Alternatives to Buses on I-76:
SEPTA Rail Feeder Bus Study

Technical Memorandum

April 2009

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals and the public with a common vision of making a great region even greater. Shaping the way we live, work and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region - leading the way to a better future.

Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. This report was primarily funded by the Pennsylvania Department of Transportation. The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

DVRPC fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations in all programs and activities. DVRPC's website may be translated into Spanish, Russian, and Traditional Chinese online by visiting www.dvrpc.org. Publications and other public documents can be made in alternative languages or formats, if requested. For more information, please call (215) 238-2871.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Service reliability for eight SEPTA bus routes operating along the Schuylkill Expressway (I-76) has deteriorated in line with rising traffic levels and congestion on the highway. On-time performance for the routes averages 65 percent, well below SEPTA's system-wide goal of 85 percent. Alternatively, re-routing the buses to streets paralleling the highway would result in longer travel times, and be redundant to other transit services in the corridor.

SEPTA personnel recognized an opportunity to take advantage of more reliable rail service and additional regional rail car seats with the delivery of 120 regional rail cars[1] and asked staff from the Delaware Valley Regional Planning Commission (DVRPC) to participate in a proactive planning exercise which would evaluate reconfiguring the expressway bus routes as feeder routes to rail line stations in the corridor. At present, the closed-door portions of the bus routes operating along the expressway carry approximately 6,700 passengers in each direction between 5:00 AM and 10:30 PM on a typical weekday. SEPTA's intention is to operate the feeder bus service, and accommodate the transferring passengers as seamlessly as possible with the rail lines to minimize inconvenience, reduce travel times, and improve the system's reliability for its passengers.

The work was iterative to some degree, and was conducted by DVRPC staff with direct participation of SEPTA staff. Coordination took place through a series of working meetings. Major activities associated with the project were:

1. Screening preliminarily identified rail stations to a set (of seven) for further study
2. Obtaining current SEPTA passenger / ridership data for the rail, bus and study station network for the analyses
3. Determining key ridership analyses periods and service levels of the involved bus routes and rail lines
4. Stratifying ridership (on-board and transferring, in both directions, for all modes, routes and stations) into 30-minute analysis intervals
5. Computing estimates of potential transferring riders from existing on-board count data of the seven expressway bus routes
6. Calculating maximum on-board loading and seating capacity conditions for trains operating on the four rail lines in the study corridor
7. Assessing on-platform activity levels at seven candidate bus-to-rail transfer station stops, and the ability of the platforms to accommodate additional transferring passengers as a consequence of feeder bus operations
8. Designing a reconfigured feeder bus network to replace the expressway routes which as best as possible ameliorates preliminary problems or shortcomings identified in steps 5 through 7, above
9. Refining passenger estimates based on the reconfigured bus route network and reiterating steps 4 though 7 for operations planning and financial analyses (providing estimated peak vehicle needs at 80%, 100%, and 110% ridership thresholds)
10. Performing field views of the rail stations, and immediate surroundings, to assess needs and recommend improvements for access, circulation and storage of the feeder buses, and platform adequacy to accommodate additional transferring passengers
11. Estimating construction costs of the physical improvements at the station facilities, and operating costs and/or savings for the feeder bus and rail services supporting the plan
12. Assessing the travel time benefits of the potential reconfigured services

SEPTA staff asked DVRPC staff to also investigate the feasibility of providing priority lane treatments along the Schuylkill Expressway to better accommodate the performance of the bus routes—as presently configured.

Substantial analyses were prepared throughout the study, the findings of which were reported at the working meetings. Discussions and decisions at the meetings led to the next steps to take for completing the project. This report supplies a summary of the work and its major findings.

[1] Delivery is anticipated to be completed by 2012, and will yield a net increase of 47 vehicles to the regional rail car fleet.

2. Transportation Services and Facilities

The study corridor is located in the western portion of the Delaware Valley Region, near to, and straddling the Schuylkill River (**Figure 1**).[2] Transportation facilities initially selected for detailed evaluation in the corridor included seven bus routes,[3] four rail lines, seven rail station stops, and an interstate highway.

The seven bus routes currently operate line haul along part of the Schuylkill Expressway between termini in the western reaches of the corridor and Central Philadelphia on the east. Four rail lines (the R6-Norristown Line, the R6-Cynwyd Line, the R5-Paoli / Thorndale Line and the Route 100-Norristown High Speed line) parallel the expressway, and provide station stops in the bus routes' local service operating areas and in Center City. Seven intervening rail stations were identified for evaluation as transfer points between the bus routes and the rail lines following the earliest study steps. **Table 1** contains a brief description of the considered study bus routes.

Table 1: Inventory of Public Transportation Services and Facilities

Bus Route	Bus Route Termini	Potential Rail Transfer Station(s)	Rail Line
9	Andorra / Upper Roxborough to Center City / Independence Mall	Wissahickon or Ivy Ridge	R6-Norristown Regional Rail Line
27	Plymouth Meeting / Barren Hill to Center City	Wissahickon or Ivy Ridge	R6-Norristown Regional Rail Line
44	Ardmore to Independence Mall	Cynwyd or Overbrook	R6-Cynwyd Regional Rail Line or R5-Paoli / Thorndale Regional Rail Line
62	Andorra/ Roxborough / Manayunk to Center City	Ivy Ridge	R6-Norristown Regional Rail Line
121	Gladwyne to Independence Mall	Cynwyd or Overbrook	R6-Cynwyd Regional Rail Line or R5-Paoli / Thorndale Regional Rail Line
124	Center City to King of Prussia / Chesterbrook	Gulph Mills, Villanova, or Norristown	Route 100-Norristown High Speed Line, R5-Paoli / Thorndale Regional Rail Line, or R6-Norristown Regional Rail Line
125	Center City to King of Prussia / Valley Forge	Gulph Mills, Villanova, or Norristown	Route 100-Norristown High Speed Line, R5-Paoli / Thorndale Regional Rail Line, or R6-Norristown Regional Rail Line

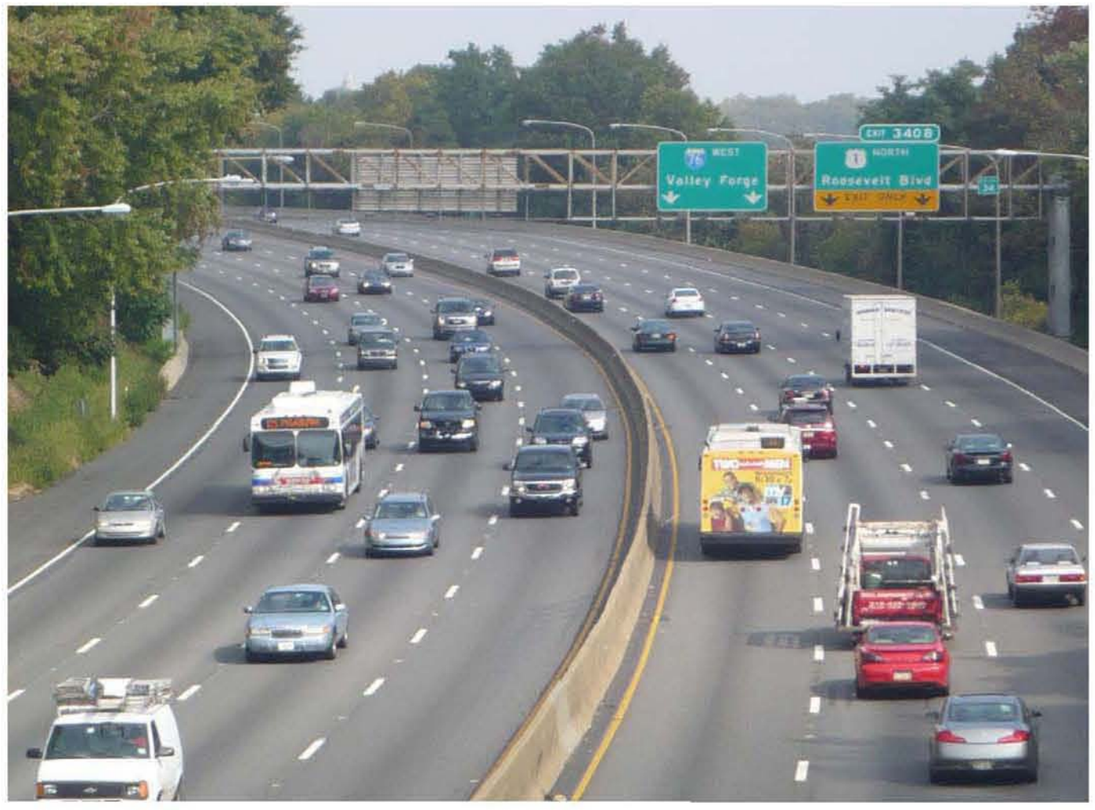
Source: SEPTA, 2008

Finally, there is the Schuylkill Expressway (I-76)—the interstate highway which serves east–west travel through the region. The highway's western terminus is the Valley Forge Interchange with the Pennsylvania Turnpike near King of Prussia. Traveling eastward, the highway traverses Center City Philadelphia, and enters southern New Jersey via the Walt Whitman Bridge. West of the US 1 interchange (City Avenue / the Roosevelt Boulevard) the "Expressway" has four travel lanes (two in each direction). Between US 1 and Center City (via 30th Street and the Vine Street Expressway, I-676) the highway provides a minimum of six travel lanes (three each way) for continuous through travel. East of Center City, I-76 typically supplies four through travel lanes (two in each direction).

[2] The stations identified in **Figure 1** represent the preliminary list of candidate stations from which seven were selected for further evaluation.
[3] Bus Route 123, operating between the 69th Street Terminal and King of Prussia, was added to the evaluations conducted in the second part of the study.

Travel lanes are 12 feet wide, and paved shoulders are provided for both directions of travel. Outside shoulders are provided for lateral clearances and emergency purposes, and vary in width. A sampling of field measurements of the outer shoulders indicated a range of widths between 7 and 14 feet (and an overall average approximating 10 feet). Inside shoulders are narrower and serve to offset the travel lanes from the median barrier. Visual observations from a "drive-through" of the highway (between Center City and Gulph Mills) indicate that the widths of the shoulder in the center median area are variable depending on the location and alignment of the highway; ranging from 1 or 2 feet wide (typical) to a maximum width of 20 feet or more.

The highway provides the closed-door, express link segment for seven bus routes operated by SEPTA from the western suburbs, through inner-ring communities, and into Center City Philadelphia. The two westernmost bus routes (Routes 124 and 125) access the highway at the Gulph Mills Interchange. The bus route on the north side of the river (Route 27) and the routes centered in the corridor (Routes 9, 62, 44, and 121) access the expressway at the City Avenue Interchange. All westbound trips (and by request eastbound trips) of the Routes 124 and 125 trips also depart the expressway at City Avenue en route from Center City to serve the Wissahickon Transportation Center—an important transfer point between bus routes servicing northern Philadelphia neighborhoods and the Routes 124 and 125 buses servicing major activity centers in the western suburbs.

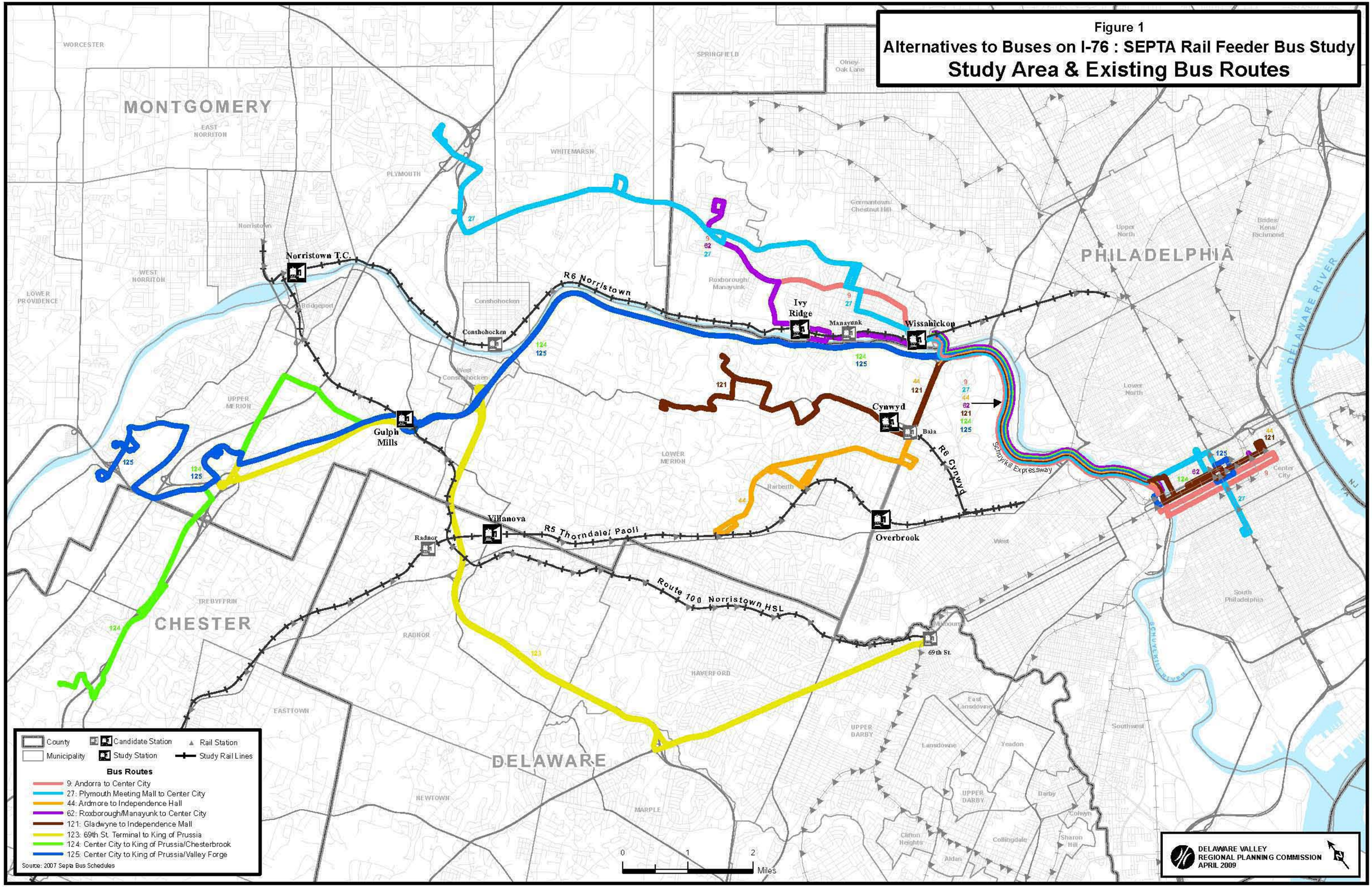


Two SEPTA buses pass one another on the Schuylkill Expressway
Photo: DVRPC, 2008

Figure 1

Alternatives to Buses on I-76 : SEPTA Rail Feeder Bus Study

Study Area & Existing Bus Routes



3. Initial "Planning" Evaluations (Tasks 3 through 7)

DVRPC used SEPTA's 2007 and 2008 ridership data to establish baseline activity on the buses and rail lines under study, and to serve in the initial assessments of the study's network of rail stations and public transportation routes. An early application of the ridership data involved aggregating per-trip passenger activity (in each direction) to 30-minute intervals for the duration of a typical weekday to compute or assess:

1. the weekday peak travel period(s)
2. initial estimates of transferring riders between potential feeder buses at the rail stations
3. on-board loading conditions and vehicle requirements (buses and train cars), and
4. platform adequacy

The examination of passenger activity associated with the study's public transportation services indicated that just about all time periods throughout the day could be justified for evaluation. As a result, ridership activity between 5:00 AM and 10:30 PM, for all modes, routes, and directions of travel was incorporated into the analyses.

Initial transferring rider estimates were prepared for the current bus routes operating on the Schuylkill Expressway with the assumption that on-board ridership during the closed door portion of the trip (i.e., the volume of passengers on the bus while operating along the Schuylkill Expressway) is essentially the "population" of potential transferring riders. In proper time frames, volumes of bus riders were assigned to the rail stations nearest the bus route and expressway ramp as transfers to/from the rail line serving that station—as though the bus route originated or terminated there as a feeder route. In turn, new transferring volumes were added to the current boarding and alighting activity at each study station to judge platform activity levels, and aggregated for all stations along a common rail line at the line's maximum load point to assess on-board seating conditions / rail vehicle requirements.[4]

Details of the initial analyses results were contained in meeting materials presented to SEPTA staff on April 22, 2008. A summary of the initial findings follows.

Passenger / Vehicle Analyses

Analyses were conducted to determine existing and potential train seating capacities to accommodate transferring bus passengers. DVRPC staff used SEPTA's train "consist sheets" to determine the number of railcars per train that served the station. That data was consistent with the rail schedules in effect when the passenger counts were taken. A review of vehicle seating capacities and service standards published by SEPTA indicated that 120 passengers (seats) are typical for train cars in the SEPTA regional rail line fleet; and 100 passengers (60 seated, 40 standees) are design thresholds for cars in the Route 100 fleet.

Current (2007) maximum load counts were summarized by 30-minute intervals for trains serving the study stations in both directions. Estimates of transferring bus riders occurring during the same timeframe were added at appropriate stations along the subject rail line, and then summed for a total estimated effect on the line.

