Parkway East
Corridor Transportation Network

PHASE 2 ALTERNATIVES ANALYSIS

Summary Report and Appendix 1: Concept Summaries

E02852
Work Order #1

July 2018
Final Report

pennsylvania
DEPARTMENT OF TRANSPORTATION

wsp

EXECUTIVE SUMMARY

The Parkway East (I-376) is a major transportation link in Southwestern Pennsylvania, extending from Downtown Pittsburgh to Monroeville. The Parkway is part of a more extensive transportation network, referred to as the Parkway East Corridor Transportation Network, consisting of the Parkway East (I-376) and its ramps between Downtown Pittsburgh and Monroeville, and also including intersecting and parallel arterial routes extending as far as the Allegheny and Monongahela rivers. It serves a broad range of users. The corridor is multimodal, serving autos and trucks on the roadway network; pedestrians and bicyclists on an adjoining network of sidewalks and trails; and transit riders on the Martin Luther King, Jr. East Busway and a network of express and local bus routes.

This project was undertaken to identify improvements that will enhance the corridor by reducing crashes, improving travel time reliability, reducing congestion and providing or enhancing travel options. Beyond the immediate project, a range of improvements was expected to be identified that could provide additional benefits throughout the corridor as part of future projects.

An extensive public involvement program was undertaken to bring adjacent communities into the discussion from the beginning and to understand the perception and needs for the project. This program included a series of 25 interviews with key stakeholders including municipalities and other organizations; a round of public meetings and elected officials briefings; a project website including an online survey; and a stakeholder meeting.

The public involvement program was supplemented by gathering and analyzing existing technical data, including previous studies of the corridor, roadway plans, and crash data. An extensive program of field data collection was undertaken, including 24-hour traffic counts at key locations, peak-hour ramp and Parkway traffic volume counts using aerial photography, and manual turning movement counts at a number of intersections. This phase of work also included the collection of origin-destination information using Bluetooth sensors.

The collected data was analyzed to develop a comprehensive technical understanding of the corridor. This included capacity analysis of existing traffic conditions at intersections and freeway interchanges to provide a baseline for analysis. Particular attention was given to identifying existing and potential capacity bottlenecks to understand the potential for improvements. A detailed VISSIM microscopic simulation model was developed for the Parkway East corridor and calibrated to model the existing conditions. A separate network assignment model was developed to project traffic growth in the corridor and to evaluate the potential impact of changes to the transportation network. An evaluation was also conducted of transit ridership and travel patterns, to identify areas of unmet demand and the potential need for additional transit service.

In the Phase 1 Screening, an initial broad list of potential improvement concepts was generated, based upon needs identified by the public and the technical analysis. This was condensed into approximately 100 concepts, which were developed further, evaluated qualitatively on a range of measures of effectiveness, and screened through a process and weighting that was developed in conjunction with key stakeholders. Approximately 70 concepts were advanced for further screening.

These concepts were developed in greater detail in the Phase 2 Screening, including, where appropriate, development of a preliminary line and grade. Several concepts were determined to be infeasible due to geometric or other constraints, while multiple options were developed for certain others. Traffic impacts, safety and user benefits were evaluated using the VISSIM simulation model and other tools as appropriate. Construction, Right-of-Way (ROW), design costs, and anticipated operating costs were estimated from the conceptual designs. Environmental constraints were evaluated along with other issues which could affect implementation. The results of this analysis was presented in a preliminary matrix for further evaluation and prioritization.

In the final phase of the project, the Department will move forward with implementing solutions. As noted in Section 6, this is already underway. During the Phase 1 Screening, multiple concepts were identified as “early action” items and were evaluated for implementation by PennDOT maintenance forces. Several additional concepts are being advanced under separate projects.

A refined matrix was developed, consisting of eleven feasible projects. As part of this project, the Department is looking to fund corridor-wide active traffic management, improvements to the Bates Street and Squirrel Hill interchanges, and two minor improvements to the Edgewood/Swissvale interchange. Additional projects including larger improvements to the Edgewood/Swissvale, Wilkinsburg, and Churchill interchanges appear to be feasible but are not being advanced at this time. Multimodal improvements including enhanced transit and bicycle facilities, may be advanced by other agencies.

Implementation of identified projects will include identifying funding, conducting environmental analysis and documentation, further public involvement, engineering design, and construction as appropriate.

TECHNICAL MEMORANDA AND REPORTS
(Prepared and Submitted Previously)

Technical Memorandum #1- Review of Previous Studies
Technical Memorandum #2 - Traffic Counts
Technical Memorandum #3 - Crash Analysis
Technical Memorandum #4 - Geometric Evaluation
Technical Memorandum #5 - Transit Demand Analysis
Technical Memorandum #6 - Capacity Analysis
Technical Memorandum #7 - Bottleneck Analysis
Public Meeting Summary
Phase 1 Alternatives Analysis Summary Report

TABLE OF CONTENTS

Appendices

1.0 INTRODUCTION

1.1 Background

The Parkway East (I-376) is a major transportation link in southwestern Pennsylvania, extending approximately 14.5 miles from the Fort Pitt Bridge in Downtown Pittsburgh to an interchange with the Pennsylvania Turnpike (I-76) and US Route 22 in Monroeville.

The Parkway is part of a more extensive transportation network, referred to as the Parkway East Corridor Transportation Network, which is the focus of this project. The corridor is defined broadly, consisting of the Parkway East (I-376) and its ramps between Downtown Pittsburgh and Monroeville, and also includes intersecting and parallel arterial routes extending as far as the Allegheny and Monongahela rivers. It serves a broad range of users including residents, commuters, visitors, shoppers, transit users and commercial traffic. The corridor is multimodal in nature, serving automobiles and trucks on the roadway network; serving pedestrians and bicyclists on an adjoining network of sidewalks and trails; and serving transit riders on the Martin Luther King, Jr. East Busway and a network of express and local bus routes.

The first major limited-access highway in the region, the Parkway East is highly constrained by hillsides, valleys, and adjacent development. Planning for the highway began in the 1930s, with the first segment opening to traffic in 1953, and the remainder being constructed and opening in phases until 1963.

The Squirrel Hill Tunnels, located on the Parkway East at the eastern border of the City of Pittsburgh, dominate traffic flow on the Parkway East, passing through a ridge where few alternate roadways are available. As a result, severe congestion regularly occurs on approaches to the tunnel, with standing queues during many hours of the day, and peak queues extending for several miles.

Traffic approaches Squirrel Hill Tunnel c. 1960.

This project was undertaken to identify improvements that will enhance the corridor by reducing crashes, improving travel time reliability, reducing congestion and providing or enhancing travel options. Beyond the immediate project, a range of improvements was expected to be identified that can provide additional benefits throughout the corridor as part of future projects. These projects may deploy the latest technology to manage traffic operations, improve efficiency and to inform the public of transportation conditions.

1.2 Study Approach

This project was structured to take a comprehensive look at the transportation needs in the corridor. As highlighted in the project flow diagram, the project began with a comprehensive program of data collection and public involvement, which fed into technical analysis to understand the operation and issues of the corridor transportation network. This understanding was summarized in a statement of purpose and need. The project team then developed a broad range of potential improvement concepts for the study area, and evaluated potential costs and benefits. From this, a range of feasible improvement projects was identified, some of which may be moved forward to implementation.

Gathering Information

Adjacent communities have expressed concern over the potential impacts of proposed improvements, and have expressed the importance of maintaining access to the Parkway and the regional transportation network. Accordingly, an extensive program of community and stakeholder engagement was conducted to gather input into corridor needs.

This was conducted in conjunction with an extensive program of gathering and analysis of existing data including previous studies of the corridor, roadway plans, and crash data. An extensive program of field data collection was undertaken, including 24-hour traffic counts at key locations, peak-hour ramp and Parkway traffic volume counts using aerial photography, and manual turning movement counts at a number of intersections. This phase of work also included the collection of origin-destination information using Bluetooth sensors.

Understanding the Corridor

The collected data was analyzed to develop a comprehensive understanding of the corridor. This included capacity analysis of existing traffic conditions at intersections and freeway interchanges to provide a baseline for analysis. Particular attention was given to identifying existing and potential capacity bottlenecks to understand the potential for improvements. A detailed microscopic simulation model was developed for the Parkway East corridor and calibrated to model existing conditions, using the VISSIM simulation model from PTV Group. A separate network assignment model was developed to project traffic growth in the corridor and to evaluate the potential impact of changes to the transportation network. An evaluation was also conducted of transit ridership and travel patterns, to identify areas of unmet demand and the potential need for additional transit service.

Study Process

Identifying Needs

A statement of purpose and needs was developed for the Parkway East Corridor Transportation Network. The needs were identified based upon the technical data and evaluation as well as on input received from stakeholders and the community during the Public Involvement process. These identified needs form the basis for developing measures of effectiveness and for determining the appropriateness of potential solutions for the corridor.

Developing Solutions

A broad range of potential improvement concepts were identified and evaluated in a two-step screening process.

In the Phase 1 Screening, an initial broad list of potential improvement concepts was generated, based upon needs identified by the public and the technical analysis. This was condensed into approximately 100 concepts, which were developed further, evaluated qualitatively on a range of measures of effectiveness, and screened through a process and weighting that was developed in conjunction with key stakeholders. Approximately 70 concepts were advanced for further screening.

These concepts were developed in greater detail in the Phase 2 Screening, including where appropriate development of a preliminary line and grade. Several concepts were determined to be infeasible due to geometric or other constraints, while multiple options were developed for certain others. Traffic impacts safety and user benefits were evaluated using the VISSIM simulation model and other tools as appropriate. Construction, ROW and design costs and anticipated operating costs were estimated from the conceptual designs. Environmental constraints were evaluated along with other issues which could affect implementation. The results of this analysis was presented in a preliminary matrix for further evaluation and prioritization.

Implementing Solutions

In the final phase of the project, the Department will move forward with implementing solutions. As noted in Section 6, this is already underway. During the Phase 1 Screening, multiple concepts were identified as “early action” items and were evaluated for implementation by PennDOT maintenance forces. Several additional concepts are being advanced under separate projects, most notably at the Bates Street interchange area.

The preliminary matrix developed in the Phase 2 Screening will serve as a basis for identifying projects for further advancement. Because of the broad range of potential improvements, ranging from intersection level to corridor level, and varying across many modes, no single measure of effectiveness is appropriate for prioritizing all needs.

It is anticipated that some projects will be advanced by the Department through maintenance forces, others may be advanced using available funds and projects, and others may be programmed for advancement at a future date. Implementation of identified projects may include environmental analysis and documentation, further public involvement, engineering design and construction as appropriate.

2.0 DATA COLLECTION

2.1 Review of Previous Studies

As part of the Parkway East Corridor Transportation Network project, WSP reviewed four studies that were previously done for the Parkway East corridor. The studies that were reviewed were:

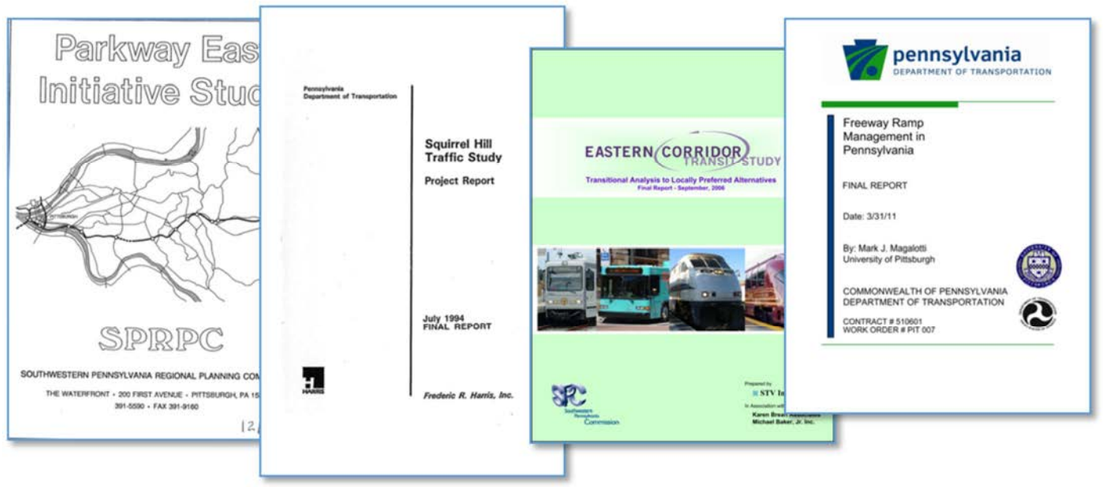
- The Parkway East Initiative Study – December 1991 by SPRPC (currently known as SPC),
- Squirrel Hill Traffic Study – July 1994 by Frederick R. Harris, Inc. (for PennDOT),
- Eastern Corridor Transit Study, Transitional Analysis to Locally Preferred Alternatives – September 2006 by STV, Inc. (for SPC), and
- Freeway Ramp Management in Pennsylvania – March 2011 by the University of Pittsburgh (for PennDOT).

All of these studies analyzed ways to relieve the recurring congestion along the Parkway East, and were summarized in Technical Memorandum #1, Review of Previous Studies.

Three of these studies, conducted over a period of twenty years, looked at the Parkway East in the vicinity of the Squirrel Hill and adjacent interchanges. These studies consistently found that ramp closures and ramp management could improve traffic flow on the Parkway East mainline, but at the cost of increased travel time and congestion on alternate arterial routes. The studies differed in whether there would be a significant reduction in congestion on the Parkway mainline. In particular, the 1991 Parkway East Initiative Study and the 2011 Freeway Ramp Management Study both determined that ramp management had the potential to reduce some, but not all of the peak period congestion at the Squirrel Hill tunnels. However, these studies did not quantify the additional delay that would be incurred by vehicles on the ramps and the arterial roadways. The one study that attempted to do this, the 1994 Squirrel Hill Traffic Study, found that many drivers would divert to unmetered ramps, resulting in little net change in Parkway queues, and that the available alternate arterial roadways had significant bottlenecks at key intersections.

A number of improvements and initiatives have been implemented following the recommendations of these studies, particularly the 1991 Parkway East Initiative Study. The first recommendation of this study, for an incident management program, was implemented with the Parkway Service Patrol which began operation on September 26, 1996. In the most recent years, this service has responded to between 200 and 600 incidents per year, consistent with the number of crashes and breakdowns projected in the study. The response of the patrol to incidents has been enhanced by the Western Regional Traffic Management Center (TMC) which also began operation in 1996.

Previous Studies were Reviewed



The 1991 study also called for geometric improvements to be made to a number of ramps along the parkway, as well as geometric modifications to the Squirrel Hill Tunnel. Improvements were made to the westbound Squirrel Hill exit ramp, the eastbound Edgewood entrance ramp and the westbound Edgewood/Swissvale entrance ramps as part of reconstruction of the Parkway in 2007, and the westbound Churchill on-ramp was extended in 2008 as part of a later phase of the project. Work was conducted in 2013 and 2014 to improve lighting in the Squirrel Hill tunnel and to remove the lowered ceiling, providing a brighter, more open space.

Little has been accomplished in terms of new highway capacity as proposed in the 1991 Parkway East Initiative Study. A Glenwood bypass and a southern beltway were proposed as part of the Mon/Fayette Expressway into Pittsburgh, under the auspices of the Pennsylvania Turnpike Commission, but this project is no longer being advanced. Although construction of the western portion of the Southern Beltway has been completed near Pittsburgh International Airport, the prospect of the Glenwood Connector appears to have been abandoned.

Transit improvements were called for in the 1991 Parkway East Initiative Study and in the 2006 Eastern Corridors Transit Study. The extension of the East Busway to Swissvale was called out in the first study and was completed in 2003. Various changes in park-and-ride facilities and bus routes have been implemented in the eastern suburbs, but these have been sporadic due to funding constraints. The Port Authority of Allegheny County is moving ahead with an evaluation of Bus Rapid Transit (BRT) between Downtown Pittsburgh, Oakland and the eastern communities, as was recommended in the Eastern Corridors study.

Finally, the 2011 Freeway Ramp Management study showed that ramp management had the potential to reduce congestion on portions of the Parkway. However, the Department recognized that rather than advancing any particular alternative, there was a need to look comprehensively at traffic conditions in the entire Parkway East Corridor and to develop options and ideas for improvements. Accordingly, the current study was initiated to provide that detailed assessment and opportunities for input.

2.2 Geometric Review

The geometry of the Parkway East corridor, from the Fort Pitt Bridge to the eastern limit at US Route 22, was evaluated utilizing the current (2014) roadway design criteria presented in PennDOT *Publication 13M, "Design Manual Part 2, Highway Design"* (DM-2) and the AASHTO Green Book. A summary of the findings is presented here.

Horizontal and Vertical Alignment

Horizontal alignment of the roadway, primarily the geometric design of horizontal curves, can affect the ability of drivers to negotiate the roadway, and can also have an effect on stopping sight distance. There are ten substandard horizontal curves in the eastbound direction, nine in the westbound direction, and fifteen that occur in both directions. Some of these curves do not have any superelevation.

Vertical alignment of the roadway, the transition between different slopes, can affect stopping sight distance and headlight projection. There are fourteen substandard vertical curves along the Parkway East corridor.

Roadway Cross-Section

Based on the AASHTO Green Book, freeway sections with two (2) lanes in a direction should provide a minimum of a four (4) foot left shoulder and a ten (10) foot right shoulder and freeway sections with three (3) lanes in a direction should provide a minimum of a ten (10) foot left shoulder and a ten (10) foot right shoulder. Right shoulders do not meet the standard width of ten feet for most of the section between Downtown and Swissvale, and left shoulders do not meet the standard of four to ten feet anywhere in the corridor.

Ramp and Interchange Geometry

Chapter 10 of the AASHTO Green Book provides design guidelines for ramp terminals. Even though much of the geometric data for the existing ramps is unknown, WSP was able to utilize Google Earth to estimate the acceleration/deceleration lengths and grades of the ramps. Based on this information, WSP was able to determine if the existing ramps met the minimum lengths recommended by the Green Book for the middle and lower design speeds recommended for ramps. Of 29 ramps, nineteen ramps (66%) met the AASHTO criteria for the middle ramp design speed and six (6) ramps (21%) met the criteria for the low ramp design speed.

The Highway Capacity Manual (HCM) states that a weaving section exists when an on-ramp is followed by an off-ramp and is connected by an auxiliary lane. The distance from where the on-ramp nose is 2 feet wide to the point where the off-ramp nose is 12 feet wide must also be less than 2500 feet long. There were three weaving sections (as defined by the HCM) identified along the Parkway East corridor.

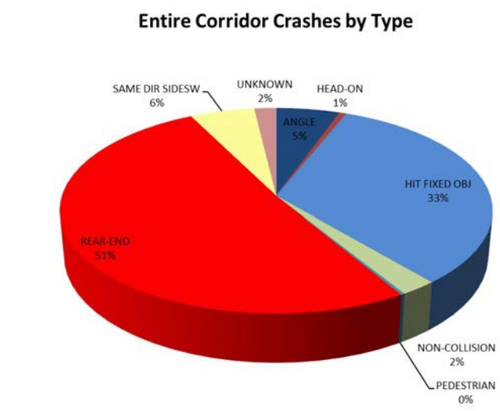
The AASHTO Green Book also provides recommendations for minimum ramp terminal spacing along roadways. Based on the guidelines in the Green Book, there are two interchanges in which ramp spacing is less than the minimum AASHTO recommendations.

2.3 Crash Analysis/Safety Study

As part of the Parkway East Corridor Transportation Network project, WSP conducted an extensive crash analysis of the Parkway East corridor. The crash analysis was conducted for I-376 from the Fort Pitt Bridge to the eastern limit at US Route 22 and the Pennsylvania Turnpike, using crash data for the three (3) year period from January 1, 2010 to December 31, 2012. During this period, there were a total of 1172 crashes (533 in eastbound direction and 639 in the westbound direction) on the Parkway East corridor.

Crash data for I-376 was obtained from the Pennsylvania Department of Transportation Engineering District 11-0 for the Parkway East Corridor project.

The breakdown of crashes by collision type, within the study area, is shown in the following chart.



This analysis was outlined in Technical Memorandum #3, Crash Analysis.

A broad array of countermeasures are typically considered as mitigations in corridors with high crash histories. These countermeasures include:

- Traffic management center operations
- Improved marking and delineations
- Shoulder rumble strips
- Improved signing
- Improved lighting
- Reduced speed limits
- Advanced warning of slow or stopped vehicles

As part of the ongoing reconstruction of the Parkway East over the past several years, a number of these possible countermeasures have already been implemented. The Department began operating a Traffic Management Center for the Parkway East in 1996, including surveillance cameras, highway advisory radio and changeable message signs. Operation of the center has been expanded to cover additional roadways and to provide coverage 24 hours a day.

Other countermeasures, including improved marking and delineations, shoulder rumble strips, and improved signing have been undertaken by the Department though maintenance work and as part of the ongoing reconstruction of the Parkway East.

Of these potential mitigation measures, the last two, reduced speed limits and enhanced advance warning appear to provide the greatest opportunities for enhanced safety in the corridor. While both are currently provided to a limited extent, a more extensive network of variable message signs and other warning devices connected to the TMC could be utilized to provide detailed, real-time information to motorists of adverse conditions, and to impose reduced speed limits in areas and times where they are appropriate.

2.4 Traffic Counts

An extensive traffic count program was conducted for the Parkway East corridor. The traffic counts consisted of aerial traffic counts, automatic traffic recorder counts, 24-hour video counts, and manual turning movement counts. The traffic counting program and data was summarized in Technical Memorandum #2, Traffic Counts.

Aerial Traffic Counts

Aerial peak period traffic counts were conducted by Skycomp, Inc. of Columbia, MD utilizing their wide-area-video service. Eight helicopters were utilized to collect high-resolution photographs at a rate of one photo per second, producing a stop-motion video of the Parkway East. From this video, count data for the I-376 mainline and ramps, queue lengths at the Squirrel Hill Tunnel, and travel times along the Parkway East corridor were collected by Skycomp. By taking all of the counts from the same video, a consistent data set could be obtained for the entire Parkway East corridor. Data collected from the video are: traffic volumes (in 15 minute increments) on the mainline and ramps, bidirectional travel times between four interchanges and the tunnels, and queue lengths approaching the tunnels. The PM peak hour traffic counts were performed on Tuesday, October 22, 2013 and the AM peak hour traffic counts were performed on Wednesday, November 6, 2013. These particular dates were selected in order to take advantage of the maximum amount of daylight in the peak periods around the transition between Daylight Savings Time and Standard Time, as well as to avoid any potential impacts of Election Day and holidays.

Automatic Traffic Recorder/24-Hour Video Counts

Automatic Traffic Recorder (ATR)/24-Hour Video Counts were performed in October and November 2013 to obtain 24-hour traffic counts at various locations to assist in calibrating the origin-destination traffic data that was being collected separately and to provide information on hourly changes in traffic flows on the Parkway East. The counts were performed at four locations on the Parkway East, and at six locations on the arterial roadway network.

Manual Turning Movement Counts

Manual Turning Movement Counts were performed on typical weekdays (Tuesday–Thursday) during the months of October and November 2013. The counts were performed during the AM (6:00 AM – 9:00 AM) and PM (3:00 PM – 6:00 PM) peak hours. These times were chosen because they typically represent the weekday AM and PM peak times of vehicular traffic. This data will be utilized in the development of the traffic models. Manual TMC's were performed at 56 locations, primarily where Parkway ramps intersect local streets, but also at key locations along the arterial roadway network.

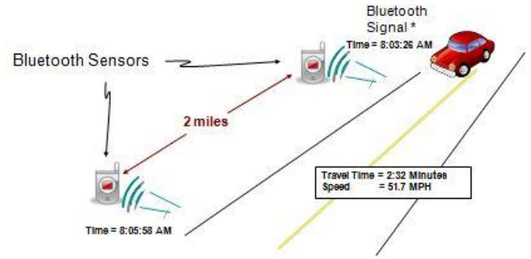
Truck Traffic

Truck traffic as a share of total vehicles varies widely throughout the course of the day, reaching or exceeding 25% of total traffic during overnight hours, but comprising only about 3% or less of peak-direction traffic during peak hours. While the share varies widely, the actual number of trucks per hour remains relatively constant throughout the day. Truck percentages are lower during daytime hours because of heavier non-truck traffic.

2.5 Origin – Destination Study

An extensive origin-destination survey was conducted for the Parkway East corridor. The survey was conducted utilizing traffic surveillance equipment employing Bluetooth technology. The survey was conducted by Traffax, Inc. of College Park, MD utilizing their BlueFAX traffic surveillance equipment. This equipment utilizes Bluetooth technology to provide accurate travel time and origin-destination data. The Bluetooth sensors captured data from vehicles traveling through the study area, and was processed using Traffax's BluSTATS software.

Bluetooth data collection



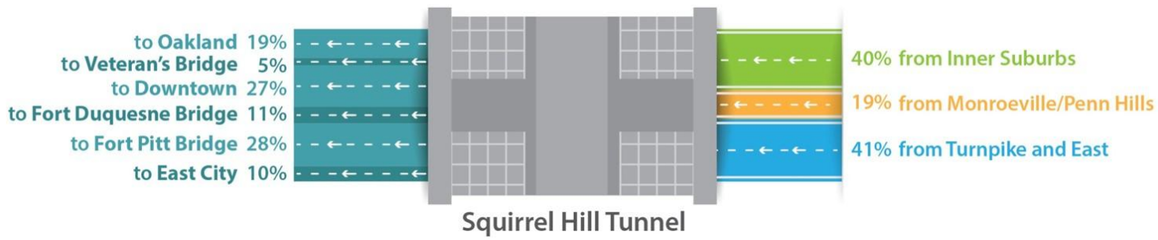
* Bluetooth signals come from cell phones, PDAs, laptops, GPS, car radios...
** Provisional patent received

Origin-data from this study was summarized into matrix form and used to calibrate the VISUM model developed for the project. Key patterns are summarized below.

Westbound AM Peak Patterns

During the AM peak period, heavy westbound traffic flow results in extensive queueing approaching the Squirrel Hill tunnel. These queues last for nearly four hours in the AM, and regularly extend as far as Churchill or even beyond. While over 2,800 vehicles in the peak hour travel the I-376 extension from Monroeville, a nearly equal volume enters the parkway from interchanges between Penn Hills and Edgewood/Swissvale. An additional 2,400 vehicles enter at Squirrel Hill, beyond the bottleneck of the tunnel, and additional traffic enters from the Boulevard of the Allies. In addition to the queue approaching

Parkway East Traffic Patterns



the Squirrel Hill tunnel, congestion can be observed at the Wilkinsburg, Edgewood/Swissvale, Squirrel Hill and Bates Street interchanges, as well as in the Downtown underpass area approaching the Fort Pitt and Fort Duquesne bridges. A particular issue was noted with traffic bypassing the Parkway queues via the Churchill and Wilkinsburg interchange ramps and auxiliary lanes.

Eastbound PM Peak Patterns

In the PM peak, heavy eastbound traffic flow results in extensive queues approaching the Squirrel Hill tunnels. These queues last for as much as four hours in the afternoon and evening which regularly extend beyond the Boulevard of the Allies to Forbes Avenue, or even further on occasion. The majority of this traffic, over 3,000 vehicles in the peak hour comes from the Downtown area and the Interstate bridges, and another 900 comes from similar origins via the Boulevard of the Allies. Slightly more than 1,200 additional vehicles enter at Bates Street and Squirrel Hill combined, and about 2,500 vehicles enter from the suburban interchanges beyond the bottleneck of the tunnel.

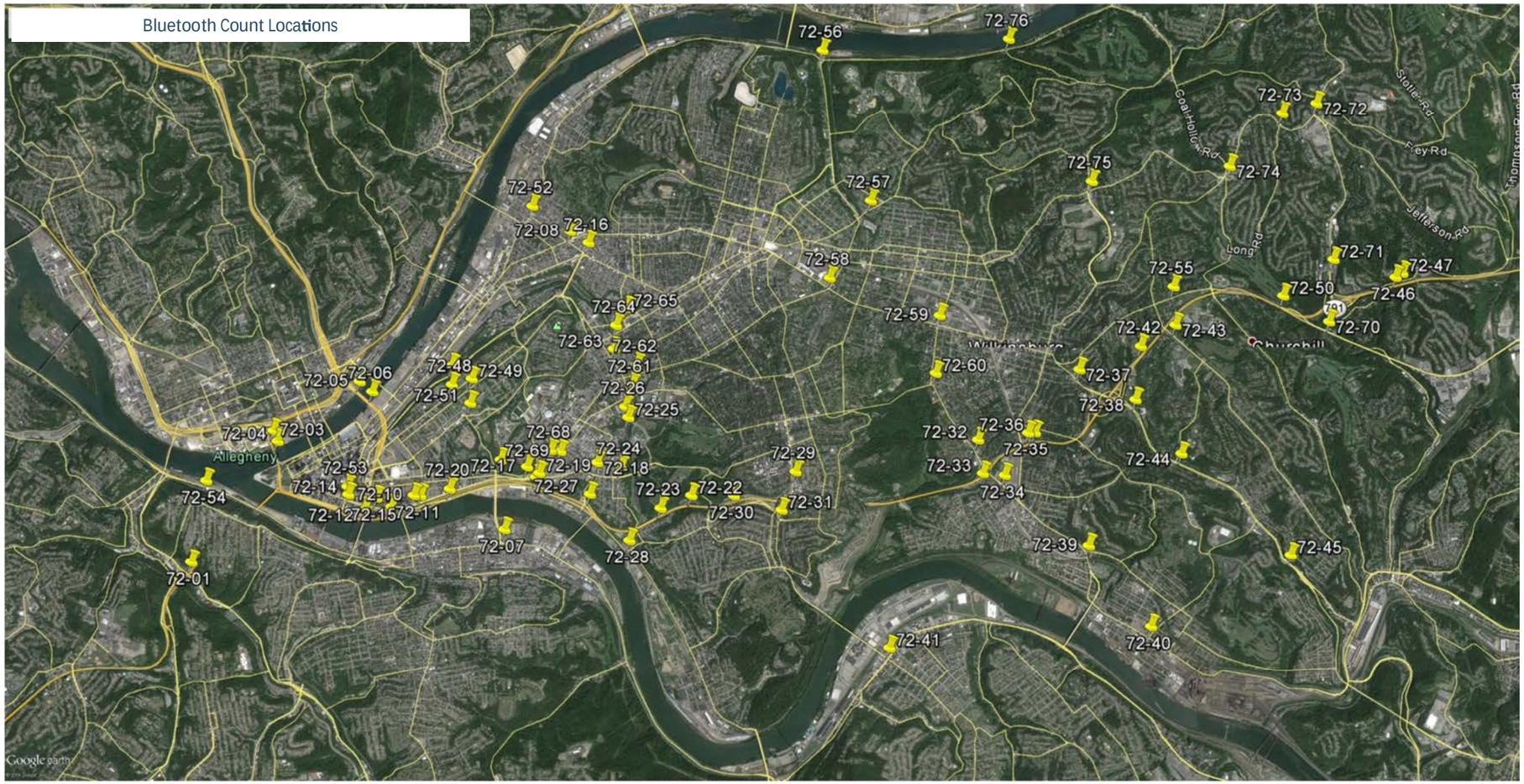
In addition to the queue approaching the Squirrel Hill interchange and tunnel, congestion can also be observed at the Bates Street interchange, on the approach to the lane drop at Squirrel Hill, at the Edgewood/Swissvale entrance ramps, approaching the lane drop at Churchill, and at the Business 22 and Route 48 exits. A particular issue was noted with traffic approaching the Squirrel Hill Tunnel. These are vehicles in the right, exit-only lane that bypass queues in the through lanes approaching the tunnel.

Travel Patterns

The Squirrel Hill tunnels primarily serve longer-distance trips, with shorter trips more likely to use alternate routes.

72% of traffic from the Turnpike and east travels to Downtown or beyond via the Squirrel Hill tunnels, and only 3% uses local roadways. However, 19% of the trips from Monroeville are destined to Oakland via the Squirrel Hill Tunnels while 6% use local routes.

By comparison, from the inner eastern suburbs, 51% travels to Downtown or beyond via the Squirrel Hill Tunnels, while 10% use local roadways. By comparison, 14% of the trips from the inner eastern suburbs are destined to Oakland via the Squirrel Hill tunnels, but 25% use local roads for this trip.



3.0 PUBLIC INVOLVEMENT

3.1 Stakeholder interviews

25 meetings were held in the corridor with key stakeholders, including municipalities, neighborhood organizations, economic development agencies and advocacy groups. The following organizations were interviewed:

- Allegheny County Department of Economic Development
- Allegheny County Department of Public Works
- Bike Pittsburgh
- Braddock Hills Borough
- Churchill Borough
- City of Pittsburgh – City Council
- City of Pittsburgh – Department of City Planning
- Council of Neighboring Communities (CONNECT)
- Edgewood Borough
- Forest Hills Borough
- Greenfield Community Association
- Oakland Planning and Development Corporation
- Oakland Transportation Management Association
- Pittsburgh Community Reinvestment Group
- Pittsburgh Public Schools – Transportation
- Port Authority of Allegheny County
- Regent Square Civic Association
- Regional Industrial Development Corporation
- Squirrel Hill Urban Coalition
- Swissvale Borough Fire Department
- Traffic 21
- Turtle Creek Council of Governments
- Urban Redevelopment Authority of Pittsburgh
- Wilkins Township Commissioners
- Wilkinsburg Borough

Interviews were conducted in December, 2013 and were held at locations convenient to the participants, including SPC offices, Swissvale Fire Department, Churchill Borough building, and the consultant's office. Prior to the interviews, participants were provide with example questions, and were given the opportunity to comment on transportation conditions and needs in the corridor, including on I-376 and its interchanges, along alternate routes, and bike/pedestrian and transit needs.

While comments were wide ranging and intensive, certain key themes were shared by a number of participants, as follows.

Likes

- Existing access to the Parkway from local neighborhoods and access to the city
- Improvements done to the Parkway to date, (tunnel ceiling removal and interchange added lanes
- ITS traffic information (could be utilized more)

Dislikes

- Congestion during peak hours on the Parkway and alternate routes
- Delays at the Squirrel Hill Tunnel
- Unpredictable on and off ramp lengths
- Lack of transit options and the capacity of existing buses and park-and-ride lots
- Transit not reliable due to Parkway East congestion
- Travel signs are not adequate (belt system not utilized, real-time information needed)
- More coordination needed to improve the efficiency of EMS response on the Parkway East

These comments were considered in developing the purpose and needs defined for the project.

3.2 Public Meeting

A series of two public meetings were held, at the Doubletree Inn in Monroeville on May 11, 2014 and at the Pittsburgh Greenfield K-8 school on May 15, 2012. 80 people signed in at the meetings, with 32 public officials attending the preceding briefings. An open house display of four stations staffed by project team members was followed by a presentation led by Dan Cessna and Victor DeFazio. The presentation was followed by a question and answer period; 50 completed comment forms were returned. The following are some of the key comments.

Participants view displays at Greenfield public meeting.

I-376 Improvements

- Improve Bates Street interchange
- Squirrel Hill interchange
- Improve Edgewood/Swissvale interchange
- Additional real-time information
- Manage lanes
- Ramp management
- Improved interchange with Fort Pitt and Fort Duquesne Bridges
- Additional lane or prevent weave Churchill to Business 22

Missing Connections

- Direct connection with I-579
- Complete interchange at Bates Street
- Intermediate exit for Monroeville
- Mon/Fayette Expressway

Additional Comments

- Consideration for traffic impacts on adjacent communities
- Don't close ramps that serve adjacent communities
- Upgrade traffic signals
- Extend East Busway/Enhance transit
- Manage traffic flow: aggressive and slower drivers
- Improve tunnel lighting

The public meetings are further documented in the Public Meeting Report.

3.3 Website

A project website was established by the project team, hosted at the URL www.I376ParkwayEast.com. The website included pages providing a project overview, facts about the history of the Parkway East, traffic flows and bridges and tunnels; the project approach, and the public involvement process. The website was updated through the course of the project as additional information and documents became available. The website was used to host an online survey. In addition to a range of questions, the survey provided map pages developed using Metro Quest which provided participants an opportunity to map their typical route through the project corridor, and to highlight likes, dislikes and areas of concern on a map. The website and survey were publicized via an email blast, a press release, and newspaper articles. 2,797 survey visitors completed 2,179 surveys with over 17,000 interests and concerns. Among the key comments received were the following.

Congestion

- Include HOV lanes
- Utilize congestion pricing
- Widen the roadway/add lanes
- Consider completing the Mon/Fayette Expressway
- Improve variable messaging to include real-time updates
- Offer carpooling incentives
- Consider closing ramp(s) during peak hours
- Maintain existing interchange access

Transit

- Add more park-and-ride lots
- Provide more transit alternatives

Safety

- Consider crash management techniques
- Provide consistent merge points and ramp lengths

Speed

- Implement an education campaign related to maintaining speed and merging
- Speed limit too low

Tunnels

- Widen tunnels
- Bypass tunnels
- Use three lanes in one direction during rush hour in the tunnel.

These comments were considered in developing the purpose and needs defined for the project.

3.4 Stakeholder Meeting

A Stakeholder Meeting was held in March, 2015 at the Churchill Borough Building. Organizations which participated in the stakeholder interviews were invited to participate. The meeting featured and overview of project progress, including presentation of the conceptual mitigation measures identified in the study. The Phase 1 screening process was introduced, and stakeholders participated in an interactive exercise to determine weighting of the various measures of effectiveness to be used in the screening. This is discussed further in Section 6 of this report.

4.0 UNDERSTANDING THE CORRIDOR

4.1 Capacity Analysis

Capacity analysis of the study intersections was performed using the standard analysis methodologies presented in the 2010 Highway Capacity Manual (HCM2010), published by the Transportation Research Board. Under this methodology, levels of service (LOS) A through F are determined as measures of adequacy for functioning of the facilities, with A the best and F the worst level of service available. LOS is a measure of the average seconds of delay that a vehicle (and its passengers) experiences while passing through an intersection.

Capacity analyses were performed on the study intersections under 2013 existing conditions. The calculated levels of service were summarized in Technical Memorandum #6 Capacity Analysis.

4.2 Network Model

A network assignment model was developed using the VISUM program, version 12.5, from PTV Group. This model was used as a basis for the future year volumes and any options that required macroscopic network changes. Data used to develop the model included traffic counts, Bluetooth origin destination survey data, existing SPC model volumes and inputs, TAZ-level origin-destination information, roadway geometry and intersection signal timing.

The model was developed for a network which included the Parkway East itself, as well as a network of arterial and local roads which serve as alternate routes to the Parkway East, This adjacent network was particularly robust in the area adjacent to the Squirrel Hill tunnel. Separate models were developed for the AM and PM peak periods, a refinement of the SPC regional model which only considers daily traffic flows, and an important factor in evaluating traffic diversion at the Squirrel Hill tunnel.

The target volumes were calculated based on the projected daily traffic volumes extracted from the 2011, 2020, and 2040 Southwestern Pennsylvania Commission (SPC) regional travel demand forecasting models. Control points where traffic growth factors were calculated were established throughout the VISUM highway network. The figure below depicts the links where the SPC traffic volumes were stored. It is noteworthy to point out that the original designed coverage of links with SPC traffic volumes was larger; however, not all the links were coded in the SPC regional highway network.

VISUM's TFlow Fuzzy was used in updating the input seed trip table based on target volumes. The 2011 AM and PM trip tables were the seed trip tables for estimating the 2020 trip tables. The resulting 2020 trip tables then became the seed trip tables for estimating the 2040 trip tables.

The trip table adjustment process was an iterative process. After each iteration, the resulting assigned volumes were compared against the target volumes. The errors of the current iteration were plotted against the previous iteration for tracking the "trend" of convergence visually, and the process was completed until an optimal and reasonable adjusted trip table was produced.

The calibrated VISUM models were used as the basis for evaluating future year traffic growth, as well for evaluating potential traffic diversion due to network changes such as new links.

4.3 Network Simulation

A network simulation model was developed using the VISSIM microscopic simulation program, version 5.40, from the PTV Group. The VISSIM links and connectors were drawn using a scaled aerial image background to keep the lengths and widths of the roadway network true to life. After the basic network geometry was drawn in, traffic signal controllers were coded in. The traffic signals were coded in using the current signal timings and plans. Loop detectors and signal heads were placed in accordance with the traffic signal plans.

Links were assigned roadway grade data from the Parkway East plans and measurements from Google Earth Pro in order to emulate vehicle acceleration/deceleration behaviors. The base model used intersection turning movement counts, Bluetooth origin-destination data, and Skycomp aerial traffic counts to determine the vehicular demand and routes.

The OD data that was obtained during the data collection effort was a representative sample of the trips made in the corridor. The OD data was factored up to match the actual volumes obtained during the aerial traffic counts since the capture rate of the Bluetooth monitors was around five percent.

Separate models were developed for the AM and PM peak periods, using traffic data from a variety of sources. The Skycomp aerial data collection provided mainline and ramp volumes counted in fifteen minute intervals. The AM and PM base models used the fifteen minute counts to emulate the non-steady state traffic flows onto the Parkway. The OD data was filtered based on specific detectors that showed trips that used the Parkway East and or Squirrel Hill Tunnel. Bluetooth detectors were grouped based on the Parkway on/off ramps used for the individual trips. An origin destination matrix was created using the Bluetooth data. The hourly ramp volumes from the Skycomp counts were used with the Furness Distribution Model to create a trip table. The Furness model is an iterative process that distributes the ramp volumes proportionally based on the values in the OD matrix. Once the ramp to ramp volumes were determined, routing decisions were coded into VISSIM. The intersections adjacent to the ramps served the purpose of metering the traffic feeding the ramps. Volumes that entered the ramps were varied to match both the turning movement counts at the intersections and the Skycomp fifteen minute ramp counts. Volume inputs were added on all links entering the network. Data collectors were placed at all on and off-ramps along the corridor to determine if the entering and exiting volumes matched the existing counts.

Desired speed decisions were placed on all links to match observed speeds. The VISSIM model was run through multiple times throughout the initial coding process to verify the operation of the network.

Accurate modeling of traffic flow through the Squirrel Hill Tunnels, including the adjacent interchanges at Squirrel Hill and at Edgewood/Swissvale was essential for this study, because of the overwhelming impact of queues at this location on peak-period traffic flows. Particular attention was given to coding and calibration of the model at these locations to replicate existing flows, merging operations, and queue formation and dissipation.

Unlike macroscopic models, the VISSIM model does not allow for a pre-set roadway capacity to be used. As in real-life traffic operation, roadway capacity is a function of interaction between vehicles given the geometric and operational constraints of the roadway. VISSIM models these interactions mathematically, based on the Wiedemann 99 car-following algorithm, which considers the operational parameters outlined in the table below.

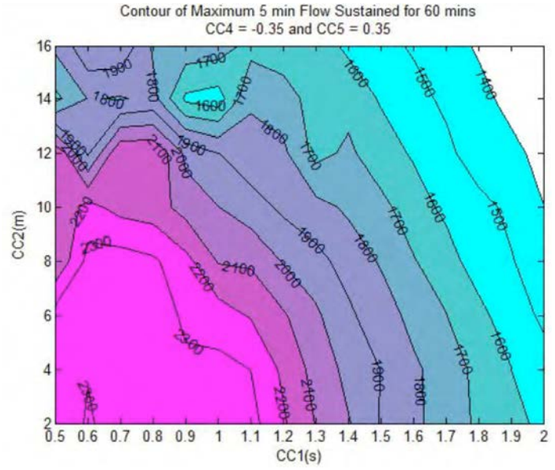
Two parameters, CC1 and CC2 directly affect roadway capacity, as shown in the graphic on the following page Default values did not accurately reflect the observed merge and bottleneck operation. These parameters were adjusted empirically based upon traffic count data and field observations , and the model was iteratively adjusted until the model accurately reflected observed queue behavior. Essentially, adjusting these parameters allow the algorithm to reflect the tendency of motorists to follow each other less aggressively while traveling through the tunnels, a reflection of he lack of shoulders and the constrained geometry. This in part results in the often observed behavior of traffic slowing in the tunnels despite posted speed limits and no evident constraints. Separate adjustments to these parameters were also required to model merging behavior at ramps before and after the tunnels, where drivers often merge and change lanes with very narrow buffers between vehicles.

Modeling of the eastbound on-ramp from Beechwood Boulevard also required customized modeling of the stop control, as drivers must react differently under free-flowing and congested conditions.

Wiedemann 99 Car Following Parameters

VISUM Network

Maximum Flows vs CC1 and CC2.



Calibration of the model included comparing measured travel times, ramp volumes, queue lengths and speeds to the VISSIM model. Model volumes were compared to field data using the GEH formula. The GEH formula is a continuous volume tolerance formula, and does not use the percentage difference between the model and field volumes. As per the Oregon Department of Transportation Protocol for VISSIM Simulation manual, the GEH value calculated using the formula below should be less than 5 to be considered acceptable.

For hourly flows, the GEH formula is:

$$GEH = \sqrt{\frac{2(m-c)^2}{m+c}}$$

Notes:
m = output traffic volume from the simulation model (vph)
c = input traffic volume (vph)

The build models were based on year 2040 volumes. The only exceptions to this were the ramp management options, which were developed with year 2020 volumes. The future year volumes were developed using VISUM, a traffic demand modeling software. Volumes output from the VISUM were applied to the calibrated existing AM and PM models. 2020 and 2040 AM and PM No Build models were copied for each alternative that was to be analyzed. Each model was modified to reflect the revised geometry of the concepts as presented in Appendix 2: Line and Grade Plans.

Build year models were run with five different random seeds to get a dataset that reflected the costs and benefits. Performance measures such as vehicle miles traveled (VMT), vehicle hours of delay (Veh-Hrs), travel times, link volumes, speeds, and emissions data were used to compare the options to the No Build models. Vehicle miles traveled and vehicle hours of delay were factored up to include the vehicles that were not served by the two hour simulation model. The vehicles that were not served indicate a lengthening of the peak hour.

4.4 Bottleneck Analysis

A bottleneck analysis was conducted along I-376 as part of this study, and was presented in Technical Memorandum #7, Bottleneck Analysis.

According to FHWA's publication, *Recurring Traffic Bottlenecks: A Primer*, "Bottlenecks are localized sections of highway where traffic experiences reduced speeds and delays due to physical restrictions, too much demand, or both." It also states that bottlenecks are "specific points on the highway system where traffic flow is restricted due to geometry, lane-drops, weaving, or interchange-related merging maneuvers".

The Squirrel Hill Tunnel is the main bottleneck point, in both directions, along the Parkway East. This is primarily due to the two-lane cross section through the tunnel in each direction, with three or more lanes, including ramps, feeding traffic into this area. Traffic flow through the tunnel is constrained by the limited horizontal and vertical clearances, which lead some drivers to slow or to increase following distances when entering the tunnel. Because of the combination of these factors, the bottleneck operation is complex and encompasses not only the tunnel itself but also the Edgewood/Swissvale and Squirrel Hill interchanges.

This analysis not only identified existing bottleneck locations along the Parkway East, but also potential bottleneck locations. These locations are significant because they could become bottleneck points under future conditions, such that they could become limiting points either due to traffic growth, or to mitigating measures that improve traffic flow through existing bottlenecks. In this latter situation, traffic flow benefits from an improvement project could be significantly reduced if the congestion point simply shifts a short distance to a new, previously hidden bottleneck location. In the first situation outlined, growth in traffic flow entering the Parkway could cause traffic volumes to increase to the point where they surpass the capacity of one or more exit ramps or the mainline itself, leading to a new bottleneck condition.

This analysis indicates that peak traffic flows along the Parkway East are in many cases closely balanced with roadway capacity. Numerous entrance and exit ramps have the potential to become bottlenecks with relatively small increases or shifts in traffic flows. In particular, the well-known bottleneck at the Squirrel Hill Tunnel is closely intertwined with bottlenecks at the adjacent ramps. If additional capacity could be added at the Squirrel Hill Tunnel, benefits could be negated by these adjacent bottlenecks, some upstream interchanges may not be able to accommodate increased flow, and additional bottlenecks could occur at downstream interchanges.

4.5 Transit Demand Analysis

A transit demand analysis was conducted, evaluating existing travel patterns by automobile and by transit, understanding the transit mode share, and determining the latent demand for potentially converting trips from automobile to transit. This was presented in Technical Memorandum #5, Transit Demand Analysis.

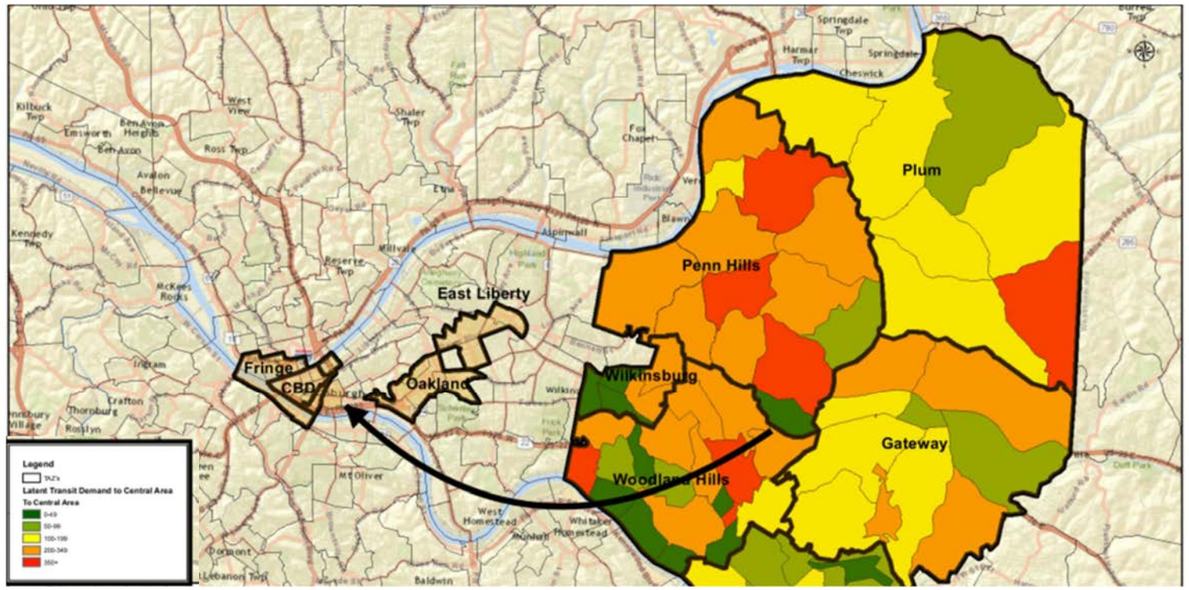
The analysis focused on Allegheny County, and on trips from the Parkway East Corridor to the employment centers in Oakland, the East Busway corridor, Downtown Pittsburgh and the Parkway West Corridor.

Analysis was based upon trip tables from SPC's regional model, including both work trips and other trips, and included person trips, automobile trips and transit trips. It found that transit mode split between the eastern suburbs and the employment centers reaches as high as 35% when good service and adequate parking and ride capacity is available. The analysis determined that transit for reverse commutes is less used, with a mode share of under 5%, dropping to about 1% for trips between the eastern suburbs and the Parkway West corridor.

The analysis indicated that there is a relatively large amount of latent travel demand in the Parkway East corridor, particular between residential areas in the eastern suburbs and the employment opportunities in Downtown, Oakland and central Pittsburgh. Latent demand to other areas studied in the corridor is relatively low. Latent demand is greatest in the Penn Hills and Woodland Hills areas, but also is spread throughout Monroeville, Plum, and southeastern Allegheny County. This is consistent with information presented by stakeholders and the public.

The full potential unmet transit demand is relatively high, and to serve it would require a very high level of transit service, with both high frequencies and convenient access. Providing such an extensive network of local routes or an adequate number of parking spaces could prove to be challenging in practice. However, it appears that there is ample demand for additional transit service and park-and-ride facilities throughout the eastern portion of the study area.

Latent Transit Demand from Eastern Area to Central Area



5.0 IDENTIFYING NEEDS

5.1 Purpose

The purpose of this project is defined as the following: To improve traffic flow, improve safety, and improve multimodal travel options in the Parkway East Corridor Transportation Network, located in Allegheny County, Pennsylvania, which consists of the Parkway East (I-376) from the Fort Pitt Bridge to the Pennsylvania Turnpike/US 22 interchange, and also includes parallel and intersecting arterial roadways.

5.2 Need

A Needs Analysis was conducted to identify and document the need for transportation improvements within the study area. The analysis was completed in accordance with the guidelines set forth in the PennDOT *Publication 319, "Needs Study Handbook for the Transportation Project Development Process"*, dated December 2010.

The Parkway East Is Congested

The Parkway East is heavily congested, and is widely known as one of the most significant traffic bottlenecks in the region. Both the eastbound and westbound approaches to the Squirrel Hill Tunnel are oversaturated for 12 or more hours out of the day, the equivalent of a Level-of-Service (LOS) F. During some periods, this oversaturation is represented by short queues approaching the tunnels. During the peak periods, lasting about four hours in both the AM and PM, these queues become extensive and severely impede traffic flow. In the AM peak period on a typical weekday, westbound queues extend 4.91 miles back from the Squirrel Hill Tunnels, while in the PM peak period, eastbound queues can extend 2.66 miles from the tunnels. Longer queues are observed on occasion, and queues can form unexpectedly at other times of the day.

Aside from the tunnels, bottlenecks and congestion points are observed at locations including: the eastbound PA Route 48 exit, Business 22 exit, the eastbound lane drop at Churchill, the westbound Wilkinsburg entrance ramp, the westbound Edgewood/Swissvale entrance ramp, the Squirrel Hill Tunnel, the eastbound Squirrel Hill entrance ramp, the eastbound Bates Street entrance ramp, the westbound Glenwood exit ramp, the westbound Boulevard of the Allies exit, the underpass area near Downtown Pittsburgh, and the Fort Duquesne/Fort Pitt Bridge ramps.

Comments from the stakeholders and the public noted that recurring peak-period congestion poses a barrier between the eastern suburbs and the remainder of the region. Limited availability of real-time traffic information contributes to the impacts.

Alternate Routes Are Congested

The roadway network feeding and surrounding the Parkway East is limited by topography, with few alternate arterial highways. Adjacent to the Squirrel Hill tunnels, Frick Park, a large cemetery, and Nine Mile Run together form barriers that greatly restrict the available alternate routes. Most alternate routes are only two lanes, and many pass through urbanized communities with dense patterns of development, multiple traffic signals, low speed limits, and conflicting pedestrian and vehicular traffic flows. A number of these intersections operate at unacceptable levels of service, travel times are generally long, and there is little available capacity in the network. Some alternate routes and the oversaturated intersections along them are as follows:

- Old William Penn Highway
  - Old William Penn Highway and Rodi Road/ Nottingham Drive
  - Old William Penn Highway and Beulah Road
- Ardmore Boulevard
  - Ardmore Boulevard and Franklin Avenue
  - Ardmore Boulevard and Brinton Avenue/ Marlboro Avenue
- Beechwood Boulevard
  - Beechwood Boulevard and Hazelwood Avenue/ Browns Hill Road
  - Beechwood Boulevard and Monitor Street
- Second Avenue
  - Second Avenue/Greenfield Avenue and Irvine Street/Saline Street
  - Second Avenue and Bridgeside Point
  - Second Avenue and Hot Metal Bridge
  - Second Avenue and Bates Street/Technology Drive
  - Second Avenue and 10th Street Bridge/ Armstrong Tunnel

Crash Rates Are Above Average

The overall crash rate of 1.01 crashes per 100 million vehicle miles on the Parkway East exceeds the statewide average of 0.56 (on similar transportation facilities) throughout most of the study corridor. An evaluation of three years of data from January 1, 2010 through December 31, 2012, showed a high proportion of rear-end crashes. Crashes were distributed throughout the corridor with some concentration at the Bates Street, Squirrel Hill, and Edgewood/Swissvale interchanges. Opportunities to improve safety should be considered where practical.

Roadway Geometry Does Not Meet Existing Design Criteria

Existing geometric roadway features on the Parkway East do not meet current design standards, based upon an evaluation using the current (2014) roadway design criteria presented in PennDOT *Publication 13M, "Design Manual Part 2, Highway Design"* (DM-2) and the AASHTO Green Book. While the Parkway was constructed prior to the current design criteria being established, opportunities to improve the geometry should be considered where practical.

Parkway East Travel Times are Unreliable

Travel times in the corridor are unpredictable. Average travel times through the corridor range from about 15 minutes during uncongested periods, to as high as 26 minutes eastbound and 29 minutes westbound. Individual trips can take even longer, with an estimated travel time reliability index showing that 7.3% of eastbound trips and 11.5% of westbound trips take more than 10% longer than the median for that time period. Stakeholders and public input shows that this unreliability requires travelers to account for the longest possible travel times, a situation exacerbated by the limited availability of real-time speed and travel time information.

Multimodal Transportation Options Are Limited

Multimodal transportation options in the study area, while available, are inadequate. While the eastern suburbs are served by several bus routes operated by the Port Authority of Allegheny County and by Westmoreland County Transit Authority, these routes only serve a limited area. There are fifteen Park and Ride lots in the east suburbs of Pittsburgh, with a total of 2,550 spaces. Nine of these lots, totaling 1,662 vehicles, fill up at an early hour. Spaces remain available throughout the day at the remaining lots, which are generally served by less frequent and non-express bus service. The unavailability of park and ride spaces leave many commuters no option except driving. Inner suburbs such as Wilkinsburg are well served by express service on the East Busway which terminates in Swissvale, with service further to the east available only on buses operating in mixed traffic. Transit ridership in most of the study area is significantly below the rates achieved in areas with more frequent and faster bus service, indicating a potential latent transit demand.

The Parkway East corridor is served by an extensive and growing network of bicycle lanes and trails, but this network is fragmented and does not extend into the eastern suburbs. 25.41 miles of protected bicycle lanes and 30.64 miles of marked, shared lanes have been designated in the City of Pittsburgh, but none extend across the city boundary. The Eliza Furnace Trail, a portion of the Three Rivers Heritage Trail, parallels the Parkway East between Downtown and Bates Street and connects to Oakland. A disconnected segment of trail extends between the Glenwood Bridge and Frick Park. The Great Allegheny Passage trail provides a continuous connection between Downtown Pittsburgh and Washington, D.C., but (located on the south bank of the Monongahela River) does not directly service the Parkway East corridor transportation network.

The public also identified a number of areas where pedestrian connectivity is lacking, particularly areas near Parkway interchanges at Squirrel Hill and Edgewood/Swissvale.

6.0 DEVELOPING SOLUTIONS

The Phase 1 Alternatives Analysis was structured to build upon the base of public input with an extensive program of data collection and analysis to identify the transportation needs in the corridor. Based upon this information, a broad range of potential improvement concepts was identified. Following consultation between the consultant team and the Department, these were refined into an initial list of 100 improvement concepts, which were presented to a committee of corridor stakeholders for comment and discussion.

