C" varies depending upon where it is at the time. For example, entering "C" at any link designation request will jump you to the first node designation request. Liberal use of both "C" and "R" will greatly speed editing of data.

Now execute the model by entering "E" at the end of the data input step. Don't modify the parameters. If your seven-node network has a population at node E of 2014, at node F of 1179 and at node G of 857, then all the data has been entered properly. If these are not the answers, there can be two reasons: someone might have previously changed the parameters or you might have made an error while typing the data.

Saving a Network

There are several reasons for saving a network. You may want to check your forecasts later, or you may want to slightly modify the network to see how population shifts, or you may be only partially finished defining the network and need to take a break. There are three ways to save the network that you are currently modifying. All of them involve the stage in HLFM that asks about viewing, modifying, saving your data, etc.

By entering "E" at this time, HLFM progresses to the calculation step, but first it gives you a chance to save your network. HLFM will prompt you for a file name. If you enter a "C" (for continue) at this prompt, HLFM assumes you are not interested in saving your data, but it temporarily stores the network in a file called "SCRATCH1". So, if you forget to formally save your data, all is not lost.

Entering "S" will allow you to save your data without continuing to the calculation step. Again, HLFM will prompt for a file name. But if a "C" is entered instead of a file name, nothing will be saved.

Entering "Q" will cause HLFM to terminate, but only after asking you for a file name. A "C" response to this prompt also will terminate the program without saving anything.

HLFM cleans deleted nodes and links from the network before it saves it to disk. This process can take one minute or more if several nodes have been deleted, so be patient.

Data may be stored on the same disk as HLFM. The disk has a fixed capacity, limiting storage to only a few networks. Therefore, it is good practice to clean up old files occasionally. There is a program on the "DOS 3.3 System Master" disk, called "FID", that is especially useful for file maintenance. It will allow you to delete any unwanted files, and it will let you move files to another disk.

There are a number of unlikely events that can make saving your data impossible. Some of these include: a disk that is full, an illegal file name, or a disk that is damaged. In these cases, HLFM will not let you save the network. HLFM will give you the option of trying to continue to the calculation step without formally saving the network. You may still be able to save it on another disk by following this simple procedure: when the error message appears, hit <return>. This will bring back the question about viewing, modifying, saving, etc. Before entering anything, insert a previously initialized disk into the disk drive. Then enter "S" or "Q". HLFM will save the network on the new disk and either terminate or come back to the question about viewing, modifying, saving, etc.

Using the Work Sheets

Several work sheets have been incorporated into HLFM to better handle many of the calculations. A work sheet is available anytime HLFM requests a number. The work sheets vary in complexity. Some work sheets just display a previously entered value and give you an opportunity to change it. Others perform mathematical procedures. Work sheets are easily found. By entering a "W" instead of a number, the work sheet will be displayed.

The next few paragraphs discuss the various work sheets. Reload "FINCHBURG" so that you can follow the discussion on the Apple. Continue to the data input step, and get ready to modify the first travel time by entering "X" for the request about the link designation.

Entering "W" instead of a number will display the "Auto Time Work Sheet". It is one of the more complicated work sheets. The current value of the travel time is displayed on line 4. This value can be changed by first entering "4" (hit <return>) and then entering the new value (hit <return>). The new value of the travel time replaces the old value on the display. Don't worry about the fact that you will be over-writing a formula that automatically appears.

This work sheet is designed to help you calculate travel time in minutes from the length of the link in miles and from the speed of the link in units of miles per hour. The first three lines of the work sheet are intended to facilitate this calculation. Line 1 has already been set to the number of minutes in an hour. You should enter the link length on line 2 and the speed on line 3. Then select line 4. An arithmetic expression will appear. To enter this expression, press the right-arrow key several times until the cursor is past the right side of the equation, and press <return>. The calculated travel time will be entered on line 4. If you fail to set either the speed or the link length before selecting line 4, the words "SPEED" or "MILES" could be imbedded in the arithmetic expression. If you completely replace these words, within the arithmetic expression, by numbers, the calculation will proceed normally.

Entering "C" advances HLFM to the next link. Entering an "R" has no effect.

The next nine work sheets aid data entry for nodes and for the whole network. They are similar in how they work, so only the first one will be described here. Advance to the first node designation question, enter "X", and then enter "W".

You should now be looking at the "Intrazonal Travel Time Work Sheet". It has two lines. You can directly change the intrazonal time by selecting line 2 and entering the correct number. Line 1 will allow you to enter that same number at every zonal centroid. You can invoke this option by selecting line 1, and then entering "Y". When you "continue" from the work sheet, all intrazonal times will be set the number that is currently on line 2.

Entering a "W" for either the node designation or link designation will cause HLFM to display designation pages. These pages are not work sheets, as there is nothing on them to change. Hitting any key will return you to the link designation request or the node designation request, depending on where you started.

The Five Function Calculator

It is permissible to use arithmetic expressions in place of numbers when entering data on the work sheets (and only on the work sheets). For instance, you could approximate the intrazonal travel time as a function of the gross area of the zone and an assumed travel speed. Arithmetic expressions can have up to 200 characters and can multiply (*), divide (/), add (+), subtract (-), and exponentiate (^). The calculator follows the BASIC rules for evaluating expressions. Exponentiation is always carried out first. Multiplication and division follow. Addition and subtraction are done last. Parentheses can be used to separate and combine terms. If the entered arithmetic expression has a syntax error (e. g., parentheses not balancing), a zero instead of the desired answer will be produced. So if an unexpected zero appears, check your expression and enter it again. All of the following expressions evaluate to 12.

```
4+8
3*4
100/5-8
(9-5)^.5*6
2*(4*(6-4)-2)
```

HLFM redefines the keyboard when in the calculator mode. Illegal characters cannot be entered. Shifting is not required to produce a "*", "+" or "^" on the Apple II+. Pressing an "A" will produce a "(" and pressing an "S" will produce a ")".

When a work sheet is first displayed, HLFM sets the variable "E" equal to the bottom line entry. This can be an especially useful feature when making constant multiple changes in data items. For example, to test the effect of a 10% reduction in basic employment at several zones, the new basic employment can be determined by entering "E*.9" for each bottom line.

The five-function calculator will not permit entry of a "C" or an "R". If the calculator is invoked by mistake, the bottom line entry may be destroyed. It can be restored by reselecting the bottom line and entering an "E" instead of an arithmetic expression.

One feature of HLFM, which can be invoked to give extraordinary power to the five-function calculator, is the definition and use of "keyboard macros". Any character on the Apple keyboard can be redefined to be any sequence of characters. For instance, the sequence of characters can be a previously defined arithmetic expression. These arithmetic expressions may contain any variable or parameter within HLFM. Keyboard macros are discussed later in this chapter.

Maintaining Data Files

HLFM has a number of features that facilitate file maintenance. These are available at the time HLFM requests the name of an old data file, just after loading or when "N" is selected from the sketch pad menu. It is possible to lock (protect the file from being over-written), unlock, and delete files. The catalog of a data disk can be displayed. And it is possible to tell HLFM to look for data on either disk drive of a two-drive system.

Drive Designation. HLFM normally looks for data on the HLFM disk that is in drive 1. This can be changed to drive 2 by entering a "2" instead of a file name. It can be changed back by entering a "1". The HLFM disk should always be in drive 1. HLFM remembers the data drive designation, and it expects to see data on this drive in all subsequent sessions (even if the computer has been turned off). A network may be moved from one disk to another by changing the drive designation once the data has been loaded into memory.

Catalog. Entering "CATALOG" instead of a file name will tell HLFM to list the files that are stored on the data disk. The amount of free space (in sectors) on the data disk will also be displayed. Hit <escape> to abort a long catalog listing.

Delete, Lock and Unlock. These functions will help you clean up old networks and protect the ones worth keeping. Locked files cannot be deleted. The syntax for these commands is illustrated by this example: "LOCK FINCHBURG".

File Naming Conventions. HLFM follows DOS 3.3 file naming conventions. Names must be shorter than 30 characters. They must start with a letter and they cannot contain commas.

Error Messages. If problems develop when saving or maintaining data files, HLFM will produce appropriate error messages. Some of them are self-explanatory. Others are referenced by number. The following list should help you determine the nature of the problem.

ERROR NUMBER	CAUSE
4	Disk is write protected, remove tab.
8	Read/write error, may be a damaged or uninitialized disk or the door may be open.
9	Disk full, use another disk.
10	File locked, use another file name or unlock it.
11	Syntax error, probably an illegal file name.

Wild Cards in File Names. It is possible to specify only the first part of a file name. If the rest of the file name is replaced by an "=", then HLFM will process the first file it encounters that matches the beginning of the file name. For example, entering "FIN=" will tell HLFM to load FINCHBURG, because it is the first file on the disk having the same beginning three letters. It is best to type enough of the name so that the request is unambiguous. The use of the "=" can be especially hazardous when deleting files.

A "?" may be specified instead of a "=". If this is done, then HLFM will prompt you for the file to be processed. When prompted, just hit the "Y" or the "N" to select the correct file. HLFM will not allow the use of the "?" when specifying the name of the file to be executed (e. g., at the "E" option at the end of the data input step.)

Space on Master Disk. About 130 sectors have been left as free space on the Master disk for scratch files. If you are using an Apple with only 64 Kbytes of memory, HLFM will want to create as many as four additional scratch files on the Master disk. These scratch files vary in size but can, at times, fully occupy this free space. If you have a 64K Apple, it is important to reserve this free space. There is still room on the Master disk for a few network files, but if the free space drops below 130 sectors, you should move unnecessary files to another disk. If disk space problems are going to develop, they will usually first become apparent during the calculation step. Fortunately, you would have already saved your network at this point. Just delete some network files and try again.

Keyboard Macros

A "macro" is a single keystroke that produces the effect of multiple keystrokes. Macros are user definable. For example, the "#" could be defined to be "FINCHBURG". Then each time the "#" is pressed, the character string, "FINCHBURG", will appear. Macros may be invoked anywhere within HLFM, except on the sketch pad. Any character may be defined as a macro and any character may appear in a macro string. Obviously, many characters should not be redefined as macros. All upper case letters are needed for either file names or HLFM commands, and all numbers and arithmetic operators are needed for data input. "Control M" is the same as a <return>; "control P" is the "insert mode" toggle; "control H" (also the left-arrow) is the backspace; "control U" (also the right-arrow) is the forward space; "control I" is the printer interface lead-in character; and "control S" is the printed output pause character. Most symbols are permissible (including <tab>, <delete>, and the up-arrow) as are all lower case characters and the remaining control characters (those invisible characters that are produced when <control> and a letter are pressed at the same time).

Macros can make data preparation a lot simpler. For example, if it were necessary to change the automobile time on many links, "X" <return> "W" <return> "4" <return> could be defined as "control W". Then, hitting "control W" at the link designation question would quickly display the "Auto Time Work Sheet" with the five-function calculator ready to accept a number.

A few macros have already been defined. "Control F" (for "fast") will produce five <returns> to advance through the data. "Control V" (for "very fast") will produce ten <returns>. "Control R" will produce five sets of "R" and <return>. "Control Q" will produce ten sets of "R" and <return>. And "Control C" will produce four sets of "C" and <return>. Try these macros at various places in the data input step to see what happens. Of course, any of them can be altered.

Macros may be defined at almost any place within HLFM, but it is best for several reasons to do it at the question about old data files. Hitting "control P" and then "control @" (i. e., hitting <shift>, <control> and "@" all at the same time) will put HLFM into the macro definition mode. The existing macros will be displayed. Any character typed immediately after a "control @" will become the next macro. Subsequent characters become the macro string. The macro string is terminated by typing another "control @". Hitting the left-arrow will erase a character. The macro definition mode is terminated by hitting "control P". Then hit <return> to restore the screen to its original condition. The new macro may be saved to disk by entering "M" (after leaving the macro definition mode, of course). The combined length of all macros and macro strings must be less than 256 characters.

Macros can considerably increase the power of the five-function calculator. Normally, the five-function calculator will accept only eighteen different characters from the keyboard; everything else is ignored. However, the five-function calculator will accept any character that is included in a macro string. Since all eighteen characters should be preserved as they are, it is usually necessary set up the macro so that it first invokes the five-function calculator and then issues the character string to be calculated. For example, assume that you want to test the effect of a 10% speed improvement on several links. You could define "control W" to be the following macro: "X" <return> "W" <return> "4" <return> "E*.9" <return> "C" <return>. Hitting "control W" at the link designation question would then cause HLFM to enter the "Auto Time Work Sheet", lower the existing time by 10%, and then advance to the next link. All this would occur in a fraction of a second.

The five-function calculator will accept variables and parameters, if they are generated by a macro. By using variables, it is possible to enhance or completely override the formulas that are at the basis of the work sheets. For example, it would be feasible to use the scale of the sketch pad to calculate automobile time as a function of the coordinates of the nodes at each end of the link. The screen length of each link has the variable name "SL", and is displayed above the first line in the "Auto Time Work Sheet". "SL" could be used instead of a number in any arithmetic expression. Assume that the network has been drawn at a scale of 20 pixels per mile and that the average speed of automobiles is 20 miles per hour. The following macro will calculate an approximate automobile travel time: "X" <return> "W" <return> "4" <return> "SL*.15" <return> "C" <return>.

Efficient use of macros requires some practice. You should try the examples that are described above on your seven-node network or on FINCHBURG. Then define a few of your own and see how they work. Macros can greatly reduce the tedium of data preparation on large networks.

Printer Utilities

Included with the HLFM "Master Disk" is a "Utility Disk". It contains the original source version of the calculation step and a few sample networks. It also contains four utility programs: a program for printing input data; a program for printing results; a program for printing a labeled drawing of the network; and a program for rescaling a network. These utility programs may be accessed from the very first menu that appears after HLFM is started. If "U" is chosen, then HLFM displays a menu of utilities. If one of the printer utilities is selected, HLFM prompts you to insert the "Utility Disk" into either drive 1 or drive 2 (whichever is most practical) and to enter the drive number. Then HLFM loads the selected utility.

The program for printing input data and the program for printing results operate similarly. First, the name of the file containing the appropriate data should be entered. Then, HLFM prompts for a comment to be printed at the beginning of the data listing. The listing may be made to an 80-column display in "slot 3" or to a printer attached to "slot 1". Nodes are referred to by an arbitrary, but unique, two-letter code. Links are referred to by the nodes at either end.

Results may only be printed from a file that has been explicitly saved. An option for saving the results in a file on your data disk is provided at the end of the calculation step. You may choose to save your results to a temporary scratch file at this time. When prompted for a file name, just enter "C" to continue. A file called "SCRATCH8" will be created on your current data disk. This scratch file may be printed by entering "D" (for default) when prompted for a file name in the results printer utility.

The utility for printing a picture of the network has been designed to work with a graphics printer and graphics printer interface. As in the case of printing a picture of the sketch pad, it is assumed that the interface is Grappler compatible. The "print something" option is also available. You also can "view" the screen image without printing it, or you can "put" (i.e., record) the image to a disk file for later processing.

Only the portion of the network that is displayed in the small window will be printed. This portion is doubled in size and has its nodes labeled before printing. All link segments within this window are accurately reproduced. By repeatedly moving the network relative to this window, a complete drawing of the network can be created. A labeled drawing of the network is essential for understanding the printed results.

The utility for rescaling the network is most useful for producing different sized drawings. Excessive use of this utility should be avoided, because repeated rounding of node coordinates can eventually destroy your network. When the original file name is entered, HLFM prompts for the rescaled file name and the rescaling factor, and asks whether the rescaling should be horizontal, vertical or both.

Install Feature

It is possible to have HLFM modify itself for specialized or advanced applications. Modifications can be performed by entering an "I" at the title screen, right after HLFM is started. In response, HLFM will prompt for an "install" file name that contains the modifications. After the modification is completed, HLFM is restarted.

The writing of an install file requires considerable knowledge of the inner workings of HLFM. However, two install files are provided on the Master disk, FORMULAS and ORIGINAL. Installing FORMULAS will change the Travel Time and Intrazonal Time Work Sheets. The Travel Time Work Sheet will subsequently calculate link times using the FHWA capacity restraint formula. The Intrazonal Time Work Sheet will subsequently approximate intrazonal time as a function of gross area of zones. Installing ORIGINAL will restore HLFM back to its original condition.

