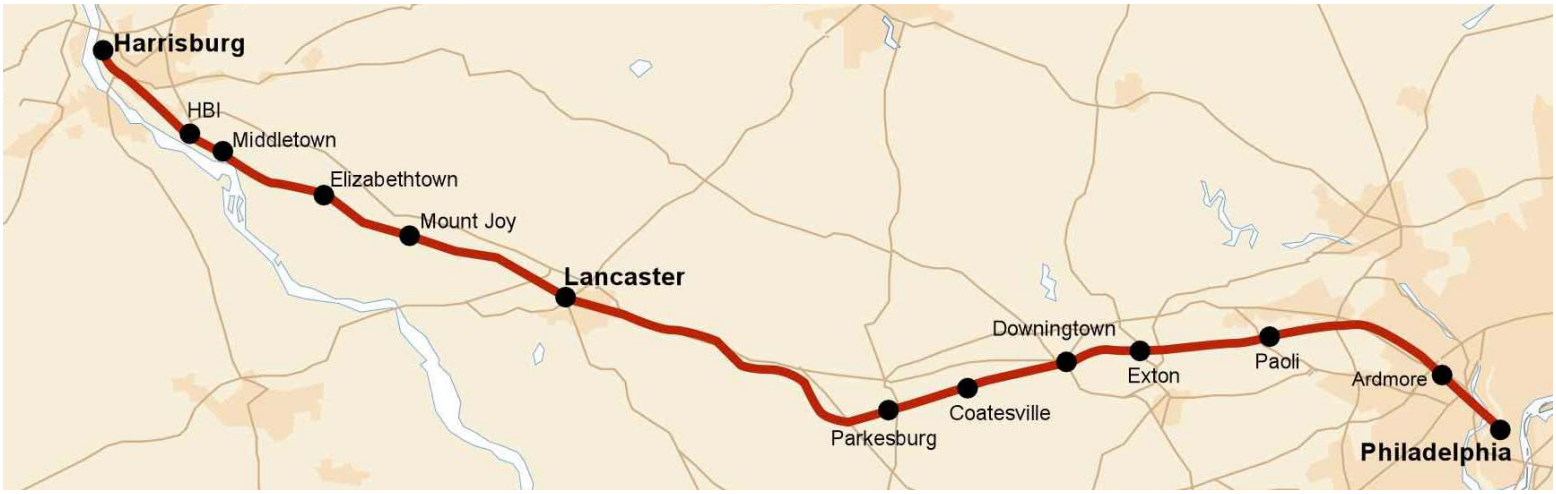
VOLUME II
Appendixes

Technical Monograph: Transportation Planning for the Philadelphia–Harrisburg "Keystone" Railroad Corridor



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16. Abstract Should the Commonwealth of Pennsylvania desire to upgrade the railroad corridor between Philadelphia and Harrisburg for improved passenger service that meets a specific travel time goal, a number of infrastructure improvements would be needed. This monograph enumerates, describes, and costs a set of improvements that could, in combination, support a trip time goal of 90 minutes between Philadelphia (Suburban Station) and Harrisburg. The operational implications of such a service are discussed. This monograph may be of technical assistance to other States that are contemplating similar rail passenger service projects.			
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NOTE: Volume I of this Technical Monograph contains the Executive Summary and Main Report.

APPENDIX A
OWNERSHIP, OPERATING RIGHTS
AND AGREEMENTS

INTRODUCTION

The following summary of ownership and operating rights and agreements is for information purposes only. It covers the portion of the Amtrak system referred to as the "Main Line-Philadelphia to Harrisburg" from Philadelphia (Zoo Interlocking) to the Division Post at Harrisburg (MP 105.2), where the line becomes the Main Line of Norfolk Southern's Harrisburg Division. It also includes the 36th St. Connection between Penn Interlocking, at 30th St. Station and Zoo Interlocking. The summary is not intended to establish the legal effects of the various agreements or the rights of the parties thereto. The summaries of the agreements do not necessarily include all of the points covered by the agreements.

