

Upper Ohio Valley Bridge System Study

Phase I Final Report

June 2000

Prepared for:

The Brooke-Hancock-Jefferson Metropolitan Planning Commission

Prepared By:

Pflum, Klausmeier & Gehrum Consultants, Inc.

In Conjunction With:

Burgess & Niple | Modjeski & Masters | Thrasher Engineering

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In cooperation with:

Ohio Department of Transportation
West Virginia Department of Transportation

Funding for this Study provided by the
Ohio Department of Transportation (ODOT)
and the West Virginia Department of Transportation (WVDOT)

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INTRODUCTION

This report summarizes the findings and conclusions drawn from Phase I of the Upper Ohio Valley Bridge System Study. This Study has been commissioned by the Brooke-Hancock-Jefferson Metropolitan Planning Commission (BHJ), which is the designated Metropolitan Planning Organization (MPO) for the Weirton/Steubenville metropolitan region. Funds for this Study have been provided by the Ohio Department of Transportation (ODOT) and the West Virginia Department of Transportation (WVDOT).

The purpose of the Phase I report is to analyze and determine the need for a new Ohio River bridge crossing within a defined study area, which extends from just north of the Fort Steuben Bridge at Steubenville, Ohio to a southern boundary delineated by the southern end of Brooke County, West Virginia. **Figure 1** illustrates the general location of the BHJ region. **Figure 2** illustrates the defined study area for this study.

This Study is an outgrowth of the BHJ *2020 Regional Transportation Plan* adopted in January of 1998. A new Ohio River crossing was identified as the top priority within the BHJ region in that Plan. Therefore, this Study was commissioned as a two-phase process, with Phase I directed towards confirming the purpose and need for a new river crossing. Assuming that a need can be confirmed, Phase II is to be directed towards identifying the best location for such a crossing. The appropriate location will be established through a process of technical analysis and consensus building among the various stakeholders in the region.

While a river crossing has been identified as the highest priority in the region, no funding for construction of such a crossing has yet been identified. This Study, once completed, will form a basis for pursuing project funding.

DEFINITION OF UPPER OHIO VALLEY BRIDGE SYSTEM

For the purpose of this Study, the Upper Ohio Valley Bridge System is defined as the three existing bridges currently located in the area, the access ramps and streets connecting to those bridges, and the principal arterial highways that are tied to the existing bridges.

The three existing bridges from north to south are the Fort Steuben Bridge, the Veterans Memorial Bridge, and the Market Street Bridge, as shown in **Figure 3**. The principal arterials are Ohio Rt. 7 and US 22 in Ohio and WV 2 and US 22 in West Virginia.

Current traffic volumes on the three bridges are as follows:

- Fort Steuben Bridge 5,000 ADT*
- Veterans Memorial Bridge 27,000 ADT
- Market Street Bridge 9,200 ADT

Traffic volumes on each of the three principal arterials peak in the general range of 21,000 to 23,000 vehicles per day, with volumes falling in the less urban areas. The volume on Ohio Rt. 7 is roughly

* Average Daily Traffic

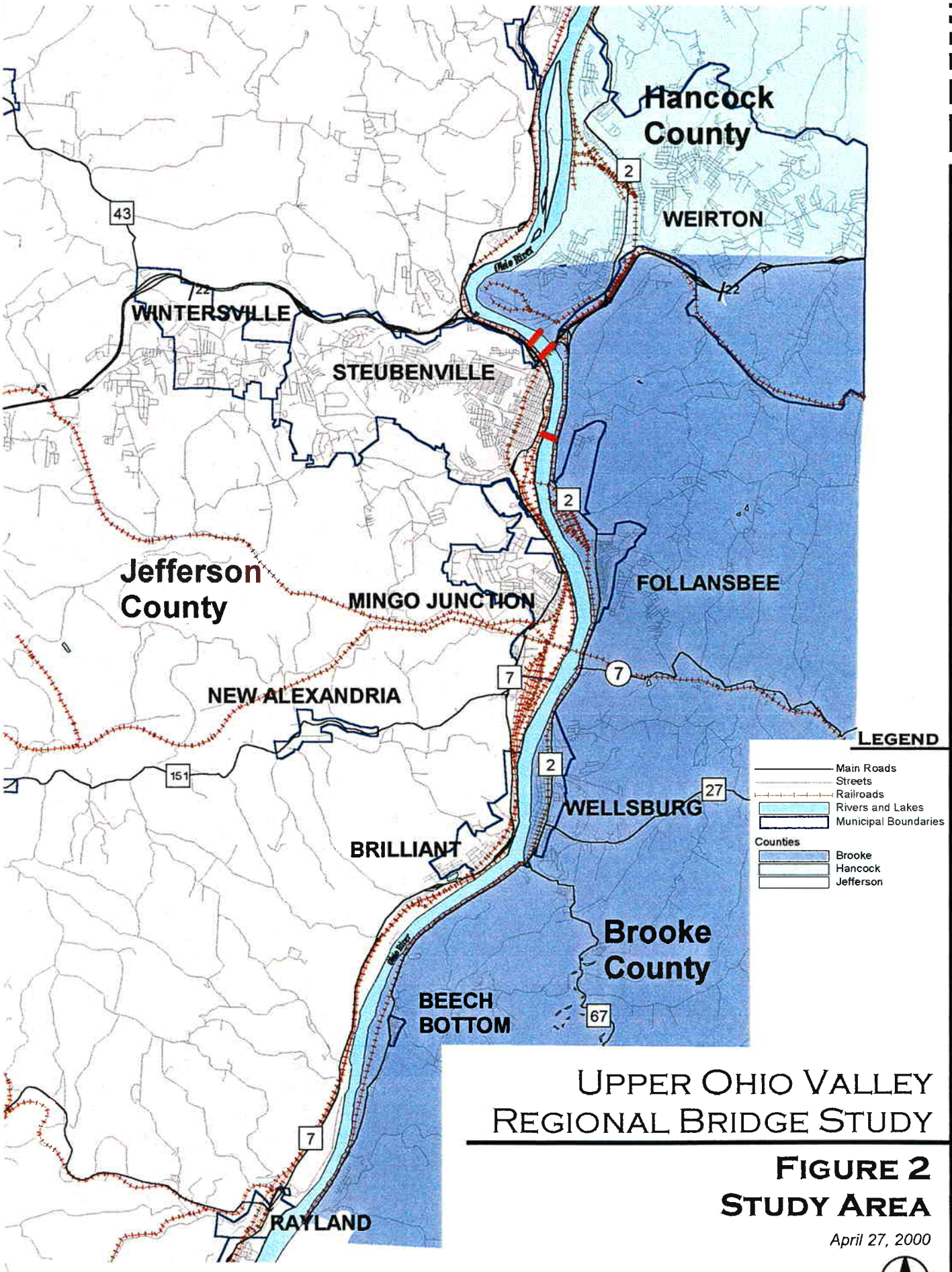
UPPER OHIO VALLEY REGIONAL BRIDGE STUDY

FIGURE 1
REGIONAL LOCATION

April 27, 2000

Pflum, Klausmeier & Gehrum Consultants, Inc.

20 0 20 40 60 Miles



UPPER OHIO VALLEY REGIONAL BRIDGE STUDY

FIGURE 2
STUDY AREA

April 27, 2000

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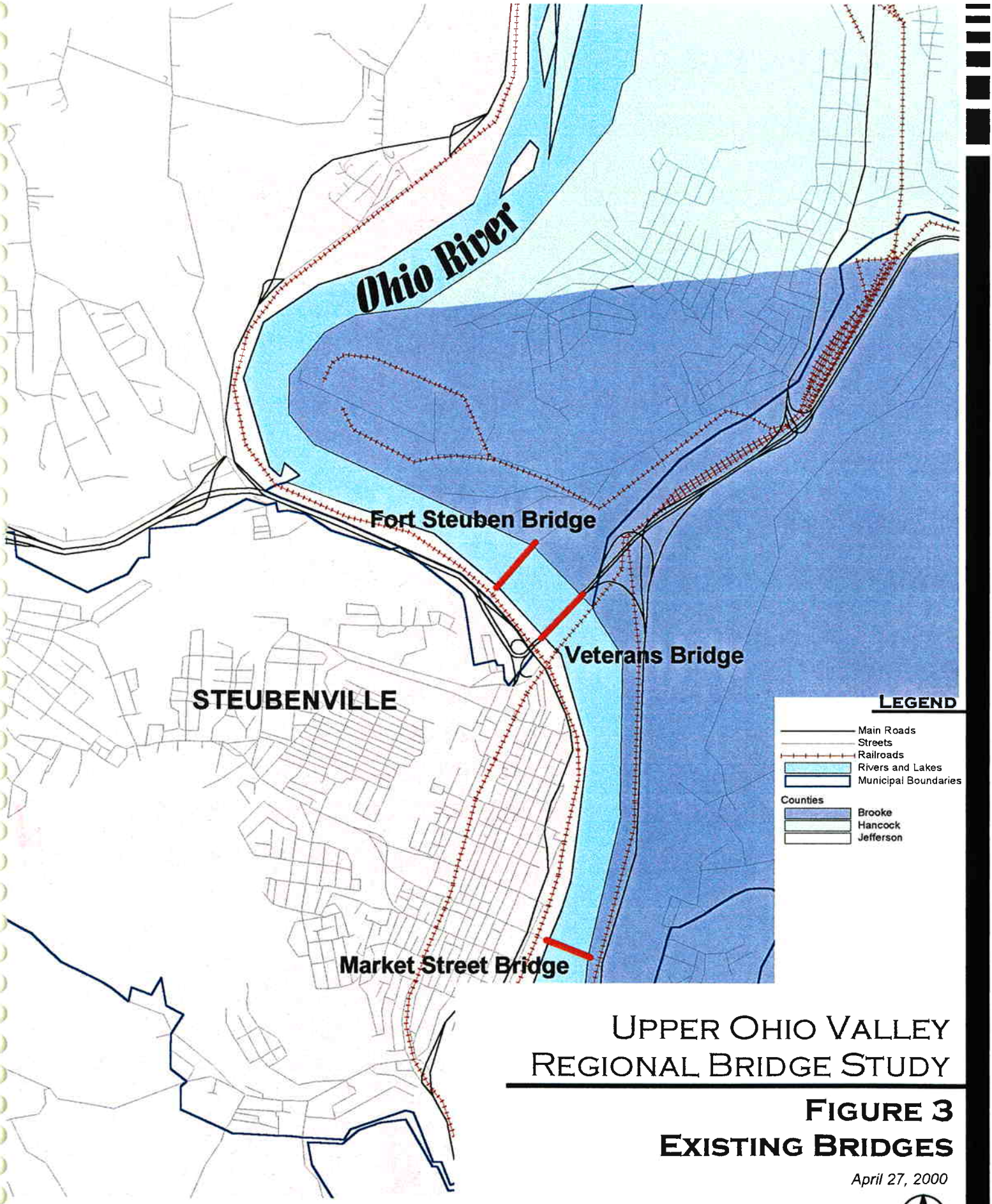
Source: BHJ-2020 Transportation Plan January 29,1998



UPPER OHIO VALLEY REGIONAL BRIDGE STUDY

FIGURE 3
EXISTING BRIDGES

April 27, 2000

Pflum, Klausmeier & Gehrum Consultants, Inc

Source: BHJ-2020 Transportation Plan January 29,1998

1000 0 1000 2000 3000 Feet

It should be noted that the closest river crossing points beyond the study area are at Wheeling, 25 miles south of Steubenville, and at East Liverpool, Ohio, 25 miles north of Steubenville.