These 100 concepts were developed further and subjected to a screening consisting of scoring on a range of measures of effectiveness (MOEs), addressing potential benefits, constraints and costs. These scores were weighted based upon criteria developed by the project team in consultation with the committee of corridor stakeholders, and used to develop a qualitative rating for each improvement concept.

From this screening, 63 alternatives were identified for further analysis and evaluation by the consultant team. Ten concepts are being evaluated by the Department as potential "Early Action" items that could be implemented via existing programs and funding, and an additional five concepts are being evaluated by the Department under separate studies. An additional nine concepts were identified that are not being advanced under this study as they would primarily affect facilities and modes under the jurisdiction of other agencies.

6.1 Brainstorming Workshop

Prior to the Phase I Alternatives Analysis, the consultant team conducted extensive data collection, technical analysis and public engagement activities, which were summarized separately. At the beginning of the Phase 1 Alternatives Analysis, the consultant team identified a preliminary list of 191 potential improvement concepts, reflecting items identified during the technical analysis or by the public during comments.

A workshop was held on January 29, 2015 at the PennDOT District 11-0 office. Workshop participation included 11 staff members from District 11-0, including the project manager; representatives from the Design, Traffic, Environmental, and Maintenance Units; as well as staff members with personal knowledge of the corridor.

Following the workshop, the project team held several more working sessions, conducted via email, telephone and in person, to further refine the list of concepts. During this process, some concepts were determined to be essentially duplicates and were eliminated, while others were broken into separate or related concepts, and some new concepts were identified from the discussion.

6.2 Initial List

At the conclusion of this process, an initial list of improvement concepts was prepared. This list included nearly 100 concepts which appeared to be feasible and to have the potential to address one or more needs identified for the project.

This list was presented to the Stakeholder Committee at a meeting on March 19, 2015. Stakeholders provided additional feedback, which was used to further refine the list and resulted in the addition of several additional concepts for the preliminary screening.

1. I-376 Managed Lanes
2. I-376 Additional VMS Signs
3. Overall Ramp Management
4. Variable Speed Limits
5. Congestion Pricing/Tolling for Tunnel
6. Truck Restrictions during Peak Hours
7. Headlight Barriers/Visual Shield
8. Visual Shields for Accident Response
9. Staging Service Patrols/Enhanced Responses
10. Extra Lanes in Squirrel Hill Tunnels
11. More Pullover Areas
12. Merge Like a Zipper Signs/Merging Education
13. Enhanced Signage for Left Exits
14. Improve Merge Wood Street/279 Eastbound connector
15. Left Lane Exit Only Signage MP 71.6
16. Fort Pitt/Commonwealth Signage
17. Fort Pitt/Wood Street Signage
18. Panther Hollow/Greenfield Roundabout
19. Bates Street Missing Ramps
20. Queue Detection on Bates Street Westbound Off-Ramp
21. Lengthen Eastbound Bates Acceleration Lane
22. Glenwood/Bates Westbound Deceleration lane
23. Eastbound Shoulder Forbes to Bates
24. Right Lane Exit Only at Bates Westbound
25. Second-Bates-Hot Metal Retiming/Phasing
26. Beechwood/Monitor Roundabout or Signal
27. Beechwood/Alger/Ronald/Greenfield Bridge Roundabout
28. Pedestrian Crossing of Beechwood Boulevard at Forward Avenue
29. Squirrel Hill - Collector/Distributor and/or Separate Lanes
30. Squirrel Hill - Eliminate Eastbound Weave
31. Squirrel Hill - Lengthen Eastbound Weave
32. Edgewood/Swissvale - Combine Eastbound Ramps
33. Reconfigure Squirrel Hill Interchange for Bikes, Peds, Aesthetics
34. Widened Shoulders Bates to Squirrel Hill
35. Reversible Lanes in Tunnels
36. Limit Tunnel Parking Closures During Peak Periods
37. 376 On-Ramp/West Swissvale Ave Traffic Control
38. 376 On-Ramp/Monongahela Ave Traffic Control
39. Ardmore/Brinton U-turn Improvements
40. I-376 to Ardmore Blvd Direct Connection
41. Reconfigure Edgewood/Swissvale Interchange
42. Third Eastbound lane Edgewood to Chestnut Street Bridge
43. Edgewood/Swissvale Eastbound Ramp Consolidation
44. Swissvale Eastbound Acceleration lane
45. Edgewood/Swissvale Westbound Ramp Yield Signs
46. Wilkinsburg Westbound Acceleration Lane
47. Combine Westbound Wilkinsburg and Ardmore Boulevard On-Ramps
48. Eliminate Business 22/Churchill Westbound Weave
49. Control Weave between Churchill and Monroeville
50. Churchill Eastbound Ramp Consolidation
51. Churchill Eastbound Crossover Barrier
52. Churchill Eastbound Acceleration Lane
53. Improve Radius on Old Gate Ramp for Truck Turns
54. Extend Third Eastbound lane past Churchill
55. Greensburg Pike Lane Drop Pavement Markings
56. Westbound Business 22 Acceleration lane
57. Access to and from East at Rodi Road
58. Curve and Speed Advisory Westbound MP 84.5
59. Forbes/Braddock Reconfiguration
60. Edgewood/Braddock Reconfiguration
61. Penn/Braddock Reconfiguration
62. Braddock Avenue Pedestrian Improvements
63. Improve Sidewalks
64. Roundabout or Flyover at Allies/Bates
65. Penn Avenue Route 8 Through Streets
66. Four Lane Bates Street
67. Improve Bottleneck on Route 28 at Highland Park Bridge
68. Improve Access to and from Homestead
69. Wilkinsburg - Penn Avenue Retiming/Adaptive
70. Braddock Avenue Retiming/Phasing/Adaptive
71. Fifth Avenue Retiming/Adaptive
72. Murray Avenue Retiming/Adaptive
73. Forbes Avenue Adaptive Traffic Signals
74. Advance Pedestrian Phases
75. Coordinate Signals on Routes 22 and 30
76. Hazelwood 885 Retiming/Adaptive
77. William Penn Retiming/Adaptive
78. Ardmore Blvd/ Brinton Road Retiming
79. Boulevard of Allies Signal Retiming
80. Improve Signal Timing at Penn/Ardmore
81. Mon-Fayette Bypass Construction
82. New Roadway from Turtle Creek Valley to Second Avenue
83. Turnpike EZ Pass Exit at Route 130
84. Water Taxi or Ferry on the Monongahela River
85. Bike Trail Connection to Junction Hollow
86. Bike Trail Connection to Saline Street
87. Forbes Avenue Cycle track
88. Greenfield Ave Bike Lanes
89. Bike Trail Connection Hazelwood to Braddock
90. Bike Trail through Hazelwood/ALMONO
91. South Oakland - Eliza Furnace Trail Bike Access
92. Real time Information on Park-and-Ride Availability and Service
93. Extend East Busway to Monroeville
94. Busway Station at Edgewood Town Center
95. Additional Park-and-Ride Lots in Monroeville
96. Additional Park-and-Ride Lots in Penn Hills
97. Squirrel Hill Commuter Parking Garage
98. Additional Park-and-Ride in Swissvale
99. Ramp Management including Peak Period Closure of Beechwood Boulevard entrance.

6.3 Measures of Effectiveness and Weighting

The preliminary concepts were subject to an initial, qualitative assessment in order to identify those that appeared to be feasible and would be subject to further evaluation. For this preliminary assessment, a range of measures of effectiveness were identified, looking at anticipated benefits, constraints and costs. These are discussed and tabulated below.

For this qualitative evaluation, each MOE was assigned a range of scores between 1 and 10, with 1 indicating a negligible impact and 10 indicating a major impact. To ensure consistency in evaluation of the improvement concepts, the rating scores were defined based upon the range of expected benefits as shown in the following table. In most cases, definitions were not made for all possible scores, but interpolation was to be permitted in the scoring process.

Benefit MOEs

Six measures of effectiveness (MOEs) were identified for evaluation of the potential benefits of the improvement concepts. Five of these are directly related to the purpose and needs for the project, including reduction in Parkway East congestion, reduction in arterial roadway congestion, improvements travel time reliability, enhanced travel options and safety improvements. The sixth MOE, improvement in fuel consumption and emissions, relates to the project area's location in a nonattainment area for air quality, and to potential funding for projects that mitigate this.

Constraint MOEs

Two measures of effectiveness (MOEs) were identified for evaluation of the potential disadvantages of the improvement

Benefit Measures of Effectiveness

BENEFITS		
Reduction of Parkway East Congestion	1 - Negligible	No anticipated impacts
	3 - Low	Improvements in off-peak flow only
	5 - Medium	Reduction in peak congestion at a single interchange
	8 - Substantial	Reduction in peak congestion at multiple interchanges
	10 - Major	Corridor-level reduction in congestion
Reduction of Arterial Roadway Congestion	1 - Negligible	No anticipated impacts
	3 - Low	Improved traffic operation at a single intersection
	5 - Medium	Improved traffic flow at multiple intersections
	8 - Substantial	Improved flow on a single corridor
	10 - Major	Improved flow on multiple corridors
Improvement in Travel Time Reliability	1 - Negligible	No anticipated change
	3 - Low	Anticipated localized incident improvement
	5 - Medium	Anticipated localized daily improvement
	8 - Substantial	Anticipated incident improvement at the corridor level
	10 - Major	Anticipated daily improvements at the corridor level
Improvement in Fuel Consumption/Emissions	1 - Negligible	No anticipated change
	3 - Low	Intersection-level reduction in congestion or delays
	5 - Medium	Reduction in congestion or delays at multiple intersections
	8 - Substantial	Reduction in stop-and-go or delays on an arterial corridor
	10 - Major	Reduction in stop-and-go or delays in the Parkway corridor
Enhances Travel Options	1 - Negligible	No anticipated change
	3 - Low	Localized improvements in access to alternative modes
	5 - Medium	Corridor level improvements in access to alternative modes
	8 - Substantial	Improved access to existing alternate modes
	10 - Major	Major new alternate mode facility
Safety Improvements	1 - Negligible	No anticipated improvement
	3 - Low	Operational change that addresses localized safety issue
	5 - Medium	Operational change that addresses broad safety issue
	8 - Substantial	Physical improvement that addresses localized safety issue
	10 - Major	Physical improvement that addresses broad safety issue

Constraint Measures of Effectiveness

CONSTRAINTS		
Environmental Constraints	1 - Negligible	No anticipated impacts
	3 - Low	Impacts consistent with Categorical Exclusion
	5 - Medium	Impacts would require Environmental Assessment
	8 - Substantial	Impacts would require Env. Impact Statement
	10 - Major	Potential for nonmitigable impacts
Community Access Limitations	1 - Negligible	No limitations on access
	3 - Low	Possible slight changes in access or delay for certain trips
	5 - Medium	Possible restriction of access on a single route/interchange
	8 - Substantial	Restriction in access to on a single route/interchange
	10 - Major	Restriction in access to multiple routes/interchanges

Cost Measures of Effectiveness

COSTS		
Construction Cost	1 - Negligible	Estimated Option Cost < $50,000
	3 - Low	$50,000 < Estimated Option Cost < $500,000
	5 - Medium	$500,000 < Estimated Option Cost < $5,000,000
	8 - Substantial	$5,000,000 < Estimated Option Cost < $20,000,000
	9 - Very High	$20,000,000 < Estimated Option Cost < $50,000,000
	10 - Major	$50,000,000 < Estimated Option Cost
Operating/Maintenance Cost	1 - Negligible	No anticipated change
	3 - Low	Minor increase in electrical or other direct cost
	5 - Medium	Large increase in electrical or other direct cost
	8 - Substantial	Additional staffing at existing facility or crew
	10 - Major	Need for additional staffing unit or crew
Property Impacts	1 - Negligible	None, project within existing right-of-way
	3 - Low	Partial takes of less than five properties
	5 - Medium	Partial takes of more than five properties
	8 - Substantial	Full taking of less than five properties
	10 - Major	Full taking of more than five properties

concepts. The first constraint MOE, environmental constraints, reflects items such as the presence of historical or cultural resources, wetlands, endangered species or parklands which could require agency review, modification of design, or mitigations. The second constraint MOE, community access limitations, is an acknowledgement of the strong concern expressed by stakeholders and the public that potential improvements not limit access to the regional highway network from their communities.

For this qualitative evaluation, each MOE was assigned a range of scores between 1 and 10, with 1 indicating a negligible impact and 10 indicating a major impact. To ensure consistency in evaluation of the improvement concepts, the rating scores were defined based upon the range of expected benefits as shown in the table at right. In most cases, definitions were not made for all possible scores, but interpolation was to be permitted in the scoring process.

Cost MOEs

Three measures of effectiveness (MOEs) were identified for evaluation of the potential cost of the improvement concepts. While these are largely self-explanatory, it is noted that while construction costs are generally higher in magnitude, there is a consistent funding stream available for capital projects. Operating and maintenance costs, while generally lower in magnitude, are typically much more challenging to fund. The property impact MOE recognizes that the acquisition of property involves both cost and potential displacements, and could be a significant factor in this constrained, highly-urbanized corridor.

For this qualitative evaluation, each MOE was assigned a range of scores between 1 and 10, with 1 indicating a negligible impact and 10 indicating a major impact. To ensure consistency in evaluation of the improvement concepts, the rating scores were defined based upon the range of expected benefits as shown in the table on the following page. In most cases, definitions were not made for all possible scores, but interpolation was to be permitted in the scoring process.

Scoring

Each of the one hundred concepts on the initial list were defined, including a conceptual physical layout if appropriate. Each defined concept was then assigned a qualitative score for each MOE by the technical team. These scores were based upon knowledge of the corridor, experience with similar projects, and professional judgement. Detailed technical analysis, line and grade plans, and cost estimates were not developed at this stage.

Weighting of MOEs

Weighted sums were calculated separately for the combined benefit, combined constraint, and combined cost MOEs. A rating was then calculated for each improvement concept as the benefits divided by the sum of the constraints and costs, as follows:

RATING = Benefits/(Constraints + Costs)

The weighting of each MOE was developed through a combination of technical evaluation and stakeholder input. The proposed MOEs were presented at the Stakeholder Meeting discussed previously, and stakeholders participated in

MOE Weighting for Phase 1 Screening

MOE	Weighting
Reduction in Parkway East Congestion	4
Reduction in Arterial Roadway Congestion	4
Improvement in Travel Time Reliability	3
Improvement in Fuel Consumption/Emissions	3
Enhances Travel Options	4
Safety Improvements	4
Environmental Constraints	3
Community Access Limitations	4
Construction Cost	4
Operating and Maintenance Cost	2
Property Impacts	3

an interactive polling used to determine the relative weight to be applied to each MOE. The weighting used in the Phase 1 Screening are tabulated above.

Preliminary Screening

The preliminary screening was conducted, reviewing and evaluating the initial list of improvement concepts. This was a qualitative screening, intended to rule out infeasible projects based upon fatal flaws or low expected benefits related to costs and constraints. Each option was scored on the MOEs according to the criteria discussed previously. The score was weighted using the factors developed with stakeholder input, Weights were assigned to each MOE based upon technical evaluation, with stakeholder input, and a final rating was calculated based on the scores for the benefit, constraint and cost MOEs. This process and the findings are discussed in the following section.

6.4 Phase 1 Screening

Ranking

The rating for the improvement concepts was a qualitative measure, and not a true benefit/cost ratio. It was useful, however, in determining the relative feasibility of the various concepts. Because of the relative weights established for the separate measures of effectiveness, the rating could range from a potential low of 0.1375 for a concept with minimal benefits and high costs and constraints, to a maximum of 13.75 for a concept with high benefits but minimal costs and constraints. Upon inspection of the overall ratings, it was determined that projects with a rating of less than 1.25 had low potential benefits in relation to the constraints and costs, and were generally eliminated from further analysis. However, a limited number of Improvement concepts with ratings less than 1.25 were recommended for further analysis because they had the potential to mitigate specific congestion, safety or operational issues where no other feasible alternatives had been identified. These are outlined below.

Department Study

Ten of the improvement concepts identified by this study were being advanced independently by the Department. If they were determined to be feasible, they would be implemented by the Department as "Early Action" items using existing programs and funds. These are as follows:

8. Visual Shields for Accident Response
9. Staging Service Patrols/Enhanced Responses
12. Merge Like a Zipper Signs/Merging Education
13. Enhanced Signage for Left Exits
15. Left Lane Exit Only Signage MP 71.6
16. Fort Pitt/Commonwealth Signage
17. Fort Pitt/Wood Street Signage
36. Limit Tunnel Parking Closures During Peak Periods
55. Greensburg Pike Lane Drop Pavement Markings
58. Curve and Speed Advisory Westbound MP 84.5

Other Projects

Five of the improvement concepts identified by the study were being advanced through separate studies or projects. These projects are outlined below.

The first four of these are located on or near the Parkway East at the Bates Street/Glenwood interchange, and are being advanced separately as mitigation measures for the Almono development in the City of Pittsburgh. The last of the concepts being advanced separately will address a bottleneck on Route 28 at the Highland Park Bridge, which serves as an alternate route to the Parkway East Corridor Network.

20. Queue Detection on Bates Street Westbound Off-Ramp
22. Glenwood/Bates Westbound Deceleration lane
25, Second-Bates-Hot Metal Retiming/Phasing
66. Bates Street Improvements
67. Improve Bottleneck on Route 28 at Highland Park Bridge

Not Recommended

Fourteen of the improvement concepts identified were not recommended for further study. While four of these appeared to provide potential benefits, during the Phase 1 Screening it was determined that they have fatal flaws which would preclude implementation.

Concept 5, which proposed congestion pricing or tolling for the Squirrel Hill Tunnel, was eliminated due to Federal laws which prohibit tolling of existing lanes on Interstate highways.

Concept 10, which proposed additional lanes in the Squirrel Hill Tunnel, was determined to be infeasible. Construction of an additional tunnel, while difficult and expensive, might be feasible. However, traffic analysis indicates that downstream bottlenecks exist at the Edgewood/Swissvale and Squirrel Hill interchanges. The required mitigations would require adding lanes to the entire Parkway East between Churchill and Downtown Pittsburgh, which is beyond the scope of this project.

Concept 35, which proposed reversible lanes in the Squirrel Hill Tunnels, would pose unacceptable safety risks due to opposing traffic in the tunnel without a physical barrier. Additionally, restricting contra-flow traffic to a single lane would create congestion which would offset benefits in the peak direction.

Concept 44, which called for extending the eastbound acceleration lane from the Edgewood interchange, can not be constructed without replacement of the existing bridges over the Parkway. Previous reconstruction projects have extended the acceleration lane as far as possible within these constraints. While this concept is being eliminated, an additional concept which will construct a third eastbound lane by replacing these existing bridges, is being advanced for further study.

An additional ten concepts were not recommended for further evaluation in this study, due to ratings below the threshold of 1.25, indicating that their benefits appeared to be low in relation to their potential costs. These are as follows:

5. Congestion Pricing/Tolling for Tunnel
10. Extra Lanes in Squirrel Hill Tunnels
19. Bates Street Missing Ramps
34. Widened Shoulders Bates to Squirrel Hill
35. Reversible Lanes in Tunnels
44. Swissvale Eastbound Acceleration lane
40. I-376 to Ardmore Blvd Direct Connection
41. Reconfigure Edgewood/Swissvale Interchange
48. Eliminate Business 22/Churchill Westbound Weave
52. Churchill Eastbound Acceleration Lane
57. Access to and from East at Rodi Road
60. Edgewood/Braddock Reconfiguration
68. Improve Access to and from Homestead
97. Squirrel Hill Commuter Parking Garage

By Others

Nine of the improvement concepts identified were not recommended for advancement in this study, because they were large projects beyond the scope of this project or they involve facilities that would primarily be owned and operated by other agencies. Concepts 81 and 83, for construction or improvement of toll highways, would be under the jurisdiction of the Pennsylvania Turnpike Commission. Concepts 87 and 88, for bicycle lane improvement on local streets, would be under the jurisdiction of the City of Pittsburgh. Five alternatives, for new or enhanced transit facilities, would be under the jurisdiction of the Port Authority of Allegheny County. The relatively high ratings on several of these concepts indicates that they may have merit. While they are not being considered further in this project because of the scope and jurisdictional issues outlined above, they could be advanced by the Department or the relevant agencies under separate projects.

81. Mon-Fayette Bypass Construction
83. Turnpike EZ Pass Exit at Route 130
84. Water Taxi or Ferry on the Monongahela River
87. Forbes Avenue Cycle Track
88. Greenfield Ave Bike Lanes
92. Real time Information on Park-and-Ride Availability and Service
93. Extend East Busway to Monroeville
94. Busway Station at Edgewood Town Center

Further Evaluation

A total of sixty-two of the improvement concepts identified in this study were recommended for further evaluation by the consultant team. Two of these, concepts 29 and 31, have ratings below 1.25, which indicates that their implementation costs may be high compared to the extensive benefits. However, these concepts would address existing issues at the Squirrel Hill interchange where few other options have been identified. The remaining sixty concepts in the following table had ratings higher than 1.25, indicating the potential for benefits that exceed the costs of implementation.

1. I-376 Managed Lanes
2. I-376 Additional VMS Signs
3. Overall Ramp Management
4. Variable Speed Limits
6. Truck Restrictions during Peak Hours
7. Headlight Barriers/Visual Shield
11. More Pullover Areas
14. Improve Merge Wood Street/279 Eastbound connector
18. Panther Hollow/Greenfield Roundabout
21. Lengthen Eastbound Bates Acceleration Lane
23. Eastbound Shoulder Forbes to Bates
24. Right Lane Exit Only at Bates Westbound

26. Beechwood/Monitor Roundabout or Signal
27. Beechwood/Alger/Ronald/Greenfield Bridge Roundabout
28. Pedestrian Crossing of Beechwood Boulevard at Forward Avenue
29. Squirrel Hill - Collector/Distributor and/or Separate Lanes
30. Squirrel Hill - Eliminate Eastbound Weave
31. Squirrel Hill - Lengthen Eastbound Weave
32. Edgewood/Swissvale - Combine Eastbound Ramps
33. Reconfigure Squirrel Hill Interchange for Bikes, Peds, Aesthetics
37. 376 On-Ramp/West Swissvale Ave Traffic Control
38. 376 On-Ramp/Monongahela Ave Traffic Control
39. Ardmore/Brinton U-turn Improvements
42. Third Eastbound lane Edgewood to East of Chestnut Street Bridge
43. Edgewood/Swissvale Eastbound Ramp Consolidation
45. Address U-turns at Allenby Avenue and South Braddock Avenue
46. Wilkinsburg Westbound Acceleration Lane
47. Combine Westbound Wilkinsburg and Ardmore Boulevard On-Ramps
49. Control Weave between Churchill and Monroeville
50. Churchill Eastbound Ramp Consolidation
51. Churchill Eastbound Crossover Barrier
53. Improve Radius on Old Gate Ramp for Truck Turns
54. Extend Third Eastbound lane past Churchill
56. Westbound Business 22 Acceleration lane
59. Forbes/Braddock Reconfiguration
61. Penn/Braddock Reconfiguration
62. Braddock Avenue Pedestrian Improvements
63. Improve Sidewalks
64. Roundabout or Flyover at Allies/Bates
65. Penn Avenue Route 8 Through Streets
69. Wilkinsburg - Penn Avenue Retiming/Adaptive
70. Braddock Avenue Retiming/Phasing/Adaptive
71. Fifth Avenue Retiming/Adaptive
72. Murray Avenue Retiming/Adaptive
73. Forbes Avenue Adaptive Traffic Signals
74. Advance Pedestrian Phases
75. Coordinate Signals on Routes 22 and 30
76. Hazelwood 885 Retiming/Adaptive
77. William Penn Retiming/Adaptive
78. Ardmore Blvd/ Brinton Road Retiming
79. Boulevard of Allies Signal Retiming
80. Improve Signal Timing at Penn/Ardmore
82. New Roadway from Turtle Creek Valley to Second Avenue
85. Bike Trail Connection to Junction Hollow
86. Bike Trail Connection to Saline Street
89. Bike Trail Connection Hazelwood to Braddock
90. Bike Trail through Hazelwood/ALMONO
91. South Oakland - Eliza Furnace Trail Bike Access
95. Additional Park-and-Ride lots in Monroeville
96. Additional Park-and-Ride lots in Penn Hills
98. Additional Park-and-Ride in Swissvale
99. Ramp Management incl. Peak Period Closure of Beechwood Blvd. Ramp.

The methodology and conclusions of the Phase 1 screening were discussed in the Phase 1 Alternatives Analysis Summary Report.

During the more detailed analysis, these 60 alternatives will be subjected to more detailed design development, cost estimation, and evaluation of benefits.

7.0 PHASE 2 SCREENING

7.1 Development of Concepts

Each of the approximately 70 concept improvements advanced to the Phase 2 Screening was developed for further analysis, including where feasible, development of a preliminary line and grade. These are presented in Appendix 2: Line and Grade Plans.

7.1.1 Design Standards

Roadway

PennDOT's *Publication 13M – Design Manual 2* was the controlling document for the design of all roadway concepts. Design criteria varied with roadway classification and type, as roadway concepts included urban freeways, urban freeway ramps, and urban arterials. AASHTO's *A Policy on Geometric Design of Highways and Streets,* 2004 (Green Book) was also used as directed by Design Manual 2 or when needed for further guidance. While ranges were typically provided, the table below indicates the specific values selected for the development of the roadway alternatives.

	Urban Freeway	Urban Free-way Ramp	Urban Arterial
Design Speed mph]	60	30-50	35
Lane Width [ft]	12	15	12
Shoulder Width [ft]	12	8 (inside), 10 (outside)	10
Stopping Sight Distance [ft]	570	200-425	250
Vertical Grade [%]	5	8	8

As discussed previously, existing geometric conditions on the Parkway East do not meet current design standards. This, along with the surrounding terrain, led to the selection of a 60 mph design speed for Parkway East improvements rather than the 70 mph typically used for freeways and interstates. The majority of mainline freeway improvements simply followed existing geometry.

Ramp design speed is based on ramp type, as typically loop ramps are designed with 30 mph and direct-movement ramps are designed with 50 mph. These were adapted to the Parkway East improvements so that ramps with significant curvature were designed for 30 mph and straighter ramps were designed for 50 mph. Designing to 30 mph was only used when necessary (predominantly at the Squirrel Hill Interchange) and was avoided for design elements immediately adjacent to the Parkway (near the merge/ diverge), only being used near the ramp terminus.

Chapter 10 of the Green Book was used for the design of acceleration lane improvements. Specifically, Exhibit 10-70 provided acceleration length based on ramp and mainline design speeds while Exhibit 10-71 adjusted for grade. All ramp entrances/acceleration lanes were considered "parallel". Further, as per the Green Book, 1,200 feet of acceleration length was provided where possible and all acceleration lanes were ended with a 300 foot long taper.

Arterial design was used only for Concept 82, the proposed roadway along the Monongahela River connecting Hazelwood and Turtle Creek.

Roadside

PennDOT's *Publication 13M – Design Manual 2,* the AASHTO Green Book, and the 2011 AASHTO *Roadside Design Guide* provided guidance for roadside design. Due to the limited terrain and right-of-way, the desired clear zone of 30' was rarely able to be provided. As a result, appropriate roadside barriers were placed as needed: concrete barriers for bridges, tunnels, and retaining walls and Type 2-S guide rail for 2:1 fill slopes or otherwise unsafe roadside areas.

Intersections

Four roundabouts were proposed as corridor improvements (Concepts 18, 26, 27, and 64). These were designed using NCHRP *Report 672: Roundabouts: An Informational Guide, Second Edition* (2010). There were also traditional intersection improvements proposed in the corridor (Concepts 59 and 61). These were designed using PennDOT's *Publication 13M – Design Manual 2* and the AASHTO Green Book.

Shared-Use Paths

Several shared use paths were proposed for the corridor (Concepts 85-91). Documents used for design guidance include PennDOT's *Publication 13M – Design Manual 2*, the AASHTO *Guide for the Development of Bicycle Facilities,* and the City of Pittsburgh *Bicycle Facilities Guidelines and Policies*. These paths were designed with a 14 foot pathway with uniform slope and 2 foot shoulders on each side. Vertical curves were all at least 100 feet long and sharp curve radii were avoided where possible.

7.1.2 Right-of-Way

Right-of-Way (ROW) parcel takes are determined from anticipated impacts from the final concept impacts with a 10 foot buffer. Temporary construction, utility, and drainage easements were not evaluated. Sound walls were proposed for sections with residential homes within 500 feet. Full ROW takes included taking both the property and building and were required for major impacts. A partial take only affected property land area. Compensation for a partial take is based on the land's square foot value. A minimum of $500 was used as the minimum paid to a claimant. Land and building values were based upon 2015 Allegheny County assessment data.

7.1.3 Utilities

Aerial utility impacts were determined from visual inspection of the proposed concepts. Underground utility impacts were determined from existing construction plans, where available. Where existing plans were not available, underground utilities were assumed based on site conditions. For preliminary estimating, utility costs were based on a contingency of the total construction costs. The contingencies are as follows:

Minor Impacts – 0 to 2.5% Contingency

Moderate Impacts – 2.5% to 5.0% Contingency

Major Impacts – 5.0% to 10% Contingency

Impacts were classified as Minor, Moderate, and Major based on the size of the proposed concept, the number of utilities within the project area, the risk of impacting the utilities, and the size and/or type of the utilities. These costs were verified by comparison of utility relocation estimates from current projects.

7.1.4 Design Concepts Abandoned

During the design development stage, several concepts were investigated that were rejected due to fatal flaws or feasibility issues. These are noted here but could not be fully assessed.

The first was a variation of Concept 31, called 31C. This consisted of a relocated eastbound on-ramp at Squirrel Hill from the Greenfield/Alger/Beechwood/Ronald intersection, running parallel to Exposition Way and curving right, under the proposed Greenfield Bridge, and descending to merge with the Parkway. The intent of this was to maximize the horizontal runout, and to thus provide a longer weave area. At the eastbound Squirrel Hill interchange However, this was rejected as a plausible vertical alignment could not be designed to provide enough clearance under the proposed Greenfield Bridge.

Another rejected concept was the original plan for 47A, which consisted of merging the existing westbound on-ramps at the Forest Hills/Wilkinsburg Interchange. This concept was rejected as Brinton Road prohibits the widening of the westbound Wilkinsburg on-ramp, which would be required to provide the taper as the ramps merge.

Finally, various alignments for shared-use bike paths adjacent to the Parkway East between Bates Street and Squirrel Hill were considered but rejected based on challenging grades and the significant switchbacks that would be required.

7.2 Evaluation of Concepts

Each of the approximately 70 concepts advanced to the Phase 2 Screening, if found to be geometrically feasible, were evaluated extensively on multiple measures of effectiveness, as outlined below. Summaries of the results for each concept are provided in the attached Appendix 1: Concept Summaries; and detailed calculations are provided separately in Appendix 4: Evaluation of Concepts.

7.2.1 Traffic Analysis

Parkway Alternatives

Traffic Impacts for concepts affecting the Parkway East mainline and interchanges were evaluated using the VISSIM simulation model developed for this project. For each concept, the VISSIM network was modified to reflect geometric and operational changes, and rerun to simulated the anticipated traffic impacts. VISSIM does not directly calculate intersection or ramp level of service, but provides more detailed measures of effectiveness on a link or network level, including travel time, vehicular delay, vehicle-miles traveled, fuel consumption and number of vehicles.

Intersection Alternatives

Traffic analysis was conducted for intersections utilizing the Highway Capacity Software and Synchro software. Analysis was conducted for roundabout improvements utilizing SIDRA software and analysis for improvements along the I-376 corridor were conducted utilizing VISSIM software. Outputs from the software (delay, vehicle miles traveled, travel time, emissions, etc.) were utilized to determine the benefits of each improvement concept as compared to the No Build condition.

Ramp Management Alternatives

For the ramp management options (concepts 3 and 99) a more extensive analysis process was used to develop the strategies to be analyzed. The project's VISSIM model was used for detailed analysis, but a separate analysis using the FreQ model was used to optimize metering rates and strategies.

FreQ is a macroscopic deterministic simulation model which was developed by the University of California at Berkeley in conjunction with the California Department of Transportation (Caltrans) to evaluate various freeway design and operational improvements. It includes a ramp metering optimization tool that generates optimum ramp metering rates for ramps in a corridor based on the user specific inputs and constraints, such as ramp and lane capacities, percentages of trucks, free-flow

speeds, and roadway geometry. The model "optimizes" mainline flow to maintain near free-flow conditions if possible, based on these inputs and constraints. FreQ will reduce the metering rate nearest the bottleneck until it reaches the minimum metering rate before moving to the next ramp upstream to reduce its metering rate. This simple algorithm can be used to get an idea of the metering rates that could result in a metering system, but it does not mimic any of the modern system-wide metering adaptive algorithms currently in use.

FreQ analysis was conducted to determine a starting point of the timings for the ramp meters. The timing used for ramp metering has a tremendous impact on how the system operates, especially the trade-offs between traffic entering the Parkway East from ramps and traffic already on the mainline Parkway. Three basic types of ramp management that highlight the spectrum of trade-offs for the Parkway East are:

- Non-restrictive Metering: The timing gives a metering rate which does not significantly restrict the number of cars per hour allowed to enter Parkway East, but makes each car stop and only releases one car at a time. The potential advantage is that platoons are broken up so each car has the rest of the ramp to pick a speed most conducive to gaps on the mainline and merge smoothly. The metering rate is close to the capacity of the ramp. The ramp traffic is prioritized.
- Restrictive Metering: Timings are set so that flow on the Parkway East is prioritized, even when that may cause back-ups on ramps and into the arterial network.
- Limited Metering: An intermediate timing regime between the Non-restrictive and Restrictive, in this case based on gap acceptance.

The optimized metering rates were then input to VISSIM for microsimulation analysis of the impact of the metering on the study area. Using FreQ avoided extensive trial-and-error within VISSIM. Results from FreQ were still used a starting point for VISSIM, though, since VISSIM is more accurate than the deterministic FreQ.

Analyzing the Parkway East with FreQ to optimize metering rates revealed several things, including that:

- Only non-restrictive metering had potential since significantly impeding the flow of traffic entering Parkway East from ramps quickly caused unacceptable queues on ramps and into the arterial network.
- Under the projected typical traffic conditions, even non-restrictive ramp metering would not be advantageous at all Parkway East ramps during both the AM and PM peaks.
- For the AM peak, the ramps with potential for being metered were those westbound approaching the Squirrel Hill Tunnel.
- For the PM peak, the ramps with potential for being metered were those eastbound on each side of the Squirrel Hill Tunnel.

This is typical of a non-restrictive "peak hour/ directional" management system. However, more detailed design of a ramp management system would be required, and full implementation would potentially allow for management of additional ramps and at different times of day in response to changing conditions.

7.2.2 Emissions

Changes in estimated emissions including CO_2, NO_x, and Volatile Organic Compounds (VOC) were calculated for each concept. Emissions for most concepts was generated using the VISSIM model. For other concepts, emissions were generated based upon estimated fuel consumption, average speeds, and vehicle miles traveled, using values tabulated in the EPA 420-F-08-028 manual. Results are tabulated on the individual concept summaries provided in the attached Appendix 1: Concept Summaries; and detailed calculations are provided separately in Appendix 4: Evaluation of Concepts. An increase in emissions from the base model is identified by a increase (positive value) in emissions.

7.2.3 Construction Cost

Construction costs were estimated based upon items and quantities tabulated using the preliminary line and grade plans developed for each concept. Items such as pavement, guiderail, sidewalk, pavement markings, and excavation were able to be directly estimated from the plans at this stage. Once quantities for these items were calculated, unit costs were estimated. Costs were estimated using the Item Price History from PennDOT's Engineering and Construction Management System (ECMS). To improve the accuracy of the estimate, prices were obtained from similar projects, preferably in District 11-0, using similar quantities. Engineering judgement and other references were used when insufficient data was available through ECMS.

Pavement base drain, geotextile, and lighting were estimated as a cost per lineal foot of the project, with the unit costs estimated from other projects. Drainage was estimated to be 30% of the pavement cost, an assumption based on engineering judgement. Structures and retaining walls were also estimated; a unit cost was developed based on costs of similar structures and retaining walls.

To account for any unknowns, a 20% contingency was applied to the total construction cost. This accounts for the fact that these designs are preliminary and all quantities and costs are simply estimates.

Results are tabulated on the individual concept summaries provided in the attached Appendix 1: Concept Summaries; and detailed calculations are provided separately in Appendix 4: Evaluation of Concepts.

7.2.4 User Benefits

Recurrent Benefits

The value of user travel time, vehicle operating costs, and safety changes were quantified to provide a benefit cost ratio. VISSIM was the default program used. The computer model used the forecasted traffic and provided the AM and PM peak values for total vehicle miles traveled, vehicle hours, and gallons consumed. The VISSIM simulation analysis period was 2 hours for each peak period. The model was run 5 times with random seeds and the results averaged. Current Parkway traffic counts were used to create a truck factor to separate trucks and car usage. This breakdown applied to the mean hourly wages, benefits, and engine efficiencies. The value for truck and car user time and benefits are from *User and Non-User Benefit Analysis for Highways*, (Red Book), AASHTO, Sept. 2010, table 5-1 and 5-2 respectively. The mean hourly wage was from the Bureau of Labor and Statistics 2014 for the Pittsburgh region.

The value of benefits were based on the anticipated traffic impacts. The majority of the concepts address capacity issues only present during the rush-hour period. As a result the changes in fuel consumption and delay is only based on the 4 hour peak periods changes with the exception of the daily analysis for Concepts 3, 26, 64, and 99 which have broader daily impacts. For these concepts a hourly expansion factor was used to convert the model output to daily values.

The inputs were then used to calculate a total user benefit for the year. A positive impact was reflected with a positive dollar or hour value. The Automobile Operating Costs was calculated from the changes in the gallons consumed multiplied by the average regional gasoline costs for 2015. Similarly the Value of Time was based on the number of vehicle hours. The number of vehicle hours were multiplied by the value of the total compensation for the respective user (truck or car). Safety is discussed in its own section below. These three benefits (Operating Costs, Value of Time, and Safety) were summed to quantify a user benefit. Similar to the operating costs, this benefit was a reoccurring benefit for the life of the project.

Non-Recurrent Benefits

Operational benefits for Concepts 7, 11, and 23 are derived from reducing incident delay, whether through limiting rubbernecking (Concept 7) or providing relief areas from distressed vehicles (Concepts 11 and 23). The assumed vehicle -hours of delay per incident were taken from *The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised),* published by the National Highway Traffic Safety Administration, DOT HS 812 013.

Average vehicle hours of delay per property damage only (PDO) crashes was utilized for all incidents from tabulated sources. This value was applied for the incidents in Concepts 11 and 23, which gain operational benefits from reducing incident duration by providing relief for vehicles. It was assumed the duration of affected incidents would be reduced 75%, meaning the duration of the capacity reduction would be reduced 75% as well. As a result, each incident could see a savings in vehicle-hours of delay of 161.25 vehicle-hours. The analysis also took into account a reduction of delay due to "rubbernecking" at crash sites. Based on published data, it was assumed this was equivalent to 50% of the direct delay from an incident.

The number of incidents affected was based on 3 years of data regarding PA state police incident responses on the Parkway East. Parkway service patrols reported an average of 457 assists (incidents) per year between 2011 and 2013. Assuming these are equally distributed along the alignment, this indicates an average of 20 incidents per mile per direction per year on the Parkway East. To determine how many incidents would be affected by the concepts, an influence area was derived for each.

For Concept 7, visual barrier would be installed along 48% of the alignment, meaning 48% of the incidents would be affected. For Concept 11, ½ mile upstream was identified as the area in which distressed vehicles could access the emergency pull-off area. This means the number of incidents affected is the number per half mile annually. Finally, for Concept 23, the shoulder would be installed along a 0.85 mile stretch. This was identified as the influence area.

Bicycle Facilities

Bicycle facility improvements required specialized user benefit calculations, based on methodology in *NCHRP Report 552, Guidelines for Analysis of Investment in Bicycle Facilities*. This analysis accounted for reduction of vehicle trips due to new bicycle trips, and also accounted for the benefit of improved facilities to existing cyclists. Analysis was based upon origin-destination and bicycle count data provided by SPC. The area adjacent to the proposed bicycle facilities currently has among the highest bicycle mode share in the region, and thus the

methodology forecast only a modest increase in cycle trips. Possible changes in land use and commuting patterns may lead to ridership growth higher than that forecast in the coming years.

Transit Facilities

User benefits for park and ride facilities were based upon a combination of reduced vehicle miles traveled and time benefit from passengers gaining usable time, based upon values tabulated in "Valuing Transit Service Quality Improvements", by Todd Litman, as published in the *Journal of Public Transportation*, 2008.

7.2.5 Design Exceptions

Few design exceptions were required for the proposed concepts. The end of the proposed off-ramp in Concept 30A would require a design exception for design speed, as the horizontal curve on the approach to Beechwood Blvd had to be designed for 25 mph. Also, the on-ramp would not provide sufficient acceleration length, however, this was done to limit construction costs by using existing pavement (this also applies to 30B).

The proposals for Concepts 46 and 47A would also require a design exception, as the shoulder would have to be narrowed temporarily under the bridge carrying Brinton Road over the Parkway. A shoulder width exception would also be needed for Concept 51 as the shoulder would need to be temporarily narrowed to account for Churchill Rd.

A design speed exception would be required for Concept 50A as the vertical curvature required to carry the ramp over the Parkway would be designed with 25 MPH vertical curves.

7.2.6 Safety

Quantification of the safety benefits was based on the methodology laid out in the AASHTO Highway Safety Manual (HSM). However, the methodology was adjusted when necessary to account for the unique conditions of the Parkway East. The basic steps utilized for the methodology were as follows:

1) Calculate crash frequency under existing conditions (N_{obs}),

2) Apply relevant Crash Modification Factor(s) (CMF) to crash frequency to determine the predicted crash frequency with the improvement ($N_{Pred} = N_{obs} * \Pi CMF_i$),

3) Calculate the reduction in crash frequency, first in terms of total crashes, followed by each severity level ($N_{red} = N_{obs} - N_{pred}$ and $N_{red,severity} = N_{red} * f_{sev}$), and

4) Use crash cost by severity to quantify the yearly savings from reduction to crash frequency ($\$_{savings} = \Sigma[N_{red,severity,i} * \$_{severity,i}]$).

The following is a discussion of each step of the methodology, including any issues faced when executing the step.

1) Calculate crash frequency under existing conditions, N_{obs}

Crash data for the Parkway East was acquired for the years 2010 through 2012 from PennDOT. This data was utilized to determine existing crash frequency for all mainline and ramp alternatives. For each concept, a station range was identified, crashes within the range were selected, and crash frequency was calculated. When relevant, crashes of only specific types (i.e., same-direction sideswipe, rear end, fatal and injury) were identified. (Note: ideally, the existing crash frequency would be adjusted using the Empirical-Bayes method, however, existing freeway Safety Performance Functions (SPFs) for urban freeways are insufficient for accurately modeling the Parkway East and its unique features, so this was not added to the analysis.)

Where observed crash data was not available (i.e., arterial intersections), existing crash frequency was calculated utilizing relevant SPFs from the HSM. The resulting predicted crash frequency was substituted as the observed crash frequency. This was mainly used for off-site improvements, specifically the arterial intersection concepts.

2) Apply relevant Crash Modification Factor(s) (CMF) to crash frequency to determine the predicted crash frequency with the improvement

$$N_{Pred} = N_{obs} * \Pi CMF_i$$

CMFs for this analysis were acquired from several sources. First, the current edition of the HSM was searched, followed by the Federal Highway Administration's (FHWA) CMF Clearinghouse. If neither provided a relevant CMF, the safety literature was scanned for relevant journal articles. This search provided CMFs for most concepts. Although PennDOT Publication 638 lays out methodology for developing Pennsylvania-specific rates, at the time of the analysis such rates were not yet available.

When a CMF was not available, engineering judgement was used. This judgement was conservative and typically only applied to specific crash types. For example, no CMF could be located for closing a ramp, so the engineers assumed a 50% reduction in sideswipe crashes within the area of the ramp merge.

Once a relevant CMF was identified, it was multiplied by the relevant observed crash frequency to determine predicted crash frequency. For example, if a CMF applied to total crashes, then it was multiplied by total crash frequency, whereas if it only applied to sideswipes, it was multiplied by sideswipe crashes.

For some concepts, two CMFs applied to the improvement. The most common scenario was separate CMFs for fatal and injury crashes and property-damage only crashes. In this case, crash frequency and crash reduction were calculated separately. Once savings were calculated separately, they were combined together for an overall savings for the concept.

3) Calculate the reduction in crash frequency, first in terms of total crashes, followed by each severity level

$$N_{red} = N_{obs} - N_{pred} \text{ and } N_{red,severity} = N_{red} * f_{sev}$$

The difference between observed crash frequency and the predicted crash frequency under the proposed improvement provides the reduced crash frequency. This reduction in total crash frequency was divided over each severity level. For this analysis, as is done in the HSM, crash severity was divided into 5 levels: fatal (K), major injury (A), moderate injury (B), minor injury (C), and property-damage only (O). The split by severity varied based on crash type reduced. The most common used in this analysis was a reduction in crashes of all types which had a split as follows:

K – 0.28%;

A – 2.14%;

B – 10.42%;

C – 33.30%; and

O – 53.86%.

Severity splits were also identified for fatal and injury crashes, sideswipe crashes, rear-end crashes, and pedestrian crashes. Severity splits were based on the observed crash data on the Parkway East, except for pedestrian crashes, which was based on FHWA research.

4) Use crash cost by severity to quantify the yearly savings from reduction to crash frequency.

$$\$_{savings} = \Sigma[N_{red,severity,i} * \$_{severity,i}]$$

Once the reduced crash frequency by severity was calculated, it was quantified using dollar amounts acquired from the HSM per severity. These dollar values were adjusted to 2016 dollars. Summation of the reduced crash costs of each severity type provided a yearly savings due to safety improvement, which can be classified as a benefit.

The table on the following page provides a summary of the CMFs used in the study. Where severity is noted, FI = fatal and injury crashes, PDO = property-damage only crashes.

7.2.7 Environmental Features

The study team identified known environmental features in the corridor by assembling the most up-to-date existing geographic information system (GIS) data and aerial imagery from various secondary sources, such as Pennsylvania Spatial Data Access (PASDA), and Allegheny County. A 25ft. buffer was added to each concept to account for construction access and potential temporary construction easements.

Among elements that were mapped included railroads, wetlands, streams, trails, cemeteries, floodplains, parks, Section 6(f) conservation grants, Stafford Act properties, historic structures, and potential hazardous waste sites.

State game lands, state forests, agricultural lands, Section 6(f) LWCF acquisitions, National Natural Landmarks, and Natural and Wild Areas, were not located in the study area.

The Parkway East from Bates Street to the Churchill Interchange was determined National Register eligible in 2006 as a part of FHWA's nationwide effort to determine eligible interstate resources. Contributing resources to the Parkway East include the Squirrel Hill Tunnels and approximately ten bridge structures. The function, the alignment, the bridges, and the Squirrel Hill Tunnels are defining features of the Parkway's historic character and significance. Any proposed transportation improvements to the Parkway East would need to be coordinated with the PHMC. Several other National Register eligible features are located near or on the Parkway East, examples include, Frick Park and Schenley Park. Depending on impacts to the National Register Parkway East and local parks and trails, 4(f) or 6(f) documents/checklists may be required.

It is anticipated that most of the concepts would require a categorical exclusion evaluation. Public involvement would be required for many of the proposed concepts. Threatened and endangered species coordination would occur with all the appropriate agencies for each improvement. For example, if tree clearing is needed for a transportation improvement the Common Hop-Tree is a known DCNR species of concern that is located in the area. Archeology, noise and air quality studies may also be required based on the magnitude of the concept.

Further explanation of data sources and mapping of the individual concepts is provided in Appendix 3: Environmental Overview Maps.

Concept	CMF(severity)	Notes	Source
3	0.64	All crashes, per ramp	Liu and Wang (2013)
4	0.92	All crashes	Bham et al. (2010)
6	1.00 (FI), 0.98 (PDO)	From reduced AADT	AASHTO (2010) (assumed using SPFs)
7	1	Assume no change	Assumed
11	0.98	Rear end crashes 0.5 mile upstream	Assumed
14	0.9	Same-direction sideswipes	Assumed
18	0.52	All intersection crashes	Rodegerdts et al. (2007)
21	0.4	Equation, all crashes	AASHTO (2010)
23	0.52 (FI), 0.64 (PDO)	Equations, all crashes	AASHTO (2010)
24	1.26 (FI)	Equation, all crashes	AASHTO (2010)
26	0.88	All intersection crashes	Rodegerdts et al. (2007)
27	0.52	All intersection crashes	Rodegerdts et al. (2007)
28	0.71	All intersection crashes	Fitzpatrick and Park (2012)
29 A&B	0.99	Assumed from cited report	Hansell (1975)
30A, B, &C	0.60 (FI), 0.67 (PDO)	All crashes, based on reduced AADT in weave area	AASHTO (2010) (assumed using SPFs)
31A	1.00 (FI), 1.00 (PDO)	Equations, All crashes in weave segment	AASHTO (2010)
31B	1.00 (FI), 1.00 (PDO)	Equations, All crashes in weave segment	AASHTO (2010)
31D	.88	Equations, All crashes in weave segment	AASHTO (2010)
32	0.5	Same-direction sideswipes in merge area	Assumed
42A	0.79 (FI)	Equation, all crashes	AASHTO (2010)
42B	0.79 (FI)	Equation, all crashes	AASHTO (2010)
43	0.5	Same-direction sideswipes in merge area	Assumed
42/43 A, B, C	0.79 (FI), 0.50 (SDS)	Equation, all crash types, same-direction sideswipes in merge area	AASHTO (2010), Assumed
46	0.65	Equation, all crashes	AASHTO (2010)
47A	0.5	Same-direction sideswipes in merge area	Assumed
47B	0.5	Same-direction sideswipes in merge areas	Assumed
49	0.5	Same-direction sideswipes in merge area	Assumed
50A	0.79 (FI)	Equation, all crashes	Assumed
50B	0.79 (FI)	Equation, all crashes	Assumed
51	0.50, 1.24	Same-direction sideswipes in merge area, All crashes (from added barrier)	Assumed, AASHTO (2010)
54	0.79 (FI)	Equation, all crashes	AASHTO (2010)
56	0.48	Equation, all crashes	AASHTO (2010)
59	0.86	All intersection crashes	Harwood et al. (2003)
61	0.58	All intersection crashes	Harwood et al. (2003)
64	0.52	All intersection crashes	Rodegerdts et al. (2007)
65	0.50	All intersection crashes	FHWA (2004)
69	0.83	All intersection crashes	Ma et al. (2015)
70	0.83	All intersection crashes	Ma et al. (2015)
71	0.83	All intersection crashes	Ma et al. (2015)
72	0.83	All intersection crashes	Ma et al. (2015)
73	0.83	All intersection crashes	Ma et al. (2015)
74	0.63	Pedestrian and bike crashes	Fayish and Gross (2009)
75	0.83	All intersection crashes	Ma et al. (2015)
76	0.83	All intersection crashes	Ma et al. (2015)
77	0.83	All intersection crashes	Ma et al. (2015)
78	0.83	All intersection crashes	Ma et al. (2015)
79	0.83	All intersection crashes	Ma et al. (2015)
80	0.83	All intersection crashes	Ma et al. (2015)
82	1.00 (FI), 0.96 (PDO)	From AADT changes	AASHTO (2010) (assumed using SPFs)
95	0.997	From reduced AADT	AASHTO (2010) (assumed using SPFs)
96	0.995	From reduced AADT	AASHTO (2010) (assumed using SPFs)
98	0.998	From reduced AADT	AASHTO (2010) (assumed using SPFs)
99	0.64	All crashes, per ramp	Liu and Wang (2013)
100A & B	0.87 (FI), 0.94 (PDO)	All crashes, based on wider shoulder	AASHTO (2010)

References for sources are summarized in Section 7.2.12.

7.2.8 MPT Impacts

A qualitative review of maintenance and protection of traffic during construction was conducted for each concept, and is provided in the attached Appendix 1: Concept Summaries.

7.2.9 ITS Strategies

A qualitative review of the suitability of ITS elements and the potential impact for traffic management strategies was conducted for each concept, and is provided in the attached Appendix 1: Concept Summaries. For concepts 1, 3,4, 6 and 99, which are ITS-based, there is potential for joint implementation as part of an integrated traffic management system.

7.2.10 Other Potential Issues

Each concept was reviewed for relevant issues of concern beyond those specifically itemized. This was a qualitative review, based upon knowledge and experience in the study area. For most concepts, no other potential issues were identified. However, it was noted that adjacent communities are concerned about loss of access to the Parkway East interchanges, and have expressed skepticism about ramp management concepts leading to loss of access.

7.2.11 Benefit Cost Ratio

A benefit cost ratio was calculated for each concept. The three user benefit elements (Operating Costs, Value of Time, and Safety) were summed to quantify a user benefit. Similar to the operating costs, this benefit was a reoccurring benefit for the life of the project, which for most concepts was 20 years from opening day although shorter periods were used for operational improvements. The annual value of the user benefits was multiplied by a discount factor to calculate a Net Present Value of the total benefit value. Yearly operating costs were also converted to a Net Present Value using the discount factor. The total cost was calculated as the capital costs and net present value of the operating costs. The Benefit Cost Ratio (B/C ratio) was calculated as the net present value of the benefits divided by the net present value of the total costs. The results for each concept are provided in the attached Appendix 1: Concept Summaries; and detailed calculations are provided separately in Appendix 4: Evaluation of Concepts.

7.2.12 References

Design Standards:

* American Association of State Highway and Transportation Officials. A Policy on Geometric Design of Highways and Streets. Washington, D.C., (2004).
* Pennsylvania Department of Transportation. Publication 13M – Design Manual Part 2, Highway Design – August 2009 Edition. Harrisburg, PA, (2009).
* American Association of State Highway and Transportation Officials. Roadside Design Guide, 4th Edition. Washington, D.C., (2011).
* Rodegerdts, L., et al. "NCHRP Report 672: Roundabouts: An Informational Guide, Second Edition". Transportation Research Board of the National Academies, Washington, D.C., (2010).

Safety Analysis - Citations	
Many Concepts	American Association of State Highway and Transportation Officials. Highway Safety Manual. Washington, D.C., 2010.
3, 99	Liu, C. and Wang, Z., "Ramp Metering Influence on Freeway Operational Safety near On-ramp Exits." International Journal of Transportation Science and Technology, Vol. 2, No. 2, Multi Science Publishing, (2013) pp. 87 -94.
4	Bham, G. H., Long, S., Baik, H., Ryan, T., Gentry, L., Lall, K., Arezoumandi, M., Liu, D., Li, T., and Schaeffer, B., "Evaluation of Variable Speed Limits on I-270/I-255 in St. Louis." RI08-025, Missouri University of Science and Technology, Rolla, MO., (2010).
18, 26, 27, 64	Rodegerdts, L. A., Blogg, M., Wemple, E., Myers, E., Kyte, M., Mixon, M., List, G., Flannery, A., Troutbeck, R., Brilon, W., Wu, N., Persaud, B., Lyon, C., Harley, D., and Carter, D., "NCHRP Report 572: Applying Roundabouts in the United States." Washington, D.C., Transportation Research Board, National Research Council, (2007).
28	Fitzpatrick, K. and Park, E.S. Safety Effectiveness of the HAWK Pedestrian Crossing Treatment, FHWA-HRT-10-042, Federal Highway Administration, Washington D.C. (2010). Also published in: Fitzpatrick, K., E.S. Park, and S. Turner. "Effectiveness of the HAWK Pedestrian Crossing Treatment". ITE Journal, Vol. 82, No. 4, Washington, D.C., (2012).
29	Hansell, R. S., "Study of Collector-Distributor Roads." (1975).
59, 61	Harwood, D. W., Bauer, K. M., Potts, I. B., Torbic, D. J., Richard, K. R., Rabbani E. R., Hauer, E., Elefteriadou, L., and Griffith, M. S., "Safety Effectiveness of Intersection Left- and Right-Turn Lanes." Washington, D.C., 82nd Transportation Research Board Annual Meeting, (2003).
65	Brich, S. C. and Cottrell Jr, B. H., "Guidelines for the Use of No U-Turn and No-Left Turn Signs." VTRC 95-R5, Richmond, Virginia Department of Transportation, (1994).
69-73, 75-80	Ma, J., Fontaine, M., Zhou, F., Hale, D., and Clements, M., "Estimation of the Safety Effects of an Adaptive Traffic Signal Control System." Presented at the 94th Annual Meeting of the Transportation Research Board, Washington, D.C., (2015).
74	Fayish, A. C. and Gross, F., "Safety Effectiveness of Leading Pedestrian Intervals Using the Empirical Bayes Method." TRB 88th Annual Meeting Compendium of Papers CD-ROM. Washington, D.C., (2009).

* American Association of State Highway and Transportation Officials. Guide for the Development of Bicycle Facilities. Washington, D.C., (1999).
* Trans Associates Engineering Consultants, Inc. "City of Pittsburgh Bicycle Facility Guidelines and Policies". Pittsburgh, PA, (2005).

Construction Costs:

* Pennsylvania Department of Transportation. ECMS Home Page. http://www.dot14.state.pa.us/ECMS/.

User Benefits:

* American Association of State Highway and Transportation Officials, User and Non-User Benefit Analysis for Highways, September, 2010.
* Blincoe, L. J., Miller, T. R., Zaloshnia, E., & Lawrence, B. A. "The economic and societal impact of motor vehicle crashes, 2010 (Revised). Report No. DOT HS 812 013. National Highway Traffic Safety Administration, Washington, D.C., 2015.

7.3 Evaluation Matrix

In the final phase of the project, the Department will move forward with implementing solutions. As noted in Section 6, this is already underway. During the Phase 1 Screening, multiple concepts were identified as "early action" items and were evaluated for implementation by PennDOT maintenance forces. Several additional concepts are being advanced under separate projects, most notably at the Bates Street Interchange area.

The preliminary matrix developed in the Phase 2 Screening will serve as a basis for identifying projects for further advancement. Because of the broad range of potential improvements, ranging from intersection level to corridor level, and varying across many modes, no single measure of effectiveness is appropriate for prioritizing all needs. The preliminary matrix tabulates a variety of measures, including user benefits, emissions, and benefit/cost ratio.

Evaluation indicated that some concepts had adverse impacts, or negative benefits, usually resulting from unanticipated increases in traffic congestion. Because of the negative benefits, these concepts are presented with negative benefit cost ratios.