SUMMARY OF OWNERSHIP AND OPERATING RIGHTS

Ownership

The portion of the NEC from Philadelphia to Harrisburg is wholly owned by Amtrak. It was conveyed to the Consolidated Rail Corporation (Conrail/CR) on April 1, 1976 by the U.S. Railway Administration (USRA) as part of the Final System Plan (FSP) resolution of the disposition of the operating assets of the bankrupt railroads of the Northeast. One month later it was transferred to Amtrak along with the rest of NEC. One of the objectives of the FSP was the preservation of intercity passenger service and commuter rail service on the NEC.

Operating Rights

Commuter Service. The Southeastern Pennsylvania Transportation Authority (SEPTA) has operating rights for commuter service. Operating rights extend westerly from Philadelphia to Cork Interlocking, but revenue service is prohibited west of Parkesburg, the last stop in Chester County, by agreement between SEPTA and PennDOT. With Philadelphia as its hub of operations, SEPTA has similar rights over the main stem of Amtrak's NEC.

Freight Service. The railroad properties of the bankrupt Northeast railroads were combined to form Conrail under the FSP on April 1, 1976. Conrail conveyed those portions of the NEC under its control to Amtrak pursuant to an Agreement of Purchase dated March 31, 1976, and retained the rights to operate over the NEC under the 1986 amended agreement, which replaced the Freight Service Agreement of April 1, 1976. Norfolk Southern assumed these rights as of the effective date of its acquisition of Conrail, June 1, 1999.

Delaware & Hudson/CP Rail has operating rights over a segment of Amtrak's Harrisburg Line from the Division Post (Property line), MP 105.2, at Harris Interlocking (MP 104.8), west of Harrisburg station, to Roy Interlocking (MP 94.3), the junction with the NS Royalton Branch. This can be used, in connection with the Enola and Port Road Branches, as an alternate route to Perryville.

Operating Control

Under the FSP, Amtrak was given full operational control of the Harrisburg Line, with responsibility for all signaling, power distribution, dispatching, and maintenance. This is currently defined in the Second Amended and Restated NEC Freight Operating Agreement, dated 10/01/86, which also provides for the operation of Norfolk Southern freight service.

OPERATING AGREEMENTS

Southeastern Pennsylvania Transportation Authority (SEPTA)

12/23/82 Harrisburg Line Access And Services Agreement

Provides for SEPTA access and operation, with no termination date, over three NEC segments as follows:

- between Marcus Hook and Arsenal (including SEPTA Media Line trains, which use Arsenal);
- between Zoo and Trenton; and
- between Zoo and Paoli (including SEPTA Manayunk Branch trains operating between 30th St. Station and Overbrook).

SEPTA pays monthly fees for use of NEC and traction power, including power from the NEC.

1/1/87 Lease Agreement

Provides for the lease of certain stations on lines owned by Amtrak to SEPTA, including 20 stations on the Harrisburg Line. The lease includes all stations from Overbrook to Downingtown, with the exception of Paoli. It

provides lease of the premises, including "... station buildings [and related equipment], platforms, passenger tunnels and overhead ... walkways, [designated] parking, and necessary access and appurtenances ... directly utilized by SEPTA...". SEPTA has the option to include Coatesville and Parkesburg.

1/31/90 Letter agreement to "... permit SEPTA access as far west as Cork Interlocking (MP 68.1) on the Harrisburg Line except that the SEPTA trains shall not be operated in revenue service west of Parkesburg." This agreement is still in effect, however, SEPTA service has been cut back to Downingtown, and trains are turned at Thorn.

Norfolk Southern (NS)

10/01/86 Freight Operating Agreement (Second Amended and Restated)

Covers NS operating rights on the NEC. Key items:

- Freight Service Easement: Rights granted to CR under the FSP to operate freight services on the NEC.
- Has been extended to apply to NS following the acquisition of Conrail rights in this territory.
- Operations: Amtrak has total operating control on NEC including dispatching, transportation supervision**,** and maintenance of way.
- Added Facilities: NS has the right, at its expense, to require Amtrak to improve or add to NEC properties, provided there is no resultant interference with commuter and intercity service.
- Compensation: NS is to pay Amtrak a specified per-car mile fee, which amount is to be adjusted annually. <u>There is to be no quality of performance payment for NS's NEC freight service.</u>

The following sidebar agreements have been extended to apply to Norfolk Southern:

05/31/89 Amendment to 10/01/86 Agreement - clarifies definition of hazardous substances transported by CR on NEC and CR liabilities and responsibilities.