HLFM now supports three different graphics input devices. Each graphics input device has an associated text file, having the structure of an install file, on the Master disk. These files are MOUSE, PADDLES, and KEY. It is possible to modify one or more of these files, using a text editor, to support other graphics input devices. This new install file should be placed on the Master disk.

Play Time

Now that you a familiar with how HLFM functions, you should try using it for a few minutes. FINCHBURG is a good test network because it's small. Change something and recalculate population and employment distribution. Change the automobile times on several links, or redistribute basic employment or increase parking charges in the CBD. The effect on population of one of your changes should be intuitively correct. Continue to change different parts of FINCHBURG until you are comfortable with the way HLFM works.

What's Missing

The only portions of HLFM that haven't been discussed are the parameter pages. If you do not intend to customize HLFM to your city, then you now have all the information you need. However, the parameter pages are the heart of HLFM, with the accuracy of forecasts depending upon how well the parameters are selected. Unfortunately, deriving new values for many of the parameters requires more effort than many people are willing to spend. But with some time and care, it is possible to adjust the parameters provided with HLFM so that it will produce consistently better forecasts. More will be said about the parameter pages in the next chapter.

CHAPTER 3

DEVELOPING NETWORKS FOR THE HIGHWAY LAND-USE FORECASTING MODEL

As seen in Chapter 2, HLFM requires an abstract representation of the city. Streets must be shown as links, intersections shown as nodes, and areas of the city shown as centroids. Each zone of the city is described in terms of land area available for various types of development, the ratio of population to employment, the intrazonal travel time, the amount of basic employment, and monetary costs of taking an automobile there. All inputs to HLFM must be developed by a unified procedure that is discussed in this chapter. Also discussed in this chapter are the meanings of many of the parameters and the implications of changing them.

Network Nodes, Centroids and Links

Networks for HLFM have only two types of elements: nodes and links. Nodes can be as complicated as "centroids" in order to represent characteristics of an area of a city, or nodes can simply be intersections. Of course, centroids can be intersections, too. Links can be either two-way or one-way. (If you are wondering, HLFM does not make special provision for "centroid connectors" that are found in many other transportation models. If a centroid needs to be connected to the rest of the network, a regular two-way link should be used instead.)

It is not difficult to produce a complete HLFM network, but the task can be time consuming. Therefore, it is a good idea to assemble all necessary materials before a single node is plotted on the sketch pad. This practice will help eliminate the possibility having to make a major revision of the network at a later time.

The construction of an HLFM network is more of an art than a science. Enough detail has to be included so that the results are sufficiently accurate, but too much detail can greatly increase the time it takes to prepare the data and to run the model. Furthermore, too much detail can unreasonably suggest that the model can reliably forecast impacts on very small parcels of land. This manual can provide general guidelines, but you should be willing to vary the procedures to suit your particular application and data.

<u>Defining Zones</u>. HLFM gives you considerable latitude in how

you define your zones. Consequently, it is possible to draw the zones so that their boundaries correspond to those of U.S. Census tracts or to traffic analysis zones (TAZs) of more traditional transportation studies. It is also possible to vary the size of zones to fit your application. Zones can be as small as a quarter square mile and as large as 10 square miles.

Before drawing the HLFM zone system, you should get maps of the highway network and maps of any other zones that you wish to respect. It is usually easiest to overlay zone boundaries on the highway network map, because zone boundaries typically follow major streets. The normal situation in small cities is that Census tracts are too large to be HLFM zones and TAZs are too small. Thus, it is necessary to subdivide Census tracts and to aggregate TAZs. If your city is like most of the rest of the world, you will soon discover that it is not possible to produce HLFM zones that are compatible with both Census tracts and TAZs.

When developing TAZs, transportation planners size their zones so that the number of "trip ends" are roughly constant. TAZs are smaller in areas of high activity (e.g., the central business district, CBD) and larger in areas of low activity (e.g., urban fringe areas). This, too, is a good procedure for sizing HLFM zones, but there are other considerations. First, zones should be smallest in places where the impact is expected to be the largest. Because HLFM can work with zones that vary greatly in size (e.g., by a factor of 40) it is possible to use HLFM for corridor analysis or small-area analysis within some rather large cities. Second, try to center each zone on a major intersection. The node representing the intersection can then do double duty as a zonal centroid. Third, when subdividing Census tracts and TAZs, avoid splitting Census block groups. This is not an especially difficult task, because block group boundaries run along nearly every street in a city. Fourth, avoid using major arterials, particularly those with substantial retail or other commercial activity, for zone boundaries. It is far easier to interpret results if major commercial areas are not split between two or more zones. Fifth, observe HLFM's limit of 40 zones.

Zonal centroids, exactly one for each zone, should be located near the center of each zone. Preferably, centroids should be at major intersections. If a centroid cannot be located on an intersection, you should try to put it somewhere else on a major street. As a last resort, a centroid can be located in a open area. In this case, a single two-way link (acting as a centroid connector) is necessary to attach the centroid to the rest of the network.

Draw your zone map in a manner that can be easily reproduced. During data preparation, you will find it useful to have several clear copies.

Representing Streets as Links. The primary purpose of the highway network is to permit accurate determination of the most efficient travel times from any zone to any other zone. Streets that detract from this purpose, particularly locals and collectors, should not be included in the network. Even some major arterials can be discarded if it is clear that they will never be on a shortest path between any pair of centroids. A drawing of the remaining streets in the network should be produced at the same scale as the zone map.

Nodes should be drawn at all intersections. Every road segment between two nodes is a link. There may be at most 320 links (less the number reserved for centroid connectors); and there may be at most 200 nodes (less the number of centroids that were not placed at intersections). Check to make sure that the number of nodes and number of links fall within these limits. Then add the centroids and centroid connectors to the network drawing. You may want to assign temporary identifiers to the links and nodes to aid data preparation; however, once the network is entered into the computer, HLFM will assign its own designations to the nodes and links.

Before drawing the network on the sketch pad, some thought should be given to the scale of the drawing and the order in which the nodes and links are to be entered. Select the smallest scale that looks good on the sketch pad. The minimum convenient spacing between nodes is eight pixels (two key-presses at the default spacing under the keyboard option). Define blocks of the network that should be plotted as a single unit. It is most convenient if the blocks are rectangular, about 200 pixels wide and 140 pixels high.

When plotting the network on the sketch pad, enter all the nodes of a block before entering any links. The order in which the nodes and links are plotted is not critical, but it is best to develop some personally satisfying procedure. A haphazard ordering can be quite inconvenient, even frustrating, when entering data and retrieving results. Separately complete each block; then tie the blocks together with links, as necessary. Save the network to disk.

If you have a graphics printer and the appropriate interface card (or graphics software), then use the network printing utility to produce a complete picture of the network. Check to see that everything has been correctly plotted. You should not attempt to enter numerical data until satisfied that the drawing of the network is final.

Determining Automobile Times

The only piece of numerical data for links is travel time. It may be determined in many different ways (e.g., floating car techniques, capacity-restraint formulas, comparisons with streets of similar characteristics). It is assumed here that you already know the length of each link. The only real problem is determining the average speed. This average speed must include all traffic delays, because HLFM does not provide for delays due to signals, stop signs, or turning movements at intersections.

One method of determining average speeds is to sample several links of each type; then drive them, record the time and distance traveled, and calculate average speed. (Traffic engineers prefer to calculate average speed by dividing the total distance by the total travel time.) The variety of link types need not be large. Links should be selected from a few different road capacities (e.g., two-lane arterial, four-lane arterial, freeway) and from a few different parts of the city (e.g., CBD, remaining fully developed areas, fringe areas). Additionally, any links that will be affected by the highway project and any links that are known to be particularly congested should be individually timed. If possible, links should be driven during the evening peak hour.

A second method involves determination of "free speed" for each link. The free speed is the speed at which a single car would travel if it were the only car on the road. Free speeds can be converted to estimated "actual" speeds by using the FHWA capacity-restraint formula. The FHWA capacity-restraint formula computes actual speeds from the free speed, the volume, and the design capacity of the road. The design capacity is less than the ultimate capacity; the design capacity most closely corresponds to the "service volume" at level of service B as defined in the 1965 <u>Highway Capacity Manual</u>. A more practical definition of design capacity is the amount of volume that would degrade speed by 15% from the free speed. The FHWA capacity-restraint formula is not presented here, but it is included in the "install" file, called FORMULAS. Installing FORMULAS converts the Travel Time Work Sheet into the FHWA capacity-restraint formula (see Chapter 2).

Free speeds are determined in much the same way as actual average speeds. Links of several types are sampled. Then they are driven during a period of time when traffic is very light, but the signalization is identical to the evening peak hour. For most cities, a good time for ascertaining free speeds is the mid-evening period (e.g., 8:00 to 10:00 p.m.)

The use of the FHWA capacity-restraint formula requires more work than determining links times directly from actual speeds. However, this formula can be quite helpful when determining additional traffic delays that might occur because of shifts in development. When the project is so large that major impacts are expected or when substantial growth in population is expected, the predicted volumes should be used to recalculate link times. If the link times change appreciably, then HLFM should be run again, with the new link times substituted for the old.

Zonal Centroid Data

Each zone requires six pieces of data: Intrazonal Time; Population to Employment Ratio; Basic Employment; Net Developable Area; Service Developable Area; and Automobile Destination Costs. The following paragraphs explain each of these data items.

Intrazonal Time. Trip times between different centroids are calculated by tracing the shortest path across the network, but HLFM cannot automatically determine times for trips that occur entirely within a single zone. An intrazonal time depends upon the size of zone and on the average speed of traffic within that zone. One method of approximating intrazonal times is to assume that the zone is square and that the length of an average intrazonal trip is one-half the length of a side. This trip length can be divided by the average speed to yield intrazonal trip time. If FORMULAS is installed, the Intrazonal Time Work Sheet facilitates this calculation.

Population to Employment Ratio. The Population to Employment Ratio can be easily calculated from Census data. Since the ratio varies little from zone to zone, it is usually sufficient to calculate it for whole Census tracts and then enter the same number for all zones within each tract. The "employment" part of this ratio requires further clarification. It is the number of full-time equivalent employees in the zone of residence (not the workplace). The ratio is related to family size, typically being larger in suburban areas and smaller near the core of the city.

Basic Employment. Basic Employment is the number of employees (at the workplace) that cannot move in response to improvements in a highway. Basic employees generally work for firms that sell their products to persons or other firms that are outside the study area. Manufacturers and some service industries (e.g., insurance company headquarters) distribute their products to geographically large markets -- so all their employees would be considered to be basic employees. Some other service industries (e.g., grocery stores and restaurants) can be classified as being strictly nonbasic. Inconveniently, there are service industries that sell their products both to local markets and to markets outside of the urban area (e.g., hospitals, banks, and large department stores). The employees in these service industries must be split between basic and nonbasic categories. The fraction of service employees that can be classified as being basic varies from city to city.

A simple example will help clarify how to split services into basic and nonbasic categories. Finchburg has a population of 30,000, and it is the county seat of Foghorn county. Foghorn county has a population of 90,000. There are 300 hospital beds in Foghorn county, 250 of them in the city of Finchburg. Here is how to allocate hospital employees as basic and nonbasic. In Foghorn county, there are 300 people per hospital bed. If hospital bed usage is constant across the county, then the people of Finchburg only use 100 beds. The remaining 150 beds in Finchburg are serving other parts of the county. So for every 10 hospital employees, four are classified as basic and 6 are classified as nonbasic.

Net Developable Area. Net Developable Area is the amount of land that is currently being used or could possibly be used for residential development. The way in which Net Developable Area is calculated depends on the assumed strength of zoning or farmland preservation regulations, the degree of local access, and the availability of sewer and water service. However, net developable area definitely excludes areas that are covered by water, marshes, environmentally sensitive areas, quarries, present and former landfills, parks and other public lands, institutionally held property, industrial parks, and land currently occupied by basic industries. Net Developable Area can be expressed in any units of area, but these units must be compatible with those used in the Service Employee per Area Parameter.

Service Developable Area. Service Developable Area is the amount of land that is currently devoted to local services (i.e., nonbasic businesses) or could possible be developed for local services. All of the exclusions for Net Developable Area apply to Service Developable Area. In addition, land should be excluded that does not have direct access to a major arterial street. Service Developable may be expressed in any units of area.

Automobile Destination Costs. These costs, such as parking charges and tolls, are associated with taking a car to a specific location. HLFM deals with only one-way trips. Consequently, costs associated with a complete round trip must be divided in half. For example, parking in Finchburg's CBD costs 10 cents per hour. The average time people spend in the CBD is 4 hours, so the total parking cost for a round trip is 40 cents. Therefore, the Automobile Destination Costs are one-half of 40 cents, i.e., 20 cents. The units of Automobile Destination Costs are cents.

Whole Urban Area Data

Three pieces of data relate to the whole urban area. Two of these are "base multipliers": the Ratio of Service Employees to Total Employees and the Ratio of Service Employees to Population. The third data item is Automobile Costs per Minute of Travel.

Base Multipliers. The two base multipliers, Ratio of Service Employees to Total Employees and the Ratio of Service Employees to Population, should be calculated by a consistent procedure. "Service employees", as used here, requires further definition. These employees are nonbasic; in other words, they sell their services only to local customers. The "service employees" in the Ratio of Service Employees to Total Employees include only those employees that serve businesses (e.g., accountants, advertising agents, workers in industrial laundries). The "service employees" in the Ratio of Service Employees to Population include only those employees that serve people (e.g., grocery store checkers, gas station attendants, doctors, criminal lawyers). Of course, employees who are in ambiguous trades must be split among the the two types of services. Figure 3.1 is an example of how Census data are used to determine the base multipliers for Finchburg.

Automobile Costs per Minute. Automobile Costs per Minute are typically gasoline costs. These costs have units of cents/minute.

Meanings of Parameters

HLFM has several parameters which control the operation of the model and help determine the distribution of activities across zones. A list of parameters and initial values, as supplied with HLFM, is shown on Table 3.1.

Trip Distribution Parameters. Three of the parameters (Residential Location, Residence Serving, and Employee Serving) control the density of activities in the city. In general, the forecasted city will be denser if the parameters are small and it will more spread out if the parameters are large. Results are most sensitive to the Residential Location Parameter and are least sensitive to the Employee Serving Parameter. There is an intrinsic relationship between the magnitude of these parameters and the average length of trips. This relationship provides a means of quickly calibrating HLFM. Calibration is discussed later in this Chapter. A rule of thumb can be used to determine if the three trip distribution parameters are approximately correct. For most cities, the trip distribution parameters will be slightly larger than the reciprocal of the average trip length, expressed in minutes.

Service Area per Employee. HLFM can be directed to reduce

FINCHBURG:
Total Population = 30,000

Industrial Category	Total	Employment Basic	Employment People	Employment Businesses
Agriculture, mining	100	100	0	0
Construction	600	50	250	300
Manufacturing	3900	3900	0	0
Transportation	550	50	150	350
Utilities	400	40	180	180
Wholesale trade	500	0	0	500
Food stores	450	0	450	0
Restaurants	700	100	500	100
General Retail	450	150	200	100
Auto sales & service	300	50	200	50
Other Retail	700	200	400	100
Banking	100	20	40	40
FIRE	250	50	100	100
Repair	450	100	100	250
Private household	100	0	100	0
Other personal	350	0	350	0
Entertainment	100	20	80	0
Hospital	700	420	280	0
Other health	400	200	200	0
Education	900	200	700	0
Welfare, Nonprofit	300	150	150	0
Professional	200	50	50	100
Public Administration	600	300	300	0
Totals	13100	6150	4780	2170

Ratio of Service Empl. to Total Empl. = 2170/13100 = 0.166
Ratio of Service Empl. to Population = 4780/30000 = 0.159

Figure 3.1. Example of a Base Multiplier Calculation

Table 3.1
Initial Values of Parameters

Parameter	Value
Residential Location	Ø.163 per minute
Employee Serving	Ø.17Ø per minute
Residence Serving	Ø.17Ø per minute
Service Area per Employee	Ø.ØØØ4 square mile
Value of Time	8 cents/minute
Work to Home Trip Rate	Ø.36 trips/employee
Home to Work Trip Rate	Ø.Ø4 trips/employee
Home to Service Trip Rate	Ø.18 trips/person
Service to Home Trip Rate	Ø.18 trips/person
Work to Service Trip Rate	Ø trips/employee
Service to Work Trip Rate	Ø trips/employee
Adjust Service Attractions?	Yes
Adjust Residential Attractions?	Yes
Scratch Slot	3
Central Tendency	3

the amount of land available in a zone for residential development in order to account for the amount of land taken up by service development. The amount of land deducted from Net Developable Area depends upon the number of service employees in a zone and the Service Area per Employee Parameter. The Service Area per Employee Parameter can be calculated by dividing the total amount of land used for services by the total number of service employees. The units of area should be the same as the units used for Net Developable Area. This adjustment in land area will occur only if the Adjust Residential Attraction Parameter is set to "Y", and the Maximum Iterations Parameter is set to a number greater than 1.