CONCLUSIONS AND DETERMINATION OF NEED

Based on the foregoing technical analysis, as well as on the adopted goals established by the Advisory Committee for this project, the following conclusions have been reached. The conclusions and basis for a finding of need are delineated below and discussed in detail in the following text.

Conclusions

1. **The existing bridges can carry both current and projected traffic volumes.**
2. **Two of the three existing bridges (Market Street & Fort Steuben) are beyond their design life.**
3. **Both older bridges will require significant renovation to continue operating for any extended period of time.**
4. **Even with renovation abrupt closure of one or both older bridges is possible, if key structural components fail.**
5. **A situation with only one river crossing would create a major safety hazard.**
6. **The concentration of all river crossing capacity in a small geographic area limits flexibility within the system.**
7. **The adopted Goals and Objectives are not satisfied with any bridge out of service.**

Basis for Finding of Need

1. **The Impending Closure of Existing Crossing Capacity Will Cause Failures in the System.**
2. **The Existing System Lacks Flexibility and Redundancy in Travel Options.**

Discussion

The current bridge system in the Upper Ohio Valley study area now has the roadway capacity to handle both present and projected future river-crossing traffic volume. This fact notwithstanding, the bridge system does have a number of significant deficiencies that must be addressed. Addressing those deficiencies will require a reconfiguration of the system including both the construction of new bridge capacity and the closure of old.

Two of the three bridges that make up the system are well past their design life. These are the Market Street and Fort Steuben Bridges. While the investment of funds in added maintenance may extend their useful life, neither bridge can be brought up to modern standards due to inherent design constraints.

Moreover, investment of added maintenance dollars does not preclude the possibility of failure of key structural features that could bring about an abrupt closure of either bridge at any time over the coming years. The time is approaching when continued investment of funds into substandard structures no longer makes sense.

Due to the nature of commerce in the BHJ region, heavy truck traffic, both in weight and volume, is a normal component of river-crossing traffic. The Market Street Bridge will never be capable of supporting commercial truck traffic, regardless of the level of maintenance or refurbishment it receives. Thus, closure of the Fort Steuben Bridge would leave the region with only one crossing capable of carrying commercial truck traffic. Should both of the older bridges within the system be forced out of service, the BHJ region could be left with only a single river crossing for all traffic, that being the Veterans Memorial Bridge.

The Veterans Memorial Bridge has ample traffic capacity on the bridge itself; however, the access system is vulnerable to blockage due to accidents. The bridge itself is periodically closed due to inspection requirements. On these occasions, the two older bridges are not adequate to handle existing or projected future traffic volumes.

The concentration of all river-crossing capacity within a small geographic area constrains the overall flexibility of the transportation system in the region. Lengthy work travel times resulting from this lack of flexibility are a significant economic burden and a deterrent to new economic development. A large portion of the industrial capacity of the BHJ region is located in the Ohio River Valley south of the current crossing locations. There appears to be some additional potential for industrial development in this area of the valley; however, successful development is clearly predicated on adequate transportation access.

The transportation system in the Ohio River Valley is heavily dependent on the two north/south Principal Arterials: WV 2 and Ohio Rt. 7. When either of these is closed due to accidents, flooding, or landslides, as does happen on occasion, few alternative routes are available. River crossings, by linking these two routes, significantly increase the transportation options available in the region for normal transportation purposes as well as the delivery of emergency services.

Two primary arguments speak to the need for added river-crossing capacity.
First, the time period required to bring new river crossing capacity on line suggests that it is imperative that the process for doing so begin now, rather than waiting for key components of the present system to fail. A circumstance in which only one river-crossing point exists within the metropolitan area would create a hazard in relation to emergency situations that is unacceptable.

Secondly, the principles embodied in the goals of this Study call for expanded flexibility in the transportation system in the BHJ region. Added river-crossing capacity will be a key element in the achievement of these goals. Given the difficulty that the BHJ region has faced in remaining economically competitive over the last two decades, improving the infrastructure that supports economic development must be considered a top priority.

For these reasons it is recommended that this Study proceed to Phase II, the identification of an appropriate river crossing location(s).

PLANNING PROCESS

The planning process utilized in this Study involves technical analysis performed by the consulting team in cooperation with the staff of BHJ, and a two-tiered public involvement process to obtain local input. The public involvement process is described in the following section, while the results of the technical analysis are described elsewhere in this report. Work on Phase I of this Study commenced in October 1999. Phase II, if undertaken, is expected to require approximately 10 months.

PUBLIC INVOLVEMENT

Public involvement in this planning process has occurred on several levels. Most directly, it has occurred through a series of public meetings held during the process to explain the work program and solicit public input. The first of these was held at the Brooke County High School on November 17, 1999 to obtain initial public input on issues related to the Study. Participants were asked to identify and rank issues that they felt should be considered as part of this Study.

A second public meeting was held at the Jefferson Community College in Steubenville on March 15, 2000 to present the findings of the consultant's technical work and discuss preliminary conclusions. A third public meeting was held on May 3, 2000 at the Buckeye Local Middle School in Brilliant, Ohio to announce the final results of Phase I. Handouts used, tabulated results generated, and copies of sign in sheets from each of the public meetings are included in the Appendix of this report.

In addition to the public meetings, public input was solicited through a project web site that allowed direct communication with the consulting team. The web site included maps, meeting minutes, data, and key findings available for review by anyone who was interested. The web site address was widely distributed at public meetings and through newspaper articles to encourage use by the public.

To assist in identifying important local issues that should be considered in the Study, members of the consulting team conducted series of key person interviews at the outset of the planning process.

Most importantly, the consulting team met on a regular basis with a local Advisory Committee made up of representatives of local government, transportation users, local employers, and interested citizen groups. The Advisory Committee established and adopted goals for this planning effort, has reviewed the work product generated as the process has moved along, and generally provided the local touchstone that ensures that the results reflect local interests and perceptions.

PLANNING CONTEXT

Over the last thirty years, the BHJ region has been passing through a significant era of change; change tied to national economic trends. For many years, this area has been included as an important part of the nation's industrial heartland. Coal mining, electric power generation, various types of manufacturing, including steel

making, formed the core of the area's economy.

Throughout the United States, all of these industries have encountered changed circumstances. Coal mining declined in northern West Virginia, eastern Ohio, and western Pennsylvania as coalfields played out and clean air regulations reduced the market for the type of coal found in the region. Steel making and other types of manufacturing have increasingly faced stiff competition from overseas. Power generation, which also had been based on the supply of locally mined coal, has also suffered from changed circumstances due to the passage of clean air legislation.

Consequently, the economic core of the region has eroded over time. Employers, in an effort to remain competitive, have tended to replace labor force with technological improvements designed to increase productivity. Nevertheless, the manufacturing sector remains the heart of the economic base of the BHJ region.

While employment is lower than it once was, these jobs tend to pay high wages and remain a very important piece of the regional economy. Currently, the manufacturing base of the BHJ region is concentrated in the Ohio River Valley in a linear pattern extending south from the Weirton-Steubenville area. **Figure 4** indicates the location of manufacturing employment in the study area.

While manufacturing employment has declined, service and commercial employment in the region has increased, again reflecting the overall trend at the national level. These jobs have different geographic distribution, tending not to be located in the Ohio Valley. Rather they are found in growing retail areas on ridgetops, east of Weirton and west of Steubenville. **Figure 5** indicates the current distribution of commercial employment in the BHJ region.

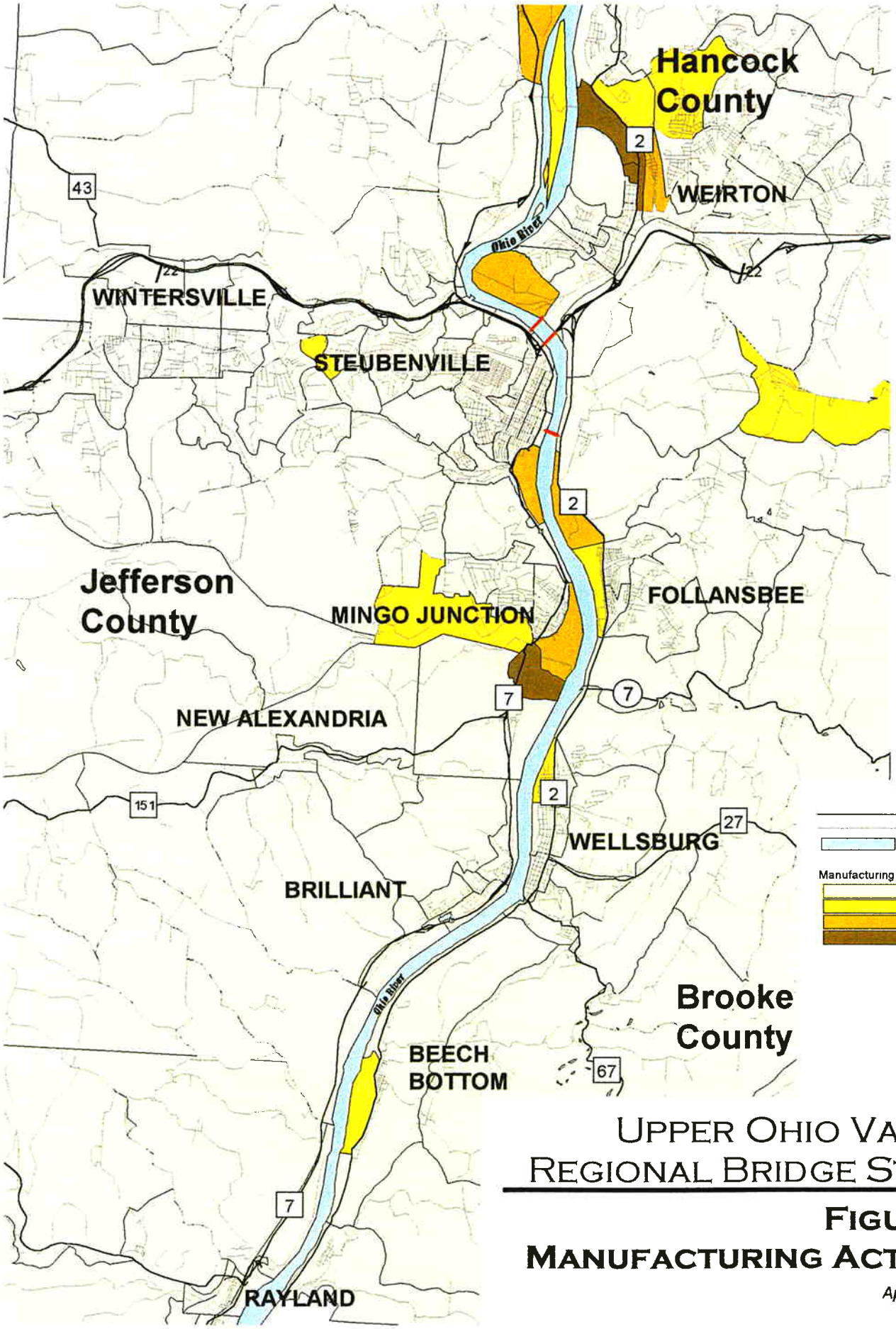
As employment has decreased in basic industries, the population characteristics of the region have changed as well. It is estimated that within the three-county BHJ region, population has declined by more than 30,000 persons since 1970, equivalent to roughly 18% of the area's 1970 population. The estimated population of the three-county BHJ region in the year 2000 was 135,966. **Figure 6** illustrates the current population distribution in the BHJ region.