04/25/80 Agreement for the Installation and Connection of Private Sidetracks for CR Service - defines the procedure and responsibilities of the parties with regard to installing sidetracks on NEC.

05/06/83 Amendment to 04/25/80 Sidetrack Agreement - provides Amtrak with option to remove or cause to be removed any sidetrack which has been in disuse for a period of 12 months.

01/08/90 Letter Agreement for Switch Maintenance Fee - CR shall pay an annual switch maintenance fee to Amtrak on any sidetrack which has handled six or less loaded cars in a calendar year.

Delaware & Hudson (CP Rail)

2/1/91 Agreement Between National Railroad Passenger Corporation (Amtrak) and D & H Corporation for Freight Operations Over Amtrak Lines in the Vicinity of Harrisburg, Pennsylvania and ... [other locations not on the Harrisburg Line]

This agreement allows D&H to use an alternate route through the Harrisburg/Enola area en route from Allentown to Potomac Yard. Trains going through Harrisburg instead of Enola can be routed over the Amtrak line instead of the CR Royalton Branch between Harris and Roy Interlockings.

Key items:

- Passenger trains have priority over freight.
- Fees are based on per car or locomotive mile, except at Zoo, where a flat rate per car of locomotive is charged.[1]
- Term - Twenty-five (25) years.

[1]The Norfolk Southern Harrisburg Line passes through Zoo, which is owned by Amtrak. A flat fee is paid because only a short distance is traveled.

APPENDIX B
CURVE ANALYSIS, PHILADELPHIA TO HARRISBURG; SPEED ANALYSIS OF CURVES AND CIVIL IMPACTS

Recent simulations and analyses of future intercity, commuter, and freight operating requirements have concluded that significant track changes are required to achieve trip time goals, improve the reliability of intercity and commuter operations, increase capacity, and provide improved operating flexibility. These needs would be satisfied by reconfiguring major terminals and interlockings, removing existing crossovers and turnouts, and installing new (mostly higher speed) turnouts and crossovers to implement desired alignment and configuration changes. Revised interlocking layouts also will be required to optimize train operations entering and leaving the additional tracks, and passing sidings that also have been recommended. The number of interlockings that will be modified and the new interlockings that are recommended are significant. Details of recommended programs are contained in the body of the report. The proposed track configurations are illustrated in Appendix E. The interlocking changes that have been recommended are summarized in the body of the report.

Track curvature imposes the most severe constraint on trip time. Consequently, realigning or changing the physical characteristics of existing curves is a primary means of reducing trip times included in this program. Several types of fixed-plant improvements can minimize the constraints to speed associated with curves:

- increasing superelevation to the maximum allowable for a particular track alignment;
- changing horizontal and vertical alignment, either within the existing right-of-way, or by acquiring land outside the existing right-of-way;
- increasing the amount of unbalanced superelevation used to calculate speeds through curves to minimize track shifts; and
- modifying spirals (the length of track that provides a smooth transition from level, tangent track to curved, superelevated track) by eliminating superelevation runoff onto the adjacent tangent sections.

The rationale for the realignments recommended in this program is summarized in this appendix.

OBJECTIVE

The results of a speed analysis of curves, and the civil impacts associated with

realigning them for the Keystone Corridor segment of the Northeast Corridor (between Philadelphia and Harrisburg) was performed by Parsons Transportation Group. The results of those analyses are summarized in the following subsection.

The goal of the Plan is to reduce the trip time between Philadelphia and Harrisburg to less than 90 minutes. There are several changes to the methods of operation, to the facilities, and to the equipment that can contribute to the overall goal.