Value of Time. The Value of Time Parameter allows HLFM to simultaneously consider both the time and monetary costs of trips. Numerous research studies have shown that the value of time for commuting trips is about half the wage rate. The Value of Time Parameter has units of cents/minute.

Central Tendency. The Central Tendency Parameter controls the amount of concentration of services. A large value of this parameter (e.g., 4.0 or more) will cause services to be concentrated in the more central areas of the city. A zero value will spread services roughly in proportion to market sizes (population and employment). The Central Tendency Parameter will have no effect on forecasts unless the Adjust Service Attraction Parameter is set to "Y". It is essential, when invoking the Central Tendency Parameter, to run the model through at least two iterations. The Central Tendency Parameter may be determined by a calibration procedure discussed later in this Chapter.

Trip Rates. Trip rates are used to estimate the volume of traffic on the roads in the city. In themselves, they do affect the distribution of employment and population. The trip rates can be set so that the volumes are for a single hour or for a whole day or for any other convenient period of time. A single peak hour is preferred, so that points of congestion can be readily spotted. There are six trip rates: one each for the work-to-home and reverse trip; one each for the home-to-service and reverse trip; and one each for the work-to-service and reverse trip.

The work-to-home and work-to-service (and reverse) trip rates are the average number of automobile driver trips of this purpose that an employee makes during the particular period of time. The home-to-shop (and reverse) trip rate is the average number of automobile driver trips of this type that a person makes during the particular period of time. Some examples will clarify how these parameters are calculated. Consider a city with the following characteristics: number of employees equals 18,000; number of work trips by automobile drivers made each day equals 16,000; fraction of work-to-home trips made during the evening peak hour is 0.36; and the fraction of home-to-work trips made during the evening peak hour is 0.04. The work-to-home trip rate for the evening peak hour is, therefore, 0.32 trips/employee (0.36 trips/trips x 16,000 automobile driver trips / 18,000 employees). Similarly, the home-to-work trip rate for the evening peak hour is 0.03556 trips/employee (0.04 trips/trips x 16,000 automobile driver trips/employee x 18,000 employees). This same city has 40,000 people who make a total of 64,000 automobile driver, home-to-service (includes shopping, personal business, school, and recreation) trips and a similar number of service-to-home trips. It is found that 10% of both trip types are made during the evening peak hour, so both trip rates equal 0.16 trips/person (0.1 trips/trips x 64,000 automobile driver trips / 40,000 persons).

It is sometimes desirable to use the predicted volumes to determine which roads will be particularly congested. If the predicted volumes are to be reasonably accurate, all trip purposes must somehow be shoehorned into the six trip rates.

Maximum Iterations. The number of iterations is controlled by the Maximum Iteration Parameter. Normally, the model should be run through only one iteration. However, a minimum of two iterations are required if adjustments are to be made in either net developable area (to account for land taken up by services) or service developable area (to account for agglomeration). Experience has shown that three iterations are sufficient for small urban areas.

Scratch Slot. This parameter has meaning only if you are running HLFM on an Apple with 128 Kbytes of memory. During the calculation step, HLFM needs to create three large scratch files. One file contains the "back node" table, and two other files contain various results. When the Scratch Slot is "3", these scratch files are stored in the computer's memory. When the Scratch Slot is "6", scratch files are stored on the Master disk. You should only change the Scratch Slot to "6", if you need to save the back node table for other purposes.

Brute Force Calibration and Sensitivity Analysis

It is good practice, when using any mathematical model, to check if possible errors in parameters will significantly affect estimates. Such a check is called "sensitivity analysis." With sensitivity analysis, a single parameter is varied by a fixed percentage (e. g., 10%) and the percentage change in the estimate is noted. The "sensitivity" is the percentage change in the estimate divided by the percentage change in the parameter. HLFM facilitates sensitivity analysis by allowing the calculation step to be rerun without having to go back to the sketch pad or data input step. When HLFM completes its calculation, it asks if you want to try again. Entering "P" displays "Model Parameter Page I". Any parameter can then be changed, and HLFM again forecasts population and employment when you continue from the page. You should note that HLFM saves some intermediate results as it calculates, so subsequent computations will go faster.

As you become more familiar with HLFM, you may find that the default parameters are not sufficiently accurate for your city. They can be easily changed, but shouldn't be without some basis. It is possible to refine the parameters (calibrate the model) by repeatedly running the program. To do this you will need to have a network prepared for a base year. It is also helpful if you have base-year population, total employment and service employment for each zone and the average trip time for each major trip purpose. It is preferable that recent home interview survey data be used to determine the average trip times. Otherwise, they can be approximated. For instance, average work-to-home times are compiled by the U.S. Census, and average trip times from other trip purposes may be transferred from other cities of similar size and geography.

Three of the parameters are called "trip distribution parameters" (Residential Location, Residence Serving, and Employee Serving). They control how concentrated the forecasted city will be. These parameters are set so that the average aggregate trip costs (both time and money) as determined by the model agrees with the base-year data. Determining the base-year average aggregate trip costs requires only a small amount of hand calculation.

An aggregate average trips cost, as reported on the Results Summary Page, is a sum of two terms: (1) average over-the-network driving time; and (2) average monetary costs, converted to units of time. This conversion of monetary costs to time units is performed by dividing them by the Value of Time Parameter. The following is an example of how aggregate average trip costs may be calculated for the base year. Surveys invariably ask respondents for door-to-door time. This door-to-door time contains, what is called, "excess time" or the amount of time spent walking to the car and pulling out to the street. Excess time must be subtracted from door-to-door time to get over-the-network time. In Finchburg the Census has reported that home-to-work time was 12 minutes in 1980. Excess time averages about 2 minutes at each end of the trip. Consequently, over-the-network time is 8 minutes (12 minutes - 2 minutes - 2 minutes = 8 minutes). Gasoline costs in Finchburg are 3 cents/minute and the value of time is 8 cents/minute. The average gasoline cost for a trip is 24 cents (8 minutes x 3 cents/minute). This is equivalent to 3 minutes of travel (24 cents / 8 cents/minute). There are not significant destination costs in Finchburg, so the aggregate average trip cost is 11 minutes (8 minutes + 3 minutes).

The three average aggregate trip costs that are reported on the Results Summary Page (work-to-home, home-to-service, and work-to-service) correspond, respectively, to the first three parameters on Model Parameter Page I (Residential Location, Residence Serving, and Employee Serving). For instance, a 10% increase in the Residential Parameter will produce about a 10% decrease in the work-to-home average aggregate trip cost. This inverse relationship also holds for the other two sets of costs and parameters. Consequently, the trip distribution parameters can be systematically varied until the average aggregate trips costs are correct for the base-year. It is not necessary to determine the parameters to more than three significant digits (e.g., 0.163), so the model needs to be run only a few times for calibration purposes.

One other parameter that could require some attention is Central Tendency. This parameter controls how must agglomeration (i.e., the tendency for businesses to locate near each other) will occur in the service sector. The Central Tendency parameter should be set so that the density of service activities, as predicted by the model, corresponds to actuality. A good measure of density is the ratio of service employment to Service Developable Area. It is typical that this ratio will be larger near the center of the city and smaller near the outskirts. You should start with a Central Tendency Parameter of zero, and then increase it gradually until the model is showing the same pattern of service density. Scatter diagrams (i.e., a graphs where the actual values are plotted on the X axis and the predicted values are plotted on the Y axis) are helpful in determining where to stop. When the Central Tendency Parameter is properly selected, the points on the scatter diagram should approximate a 45 degree line, passing through the origin.

Land-use models predict equilibrium conditions for a city, but it is unlikely that your base-year data represents an equilibrium situation. Cities are always changing -- moving to another stage of development. Consequently, it would be surprising if any land-use model accurately predicted the base-year case. Instead, we would expect the model to over-estimate the amount of development in zones that are growing and to under-estimate the amount of development in zones that are declining. These differences between actual and estimated levels of development can be quite pronounced if the city has recently undergone a major change in its transportation system or a major change in its land-use policy. It is imperative that you resist the temptation to change the base-year data (particularly, the two developable areas) so that you can get an exact match between actual and estimated levels of development. Otherwise, you could build a substantial amount of error into your forecasts. It is simply not appropriate to "calibrate" your data.

Parameters should only be modified when data is available to verify that the modification is reasonable. HLFM can produce accurate forecasts at selected zones in the base year using a complete set of false parameters. Then problems will develop when the bad parameters are used to forecast population and employment for a future year. The laws of statistics state that there must be many more pieces of base-year data than parameters to be determined. Unless your base year population and employment data are dependable, limit calibration to the trip distribution parameters using average trip times from similar cities.

CHAPTER 4

INSIDE THE HIGHWAY LAND-USE FORECASTING MODEL

HLFM is built around the the Lowry-Garin land-use model (Lowry, 1964; Garin, 1966). Essentially, the Lowry-Garin model predicts the amount of employment and the amount of population in each zone that is within an urban area. To do this, the model requires information about the highway system, information about demographic and socioeconomic characteristics of the population, and information about existing and proposed land uses. HLFM extends the Lowry-Garin model by permitting constraints on the total amount of land that may be allocated to various activities and by allowing for the possibility for agglomeration in services. HLFM also enables the planner to maintain consistency between projected land use and the volume of traffic that occurs on the streets in the city.

HLFM is designed to produce a forecast that is consistent with the original description of the physical transportation network. Operationally, this means that congestion (and travel delays) that are predicted by the model should be fully represented in the forecast. This condition will not be satisfied when the initial travel times for the streets in the network are chosen arbitrarily. Instead, an iterative procedure (shown in Figure 4.1) is required to modify initial travel times until this condition holds. This iterative procedure is called an "equilibrium land-use model".

In an equilibrium land-use model, like HLFM, network characteristics and land use characteristics are specified by the planner. The model first calculates time and cost of travel between all pairs of zones on the basis of only the given network description. Then spatial distributions of population and employment are calculated using trip distribution equations and the Lowry-Garin model. These population and employment distributions are used by HLFM to predict travel patterns in the urban area, which includes traffic volumes on each street. The planner can then observe where congestion has developed, recalculate travel times for those particular streets, and rerun the Lowry-Garin model. When the travel patterns are unchanged over two successive iterations, the planner can terminate the procedure.

The allocation phase of the equilibrium model in Figure 4.1 is expanded in Figure 4.2. Three trip distribution equations (work-to-home, home-to-service, and work-to-service) are used to

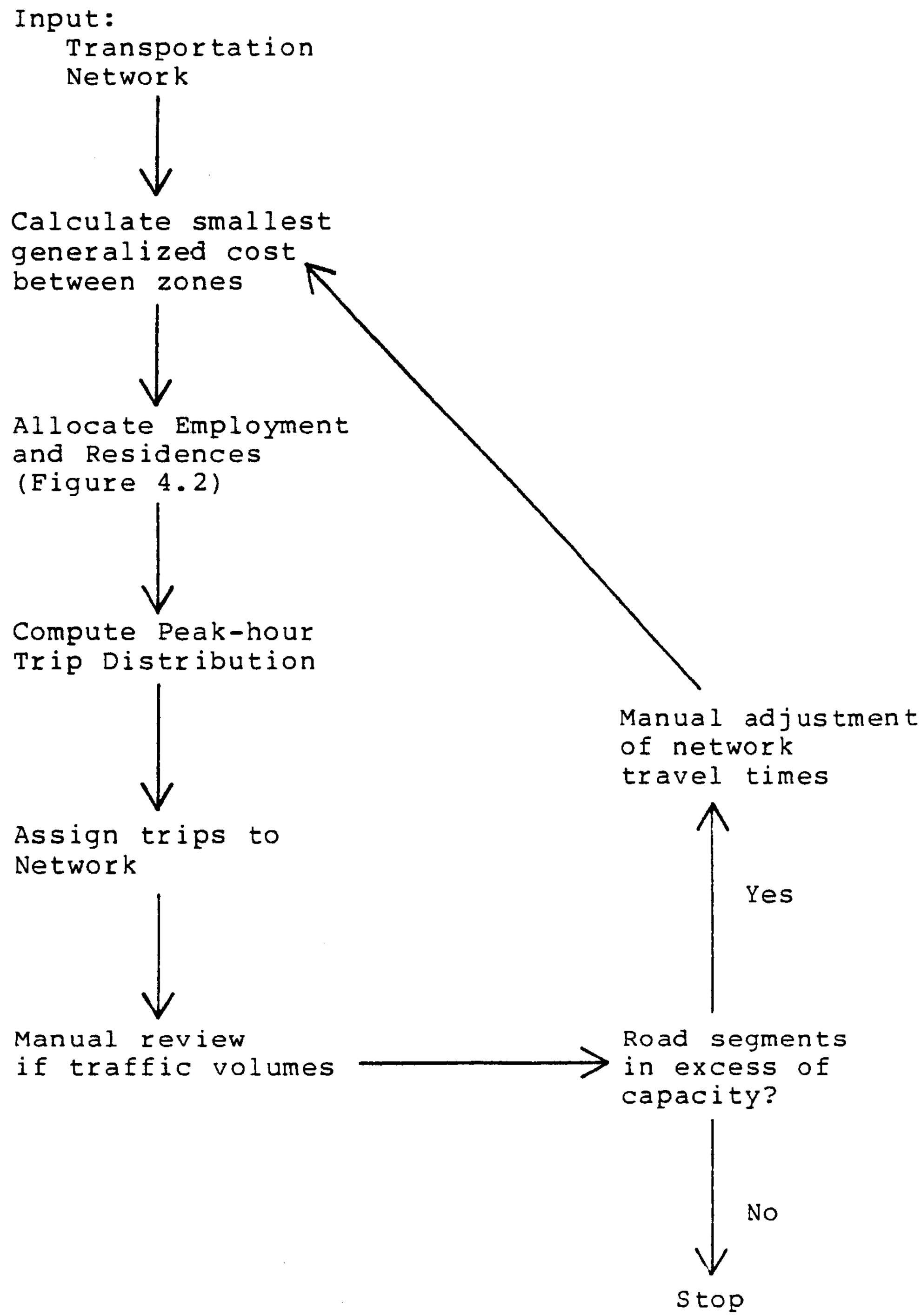

Figure 4.1. Major Steps in the Use of HLFM as an Equilibrium Land Use Model

construct the employment conservation equation that is at the heart of the Lowry-Garin model. This employment conservation equation, derived later in this chapter, is solved for the spatial distribution of total employment. Once the spatial distribution of total employment has been found, then the spatial distribution of population can be calculated from the same work-to-home trip distribution equation.

Garin Version of the Lowry Model

The Garin version of the Lowry model is a series of matrix equations that forecasts the distribution of population and employment in an urban area. The Lowry-Garin model recognizes only four land-use activities: residential, basic industries, service industries for population and service industries for businesses. Basic industries (i.e., industries that receive their income from outside the urban area) are assumed to be fixed at known locations. The Lowry-Garin model attempts to maintain proximity of workers' residences to their workplaces and to maintain proximity of service industries to their respective markets (either residences or other business, depending on the type of service activities).

The Lowry-Garin model is derived here by constructing an employment conservation equation. Let E be a vector of total employment (each element, e_i, of E being the total employment of the ith zone), E_B be a vector of basic employment, E_R be a vector of service employment required by residences, and E_W be a vector of service employment required by workers (i.e., businesses). Total employment is thus the sum of its three components:

$$E = E_B + E_R + E_W \quad . \qquad (4.1)$$

Each of the three vectors on the right hand side of Equation 1 represent the spatial distribution of a sector of employment in the urban area. Basic employment, E_B, is the only exogenous variable in the Lowry-Garin model. Employment serving residences, E_R, and employment serving workers, E_W, are dependent upon trip making patterns, the transportation system, and existing land use. Essentially, Equation 1 states the obvious condition that total employment in each zone must be equal to the sum of that zone's employment over all sectors.