The decline in population in the BHJ region has occurred disproportionately among younger age groups, meaning that over time, the region's population has grown older. While the trend towards an older population is prevalent throughout the United States, it has occurred more rapidly in the BHJ region. For these reasons, there is a very strong and understandable desire in the BHJ region to find ways to counter these trends and restore stability and even growth to the area's economic and population base.

Population and employment projections for the region tend to suggest, as projections usually do, the continuation of past trends. Projections should be seen as what they are, reliance on the past to predict the future. Planning, by its nature, is an effort to influence the course of events. As will be seen shortly, this planning effort is no different.

A prime example of this effort is the planning now underway by the State of West Virginia to improve WV 2, the principal arterial running north/south on the West Virginia side of the Ohio River Valley. This road is now a two-lane highway through much of its length.

Currently there are two major construction projects underway to widen sections of this route to four lanes, with plans in the works to widen the remaining sections in the future. The primary reasons for this project is need to correct safety problems caused by both roadway geometrics and landslides as well as the desire to improve the competitive position of towns along the West Virginia side of the Ohio River, including Follansbee, Wellsburg, Beech Bottom and others. In fact, this effort to improve WV 2 extends as far down river as the City of Parkersburg, more than 80 miles from Weirton.



UPPER OHIO VALLEY REGIONAL BRIDGE STUDY

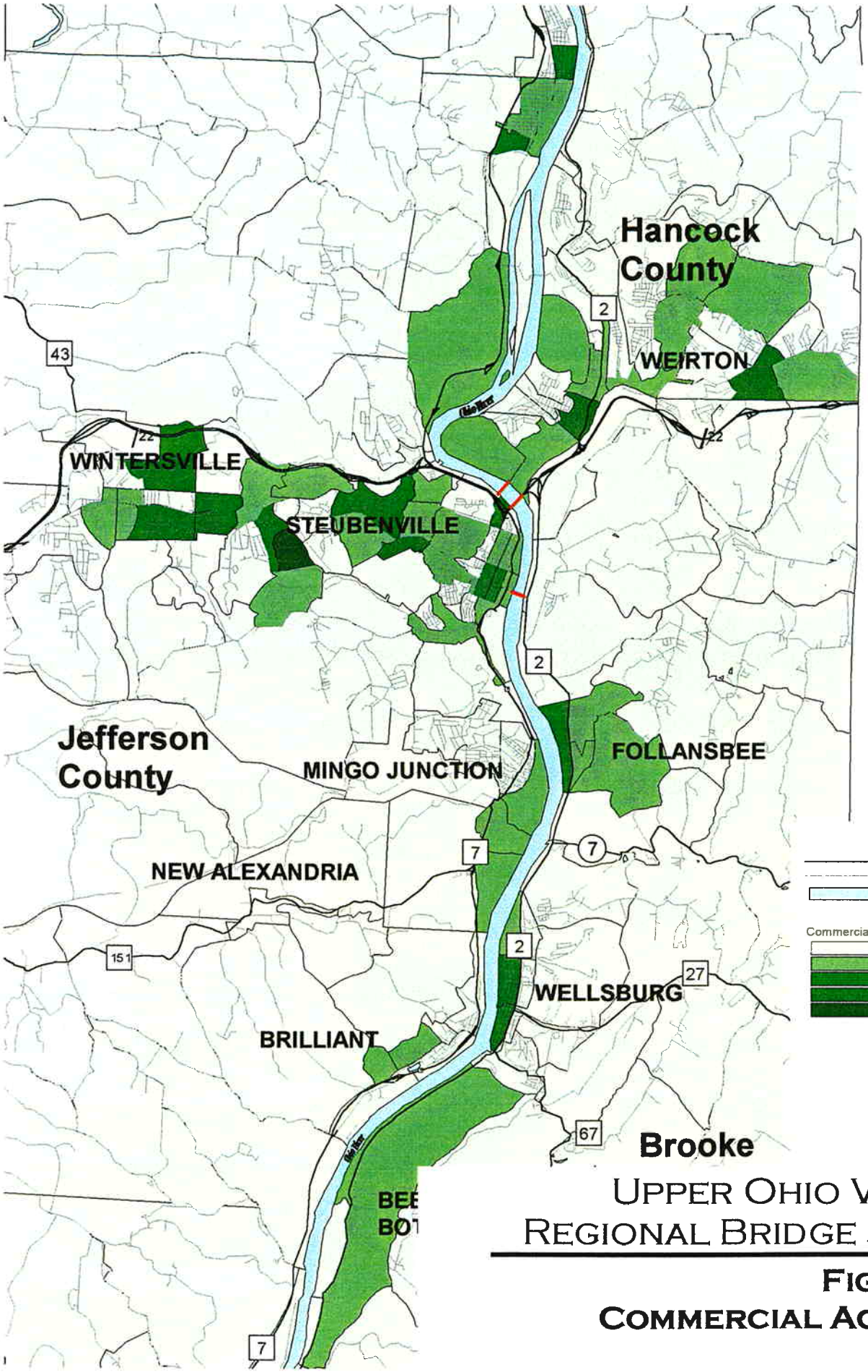
FIGURE 4
MANUFACTURING ACTIVITY

April 27, 2000

5000 0 5000 10000 15000 Feet

Pflum, Klausmeier & Gehrum Consultants, Inc

Source: BHJ-2020 Transportation Plan January 29,1998



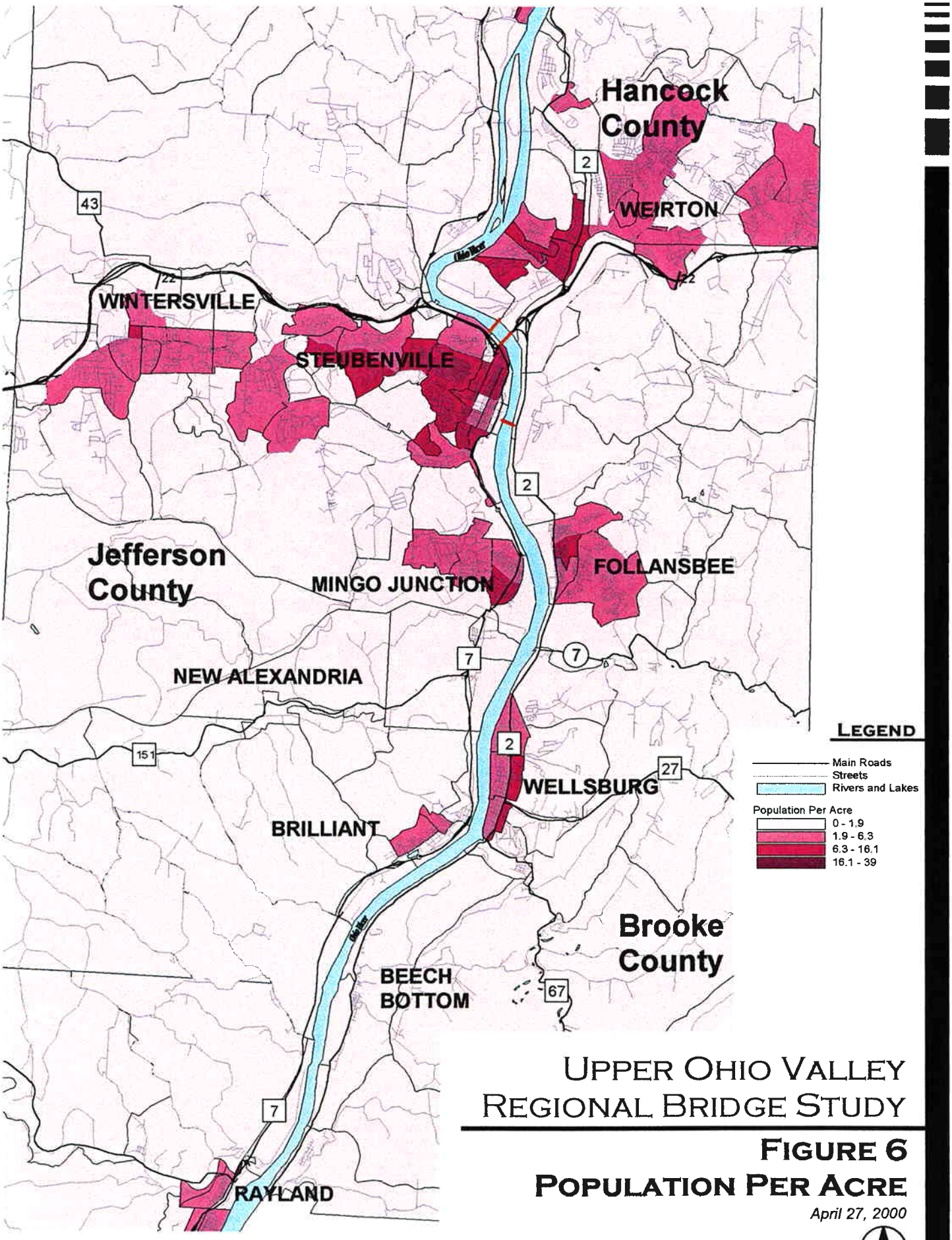
UPPER OHIO VALLEY REGIONAL BRIDGE STUDY

FIGURE 5
COMMERCIAL ACTIVITY

April 27, 2000

Pflum, Klausmeier & Gehrum Consultants, Inc

Source: BHJ 2020 Transportation Plan January 29,1998



UPPER OHIO VALLEY REGIONAL BRIDGE STUDY

FIGURE 6
POPULATION PER ACRE

April 27, 2000

Pflum, Klausmeier & Gehrum Consultants, Inc.