In general, benefit/cost ratios greater than 1 indicate that benefits are projected to exceed costs. In some cases, very high benefit/cost ratios result from low projected costs, even though benefits may also be modest.

This study evaluated a broad range of concepts, addressing multimodal improvements as well as a improvements on the Parkway mainline and interchanges as well as on arterial roadways. To facilitate comparison of similar concepts, the following matrix is divided by improvement type, location and mode. Other presentations are possible, including sorting by benefit/cost ratio, particular benefits, or cost constraints.

The following sections provide discussion of the relative performance of the concepts in the different groupings.

Corridor Improvements

Eight corridor level concepts were evaluated. Most of these, including Concepts 1, 2, 3A, 3B, 4, and 99 were traffic management options based on implementation of ITS concepts. Concept 6, peak-hour truck restrictions, could be implemented via static signage or in conjunction with ITS improvements. The final corridor-level concept evaluate, 7, consisted of installation of physical headlight barriers throughout the corridor.

In general, the traffic management/ITS options were highly rated, reflecting the relatively low cost of installation and the benefits of traffic management. Managed lanes, Concept 1, was estimated to have a benefit cost ratio of 2.75. Additional VMS signs were projected to have a benefit-cost ratio of 11.58, while variable speed limits, Concept 4, would have a benefit cost ratio of 5.02. Peak-hour truck restrictions were projected to have a negative benefit-cost ratio, due to the additional vehicle miles that would result from trucks choosing alternate routes.

Ramp management was investigated in Concepts 3A, 3B and 99. Our evaluation of Concept 3A showed that ramp management would provide net user benefits, which combined with a relatively low implementation cost, results in a benefit-cost ratio of 2.75. This evaluation was based upon a conservative implementation, using non-restrictive management strategies to maintain full existing access to the Parkway from adjacent communities, and was limited to operation during peak periods in the peak direction. Following initial implementation, as the system gains acceptance, ramp management could be extended to other time periods and become more active, potentially increasing benefits further. Such management provides potential improvements at interchanges such as Bates Street and Edgewood/Swissvale, where poor ramp geometry causes capacity constraints but may be cost-prohibitive to improve. Full implementation of ramp management to the entire Parkway East would increase costs but provide little measurable initial benefit, resulting in a lower benefit-cost ratio of 1.62.

Our evaluation of Concept 99, ramp management combined with a PM peak period closure of the eastbound Beechwood Boulevard off-ramp, indicates that this would have negative overall user benefits. VISSIM analysis indicates that

Corridor Improvements

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
1	I-376 Managed Lanes	$9,470,000.00	$0.00	$860,000.00	$13,030,502.37	$250,000.00	$2,381,317.19	$2,381,317.19	0			2.75
1A	Managed Lanes	$12,931,000.00	$0.00	$876,000.00	$18,166,757.76	$366,250.00	$2,381,317.19	$2,381,317.19	0			1.97
2	I-376 Additional VMS Signs	$1,940,000.00	$0.00	$180,000.00	$4,613,954.95	$180,000.00	$3,555,573.55	$1,731,867.05	0			11.58
3A	Parkway East Ramp Management—Partial Implementation	$1,988,665.45	$0.00	$166,878.68	$3,652,578.33	$116,250.00	$706,625.53	$884,460.47	235196			2.25
3B	Parkway East Ramp Management—Full Implementation	$3,430,974.02	$0.00	$297,997.64	$5,066,040.72	$116,250.00	$706,625.53	$884,460.47	235196			1.62
4	Parkway East Variable Speed Limits	$2,280,000.00	$0.00	$210,000.00	$5,182,822.40	$210,000.00	$1,731,867.05	$1,731,867.05	0			5.02
6	Parkway East Peak Hour Truck Restrictions	$1,720,000.00	$0.00	$290,000.00	$1,681,631.08	$0.00	-$4,857,946.74	$39,275.20	16007489			-43.40
7	Parkway East Headlight Barriers	$2,520,000.00	$0.00	$420,000.00	$2,472,179.67	$0.00	$146,752.11	$0.00	0			0.89
99	Ramp Management - Beechwood Boulevard PM Ramp Closure	$1,854,102.49	$0.00	$168,554.77	$3,670,646.63	$116,250.00	-$386,905.43	$848,212.09	-3256230			-1.58

Parkway Central

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
11	Additional Pullover Areas	$434,000.00	$0.00	$72,000.00	$425,713.67	$0.00	$22,116.86	$2,426.98	0			0.78
14	Improve Wood Street Merge	$1,500.00	$0.00	$250.00	$1,466.18	$0.00	$5,343.07	$5,343.07	0			54.75
23	Widen Eastbound Shoulder Forbes to Bates	$70,600,000.00	$0.00	$11,800,000.00	$69,188,000.00	$0.00	$115,254.35	$81,692.04	0			0.03

Bates Street Interchange

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
21	Lengthen Eastbound Bates Acceleration Lane	$10,700,000.00	$0.00	$1,800,000.00	$10,603,500.68	$0.00	$7,047,718.73	$338,318.21	-4901558			9.99
24	Bates Street Right Lane Exit Only											N/A

Squirrel Hill Interchange

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
29A	Eastbound Collector— Distributor - Bates to Squirrel Hill	$94,500,000.00	$200,000.00	$15,700,000.00	$92,514,743.91	$0.00	$3,025,182.71	$22,554.55	-47725577			0.49
29B	Eastbound Collector— Distributor - Squirrel Hill Intersection	$36,700,000.00	$0.00	$6,100,000.00	$36,039,955.60	$0.00	$1,344,343.74	$6,645.54	4156320			0.56
30A	Squirrel Hill Eliminate Eastbound Weave - New EB Off Ramp	$24,000,000.00	$200,000.00	$4,000,000.00	$23,452,974.39	$0.00	$696,979.65	$257,504.19	-290066			0.45
30B	Squirrel Hill Eliminate Eastbound Weave - Underpass Off-Ramp	$33,400,000.00	$1,800,000.00	$5,300,000.00	$32,717,941.69	$0.00	$2,303,410.27	$396,383.26	-1470875			1.06
30B Rev	Squirrel Hill Eliminate Eastbound Weave - Underpass Off-Ramp	$38,000,000.00	$1,800,000.00	$6,000,000.00	$37,267,250.47	$0.00	$2,314,849.15	$407,822.14	-1470875			0.93
30C	Squirrel Hill Eliminate Eastbound Weave - Underpass Off-Ramp	$41,900,000.00	$600,000.00	$6,900,000.00	$41,097,307.15	$0.00	$2,812,191.01	$396,383.26	-1845314			1.03
30C Rev	Squirrel Hill Eliminate Eastbound Weave - Underpass Off-Ramp	$46,900,000.00	$600,000.00	$7,700,000.00	$46,125,938.02	$0.00	$2,823,629.89	$407,822.14	-1845314			0.92
31A	Lengthen Weave Horseshoe On-Ramp	$36,200,000.00	$1,100,000.00	$5,800,000.00	$34,317,091.42	$0.00	-$1,608,722.56	$0.00	1253804			-0.70
31B	Eastbound On-Ramp from Intersection	$19,000,000.00	$2,300,000.00	$2,800,000.00	$18,643,897.29	$0.00	$974,189.63	$0.00	-674608			0.78
31D	New EB On-Ramp from Beechwood Blvd.	$18,800,000.00	$1,200,000.00	$2,900,000.00	$18,516,898.22	$0.00	$1,240,687.72	$0.00	-878583			1.01
31D Rev	New EB On-Ramp from Beechwood Blvd.	$29,700,000.00	$1,200,000.00	$4,800,000.00	$29,251,744.51	$0.00	$1,252,126.60	$11,438.88	-878583			0.64

Edgewood/Swissvale Interchange

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
32	Edgewood/Swissvale Ramps - Combine Eastbound Ramps	$3,190,000.00	$0.00	$530,000.00	$3,121,445.05	$0.00	-$293,565.40	$40,073.00	326010			-1.41
37	Edgewood/Swissvale - West Swissvale Ave Traffic Control	$1,620.00	$0.00	$270.00	$1,585.06	$0.00	$19,040.38	$0.00	-15129			180.46
38	Edgewood/Swissvale - Monongahela Ave Traffic Control	$157,000.00	$0.00	$26,000.00	$154,506.29	$0.00	$37,806.31	$0.00	-31820			3.68
42A	Third Eastbound Lane Edgewood to Existing Lane	$37,500,000.00	$200,000.00	$6,200,000.00	$36,727,563.28	$0.00	$3,524,603.28	$54,976.71	-3935749			1.44
42B	Third Eastbound Lane Separate Alignment	$54,700,000.00	$600,000.00	$9,000,000.00	$53,739,362.95	$0.00	$2,197,387.58	$54,976.71	-1642181			0.61
42/43A	Edgewood/Swissvale Eastbound Combine Ramps	$71,900,000.00	$600,000.00	$11,900,000.00	$70,416,173.79	$0.00	$183,120.27	$81,692.04	-86938			0.04
42/43B	Edgewood/Swissvale Eastbound Combine Ramps	$30,700,000.00	$200,000.00	$5,100,000.00	$30,246,624.59	$0.00	-$134,830.71	$81,692.04	149399			-0.07
42/43C	Edgewood/Swissvale Eastbound Combine Ramps	$61,200,000.00	$200,000.00	$10,200,000.00	$60,128,583.50	$0.00	$7,189,861.97	$26,715.33	-5509806			1.80
43	Edgewood/Swissvale Eastbound Ramp Consolidation	$50,400,000.00	$100,000.00	$8,400,000.00	$49,243,826.88	$0.00	$5,291,707.64	$26,715.33	-4059880			1.61
45	U-Turns at Allenby Avenue											N/A

Wilkinsburg Interchange

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
39	Wilkinsburg Ardmore/Brinton U-Turns											N/A
46	Wilkinsburg Westbound Acceleration Lane	$5,990,000.00	$0.00	$1,000,000.00	$5,887,451.19	$0.00	-$135,617.38	$197,352.29	287510			-0.35
47A	Wilkinsburg Interchange - Combine Westbound On- Ramps	$44,400,000.00	$0.00	$7,400,000.00	$43,550,390.50	$0.00	$2,297,876.07	$13,357.67	-1799780			0.79
47B	Wilkinsburg Interchange - Single Point Urban Interchange	$92,400,000.00	$500,000.00	$15,300,000.00	$90,551,377.33	$0.00	$9,925,413.15	-$301,135.54	-7839994			1.65

Churchill and Monroeville Interchanges

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
49	Control Churchill Weave with Markings	$9,710.00	$0.00	$1,620.00	$9,510.36	$0.00	$190,100.80	$13,357.67	-148603			300.29
50A	Churchill Eastbound Ramp Closure	$23,800,000.00	$0.00	$4,000,000.00	$23,453,226.84	$0.00	-$8,878,227.73	$76,121.60	6717663			-5.69
50B	Churchill EB Ramp Consolidation William Penn Ramp Closure	$748,000.00	$0.00	$125,000.00	$732,307.04	$0.00	-$23,705,360.43	$76,121.60	46415277			-486.30
51	Control Churchill Weave with Barrier	$518,000.00	$0.00	$86,000.00	$507,355.35	$0.00	$24,809.09	-$112,303.39	-30216			0.73
53A	Old Gate Ramp Improve Truck Turning Radius	$287,000.00	$99,000.00	$31,000.00	$281,495.06	$0.00	$0.00	$0.00	0			N/A
53B	Old Gate Ramp Allow Truck Oversteer	$396,000.00	$0.00	$66,000.00	$387,785.14	$0.00	$0.00	$0.00	0			N/A
54	Churchill Extend Third Eastbound Lane	$16,500,000.00	$0.00	$2,700,000.00	$16,139,321.22	$0.00	$381,176.27	$93,037.51	-235583			0.35
56	Business 22 Extend WB Acceleration Lane	$7,950,000.00	$0.00	$1,330,000.00	$7,795,977.74	$0.00	-$731,181.18	$261,793.86	819532			-1.41

Active Transportation/Multimodal

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
28	Beechwood/Forward Pedestrian Crossing	$632,000.00	$0.00	$105,000.00	$618,498.16	$0.00	$26,722.09	$26,722.09	0			0.65
33	Squirrel Hill Interchange Complete Streets											N/A
62	Braddock Avenue Pedestrian Improvements	$544,500.00	$0.00	$65,000.00	$533,610.00	$0.00	$0.00	$0.00	0			N/A
63	Improve Sidewalks Arterial Roadways	$8,880,000.00	$0.00	$1,480,000.00	$8,701,861.66	$0.00	$0.00	$0.00	0			N/A
74	Signal Retiming Advance Pedestrian Phases	$476,000.00	$0.00	$79,000.00	$466,712.06	$0.00	$256,961.82	$256,961.82	0			2.90
85	Bike Trail Connection to Junction Hollow	$4,680,000.00	$120,000.00	$760,000.00	$4,590,152.35	$0.00	$124,178.43	$0.00	-2535			0.41
86A	Bike Trail Saline Street to Squirrel Hill	$29,400,000.00	$1,100,000.00	$4,700,000.00	$28,741,889.66	$0.00	$148,197.80	$29,803.10	-14975			0.08
86B	Bike Trail Saline Street to Pocusset Street	$17,400,000.00	$200,000.00	$2,900,000.00	$17,044,805.61	$0.00	$136,826.53	$0.00	-11050			0.12
89	Bike Trail Hazelwood to Braddock	$7,460,000.00	$80,000.00	$1,230,000.00	$7,308,872.55	$0.00	$182,177.47	$0.00	-125578			0.37
90	Bike Trail Hazelwood/Almono	$714,000.00	$0.00	$119,000.00	$699,056.76	$0.00	$143,126.84	$0.00	-2148			3.08
91	Bike Trail Connection to South Oakland	$11,400,000.00	$100,000.00	$1,900,000.00	$11,079,606.61	$0.00	$123,277.08	$0.00	-2749			0.17
95	Monroeville Park and Ride	$2,200,000.00	$2,200,000.00	$0.00	$7,702,623.58	$347,856.00	$493,643.62	$12,479.20	-315714			1.25
96	Penn Hills Park and Ride	$1,584,000.00	$685,000.00	$150,000.00	$13,667,667.92	$759,840.00	$696,874.95	$20,798.67	-362826			0.96
98	Swissvale Park and Ride	$3,000,000.00	$0.00	$500,000.00	$7,272,382.65	$272,000.00	$254,456.88	$2,640.78	-110068			0.72
100A	Transit Only Hard Shoulder Running	$38,200,000.00	$2,300,000.00	$6,000,000.00	$37,436,000,00	$0.00	$279,465.60	$124,186.26	0			0.05
100B	Transit Only Hard Shoulder Running	$38,200,000.00	$2,300,000.00	$6,000,000.00	$37,436,000,00	$0.00	$279,465.60	$124,186.26	0			0.05

Arterial Improvements

Concept		Construction Cost	ROW Cost	Design Cost	Total Capital Cost	Annual O&M Cost	User Benefits	Safety Benefits	Emissions	NEPA Level	Other	BCR
18	Panther Hollow/Greenfield Roundabout	$2,760,000.00	$200,000.00	$430,000.00	$2,706,432.63	$0.00	-$2,157,446.78	$105,948.15	1776476			-11.98
26	Beechwood/Monitor Roundabout	$3,810,000.00	$1,610,000.00	$370,000.00	$3,737,359.13	$0.00	$3,353,085.56	$2,140.63	-2619831			13.48
27	Beechwood/Alger/Greenfield Roundabout	$2,240,000.00	$560,000.00	$280,000.00	$2,186,529.71	$0.00	$103,738.95	$57,250.29	-41724			0.71
59	Forbes/Braddock Intersection Reconfiguration	$408,000.00	$0.00	$68,000.00	$399,825.94	$0.00	$688,859.06	$29,922.76	-559755			25.88
61	Penn/Braddock Intersection Improvements	$679,000.00	$46,000.00	$106,000.00	$665,958.64	$0.00	$337,702.26	$113,473.71	-198208			7.62
64	Allies/Bates Roundabout	$10,430,000.00	$3,790,000.00	$1,110,000.00	$10,226,337.96	$0.00	-$3,004,048.37	$161,247.21	2484353			-4.41
65	Penn Avenue Through Streets Concept	$19,797.07	$0.00	$3,299.51	$3,234.00	$0.00	$1,237,225.00	$1,374,417.74	107679			1661.26
69	Signal Retiming - Wilkinsburg/Penn Avenue	$1,600,000.00	$0.00	$270,000.00	$1,569,350.14	$0.00	$3,145,375.66	$792,359.38	-16491			8.70
70	Signal Retiming - Braddock Ave	$1,280,000.00	$0.00	$210,000.00	$1,260,213.57	$0.00	$1,133,032.02	$437,826.06	-2495			3.90
71	Signal Retiming - Fifth Ave	$761,000.00	$0.00	$127,000.00	$746,158.11	$0.00	$4,261,548.20	$1,040,183.51	-20471			24.80
72	Signal Retiming - Murray Ave	$863,000.00	$0.00	$144,000.00	$845,344.70	$0.00	$887,331.43	$200,991.23	-4362			4.56
73	Signal Retiming - Forbes Avenue	$673,000.00	$0.00	$112,000.00	$660,062.95	$0.00	$3,554,982.42	$694,585.42	-18177			23.39
75	Signal Retiming on Route 22 and Route 30	$908,000.00	$0.00	$151,000.00	$889,650.06	$0.00	$7,932,488.70	$967,263.86	-44263			38.72
76	Signal Retiming - Hazelwood Rt. 885	$175,000.00	$0.00	$29,000.00	$172,190.33	$0.00	$875,757.30	$210,131.86	-4230			22.09
77	Signal Retiming - William Penn Highway	$58,600.00	$0.00	$9,800.00	$57,396.78	$0.00	$567,931.26	$74,768.33	-3134			42.97
78	Signal Retiming - Ardmore Boulevard	$29,303.72	$0.00	$4,900.00	$28,698.77	$0.00	$272,257.58	$54,124.87	-1387			41.20
79	Signal Retiming - Boulevard of the Allies	$1,160,000.00	$0.00	$190,000.00	$1,138,874.30	$0.00	$1,456,074.41	$265,078.36	-7569			5.55
80	Signal Retiming Penn/Ardmore Intersection	$29,303.39	$0.00	$4,900.00	$28,698.39	$0.00	$105,353.48	$56,384.36	-53147			15.94
82	New Road Turtle Creek to 2nd Avenue	$329,353,381.88	$353,381.88	$55,000,000.00	$322,231,453.09	$0.00	$5,813,101.83	$145,463.70	-16711449			0.27

elimination of the merge near the tunnel entrance would improve mainline flow, actually resulting in the standing queue on the Parkway East dissipating earlier. However, the traffic diverted by the ramp closure would incur additional costs in vehicle miles travelled and delay, and existing traffic on corridors including Commercial Street, Bates Street, Penn Avenue and Forbes Avenue would also incur additional delay. The combined costs of this diverted traffic would offset the benefits incurred by mainline Parkway traffic, resulting in the negative overall benefit-cost ratio of –1.58.

Headlight barriers would show a positive benefit, but would be less than the projected cost, with a benefit cost ratio 0.89.

There is a significant amount of similarity between the various ITS concepts evaluated for the corridor. In particular, managed lanes, additional speed limits, and variable speed limits could use much of the same infrastructure. These could be combined into a broader system of active traffic management (ATM), which could also include VMS signs and incident management on ramps, although not including ramp metering or routine ramp closures. These elements of concepts 1, 2, 3B, and 4 were subsequently combined into Concept 1A, which would show a benefit cost ratio of 1.97.

Parkway Central

Three concepts were investigated on the Parkway Central, including operational improvements to the Wood Street merge (Concept 14), additional pullover areas (Concept 11), and a widened shoulder eastbound from Forbes to Bates (Concept 23). Concept 14, consisting of low-cost operational changes, showed a benefit cost ratio of 54.75. The high cost of the geometric changes necessary to accommodate wider shoulders and pullover areas resulted in these concepts having a benefit-cost ratio less than 1.

Bates Street Interchange

Two concepts were evaluated at the Bates Street interchange. Lengthening the eastbound acceleration lane showed a benefit-cost ratio of 9.99. Designation of an exit-inbound only lane at Glenwood (Concept 24) was not evaluated further as a separate project is exploring improvements to this ramp. Additional concepts investigated improvements between Bates Street and Squirrel Hill, and this is discussed as part of the Squirrel Hill interchange.

Squirrel Hill Interchange Concepts

Two concepts evaluated a collector-distributor roadway. Concept 29A evaluated a collector-distributor roadway from the Bates Street on-ramp eastbound through the Squirrel Hill interchange and determined that at had a benefit-cost ratio of 0.49 due to increased congestion for exiting traffic. Offsetting mainline improvements. Concept 29B evaluated a collector-distributor roadway at the Squirrel Hill interchange only, and it showed a benefit-cost ratio of 0.56 for similar reasons.

A number of related concepts, 29A, 29B, 30A, 30B, 30C, 31A, 31B, and 31D, explored improvement of the eastbound weave/merge approaching the Squirrel Hill tunnel. Layout of these concepts was extremely challenging, with the Parkway East constrained by a narrow valley, the Squirrel Hill Tunnel, the grade of the Parkway mainline, and numerous bridges and ramps in the interchange area. Because of these constraints, the concepts advanced would be expensive to build, and would provide only limited improvement in the eastbound weave area. However, all concepts advanced would replace the existing eastbound ramp stop with a merge conditions.

Refined Matrix

Location	Project	Benefit Cost Ratio	User Benefits	Safety Benefits	Emission Reduction	Estimated Cost	Implementation
Corridor-Wide	Active Traffic Management	Moderate	High	High	Low	$13 Million	Medium Term to Long Term
Bates Street	Lengthen Eastbound On-Ramp	Moderate	High	High	High	$10.7 Million	Medium Term to Long Term
Squirrel Hill	Eliminate Eastbound Weave	Moderate	High	High	High	$19M to 42 Million	Long Term
Edgewood/Swissvale	West Swissvale Avenue Traffic Control	High	Moderate	Low	Moderate	$2K	Short, Medium or Long Term
Edgewood/Swissvale	Full Access at Monongahela Avenue	Moderate	Moderate	Low	Moderate	$150K	Short, Medium or Long Term
Edgewood/Swissvale	Eastbound Ramp Consolidation	Moderate	High	Moderate	High	$61.3 Million	Long Term
Wilkinsburg	Single-Point Interchange	Moderate	High	Poor	High	$92.4 Million	Long Term
Churchill	Control Eastbound Weave	High	Moderate	Moderate	High	$10K	Short, Medium or Long Term
Multimodal	Additional Park-and-Ride Lots	Low	High	Moderate	High	$1.5 to 3.0 Million per location	Medium Term to Long Term
Multimodal	Bicycle Trail Connection to Junction Hollow	Low	Moderate	Moderate	Moderate	$4.7 Million	Medium Term to Long Term
Arterial Roadways	Signal Retiming	High	High	High	Moderate	$30k to $1.6 Million per corridor	Short, Medium or Long Term
						K = 1,000	

Several additional concepts were explored but were abandoned as they were not geometrically feasible.

One of the geometric constraints on interchange configuration is the existing Ramp D structure, which carries the westbound on and off ramps over the Parkway mainline to Beechwood Boulevard. This existing structure is narrow with no shoulders, and has substandard curve radii on both the approach and departure. Because of this geometry, tractor trailers frequently scrape the barriers on either side. Autoturn analysis confirmed that the roadway geometry does not physically permit longer vehicles to traverse these ramps without encroaching on the barriers,. Accordingly, the Department requested that replacement of this structure be considered as part of the interchange reconfiguration. Concepts 30B, 30C and 31D were revised to include replacement of this structure, with additional costs and adjustment to benefits.

User benefits were estimated based upon VISSIM simulation modeling. The standing queues approaching the Squirrel Hill tunnel turned out to be a controlling limitation. To some extent improvements in ramp operation were offset by corresponding degradation in mainline operation, and minor changes in travel time and VMT resulted from physical changes to the configuration of long ramps. Safety benefits were calculated for Concepts 29A, 29B, 30A, 30B and 30C which improved the overall benefits of these concepts. However, based upon the Highway Safety Manual methodology, the proposed geometric improvements (increase in weave length) in Concepts 31A, 31B, and 31C were not significant enough to result in a measurable safety improvement. Concepts 30B-Revised, 30C Revised and 31D Revised also included estimated benefits from providing a shoulder adjacent to the barrier on the Ramp D structure.

As a result of limited benefits and high construction costs, concept 31A actually has a negative benefit-cost ratio. The best performance is seen for concepts 30B and 30C, which each have a benefit-cost ratios of 1.06 and 1.03, respectively. The revised versions of these concepts demonstrate lower benefit-cost ratios, reflecting the increased cost of structure replacement, and the small increase in safety benefits from reducing PDO crashes.

This analysis does not address the perception of a safety risk at the existing stop-controlled ramp. This was noted during the public involvement process, and appears to be a widespread concern. However, the Highway Safety Manual does not provide a framework for calculating benefits based upon reducing a perceived risk, and no other documented methodology was identified for this. Accordingly, it was not possible to assign a measurable benefit to elimination of the stop control.

Edgewood/Swissvale

Several different approaches were considered for improvement of the eastbound merges at the Edgewood/ Swissvale interchange. Concepts 32 and 43 proposed consolidating the eastbound ramps to a single merge point. Concepts 42A and 42B proposed extending the Swissvale on-ramp from Braddock Avenue to connect with the third eastbound lane east of the interchange. Concepts 32 and 43 were relatively low-cost to construct, while concepts 42A and 42B were extremely expensive due to the need to cross under the Norfolk Southern mainline, the East Busway, and local streets.

User benefits were estimated based upon VISSIM simulation modeling. It was determined that concept 32 actually resulted in deceased user benefit, and thus negative benefit-cost ratios. This concept eliminated the substandard merge at the Monongahela Avenue on-ramp, and concentrated the combined traffic at the Braddock Avenue ramp. While this merge has somewhat better geometric conditions than the Monongahela Avenue Ramp, it is still substandard and the combined volumes exceeded the capacity of the ramp, increasing congestion and delay on both the ramps and the mainline Parkway East.

Concepts 42A and 42B investigated an alternate approach, extending the Braddock Avenue ramp to enter the Parkway as a free-flowing lane. Two different alignments were considered: adding a third lane under the existing combined railroad/transit/roadway bridge, and a tunnel under that combined corridor alignment. The first would be expensive to construct and tremendously disruptive. The second would have much more limited construction impacts, but would be more expensive to construct.

A hybrid of Concept 43 and 42B (42/43A) was evaluated, consolidating the ramps and allowing it to enter the Parkway as a free-flowing additional lane. This hybrid concept showed the greatest overall benefits of those considered for this interchange, but they did not offset the high cost of structures tunneling and roadway that would be needed to construct the new alignment. More detailed engineering and geotechnical exploration could refine the estimated construction cost, but it is unlikely to result in a benefit-cost ratio over 1.

Analysis was conducted on a variation of this hybrid concept (42/43B), to determine whether the full five-lane cross section could be accommodated within the existing cartway, without replacing the bridges. The existing width between abutments, would accommodate the lanes, but with less than one foot offset to the barriers under the structures. Because of the arch shape of the bridges, clearance requirements would not be met in the outside lanes, requiring posting of limitations for truck traffic. Lowering of the Parkway to maintain clearance was investigated, but it appears that the elevation of the bridge footings would preclude this. Traffic analysis indicated that the lack of clearance to the barriers, combined with the low vertical clearance, would create a tunnel effect, and would reduce capacity similar to what occurs at the Squirrel Hill Tunnel. This would have an adverse impact on inbound traffic flows that would more than offset the benefit to outbound traffic, resulting in negative overall benefits for this variant of the hybrid.

Based upon this evaluation, it appears that geometric improvements at this interchange would provide limited benefits, but not significant enough to offset construction costs. Ramp Management may provide a lower cost opportunity to work within the constraints of the existing roadway.

Rating Thresholds

Rating	Benefit Cost Ratio	User * Benefits	Safety* Benefits	Emission* Reduction
Poor	<0	< $0	< $0	<0 Kg
Low	Between 0 and 1	$0	$0	0 Kg
Moderate	Between 1 and 10	Between $0 and $200 K	Between $0 and $100K	Between 0 and 100,000 Kg
High	> 10	> $200 K	>$100 K	> 100,000 Kg

* Rating based on estimated annual benefits.

Wilkinsburg Interchange

Two approaches were considered for reconfiguration of the Wilkinsburg interchange. Concept 47A is a realignment of the two westbound on-ramps, merging the ramp from Wilkinsburg into the ramp from Forest Hills before merging with the Parkway mainline. Concept 47B is a complete reconfiguration of the interchange to a single-point urban interchange, or SPUI, configuration. Construction costs for both concepts are significant, but are much higher for the SPUI because of the more extensive work required.

User benefits were estimated using VISSIM simulation. For Concept 47A, a net travel time improvement was indicated. The consolidated on-ramp constrains capacity and reduces the number of vehicles entering the Parkway. This increases delay on ramps and local streets which outweighs the improvement in speeds and traffic flow between Penn Hills and Wilkinsburg during the AM peak. Concept 47B has similar ramp impacts and a similar constraining impact on traffic entering the westbound Parkway during the AM peak but additional benefits are gained in reducing VMT and delay by providing more direct movements through this heavily-used interchange. However, queues on local streets may impede through traffic, and some traffic may divert to other routes. Concept 47A has a negative benefit-cost ratio, but Concept 47B, the SPUI shows projected benefits exceeding construction costs.

Churchill Interchange

Two different approaches were considered at this interchange, controlling the weave and combining the eastbound ramps. In concepts 49 and 51, traffic would be prohibited from weaving from the left side on-ramp from Old William Penn Highway to the right side exit ramp to Business 22, by a painted line or a physical barrier, respectively. Both showed significant improvements in traffic flow, and positive benefit-cost ratios. Because of the extremely low cost of implementation, Concept 49 had a very high benefit-cost ratio. However, without a physical barrier, it is possible that poor compliance could reduce some of the potential benefits.

Consolidation of eastbound ramps was considered in Concepts 50A and 50B. 50A had higher construction costs due to construction of a structure over the Parkway East, while 50B used an existing ramp and eliminated the other. Both would allow traffic from Churchill to enter via an added lane. Both concepts showed an adverse impact on traffic operations based upon VISSIM simulation. Review of the model indicated that shifting all traffic entering at Churchill to the right lane, combined with the existing heavy demand for the right lane to exit at Business 22, created a weave condition that was over capacity. This caused queuing for the ramp traffic which also affected the mainline traffic. In addition, in Concept 50B, traffic entering from Old William Penn Highway was rerouted via Beulah Road and Churchill Road and incurred additional delay. Because of the negative benefits, both 50A and 50B have negative benefit-cost ratios.

7.3.1 Refined Matrix

Based upon the analysis summarized in the preliminary matrix, a total of 25 concepts appeared to be feasible for further consideration, based upon favorable benefit-cost ratios, technical feasibility, and environmental constraints. To assist in further evaluation, a refined matrix was developed consolidating similar concepts into candidate projects for consideration. For example, several potential ramp reconfigurations at Squirrel Hill were similar in projected benefits and costs, and were grouped together; and signal retiming on arterial roadways were also grouped together. A total of 11 projects were included in this refined matrix. For each project, a summary rating was developed including indexed values for benefit cost ratios, user benefits, safety benefits, and emissions reduction; an estimated cost for implementation, and the estimated time frame.

The following projects were included in the refined matrix, which is presented above:

Active Traffic Management (Corridor Wide)

This project would provide an intelligent transportation system of managed lanes along the Parkway East using overhead lane controls, variable speed limits and variable message signs, with additional signs at entrance ramps. This system would be tied into the District Traffic Management Center (TMC), and could provide advance warning of congestion and incidents, shifting traffic lanes, advisory speed limits under adverse conditions, speed harmonization approaching the tunnels. Ramp management as from concepts 3A and 3B is not specifically included in the proposed active traffic management due to community concerns. However, the proposed ATM system would include ramp closures for emergencies or incident management. Concept 1A combines elements from concepts 1,2,4 and incident ramp management elements from concept 3B.

Bates Street: Lengthen Eastbound On-Ramp

This project would improve the existing Bates Street eastbound on-ramp by providing a 1200' acceleration lane and a 300' taper, allowing vehicles to attain mainline speeds prior to merging, as well as providing a longer merging distance. This is based on Concept 21 from the preliminary matrix.

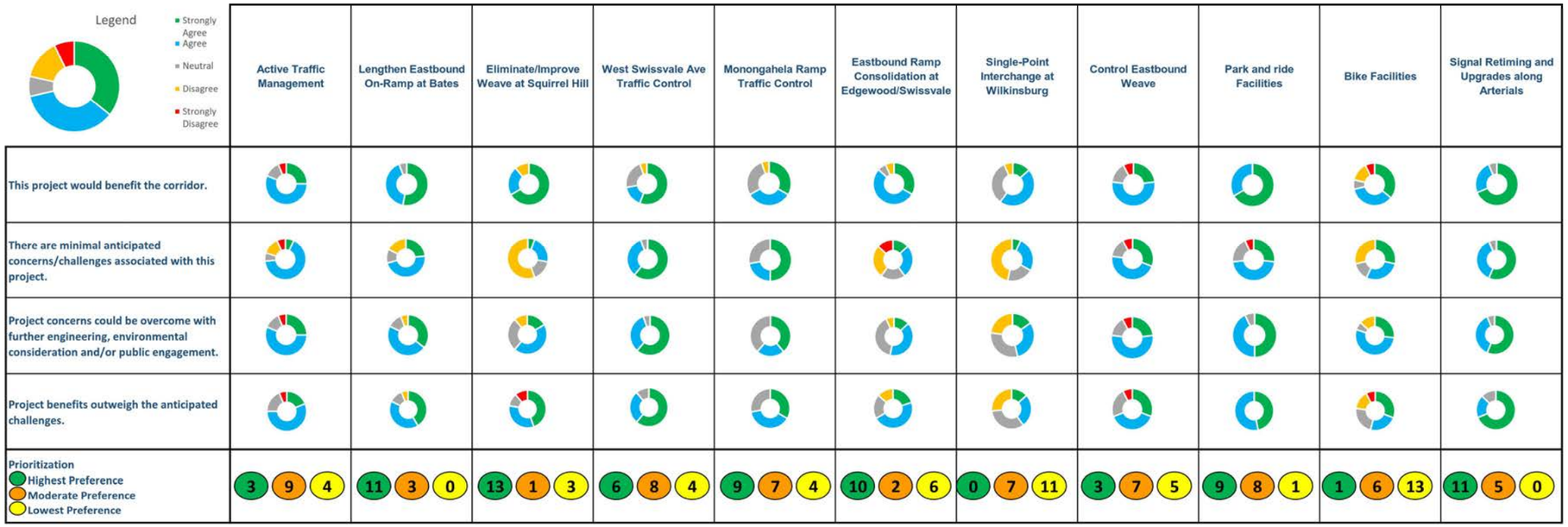
Squirrel Hill: Eliminate Eastbound Weave

This project would eliminate the current eastbound crossover and weave area approaching the tunnel, by constructing a new exit ramp from the Parkway near the Greenfield Avenue Bridge that would pass under the eastbound entrance ramp to connect with Beechwood Boulevard. The eastbound entrance ramp would be reconfigured or relocated to allow for acceleration before merging into the Parkway mainline and thus eliminate the existing stop sign on the entrance ramp. This is based on Concepts 30B, 30C and 31D from the preliminary matrix, and could be a variation or combination of elements of those concepts. This project could also include the replacement of the Ramp D structure, as included in Concepts 30B-Revised, 30C-Revised and 31D-Revised, although this would result in higher costs and a lower direct benefit-cost ratio.

West Swissvale Avenue Traffic Control

This project would modify the traffic control at the Swissvale Avenue westbound entrance ramp at the Edgewood / Swissvale interchange. The modification would reassign priority to the traffic on the loop ramp from northbound Braddock Avenue, by relocating stop control to the West

Summary of Stakeholder Input on Concepts Presented



Swissvale Avenue approach. This is based on Concept 37 in the preliminary matrix.

Full Access at Monongahela Avenue

This concept would modify the traffic control at the Edgewood/Swissvale interchange at the intersection of the entrance ramp from Monongahela Avenue by permitting left turns from northbound Monongahela Avenue onto the eastbound on-ramp. This is based on Concept 38 in the preliminary matrix.

Edgewood/Swissvale Eastbound Ramp Consolidation

This concept would replace the two existing eastbound entrance ramps and substandard merges at the interchange with a combined ramp from Monongahela Avenue that would pass over Braddock Avenue on a separate structure, merge with the ramp from Braddock Avenue, and provide an acceleration lane before joining the Parkway mainline as an added lane. This concept will require replacing the combined structure carrying Norfolk Southern, the East Busway and local streets over the Parkway, as well as the Chestnut Street bridge. This is based on Concept 42/43C from the preliminary matrix.

Wilkinsburg Single-Point Interchange

This project would completely reconfigure the Wilkinsburg interchange to a single-point urban interchange, with a new signalized intersection on Ardmore Boulevard at the intersection of the proposed on-and off-ramps in all directions. The revised interchange would allow for all movements to be made directly, including access to eastbound Ardmore Boulevard from westbound _I-376, and elimination of existing circuitous movements. This is based on Concept 47B from the preliminary matrix.

Control Eastbound Weave (Churchill)

This project would reconfigure the Churchill interchange eastbound to prevent traffic entering on the left from crossing over and exiting at Business 22 to Wilkins and Monroeville. While this could be accomplished through pavement markings at low cost, low compliance would be anticipated and the option of a physical barrier is recommended for advancement. This is based on concept 49 in the preliminary matrix.

Park-and-Ride Lots

This project would consist of additional park and ride lots with connections to transit service in the eastern suburban communities. While the evaluation was based upon specific sites in Penn Hills, Monroeville, and Swissvale, the actual location of these facilities would be subject to further study. This is based on concepts 95, 96 and 98 in the preliminary matrix.

Bicycle Trail Connection to Junction Hollow

This project would connect the Eliza Furnace Trail and the Junction Hollow trail with a separated facility along the CSX railroad under the Parkway East and Swinburne Street and passing over Saline Street. Other bicycle facilities investigated in the study show merit, and although not warranted by the cost-benefit analysis used in this study, may be justified by improved connectivity, quality of life and other metrics. This is based on Concept 85.

Signal Retiming on Arterial Roadways

This project would consist of signal retiming and upgrade to adaptive signal control on corridors in the study area, potentially including Braddock Avenue, Penn Avenue, Fifth Avenue, William Penn Highway, and other routes. This is based on Concepts 69,70, 71,72,73,7576,77,78,79 and 80.

For the refined matrix, qualitative ratings of Poor, Low, Moderate, and High were assigned to several of the metrics, based upon the results of the detailed analysis conducted as part of the Phase 2 evaluation.

7.4 Public Involvement

7.4.1 Stakeholder Meeting

A Stakeholder Meeting was held on January 26, 2017 at the Churchill Borough Building. Organizations which participated in the stakeholder interviews were invited to participate, and 23 stakeholders participated.

Dan Cessna, P.E., PennDOT D-11 District Executive, welcomed participants and explained the importance of stakeholder input to the process. Victor DeFazio, P.E., PennDOT's Project Manager, reviewed the five-step project approach and work to date. He reviewed the screening process, from 100 initial concepts to the 25 that were determined to be feasible in the Phase 2 screening, which were then tabulated as the 11 projects included in the Refined Matrix.

Mr. DeFazio reported on a number of projects that were identified in Phase 1 that have been implemented or will be implemented soon as early action, including:

- Penn Avenue Signal Upgrades
- Signal Retiming
- Staging of service patrols
- Enhanced signage of left exits
- Limiting peak-period closures of tunnels, and
- Improved merge at Fort Pitt Blvd/Wood Street on-ramps.

He also identified several projects identified in Phase 1 that are being advanced as separate projects.

Mr. DeFazio and the consultant team reviewed the 11 potential projects identified in the Refined Matrix. During the review, stakeholders were asked to consider whether the project would benefit the corridor, whether they had concerns, whether the concerns could be overcome during project development, and the priority that should be given to that project. Each of the 11 potential projects was reviewed separately, with descriptions, graphics and plans as needed. At the end of each description, participants were given an opportunity to ask questions for clarification, and were then asked to complete an evaluation form on the questions outlined previously. The table below summarizes the responses received from the participants to the questions on the evaluation forms. Specific written comments received are documented in the separate Meeting Summary Report.

In addition, an exercise was conducted with the stakeholders to help prioritize the potential improvements. For this exercise, each participant received 11 stickers when they arrived at the meeting, one for each potential improvement, with four green stickers to indicate highest preference, four orange stickers to indicate moderate preference, and three yellow stickers to indicate lowest preference. During the exercise, the stakeholders were given time to affix stickers to a board indicating their relative preferences for the various potential improvements. The number of each color sticker posted for the improvements are also summarized in the table below.

7.4.2 Public Officials Briefing

A briefing was held on September 28, 2017 to provide a project update to elected officials and to the project stakeholder committee, and to advise them of the final findings of the alternatives analysis. This meeting was held at the Yagle Community Center at the Churchill Borough Building, and a total of 21 elected officials, official representatives, and stakeholders attended.

At this meeting, Cheryl Moon-Sirianni, P.E., Acting District Executive (now District Executive) for Engineering District 11-0, provided an overview of the project and stressed the importance of PennDOT, municipalities, and elected officials to work together.

Victor DeFazio, P.E., PennDOT's project manager, reviewed the history of the project, from initial data collection and gathering, and the development of potential improvement concepts, through the high-level Phase 1 screening and the more detailed analysis in the Phase 2 screening. He reviewed the eleven potential improvement concepts presented at the previous meeting, and noted that based upon the evaluation that was conducted, all of them appear to be feasible. However, with limited financial resources, PennDOT will not be able to advance all of them at this time. Some potential improvements might be better undertaken by other agencies, such as the Port Authority of Allegheny County or local municipalities; while others might be reconsidered at a later date if funding conditions were to change.

Mr. DeFazio also noted that based upon input at the previous stakeholder meeting, an additional concept was evaluated: Hard Shoulder Running or HSR. This concept would consist of widening the shoulder on the inbound side of the Parkway East from Churchill to Edgewood Avenue to accommodate bus travel during the A.M. peak period. This would also include a new bus-only exit ramp to Edgewood Avenue to allow buses to connect to the Martin Luther King, Jr. East Busway. Analysis indicated that this would be feasible, but due to the limited projected benefits, it would not be advanced through this project. However, the findings would be shared with the Port Authority of Allegheny County, and it could be considered further in conjunction with other transit and pedestrian improvements.

Throughout the discussion, many sources of funding were suggested to the municipal officials in attendance who may want to implement related improvements independently of PennDOT's projects. Funding programs such as Automated Red Light Enforcement (ARLE), Green Light Go!, PennDOT's Multimodal Fund, and SPC SMART grants were mentioned, among others. To assist those municipalities, the project team agreed to place a full list of funding resources on the project website.

8.0 Implementation

8.1 Final Matrix

As presented to the elected officials and stakeholders by District 11 representatives on September 28, 2017, all eleven of the potential improvements presented in the refined matrix are candidates for eventual implementation. However, only five are being actively considered for advancement by PennDOT at this time. These include two small, readily implementable improvements at the Edgewood/Swissvale interchange, and three more extensive improvements through the Parkway East Corridor and at the Bates Street and Squirrel Hill interchanges. These projects were outlined in detail previously in this report.

The improvements to be advanced include:

- Corridor-Wide Active Traffic Management
- Lengthen Eastbound On-Ramp at Bates Street Interchange
- Eliminate/Improve Weave at Squirrel Hill Interchange:
- Allow Full Access at Monongahela Avenue (Edgewood/ Swissvale Interchange)
- West Swissvale Avenue Traffic Control

The following projects were presented to the stakeholders in January, but for various reasons will not be advanced at this time.

Eastbound Ramp Consolidation at the Edgewood/Swissvale Interchange

Addressing these challenges appears to be technically feasible, but it would be expensive to construct. However, this project would result in improved safety and would result in a significant reduction in travel time and user cost savings and shows a projected good benefit to cost ratio even despite the high costs. it is not being actively advanced at this time.

Single-Point Interchange at Wilkinsburg/Forest Hills

This project would have a very high construction cost and would have a lot of impacts to the community, but might be feasible in the future as an alternative to replacing existing bridges at the interchange.

Control Eastbound Weave at Churchill Interchange

This concept would reconfigure the Churchill Interchange eastbound to prevent traffic entering on the left from William Penn Highway from crossing over and exiting at Business 22 to Wilkins and Monroeville. This could be accomplished at low cost with paint and signs, but drivers may or may not abide by those restrictions. A concrete barrier could be constructed, but that would be another fixed object that could be involved in crashes.

Multimodal Improvement Concepts

The study found a high demand for additional transit and park-and ride facilities along the corridor. These may be candidates for advancement by local municipalities or other agencies, potentially in conjunction with other transit and pedestrian improvements such as the potential extension of the Martin Luther King, Jr. East Busway.

Bicycle Facilities

The study evaluated a number of potential bicycle improvements in the project corridor. These may be candidates for advancement by local municipalities or other agencies.

Signal Retiming and Upgrades on Arterial Roadways

Signal retiming and upgrades provide significant traffic operation benefits at relatively low cost. These upgrades are undertaken by the Department on an ongoing basis as part of larger projects, and are also being advanced by SPC as part of the Regional Traffic Signals program.

8.2 NEXT STEPS

The final step of the approach laid out to the public and stakeholders at the beginning of the Project is Implementing Solutions,. Having identified a range of candidate projects in the Final Matrix, the next steps will involve finding funding, securing environmental clearance and then designing and building the project.

For the shorter-term projects (West Swissvale Ave. and Monongahela Ramp traffic control), the project team will coordinate with representatives from both Swissvale and Edgewood Boroughs and pursue implementation through PennDOT forces or other contracts.

The longer-term projects (Active Traffic Management, lengthening the eastbound Bates on-ramp, and eliminating/ improving the weave at the Squirrel Hill interchange) will require identification of funding, coordination with local stakeholders, conducting environmental studies, and then designing and building the project. PennDOT District 11 has already applied for Congestion Mitigation and Air Quality Improvement (CMAQ) funding for Active Traffic Management, and has started the process with Southwestern Pennsylvania Commission (SPC) to apply for Congestion Mitigation and Air Quality Improvement (CMAQ) funding for improvements to the Bates Street interchange as well. Improvements to the Squirrel Hill interchange also remain a viable project, but would require a significant amount of additional funding to be programmed for the region, and thus

PennDOT has tried to procure funding for some of these (and similar) improvements through the statewide Interstate Transportation Improvement Program (TIP). In recent years, the Interstate TIP funds have been more focused on maintenance or rehabilitation of existing roadways, rather than congestion management projects like these. For the projects that have come out of this study, more creative funding sources may need to be found, working with elected officials and the municipalities to ensure that these improvements can be made.

8.2 Conclusion

The I-376 Parkway East Corridor Transportation Network project was undertaken by PennDOT District 11-0 to identify and advance improvements in the project corridor, which was broadly defined as consisting of the I-376 between Downtown Pittsburgh and I-76 in Monroeville, as well as the network of intersecting and parallel arterial routes in the corridor. The project was multimodal in scope, considering pedestrians, bicycles, and transit, in addition to Interstate and local vehicular traffic.

The study began with a comprehensive assessment of transportation needs, including evaluation of roadway needs, traffic operations, and safety conditions. This evaluation was based in part on extensive traffic count and origin-destination data collected in the project area, and on simulation modeling of traffic operations. This was supplemented by an extensive public involvement program, which included interviews with project stakeholders, a project website and interactive online survey, and public meetings. These provided an opportunity for residents and users of the transportation network to identify problems and needs for consideration in the project.

Based upon the results of the technical evaluation and the public input, the project team identified a broad range of potential improvement concepts. 100 concepts were advanced into the Phase 1 Screening, which included a qualitative evaluation of potential benefits, capital and operating costs, and constructability. 60 of these concepts were advanced for more detailed evaluation in the Phase 2 screening.

In the Phase 2 screening, the concepts were developed further, including conceptual line and grade plans where applicable. Transportation impacts were evaluated using simulation modeling, and served as a basis to estimate user and air quality benefits. Potential safety benefits were also evaluated. In some cases, variations on the concept were identified and evaluated as well, leading to nearly 70 concepts being evaluated in total.

As a result of the Phase 2 screening, 11 concepts were identified as being feasible, covering a range of from corridor-level to interchange level improvements to the Parkway, and also including transit and bicycle improvements as well as upgrades to local roads. These concepts were shared with the stakeholder committee, and with input from the committee, the District has determined that the following concepts will be advanced further:

- Corridor-Wide Active Traffic Management
- Lengthen Eastbound On-Ramp at Bates Street Interchange
- Eliminate/Improve Weave at Squirrel Hill Interchange:
- Allow Full Access at Monongahela Avenue (Edgewood/ Swissvale Interchange)
- West Swissvale Avenue Traffic Control

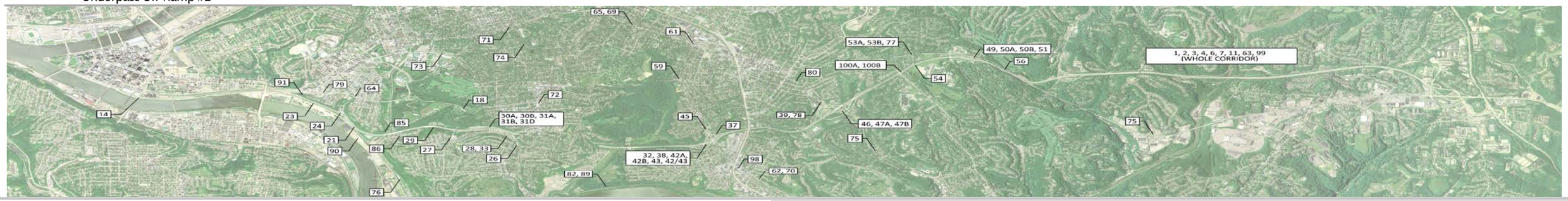
The remaining concepts presented to the stakeholders appear to be viable, but the Department will not be advancing them at this time. In some cases, they may be candidates for advancement by other agencies, or the Department may reconsider them if funding conditions change.

For the concepts being advanced further, the Department is seeking to identify funding. As appropriate, these concepts will then be advanced for further design and public input, environmental reviews, and potentially for construction.

This concludes the Phase 2 Alternatives Analysis of the I-376 Parkway East Corridor Transportation Study.

CONCEPTS EVALUATED

Title	Description	Page
Concept 1	I-376 Managed Lanes	29
Concept 1A	I-376 Active Traffic Management	30
Concept 2	I-376 Additional VMS Signs	31
Concept 3A	Parkway East Ramp Management - Partial Implementation	32
Concept 3B	Parkway East Ramp Management - Full Implementation	33
Concept 4	Parkway East Variable Speed Limits	34
Concept 6	Parkway East Peak Hour Truck Restrictions	35
Concept 7	Parkway East Headlight Barriers	36
Concept 11	Additional Pullover Areas	37
Concept 14	Improve Wood Street Merge	38
Concept 18	Panther Hollow/Greenfield Roundabout	39
Concept 21	Lengthen Eastbound Bates Acceleration Lane	40
Concept 23	Widen Eastbound Shoulder Forbes to Bates	41
Concept 24	Bates Street Right Lane Exit Only	42
Concept 26	Beechwood/Monitor Roundabout	43
Concept 27	Beechwood/Alger/Greenfield Roundabout	44
Concept 28	Beechwood/Forward Pedestrian Crossing	45
Concept 29A	Eastbound Collector— Distributor Bates to Squirrel Hill	46
Concept 29B	Eastbound Collector— Distributor Squirrel Hill Interchange	47
Concept 30A	Squirrel Hill Eliminate Eastbound Weave New Eastbound Off-Ramp	48
Concept 30B	Squirrel Hill Eliminate Eastbound Weave Underpass Off-Ramp #1	49
Concept 30B Revised	Squirrel Hill Eliminate Eastbound Weave Underpass Off-Ramp #1	50
Concept 30C	Squirrel Hill Eliminate Eastbound Weave Underpass Off-Ramp #2	51
Concept 30C Revised	Squirrel Hill Eliminate Eastbound Weave Underpass Off-Ramp #2	52
Concept 31A	Lengthen Weave Horseshoe On-Ramp	53
Concept 31B	Eastbound On-Ramp from Intersection	54
Concept 31D	New EB On-Ramp from Beechwood Blvd.	55
Concept 31D Revised	New EB On-Ramp from Beechwood Blvd.	56
Concept 32	Edgewood/Swissvale Ramps Combine Eastbound Ramps	57
Concept 33	Squirrel Hill Interchange Complete Streets	58
Concept 37	Edgewood/Swissvale West Swissvale Ave Traffic Control	59
Concept 38	Edgewood/Swissvale Monongahela Ave Traffic Control	60
Concept 39	Wilkinsburg Ardmore/Brinton U-Turns	61
Concept 42A	Third Eastbound Lane Edgewood to Existing Lane	62
Concept 42B	Third Eastbound Lane Separate Alignment	63
Concept 42/43A	Edgewood/Swissvale Eastbound Combine Monongahela and Braddock Ramps #1	64
Concept 42/43B	Edgewood/Swissvale Eastbound Combine Monongahela and Braddock Ramps #2	65
Concept 42/43C	Edgewood/Swissvale One Eastbound On-ramp into Third Lane New Bridge Structures	66
Concept 43	Edgewood/Swissvale Eastbound Ramp Consolidation Without Added Lane	67
Concept 45	U-Turns at Allenby Avenue	68
Concept 46	Wilkinsburg Westbound Acceleration Lane	69
Concept 47A	Wilkinsburg Interchange Combine Westbound On-Ramps	70
Concept 47B	Wilkinsburg Interchange Single-Point Urban Interchange	71
Concept 49	Control Churchill Weave with Markings	72
Concept 50A	Churchill Eastbound Ramp Closure	73
Concept 50B	Churchill Eastbound Ramp Consolidation William Penn Ramp Closure	74
Concept 51	Control Churchill Weave with Barrier	75
Concept 53A	Old Gate Ramp Improve Truck Turning Radius	76
Concept 53B	Old Gate Ramp Allow Truck Oversteer	77
Concept 54	Churchill Extend Third Eastbound Lane	78
Concept 56	Business 22 Extend WB Acceleration Lane	79
Concept 59	Forbes/Braddock Intersection Reconfig.	80
Concept 61	Penn/Braddock Intersection Improvements	81
Concept 62	Braddock Avenue Pedestrian Improvements	82
Concept 63	Improve Sidewalks Arterial Roadways	83
Concept 64	Allies/Bates Roundabout	84
Concept 65	Penn Avenue Through Streets Concept	85
Concept 69	Signal Retiming - Wilkinsburg/Penn Avenue	86
Concept 70	Signal Retiming - Braddock Ave	87
Concept 71	Signal Retiming - Fifth Ave	88
Concept 72	Signal Retiming - Murray Ave	89
Concept 73	Signal Retiming - Forbes Avenue	90
Concept 74	Signal Retiming Advance Pedestrian Phases	91
Concept 75	Signal Retiming on Route 22 and Route 30	92
Concept 76	Signal Retiming - Hazelwood Rt. 885	93
Concept 77	Signal Retiming - William Penn Highway	94
Concept 78	Signal Retiming - Ardmore Boulevard	95
Concept 79	Signal Retiming - Boulevard of the Allies	96
Concept 80	Signal Retiming Penn/Ardmore Intersection	97
Concept 82	New Road Turtle Creek to 2nd Avenue	98
Concept 85	Bike Trail Connection to Junction Hollow	99
Concept 86A	Bike Trail Saline Street to Squirrel Hill	100
Concept 86B	Bike Trail Saline Street to Pocusset Street	101
Concept 89	Bike Trail Hazelwood to Braddock	102
Concept 90	Bike Trail Hazelwood/Almono	103
Concept 91	Bike Trail Connection to South Oakland	104
Concept 95	Monroeville Park and Ride	105
Concept 96	Penn Hills Park and Ride	106
Concept 98	Swissvale Park and Ride	107
Concept 99	Ramp Management - Beechwood Boulevard PM Ramp Closure	108
Concept 100A	Transit Only Hard Shoulder Running—Ramp to Existing Busway Entrance	109
Concept 100B	Transit Only Hard Shoulder Running—Ramp to Relocated Busway Entrance	110



pennsylvania DEPARTMENT OF TRANSPORTATION

Parkway East Corridor Transportation Network

Description

This concept would implement one type of managed lanes, active traffic management, for most of Parkway East. The systems have been proven to improve safety by giving credible indications to drivers to gradually slow approaching queues they cannot see and merge out of lanes blocked by crashes, exit queues, emergency maintenance, or a supplement to planned work zone closures.

The system includes a series of sign bridges (gantries) with color dynamic message signs (approximately 5' x 5'), located over each lane, to give lane use control indications for open, need to merge, or closed. For open lanes where there are queues ahead, the speed displayed would decrease across subsequent sets of signs to slow drivers. The speed displays can also take the place of variable speed limit signs used to reduce speeds uniformly along a roadway, such as during icy conditions. The system also includes dynamic message signs for text explanations to accompany the guidance to drivers on lane use and speed. The gantries also house lane-by-lane detection to support operations.

This system would be tied into the Traffic Management Center (TMC) and the software would have automation capabilities to increase the efficiency of TMC operators and effectiveness of the system while ensuring that agency policies are followed and operator judgment can overrule automation when necessary.

Utility impacts are not anticipated.

Transportation Impacts

The managed lanes system is expected to provide a safety benefit by reducing crashes which also creates an indirect benefit to traffic flow, especially to travel time reliability. Implementations of this type of managed lanes in the United States do not typically provide statistically significant capacity improvements. Due to this observed result and the difficulty modeling the impact of this type of managed lanes, modeling was not undertaken to document traffic flow impacts.

Based on experience of similar systems in the United States, a 20% reduction in crashes can be assumed. On the Parkway East, over 62% of crashes are angle, rear-end or sideswipe crashes, which are crash types likely to be mitigated by managed lanes.

Other Potential Issues

Active traffic management has not been implemented in this region, and public information would be required to explain potential benefits.

Environmental Features

This concept should qualify for a Categorical Exclusion, consisting of installation of traffic control devices where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control.

ITS Strategies

Managed lanes are anticipated to be integrated into the existing I-376 freeway management system at the District 11-0 Traffic Management Center.

Design Exceptions

This concept includes no physical roadway construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

This concept includes variable message signs and lane control systems that would allow for open, restricted, or closed designation of lanes in each segment. This system would be tied into the TMC and would allow operators to close one or more lanes in advance of disabled vehicles, ramp queues, or other incidents. Dynamic speed limits are compatible but are evaluated separately.