Employment in industries that serve workers, E_W, is calculated by distributing service employees around all employment locations as given by the vector E. Define h_{ij} as the conditional probability that an employee in zone j is served by another employee in zone i. Denote this matrix of conditional probabilities as H. Also define f as the number of service employees required for each employee, averaged across the whole

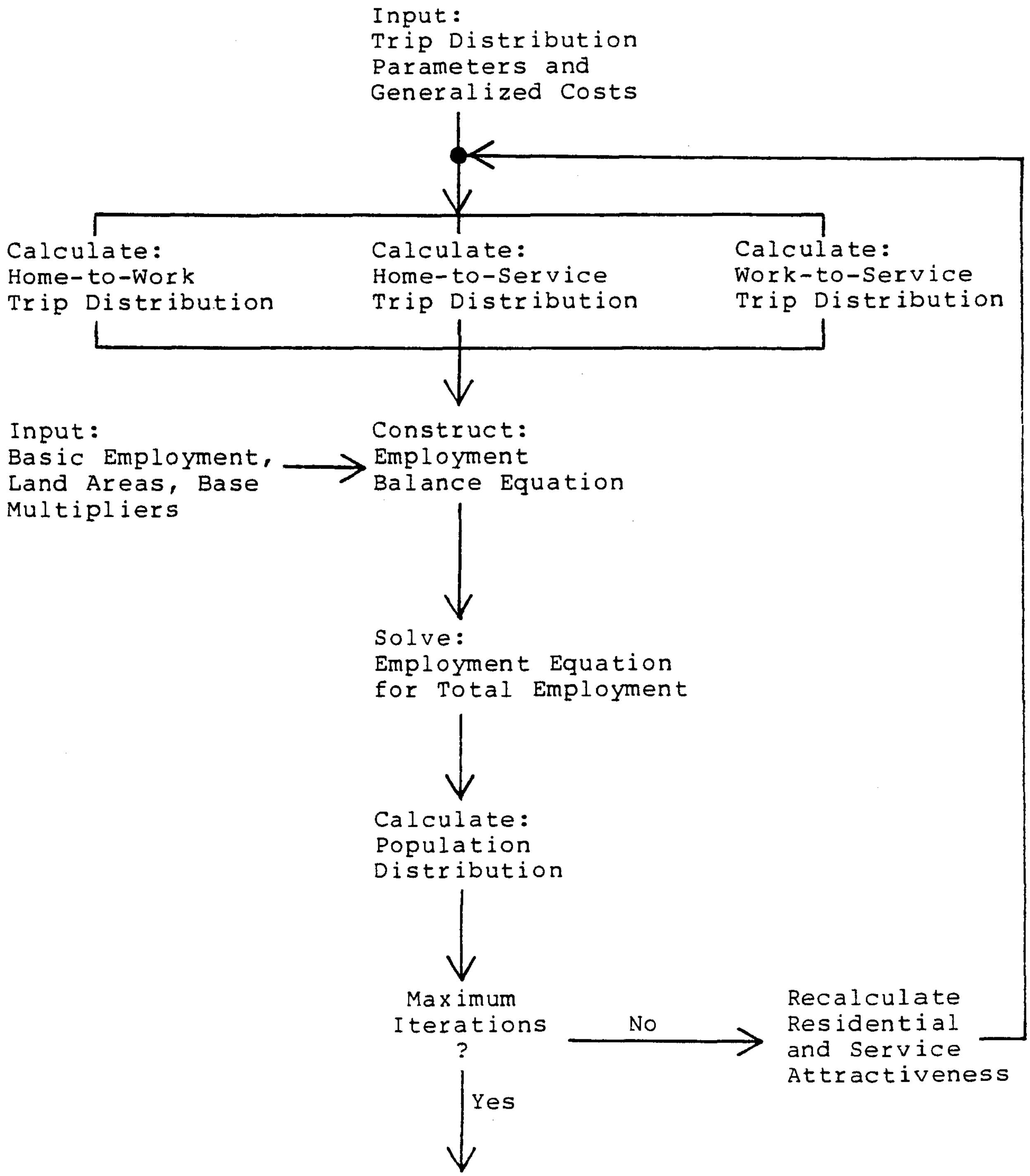

Figure 4.2. Allocation of Employment and Residences

urban area. The matrix H is used to distribute service employees to zones according to the location of total employment. That is,

$$E_W = f\ H\ E \quad . \qquad (4.2)$$

A similar relation can be constructed for employees serving the entire population. Define b_{ij} as the conditional probability that an individual who lives in j is served by an employee in i. This conditional probability matrix is B. Also define g as the number of employees that serve each individual, averaged across the whole urban area. Then, as in Equation 2,

$$E_R = g\ B\ P \quad , \qquad (4.3)$$

where P is the population vector, containing elements, p_i, each of which is the population in zone i.

Population distribution is computed from total employment. Define a_{ij} as the conditional probability that an individual working in j lives in i. Let A be the matrix of these conditional probabilities. Also define q_i as the ratio of population to employees in residential zone i. Furthermore, let

$$Q = [K_{ij}\ q_i] \quad , \qquad (4.4)$$

where K_{ij} is the Kronecker delta. That is,

$$K_{ij} = 1 \text{ if } i = j \quad ,$$

or

$$K_{ij} = 0 \text{ if } i \neq j \quad .$$

Note that Q is a diagonal matrix. Populations of all the zones are found from:

$$P = A\ Q\ E \quad . \qquad (4.5)$$

Consequently, from Equations 3 and 5,

$$E_R = g\ B\ A\ Q\ E \quad . \qquad (4.6)$$

Substituting Equations 2, 3, and 6 into Equation 1 reduces the employment conservation equation to one with terms for only total employment, E, and, basic employment E_B, i.e.,

$$E = E_B + g\ B\ A\ Q\ E + f\ H\ E \quad . \tag{4.7}$$

Equation 7 can be solved for the spatial distribution of total employment, E, in terms of basic employment. Specifically,

$$E = (I - g\ B\ A\ Q - f\ H)^{-1} E_B \quad . \tag{4.8}$$

The spatial distribution of population can be computed from Equation 5, and the spatial distributions of employment in the two service sectors, E_W and E_R, are directly computed from Equations 2 and 6.

The base multipliers (g, f and q_i) should be prepared by the planner from existing data sources. The three conditional probability matrices (A, B and H) are computed from trip distribution equations that are discussed in the next section.

Trip Distribution

The trip distribution equation most often encountered in recent literature and the one used in HLFM has an exponential deterrence function. Specifically for work-to-home trips, the A matrix can be found by

$$a_{ij} = w_i \exp\{-u^a c_{ij}\} \Big/ \sum_i w_i \exp\{-u^a c_{ij}\} \quad , \tag{4.9}$$

where c_{ij} is the generalized cost of travel between zones i and j, w_i is the "attractiveness" for residential zone i, and u^a is the work-to-home parameter. HLFM uses net developable area for w_i. This trip distribution equation implies that modal choice decisions do not enter into the location process, and c_{ij} can apply to all travelers regardless of chosen mode.

The generalized cost of travel is computed as if trips followed the shortest path between pairs of zones in the urban area. That is,

$$c_{ij} = (1 + y / v)\ t_{ij} + d_j / v \quad , \tag{4.10}$$

where t_{ij} is the shortest travel time, y is the cost per minute, v is the value of time parameter, and d_j is the automobile destination cost.

An efficient calibration technique has been developed for the case where all constants of the generalized cost function are known -- as is the normal situation with HLFM (I. Williams, 1976; Hyman, 1969; Hathaway, 1975; and Evans, 1971). The maximum likelihood estimate of u^a (or, in fact, any trip distribution parameter) satisfies the condition that predicted average cost of travel over all trips, $c(u^a)$, equals observed average cost of travel, c*:

$$c(u^a) = c^* \quad . \qquad (4.11)$$

Here the computed generalized cost of travel is shown as a function of u^a. HLFM calculates $c(u^a)$ each time it is run. So if the planner has independent knowledge of c*, the average network generalized cost, then HLFM can be used to calibrate itself.

The B and H matrices for home-to-service and work-to-service trips, respectively, in the Lowry-Garin model are constructed similarly to the A matrix. Again, singly constrained trip distribution models of the exponential type are used. Generalized cost functions are constructed for trips to each service sector; and service attractiveness, s_i, is used in place of the residential attractiveness, w_i. Again, mode distinctions are ignored, resulting in two equations:

$$b_{ij} = s_i \exp\{-u^b c_{ij}\} \Big/ \sum_i s_i \exp\{-u^b c_{ij}\} \ , \qquad (4.12)$$

and

$$h_{ij} = s_i \exp\{-u^h c_{ij}\} \Big/ \sum_i s_i \exp\{-u^h c_{ij}\} \ . \qquad (4.13)$$

In these equations u^b is the home-to-service parameter and u^h is the work-to-service parameter. The service attractiveness, s_i, should be chosen to reflect the size of the ith zone. The data input step of HLFM requests that s_i be the "nonbasic developable area"; or, in other words, the total amount of land in a zone, less land that is either unusable for development or devoted to basic industry.

Adjustments to Residential Attractiveness

Land area does not formally appear in either the Lowry-Garin model or in the trip distribution equations. Nonetheless, land area has been introduced into HLFM by making residential attractiveness, w_i, equal to net developable area and by making service attractiveness, s_i, equal to service developable area. The trip distribution equations will assign activities to zones roughly in proportion to these developable areas. If, for instance, it is found that HLFM is assigning too much population to a given zone, the population can be reduced on subsequent runs by decreasing net developable area.

One reason why activities can be over-assigned to a zone is that the Lowry-Garin model disregards land capacity. If a zone is almost fully occupied by service activities, then only a few people should be able to live there. But the Lowry-Garin model will assign people to the zone as if the service activity did not exist at all.

HLFM can be instructed to reduce residential trip attractiveness in response to large allocations of service employees to a zone. This is an iterative procedure as indicated in Figure 4.2. In order to use this feature three parameters must be changed. The "adjust residential attractiveness?" question must be answered "Y"; "maximum iterations" must be set to a number greater than 1; and "service/area per employee" must be set to a number greater than zero. When HLFM is run, the residential attractiveness on iteration n (after the first iteration) are based on the amount of service allocated at iteration n - 1. Specifically,

$$W^n = W^1 - z\ (E_R^{n-1} + E_W^{n-1}) \quad , \qquad (4.14)$$

where

W^n = the vector of residential attractiveness at iteration n;

W^1 = the vector of residential attractiveness at the first iteration as specified in the data input step;

z = service area/employee;

E_R^{n-1} = the vector of the number of employees that serve residences as calculated on iteration n-1; and

E_W^{n-1} = the vector of the number of employees that serve other employees as calculated in iteration n-1.

Residential attractiveness at any iteration, W^n, is constrained to be greater than or equal to zero. This procedure for adjusting residential attractiveness effectively incorporates the notion of land capacity into the forecasts.

Adjustments to Service Attractiveness

Even in small cities, significant agglomeration in the service sector can occur. The Lowry-Garin model does not provide for agglomeration even though Lowry did recognize that certain zones would attain high levels of service activities. The original Lowry model permitted the planner to set the minimum amount of service employment that could occur in a zone.

HLFM handles agglomeration by making upward adjustments of service attractiveness from those set by the planner. The underlying assumption in HLFM is as follows: agglomeration will occur in zones which have the highest potential to attract a disproportionately large share of customers. These zones will tend to be central to the region or near large concentrations of population. A minimum of two iterations of HLFM are required -- the first iteration establishes the "potential" and the second iteration actually distributes the home-to-service and work-to-service trips according to this potential. The measure of potential is continually updated as the number of iterations is increased.

Here is a summary of how each iteration is handled.

Iteration 1:

a. Guess the population in each zone for the first iteration as a multiple of basic employment in the same zone using this equation:

$$p_i^1 = e_{Bi} \; [q_i \; / \; (1 - q_i \; g - f)] \quad , \qquad (4.15)$$

where e_{Bi} is the basic employment in zone i.

b. Run the Lowry-Garin model using service developable area, S^1, as specified by the planner for the measure of service attractiveness. At the same time calculate service potential, M^1:

$$M^1 = g \; B^1 P^1 \quad . \qquad (4.16)$$

Notice that M^1 would have been the same as E_R if P^1 had been gotten from the Lowry model instead by just guessing it through Equation 15. Calculate a new population vector, P^2, in the normal way with Equation 5.

c. Recalculate the measure of service attractiveness, s_i^2, for the second iteration.)

$$s_i^2 = s_i^2 \ (m_i^1 \ / \ s_i^1)^k \qquad , \qquad (4.17)$$

where k is the central tendency parameter. Then continue to the next iteration.

Subsequent iterations:

a. Estimate service potential, M, while the Lowry-Garin model is being run

$$M^n = g \ B^1 P^n \qquad , \qquad (4.18)$$

where P^n had been calculated on the previous iteration and B^1 is from the first iteration.

b. Recalculate service attractiveness,

$$s_i^{n+1} = s_i^1 \ (m_i^n \ / \ s_i^1)^k \qquad . \qquad (4.19)$$

For this procedure to work well, the term $(m_i^n \ / \ s_i^1)$ should be a measure of concentration, so s_i^1 should be a measure of the size of the zone. It can be seen from Equation 19 that when k equals zero the results will be identical to the case of no agglomeration. As k is increased, service employment will increase in the more central zones and decrease in outlying zones. A large value of k can force HLFM to forecast that all service employment will be located in a single zone.

Traffic Assignment

Traffic is loaded on the network using all-or-nothing assignment. There are a total of six trip purposes, and the amount of traffic is governed by the six corresponding trip rate parameters. The number of work-to-home trips between zones i and j are found from:

$$T_{ij}^{wh} = r^{wh} \ e_i \ a_{ij} \qquad , \qquad (4.20)$$

where r^{wh} is the work-to-home trip rate parameter. For the reverse trip:

$$T^{hw}_{ji} = r^{hw} e_i a_{ij} \quad , \qquad (4.21)$$

where r^{hw} is the home-to-work trip rate parameter. Similarly, the home-to-service trips can be found from:

$$T^{hs}_{ji} = r^{hs} p_i b_{ij} \quad , \qquad (4.22)$$

and the service-to-home trips are found from:

$$T^{sh}_{ji} = r^{sh} p_i b_{ij} \quad , \qquad (4.23)$$

where r^{hs} is the home-to-service trip rate and r^{sh} is the service-to-home trip rate. Finally, work-to-service trips are computed by:

$$T^{ws}_{ij} = r^{ws} e_i h_{ij} \quad , \qquad (4.24)$$

and service-to-work trips are computed by:

$$T^{sw}_{ji} = r^{sw} e_i h_{ij} \quad , \qquad (4.25)$$

where r^{ws} is the work-to-service trip rate and r^{sw} is the service-to-work trip rate.

It should be noted that the work-to-home, the work-to-service, and the corresponding reverse trip rates are based upon total employment in zones. The home-to-service and service-to-home trip rates are based upon population in zones.

Other Computational Considerations

Computation Time. If you are dealing with a large network, be prepared to wait a few minutes for HLFM's ridership estimates. You may estimate computation time for the first iteration in minutes by the following formula:

$$\text{Computation time} = 0.03\ (\text{centroids})^2 \quad .$$

Calculations will take a little less time if there are relatively few network nodes. Expect calculation time to increase by as much as 5Ø percent for each iteration beyond the first.

Error Handling. HLFM is designed to check for many common errors. However, a particularly creative user can find ways to abort computation in the middle of the calculation step. The causes of most errors are improper specification of the network or improper setting of parameters.

During the sketch pad and data input steps, HLFM's usual response to an obvious error is to not do anything. If you find that HLFM is repeating a question, it is because it didn't like your previous answer. On the sketch pad HLFM will not let you plot the 2Ø1st node, it will not let you plot a node in the menu area, it will not let you select an already blue node as the starting node for a link, it will not let you continue from the sketch pad if nothing has been plotted, and it will not let you plot the 321st link. If the sketch pad is not responding in other situations, it is probably because you have missed with the arrows. In the data input step HLFM will not let you designate more than 4Ø centroids.

It is impossible for HLFM to check whether the data you have entered has been typed correctly. Therefore, you should be very careful when entering data and you should always view any new data you have entered. HLFM's response to erroneous data is an erroneous forecast of ridership.