[4] Maximum passenger load points on the evaluated rail lines were:
For regional rail lines to/from the south – inbound, before; or outbound, after 30th Street
For regional rail lines to/from the north – inbound, before; or outbound, after Temple University
For the Route 100 – inbound, before; or outbound, after 69th Street Terminal

Summary Findings of the Initial Planning Work

1. The R6-Norristown Line currently exhibits frequency of service shortcomings in the off-peak hours vs. the existing service levels of the bus routes that do or would serve the stations as feeder buses—indicating that transfers to the train might be time consuming and inconvenient.

2. Inadequate seating in the predominant direction during the peak hours is a present shortcoming on the R5-Paoli / Thorndale and the R6-Norristown lines—indicating a present need for longer trains or more frequent service.

3. The Overbrook Station on the R5-Paoli / Thorndale Line should replace Cynwyd Station on the R6-Cynwyd Line as the feeder bus receptor station in this part of the corridor because higher levels of train service are supplied by the R5 Line.

4. Schemes for configuring the feeder bus route network should consider the planning step's estimates of rail-bus transferring passengers to more evenly distribute transfers from the Wissahickon Station to the Ivy Ridge Station, and from the Gulph Mills Station to the Villanova and/or Norristown Transportation Center stations. This would result in reducing transferring activity, bus route and station passenger loadings, and possible platform congestion.

5. A subsequent "design" task should be performed to structure a feeder bus network for the study rail stations (guided by suggestion in #4, above), refine transferring passenger estimates, and evaluate potential travel time differences between existing conditions and the potential rail-feeder bus plan. The steps performed in the planning work (e.g., computing / assessing maximum loads, station boarding levels, and platform adequacy) should be reiterated as the basis for service and facility recommendations and cost estimates.

Passengers prepare to board the R6 – Norristown at Ivy Ridge Station
Photo: DVRPC, 2008

4. "Design" Data Enhancements and Evaluations (Tasks 8 and 9)

The results of the prior planning tasks supplied information needed to advance the study, including: reconfiguring the expressway bus routes as feeder buses to rail stations in the corridor, and refining the estimates of transferring passengers at the stations. In turn, the enhanced ridership estimates were re-evaluated to determine on-board loading and seating conditions for determining peak vehicle requirements; platform adequacy, station access, and circulation and storage recommendations—all to support the development of operating and capital costs for use in the financial analysis aspects of the study.

Details of the design-level analyses were contained in materials presented to SEPTA staff at meetings held on July 22, 2008 and September 12, 2008. A summary of the findings follows.

Feeder Bus Networks

SEPTA staff reconfigured the seven I-76 bus routes to serve as feeder buses to six remaining study rail stations. Their staff considered the findings of the planning steps, imminent route changes per SEPTA's proposed service plan for the upcoming fiscal year, and needs for potential new alignments (or routes) to close coverage gaps that may have resulted after reconfiguring the existing expressway bus routes.

Two significant changes were included in designing the proposed feeder bus routes. First, SEPTA's Bus Route 121 is being discontinued as a separate route and integrated with the Route 44 bus for limited peak hour services to Gladwyne.[5] This change will have a bearing on estimated transferring activity at the Overbrook Station. Second, the Route 123 bus operating between the 69th Street Terminal and King of Prussia, and currently serving the Gulph Mills Station (in the eastbound direction only), was proposed for inclusion by SEPTA staff at a July 22, 2008 working meeting for the project. Route 123's proposed reconfiguration would supply coverage on Henderson Road after realigning routes 124 and 125. Route 123, as envisioned in the feeder bus network, would provide bi-directional service between the Gulph Mills Station and activity centers located along US 202.

Figures 2 and 3, respectively, illustrate the reconfigured suburban and city bus routes designed to feed the study rail stations. In the Suburban Division's bus re-routing plan Route 123 would serve Gulph Mills Station, Route 124 would serve the Norristown Transportation Center, and Route 125 would serve the Villanova Station. Both Routes 124 and 125 would be designated as "200 Series" routes, the 220Y and 200Z, respectively.

In the City Division's proposal, Route 44 would be directed to the Overbrook Station on the R5 Line. Routes 9, 27, and 62 would be restructured into four proposed routes serving the two R6 Line stations:

- **Lower Roxborough Feeder to Wissahickon (LRFtW)** – a short circular route through Roxborough that covers portions of existing Routes 9, 27, and 35; and would terminate at Wissahickon Station on the R6 Line
- **Ridge Ave Feeder to Ivy Ridge (RAFtIR)** – most closely resembles Route 9, proposed to turn off Ridge Avenue at Fountain Street to serve Ivy Ridge R6 Station
- **Henry Ave Feeder to Ivy Ridge (HAFtIR)** – most closely resembles Route 27, proposed to turn from Henry Avenue at Leverington Avenue to serve Ivy Ridge Station
- **Ridge Ave Local (RAL)** – is essentially existing Route 9's alignment with the exception that it terminates at Wissahickon Station instead of Center City

Refined Passenger Estimates

DVRPC staff refined the transferring passenger estimates associated with the proposed reconfigured bus routes using information contained in **Figure 4** and **Tables 2 and 3**. **Figure 4** shows the path of each existing bus route, and isolates and identifies unique segments associated with each. The isolation of unique segments assisted in determining ridership for the proposed feeder bus routes along the same segment. **Tables 2 and 3**, respectively, quantify existing outbound and inbound bus boardings and alightings, within each route segment, by half-hour time intervals, according to actual ride checks performed by SEPTA in 2007 and 2008.

The vast majority of the work to refine the passenger estimates was performed by substituting segment-by-segment ridership where existing and proposed route alignments coincide. Judgment was necessarily applied when splitting ridership along segments served by multiple bus routes. No estimates were made for brand new alignments. At the same time, very few new street segments were added as part of the feeder network, and where there were they were short in length. Detailed explanations and underlying assumptions of the estimating process were included in a fourth technical memorandum prepared for the study (presented to SEPTA staff on September 12, 2008).

[5] This service change was instituted by SEPTA during the course of this study.

Figure 2

Alternatives to Buses on I-76 : SEPTA Rail Feeder Bus Study

Reconfigured Suburban Routes

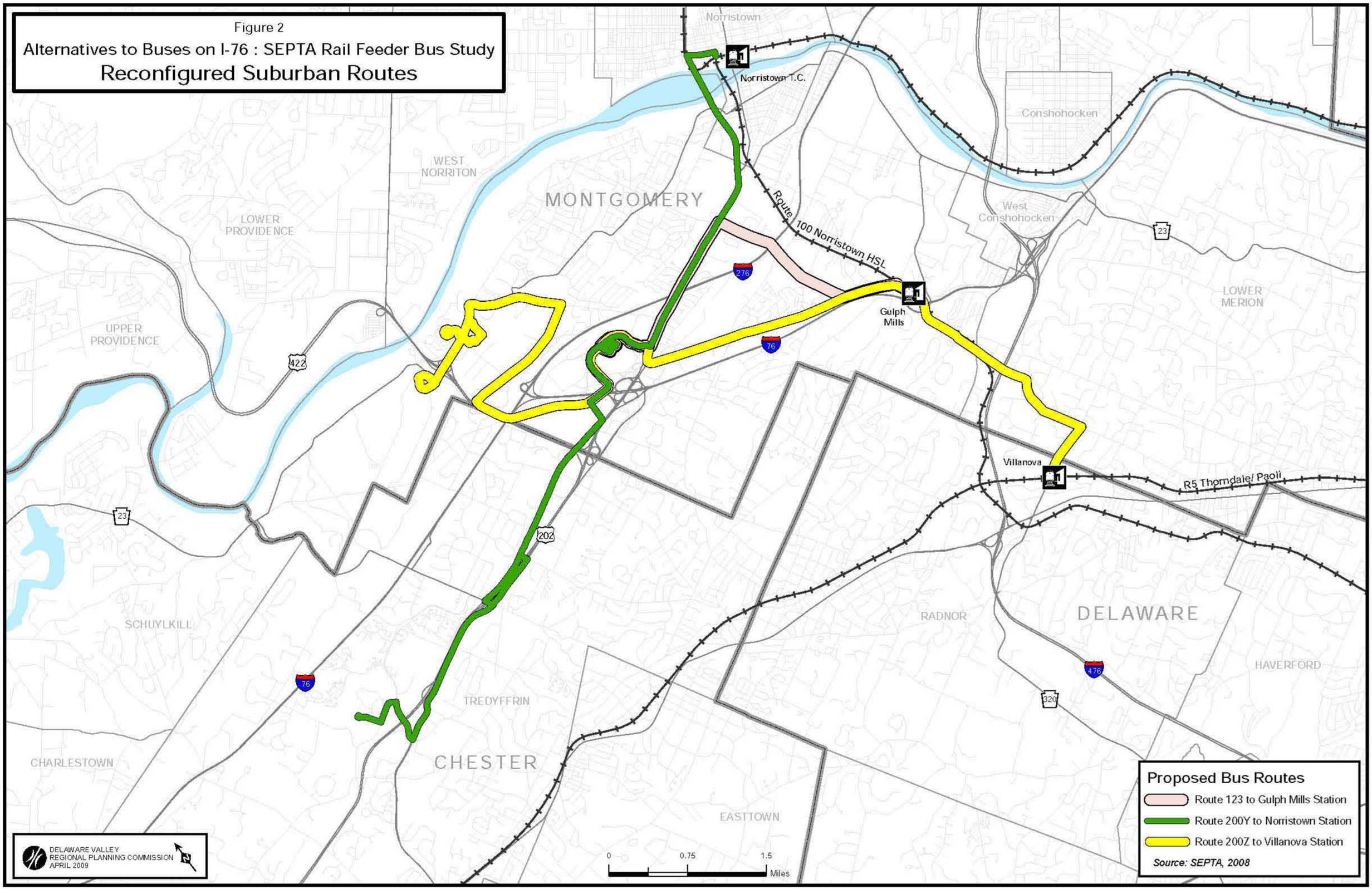


Figure 3

Alternatives to Buses on I-76 : SEPTA Rail Feeder Bus Study

Reconfigured City Routes

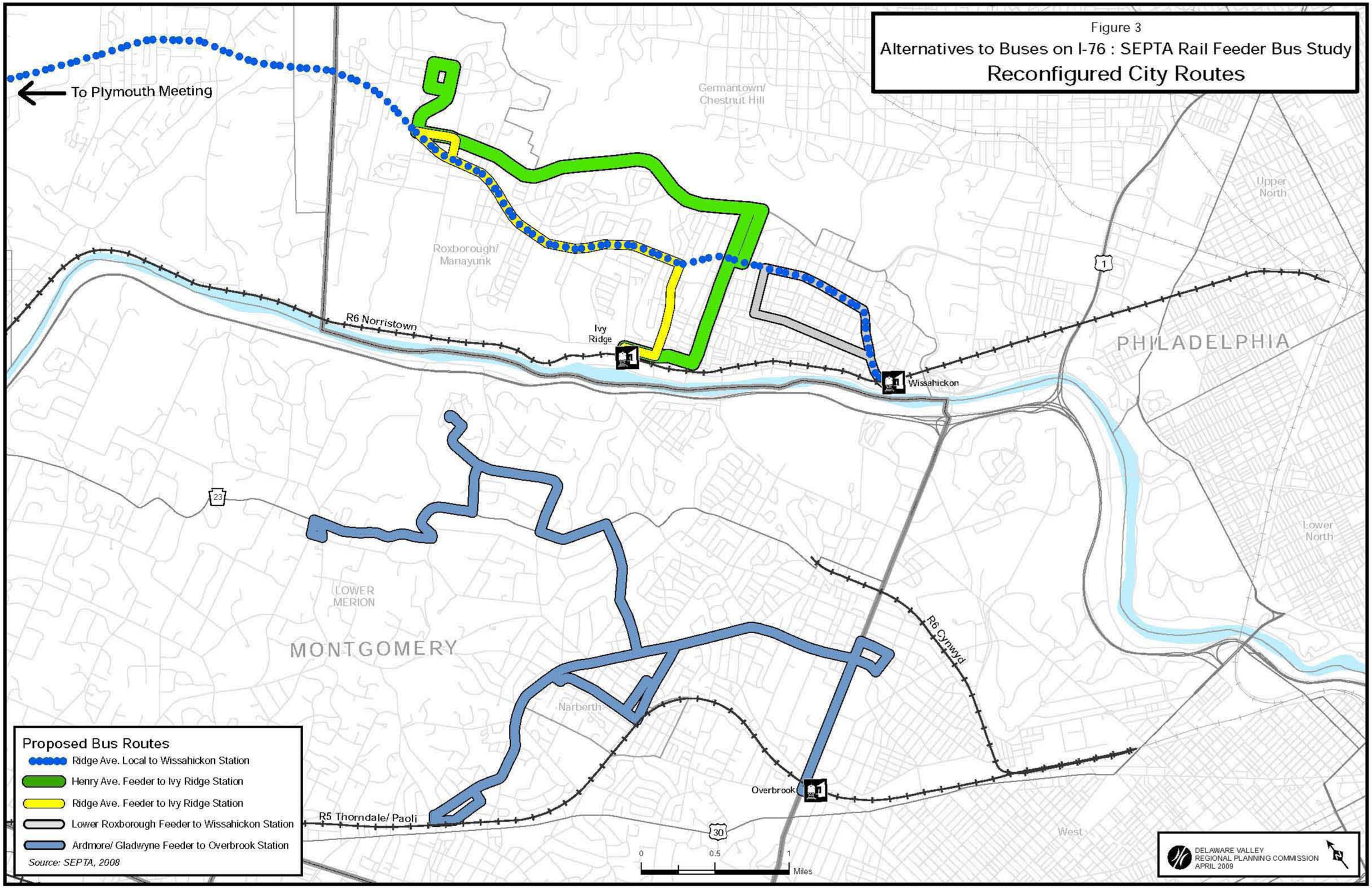


Table 2: Existing Outbound Bus Ridership by Segment

		Half hour beginning																																		
Segment (see fig. 4)	bd / lv	5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	SUM
1	lv	1		39	32	21	31	31	23	6	5	14		4	1			9	0	7		3		7	4	4	1		2	0		2		1		12	260
2	lv		9	31	28	34	53	28	28	14	6	0	8		14		15		9	4	8		10	6	12	10	8	9	2	3	3		0		3	4	359
3	lv	18	18	47	38	33	42	37	89	74	48	49	56	39	93	21	56	45	62	47	41	44	27	48	44	22	24	3	12	2	7	3	3	5	6	7	1,210
4	lv		1	1	1	9	4	3	3	3	5	2	3		10		0		0	0	4		1	4	2	2	0	2	0	1			1		3		65
5	lv	4		18	20	3	9	11	4	6	4	4		9	2			16	6	7		3		7	1	5	4		2	1		1		1		4	152
6	lv	0	4	12	7	4	5	5	4	1	11	0	1	0	1	0	0	0	4	1	3	0	1	3	5	1	3	0	3	1	2	1	0	0	0	0	83
7	lv		0		18	14	47	12	39	17	13	12	8	17	0	18	4	13	13	12	10	7	8	25	3	19	9	7	5	17		4	0	7	0	0	378
8	lv					22		40		10											2		5			8	5				4						96
9	lv		0	0	41	9	20	73	67	40	30	38	17	34	17	33	24	32	14	48	32	66	46	48	92	100	91	65	41	34	16	23	14	19	13	9	1,246
10	lv																							11	11	12	15	8									57
11	lv		0	1	3	1	7	5	8	4	5	1	12	5	4	4	10	10	4	9	14	4	18	31	62	43	64	30	12	10	7	9	7	2	5	0	411
12A	lv	0	2	4	5	2	4	13	11	10	4	8	13	5	13	1	8	15	5	10	12	9	14	23	18	29	75	14	14	11	8	10	6	19		6	401
12B	lv	4	1	1	12	4	10	17	12	8	8	7	15	11	8	2	6	25	1	9	13	15	15	17	7	15	35	11	5	8	11	2	3	6		2	326
12C	lv	1	4	8	9	5	11	11	5	15	10	9	11	6	13	9	12	10	3	14	17	11	12	13	11	19	25	8	5	8	5	1	1	8		5	315
13	lv	3	0	5	4	4	3	4	9	2	7	1	5	2	2	2	2	11	3	8	7	6	12	17	17	20	27	20	5	7	2	3	2	3	0	3	228
14	lv		3	1	2	4	8	5	7	3	7	0	18	6	5	3	14	9	5	11	13	11	13	20	36	29	55	22	8	3	6	3	6	7	2	3	348
15	lv	5	6	9	5	2	7	4	7	8	6	3	12	3	7	3	7	5	7	5	5	14	2	5	0	2	5	0	1	2	1	7	4	9		0	168
16	lv																							6	3	2	0	1									12
17	lv		25	19	44	19	36	26	27	24	20	4	18	7	8	15	20	3	34	36	45	10	30	28	12	20	24	9	6	4	4	12	0	18	3	10	620
18	bd	7	10	24		21		19	31	26	24	28	18	25	39	42	36	29	20	22	24	26	29	35	24	33	24	5	0		10	9					640
18	lv																																				0
19	lv	3	6	5		11		19	19	11	10	11	5	9	7	24	14	13	9	7	1	5	12	14	16	27	16	7	0		10	8					299
Total	lv	39	79	201	269	201	297	344	362	256	199	163	202	157	205	135	192	216	179	235	227	208	226	333	356	389	486	216	123	112	86	89	47	105	35	65	7,034