Source: BHJ-2020 Transportation Plan January 29,1998

ADOPTED GOALS AND OBJECTIVES

Based on input received at public meetings, interviews, and the local knowledge of Advisory Committee members, the following goals and objectives were adopted to guide the work performed on this study.

GOALS

1. **Maintain and enhance transportation capacity, safety and reliability for existing businesses, their employees, and all residents**

2. **Provide enhanced access for expansion and retention of businesses, and attraction of new businesses to the region**

3. **Draw more traffic and commerce into the Upper Ohio Valley**

4. **Develop linkages to high capacity inter-modal transportation by strengthening the connections to river ports and railroads**

5. **Enhance emergency management options to provide alternative routes in case of flood, natural disaster or accident**

6. **Improve travel times throughout the region**

7. **Ensure that the cross-river transport network from Wheeling north to Steubenville is sufficiently robust to carry all weights and sizes of commercial vehicles**

OBJECTIVES

Goal #1 *- Maintain and enhance transportation capacity, safety and reliability for existing businesses, their employees, and all residents*

- Provide alternative and redundant routes for truck traffic
- Alleviate congestion and maintain an acceptable minimum Level of Service (LOS) to enhance shipment of goods and movement of employees
- Accurately measure constraints of roadways and strive to upgrade river crossings and connecting roadways to at least current minimum standards for geometry

Goal #2 *- Provide enhanced access for expansion and retention of businesses, and attraction of new businesses to the region*

- Evaluate transportation improvements and alternatives for their ability to serve existing and potential future development sites
- Evaluate transportation improvements that can better tie together the BHJ region with adjacent economic market areas
- Prioritize improvements in transportation facilities and cross-river travel that can serve targeted economic development objectives for the BHJ region

***Goal#3** - Draw more traffic and commerce into the Upper Ohio Valley*

- Develop transportation system improvements that will provide greater interconnection with surrounding regions, states, municipalities, and marketplaces
- Build an efficient and effective transportation network that will become a regional strength and draw additional traffic and customers into the Steubenville-Weirton marketplace

***Goal #4** - Develop linkages to high capacity inter-modal transportation by strengthening the connections to river ports and railroads*

- Consider access to rail and river port facilities as a locational criteria for transportation improvements and cross-river travel routes

***Goal #5** - Enhance Emergency Management Options to Provide Alternative Routes in Case of Flood, Natural Disaster or Accident*

- Redundancy of the transportation network and cross-river linkages during times of accident, flooding or other natural disaster should be a planning criteria for new major investments in infrastructure
- Roadway design standards for new travel facilities should account for the weight and size of vehicles expected to travel during times of emergency and at all other times

***Goal #6** - Improve travel times throughout the region*

- Establish minimum desirable Levels of Service and adequate standards for roadway and bridge design
- Establish time of travel as a critical planning criteria for prioritizing capital improvements

***Goal #7** - Ensure that the cross-river transport network from Wheeling north to Steubenville is sufficiently robust to carry all weights and sizes of commercial vehicles*

- Establish planning criteria for the larger tri-state region in concert with the states of Ohio, West Virginia, and Pennsylvania to ensure that improvements in the Steubenville-Weirton area help enhance and optimize the larger transportation network for all modes

BRIDGE CONDITION ANALYSIS

MARKET STREET BRIDGE

Description

The Market Street Bridge spans over the Ohio River at Steubenville, Ohio, and is approximately 1,800 feet long. The West Virginia Department of Transportation is responsible for maintaining the bridge. It consists of two girder-approach spans (32 feet each), three through-truss spans (112 feet each) and a suspension bridge (324 feet, 700 feet, 274 feet) to span over the main river channel. The cross-section includes a two-lane roadway and a pedestrian walkway. The roadway carries an average of 9,200 vehicles per day based on Ohio Department of Transportation traffic data. The west end of the bridge extends into downtown Steubenville.

History

The original structure was erected in 1904 and was designed to carry two lanes of traffic and/or trolleys. Several rehabilitation projects have occurred to the bridge during its history.

In 1941, the original timber deck was removed and replaced with a "Neeld" floor and steel plate sidewalk. In addition, the cable anchors were modified, the stiffening trusses were replaced, and the towers were reinforced as part of the rehabilitation.

In 1953, the Neeld floor system was replaced with a 5-inch, I-Beam-Lok (open grid-type) floor, and the truss system was strengthened.

In 1981, a $5 million rehabilitation was performed on the Bridge. A new open-grid deck floor was installed, the majority of the floor stringers were replaced, floor beams were strengthened, a new roadway lighting system installed, and the entire Bridge was repainted. The cross bracing in the suspension span towers was also modified. Repairs to Pier Nos. 2, 3, and 4 were made as well as Bent Nos. 5, 6, and 7.

Condition Evaluation

The most recent inspection reports (1991 and 1995) were reviewed to determine the condition of the structure.

The Bridge is currently posted for 5 tons based upon information provided in the 1995 Interim Inspection Report. The 1981 rehabilitation increased the rating from 3 tons to 15 tons. At some point after the 1981 work, the Bridge was re-analyzed, and it was determined that the holes in the suspension span towers (to accommodate the pedestrian walkway) reduced the rating to its current 5 tons. This low posting limits the structure to automobile and light truck traffic.

The roadway width is 20'-8", which does not meet current roadway geometric standards for lane and shoulder requirements. Widening of the Bridge would not be feasible because of the width limitations imposed by the suspension span stiffening trusses.

The stringers and floor beams are in fair condition, a result of the open-grid deck permitting debris to accumulate on these members. The fracture-critical main cables rub against the stiffening trusses, resulting

in excessive wear. The pin-connected eyebars used for the stiffening truss bottom chords and the main cable anchorages exhibit pack rust and section loss.

Department of Transportation Survey

As part of this Study, Modjeski & Masters, Inc. contacted the West Virginia Department of Transportation to discuss the history, current condition, and future plans for the Market Street Bridge. District personnel confirmed the past work indicated above had been performed on the Bridge. They would like to increase the current posted rating from the current 5 tons to a 15-ton rating. Although no repair contracts have been planned for the immediate future, $800,000 has been placed in a reserve account for renovation of the Bridge. It is anticipated that a contract would not be issued until at least 2003/2004. The Bridge is not considered historic, so funding is not available from that source.

Site Visit

As part of the Bridge assessment, a site visit was conducted on Tuesday, January 18, 2000, to gain familiarity with the structure prior to providing a summary on its condition. A brief meeting at Brooke-Hancock-Jefferson Metropolitan Planning Commission's (BHJ) offices was held with representatives from both the BHJ and the West Virginia Department of Transportation prior to the site visit to discuss the current condition of the Bridge. The Bridge was walked from end-to-end using the pedestrian walkway on the downstream side. Observations of the Bridge's existing condition were limited to those areas visible from the walkway. The following is a summary of that visit:

- The steel open-grid roadway deck is in good condition, although rounding of the skid-resistant grooves in the main support bars was noted.

- The hole in the main tower to permit pedestrian access, and which supposedly controls the structure rating, was viewed. It appears as though the hole is in the fascia plate only, which is connected with tack welds to the main tower columns.

- The main cables touch the stiffening truss at the main span centerline. Portions of the stiffening truss have been coped out to relieve interference.

- The paint system is in fair condition, although the primer is beginning to bleed through.

- A significant amount of automobile traffic was noted crossing the Bridge during the visit both into and out of Steubenville.

Recommended Repairs

Significant rehabilitation of the existing structure would be required in order to meet today's traffic load demands. If rehabilitation were to be considered a viable alternative for the Bridge, the following items, at a minimum, would be included:

- Strengthen the suspension span towers to increase the Bridge's rating to 15 tons.
- Repair welded details used for previous repairs.
- Remove pack rust and repaint the towers.
- Strengthen to permit emergency vehicles (for example, fire trucks) to safely cross the structure.
- Retrofit suspected fatigue-prone field welds used on the stiffening trusses during previous renovations.
- Retrofit the stiffening truss to eliminate interference with the main cables.
- Inspect and repair main cable and suspender ropes. Clean and re-caulk cable bands.
- Contain, clean, prime and repaint the (suspected) lead-based paint system on the towers and superstructure.
- Perform concrete repairs (shotcrete/epoxy injection) to Abutment No. 2 and the Ohio Anchorage.

Cost Estimate

As part of this Phase One Study, a cost estimate was developed based upon the repairs noted above. These cost estimates were based upon information provided in the inspection reports and the Department survey only. Contract plans were not available for determining repair quantities. This estimate is based solely on the limited sketches and photographs provided in the inspection reports. The costs included in this estimate are based upon repairs that will extend the service life of the Bridge minimally. Its load-carrying capacity will be slightly improved, but the deficient roadway geometrics will not be improved. The estimated cost of maintenance rehabilitation for the Market Street Bridge is $5.6 million. A detailed cost estimate is included in the Appendix of this report.

Summary

Given the age of the Market Street Bridge, the remaining service life is nearing its end. Rehabilitation will slow its rate of deterioration, but the Bridge will remain deficient in terms of both roadway geometrics and load-carrying capacity. With a structure of this type and age, concerns will continue to exist over the integrity of the main cables, cable anchorages and the supporting piers. The costs included in the estimate do not account for these unknowns. The current funding reserve for future repairs will not be sufficient to extend its service life for the long-term. The Owner will have difficulty securing additional repair funds, given the age, condition and structural capacity of the Bridge.

FORT STEUBEN BRIDGE

Description

The Fort Steuben Bridge spans over the Ohio River just north of Steubenville, Ohio, and is approximately 1,585 feet long. The Ohio Department of Transportation is responsible for maintenance of the structure. It consists of four-deck girder approach spans (60 to 90 feet in length each) and a suspension bridge (283-, 688- and 283-foot spans) that crosses over the main river channel. The cross-section includes two traffic lanes and a pedestrian walkway. The roadway carries an average of 6,000 vehicles per day (1996), of which approximately 17% is heavy truck traffic.

History

The original structure was erected in 1928.

In 1972, the Bridge underwent a major rehabilitation during which many fatigue-prone weld details were used to connect strengthening plates to various truss chords and diagonals. Review of inspection reports indicates that no cracks were found in the welds, strengthening plates, or base metal of any of the fatigue-prone details, with the exception of the suspender rope protection beams. It is suspected that the repaired members were in service (under load) when the strengthening plates were added.

In addition, the deck was replaced with a 4-1/4 -inch concrete-filled steel-grid deck. In order to accommodate the new deck, the existing stringers were re-spaced, and a new centerline stringer was added. During this time, the superstructure was painted.

