MICHIGAN DEPARTMENT OF TRANSPORTATION

BUREAU OF TRANSPORTATION PLANNING

MICHIGAN'S STATEWIDE
TRANSPORTATION MODELING SYSTEM

VOLUME II-D

TRANSPORTATION IMPACT ANALYSIS USING INTERACTIVE COLOR GRAPHICS

STATEWIDE PROCEDURES SECTION

FEBRUARY, 1980

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TRANSPORTATION IMPACT ANALYSIS

USING INTERACTIVE COLOR GRAPHICS

VOLUME II-D

By Joyce Newell

STATE OF MICHIGAN

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JOHN P. WOODFORD, DIRECTOR

February 6, 1980

Mr. Sam F. Cryderman
Michigan Department of
Transportation
Bureau of Transportation Planning
P.O. Box 30050
Lansing, Michigan 48909

Dear Mr. Cryderman:

The Transportation Planning Services Division is pleased to present Volume II-D in the Statewide Transportation Modeling System Series. This report documents a powerful tool for presenting transportation planning information and analytical results concisely and effectively for reports and other presentations.

Preparation of color graphics for reports or slides may be completed quickly with the aid of the color graphics computer terminal and software applications described in this report. Another major advantage of the process described is that it is completely integrated with the Statewide Transportation Analysis System. All graphics resulting from this process use data generated by other components of the analysis system. Therefore, this process is heavily application-oriented and has been used for public meetings in Planning Region 7.

This report and the color graphics production system described therein reflect the efforts of Miss Joyce Newell and Messrs. Terry Gotts and Alan Friend of the Statewide Transportation Planning Procedures Section, under the supervision of Mr. Richard E. Esch.

Sincerely,

G. Robert Adams
Administrator
Transportation Planning Services Division

MICHIGAN

PREFACE

PREFACE

Growing public interest and present federal regulations pertaining to transportation planning have resulted in increased public involvement in all phases of transportation planning. This involvement, while needed and desired, imposes new demands upon any responsible transportation agency. One area of concern must be the effective, concise, and informative presentation of all analysis. This often entails months of graphical preparation, particularly when slide or color presentations are desired. This report describes an alternative which is now available. It involves the use of a color graphics computer terminal; and, although it has been available for only a short time, several applications have already been completed. It is felt that proper utilization of this tool will greatly reduce the elapse time between analysis and final preparation of reports and public hearings. Color diagrams would become much more feasible. This is especially desirable because many concepts can be displayed much more quickly and effectively in color than in black and white.

This is Volume XIX in the Statewide Series of reports. Other reports in the series are listed on the following pages.

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VOLUME I-A - REGION 4 WORKSHOP TOPIC SUMMARIES
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INTRODUCTION

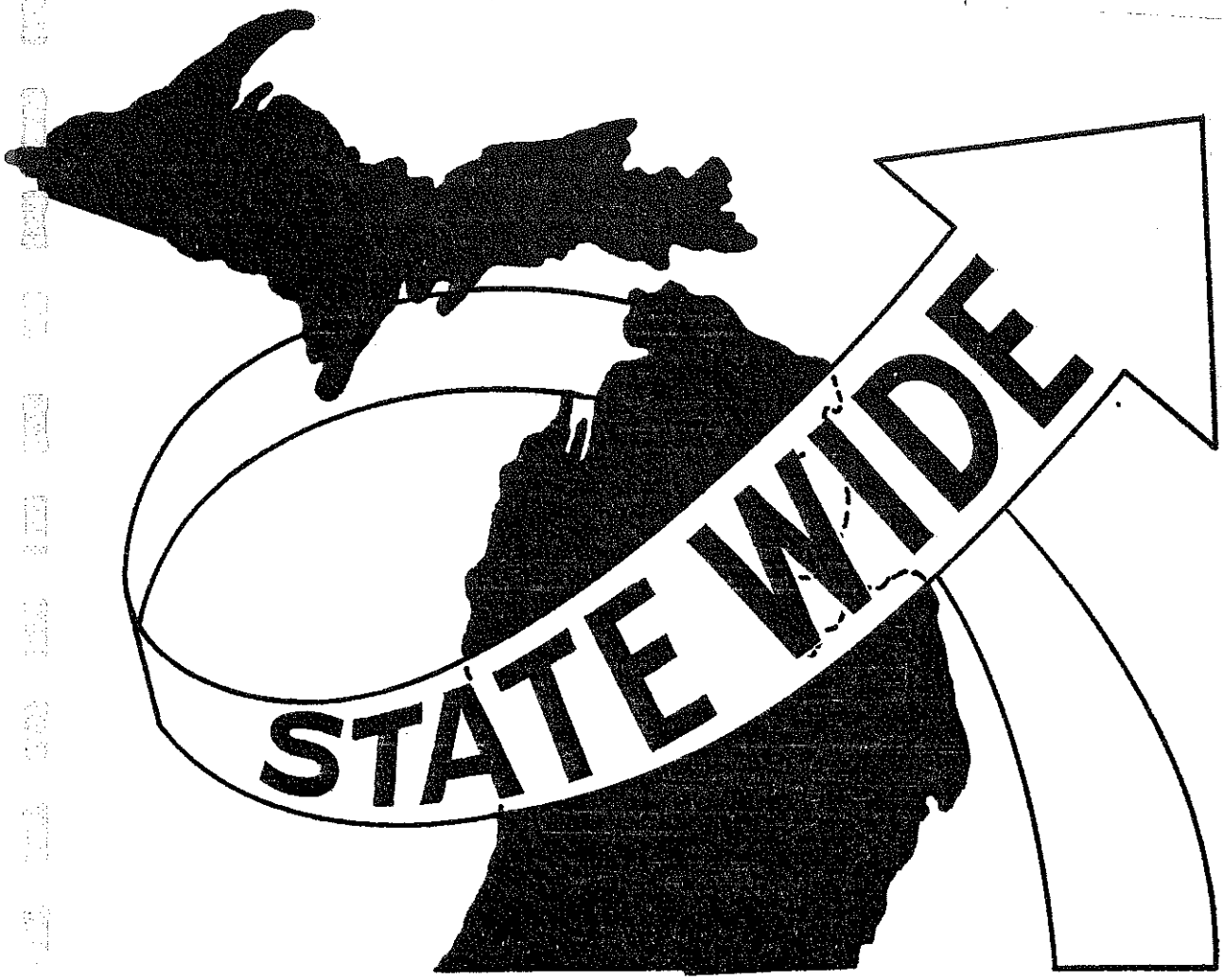
INTRODUCTION

Public involvement is a rapidly growing element of present-day transportation planning. Federal legislation requires transportation planners to carefully consider all concerns expressed by interested citizens. These concerns have increased rapidly in the past few years. Social, economic, and environmental disruptions have become an important issue and cannot be ignored. As these problems continue to increase, it may be certain that public involvement will also increase. This involvement places importance upon clear, definitive, and concise methods of data presentation. The range and complexity of the relevant data and the necessity of considering all possible alternatives places additional requirements upon any transportation agency when preparing for public hearings or when documenting the need or justification for a given route. Time saved in graphics preparation naturally enables a project to proceed quickly which would result in construction cost savings. If the graphical presentations could be easily generated and regenerated as new information or alternatives are requested, questions from concerned citizens could be answered quickly and effectively. Concise graphics would also result in fewer questions and more rapid comprehension of relevant information and comparative data.