Source: DVRPC, 2008

Table 3: Existing Inbound Bus Ridership by Segment

Segment (see fig. 4)	bd / lv	Half hour beginning 5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	SUM
1	bd			3	3	2	0	2	1		2		2	5		1			4		9	0	12	11	18	14	22	5	10	3	2	2		10		6	149
2	bd		0		3	5	21	4		2	3		4		1		8		10		0	13	21	34	40	14	20	16	11		10		6	0	7	4	257
3	bd		4	4	7	3	3	6	0	2	20	4	6	17	7	16	21	10	35	5	25	46	49	73	66	60	52	51	45	16	42	58	33	42	110	104	1,042
4	bd		0		3	1	3	0		0	0		0		1		0		0		4	3	1	3	0	2	0	2	0		2		4	2	0	0	31
5	bd			4	0	9	2	6	7		1		1	0		5			4		3	10	5	6	5	3	0	8	0	0	0	2		4		8	93
6	bd		3	0	5	2	2	4	1	0	2	0	3	1	0	0	1	0	1	0	5	3	7	3	8	3	0	3	2	0	0	4	0	1	0	0	64
7	bd			4	16	6	12	28	10	4	6	8	4	11	6	17	4	12	6	12	23	35	12	25	18	19	34	33	7	4	6	9	4	2		1	398
8	bd					10		10		9		0									18		15		10			7		1		0					80
9	bd			26	41	95	66	135	71	41	28	38	25	48	19	58	23	29	22	35	36	34	53	48	79	60	54	58	13	24	11	18	7	11	0	0	1,306
10	bd				11	26	14	2																													53
11	bd			5	19	43	48	124	11	45	10	2	7	6	9	19	11	1	11	6	2	3	11	10	1	3	2	3	4	1	3	2	1	0	2	2	427
12A	bd	9	4	24	26	19	56	50	32	17	20	18	19	7	10	10	12	10	11	4	8	18	2	17	8	13	3	7	4	1		3	1	2	0	7	452
12B	bd	5	5	10	11	7	28	23	10	8	14	12	10	4	16	11	10	10	22	3	12	24	4	8	11	15	9	8	5	0		1	5	0	3	5	329
12C	bd	4	6	15	20	11	31	26	16	15	18	8	2	3	14	8	25	18	17	2	9	8	9	13	9	9	4	8	3	2		9	10	0	1	2	355
13	bd	3	3	6	18	31	20	23	15	7	10	11	8	2	8	5	7	4	3	2	1	5	1	7	6	5	1	6	2	4	0	2	2	1	3	0	232
14	bd			11	26	46	28	83	5	24	8	8	5	3	5	5	13	0	10	9	10	10	13	7	7	4	3	0	2	0	2	4	2	1	1	1	356
15	bd	1	2	2	2	0	7	5	3	9	0	3	6	0	7	6	3	6	5	1	7	14	1	7	3	27	4	13	3	2		2	6	2	8	8	175
16	bd				3	10	6	2																													21
17	bd			5	6	22	15	22	2	17	8	8	3	11	2	12	7	0	20	15	7	31	34	27	46	38	44	18	34	6	12	7	9	2	16	1	507
18	bd lv								0	0	7	3	1	5	2	7	6	10	21	10	16	40	37	18	26	26	19	31	15	7	15		26		85		0 433
19	bd								0	0	6	0	0	1	2	5	0	1	9	7	5	14	12	0	9	1	0	1	1	1	3		6		12		96
Total	**bd**	**22**	**27**	**119**	**220**	**348**	**362**	**555**	**184**	**200**	**156**	**120**	**105**	**119**	**107**	**178**	**145**	**101**	**190**	**101**	**184**	**271**	**262**	**299**	**344**	**290**	**252**	**247**	**146**	**65**	**93**	**123**	**96**	**80**	**163**	**149**	**6,423**

Source: DVRPC, 2008

Figure 4

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Bus Routes & Analysis Segments

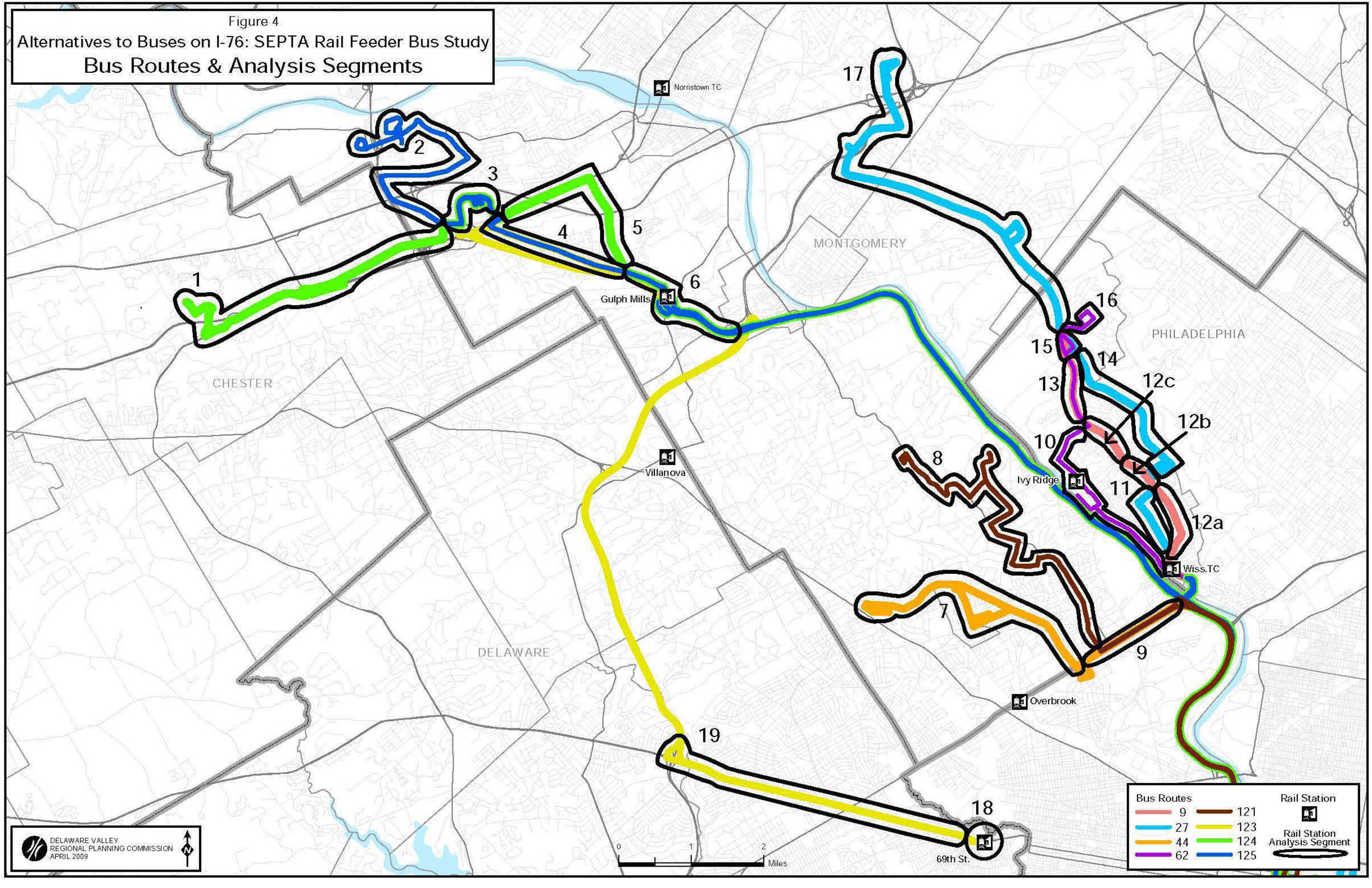


Table 4 summarizes the final estimates of transferring riders (by proposed feeder bus route, direction, and rail station) tallied in 30-minute intervals. From the data, DVRPC was able to calculate peak vehicle (bus) needs—also shown in **Table 4**. The values were also used as inputs to compute on-board seating conditions / peak train car requirements on the study rail lines, and to evaluate platform adequacy at the stations. The information in **Table 4** was also provided to SEPTA, along with the proposed feeder bus route maps to compute operating costs of the feeder bus plan (and/or savings vs. current bus operations along I-76).

A review of the final estimates indicated that the final estimates for transferring bus riders are in general agreement with existing volumes of bus riders along the closed-door portions of the expressway bus routes—about 5,000 transferring passengers have been estimated for the restructured operating plan (as compared with approximately 6,700 daily bus riders along the Schuylkill Expressway[6]). Additionally, transferring passenger assignments have been more evenly distributed across the set of study rail stations and rail lines, versus the planning level station assignments, as a consequence of the reconfigured bus routes.

Vehicle Requirements

Peak bus requirements to accommodate ridership estimates (at 100% thresholds) of the feeder bus routes are also indicated in **Table 4**. The vehicle estimates are computed in 30-minute intervals and assumed a maximum of 65 passengers (including standees) for a standard 40-foot long SEPTA bus, and all passengers are to be accommodated with as little wait as possible between modes. They do not account for the feeder bus route's length, frequency of service or route cycle time. These considerations would be accounted for by SEPTA staff as part of the scheduling work to compute the operating costs associated with the feeder bus plan.

On the rail side, it was indicated in the descriptions and summary of the planning work that selected trains on the R6 Line and the R5-Paoli / Thorndale Line are deficient in the number of seats available to accommodate the volume of riders using the lines in 2007. These conditions suggest that SEPTA's new rail car order is justified in part just to address current demands along these two regional rail lines—excluding any consideration of the addition of substantial volumes of transferring passengers or conditions along the remainder of the regional rail network.

Tables 5, 6, and 7 provide detailed summaries of the rail-side effects of transferring riders to/from the final reconfigured feeder bus routes, respectively for the R6-Norristown Regional Rail Line, the R5-Paoli / Thorndale Regional Rail Line, and the Route 100-Norristown High Speed Line. In the tables, estimates of transferring bus riders per the feeder bus network are superimposed at appropriate stations, and maximum load counts are summarized by 30-minute interval. The work replicates activities performed in the planning tasks, and the values in the tables were used for determining platform adequacy at individual stations; and the cumulative effects of multiple feeder bus receptor stations along individual rail lines—for the purpose of determining maximum on-board loading conditions / seating capacity and associated rail vehicle needs.

Rail frequencies are assumed to be adequate throughout the day to serve all of the transferring passengers. In fact, this would be a scheduling detail that SEPTA staff would need to address with the new rail car order, and when the feeder bus plan is implemented. Generally speaking however, satisfying the peak periods' vehicle requirements usually covers the number of cars required for off-peak service.

SEPTA's service standards were considered; and fleet averages were used for seating capacities for each type of railcar serving the lines (according to SEPTA's schedules and consist information coinciding with their passenger counts). Accordingly, passenger capacities of 120 seats per regional rail car (with no standees), and 100 passengers per Route 100 vehicle (60 seated and 40 standees) were used to determine the amount of train cars required to accommodate transferring passengers associated with the feeder bus plan (at the 100% passenger estimate threshold).

[6] There are reasons why the totals do not agree. Current riders may be using one of the study bus routes that may not be available to them following route reconfiguration. For example, in certain circumstances existing expressway bus routes were realigned, and left previously served street segments unserved. Typically, there is an existing local service bus route operating along the same street segment which would close the service gap (like Route 65 along City Avenue making up for the reconfigured Route 44). In this situation, "lost" riders were not reassigned to the replacement bus route per se, but were assigned to the study rail station estimates. In the case of the Route 123's abandonment, of the Gulph Mills to West Chester Pike segment, on-board through ridership levels were so low as to be inconsequential. Most of the route's ridership was determined to be local—along West Chester Pike. Service along West Chester Pike would be replaced by existing bus routes 104, 112, and 120.

Table 4: Reconfigured Bus Route Ridership Estimate Summary

Route (see figs. 2&3)	Rail Station	Half hour beginning 5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	SUM
Inbound																																				
44	Overbrook	0	0	4	16	11	12	33	10	10	6	8	4	11	6	17	4	12	6	12	37	35	27	25	25	19	34	40	7	5	6	9	4	2	0	1	458
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
123	Gulph Mills	1	1	7	5	10	8	8	13	3	5	6	5	10	3	9	13	12	19	6	23	41	54	64	60	71	46	50	28	9	23	17	29	8	78	21	765
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	2	1	37
124	Norristown	0	0	8	3	8	2	9	4	0	19	0	6	15	0	18	0	0	18	0	20	11	14	40	40	27	38	13	27	11	22	56	0	24	0	51	501
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
125	Vilanova	0	1	0	7	6	22	5	0	2	3	0	4	0	4	0	11	0	12	0	4	19	25	40	42	19	22	20	13	0	13	0	11	10	17	21	354
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
LRFtW	Wissahickon	5	19	24	23	26	48	36	35	23	19	10	29	11	10	7	23	6	24	24	20	12	17	15	21	21	18	8	5	1	3	5	2	8	6	9	566
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
RAFtIR	Ivy Ridge	4	5	11	20	21	28	26	16	14	14	10	7	3	13	8	17	13	12	2	7	11	5	12	8	16	4	11	3	4	0	6	8	1	5	4	351
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
HAFtIR	Ivy Ridge	0	1	17	36	78	51	109	8	44	16	17	10	14	9	19	21	2	32	24	19	46	47	36	54	51	48	22	37	7	14	12	13	4	20	5	942
	Buses needed	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37
RAL	Wissahickon	13	12	33	44	38	84	74	42	30	38	31	26	10	34	24	33	28	39	7	23	44	10	29	23	37	14	23	10	4	0	9	13	2	8	12	906
	Buses needed	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37
Total		30	47	112	161	206	264	309	136	134	128	91	99	81	87	111	130	81	169	84	161	226	208	269	281	270	231	195	139	48	89	121	88	68	142	131	5,093
Outbound																																				
44	Overbrook	0	0	0	18	30	47	44	39	23	13	12	8	17	0	18	4	13	13	12	12	7	11	25	3	24	12	7	5	17	2	4	0	7	0	0	447
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
123	Gulph Mills	10	6	56	39	37	56	40	63	46	25	28	19	22	41	22	28	32	26	21	30	28	21	43	31	17	16	1	2	1	3	3	0	3	2	4	821
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
124	Norristown	14	0	57	74	31	50	52	41	30	21	23	0	26	22	0	0	37	33	26	0	25	0	19	24	16	12	0	13	3	0	5	0	5	0	13	671
	Buses needed	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	36
125	Vilanova	0	11	31	27	42	58	34	40	25	14	7	22	0	33	0	23	0	13	7	16	0	13	13	17	13	9	11	2	4	4	0	2	0	7	6	502
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
LRFtW	Wissahickon	0	1	3	7	12	10	20	8	14	4	9	8	5	10	7	12	8	17	15	15	19	38	23	22	36	57	15	21	8	13	12	8	11	8	5	474
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
RAFtIR	Ivy Ridge	4	4	9	8	5	9	9	9	11	10	6	12	5	10	6	9	12	5	13	14	13	13	17	14	20	28	14	5	8	4	4	3	8	0	4	327
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
HAFtIR	Ivy Ridge	2	30	23	48	24	46	32	36	30	29	5	40	14	15	19	36	14	41	49	60	26	44	56	51	52	81	32	14	8	10	17	7	28	5	13	1,035
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	36
RAL	Wissahickon	8	6	12	23	10	21	32	27	24	20	17	33	18	24	9	19	45	9	27	33	33	35	45	30	50	100	32	17	22	19	11	9	24	0	9	853
	Buses needed	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	36
Total		45	66	199	252	199	306	271	271	210	145	115	150	115	162	89	139	168	165	178	187	158	182	248	200	235	323	120	88	77	64	64	37	94	30	61	5,377

Source: DVRPC, 2008

Table 5: R6 Platform Activity and Ridership Estimates

Route	IB / OB	Half hour beginning 5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	SUM
R6 Peak Load	IB				196	302	828	766	603	277	185		103		78		87		49		72		61	92		107	103	84	43		41		23		19		**4,119**
Existing	OB		14		62	77	121	131	62		66	31		66		70		97		126		188		315	374	830	528	382	274		194		135		66		**4,209**
NTC Platform	IB	0	0	8	29	50	153	133	78	54	63	0	30	15	22	18	20	0	33	0	42	11	28	65	40	75	73	46	43	11	34	56	7	24	6	51	**1,316**
with NTC bus routes	OB	14	18	57	100	67	94	97	66	30	31	33	0	43	22	22	0	61	33	61	0	71	0	98	102	146	67	59	40	3	21	5	22	5	8	13	**1,508**
R6 Peak Load	IB	0	0	8	199	310	830	775	607	277	204	0	109	15	78	18	86	0	67	0	92	11	75	132	40	134	141	97	70	11	63	56	23	24	19	51	**4,620**
with NTC bus routes	OB	14	14	57	136	108	171	183	103	30	87	54	0	92	22	70	0	134	33	152	0	213	0	334	398	846	540	382	287	3	194	5	135	5	66	13	**4,880**
IR Platform	IB	4	6	28	71	126	213	247	116	84	49	27	27	17	27	27	48	15	47	27	33	57	57	53	62	72	55	37	41	10	17	18	21	5	24	8	**1,776**
with IR bus routes	OB	5	35	32	59	30	59	43	48	41	39	15	52	23	26	27	46	33	47	70	73	58	56	108	112	220	162	103	54	16	40	22	22	36	15	17	**1,844**
R6 Peak Load	IB	4	6	28	251	401	907	901	627	335	215	27	120	17	101	27	125	15	92	27	99	57	114	141	62	174	155	118	83	10	55	18	44	5	43	8	**5,412**
with IR bus routes	OB	5	48	32	118	106	177	172	108	41	105	42	52	85	25	95	46	123	47	187	73	227	56	387	439	902	636	428	294	16	208	22	145	36	71	17	**5,571**
Wiss Platform	IB	18	31	57	91	89	206	207	174	80	83	41	66	21	58	31	61	34	69	31	57	56	34	51	44	78	43	37	21	5	6	13	16	10	17	21	**1,959**
with Wiss bus routes	OB	8	17	15	41	41	39	60	39	38	27	28	41	29	34	21	31	57	25	55	48	65	73	95	83	143	219	104	90	29	47	23	37	34	13	14	**1,765**
R6 Peak Load	IB	18	31	57	263	365	960	876	680	330	242	41	158	21	122	31	143	34	112	31	115	56	88	135	44	165	135	114	58	5	44	13	38	10	33	21	**5,591**
with Wiss bus routes	OB	8	21	15	91	99	152	183	96	38	90	57	41	89	34	85	31	149	25	168	48	239	73	383	426	915	685	429	312	29	226	23	152	34	74	14	**5,536**
R6 Peak Load	IB	22	37	93	321	472	1,041	1,020	709	388	291	69	181	52	145	77	180	49	173	58	162	124	155	224	147	259	225	160	126	26	80	87	59	39	57	80	**7,386**
Cumulative	OB	27	55	105	221	159	258	276	182	109	151	91	93	134	81	111	77	212	105	255	121	303	129	474	515	1,003	805	475	345	48	240	49	162	76	79	44	**7,569**
Rail cars needed	**IB**	1	1	1	3	4	9	9	6	4	3	1	2	1	2	1	2	1	2	1	2	2	2	2	2	3	2	2	2	1	1	1	1	1	1	1	80
	OB	1	1	1	2	2	3	3	2	1	2	1	1	2	1	1	1	2	1	3	2	3	2	4	5	9	7	4	3	1	2	1	2	1	1	1	79