In 1986, the entire structure was painted again, and in 1996, the cable-related portions, which include the main suspension cables, suspenders, spreader brackets, and suspender sockets, were painted.

In 1992, a high performance rubberized asphalt wearing surface was installed.

In 1998, emergency repairs were performed to the approach girder bearings.

Condition Evaluation

Currently, this structure is appraised to be in poor condition. Deterioration of the suspension-span stringers, caused by leaking deck deflection joints, governs the appraisal rating. The Level of Service is low because of the narrow roadway and the fact that the bridge terminates into a T-intersection on the Ohio side of the structure.

The bridge is currently not posted, but is limited to 100-percent of the Ohio legal loads at the operating level of stress. Permit loads are not permitted on the structure.

The wearing surface of the suspended span is in poor condition and requires resurfacing. Inadequate stiffening of the steel grid and patching of holes was indicated in the inspection reports. Other floor system components, which include the concrete-filled grid deck, curbs, sidewalk, railing, deck joints and drainage scuppers, are in fair to good condition with some deficiencies. The original stringers that were repositioned resulted in additional holes in the floorbeams, thus

reducing the load-carrying capacity of the member and increasing the areas for potential corrosion to occur.

The structural metalwork of the approach girders, stiffening truss, floor beams, and towers are in fair to good condition. Rating values were not provided; therefore, areas of overstress could not be assessed.

Main cables, suspenders, cable bands, and anchor chain are in fair to good condition. Typical pack rust at the eyebar interfaces and missing caulk along the bottom of the anchor chain is common.

Substructure items, which include the abutments and piers, are in fair to good condition. Random cracking and areas of delaminated concrete is noted in the inspection reports.

The paint system currently is in poor condition. Most of the paint damage is located under the deck and is due to roadway leakage. The newer paint that was applied to the cable- related portions in 1996 is in generally good condition.

Department of Transportation Survey

As part of this Study, Modjeski & Masters, Inc. contacted the Ohio Department of Transportation to discuss the history, current condition, and future plans for the Fort Steuben Bridge. District personnel confirmed the past work performed on the Bridge. A construction contract will be let for bid this spring, and will include repair of stringers, deflection joints, deficient deck areas, and a new asphalt wearing surface. The estimated cost for the contract is approximately $300,000. Two additional repair contracts have also been proposed: for FY 2003, a complete coat of epoxy paint will be added (Estimated Cost - $620,000); for FY 2005, the steel grid deck will be replaced (Estimated Cost - $2,300,000). Funding for the painting and redecking has not been secured. Supposedly, there is an agreement made with local agencies that if the cost to maintain the Bridge exceeded $200,000 per year, the Bridge would be closed down. The Bridge is not considered historically significant, so funding from this reserve is not available.

Site Visit

As part of the Bridge assessment, a site visit was conducted on Tuesday, January 18, 2000, to gain familiarity with the structure prior to providing a summary on its condition. A brief meeting at BHJ offices was held with representatives from both the BHJ Metropolitan Planning Commission and the Ohio Department of Transportation, prior to the site visit, to discuss the current condition of the Bridge. The Bridge was walked from end-to-end using the pedestrian walkway on the downstream side. Observations of the Bridge's existing condition were limited to those areas visible from the walkway. The following is a summary of that visit:

- The roadway-wearing surface is beginning to delaminate from the concrete-filled grid. Deterioration of the concrete fill was also noted in some locations.
- The deck deflection joints were in poor condition.
- The sidewalk has numerous patches with a non-skid epoxy-wearing surface.
- The paint system is in fair condition.
- A large number of pigeons were seen roosting on the Ohio tower and the adjacent main cables.
- The majority of the traffic using the structure during the site visit were trucks destined for the industrial facilities in Weirton.

Recommended Repairs

If renovation were a viable option, the following repairs would, at a minimum, be required:

- Retrofit fatigue-prone details from previous renovations.
- Repair or replace deteriorated floor system components, which would include the grid deck, stringers and floor beams.
- Install new deck wearing surface.
- Clean and re-caulk the cable bands.
- Clean, prime and repaint the structure.

Cost Estimate

As part of this Phase One Study, a cost estimate was made based upon the repairs noted above. The cost estimate was developed from information provided in the inspection reports and the Department survey only. Contract plans were not available for determining repair quantities. This estimate is based upon the limited sketches and photographs provided in the inspection reports. The cost estimate is based upon the repairs that will slow the rate of deterioration and maintain its current load-carrying capacity. No improvements will be made to the roadway geometrics. The estimated cost to perform the repairs is $4.0 million. A detailed cost estimate is included in the Appendix of this report.

Summary

The service life of this Bridge is nearing its end. Costly repairs will be required in order to extend the Bridge's remaining service life. More importantly, the fact that the structure is a suspension bridge eliminates the possibility of widening the roadway, with no increase in traffic capacity. Given the age of the structure, there will be a continuing concern over the integrity of the main cables, cable anchorages and main piers. No costs are included in the estimate for these unknowns. With a newer alternative crossing nearby (Veterans Memorial Bridge), major repairs and the needed funding for this Bridge will be difficult to justify. Although plans and estimated budgets for repairs have been established by the Owner, no source of funding has been secured at this time.

VETERANS MEMORIAL BRIDGE

Description

The Veterans Memorial Bridge crosses the Ohio River between Weirton, West Virginia and Steubenville, Ohio. The structure is a cable-stayed bridge, with an 820-foot forespan and 688-foot backspan, and a total bridge length, including approach spans, of 1,965 feet. A single concrete tower supports the forespan and the backspan. The Ohio and West Virginia Departments of Transportation share ownership and maintenance costs for the structure. The Bridge was opened in May 1990, and carries four through-traffic lanes and two acceleration/ deceleration lanes for the ramp structures adjacent to the Bridge.

History

The structure has been functioning problem-free since its opening with the exception of concrete panels replaced at the tower shortly after opening.

Condition Evaluation

The only deficiencies noted in the most recent inspection reports are routine maintenance items typically associated with cable-stayed bridges.

Recommended Repairs

None, other than routine maintenance of the cables and supporting assemblies.

Department of Transportation Survey

No formal survey was conducted with the Department, since the Bridge is essentially new, and no significant deficiencies were noted in the inspection reports.

Cost Estimate

No cost estimate for repairs were developed, since the first appreciable cost (redecking) would fall beyond the life expectancy of the Market Street and Fort Steuben Bridges.

Summary

The Veterans Memorial Bridge provides an efficient river crossing for traffic in the immediate area.

PROPOSED NEW BRIDGE

As part of this preliminary study, Modjeski & Masters, Inc. has developed preliminary costs for a new Ohio River bridge crossing within the study area. Based upon the topography and existing roadway network, costs for three variations were developed including a short, medium, and long structure across the Ohio River.

The preliminary cost estimate is based on the plan area for each alternative. That is, we have assumed a four-lane divided highway with shoulders (82-foot total width), and a structure overall length scaled from a regional roadway map. The profile of the new Bridge is unknown at this time, so definitive heights for piers cannot be estimated.

The approach spans are assumed to be multi-girder structures, and the main span is a tied-arch structure (similar to the newer crossings in the Wheeling, West Virginia area). Costs are based on square foot averages for these structure types. No costs are included for approach roadway construction necessary to connect to the existing traffic network, nor any allowance included for right-of-way acquisition, relocation of utilities, resolution of environmental, historic or archeological issues, or unique foundation problems that may be encountered at the selected location for the new Bridge.

The estimated cost for each variation (main bridge and approach structures only) is presented below:

Short Structure	$39.6 Million
Medium Structure	$43.6 Million
Long Structure	$77.1 Million

TRAVEL DEMAND MODEL ANALYSIS - FUTURE TRAFFIC*

The BHJ Travel Demand Model is a series of mathematical programs designed to predict travel behavior across specific transportation alternatives. This particular type of model is required of all MPOs in Ohio. Besides determining effects of transportation alternatives in corridor or regional studies, the model is also instrumental in determining air quality and environmental conformity for the region. The model measures regional travel *demand* for a specific alternative. The travel demand model is an extremely useful tool in corridor and regional studies because it presents a consistent, objective summary of different transportation alternatives.

The focus of the BHJ Travel Demand Model in this Study is to determine if a transportation need exists for a new Ohio River crossing in the region. The consultant team in coordination with BHJ staff focused their attention to finding if total river crossings (i.e., vehicles that use one of the three bridges) exceed the supply (capacity) of those bridges. The first part of the analysis concentrated on river-crossing demand under current conditions and in the horizon year. The second part of the analysis examined river-crossing demand if one or two bridges become inoperable by 2020. Both parts of the analysis use daily river crossings for comparison because it is the most commonly used level of analysis.

Figure 7 shows the daily river crossings for 1999 and 2020 analysis years. Overall, total Ohio River crossings in the region increase 10% over the 21-year period, from 43,700 to 48,100. Veterans Memorial Bridge has the highest daily volume of the three bridges. Its use increases 9.6%, from 29,100 vehicles/day in 1999 to 31,900 vehicles/day in 2020. Use of the Market Street Bridge increases 16%, from 10,000 to 11,600 vehicles/day respectively. Volumes on the Fort Steuben Bridge remain constant for both years (4,600 vehicles/ day). While there is growth in demand to cross the Ohio River, it does not appear to overwhelm any of the three facilities.

It is important to note that these results are directly attributable to the population, employment, and highway project forecasts in the model. The population and employment forecasts were developed by BHJ using standard planning techniques. To ensure a fair and consistent analysis, only existing streets and committed highway projects were included in the highway networks. Committed projects are defined as those being in the local Transportation Improvement Program.

* Prepared by team member Burgess & Niple.

The growth in total regional river crossings does not provide evidence of need for a new river crossing. Consequently, the consultant team studied the travel demand for crossing the river if one or two bridges were inoperable in 2020. Four alternatives were specified:

- **2020 Base Alternative**. This alternative assumes that all three Ohio River bridges remain open and fully operational in 2020.
- **2020 Fort Steuben Bridge Removed (FSBR)**. This alternative assumes that the Veterans Memorial and Market Street Bridges are open and fully operational in 2020. The Fort Steuben Bridge is closed to traffic.
- **2020 Market Street Bridge Removed (MSBR).** This alternative assumes that the Fort Steuben and Veterans Memorial Bridges are open and fully operational in 2020. The Market Street Bridge is closed to traffic.
- **2020 Fort Steuben and Market Street Bridges Removed (FS&MSBR)**. This alternative assumes that only the Veterans Memorial Bridge is open and fully operational in 2020. The Fort Steuben and Market Street bridges are closed to traffic.

The Veterans Memorial Bridge is the region's youngest bridge and, therefore, is always assumed to be fully operable in 2020.