Much of the analysis in regional system planning and project justification is derived from the Michigan statewide transportation modeling system. This system rapidly generates requested data for many transportation alternatives and their corresponding travel, social, and economic impacts. This report describes and demonstrates an addition to this system which is capable of producing colored graphical displays of the resultant analysis. The hardware

requirements for this process are discussed in detail later in this report. Access to some of the necessary hardware is now available to the Michigan Department of Transportation. Computer software has been developed and several practical applications have been demonstrated. Examples of these applications are included in the following pages along with brief explanations of each one. For this report, color prints are used for the examples. Xerographic copies or slides are also feasible, as discussed in conjunction with the description of hardware requirements which will follow later.

APPLICATIONS



APPLICATIONS

The following pages contain examples and brief explanations of potential color graphic applications. Much of the software necessary to obtain them was created or adapted from already existing processes within a period of two months. Some existing graphic programs were changed slightly to incorporate the color features. Other programs were written in entirety with considerable ease. There are many ways in which these programs could be improved, such as a better quality of letter styles, additional legends, etc. Such improvements could realistically be made within a reasonable length of time. Any comments or suggestions received will be seriously considered for future implementations.

The statewide transportation modeling system contains three basic data sources. These are network data, socio-economic data, and facility data. Some examples of each of these data sources are shown in Figures 1-3. Combinations of this data are used in all portions of the analysis system. Network data includes information about trunkline roads and is used, along with population data, to help predict future traffic assignments, highway needs and deficiencies, and accessibility measures. Socio-economic and facility data are summarized to zones and, in conjunction with traffic data, may be used to determine various social, economic, and travel impacts. The 547 zone system, used extensively for statewide and regional transportation planning, is shown in Figure 4.

STATEWIDE HIGHWAY NETWORK

LINK FILE

CONTENTS OF EACH HIGHWAY SEGMENT OR LINK

AVERAGE SPEED
DISTANCE
URBAN-RURAL DESIGNATION
TYPE OF ROUTE
TRAFFIC VOLUME CAPACITY
AVERAGE ANNUAL DAILY TRAFFIC VOLUME
COMMERCIAL TRAFFIC VOLUME
DESIGN HOUR VOLUME
ACCIDENT FATAL RATE
ACCIDENT INJURY RATE
ACCIDENT RATE
NUMBER OF LANES
LANE WIDTH
SURFACE CONDITION
RIGHT OF WAY
SIGHT RESTRICTION

FIGURE 2

STATEWIDE SOCIO-ECONOMIC DATA FILE

CENSUS OF POPULATION

GENERAL

SCHOOL ENROLLMENT BY TYPE OF SCHOOL
YEARS OF SCHOOL COMPLETED
CITIZENSHIP BY AGE

INCOME

FAMILY INCOME
INCOME BY OCCUPATION AND SEX
RATIO OF FAMILY INCOME TO POVERTY LEVEL

LABOR FORCE

EMPLOYMENT BY AGE
EMPLOYMENT BY OCCUPATION AND SEX
EMPLOYMENT BY INDUSTRY AND SEX

SOCIAL

AGE BY SEX
TYPE OF FAMILY
MARITAL STATUS

CENSUS OF HOUSING

OCCUPANCY

OCCUPANCY/VACANCY STATUS
NUMBER OF PERSONS IN UNIT
NUMBER OF PERSONS PER ROOM

EQUIPMENT

AIR CONDITIONING
TYPE OF HEATING FUEL
SOURCE OF WATER

STRUCTURAL

YEAR STRUCTURE BUILT
UNITS IN STRUCTURE
STORIES IN STRUCTURE

CENSUS OF RETAIL TRADE

NUMBER OF ESTABLISHMENTS
DOLLARS OF SALES

CENSUS OF SELECTED SERVICE INDUSTRIES

NUMBER OF ESTABLISHMENTS
RECEIPTS IN DOLLARS

CENSUS OF WHOLESALE TRADE

NUMBER OF ESTABLISHMENTS
DOLLARS OF SALES

CENSUS OF MANUFACTURES

NUMBER OF EMPLOYEES
VALUE ADDED

CENSUS OF AGRICULTURE

NUMBER OF ACRES IN FARMS
HARVESTED CROPLAND (ACRES)