Source: DVRPC, 2008

SEPTA wayfinding sign at Norristown Transportation Center
Photo: DVRPC, 2008

Table 6: R5 Platform Activity and Ridership Estimates

Route	IB / OB	Half hour beginning 5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	SUM
R5 Peak Load	IB			137	616	646	1,538	2,299	928	892	284	227	154	147	123	125	126	110	87	57	95	70	169	138	168	241	256	216	162	103	96		82		79		**10,371**
Existing	OB		83	103	173	335	208	203	132	77	88	61	75	86	83	114	129	135	121	198	158	314	273	642	1,296	1,310	805	904	465	344	182	211	110	160		152	**9,730**
Villanova Platform	IB	0	3	1	12	25	42	29	18	13	12	9	18	4	12	12	18	10	27	16	14	40	58	62	83	69	65	76	26	14	22	12	22	25	17	36	**923**
with Route 125	OB	0	11	33	41	53	83	116	81	63	28	33	34	15	41	10	38	12	23	17	22	15	26	23	25	34	26	31	14	21	21	0	24	0	31	6	**1,049**
R5 Peak Load	IB	0	1	137	623	652	1,560	2,304	928	894	287	227	158	147	127	125	137	110	99	57	99	89	194	178	210	260	278	236	175	103	109	0	93	10	96	21	**10,725**
with Route 125	OB	0	94	134	200	377	266	237	172	102	102	68	97	86	116	114	152	135	134	205	174	314	286	655	1,313	1,323	814	915	467	348	186	211	112	160	7	158	**10,232**
Overbrook Platform	IB	0	26	42	87	133	83	164	73	48	37	47	28	55	30	72	39	50	36	66	81	85	99	95	156	125	122	119	35	47	27	46	17	61	0	36	**2,264**
with Route 44	OB	0	26	18	89	88	83	129	99	60	46	51	26	51	23	54	40	53	37	76	53	81	78	95	144	160	127	91	54	67	27	44	19	72	10	42	**2,208**
R5 Peak Load	IB	0	0	161	663	728	1,600	2,433	991	933	311	264	177	194	143	186	147	144	110	95	159	131	236	199	252	305	331	300	179	126	110	23	91	10	79	1	**11,809**
with Route 44	OB	0	83	103	222	372	270	302	221	130	124	102	96	129	96	157	151	172	145	246	194	371	319	703	1,368	1,409	885	960	501	387	196	232	121	181	10	159	**11,112**
R5 Peak Load	IB	0	1	161	670	734	1,622	2,438	991	935	314	264	181	194	147	186	158	144	121	95	163	149	261	239	294	324	352	320	191	126	123	23	103	20	96	22	**12,162**
Cumulative	OB	0	94	134	249	414	328	336	261	155	137	108	118	129	128	157	174	172	157	253	210	371	331	716	1,385	1,422	894	971	503	390	200	232	122	181	17	164	**11,614**
Rail cars needed	IB	1	1	1	6	6	14	20	8	8	3	2	2	2	1	2	1	1	1	1	1	1	2	2	3	3	3	3	2	1	1	1	1	0	1	0	106
	OB	1	1	1	2	4	3	3	2	1	1	1	1	1	1	1	2	2	1	2	2	3	3	6	12	12	8	8	4	3	2	2	1	2	0	1	99

Source: DVRPC 2008

Table 7: Route 100 Platform Activity and Ridership Estimates

Route	IB / OB	Half hour beginning 5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	SUM
Rt 100 Peak Load	IB			76	190	195	266	203	71	110	40	66	27	61	21	79	21	75	86	98	101	159	212	240	198	282	205	40	84	77	40	85	43	111	53	92	**3,707**
Existing	OB	50	79	201	187	316	232	250	215	115	44	129	56	81	38	102	59	80	73	96	60	103	100	166	156	172	215	179	121	61	51	70	46	46	26	45	**4,020**
Gulph Mills Platform	IB	1	1	18	20	36	24	23	19	15	9	6	8	9	3	10	19	14	22	20	39	69	100	122	119	136	110	71	52	21	41	16	32	14	91	38	**1,348**
with Route 123	OB	29	12	133	104	151	125	114	97	54	30	34	24	30	51	27	42	38	32	30	45	44	33	74	52	48	27	9	6	5	4	4	4	6	3	11	**1,534**
Rt 100 Peak Load	IB	1	2	83	195	207	275	214	87	115	46	74	33	72	25	91	37	89	107	105	123	201	268	306	260	357	253	92	111	86	64	100	72	119	131	111	**4,508**
with Route 123	OB	60	86	257	225	355	288	293	281	162	70	158	76	104	79	128	89	113	99	118	90	131	123	210	188	194	233	182	123	62	56	74	46	48	28	49	**4,878**
Rail cars needed*	IB	1	1	1	2	3	3	3	1	2	1	1	1	1	1	1	1	1	2	2	2	3	3	4	3	4	3	1	2	1	1	1	1	2	2	2	64
	OB	1	1	3	3	4	3	3	3	2	1	2	1	2	1	2	1	2	1	2	1	2	2	3	2	2	3	2	2	1	1	1	1	1	1	1	64

*Does not include Bryn Mawr Local trains

Source: DVRPC, 2008

Further scheduling work would be necessary upon delivery of the new rail cars to best distribute the additional rail cars throughout the system, and when implementing the feeder bus plan to: synchronize the regional rail and feeder bus headways. Without the benefit of that completed work for the rail feeder plan, it has been assumed that rail and bus schedules have been developed at 30-minute headways, and synchronized. Given that assumption, **Table 8** identifies the numbers of buses and rail vehicles needed to accommodate projected transferring ridership demands (at 80%, 100%, and 110% thresholds).

Table 8: Rail-Feeder Bus Plan's Peak Vehicle Requirements

	Passenger Estimate Planning Threshold					
Proposed Route	**80%**		**100%**		**110%**	
(Rail Station Served)	**IB**	**OB**	**IB**	**OB**	**IB**	**OB**
Suburban Bus Routes						
123 (Gulph Mills)	1	1	2	1	2	2
200Y (Norristown)	1	1	1	2	1	2
200Z (Villanova)	1	1	1	1	1	1
City Bus Routes						
44 (Overbrook)	1	1	1	1	1	1
LRFtW (Wissahickon)	1	1	1	1	1	1
RAFtIR (Ivy Ridge)	1	1	1	1	1	1
HAFtIR (Ivy Ridge)	2	1	2	2	2	2
RAL (Wissahickon)	2	2	2	2	2	2
Rail Line						
R6-Norristown Regional Rail Line	7	7	9	9	10	10
R5-Paoli / Thorndale Regional Rail Line	17	10	20	12	23	14
Route 100-Norristown High Speed Line	3	3	4	4	4	4

Note: The values in **Table 8** are the number of vehicles needed to serve the peak transferring volume of passengers at a station. They do not account for route length, frequency of service or route cycle time.

Source: DVRPC, 2008

Platform Adequacy Analyses

Analyses were conducted to determine the level of platform activity that would result with the feeder bus route network serving stations. The implications of radical increases of people on the platforms could be manifested in overcrowding and increased dwell times—suggesting: lengthening or raising platforms; adding more cars to the trains; and/or providing more frequent service on the rail lines.

The analyses was qualitative and assumed actual 2007 boarding and alighting passenger volumes and patterns at the stations, plus projected transfers to / from the feeder buses to yield the resultant passenger activity on the platforms in 30-minute time frames. **Tables 5, 6, and 7** contain the results for the R5, R6, and Route 100 study rail lines, respectively. The restructured feeder routes more evenly distribute transferring bus riders across the study rail stations than was the case for the planning step's assignments. More specifically, passenger activity levels have been spread from the Wissahickon Station to the Ivy Ridge Station and from the Gulph Mills Station to the Villanova and Norristown Transportation Center stations.

5. Station Improvements (Task 10)

On April 1, 2008, DVRPC staff conducted field visits to the set of study stations and immediate surroundings to update conditions that have occurred since the aerial photographs were taken in 2005, and inventory opportunities and constraints that related to access, circulation and storage needs for the feeder buses, automobile parking replacement / expansion possibilities, and platform adequacy for the additional passengers at the stations.

The findings of the field work were illustrated on station area aerial photographs, and shared with SEPTA staff in meetings held on April 22, 2008 and August 21, 2008. The SEPTA representatives conducted their own field recognizance to contribute their improvement ideas. The improvements described and illustrated later in this chapter reflect a collaborative synthesis of the independent work and reviews of SEPTA and DVRPC, and as such are contained as part of the study recommendations.

Concurrent Improvement Projects

In addition to the new regional rail car order (giving the impetus for this study), it is important to identify a series of other ongoing improvement plans and projects—being advanced by SEPTA and PennDOT at or in the vicinity of the study stations—that may influence or be influenced by the findings of this study. As such, the development of final station improvements should, where possible, integrate this study's suggested set of improvements with the scope of the following concurrent projects (and vice versa) to advance each improvement program.

1. **Ivy Ridge Station** – SEPTA has prepared a conceptual design and cost estimate for SEPTA's Long-Range Plan to include ADA accessibility improvements and new, extended high level platforms at the Ivy Ridge Station. Parking expansion opportunities for the station were also identified in their work.

2. **Wissahickon Station** – SEPTA has prepared a conceptual design and cost estimate for SEPTA's Long-Range Plan to include ADA accessibility improvements and new, extended high level platforms at the Wissahickon Station. Parking expansion opportunities for the station were also identified in their work. [It should be noted that in late September 2008, SEPTA constructed the expansion (estimated 48 parking spaces gained), along with repaving and restriping of the existing parking lot.]

PennDOT is advancing five bridge replacements within the scope of the Gustine Lake Bridge Replacement Project (PA Transportation Improvement Program MPMS # 50931). The bridges are located within the Gustine Lake Interchange—a network of roads, ramps, and bridges linking I-76, City Avenue, Ridge Avenue, the Lincoln Drive, and Kelly Drive. SEPTA's express and local buses operate through the interchange. Besides the bridge replacements, consolidation of several ramps will permit conversion of one grade separated ramp intersection with Ridge Avenue to an at-grade signalized intersection. The project will stay within present rights-of-way, and long-term vehicular access throughout the interchange will not be affected by the project (i.e., no additional connections between highway facilities are proposed).

Traffic movement will be maintained throughout the interchange during construction (scheduled in two stages, to begin in early 2010 and last two construction seasons). At the very least, the concept behind, or the actual improvements at the Wissahickon Station (noted in the following section) if installed prior to the bridge replacements project, could serve as a mitigation strategy while the project is in construction.

3. **Villanova Station** – SEPTA is proposing to construct a pedestrian overpass from the station to a newly constructed parking garage located on the outbound side of the tracks (PA Transportation Improvement Program MPMS #15407). At this time, SEPTA is finalizing the conceptual improvement plan for the station with Villanova University and Amtrak. Following that agreement, a design contract for the project will be awarded. The final scope for the project will be determined in the design phase which will consider the following elements: the pedestrian bridge's span (e.g., over the tracks to serve both platforms), constructing a new underpass, relocating the station, extending and elevating the platforms, and improvements to comply with ADA accessibility requirements.

   SEPTA is presently evaluating the benefits and developing the installation of a new interlocking just west of the Villanova Station. At present the interlocking is located at Bryn Mawr Station.

4. **Route 100 Extension** – SEPTA's Capital Program for Fiscal Years 2009-2020 contains a "New Starts" project to extend the Route 100, Norristown High Speed Line, approximately 4.9 miles from a junction north of the Hughes Park Station northward to the King of Prussia and the Valley Forge area. Four new stations are proposed including a stop within the King of Prussia Mall complex. Bus routes serving the area will be revised to coordinate with the extended rail line.

SEPTA's Bus Routes 123, 124 and 125 are presently among the set of bus routes serving the Mall, and presumably would be revised with the Route 100's extension—whether they are reconfigured with the potential feeder bus plan or not.

Study Station Improvement Recommendations

The recommendations emanating expressly from this study's work are summarized in the following narrative, and illustrated on a set of station area aerial photographs (see **Figures 5, 6, 7, 8, 9, and 10**).

- **Norristown Transportation Center, Figure 5 (served by: Proposed Feeder Bus Route 200Y)** – The Norristown Transportation Center is a transportation hub including the Route 100 Line's western terminal station, the R6 Line's Norristown Station, and eight SEPTA bus routes. The station's configuration is designed for easy bus access and accommodates substantial volumes of buses, and drop-offs by taxis and private autos. All bus berths on the property are needed to serve existing peak and off-peak period bus operations. A newly constructed parking garage (opposite the NTC on Lafayette Street and owned by SEPTA), opened on April 7, 2008. The garage includes a busway on the ground floor to be leased to one or more intercity bus services.

  The recommendation for the Norristown Transportation Center is institutional in nature. SEPTA should investigate availability and pursue agreements to obtain or share bus berths in the new parking garage for storage / staging of the proposed feeder buses. Patronage estimates indicate storage for two 40-foot long buses would accommodate peak ridership.

- **Ivy Ridge, Figure 6 (served by: Proposed Feeder Bus Routes RAFtIR and HAFtIR)** – There is currently a Route 62 bus stop on Umbria Street near the station's eastern entrance. As laid out, the configuration of the Ivy Ridge Station property is not suited for bus access and on-site circulation that would be convenient for transferring passengers. The station's parking area is heavily utilized, and arranged in long, narrow rows. The recently lengthened boarding platforms to the R6 Line are located at the bottom of a grade, below the parking lots, and are accessed by a lengthy and steep staircase. While the staircase was also recently rehabbed, it remains an obstruction to individuals with the slightest mobility impairment. A privately owned vacant parcel is located at platform elevation, on the west (inbound) side of the tracks. Vehicular access to the parcel is provided to Umbria Street by Parker Avenue (in poor condition) along the station's northern property line. Parker Avenue travels under a bridge (clearances are adequate for a bus), and crosses the R6 tracks at-grade (protected by cross bucks and flashing lights, no gates). Access to the private property is secured by gates.

  The recommendations for the Ivy Ridge Station are capital in nature.

  Ivy Ridge Station Improvements:

  1) Parker Avenue, west of Umbria Street
     a) Construct an "at-rail-grade-elevation" bus turnaround bulb / storage area, capable of accommodating 180-degree bus turns and storage for three 40-foot long buses. The improvement will require extensive excavation and the installation of a retaining mechanism.
     b) Improve Parker Avenue to accommodate buses.
  2) Platform Area
     a) Construct a pedestrian walkway between the outbound platform and the bus turnaround bulb constructed at the base of Parker Avenue.
  3) Parking Lot Expansion
     a) Construct additional parking – on the level area adjacent to the bridge over Parker Avenue—accessed from within the SEPTA lot.

- **Wissahickon, Figure 7 (served by Proposed Feeder Bus Routes LRFtW and RAL)** – The Wissahickon Station is the least accessible to buses of all the stations surveyed. The outbound side of the station does not show promise for accommodating buses due to adjacent residential land use, on-street parking, narrow streets, and sharp intersection angles. The station's single parking lot (which is very long and narrow) is located on the inbound side, and is accessed via a skewed angle driveway intersecting Ridge Avenue at the top of a steep grade. Sidewalks along Ridge Avenue are too narrow to construct designated bus pull-off lanes and accommodate pedestrians as well. The station's pedestrian tunnel travels beneath the tracks, and also travels under Ridge Avenue to allow safe pedestrian crossing to a staircase that connects with Ridge Avenue (up) and Main Street (down). The staircase is in severe disrepair compromising pedestrian access to the eastbound side of Ridge Avenue. Adequate cartway space exists for eastbound buses to pick-up / discharge transferring passengers (as occurs today). However, given the potential volume of additional buses involved, the volume of general traffic, and geometric conditions along the station's frontage, adverse operational and safety impacts would likely result, if large-scale staging and storage were occurring on the eastbound side of Ridge Avenue.