SUMMARY OF COSTS AND BENEFITS

Concept 1

Construction Cost	
VMS	$4,520,000.00
Sign Structures	$3,620,000.00
Power, Comm and Detection	$280,000.00
System Integration	$190,000.00
Bridge	$0.00
Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$860,000.00
ROW	$0.00
Total	$9,470,000.00
Operating Cost	
Maintenance	$150,000.00
Operations	$100,000.00
Total	$250,000.00
User Benefits	
Travel Time (Daily)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$2,381,317.19
Total	$2,381,317.19
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$35,774,059.86
NPV Operating Costs	$3,755,700.84
NPV Capital Costs	$9,274,801.54
Total Costs	$13,030,502.37
Benefit:Cost Ratio	2.75

Description

This concept would implement one type of managed lanes, active traffic management, for most of Parkway East. The systems have been proven to improve safety by giving credible indications to drivers to gradually slow approaching queues they cannot see and merge out of lanes blocked by crashes, exit queues, emergency maintenance, or a supplement to planned work zone closures.

The system includes a series of sign bridges (gantries) with color dynamic message signs (approximately 5' x 5'), located over each lane, to give lane use control indications for open, need to merge, or closed. For open lanes where there are queues ahead, the speed displayed would decrease across subsequent sets of signs to slow drivers. The speed displays can also take the place of variable speed limit signs used to reduce speeds uniformly along a roadway, such as during icy conditions. The system also includes dynamic message signs for text explanations to accompany the guidance to drivers on lane use and speed. The gantries also house lane-by-lane detection to support operations.

This system would be tied into the Traffic Management Center (TMC) and the software would have automation capabilities to increase the efficiency of TMC operators and effectiveness of the system while ensuring that agency policies are followed and operator judgment can overrule automation when necessary.

Utility impacts are not anticipated.

Transportation Impacts

The managed lanes system is expected to provide a safety benefit by reducing crashes which also creates an indirect benefit to traffic flow, especially to travel time reliability. Implementations of this type of managed lanes in the United States do not typically provide statistically significant capacity improvements. Due to this observed result and the difficulty modeling the impact of this type of managed lanes, modeling was not undertaken to document traffic flow impacts.

Based on experience of similar systems in the United States, a 20% reduction in crashes can be assumed. On the Parkway East, over 62% of crashes are angle, rear-end or sideswipe crashes, which are crash types likely to be mitigated by managed lanes.

Other Potential Issues

Active traffic management has not been implemented in this region, and public information would be required to explain potential benefits.

Environmental Features

This concept should qualify for a Categorical Exclusion, consisting of installation of traffic control devices where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control.

ITS Strategies

Managed lanes are anticipated to be integrated into the existing I-376 freeway management system at the District 11-0 Traffic Management Center.

Design Exceptions

This concept includes no physical roadway construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

This concept includes variable message signs and lane control systems that would allow for open, restricted, or closed designation of lanes in each segment. This system would be tied into the TMC and would allow operators to close one or more lanes in advance of disabled vehicles, ramp queues, or other incidents. Dynamic speed limits are compatible but are evaluated separately.

SUMMARY OF COSTS AND BENEFITS

Concept 1A

Construction Cost	
VMS	$4,520,000.00
Sign Structures	$3,620,000.00
Power, Comm and Detection	$280,000.00
System Integration	$190,000.00
Supplemental Roadway Construction	$31,000.00
Earthwork	$3,000.00
Pavement	$119,000.00
Ramp Metering	$3,280,000.00
Additional Lump Sum	$12,000.00
Design and PM	$876,000.00
ROW	$0.00
Total	$12,931,000.00
Operating Cost	
Maintenance	$166,250.00
Operations	$200,000.00
Total	$366,250.00
User Benefits	
Travel Time (Daily)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$2,381,317.19
Total	$2,381,317.19
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$35,774,059.86
NPV Operating Costs	$5,502,101.73
NPV Capital Costs	$12,664,656.03
Total Costs	$18,166,757.76
Benefit:Cost Ratio	1.97

Description

This concept would provide additional Variable Message Signs (VMS) along the Parkway East Corridor. There are currently five (5) VMS in the westbound direction approaching Bates Street, the Boulevard of the Allies, Edgewood, Greensburg Pike, and Penn Hills. There are three (3) VMS in the eastbound direction near the County Jail, Greensburg Pike, and Penn Hills. The rest of the corridor is void of any dynamic traveler information instrumentation. It is particularly important to allow travelers to benefit from accurate and timely traveler information approaching the Squirrel Hill tunnel from either direction as well as other major interchange/decision points. This concept proposes implementation of six (6) new full matrix variable message signs along the corridor. All VMS would be operated under the current ITS system. Fully integrated with PennDOT NextGen ATMS software, VMS boards would alert drivers on current roadway conditions, including delays, incidents, weather related messages, travel times, emergency alerts and alternate routes. The comprehensive VMS system would be supported by roadway sensors as well as other sources of data including probe vehicle data obtained by the Department.

The VMS signs and the related sign structures, controller, power and communications would be designed and constructed in compliance with PennDOT's current ITS standards, Publication 646, "Intelligent Transportations System Design Guide" and Publication 647, "Civil and Structural Standard for Intelligent Transportations Systems". No constructability issues are anticipated. Power and communication links should be present at the proposed sign locations. The Department's current ATMS software has the capability to operate the additional VMS.

Utility impacts are not anticipated.

Transportation Impacts

Nearly 80% of motorists utilize traveler information to make daily decisions about route and departure time. Once the driver leaves for his/her destination, the accuracy and timeliness of the information received while travelling becomes very important. This is particularly important for a corridor such as the Parkway East where alternate routes are scarce, the roadway is congested, and a tunnel is present. Well maintained and operated VMS systems are proven to maximize the efficiency and capacity of the roadway by providing current system information to drivers, reduce the impact of the congestion, and increase the safety by alerting motorists of upcoming hazards.

The system is expected to improve safety along the corridor by providing accurate and timely information on roadway conditions. The most common benefit of a well-operated ITS system is the reduction of secondary crashes during adverse weather conditions and/or congested travel conditions. ITS systems are usually a combination of different devices. It should be noted that the safety benefits of VMS would dramatically increase if combined/coordinated with other ITS concepts proposed for the corridor, especially variable speed limit signs, ramp management and Active Transportation and Demand Management (ATDM).

Environmental Features

This concept should qualify for a Categorical Exclusion, consisting of installation of traffic control devices where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control measures.

ITS Strategies

VMS signs are anticipated to be integrated into the existing I-376 freeway management system at the District 11-0 Traffic Management Center.

Design Exceptions

This concept includes no physical roadway construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Additional VMS signs can alert motorists to adverse conditions or roadway incidents, allowing them to exercise appropriate caution.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 2

Construction Cost	
VMS	$520,000.00
Sign Structures	$750,000.00
Power, Comm and Detection	$220,000.00
System Integration	$270,000.00
Bridge	$0.00
Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$180,000.00
ROW	$0.00
Total	$1,940,000.00
Operating Cost	
Maintenance	$36,000.00
Operations	$144,000.00
Total	$180,000.00
User Benefits	
Travel Time (Daily)	0hr
Value of Travel Time (Annual)	$1,823,706.50
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$1,731,867.05
Total	$3,555,573.55
Emissions	
CO2	0kg
NOx	0kg
VOC	0kg
Benefit:Cost Ratio	
NPV Benefits	$53,414,682.20
NPV Operating Costs	$2,704,104.60
NPV Capital Costs	$1,909,850.34
Total Costs	$4,613,954.95
Benefit:Cost Ratio	11.58

Description

This concept would implement ramp management along the corridor to minimize the interference of vehicles entering I-376 and prevent the stop-and-go traffic that ripples upstream and slows the entire corridor. Ramp management enables smoother freeway merging and keeps the freeway moving by releasing one vehicle at a measured rate from the feeding ramps. It is particularly effective during recurring congestion periods such as typical peak hours.

As a result of the microsimulation modeling and analyses conducted to measure the impacts of implementing ramp management along the I-376 corridor, it was determined that a "peak hour / directional" management would yield the best results. No ramp closures are proposed in this concept.

During the AM peak period, 7 ramps approaching the Squirrel Hill tunnel in the westbound direction would be metered: Rodi Road, Business 22, Churchill, Forest Hills, Wilkinsburg, Swissvale and Edgewood.

During the PM peak 7 ramps bracketing the tunnel would be metered: Grant Street, Bates Street, Edgewood, Swissvale, and Ardmore Boulevard. Initial management rates at these intersections would be non-restrictive, and would not reduce access to the Parkway from any interchanges.

The cost and benefits of implementing the ramp management system along the I-376 corridor in this sub-concept is based on a Phase 1 limited deployment strategy for a total of 14 ramps. A potential second phase of implementation expanded to the entire corridor is considered in Concept 3B.

Transportation Impacts

The non-restrictive ramp management scenario showed limited impacts on congestion during the AM peak period, resulting in a decrease in travel time from the Penn Hills to the Squirrel Hill Tunnel. A more restrictive ramp management was investigated which had the potential to reduce total delay by nearly 18 minutes, but appeared to be impractical due to ramp queues which imposed delays of similar magnitude. The impact of these queues would effectively close off access to the Parkway from metered ramps.

PM analysis showed similar findings, with only a 14 second reduction in average travel time from the Grant Street on-ramp to the west portal of the Squirrel Hill Tunnel. More restrictive management strategies were limited due to potential for queues to back to the Fort Pitt Bridge, the Boulevard of the Allies, and Bates Street.

VISSIM simulation modeling indicated a very minor drop in total network delay in the AM peak, offset by an increase in total delay during the PM peak period. This is due in part to the delay incurred by vehicles at the ramp meters, without corresponding increases in travel speeds on the mainline.

However, this should to some extent be offset by safety improvements. Ramp management systems are known to increase safety and efficiency of the mainline, especially during congested conditions. The Minnesota DOT, who operates 400+ ramp meters, conducted a study to measure the impact of the flow control. The study revealed that there was a 21% reduction in crashes, 8% increase in mainline speeds, 22% reduction in travel time, and 16% increase in throughput.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Environmental Features

While no impacts on defined environmental features were identified as work is anticipated to be completely within the existing right-of-way, potential traffic impacts and concerns could require environmental documentation such as a Categorical Exclusion.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

MPT

Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control measures

ITS Strategies

Ramp management is anticipated to be integrated into the existing District 11-0 Traffic Management Center. PennDOT's NextGen ATMS software could require an additional module to operate ramp management.

Safety Benefits

Research published in 2013 indicates ramp meters result in a 36% reduction in crash frequency in the vicinity of on-ramps.

Other Potential Issues

Ramp management has been received skeptically, with strong opposition to any concept that would close ramps. Benefits would need to be explained to the public, and ramp management strategies must maintain access to the surrounding areas. A public education component and public involvement would be anticipated for this concept.

SUMMARY OF COSTS AND BENEFITS
Concept 3A

Construction Cost	
Roadway Construction	$31,000.00
Earthwork	$3,000.00
Pavement	$119,000.00
Walls	$0.00
Bridges	$0.00
Ramp Management	$1,668,786.77
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$166,878.68
ROW	$0.00
Total	$1,988,665.45
Operating Cost	
Maintenance, Power & Comm	$16,250.00
Operations	$100,000.00
Total	$116,250.00
User Benefits	
Travel Time (Day)	-58.90 hr
Value of Travel Time (Annual)	-$257,641.04
Automobile Operating Costs (Annual)	$79,806.09
Safety (Annual)	$884,460.47
Total	$706,625.53
Emissions (Annual)	
CO2	234107 kg
NOx	440 kg
VOC	648 kg
Benefit:Cost Ratio	
NPV Benefits	$8,217,673.90
NPV Operating Costs	$1,853,626.19
NPV Capital Costs	$1,798,952.14
Total Costs	$3,652,578.33
Benefit:Cost Ratio	2.25

Description

This concept would implement ramp management along the corridor to minimize the interference of vehicles entering I-376 and prevent the stop-and-go traffic that ripples upstream and slows the entire corridor. Ramp management enables smoother freeway merging and keeps the freeway moving by releasing one vehicle at a measured rate from the feeding ramps. It is particularly effective during recurring congestion periods such as typical peak hours.

As a result of the microsimulation modeling and analyses conducted to measure the impacts of implementing ramp management along the I-376 corridor, it was determined that a "peak hour / directional" management would yield the best results. No ramp closures are proposed in this concept.

During the AM peak period, 13 ramps in the westbound direction would be metered: PA Turnpike Ramp, both Haymaker Road ramps, Rodi Road, Business 22, Churchill, Forest Hills, Wilkinsburg, Swissvale, Edgewood, Forward Avenue, Beechwood Boulevard, and the Boulevard of the Allies.

During the PM peak 12 ramps in the eastbound direction would be metered: Fort Pitt Boulevard, Grant Street, the Boulevard of the Allies, Bates Street, Squirrel Hill, Edgewood, Swissvale, Wilkinsburg, Forest Hills, Old William Penn Highway, Churchill, and Penn Hills. Initial management rates at these intersections would be non-restrictive, and would not reduce access to the Parkway from any interchanges.

This sub concept is based upon a full implementation of ramp management at all 25 ramps in the corridor. It would not provide substantial additional benefits initially over the partial installation, but would provide greater flexibility for system management.

Transportation Impacts

The non-restrictive ramp management scenario showed limited impacts on congestion during the AM peak period, resulting in a decrease in travel time from the Penn Hills to the Squirrel Hill Tunnel. A more restrictive ramp management was investigated which had the potential to reduce total delay by nearly 18 minutes, but appeared to be impractical due to ramp queues which imposed delays of similar magnitude. The impact of these queues would effectively close off access to the Parkway from metered ramps.

PM analysis showed similar findings, with only a 14 second reduction in average travel time from the Grant Street on-ramp to the west portal of the Squirrel Hill Tunnel. More restrictive management strategies were limited due to potential for queues to back to the Fort Pitt Bridge, the Boulevard of the Allies, and Bates Street.

VISSIM simulation modeling indicated a very minor drop in total network delay in the AM peak, offset by an increase in total delay during the PM peak period. This is due in part to the delay incurred by vehicles at the ramp meters, without corresponding increases in travel speeds on the mainline.

However, this should to some extent be offset by safety improvements. Ramp management systems are known to increase safety and efficiency of the mainline, especially during congested conditions. The Minnesota DOT, who operates 400+ ramp meters, conducted a study to measure the impact of the flow control. The study revealed that there was a 21% reduction in crashes, 8% increase in mainline speeds, 22% reduction in travel time, and 16% increase in throughput.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Environmental Features

While no impacts on defined environmental features were identified as work is anticipated to be completely within the existing right-of-way, potential traffic impacts and concerns could require environmental documentation such as a Categorical Exclusion.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

MPT

Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control measures

ITS Strategies

Ramp management is anticipated to be integrated into the existing District 11-0 Traffic Management Center. PennDOT's NextGen ATMS software could require an additional module to operate ramp management.

Safety Benefits

Research published in 2013 indicates ramp meters result in a 36% reduction in crash frequency in the vicinity of on-ramps.

Other Potential Issues

Ramp management has been received skeptically, with strong opposition to any concept that would close ramps. Benefits would need to be explained to the public, and ramp management strategies must maintain access to the surrounding areas. A public education component and public involvement would be anticipated for this concept.

SUMMARY OF COSTS AND BENEFITS
Concept 3B

Construction Cost	
Supplemental Roadway Construction	$31,000.00
Earthwork	$3,000.00
Pavement	$119,000.00
Walls	$0.00
Bridges	$0.00
Ramp Management	$2,979,976.38
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$297,997.64
ROW	$0.00
Total	$3,430,974.02
Operating Cost	
Maintenance, Power & Comm	$16,250.00
Operations	$100,000.00
Total	$116,250.00
User Benefits	
Travel Time (Day)	-58.90 hr
Value of Travel Time (Annual)	-$257,641.04
Automobile Operating Costs (Annual)	$79,806.09
Safety (Annual)	$884,460.47
Total	$706,625.53
Emissions (Annual)	
CO2	234107 kg
NOx	440 kg
VOC	648 kg
Benefit:Cost Ratio	
NPV Benefits	$8,217,673.90
NPV Operating Costs	$1,853,626.19
NPV Capital Costs	$3,212,414.54
Total Costs	$5,066,040.72
Benefit:Cost Ratio	1.62

Description

This concept would provide Variable Speed Limit Signs (VSLS) along the Parkway East Corridor. The static posted speed limit signage is substandard along the corridor. 1 VSLS would be installed after each interchange area in both directions and at a minimum of ½ mile apart. This criteria yields a total of 58 VSLS. The VSLS would be enforceable, and manufactured and installed in accordance with PennDOT's current guidelines, standards and requirements, including Publication 46, "Traffic Engineering Manual", Publication 212, "Official Traffic Control Devices", and PA Code 67. All VSLS would be connected to continuous power and communications network and operated by PennDOT's NextGen ATMS software. There are locations along the corridor where there are truck specific speed limit signs. These signs are replaced by VSLS (for trucks only) at their current locations.

Utility impacts are not anticipated.

Transportation Impacts

The primary goal of VSLS system is to slow traffic uniformly in order to prevent stop-and-go conditions and to allow smooth traffic flow along the corridor. The VSLS system requires a comprehensive detection monitoring capability to support its operation including roadway weather condition monitoring. The TMC should be capable of detecting the roadway conditions and automatically update the speed limits along the corridor in a fail-safe fashion. The system needs a robust integration and implementation strategy along with strong and compliant logic and algorithms to operate. The VSLS system is expected to respond to two specific conditions to maximize its positive impact: 1.) Weather related variable speed limits (when conditions deteriorate, speed limits would be reduced accordingly); 2.) Congestion related variable speed limits (implementing a reduced speed limit to reduce the stop-and-go traffic conditions).

Studies from the United Kingdom show that the VSLS system helped reduce the property damage only crashes by 20% whereas Germany shows an overall 30% reduction in crashes on facilities with VSLS implemented. It has also been observed that properly operated VSLS systems delay the onset of congestion. ITS systems are usually a combination of different devices. It should be noted that the safety benefits of VSLS would dramatically increase if combined/coordinated with other ITS concepts proposed for the corridor, especially additional VMS, ramp management and ATDM.

Environmental Features

This concept should qualify for a Categorical Exclusion, consisting of installation signs and associated equipment where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control measures.

ITS Strategies

VSLS signs are anticipated to be integrated into the existing I-376 freeway management system at the District 11-0 Traffic Management Center.

Design Exceptions

This concept includes no physical roadway construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

The system can improve safety by reducing primary and secondary crashes during adverse weather and congestion conditions. Implementing a more uniform speed in tune with the current roadway conditions will reduce the possibility of erratic driver behavior and crashes. Research published in 2010 indicates variable speed limits are associated with an 8% reduction in crash frequency on urban interstate corridors.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 4

Construction Cost	
VSLS	$580,000.00
Sign Structures	$200,000.00
Power, Comm and Detection	$1,050,000.00
System Integration	$240,000.00
Bridge	$0.00
Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$210,000.00
ROW	$0.00
Total	$2,280,000.00
Operating Cost	
Maintenance	$70,000.00
Operations	$140,000.00
Total	$210,000.00
User Benefits	
Travel Time (Daily)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$1,731,867.05
Total	$1,731,867.05
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$26,017,498.08
NPV Operating Costs	$3,154,788.70
NPV Capital Costs	$2,028,033.70
Total Costs	$5,182,822.40
Benefit:Cost Ratio	5.02

Description

This concept would prohibit truck traffic on the Parkway East during peak periods, with the aim of freeing up roadway capacity and reducing conflicts during stop-and-go traffic between trucks and cars with different acceleration and deceleration profiles. This would be accomplished by posting dynamic signs at entrance ramps and approaches to the Parkway East from the Parkway West and from the Pennsylvania Turnpike. We anticipate that these restrictions would be in effect from 6:00 AM to 9:00 AM and 3:00 to 6:00 PM on weekdays.

In order to maintain commercial traffic, detour routes would be posted. The primary detour route would be SR 0028 between the Fort Duquesne Bridge and the Turnpike, providing a through route as well as local access via the Highland Park Bridge and other truck routes. Other detour routes for shorter trips may include Fifth Avenue, Forbes Avenue, Penn Avenue, Second Avenue, and SR 0008, SR 0837 and SR 0130.

Utility impacts are not anticipated.

Transportation Impacts

This change is projected to affect about 107 trucks per hour in the AM, and 114 per hour in the PM, for a total of about 650 total truck-trips per day that would be detoured. It is estimated that direct costs to truck operators would be approximately $5,782 daily, including wages and fuel costs. An additional 929 gallons per day of fuel would be used, which would result in a corresponding increase in emissions.

The model shows that removing trucks from the traffic stream during peak periods results in an overall system increase in average speed of 1.6 mph (8%) in the AM and 2.2 mph (11%) in the PM peak. This increased speed during the peaks allows the system to operate slightly more efficiently in terms of number of vehicles processed through the system. For example, 56 and 106 more vehicles can travel through the Squirrel Hill Tunnel in the AM and PM peak periods, respectively, when trucks are prohibited. Average speed in the tunnel appears to increase by 0.5 mph (1.5%) in the AM peak and 1.3 mph (8%) in the PM peak. The AM peak model shows a 2.15 minute decrease in the average travel time from the Penn Hills Interchange to the East portal of the Squirrel Hill Tunnel.

Some segments are negatively affected by the truck restrictions. The Monongahela Avenue eastbound on ramp handles a lower volume, lower speed and higher density. This might be due to fewer large gaps in the mainline traffic stream at the Edgewood Swissvale Interchange (trucks have longer headways than automobiles).

This evaluation does not include additional delay that would be created by increased truck traffic on Route 28.

Environmental Features

This concept may qualify for a Categorical Exclusion, consisting of installation of signs and associated equipment where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign placement.

MPT

Installation of ITS devices, communication equipment and signage should be constructible under temporary, short-term traffic control measures

ITS Strategies

Existing VMS signage, HAR and other ITS devices can be used to advise travelers of truck restrictions.

Design Exceptions

This concept includes no physical roadway construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

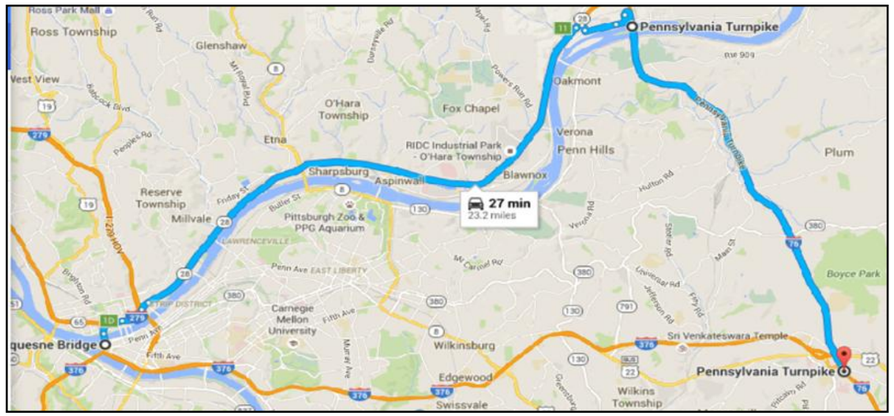
While reducing truck traffic on the parkway may reduce crash frequency, additional truck traffic on local alternative routes could result in increased conflicts with traffic and pedestrians on those routes.

Other Potential Issues

Motorists and communities along alternative routes could object to increased traffic.

SUMMARY OF COSTS AND BENEFITS
Concept 6

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$1,260,000.00
Utilities	$0.00
Additional Lump Sum	$170,000.00
Design and PM	$290,000.00
ROW	$0.00
Total	$1,720,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	466hr
Value of Travel Time (Annual)	-$387,546.82hr
Automobile Operating Costs (Annual)	-$4,509,675.11
Safety (Annual)	$39,275.20
Total	-$4,857,946.74
Emissions (Annual)	
CO2	15979179kg
NOx	42255kg
VOC	-13945kg
Benefit:Cost Ratio	
NPV Benefits	-$72,979,978.58
NPV Operating Costs	$0.00
NPV Capital Costs	$1,681,631.08
Total Costs	$1,681,631.08
Benefit:Cost Ratio	-43.40



pennsylvania
DEPARTMENT OF TRANSPORTATION

Parkway East
Corridor Transportation Network

Concept 6

Parkway East
Peak Hour Truck Restrictions

Description
This concept would install a taller median barrier called a glare screen. This would prevent on-coming headlights from shining into drivers' eyes and could also reduce rubbernecking by blocking views of the opposing lanes.

Installation of the glare screen is limited to locations where it would not impede stopping sight distance along horizontal curves. Due to restrictive geometry and limited sight distance, the barrier can only be placed on curves with radii greater than 5,250' and tangents of 1,000' or longer.

Based on these criteria glare screen can be used on 29,800 ft. of the 62,300 ft. of the corridor analyzed (48%). Included in this length is 3,750 ft. of structure-mounted glare screen.

Utility impacts are not anticipated.

Transportation Impacts
Direct benefits are real, but are difficult to quantify.

Glare from oncoming headlights can affect driver visibility distance, reaction time, and recovery time. Reducing these impacts with headlight barriers should reduce hit fixed object crashes, which account for nearly 33% of the total crashes on the Parkway East. "Rubbernecking" can also be reduced with the installation of glare screen. "Rubbernecking" can be a contributing factor in nearly 10% of crashes.

Research indicates that rubbernecking is a significant cause of traffic congestion following freeway incidents, causing an average delay of 107 vehicle-hours of delay per incident.

Environmental Features
No environmental impacts are anticipated.

ROW Impacts
This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT
Installation of glare screen should be constructible under temporary, short-term traffic control measures.

ITS Strategies
No applicable ITS strategies.

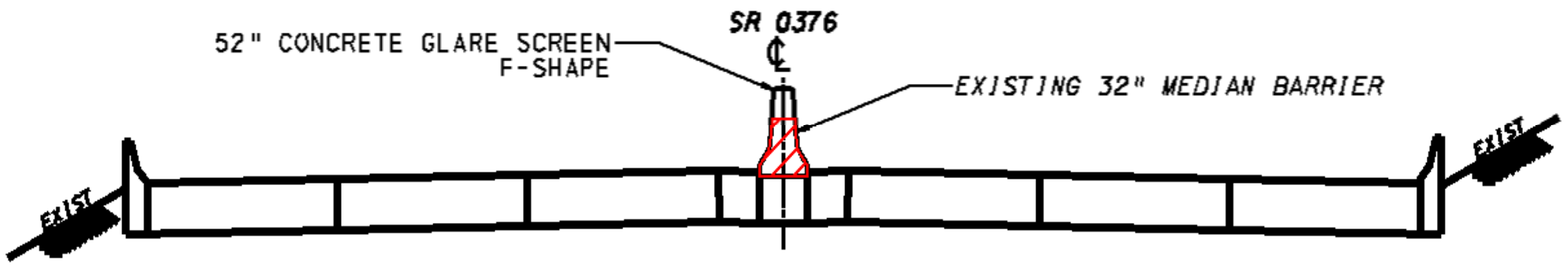
Design Exceptions
No design exceptions are anticipated for construction of this concept. Glare screen would only be placed where adequate stopping sight distance is provided.

Safety Benefits
Installation of a glare screen can reduce visual distraction caused by headlights on oncoming traffic and could also reduce "rubbernecking" by blocking views of the opposing lanes. However, this is not quantifiable.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 7

Construction Cost	
Supplemental Roadway Construction	$1,880,000.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$220,000.00
Design and PM	$420,000.00
ROW	$0.00
Total	$2,520,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	32.93 hr
Value of Travel Time (Annual)	$146,752.11
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$146,752.11
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$2,204,628.07
NPV Operating Costs	$0.00
NPV Capital Costs	$2,472,179.67
Total Costs	$2,472,179.67
Benefit:Cost Ratio	0.89



Description

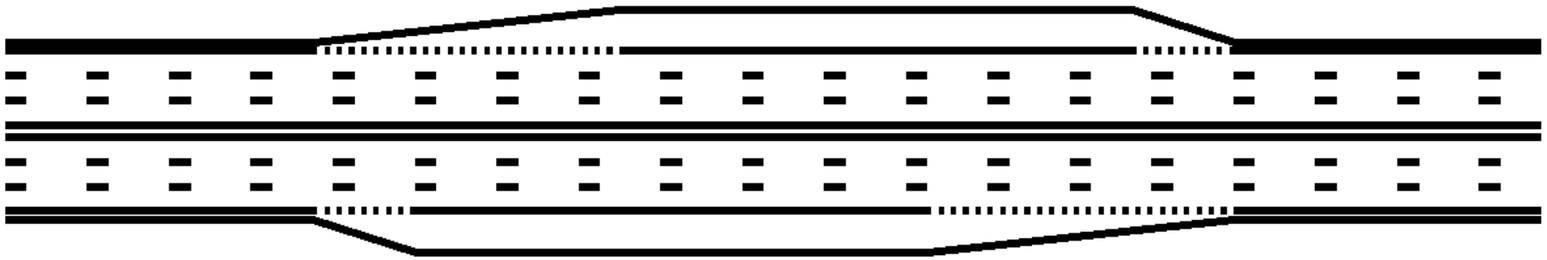
This concept would provide additional emergency pullover areas along the Parkway East Corridor (between the Fort Pitt Bridge and the Squirrel Hill Tunnel) in areas where adequate shoulders do not exist. Previous projects have implemented a number of pullover areas which currently are in place. However, there remain significant stretches where stopped vehicles cannot leave the road, creating safety hazards and interference with traffic flows.

In addition to the four existing pullover areas, nine have been proposed, five in the eastbound direction and four in the westbound direction. Specific locations are located in the appendix to this report.

These locations were identified at transitions between cut and fill sections where earthwork could be minimized and right-of-way is more available.

Utility impacts are not anticipated.

Option	ROW	RW Cost	NPV Costs	Safety & Delay Benefits	B/C Ratio
EB-3	$0.00	$324,000.00	$743,233.67	$20,394.50	0.41
EB-5	$0.00	$324,000.00	$743,233.67	$20,394.50	0.01
EB-6	$5,510.00	$432,000.00	$854,473.47	$21,099.10	0.37
EB-7	$1,000.00	$26,400.00	$452,565.67	$22,508.31	0.75
EB-8	$0.00	$0.00	$425,713.67	$22,860.62	0.81
WB-1	$65,300.00	$0.00	$489,707.67	$21,451.40	0.66
WB-2	$33,300.00	$432,000.00	$881,707.67	$21,099.10	0.36
WB-3	$1,807.00	$360,000.00	$780,284.53	$26,383.64	0.51
WB-6	$132,253.00	$0.00	$555,321.61	$22,860.61	0.62



Transportation Impacts

Direct benefits are difficult to quantify, but would primarily result from reducing congestion caused by incidents such as minor crashes and disabled vehicles. In some cases, vehicles are not able to reach existing pullover areas, and either remain in travel lanes, partially pull off into narrow shoulders, or pull into entrance gore areas. This is particularly notable in the eastbound direction between Grant Street and Forbes Avenue, and from the Boulevard of the Allies to Bates Street.

The effects of this vary greatly based on the location, duration, and nature of the incident, and is impossible to predict. However, on average a low-severity crash on an urban interstate blocks travel lanes for approximately 41 minutes, and can result in 215 vehicle-hours of delay. Adequate pullover areas can reduce the number of incidents that impact traffic, and reduce the severity of those impacts.

Environmental Features

Environmental impacts would depend on the actual locations selected. Potential areas could involve the Penn Lincoln Parkway East and Schenley Park historic districts, the Great Allegheny Passage Trail, and known EPA waste sites.

ROW Impacts

If all proposed pullovers are constructed, a total of 21,283 SF of partial right-of-way takes would be required from 9 parcels of varying ownership (city, county, and private owners).

MPT

Construction of the pullover areas would require closing any existing shoulders as well as lane closures, which could take place during weekends or nighttime hours.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Emergency pullovers provide a safe refuge for motorists to remove their vehicle from the mainline traffic stream for emergency situations. This allows mainline traffic to continue to flow unimpeded. It was assumed each pull-off will reduce the frequency of rear-end crashes within 1/2 mile upstream by 2%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 11

Construction Cost	
Supplemental Roadway Construction	$145,000.00
Earthwork	$14,000.00
Pavement	$113,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$90,000.00
Design and PM	$72,000.00
ROW	$0.00
Minimum Estimated Total	$434,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0hr
Value of Travel Time (Annual)	$19,689.89
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$2,426.98
Total	$22,116.86
Emissions (Annual)	
CO2	kg
NOx	kg
VOC	kg
Benefit:Cost Ratio	
NPV Benefits (Average)	$332,257.25
NPV Operating Costs	$0.00
NPV Capital Costs	$425,713.67
Total Costs	$425,713.67
Benefit:Cost Ratio	0.78

Description

This concept would improve the eastbound merge between Ramp A from the Fort Duquesne Bridge and Ramp R from Wood Street. Under the existing configuration, the ramps join together following a short acceleration lane, but with lane changes and merging prohibited through the Grant Street underpass, the ramps merge within an abbreviated 300-foot taper, with no parallel approach. At the merge point, horizontal and vertical curves and restricted sight distance make cooperative merging difficult, particularly under heavy traffic conditions.

A review of roadway geometry indicates that the cartway is severely constrained by surrounding facilities, including the Grant Street ramps, the underpass, the Smithfield Street Bridge, and the I-376 mainline. As a result, physical changes to improve the approach runout and the taper length do not appear to be feasible.

Ramp management was investigated as a potential mitigation measure to improve the merge releasing vehicles on the two ramps separately. The heavy volumes on Ramp A from I-279 cannot be accommodated through a single-lane meter, and the geometric constraints described above do not permit widening the ramp.

The recommended alternative is to provide advance notice of the merge by replacing existing W4-2L signage with W4-1L signs.

Utility impacts are not anticipated.

Transportation Impacts

Direct user benefits from this concept are difficult to project. Revised signage is not anticipated to impact the capacity of the ramp, but it should improve cooperative merging and result in fewer vehicles slowing or stopping at the merge point, and should provide corresponding safety benefits.

Environmental Features

This concept should qualify for a Categorical Exclusion consisting of installation of fencing, signs, pavement markings, traffic signals, and railroad warning devices where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of signage is anticipated to take place under temporary, short-term traffic control measures

ITS Strategies

No applicable ITS strategies.

Design Exceptions

This concept includes no physical roadway construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Advance notice of the merge may allow drivers to merge cooperatively, reducing crash potential from unexpected lane changes or vehicles stopping at the merge point. It was assumed this improved signage will reduce sideswipe crashes at the merge by 10%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 14

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$1,250.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$250.00
ROW	$0.00
Total	$1,500.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$5,343.07
Total	$5,343.07
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$80,267.83
NPV Operating Costs	$0.00
NPV Capital Costs	$1,466.18
Total Costs	$1,466.18
Benefit:Cost Ratio	54.75

Description

This concept would construct a roundabout in Schenley Park at the intersection of Panther Hollow Road/Hobart Street and Greenfield Road/Bartlett Street, replacing an existing signalized intersection. Analysis indicates a two-lane roundabout with a 180-foot inscribed circle would accommodate traffic volumes at this location. Right-turn bypass lanes would be constructed for vehicles turning right from Bartlett Street onto Panther Hollow Road and for vehicles turning right from Panther Hollow Road onto Greenfield Road. Pedestrian movements would be accommodated with crosswalks.

The Bartlett Street approach leg would provide one entrance lane with one right-turn bypass lane and one exit lane. Each of the other three approach legs would provide two entrance lanes and two exit lanes. The Panther Hollow Road approach would also provide a right turn bypass lane to help serve the heavy PM right turn volume heading towards the Greenfield Bridge.

Geometric design criteria is based on NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition. This concept uses the Urban Two-Lane roundabout template which accommodates a city bus in the circulatory roadway. A truck apron would accommodate WB-50 semi-trailers in the circulatory roadway.

Minor utility impacts are anticipated based on assumed underground utilities.

Transportation Impacts

An analysis of design year 2040 peak hour volumes resulted in overall intersection Level of Service (LOS) E in the AM peak hour and LOS D in the PM peak hour. The LOS is based on average vehicle delay.

If the traffic signal were to remain at this intersection, it is anticipated that all of the approaches would operate at LOS D or better in both the AM and PM peak hours.

The roundabout shows a significant degradation in LOS and a corresponding increase in delay, most notably in the PM peak period.

The highest-volume movement in both the AM and PM is the Greenfield Road northbound left onto Panther Hollow Road. Eastbound and westbound through movements are also relatively heavy as is the Bartlett Street right turn onto Panther Hollow Road; this movement would be accommodated with a right-turn bypass lane.

It appears that the traffic patterns at this intersection are not well-suited for roundabout control. The intersection serves primarily to collect traffic heading westwards towards Oakland from various approaches during the AM peak period, and to distribute traffic from Oakland to the various approaches during the PM peak hour. There is relatively little crossing movement. Under roundabout control the heavy east– and westbound flows need to yield to the smaller cross flows when entering the roundabout, resulting in increased delays as compared to signalized operation. The roundabout should provide some benefits in off-peak periods, but not offsetting the peak hour impacts.

ITS Strategies

No applicable ITS strategies.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Schenley Park Historic District. It would also involve coordination with Schenley Park regarding recreational uses. A trail within the park is adjacent to this concept. Section 4(f) forms would be expected. Land and Water Conservation Funds were used at the Schenley Park Fountain and Oval. Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries. A NPDES permit may be required.

ROW Impacts

The roundabout would require a partial take of about 65,500 sf in Schenley Park.

MPT

The intersection could remain open to traffic during construction because of the relatively wide existing approach widths. Temporary lane closures would be required. Short pedestrian detours could be implemented.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Research indicates roundabouts can reduce crash frequency by 48% compared to signalized intersections, while significantly reducing injury crashes (by 78%) by eliminating high-speed left-turn crashes.

Other Potential Issues

Modern roundabouts are often controversial when first introduced to an area, such as the Pittsburgh urban core, that is not familiar with their potential benefits.

SUMMARY OF COSTS AND BENEFITS
Concept 18

Construction Cost	
Supplemental Roadway Construction	$620,000.00
Earthwork	$90,000.00
Pavement	$1,130,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$70,000.00
Additional Lump Sum	$220,000.00
Design and PM	$430,000.00
ROW	$200,000.00
Total	$2,760,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-379.8695833 hr
Value of Travel Time (Annual)	-$1,659,769.37
Automobile Operating Costs (Annual)	-$603,625.57
Safety (Annual)	$105,948.15
Total	-$2,157,446.78
Emissions (Annual)	
CO2	1768214 kg
NOx	3316 kg
VOC	4947 kg
Benefit:Cost Ratio	
NPV Benefits	-$32,410,898.76
NPV Operating Costs	$0.00
NPV Capital Costs	$2,706,432.63
Total Costs	$2,706,432.63
Benefit:Cost Ratio	-11.98

Description
This concept would improve the existing Bates Street on-ramp by providing a 1200' acceleration lane and a 300' taper, allowing vehicles to attain mainline speeds, as well as providing a longer merging distance. The design also includes a 12' shoulder adjacent to the acceleration lane.

Construction of the acceleration lane would require a 1,600-foot retaining wall to support the Parkway above the adjacent properties.

Minor utility impacts are anticipated based on aerial utilities and assumed underground utilities.

Transportation Impacts
The PM peak model shows that lengthening the acceleration lane would increase ramp volume by approximately 90 vehicles in the PM peak period. Average vehicle speeds would increase by 7 percent and density would increase by 16 percent on the section from Bates Street to the tunnel portal.

Overall, travel time on the eastbound Parkway towards the Squirrel Hill degrades by about 4 seconds, as the increased ramp volume leads to an increase in congestion at the tunnel.

Much of the efficiency gains could appear outside of the PM peak period at this location when the mainline is flowing more smoothly (not at jam density) with sufficient gaps available for merging ramp vehicles to take advantage of the longer acceleration lane.

Safety Benefits
An improved acceleration lane should provide for a more efficient operation of the merge area as well as lowering crash frequency. By providing a longer acceleration lane, motorists should be able to attain a speed almost the same as the mainline operating speed prior to merging with the mainline traffic. This will reduce unexpected lane changes and mismatches of vehicle speeds. The Highway Safety Manual indicates by lengthening the acceleration lane as proposed, crash frequency at the merge can be reduced by 60%.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. This concept would impact the Great Allegheny Passage Trail, which is a Section 4 (f) resource. A Section 4(f) form would be required for impacts to the Great Allegheny Passage. The trail was once the Baltimore and Ohio Railroad which is an eligible historic district. Section 106 coordination would be necessary. One EPA Waste Site is located near this site. This area was once part of the Jones & Laughlin South Side Steel Works which was a historic district but it has been demolished.

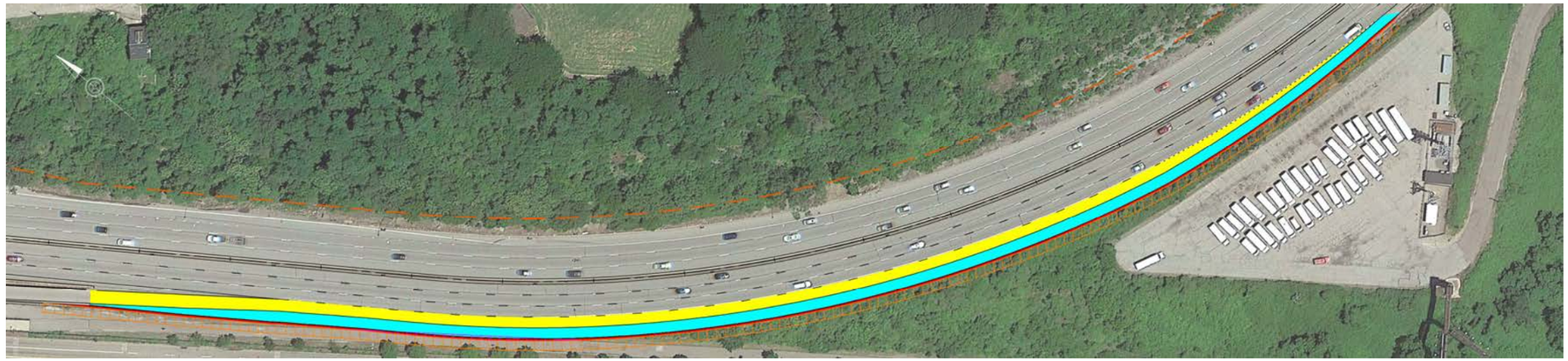
ROW Impacts
This alignment would require sliver takes, totaling nearly 15,000 sf, from 4 parcels, 3 of which are owned by the City of Pittsburgh.

MPT
Closures of the Bates Street ramp, as well as Parkway East lane and shoulder closures, would be required during construction. These closures would take place during weekends or nighttime.

ITS Strategies
There is the possibility of providing ramp management on the reconstructed ramp.

Design Exceptions
The reconstructed ramp would be designed to current standards. No design exceptions are anticipated.

Potential Issues
None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 21

Construction Cost	
Supplemental Roadway Construction	$500,000.00
Earthwork	$300,000.00
Pavement	$500,000.00
Walls	$6,500,000.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$200,000.00
Utilities	$200,000.00
Additional Lump Sum	$700,000.00
Design and PM	$1,800,000.00
ROW	$0.00
Total	$10,700,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	1147 hr
Value of Travel Time (Annual)	$5,062,699.98
Automobile Operating Costs (Annual)	$1,646,700.54
Safety (Annual)	$338,318.21
Total	$7,047,718.73
Emissions (Annual)	
CO2	-4879694 kg
NOx	-9398 kg
VOC	-12466 kg
Benefit:Cost Ratio	
NPV Benefits	$105,876,492.59
NPV Operating Costs	$0.00
NPV Capital Costs	$10,603,500.68
Total Costs	$10,603,500.68
Benefit:Cost Ratio	9.99

Description

This concept would provide a 12-foot wide right shoulder along the eastbound Parkway East from the Forbes Avenue exit to the Bates Street on-ramp. The existing 6-foot shoulder at this location is substandard. This area of the Parkway East also has substandard stopping sight distance due to the horizontal curve.

Construction of this shoulder would require widening an existing 1,150-foot structure carrying the eastbound Parkway mainline near the Forbes Avenue off-ramp, construction of a 3,860-foot long retaining wall to support the widened eastbound Parkway mainline cross-section above the Eliza Furnace Trail, and widening of the Bates Street overpass.

Moderate utility impacts are anticipated based on assumed underground utilities. Assumed utility crossings, located at the Parkway mainline crossing of Bates Street, could be impacted by the proposed retaining wall.

Transportation Impacts

Direct benefits are difficult to quantify, but would primarily result from improved safety and from reducing congestion caused by incidents such as minor crashes and disabled vehicles.

Full-width shoulders provide space for disabled vehicles to leave the roadway and thus reduce the risk of rear-end crashes. They can also provide space for drivers to avoid crashes and provide a recovery area for drivers who have left their lane.

On the existing Parkway, in some cases, vehicles are not able to pull off of the mainline travel lanes due to substandard shoulder width and either remain in travel lanes, partially pull off into narrow shoulders, or pull into entrance gore areas. This is particularly notable in the eastbound direction between Grant Street and Forbes Avenue, and from the Boulevard of the Allies to Bates Street.

Shoulders improve capacity by increasing driver comfort, and by reducing congestion caused when incidents block travel lanes. The effects of this vary greatly on the location, duration, and nature of the incident, and is impossible to predict. However, on average a low-severity crash on an urban interstate blocks travel lanes for approximately 41 minutes, and can result in 215 vehicles-hours of delay. Adequate shoulder width can reduce the number of incidents that impact traffic, and reduce the severity of those impacts.

ITS Strategies

No applicable ITS strategies.

Environmental Features

This concept would impact the Great Allegheny Passage Trail, and would require a Section 4(f) form . The trail was once the Baltimore and Ohio Railroad which is an eligible historic district. Section 106 coordination would be necessary. This area was once part of the Jones & Laughlin South Side Steel Works which was a historic district but it has been demolished. Several EPA Waste Sites are located just south of the concept.

ROW Impacts

The alignment would require full or sliver takes of 10 small parcels, all owned by the City of Pittsburgh. The right-of-way impact would total about 9,000 sf.

MPT

Construction would require closing the existing right shoulder as well as lane closures, which would take place during weekends or nighttime.

Design Exceptions

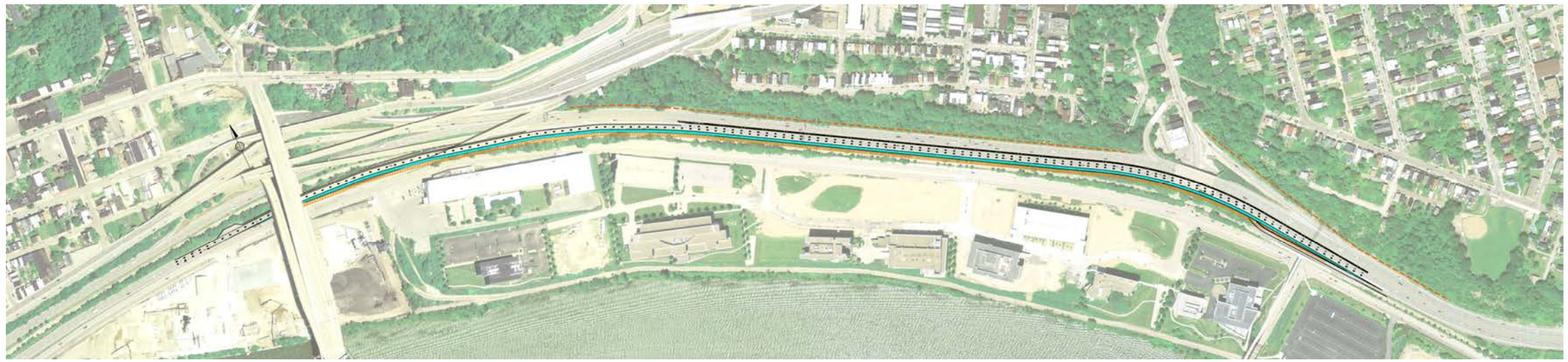
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed.

Other Potential Issues

None identified.

Safety Benefits

Full-width shoulders can improve safety in multiple ways. They provide space for disabled vehicles. They can also provide space for drivers to avoid crashes and provide a recovery area for drivers who have left their lane. The HSM indicates that widening the shoulder as proposed can reduce the frequency of fatal and injury crashes by 48% and PDO crashes by36%.



SUMMARY OF COSTS AND BENEFITS
Concept 23

Construction Cost	
Supplemental Roadway Construction	$1,500,000.00
Earthwork	$200,000.00
Pavement	$900,000.00
Walls	$27,600,000.00
Bridges	$21,200,000.00
Traffic Signals	$0.00
Signage	$1,400,000.00
Utilities	$1,600,000.00
Additional Lump Sum	$4,400,000.00
Design and PM	$11,800,000.00
ROW	$0.00
Total	$70,600,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$33,562.31
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$81,692.04
Total	$115,254.35
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$1,731,443.46
NPV Operating Costs	$0.00
NPV Capital Costs	$69,188,000.00
Total Costs	$69,188,000.00
Benefit:Cost Ratio	0.03

Description
This concept would designate the westbound right lane as exit only at the Glenwood/Bates Street interchange. This would reduce impacts of ramp queues on through traffic movements on the Parkway as well as improve safety. Designation of the "Exit Only" lane could be done dynamically, using signage and lane control arrows, or could involve a physical reconstruction of the ramp area.

Utility impacts are not anticipated.

No further analysis was conducted on this alternative as improvements to this interchange is planned under an independent project.

Transportation Impacts
In the immediate vicinity of the interchange, the mainline lanes and the exit only lane appear to operate efficiently in the design year. However, upstream of the interchange, some congestion is anticipated to occur as motorists decide which lanes to be in as they approach the lane drop.

No further analysis was conducted on this alternative as improvements to this interchange is planned under an independent project.

Environmental Features
While no impacts on defined environmental features were identified as work is anticipated to be completely within the existing right-of-way, potential traffic impacts and concerns could require environmental documentation.

ROW Impacts
There are no ROW impacts anticipated with this alternative.

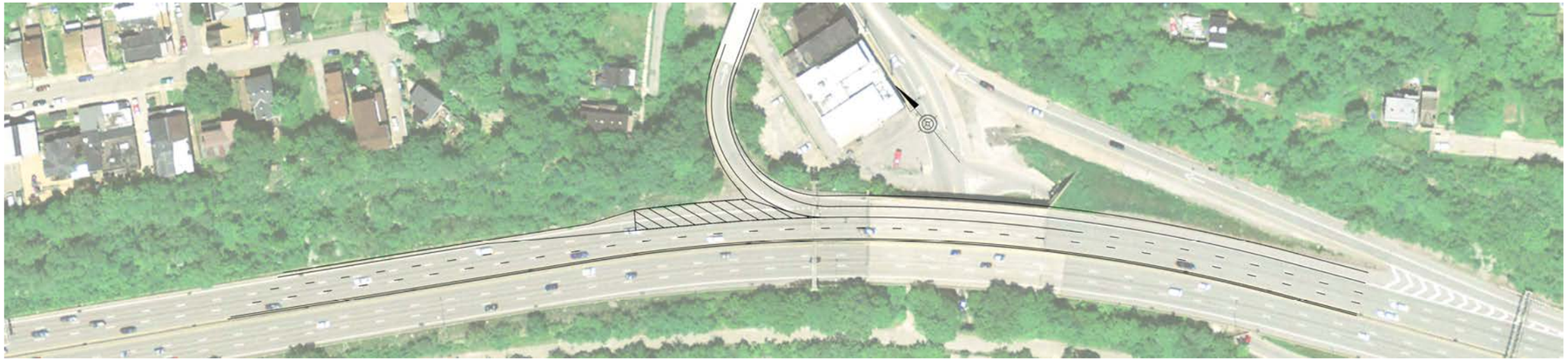
MPT
Changes to pavement markings and signage would be conducted under short-term temporary traffic control measures.

ITS Strategies
A lane drop at Bates Street could be implemented at certain times or under certain conditions from the District 11-TMC on a dynamic basis, using dynamic message signs, variable speed limits, and managed lane controls.

Design Exceptions
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Safety Benefits
Since the Glenwood exit at the Bates Street Interchange is substandard, this option would provide a lane drop at this ramp allowing vehicles adequate distance to decelerate before accessing the loop ramp that is posted with a 20 mph speed advisory. However, the HSM indicates that converting this off-ramp to a lane drop results in a 25% increase in crash frequency.

Potential Issues
None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 24

Construction Cost	
Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Admin	$0.00
Design and PM	$0.00
ROW	$0.00
Total	$0.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO	kg
NOx	kg
VOC	kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$0.00
Total Costs	$0.00
Benefit:Cost Ratio	Not Calculated

Description

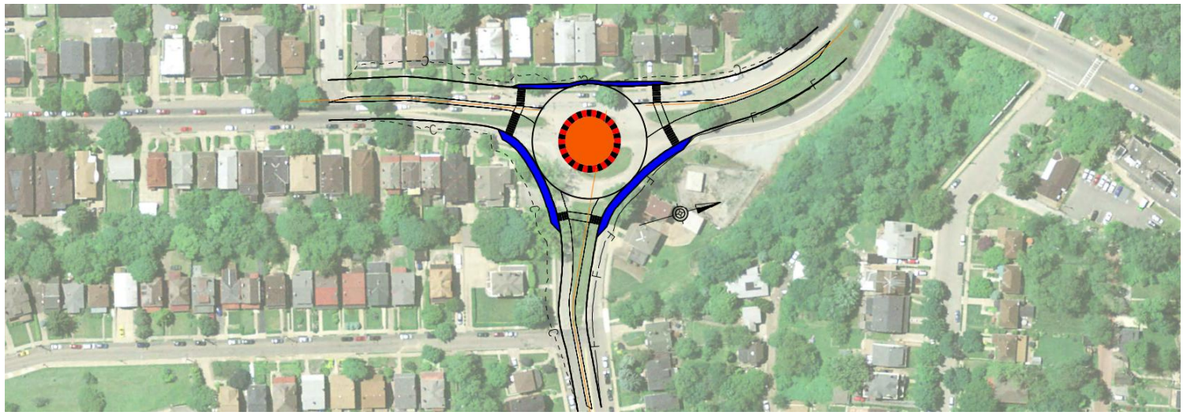
This concept would construct a roundabout at the intersection of Beechwood Boulevard and Monitor Street, replacing an existing unsignalized intersection. Analysis indicates a two-lane roundabout with a 150-foot inscribed circle would accommodate traffic volumes at this location. The roundabout can provide a traffic calming effect at the entrance to a residential community from the I-376 interchange area, and would facilitate turning movements while accommodating heavy traffic flows.

Pedestrian movements would be accommodated with crosswalks. The Monitor Street approach leg would provide one entrance lane and one exit lane. Each of the two Beechwood Boulevard approach legs would provide two entrance lanes and two exit lanes.

Geometric design criteria is based on NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition. The design uses the urban two-lane roundabout template which accommodates a city bus in the circulatory roadway. A truck apron would accommodate WB-50 semi-trailers.

The steep western hillside opposite the Monitor Street approach would limit the location of the inscribed circle to a less-than-ideal spot to the east. The resultant location of the center island would cause a fastest path issue by allowing the Beechwood Boulevard southbound through movement to travel too fast through the circulatory roadway. Those vehicles would not be appropriately slowed by the central island since it would be located to the east.

Moderate utility impacts are anticipated based on aerial utilities and assumed underground utilities. Relocation of aerial utilities could be required.



Transportation Impacts

An analysis of design year 2040 peak hour volumes resulted in overall intersection LOS C in the AM peak hour and LOS D in the PM peak hour. The LOS is based on average vehicle delay.

If the intersection were to remain stop-controlled, it is anticipated that the Monitor Avenue approach would operate at LOS F in both the AM and PM peak hours.

Directional splits are pronounced on Beechwood Boulevard. During the AM peak, the highest-volume movement is Beechwood Boulevard northbound through while in the PM peak the highest-volume movement is southbound through. There is a high left turn volume from Beechwood Boulevard onto Monitor Street in the PM peak. Monitor Street volumes, while substantial, are relatively low as compared with Beechwood Boulevard volumes.

The improvement in LOS occurs because current intersection operations are strongly influenced by heavy delays on the Monitor Street approach. The roundabout operation significantly improves the ease of left turns with little degradation of through movements, and also creates gaps which improve right turns.

Environmental Features

GIS mapping did not reveal any sensitive features within this concept.

ROW Impacts

This roundabout would require full takes of 12 properties, for a total take of about 49,000 sf. All 12 properties include residential units.

MPT

The intersection could remain open to traffic during construction because of the relatively wide existing approach widths. Temporary lane closures would be used to shift traffic away from the construction zones. Short pedestrian detours might be implemented as construction progresses through the three sides of the intersection. Automobile traffic on Monitor Street could be detoured temporarily onto Lilac Street for a short period.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Research indicates conversion of a three-legged minor-stop control intersection to a roundabout can reduce crashes by 12%, while reducing injury crashes by 78%. This is due to migration of crashes from high-speed, high-severity types (i.e., left-turn) to low speed sideswipes and rear-ends.

Other Potential Issues

Modern roundabouts are often controversial when first introduced to an area, such as the Pittsburgh urban core, that is not familiar with their potential benefits.

SUMMARY OF COSTS AND BENEFITS
Concept 26

Construction Cost	
Supplemental Roadway Construction	$340,000.00
Earthwork	$220,000.00
Pavement	$990,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$80,000.00
Additional Lump Sum	$200,000.00
Design and PM	$370,000.00
ROW	$1,610,000.00
Total	$3,810,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	550 hr
Value of Travel Time (Annual)	$2,485,545.74
Automobile Operating Costs (Annual)	$865,399.19
Safety (Annual)	$2,140.63
Total	$3,353,085.56
Emissions (Annual)	
CO2	-2608877 kg
NOx	-5220 kg
VOC	-5735 kg
Benefit:Cost Ratio	
NPV Benefits	$50,372,744.97
NPV Operating Costs	$0.00
NPV Capital Costs	$3,737,359.13
Total Costs	$3,737,359.13
Benefit:Cost Ratio	13.48

Description

This concept would construct a roundabout at the intersection of Beechwood Boulevard/Alger Street and Ronald Street/ Greenfield Bridge, replacing an existing signalized intersection. Analysis indicates a single-lane roundabout with a 105-foot inscribed circle would accommodate traffic volumes at this location. The roundabout can provide a traffic calming effect at the entrance to a residential community from the free-flowing roadways in Schenley Park, and would facilitate turning movements while accommodating heavy peak-period traffic flows.

Right-turn bypass lanes would be constructed for vehicles turning right from Greenfield Bridge onto Alger Street and for vehicles turning right from Ronald Street onto Beechwood Boulevard. Pedestrian movements would be accommodated with crosswalks.