INDUSTRIAL EXPANSION

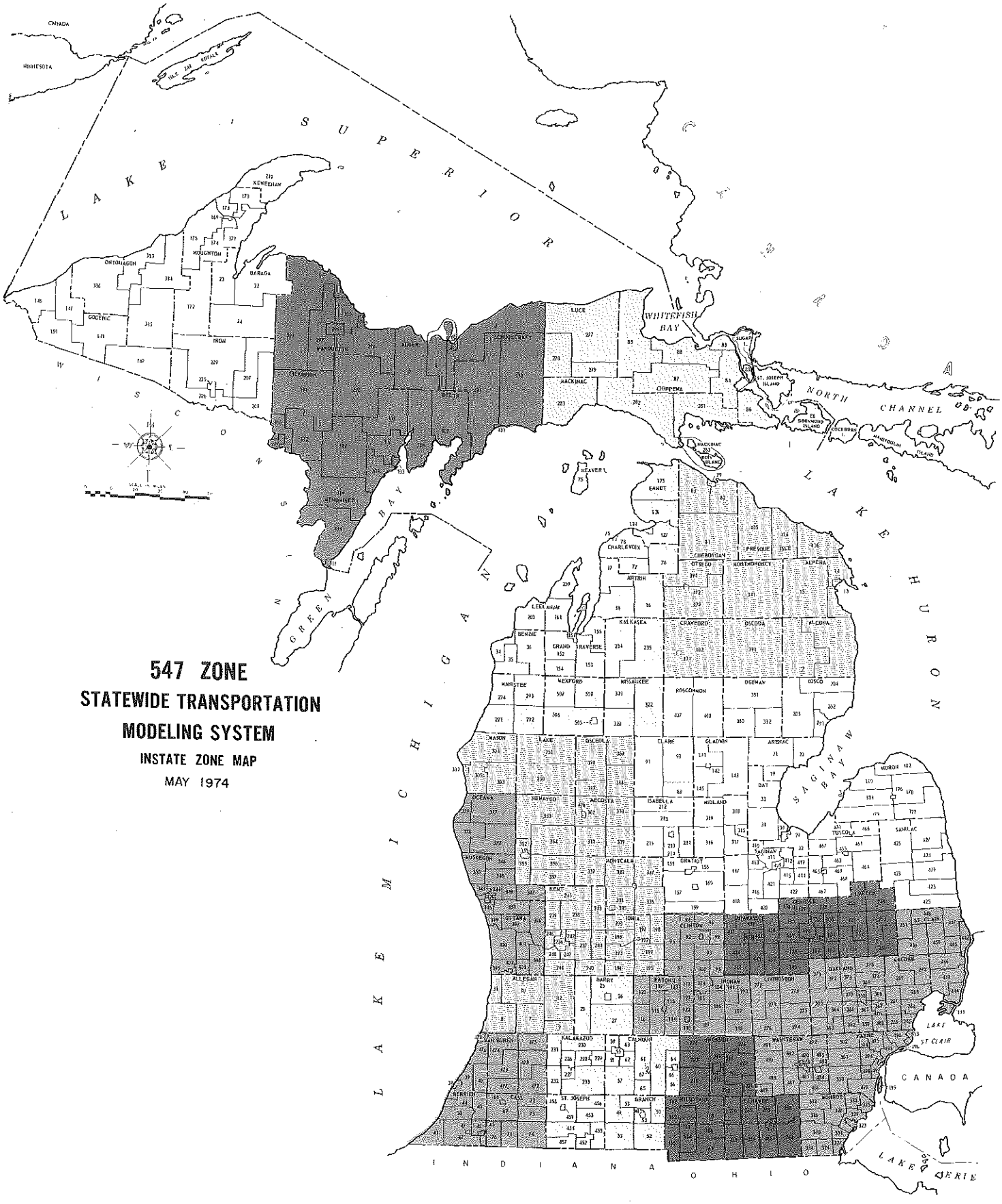
NUMBER OF EXPANSIONS
EMPLOYMENT CHANGE

*THOSE ITEMS LISTED HERE ARE SAMPLES TAKEN FROM THE COMPLETE FILE WHICH CONTAINS OVER 1000 ITEMS

STATEWIDE FACILITY FILE

AIRPORTS - 110
AMBULANCE SERVICE - 120
BUS TERMINALS - 130
CAMPGROUNDS, PUBLIC - 140
CAMPGROUNDS, PRIVATE - 142
CERTIFIED INDUSTRIAL PARKS - 150
CITIES OVER 30,000 POPULATION - 160
CITIES OVER 5,000 POPULATION - 170
CIVIL DEFENSE TERMINALS - 180
COLLEGES, NONPUBLIC - 190
COLLEGES, PUBLIC COMMUNITY - 200
COLLEGES AND UNIVERSITIES, PUBLIC 4-YEAR - 210
COMMERCIAL CENTERS, MAJOR - 212
CONVENTION CENTERS - 220
DENTISTS - 222
ELECTRICAL GENERATING PLANTS - 225
GAME AREAS - 230
GOLF COURSES - 240
GRAIN ELEVATORS - 243
HEALTH SCREENING CLINICS, EPSDT - 246
HIGH SCHOOLS - 250
HISTORIC SITES - 260
HOMES FOR THE AGED - 270
HORSEBACK ENTERPRISES - 277
HOSPITALS - 280
ICE ARENAS - 281
MANUFACTURERS - 300
MARINAS - 304
MENTAL HEALTH CENTERS - 310
NEWSPAPERS, DAILY - 320
NEWSPAPERS, WEEKLY AND BIWEEKLY - 330
NURSING HOMES - 340
OIL PROCESSING AND STORAGE PLANTS - 342
PHARMACIES - 344
PHYSICIANS - 345
POLICE DEPT'S, CITY - 346
POLICE DEPT'S, COUNTY - 347
POLICE DEPT'S, STATE - 348
POLICE DEPT'S, TOWNSHIP - 349
PORTS - 350
RAIL TERMINALS - 360
SECRETARY OF THE STATE OFFICES - 370
SEWAGE TREATMENT FACILITIES - 380
SKI RESORTS - 390
SNOWMOBILE TRAILS - 400
STATE PARKS - 410
TOURIST ATTRACTIONS - 430
TRAILER ON FLAT CAR TERMINALS - 433
TRANSIT SYSTEMS, BUS - 435
TREASURY OFFICES - 440
TRUCK TERMINALS - 450
UNEMPLOYMENT OFFICES - 460
VOCATIONAL REHABILITATION CENTERS - 465
WEATHER SERVICE STATIONS, NATIONAL - 470
WHOLESALE TRADE CENTERS - 480

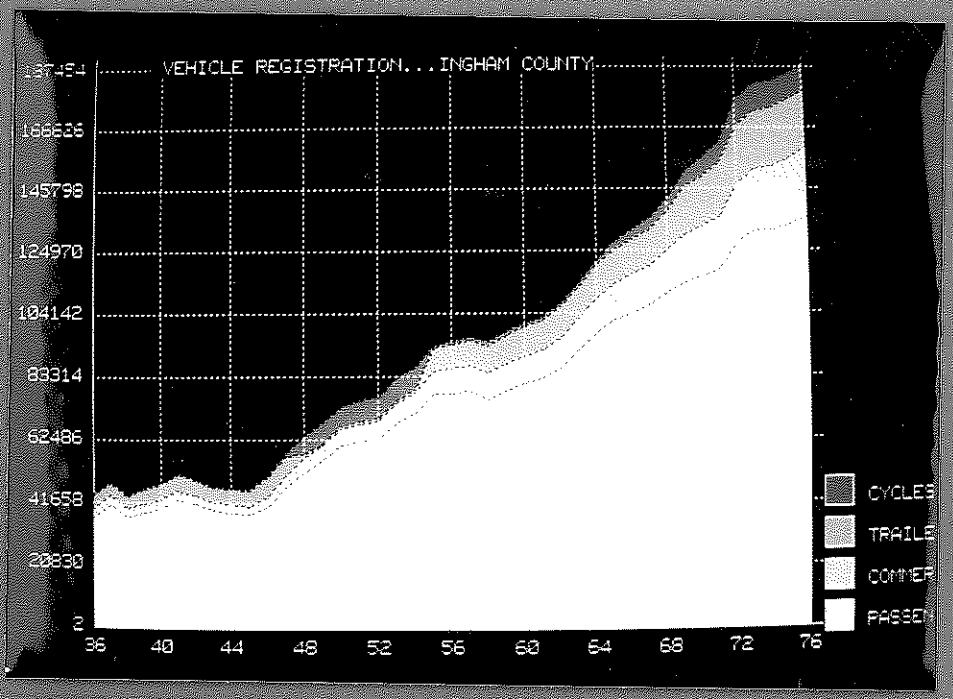
FIGURE 4


547 ZONE
STATEWIDE TRANSPORTATION
MODELING SYSTEM
INSTATE ZONE MAP
MAY 1974
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ST CLAIR
LAKE ERIE
CANADA
MINNESOTA
WISCONSIN
INDIANA
OHIO
GREEN BAY
SAGINAW BAY
NORTH CHANNEL
WHITEFISH BAY
MACKINAC
CHIPPEWA
LUCE
ONTONAGON
GOGEBIC
IRON
BARAGA
HOUGHTON
KEWEENAW
MARQUETTE
DICKINSON
MENOMINEE
DELTA
SCHOOLCRAFT
ALGER
EMMET
CHARLEVOIX
CHEBOYGAN
PRESQUE ISLE
OTSEGO
MONTMORENCY
ALPENA
ANTRIM
LEELANAU
BENZIE
GRAND TRAVERSE
KALKASKA
CRAWFORD
OSCODA
ALCONA
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
ARENAC
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
BAY
HURON
TUSCOLA
SANILAC
MUSKEGON
MONTCALM
GRATIOT
KENT
IONIA
SHIAWASSEE
GENESEE
ST CLAIR
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
MACOMB
OAKLAND
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
MONROE
VAN BUREN
ST JOSEPH
BRANCH
HILLSDALE
LENAWEE
BERRIEN
CASS

The following page illustrates three methods of displaying numerical data. The first picture displays vehicle registrations from 1936-1976 by vehicle type. This graphic tool is especially useful for line graphics when data sets may be accumulated, as with this data, or where succeeding lines have increasing data values (i.e. whenever the lines to be plotted do not cross each other). Much time series data could be clearly displayed in this way. Line graphs which may have crossing lines would have to be plotted slightly differently, resulting in only the lines being drawn in the selected colors instead of filling the area under each line with color.

The second picture shows the use of color for "pie" diagrams. These diagrams are especially useful to demonstrate proportional data such as highway needs information.