  An additional requirement desired by SEPTA for the Wissahickon Regional Rail Station is that it should be functionally "connected" with the Wissahickon Transportation Center (WTC). The WTC is a local hub where study area bus routes and some North Philadelphia bus routes originate, terminate, serve, and/or otherwise accommodate a large volume of transferring passengers oriented to/from the western suburbs. In respect to this study's

work, the integration of the two stations is particularly necessary with the potential reconfiguration of suburban Bus Routes 124 and 125.

The recommendations for Wissahickon Station are capital intensive, largely due to the improvements required to overcome the vertical and horizontal separation between the transportation center and the regional rail station.

Wissahickon Station Improvements:

1) South-side station driveway from Ridge Avenue -
   a) Reconstruct the station's driveway to accommodate left-in and right-out access for 40-foot long buses.
2) South-side parking area -
   a) Alter parking area to accommodate 180-degree turns by 40-foot buses, to deliver passengers to the platform area. Patronage thresholds indicate storage for three 40-foot long buses would accommodate peak ridership of the feeder bus plan.
   b) Extend the parking lot eastward to the maximum extent possible beyond the existing paved parking area. [Note: SEPTA has already completed this improvement with a general upgrade of the existing parking lot. Estimated 48 spaces gained.]
3) Connection between the Wissahickon rail station and the Wissahickon Transportation Center –
   a) Install an elevator with complementary staircase (from Ridge Avenue opposite the WTC) and pedestrian bridge.

- **Villanova, Figure 8 (served by: Proposed Feeder Bus Route 200Z)** – The roadway configuration supplying the station's ingress and egress also serves the north campus of Villanova University, and is very favorable for bus access (SEPTA has used the station in the past for special bus service during periods of City Transit work stoppages). The access roadways intersecting Spring Mill Road (PA 320) form a full movement, mini-interchange. A highway underpass provides safe access for all directions of vehicular travel, and grade separated crossings for pedestrians on the outbound side of the station. The outbound station building and platform is accompanied by an adjacent kiss-and-ride loop, and a new parking garage has been built on the outbound side of the tracks by Villanova University to support its needs.

  There are no physical improvements identified for the station needed to support the feeder bus plan. The kiss-and-ride loop is large enough to handle bus maneuvering and storage for just one 40-foot long bus (required to accommodate peak transferring ridership in the feeder bus plan). SEPTA should investigate ownership of the roadways serving the station; and if necessary seek the university's acceptance / approval to operate or stage buses on a long-term basis on its roadways.

- **Overbrook, Figure 9 (served by: Proposed Feeder Bus Route 44)** – Overbrook Station is currently served by two SEPTA bus routes—the 65 bus operates along City Avenue and 63rd Street, and the G bus directly serves the property. Route G buses enter and exit on the station's outbound side from Drexel Road. There is enough area on the property to store three buses simultaneously. Presently 40-foot long buses perform a three-point turn on the station premises to maneuver to the station building and platform. The proposed improvement plan at the station includes circulation improvements to rectify this shortcoming.

  The plan also recommends delivering the extended Route 44 feeder bus to the inbound side of the station, and accommodating bus access and circulation with the set of capital access and circulation improvements outlined below. On-site circulation improvements on both sides of the station would necessitate removal of automobile parking spaces.

  Overbrook Station Improvements:

  1) North-side / outbound parking area -
     a) Construct circulation improvements to accommodate forward motion 180-degree turns by Route G's 40-foot long buses, to deliver passengers to the station and platform area.
  2) South-side / inbound parking area -
     a) Construct circulation improvements to accommodate forward motion 180-degree turns by the proposed feeder Route 44's 40-foot long buses, to deliver transferring passengers to the station and platform area. Estimates of peak storage needs for the reconfigured 44 bus are just one vehicle.
  3) South-side station driveway -
     a) Improve the 63rd Street / Station driveway intersection's geometry, curb and sidewalk to accommodate bus entry/exit, including rounding of curb and sidewalk.

- **Gulph Mills, Figure 10 (served by: Proposed Feeder Bus Route 123)** – The Gulph Mills Station has recently been reconstructed, and the platforms lengthened. The station is ADA accessible. The South Gulph Road (inbound) side of the station is not suitable for accommodating bus movements—only right-turns to and from South Gulph Road and the station's inbound parking lot are permitted. Consequently, SEPTA bus operations take place on the Trinity Road (outbound) side of the station. Two large bus shelters are present on the outbound side of the station, and buses enter and exit the facility without problem.

There are no physical improvements identified for the station needed to support the feeder bus plan. The property easily handles on-site bus maneuvering. Peak vehicle storage requirements are two 40-foot long buses to accommodate the Route 123 feeder bus (note: this route presently serves the station, and the relocation of feeder routes 124 and 125 to other stations will obviate any future storage space problems for buses).

Construction cost estimates for the station improvements were prepared by SEPTA staff and are itemized on **Figures 5, 6, 7, 8, 9, and 10**. In addition to the mentioned improvements, SEPTA included standard station amenities that normally accompany such improvements; such as shelters, lighting, and signage. Conversely, the estimates do not include ADA accessibility improvements or raised platforms where they are not now provided.

Improving bus access at Overbrook Regional Rail Station is one of many recommended improvements
Photo: DVRPC, 2008

Figure 5

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Norristown Transportation Center Improvements

Figure 6

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Ivy Ridge Rail Station Improvements

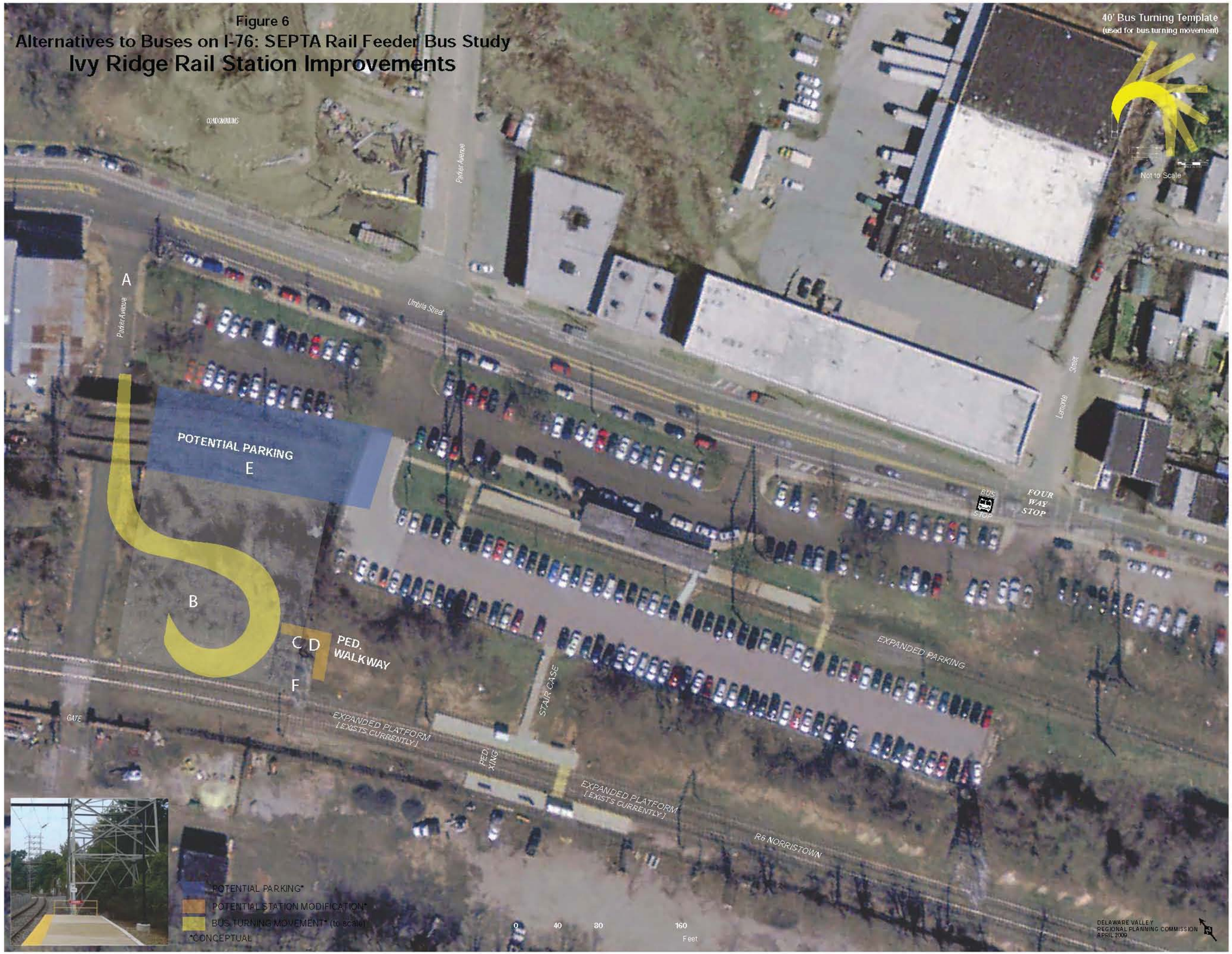


Figure 7

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Wissahickon Rail Station Improvements

Figure 6

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Ivy Ridge Rail Station Improvements

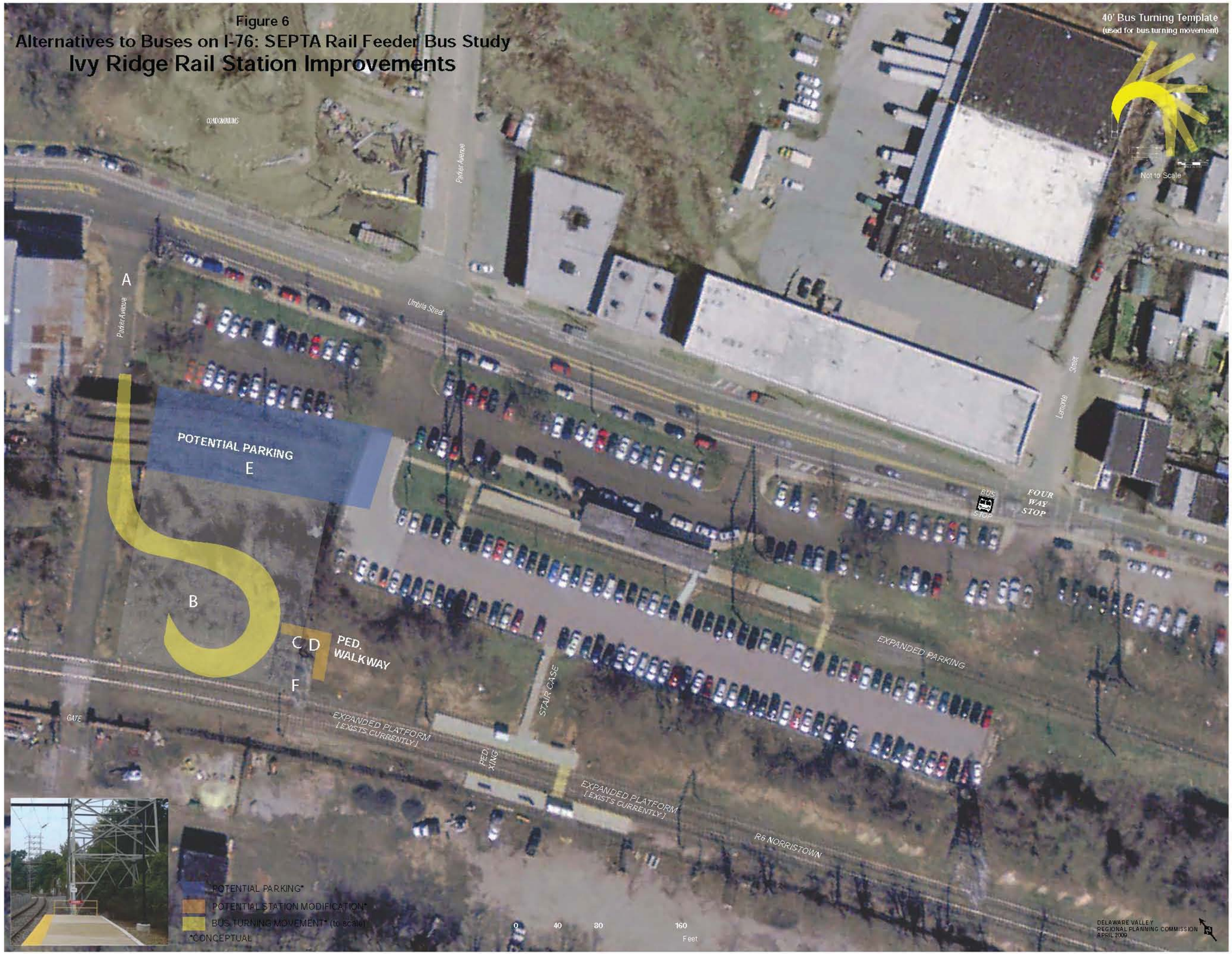


Figure 9

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Overbrook Rail Station Improvements

Figure 10

Alternatives to Buses on I-76: SEPTA Rail Feeder Bus Study

Gulph Mills Route 100 Station Improvements

6. Capital and Operating Costs (Task 11)

Task 11 was completed by a variety of SEPTA staff and is summarized in **Table 9**. **Appendix A** contains the full versions of the cost estimates supplied by SEPTA. Each subtotal represents the calculations and work of a separate SEPTA entity or department; Project Control (construction), Suburban Transit and City Transit (for bus and Route 100), and Regional Rail respectively. The operating costs for all modes are fully allocated and are not offset by fare revenue. Not provided were the underlying costs to operate the existing service on the two regional rail lines. Costs provided and shown only represent additional regional rail service.

In summary, the costs to implement the service (total capital improvements, estimated at just over $6 million) could be offset by approximately three years of operational savings (estimated at just under $2 million per year) if fully implemented.

Table 9: Summary of Capital and Operating Costs of the Fully Implemented Plan

Description: Station / Route / Facility	FY 2008 Unit Costs: Construction Cost for Capital Improvements		Fully Allocated Annual Operating Costs: Proposed Service	Change from Existing
Rail Stations				
Norristown Transportation Center (Fig. 5)	N/A			
Ivy Ridge Regional Rail Station (Fig. 6)	$1,075,000			
Wissahickon Regional Rail Station (Fig. 8)	$4,900,000			
Villanova Regional Rail Station (Fig. 9)	N/A			
Overbrook Regional Rail Station (Fig. 10)	$350,000			
Gulph Mills Route 100 Station (Fig. 11)	N/A			
Subtotal - Rail Stations	**$6,325,000**			
Suburban Division (see Figure 2)				
Bus Route 123 (to Gulph Mills)			$2,122,588	$23,811
Bus Route 200Y (to Norristown)			$1,820,669	-$1,073,776
Bus Route 200Z (to Villanova)			$3,176,787	-$635,802
Subtotal - STD Buses			**$7,120,044**	**-$1,685,767**
Route 100-Norristown High Speed Line			$10,951,693	$1,283,788
Subtotal - STD Bus and Route 100			**$18,071,737**	**-$401,979**
City Division (see Figure 3)				
Bus Route 44 (to Overbrook)			$1,316,910	-$5,028,664
Bus Route RAL (to Wissahickon)			$777,684	$777,684
Bus Route RAFtIR (to Ivy Ridge)			$1,208,937	-$4,126,352
Bus Route HAFtIR (to Ivy Ridge)			$1,389,029	-$5,984,829
Bus Route LRFtW (to Wissahickon)			$780,369	$780,369
Bus Route 62 (service deletion)			$0	-$233,343
Subtotal CTD Buses			**$5,472,929**	**-$13,815,135**
Regional Rail Division (additional service)				
R6-Norristown Regional Rail Line			$7,048,596	$7,048,596
R5-Paoli / Thorndale Regional Rail Line			$5,216,878	$5,216,878
Subtotal Regional Rail			**$12,265,474**	**$12,265,474**
TOTALS	**$6,325,000**		**$35,810,140**	**-$1,951,640**

Source: SEPTA, 2008

7. Travel Time Analyses (Task 12)

SEPTA staff supplied two components of performance data for DVRPC to assess and consider in evaluating the effectiveness of the potential plan:

- A log of dates, times, and locations of incidents or shut downs along the Schuylkill Expressway—including the bus routes affected and the duration of time that the events lasted during which buses were diverted from I-76 (and their regular service routes)—between October 7, 2008 and December 30, 2008,[7] and
- Before and after travel time estimates associated with the rail lines and reconfigured feeder bus routes contained in the plan

Disruptions due to Incidents

Analysis of the incident log report proved interesting, but not useful for measuring the effectiveness of the plan's ability to yield a more timely or reliable trip for the customer.

From the data: 42 individual interruptions were recorded on the expressway over the three month reporting period. Individual events lasted between 20 minutes and 10.5 hours. The total amount of the time that SEPTA's bus services were interrupted and diverted from I-76 ranged from two percent of its total service operating hours over the three month reporting period (west of City Avenue) to four percent of the total operating hours (east of City Avenue). Roughly 30 percent of the disrupted operating time occurred in the weekday peak travel periods, 30 percent of the time was distributed throughout the rest of the weekday, and 40 percent took place on weekends.

None of these indicators are applicable to computing additional travel time required to complete a scheduled trip, since presumably the buses leave the expressway and follow diversion routes to return to opened portions of the expressway, or use alternate routes to complete their trips. Improved communications (between emergency service providers, SEPTA Control Center and the bus operators) about the incidents and how to react to them may be the only strategy that can help. Still, that won't address the fact that interruptions along the expressway occur randomly, are not predictably measureable and therefore cannot be effectively managed in a mixed-traffic environment.

For a more reliable, but not necessarily event-free trip separate facilities which remove some of the variables associated with expressway travel would be more suitable. DVRPC examined two such priority treatments for this study. The results are contained in **Appendix B**.