The Greenfield Bridge approach leg would provide two entrance lanes and one exit lane. The right lane of the two entrance lanes would drop into the right turn bypass lane and would not enter the one-lane circulatory roadway.

Each of the other three approach legs would provide one entrance lane and one exit lane. Due to existing alignment of the intersection roads, the Ronald Street approach would also provide a right turn bypass to help accommodate larger right-turning vehicles onto Beechwood Boulevard.

Geometric design criteria is based on NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition. The design uses the urban one-lane roundabout template which accommodates a city bus in the circulatory roadway. A truck apron would accommodate WB-50 semi-trailers.

Major utility impacts are anticipated based on aerial utilities and assumed underground utilities. Relocation of aerial utilities would be required.

Transportation Impacts

An analysis of design year 2040 peak hour volumes resulted in overall intersection LOS B in both the AM and PM peak hours. The LOS is based on average vehicle delay.

If the intersection were to remain signalized, it is anticipated that the entire intersection would operate at LOS B in the AM peak hour and LOS C in the PM peak hour.

A large directional split exists between AM and PM peaks. 54 percent of the entering volume heads north towards the Greenfield Bridge in the AM peak and 49 percent of the entering volume heads east to Beechwood Boulevard in the PM peak. The heaviest AM volume is the through movement from Ronald Street onto the Greenfield Bridge and the heaviest PM volumes is the left turn from the Greenfield Bridge onto Beechwood Boulevard and the through movement from Greenfield Bridge to Ronald Street.

Environmental Features

Several EPA Waste Sites are located near this concept. The once ineligible Greenfield Bridge was located adjacent to this concept. It has been demolished and is currently under construction.

ROW Impacts

This roundabout would require full takes of four properties, for a total take of about 39,950 sf. The four properties consist of: two commercial businesses, one residential unit, and a vacant lot.

MPT

Construction could require a temporary detour of vehicular traffic because the narrow right-of-way could limit any necessary over-widening on the existing one-lane approaches.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

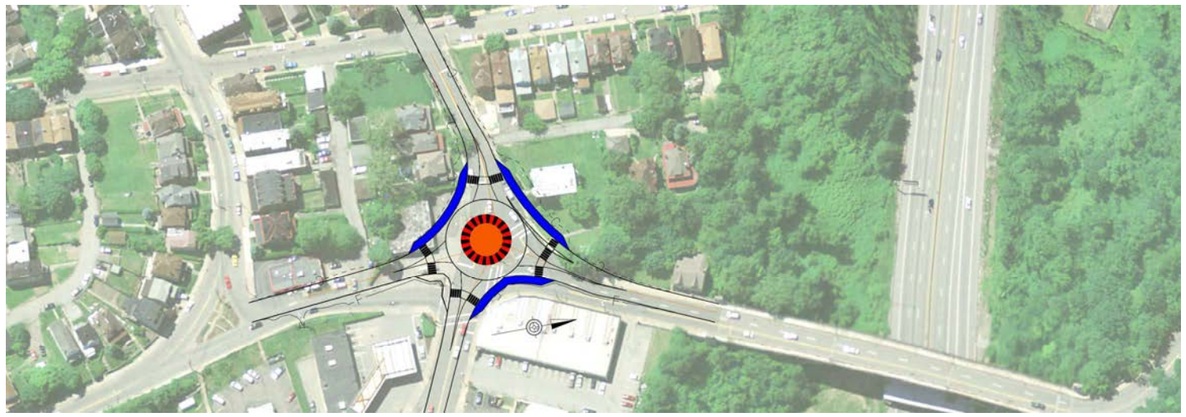
No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Research indicates roundabouts can reduce crash frequency by 48% compared to signalized intersections, while significantly reducing injury crashes (by 78%) by eliminating high-speed left-turn crashes.

Other Potential Issues

Modern roundabouts are often controversial when first introduced to an area, such as the Pittsburgh urban core, that is not familiar with their potential benefits.



SUMMARY OF COSTS AND BENEFITS
Concept 27

Construction Cost	
Supplemental Roadway Construction	$370,000.00
Earthwork	$70,000.00
Pavement	$700,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$90,000.00
Additional Lump Sum	$170,000.00
Design and PM	$280,000.00
ROW	$560,000.00
Total	$2,240,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	7 hr
Value of Travel Time (Annual)	$32,737.18
Automobile Operating Costs (Annual)	$13,751.48
Safety (Annual)	$57,250.29
Total	$103,738.95
Emissions (Annual)	
CO2	-41551 kg
NOx	-84 kg
VOC	-89 kg
Benefit:Cost Ratio	
NPV Benefits	$1,558,449.82
NPV Operating Costs	$0.00
NPV Capital Costs	$2,186,529.71
Total Costs	$2,186,529.71
Benefit:Cost Ratio	0.71

Description
This concept would provide for a pedestrian crossing of Beechwood Boulevard at Forward Avenue, through designation of a painted crosswalk, flashing beacons and warning signs, curb ramps, and a refuge island. As part of this concept, pedestrian crosswalks in the interchange vicinity would be upgraded. Under existing conditions, the pedestrian crossing at this intersection is not facilitated, although the end of the concrete barrier in the Beechwood Boulevard median permits crossing between the sidewalks on the various approaches.

Utility impacts are not anticipated.

Transportation Impacts
If a HAWK (High-Intensity Activated Crosswalk) were constructed at this location the traffic along Beechwood Boulevard would be required to stop when the HAWK is activated by a pedestrian. This intersection is approximately 1000 feet from the mainline Parkway and this section of Beechwood Boulevard is essentially an off-ramp from the Parkway. Therefore, there is a possibility that traffic stopped at the HAWK signal could queue back to the mainline Parkway.

Environmental Features
GIS mapping did not reveal any sensitive features within this concept. However, this concept could involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

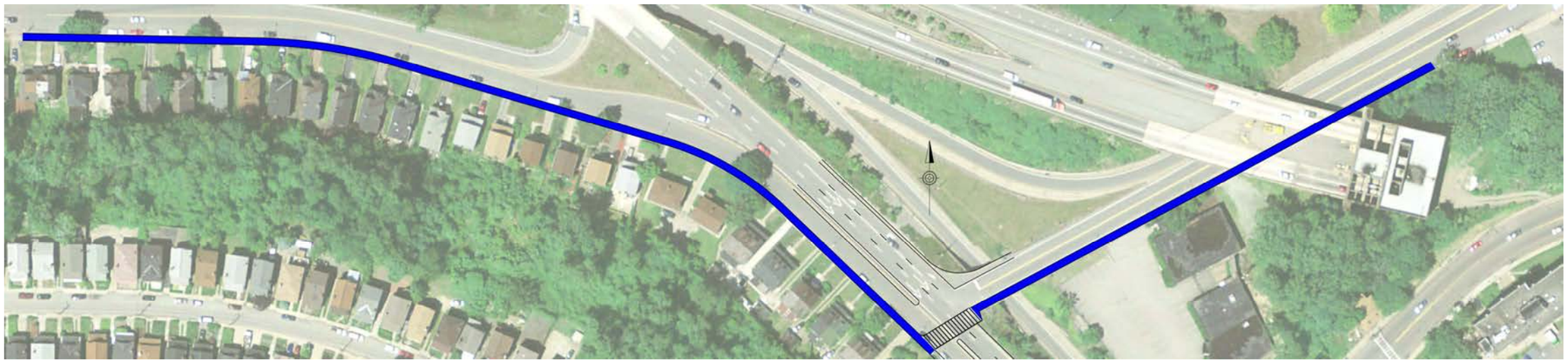
MPT
Installation of signage, beacons and pavement markings is anticipated to take place under temporary, short-term traffic control measures

ITS Strategies
No applicable ITS strategies.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
Research published in 2010 found that HAWK pedestrian crossing treatments can reduce crash frequency at the intersection by 29%. This can be very beneficial, as most of these will be pedestrian, which tend to be high-severity crashes.

Other Potential Issues
None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 28

Construction Cost	
Supplemental Roadway Construction	$127,000.00
Earthwork	$0.00
Pavement	$203,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$94,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$103,000.00
Design and PM	$105,000.00
ROW	$0.00
Total	$632,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$26,722.09
Total	$26,722.09
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$401,440.67
NPV Operating Costs	$0.00
NPV Capital Costs	$618,498.16
Total Costs	$618,498.16
Benefit:Cost Ratio	0.65

Description

This concept would eliminate the existing weaving sections on the eastbound Parkway East between Bates Street and the Squirrel Hill Tunnel by constructing a parallel eastbound collector-distributor (c-d) roadway. This roadway maintains all existing entering and exiting movements, but separates merging and through traffic from the mainline through lanes.

The c-d roadway consists of a single 12-foot lane, with a 3-foot left shoulder and 12-foot right shoulder. The c-d roadway begins at station 779+50 (in the vicinity of the Bates Street on-ramp), where the existing rightmost mainline lane would be designated as exit-only for Squirrel Hill and would enter the c-d roadway. The existing Bates Street and Squirrel Hill on-ramps would be reconfigured to join the c-d roadway, as would the exit gore at the existing Squirrel Hill off-ramp. The c-d roadway would then merge into the Parkway mainline with a 500' acceleration lane and 300' taper just west of the Squirrel Hill tunnel portal. The existing right eastbound lane would be eliminated for the length of the c-d roadway and used as a shoulder, off-setting a portion of the additional cross-section width.

Construction of the c-d roadway would require significant structures. A 1,950-foot retaining wall would be constructed east of Bates Street to support the c-d roadway above the adjacent properties. Four additional retaining walls of 1,070, 1,065, 920 and 690 feet would be required to support the hillside above the widened section in cut areas, and an additional 475' retaining wall would be required to support the c-d taper area above the interchange ramps. Three mainline structures would need to be widened to accommodate the c-d section: 1,140 feet over Boundary Street, 510 feet over Saline Street, and 280 feet over Forward Avenue.

Transportation Impacts

The c-d roadway results in vastly changed traffic flows eastbound during the PM peak period. In general, the Parkway mainline flow improves significantly, with travel time from Downtown to the tunnel reducing by 35%. However, this is offset by adverse impacts for traffic using the c-d roadway. Travel time to the Squirrel Hill exit ramp via the c-d roadway would increase by just over nine minutes.

Traffic flow on the Parkway mainline near Bates Street improves significantly, carrying nearly 5.5% higher volumes and at an increase in speed of about 3 mph. Speed decreases and congestion increases dramatically at the merge with the c-d roadway. The low capacity of this merge causes traffic to back through the length of the c-d roadway, and this option restricts vehicles using the eastbound Squirrel Hill ramp.

In the freeway segment near Bates Street, the model shows an improvement with 5.5 percent higher volume and nearly 3 mph higher speed. However, the average speed of vehicles entering the Squirrel Hill tunnel is reduced by about 6%.

AM traffic speeds and volumes are relatively unaffected by the changes.

Utility Impacts

Major utility impacts are anticipated based on aerial and underground utilities, including large existing sanitary sewers.

ITS Strategies

Managed lanes and VMS signs could be used to direct traffic to the c-d roadway for incident management.

Environmental Features

This concept has multiple issues including Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the Schenley Park Historic District; Section 4(f) coordination regarding the recreational uses of Schenley Park and the Great Allegheny Passage Trail; and Section 6(f) coordination Two EPA Waste Sites are located in proximity to the concept. Land and Water Conservation Funds were used at the Schenley Park Fountain and Oval. The Parkway East from the Churchill/U.S. 22 Interchange to Bates Street was determined eligible in 2006 as part of the list of "Nationally and Exceptionally Significant Features of the Federal Interstate Highway System.

ROW Impacts

The alignment would require taking all or a portion of 50 parcels, totaling about 57,000 sf. Over half of these parcels are vacant and/or owned by the City of Pittsburgh, but several contain dwellings or other buildings. Taking of 4 dwellings is anticipated.

MPT

Much of the c-d roadway can be constructed offline with shoulder closures, however lane closures would be required during construction of barriers and new shoulders.

Design Exceptions

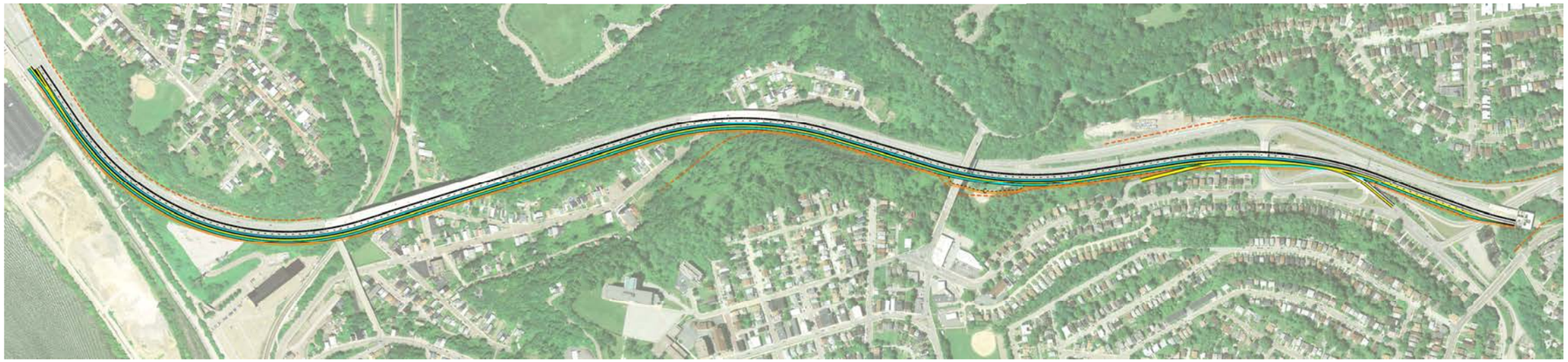
No design exceptions are anticipated for new construction in this concept.

Safety Benefits

This is a complicated treatment, but it is estimated to reduce crash frequency by 1%.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 29A

Construction Cost	
Supplemental Roadway Construction	$4,200,000.00
Earthwork	$500,000.00
Pavement	$4,500,000.00
Walls	$21,100,000.00
Bridges	$36,700,000.00
General ITS	$400,000.00
Signage	$1,200,000.00
Utilities	$4,100,000.00
Additional Lump Sum	$5,900,000.00
Design and PM	$15,700,000.00
ROW	$200,000.00
Total	$94,500,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-271 hr
Value of Travel Time (Annual)	-$1,196,766.17
Automobile Operating Costs (Annual)	$4,199,394.34
Safety (Annual)	$22,554.55
Total	$3,025,182.71
Emissions (Annual)	
CO2	-47552348 kg
NOx	-79058 kg
VOC	-94172 kg
Benefit:Cost Ratio	
NPV Benefits	$45,446,724.99
NPV Operating Costs	$0.00
NPV Capital Costs	$92,514,743.91
Total Costs	$92,514,743.91
Benefit:Cost Ratio	0.49

Description
This concept would eliminate the existing weaving sections on the eastbound Parkway East between the Squirrel Hill Tunnel on-ramp and off-ramp by constructing a parallel eastbound collector-distributor (c-d) roadway. This roadway maintains all existing entering and exiting movements, but separates the merge/diverge traffic from the through traffic on the mainline lanes.

The c-d roadway consists of a single 12-foot lane, with a 3-foot left shoulder and 12-foot right shoulder. The c-d roadway begins at station 843+60 (approximately 850 feet west of the Squirrel Hill on-ramp), where the existing rightmost mainline lane would be designated as exit-only for Squirrel Hill and would enter the c-d roadway. The existing Squirrel Hill on-ramp would be reconfigured to join the c-d roadway, as would the exit gore at the existing Squirrel Hill off-ramp. The c-d roadway would then merge into the Parkway mainline with a 500' acceleration lane and 300' taper just west of the Squirrel Hill tunnel portal.

Construction of the c-d roadway would require three retaining walls. The mainline structure over Forward Avenue (280 feet) would need to be widened to accommodate the c-d section.

Transportation Impacts
The c-d roadway improves traffic flows eastbound during the PM peak period. In general, the Parkway mainline flow improves. A shortened c-d roadway has the advantage of allowing vehicles entering from the Bates Street ramp to merge into the mainline and still reduce weaving with the mainline at the Squirrel Hill eastbound interchange.

Traffic flow on the Parkway mainline near Bates Street improves significantly, carrying nearly 5.2% higher volumes. Eastbound travel time improved by about 30 seconds in the PM. The c-d ramp does not restrict the eastbound entering traffic at Squirrel Hill unlike the full c-d roadway from Bates Street to the Squirrel Hill Interchange.

In the freeway segment near Bates Street, the model shows an improvement with 5.5 percent higher throughput. The model also shows that the average speed of vehicles entering the Squirrel Hill tunnel increased by 13%.

AM traffic speeds and volumes are relatively unaffected by the changes.

Utility Impacts
Major utility impacts are anticipated based on aerial and underground utilities, including large existing sanitary sewers.

ITS Strategies
No applicable ITS strategies.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

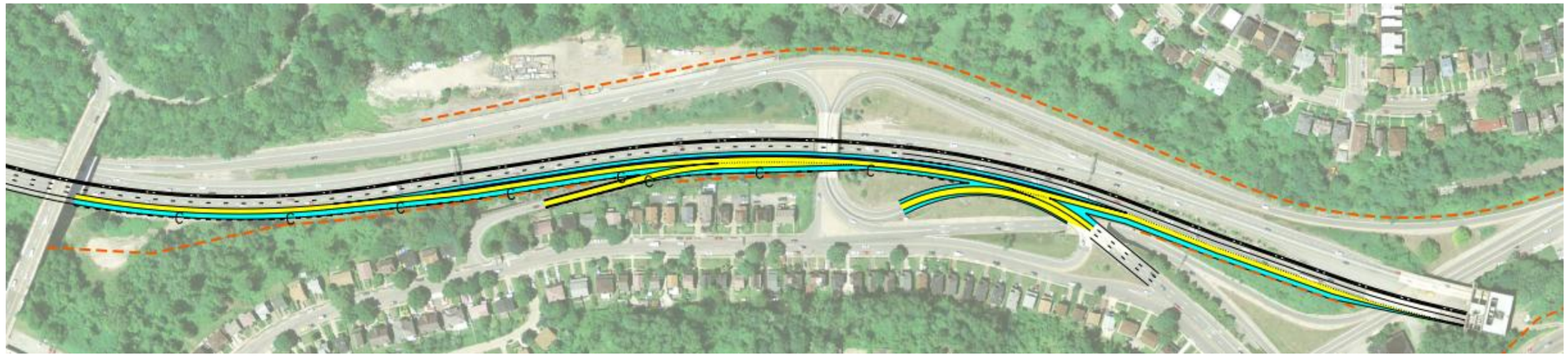
ROW Impacts
Overall, ROW impacts are negligible. The alignment would require sliver takes and easements from 8 properties along Beechwood Blvd.

MPT
No applicable ITS strategies.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
This is a complicated treatment, but it is estimated to reduce crash frequency by 1% due to moving the conflicts from the weave away from the mainline.

Other Potential Issues
None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 29

Construction Cost	
Supplemental Roadway Construction	$1,100,000.00
Earthwork	$100,000.00
Pavement	$1,200,000.00
Walls	$10,500,000.00
Bridges	$10,000,000.00
General ITS	$400,000.00
Signage	$900,000.00
Utilities	$4,100,000.00
Additional Lump Sum	$2,300,000.00
Design and PM	$6,100,000.00
ROW	$0.00
Total	$36,700,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	382 hr
Value of Travel Time (Annual)	$1,699,299.32
Automobile Operating Costs (Annual)	-$361,601.12
Safety (Annual)	$6,645.54
Total	$1,344,343.74
Emissions (Annual)	
CO2	4111116 kg
NOx	20630 kg
VOC	24574 kg
Benefit:Cost Ratio	
NPV Benefits	$20,195,811.69
NPV Operating Costs	$0.00
NPV Capital Costs	$36,039,955.60
Total Costs	$36,039,955.60
Benefit:Cost Ratio	0.56

Description
This concept would eliminate the eastbound weaving section at Squirrel Hill by relocating the off-ramp west of the existing on-ramp (Ramp B). The right mainline lane would exit onto the new ramp (called Ramp X) at station 831+00 and rise to intersect Beechwood Boulevard at the intersection with the existing eastbound on-ramp. Once traffic exits, the existing third lane would be converted to a shoulder, then utilized as an acceleration lane by traffic entering on the existing Ramp B.

The relocated Ramp X off-ramp would be constructed with a 1,300' retaining wall passing under the reconstructed Greenfield Bridge, partially cantilevered over the I-376 mainline shoulder.

The intersection of the relocated off-ramp, the existing on-ramp and Beechwood Boulevard would be signalized. At this intersection, it would be anticipated that parking would prohibited along both sides of Beechwood Boulevard in the vicinity of the ramps. This would allow for an eastbound left turn lane and a westbound right turn lane on Beechwood Boulevard.

Moderate utility impacts are anticipated based on aerial utilities and underground utility crossings. Proposed Ramp X construction could impact aerial utilities.

Transportation Impacts
By moving the existing eastbound off ramp to a more logical location upstream of (instead of downstream of) the Squirrel Hill on ramp, the model shows several overall system-wide improvements, including: 1.2 percent increase in average vehicle speed, 1.8 percent lower average delay time and 5.5 percent decrease in latent demand.

During the PM peak, the eastbound Squirrel Hill on ramp shows a marginal volume increase, a 7 mph (58 percent) higher average speed and a 37 percent decrease in density, improvements for both the local system and the individual motorists.

Safety Benefits
Safety benefits will be gained by reducing vehicle conflicts when removing the weave. Though no CMF exists for weave removal, HSM predictions were done without the weave and compared to existing conditions. Predictions indicate a 40% reduction in fatal and injury crash frequency and 33% reduction in PDO crash frequency. Incalculable benefits will be garnered by removing stop control from entering traffic.

ITS Strategies
Ramp management on realigned ramp.

Other Potential Issues
None identified.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
This alignment requires partial takes of 8 parcels, and the full take of one parcel with an occupied dwelling, for a total take of about 36,000 sf. 4 partial takes are from properties containing occupied dwellings.

MPT
Phase 1: Construct proposed off ramp and walls west of the interchange. Would require closure of mainline I-376 eastbound right shoulder, as well as weekend lane closures of SR 0376 mainline.

Phase 2. Convert existing third lane to a shoulder. Would require closure of the shoulder and weekend lane closures of SR 0376 mainline.

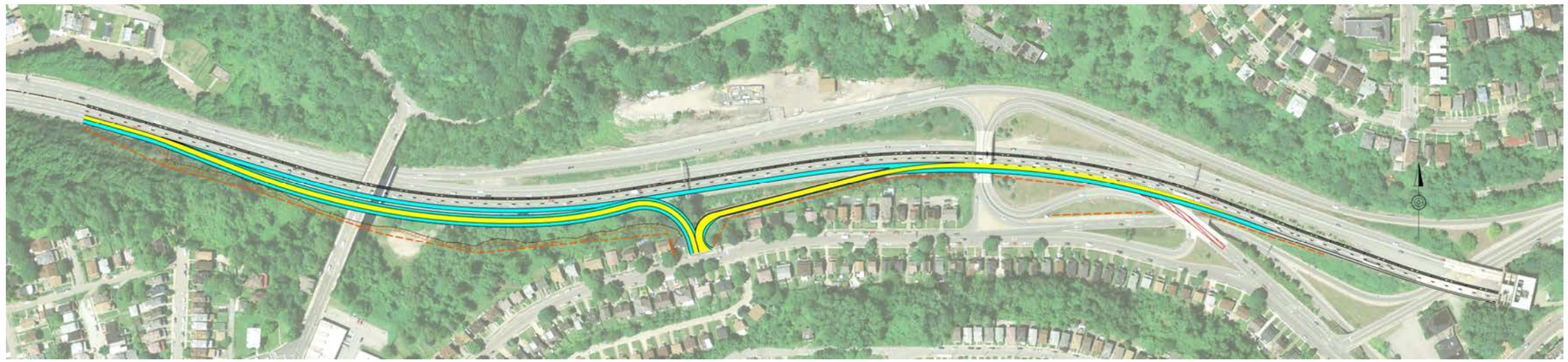
Phase 3: Construct signalized intersection on Beechwood Boulevard and tie in the proposed off ramp. Would require temporary lane shift on Beechwood Boulevard.

Phase 4: Close existing off ramp and complete construction of proposed acceleration lane.

Design Exceptions
A design exception would be required for the 25 mph design speed on the horizontal curve on the new Ramp X approaching Beechwood Boulevard. Meeting the 30 mph design speed would have been infeasible. Also, the acceleration distance provided for Ramp B is insufficient, however, this utilizes existing pavement, reducing potential construction costs.

SUMMARY OF COSTS AND BENEFITS
Concept 30A

Construction Cost	
Supplemental Roadway Construction	$1,600,000.00
Earthwork	$1,800,000.00
Pavement	$1,200,000.00
Walls	$9,600,000.00
Bridges	$3,400,000.00
Traffic Signals	$200,000.00
Signage	$100,000.00
Utilities	$400,000.00
Additional Lump Sum	$1,500,000.00
Design and PM	$4,000,000.00
ROW	$200,000.00
Total	$24,000,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	78 hr
Value of Travel Time (Annual)	$339,861.84
Automobile Operating Costs (Annual)	$99,613.62
Safety (Annual)	$257,504.19
Total	$696,979.65
Emissions (Annual)	
CO2	-288665 kg
Nox	-527 kg
VOC	-874 kg
Benefit:Cost Ratio	
NPV Benefits	$10,470,588.19
NPV Operating Costs	$0.00
NPV Capital Costs	$23,452,974.39
Total Costs	$23,452,974.39
Benefit:Cost Ratio	0.45



Description

This concept would eliminate the eastbound weave at the Squirrel Hill Interchange by moving the exit gore approximately 1600 feet to the west and constructing an extended Ramp E that passes under Ramp B, the eastbound entrance ramp, parallels the Parkway mainline, and joins the existing Ramp E alignment at the Ramp G overpass.

Ramp B would be relocated onto a new structure over the relocated Ramp E, to be constructed along the existing Ramp B alignment and profile. Once traffic exits, the existing third lane would be converted to a shoulder, then utilized as an acceleration lane by traffic entering on the existing Ramp B.

The existing Ramp A/Ramp D structure over SR 0376 would need to be replaced and extended over the relocated Ramp E.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction.

Transportation Impacts

Movement of the eastbound off-ramp to a more logical position (upstream of the eastbound on-ramp) primarily impacts the network during the PM peak period. In terms of network performance, the average speed increased by 1% along with a 1.7% decrease in delay.

Even though traffic volumes remained the same on the Squirrel Hill on-ramp, it realized improvements from this realignment; a 36% increase in average speed and a 27% decrease in density. These improvements can be attributed to the removal of the existing stop condition on the ramp.

Safety Impacts

Safety benefits will be gained by reducing vehicle conflicts when removing the weave. Though no CMF exists for weave removal, HSM predictions were done without the weave and compared to existing conditions. Predictions indicate a 40% reduction in fatal and injury crash frequency and 33% reduction in PDO crash frequency. Incalculable benefits will be garnered by removing stop control from entering traffic.

Design Exceptions

The acceleration distance provided for Ramp B is insufficient, however, this utilizes existing pavement, reducing potential construction costs. A design exception is required for the 9.70% upgrade on redesign Ramp E, which is needed to meet clearance requirements under Ramp B, existing Ramp D structure, and tie into the existing off ramp.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts

Widening to accommodate ramp relocation would require sliver takes of 3 parcels, and 1 occupied dwelling. Depending on ROW negotiations this concept could require the complete taking of 15 parcels. All affected parcels appear to be occupied residential properties along Beechwood Boulevard.

MPT

Phase 1: Construct extended Ramp A/Ramp D Bridge. Would require closure of Ramp A and Ramp D, as well as weekend/ nighttime closures of SR 0376 mainline.

Phase 2. Construct relocated Ramp B structure. Would require closure of Ramp B.

Phase 3: Construct relocated Ramp E. This may not require any closures.

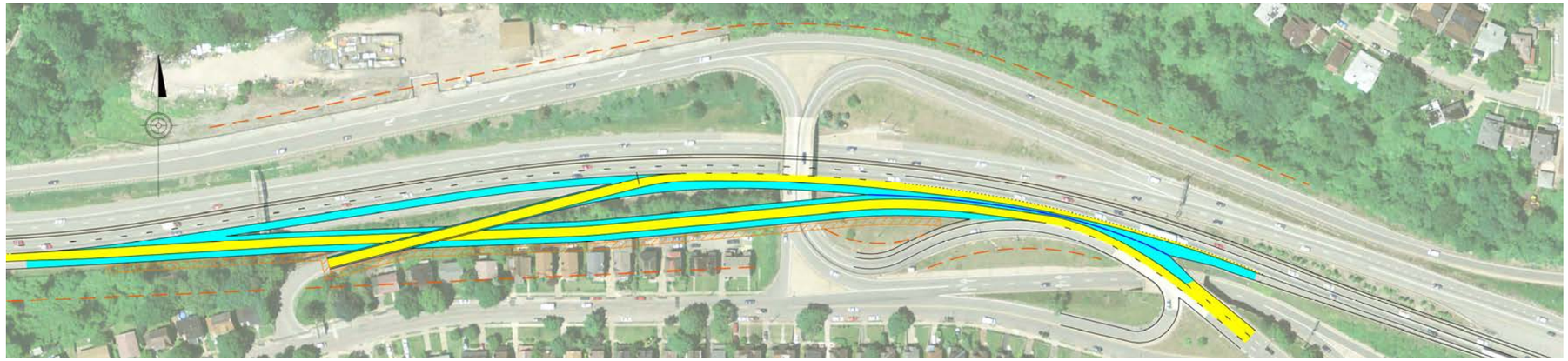
Phase 4: Construct gore areas to align with relocated ramps. This could require weekend closures of ramps and mainline.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 30B

Construction Cost	
Supplemental Roadway Construction	$1,600,000.00
Earthwork	$700,000.00
Pavement	$1,400,000.00
Walls	$11,000,000.00
Bridges	$8,200,000.00
Traffic Signals	$200,000.00
Signage	$300,000.00
Utilities	$900,000.00
Additional Lump Sum	$2,000,000.00
Design and PM	$5,300,000.00
ROW	$1,800,000.00
Total	$33,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	318.00 hr
Value of Travel Time (Annual)	$1,418,306.15
Automobile Operating Costs (Annual)	$488,720.86
Safety (Annual)	$396,383.26
Total	$2,303,410.27
Emissions (Annual)	
CO2	-1464583 kg
NOx	-2893 kg
VOC	-3399 kg
Benefit:Cost Ratio	
NPV Benefits	$34,603,679.50
NPV Operating Costs	$0.00
NPV Capital Costs	$32,717,941.69
Total Costs	$32,717,941.69
Benefit:Cost Ratio	1.06

Description
This concept would eliminate the eastbound weave at the Squirrel Hill Interchange by moving the exit gore approximately 1600 feet to the west and constructing an extended Ramp E that passes under Ramp B, the eastbound entrance ramp, parallels the Parkway mainline, and joins the existing Ramp E alignment at the Ramp G overpass.

Ramp B would be relocated onto a new structure over the relocated Ramp E, to be constructed along the existing Ramp B alignment and profile. Once traffic exits, the existing third lane would be converted to a shoulder, then utilized as an acceleration lane by traffic entering on the existing Ramp B.

The existing Ramp A/Ramp D structure over SR 0376 would need to be replaced and extended over the relocated Ramp E.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction.

Transportation Impacts
Movement of the eastbound off-ramp to a more logical position (upstream of the eastbound on-ramp) primarily impacts the network during the PM peak period. In terms of network performance, the average speed increased by 1% along with a 1.7% decrease in delay.

Even though traffic volumes remained the same on the Squirrel Hill on-ramp, it realized improvements from this realignment; a 36% increase in average speed and a 27% decrease in density. These improvements can be attributed to the removal of the existing stop condition on the ramp.

Safety Impacts
Safety benefits will be gained by reducing vehicle conflicts when removing the weave. Though no CMF exists for weave removal, HSM predictions were done without the weave and compared to existing conditions. Predictions indicate a 40% reduction in fatal and injury crash frequency and 33% reduction in PDO crash frequency. Incalculable benefits will be garnered by removing stop control from entering traffic.

Design Exceptions
The acceleration distance provided for Ramp B is insufficient, however, this utilizes existing pavement, reducing potential construction costs. A design exception is required for the 9.70% upgrade on redesign Ramp E, which is needed to meet clearance requirements under Ramp B, existing Ramp D structure, and tie into the existing off ramp.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
Widening to accommodate ramp relocation would require sliver takes of 3 parcels, and 1 occupied dwelling. Depending on ROW negotiations this concept could require the complete taking of 15 parcels. All affected parcels appear to be occupied residential properties along Beechwood Boulevard.

MPT
Phase 1: Construct extended Ramp A/Ramp D Bridge. Would require closure of Ramp A and Ramp D, as well as weekend/ nighttime closures of SR 0376 mainline.

Phase 2. Construct relocated Ramp B structure. Would require closure of Ramp B.

Phase 3: Construct relocated Ramp E. This may not require any closures.

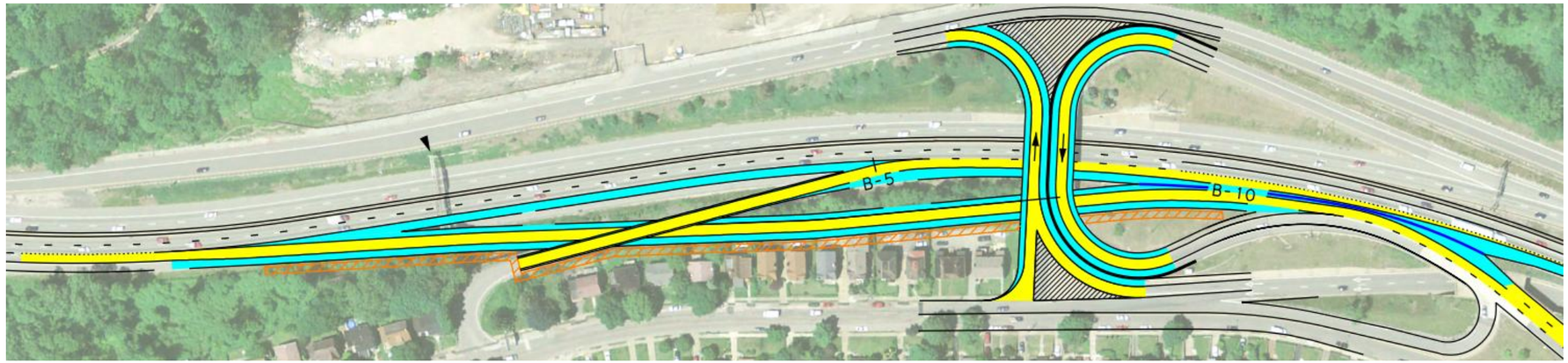
Phase 4: Construct gore areas to align with relocated ramps. This could require weekend closures of ramps and mainline.

ITS Strategies
There is the potential for Ramp management on the realigned on-ramp.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 30B Revised

Construction Cost	
Supplemental Roadway Construction	$1,600,000.00
Earthwork	$700,000.00
Pavement	$1,500,000.00
Walls	$11,000,000.00
Bridges	$11,700,000.00
Traffic Signals	$200,000.00
Signage	$300,000.00
Utilities	$900,000.00
Additional Lump Sum	$2,300,000.00
Design and PM	$6,000,000.00
ROW	$1,800,000.00
Total	$38,000,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	318.00 hr
Value of Travel Time (Annual)	$1,418,306.15
Automobile Operating Costs (Annual)	$488,720.86
Safety (Annual)	$407,822.14
Total	$2,314,849.15
Emissions (Annual)	
CO2	-1464583 kg
NOx	-2893 kg
VOC	-3399 kg
Benefit:Cost Ratio	
NPV Benefits	$34,775,523.54
NPV Operating Costs	$0.00
NPV Capital Costs	$37,267,250.47
Total Costs	$37,267,250.47
Benefit:Cost Ratio	0.93



Description

This concept would eliminate the eastbound weave at the Squirrel Hill Interchange by moving the exit gore approximately 1600 feet to the west and constructing an extended Ramp E that passes under Ramp B, the eastbound entrance ramp, parallels the Parkway mainline, and joins the existing Ramp E alignment at the Ramp G overpass.

Ramp E would tunnel under the new Ramp B alignment. The new Ramp B would intersect with Beechwood Boulevard approximately 1000 feet to the west of the existing ramp and would be provided with an adequate on-ramp before entering the Squirrel Hill Tunnel. Once traffic exits, the existing third lane would be converted to a shoulder, then utilized as an acceleration lane by traffic entering on the existing Ramp B.

The existing Ramp A/Ramp D structure over SR 0376 would need to be replaced and extended over the relocated Ramp E.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction.

Transportation Impacts

Movement of the eastbound off-ramp to a more logical position (upstream of the eastbound on-ramp) primarily impacts the network during the PM peak period. Even though traffic volumes remained the same on the Squirrel Hill on-ramp, it realized improvements from this realignment. Delay on the ramp decreased by 84% and speed nearly doubled.

These improvements can be attributed to the removal of the weave and existing stop condition on the ramp.

Safety Impacts

Safety benefits would be gained by reducing vehicle conflicts when removing the weave. Though no CMF exists for weave removal, HSM predictions were done without the weave and compared to existing conditions. Predictions indicate a 40% reduction in fatal and injury crash frequency and 33% reduction in PDO crash frequency. The reduction would be in multi-vehicle crashes. Incalculable benefits would be garnered by removing stop control from entering traffic.

Design Exceptions

No design exceptions are anticipated for the construction of the new ramps.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts

Construction of the new on ramp will result in 4 full takes, including 3 houses on Beechwood Boulevard. Both new ramps will also require small takes from the edges of 18 properties along Beechwood Boulevard.

MPT

Phase 1: Construct extended Ramp A/Ramp D Bridge. Would require closure of Ramp A and Ramp D, as well as weekend/nighttime closures of SR 0376 mainline.

Phase 2: Construct the western portions of the relocated Ramp E and Ramp B. Existing ramps can remain open. Nighttime lane closures along the Parkway would be necessary for Ramp E tie-in work. Beechwood Boulevard could require lane closures, potentially on nights and weekends.

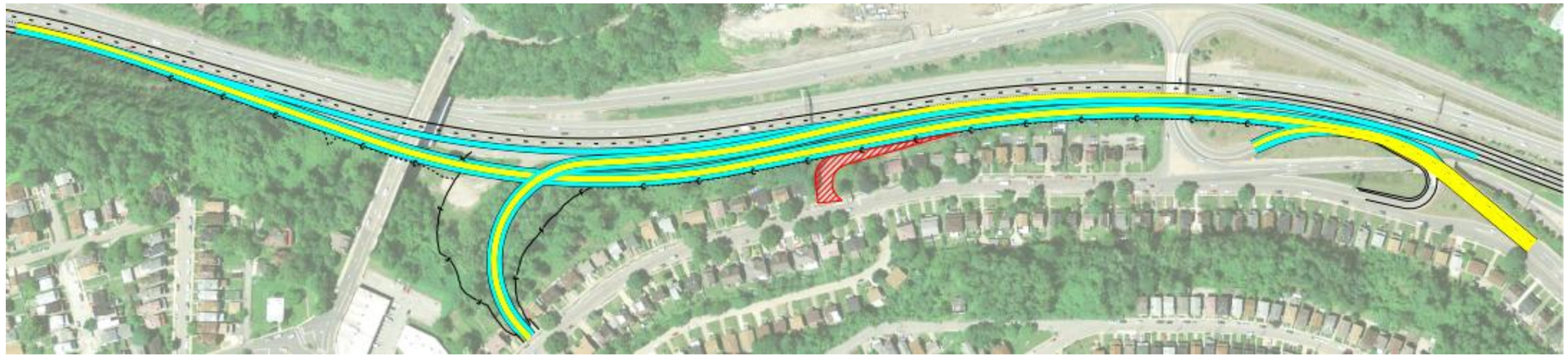
Phase 3: Construct eastern portions of relocated Ramp E and Ramp B. This would require closures of both of the eastbound ramps. This portion of work could also require nighttime or weekend lane closures along the Parkway for tie-in work.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 30C

Construction Cost	
Supplemental Roadway Construction	$2,900,000.00
Earthwork	$2,700,000.00
Pavement	$3,100,000.00
Walls	$10,100,000.00
Bridges	$11,700,000.00
Traffic Signals	$100,000.00
Signage	$300,000.00
Utilities	$900,000.00
Additional Lump Sum	$2,600,000.00
Design and PM	$6,900,000.00
ROW	$600,000.00
Total	$41,900,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	405hr
Value of Travel Time (Annual)	$1,801,484.50
Automobile Operating Costs (Annual)	$614,323.25
Safety (Annual)	$396,383.26
Total	$2,812,191.01
Emissions (Annual)	
CO2	-1837361kg
Nox	-3613kg
VOC	-4340kg
Benefit:Cost Ratio	
NPV Benefits	$42,246,992.57
NPV Operating Costs	$0.00
NPV Capital Costs	$41,097,307.15
Total Costs	$41,097,307.15
Benefit:Cost Ratio	1.03

Description
This concept would eliminate the eastbound weave at the Squirrel Hill Interchange by moving the exit gore approximately 1600 feet to the west and constructing an extended Ramp E that passes under Ramp B, the eastbound entrance ramp, parallels the Parkway mainline, and joins the existing Ramp E alignment at the Ramp G overpass.

Ramp E would tunnel under the new Ramp B alignment. The new Ramp B would intersect with Beechwood Boulevard approximately 1000 feet to the west of the existing ramp and would be provided with an adequate on-ramp before entering the Squirrel Hill Tunnel. Once traffic exits, the existing third lane would be converted to a shoulder, then utilized as an acceleration lane by traffic entering on the existing Ramp B.

The existing Ramp A/Ramp D structure over SR 0376 would need to be replaced and extended over the relocated Ramp E.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction.

Transportation Impacts
Movement of the eastbound off-ramp to a more logical position (upstream of the eastbound on-ramp) primarily impacts the network during the PM peak period. Even though traffic volumes remained the same on the Squirrel Hill on-ramp, it realized improvements from this realignment. Delay on the ramp decreased by 84% and speed nearly doubled.

These improvements can be attributed to the removal of the weave and existing stop condition on the ramp.

Safety Impacts
Safety benefits would be gained by reducing vehicle conflicts when removing the weave. Though no CMF exists for weave removal, HSM predictions were done without the weave and compared to existing conditions. Predictions indicate a 40% reduction in fatal and injury crash frequency and 33% reduction in PDO crash frequency. The reduction would be in multi-vehicle crashes. Incalculable benefits would be garnered by removing stop control from entering traffic.

Design Exceptions
No design exceptions are anticipated for the construction of the new ramps.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
Construction of the new on ramp will result in 4 full takes, including 3 houses on Beechwood Boulevard. Both new ramps will also require small takes from the edges of 18 properties along Beechwood Boulevard.

MPT
Phase 1: Construct extended Ramp A/Ramp D Bridge. Would require closure of Ramp A and Ramp D, as well as weekend/ nighttime closures of SR 0376 mainline.

Phase 2: Construct the western portions of the relocated Ramp E and Ramp B. Existing ramps can remain open. Nighttime lane closures along the Parkway would be necessary for Ramp E tie-in work. Beechwood Boulevard could require lane closures, potentially on nights and weekends.

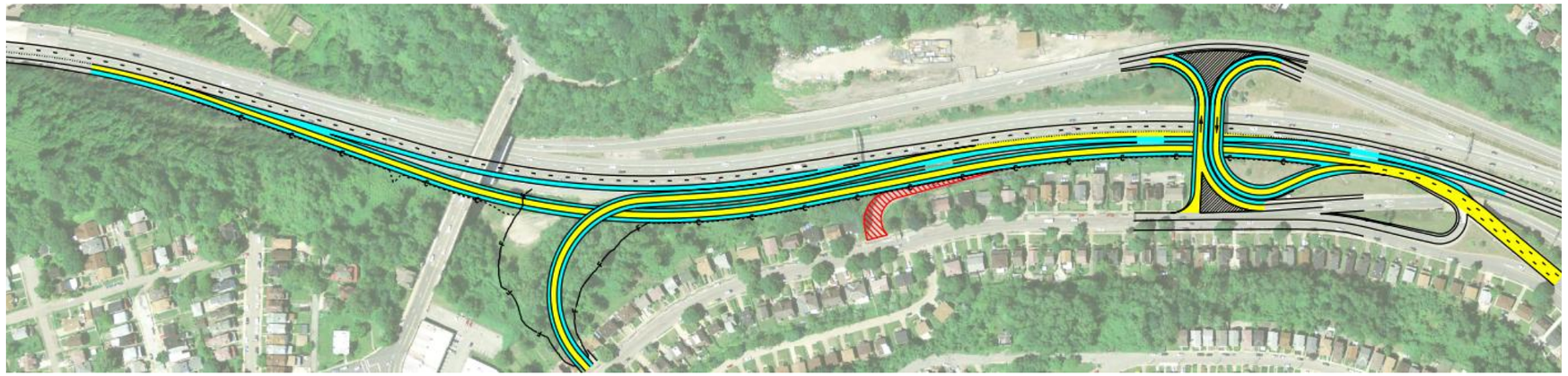
Phase 3: Construct eastern portions of relocated Ramp E and Ramp B. This would require closures of both of the eastbound ramps. This portion of work could also require nighttime or weekend lane closures along the Parkway for tie-in work.

ITS Strategies
There is the potential for Ramp management on the realigned on-ramp.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 30C Revised

Construction Cost	
Supplemental Roadway Construction	$2,900,000.00
Earthwork	$2,700,000.00
Pavement	$3,200,000.00
Walls	$10,100,000.00
Bridges	$15,500,000.00
Traffic Signals	$100,000.00
Signage	$300,000.00
Utilities	$900,000.00
Additional Lump Sum	$2,900,000.00
Design and PM	$7,700,000.00
ROW	$600,000.00
Total	$46,900,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	405hr
Value of Travel Time (Annual)	$1,801,484.50
Automobile Operating Costs (Annual)	$614,323.25
Safety (Annual)	$407,822.14
Total	$2,823,629.89
Emissions (Annual)	
CO2	-1837361kg
Nox	-3613kg
VOC	-4340kg
Benefit:Cost Ratio	
NPV Benefits	$42,418,836.62
NPV Operating Costs	$0.00
NPV Capital Costs	$46,125,938.02
Total Costs	$46,125,938.02
Benefit:Cost Ratio	0.92



Description

This concept would lengthen the weave area at Squirrel Hill by replacing the existing Ramp B on-ramp with a relocated ramp from Ramp A, passing over the Parkway mainline in a horseshoe configuration near the reconstructed Greenfield Bridge, and merging into the eastbound Parkway at station 848+00 with an acceleration lane and taper that meet design standards. This would provide an additional 450' of weave distance.

The relocated Ramp B would pass over the Parkway mainline on a 340 foot structure. A 540 foot retaining wall would be required to support the Pocusset Street trail above the relocated Ramp B, and a 1,880 foot retaining wall be required to support Beechwood Boulevard and abutting properties.

Traffic to I-376 eastbound would be able to access the relocated Ramp B via existing Ramp C from Forward Avenue and existing Ramp G from Beechwood Boulevard. The relocated ramp would function as a weaving section between existing Ramps C and G, and Ramp A and relocated Ramp B.

Moderate utility impacts are anticipated based on aerial utilities and underground utility crossings. Proposed Ramp B relocation could impact aerial utilities.

Transportation Impacts

The traffic model showed that the eastbound travel time between Grant Street Interchange and Squirrel Hill Tunnel portal is anticipated to decreases by 9 seconds in the build scenario, an average travel time savings of 0.5 percent.

Lengthening the eastbound weave at Squirrel Hill by moving the on-ramp primarily impacts performance during the PM peak period. The network saw small degradations, with a 0.4% decrease in average speed and a 1% increase in average delay per vehicle. In terms of ramp performance, there was only a 1.6% increase in volume, indicating only a marginal increase in the amount of traffic the ramp can serve. There were significant changes in ramp speed (a 266% increase) and density (a 72% decrease), however, these were from the significant increase in ramp length and the removal of the stop condition. Relocation of this ramp had negligible impact on the upstream Parkway mainline and the existing Squirrel Hill interchange weave.

On the local network, congestion has increased on Beechwood Blvd and Forward Ave as vehicles desiring to travel eastbound must use the local network to access the new ramp. This option also introduces lane change decision on Ramp A.

Safety Benefits

Although extending the weave is believed to improve safety, the HSM indicates that lengthening the weave as planned would result in no change in crash frequency, as the improvement is not long enough. Incalculable benefits will be garnered by removing stop control from entering traffic.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the Schenley Park Historic District. It would also involve Section 4(f) coordination regarding the recreational uses of Schenley Park. Land and Water Conservation Funds were used at the Schenley Park Fountain and Oval. Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries.

ROW Impacts

Widening to accommodate ramp relocation would require partial takes of 22 parcels, and could require complete taking of one residential dwelling, for a total take of about 142,000 sf. Most of the affected parcels appear to be occupied residential properties along Beechwood Boulevard. The proximity of the new ramp to some of these homes could result in additional full takes.

MPT

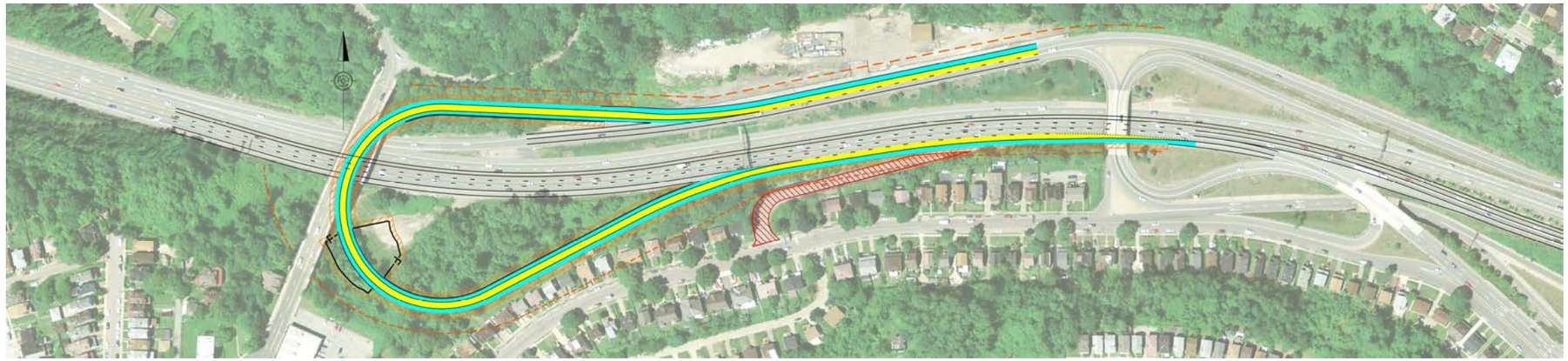
The majority of the ramp is being constructed on a new alignment and can be constructed without affecting traffic flow. The existing Ramp B can remain operational through most of this work. Construction of the acceleration lane and the tie-in to Ramp A could require lane closures, potentially on nights and weekends.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.



SUMMARY OF COSTS AND BENEFITS
Concept 31A

Construction Cost	
Supplemental Roadway Construction	$1,500,000.00
Earthwork	$1,800,000.00
Pavement	$1,600,000.00
Walls	$17,700,000.00
Bridges	$3,400,000.00
Traffic Signals	$100,000.00
Signage	$300,000.00
Utilities	$700,000.00
Additional Lump Sum	$2,200,000.00
Design and PM	$5,800,000.00
ROW	$1,100,000.00
Total	$36,200,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-267 hr
Value of Travel Time (Annual)	-$1,192,987.53
Automobile Operating Costs (Annual)	-$415,735.03
Safety (Annual)	$0.00
Total	-$1,608,722.56
Emissions (Annual)	
CO2	1248483 kg
NOx	2477 kg
VOC	2843 kg
Benefit:Cost Ratio	
NPV Benefits	-$24,167,522.65
NPV Operating Costs	$0.00
NPV Capital Costs	$34,317,091.42
Total Costs	$34,317,091.42
Benefit:Cost Ratio	-0.70

Description
This concept would lengthen the weave area at Squirrel Hill by replacing the existing Ramp B on-ramp with a relocated ramp from the intersection of Beechwood Boulevard and the Greenfield Bridge and merging into the eastbound Parkway at station 849+00 with an acceleration lane and taper that meet design standards. This would provide an additional 350' of weave distance.

A 500 foot retaining wall would be required to support relocated Ramp B above the Parkway Mainline, and a 790 foot retaining wall would be required to support Beechwood Boulevard and abutting properties above the ramp.

This configuration complicates the operation of the Beechwood Boulevard/Greenfield Bridge/Ronald Street intersection by introducing an additional leg. The heavy PM peak flow from the Greenfield Bridge to I-376 eastbound would need to turn left at this intersection to access the relocated ramp.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction. Proposed Ramp B relocation could impact aerial utilities.

Transportation Impacts
Lengthening the eastbound weave at the Squirrel Hill Interchange by moving the on-ramp primarily impacts performance during the PM peak period. Movement of the ramp is anticipated to improve network performance. For example, average speeds increase 7% and average delay per vehicle decrease 10%. There would also be a 40% decrease in latent demand and a 38% decrease in latent delay. Performance on the ramp would improve slightly with a 8% increase in volume. Due to the significant change in ramp length and the removal of the stop condition, average speed and density changes, with a 264% increase in speed and a 70% decrease in density.

Eastbound travel time between Grant Street Interchange and Squirrel Hill Tunnel portal decreases by 78 seconds in the build scenario, an average travel time savings of 4 percent.

Safety Benefits
Although extending the weave is believed to improve safety, the HSM indicates that lengthening the weave as planned would result in no change in crash frequency, as the improvement is not long enough. Incalculable benefits will be garnered by removing stop control from entering traffic.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. Three EPA Waste Sites are located at the corner of Beechwood Boulevard /Alger Street and Greenfield Bridge/Ronald Street. This concept would impact a neighborhood shopping center that contains Subway, Pizza Hut, etc.

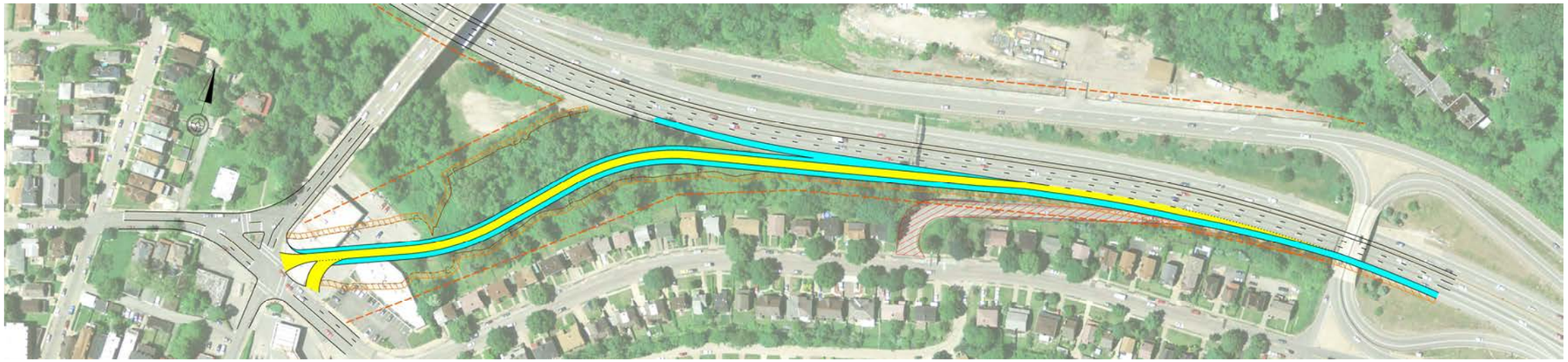
ROW Impacts
Widening to accommodate ramp relocation would require partial takes of 17 parcels, and could require complete taking of 2 commercial properties for a total take of about 110,000 sf. Most of the other affected parcels appear to be occupied residential properties along Beechwood Boulevard.

MPT
The majority of the ramp is being constructed on a new alignment and can be constructed without affecting traffic flow. Existing Ramp B can remain operational through most of this work. Construction of the acceleration lane and the tie-in to Beechwood Boulevard could require lane closures, potentially on nights and weekends.

ITS Strategies
There is the potential for Ramp management on the realigned on-ramp.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Other Potential Issues
None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 31B

Construction Cost	
Supplemental Roadway Construction	$900,000.00
Earthwork	$1,200,000.00
Pavement	$1,000,000.00
Walls	$8,500,000.00
Bridges	$0.00
Traffic Signals	$300,000.00
Signage	$300,000.00
Utilities	$600,000.00
Additional Lump Sum	$1,100,000.00
Design and PM	$2,800,000.00
ROW	$2,300,000.00
Total	$19,000,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	171 hr
Value of Travel Time (Annual)	$744,961.96
Automobile Operating Costs (Annual)	$229,227.67
Safety (Annual)	$0.00
Total	$974,189.63
Emissions (Annual)	
CO2	-671470 kg
NOx	-1259 kg
VOC	-1879 kg
Benefit:Cost Ratio	
NPV Benefits	$14,635,059.26
NPV Operating Costs	$0.00
NPV Capital Costs	$18,643,897.29
Total Costs	$18,643,897.29
Benefit:Cost Ratio	0.78

Description

This concept would lengthen the weave area at the Squirrel Hill Interchange by replacing the existing Ramp B on-ramp with a relocated ramp from Beechwood Boulevard at a new intersection east of the Greenfield Bridge and merging into the eastbound Parkway at station 848+00 with an acceleration lane and taper that meet design standards. This would provide an additional 450' of weave distance.

An 800 foot retaining wall would be required to support the relocated Ramp B above the Parkway Mainline, and a 500 foot retaining wall be required to support Beechwood Boulevard and abutting properties above the ramp.

Access to the new ramp would be via a new unsignalized intersection on Beechwood Boulevard. Stopping sight distance to this intersection for eastbound traffic is limited by a horizontal curve on Beechwood Boulevard, although the existing building setbacks minimize the restriction.

An alternative configuration was considered as Concept 31C, which would begin the relocated Ramp B at the end of Exposition Way and loop under the bridge to join the Parkway mainline. This concept was eliminated from consideration as it was not possible to fit the relocated ramp under the reconstructed Greenfield Bridge.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction. Proposed Ramp B relocation could impact aerial utilities.

Transportation Impacts

Lengthening the eastbound weave at the Squirrel Hill Interchange by moving the on-ramp primarily impacts performance during the PM peak period. This alternative is expected to provide a 7.5% increase in network speed but a 10% decrease in average vehicle delay. The new ramp increases ramp volume by 7%, accompanied by a 159% increase in speed and a 59% decrease in density. These are due to the lengthening of the ramp and the removal of the stop condition. There was no impact on the mainline upstream of the on-ramp nor on the weave.