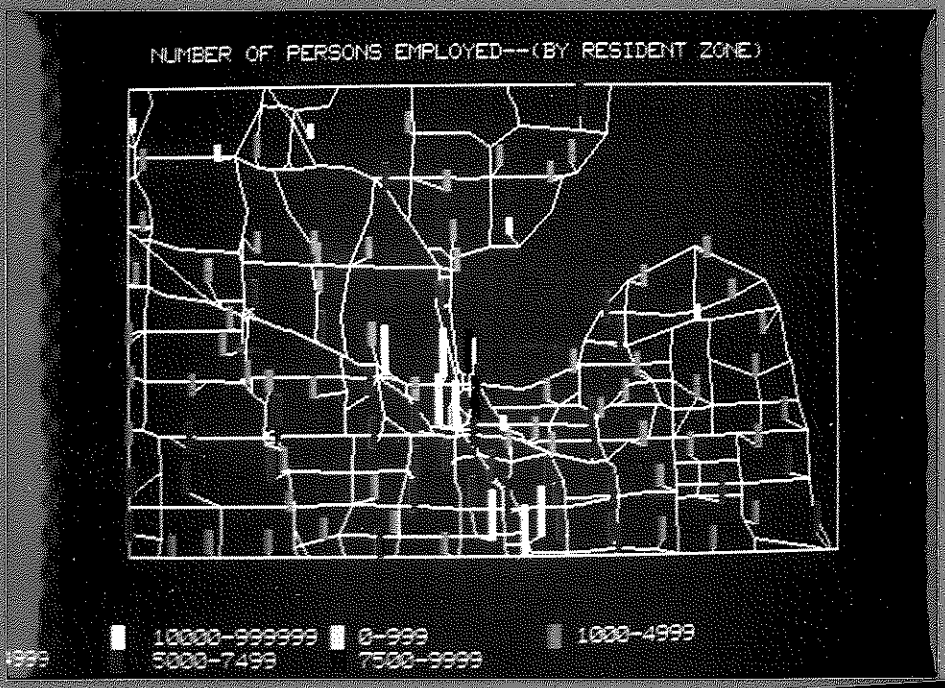
Data summarized to geographic areas may be displayed as shown in the third photograph. This picture depicts the number of persons below the poverty level, data selected from the 1970 census data and summarized to the 547 zone level. Zones (or areas) with 306 or fewer persons below the poverty level are shaded lightest, those with 839 or more are shaded darkest. This kind of information may be used in transit planning to document proposed programs.


VEHICLE REGISTRATION...INGHAM COUNTY
187454
166638
145798
124970
104142
83314
62486
41658
20830
2
36
40
44
48
52
56
60
64
68
72
76
CYCLES
TRAILS
COMMER
PASSEN


MICHIGAN HIGHWAY NEEDS---INGHAM COUNTY TRUNKLIN
82%
8%
ADMINISTRATION
(26534)
MAINTENANCE
(27774)
STOPGAP
(11460)
IDENTIFIED CONTSTRUC
(292444)

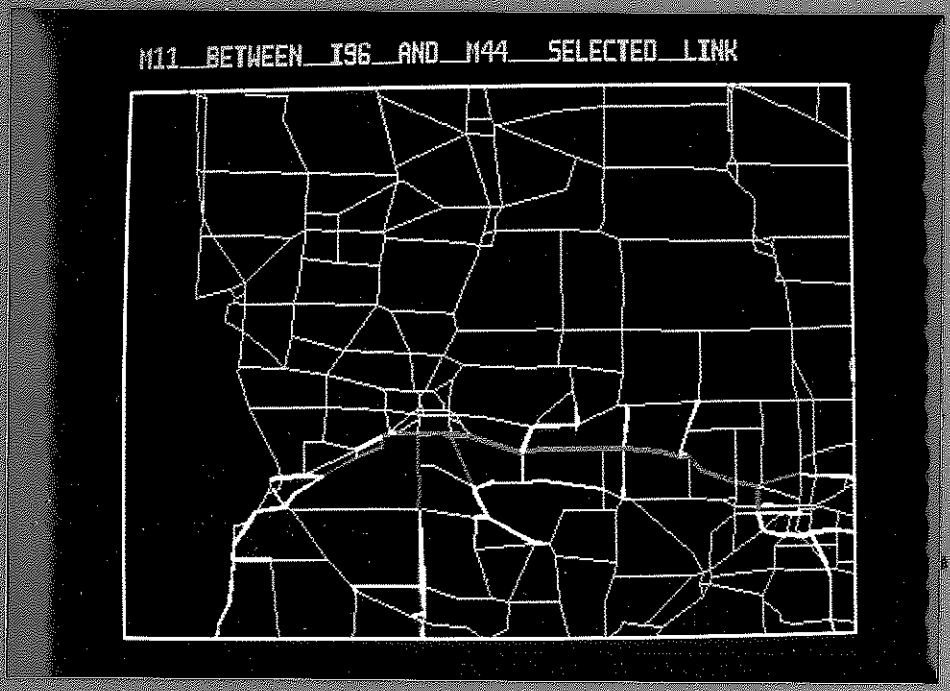

PERSONS BELOW POVERTY LEVEL
839. - 9817.
679. - 838.
560. - 678.
439. - 559.
307. - 438.
23. - 306.

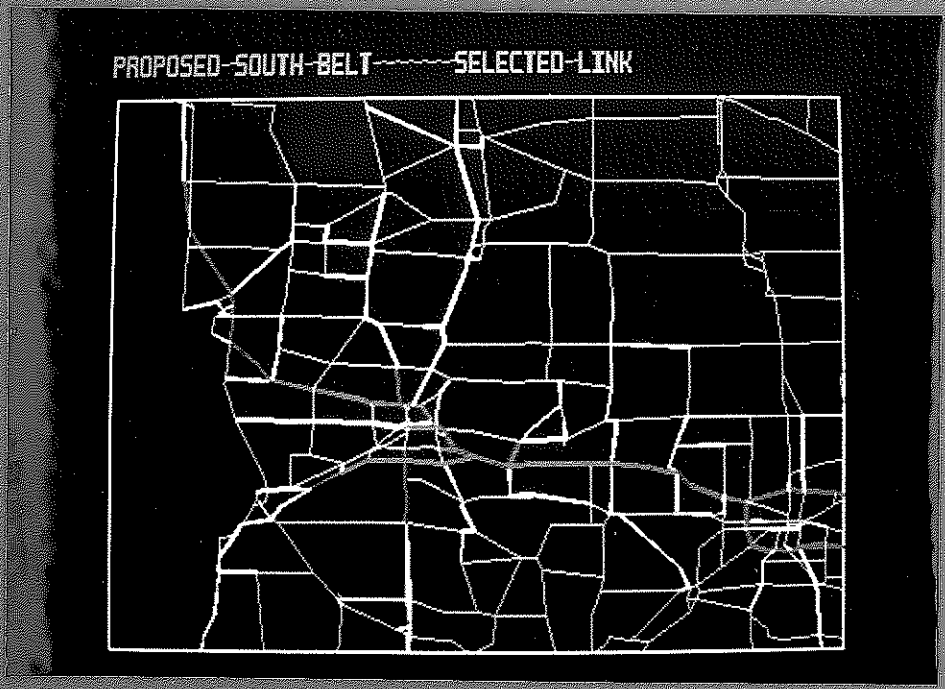
Geographically summarized data may also be displayed in conjunction with a highway network. The following page demonstrates this. Taller bars or larger circles, as well as different color shades (or totally different colors if desired) indicate the number of employed persons by zone of residence. Already existing software was used for this display with only minor changes to incorporate color. The descriptive legend was not automatically produced. The software could be changed easily to produce a neater legend automatically. Both diagrams utilized the network data and socio-economic data files.