Travel Time Analyses

Before and after travel time estimates associated with the rail lines and reconfigured feeder bus routes, for peak and off-peak conditions, were evaluated. A copy of the data submitted for the analyses is contained in **Appendix C**.

Observations regarding the data were as follows:

- Travel time savings were generally determined for the reconfigured services / stations closest to Center City (between 2 and 10 fewer minutes of travel per trip). These would include the following proposed routes:
  - *Lower Roxborough Feeder Bus to Wissahickon Station (LRFtW)*
  - *Ridge Avenue Feeder Bus to Ivy Ridge Station (RAFtIR)*
  - *Henry Avenue Feeder Bus to Ivy Ridge Station (HAFtIR)*
  - *Ridge Avenue Local Bus serving Wissahickon Station (RAL)*, and
  - *Route 44 Feeder Bus to Overbrook Station*

- Travel time losses were generally indicated for the service rearrangements located in the remoter suburbs (between 2 and 36 additional minutes of travel per trip). These would include the following proposed routes:
  - *Route 123 Feeder Bus to Gulph Mills Station*
  - *Route 200Y Feeder Bus to Norristown Station*
  - *Route 200Z Feeder Bus to Villanova Station*

The evaluation of travel time differences added dimension to the study, and an invaluable perspective for staging the project's recommendations for implementation.

[7] As reported by SEPTA's Control Center

8. Summary, Conclusions and Recommendations

Congestion along the Schuylkill Expressway (I-76) has, over time, detrimentally affected operations for eight SEPTA express bus routes that operate along the highway. SEPTA staff saw opportunity to revise bus operations in the Schuylkill Expressway corridor to take advantage of inherent travel time and service reliability of the rail network with the delivery of 120 new regional rail cars. DVRPC and SEPTA staff jointly conducted a worst case transportation planning exercise to estimate utilization, supporting facility and vehicle needs, and costs (or savings) associated with reconfiguring the eight expressway bus routes in to a feeder bus network serving six rail stations in the corridor.

Approximately 6,700 bus riders travel in each direction between 5:00 AM and 10:30 PM on the eight bus routes operating between Center City Philadelphia and points west in the Schuylkill Expressway corridor. A network of feeder bus routes were designed by SEPTA to replace the expressway bus routes based on early planning work conducted by DVRPC. Subsequent ridership estimates for the reconfigured feeder routes, prepared by DVRPC staff, indicated that about 5,000 of the riders could be served by the new route structure, and that almost all would have alternate access to the study rail stations because of alternate existing SEPTA bus route alignments.[8] Therefore, just about all riders were assigned to rail-side operations / analyses. The estimates and analyses were prepared in 30-minute time intervals for planning purposes: to correspond with future rail and bus service headways. Bus and rail service levels were determined, peak vehicle requirements to accommodate the transferring loads computed (at 80%, 100%, and 110% patronage thresholds), and station improvements identified as the basis for estimating operating and capital expenditures of the feeder bus plan.

Significant amounts of mileage and time are accrued during the expressway portion of the analyzed bus routes. SEPTA reported the current annual cost for the analyzed bus routes and the Route 100 as being nearly $38 million. The changes proposed through route reconfiguration would shorten the routes; though may require greater frequencies. The reconfigured routes have an estimated annual operating cost savings of $14.2 million. Costs for additional rail levels of service needed to meet both the ridership and frequency of the feeder bus plan was calculated at $12.3 million annually for the R6 and R5 lines (combined). Total operational cost savings for the entire plan are estimated at $1.9 million annually.

During the study effort it was determined that the Overbrook, Ivy Ridge, and Wissahickon regional rail stations would need capital improvements to accommodate the number of buses and additional passengers associated with the feeder bus plan. SEPTA staff prepared cost estimates in year 2008 dollars for the needed improvements as independently identified and mutually determined by their engineers and the project planners from SEPTA and DVRPC. Wissahickon Station is the least accessible station for buses, and coupled with the lack of connectivity between the rail station and associated bus transfer center (the WTC) is the most costly to improve. SEPTA estimated improvements to Wissahickon Station to be $4.9 million (the elevators alone would cost approximately $4.5 million). Improvement costs at Ivy Ridge Station were estimated to be $1.075 million, and $350,000 at Overbrook Station. Total improvement costs may be as high as $6.2 million, though this value could be offset by approximately three years operational savings if the project were fully implemented.

Upon closer inspection of the improvement costs and consideration of the results of the travel time analyses, it became clear that the entire plan need not and should not be implemented as one "package."

For example, while operating cost savings and no capital costs are associated with the Suburban Transit Division's set of route proposals and stations (serving a combined total of 1,825 daily transferring passengers, at Norristown - 600 passengers, Gulph Mills - 800 passengers, and Villanova - 425 passengers), advancing this part of the plan does not, at this time, satisfy SEPTA's intent to reduce customer travel times and inconvenience. One way travel time increases were estimated to be more the 30-minutes for some transferring trips in the STD set of route reconfigurations.

Conversely, travel time savings are expected for the more heavily patronized City Transit Division's set of reconfigured bus routes and rail stations (serving a combined total of 3,200 roundtrip transferring passengers, at Ivy Ridge - 1,350 passengers, Wissahickon - 1,400 passengers, and Overbrook - 450 passengers). Additionally, implementing the City Division's portion alone obviates the need for the elevator connection between the Wissahickon Regional Rail Station and the Wissahickon Transportation Center—significantly reducing the capital requirements for this half of the feeder bus plan (**Table 10**).

[8] The 1,700 or so "lost" riders are attributable in most part to abandoned segments, following reconfiguration of the study bus route alignments to serve as feeders. The majority of these route segments are covered by other existing SEPTA bus routes that will continue to operate along the segment and serve the rail stations. Consequently, feeder bus riders lost due to route reconfigurations are not lost to the SEPTA system; and in the estimating process for the study, the lost riders were still assigned to the rail stations to estimate the total effect of the plan on the rail side.

Table 10: Financial Analysis of Implementing Only the CTD's Stations and Bus Routes

R6 Line, *City Bus Routes* Only Ivy Ridge and Wissahickon Stations		
Expense	$ Amount	Additional / Savings
Rail (above existing)	6.0 mil/yr	Additional
Buses (below existing)	8.8 mil/yr	Savings
Total Operations	2.8 mil/yr	Savings
Construction		
Cost (excludes elevators at Wissahickon)	1.48 mil	
Pay-off time frame	6.3 months	
Daily Roundtrip Transferring Passengers		~2,750
R5 Line, *Bus Route 44* Only Overbrook Station		
Expense	$ Amount	Additional / Savings
Rail (above existing)	6.2 mil/yr	Additional
Bus (below existing)	5.0 mil/yr	Savings
Total Operations	1.2 mil/yr	Additional
Construction		
Cost	0.35 mil	
Pay-off time frame	Never (operating costs escalate annually)	
Daily Roundtrip Transferring Passengers		~450

Source: DVRPC, 2009

The City Transit Division stations will require $1.8 million worth of physical improvements to accommodate the buses that would feed them. The larger set of improvements and construction costs are identified for the Ivy Ridge and Wissahickon Stations, and can be recovered through operating savings in less than one year. The investment at Overbrook will not be recouped. Still, the Overbrook Station improvements may be judged worthwhile to rectify the existing three-point turn performed by the Route G Bus on the outbound side of the property, and to supply the proposed reconfigured Route 44 Bus with a protected and visible space for layovers on the inbound side of the station.

RECOMMENDATIONS

In consideration of the study's undertakings and findings, it is recommended that incremental steps should be taken to institute the plan, hone or temper ridership demand, and phase implementation of needed auxiliary projects—so that the overall investments can be controlled and benefits maximized. These include:

1. Add, in staged-order, the individual operating aspects and capital improvement projects required to implement the rail-feeder bus plan to SEPTA's Service Plan, and Capital Budget and Capital Program.
   - Coordinate this study's suggested station improvements with other projects and programs being developed for implementation. Those determined through this study included:
     - **Ivy Ridge Station** – ADA improvements included in SEPTA's long-range plan;
     - **Wissahickon Station** – ADA improvements included in SEPTA's long-range plan, and PennDOT's Gustine Lake Bridge Replacement Project (PA Transportation Improvement Program MPMS # 50931); and
     - **Villanova Station** – Varied station improvements (PA Transportation Improvement Program MPMS # 15407), and a new interlocking west of the station. [**Note**: no physical improvements are suggested *by this study* for the Villanova Station.]
2. Construct the proposed parking expansion at the Ivy Ridge Station on the R6 Line—currently required. Estimated construction cost: $235,000.
3. Survey all express bus patrons to determine ridership patterns and potential degree of participation in the feeder bus plan.
4. Survey transferring bus patrons at the Wissahickon Transportation Center to:
   - Determine patterns of ridership between the North Philadelphia bus routes and Suburban Routes 124 and 125;
   - Assess whether remote re-routings and/or alternate connections can be established to serve those patterns, and reduce the transferring volumes (and corresponding capital investment) between the Wissahickon Transfer Center and the Wissahickon Regional Rail Station to ease implementation of the suburban route changes.
5. Following the delivery of the new regional rail cars—implement the City Transit Division's rail and bus route reconfigurations, and outstanding station improvements at the Overbrook Station, Ivy Ridge Station, and Wissahickon Station—**excluding the elevators at Wissahickon**. Estimated construction cost: $1,590,000.

6. Monitor highway travel conditions and reevaluate travel time benefits of the Suburban Bus Route reconfigurations to determine if worsening highway conditions compensate for the added transferring travel times associated with the feeder bus plan; **or** implement wholesale, area-wide bus route changes with the proposed Route 100 extension to the King of Prussia Mall (slated to occur between 2011 and 2020, per DVRPC's Long Range Plan)—whichever comes first.

7. Construct the elevators at the Wissahickon Station / Wissahickon Transfer Center (if the STD route reconfigurations are warranted in forthcoming travel time evaluations; see item #6, above). Estimated construction cost: $4,500,000.

8. Institute the Suburban Bus Route service changes (serving Norristown, Villanova and Gulph Mills stations). There are no capital improvement projects suggested for these stations *by this study.*

The underlying issue of the study was the poor on-time performance for bus routes operating on the Schuylkill Expressway. Considering that for the most part the duplicating rail service is already in place (less the needed frequency), financial savings may be realized by SEPTA and time savings may be realized by SEPTA customers. However, the existing SEPTA fare structure is not conducive to the multi-modal travel studied here, particularly for individuals commuting to part-time jobs. Both SEPTA and DVRPC agreed that the fare issue raises concerns regarding environmental justice. This study does no more than recognize that this issue exists; a subsequent study would need to occur, if SEPTA intends to implement the service changes outlined in this study.

Improving bus / rail connections can reduce operating costs and improve service reliability
Photo: DVRPC, 2008

APPENDICES

A. SEPTA Cost Estimates (all costs in 2008 dollars)

B. Priority Treatments for High Occupancy Vehicles

C. Before and After Travel Time Estimates

APPENDIX A. SEPTA COST ESTIMATES

VEHICLE REQUIREMENTS / OPERATIONAL COSTS

SEPTA calculated operational cost estimates for the level of service required to accommodate the estimated ridership. These estimates are given in the following tables:

SEPTA Suburban Division Bus and Route 100 Services (2008 unit costs)

ANNUAL	ROUTE 124	200 SERIES ROUTE CONNECTING WITH R6 AT NORRISTOWN TC	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	675,699	337,831	-337,868
VEHICLE HOURS	35,757	25,647	-10,110
PEAK VEHICLES	7	5	-2
PASSENGERS	465,080	408,785	-56,295
TOTAL COST [F/A]	$2,894,445	$1,820,669	-$1,073,776
REVENUE	$586,001	$515,069	-$70,932
NET DEFICIT	$2,308,444	$1,305,600	-$1,002,844
OPERATING RATIO	20%	28%	8%
SUBSIDY PER PASSENGER	$6.22	$4.45	-$1.77

ANNUAL	ROUTE 125	200 SERIES ROUTE CONNECTING WITH R5 AT VILLANOVA STATION	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	635,621	479,732	-155,889
VEHICLE HOURS	35,108	32,640	-2,468
PEAK VEHICLES	8	6	-2
PASSENGERS	517,200	298,360	-218,840
TOTAL COST [F/A]	$3,812,589	$3,176,787	-$635,802
REVENUE	$589,608	$340,130	-$249,478
NET DEFICIT	$3,222,981	$2,836,657	-$386,324
OPERATING RATIO	15%	11%	-4%
SUBSIDY PER PASSENGER	$7.37	$10.65	$3.28

ANNUAL	ROUTE 123	NEW ROUTE CONNECTING WITH 100 TRAINS AT GULPH MILLS STATION	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	364,588	286,305	-78,283
VEHICLE HOURS	19,531	25,238	5,707
PEAK VEHICLES	4	3	-1
PASSENGERS	368,450	564,190	195,740
TOTAL COST [F/A]	$2,098,777	$2,122,588	$23,811
REVENUE	$575,358	$643,177	$67,819
NET DEFICIT	$1,523,419	$1,479,411	-$44,008
OPERATING RATIO	27%	30%	3%
SUBSIDY PER PASSENGER	$5.70	$3.76	-$1.94

ANNUAL	ROUTE 100	ROUTE 100 ADDITIONAL SERVICE AS PART OF RAIL-BUS CONNECTOR SERVICE AT GULPH MILLS	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	852,944	1,102,668	249,724
VEHICLE HOURS	42,017	53,057	11,040
PEAK VEHICLES	16	19	3
PASSENGERS	2,703,720	3,267,910	564,190
TOTAL COST [F/A]	$9,667,905	$10,951,693	$1,283,788
REVENUE	$3,287,724	$3,970,394	$682,670
NET DEFICIT	$6,380,181	$6,981,299	$601,118
OPERATING RATIO	34%	36%	2%
SUBSIDY PER PASSENGER	$3.58	$3.35	-$0.23

ANNUAL	SUBURBAN DIVISION BUS TOTALS (excludes ROUTE 100)			
	EXISTING	PROPOSED	DIFFERENCE	
VEHICLE MILES	1,675,908	1,103,868	-572,040	-34%
VEHICLE HOURS	90,396	83,525	-6,871	-8%
PEAK VEHICLES	19	14	-5	-26%
BUS PASSENGERS	1,350,730	1,271,335	-79,395	-6%
TOTAL COST [F/A]	$8,805,811	$7,120,044	-$1,685,767	-19%
REVENUE	$1,750,967	$1,498,376	-$252,591	-14%
NET DEFICIT	$7,054,844	$5,621,668	-$1,433,176	-20%
OPERATING RATIO	20%	21%	1%	6%
SUBSIDY PER PASSENGER	$6.52	$5.60	-$0.92	-14%

SEPTA City Division Bus Services (2008 unit costs)

ANNUAL	ROUTE 9	RIDGE AVENUE LOCAL	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	515,420	117,728	-397,692
VEHICLE HOURS	43,190	6,534	-36,656
PEAK VEHICLES	9	3	-6
PASSENGERS	1,572,085	360,000	-1,212,085
TOTAL COST [F/A]	$5,335,289	$1,208,937	-4,126,352
REVENUE	$1,430,597	$327,600	-1,102,997
NET DEFICIT	$3,904,692	$881,337	-3,023,355
OPERATING RATIO	27%	27%	0
SUBSIDY PER PASSENGER	$3.39	$3.36	0

ANNUAL	ROUTE 27	HENRY AVENUE FEEDER TO IVY RIDGE	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	758,980	135,183	-623,797
VEHICLE HOURS	54,179	12,301	-41,878
PEAK VEHICLES	13	3	-10
PASSENGERS	1,299,542	425,000	-874,542
TOTAL COST [F/A]	$7,373,858	$1,389,029	-$5,984,829
REVENUE	$1,182,583	$386,750	-$795,833
NET DEFICIT	$6,191,275	$1,002,279	-$5,188,996
OPERATING RATIO	16%	28%	12%
SUBSIDY PER PASSENGER	$5.67	$3.27	-$2.41

ANNUAL	ROUTE 62		Route 62 Savings
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	10,892	0	-10,892
VEHICLE HOURS	796	0	-796
PEAK VEHICLES	1	0	-1
PASSENGERS	33,210	0	-33,210
TOTAL COST [F/A]	$233,343	$0	-$233,343
REVENUE	$30,221	$0	-$30,221
NET DEFICIT	$203,122	$0	-$203,122
OPERATING RATIO	13%	0%	-13%
SUBSIDY PER PASSENGER	$7.03	$0.00	-$7.03

ANNUAL	NEW ROUTE	LOWER ROXBOROUGH FEEDER TO WISSAHICKON	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	0	42,669	42,669
VEHICLE HOURS	0	6,621	6,621
PEAK VEHICLES	0	2	2
PASSENGERS	0	325,000	325,000
TOTAL COST [F/A]	$0	$780,369	$780,369
REVENUE	$0	$295,750	$295,750
NET DEFICIT	$0	$484,619	$484,619
OPERATING RATIO	0%	38%	38%
SUBSIDY PER PASSENGER	$0.00	$2.40	$2.40

ANNUAL	COMBINATION OF ROUTES 9, 27, 35	RIDGE AVE FEEDER	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	0	63,875	63,875
VEHICLE HOURS	0	4,901	4,901
PEAK VEHICLES	0	3	3
PASSENGERS	0	280,000	280,000
TOTAL COST [F/A]	$0	$777,684	$777,684
REVENUE	$0	$254,800	$254,800
NET DEFICIT	$0	$522,884	$522,884
OPERATING RATIO	0%	33%	33%
SUBSIDY PER PASSENGER	$0.00	$2.78	$2.78