PM eastbound travel time between Grant Street Interchange and Squirrel Hill Tunnel portal decreases by almost 2.5 minutes in the build scenario, an average travel time savings of 7.7 percent.

Safety Benefits

Although extending the weave is believed to improve safety, the HSM indicates that lengthening the weave as planned would result in no change in crash frequency, as the improvement is not long enough. Incalculable benefits will be garnered by removing stop control from entering traffic.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. Three EPA Waste Sites are located at the corner of Beechwood Boulevard /Alger Street and Greenfield Bridge/Ronald Street.

ROW Impacts

Widening to accommodate ramp relocation would require partial takes of 10 parcels, and could require complete taking of one commercial property and 1 occupied dwelling unit for a total take of about 99,000 sf. Most of the other affected parcels appear to be occupied residential properties along Beechwood Boulevard.

MPT

The majority of the ramp is being constructed on a new alignment and can be constructed without affecting traffic flow. Existing Ramp B can remain operational through most of this work. Construction of the acceleration lane and the tie-in to Beechwood Boulevard could require lane closures, potentially on nights and weekends.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 31D

Construction Cost	
Supplemental Roadway Construction	$1,000,000.00
Earthwork	$2,500,000.00
Pavement	$900,000.00
Walls	$8,100,000.00
Bridges	$0.00
Traffic Signals	$100,000.00
Signage	$300,000.00
Utilities	$600,000.00
Additional Lump Sum	$1,200,000.00
Design and PM	$2,900,000.00
ROW	$1,200,000.00
Total	$18,800,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	215 hr
Value of Travel Time (Annual)	$943,581.97
Automobile Operating Costs (Annual)	$297,105.75
Safety (Annual)	$0.00
Total	$1,240,687.72
Emissions (Annual)	
CO2	-874568 kg
NOx	-1659 kg
VOC	-2357 kg
Benefit:Cost Ratio	
NPV Benefits	$18,638,607.63
NPV Operating Costs	$0.00
NPV Capital Costs	$18,516,898.22
Total Costs	$18,516,898.22
Benefit:Cost Ratio	1.01

Description

This concept would lengthen the weave area at the Squirrel Hill Interchange by replacing the existing Ramp B on-ramp with a relocated ramp from Beechwood Boulevard at a new intersection east of the Greenfield Bridge and merging into the eastbound Parkway at station 848+00 with an acceleration lane and taper that meet design standards. This would provide an additional 450' of weave distance.

An 800 foot retaining wall would be required to support the relocated Ramp B above the Parkway Mainline, and a 500 foot retaining wall be required to support Beechwood Boulevard and abutting properties above the ramp.

Access to the new ramp would be via a new unsignalized intersection on Beechwood Boulevard. Stopping sight distance to this intersection for eastbound traffic is limited by a horizontal curve on Beechwood Boulevard, although the existing building setbacks minimize the restriction.

An alternative configuration was considered as Concept 31C, which would begin the relocated Ramp B at the end of Exposition Way and loop under the bridge to join the Parkway mainline. This concept was eliminated from consideration as it was not possible to fit the relocated ramp under the reconstructed Greenfield Bridge.

Major utility impacts are anticipated based on aerial utilities and underground utility crossings. Large existing sanitary sewers could be impacted as part of the proposed construction. Proposed Ramp B relocation could impact aerial utilities.

Transportation Impacts

Lengthening the eastbound weave at the Squirrel Hill Interchange by moving the on-ramp primarily impacts performance during the PM peak period. This alternative is expected to provide a 7.5% increase in network speed but a 10% decrease in average vehicle delay. The new ramp increases ramp volume by 7%, accompanied by a 159% increase in speed and a 59% decrease in density. These are due to the lengthening of the ramp and the removal of the stop condition. There was no impact on the mainline upstream of the on-ramp nor on the weave.

PM eastbound travel time between Grant Street Interchange and Squirrel Hill Tunnel portal decreases by almost 2.5 minutes in the build scenario, an average travel time savings of 7.7 percent.

Safety Benefits

Although extending the weave is believed to improve safety, the HSM indicates that lengthening the weave as planned would result in no change in crash frequency, as the improvement is not long enough. Incalculable benefits will be garnered by removing stop control from entering traffic.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. Three EPA Waste Sites are located at the corner of Beechwood Boulevard /Alger Street and Greenfield Bridge/Ronald Street.

ROW Impacts

Widening to accommodate ramp relocation would require partial takes of 10 parcels, and could require complete taking of one commercial property and 1 occupied dwelling unit for a total take of about 99,000 sf. Most of the other affected parcels appear to be occupied residential properties along Beechwood Boulevard.

MPT

The majority of the ramp is being constructed on a new alignment and can be constructed without affecting traffic flow. Existing Ramp B can remain operational through most of this work. Construction of the acceleration lane and the tie-in to Beechwood Boulevard could require lane closures, potentially on nights and weekends.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 31D Revised

Construction Cost	
Supplemental Roadway Construction	$1,000,000.00
Earthwork	$2,500,000.00
Pavement	$1,000,000.00
Walls	$8,100,000.00
Bridges	$8,300,000.00
Traffic Signals	$100,000.00
Signage	$300,000.00
Utilities	$600,000.00
Additional Lump Sum	$1,800,000.00
Design and PM	$4,800,000.00
ROW	$1,200,000.00
Total	$29,700,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	215 hr
Value of Travel Time (Annual)	$943,581.97
Automobile Operating Costs (Annual)	$297,105.75
Safety (Annual)	$11,438.88
Total	$1,252,126.60
Emissions (Annual)	
CO2	-874568 kg
NOx	-1659 kg
VOC	-2357 kg
Benefit:Cost Ratio	
NPV Benefits	$18,810,451.68
NPV Operating Costs	$0.00
NPV Capital Costs	$29,251,744.51
Total Costs	$29,251,744.51
Benefit:Cost Ratio	0.64

Description

This concept would combine the eastbound on-ramps at Edgewood/Swissvale by eliminating the existing SR 8010 Ramp X from Monongahela Avenue, and providing an additional entrance to the existing SR 8010 Ramp G to allow access from southbound Braddock Avenue and eastbound Monongahela Avenue. The realigned Ramp G would join the Parkway East at the existing location, maintaining the current substandard acceleration length and taper. This concept could be combined with Concepts 42A and 42B which improve the merge by transitioning Ramp G to an added third mainline lane.

This concept requires modification to the traffic signal phasing at the intersection of Braddock Avenue and Monongahela Avenue to provide protective left turn phasing onto the realigned ramp.

Minor utility impacts are anticipated based on aerial utilities and assumed underground utilities.

Transportation Impacts

By eliminating the Monongahela Avenue eastbound merge and combining the volume with the existing Ramp G volume, the combined merge volume appears to have an overall detrimental effect both locally and network wide in the PM peak. The traffic model showed that the Ramp G volume decreases by 25 percent, its average ramp speed decreases by almost 4 percent and its density decreases by over 22 percent. This could be a result of increasing volume at the existing Ramp G merge.

From an overall network perspective, average speed decreases by 7.8 percent, total travel time decreases by 2.5 percent and average delay per vehicle decreases by 10 percent in the PM peak hour. While the combined movement might be more convenient for local traffic wanting to access I-376 eastbound from the Swissvale and Swisshelm Park area to the southwest of the Edgewood Swissvale Interchange—eliminating a difficult left turn maneuver from Schoyer Avenue onto South Braddock Avenue—the concept alone does not improve efficiency. However, when combined with an add-lane concept such as Concepts 42A or 42B, a marked improvement might be realized.

Eastbound travel time between the Squirrel Hill Tunnel portal and Rodi Road decreases by 3 seconds for an average travel time savings of 1 percent.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. 1 EPA Waste is located near the concept. There is a BP Gas Station near the concept that has underground storage tanks.

ROW Impacts

No additional right-of-way would be required for this project.

MPT

Ramp G would need to be closed during realignment, with traffic detoured to Ramp X accommodated with temporary traffic signal modifications.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Design Exceptions

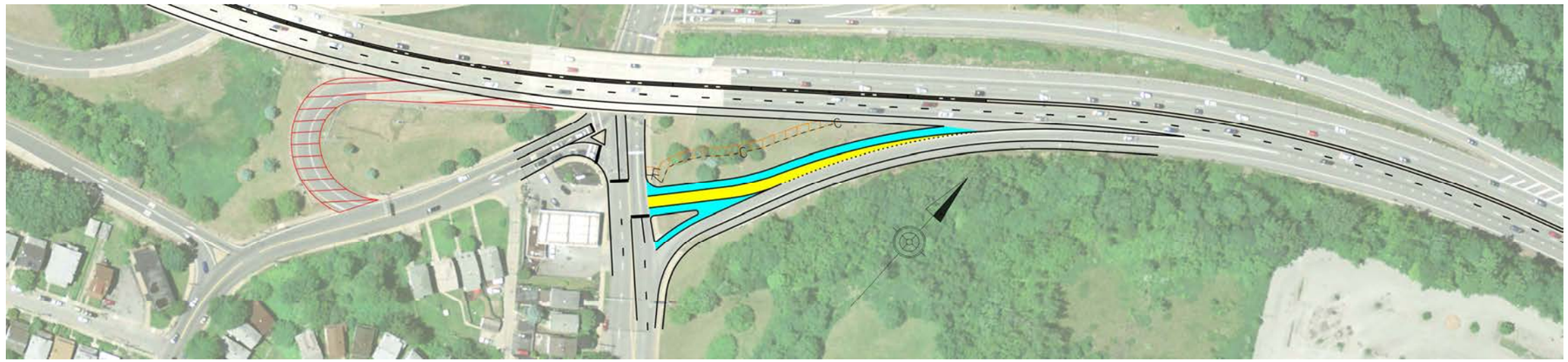
No design exceptions are anticipated for new construction in this concept.

Safety Benefits

No CMF exists for removing the merge at Ramp X; it was estimated this would result in a 50% reduction of sideswipe crashes in the merge area. However, crash frequency on Braddock Avenue will likely increase due to additional turning movements and Ramp G due to increased traffic.

Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS

Concept 32

Construction Cost	
Supplemental Roadway Construction	$1,850,000.00
Earthwork	$20,000.00
Pavement	$160,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$250,000.00
Signage	$60,000.00
Utilities	$60,000.00
Additional Lump Sum	$260,000.00
Design and PM	$530,000.00
ROW	$0.00
Total	$3,190,000.00
Operating Cost	
Negligible	$0.00
	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-48 hr
Value of Travel Time (Annual)	-$229,859.83
Automobile Operating Costs (Annual)	-$103,778.56
Safety (Annual)	$40,073.00
Total	-$293,565.40
Emissions (Annual)	
CO2	324841 kg
NOx	702 kg
VOC	467 kg
Benefit:Cost Ratio	
NPV Benefits	-$4,410,175.21
NPV Operating Costs	$0.00
NPV Capital Costs	$3,121,445.05
Total Costs	$3,121,445.05
Benefit:Cost Ratio	-1.41

Description

This concept intended to reconfigure Beechwood Boulevard as a "Complete Street" through the Squirrel Hill Interchange area, maintaining vehicular traffic while improving bicycle and pedestrian accommodations. This concept attempted to provide a two-way Complete Street roadway, which would replace the existing SR 8008 Ramp G underpass.

No alignment was identified that could accommodate the conflicts between the short distance between the I-376 off-ramp and the intersection with the reconfigured Beechwood Boulevard, and this concept was eliminated from further consideration. Concept 28 meets some of the objectives of this concept by enhancing pedestrian facilities in this area.

Utility impacts are not anticipated.

Transportation Impacts

Not evaluated.

Environmental Features

Not evaluated.

ROW Impacts

Not evaluated.

MPT

Not evaluated.

ITS Strategies

Not evaluated.

Design Exceptions

Not evaluated.

Safety Benefits

Not evaluated.

Other Potential Issues

Not evaluated.

SUMMARY OF COSTS AND BENEFITS

Concept 33

Construction Cost	
Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Admin	$0.00
Design and PM	$0.00
ROW	$0.00
Total	$0.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO	kg
NOx	kg
VOC	kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$0.00
Total Costs	$0.00
Benefit:Cost Ratio	Not Calculated

Description

This concept would modify the traffic control at the Edgewood/Swissvale Interchange at the intersection of Ramp E and Swissvale Avenue. The modification would reassign priority to Ramp E, the loop ramp from northbound Braddock Avenue, by relocating stop control to West Swissvale Avenue.

In addition to the Ramp E movement being the larger flow, this would provide a more intuitive operation, as vehicles approaching the merge from Ramp E view traffic approaching from West Swissvale Avenue at the yield point at an angle outside the driver's typical cone of vision, while traffic approaching from West Swissvale Avenue has an unobstructed view of traffic approaching the yield point on Ramp E.

Utility impacts are not anticipated.

Transportation Impacts

By switching the yield-control from the Ramp E westbound on-ramp to stop-control on the West Swissvale Avenue approach, the intersection should operate more efficiently as the Swissvale on-ramp has a higher traffic volume.

In the 2040 No Build condition, the on-ramp is anticipated to operate as LOS C in the AM peak hour. Under the 2040 Build condition with the stop sign relocated, the Swissvale Avenue approach is anticipated to operate at LOS B in the AM peak hour.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of signs where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of signage is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

There is the potential for Ramp management on the realigned on-ramp.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Improved visibility at the merge point may result in improved safety.

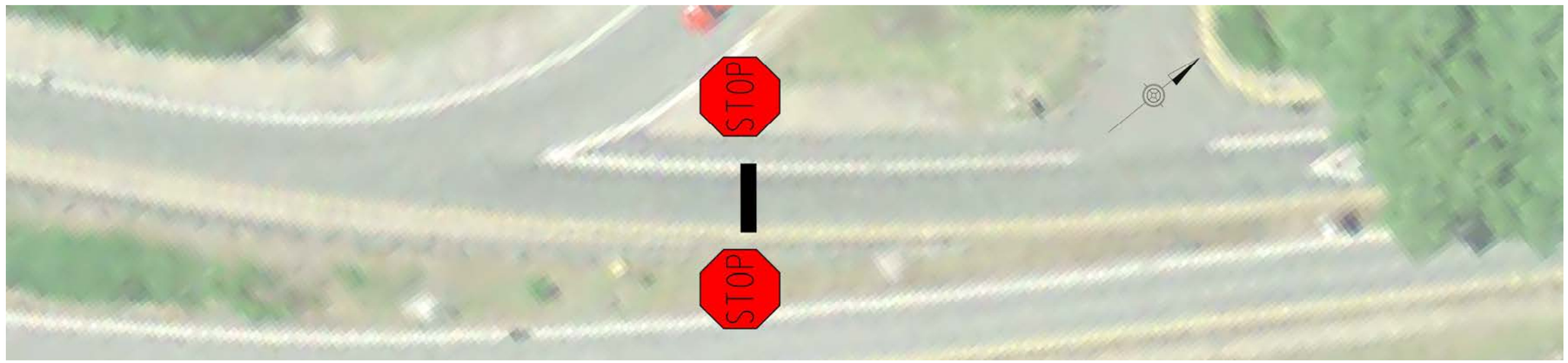
Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS

Concept 37

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$1,250.00
Utilities	$0.00
Additional Lump Sum	$100.00
Design and PM	$270.00
ROW	$0.00
Total	$1,620.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	3 hr
Value of Travel Time (Annual)	$14,042.82
Automobile Operating Costs (Annual)	$4,997.56
Safety (Annual)	$0.00
Total	$19,040.38
Emissions (Annual)	
CO2	-15066 kg
NOx	-30 kg
VOC	-33 kg
Benefit:Cost Ratio	
NPV Benefits	$286,039.82
NPV Operating Costs	$0.00
NPV Capital Costs	$1,585.06
Total Costs	$1,585.06
Benefit:Cost Ratio	180.46



Description
This concept would modify the traffic control at the Edgewood/Swissvale Interchange at the intersection of Ramp X and Monongahela Avenue by permitting left turns from northbound Monongahela Avenue onto the eastbound on-ramp. This would also require limited modification of the corner radius at Monongahela Avenue to facilitate these turns.

This would enhance access to I-376 eastbound from portions of Swisshelm Park and Swissvale which must currently travel indirect routes via local streets to reach Ramp G.

Utility impacts are not anticipated.

Transportation Impacts
By allowing left turns from Monongahela Avenue onto Ramp X (eastbound on-ramp), traffic from Swissvale would not be required to recirculate to Braddock Avenue to access the Parkway East. This would ease congestion along Braddock Avenue. The left turn from Monongahela Avenue to Ramp X is anticipated to operate at LOS B during the PM peak hour under the 2040 Build condition.

Environmental Features
This concept should qualify for a Categorical Exclusion consisting of installation of signs and pavement markings where no substantial land acquisition or traffic disruption would occur.

ROW Impacts
This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT
Installation of signage and modification to curbs and pavement is anticipated to take place under temporary, short-term traffic control measures, which could include short-term closures of Ramp X.

ITS Strategies
There is the potential for Ramp management on the realigned on-ramp.

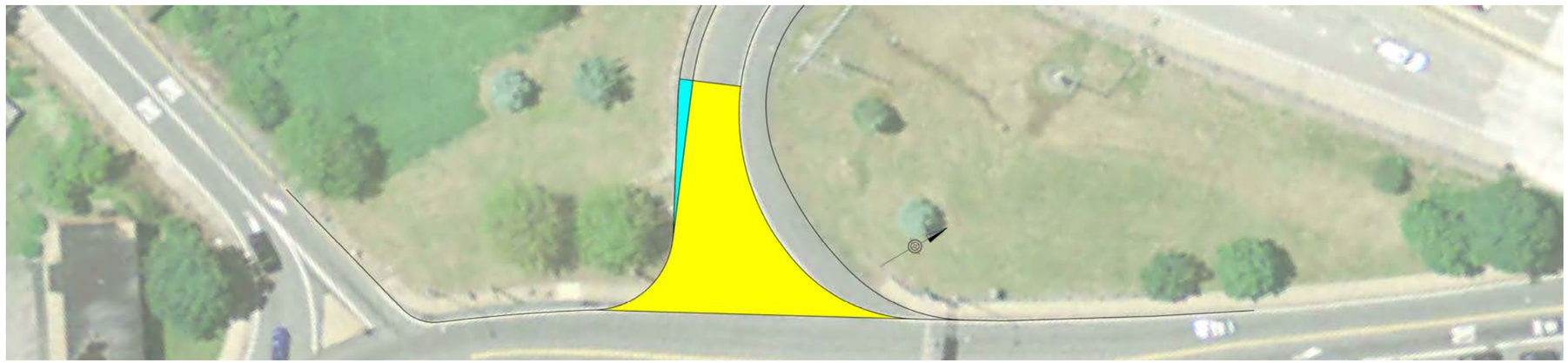
Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
Allowing left turns would introduce additional conflict points, but sight distance, at this location, appears adequate.

Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 38

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$6,000.00
Pavement	$51,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$1,000.00
Utilities	$0.00
Additional Lump Sum	$73,000.00
Design and PM	$26,000.00
ROW	$0.00
Total	$157,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	6 hr
Value of Travel Time (Annual)	$27,168.86
Automobile Operating Costs (Annual)	$10,637.45
Safety (Annual)	$0.00
Total	$37,806.31
Emissions (Annual)	
CO2	-31680 kg
NOx	-62 kg
VOC	-78 kg
Benefit:Cost Ratio	
NPV Benefits	$567,956.79
NPV Operating Costs	$0.00
NPV Capital Costs	$154,506.29
Total Costs	$154,506.29
Benefit:Cost Ratio	3.68



Description

This concept considered ways to improve the operation of the U-turn movement from westbound Ardmore Boulevard to eastbound Ardmore Boulevard at Brinton Road. This movement is required to access eastbound Ardmore Boulevard (US 30) from I-376 westbound due to the lack of a direct interchange ramp.

Traffic data collection and modeling indicated that a significant amount of traffic during the AM peak period uses Ramp G and this U-turn to access Ramp C to re-enter the westbound Parkway, a short-cut movement that significantly increases traffic congestion on the I-376 mainline. Improving operation of the U-turn has the potential to attract additional short-cut traffic and further degrade Parkway operation.

Accordingly, Concept 39 was not developed further, and other options were pursued to provide more direct access from westbound I-376 to eastbound US Route 30 (Ardmore Boulevard), as in concepts 47A and 47B.

Transportation Impacts

Not evaluated.

Environmental Features

Not evaluated.

ROW Impacts

Not evaluated.

MPT

Not evaluated.

ITS Strategies

Not evaluated.

Design Exceptions

Not evaluated.

Safety Benefits

Not evaluated.

Other Potential Issues

Not evaluated.

SUMMARY OF COSTS AND BENEFITS

Concept 39

Construction Cost	
Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$0.00
ROW	$0.00
Total	$0.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$0.00
Total Costs	$0.00
Benefit:Cost Ratio	Not Calculated

Description
This concept would extend the third eastbound lane on eastbound I-376 from the Swissvale eastbound on-ramp (Ramp G) to the eastern side of the Chestnut Street overpass, the beginning of the existing truck climbing lane.

Widening the Parkway mainline to provide the third lane would require replacing several bridges, including the Chestnut Street Bridge and the complex structure which carries Edgewood Avenue, the Norfolk Southern railroad mainline, the Port Authority's Martin Luther King, Jr. East Busway, and the Laurel Street access to Edgewood Town Centre.

In addition, 2 retaining walls, 975 foot and 840 foot, would be required to support the hillsides above the widened Parkway mainline.

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact existing sanitary lines. Relocation of aerial utilities could be required along Edgewood Avenue.

Transportation Impacts
Converting the eastbound on-ramp from Braddock Avenue to a lane add by constructing a third lane to the existing third lane, east of the Chestnut Street bridge, mainly affects performance during the PM peak period. Overall impacts on the network included an 8% decrease in average speed and a 11.5% decrease in average vehicle delay. The eastbound on-ramp from Braddock Avenue saw marginal changes in volume, velocity, and density. There was no impact on the Parkway upstream of downstream of the ramp.

Eastbound travel time between the Squirrel Hill Tunnel portal and Rodi Road increases by 3 seconds for an average travel time loss of 1 percent.

Safety Benefits
According to the HSM, converting this merge to an add-lane will reduce fatal and injury crash frequency in the vicinity by 21%.

ITS Strategies
Ramp management on realigned ramp.

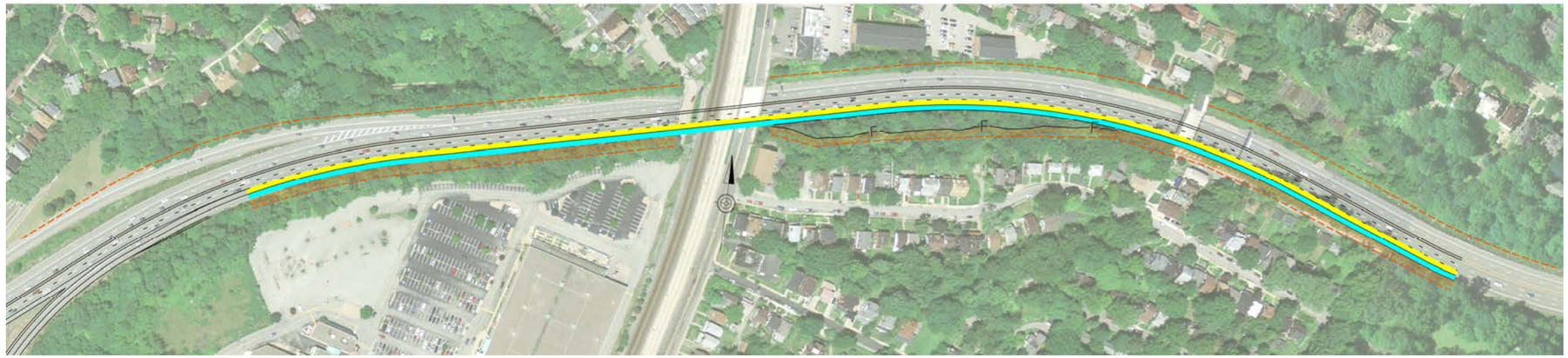
Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. It could also impact an unnamed tributary of Nine Mile Run. A NPDES permit may be required. Noise studies may be required.

ROW Impacts
This alignment would require partial takes of 17 properties, for a total take of about 48,000 sf. 10 properties containing residential properties would be affected. A portion of the Edgewood Towne Centre property would be taken, and easements would be required from Edgewood Borough, Norfolk Southern Railroad, and the Port Authority of Allegheny County.

MPT
Lengthening the combination bridge structure over the Parkway East would be a complex, phased process. It could include East Busway closure to provide temporary tracks during replacement of the rail structure, and then to accommodate mixed traffic during replacement of the Edgewood Avenue structure. Construction of the third Parkway lane would require lane closures on the Parkway mainline, potentially during night-time or weekend periods.

Design Exceptions
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Other Potential Issues
Potential disruption of rail traffic and potential multi-year closure of East Busway during bridge replacement.



SUMMARY OF COSTS AND BENEFITS
Concept 42A

Construction Cost	
Supplemental Roadway Construction	$700,000.00
Earthwork	$300,000.00
Pavement	$1,000,000.00
Walls	$11,700,000.00
Bridges	$13,200,000.00
Traffic Signals	$0.00
Signage	$600,000.00
Utilities	$1,200,000.00
Additional Lump Sum	$2,400,000.00
Design and PM	$6,200,000.00
ROW	$200,000.00
Total	$37,500,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	487.00 hr
Value of Travel Time (Annual)	$2,172,748.01
Automobile Operating Costs (Annual)	$1,296,878.57
Safety (Annual)	$54,976.71
Total	$3,524,603.28
Emissions (Annual)	
CO2	-3919451 kg
NOx	-7884 kg
VOC	-8414 kg
Benefit:Cost Ratio	
NPV Benefits	$52,949,422.04
NPV Operating Costs	$0.00
NPV Capital Costs	$36,727,563.28
Total Costs	$36,727,563.28
Benefit:Cost Ratio	1.44

Description

This concept would extend Ramp C on a separate alignment to meet the third eastbound lane on eastbound I-376 as an added lane at its current start as a hill climbing lane east of Chestnut Street.

This alignment would avoid modifications to the complex bridges carrying Edgewood Avenue, the Norfolk Southern Railroad mainline, the Port Authority's East Busway and Laurel Street, by tunneling under these facilities on the new alignment. It is anticipated that this tunnel, about 200' feet in length, would be constructed from full-section pre-cast segments jacked under the active transportation facilities.

The Chestnut Street Bridge would then be replaced with a longer structure to accommodate the additional lane on I-376.

In addition, 2 retaining walls, 1,820 foot and 1,620 foot, would be required to support the hillsides above the widened Parkway mainline.

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact existing sanitary lines. Relocation of aerial utilities could be required at the Edgewood Avenue crossing.

Transportation Impacts

By converting Ramp C from a merge to an add-lane, the PM peak model shows only negligible changes to the freeway segment with less than 1 percent decrease in density. The on-ramp shows a slight increase in volume (approximately four vehicles per hour or 0.5 percent), an increase in speed (average speed increase of 14 miles per hour), and a decrease in density (30.7 percent decrease). This concept may not be delivering the anticipated level of benefit in part because it does not provide improvement to the merge at the existing Monongahela Avenue entrance ramp, which appears to be a significant cause of turbulence and congestion on the Parkway mainline.

From an overall network perspective, average speed increases by 1.5 percent, total delay time decreases by 2 percent and total travel time decreases by 0.6 percent.

This concept should enhance benefits when combined with a reconfiguration of the interchange ramps in Concept 32.

Safety Benefits

According to the HSM, converting this merge to an add-lane will reduce fatal and injury crash frequency in the vicinity by 21%.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the eligible Union Switch & Signal historic boundary. 1 EPA Waste is located near the concept. There is a BP Gas Station near the concept that has underground storage tanks. It could also impact an unnamed tributary of Nine Mile Run. A NPDES permit and noise studies may be required.

ROW Impacts

This alignment would require partial or full takes of 17 properties, for a total take of about 109,000 sf. 1 residential unit would be taken, and an additional 7 properties containing residential properties would be affected. A portion of the Edgewood Towne Centre property would be taken, and easements would be required from Edgewood Borough, Norfolk Southern Railroad, and the Port Authority of Allegheny County.

MPT

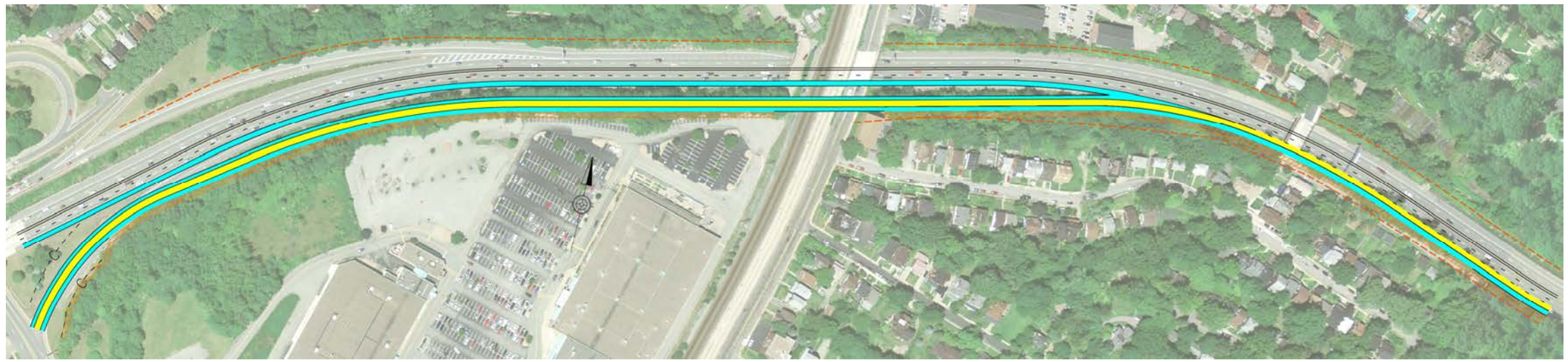
The additional lane and tunnel would be constructed on a separate alignment without disruption of Parkway traffic, aside from short-term lane closures at the tie-in point. Existing Ramp G could remain open for a majority of the project. It would require a closure during tie-in work but traffic could be detoured via Ramp X with temporary traffic signal and control modifications.

ITS Strategies

Ramp management on realigned ramp.

Other Potential Issues

Negotiating easement under rail lines and East Busway, tunnel construction.



SUMMARY OF COSTS AND BENEFITS
Concept 42B

Construction Cost	
Supplemental Roadway Construction	$1,200,000.00
Earthwork	$300,000.00
Pavement	$2,200,000.00
Walls	$17,100,000.00
Bridges	$19,200,000.00
Traffic Signals	$0.00
Signage	$600,000.00
Utilities	$1,100,000.00
Additional Lump Sum	$3,400,000.00
Design and PM	$9,000,000.00
ROW	$600,000.00
Total	$54,700,000.00
Operating Cost	
Negligible	$0.00
	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	358 hr
Value of Travel Time (Annual)	$1,596,093.37
Automobile Operating Costs (Annual)	$546,317.49
Safety (Annual)	$54,976.71
Total	$2,197,387.58
Emissions (Annual)	
CO2	-1635123 kg
NOx	-3220 kg
VOC	-3838 kg
Benefit:Cost Ratio	
NPV Benefits	$33,010,921.44
NPV Operating Costs	$0.00
NPV Capital Costs	$53,739,362.95
Total Costs	$53,739,362.95
Benefit:Cost Ratio	0.61

Description

This concept combines portions from both concept 42B and 43. It utilizes the single merge point of Ramp X and Ramp G from Concept 43. It also utilizes the separate alignment of the on-ramp to form an add lane east of Chestnut Street from Concept 42B.

Ramp X, from Monongahela Avenue, would be constructed on a separate alignment over South Braddock Avenue and the merge with Ramp G. To avoid modification to the complex bridges carrying Edgewood Avenue, Norfolk Southern Railroad, the East Busway, and Laurel Street, a tunnel under these structures would be provided for the realigned Ramps G and X.

The Chestnut Street Bridge would need replaced to accommodate the additional lane on I-376. Also, two retaining walls, 1,820 feet and 1,620 feet, would be needed to support the hillside above the mainline Parkway East.

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact existing sanitary lines. Relocation of aerial utilities could be required at the Edgewood Avenue crossing.

Transportation Impacts

This concept shows negligible differences as compared to the no build condition. In the PM peak hour the overall system shows a decrease in average speed of 0.05 percent, a negligible decrease in total travel, and a 0.1 percent increase in average delay per vehicle. Benefits stem from combining ramp G and X into an add lane. The new alignment reduces merging conflicts with the mainline traffic and allows entering traffic to accelerate up to speed with a longer acceleration lane.

Safety Benefits

According to the HSM, converting this merge to an add-lane will reduce fatal and injury crash frequency in the vicinity by 21%. This will be supplemented with the removal of the merge at Ramp X, which is estimated to result in a 50% reduction in sideswipe crashes at the existing merge area.

MPT

The additional lane and tunnel will be constructed on a separate alignment without disruption of Parkway traffic, aside from short-term lane closures at the tie-in point. Existing Ramp G will be closed for this work, but traffic can be detoured via Ramp X with temporary traffic signal modifications

The additional lane and tunnel will be constructed on a separate alignment without disruption of Parkway traffic, aside from short-term lane closures at the tie-in point. Existing Ramp G will be closed for this work, but traffic can be detoured via Ramp X with temporary traffic signal modifications.

ITS Strategies

Ramp management on realigned ramp.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the eligible Union Switch & Signal historic boundary. One EPA Waste is located near the concept. There is a BP Gas Station near the concept that has underground storage tanks. It could also impact an unnamed tributary of Nine Mile Run. Existing Ramp X appears to be constructed partially within the same parcel as the City of Pittsburgh's Frick Park, however, this area is not designated as part of the park boundary or the Frick Park historic district boundary. It is anticipated that a Section 4(f) No Use form may need to be completed. Land and Water Conservation Funds were used at Frick Park for the "Frick Park Trail". Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries.

ROW Impacts

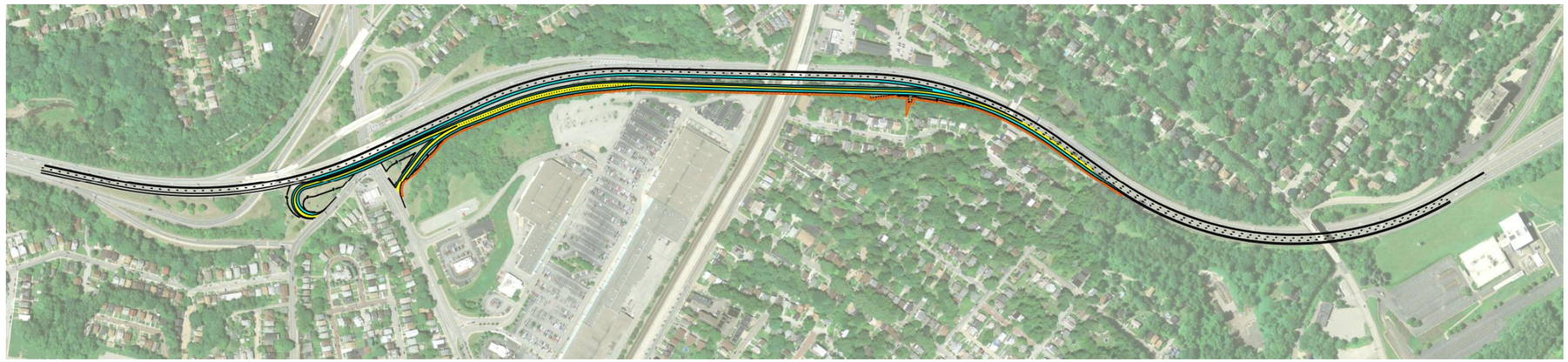
This alignment would require partial or full takes of 14 properties, for a total take of about 127,000 sf. 1 residential unit would be taken, and an additional 7 properties containing residential properties would be affected. A portion of the Edgewood Towne Centre property would be taken, and easements would be required from Edgewood Borough, Norfolk Southern Railroad, and the Port Authority of Allegheny County.

Design Exceptions

No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 42B-43A

Construction Cost	
Supplemental Roadway Construction	$1,200,000.00
Earthwork	$300,000.00
Pavement	$2,200,000.00
Walls	$16,500,000.00
Bridges	$33,000,000.00
Traffic Signals	$0.00
Signage	$600,000.00
Utilities	$1,100,000.00
Additional Lump Sum	$4,500,000.00
Design and PM	$11,900,000.00
ROW	$600,000.00
Total	$71,900,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	16 hr
Value of Travel Time (Annual)	$73,117.68
Automobile Operating Costs (Annual)	$28,310.55
Safety (Annual)	$81,692.04
Total	$183,120.27
Emissions (Annual)	
CO2	-86595 kg
NOx	-179 kg
VOC	-165 kg
Benefit:Cost Ratio	
NPV Benefits	$2,750,979.79
NPV Operating Costs	$0.00
NPV Capital Costs	$70,416,173.79
Total Costs	$70,416,173.79
Benefit:Cost Ratio	0.04

Description

This concept combines concept 42A with 43. It utilizes the single merge point of Ramp X and Ramp G from Concept 43. It also provides an added third lane to the eastbound Parkway.

Ramp X, from Monongahela Avenue, would be constructed on a separate alignment over South Braddock Avenue and the merge with Ramp G. At the merge point with the Parkway, the ramp would become a third mainline travel lane in the eastbound direction. To avoid modification to the complex bridges carrying Edgewood Avenue, Norfolk Southern Railroad, the East Busway, and Laurel Street, this concept proposes that the entire Parkway East be shifted to the north to fit all five mainline lanes under this structure. It is estimated that this alignment underneath these structures would provide five twelve-foot lanes with approximately one foot shoulders in both directions. The same cross-section would be utilized under the existing Chestnut Street Bridge. However, required design vertical clearance of 16'6" cannot be maintained in the outbound lanes under the structures.

Five retaining walls of 1,135 feet, 485 feet, 920 feet, 175 feet, and 485 feet, would be needed to support the hillside above the widened mainline Parkway East.

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact existing sanitary lines. Relocation of aerial utilities could be required at the Edgewood Avenue crossing.

The possibility of lowering the Parkway mainline to provide required overhead clearance at the bridges was investigated. Based upon available information, it appears that there is not sufficient clearance above the bridge footers to permit this without bridge replacement.

Transportation Impacts

This concept shows an increase in congestion in both the AM and PM models. While combining Ramp X and Ramp G to connect to an added eastbound thru lane will improve flow on the outbound side, this is offset by increased congestion on the inbound side. The restricted vertical clearance and lack of shoulder or offset barrier will create a tunnel condition, with impacts on traffic flow similar to those seen at the Squirrel Hill tunnel. In addition, truck restrictions in the outboard lanes will result in additional turbulence in the traffic flow. Simulation analysis indicated an increase in AM peak travel time of 3.3 minutes due to these restrictions.

Geometric Constraints

The arch bridges at Chestnut Street, Laurel Street and Edgewood Avenue provide inadequate vertical clearance in the outboard lanes in this concept. Review of bridge construction plans indicate that the elevation of the bridge footings will not accommodate lowering the roadway to provide adequate clearance. Outboard lanes will need to be posted with vertical clearance restrictions, resulting in some traffic impacts and risks of vehicles striking the bridges.

Safety Benefits

According to the HSM, combining this merge to an add-lane would reduce fatal and injury crash frequency in the vicinity by 21%. This would be supplemented with the removal of the merge at Ramp X, which is estimated to result in a 50% reduction in sideswipe crashes at the existing merge area. The reduction in shoulder width under the bridges would likely increase crash frequency in those areas, however, the length is too small to actually predict the effect.

ITS Strategies

Ramp management on realigned ramp.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the eligible Union Switch & Signal historic boundary. One EPA Waste is located near the concept. There is a BP Gas Station near the concept that has underground storage tanks. It could also impact an unnamed tributary of Nine Mile Run. Existing Ramp X appears to be constructed partially within the same parcel as the City of Pittsburgh's Frick Park, however, this area is not designated as part of the park boundary or the Frick Park historic district boundary. It is anticipated that a Section 4(f) No Use form may need to be completed. Land and Water Conservation Funds were used at Frick Park for the "Frick Park Trail". Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries.

ROW Impacts

This alignment would require partial or full takes of 13 properties, for a total take of about 117,000 sf. No residential units will be taken. All but 1 are partial takes. All takes are on the southern side of the Parkway, as widening to the north side is within the ROW.

Design Exceptions

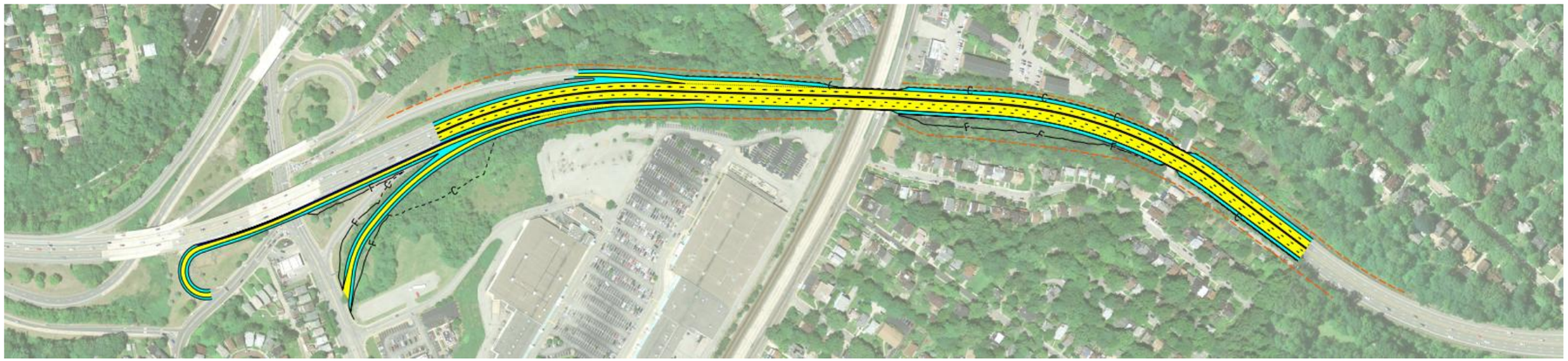
Design exceptions will be required at both overpasses where shoulder width is reduced to less than 2 feet.

MPT

The construction for the shifting of the Parkway and the third mainline lane will require nighttime and weekend lane closures in both directions of the Parkway East.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 42-43B

Construction Cost	
Supplemental Roadway Construction	$2,700,000.00
Earthwork	$700,000.00
Pavement	$5,000,000.00
Walls	$9,000,000.00
Bridges	$4,300,000.00
Traffic Signals	$0.00
Signage	$600,000.00
Utilities	$1,100,000.00
Additional Lump Sum	$2,000,000.00
Design and PM	$5,100,000.00
ROW	$200,000.00
Total	$30,700,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-37.95 hr
Value of Travel Time (Annual)	-$165,718.23
Automobile Operating Costs (Annual)	-$50,804.52
Safety (Annual)	$81,692.04
Total	-$134,830.71
Emissions (Annual)	
CO2	148702 kg
NOx	278 kg
VOC	419 kg
Benefit:Cost Ratio	
NPV Benefits	-$2,025,535.25
NPV Operating Costs	$0.00
NPV Capital Costs	$30,246,624.59
Total Costs	$30,246,624.59
Benefit:Cost Ratio	-0.07

Description

This concept combines concept 42A with 43. It utilizes the single merge point of Ramp X and Ramp G from Concept 43. It also provides an added third lane to the eastbound Parkway .

Ramp X, from Monongahela Avenue, would be constructed on a separate alignment over South Braddock Avenue and the merge with Ramp G. At the merge point with the Parkway, the ramp would become a third mainline travel lane in the eastbound direction. This option assumes that the complex bridges carrying Edgewood Avenue, Norfolk Southern Railroad, the East Busway, and Laurel Street would be reconstructed to accommodate the additional mainline travel lane. The same cross-section would be utilized under the Chestnut Street Bridge which would also need replaced.

Three retaining walls of 220 feet, 1,020 feet, and 840 feet, would be needed to support the hillside above the widened mainline Parkway East.

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact existing sanitary lines. Relocation of aerial utilities could be required at the Edgewood Avenue crossing.

Transportation Impacts

This concept shows a decrease in congestion in both the AM and PM models. Combining Ramp X and Ramp G to connect to an added eastbound thru lane will improve flow on the outbound side. Merging conflicts are greatly reduced due to the ramps combining to add a lane under the replaced bridges at Edgewood Avenue, Norfolk Southern Railroad, the East Busway, Laurel Street and Chestnut Street.

Safety Benefits

According to the HSM, combining this merge to an add-lane would reduce fatal and injury crash frequency in the vicinity by 21%. This would be supplemented with the removal of the merge at Ramp X, which is estimated to result in a 50% reduction in sideswipe crashes at the existing merge area.

ITS Strategies

Ramp management on realigned ramp.

MPT

The construction of the bridges over the mainline Parkway and constructing the third mainline lane will require nighttime and weekend lane closures of the Parkway East. Temporary shutdown of the Parkway for overhead bridge erection may be necessary. Replacement of the bridge carrying the Norfolk Southern Railroad would require maintaining rail traffic at all times.

Chestnut Street would be closed during replacement, and may require temporary changes to the existing one-way traffic pattern on Elm Street.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the eligible Union Switch & Signal historic boundary. One EPA Waste is located near the concept. There is a BP Gas Station near the concept that has underground storage tanks. It could also impact an unnamed tributary of Nine Mile Run. Existing Ramp X appears to be constructed partially within the same parcel as the City of Pittsburgh's Frick Park, however, this area is not designated as part of the park boundary or the Frick Park historic district boundary. It is anticipated that a Section 4(f) No Use form may need to be completed. Land and Water Conservation Funds were used at Frick Park for the "Frick Park Trail". Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries.

ROW Impacts

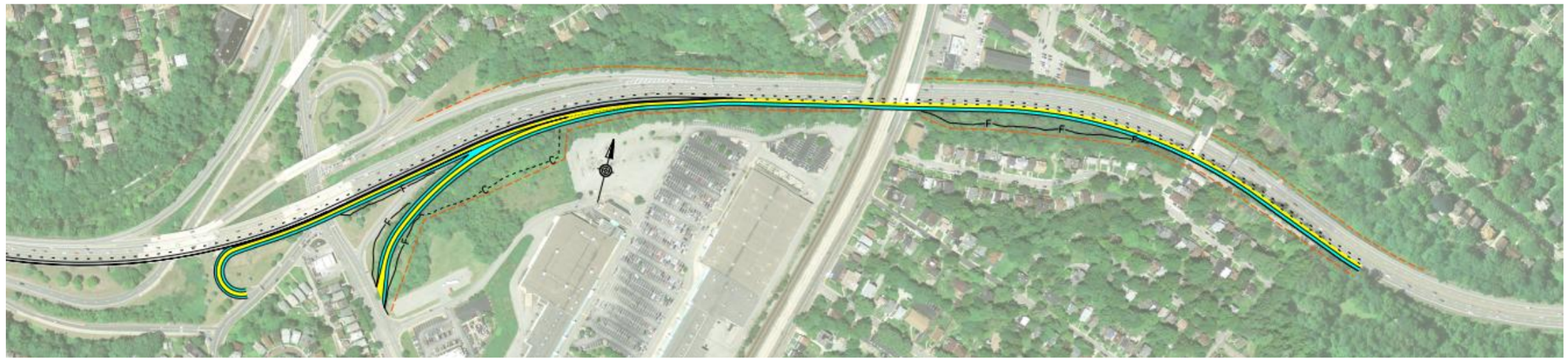
This alignment would require partial or full takes of 20 properties, for a total take of about 133,633 sf. No residential units will be taken. All but 1 are partial takes. All takes are on the southern side of the Parkway, as widening to the north side is within the ROW.

Design Exceptions

No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 42-43C

Construction Cost	
Supplemental Roadway Construction	$1,900,000.00
Earthwork	$1,100,000.00
Pavement	$2,000,000.00
Walls	$10,700,000.00
Bridges	$29,500,000.00
Traffic Signals	$0.00
Signage	$700,000.00
Utilities	$1,100,000.00
Additional Lump Sum	$3,800,000.00
Design and PM	$10,200,000.00
ROW	$200,000.00
Total	$61,200,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	1150 hr
Value of Travel Time (Annual)	$5,331,431.92
Automobile Operating Costs (Annual)	$1,831,714.73
Safety (Annual)	$26,715.33
Total	$7,189,861.97
Emissions (Annual)	
CO2	-5486188 kg
NOx	-10822 kg
VOC	-12796 kg
Benefit:Cost Ratio	
NPV Benefits	$108,011,882.56
NPV Operating Costs	$0.00
NPV Capital Costs	$60,128,583.50
Total Costs	$60,128,583.50
Benefit:Cost Ratio	1.80

Description

This concept combines the eastbound on-ramps at Edgewood/ Swissvale by extending the existing SR 8010 Ramp X from Monongahela Avenue on a separated alignment over South Braddock Avenue and merges it with the existing SR 8010 Ramp G before entering the I-376 mainline. This combined ramp enters the Parkway as an added third lane, and the mainline will be widened to extend this lane to west of the Chestnut Street Bridge. This replaces the two existing substandard merges with an added lane, as well as provide additional eastbound capacity.

Widening the Parkway mainline to provide the third eastbound lane would require replacing the complex structure which carries Edgewood Avenue, the Norfolk Southern Railroad mainline, the Port Authority's Martin Luther King, Jr. East Busway, and the Laurel Street access to Edgewood Town Centre. A 1,860 foot retaining wall would be required to support the hillside above the widened Parkway mainline.

Utility impacts are anticipated to be medium based on aerial utilities, potential sanitary lines, and communications to the variable message board. Relocation of aerial utilities could be required along Braddock Avenue and the Edgewood Avenue crossing.

Transportation Impacts

By combining the two eastbound ramps into one merge point, the PM model shows an overall increase in efficiency. Interchange area delay decreases 7% in the PM model. Speeds increased 7.9% with the new ramp configuration. The single ramp is sufficient to carry the combined volumes. The model showed the addition of a third lane helped vehicles merge more efficiently.

Safety Benefits

No CMF exists for removing the merge at Ramp X; it was estimated this would result in a 50% reduction of sideswipe crashes in the merge area. However, crash frequency on Ramp G will likely increase due to increased traffic.

MPT

Lengthening the combination bridge structure over the Parkway East would be a complex, phased process. It could include East Busway closure to provide temporary tracks during replacement of the rail structure, and then to accommodate mixed traffic during replacement of the Edgewood Avenue structure. Construction of the third Parkway lane would require lane closures on the Parkway mainline, potentially during night-time or weekend periods.

Ramps G and X would be closed during ramp realignment, and lane closures on the Parkway East would be required during construction of the ramp tie-in.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the eligible Union Switch & Signal historic boundary. One EPA Waste is located near the concept. There is a BP Gas Station near the concept that has underground storage tanks. It could also impact an unnamed tributary of Nine Mile Run. Existing Ramp X appears to be constructed partially within the same parcel as the City of Pittsburgh's Frick Park, however, this area is not designated as part of the park boundary or the Frick Park historic district boundary. It is anticipated that a Section 4(f) No Use form may need to be completed.

ROW Impacts

This alignment would require partial or full takes of 29 properties, for a total take of about 175,000 sf. 1 residential unit would be taken, and an additional 15 properties containing residential properties would be affected. A portion of the Edgewood Towne Centre property would be taken, and easements would be required from Edgewood Borough, Norfolk Southern Railroad, and the Port Authority of Allegheny County.

ITS Strategies

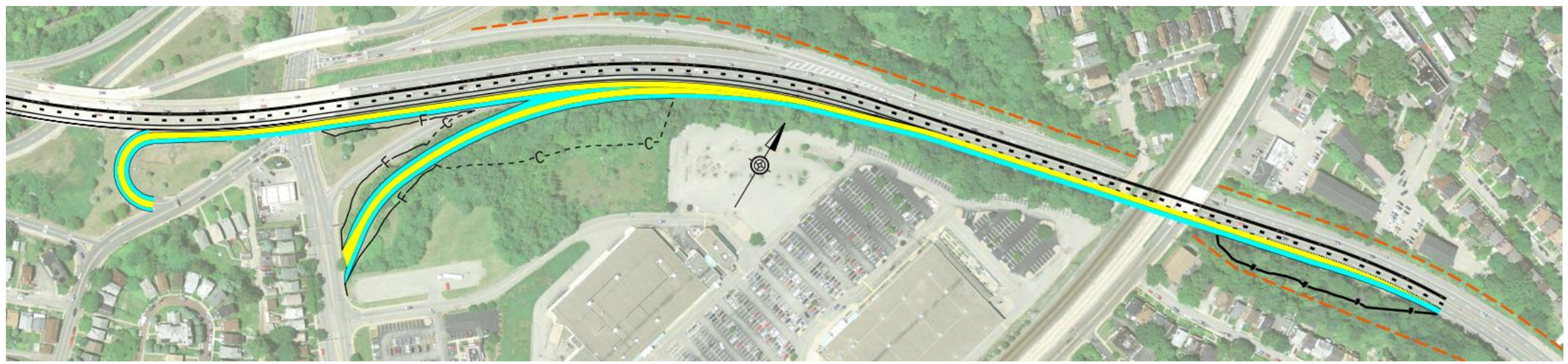
Ramp management on realigned ramp.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 43

Construction Cost	
Supplemental Roadway Construction	$1,500,000.00
Earthwork	$900,000.00
Pavement	$1,600,000.00
Walls	$8,400,000.00
Bridges	$25,300,000.00
Traffic Signals	$0.00
Signage	$400,000.00
Utilities	$600,000.00
Additional Lump Sum	$3,200,000.00
Design and PM	$8,400,000.00
ROW	$100,000.00
Total	$50,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	844 hr
Value of Travel Time (Annual)	$3,915,970.96
Automobile Operating Costs (Annual)	$1,349,021.35
Safety (Annual)	$26,715.33
Total	$5,291,707.64
Emissions (Annual)	
CO2	-4042510 kg
NOx	-7983 kg
VOC	-9387 kg
Benefit:Cost Ratio	
NPV Benefits	$79,496,283.28
NPV Operating Costs	$0.00
NPV Capital Costs	$49,243,826.88
Total Costs	$49,243,826.88
Benefit:Cost Ratio	1.61

Description

This concept considered ways to control U-turns traveling northbound on South Braddock Avenue at Allenby Avenue and nearby driveways. This includes vehicles turning left into side streets and driveways and turning around, as well as U-turns.

These turns are generally observed during the AM peak period and appear to result from motorists attempting to access Ramp F from southbound Braddock Avenue to avoid excessive queues on Ramp E from northbound Braddock Avenue.

Traffic analysis and modeling indicates that the merge between Ramp E and Ramp F essentially dictates that the 2 ramps have equal capacity during peak periods, as queued vehicles alternate at the merge point. However, demand from the south on Braddock Avenue exceeds demand from the north, in part because traffic originating north of the Parkway has better access to alternate roads to Oakland and other employment centers in the city.

Signage currently prohibits U turns at Allenby Avenue and left turns into Ramp F. A physical median barrier would be needed to further control these movements, but such a barrier would impede access to the abutting properties at all times, which could devalue those properties and/or encourage U-turns in the southbound direction.

Based upon these findings, the most effective way to control the U-turn movements is to use ramp management strategies to provide a better balance between demand and capacity on Ramps E and F. This is included in Concept 3 and Concept 99. Concept 45 is not being advanced further.

Transportation Impacts

Not evaluated.

Environmental Features

Not evaluated.

ROW Impacts

Not evaluated.

MPT

Not evaluated.

ITS Strategies

Not evaluated.

Design Exceptions

Not evaluated.

Safety Benefits

Not evaluated.

Other Potential Issues

Not evaluated.

SUMMARY OF COSTS AND BENEFITS

Concept 45

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$0.00
ROW	$0.00
Total	$0.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$0.00
Total Costs	$0.00
Benefit:Cost Ratio	Not Calculated

Description
This concept would improve the existing westbound entrance from Wilkinsburg on SR 8012 Ramp C by providing a longer acceleration lane and merge area. While the existing ramp geometry meets design standards, because of the steep grade and the horizontal curve, the merge does not appear to operate at ideal capacity.

The merge length would be extended by approximately 650 feet, from its current location at station 1021+00 to station 1014+50. The design also includes a 12' shoulder adjacent to the acceleration lane, except where it is temporary narrowed under the Brinton Road bridge because of clearance issues.

Most of the acceleration lane would utilize existing pavement, however, some widening is required. As a result, a 405 foot retaining wall is required to support the hillside against the Parkway. This concept should not require alterations to the Brinton Road bridge over the Parkway.

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact an existing sanitary line and an existing gas line.

Transportation Impacts
This improvement is anticipated to have overall negative impacts on the system during the AM peak hour. There would be a 1.5 percent decrease in average speed, a 0.7 percent increase in travel time, and a 1.7 percent increase in average delay per vehicle. It is also anticipated to increase the travel time from the Penn Hills Interchange to the eastern portal of the Squirrel Hill Tunnel by 2.4 minutes.

Extending the acceleration lane allows more vehicles to be serviced. The model indicated that approximately 70 more vehicles could be serviced due to the improvement. This would increase the volume and congestion on the mainline, therefore, increasing delay and travel time in this section of the roadway.

This alternative does not appear to have any effect on Squirrel Hill Tunnel throughput.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. 1 EPA Waste Site is located near the concept.

ROW Impacts
This alignment would require sliver takes from 8 parcels, each with occupied dwellings.

MPT
Construction would require closing Ramp C, as well as lane closures on the Parkway mainline, potentially at night or on weekends.

ITS Strategies
No applicable ITS strategies.