NUMBER OF PERSONS EMPLOYED--(BY RESIDENT ZONE)
10000-999999
0-999
1000-4999
5000-7499
7500-9999

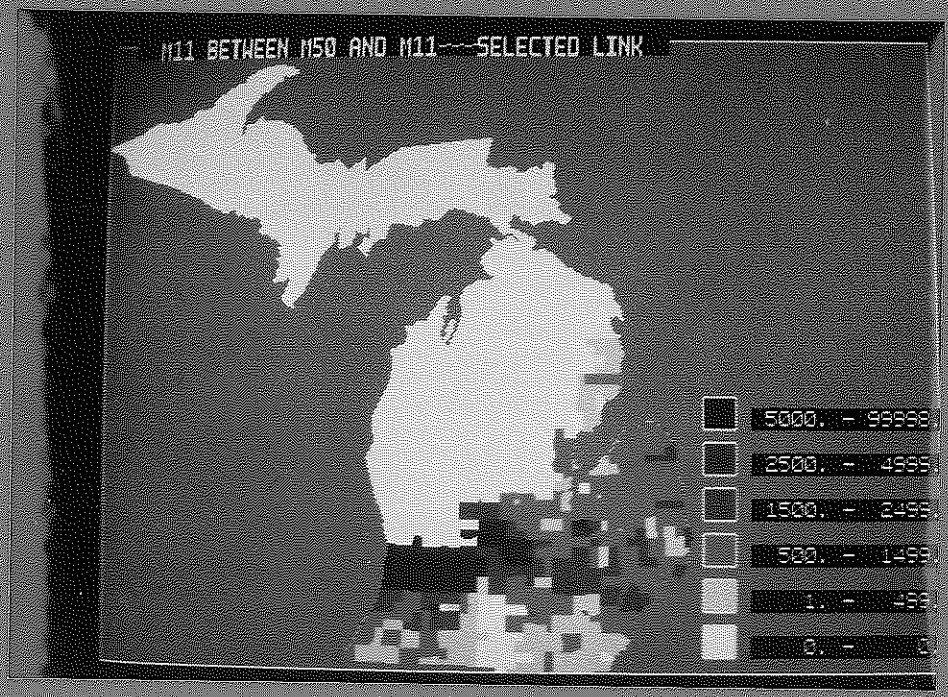

NUMBER OF PERSONS EMPLOYED (BY RESIDENT ZONE)
10000-999999
0-999
1000-4999

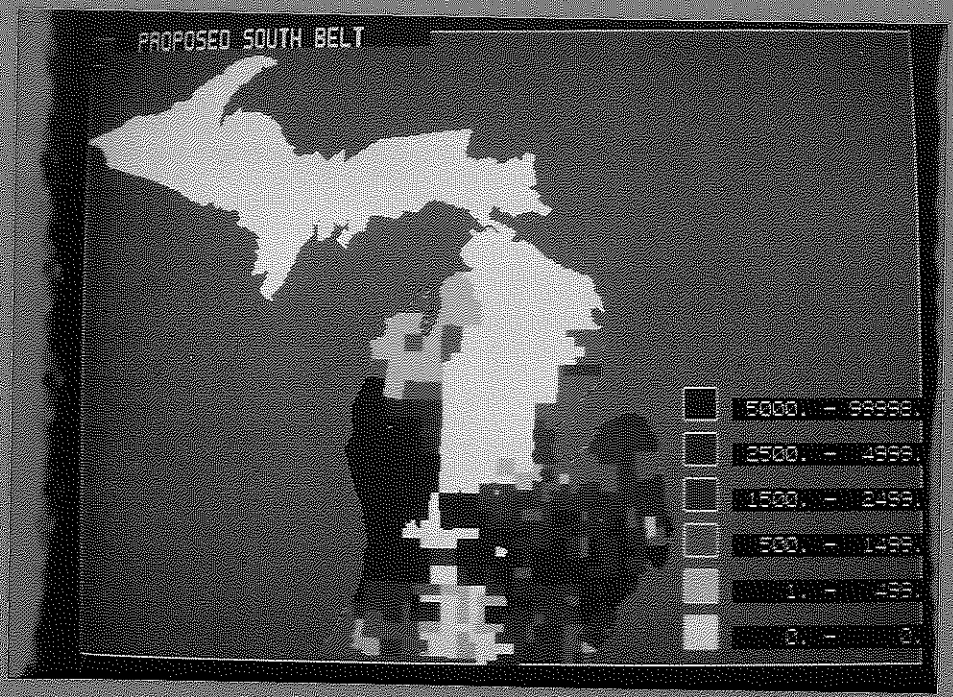
One phase of the state transportation modeling system allows the user to generate projected travel volumes for any selected link (a portion of road) which may be of special concern. The following page demonstrates these results in color for two different selected links. The first picture is a selected link on M-11 in southern Grand Rapids. The second link is on a proposed southbelt around Grand Rapids. Roads directly affected by the selected links are red, less directly affected roads are yellow, and all other roads are green. In this application, color enables analysts to quickly compare the service areas of these two roads and the level of significance they play in the trunkline system. Note also the letter style used here in comparison to the previous prints. Alternate letter styles are still in testing stages for use in these programs. This letter set was defined in less than half an hour and entered interactively. Future development should incorporate alternate letter styles as part of the automatic display.


M11 BETWEEN I96 AND M44 SELECTED LINK


PROPOSED-SOUTH-BELT------SELECTED-LINK

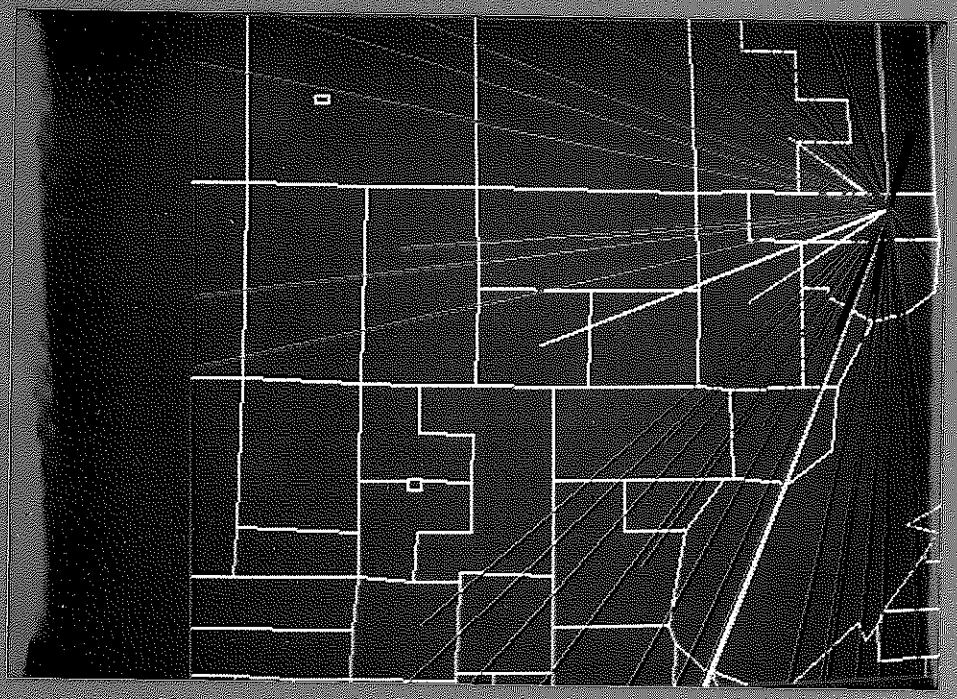
Another effective method of depicting the comparative traffic patterns of different roads is shown on the following page. The information needed for this display was the same as for the preceding page. Here, however, traffic was summarized to both the zone of trip origin and the zone of trip destination rather than actually assigned to the highway links. This display method shows geographical areas which would be heavily impacted by changes in a given section of highway rather than the highway sections which would be most affected. Again, color enables analysts to quickly grasp the major differences, especially when using varying shades of one color. This is an effective method of presenting travel data at public hearings.