ANNUAL	ROUTES 44 & 121	ROUTE 44	
	EXISTING	PROPOSED	DIFFERENCE
VEHICLE MILES	548,640	108,366	-440,274
VEHICLE HOURS	45,511	6,254	-39,257
PEAK VEHICLES	14	4	-10
PASSENGERS	1,266,580	450,000	-816,580
TOTAL COST [F/A]	$6,345,574	$1,316,910	-$5,028,664
REVENUE	$1,152,588	$409,500	-$743,088
NET DEFICIT	$5,192,986	$907,410	-$4,285,576
OPERATING RATIO	18%	31%	13%
SUBSIDY PER PASSENGER	$5.01	$2.93	-$2.08

ANNUAL	CITY DIVISION BUS TOTALS			
	EXISTING	PROPOSED	DIFFERENCE	
VEHICLE MILES	1,833,932	467,821	-1,366,111	-74%
VEHICLE HOURS	143,676	36,611	-107,065	-75%
PEAK VEHICLES	37	15	-22	-59%
BUS PASSENGERS	4,171,417	1,840,000	-2,331,417	-56%
TOTAL COST [F/A]	$19,288,065	$5,472,929	-$13,815,136	-72%
REVENUE	$3,795,989	$1,674,400	-$2,121,589	-56%
NET DEFICIT	$15,492,075	$3,798,529	-$11,693,546	-75%
OPERATING RATIO	20%	31%	11%	55%
SUBSIDY PER PASSENGER	$4.62	$2.97	-$1.65	-36%

ANNUAL	SUBURBAN and CITY DIVISIONS BUS TOTALS (excludes ROUTE 100)			
	EXISTING	PROPOSED	DIFFERENCE	
VEHICLE MILES	3,509,840	1,571,689	-1,938,151	-55%
VEHICLE HOURS	234,072	120,136	-113,936	-49%
PEAK VEHICLES	56	29	-27	-48%
BUS PASSENGERS	5,522,147	3,111,335	-2,410,812	-44%
TOTAL COST [F/A]	$28,093,876	$12,592,973	-$15,500,903	-55%
REVENUE	$5,546,956	$3,172,776	-$2,374,180	-43%
NET DEFICIT	$22,546,919	$9,420,197	-$13,126,722	-58%
OPERATING RATIO	20%	25%	5%	28%
SUBSIDY PER PASSENGER	$5.09	$4.05	-$1.04	-20%

ANNUAL	SUBURBAN and CITY DIVISION BUS TOTALS (includes ROUTE 100)			
	EXISTING	PROPOSED	DIFFERENCE	
VEHICLE MILES	4,362,784	2,674,357	-1,688,427	-55%
VEHICLE HOURS	276,089	173,193	-102,896	-49%
PEAK VEHICLES	72	48	-24	-48%
BUS PASSENGERS	8,225,867	6,379,245	-1,846,622	-44%
TOTAL COST [F/A]	$37,761,781	$23,544,666	-$14,217,115	-55%
REVENUE	$8,834,680	$7,143,170	-$1,691,510	-43%
NET DEFICIT	$28,927,100	$16,401,496	-$12,525,604	-58%
OPERATING RATIO	23%	30%	7%	28%
SUBSIDY PER PASSENGER	$4.59	$3.69	-$0.90	-20%

COSTING FOR ADDED R5 PAOLI-THORNDALE and R6 NORRISTOWN SERVICE for I-76 BUS REROUTINGS *11/28/2008*

R6 Norristown

ITEM	ROUTE	SERVICE DESCRIPT.	DIST.	CARS	CAR MILEAGE	ROUND TRIP CAR MILES	ANNUAL CAR MILES	Annual Cost Per Car Per Year	ANNUAL PROP. POW. MAINT. COSTS	ANNUAL AMT ACCESS COSTS	TOTAL ANNUAL COSTS
1	R6 Norristown	Additional Peak Cars		8				57,200			$457,600
2	R6 Norristown	Additional Peak Car Miles			805.2		205326		$646,777		$646,777
3	R6 Norristown	Half-hour Off-peak Service	19	2	532	1064	271320		$854,658		$854,658
4	R6 Norristown	Half-hour Saturday Service	19	2	798	1596	82992		$261,425		$261,425
5	R6 Norristown	Half-hour Sunday Service	19	2	760	1520	79040		$248,976		$248,976
								R6 Norristown Car/mileage Costs			***$2,469,436***

R5 Paoli-Thorndale

ITEM	ROUTE	SERVICE DESCRIPT.	DIST.	CARS	CAR MILEAGE	ROUND TRIP CAR MILES	ANNUAL CAR MILES	Annual Cost Per Car Per Year	ANNUAL PROP. POW. MAINT. COSTS	ANNUAL AMT ACCESS COSTS	TOTAL ANNUAL COSTS
6	R5 Paoli-Thorndale	Additional Peak Cars		4	0	0	0	57,200	$0		$228,800
7	R5 Paoli-Thorndale	Additional Peak Car Mileage			314.4		80,172		$252,542		$252,542
8	R5 Paoli-Thorndale	Half-hour Off-peak Service Villanova Locals	17.5		315	630	160,650		$506,048		$506,048
							Daily Train Miles	Annual Train Miles			
9	R5 Paoli-Thorndale	Half-hour Off-peak Service Villanova Locals	10.1				182	46,359		$362,527	$362,527
10	R5 Paoli-Thorndale	Saturday Half-hour Service Villanova Locals	17.5		455	910	47,320		$149,058		$149,058
							Daily Train Miles	Annual Train Miles			
11	R5 Paoli-Thorndale	Saturday Half-hour Off-peak Service Villanova Locals	10.1				263	13,655		$106,784	$106,784
12	R5 Paoli-Thorndale	Sunday Half-hour Service Villanova Locals	17.5		770	1540	89,320		$281,358		$281,358
							Daily Train Miles	Annual Train Miles			
13	R5 Paoli-Thorndale	Sunday Half-hour Off-peak Service Villanova Locals	10.1				444	25,775		$201,562	$201,562
								R5 Paoli/Thorndale Car/mileage Costs			***$2,088,679***

Labor Costs for Increased service

		SERVICE DESCRIP.	TIME CAR HOURS	RATE	Round Trips	TOTAL LABOR COST	ANNUAL LABOR COST	TOTAL ANNUAL LABOR COST
1L	R6 Norristown	Additional Peak Assist.Cond.	30	$22		$660	$168,300	$168,300
2L	R6 Norristown	Additional Peak Crew Hours	4.2	$103		$432	$110,206	$110,206
3L	R6 Norristown	Additional Off-peak Crew Hours	2.2	$103	13	$2,943	$750,450	$750,450
4L	R6 Norristown	Additional Saturday Crew Hours	2.2	$154	21	$7,131	$1,818,397	$1,818,397
5L	R6 Norristown	Additional Sunday Crew Hours	2.2	$154	20	$6,791	$1,731,807	$1,731,807
6L	R5 Paoli-Thorndale	Additional Peak Crew Hours	20	$22		$440	$112,200	$112,200
8L	R5 Paoli-Thorndale	Additional Off-peak Crew Hours	2.5	$103	9	$2,315	$590,389	$590,389
10L	R5 Paoli-Thorndale	Additional Saturday Crew Hours	2.5	$154	13	$5,016	$260,852	$260,852
11L	R5 Paoli-Thorndale	Additional Sunday Crew Hours	2.5	$154	22	$8,489	$2,164,759	$2,164,759
							R5 Paoli/Thorndale, R Norristown Labor Costs	***$7,707,359***
							Grand Total	***$12,265,473***

Capital Improvements

SEPTA Project Control conducted cost estimates for the recommended improvements at three regional rail stations (the remaining stations are recommended for only financially insignificant improvements). The cost estimates are summarized in the following memo:

CAPITAL IMPROVEMENTS

SEPTA provided cost estimates for the recommended improvements at three Regional Rail Stations (the remaining stations are recommended for only insignificant improvements). The cost estimates are summarized as follows:

R6 Wissahickon Station - $4,200,000 - $4,900,000.
R6 Ivy Ridge Station - $1,000,000 - $1,075,000.
R5 Overbrook Station - $300,000 - $350,000.

R6 Wissahickon Station Inbound Side

Changes to accommodate connecting buses

- Widen and re-grade the existing parking lot entrance from Ridge Avenue, including added lighting
- Relocate the existing station sign to west side of entrance drive
- Install new flashing warning sign on Ridge Avenue
- Cut back as small portion of the existing inbound canopy to allow for bus height
- Reconfigure a portion of the existing lot to allow for bus flow as well as layover space
- Re-stripe a portion of Ridge Avenue and inbound parking lot
- Install new guard rail at widened entrance

Connection to Wissahickon Transportation Center (TC)

- From elevation 90' (southeast parking area of the Wissahickon Station) to elevation 35' at Ridge Avenue.
- Elevator structure is assumed to be located north and east of the existing commercial property across from Wissahickon TC.
- Elevator shaft tower is assumed to be a substantial Steel Tube Frame Structure including transparent glass panels
- Vertical rise is assumed to be 55 feet. Three ventilator fans are included in the cost estimate
- Two MRL elevators were assumed in the estimate
- A truss bridge will connect the station parking lot to the elevator tower and is assumed to be enclosed in a wire mesh, including a metal roof.
- A pre-cast stairway is incorporated into the estimate, and is assumed to be located adjacent to the tower.
- Normal lighting fixtures were included at the tower entrances, bridge approaches and at both elevations.
- Minor improvements to pathways to and from the elevator tower are included
- The pathway across Ridge Avenue, adjacent to the Wissahickon TC includes an existing pedestrian signal system and was not assumed to be upgraded.
- Minor landscaping was included to re-establish vegetative growth.

R6 Ivy Ridge Station Option for bus loop off of Parker Avenue with Walkway

- Create a 160' x 120' queuing asphalt paved bus passenger drop off location, just north of the outbound platform
- Construct a pedestrian on-grade walkway to the outbound platform
- Install a small passenger waiting shelter
- Construct additional parking at the southeast portion of the adjacent top of slope parking lot (180' x 95')
- Re-grade adjacent areas to both the additional parking and bus loop in lieu of constructing retaining walls. Re-seed these areas.
- Additional site lighting
- Mill existing asphalt surface and overlay with 11/2 " wearing course (new asphalt pavement overlay area assumed to be 1,800 SY)
- Minor pavement striping
- All existing finish grade elevations held
- Storm water management not included in estimate
- Passenger grade crossing included
- Additional signage included

R5 Overbrook Station Bus Loop

- Construct new bus loop passenger drop off / pick up in the outbound parking lot
- Construct new bus loop passenger drop off / pick up in the inbound parking lot
- Widen entrance to inbound parking lot
- Additional site lighting
- Install small bus shelter on the inbound pick up / drop off

APPENDIX B. PRIORITY TREATMENTS FOR HIGH OCCUPANCY VEHICLES

Opportunity exists for SEPTA to improve its service reliability and customer travel times in the Schuylkill Expressway (I-76) corridor via the delivery of 120 new regional rail cars anticipated by 2012. The formal study investigated means of improving services within the corridor by reconfiguring eight bus routes, which presently operate along the expressway, into feeder bus routes focused at six rail stations in the corridor.

At the study's outset, SEPTA staff also asked DVRPC staff to include an investigation of the feasibility of providing priority lane treatments along the Schuylkill Expressway to better accommodate the performance of the bus routes—as presently configured. This appendix presents the findings of that work.

Two priority strategies were investigated: high occupancy vehicle lanes on the expressway, and bus-only use of the expressway's shoulders. The analyses addressed warrants and/or practices used to establish these special treatments along freeways; and included analyses of volume, speed, and physical characteristics of the Schuylkill Expressway to indicate the appropriateness of the strategies.

HIGH OCCUPANCY VEHICLE LANES (HOV LANES)

HOV facilities are common along freeways in many of the country's urban areas, but none are present on Philadelphia area expressways. An HOV lane is a highway lane designated for vehicles with multiple occupants. As a warrant for consideration, HOV lanes should accommodate at least the same number of people as each adjacent non-HOV lane over the same time interval. In turn, fewer vehicles in the high occupancy lane results in a less congested travel environment, faster speeds, and shorter travel times.

Most HOV lanes require a minimum of two passengers per vehicle (HOV 2+). In the Los Angeles area some HOV facilities require three or more passengers (HOV 3+). Some HOV lanes are in effect and enforced 24 hours per day, but most are only enforced during peak commutation hours. After the peak, the lanes are returned to general traffic's use. There may be a toll charged (HOT Lanes) or they may be free.

In theory, there are two ways to provide an HOV lane. Converting an existing travel lane to HOV use is nearly impossible due to public opposition related to the congestion that it would create in the remaining general purpose lanes.[1] Traffic volumes along the Schuylkill Expressway are very high and balanced by direction during the peaks and so is SEPTA's express bus service—conceptually suggesting that simultaneous HOV facilities for both directions of travel are appropriate. Removal of a general purpose lane for HOV use in each direction would leave the Schuylkill Expressway with one general purpose travel lane in each direction west of the City Avenue Interchange, and two lanes in each direction between City Avenue and Center City.

Current peak hour volumes (one direction) compared to ideal capacities along basic uninterrupted freeway segments (i.e., 2,200 passenger cars per hour per lane, which excludes the effects of merging and diverging in and around ramp junctions, etc.[2]) yield volume-capacity ratios of 0.96 west of City Avenue, and 0.81 east of the interchange along I-76. Removal of a travel lane west of City Avenue would increase congestion by 100 percent (i.e., to a v-c ratio of 1.96). East of City Avenue, the v-c index would rise by 50 percent (i.e., to 1.22).

More realistically: adding new designated lanes is the more accepted and practiced way of introducing HOV facilities. Still, the rule remains the same: the number of people using the new HOV lane must be equal to or greater than the number of people traveling in the adjacent general purpose lanes. Once the parameters were clarified, analyses for determining this most basic criterion were performed and warrants determined.

Calculations were conducted for each direction of flow east and west of City Avenue for both the morning and evening peak periods. The computations, contained in **Tables B-1 and B-2** summarize the work. In the tables actual bus passenger volumes from the SEPTA ride checks are shown, as are bus counts from the SEPTA schedules, and Traffic.com traffic count data. Vehicle occupancies for the remainder of the traffic stream are assumed at 1.17 persons per vehicle[3] to supply the necessary data for calculating the number of people traveling in single occupant vehicles (cars, motor cycles, trucks, etc.), and those in multiple occupancy vehicles (e.g., other buses, and cars with two or more occupants).[4]

---

[1] American Association of State Highway and Transportation Officials (AASHTO)
[2] *2000 Highway Capacity Manual,* Transportation Research Board (TRB)
[3] Based on survey results of vehicle occupancies in the in the Philadelphia metropolitan region. DVRPC uses this value in its regional travel demand forecasting model to convert person trips to vehicle trips along expressways in the region.
[4] Ultimately a liberal estimate is provided, as it assumes all origins and destinations are accommodated in the facility design; and all multiple occupant vehicles will use the HOV lane.

East of City Avenue, adding an HOV lane in each direction would yield a lane count of four lanes in each direction. Consequently, it must be established that one-quarter (25%) of the people on the highway would travel in the HOV lane during the analysis period. West of City Avenue, where the lane count in each direction would be three lanes after adding an HOV lane, requires that one-third (33%) of the people travel in the HOV lane. These thresholds are not attainable if SEPTA buses were to occupy the HOV lanes alone (i.e., East of City Avenue, SEPTA bus passengers account for at most 13% to 15% of the peak flows on the expressway). So an allowance for 2+ occupant vehicles was included (assumed at 17% of the persons traveling in the other vehicles in the stream of traffic).

Given those assumptions, in the segment between City Avenue and Center City, the Schuylkill Expressway would justify a 2+ HOV lane for each direction of travel throughout the morning and evening peak periods (i.e., between 26% and 34% of the people would be traveling in high occupancy vehicles—25% needed). It is estimated that providing an HOV lane between the City Avenue and 30th Street interchanges would save approximately seven minutes of travel time in each direction during the peak periods. West of the City Avenue interchange, where SEPTA operates fewer buses, warrants for HOV facilities are not met (between 25% and 32% of the people would be traveling in high occupancy vehicles—33% needed).

Adding capacity along I-76 has often been discussed. Effecting the improvement would require support from jurisdictions throughout the region (including the federal and state governments). The costs to advance and provide conventional widening or elevated lanes would be exorbitant—perhaps prohibitively so given the nominal travel time benefits, the severe climate surrounding transportation assistance funding and the opportunities that would be lost to advance a wider array of improvements across more jurisdictions. Another method of priority treatments that might deliver reliable bus service on I-76, potentially in a more cost effective manner, is to allow buses the use of the expressway's shoulders.

Bus-Only Shoulders (BOS)

BOS have been used effectively across the United States. San Diego, California; Miami, Florida; Falls Church, Virginia in the Washington, D.C. metro area; and Minneapolis, Minnesota are some cities employing the congestion mitigation strategy.

Minneapolis is the nationwide leader in advancing the state of the art for BOS. The Federal Transit Administration's report entitled: *Bus-Only Shoulders in the Twin Cities* notes that the city has ten times the number of BOS installations than the rest of the nation combined. For these reasons, Minneapolis's BOS guidelines provided the basis for analyzing the applicability of BOS treatments along the Schuylkill Expressway within the limits of the study corridor. Their guidelines include:

- A bus traveling on a BOS lane may not travel faster than 35 miles per hour, and may not travel faster than 15 miles per hour faster than traffic in the adjacent general purpose traffic lanes. If traffic is moving at 35 miles per hour or greater in the general purpose lanes, the bus may not use the shoulder.
- A bus may use the shoulder when passing on and off ramps, but the bus driver is responsible for yielding to the vehicles exiting and entering the freeway.
- Shoulders should be constructed seven inches thick to support BOS.
- The bus driver is responsible for avoiding vehicles and debris on the shoulder.
- When driving on a shoulder, the bus's four-way flashers must be on.
- The shoulder must have an effective width of 10 feet if no fixed object is present, and 11.5 feet if a fixed-object is present (i.e. guardrail, curb, bridge stanchion).