Figure 8 shows the daily volumes on the bridges under each alternative. The results of the base alternative correspond exactly to the 2020 results shown earlier. The base alternative is estimated to draw 48,100 vehicles/day across the Ohio River. This is the highest regional river crossings of all the alternatives. One peculiar trip movement was found. If all three bridges are open, the model shows a double-crossing movement. A "double-crosser" is a vehicle that crosses the river twice; that is, the origin and destination of the trip are on the same side of the river. This type of movement is common in cities with multiple bridges that are close to each other. The double-crossing movement in this region occurs on the Market Street and Fort Steuben bridges in a northbound direction and on the Fort Steuben and Veterans Memorial Bridges in the southbound direction. The total amount of double crossing accounts for 6% of total regional river crossings. This movement will have an impact on reporting results for the other alternatives since the opportunities to double cross will be reduced.

One of the major assumptions in travel demand forecasting is that people will typically behave in the future as they currently do. For example, assume a person travels 25 minutes from home to work each morning. His or her daily journey requires crossing the Ohio River using one of the three available bridges. If that bridge becomes permanently inoperable, that person's daily work trip length increases to 45 minutes. Since the person travels 25 minutes to work under current conditions, the model assumes that that person would either move or change jobs by 2020 so that their work trip would again be 25 minutes. In most cases, this would result in the person's home and job being on the same side of the river. The net result of this assumption is that total regional river crossings will decline because everyday trips will be considered to be too far and take too long. This is an

Figure 7

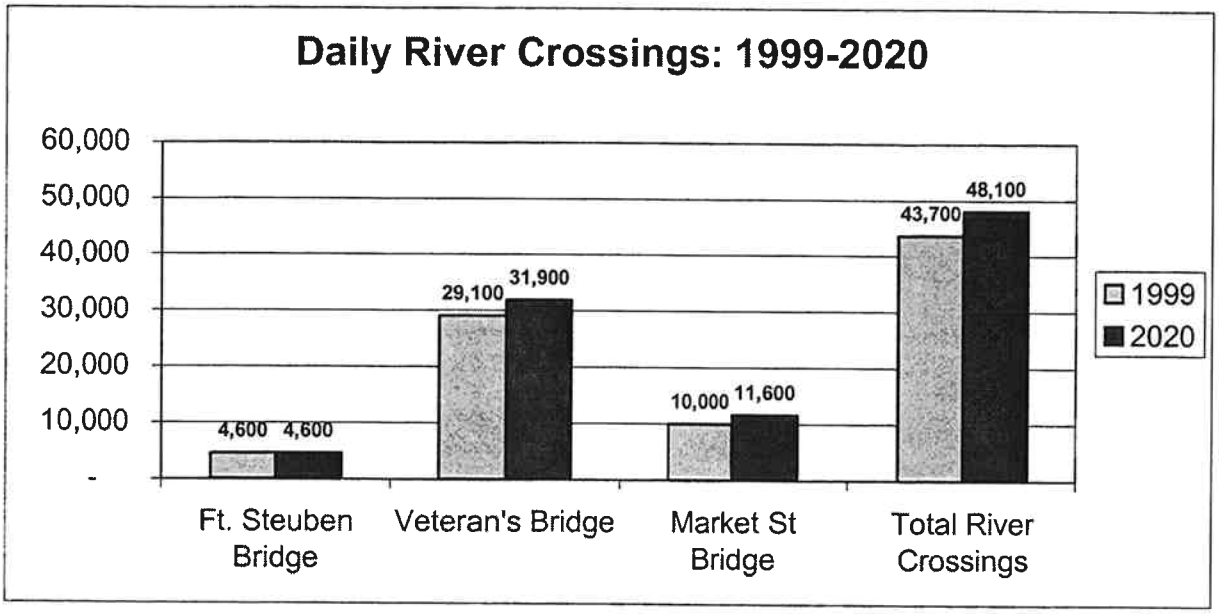


Figure 8
Projected Traffic Volumes

Volumes	Alternatives			
	All bridges remain	Fort Steuben removed	Market Street removed	Fort Steuben & Market Street removed
Fort Steuben Bridge	4,600	---	4,600	---
Veterans Memorial Bridge	31,900	32,300	43,100	42,700
Market Street Bridge	11,600	10,900	---	---
Total River Crossings	48,100	43,200	47,700	42,700

important point to consider before reporting the results of the following three alternatives.

If the Fort Steuben Bridge is inoperable in 2020, total river-crossing demand in the region falls to 43,200 vehicles/day. The reduction occurs for several reasons. The model shows that the double-crossing movement in the Base Alternative is no longer a viable option. The total river crossings are reduced by 6%. Although some trips using the Fort Steuben Bridge in the Base Alternative transferred to the Veterans Memorial Bridge, only one-fourth of the trips transfer (about 1,000). The remaining trips using the Fort Steuben Bridge in the Base Alternative simply choose not to cross the Ohio River. The remaining options (i.e., Veterans Memorial or Market Street) are not viable alternatives because people perceive a greatly increased distance and hassle to cross the river. The model estimates that most of the trips using the Fort Steuben Bridge in the Base Alternative do not use any bridge if the Fort Steuben Bridge is inoperable.

Total regional river crossing demand decreases slightly to 47,700 vehicles/day if the Market Street Bridge is inoperable in 2020. The model shows that the trips using the Market Street Bridge in the Base Alternative are much more *inelastic* than are those using the Fort Steuben Bridge in the Base Alternative. Almost all of these trips transferred to the Veterans Memorial Bridge, causing the Veterans Memorial Bridge traffic to rise over 11,000 vehicles/day compared to the Base Alternative. The remaining trips using the Market Street Bridge in the Base Alternative choose to stay of the same side of the river because of the corresponding increase in time and distance.

If both Fort Steuben and Market Street Bridges are inoperable, total regional river crossing demand is reduced to 42,700 vehicles/day. This represents the lowest total regional river crossings of all four alternatives. The closing of the Fort Steuben and Market Street Bridges has a combined overall effect in this alternative. Trips using the Fort Steuben Bridge in the Base Alternative transfer to the Veterans Memorial Bridge or choose not to cross the river, just as in the second alternative (FSBR). Trips using the Market Street Bridge in the Base Alternative transfer to the Veterans Memorial Bridge (just as they did in the third alternative (MSBR). The double-crossing movement in the Base Alternative is completely eliminated, again reducing the number of river crossings.

The results of this analysis show that the projected growth in river-crossing demand is not expected to increase dramatically if all three bridges remain open. If the Fort Steuben Bridge, Market Street Bridge, or both bridges are inoperable in the future, the increased demand on the Veterans Memorial Bridge does not appear to be excessive.

TRAFFIC OPERATIONS ANALYSIS*

The purpose of the traffic operations analysis is to define, analyze, and make recommendations regarding the traffic operations of the existing bridges and adjacent roadways in the Steubenville, Ohio/Weirton, West Virginia area. It is also intended as a point of reference with respect to larger questions regarding the overall bridge system within the project study area.

After reviewing data provided by various agencies as well as information obtained during site visits, we have identified areas with high accident rates, deficient geometrics, and inadequate signal operations. We have also performed accident analyses to determine types of accidents, probable causes, and possible countermeasures. In addition, the capacity of the three existing bridges was also analyzed, particularly with regard to how traffic would operate if one or more of the bridges were closed. All analyses were performed using both existing traffic and 20-year projected traffic volumes.

All traffic counts, capacity analyses, and accident data used for this report are included in the Appendix. Reproductions of photographs taken at key locations have also been included. In some cases assumptions as to probable traffic distribution were made in order to analyze the impact of bridge closures on roadways and intersections. All these assumptions were made based on knowledge of the study area, field observations, and common traffic engineering practices.

* Prepared by team member Pflum, Klausmeier and Gehrum Consultants

Bridge System Description

The project area spans the Ohio River and includes the eastern portion of Steubenville, Ohio and the western reaches of the Weirton, West Virginia area. The primary roadways involved are Ohio Rt. 7, US 22 and WV 2. Other streets included in the study area are University Boulevard in Steubenville and Freedom Way in Weirton. Ohio Rt. 7 and WV 2 are north-south routes, and US 22 is an east-west route, which crosses the Ohio River via the Veterans Memorial Bridge. This Bridge as well as the Fort Steuben and Market Street Bridges are also included in the study area, and are the primary focus of the study.

The Market Street Bridge, constructed in 1904, has a vehicular weight limit of 5 tons and is located south of the Veterans Memorial Bridge near downtown Steubenville. The Fort Steuben Bridge, dating from 1928, does not have a weight limit, but is very narrow so that large trucks cannot pass each other on the Bridge. It is located immediately north of the Veterans Memorial Bridge. Currently the Market Street Bridge has an Average Daily Traffic volume (ADT) of 9,200 vehicles, and the Fort Steuben Bridge has an ADT of 5,910 vehicles. Several key intersections in the immediate vicinity of the Bridges have also been considered as part of this Study. The following signalized intersections were examined: University Boulevard/ Ohio Rt. 7 and University Boulevard/7th Street/US 22 ramps in Steubenville; WV 2/Market Street Bridge and US 22/WV 2/Main Street/Freedom Way in Weirton.

The traffic volumes used for this portion of the Study were obtained from several sources. Data was provided by both ODOT and WVDOT; in addition, spot traffic counts were performed at several locations within the project area to ascertain turning movement and directional volumes at key intersections and locations.

Existing Conditions Analysis

Accident Analysis

Accident data was provided by the Ohio Department of Public Safety (ODPS), the West Virginia Department of Transportation (WVDOT), Division of Highways, and BHJ. The records from all sources were for the three-year period from 1996 through 1998. The ODPS data provided information on accidents, which occurred on Ohio Rt. 7 (Dean Martin Boulevard within the Steubenville city limits), US 22, University Boulevard, and the associated ramps and intersections. The WVDOT data listed accidents on the Fort Steuben Bridge, Veterans Memorial Bridge and the Market Street Bridge. No crashes involving animals were considered in this Study. On the Ohio side 100 accidents were recorded during the three-year period within the limits of the project; the location of sixteen of these accidents could not be determined accurately from the data provided and were not used in the analysis. The accidents analyzed occurred in the area between the Ohio Rt. 7/US 22 split to the north and University Boulevard to the south, including ramps to and from the Fort Steuben and Veterans Memorial Bridges. The total length of roadways involved in this area is less than 2 miles, which indicates a very high accident rate for the area. Accident rates for straight-through sections of roadway and for intersections or other spot locations are calculated in different ways. For this Study accident rates were calculated at specific locations using the following formula,

$$R_e = (A \times 1{,}000{,}000)/(3 \times 365 \times v_e)$$

where R_e is the calculated accident rate, A is the number of accidents occurring in a three-year period and v_e is the total volume of vehicles passing through an intersection or location in a 24-hour period. The rate is expressed in number of accidents per million vehicles entering the intersection.