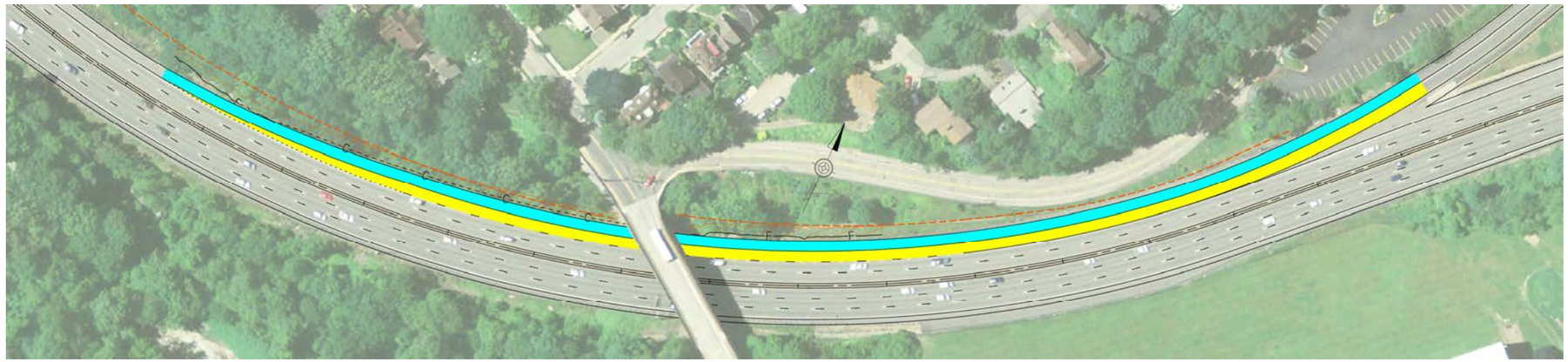
Design Exceptions
The shoulder would need to be narrowed for a short distance due to the existing Brinton Road Bridge.

Safety Benefits
According to the HSM, the proposed lengthening of the acceleration lane should reduce crash frequency at the merge by 35%.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 46

Construction Cost	
Supplemental Roadway Construction	$500,000.00
Earthwork	$20,000.00
Pavement	$520,000.00
Walls	$3,300,000.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$220,000.00
Additional Lump Sum	$430,000.00
Design and PM	$1,000,000.00
ROW	$0.00
Total	$5,990,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-52 hr
Value of Travel Time (Annual)	-$239,470.42
Automobile Operating Costs (Annual)	-$93,499.25
Safety (Annual)	$197,352.29
Total	-$135,617.38
Emissions (Annual)	
CO2	286381 kg
NOx	592 kg
VOC	537 kg
Benefit:Cost Ratio	
NPV Benefits	-$2,037,353.29
NPV Operating Costs	$0.00
NPV Capital Costs	$5,887,451.19
Total Costs	$5,887,451.19
Benefit:Cost Ratio	-0.35



Description

This concept would combine the westbound on-ramps at the Forest Hills/Wilkinsburg Interchange by relocating SR 8012 Ramp C to merge into a realigned SR 8012 Ramp A before merging into the westbound Parkway East mainline. This concept also improves the existing merge by providing a longer acceleration lane and merge area. The design also includes a 12' shoulder adjacent to the acceleration lane.

This concept would also provide a spur from Ramp F to Ardmore Boulevard to accommodate traffic destined to eastbound Ardmore Boulevard from the westbound Parkway East. The intersection of this ramp spur with Ardmore Boulevard would be signalized.

Construction of the acceleration lane would require multiple retaining walls, including 1,080 feet to support the realigned Ramps A and C above the Parkway, 880 feet to support the hillside above the extended acceleration lane and taper, and walls at 525 feet and two at 625 feet along Ramps A and C. This concept does not appear to require alterations to the Brinton Road Bridge over the Parkway

Moderate utility impacts are anticipated based on aerial utilities and underground utilities. Proposed construction could impact an existing gas line. Relocation of aerial utilities could be required along Ardmore Boulevard.

Transportation Impacts

Currently, there are two full-length on-ramps that provide storage for all of the queued vehicles waiting to enter the westbound Parkway East. There are two separate westbound on-ramps at this interchange and vehicles enter the mainline by alternating turns with the mainline traffic.

The AM peak model revealed that combining the ramps would result in a 4.1 minute decrease in average travel time from the Penn Hills Interchange to the East portal of the Squirrel Hill Tunnel. This is the result of a reduction in the number of vehicles able to enter the Parkway via this ramp, from approximately 800 vehicles per hour currently to only about 680 vehicles per hour. The additional vehicles would contribute to queueing on Ardmore Boulevard, and could lead to increased traffic on Penn Avenue.

Even though the average delay per vehicle was reduced with this alternative, this can be attributed to not as many overall vehicles being serviced through the system.

This alternative does not appear to affect Squirrel Hill Tunnel throughput.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. This concept could also impact a section of Nine Mile Run. 4 EPA Waste Sites are located near the concept and a Captive Hazardous Waste Generator is located near the concept.

ROW Impacts

This alignment would require sliver takes from 8 parcels, each with occupied dwellings.

MPT

Closures of Ramps A and C would be required during construction, although it should be possible to phase the work to keep one ramp open at all times except for short-term work. Construction of the taper and acceleration lane would require lane closures on the Parkway mainline, potentially at night or on weekends.

ITS Strategies

Ramp management on realigned ramps.

Design Exceptions

The shoulder would need to be narrowed for a short distance due to the existing Brinton Road Bridge.

Safety Benefits

No CMF exists for removing a merge; it was estimated this would result in a 50% reduction of sideswipe crashes in the merge area.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 47A

Construction Cost	
Supplemental Roadway Construction	$2,600,000.00
Earthwork	$500,000.00
Pavement	$2,900,000.00
Walls	$9,000,000.00
Bridges	$18,500,000.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$700,000.00
Additional Lump Sum	$2,800,000.00
Design and PM	$7,400,000.00
ROW	$0.00
Total	$44,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	377 hr
Value of Travel Time (Annual)	$1,689,010.95
Automobile Operating Costs (Annual)	$595,507.46
Safety (Annual)	$13,357.67
Total	$2,297,876.07
Emissions (Annual)	
CO2	-1792206 kg
NOx	-3573 kg
VOC	-4002 kg
Benefit:Cost Ratio	
NPV Benefits	$34,520,540.38
NPV Operating Costs	$0.00
NPV Capital Costs	$43,550,390.50
Total Costs	$43,550,390.50
Benefit:Cost Ratio	0.79

Description

This concept completely reconfigures the Wilkinsburg Interchange to a single-point urban Interchange, with a new signalized intersection on Ardmore Boulevard at the intersection of the proposed Ramps E, F, G and H. The revised interchange would allow for all movements to be made directly, including access to eastbound Ardmore Boulevard from westbound I-376, and elimination of the current circuitous moves from eastbound Ardmore Boulevard to eastbound I-376, and from westbound Ardmore Boulevard to westbound I-376. Ramp G, which crosses under the Parkway mainline twice, would be replaced by a direct movement on proposed Ramp B. Vehicles would no longer be able to pass through the interchange ramps to bypass congestion on the Parkway mainline.

Construction of the interchange would require three retaining walls: 850-foot to support the Parkway above proposed Ramps C and G, 1,350-foot to support the hillside above proposed Ramp B, and 715-foot to support the hillside above proposed Ramp E.

This concept eliminates all existing ramp structures within the interchange, retaining only the I-376 mainline structure over Ardmore Boulevard, and would not require any additional structures.

Moderate utility impacts are anticipated based on aerial utilities and assumed underground utilities. Relocation of aerial utilities could be required along Ardmore Boulevard.

Transportation Impacts

Currently, there are two full-length on-ramps that provide storage for all of the queued vehicles waiting to enter the westbound Parkway East. There are two separate westbound on-ramps at this interchange and vehicles enter the mainline by alternating turns with the mainline traffic.

The AM peak model reveals that combining the ramps would result in a 5.4 minute decrease in average travel time from the Penn Hills Interchange to the East portal of the Squirrel Hill Tunnel. This is the result of a reduction in the number of vehicles able to enter the Parkway via this ramp, from approximately 800 vehicles per hour currently to only about 615 vehicles per hour. The additional vehicles would contribute to queueing on Ardmore Boulevard, and could lead to increased traffic on Penn Avenue. The SPUI interchange configuration would also significantly reduce ramp lengths and corresponding vehicle storage, and thus an increase can be expected in vehicles queues on Ardmore Boulevard.

In the PM peak model, there is a marginal decrease in the travel time from the East Portal to the Penn Hills Interchange.

Safety Benefits

No CMF exists for removing a merge; it was estimated this would result in a 50% reduction of sideswipe crashes in the merge area. However, adding a signalized intersection to Ardmore Blvd will increase crash frequency due to the increase in turning movements.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. 3 EPA Waste Sites are located near the concept and a Captive Hazardous Waste Generator is located near the concept. The concept is in close proximity to the Woodlawn Cemetery. Impacts to an unnamed tributary to Turtle Creek are possible. A NPDES permit may be required.

ROW Impacts

The reconfigured interchange can be largely constructed within the existing footprint; however, cut and fill slopes would require partial takes from fifteen properties.

MPT

Construction would require multiple phases to construct and relocate ramps, but it appears to be possible to maintain most interchange movements during the process.

ITS Strategies

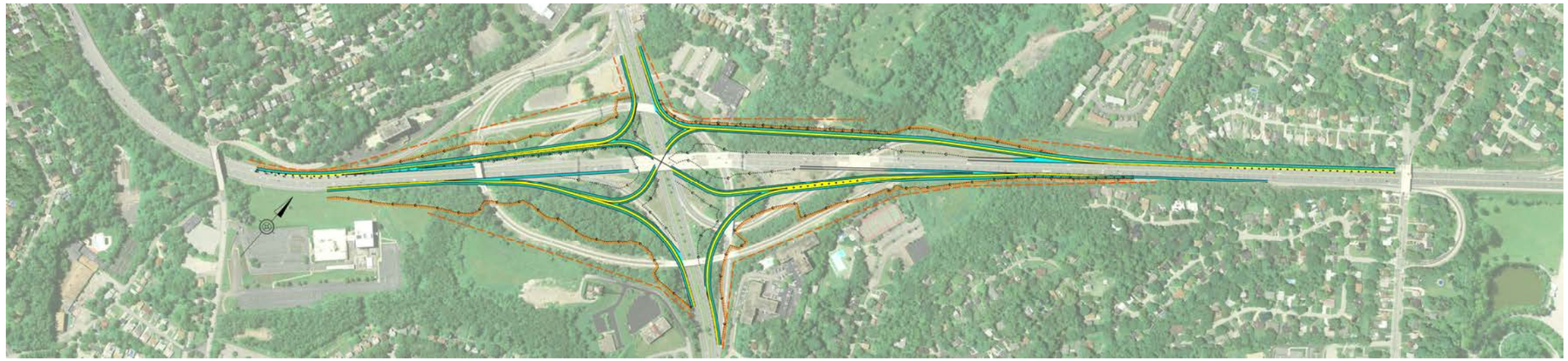
Ramp management on realigned ramp.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Other Potential Issues

Single-point urban interchanges have not been implemented in this region and should be accompanied by public education to explain the potential benefits.



SUMMARY OF COSTS AND BENEFITS
Concept 47B

Construction Cost	
Supplemental Roadway Construction	$5,400,000.00
Earthwork	$22,800,000.00
Pavement	$7,100,000.00
Walls	$30,200,000.00
Bridges	$2,100,000.00
Traffic Signals	$200,000.00
Signage	$1,400,000.00
Utilities	$1,700,000.00
Additional Lump Sum	$5,700,000.00
Design and PM	$15,300,000.00
ROW	$500,000.00
Total	$92,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	1710 hr
Value of Travel Time (Annual)	$7,618,437.37
Automobile Operating Costs (Annual)	$2,608,111.33
Safety (Annual)	-$301,135.54
Total	$9,925,413.15
Emissions (Annual)	
CO2	-7806301 kg
NOx	-15376 kg
VOC	-18317 kg
Benefit:Cost Ratio	
NPV Benefits	$149,107,529.92
NPV Operating Costs	$0.00
NPV Capital Costs	$90,551,377.33
Total Costs	$90,551,377.33
Benefit:Cost Ratio	1.65

Description
This concept would control the eastbound movement at Churchill from the William Penn Highway on-ramp to the Business 22 Monroeville off-ramp by painting a solid white line to prohibit crossing over from the left lane until after the exit gore area.

Utility impacts are not anticipated.

Transportation Impacts
Direct benefits from this concept are difficult to quantify. Traffic patterns would not be significantly affected, as most motorists would be able to continue to use preferred ramps at Churchill. Safety benefits, and a decrease in motorist frustration, can be anticipated as vehicles no longer make multiple lane changes in a short distance. The model showed that controlling the weave from the William Penn Highway on ramp to the Business 22 off-ramp reduced congestion due to weaving between these ramps. This did, however, cause friction with more vehicles having to use the short Eastbound Churchill Road on-ramp to reach the Business 22 off-ramp.

Pavement markings and signage would convey the prohibition of lane changing, but would not physically prevent it. In the absence of a physical barrier, violations are possible, particularly among more aggressive drivers. Concept 51 is similar to this one except that it would provide a physical barrier.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
All work is anticipated to take place in the existing ROW.

MPT
Installation of signage and pavement markings is anticipated to take place under temporary, short-term traffic control measures, which could include ramp closures.

ITS Strategies
No applicable ITS strategies.

Design Exceptions
This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits
No CMF exists for removing the weave, however, it was estimated that the frequency of sideswipe crashes on the segment would be reduced 50%.

Other Potential Issues
Opposition is possible from motorists who are well-served by the current weaving condition.

SUMMARY OF COSTS AND BENEFITS
Concept 49

Construction Cost	
Supplemental Roadway Construction	$8,090.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$1,620.00
ROW	$0.00
Total	$9,710.00
Operating Cost	
Negligible	$0.00
	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	28 hr
Value of Travel Time (Annual)	$128,180.05
Automobile Operating Costs (Annual)	$48,563.09
Safety (Annual)	$13,357.67
Total	$190,100.80
Emissions (Annual)	
CO2	-148008 kg
Nox	-303 kg
VOC	-292 kg
Benefit:Cost Ratio	
NPV Benefits	$2,855,846.96
NPV Operating Costs	$0.00
NPV Capital Costs	$9,510.36
Total Costs	$9,510.36
Benefit:Cost Ratio	300.29

Description
This concept would reconfigure the Churchill Interchange eastbound by realigning the existing on-ramp from William Penn Highway over the I-376 eastbound mainline to provide a right side on-ramp in the vicinity of the existing Ramp B (Churchill on-ramp). With elimination of the left add lane from William Penn Highway, the Parkway mainline lanes can be realigned to the north, allowing the relocated SR 2110 to become a lane add. The existing Ramp B access from Churchill Road would be eliminated.

A 350-foot structure would be constructed over the eastbound Parkway East to carry the relocated ramp. 2 MSE retaining walls, 400 foot and 650 foot, would be required to support the relocated ramps.

Utility impacts are anticipated to be low based on aerial utilities and underground utilities. An existing underground telephone line and an existing water line could be impacted by the proposed construction.

Transportation Impacts
This alternative would eliminate the eastbound left-entrance onto the Parkway by carrying the ramp over the Parkway and entering via the existing alignment of the eastbound entrance from Churchill Road. It mainly impacts the network during the PM peak hour.

Traffic analysis showed that this concept had an adverse impact on network operation. This concept adds traffic entering from Churchill into the right lane, which currently accommodates a heavy volume exiting at Business 22. The resultant weaving resulted in a significant increase in congestion.

There was a 9% decrease in average speed at the merge and a 13% increase in average vehicle delay. In terms of ramp performance, there was a 28% increase in volume, a 55% decrease in speed, and a 188% increase in density. There was also a significant decrease in performance on the mainline upstream of the proposed on-ramp, with a 28% decrease in volume, a 75% decrease in speed, and a 195% increase in density, representing the shock wave from this new bottleneck. .

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
All construction would be expected to take place within the existing right-of-way.

MPT
The existing eastbound on ramps would be closed during construction of the overhead structure and reconfiguration of the ramp realignment of the through Parkway lanes could require weekend or nighttime Parkway closures. A single-lane detour may be possible via Ramp A, Beulah Road, and the new ramp.

ITS Strategies
Ramp management on realigned ramp.

Design Exceptions
The vertical curvature required to cross the Parkway would be insufficient and require a design exception for a ramp with a design speed of 25 mph.

Safety Benefits
By replacing the substandard Ramp B merge with an add lane, fatal and injury crash frequency in the area should be reduced by 21% according to the HSM.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 50A

Construction Cost	
Supplemental Roadway Construction	$1,100,000.00
Earthwork	$600,000.00
Pavement	$1,100,000.00
Walls	$6,000,000.00
Bridges	$8,800,000.00
Traffic Signals	$0.00
Signage	$500,000.00
Utilities	$200,000.00
Additional Lump Sum	$1,500,000.00
Design and PM	$4,000,000.00
ROW	$0.00
Total	$23,800,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-1513 hr
Value of Travel Time (Annual)	-$6,709,816.15
Automobile Operating Costs (Annual)	-$2,244,533.18
Safety (Annual)	$76,121.60
Total	-$8,878,227.73
Emissions (Annual)	
CO2	6688308 kg
NOx	13044 kg
VOC	16311 kg
Benefit:Cost Ratio	
NPV Benefits	-$133,375,869.24
NPV Operating Costs	$0.00
NPV Capital Costs	$23,453,226.84
Total Costs	$23,453,226.84
Benefit:Cost Ratio	-5.69

Description
This concept would reconfigure the Churchill Interchange eastbound by eliminating the existing on-ramp from William Penn Highway to I-376 eastbound, with traffic directed to a realigned SR 8016 Ramp B. With elimination of the left added lane from William Penn Highway, the Parkway mainline lanes can be realigned to the north, allowing the relocated Ramp B to become a lane add.

No structures or retaining walls would be required.

Utility impacts are not anticipated.

Transportation Impacts
This alternative closes the William Penn Highway eastbound on ramp and shifts eastbound Parkway traffic so the Churchill Road eastbound on ramp becomes a lane add.

Traffic analysis showed that this concept had an adverse impact on network operation, primarily during the PM peak period. This concept adds traffic entering from Churchill into the right lane, which currently accommodates a heavy volume exiting at Business 22. The resultant weaving resulted in an significant increase in congestion.

The model indicated a 33% decrease in average speed at the merge with a 69% increase in average vehicle delay, a 54% increase in latent demand, and a 57% increase in latent delay. There was a 289% increase in volume on the entrance ramp, accompanied with a 72% decrease in speed and a 1310% increase in density. Performance on the Parkway upstream of this location was also impacted, with a 42% decrease in volume, an 85% decrease in speed, and a 277% increase in density, showing significant congestion on the link.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
All construction is expected to take place within the existing right-of-way.

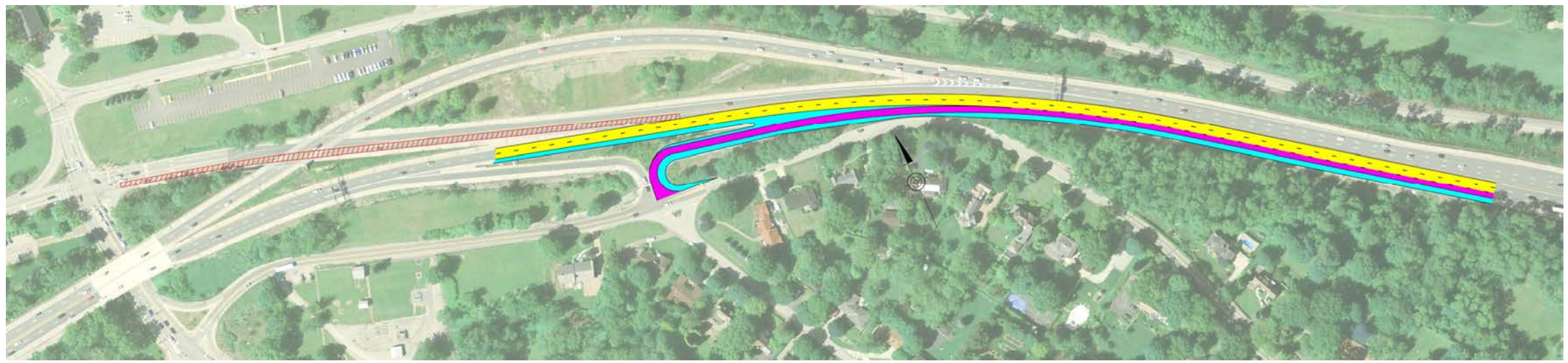
MPT
Realignment of the through Parkway lanes could require weekend or nighttime Parkway closures. Detours could be possible via the existing ramps.

ITS Strategies
Ramp management on realigned ramp.

Design Exceptions
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Safety Benefits
By replacing the substandard Ramp B merge with an add lane, fatal and injury crash frequency in the area should be reduced by 21% according to the HSM.

Other Potential Issues
None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 50B

Construction Cost	
Supplemental Roadway Construction	$8,000.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Signals	$6,000.00
Signage	$499,000.00
Utilities	$0.00
Additional Lump Sum	$110,000.00
Design and PM	$125,000.00
ROW	$0.00
Total	$748,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-5360 hr
Value of Travel Time (Annual)	-$23,735,668.13
Automobile Operating Costs (Annual)	-$45,813.90
Safety (Annual)	$76,121.60
Total	-$23,705,360.43
Emissions (Annual)	
CO2	46211140 kg
NOx	89778 kg
VOC	114359 kg
Benefit:Cost Ratio	
NPV Benefits	-$356,120,968.16
NPV Operating Costs	$0.00
NPV Capital Costs	$732,307.04
Total Costs	$732,307.04
Benefit:Cost Ratio	-486.30

Description
This concept would control the eastbound movement at Churchill from the William Penn Highway on-ramp to the Business 22 Monroeville off-ramp by constructing a physical barrier to prohibit crossing over from the left lane until after the exit gore area

Utility impacts are not anticipated.

Transportation Impacts
Direct benefits from this concept are difficult to quantify. Traffic patterns would not be significantly affected, as most motorists would be able to continue to use preferred ramps at Churchill. The model showed that controlling the weave from the William Penn Highway on ramp to the Business 22 off-ramp reduced congestion due to weaving between these ramps. This did, however, cause friction with more vehicles having to use the short Eastbound Churchill Road on-ramp. Safety benefits, and a decrease in motorist frustration, can be anticipated as vehicles would no longer make multiple lane changes to exit at Business Route 22.

This concept differs from Concept 49 in providing a physical barrier that would prevent violations.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. The concept is adjacent to Lawn & Ophelia Playground.

ROW Impacts
All work is anticipated to occur within the existing right-of-way.

MPT
Installation of signage, barrier and pavement markings is anticipated to take place under temporary, short-term traffic control measures, which could include ramp closure.

ITS Strategies
No applicable ITS strategies.

Design Exceptions
A design exception may be required for the reduced right shoulder required to accommodate the barrier width.

Safety Benefits
It was estimated eliminating the weave will reduce sideswipe crash frequency by 50%, however, this will be offset by a 24% increase in total crash frequency due to the introduction of a barrier to the segment.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 51

Construction Cost	
Supplemental Roadway Construction	$171,000.00
Earthwork	$0.00
Pavement	$165,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$96,000.00
Design and PM	$86,000.00
ROW	$0.00
Total	$518,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	28 hr
Value of Travel Time (Annual)	$128,180.05
Automobile Operating Costs (Annual)	$8,932.42
Safety (Annual)	-$112,303.39
Total	$24,809.09
Emissions	
CO2	-30142 kg
Nox	-74 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$372,702.03
NPV Operating Costs	$0.00
NPV Capital Costs	$507,355.35
Total Costs	$507,355.35
Benefit:Cost Ratio	0.73

Description
This concept would reconfigure the ramp entrance opposite Old Gate Road in Churchill to resolve problems caused by trucks turning right onto the narrow ramp. This concept relocates the edge of the ramp to provide an 80 foot radius, sufficient to accommodate right-turning WB-67 trucks without oversteering.

Moderate utility impacts are anticipated based on aerial utilities, assumed underground utilities, and in comparison to the overall proposed construction costs for the concept. Relocation of aerial utilities could be required along William Penn Highway.

Transportation Impacts
No measurable changes in delay or LOS are anticipated.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway

ROW Impacts
A partial take may be required of 1 parcel, which contains an occupied dwelling.

MPT
Installation of curb, pavement, signage and pavement markings is anticipated to take place under temporary, short-term traffic control measures, which may include ramp closures.

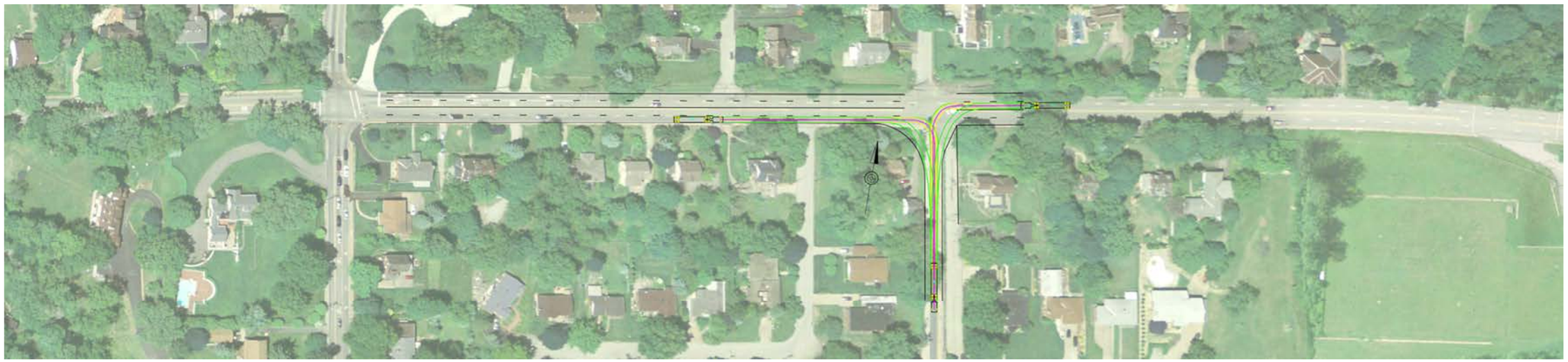
ITS Strategies
No applicable ITS strategies.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
The provision of adequate turning radius should reduce the risk of property damage caused by trucks unable to turn within the available space.

Other Potential Issues
None identified.

.



SUMMARY OF COSTS AND BENEFITS
Concept 53A

Construction Cost	
Supplemental Roadway Construction	$18,000.00
Earthwork	$21,000.00
Pavement	$78,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$5,000.00
Additional Lump Sum	$35,000.00
Design and PM	$31,000.00
ROW	$99,000.00
Total	$287,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO2	0 kg
Nox	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$281,495.06
Total Costs	$281,495.06
Benefit:Cost Ratio	Not Calculated

Description
This concept would reconfigure the ramp entrance opposite Old Gate Road in Churchill to resolve problems caused by trucks turning right onto the narrow ramp. This concept relocates the edge of the ramp to provide a slightly-improved 30 foot radius to accommodate smaller trucks, and relocates the barrier between Ramp S and McCrea Road southbound to allow WB-67 trucks to oversteer and access the ramp. The profile of the existing ramp would be adjusted to meet McCrea Road. The relocated barrier would be replaced with a painted barrier to delineate the separation between the ramp and the local road.

Moderate utility impacts are anticipated based aerial utilities, assumed underground utilities, and in comparison to the overall proposed construction costs for the concept. Relocation of aerial utilities may be required along William Penn Highway.

Transportation Impacts
No measurable changes in delay or LOS are anticipated.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway .

ROW Impacts
This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

MPT
Installation of curb, pavement, signage pavement markings and barrier modification is anticipated to take place under temporary, short-term traffic control measures, which could include ramp closures.

ITS Strategies
No applicable ITS strategies.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
The provision of adequate turning radius should reduce the risk of property damage caused by trucks unable to turn within the available space.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 53B

Construction Cost	
Supplemental Roadway Construction	$48,000.00
Earthwork	$58,000.00
Pavement	$171,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$5,000.00
Additional Lump Sum	$48,000.00
Design and PM	$66,000.00
ROW	$0.00
Total	$396,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO2	0 kg
Nox	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$387,785.14
Total Costs	$387,785.14
Benefit:Cost Ratio	Not Calculated

Description
This concept would extend the third eastbound mainline lane from its current end just past Greensburg Pike at station 1095+00 to a lane drop at SR 8016 Ramp A at Churchill.

The 195 foot long mainline structure over Beulah Road would need to be widened to accommodate the additional lane. No retaining walls are anticipated to be required.

Utility impacts are anticipated to be low based on aerial utilities. Relocation of aerial impacts could be required at the Beulah Road crossing.

Transportation Impacts
This alternative adds eastbound capacity by extending the third lane from the Wilkinsburg Interchange to the Churchill eastbound off-ramp, mainly affecting the network during the PM peak. Based on the traffic model, impacts on the network would be marginally positive, evidenced by a 0.6% increase in average speed, a 5% increase in average vehicle delay. Extending the third lane improves the throughput which causes some increased congestion and weaving at the William Penn Highway on-ramp and Business 22 off-ramps.

In the AM peak, there were small improvements to the network, as shown by a 2% increase in average speed, and a 0.8% decrease in average vehicle delay.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
A partial take could be required from 1 large parcel, which contains a commercial building.

MPT
Mainline lane closures could be required during weekend or night time hours.

ITS Strategies
No applicable ITS strategies.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
Extending the third lane to the Churchill interchange eliminates a marge; ergo it was modeled as a lane add. According to the HSM, this should reduce fatal and injury crash frequency on the segment by 21%.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 54

Construction Cost	
Supplemental Roadway Construction	$1,100,000.00
Earthwork	$1,000,000.00
Pavement	$1,400,000.00
Walls	$5,400,000.00
Bridges	$3,300,000.00
Traffic Signals	$0.00
Signage	$400,000.00
Utilities	$100,000.00
Additional Lump Sum	$1,100,000.00
Design and PM	$2,700,000.00
ROW	$0.00
Total	$16,500,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	47 hr
Value of Travel Time (Annual)	$210,745.45
Automobile Operating Costs (Annual)	$77,393.31
Safety (Annual)	$93,037.51
Total	$381,176.27
Emissions	
CO2	-234619 kg
NOx	-475 kg
VOC	-489 kg
Benefit:Cost Ratio	
NPV Benefits	$5,726,336.16
NPV Operating Costs	$0.00
NPV Capital Costs	$16,139,321.22
Total Costs	$16,139,321.22
Benefit:Cost Ratio	0.35

Description
This concept would extend the acceleration lane at SR 8018 Ramp A from Business 22 by approximately 1,200 feet to meet design standards. The existing ramp carries heavy traffic volumes that are platooned from the traffic signal at Rodi Road. Additional acceleration and merging length should improve operations during the AM peak hours. It should improve operations during non-peak hours.

Geotechnical engineering would be required to design the 1:1 fill slope required to avoid impacting McCrady Road.

No utilities appear to be located within the proposed construction area, and utility impacts are not anticipated.

Transportation Impacts
Traffic analysis indicates that this concept would result in an adverse impact on Parkway traffic. The longer acceleration lane appears to provide an improved merge operation, allowing for more efficient flow of traffic entering from Route 22. However, this has the effect of reducing capacity for traffic on the Parkway mainline, creating a localized bottleneck that creates increased congestion and reduced travel speeds east of the interchange.

Environmental Features
This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East.

ROW Impacts
This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT
Closure of the existing ramp would be required, and weekend or nighttime lane closures of the westbound mainline.

ITS Strategies
No applicable ITS strategies.

Design Exceptions
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards

Safety Benefits
According to the HSM, extending the acceleration lane as proposed will result in a 52% reduction in crash frequency on the segment.

Other Potential Issues
None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 56

Construction Cost	
Supplemental Roadway Construction	$690,000.00
Earthwork	$110,000.00
Pavement	$710,000.00
Walls	$4,000,000.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$560,000.00
Utilities	$0.00
Additional Lump Sum	$550,000.00
Design and PM	$1,330,000.00
ROW	$0.00
Total	$7,950,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-160 hr
Value of Travel Time (Annual)	-$724,222.45
Automobile Operating Costs (Annual)	-$268,752.58
Safety (Annual)	$261,793.86
Total	-$731,181.18
Emissions (Annual)	
CO2	816203 kg
NOx	1659 kg
VOC	1671 kg
Benefit:Cost Ratio	
NPV Benefits	-$10,984,391.02
NPV Operating Costs	$0.00
NPV Capital Costs	$7,795,977.74
Total Costs	$7,795,977.74
Benefit:Cost Ratio	-1.41

Description

This concept reconfigures the intersection of Forbes Avenue and Braddock Avenue to provide better accommodation for major traffic movements and to improve intersection capacity.

The southbound approach would be reconstructed to provide a left/through lane, a through lane and a right turn lane. This would require widening within the existing right-of-way. Parking on Braddock Avenue would be restricted on the west curb line south of Forbes Avenue (next to the Frick Park), and on the north curb line of Forbes Avenue, east of Braddock Avenue, to accommodate travel lanes.

The radius on the northwest corner would be reduced to shorten pedestrian crossings, and crosswalks would be realigned.

Moderate utility impacts are anticipated based on aerial utilities, assumed underground utilities, and in comparison to the overall proposed construction costs for the concept. Relocation of aerial utilities would be required along Braddock Avenue.

Transportation Impacts

If these improvements are constructed, the intersection of Forbes Avenue and Braddock Avenue should operate at LOS D or better along all approaches for the AM and PM peak hours in the design year 2040. If the improvements are not constructed, the eastbound approach of Forbes Avenue could operate at LOS F in the PM peak hour. All other approach movements should operate at LOS D or better in both the AM and PM peak hours.

ITS Strategies

Connect traffic signal to City of Pittsburgh's central traffic signal system.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Frick Park Historic District. It would also involve coordination with Frick Park regarding recreational uses. A Section 4(f) form would be expected. Land and Water Conservation Funds were used at Frick Park for the "Frick Park Trail". Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries.

ROW Impacts

All roadway construction is anticipated to place within existing right-of-way.

MPT

Installation of curb, pavement, signage, pavement markings and signal equipment is anticipated to take place under temporary, short-term traffic control measures, which could include lane closures and flagging operations.

Design Exceptions

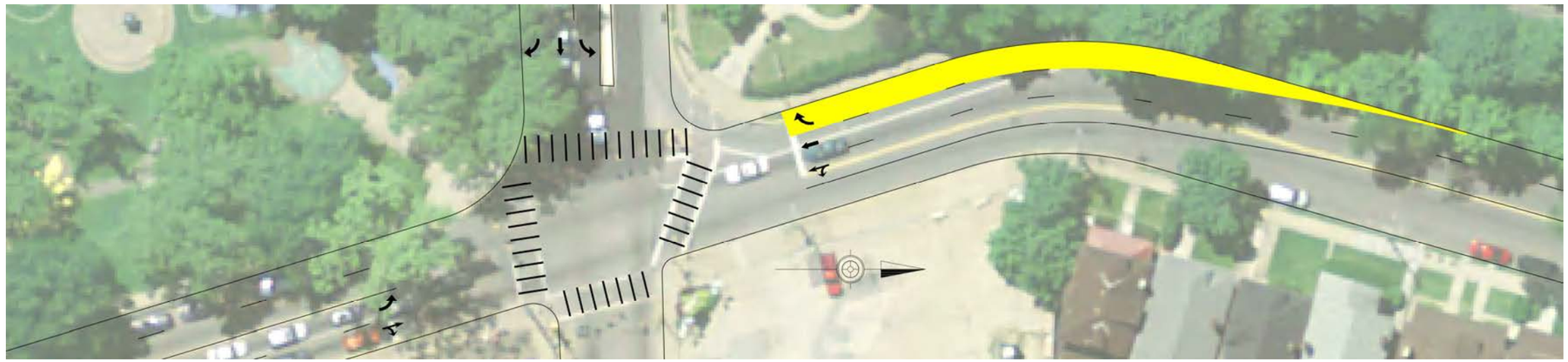
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Safety Benefits

Introducing a right-turn lane to remove turning vehicles from the through traffic stream will result in a 14% reduction in crash frequency, per research published in 2002.

Other Potential Issues

Parking restrictions along Braddock Avenue could interfere with visitors to Frick Park playgrounds and ball fields, as well as customers for adjacent businesses.



SUMMARY OF COSTS AND BENEFITS
Concept 59

Construction Cost	
Supplemental Roadway Construction	$3,000.00
Earthwork	$1,000.00
Pavement	$31,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$250,000.00
Signage	$3,000.00
Utilities	$4,000.00
Additional Lump Sum	$48,000.00
Design and PM	$68,000.00
ROW	$0.00
Total	$408,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	106 hr
Value of Travel Time (Annual)	$472,199.72
Automobile Operating Costs (Annual)	$186,736.58
Safety (Annual)	$29,922.76
Total	$688,859.06
Emissions (Annual)	
CO2	-557323 kg
NOx	-1091 kg
VOC	-1341 kg
Benefit:Cost Ratio	
NPV Benefits	$10,348,594.19
NPV Operating Costs	$0.00
NPV Capital Costs	$399,825.94
Total Costs	$399,825.94
Benefit:Cost Ratio	25.88

Description
This concept reconfigures the intersection of Penn Avenue with Braddock Avenue by widening Penn Avenue to provide left turn lanes on all approaches. This is combined with improved turning radii and upgraded signal phasing to provide protected/permitted or protected/prohibited phasing as warranted.

Moderate utility impacts are anticipated based on aerial utilities, assumed underground utilities, and in comparison to the overall proposed construction costs for the concept. Relocation of aerial utilities would be required along Braddock Avenue.

Transportation Impacts
If these improvements are constructed, the intersection of Penn Avenue and Braddock Avenue should operate at LOS D or better along all approaches for the AM and PM peak hours in the design year 2040. If the improvements are not constructed, the northbound approach of Forbes Avenue could operate at LOS E in the AM peak hour. All other approach movements should operate at LOS D or better in both the AM and PM peak hours.

Environmental Features
This concept has several EPA Waste Sites within its limits and a captive hazardous waste generator which is listed as the Exxon Gas Station. The Shady Lane Preschool is located in 1 quadrant.

ROW Impacts
This concept would require partial takes from 4 properties, for a total take of 3,700 sf. Easements would be required from 3 additional properties.

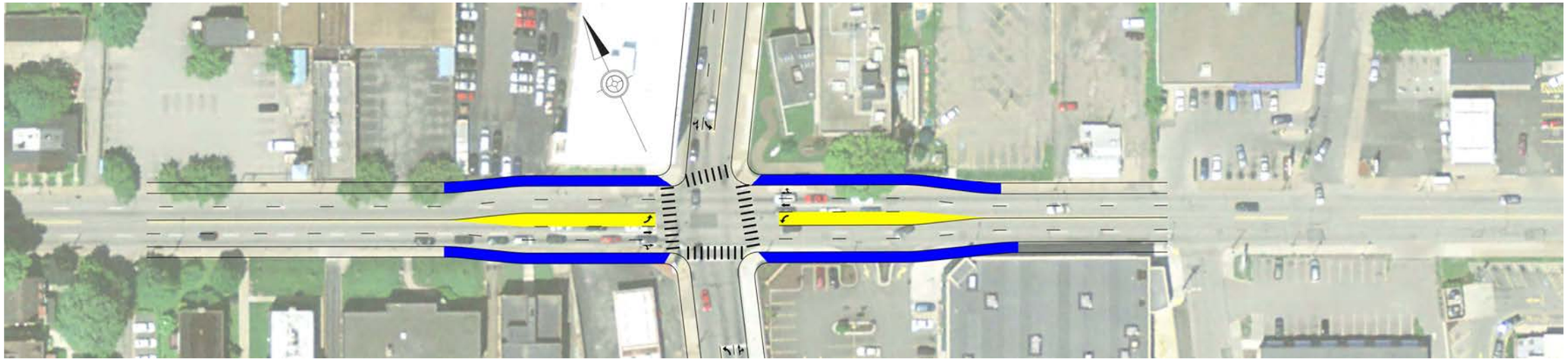
MPT
Installation of curb, pavement, signage, and pavement markings is anticipated to take place under temporary, short-term traffic control measures, which could include lane closures and flagging operations.

ITS Strategies
Connect traffic signal to City's central system.

Design Exceptions
No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Safety Benefits
Introducing left-turn lanes to remove turning vehicles from the through traffic stream will result in a 42% reduction in crash frequency, per research published in 2002.

Other Potential Issues
None Identified.



SUMMARY OF COSTS AND BENEFITS
Concept 61

Construction Cost	
Supplemental Roadway Construction	$14,000.00
Earthwork	$15,000.00
Pavement	$174,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$250,000.00
Signage	$3,000.00
Utilities	$9,000.00
Additional Lump Sum	$62,000.00
Design and PM	$106,000.00
ROW	$46,000.00
Total	$679,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	35 hr
Value of Travel Time (Annual)	$158,686.27
Automobile Operating Costs (Annual)	$65,542.27
Safety (Annual)	$113,473.71
Total	$337,702.26
Emissions (Annual)	
CO2	-197376 kg
NOx	-394 kg
VOC	-438 kg
Benefit:Cost Ratio	
NPV Benefits	$5,073,234.63
NPV Operating Costs	$0.00
NPV Capital Costs	$665,958.64
Total Costs	$665,958.64
Benefit:Cost Ratio	7.62

Description

This concept would provide pedestrian improvements along Braddock Avenue in the Edgewood/Swissvale Interchange area, especially from Towne Centre Drive to Charleston Avenue. This includes replacing missing sidewalk or sidewalk in fair or poor condition, installing ADA-accessible curb ramps where they do not currently exist, and upgrading crosswalks and pedestrian signage. This builds upon the recommendation of the Road Safety Audit conducted along Braddock Avenue.

Based upon field investigation, it is estimated that up to 15,525 linear feet of sidewalk would be replaced, along with 131 new accessible curb ramps. However, it was determined that this concept is the part of a larger project that has been allotted TAP funding. The costs in the summary table to the right are the costs associated with the funded project.

Utility impacts are not anticipated.

Transportation Impacts

These improvements would provide an enhanced pedestrian environment in the Braddock Avenue corridor. This would provide greater accessibility to transit and for walking trips, and would allow for more flexibility in travel mode choice, particularly between residential neighborhoods and commercial and employment opportunities.

Based upon field investigation, it is estimated that up to 15,525 linear feet of sidewalk would be replaced, along with 131 new accessible curb ramps.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117 (c)(3), consisting of construction of bicycle and pedestrian lanes, paths and facilities.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

MPT

Installation of curb, pavement, signage, pavement markings and signal equipment is anticipated to take place under temporary, short-term traffic control measures, which could include lane closures and flagging operations

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Safety Benefits

Enhanced pedestrian facilities can improve safety by removing pedestrians from the roadway or enhancing crossing opportunities.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS

Concept 62

Construction Cost	
Pedestrian Improvements	$479,500.00
Earthwork	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$65,000.00
ROW	$0.00
Total	$544,500.00
Operating Cost	
Negligible	$0.00
	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$533,610.00
Total Costs	$533,610.00
Benefit:Cost Ratio	Not Calculated

Description

This concept would provide pedestrian improvements along arterial roadways in the Parkway East corridor. The roadways investigated include:

- Ardmore Boulevard from Penn Avenue to Electric Avenue
- Rodi Road from Frankstown Road to Business Route 22,
- Greensburg Pike from Penn Avenue to the Tri-Boro Expressway,
- Beulah Road from Frankstown Road to the Tri-Boro Expressway,
- Frankstown Road from Dallas Avenue to Rodi Road, and Penn Avenue from Bakery Square to Beulah Road.

Pedestrian improvements along Braddock Avenue were considered separately as Concept 62.

For this evaluation, it was assumed that sidewalks would be constructed in segments of these roads where sidewalks do not currently exist, existing sidewalks in poor condition would be replaced, and ADA accessible ramps meeting current standards would be installed where they do not exist.

Based upon field investigation, it is estimated that up to 51,000 linear feet of sidewalk would be replaced, along with 251 new accessible curb ramps.

Utility impacts are not anticipated.

Transportation Impacts

These improvements would provide an enhanced pedestrian environment in the Braddock Avenue corridor. This would provide greater accessibility to transit and for walking trips, and would allow for more flexibility in travel mode choice, particularly between residential neighborhoods and commercial and employment opportunities.

These benefits would be particularly concentrated in lower-density areas outside of the urban core, where pedestrian accommodations are generally more limited.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFT 771.117 (c)(3), consisting of construction of bicycle and pedestrian lanes, paths and facilities.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

MPT

Installation of curb, pavement, signage, pavement markings and signal equipment is anticipated to take place under temporary, short-term traffic control measures, which could include lane closures and flagging operations

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept. Existing geometric conditions on the roadway would not be changed and may not meet current design standards.

Safety Benefits

Enhanced pedestrian facilities can improve safety by removing pedestrians from the roadway or enhancing crossing opportunities.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 63

Construction Cost	
ADA Ramps	$90,000.00
Earthwork	$0.00
Sidewalk	$6,700,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$610,000.00
Design and PM	$1,480,000.00
ROW	$0.00
Total	$8,880,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$0.00
Total	$0.00
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$0.00
NPV Operating Costs	$0.00
NPV Capital Costs	$8,701,861.66
Total Costs	$8,701,861.66
Benefit:Cost Ratio	Not Calculated

Description

This concept would provide a roundabout at the intersection of Bates Street and Boulevard of the Allies replacing an existing signalized intersection where left turns are currently prohibited on 3 of the 4 existing approaches.

Analysis indicates a two-lane roundabout with a 180-foot inscribed circle would geometrically accommodate traffic volumes at this location. Right-turn bypass lanes could be constructed for vehicles turning right from Boulevard of the Allies eastbound onto Bates Street southbound. Pedestrian movements would be accommodated with crosswalks.

The northern Bates Street leg would provide 1 entrance lane and 1 exit lane.

Each of the other 3 legs would provide 2 entrance lanes and 2 exit lanes. A third lane on the Boulevard of the Allies eastbound approach could drop into a right turn bypass lane towards Bates Street southbound.

Geometric design criteria is based on NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition. The design uses the Urban Two-Lane roundabout template which accommodates a city bus in the circulatory roadway. A truck apron would accommodate WB-50 semi-trailers in the circulatory roadway.

Utility impacts are anticipated to be high based on aerial utilities and underground utilities. What appears to be a large Duquesne Light facility is highly impacted by the proposed construction. Relocation of this facility is most likely not a feasible option. A 35% contingency of the construction cost was utilized for the preliminary estimate.

Transportation Impacts

An analysis of design year 2040 peak hour volumes resulted in overall intersection LOS F in the AM and F in the PM. The LOS is based on average vehicle delay.

The overall highest-volume movement in the PM is Boulevard of the Allies eastbound through towards Schenley Park. This movement could be accommodated with a right-turn bypass lane.

Directional splits are pronounced on Boulevard of the Allies. During the AM peak, the primary movement is westbound towards downtown while in the PM peak the primary movement is the eastbound through towards Schenley Park.

ROW Impacts

This roundabout would require partial or full takes of 34 properties, for a total take of about 212,525 sf. A total of 22 residential units would be taken, and an additional 4 residential properties would be affected. A portion of property owned by Duquesne Light, which appears to be a large utility facility, is highly impacted by the proposed construction and assumed to be a total take. Relocation of this facility is most likely, not a feasible option.

Safety Benefits

Research indicates roundabouts can reduce crash frequency by 48% compared to signalized intersections, while significantly reducing injury crashes (by 78%) by eliminating high-speed left-turn crashes.

Environmental Features

GIS mapping did not reveal any sensitive features within this concept.

MPT

Boulevard of the Allies is a major alternative to the Parkway East and PM peak volumes can be especially heavy. Bates Street is a major conduit linking the Parkway with Oakland Universities and Hospitals. Any temporary detours during construction would need to be well planned and limited. The relatively wide right-of-way on Boulevard of the Allies could be exploited using lane closures to shift traffic away from the work zone thus maintaining traffic during construction. Short detours or one lane bi-directional flagging could be needed on the potentially cramped Bates Street approaches.

ITS Strategies

No applicable ITS strategies

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

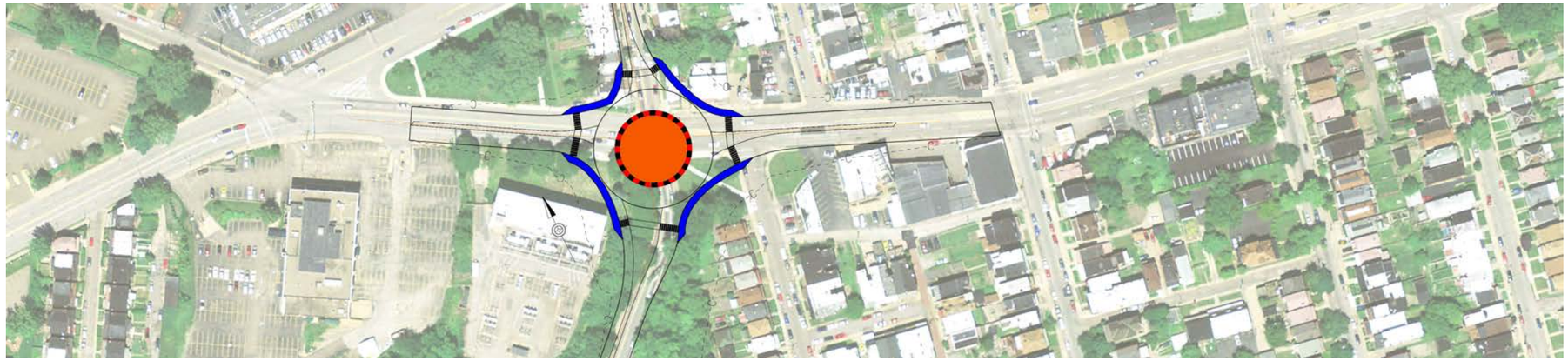
Other Potential Issues

Modern roundabouts are often controversial when first introduced to an area, such as the Pittsburgh urban core, that is not familiar with their potential benefits.

Site topography is less than ideal for a roundabout. The intersection sits in a sag curve on Boulevard of the Allies and Bates Street slopes down hill steeply away from the intersection.

SUMMARY OF COSTS AND BENEFITS
Concept 64

Construction Cost	
Supplemental Roadway Construction	$700,000.00
Earthwork	$1,400,000.00
Pavement	$1,400,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$250,000.00
Utilities	$1,310,000.00
Additional Lump Sum	$470,000.00
Design and PM	$1,110,000.00
ROW	$3,790,000.00
Total	$10,430,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-531 hr
Value of Travel Time (Annual)	-$2,321,141.82
Automobile Operating Costs (Annual)	-$844,153.76
Safety (Annual)	$161,247.21
Total	-$3,004,048.37
Emissions (Annual)	
CO2	2472799 kg
NOx	4637 kg
VOC	6918 kg
Benefit:Cost Ratio	
NPV Benefits	-$45,129,227.88
NPV Operating Costs	$0.00
NPV Capital Costs	$10,226,337.96
Total Costs	$10,226,337.96
Benefit:Cost Ratio	-4.41



Description

This concept would provide "through street" improvements to the Penn Avenue corridor, including elimination or restriction of turning movements at some intersections.

This option would prohibit left turns along Penn Avenue in Wilkinsburg at intersections without an exclusive left turn lane. Motorists wanting to turn left would be required to make a right turn before the street they wanted to proceed left on and drive around the block to that roadway. This would prevent traffic from queuing when a motorist has to wait for a gap in oncoming traffic to make a left turn.

Utility impacts are not anticipated.

Transportation Impacts

Analysis of the Penn Avenue "through streets" concept indicates that it would result in a slight increase in user-delay through the Penn Avenue corridor. While some improvements would occur to Penn Avenue traffic flows, by removing left turning vehicles from the traffic stream, this would be more than offset by the additional time needed to service re-routed trips. These rerouted trips would also incur additional delay due to the need to circulate around the block to make turns. In some cases, such as South Lang Street, Carnegie Place, and West Street, as well as some private driveways, alternate routes are quite circuitous.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8).

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for sign or signal placement.

MPT

Installation of signage, pavement markings and signal equipment is anticipated to take place under temporary, short-term traffic control measures, which could include lane closures and flagging operations

ITS Strategies

Connect traffic signals to City's central system or PennDOT District 11 Traffic Management Center.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research cited by FHWA indicates that prohibition of left turns results in a 50% reduction in crashes at signalized intersections. Using HSM methodology for the intersections would provide a potential reduction of almost 23 intersection crashes annually along Penn Avenue.

Other Potential Issues

While this project would enhance safety, it would limit access to local communities and neighborhoods and require indirect access routes. Although overall traffic impacts would be minor, community opposition could arise.

SUMMARY OF COSTS AND BENEFITS
Concept 65

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$12,467.52
Signage	$2,808.00
Utilities	$0.00
Additional Lump Sum	$1,222.04
Design and PM	$3,299.51
ROW	$0.00
Total	$19,797.07
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	-23 hr
Value of Travel Time (Annual)	-$100,604.76
Automobile Operating Costs (Annual)	-$36,587.98
Safety (Annual)	$1,374,417.74
Total	$1,237,225.00
Emissions (Annual)	
CO2	107178 kg
NOx	201 kg
VOC	300 kg
Benefit:Cost Ratio	
NPV Benefits	$5,372,525.24
NPV Operating Costs	$0.00
NPV Capital Costs	$3,234.00
Total Costs	$3,234.00
Benefit:Cost Ratio	1661.26

Description

This concept would upgrade the traffic signal system along Penn Avenue in the City of Pittsburgh and Wilkinsburg with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 23 signals from Negley Avenue to Ardmore Boulevard would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 69

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$1,330,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$270,000.00
ROW	$0.00
Total	$1,600,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	435 hr
Value of Travel Time (Annual)	$1,369,607.03
Automobile Operating Costs (Annual)	$983,409.25
Safety (Annual)	$792,359.38
Total	$3,145,375.66
Emissions (Annual)	
CO2	-16414 kg
NOx	-31 kg
VOC	-46 kg
Benefit:Cost Ratio	
NPV Benefits	$13,658,477.67
NPV Operating Costs	$0.00
NPV Capital Costs	$1,569,350.14
Total Costs	$1,569,350.14
Benefit:Cost Ratio	8.70

Description

This concept would upgrade the traffic signal system along Braddock Avenue in the City of Pittsburgh, Edgewood and Swissvale with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 9 signals from Penn Avenue to Roslyn Street would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 70

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$1,070,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$210,000.00
ROW	$0.00
Total	$1,280,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	78 hr
Value of Travel Time (Annual)	$243,856.18
Automobile Operating Costs (Annual)	$451,349.78
Safety (Annual)	$437,826.06
Total	$1,133,032.02
Emissions (Annual)	
CO2	-2484 kg
NOx	-5 kg
VOC	-7 kg
Benefit:Cost Ratio	
NPV Benefits	$4,920,077.68
NPV Operating Costs	$0.00
NPV Capital Costs	$1,260,213.57
Total Costs	$1,260,213.57
Benefit:Cost Ratio	3.90

Description

This concept would upgrade the traffic signal system along Fifth Avenue in the City of Pittsburgh with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 27 signals from the Birmingham Bridge to Penn Avenue would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to City's central system, and incorporate adaptive control.

Design Exceptions

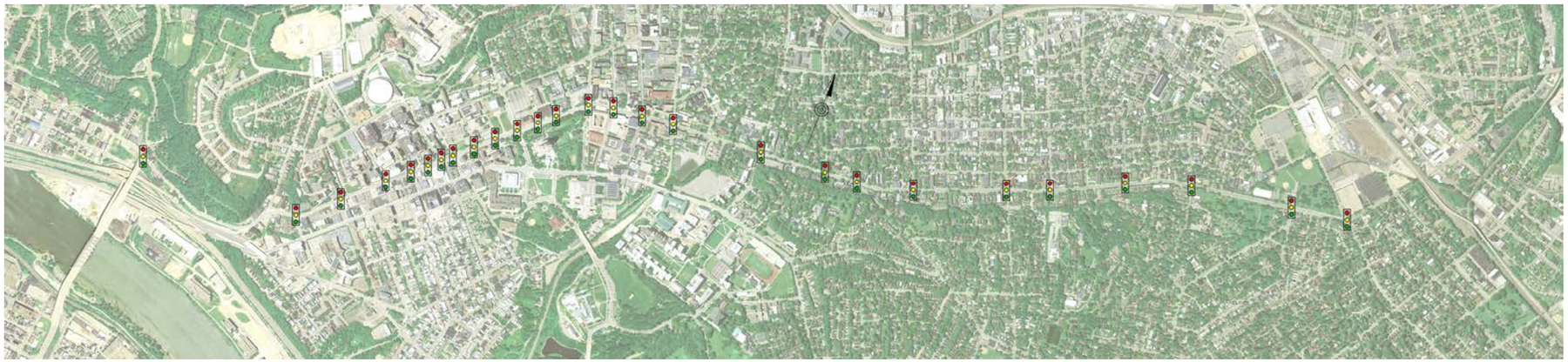
This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.



SUMMARY OF COSTS AND BENEFITS
Concept 71

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$634,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$127,000.00
ROW	$0.00
Total	$761,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	636 hr
Value of Travel Time (Annual)	$2,000,569.50
Automobile Operating Costs (Annual)	$1,220,795.18
Safety (Annual)	$1,040,183.51
Total	$4,261,548.20
Emissions (Annual)	
CO2	-20376 kg
NOx	-38 kg
VOC	-57 kg
Benefit:Cost Ratio	
NPV Benefits	$18,505,344.75
NPV Operating Costs	$0.00
NPV Capital Costs	$746,158.11
Total Costs	$746,158.11
Benefit:Cost Ratio	24.80

Description

This concept would upgrade the traffic signal system along Murray Avenue in the City of Pittsburgh with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 9 signals from Wilkins Avenue to Lilac Street would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS

Concept 72

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$719,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$144,000.00
ROW	$0.00
Total	$863,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	136 hr
Value of Travel Time (Annual)	$426,239.01
Automobile Operating Costs (Annual)	$260,101.20
Safety (Annual)	$200,991.23
Total	$887,331.43
Emissions (Annual)	
CO2	-4341 kg
NOx	-8 kg
VOC	-12 kg
Benefit:Cost Ratio	
NPV Benefits	$3,853,147.57
NPV Operating Costs	$0.00
NPV Capital Costs	$845,344.70
Total Costs	$845,344.70
Benefit:Cost Ratio	4.56

Description

This concept would upgrade the traffic signal system along Forbes Avenue in the City of Pittsburgh with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 21 signals from the Birmingham Bridge to South Braddock Avenue would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS

Concept 73

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$561,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$112,000.00
ROW	$0.00
Total	$673,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	565 hr
Value of Travel Time (Annual)	$1,776,397.14
Automobile Operating Costs (Annual)	$1,083,999.87
Safety (Annual)	$694,585.42
Total	$3,554,982.42
Emissions (Annual)	
CO2	-18092 kg
NOx	-34 kg
VOC	-51 kg
Benefit:Cost Ratio	
NPV Benefits	$15,437,153.89
NPV Operating Costs	$0.00
NPV Capital Costs	$660,062.95
Total Costs	$660,062.95
Benefit:Cost Ratio	23.39

Description

This concept would provide advance pedestrian phases at signalized intersections along arterial roadways in the Parkway East corridor, allowing pedestrians to start crossing before conflicting vehicular turning movements. It is assumed that installing the advance pedestrian phases would require controller modifications, pedestrian countdown signal heads, and vibrotactile pushbuttons.