A sampling of peak period speed readings from Traffic.com equipment installed along the highway is summarized in **Table B-3**.[5] The speed data from the same recording instruments can be variable from day to day within the same clock hour. Of the 48 samples, 13 readings (27%) indicate average operating speeds below 35 miles per hour. Further, average speed conditions, supportive of BOS applications, are not necessarily continual between adjacent interchanges so that extended use of the shoulders is not assured.

[5] The information contained in **Table B-3** reflects a limited sampling of data collected by the sensors located east and west of City Avenue as a representation of operating speeds in the six lane and the four lane segments of I-76. Traffic.com's traffic sensors are not necessarily installed to record traffic in both directions of travel, or between every interchange.

Through travel lanes along the expressway are 12 feet wide, and paved shoulders are provided for both directions of travel. A sampling of field measurements of the outer shoulders from Center City to Gulph Mills indicated an overall average width of about 10 feet. The outer shoulder may be bordered by a "Jersey" barrier. Typically, behind the barrier are steep slopes, up or down. Overall, widths of the shoulders bordering the center median are much narrower than the outer shoulders. Cut and fill operations to physically widen the expressway's outer shoulders for consistent 11.5-feet (minimum) effective widths would also be expensive. Restriping for narrower median shoulders and/or through lanes to yield wider outer shoulders was not investigated, but may be an option. These actions would require PennDOT and Federal Highway Administration consideration and approval. In the end, none of the techniques described to provide BOS priority treatment is unequivocally supported by the speed data along the expressway.

Additionally, while not a stated guideline of the Minneapolis practices. Enforcement of the shoulder's use to buses should be a concern. To be self-enforcing, minimum one-way bus volumes of 60 to 90 buses per hour[6] would be necessary. SEPTA's schedules indicate at most 33 buses per hour are operating on the expressway during the rush hours (east of City Avenue, in the westbound direction, between 7:00 and 8:00 AM).

Table B-3: Sample Peak Hour Operating Speeds along I-76

						AM Peak			PM Peak		
	Sensor ID	ID 2	Dir/LnCt	Nearest Exit	Date	0600-0700	0700-0800	0800-0900	1600-1700	1700-1800	1800-1900
East of City Ave / Roosevelt Blvd (US 1)	PA 076925	973	Eb/3	Spring Garden	5/20/2008	45.08	38.82	36.58	17.51	17.15	39.37
					5/21/2008	48.69	46.91	48.01	28.49	34.43	56.45
					5/22/2008	56.26	45.76	38.37	29.14	28.27	33.98
					Average	50.01	43.83	40.99	25.05	26.62	43.27
	PA 076920	1433	Wb/3	Girard	10/10/2006	58.03	59.97	59.74	56.69	44.81	54.13
					10/11/2006	57.38	58.65	56.16	54.88	47.87	36.62
					10/12/2006	57.90	59.91	59.93	57.69	55.31	49.65
					Average	57.77	59.51	58.61	56.42	49.33	46.80
	PA 076905	953	Wb/3	Montgomery	10/10/2006	55.24	56.42	51.17	49.87	38.18	55.81
					10/11/2006	55.47	33.75	29.60	36.82	40.26	35.49
					10/12/2006	55.36	56.25	57.43	50.62	54.81	55.13
					Average	55.36	48.81	46.07	45.77	44.42	48.81
	PA 076905	953	Eb/4	Montgomery	10/10/2006	46.39	29.94	21.53	57.22	59.16	57.68
					10/11/2006	46.81	51.82	27.44	13.43	12.28	15.32
					10/12/2006	44.55	33.78	25.51	22.08	18.49	28.23
					Average	45.92	38.51	24.83	30.91	29.98	33.74
West of City Ave / Roosevelt Blvd (US 1)	PA 76880	2495	Eb/2	Belmont	10/10/2006	50.40	43.29	17.61	60.92	42.34	46.35
					10/11/2006	52.00	33.82	42.67	43.08	24.44	33.58
					10/12/2006	46.80	36.88	49.04	57.82	59.43	58.94
					Average	49.73	38.00	36.44	53.94	42.07	46.29
	PA 076875	2496	Wb/2	Belmont	10/10/2006	47.15	27.09	27.59	44.02	61.36	63.01
					10/11/2006	40.76	26.33	26.60	27.76	32.03	47.10
					10/12/2006	45.30	27.25	28.15	41.88	59.55	59.73
					Average	44.40	26.89	27.45	37.89	50.98	56.61
	PA 076850	933	Wb/2	2 mi E of Consh	10/10/2006	57.36	56.29	49.98	48.11	40.70	38.76
					10/11/2006	26.33	36.08	53.09	49.08	38.13	43.39
					10/12/2006	56.10	48.90	40.04	54.96	50.86	56.63
					Average	46.60	47.09	47.70	50.72	43.23	46.26
	PA 076845	913	Eb/2	1 mi E of Consh	10/10/2006	48.76	38.24	22.23	30.59	24.43	21.88
					10/11/2006	44.70	28.83	29.80	20.43	17.39	11.90
					10/12/2006	41.42	32.76	30.55	22.13	37.25	32.27
					Average	44.96	33.28	27.53	24.38	26.36	22.02

Legend: Average operating speeds < 35 mph

source: Traffic.com

DVRPC, 2008

[6] *Transit Capacity and Quality of Service Manual*, TCRP Report 100, Transportation Research Board (TRB), 2nd Edition, 2003.

APPENDIX C. BEFORE AND AFTER TRAVEL TIME ESTIMATES

SEPTA staff provided the travel time estimates associated with the existing services in the corridor and for the reconfigured rail-feeder bus route network. Their work is represented on the spreadsheets shown on this page. DVRPC staff evaluated this information as part of the travel time assessment contained in Chapter 7 of the report.

I-76 TRIP COMPARISON
(CTD Bus Routes)

	Existing	Proposed
	Route 9	Ridge Ave local
Center City - Ridge & Lyceum	Peak 32 mins Off 31 mins	Peak 24 mins Off 24 mins
Center City - Ridge & Domino	Peak 36 mins Off 35 mins	Peak 28 mins Off 28 mins
Center City - Ridge & Cathedral	Peak 45 mins Off 44 mins	Peak 36 mins Off 36 mins
	Route 27	Henry Ave Local
Center City - Ridge & Lyceum	Peak 26 mins Off 24 mins	(See Ridge Ave Local) (See Ridge Ave Local)
Center City - Ridge & Cathedral	Peak 37 mins Off 35 mins	Peak 39 mins Off 39 mins
Center City - Plymouth Meeting Mall	Peak 56 mins Off 55 mins	Peak 51 mins (via Ridge Ave Local) Off 50 mins (via Ridge Ave Local)
	Route 62	Ridge Ave feeder
Center City - Wissahickon	Peak 25 mins	Peak 15 mins
Center City - Ridge & Domino	Peak 42 mins	Peak 32 mins
Center City - Ridge & Cathedral	Peak 49 mins	Peak 39 mins
	Route 44	Route 44
Center City - Gladwyn	Peak 41 mins Off 39 mins	Peak 34 Off 32
Center City - Ardmore	Peak 42 mins Off 40 mins	Peak 36 Off 34

I-76 TRIP COMPARISON
(STD Bus Routes)

	Existing	Proposed
	Route 123	Route 123
69th St - KOP	Peak 37 mins Off 33 mins	Peak 39 mins Off 39 mins
30th St - KOP	Peak 55 mins Off 51 mins	Peak 57 mins Peak 57 mins
Center City - KOP	Peak 60 mins Off 60 mins	Peak 62 mins Off 62 mins
	Route 124	200y
Wissahickon - KOP	Peak 34 mins Off 29 mins	Peak 48 mins* Off 48 mins
30th St - KOP	Peak 43 mins Off 39 mins	Peak 71 mins* Off 71 mins
Center City - KOP	Peak 55 mins Off 51 mins	Peak 61 mins* Off 61 mins
	Route 125	200z
Wissahickon - KOP (T)	Peak 31 mins Off 26 mins	Peak 58 mins* Off 62 mins
30th St - KOP	Peak 43 mins Off 36 mins	Peak 52 mins* Off 53 mins
Center City - KOP	Peak 55 mins Off 47 mins	Peak 62 mins* Off 63 mins
	Route 124	200y
Wissahickon - Chesterbrook	Peak 51 mins Off 47 mins	Peak 58 mins* Off 66 mins
30th St - Chesterbrook	Peak 61 mins Off 57 mins	Peak 81 mins* Off 89 mins
Center City - Chesterbrook	Peak 73 mins Off 69 mins	Peak 71 mins* Off 79 mins
	Route 125	200z
Wissahickon - PNCGIS (T) (Valley Forge and Moore Roads)	Peak 53 mins Off 44 mins	Peak 65 mins* Off 69 mins
30th St - PNCGIS (Valley Forge and Moore Roads)	Peak 63 mins Off 54 mins	Peak 62 mins* Off 67 mins
Center City -PNCGIS (Valley Forge and Moore Roads)	Peak 74 mins Off 65 mins	Peak 72 mins* Off 77 mins

* Average of Local and Express Service
(T) Transfer required at KOP (King of Prussia)

Source: SEPTA, February 2009

Table B-1: HOV Warrant Analysis for I-76 Eastbound

EASTBOUND

Time	East of City Ave Bus Pass.	Total Buses	Ct	Vpass	% on buses
0600-0700	423	24	2,491	2,886	14.7%
0700-0800	792	29	4,935	5,740	13.8%
0800-0900	307	19	5,365	6,255	4.9%
1600-1700	349	20	4,131	4,810	7.3%
1700-1800	194	14	4,524	5,277	3.7%
1800-1900	109	12	4,332	5,054	2.2%

Time	Cph	SOVph	2+Vph	HOVph	people per hour 2+V & Bus	people per hour SOV	Threshold to Exceed	% in 2+V & Bus
0600-0700	2,467	2,122	345	369	1,114	2,122	25%	34%
0700-0800	4,906	4,219	687	716	2,166	4,219	25%	34%
0800-0900	5,346	4,598	748	767	1,804	4,598	25%	28%
1600-1700	4,111	3,535	576	596	1,500	3,535	25%	30%
1700-1800	4,510	3,879	631	645	1,457	3,879	25%	27%
1800-1900	4,320	3,715	605	617	1,319	3,715	25%	26%

Time	West of City Ave Bus Pass.	Total Buses	Ct	Vpass	% on buses
0600-0700	20	4	1,634	1,907	1.0%
0700-0800	44	4	3,764	4,399	1.0%
0800-0900	37	4	3,985	4,658	0.8%
1600-1700	118	4	3,780	4,418	2.7%
1700-1800	81	4	4,073	4,761	1.7%
1800-1900	46	3	4,235	4,951	0.9%

Time	Cph	SOVph	2+Vph	HOVph	people per hour 2+V & Bus	people per hour SOV	Threshold to Exceed	% in 2+V & Bus
0600-0700	1,630	1,402	228	232	476	1,402	33%	25%
0700-0800	3,760	3,234	526	530	1,097	3,234	33%	25%
0800-0900	3,981	3,424	557	561	1,152	3,424	33%	25%
1600-1700	3,776	3,247	529	533	1,175	3,247	33%	27%
1700-1800	4,069	3,499	570	574	1,220	3,499	33%	26%
1800-1900	4,232	3,640	592	595	1,231	3,640	33%	25%

DVRPC, 2008

Table B-2: HOV Warrant Analysis for I-76 Westbound

WESTBOUND

Time	East of City Ave Bus Pass.	Total Buses	Ct	Vpass	% on buses
0600-0700	305	22	2,080	2,408	12.7%
0700-0800	414	33	4,296	4,988	8.3%
0800-0900	326	22	4,690	5,462	6.0%
1600-1700	629	24	3,984	4,633	13.6%
1700-1800	480	20	3,917	4,559	10.5%
1800-1900	226	16	5,023	5,858	3.9%

Time	Cph	SOVph	2+Vph	HOVph	people per hour 2+V & Bus	people per hour SOV	Threshold to Exceed	% in 2+V & Bus
0600-0700	2,058	1,770	288	310	881	1,770	25%	33%
0700-0800	4,263	3,666	597	630	1,608	3,666	25%	30%
0800-0900	4,668	4,014	654	676	1,633	4,014	25%	29%
1600-1700	3,960	3,406	554	578	1,738	3,406	25%	34%
1700-1800	3,897	3,351	546	566	1,571	3,351	25%	32%
1800-1900	5,007	4,306	701	717	1,628	4,306	25%	27%

Time	West of City Ave Bus Pass.	Total Buses	CT	Vpass	% on buses
0600-0700	235	7	1,940	2,262	10.4%
0700-0800	223	8	3,809	4,447	5.0%
0800-0900	180	5	4,356	5,091	3.5%
1600-1700	84	4	3,647	4,262	2.0%
1700-1800	45	4	3,859	4,510	1.0%
1800-1900	8	3	3,817	4,462	0.2%

Time	Cph	SOVph	2+Vph	HOVph	people per hour 2+V & Bus	people per hour SOV	Threshold to Exceed	% in 2+V & Bus
0600-0700	1,933	1,662	271	278	776	1,662	33%	32%
0700-0800	3,801	3,269	532	540	1,287	3,269	33%	28%
0800-0900	4,351	3,742	609	614	1,398	3,742	33%	27%
1600-1700	3,643	3,133	510	514	1,104	3,133	33%	26%
1700-1800	3,855	3,315	540	544	1,124	3,315	33%	25%
1800-1900	3,814	3,280	534	537	1,076	3,280	33%	25%

DVRPC, 2008

Abbreviations for Tables B-1 and B-2

HOV	High Occupancy Vehicle: Bus, or Car with 2 or more Occupants
Vph	Vehicles Per Hour
Cph	Cars Per Hour, Vph - BUSph
SOV	Single Occupant Vehicle
SOVph	Single Occupant Vehicles per hour, Cph * (1/1.17)
2+V	Double Occupant Vehicle
2+Vph	Double Occupant Vehicles per hour, Cph * 0.14
HOVph	High Occupancy Vehicles per hour, 2+Vph + BUSph
BUSph	Buses Per Hour
Ct	Traffic Count
Bus Pass.	Total Bus Passengers
Vpass	Vehicle Passengers, (Ct - BUSph) * Average Occupancy
Average Occupancy = 1.17 persons per vehicle	

Publication Abstract

Title: ***Alternatives to Buses on I-76:*** ***SEPTA Rail Feeder Bus Study*** **(Technical Memorandum)**	**Date Published:** **April 2009** **Publication No.:** **09010**

Geographic Area Covered: the Schuylkill Expressway (I-76) Corridor from Center City Philadelphia to points west in the corridor, involving portions of Montgomery and Delaware counties, Pennsylvania

Key Words: express bus routes, feeder bus routes, rail stations, intermodal connections, station improvements, operating costs, capital costs, bus priority treatments

ABSTRACT

Service reliability for eight SEPTA bus routes operating along the Schuylkill Expressway (I-76) has deteriorated in line with rising traffic levels and congestion on the highway. On-time performance for the routes is well below SEPTA's system-wide service goal, affecting as many as 6,700 weekday bus passengers in each direction. Opportunity to improve service reliability and customer travel times in the I-76 corridor has been recognized by SEPTA via the anticipated delivery of 120 new regional rail cars.

To that end, DVRPC and SEPTA staff jointly conducted a transportation planning exercise to estimate utilization, travel time benefits, supporting facility and vehicle needs, and costs (or savings) associated with reconfiguring the expressway bus routes into a feeder bus network serving six rail stations in the corridor.

The work was iterative, and substantial analyses were prepared and reported, including:

- Preliminary estimates of potential bus-rail transferring passengers
- A reconfigured feeder bus network to replace the expressway routes
- Refined transferring passenger estimates based on the reconfigured feeder bus route network
- Assessments of station platforms to accommodate additional transferring passengers as a consequence of feeder bus operations
- Estimated peak vehicle needs (bus and rail) at 80%, 100% and 110% passenger thresholds
- Recommended improvements for access, circulation and storage of the feeder buses, and platforms to accommodate additional transferring passengers at the rail stations
- Estimated construction costs of the physical improvements at the station facilities, and operating costs and/or savings for the feeder bus and rail services supporting the plan
- Assessment of the plan's travel time benefits

Subsequent steps are identified for SEPTA to further evaluate, hone and implement the plan. The study also included an investigation of the feasibility of providing priority treatments along the Schuylkill Expressway to better accommodate the performance of the bus routes—as presently configured. Two priority strategies were investigated: high occupancy vehicle lanes on the expressway, and bus-only use of the expressway's shoulders. The report's appendix includes the findings of that work.

For More Information Contact: Delaware Valley Regional Planning Commission
190 North Independence Mall West - 8th Floor
Philadelphia, PA 19106-1520
Tel: 215-592-1800 Fax: 215-592-9125 website: www.dvrpc.org

Staff contacts:	**Direct phone:**	**Email:**
Michael D. Becker, Project Planner	215-238-2834	mbecker@dvrpc.org
Jerry Coyne, Project Manager	215-238-2850	jcoyne@dvrpc.org