For Further Reading

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APPENDIX E

Procedures for Completing the Detailed Checklist

PROCEDURES FOR COMPLETING
DETAILED CHECKLIST FOR SECONDARY LAND-USE
IMPACTS OF HIGHWAY PROJECTS

1. Summary description of the major secondary land-use impacts identified in this analysis.

2. Description of existing constraints on development.

[Identify areas that can not be readily developed because the areas are already fully developed, cannot be provided with water or sewer service, are unsuitable for construction (e.g., steep slopes, water coverage, high water tables, or environmentally unsound) or are restrained from development by action of governmental units.]

3.1. Spatial distribution of existing industrial activity.

* Obtain recent figures for industrial (manufacturing) employment at the city or county level.

  [Primary sources include: U.S. Bureau of the Census, Census of Population; City and County Data Book, 1982 (also available for 1972, 1977, and 1983); U.S. Department of Commerce, County Business Patterns; local city and county planning officials; and Wisconsin regional planning commissions. From this data, find the predominant trend in manufacturing employment over the past 5-10 years (increasing, stable, or decreasing).]

* Obtain projections of manufacturing employment at the city or county level from city, county, or regional planners. Discuss with planners the expected accuracy of these projections in relation to the trends you have identified.

* Identify existing areas zoned for industrial activity. Obtain land use and zoning maps from city and county planning officials. With planners, estimate the occupancy rates in industrial areas. Also find out if there are any new industrial zones planned for the next five to ten years.

* Identify the major industrial employers (with 200 or more employes), indicate their location on map.

3.2. Estimate how the proposed action will affect the spatial distribution of industrial activity.

[Estimate pre- and post-project accessibility (travel time) from the main industrial zones (and locations of major employers) to: (i) the most accessible highway interchange; (ii) key transportation facilities (rail,air, water); (iii) the major commercial districts; and (iv) the other main industrial zones. (See example for technique.)]

* Will the proposed action result in improved access to freeways or highways for industrial parks or other areas zoned for industrial use?

  [Identify which areas would benefit in terms of accessibility.]

* Does the project lead to improved accessibility for certain industrial zones to rail, port, or airport facilities?

  [Accessibility impacts determined as above.]

* Does the project lead to improved accessibility for certain industrial zones to distribution and warehouse facilities?

  [Accessibility impacts determined as above.]

* Does the project lead to improved accessibility for certain industrial zones to business services?

  [Accessibility impacts determined as above.]

* Is accessibility to certain industrial zones so greatly improved by the project that new industries are more likely to locate there?

  [In the event that employment trends and projections indicate increasing (or stable) employment, assume that new industries will locate in those unfilled industrial zones which have greatest accessibility to interstate highways, to business services, and other transportation facilities, in that order.]

* Is accessibility to certain industrial zones so greatly improved that existing industries are likely to transfer their plants to these industrial zones?

  [If the accessibility to interstate freeways or state highways (and business services and other transport facilities) is substantially improved, then it may be safe to assume (for the purposes of this analysis) that some proportion of existing industries may be likely to shift operations to these industrial areas over the next 5 years if these areas are not capacity contrained.]

* Are any new areas likely to be rezoned for industrial use because of this project?

  [Guestimate the need for new industrial space by evaluating the employment trends and projections in terms of the capacity utilization of existing industrial areas. Discuss your "guestimate" with appropriate city, county, and regional planning officials.]

4.1. <u>Describe the spatial distribution of existing commercial activity within 10 miles of the Project.</u>

* Obtain employment figures for wholesale, retail, and services industries.

  [Use sources and procedures identified in 2.1.]

* Obtain land use or zoning maps and identify areas zoned for commercial activities.

  [Obtain land use and zoning maps from city and county planning officials. With planners, estimate the occupancy rates in commercial centers. Also find out if there are any new shopping centers planned for the next five to ten years.]

* Identify areas with commercial activity of greatest density.

4.2. <u>Estimate how the proposed action will affect the spatial distribution of commercial activity.</u>

  [Estimate the difference in pre- and post-project accessibility (travel time) from the main commercial centers to: (i) the most accessible highway interchange; and (ii) travel time distances of 10, 20, and 30 minutes driving time. (See case study for technique.)]

* Will the proposed action create additional traffic and therefore improve consumer visibility and accessibility for certain commercial zones?

  [What are before and after traffic counts along streets passing through or next to major commercial zones?]

* Will the project increase the commercial trade area? How many more consumers will be within 25-30 minutes travel time distance from major commercial centers as a result of this project?

[Compare the before and after travel time accessibility contours along major arterials from major commercial areas. If the trade area population increases by more than 5-10 percent, then the project is likely to contribute to increased commercial activity. If existing shopping centers are close to capacity, then the project may create the demand for a new shopping center.]

* Are there any regional or superregional shopping centers (400,000 sq. ft. or more of gross leasable area (GLA)) within 10 miles of the project?

* What percentage of total GLA at regional shopping center is currently being leased (i.e., is there excess space at existing shopping centers)?

[For this information, contact shopping center management groups and commercial real estate brokers.]

* Will the proposed action improve consumer accessibility to a major highway intersection or interchange -- that would likely generate new or additional commercial activity at the interchange?

[Compare before and after project traffic counts. If estimated after Project traffic counts are higher by more than 20 percent, and if existing shopping centers are at or near full capacity, and if sites at the interchange are zoned commercial (or could be zoned commercial because water and sewerage is available), then the project may generate new commercial activity.]

* Will the proposed action improve accessibility to major outlying commercial areas at the expense of the central business district (CBD)?

[Compare the before and after project traffic counts.]

5.1. Describe briefly the spatial distribution of existing residential location in any urbanized area within 10 miles of the Project.

* Obtain population data and identify recent and projected growth trends.

* Obtain land-use and zoning maps to determine areas zoned for residential activity; contact city hall to see if any major changes in residential zoning are anticipated.

* Obtain data on existing and projected future residential densities.

5.2. Estimate how the proposed action will affect the spatial distribution of residential location.

* Evaluate the magnitude of Project impacts on the location of industrial and commercial activity.

[If the location of major employers is likely to shift in response to the Project, then it is likely that shifts in residential location will follow.]

* Estimate the project impact on travel time accessibility for residential activity.

[Use the procedures for estimating pre- and post-project travel time accessibility between the major residential areas and major employment centers; assess the magnitude of reductions in travel times on the possibility of residential development due to the project.]

* Evaluate the likelihood that the Project will result in residential rezoning.

[If the accessibility impacts are very significant and/or the project is likely to lead to important shifts in the location of industrial and commercial activities, then residential rezoning may be likely.]

* Estimate the likelihood that the Project will contribute to deterioration in community and neighborhood qualities or to a decline in community residential values.

[Shifts in the location of commercial and industrial firms into residential areas may cause a deterioration in neighborhood qualities.]

6. Estimate how the Project might impact agricultural activity within 10 miles of the Project.

[Evaluate whether the project is likely to expand residential, commercial, or industrial activity beyond the fringes of the existing urbanized area.]

7. Describe changes in land values that may occur because of or in anticipation of the project.

[Estimate the long run impacts of the Project on the spatial distribution of industrial, commercial, and residential land. The value of any land that benefits, directly or indirectly, by an improvement in accessibility is likely to go up in the long run.]

8. Describe any expected changes to commuting patterns and mass transit in any urbanized area within 10 miles of the Project.

[Evaluate how any changes in the location of industrial and commercial activities (centers of employment) relative to that of residential areas may impact commuting patterns and assess whether these changes are likely to increase or decrease the use of mass transit.]

9. Estimate how the Project will affect any public land-use or public service.

[Identify the location of major public employers and public service providers. Evaluate the accessibility impacts of the Project on the public employees in going to work and on the public service user in traveling to obtain public services.]

APPENDIX F

Checklist Example: Eau Claire

DETAILED CHECKLIST FOR SECONDARY LAND-USE IMPACTS OF HIGHWAY PROJECTS: COMPLETED CASE STUDY

U. S. Highway 12 Widening Project in Eau Claire, WI

Introduction

This case study illustrates the procedure for completing the "checklist" approach for evaluating secondary land-use impacts of transportation projects. The transportation project selected is the expansion of U. S. Highway 12 (Clairemont Avenue) in Eau Claire, Wisconsin -- a project completed in 1970. The project widened Clairemont Avenue from a two to six lane principal arterial.

Preparation of this case study followed the overall approach of this research study to evaluate the land-use impacts of projects completed around 1970 so that the projected and actual impacts could be compared. In completing the detailed checklist, every effort was made to use actual data; however, because of the difficulty in finding historical data for 1970, it was sometimes necessary, for the sake of illustrating this procedure, to estimate conditions and data for 1970 or resort to more, readily accessible, recent data.

The case study closely follows the "Detailed Checklist for Secondary Land-Use Impacts of Highway Projects" found in Appendix E.

Case Study

1. Summary description of the major secondary land-use impacts identified in this analysis

Overall, the project is likely to have limited impacts on the location of industrial, commercial, and residential activities within Eau Claire and vicinity. The project will reduce driving times along the 3.25 mile length of Clairemont Avenue by 2.5 minutes. This improvement in accessibility and resulting increase in traffic volumes is likely to have a major impact on the location of commercial activities. It is expected that strip commercial development will intensify along Clairemont Avenue -- and commercial development is likely to cluster most heavily at the endpoints of the project. The only potentially significant, negative impact identified is that the project may adversely affect the commercial attractiveness of the CBD.

2. Description of existing constraints on development

The 1967 Eau Claire Land Use Plan provides a general guide for development of the Eau Claire area until 1990. The Land-Use Plan recommends a policy of encouraging residential growth to the north and west to make better use of existing public facilities in those areas and to achieve a more balanced community. The Plan also identifies land to be withheld from development or restricted from development. Land to be restricted in use falls into six area types:

* floodplains
* airport noise abatement zone
* areas that cannot be supplied with municipal utilities
* agricultural areas
* open space

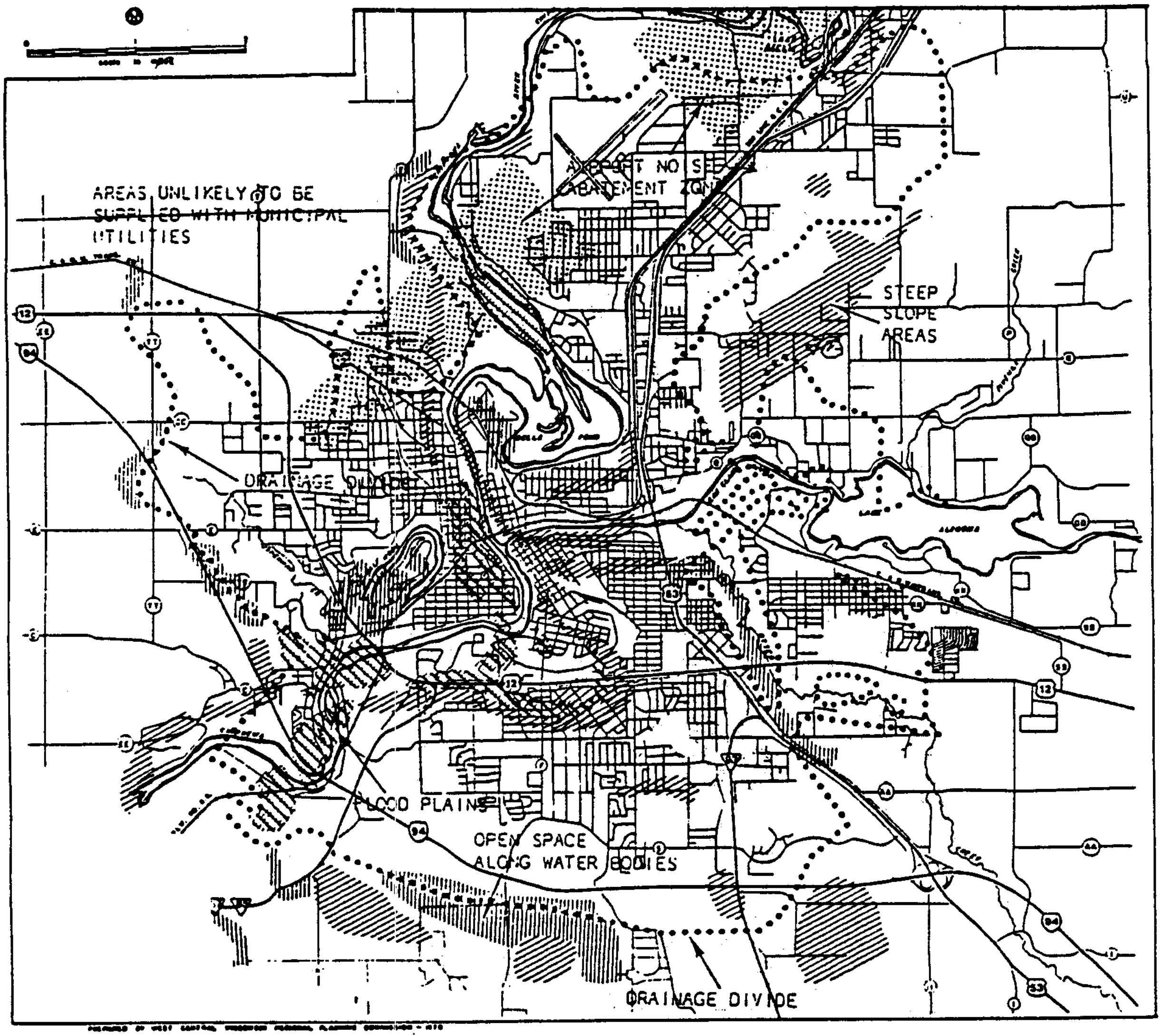
The land to be restricted from use is shown in Figure F.1. The floodplains areas are predominately adjacent to the Chippewa River and are unsafe for development. Areas near the airport are unsuitable for residential purposes; the Federal Aviation Agency has proposed buffer zones for noise abatement that extend 15,000 feet beyond the ends of the runway. Steep slope areas (above Harding Avenue and the slopes of Mt. Washington) are designated as not suitable for residential development. Because of the natural drainage areas (see drainage divide on figure) it is unlikely that certain areas adjacent to Eau Claire will be supplied with municipal utilities. Accordingly, the Plan discourages the intensive development of those areas. The Plan also recommends that urban sprawl to agricultural lands be restricted using agricultural zoning. Finally, the Plan recommends that because wooded areas, lakes and streams, and slopes offer opportunities for significant open space and scenic contrast, that development in these areas should be constrained.

3.1. Spatial distribution of existing industrial activity

3.1.a. Industrial employment data

Employment data for Eau Claire City and Chippewa Falls City for 1950 to 1980 are given in Table F.1. Employment data for 1980 are included in this illustration for completeness. However, in using this historical case study, the focus is on data up to 1970 because the project was undertaken then.

Manufacturing employment in Eau Claire City declined dramatically from 1950 to 1960, dropping from 4,829 to 3,887. During the 1960s, employment in manufacturing rebounded to reach 4,163 in 1970. Manufacturing employment in Chippewa Falls City increased from 970 to 1,401 during 1960 to 1970.



- Steep Slope Areas
- Areas Unlikely to be Supplied with Municipal Utilities
- Airport Noise Abatement Zone
- Flood Plains
- •••• Drainage Divide

Figure F.1. Existing Constraints on Development Near the Project.

Table F.1

EMPLOYMENT IN EAU CLAIRE CITY AND CHIPPEWA FALLS CITY
IN 1960 TO 1980

	1950	1960	1970	1980
Manufacturing		4,857	5,564	4,802
Eau Claire City	4,829	3,887	4,163	3,454
Chippewa Falls City		970	1,401	1,348
Wholesale		857	884	1,138
Eau Claire City	696	727	760	998
Chippewa Falls City		130	124	140
Retail		3,418	4,585	6,198
Eau Claire City	2,636	2,598	3,686	5,255
Chippewa Falls City		820	899	943
Services		3,268	5,214	6,490
Eau Claire City	1,655	2,378	4,041	5,241
Chippewa Falls City		890	1,173	1,249
FIRE		645	866	1,507
Eau Claire City	436	545	731	1,286
Chippewa Falls City		100	135	221
TOTAL		13,045	17,113	20,135
Eau Claire City	10,252	10,135	13,381	16,234
Chippewa Falls City		2,910	3,732	3,901

Source: U.S. Bureau of the Census, Census of Population, General Social and Economic Characteristics, 1950, 1960, 1970, 1980.

Note: This table shows employment by place of residence.