Ohio Rt. 7/University Boulevard

The intersection of Ohio Rt. 7 and University Boulevard had the highest number of accidents at a single location, with 24 crashes in the three-year period. This translates to an accident rate of 1.6 accidents per million entering vehicles. Of these crashes, ten were angle-type accidents, mostly involving northbound left-turning vehicles and southbound through vehicles. There were also seven rear-end type accidents at this location. Bad weather or slippery pavement was not a factor in 58% of the crashes. There were a total of six injuries from two of these crashes. No fatalities occurred from accidents at this location.

University Boulevard/7th Street/US 22 Ramps

The intersection of University Boulevard and 7th Street/US 22 ramps was the site of thirteen accidents during the analysis period. The accident rate at this intersection is 0.8 accidents per million entering vehicles, with 85% of them occurring on dry pavement during clear weather. Nine (69%) of these accidents were angle type, seven of which were caused by eastbound vehicles turning left into the path of westbound traffic. There were no fatalities resulting from accidents at this intersection, but there were nine injuries from five of the crashes.

Westbound US 22 Ramps

On the ramp from westbound Veterans Memorial Bridge to Ohio Rt. 7, there were three overturned semi-trailers in the three-year period. While this is a small percentage of the total accidents, due to the location and nature of the accidents, there is the possibility of a great impact on the surrounding area. According to a conversation with Dave Snelting (City of Steubenville Engineer), these accidents generally cause the Veterans Memorial Bridge to close, forcing all traffic to use either the Fort Steuben Bridge or the Market Street Bridge. Other accidents on this ramp include five one-vehicle accidents involving crashing into the concrete barrier and five rear-end type accidents near the merge with Ohio Rt. 7. For purposes of this Study, the ramps were treated as a spot location rather than a through section because of the minimal length of roadway involved. Accident rate calculations for through roadways take into consideration the length of the section in miles. A total of 23 accidents occurred during a three-year period along the entire ramp sections, for a rate of 0.77 accidents per million vehicles using the ramps. One of these accidents produced two injuries and no fatalities.

Veterans Memorial Bridge

The accident data provided by the WVDOT indicates 23 identifiable accidents occurred on the Veterans Memorial Bridge between 1996 through 1998. In addition there were eleven accidents that were not analyzed because the location or other factors could not be determined from the data. More than fifty percent of the analyzed accidents (12/23) were fixed object-type crashes, with motorists striking fences, concrete median barrier, etc. Half of this type accident occurred during wet or slippery conditions. Of the total accidents, 35% occurred on wet or snowy pavement. There were a total of 12 injuries resulting from nine of the accidents; there were no fatalities.

Capacity Analysis

According to the Highway Capacity Manual (HCM), the capacity of a roadway indicates its ability to accommodate a moving stream of vehicles. Capacity refers to the maximum hourly rate of vehicles to proceed through a certain point or section of roadway under specific conditions. The rates indicated in this report assume ideal conditions, which include good weather, good pavement conditions, users familiar with the roadway, and no incidents to impede

traffic flow. Specific factors such as lane width, shoulder width, design speed, terrain, horizontal alignment of the roadway, and volume of trucks can also affect capacity. Level of Service (LOS), as defined by the HCM, is a function of average delay encountered by the motorist. Delay, of course, is a measure of driver discomfort, frustration, fuel consumption and the cost of lost travel time. Levels of service are given in terms of average delay per vehicle for signalized and unsignalized intersections. The criteria that is used by the American Association of State Highway and Transportation Officials (AASHTO), and the Ohio Department of Transportation (ODOT) and Municipal Engineering Departments for signalized intersections is as follows:

LEVEL OF SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS

Level Of Service*	Delay/Vehicle (Second)	Description
A	< 5.0	Most vehicles do not stop at all.
B	5.1 to 15.0	More vehicles stop than for LOS A.
C	15.1 to 25.0	The number of vehicles stopping is significant, although many pass through without stopping.
D	25.1 to 40.0	Many vehicles stop. Individual cycle failures are noticeable.
E	40.1 to 60.0	Considered to be the limit of Acceptable delay. Individual cycle failures are frequent.
F	> 60.0	Unacceptable delay.

*LOS "C" and "D" are generally accepted as a reasonable design criteria. LOS "E" and "F" are generally unacceptable.

Both capacity and LOS calculations have been used to analyze the traffic operations in the study area. The bridges were analyzed using capacity, while signalized intersections were analyzed using Highway Capacity Software (HCS) to determine the LOS. Analysis was made for various scenarios involving the closure of one or more of the bridges in the study area.

Bridge Analysis

In addition to closures due to traffic accidents, the Veterans Memorial Bridge closes each year during annual inspections. At these times there is advance notification and detour signage to guide motorists to the Fort Steuben and Market Street Bridges. During closures of the Veterans Memorial Bridge, these two bridges must carry an additional volume of 26,500 vehicles per day.

Assuming two-thirds of the Veterans Memorial Bridge traffic would use the Fort Steuben Bridge, the daily traffic volume would be increased to 23,577 vehicles. Based on 1997 traffic counts provided by ODOT for the Fort Steuben Bridge, approximately 20% of the daily traffic occurs during the peak hour of 7:00-8:00 a.m. Hourly traffic volume breakdowns are not available for the Veterans Memorial Bridge, therefore, it cannot be determined when the peak hour occurs. For the increased daily traffic volume, we have assumed that the peak hour volume would be 12% of the ADT, or 2,829 vehicles in the peak hour on the Fort Steuben Bridge.

Under ideal conditions the maximum capacity for a two-lane facility is 2,800 passenger cars per hour. Note that this figure does not account for truck traffic; the traffic on the Fort Steuben Bridge is composed of 20% trucks, which lowers the capacity of the bridge to 2,268 vehicles per hour. Due to the narrow lanes and the "no passing" regulation, the actual capacity of the bridge would be even lower. Since the resultant peak hour volume already exceeds capacity, these additional factors have been ignored.

With one-third of the Veterans Memorial Bridge traffic using the Market Street Bridge, the daily traffic volume increases to 18,033 vehicles. From a peak hour traffic count performed in January 2000, it was determined that the peak hour volume on the Market Street Bridge is approximately 7% of the ADT. This is lower than normal, possibly due to traffic conditions on the day the counts were performed. Assuming a peak hour volume of 10% of ADT, the resultant volume on the Market Street Bridge would be 1,803 vehicles during the peak hour. This is lower than the 2,800 maximum. However, since there is a traffic signal at the eastern end of the Bridge, the capacity at the intersection of WV 2 and the Bridge is controlled by the signal operation.

Lane capacity at a signalized intersection is based on the ratio between the green time for the relevant lane and the total cycle length of the signal. Using signal timing values obtained in the field, the capacity for the eastbound lane of the Market Street Bridge is calculated to be 665 vehicles per hour. According to the January counts, 59% of the traffic on the Bridge is eastbound during the afternoon peak hour. After adding the Veterans Memorial Bridge traffic, the eastbound peak hour volume on the Market Street Bridge would be 1,064 vehicles. HCS analysis shows that the intersection fails under this volume of traffic.

If the Fort Steuben Bridge is closed during closures due to accidents or inspections, all traffic from both that bridge and the Veterans Memorial Bridge would be rerouted to the Market Street Bridge. The resultant peak hour volume would be 3,893 vehicles. This would cause a

breakdown of traffic operations on the Bridge itself as well as on the streets of Steubenville. The roadways and intersections through downtown Steubenville are not at full capacity now, but nearly quadrupling the traffic would have a significantly negative impact on the local street system. No heavy vehicles can use the Market Street Bridge, so all truck traffic would be forced north to East Liverpool or south to Martins Ferry, a distance of 20-25 miles in either direction.

Looking at the reverse situation, if either the Market Street or Fort Steuben Bridge or both were to be closed, all traffic from those bridges would be rerouted to the Veterans Memorial Bridge. Using the ideal conditions capacity of 2,300 passenger cars per hour per lane for basic freeway sections, the maximum capacity on the Veterans Memorial Bridge is 13,800 passenger cars per hour. According to the traffic model prepared by Burgess & Niple, if both the Fort Steuben and Market Street Bridges are eliminated, river-crossing traffic is reduced by 10% due to a decrease in vehicles "double-crossing" the river. Therefore, with an adjusted ADT of 37,449 vehicles and assuming a peak hour volume of 10% of ADT, the through section of the Bridge can accommodate a peak hour volume of 3,745 vehicles from the additional traffic of both the Fort Steuben and Market Street bridges.

However, due to geometry and number of lanes, the ramp sections cannot support the same volume of traffic as the Bridge itself. Under ideal conditions a one-lane ramp section can accommodate 1,700 passenger cars per hour. The curvature and reduced speed of the exit ramps on the Ohio side of the Bridge greatly reduce the capacity. With a peak hour volume of 3,745 vehicles and assuming a 50/50 directional split, there would be 1,873 vehicles exiting at the west end of the Bridge. According to recent afternoon peak hour traffic counts, 45% of westbound vehicles exit to southbound Ohio Rt. 7. A projected total volume of 843 vehicles would use this ramp during the afternoon peak.

The ramp to southbound Ohio Rt. 7 is a single lane with a high degree of curvature. Due to prevailing conditions, the capacity of the ramp from westbound US 22 to southbound Ohio Rt. 7 would be much less than the ideal capacity. For purposes of this Study, the capacity has been estimated as 1,000 vehicles per hour, based on horizontal and vertical alignment, truck volume, and merging at the ramp terminus.

At the east end of the Veterans Memorial Bridge, the ramps have better geometrics, but at the intersection of the US 22 ramp with northbound WV 2 (Main Street) and Freedom Way, the angle of the intersection makes the left-turn movement difficult for large trucks. Closure of the Fort Steuben Bridge would force a significant amount of truck traffic through this intersection. Since the majority of the trucks currently using the Fort Steuben Bridge use it to access the Half Moon Industrial Park, a left turn onto Freedom Way from the US 22 ramp would be required.

PKG was provided with conceptual drawings for a new interchange between US 22, southbound WV 2 and Freedom

Way, that might provide an alternative should the Fort Steuben Bridge be closed.

Field observation indicates that the concept as provided fails to account for adequate vertical clearances between ramps. While such an interchange may be possible, a detailed feasibility analysis would be required. Certainly, the physical geometry of the location provides significant challenges that would need to be overcome for such an interchange to be workable.