One of these changes is to increase the speed of the trains. Increasing the speed may require one or all of the following:

- more powerful or additional locomotives;
- coaches that can provide comfort at greater unbalanced speeds, tilt vehicles will be needed for unbalanced superelevation greater than 5 inches;
- tracks and track beds that can withstand the energies transferred at higher speed (including greater imbalance); and
- alignments that can accommodate the greater speeds without exceeding acceptable limits for:
  - actual superelevation,
  - unbalanced superelevation,
  - lateral acceleration to the passenger
  - spiral lengths limited by:
    - rate of change of change of actual superelevation or twist,
    - rate of change of change of lateral acceleration to the passenger or jerk.

The objective of this analysis was to propose realignments to the existing curves so that proposed speeds can be reached and to identify civil impacts caused by the proposed realignments. The results of the analysis were used to develop a project estimate for realigning curves. The methodology employed to perform the analysis and the results of the analysis are presented in this subsection.

CRITERIA AND SCOPE

Criteria

The criteria utilized in the performance of this analyses were as follows.

Maximum actual superelevation should not exceed 6 inches. Actual superelevation was chosen in increments commensurate with the runoff rates specified by Amtrak and speed.

Maximum unbalanced superelevation should not exceed 5 inches; this assumes the use of conventional, non-tilt equipment.

Maximum lateral acceleration parallel to the floorboards should not exceed 0.15 g.

For conventional coach equipment at 6 inches of unbalanced superelevation the roll angle should be 2.87 degrees and lateral acceleration parallel to floorboards should be 0.15 g.

All actual superelevation should be introduced and removed over the entire length of the spiral; actual superelevation should not be introduced and removed on the adjacent tangents.

Maximum jerk rate through the spiral should be 0.04 g per sec.

Maximum track twist rate (introduction and removal rate of actual superelevation) through existing spirals for speeds less than, and equal to 90 miles per hour, should be 3/8-inch in 31 feet. For speeds greater than 90 miles the maximum twist rate through existing spirals should be 1/4" in 31 feet.

Track twist rates for alignments specified by Amtrak at proposed speed:

- speeds from 0 to 50 miles per hour, 1/2-inch per 31 feet;
- speeds from 51 to 70 miles per hour, 3/8-inch per 31 feet; and
- speeds from 71 to 125 miles per hour, 1/4-inch per 31 feet.

Scope

The curves to be considered in the analysis were those located between Philadelphia 30th Street Station and Harrisburg Station. Studies recently performed for PaDOT proposed maximum speeds for individual curves. These were speeds were used as initial speed goals, but were modified as necessary to reflect the iterative analysis process subsequently defined. Maximum speed sought was 110 mph.

Presently maximum speed for passenger trains in the corridor is 90 mph. Maximum authorized speeds vary by location and are specified in the Amtrak Employees Timetable. The analysis was based for the most part on data for Track 1; where data was unavailable Track 3 data was used.

One product of the analysis was the conclusion that, with a limited number of exceptions, each curve on the corridor had to be modified to some degree - usually both spiral length or superelevation changed. For each curve the highest speeds that can be reached without realignment or adjustment to the actual superelevation on each of the existing curves, while satisfying safety and comfort criteria, were calculated. An iterative process was then followed to identify the maximum speed attainable (in five mph increments) on each curve. Changes to superelevation and spiral length were determined.

The analysis indicates that the speed improvements can be attained in many instances by merely surfacing and aligning the track as part of a normal maintenance cycle.

The study did not identify specific curves that should have their degree of curvature decreased to enable speeds to be increased. Curves whose degree of curvature is 1.1 degree or more would not support speeds of 110 mph or more[1], and therefore would be candidates for further detailed analysis in subsequent studies. Curves to be modified should be selected on the basis of their cost effectiveness - the cost per minute saved as the result of the modification. The analysis will require that Train Performance Calculation (TPC) runs be made to determine the time savings as the result of each curve modification. The cost of each modification also will have to be estimated, and by dividing the cost by the time for all curve modifications a cost effective listing could be developed, which would assist the planner in evaluating which improvements should be funded.

A second product was the calculation of the highest speeds that can be reached with realignment to improve spiral lengths and with adjustment to the actual superelevation, while satisfying safety and comfort criteria. The result of the analysis was a list of proposed realignments to reach the proposed speeds. In addition to safety and comfort criteria the proposed realignments will comply with standard Amtrak field maintenance practices. No required shifts in excess of three-feet. Curves requiring shifts between 6 inches and 3 feet are shown in Table 1. Curves requiring shifts of about 6 inches are shown in Table 2.