These data in Table F.1 reveal the profound structural changes occurring during 1950 to 1970. The proportion of employment in manufacturing in Eau Claire City declined from 47 percent in 1950 to 31 percent in 1970. The share of employment in retail and services, on the other hand, increased significantly. These overall trends in employment are reflections of similar shifts in the state and national economies.

3.1.b. Projections of manufacturing employment

Table F.2 shows employment projections for Eau Claire City in 1967 for the year 1990. The projections provide only very aggregate sectors: trade and services, and other employment.

In these projections, trade and services employment is expected to grow rapidly and to more than offset declining employment in other sectors. The projections, although they lack sectoral detail, appear to predict a decline in manufacturing employment.

More recent manufacturing employment projections -- for Eau Claire county up to 2010 -- are given in Table F.3.

The future growth of manufacturing employment in Eau Claire City and Chippewa Falls City is likely to remain stable in the short term in response to overall regional economic trends. An upturn in manufacturing employment growth may occur in the area as manufacturing activities spin off from the Twin Cities. The recent expansion of Cray Research in Chippewa Falls is an example of this trend. However, for purposes of estimating secondary land-use impacts of the current project, the growth of manufacturing activity in Eau Claire City and Chippewa Falls City is likely to be minimal.

3.1.c. Identification of existing areas zoned for industrial activity

The existing areas zoned for industrial activity are shown on Figure F.2. All industrial zones have excess capacity; all have occupancy rates of 60 percent or less. There are no new industrial zones planned.

Table F.2

EMPLOYMENT PROJECTIONS: EAU CLAIRE 1990

	1967	1990
Trade and Services Employment	9,901	14,100
Other Employment	10,057	8,500
Total Employment	19,958	22,600

Source: *Eau Claire Land Use Plan*, Barton-Aschman, 1967.

Table F.3

EMPLOYMENT PROJECTIONS FOR EAU CLAIRE COUNTY

	Actual			Projected		
	1970	1975	1980	1990	2000	2010
Manufacturing	6,202	4,729	4,947	5,416	5,701	6,015
Wholesale & Retail	6,727	7,310	9,579	12,075	13,096	14,092
Other	18,513	19,081	19,552	22,226	23,497	24,436
TOTAL	31,442	31,120	34,078	39,707	42,294	44,343

Sources: Abere, D. "Employment Projections for Eau Claire County, Wisconsin: 1980-2010," University of Wisconsin-Milwaukee, 1985. Bureau of the Census, U.S. Department of Commerce, County Business Patterns, Wisconsin, adjusted to reflect self-employed and unpaid family workers.

Note: This table shows employment in establishments.

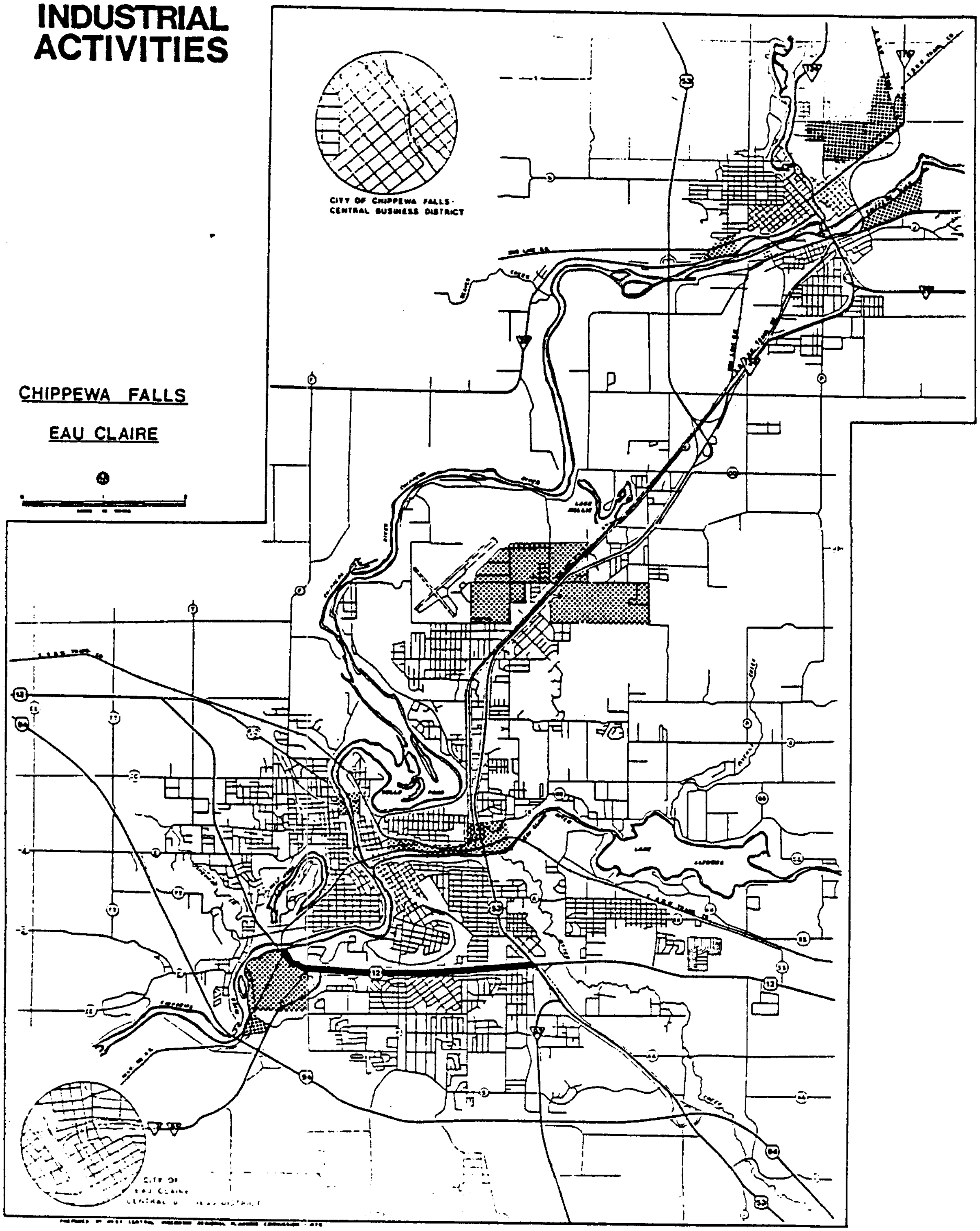


Figure F.2. Industrial Locations in Eau Claire

3.1.d. Identification of major employers

Major employers with 200 or more employees are shown in Figures F.3 and F.4. Manufacturing firms are highlighted. As can be seen in Figure F.3, no major manufacturing employers are located in the general vicinity of the project.

3.2. Evaluate Project impact on the spatial distribution of industrial activity

3.2.a. Travel time accessibility

One of the major factors important to industrialists in locating their plants is accessibility to markets and suppliers. In selecting industrial sites, managers are concerned with access to interstate highways, airport, other transport facilities, and to the central business district. In assessing how a highway project might affect the spatial distribution of industrial activity, the most important question is how will the project affect travel time accessibility from the major industrial zone.

Pre- and post-project travel time accessibility is determined by assessing the changes in speed (and distance) that result from the project.

In the case of the U. S. Highway 12 (Clairemont Avenue) project, average driving speeds along Clairemont Avenue have increased from an estimated 28 mph (assuming at or below capacity on a one lane, principal arterial in a residential area) to an estimated 37 mph (on the same road expanded into three lanes each direction). These estimated speeds are consistent with no over capacity traffic loads.

Traffic count data for several years preceding construction on the project indicate, however, that some traffic congestion was likely during peak hours. The pre-project design capacity of one-way traffic along Clairemont Avenue was 708 vehicles per hour. Two-way traffic counts along portions of Clairemont Avenue in 1967 exceeded 18,000 and 19,000 average daily volumes (ADV), which implies one-way ADV of 9,000 and higher. Assuming that evening peak volumes are approximately 9 percent of ADV, the one-way evening peak volumes of 810 vehicles per hour are estimated for 1967. Some congestion along Clairemont Avenue therefore must have lowered average speeds at least during peak hours.

Because of this congestion, we assume that the pre-project speeds along Clairemont Avenue were, on average, 25 mph. The project, the portion of Clairemont Avenue widened to three lanes, is 3.25 miles. Thus, the running time along the project is estimated to have decreased from approximately 7.8 minutes to 5.3

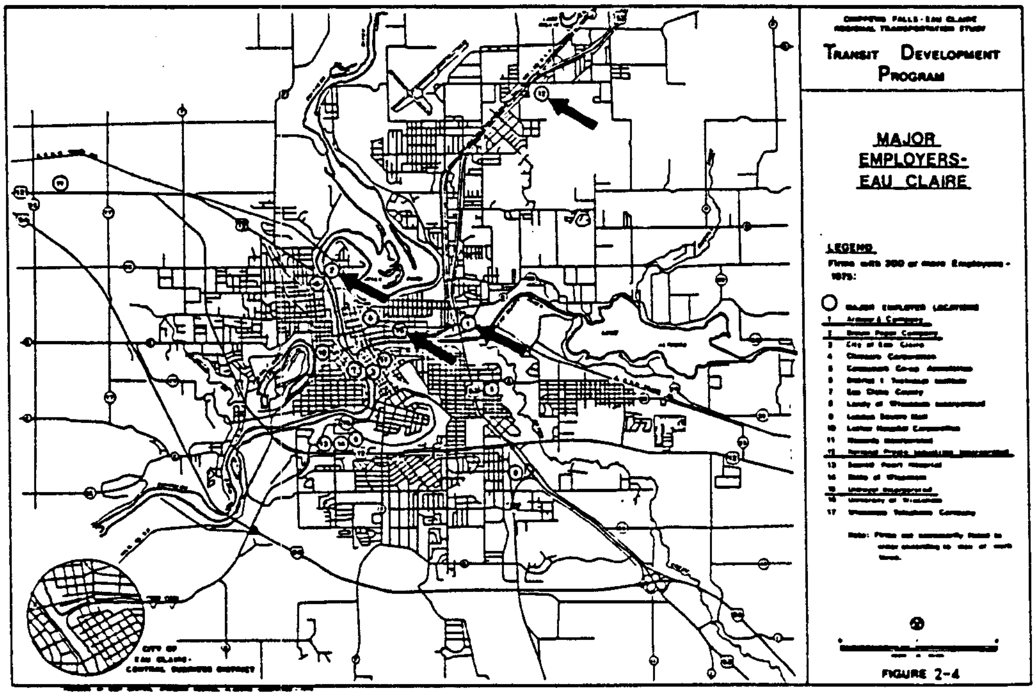


Figure F.3. Major Employers in Eau Claire

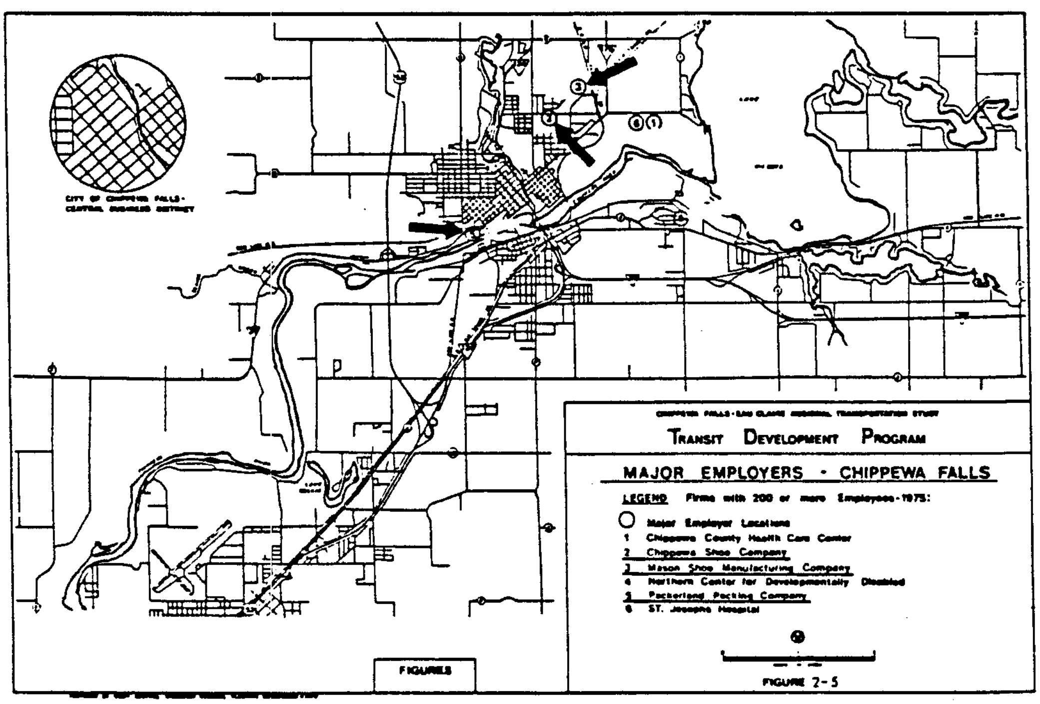


Figure F.4. Major Employers in Chippewa Falls minutes, a 2.5 minute (32 percent) reduction in travel time.

3.2.b. Project impact on accessibility from industrial zones to freeway, transfer depots, CBD

As shown on Figure F.2, only one industrial zone will have direct accessibility gains as a result of this project: the industrial zone at the west end of the project. The project will yield a 2.5 minute travel time decrease while driving to Highway 53. This travel time savings will lead to relatively minor improvements in accessibility to other industrial zones, to the central business district, to other commercial areas and to other transportation depots, such as the airport.

3.2.c. Project impact on accessibility to major highway interchanges

In terms of accessibility to a major interstate highway, the industrial zone at the west end of the project is already well situated, adjacent to an interchange with Interstate 94. The project does little to improve accessibility of this industrial zone to the interstate highway.

3.2.d. Project impact on industrial location decisions

As shown in section 3.1.a, manufacturing employment in Eau Claire and Chippewa Falls has shown a significant decline. Trends suggest that manufacturing employment growth will be modest at best. However, the lack of growth in manufacturing employment does not mean that the spatial distribution of manufacturing activities will be unchanged. Even if manufacturing employment were to remain stable or to decline, new manufacturing firms will be established as other firms go out of business, and there will be some movement of existing firms within the SMSA.

Where will new manufacturing firms locate? The industrial zone with the greatest accessibility to the interstate highway interchange, which also has excess capacity, is at the west end of the project (see Figure F.2). The general accessibility improvements accruing to this zone as a result of the project, although marginal, may attract new industry to locate there. But, because of the zone's location relative to the interstate highway, the zone would possess this advantage in the absence of the project.

In sum, we find that industrial employment is not growing and industrial zones have considerable excess capacity. We also find that the project will have a minimal affect on travel time accessibility for all industrial zones. Thus, we conclude that the project is likely to have very little impact on the location of industrial activity within Eau Claire City and Chippewa Falls City.

3.2.e. Likelihood of industrial rezoning because of Project

Existing industrial zones have excess capacity and industrial employment is not growing. Moreover, the project has limited impact on accessibility for industrial firms. Therefore, the project is not likely to lead to any industrial rezoning.

4.1. Spatial distribution of existing commercial activity

4.1.a. Commercial employment data

Employment in commercial activities for Eau Claire City and Chippewa Falls City in 1950 to 1980 is shown in Table F.4. Again, 1980 data are shown for illustration purposes but are not used in this case study. Employment growth in the retail, services, and FIRE sectors is extremely rapid. Total commercial employment has increased by 59 percent between 1960 and 1970.

Over this period, the Eau Claire-Chippewa Falls SMSA has become the primary wholesale/retail trade and services center for West Central Wisconsin. Customers for trade and services are drawn from all surrounding counties including Eau Claire, Chippewa Falls, Dunn, Barron, Rusk, Clark, Jackson, Buffalo, and Pepin counties. Figure F.5 shows travel time accessibility from the project area to outlying areas. The trade area for high order goods and services purchases in Eau Claire extends even beyond the 50 minute travel time radius shown in Figure F.5.

4.1.b. Projections of commercial employment

Projections made in 1967 for trade and service employment in Eau Claire (see Table F.2) indicate an increase of 4,199 jobs in Eau Claire over this period. Because of this projected increase in commercial activity, we want to examine closely the potential impacts of the project on the location of retail outlets and other commercial establishments.