The following corridors are included:

- Ardmore Boulevard from Penn Avenue to Electric Avenue,
- Rodi Road from Frankstown Road to Business Route 22,
- Greensburg Pike from Penn Avenue to the Tri-Boro Expressway,
- Beulah Road from Frankstown Road to the Tri-Boro Expressway,
- Frankstown Road from Dallas Avenue to Rodin Road, and Penn Avenue from Bakery Square to Beulah Road, and
- Braddock Avenue from Penn Avenue to Roslyn Street.

Utility impacts are not anticipated.

Transportation Impacts

This concept would improve safety and mobility for local road users and would encourage the walking mode to remove what would otherwise be motor vehicles from the corridors adjacent.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way. Limited easements could be required for signal placement.

MPT

Short Term temporary traffic control with minor or no encroachments into the traffic lanes would be used to facilitate construction.

ITS Strategies

No specific ITS strategies associated with pedestrian signals.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

A CMF published in 2009 indicates that implementing lead pedestrian intervals can reduce pedestrian crashes at intersections by 37%. This is especially beneficial because pedestrian crashes tend to be high-severity events.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 74

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$397,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$79,000.00
ROW	$0.00
Total	$476,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0 hr
Value of Travel Time (Annual)	$0.00
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$256,961.82
Total	$256,961.82
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$1,352,844.28
NPV Operating Costs	$0.00
NPV Capital Costs	$466,712.06
Total Costs	$466,712.06
Benefit:Cost Ratio	2.90

Description

This concept would upgrade the traffic signal system along Business Route 22 in Wilkins and Monroeville with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 14 signals from Rodi Road to the Pennsylvania Turnpike would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The signals along Route 30 recently upgraded and retimed by SPC in Phase 1 of their Regional Traffic Signals Program. The cost estimate assumes the installation of adaptive signals for both routes.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 75

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$757,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$151,000.00
ROW	$0.00
Total	$908,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	1375 hr
Value of Travel Time (Annual)	$4,325,625.24
Automobile Operating Costs (Annual)	$2,639,599.60
Safety (Annual)	$967,263.86
Total	$7,932,488.70
Emissions (Annual)	
CO2	-44056 kg
NOx	-83 kg
VOC	-124 kg
Benefit:Cost Ratio	
NPV Benefits	$34,446,034.94
NPV Operating Costs	$0.00
NPV Capital Costs	$889,650.06
Total Costs	$889,650.06
Benefit:Cost Ratio	38.72

Description

This concept would upgrade the traffic signal system along Second Avenue/Irvine Street (SR 885) in the City of Pittsburgh with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 8 signals from the Glenwood Bridge to Greenfield Avenue would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to City's central system, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 76

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$146,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$29,000.00
ROW	$0.00
Total	$175,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	131 hr
Value of Travel Time (Annual)	$413,374.48
Automobile Operating Costs (Annual)	$252,250.96
Safety (Annual)	$210,131.86
Total	$875,757.30
Emissions (Annual)	
CO2	-4210 kg
NOx	-8 kg
VOC	-12 kg
Benefit:Cost Ratio	
NPV Benefits	$3,802,888.04
NPV Operating Costs	$0.00
NPV Capital Costs	$172,190.33
Total Costs	$172,190.33
Benefit:Cost Ratio	22.09

Description

This concept would upgrade the traffic signal system along William Penn Highway in Churchill with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 2 signals from Greensburg Pike to US Route 22 would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 77

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$48,800.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$9,800.00
ROW	$0.00
Total	$58,600.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	97 hr
Value of Travel Time (Annual)	$306,269.80
Automobile Operating Costs (Annual)	$186,893.13
Safety (Annual)	$74,768.33
Total	$567,931.26
Emissions (Annual)	
CO2	-3119 kg
NOx	-6 kg
VOC	-9 kg
Benefit:Cost Ratio	
NPV Benefits	$2,466,184.41
NPV Operating Costs	$0.00
NPV Capital Costs	$57,396.78
Total Costs	$57,396.78
Benefit:Cost Ratio	42.97

Description

This concept would retime the traffic signal at the intersection of Ardmore Boulevard and Brinton Road/Marlborough Avenue in Forest Hills with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 78

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$24,403.72
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$4,900.00
ROW	$0.00
Total	$29,303.72
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	43 hr
Value of Travel Time (Annual)	$135,379.60
Automobile Operating Costs (Annual)	$82,753.10
Safety (Annual)	$54,124.87
Total	$272,257.58
Emissions (Annual)	
CO2	-1380 kg
NOx	-3 kg
VOC	-4 kg
Benefit:Cost Ratio	
NPV Benefits	$1,182,251.16
NPV Operating Costs	$0.00
NPV Capital Costs	$28,698.77
Total Costs	$28,698.77
Benefit:Cost Ratio	41.20

Description

This concept would upgrade the traffic signal system along the Boulevard of the Allies in the City of Pittsburgh with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors. For this evaluation, it was assumed that 5 signals from Craft Avenue to Dawson Street would be upgraded.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans.

These signals were recently upgraded and retimed by SPC in Phase 1 of their Regional Traffic Signals Program, and this concept is not being advanced.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to City's central system, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 79

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$970,000.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$190,000.00
ROW	$0.00
Total	$1,160,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Daily)	235 hr
Value of Travel Time (Annual)	$739,646.27
Automobile Operating Costs (Annual)	$451,349.78
Safety (Annual)	$265,078.36
Total	$1,456,074.41
Emissions (Annual)	
CO2	-7533 kg
NOx	-14 kg
VOC	-21 kg
Benefit:Cost Ratio	
NPV Benefits	$6,322,856.80
NPV Operating Costs	$0.00
NPV Capital Costs	$1,138,874.30
Total Costs	$1,138,874.30
Benefit:Cost Ratio	5.55

Description

This concept would retime the traffic signal at the intersection of Ardmore Boulevard /Ross Avenue and Penn Avenue in Wilkinsburg with retiming, phasing modifications, signal system interconnection, and potentially with adaptive traffic signal timing technology. This is similar to the SINC and SINC-UP programs implemented by SPC in other regional corridors.

This concept does not include complete upgrades of traffic signals or replacement of signal heads, poles, conduit or other signal hardware beyond that needed to support the new coordinated timing plans. The cost estimate assumes the installation of adaptive signals.

Utility impacts are not anticipated.

Transportation Impacts

Costs and benefits for corridor-level signal retiming projects were estimated based upon data from SPC's Regional Traffic Signals Program, adjusted for traffic volumes and corridor size. The projected benefits are shown in the summary table at right. Signal retiming projects typically only provide benefits for a limited time, as traffic patterns, change, and retiming would be required on a regular basis to maintain optimal operation.

Benefits from adaptive signals should be somewhat higher, as the signals would reoptimize for changing traffic patterns throughout the day, and on an ongoing basis, reducing or eliminating the need for periodic retiming.

In addition to reduced delay, fuel consumption and emissions, there is a potential for improved safety from fewer vehicle stops in coordinated corridors.

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of installation of traffic signals where no substantial land acquisition or traffic disruption would occur.

ROW Impacts

This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT

Installation of upgraded signal equipment is anticipated to take place under temporary, short-term traffic control measures.

ITS Strategies

Connect signals to District 11 Traffic Management Center, and incorporate adaptive control.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Research published in 2015 indicates the installation of adaptive traffic signals can reduce crash frequency at intersections by 17%.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 80

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$24,403.39
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$4,900.00
ROW	$0.00
Total	$29,303.39
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	7 hr
Value of Travel Time (Annual)	$31,452.25
Automobile Operating Costs (Annual)	$17,516.87
Safety (Annual)	$56,384.36
Total	$105,353.48
Emissions (Annual)	
CO2	-52926 kg
NOx	-106 kg
VOC	-114 kg
Benefit:Cost Ratio	
NPV Benefits	$457,486.90
NPV Operating Costs	$0.00
NPV Capital Costs	$28,698.39
Total Costs	$28,698.39
Benefit:Cost Ratio	15.94

Description

This concept would provide a new, two-lane arterial roadway along the Monongahela River from the Turtle Creek Valley to Second Avenue, to provide an alternative to the Parkway East for shorter trips originating south of the Parkway East, an area with few alternate routes.

For this study, the alignment was evaluated solely on its ability to affect traffic patterns and congestion on the Parkway East. A full study of the transportation needs and impacts on the Mon Valley is beyond the scope of this study.

To reduce costs, this concept assumed the use of existing Braddock Avenue from the Tri-Boro Expressway in East Pittsburgh, through Braddock to a location adjacent to the Rankin Bridge ramps and the Carrie Furnace site access road.

From this point west, a two-lane arterial continues parallel to the existing railroad tracks, passing under the Homestead Grays Bridge, and connecting with Second Avenue (SR 885) just north of the Glenwood Bridge. One signalized intersection is proposed, with an access road that would connect to Old Browns Hill Road near Nine Mile Run.

Significant structural engineering is required along this roadway. Between Duck Hollow and the Homestead Grays Bridge, a 4,000-foot viaduct would be required to straddle the existing CSX Railway line.

Extensive retaining walls would be required to hold back the steep hillside along the river. These walls have a total length of 15,450 feet.

Moderate utility impacts are anticipated. Due to lack of access and no existing plans, utilities cannot be determined within the proposed construction area. A 5% contingency of the construction cost was utilized for the preliminary estimate.

Transportation Impacts

Simulation modeling indicated that a new roadway would only attract a modest amount of traffic, about a bidirectional total of 246 vehicles per hour from the Parkway East. Although relatively modest, this would reduce peak-direction travel times by up to 354 seconds. Diverted traffic is almost exclusively between Squirrel Hill and Edgewood/Swissvale interchanges, with little traffic shown west of the Homestead Grays Bridge.

Forecasting full traffic volumes on this new roadway was beyond the scope of this project, which was only evaluating the impacts on the Parkway East corridor network. This concept might attract significant additional traffic from the South Hills and Mon Valley communities from other transportation corridors.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

ROW Impacts

Significant ROW takes are required for this concept, many of them partial, totaling 1.7 million square feet in acquisitions affecting 4 buildings. This also requires vertical easement from CSX Railroad for the proposed viaduct.

ITS Strategies

No applicable ITS strategies.

Environmental Features

This concept would involve Section 106 coordination regarding the Baltimore and Ohio Railroad Historic District. It would involve coordination with Swissvale Memorial Park which would be considered a Section 4(f) Resource and also involve coordination regarding the Section 6(f) LWCF Grants that the park had received. Frick Park's boundary also potentially extends to just behind Duck Hollow and this concept could impact park woodland and the under construction Nine Mile Trail. Land and Water Conservation Funds were used at Frick Park for the "Frick Park Trail". Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries. The concept crosses Nine Mile Run and its floodplain. There is a boat launch at Nine Mile Run and trailheads for the Tree Rivers Heritage Trail which is adjacent to this alternative. One captive hazardous waste site, Almono LP is located within the concept. A NPDES permit may be required.

MPT

The roadway would be constructed primarily in a new alignment, with little impact on existing roadways. Connections to existing roads would require short-term traffic control.

Safety Benefits

Safety performance functions for the Parkway East and the new roadway indicate that the migration of AADT from the Parkway to the new roadway will reduce PDO crash frequency by 4%, but no change in fatal and injury crash frequency will be realized.

Other Potential Issues

New capacity in this corridor could be highly controversial, as a legacy of the planned Mon-Fayette expressway. There could be a need for railroad relocation near the Glenwood Bridge.

SUMMARY OF COSTS AND BENEFITS
Concept 82

Construction Cost	
Supplemental Roadway Construction	$11,000,000.00
Earthwork	$10,000,000.00
Pavement	$15,000,000.00
Walls	$122,000,000.00
Bridges	$84,000,000.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$12,000,000.00
Additional Lump Sum	$20,000,000.00
Design and PM	$55,000,000.00
ROW	$353,381.88
Total	$329,353,381.88
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	1041 hr
Value of Travel Time (Annual)	$4,607,461.66
Automobile Operating Costs (Annual)	$1,060,176.47
Safety (Annual)	$145,463.70
Total	$5,813,101.83
Emissions (Annual)	
CO2	-16480196 kg
NOx	-105538 kg
VOC	-125714 kg
Benefit:Cost Ratio	
NPV Benefits	$87,329,085.61
NPV Operating Costs	$0.00
NPV Capital Costs	$322,231,453.09
Total Costs	$322,231,453.09
Benefit:Cost Ratio	0.27

Description

This concept consists of providing a continuous bicycle and pedestrian connection between the Eliza Furnace Trail and the Junction Hollow Trail, replacing the current indirect route along Second Avenue, Greenfield Avenue and Saline Street.

As shown, the trail would extend at-grade from the existing trail head through the surface parking lot separated by pavement markings and delineators, with a crossing of traffic at the lot entrance. An alternate routing along the lot perimeter would be completely separated but more circuitous.

North of the lot, the trail would be constructed parallel to the CSX Railroad tracks under the Swinburne and I-376 bridges. This would require retaining walls to support Swinburne Street.
The trail would pass over Boundary Street on a 200-foot long structure, and would come to grade to meet the existing Junction
Hollow Trail near the soccer fields.

Bicycle access to Greenfield Avenue and Second Avenue would remain via the site driveway or via Boundary Street.

Minor utility impacts are anticipated. Utility impacts can be minimized during the trail design process.

Transportation Impacts

Bicycle commuting forecasts were derived from using existing average daily bicycle counts on the Three Rivers Eliza Furnace Trail (2014) and the 2014 American Community Survey (ACS) data on percent of work trips made by bicycle, by Census Tract. With improved bicycle facilities, it is estimated that bicycle ridership could reach 4.1% of trips made (as currently exists in other Census Tracts with good bicycle infrastructure).

This 4.1% bicycle ridership was then applied to the applicable Traffic Analysis Zone (TAZ) level person trip origin/ destination data to forecast the expected number of annual trips between TAZ's that adjoin the proposed bike trail and the Central Business District that would be accommodated by bicycle. What is not included in the forecast is discretionary recreational trips that would be generated by the construction of the trail.

In addition to serving a portion of the approximately 686 daily bicycle trips already taken on the Eliza Furnace Trail, construction of the Bike Trail Connection to Junction Hollow is forecasted to generate 6 new daily bicycle trips and 1,004 new annual bicycle trips. This does not account for additional trips due to population growth or travel pattern changes.

Construction of the Bike Trail Connection to Junction Hollow is projected to yield the following annual environmental benefits (based on EPA standard formulas):

- VMT reduction of 6,825
- 286.7 gallons of fuel
- 15.5 lbs. of VOC
- 141.1 lbs. of CO
- 10.4 lbs. of NO_x
- 0.07 lbs. of PM_{10}
- 0.06 lbs. of $PM_{2.5}$
- 5,531.5 lbs. of CO_2

Environmental Features

This concept would require coordination with the Great Allegheny Passage Trail, which is a Section 4(f) resource. A Section 4 (f) form would be required. The Four Mile Run Playground is adjacent to the concept. One EPA Waste Site is located near the concept. A NPDES permit may be required.

ROW Impacts

7 partial takes are proposed totaling 44,813 sf. The trail would eliminate 8 parking spaces from a commercial business. No residential impacts are anticipated.

MPT

Phase 1: Construct trail on new alignment, including bridge over Boundary Street. This could require short-term closures of Boundary Street.
Phase 2. Construct tie-in to existing trail using short-term traffic control.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Cyclists and pedestrians would be provided with a convenient alternative to the existing circuitous routing on a narrow walkway.

Other Potential Issues

Trail alignment is on a narrow alignment adjacent to CSX right-of-way, and railroad coordination may be required.

SUMMARY OF COSTS AND BENEFITS
Concept 85

Construction Cost	
Supplemental Roadway Construction	$70,000.00
Earthwork	$180,000.00
Pavement	$190,000.00
Walls	$1,370,000.00
Bridges	$1,570,000.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$70,000.00
Additional Lump Sum	$350,000.00
Design and PM	$760,000.00
ROW	$120,000.00
Total	$4,680,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Mobility Benefits	$26,743.24
Health Benefits	$88,521.73
Decreased Auto Use	$8,913.45
Total	$124,178.43
Emissions (Annual)	
CO2	-2523 kg
NOx	-5 kg
VOC	-7 kg
Benefit:Cost Ratio	
NPV Benefits	$1,865,508.06
NPV Operating Costs	$0.00
NPV Capital Costs	$4,590,152.35
Total Costs	$4,590,152.35
Benefit:Cost Ratio	0.41

Description

This concept extends a bike trail from the City Public Work facility on Second Avenue, over CSX Railroad, along Saline Street, then along the north side of I-376 to connect in with a potential park-and-ride facility at an existing parking lot on Forward Avenue. This concept would link Squirrel Hill neighborhoods with Downtown via the Three Rivers Heritage Eliza Furnace Trail. The existing park-and-ride lot located at Forward Avenue could offer park-and-ride opportunities for those seeking to access the bike trail via car.

As shown, the trail would extend at-grade from the existing trail head through the surface parking lot separated by pavement markings and delineators, with a crossing of traffic at the lot entrance. An alternate routing along the lot perimeter would be completely separated but more circuitous.

Minor utility impacts are anticipated. Utility impacts can be minimized during the trail design process.

ROW Impacts

Creation of the trail would eliminate 110 parking space from several businesses, Saint John Chrysostom Byzantine Catholic Church, and numerous residences. The bike trail would require 15 partial takes and 5 total takes totaling 114,378 sf. 3 residential parcels, 8 parcels from the City of Pittsburgh, Four Mile Run Park, and Schenley Park would be impacted.

Transportation Impacts

Bicycle commuting forecasts were derived from existing average daily bicycle counts on the Three Rivers Eliza Furnace Trail (2014) and the 2014 American Community Survey (ACS) data on percent of work trips made by bicycle, by Census Tract. With improved bicycle facilities, it is estimated that bicycle ridership could reach 4.1% of trips made (as currently exists in other Census Tracts with good bicycle infrastructure). This 4.1% bicycle ridership was then applied to the applicable Traffic Analysis Zone (TAZ) level person trip origin/ destination data to forecast the expected number of annual trips between TAZ's that adjoin the proposed bike trail and the Central Business District that would be accommodated by bicycle. What is not included in the forecast is discretionary recreational trips that would be generated by the construction of the trail.

In addition to serving a portion of the approximately 686 daily bicycle trips currently taken on the Eliza Furnace Trail, construction of the Bike Trail Connection to Saline Street is forecasted to generate 24 new daily bicycle trips and 4,384 new annual bicycle trips. This does not account for additional trips due to population growth or travel pattern changes.

Construction of the Bike Trail Connection to Saline Street is projected to yield the following annual environmental benefits (based on EPA standard formulas):

- VMT reduction of 40,330.2
- 1,693.9 gallons of fuel
- 91.7 lbs. of VOC
- 834 lbs. of CO
- 61.5 lbs. of NO_x
- 0.39 lbs. of PM_{10}
- 0.36 lbs. of $PM_{2.5}$
- 32,686.8 lbs. of CO_2

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the Schenley Park Historic District. It would also involve coordination with Schenley Park regarding recreational uses. This concept would require coordination with the Great Allegheny Passage Trail, which is a Section 4(f) resource. The Four Mile Run Playground would be impacted by this concept. Section 4(f) forms would be expected. Land and Water Conservation Funds were used at the Schenley Park Fountain and Oval. Section 6(f) coordination should also be initiated to confirm that the concept is located outside of the Section 6(f) boundaries. One EPA Waste site is located near the concept. A NPDES permit may be required.

MPT

Requires short term temporary traffic control along Saline Street, coordination with the railroad, temporary right shoulder closure of Forward Avenue I-376 westbound on ramp.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Cyclists and pedestrians would be provided with a separated alternative to existing on-street routes to Squirrel Hill.

Other Potential Issues

Coordination with CSX railroad.

SUMMARY OF COSTS AND BENEFITS
Concept 86A

Construction Cost	
Supplemental Roadway Construction	$300,000.00
Earthwork	$1,200,000.00
Pavement	$700,000.00
Walls	$18,700,000.00
Bridges	$500,000.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$400,000.00
Additional Lump Sum	$1,800,000.00
Design and PM	$4,700,000.00
ROW	$1,100,000.00
Total	$29,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Mobility Benefits	$27,469.39
Health Benefits	$90,925.31
Decreased Auto Use	$29,803.10
Total	$148,197.80
Emissions (Annual)	
CO2	-14906 kg
NOx	-28 kg
VOC	-42 kg
Benefit:Cost Ratio	
NPV Benefits	$2,226,346.41
NPV Operating Costs	$0.00
NPV Capital Costs	$28,741,889.66
Total Costs	$28,741,889.66
Benefit:Cost Ratio	0.08

Description

This concept extends a bike trail from the City Public Work facility on Second Avenue, over the CSX Railroad, along Saline Street, to a set of stairs to the intersection of Greenfield Ave and Pocusset St, where the City of Pittsburgh is constructing a pedestrian crossing. Bicyclists can then connect to the Pocusset Street bike trail through Schenley Park, linking Squirrel Hill neighborhoods with Greenfield, and eventually Downtown via the Three Rivers Heritage Eliza Furnace Trail. The existing park-and-ride lot located at Forward Avenue could offer park-and-ride opportunities for those seeking to access the bike trail via car.

As shown, the trail would extend at-grade from the existing trail head through the surface parking lot separated by pavement markings and delineators, with a crossing of traffic at the lot entrance. An alternate routing along the lot perimeter would be completely separated but more circuitous. Minor utility impacts are anticipated. Utility impacts can be minimized during the trail design process.

ROW Impacts

Creation of the trail would eliminate 110 parking space from several businesses, Saint John Chrysostom Byzantine Catholic Church, and numerous residences. The bike trail will require 7 partial takes and 4 total takes totaling 52,615 sf. Four Mile Run Park, and Schenley Park will be impacted.

Transportation Impacts

Bicycle commuting forecasts were derived from existing average daily bicycle counts on the Three Rivers Eliza Furnace Trail (2014) and the 2014 American Community Survey (ACS) data on percent of work trips made by bicycle, by Census Tract. With improved bicycle facilities, it is estimated that bicycle ridership could reach 4.1% of trips made (as currently exists in other Census Tracts with good bicycle infrastructure). This 4.1% bicycle ridership was then applied to the applicable Traffic Analysis Zone (TAZ) level person trip origin/ destination data to forecast the expected number of annual trips between TAZ's that adjoin the proposed bike trail and the Central Business District that would be accommodated by bicycle. What is not included in the forecast is discretionary recreational trips that would be generated by the construction of the trail.

In addition to serving a portion of the approximately 686 daily bicycle trips currently taken on the Eliza Furnace Trail, construction of the Bike Trail Connection to Saline Street is forecasted to generate 19 new daily bicycle trips and 3,468 new annual bicycle trips. This does not account for additional trips due to population growth or travel pattern changes.

Construction of the Bike Trail Connection to Saline Street is projected to yield the following annual environmental benefits (based on EPA standard formulas):

- VMT reduction of 29,760.59
- 1,249,94 gallons of fuel
- 67.7 lbs. of VOC
- 615.45 lbs. of CO
- 45.37 lbs. of NO_x
- 0.29 lbs. of PM_{10}
- 0.27 lbs. of $PM_{2.5}$
- 24,120.36 lbs. of CO_2

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East and the Schenley Park Historic District. It would also involve coordination with Schenley Park regarding recreational uses. This concept would require coordination with the Great Allegheny Passage Trail, which is a Section 4(f) resource. The Four Mile Run Playground would be impacted by this concept. Section 4(f) forms would be expected. 1 EPA Waste site is located near the concept. A NPDES permit may be required.

MPT

Requires short term temporary traffic control along Saline Street, coordination with the railroad, temporary right shoulder closure of Forward Avenue I-376 westbound on ramp.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Cyclists and pedestrians would be provided with a separated alternative to existing on-street routes to Squirrel Hill.

Other Potential Issues

Coordination with CSX railroad.

SUMMARY OF COSTS AND BENEFITS
Concept 86B

Construction Cost	
Supplemental Roadway Construction	$100,000.00
Earthwork	$800,000.00
Pavement	$1,000,000.00
Walls	$10,400,000.00
Bridges	$500,000.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$400,000.00
Additional Lump Sum	$1,100,000.00
Design and PM	$2,900,000.00
ROW	$200,000.00
Total	$17,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Mobility Benefits	$27,272.79
Health Benefits	$90,274.56
Decreased Auto Use	$19,279.18
Total	$136,826.53
Emissions (Annual)	
CO2	-10999 kg
NOx	-21 kg
VOC	-31 kg
Benefit:Cost Ratio	
NPV Benefits	$2,055,518.05
NPV Operating Costs	$0.00
NPV Capital Costs	$17,044,805.61
Total Costs	$17,044,805.61
Benefit:Cost Ratio	0.12

Description
This concept extends the existing Duck Hollow paved bike trail to both the east and west along the north shore of the Monongahela River. The western extension would provide a connection to Second Avenue in Hazelwood in the vicinity of the Glenwood Bridge. The eastern extension would connect the existing trail head parking area at Nine Mile Run to the Carrie Furnace Site near the Rankin Bridge. The finished concept would connect Braddock and other eastern neighborhoods with Hazelwood, the Almono site, and Downtown.

The existing Duck Hollow Trail currently ends abruptly at a fence blocking active railroad tracks beneath the Glenwood Bridge.
Minor utility impacts are anticipated. Utility impacts can be minimized during the trail design process.

ROW Impacts
This alignment would require partial takes of 8 properties, for a total take of 13.97 acres. All 8 properties are currently vacant. Easements would be required from the Baltimore & Ohio Railroad Company and the City of Pittsburgh. The proposed trail goes through and terminates within the Carrie Furnace Site currently slated for development. Right-of-way impacts through the site would require further investigation.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Safety Benefits
Bicyclists and pedestrians would be provided with a separated alternate to existing on-street routes.

Transportation Impacts
Bicycle commuting forecasts were derived from existing average daily bicycle counts on the Three Rivers Eliza Furnace Trail (2014) and the 2014 American Community Survey (ACS) data on percent of work trips made by bicycle, by Census Tract. With improved bicycle facilities, it is estimated that bicycle ridership could reach 4.1% of trips made (as currently exists in other Census Tracts with good bicycle infrastructure). This 4.1% bicycle ridership was then applied to the applicable Traffic Analysis Zone (TAZ) level person trip origin/ destination data to forecast the expected number of annual trips between TAZ's that adjoin the proposed bike trail and the Central Business District that would be accommodated by bicycle. What is not included in the forecast is discretionary recreational trips that would be generated by the construction of the trail.

In addition to serving a portion of the approximately 686 daily bicycle trips currently taken on the Eliza Furnace Trail, construction of the Bike Trail Hazelwood to Braddock is forecasted to generate 15 new daily bicycle trips and 2,642 new annual bicycle trips. This does not account for additional trips due to population growth or travel pattern changes.

Construction of the Bike Trail Hazelwood to Braddock is projected to yield the following annual environmental benefits (based on EPA standard formulas):

- VMT reduction of 33,828.1
- 1,420.4 gallons of fuel
- 76.9 lbs. of VOC
- 699.4 lbs. of CO
- 51.6 lbs. of NO_x
- 0.33 lbs. of PM_{10}
- 0.31 lbs. of $PM_{2.5}$
- 27,408.9 lbs. of CO_2

Environmental Impacts
Coordination with the Three Rivers Heritage Trail regarding these improvements and a Section 4(f) form would be expected. Coordination with the Nine Mile Trail would be expected. This concept could involve Section 106 coordination regarding the Baltimore and Ohio Railroad Historic District and the Pittsburgh and Lake Erie Railroad Historic District. A portion of the concept is located in the floodplain of the Monongahela River which is adjacent. Carrie Furnace is a Rivers of Steel National Heritage Area. Section 106 coordination regarding the Carrie Blast Furnaces would be required. The Carrie Furnace site is slated for development. A NPDES permit may be required.

MPT
Connecting to Second Avenue Route 885 would be accomplished with temporary lane closures.

ITS Strategies
No applicable ITS strategies.

Other Potential Issues
Crossing the active railroad tracks in the vicinity of the Glenwood Bridge to connect with Second Avenue, ALMONO and the Eliza Furnace Trail could be accomplished as follows:

Provide a 500-foot ramp up to the existing Glenwood Bridge sidewalk. The existing sidewalk or bridge deck would carry the trail across the tracks.

Provide a 500-foot ramp and a new Bike/Pedestrian structure parallel to the Glenwood Bridge to cross the railroad tracks.

SUMMARY OF COSTS AND BENEFITS
Concept 89

Construction Cost	
Supplemental Roadway Construction	$170,000.00
Earthwork	$1,770,000.00
Pavement	$1,620,000.00
Walls	$1,080,000.00
Bridges	$870,000.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$120,000.00
Additional Lump Sum	$520,000.00
Design and PM	$1,230,000.00
ROW	$80,000.00
Total	$7,460,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Mobility Benefits	$27,095.22
Health Benefits	$89,686.78
Decreased Auto Use	$65,395.47
Total	$182,177.47
Emissions (Annual)	
CO2	-124994 kg
NOx	-234 kg
VOC	-350 kg
Benefit:Cost Ratio	
NPV Benefits	$2,736,816.31
NPV Operating Costs	$0.00
NPV Capital Costs	$7,308,872.55
Total Costs	$7,308,872.55
Benefit:Cost Ratio	0.37

Description

This concept extends a bicycle trail through the Almono development site from the intersection of Second Avenue at Hot Metal Street to the intersection of Second Avenue and Hazelwood Avenue. The trail would be constructed on streets to rebuilt as part of the site development.

Minor utility impacts are anticipated. Utility impacts can be minimized during the trail design process.

No further analysis was conducted on this alternative as this improvement is being constructed under site work as part of the Almono project.

Transportation Impacts

Bicycle commuting forecasts were derived from existing average daily bicycle counts on the Three Rivers Eliza Furnace Trail (2014) and the 2014 American Community Survey (ACS) data on percent of work trips made by bicycle, by Census Tract. With improved bicycle facilities, it is estimated that bicycle ridership could reach 4.1% of trips made (as currently exists in other Census Tracts with good bicycle infrastructure). This 4.1% bicycle ridership was then applied to the applicable Traffic Analysis Zone (TAZ) level person trip origin/ destination data to forecast the expected number of annual trips between TAZ's that adjoin the proposed bike trail and the Central Business District that would be accommodated by bicycle. What is not included in the forecast is discretionary recreational trips that would be generated by the construction of the trail.

In addition to serving a portion of the approximately 686 daily bicycle trips currently taken on the Eliza Furnace Trail, construction of the Bike Trail Through Hazelwood/ Almono is forecasted to generate 4 new daily bicycle trips and 723 new annual bicycle trips. This does not account for additional trips due to population growth or travel pattern changes.

Construction of the Bike Trail Through Hazelwood/ Almono is projected to yield the following annual environmental benefits (based on EPA standard formulas):

- VMT reduction of 5,785.9
- 243 gallons of fuel
- 13.2 lbs. of VOC
- 119.7 lbs. of CO
- 8.8 lbs. of NO_x
- 0.06 lbs. of PM_{10}
- 0.05 lbs. of $PM_{2.5}$
- 4,689.4 lbs. of CO_2

Environmental Features

This area was once part of the Jones & Laughlin South Side Steel Works which was a historic district but it has been demolished. Several EPA Waste Sites are located nearby. Coordination would be needed with the Three Rivers Heritage Trail. This area is slated for development. A NPDES permit may be required.

ROW Impacts

These trails would be designated within the street right-of-way anticipated to be dedicated by the City of Pittsburgh to serve the proposed development.

MPT

Construction would be concurrent with Almono Signature Boulevard and would be completed with little impact to the traveling public.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Bicyclists and pedestrians would be provided with a separated alternate to existing on-street routes.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 90

Construction Cost	
Supplemental Roadway Construction	$7,000.00
Earthwork	$0.00
Pavement	$468,000.00
Walls	$0.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$12,000.00
Additional Lump Sum	$108,000.00
Design and PM	$119,000.00
ROW	$0.00
Total	$714,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Mobility Benefits	$26,683.00
Health Benefits	$89,686.78
Decreased Auto Use	$26,757.06
Total	$143,126.84
Emissions (Annual)	
CO2	-2138 kg
NOx	-4 kg
VOC	-6 kg
Benefit:Cost Ratio	
NPV Benefits	$2,150,166.37
NPV Operating Costs	$0.00
NPV Capital Costs	$699,056.76
Total Costs	$699,056.76
Benefit:Cost Ratio	3.08

Description

This concept would provide a trail connection from South Oakland to the Eliza Furnace Trail, consisting of a sloped alignment from the western end of Lawn Street, following hillside contours to an unused pedestrian tunnel under the Parkway East to the trail.

Minor utility impacts are anticipated. Utility impacts can be minimized during the trail design process.

Transportation Impacts

Bicycle commuting forecasts were derived from existing average daily bicycle counts on the Three Rivers Eliza Furnace Trail (2014) and the 2014 American Community Survey (ACS) data on percent of work trips made by bicycle, by Census Tract. With improved bicycle facilities, it is estimated that bicycle ridership could reach 4.1% of trips made (as currently exists in other Census Tracts with good bicycle infrastructure). This 4.1% bicycle ridership was then applied to the applicable Traffic Analysis Zone (TAZ) level person trip origin/ destination data to forecast the expected number of annual trips between TAZ's that adjoin the proposed bike trail and the Central Business District that would be accommodated by bicycle. What is not included in the forecast is discretionary recreational trips that would be generated by the construction of the trail.

In addition to serving a portion of the approximately 686 daily bicycle trips currently taken on the Eliza Furnace Trail, construction of the South Oakland Eliza Furnace Bike Trail Access is forecasted to generate 9 new daily bicycle trips and 1,683 new annual bicycle trips. This does not account for additional trips due to population growth or travel pattern changes.

Construction of the South Oakland Eliza Furnace Bike Trail Access is projected to yield the following annual environmental benefits (based on EPA standard formulas):

- VMT reduction of 7,403.6
- 311 gallons of fuel
- 16.8 lbs. of VOC
- 153.1 lbs. of CO
- 11.3 lbs. of NO_x
- 0.07 lbs. of PM_{10}
- 0.07 lbs. of $PM_{2.5}$
- 6,000.5 lbs. of CO_2

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. This concept would involve coordination with the GAP Trail.

ROW Impacts

This alignment would require partial or full takes of 29 properties, for a total take of 141,500 sf. All 29 properties are currently vacant.

MPT

Requires temporary right shoulder closure of I-376 westbound short term lane restrictions on the Eliza Furnace Trail and Second Avenue.

ITS Strategies

No applicable ITS strategies.

Design Exceptions

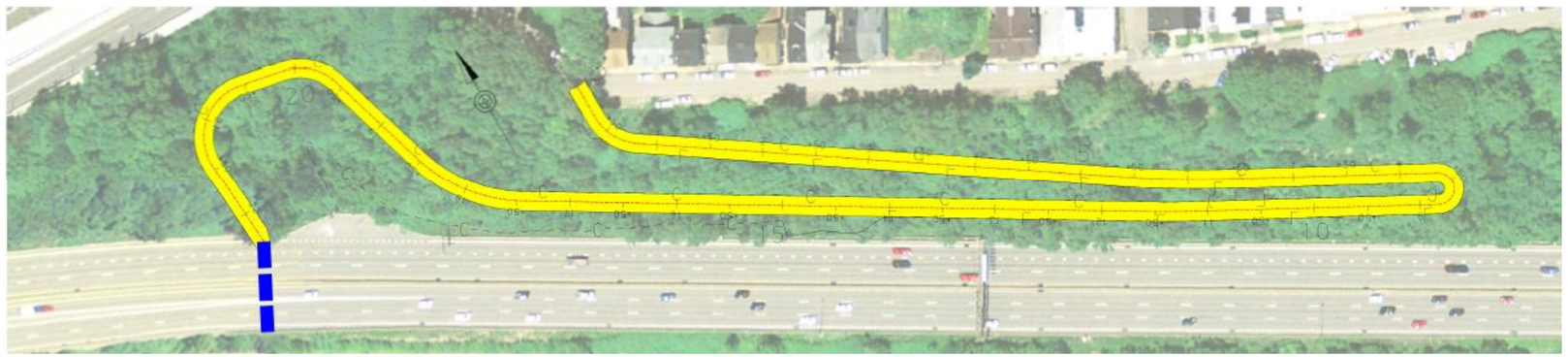
No design exceptions are anticipated for new construction in this concept.

Safety Benefits

Cyclists and pedestrians would be provided a separate alternative to on-street routes to reach South Oakland.

Other Potential Issues

The trail alignment would replace a significant section of what is currently a wooded hillside above the Parkway East with trail and retaining walls. Reuse of the unused pedestrian tunnel could pose issues for personal safety because of its subgrade position and limited visibility from adjacent areas.



SUMMARY OF COSTS AND BENEFITS
Concept 91

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$200,000.00
Walls	$8,300,000.00
Bridges	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$100,000.00
Additional Lump Sum	$800,000.00
Design and PM	$1,900,000.00
ROW	$100,000.00
Total	$11,400,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Mobility Benefits	$26,889.11
Health Benefits	$89,004.54
Decreased Auto Use	$7,383.43
Total	$123,277.08
Emissions (Annual)	
CO2	-2737 kg
NOx	-5 kg
VOC	-8 kg
Benefit:Cost Ratio	
NPV Benefits	$1,851,967.33
NPV Operating Costs	$0.00
NPV Capital Costs	$11,079,606.61
Total Costs	$11,079,606.61
Benefit:Cost Ratio	0.17

Description

This concept would provide a new Park and Ride facility in Monroeville, using a property that was a former car dealership and is currently for sale. The site is located on Golden Mile Highway. This location is served by Port Authority bus route P12, Holiday Park Flyer, which would provide express peak-period service to downtown Pittsburgh via the East Busway.

Without demolition of the existing building, the site would be able to accommodate approximately 100 park-and-ride parking spaces; this would allow the site to be used for commuter park-and-ride and still allow the building to be leased to a tenant with remaining parking used for tenant business.

Utility impacts are not anticipated.

Transportation Impacts

This park-and-ride location would provide access to the Holiday Park Flyer route. Using a methodology that captures 10% of the latent transit demand of the area (based on Traffic Analysis Zone [TAZ] data), this park-and-ride location has the potential to attract approximately 93 new daily riders to the Holiday Park Flyer route.

During peak periods, the Holiday Park Flyer operates on 10-15 minute headways. It is expected that 93 additional daily riders to the route would require an additional 2 buses be added to the route daily to accommodate additional ridership and provide more frequent headways.

Based on converting 93 trips between the Monroeville area and Downtown from automobile trips to transit trips due to the park-and-ride location, the expected reduction in annual Vehicle Miles Traveled (VMT) is 714,240.

The expected annual VMT reduction of 714,240 is projected to yield the following annual fuel consumption and emission reductions (based on EPA standard formulas):

- 29,998 gallons of fuel
- 1,624 lbs. of VOC
- 14,770 lbs. of CO
- 6.9 lbs. of PM_{10}
- 6.4 lbs. of $PM_{2.5}$
- 578,877 lbs. of CO_2
- 1,089 lbs. of NO_x

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of transportation corridor fringe parking facilities.

ROW Impacts

This concept would not involve designation of right-of-way, but would require leasing or purchase of property to accommodate the parking structure.

MPT

Construction, if necessary, would occur off-road.

ITS Strategies

Potential for real-time information on space availability and bus arrival to be provided.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Safety performance functions indicate the reduction in AADT will result in a 0.3% reduction in crash frequency on the Parkway East.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 95

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$0.00
ROW	$2,200,000.00
Total	$2,200,000.00
Operating Cost	
Additional service on Route P12	$297,856.00
Lot annual O&M	$50,000.00
Total	$347,856.00
User Benefits	
Travel Time (Day)	112 hr
Value of Travel Time (Annual)	$373,888.57
Automobile Operating Costs (Annual)	$107,275.84
Parking Savings (Annual)	$108,810.00
Safety (Annual)	$12,479.20
Total	$493,643.62
Emissions (Annual)	
CO2	-314246 kg
NOx	-589 kg
VOC	-879 kg
Benefit:Cost Ratio	
NPV Benefits	$9,606,226.22
NPV Operating Costs	$5,546,623.58
NPV Capital Costs	$2,156,000.00
Total Costs	$7,702,623.58
Benefit:Cost Ratio	1.25

Description

This concept would provide a new Park and Ride facility in Penn Hills, using a vacant property that was formerly a restaurant and is currently for sale. The site is located near the intersection of Rodi Road and Universal Road. This location is served by Port Authority bus route P16, Penn Hills Flyer, which would provide express peak-period service to downtown Pittsburgh via the East Busway.

The site is located near the intersection of Universal Road and Rodi Road, adjacent to the Penn No. 7 Volunteer Fire Company, in Penn Hills.

With demolition of the existing buildings, the site would be able to accommodate approximately 150 parking spaces.

Utility impacts are not anticipated.

Transportation Impacts

This park-and-ride location would provide access to the Penn Hills Flyer route. Using a methodology that captures 10% of the latent transit demand of the area (based on Traffic Analysis Zone [TAZ] data), this park-and-ride location has the potential to attract approximately 150 new daily riders to the Penn Hills Flyer route.

During peak periods, the Penn Hills Flyer operates on 15-20 minute headways. It is expected that 150 additional daily riders to the route would require an additional 4 buses be added to the route daily to accommodate additional ridership and provide more frequent headways.

Based on converting 150 trips between the Penn Hills area and Downtown from automobile trips to transit trips due to the park-and-ride location, the expected reduction in annual Vehicle Miles Traveled (VMT) is 820,800.

The expected annual VMT reduction of 820,800 is projected to yield the following annual fuel consumption and emission reductions (based on EPA standard formulas):

- 34,474 gallons of fuel
- 1,867 lbs. of VOC
- 16,974 lbs. of CO
- 1,251 lbs. of NO_x
- 7.9 lbs. of PM_{10}
- 7.4 lbs. of $PM_{2.5}$
- 665,241 lbs. of CO_2

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of transportation corridor fringe parking facilities.

ROW Impacts

This concept would not involve designation of right-of-way, but would entire leasing or purchase of property to accommodate the parking structure.

MPT

Construction, if necessary, would occur off-road.

ITS Strategies

Potential for real-time information on space availability and bus arrival to be provided.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

Safety performance functions indicate the reduction in AADT will result in a 0.5% reduction in crash frequency on the Parkway East.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 96

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$749,000.00
Walls	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$150,000.00
ROW	$685,000.00
Total	$1,584,000.00
Operating Cost	
Additional service on Route P16	$684,840.00
Lot annual O&M	$75,000.00
Total	$759,840.00
User Benefits	
Travel Time (Day)	165 hr
Value of Travel Time (Annual)	$552,792.24
Automobile Operating Costs (Annual)	$123,284.04
Parking Savings (Annual)	$175,500.00
Safety (Annual)	$20,798.67
Total	$696,874.95
Emissions (Annual)	
CO2	-361139 kg
NOx	-677 kg
VOC	-1010 kg
Benefit:Cost Ratio	
NPV Benefits	$13,105,517.31
NPV Operating Costs	$12,115,779.12
NPV Capital Costs	$1,551,888.80
Total Costs	$13,667,667.92
Benefit:Cost Ratio	0.96

Description

This concept would provide an expanded Park and Ride facility in Swissvale by constructing a deck over a municipal parking lot between Washington Avenue and Dickson Street, adjacent to the East Busway. All-day express bus service is provided on the East Busway to Oakland and Downtown Pittsburgh via Port Authority bus routes P1, P2 and P3.

This concept builds a structured parking deck over a municipal parking lot located in Swissvale. The parking structure would need to be erected in order to preserve municipal parking for local businesses while providing for parking on an upper level for park-and-ride commuters.

Such a parking structure would be able to supply about 80 parking spaces on an upper level for park-and-ride commuters while maintaining the majority of parking on the lower level for municipal parking.

Utility impacts are not anticipated.

Transportation Impacts

This park-and-ride location would provide access to the East Busway. Using a methodology that captures 10% of the latent transit demand of the area (based on Traffic Analysis Zone [TAZ] data), this park-and-ride location has the potential to attract approximately 80 new daily riders to the East Busway route.

Since the East Busway route operates with headways of 3 to 8 minutes during peak periods, it is expected that 80 additional daily riders to the route can be absorbed within the existing operations.

Based on converting 80 trips between the Swissvale area and Downtown from automobile trips to transit trips due to the park-and-ride location, the expected reduction in annual Vehicle Miles Traveled (VMT) is 249,600.

The expected annual VMT reduction of 249,600 is projected to yield the following annual fuel consumption and emission reductions (based on EPA standard formulas):

- 10,483 gallons of fuel
- 567 lbs. of VOC
- 5,162 lbs. of CO
- 381 lbs. of NO_x
- 2.4 lbs. of PM_{10}
- 2.3 lbs. of $PM_{2.5}$
- 202,296 lbs. of CO_2

Environmental Features

This concept should qualify for a Categorical Exclusion under 23 CFR 771.117(c)(8), consisting of transportation corridor fringe parking facilities.

ROW Impacts

This concept would not involve designation of right-of-way, but would entire leasing or purchase of property to accommodate the parking structure.

MPT

Construction, if necessary, would occur off-road.

ITS Strategies

Potential for real-time information on space availability and bus arrival to be provided.

Design Exceptions

This concept includes no physical construction, and thus geometric design standards are not applicable. Existing geometric conditions on the roadway would not be changed.

Safety Benefits

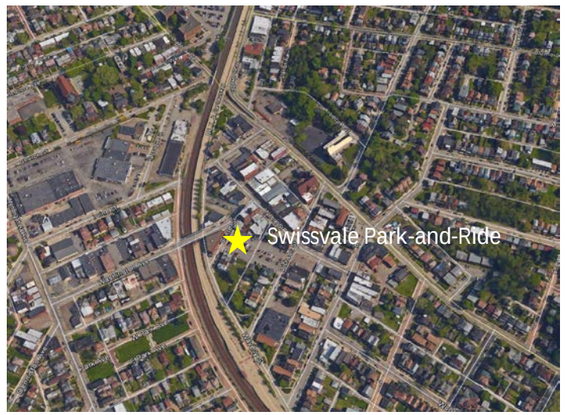
Safety performance functions indicate the reduction in AADT will result in a 0.2% reduction in crash frequency on the Parkway East.

Other Potential Issues

None identified.

SUMMARY OF COSTS AND BENEFITS
Concept 98

Construction Cost	
Supplemental Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$2,500,000.00
Walls	$0.00
Traffic Signals	$0.00
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$500,000.00
ROW	$0.00
Total	$3,000,000.00
Operating Cost	
Deck annual O&M	$272,000.00
LEASE TBD	$0.00
Total	$272,000.00
User Benefits	
Travel Time (Day)	64 hr
Value of Travel Time (Annual)	$214,416.38
Automobile Operating Costs (Annual)	$37,399.71
Parking Savings (Annual)	$93,600.00
Safety (Annual)	$2,640.78
Total	$254,456.88
Emissions (Annual)	
CO2	-109556 kg
NOx	-205 kg
VOC	-307 kg
Benefit:Cost Ratio	
NPV Benefits	$5,228,790.04
NPV Operating Costs	$4,337,086.65
NPV Capital Costs	$2,935,296.00
Total Costs	$7,272,382.65
Benefit:Cost Ratio	0.72



Description
This concept implements ramp management, as discussed in Concept 3, along with the closure of the eastbound Beechwood Boulevard on-ramp during the PM peak hour.

Through microsimulation modeling and analyses conducted to measure the impacts of implementing ramp management along the I-376 corridor, it was determined that a "peak hour / directional" management would yield the best results.

During the AM peak period, 7 ramps approaching the Squirrel Hill Tunnel in the westbound direction would be metered: Rodi Road, Business 22, Churchill, Ardmore Boulevard, Wilkinsburg, Swissvale and Edgewood.

During the PM peak 5 ramps bracketing the Squirrel Hill tunnel would be metered: Grant Street, Bates Street, Edgewood, Swissvale, and Ardmore Boulevard; and the eastbound Beechwood Boulevard on-ramp would be closed. Initial management rates at these intersections would be non-restrictive, and would not reduce access to the Parkway from any interchanges.

The cost and benefit of implementing the ramp management system along the I-376 corridor is based on this Phase 1 limited deployment strategy for a total of 13 ramps. A potential second phase of implementation would expand management capabilities to the entire corridor by installing meters on the remaining 14 ramps. This is estimated to cost an additional $2 million over the tabulated Phase 1. It would not provide substantial additional benefits under the initially recommended management scenario.

Safety Benefits
Research published in 2013 indicates ramp meters result in a 36% reduction in crash frequency in the vicinity of on-ramps.

Transportation Impacts
The model indicates that closing the eastbound Beechwood Boulevard on-ramp during the PM peak would result in a significant reduction in travel time on the eastbound Parkway. The PM peak model shows an 11.3 minute decrease in average travel time from the Grant Street on-ramp to the Squirrel Hill Tunnel.

Observation of the model indicates that the standing queue approaching the Squirrel Hill tunnel dissipated during the peak period simulation. Severe congestion was observed at the Bates Street ramp and some intermittent queueing from the Braddock Avenue on-ramp back towards the tunnel. However, the combined length of these queues and the resulting delay appears to be significantly less than the base conditions.

This appears to be due to a combination of removing friction from the merge just before the tunnel entrance, and also because of diversion of traffic off of the Parkway East. Our modeling indicated that an average of about 561 vehicles would be detoured from the closed ramp. About two-thirds of the detoured traffic would enter the Parkway using Bates Street. Most of the remainder would use alternate routes to Braddock Avenue or Penn Avenue, but some would avoid the Parkway entirely.

The detoured vehicles will travel longer distances and incur additional delays along their new routes, somewhat offsetting the benefits of the closure to Parkway traffic. Existing traffic along the alternate routes will also incur offsetting increases in delay due to the additional traffic. Such congestion will be most notable in central Oakland, on Forward Avenue and Commercial Street, on Penn Avenue and on Braddock Avenue.

Environmental Features
While no impacts on defined environmental features were identified as work is anticipated to be completely within the existing right-of-way, potential traffic impacts and concerns could require environmental documentation such as a Categorical Exclusion.

ROW Impacts
This concept is anticipated to be constructed entirely within the existing right-of-way.

MPT
Installation of ITS devices and communication equipment should be constructible under temporary, short-term traffic control measures.

ITS Strategies
Ramp management is anticipated to be integrated into the existing I-376 freeway management system at the District 11-0 Traffic Management Center.

Design Exceptions
No design exceptions are anticipated for new construction in this concept.

Other Potential Issues
Ramp management has been received skeptically, with strong opposition to any concept that would close ramps. Some public openness exists for closure of the Beechwood Boulevard ramp, but benefits would need to be explained to the public, and ramp management strategies must maintain access to the surrounding communities. A public education component and public involvement would be anticipated for this concept.

SUMMARY OF COSTS AND BENEFITS
Concept 99

Construction Cost	
Roadway Construction	$0.00
Earthwork	$0.00
Pavement	$0.00
Walls	$0.00
Bridges	$0.00
Ramp Metering	$1,685,547.72
Signage	$0.00
Utilities	$0.00
Additional Lump Sum	$0.00
Design and PM	$168,554.77
ROW	$0.00
Total	$1,854,102.49
Operating Cost	
Maintenance, Power & Comm	$16,250.00
Operations	$100,000.00
Total	$116,250.00
User Benefits	
Travel Time (Day)	10 hr
Value of Travel Time (Annual)	-$2,426,815.88
Automobile Operating Costs (Annual)	$1,191,698.35
Safety (Annual)	$848,212.09
Total	-$386,905.43
Emissions (Annual)	
CO2	-3255303 kg
NOx	-423 kg
VOC	-504 kg
Benefit:Cost Ratio	
NPV Benefits	-$5,812,404.22
NPV Operating Costs	$1,853,626.19
NPV Capital Costs	$1,817,020.44
Total Costs	$3,670,646.63
Benefit:Cost Ratio	-1.58

Description

This concept would provide hard shoulder running inbound for transit vehicles only in the AM peak period from Churchill to Edgewood Avenue, with connection via a new ramp connecting to the Port Authority's East Busway. This would provide buses an alternate route from the eastern suburbs to the Busway, providing more reliable travel times than the current route via Penn Avenue and other local streets.

Hard shoulder running for all vehicles rather than just transit was not considered, as shoulder running would not extend as far as exit 77, and vehicles would need to merge back into through traffic lanes. Effectively, this would provide additional queuing but would not increase capacity. Shoulder running could connect to a new transit only ramp and thus allow transit vehicles to bypass congestion.

The existing westbound shoulder on the Parkway would be reconstructed and widened to accommodate vehicular traffic. There would not be any shoulder widening from the Churchill on-ramp (Ramp S) to the Wilkinsburg off-ramp as transit vehicles would utilize the existing add lane in this segment. A new off-ramp to Edgewood Avenue would exit westbound I-376 in the vicinity of the Chestnut Street bridge, near an existing crossover entrance to the East Busway.

Minor utility impacts are anticipated based on assumed underground utilities.

Safety Benefits

The HSM indicates that widening the shoulder from 10 foot to 12 foot can reduce the frequency of fatal and injury crashes by 13% and PDO crashes by 6%. This may be offset to some extent by the effect of buses traveling on the shoulder during AM peak hour, but as the number of buses is small, the influence is expected to be negligible.

Transportation Impacts

Inbound busses on Port Authority bus routes P12 and P67 would be able to use HSR to access the East Busway. Outbound trips would continue to use local streets or the Parkway mainline. Currently, these routes combined provide about 24 inbound trips during the AM peak, carrying about 795 daily riders. These riders would see a reduction of travel time of about 4 minutes on each trip. During the PM peak, the suburban portion of the Parkway is generally uncongested, and HSR would provide no benefit.

Impact on general traffic would be limited. The 24 trips on the shoulder would not have a measurable effect on vehicular travel times on the Parkway mainline. These buses would be rerouted from local streets including Penn Avenue, but the reduction of 24 buses over the peak period would have a negligible impact on overall flows.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. It could also impact an unnamed tributary of Nine Mile Run. A NPDES permit and noise studies may be required.

ROW Impacts

This alignment would require 2 full takes and 3 sliver takes, all with occupied dwellings.

MPT

Construction would require closing the existing right shoulder as well as lane closures, which would take place during weekends or nighttime.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Other Potential Issues

None Identified.

SUMMARY OF COSTS AND BENEFITS
Concept 100A

Construction Cost	
Supplemental Roadway Construction	$1,400,000.00
Earthwork	$300,000.00
Pavement	$2,100,000.00
Walls	$4,500,000.00
Bridges	$16,700,000.00
Traffic Signals	$200,000.00
Signage	$1,700,000.00
Utilities	$700,000.00
Additional Lump Sum	$2,300,000.00
Design and PM	$6,000,000.00
ROW	$2,300,000.00
Total	$38,200,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0.1 hr
Value of Travel Time (Annual)	$155,279.34
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$124,186.26
Total	$279,465.60
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$1,865,625.78
NPV Operating Costs	$0.00
NPV Capital Costs	$37,436,000.00
Total Costs	$37,436,000.00
Benefit:Cost Ratio	0.05

Description

This concept would provide hard shoulder running inbound for transit vehicles only in the AM peak period from Churchill to Edgewood Avenue, with connection via a new ramp connecting to the Port Authority's East Busway. This would provide buses an alternate route from the eastern suburbs to the Busway, providing more reliable travel times than the current route via Penn Avenue and other local streets.

Hard shoulder running for all vehicles rather than just transit was not considered, as shoulder running would not extend as far as exit 77, and vehicles would need to merge back into through traffic lanes. Effectively, this would provide additional queuing but would not increase capacity. Shoulder running could connect to a new transit only ramp and thus allow transit vehicles to bypass congestion.

The existing westbound shoulder on the Parkway would be reconstructed and widened to accommodate vehicular traffic. There would not be any shoulder widening from the Churchill on-ramp (Ramp S) to the Wilkinsburg off-ramp as transit vehicles would utilize the existing add lane in this segment. A new off-ramp to Edgewood Avenue would exit westbound I-376 in the vicinity of the Chestnut Street bridge, connecting to an existing crossover entrance to the East Busway.

Minor utility impacts are anticipated based on assumed underground utilities.

Safety Benefits

The HSM indicates that widening the shoulder from 10 foot to 12 foot can reduce the frequency of fatal and injury crashes by 13% and PDO crashes by 6%. This may be offset to some extent by the effect of buses traveling on the shoulder during AM peak hour, but as the number of buses is small, the influence is expected to be negligible.

Transportation Impacts

Inbound busses on Port Authority bus routes P12 and P67 would be able to use HSR to access the East Busway. Outbound trips would continue to use local streets or the Parkway mainline. Currently, these routes combined provide about 24 inbound trips during the AM peak, carrying about 795 daily riders. These riders would see a reduction of travel time of about 4 minutes on each trip. During the PM peak, the suburban portion of the Parkway is generally uncongested, and HSR would provide no benefit.

Impact on general traffic would be limited. The 24 trips on the shoulder would not have a measurable effect on vehicular travel times on the Parkway mainline. These buses would be rerouted from local streets including Penn Avenue, but the reduction of 24 buses over the peak period would have a negligible impact on overall flows.

Environmental Features

This concept would involve Section 106 coordination regarding the eligible Penn-Lincoln Parkway East. It could also impact an unnamed tributary of Nine Mile Run. A NPDES permit and noise studies may be required.

ROW Impacts

This alignment would require 2 full takes and 14 sliver takes, all with occupied dwellings.

MPT

Construction would require closing the existing right shoulder as well as lane closures, which would take place during weekends or nighttime.

Design Exceptions

No design exceptions are anticipated for new construction in this concept.

Other Potential Issues

None Identified.

SUMMARY OF COSTS AND BENEFITS
Concept 100B

Construction Cost	
Supplemental Roadway Construction	$1,400,000.00
Earthwork	$300,000.00
Pavement	$2,100,000.00
Walls	$4,500,000.00
Bridges	$16,700,000.00
Traffic Signals	$200,000.00
Signage	$1,700,000.00
Utilities	$700,000.00
Additional Lump Sum	$2,300,000.00
Design and PM	$6,000,000.00
ROW	$2,300,000.00
Total	$38,200,000.00
Operating Cost	
Negligible	$0.00
Total	$0.00
User Benefits	
Travel Time (Day)	0.1 hr
Value of Travel Time (Annual)	$155,279.34
Automobile Operating Costs (Annual)	$0.00
Safety (Annual)	$124,186.26
Total	$279,465.60
Emissions (Annual)	
CO2	0 kg
NOx	0 kg
VOC	0 kg
Benefit:Cost Ratio	
NPV Benefits	$1,865,625.78
NPV Operating Costs	$0.00
NPV Capital Costs	$37,436,000.00
Total Costs	$37,436,000.00
Benefit:Cost Ratio	0.05