Actual bridge impacts will need to be confirmed on a bridge-by-bridge basis. Where there are no undergrade bridges and the shifts are less than 6 inches, the realignments can be performed with regular maintenance procedures, and will not result in significant additional civil costs. Curves that have turnouts to industrial spurs within their length have not been identified, but need to be; since turnouts will limit the actual superelevation and the speed in the curve. In these cases the realignment will be more significant resulting in increased costs.

The analysis technique (a spreadsheet) made it easier to answer "what-if?" questions, such as, how much will the proposed speed be reduced if the realignment shift was reduced so as not to impact bridge B? Or, how much additional shift would be required to increase the proposed speed on curve A?

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[1]Assuming maximum actual superelevation of six inches and maximum unbalanced superelevation of five inches.

Table 1
Curves Requiring Shifts Between 6 Inches and 3 Feet

Cve No.	Trk No.	Curve degrees	Radius feet	West Spiral	East Spiral	Total Measured length	Avg Ea Exist	110 mph V	Avg Ea Prop	Optimal Ls	Expected Max Shift
616	3	2.0000	2,865	350	510	2,000	5.25	80	4.13	512	**2.02**
679	1	1.0000	5,730	550	640	2,460	3.25	110	3.50	434	**1.61**
692	1	0.7667	7,473	400	620	3,420	2.00	110	2.50	310	**1.61**
617	3	2.0000	2,865	410	400	1,640	5.00	80	4.13	512	**1.48**
649	1	1.0833	5,289	340	570	3,220	3.00	110	4.25	527	**1.28**
624	3	4.0000	1,432	300	190	1,640	4.50	50	4.50	279	**1.21**
671	1	2.0333	2,818	530	650	3,480	5.50	80	4.75	589	**1.12**
695	1	2.1000	2,728	490	560	1,800	5.75	80	4.50	558	**1.09**
688	1	0.7000	8,185	570	330	2,090	1.75	110	2.75	341	**1.06**
706	1	0.5000	11,459	320	560	3,180	1.50	110	1.50	186	**1.01**
663	1	**3.9000**	1,469	430	370	2,220	5.50	60	5.00	413	**0.96**
669	1	1.5833	3,619	680	550	3,040	5.50	95	5.00	620	**0.94**
630	1	2.1167	2,707	430	510	2,080	5.50	75	4.00	496	**0.94**
657	1	2.0000	2,865	510	430	4,160	5.00	80	4.00	496	**0.89**
708	1	0.9000	6,366	340	560	1,520	2.25	110	3.50	434	**0.82**
629	1	2.0000	2,865	440	530	1,680	5.75	80	4.00	496	**0.76**
694	1	1.0333	5,545	530	430	1,560	3.50	95	3.50	434	**0.70**
639	1	**2.3500**	2,438	400	350	2,610	5.75	70	4.88	403	**0.68**
612	1	2.3167	2,473	350	430	4,840	4.75	70	4.88	403	**0.67**
1a	1	4.8000	1,194	270	220	970	2.50	50	3.75	233	**0.66**
691	1	0.5000	11,459	300	450	3,790	0.62	110	1.25	155	**0.65**
675	1	1.0000	5,730	400	500	2,050	3.00	100	3.25	403	**0.64**
686	1	1.2000	4,775	470	300	940	3.25	95	3.25	403	**0.63**
651	1	0.7500	7,640	340	170	2,530	2.50	110	3.00	372	**0.60**
710	1	2.1000	2,728	280	350	900	5.40	70	2.75	341	**0.58**
638	1	3.0000	1,910	430	370	2,270	5.50	65	4.88	403	**0.56**
0a	1	4.9000	1,169	70	130	800	1.75	45	2.25	140	**0.52**
661	1	2.0167	2,841	530	470	2,240	5.75	75	4.00	496	**0.51**
664	1	2.0000	2,865	530	480	2,660	5.50	80	4.00	496	**0.51**
652	1	0.7667	7,473	330	220	990	2.00	110	3.00	372	**0.50**