M11 BETWEEN M50 AND M11---SELECTED LINK
5000. - 99999
2500. - 4999
1500. - 2499
500. - 1499
1. - 499
0. - 0


PROPOSED SOUTH BELT
5000. - 99999.
2500. - 4999.
1500. - 2499.
500. - 1499.
1. - 499.
0. - 0.

Another data source often used in conjunction with the statewide transportation modeling system is the major and minor origin-destination information. This is travel information collected by on-the-road surveys. The next two pictures graphically display information. Trips originating or terminating in zone 204 (the zone including Oscoda Air Force Base) are shown in the first figure. "Desire lines" radiate from Oscoda Air Force Base (origin/destination) and stop in the zone including the other end (destination/origin) of the trip. The software for this display was quickly revised from a black and white graphics program to include color (no legend has yet been added). Red lines, which are narrower than any other ones, depict the fewest trips while the three short and very thick black lines show the most frequent trip origin-destinations for trips generated by the Oscoda Air Force Base.

The lower figure on the following page shows the same data via shaded zone areas instead of colored "desire lines." Areas colored aqua are more "attractive" to Oscoda Air Force Base as shown by the larger frequency of trips between those zones and the zone containing the Oscoda Base. The area shaded orange is the zone containing the Air Force Base and the legend states that 30-99 trips begin and end in that zone. This diagram was produced, then all colors were changed to black. Five of the colors were then retrieved one by one. This was accomplished using one "learned key" for each color. This procedure may be used to assist in showing a progressive "building" process or even to facilitate the production of color separation plates for printing purposes.

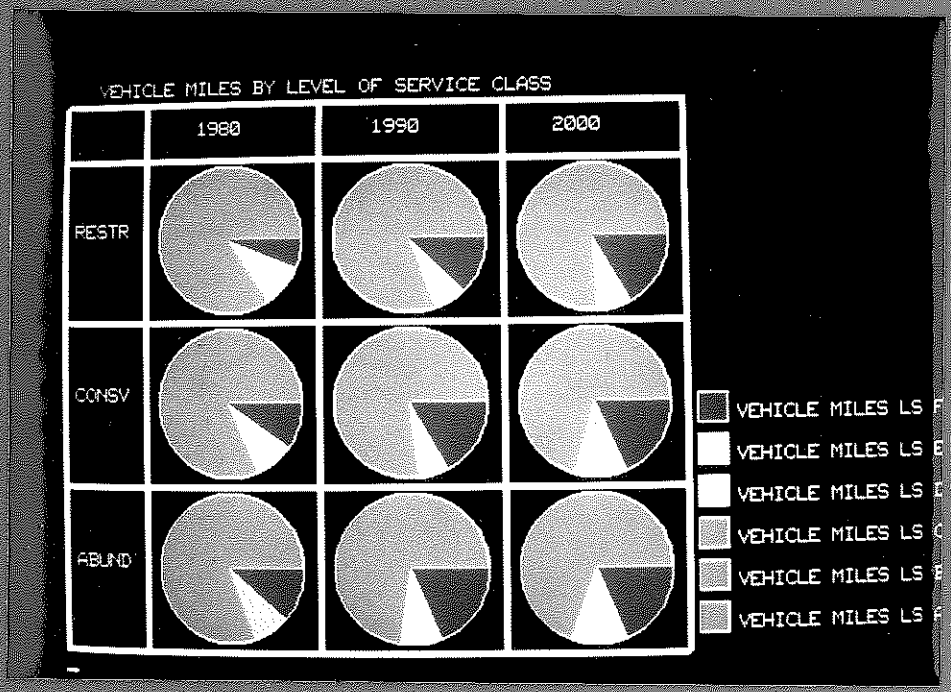


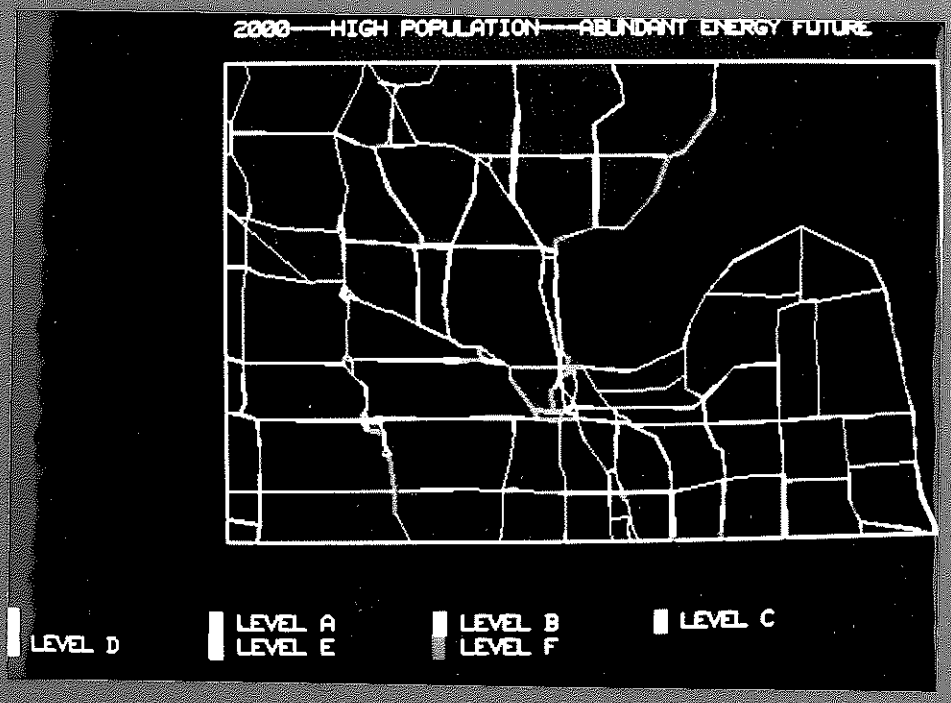

TRIPS FROM OSCODA AIR FORCE BASE
100. - 99999.
30. - 99.
20. - 29.
10. - 19.
1. - 9.
0. - 0.

The final four examples of the color graphics tools presented here depict data as generated by a recently developed process which assists in the measurement of population and energy impacts upon the multi-modal transportation needs. That process is described in detail in a report titled "Impact of Population and Energy on Transportation Needs - A Multi-Modal Approach," Volume XIII-D of the Statewide Series of reports. That process has been used with nine potential futures: three population projections and three energy futures. The three population projections used were: 1980 - low population, 1990 - medium population, and 2000 - high population. The energy futures selected were: abundant - readily available fuel at reasonable prices, conserved - higher priced fuel with moderate shortages, and restricted - expensive fuel with serious shortages. For each combination of population and energy, trips were projected by transportation mode and assigned to the corresponding networks.