Intersection Analysis

In addition to affecting the Bridge and ramps, any bridge closures will also have an effect on the traffic at intersections adjacent the bridges. The intersections of University Boulevard with Ohio Rt. 7 and 7th Street/US 22 ramps will be impacted. Currently the signalized intersection of University Boulevard and Ohio Rt. 7 operates at a Level of Service (LOS) "B" with an average delay of 9.5 seconds per vehicle. If the Fort Steuben Bridge is closed, therefore, altering traffic patterns and volumes through this intersection so that motorists can access the Veterans Memorial Bridge, the LOS remains "B" with a delay of 11.4 seconds per vehicle. The northbound left-turn movement is impacted the most, dropping from LOS "C" to LOS "D". If traffic from the Market Street Bridge is also considered at this intersection, there is a minimal increase in the delay, to 11.6 seconds per vehicle.

The intersection of University Boulevard and 7th Street/US 22 ramps currently operates at LOS "B" with a delay of 12.5 seconds per vehicle. Southbound traffic is currently at LOS "D" based on signal timings obtained in the field.

Observations at this intersection do not indicate that the operation is deficient, however. This is probably due to vehicles turning right during the red phase when there are sufficient gaps in westbound traffic. This incidence is not accounted for in the capacity analysis. When the traffic which now uses the Fort Steuben Bridge is added, the delay increases to 12.8 seconds per vehicle, for a LOS "B". Due to increased westbound traffic, the eastbound left-turn movement sustains the greatest impact but remains at LOS "B". If the Market Street Bridge is also closed and the resultant traffic is considered in the capacity analysis of the University Boulevard/7th Street/US 22 ramps intersection, the overall LOS remains at "B" with a delay of 13.0 seconds per vehicle. There are no additional significant changes to any individual movements.

According to field observations and a capacity analysis based on peak hour traffic counts, the signal at WV 2 and the Market Street Bridge currently operates at LOS "B" with a delay of 13.4 seconds per vehicle. This analysis is based on timing obtained in the field. There are plans to widen WV 2 in this area, including lengthening the turn lanes for the Market Street Bridge. However, if the Bridge is closed, the turn lanes would be unnecessary as would the signal.

Future Traffic

In addition to analyzing operating conditions under existing traffic, we have also looked at future conditions. Projected bridge traffic volumes for the year 2020 were used to determine the impact of increased traffic on the project area. The projected ADT volumes for each bridge are as follows:

Fort Steuben Bridge	4,631 vehicles
Veterans Memorial Bridge	31,907 vehicles
Market Street Bridge	11,630 vehicles

Accident Analysis

It is a foregone conclusion that as traffic increases, the number of traffic accidents also increases. What is difficult to determine is whether the accidents increase at the same rate as the volume of traffic. For instance, an increase in traffic volumes of 30% could result in an increase in accidents of 35% due to reduced level of service, increased congestion, driver frustration, etc. The relationship between increased traffic and the resulting increase in accidents is impossible to quantify, therefore, a straight 1:1 ratio has been used for purposes of this Study. Using this assumption, while the actual number of accidents at each analyzed location would increase, the calculated accident rate per million entering vehicles would not change. Again, this may not be a true scenario but is impossible to predict at any given location.

Capacity Analysis

Using the projected traffic volumes listed above, a capacity analysis using HCS was performed for the University Boulevard/ Ohio Rt. 7 and University Boulevard/7th Street/US 22 ramps intersections. Traffic was distributed in the same manner and proportions as is indicated by existing conditions. Capacity on the bridge sections was also examined with the future volumes.

Bridge Analysis

When compared to the existing volume, the traffic on the Fort Steuben Bridge is expected to reduce by nearly 1,300 vehicles per day, or approximately 22%. Therefore, if all three bridges remain open, there will not be a capacity problem on this Bridge. Adding in two-thirds of the increased traffic from the Veterans Memorial Bridge during closures results in an ADT of 25,902 vehicles. Using the same factors as before, namely that 12% of this traffic would occur during the peak hour, the volume on the Fort Steuben Bridge would rise to 3,108 vehicles during the peak hour.

The Market Street Bridge traffic is expected to rise from 9,200 vehicles per day currently to 11,630 vehicles per day in the year 2020. This is an increase of approximately 26%. When one-third of the Veterans Memorial Bridge traffic is added to this the resultant ADT becomes 22,266 vehicles per day. Assuming a peak hour volume of 10% of ADT indicates a volume of 2,227 vehicles in the peak hour, with 1,314 of that traffic eastbound. With the signal at the eastern end of the Bridge controlling lane capacity, the projected traffic is well above the capacity of the Market Street Bridge.

Total future traffic on the three bridges is 48,168 vehicles per day. As stated previously, if the Market Street and Fort

Steuben Bridges close the amount of river-crossing traffic decreases by approximately 10%. The projected volume on the Veterans Memorial Bridge for the year 2020 if both bridges close is 42,721 vehicles per day. This leads to a peak hour volume of 4,272 vehicles, and westbound traffic of 2,136 vehicles. Maintaining the earlier directional distribution, the projected number of vehicles exiting from westbound Veterans Memorial Bridge to southbound Ohio Rt. 7 during the peak hour is 961. This rapidly approaches the estimated capacity for the westbound-southbound ramp of 1,000 vehicles per hour.

Intersection Analysis

By comparing the projected bridge volumes to the existing volumes, an annual growth rate was calculated and then applied to the existing peak hour volumes at the two intersections on University Boulevard. The growth rate on both the Veterans Memorial Bridge and the Market Street Bridge is approximately 1% per year. The Fort Steuben Bridge was not used for this purpose since a decline is projected rather than an increase.

When the growth factor was applied to the traffic at the Ohio Rt. 7/University Boulevard intersection, the results of the HCS analysis show an overall intersection LOS of "C" with an average delay of 16.8 seconds per vehicle. This was performed maintaining existing timing. The delay for northbound left turns was 60.7 seconds per vehicle, indicating LOS "F". Eastbound left-turning traffic dropped to LOS "D" with a delay of 34.4 seconds per vehicle.

At the University Boulevard/7th Street/US 22 ramps intersection using the projected traffic volumes yielded an overall LOS of "C" with a delay of 21.0 seconds per vehicle. However, the northbound traffic is at LOS "F" and the southbound at LOS "E".

Summary & Recommendations

Based on the data and analyses outlined above, certain conclusions can be reached regarding the current operating conditions of the bridges and adjacent roadways. The bridges themselves do not appear to be over capacity at this time. Neither does there appear to be any significant capacity problems at the nearby intersections. However, there are a high number of accidents at both the University Boulevard/ Ohio Rt. 7 and University Boulevard/7th Street/US 22 ramps intersections. Without additional data for similar intersections (volumes, geometric configuration, etc.), it is impossible to state whether the actual accident rate is low, high or moderate. Based strictly on the average number of crashes per year, it appears that this is a high accident area.

In summary, if both the Fort Steuben and Market Street Bridges were to be closed, there would be nearly double the amount of traffic on the Veterans Memorial Bridge. At this time it appears that the adjacent roadways and intersections may be seriously affected by the increased traffic but alterations to signal timing could alleviate some of the effects.

- While the bridge can accommodate the increased volume, the ramp systems cannot.

- If the Veterans Memorial Bridge is closed due to traffic accidents or inspections, the traffic on the other two bridges will exceed capacity.
- If only one of these bridges remains open to traffic, the impact of closures of Veterans Memorial Bridge will be even more severe.
- Also, at times when the Bridge is closed due to accidents or inspection, the nearest existing Ohio River crossing is at such a distance from the Weirton/Steubenville area that the impact on local traffic would be seriously impacted, essentially cutting the two cities off from one another.

After analyzing the data and reviewing the results, some recommendations can be made as to improving the existing conditions and planning for future traffic increases. Recommendations for how to improve both accident occurrences and capacity are presented below.

Accident Analysis

There are standard accepted countermeasures for decreasing accidents based on the type of crashes experienced. For example, angle type accidents involving left-turning vehicles are often caused by driver frustration from lengthy delays. Rather than wait for an adequate gap, the driver attempts to turn in front of oncoming traffic, thus causing an accident. In the case of the intersection of Ohio Rt. 7/University Boulevard, there is a delay of 20.6 seconds per vehicle for northbound left turns. The most effective countermeasure for angle-type accidents would be to permit left turns only during the protected (green arrow) phase. However, this reduces the overall efficiency of the intersection. Another possibility is to adjust the timing of the signals to allow more green time for the problematic left-turn movement.

Preliminary HCS analysis with existing traffic volumes indicates that the timing can be adjusted to provide a longer permitted phase for northbound left turns without adversely affecting the other movements. In fact, the overall delay is reduced to 9.1 seconds per vehicle from 9.5 seconds.

At the University Boulevard/7th Street/US 22 ramps intersection, the current delay for eastbound left turns is less than six seconds per vehicle, indicating that driver frustration is not the reason behind the high number of angle accidents. There is also not a sight distance problem at this intersection, so the only effective countermeasure would be to restrict left turns to the protected phase, thereby eliminating the conflict with opposing traffic. Although there would be an increase in delay, the reduction of accidents should take precedence.

On the ramps from westbound US 22 to Ohio Rt. 7, there is no easy solution to reduce accidents. There is existing signage on the Veterans Memorial Bridge indicating a sharp curve with reduced speeds ahead. Other countermeasures to reduce accidents would involve redesign of the ramps to lessen the degree of curvature or altering the merge area at southbound Ohio Rt. 7. Neither of these appears feasible due to space constraints and the high cost of rebuilding freeway ramps.

On the Veterans Memorial Bridge, many of the accidents appear to occur during wet or slippery conditions. New signage indicating "Slippery When Wet" or "Bridge Freezes Before Roadway" may help to alleviate this problem.

Capacity Analysis

With regard to the capacity of the nearby intersections, currently there are no significant problems with overall LOS at any of the intersections. However, as indicated above at the Ohio Rt. 7/ University Boulevard intersection, the same timing changes that would reduce accidents would also improve the LOS of the northbound left-turn movement. This holds true both for existing traffic and with volumes from the Fort Steuben and Market Street bridges included.

When future traffic volumes are considered, much can be done to improve LOS through simple timing changes. At the Ohio Rt. 7/University Boulevard intersection, the overall LOS can be increased to "B" with an average delay of 13.1 seconds per vehicle. No individual movement would have a LOS lower than "C".

At the University Boulevard/7th Street/US 22 ramps intersection, an overall LOS "B" with a delay of 13.5 seconds per vehicle can be achieved through timing adjustments. Again, individual movements are at a LOS "C" or better.

If it is determined that either the Fort Steuben or Market Street Bridge or both must be closed due to structural deficiencies or other reasons, another bridge will be needed to accommodate traffic demands.

Since there is a high volume of truck traffic on the Fort Steuben Bridge that would be rerouted to the Veterans Memorial Bridge, an interchange to Freedom Way would prevent possible delays and accidents at the intersection of WV 2/Main Street and Freedom Way. As stated this idea will require further study. If such an interchange project is not feasible, the intersection at the end of the existing ramps to northbound WV 2 and Freedom Way will require widening or realignment to accommodate the increase in truck traffic.

APPENDIX