Table 2
Curves Requiring Shifts of About 6 Inches

Cve No.	Trk No.	Curve degrees	Radius feet	West Spiral	East Spiral	Total Measured length	Avg Ea Exist	110 mph V	Avg Ea Prop	Optimal Ls	Expected Max Shift
627	1	1.1000	5,209	330	110	1,760	3.00	75	1.75	217	**0.49**
682	1	1.0833	5,289	400	500	2,970	2.00	100	3.50	434	**0.49**
698	1	0.9833	5,827	460	530	3,760	3.50	110	3.75	465	**0.46**
678	1	1.0833	5,289	580	550	4,160	3.50	110	4.25	527	**0.46**
628	1	2.0333	2,818	530	570	1,370	5.75	80	4.50	558	**0.45**
659	1	1.0000	5,730	500	430	1,800	3.50	110	4.00	496	**0.44**
700	1	1.4000	4,093	490	450	2,360	4.50	95	4.00	496	**0.44**
653	1	0.7500	7,640	420	390	1,810	2.50	110	2.50	310	**0.44**
699	1	1.9500	2,938	530	550	3,400	5.75	80	4.50	558	**0.43**
621	3	1.5000	3,820	280	370	1,370	3.50	80	2.75	341	**0.41**
648	1	1.0000	5,730	440	520	2,790	3.25	110	4.00	496	**0.38**
681	1	1.0000	5,730	430	490	2,620	3.50	105	3.50	434	**0.38**
667	1	1.0000	5,730	500	450	4,590	2.75	110	4.00	496	**0.32**
683	1	1.0000	5,730	480	440	1,950	2.50	105	3.50	434	**0.31**
620	3	3.0000	1,910	340	310	1,120	5.75	65	4.00	331	**0.29**
647	1	0.5000	11,459	280	330	970	1.50	110	1.50	186	**0.27**
626	3	1.1667	4,911	370	330	860	3.00	90	3.00	372	**0.25**
650	1	0.5000	11,459	360	170	3,810	1.50	110	2.00	248	**0.25**
690	1	1.0000	5,730	470	400	2,330	2.50	105	3.50	434	**0.24**
689	1	0.6667	8,594	260	370	1,240	2.75	110	2.75	341	**0.24**
618	3	1.1167	5,131	340	260	880	3.75	85	2.50	310	**0.23**
641	1	1.0000	5,730	430	440	2,120	3.25	105	3.75	465	**0.23**
660	1	1.0000	5,730	430	470	1,430	3.25	105	3.75	465	**0.23**
672	1	2.0000	2,865	480	480	2,700	5.25	80	4.00	496	**0.23**
614	1	0.3667	15,626	330	320	2,080	1.25	110	1.25	155	**0.23**
634	1	0.5000	11,459	330	320	1,240	1.75	110	1.75	217	**0.22**
703	1	0.7500	7,640	420	320	1,160	1.25	110	3.00	372	**0.21**
608	1	1.2000	4,775	270	330	870	2.50	85	2.50	310	**0.20**
696	1	0.5000	11,459	320	250	1,190	1.50	110	1.75	217	**0.20**
673	1	1.0833	5,289	420	460	2,560	3.25	100	3.50	434	**0.18**
653E	1	0.5000	11,459	330	250	690	1.00	110	2.00	248	**0.17**
704	1	1.0000	5,730	450	440	2,250	3.25	110	3.75	465	**0.16**
654E	1	0.5000	11,459	300	270	1,120	1.00	110	1.75	217	**0.16**
642	1	0.8333	6,876	370	420	1,530	2.75	110	3.25	403	**0.15**
613	1	1.5000	3,820	400	420	3,540	4.00	85	3.25	403	**0.15**
654	1	0.5000	11,459	320	140	780	1.25	110	2.00	248	**0.15**
674	1	0.5000	11,459	320	160	1,410	0.50	110	2.00	248	**0.15**
702	1	0.4000	14,324	290	210	1,170	1.50	110	1.50	186	**0.14**
668	1	0.8000	7,162	320	270	1,620	1.25	100	2.50	310	**0.13**
670	1	1.2000	4,775	420	390	890	3.75	95	3.25	403	**0.12**
677.1	1	0.5000	11,459	180	260	510	1.00	100	1.50	186	**0.12**
12A	3	0.6000	9,549	200	110	510	0.75	80	1.00	124	**0.11**
623	3	2.3333	2,456	320	310	1,890	5.50	70	3.75	310	**0.11**
676	1	0.3000	19,099	240	240	3,960	0.75	110	0.75	93	**0.11**
605	4	1.2500	4,584	0	0	0	1.00	70	1.00	108	**0.11**
645	1	**0.2500**	22,919	320	200	1,810	1.75	110	1.75	217	**0.10**
684	1	0.2000	28,648	280	200	2,780	1.00	110	1.00	124	**0.09**