The first figure on the following page summarizes one of the impacts upon the highway network. It depicts the number of vehicle miles projected for each of the nine futures by the Level of Service provided. Green is used to show the vehicle miles traveled on roads with a Level of Service "C" or better. Red shows vehicle miles traveled on roads with a Level of Service "F," and yellow shows vehicle miles on roads with Level of Service "D" or "E." The vehicle miles for any Level of Service vary from future to future much as would be expected. A department may quickly see how the magnitude of potential problem roads varies depending upon population and energy impacts.

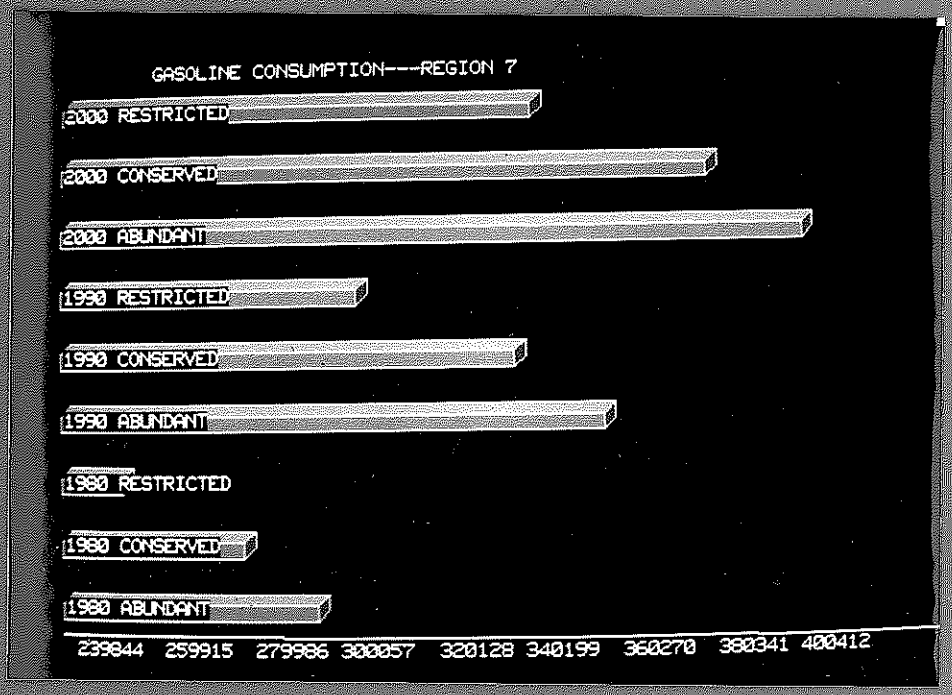
The second diagram displays a highway network for the energy and population future depicted in the lower right-hand corner of the preceding diagram. This highway network diagram includes all state trunkline roads in planning

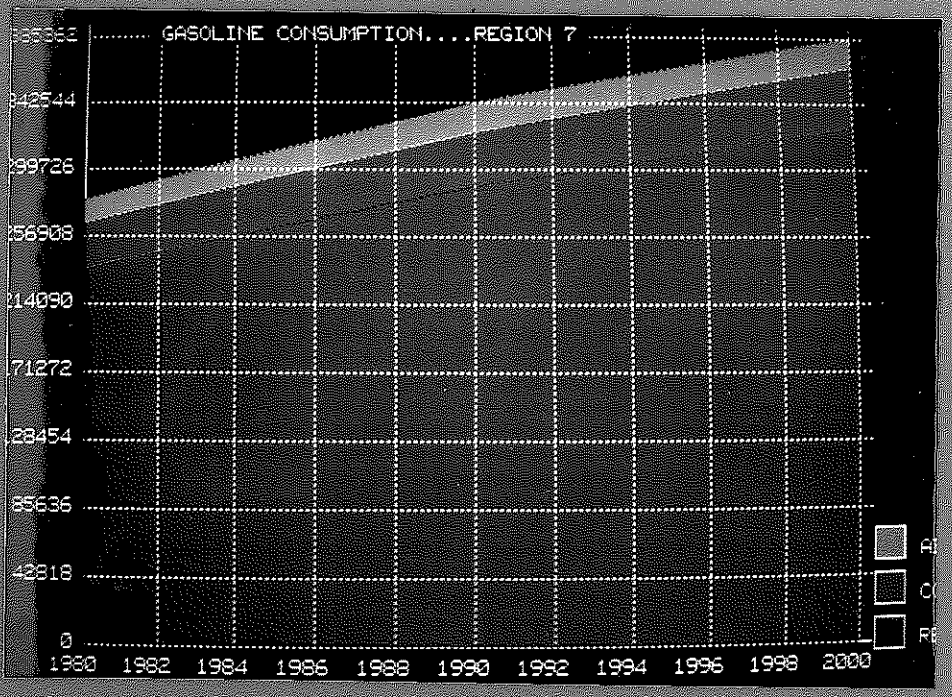

VEHICLE MILES BY LEVEL OF SERVICE CLASS
1980
1990
2000
RESTR
CONSV
ABUND
VEHICLE MILES LS F
VEHICLE MILES LS E
VEHICLE MILES LS D
VEHICLE MILES LS C
VEHICLE MILES LS B
VEHICLE MILES LS A


2000--HIGH POPULATION--ABUNDANT ENERGY FUTURE
LEVEL D
LEVEL A
LEVEL E
LEVEL B
LEVEL F
LEVEL C

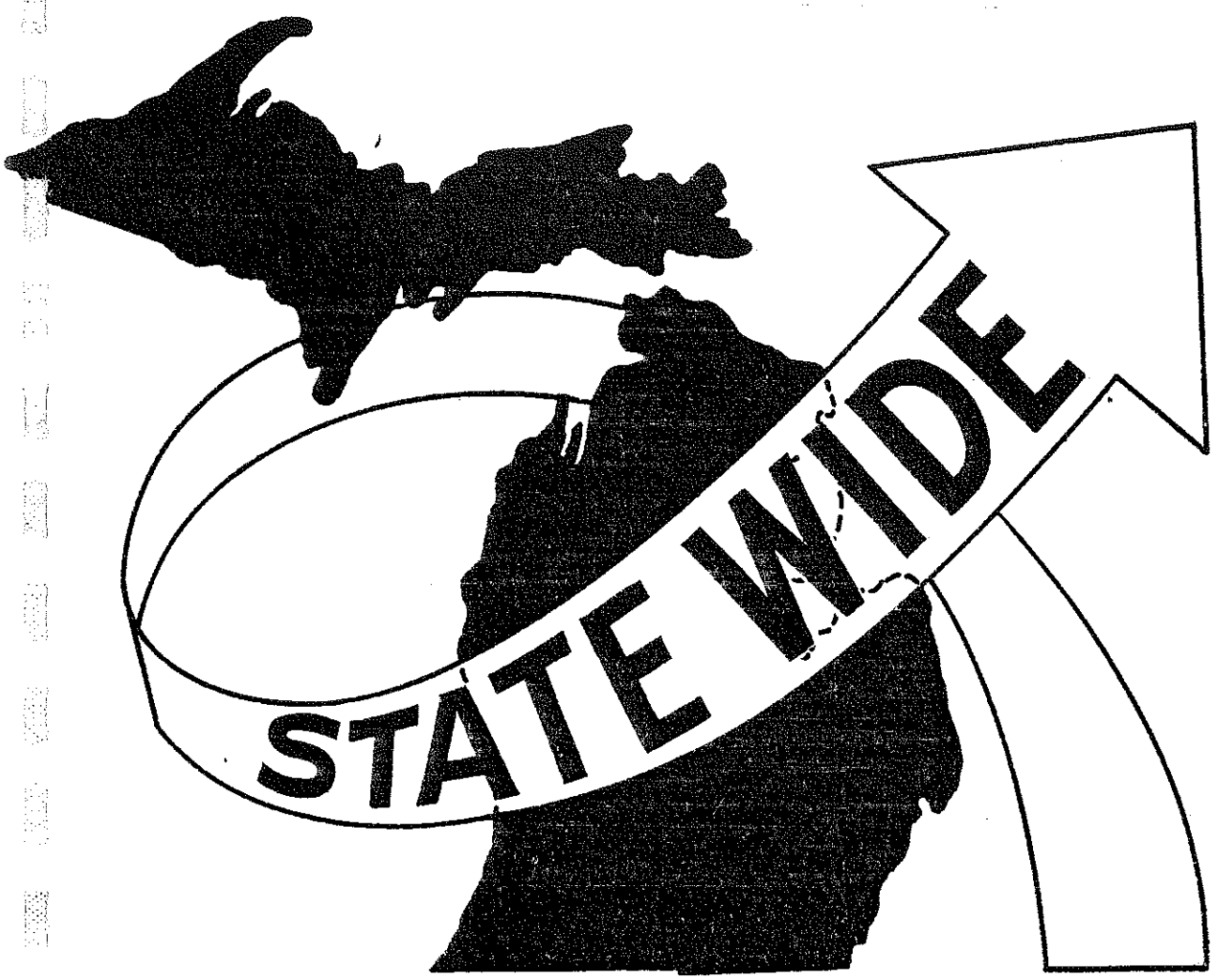
Region Seven. As the legend indicates, the colors used here correspond to those in the 9-pie diagram. Therefore, those roads in red are critical roads which should be seriously considered for improvement. If the same roads appear in red for all nine futures studied, money used to improve those roads would be well spent.