Table F.4

COMMERCIAL EMPLOYMENT IN EAU CLAIRE CITY AND CHIPPEWA FALLS CITY IN 1950 TO 1980

	1950	1960	1970	1980
Wholesale		750	884	1,138
Eau Claire City	686	625	760	998
Chippewa Falls City		130	124	140
Retail		2,990	4,585	6,198
Eau Claire City	2,636	2,170	3,686	5,255
Chippewa Falls City		820	899	943
Services		3,180	5,214	6,490
Eau Claire City	1,655	2,290	4,041	5,241
Chippewa Falls City		890	1,173	1,249
FIRE		594	866	1,507
Eau Claire City	436	494	731	1,286
Chippewa Falls City		100	135	221
TOTAL COMMERCIAL		7,519	11,549	15,333
Eau Claire City	5,423	5,579	9,218	12,780
Chippewa Falls City		1,940	2,331	2,553

Source: U.S. Bureau of the Census, Census of Population, General Social and Economic Characteristics, 1950, 1960, 1970, 1980.

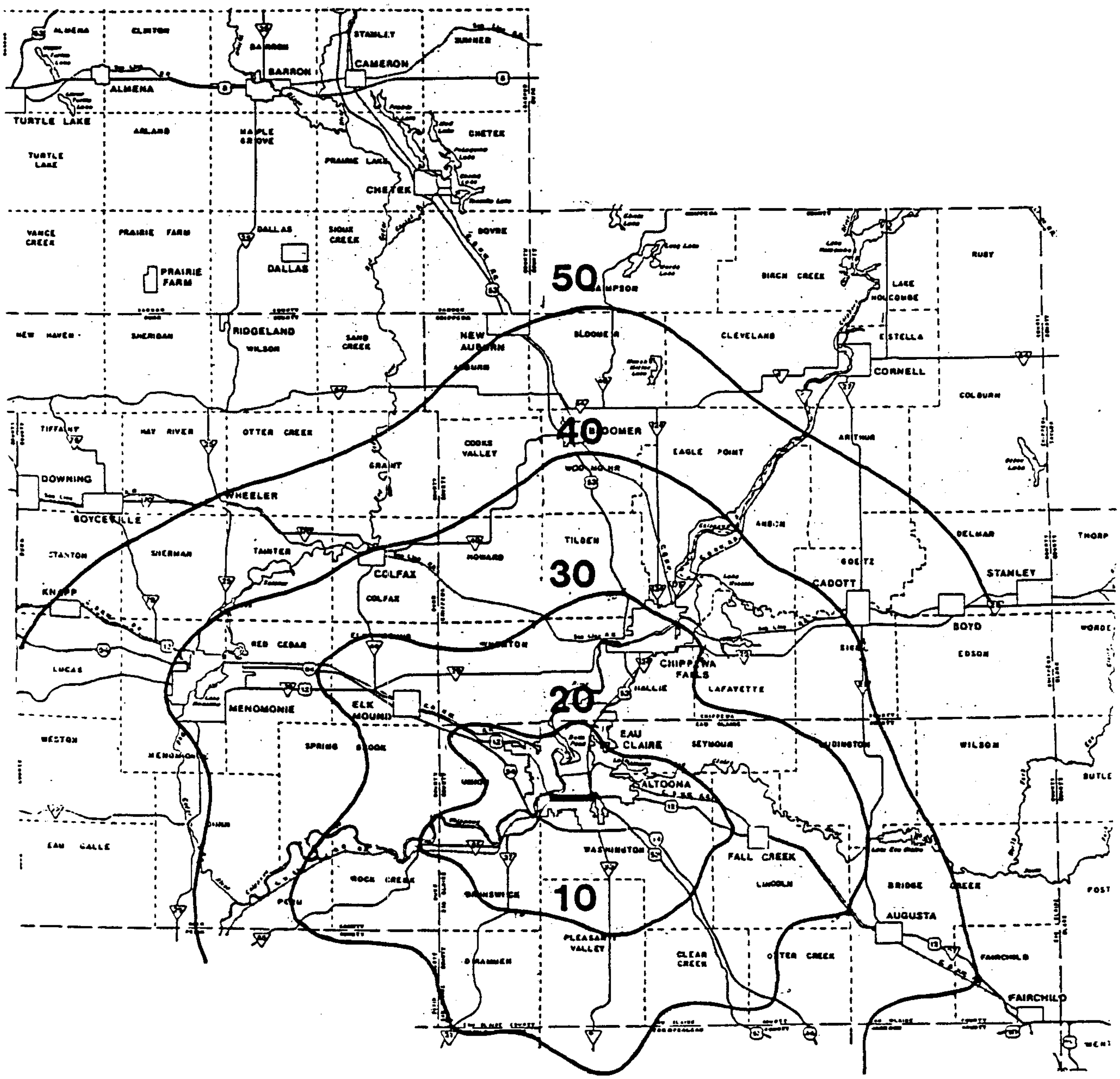


Figure F.5. Travel Time Contours from Project Center

4.1.c. Identification of areas zoned for commercial activity

The areas zoned for commercial activity are shown on Figure F.6. The major commercial zones in proximity of the project are at the east and west ends of the project (shown by the solid black line) and in the central business district of Eau Claire, just north of the center of the project.

The major shopping area locations are shown in Figures F.7 and F.8. The shopping areas closest to the project are: London Square Mall, Shopko Plaza Shopping Center, K-Mart, and the Putnam Heights Shopping Center. In 1969, the occupancy rates of these shopping areas were London Square Mall (did not exist), Shopko Plaza Shopping Center (did not exist), K-Mart (75 percent), and the Putnam Heights Shopping Center (90 percent).

In 1970, development of a shopping center at what is now London Square Mall was under consideration.

4.2. How the Project will affect spatial distribution of commercial activities

4.2.a. Project impact on travel time accessibility to commercial zones

As shown in 3.2.a., the project will reduce driving times along Clairemont Avenue from Highway 53 to the Chippewa River from 7.8 to 5.3 minutes -- a reduction of 32 percent.

The reductions in travel time along Clairemont Avenue also contribute to increases in accessibility between commercial zones at either end of the project and the central business district.

Accessibility to the I-94 interchange is relatively unaffected by the project. However, some reduction in congestion will likely result because of the project.

The project is not likely to lead to any significant increases in the population that will be within a 30 minutes driving time of the commercial zones. Figure F.5 shows the accessibility contours from the project. These contours are essentially unchanged by the project.

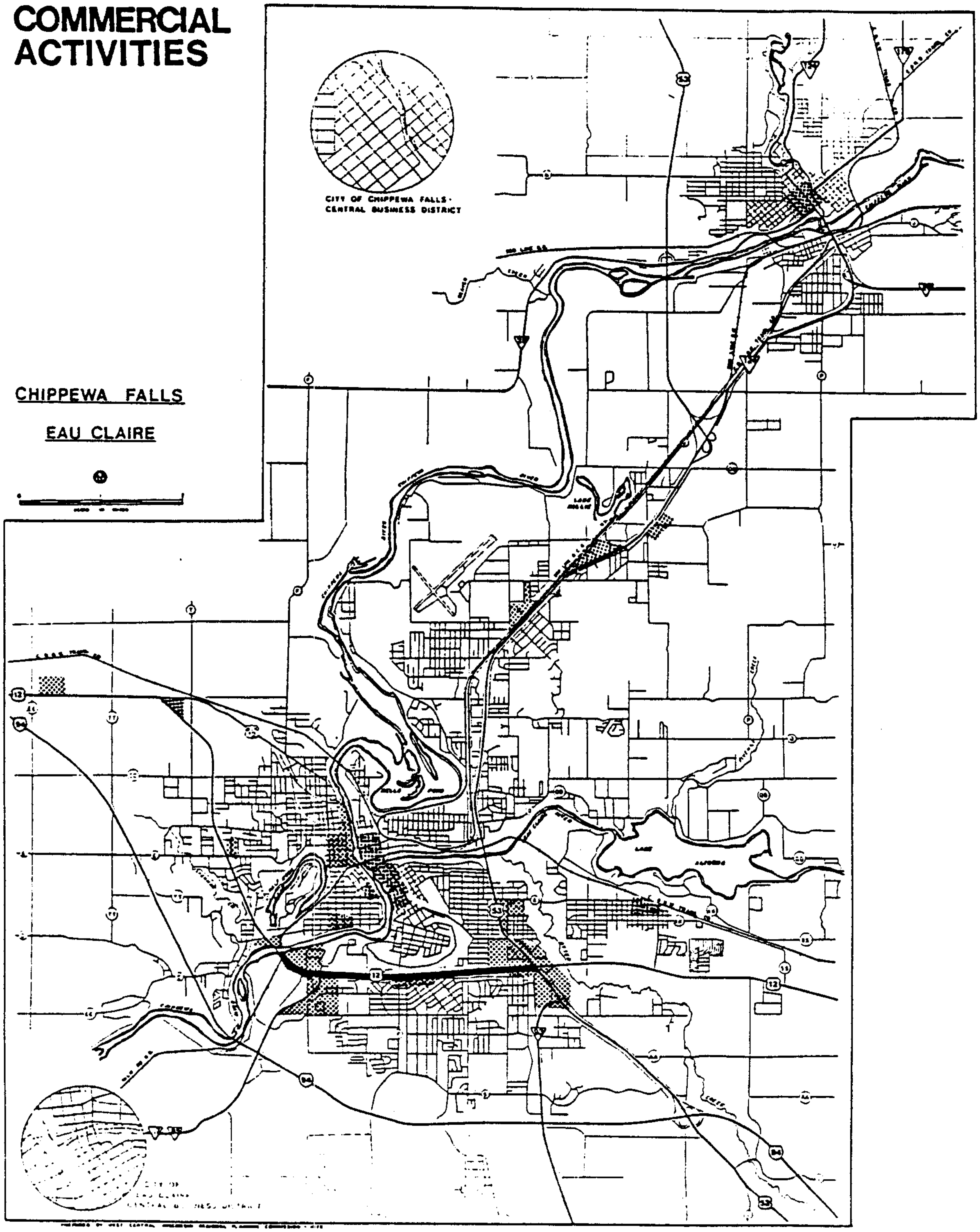


Figure F.6. Commercial Locations in Eau Claire

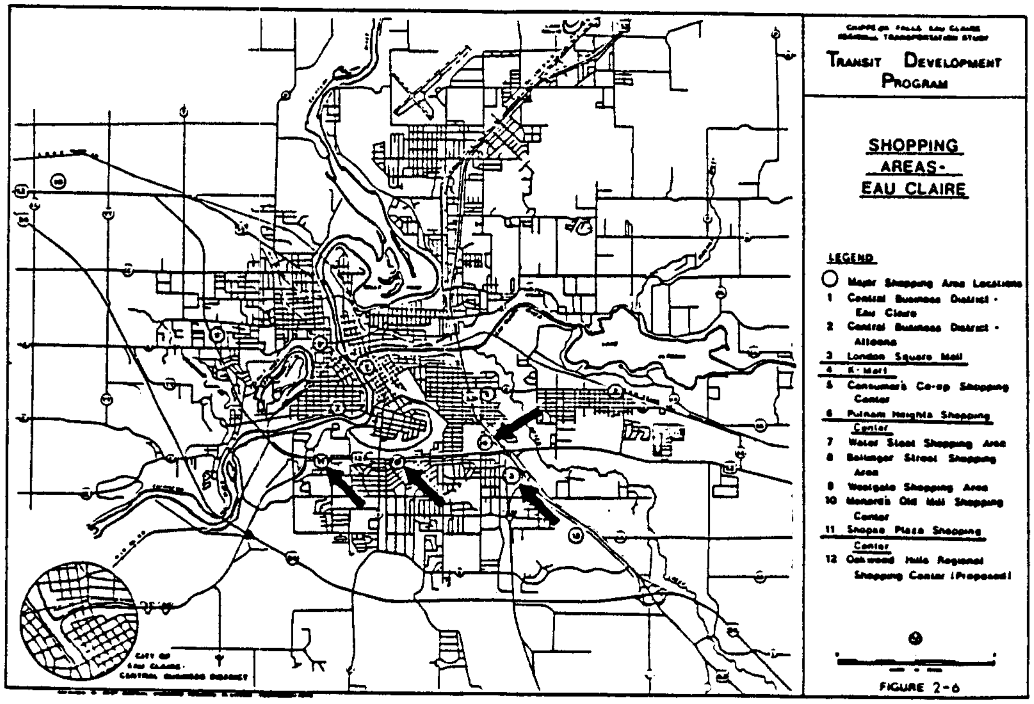


Figure F.7. Major Shopping Areas in Eau Claire

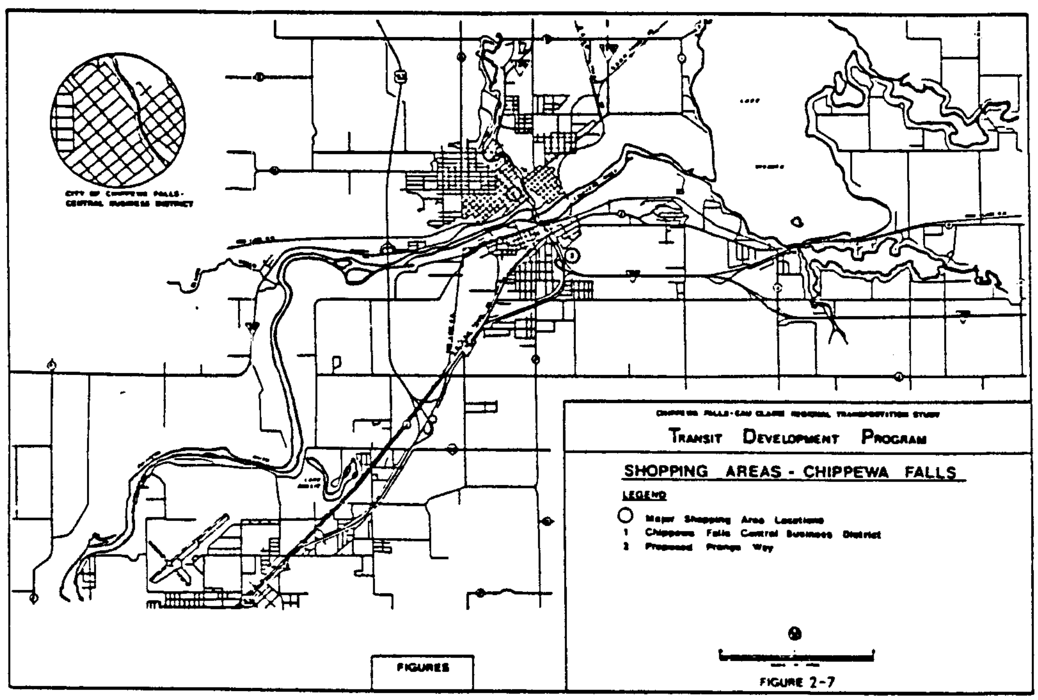


Figure F.8. Major Shopping Areas in Chippewa Falls

4.2.b. Project impact on consumer visibility of commercial business activity

Because it is very important for most retail and service businesses to be visible to consumers, these businesses typically locate along major highways and arterials. The impact of the project on the desirability of certain locations for commercial businesses can be estimated by comparing pre-project and forecasted traffic volumes through commercial zones (see Table F.5). For the purposes of this example, forecasted traffic volumes are drawn from the 1972 edition of "Wisconsin Traffic Data."

In order to account for the general increases in traffic volumes expected from 1970 to 1972, the average daily volumes (ADVs) of a wide selection of locations throughout Eau Claire were averaged. On average, the ADVs in Eau Claire increased by approximately 13 percent from 1970 to 1972.

Thus, the increases in traffic volumes along the project are very high. This suggests that retail and service businesses may be attracted to locate along the project. It is very likely that strip development of commercial activities may intensify along Clairemont Avenue because of the project.

4.2.c. Project impact on the commercial trade area

Commercial trade areas can be roughly categorized as primary or secondary trade areas. The primary trade area of a region is typically defined as the local area from which consumers are drawn, accounting for approximately 80 to 90 percent of sales. The secondary trade area is defined as the broadest area from which consumers can be drawn. Maximum driving times for customers within the primary trade area range from 15 to 20 minutes. The maximum driving time is between 30 and 50 minutes for the secondary trade area.

Commercial developers typically estimate the demand for new shopping centers in terms of levels of population and income within the commercial trade areas.