Table 2
Curves Requiring Shifts of About 6 Inches

Cve No.	Trk No.	Curve degrees	Radius feet	West Spiral	East Spiral	Total Measured length	Avg Ea Exist	110 mph V	Avg Ea Prop	Optimal Ls	Expected Max Shift
697	1	1.0167	5,636	430	420	1,890	3.50	105	3.50	434	**0.09**
2a	1	1.3000	4,407	180	160	580	1.00	70	2.25	186	**0.09**
655	1	0.5000	11,459	200	230	630	0.50	110	2.00	248	**0.08**
687	1	0.5000	11,459	200	230	800	1.25	110	2.00	248	**0.08**
685	1	1.2000	4,775	360	380	1,190	2.00	90	3.00	372	**0.08**
631	1	0.2000	28,648	120	260	1,320	1.00	110	1.00	124	**0.08**
709	1	0.2500	22,919	200	200	630	0.50	70	0.50	62	**0.07**
705	1	0.2000	28,648	190	220	1,870	1.00	110	1.00	124	**0.05**
646	1	0.5000	11,459	220	240	890	1.25	110	2.00	248	**0.05**
693	1	1.9833	2,889	530	530	3,500	5.75	80	4.25	527	**0.05**
2b	1	1.2000	4,775	170	160	610	0.75	70	1.88	155	**0.04**
632	1	0.5000	11,459	240	270	1,550	1.25	110	2.00	248	**0.04**
680	1	1.0833	5,289	430	440	2,570	3.50	100	3.50	434	**0.04**
640	1	1.6000	3,581	530	530	1,720	6.00	90	4.25	527	**0.04**
658	1	1.0833	5,289	460	460	2,060	3.25	105	3.75	465	**0.04**
637	1	0.2000	28,648	140	180	5,050	0.75	110	0.75	93	**0.03**
707	1	0.3500	16,370	270	260	2,200	2.00	110	2.00	248	**0.03**
666	1	0.5833	9,823	240	260	1,220	0.75	105	2.00	248	**0.03**
665	1	0.5000	11,459	210	200	1,780	0.75	105	1.75	217	**0.03**
625	3	0.5000	11,459	260	240	5,630	1.25	110	2.00	248	**0.02**
656	1	0.5000	11,459	240	260	880	0.50	110	2.00	248	**0.02**
615	1	0.9667	5,927	400	400	1,370	3.75	105	3.25	403	**0.02**

The analysis technique resulted in an estimate that is considered accurate to plus and minus 0.1-foot for simple spiraled curves, provided that the radius (degree of curvature) was not changed or the spirals were not changed by a significantly unequal amount. For compound curves the analysis technique is not reliable. For these more challenging realignments dummy cogos should be run to determine the shifts. A dummy cogo[2] is a cogo that properly uses all of the geometric elements (degree of curvature, spiral length, and intersection angle) of the alignment but the coordinates are not associated to any specific location. A dummy cogo previously was performed on a two centered compound curve on the New Haven Line between New Rochelle, NY and New Haven, CT, which was judged to be an extreme case[3]. From this cogo analysis it was judged that the maximum predicted shift will not be exceeded throughout the curve. However, the general characteristics of the shifting shown for compound curves should not be relied upon. The eight compound curves in the Keystone Corridor would require much more detailed investigation than was possible in this study, if the contemplated improvements are undertaken.