The final page of diagrams show two possible methods of depicting one economical impact based upon each of the nine futures. The first diagram shows potential gasoline consumption in Region Seven by future in the form of a bar graph. The second display uses a line graph to show the same data. The green line shows expected gasoline consumption given abundant energy, red depicts a conserved energy future, and blue indicates the restricted energy condition. It should be noted here that in these diagrams, no consideration was given to the EPA requirements pertaining to future miles per gallon. These requirements have since been included and causes the consumption estimates to decrease over time.


GASOLINE CONSUMPTION---REGION 7
2000 RESTRICTED
2000 CONSERVED
2000 ABUNDANT
1990 RESTRICTED
1990 CONSERVED
1990 ABUNDANT
1980 RESTRICTED
1980 CONSERVED
1980 ABUNDANT
239844 259915 279986 300057 320128 340199 360270 380341 400412


GASOLINE CONSUMPTION....REGION 7
342544
299726
256908
214090
171272
128454
85636
42818
0
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000

HARDWARE REQUIREMENTS



HARDWARE REQUIREMENTS

There are two basic "hardware" requirements for implementing a computerized system of color graphics. First, a Cathode Ray Tube (CRT) computer terminal capable of drawing in color is required; and, secondly, an agency should have equipment by which to obtain a color copy of the computer display. A third requirement is access to a computer which supports, preferably, a high level FORTRAN (programming language) compiler.

There are presently several color CRT's on the market. When selecting a color CRT, an agency should carefully consider screen size, resolution, and the number of colors simultaneously available. The screen should be large enough to display desired data effectively without need for oversimplification. High resolution is important both to provide more accurate maps and graphs and to produce clearer copies. A large range of available colors and/or patterns is also very helpful when complex diagrams or gradual shadings are desired. The ability to change colors both programmatically and locally is also very important to assist in selecting pleasing and meaningful color schemes. A method of "pointing" to a particular place on the screen and passing location and color information back to the host computer is also very useful. This usually is accomplished with a crosshair cursor or light pen. Screening colors (the ability to "erase" any or all colors in a given display) is helpful showing a progressive series of diagrams. This feature could also be used to facilitate the creation of color plates for printing purposes. Alphanumeric characters must be available to provide labeling and legend capabilities.

Different character sizes and styles are also a very desirable feature. The ability to locally create or modify displays would allow special, one-time applications to be handled with ease. Finally, available peripheral devices should be considered. Some of these devices are: a digital plotter; tape drives for storage of data or displays; and some type of hardcopy unit, most preferably a color copier. Another useful feature would be to provide some method for obtaining good quality slides. This may often be accomplished by merely photographing the screen, providing the CRT has high resolution. The prints in this report were made from slides produced in that fashion. It should be noted, however, that this process is rather time consuming and expensive with costs increasing rapidly as print size increases. Photographic reproduction is, therefore, ideal only when color slides are desired.

After obtaining a color CRT, the need for some kind of a color copier becomes evident. The CRT cannot easily be transported to each location where color presentations are desired, much less bound into reports. As already stated, photographic copies are not always ideal and any gray-scale copier would not utilize the color CRT capabilities. Some experimentation has been done by the department on the Xerox 6500 CGP which is a color copier that interfaces with a color CRT. It is capable of simultaneously reproducing eight colors and shades of those eight colors if they are "mixed" in patterns or half tones. After the initial high cost of the copier, copies are approximately 4-8¢ depending on volume per sheet and are made on standard paper or transparency material. The Xerox 6500 CGP can operate in the computer mode or independently as a xerographic color copier or in both modes simultaneously to produce composites. The growing market for such a copier suggests that soon many such color copiers may become available.

The examples used for this report were produced on a Tektronix 4027 color graphics terminal. This terminal allows the selection of up to eight colors from a 64-color palette for simultaneous display. The eight colors may also be paired in up to 120 different user-defined patterns or color combinations when "filling" polygons. This terminal allows the scrolling of graphics and alpha-numerics and includes firmware which simplifies programming and leads to more efficient memory use. The Tektronix 4027 allows graphic input via a crosshair cursor by which a user may communicate with the host computer. Special, user-definable character sets are possible. As the preceeding photographs indicate, resolution is sufficient to produce presentable copies. The Tektronix 4027 is also fully compatible with all other Tektronix terminals and peripheral devices.

Other color graphics terminals are also available, each with different features. When purchasing a color CRT, an agency should seriously consider possible uses, list all the features desired, and then choose the CRT most appropriate for the applications desired.

CONCLUSION

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Increased public involvement has caused new emphasis to be placed upon meaningful data presentations. Many types of data can be most easily depicted in color diagrams. Until recently, however, cost and preparation time for color graphics has been prohibitive. This report has demonstrated a method of producing color graphics quickly with the added benefit of easy modification and regeneration of the graphic displays. The examples in this report are merely meant to demonstrate potential uses. Other uses are definitely feasible as interest and needs dictate.

Michigan's new color process is directly connected to the statewide transportation modeling system and, therefore, is heavily application oriented. The integration of equipment with the transportation analysis system has enabled the department to utilize it very quickly for actual applications. Planning Region Seven has already obtained many color graphics for use in their public meetings. These graphics were produced with a drastic reduction in the graphics production time formerly required for similar displays. Color slides and prints were also very inexpensive in comparison to previous costs for producing color graphics.

While the color process discussed here cannot, nor should not, be expected to produce the color graphics needed for all future color presentations, it may realistically be used to display much of the data directly obtained from the statewide transportation modeling system. Furthermore, for both the applications demonstrated here and for many additional applications which may be desired, the cost and time required for color graphic productions strongly support the practicality of Michigan's color graphics system.