The task here is to determine whether or not a highway project will significantly increase the commercial trade area -- stimulating new commercial sales and activities. A procedure for estimating the impact of a highway project on the size of the commercial trade area is to determine the increase in population that would reside within 30 to 50 minutes driving time from the major commercial centers, if the project were undertaken.

For this project, the primary trade area is considered to include the urbanized areas of Eau Claire and Chippewa Falls and all those areas within 20 minutes travel time (see Figure F.5).

Table F.5

PRE- AND POST-PROJECT AVERAGE DAILY TRAFFIC VOLUMES

Location	1970	1972	% Change
Hwy. 85 and Clairemont Avenue	7,440	10,605	+42.5
Clairemont and State Street	9,970	15,595	+56.4
Clairemont and Rudolf Road	7,795	14,925	+91.5
Clairemont and Hwy. 53	6,440	10,685	+65.9

Source: "Wisconsin Traffic Data," 1970, 1972.

The secondary trade area extends to the 50 minute contour.

Because this project consists of widening a 3.25 mile stretch of Clairemont Avenue and results in a travel time reduction of only 2.5 minutes along Clairemont Avenue, the accessibility impacts on commercial trade areas are limited. Any increases in commercial trade areas resulting from this project are expected to be minor. For all intents and purposes, accessibility within the commercial trade areas is likely to remain roughly equivalent to that shown in Figure F.5.

4.2.d. Existing regional shopping centers

The only regional shopping centers within 10 miles of the project are the planned London Square Mall, Putnam Heights Shopping Center and the central business districts (CBDs) of Eau Claire and Chippewa Falls. The planned London Square Mall, yet to be built, is assumed to have had 0% of its grosss leasable area (GLA) leased at the time of the project. It is not possible to estimate directly the percentage of GLA leased in either of the CBDs. However, in Eau Claire there was general consensus that businesses in the CBD were beginning to decentralize.

Because the existing regional shopping areas have excess capacity, and because the project is not likely to produce any significant increase in the primary or secondary trade areas, there is little evidence to suggest that the project will induce a new shopping center. This conclusion also stems from the marginal project impact on consumer accessibility to major highway interchanges.

4.2.e. Project impact on consumer accessibility to an interstate highway interchange

The project is likely to lead to minor improvements in accessibility to two of the three I-94 interchanges in Eau Claire. The reduction of congestion at the intersection of Clairemont Avenue and County Highway 85 (Hendrickson Drive, which connects to I-94) may increase the attractiveness of commercial developments in between Clairemont Avenue and the I-94/County 85 interchange.

Another corridor/interchange with potential for reduced commercial development is the 3 mile stretch of Highway 53 connecting Clairemont Avenue to I-94. However, the interchange is 3 miles away from the existing commercial developments on Clairemont Avenue and there is virtually no commercial development along this corridor.

4.2.f. Project impact on commercial activities in the CBD

The project is located more than 0.75 miles from the Eau Claire's central business district (CBD) and does not directly improve accessibility of consumers to the CBD. In fact, close inspection of Figure F.6 reveals that the project may serve to improve the linkages and accessibility to and between two of the shopping areas which pose the greatest competitive threat to commercial activities within the CBD. Because of the project's positive impact on accessibility to the commercial activities along Clairemont Avenue, it is likely that the project may adversely affect the commercial attractiveness of the CBD.

5.1. Spatial distribution of existing residential locations

5.1.a. Population data and projections

The population of Eau Claire County increased by 15.3 percent from 1960 to 1970. For analyzing the impact of this project, it is assumed that this trend will continue.

5.1.b. Identification of existing areas zoned for residential location

Figure F.9 shows the pattern of residential location in Eau Claire and Chippewa Falls in relation to the project. This map does not define residential zoning demarcations, but is an approximation of the status of areas zoned for residential development in 1970.

The residential neighborhoods in the areas directly south of the project are likely to gain most in term of improvements in accessibility by the widening of Clairemont Avenue.

5.1.c. Identification of residential densities

Dwelling-unit densities are used as a proxy for population densities. Forecasted densities in Eau Claire and Chippewa Falls for 1975 and 2000 are shown in Figures F.10 and F.11. In the residential areas just south of the project, the forecast suggests that there is likely to be increasing population densities in six of the most southerly neighborhoods between Clairemont Avenue and I-94.

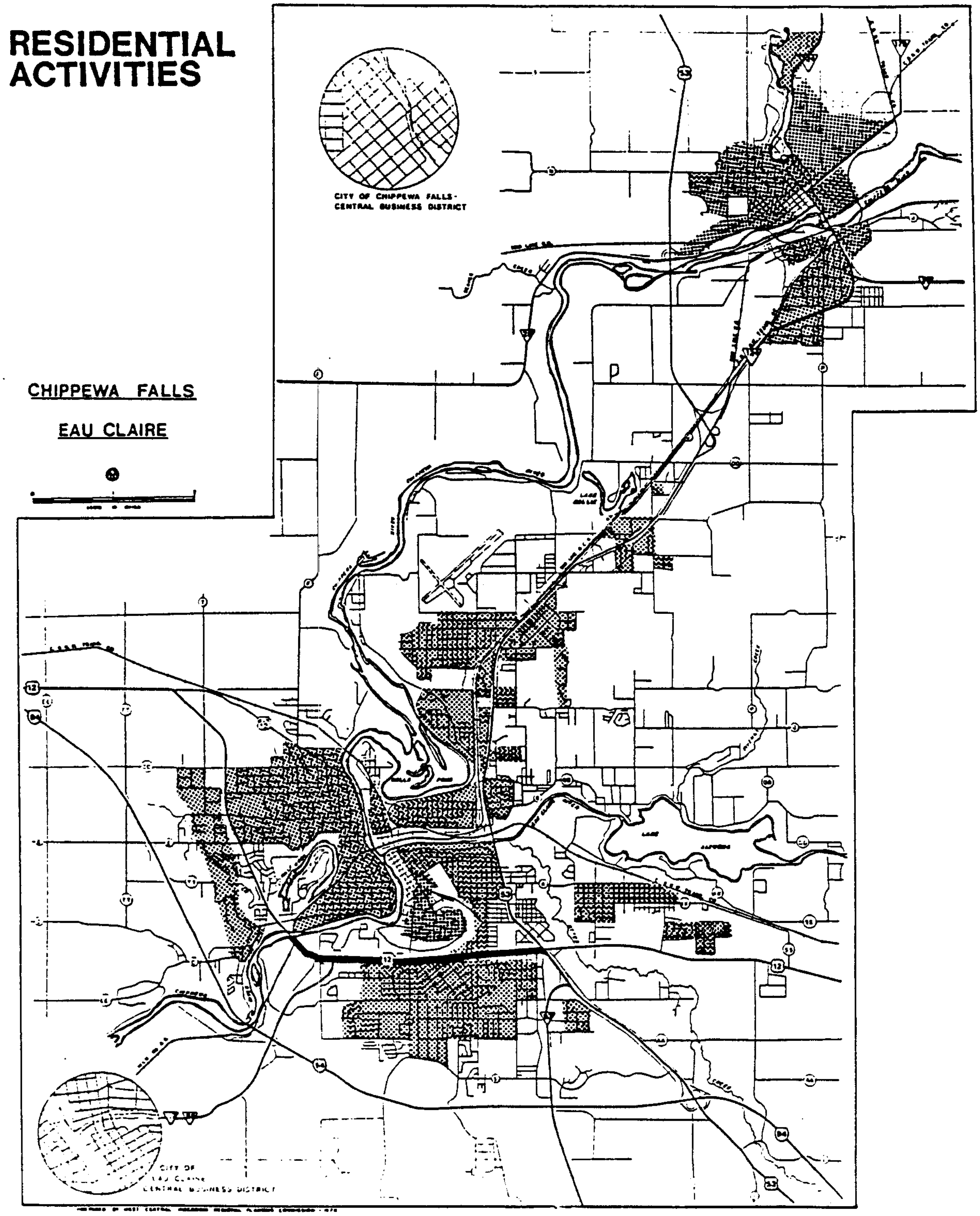


Figure F.9. Location of Residential Areas in Eau Claire

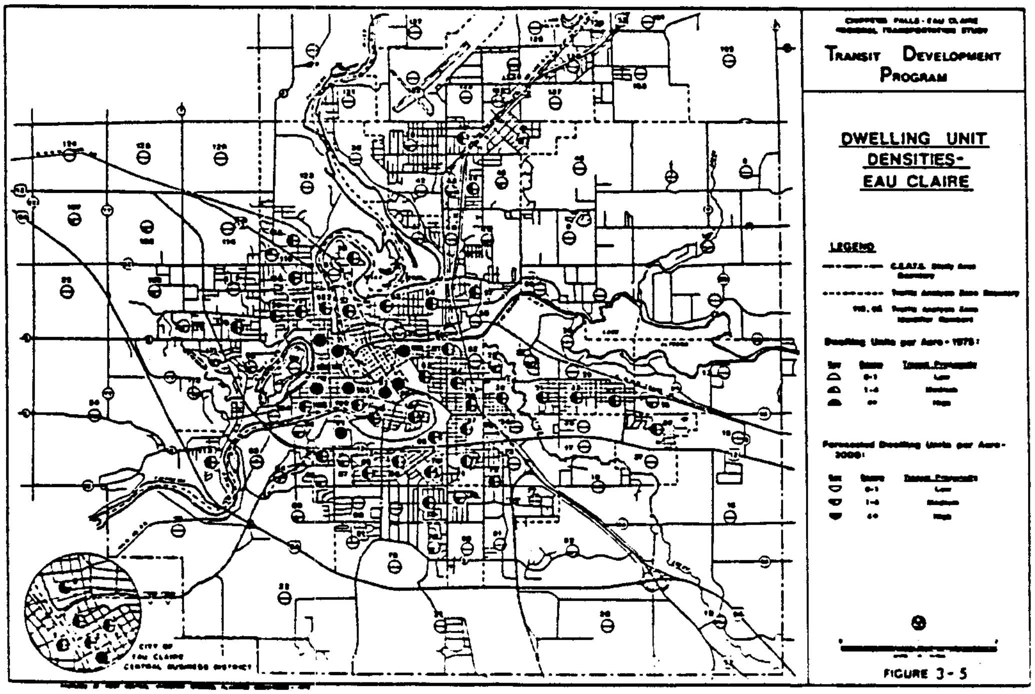


Figure F.1Ø. Forecasted Dwelling-Unit Densities in Eau Claire

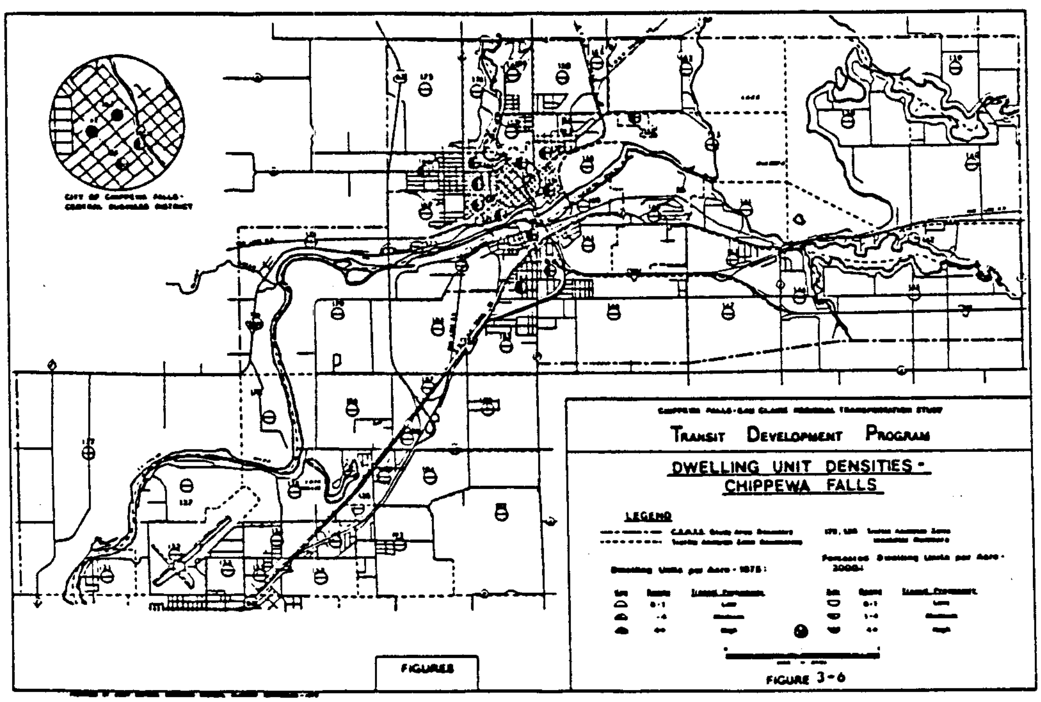


Figure F.11. Forecasted Dwelling-Unit Densities in Chippewa Falls

5.2. How the Project will affect the spatial distribution of residential location and densities

5.2.a. Project impact on travel time accessibility for residential activity

The primary considerations affecting residential location choice are the transportation costs to work, shopping, and recreation in relation to rent or cost of housing. The task here is to determine the magnitude of the impact of this project on the demand for housing within existing neighborhoods as well as for new housing developments or subdivisions. Typically, changes in residential location will occur if there are changes in the location of major employment centers, both industrial employment and service employment. But, changes in residential location are also likely to result from changes in accessibility to jobs and commercial centers. Transportation projects that reduce the travel time of the home-to-work trip often give rise to housing developments further away from the work centers because workers can minimize their rent by moving further out while keeping their travel times constant.

The project will reduce the driving time of driving along Clairemont Avenue from the bridge to Highway 53 by 2.5 minutes. It is unlikely that this project will have major impact on home-to-work travel times. At most, this accessibility improvement is only likely to have an impact on residential locations that extend in either direction from the endpoints of the project. For example, the project may possibly contribute to increased demand for housing development in areas west of the project, in western Eau Claire, and in areas to the east of the project, south of Altoona. Since the project is likely to have a very limited impact on the location of industrial or service employment within Eau Claire, it is also quite likely that the project's impact on residential location will be minor.

5.2.b. Likelihood of Project to result in residential rezoning

Because the accessibility impacts of the project are relatively minor, it is not likely that the project, by itself, will induce a change in residential zoning patterns. Generally, however, the project is likely to contribute to the gradual expansion of the urbanized area in south Eau Claire.

5.2.c. Likelihood of Project to contribute to a deterioration in community/neighborhood qualities or a decline in community residential values

Because the overall impacts of the project are expected to be minor, the project is not likely to lead to any significant deterioration in neighborhood qualities or values. However, the strip commercial development that is anticipated along Clairemont Avenue, particularly at the endpoints of the project, may penetrate the fringes of the established residential communities in those areas.

6. Project impact on agricultural activity within 10 miles of the Project

The impact of a project on agricultural activity in the area is a key consideration in assessing whether or not there is potential for any significant negative impacts of the project. Generally, if a transportation project has a major impact on residential development on the fringes of the urbanized area, then it is likely that some farming activities will be adversely affected. While this does not mean that the overall impact of the project will be negative, it does call attention to one possible negative effect that may have to be reconciled.

The overall impact of this project is likely to be limited to areas within the urbanized area of Eau Claire. Therefore, it is not anticipated that agricultural activity will be affected at all by this project.

7. Project impact on land values

In general, the likely impact of a transportation project on land values is an increase in the value of any land that benefits, directly or indirectly, by an improvement in accessibility. In other words, accessibility improvements are generally capitalized into land values.

It is expected that the major impact of this project on land values will be the increase in the value of commercial real estate along Clairemont Avenue. In addition, if some portion of commercial activity from the Eau Claire CBD is attracted to Clairemont Avenue, there may be some decline in land values in the CBD. Finally, because of some gains in accessibility for residential areas just south of the project, these areas may experience a small increase in land values as a result of the project.

8. Project impact on commuting patterns and mass transportation

Because the influence of the project on industrial, commercial, and residential activity is likely to be minor, it is not anticipated that this project will change commuting patterns.

9. Project impact on public land use or public services

The major public land uses in the vicinity of the project include the University of Wisconsin--Eau Claire, State of Wisconsin offices, and the District 1 Technical Institute. All of these facilities are clustered at the west end of Clairemont Avenue (see Figure F.3).

It is unlikely that the project will have any impact on the location of these public facilities. The project will yield accessibility benefits to the employees and users of these public facilities.