METHODOLOGY

Soft Realignments

There are two types of alignment changes: soft and hard. Soft alignment changes are changes in unbalanced superelevation, lateral acceleration to the passenger, and jerk that do not require physical changes. Therefore, there would be no cost associated with obtaining desired the speeds. These realignments would assume that the existing track twist (rate of introduction of superelevation) is acceptable. However, the present analysis did not identify any soft realignments between Philadelphia and Harrisburg.

Hard Realignments

Hard alignment changes are changes to actual superelevation, degree of curvature, and/or spiral lengths. Hard changes result in a physical change to the track, and when certain thresholds are reached, hard changes will impact adjacent or supporting facilities, such as, overhead bridges, undergrade bridges, signal towers, catenary towers, station platforms, etc.

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[2]Cogo, short for coordinate geometry, is a technique used to verify the mathematical feasibility of a concept.

[3]The Northeast Corridor Transportation Plan, New York City to Boston, Volume 2, Appendix I, July 1995.

Actual Superelevation on Tangent, Maximum Twist, etc. To meet comfort standards it was not considered acceptable to extend actual superelevation or track twist on to the tangents. Introduction and removal of actual superelevation should be linear, and should occur over the length of the spiral. As curve improvements are implemented occurrences of superelevation on tangents should be eliminated.

Shifts and Impacts

Right of way is generally not considered a factor unless the shift is very large and in those cases right of way would have been considered separately. The shifts identified in this study were not considered sufficient to require right-of-way acquisition. In general, the impacts of track shifts on overhead and undergrade bridges are of greatest concern, as is a determination whether the change can be made as part of a routine track maintenance surfacing operation.

Although each bridge located on the body of a curve ultimately will have to be individually evaluated to determine the impact of the assumed track shift, for these analyses it was generally assumed that if a specific shift exceeded the followings limits, the bridge would be impacted:

- open deck bridges with no additional improvement work proposed--any shift or change in superelevation;
- open deck bridges with through girders, or through deck girders scheduled for tie replacement--6 inches;
- open deck bridges with deck girders scheduled for tie replacement--1-foot;
- open deck bridges scheduled for conversion to ballasted deck--2 feet;
- ballasted bridges--2 feet; and
- overhead bridges--3 feet.

Bridges requiring replacement should be designed to accommodate the proposed alignment changes.

It also has been assumed that realignments that require shifts of 6 inches, and less, would be accomplished through regular maintenance practices and procedures. If the shift exceeds 6 inches, the track shifting cannot be done as part of maintenance and will require an independently scheduled effort.

Analysis Guidelines, Assumptions and Techniques

The analysis process utilized to analyze speeds and curves, and evaluate impacts on structures is subsequently described. The following are the guidelines, assumptions, and techniques for doing the analysis.

Degree of Curvature, Radius

The radius and degree of curvature were not changed.

Actual Superelevation

For curves whose superelevation is proposed to be changed, superelevation has been assumed to be implemented in increments in accordance with the way superelevation is introduced in the spiral by railroad maintenance personnel.

Unbalanced Superelevation

Unbalanced superelevation was computed from the following equation.

$$E_u = 0.0007 * D_c * V^2 - E_a$$

where E_u is unbalanced superelevation in inches
E_a is actual superelevation in inches
D_c is degree of curvature in decimal degrees
V is speed in miles per hour.

In accordance with previous agreed assumptions, unbalanced superelevation was limited to a maximum of 5 inches.

Lateral Acceleration Parallel to the Vehicle's Floor boards

When unbalanced superelevation occurs, passengers are subjected to a steady state lateral acceleration. This acceleration is the component of centripetal acceleration that is parallel to the floor boards of the vehicle. The calculation for this component takes into account the floor board rotation due to actual superelevation and the roll of the car body as it's suspension responds to the centripetal lateral acceleration. The lateral acceleration is computed from the following equation.

$$A_L = \{[(E_a + E_u) / G * COS(THETA - PHI * E_u / 6)] - SIN(THETA - PHI * E_u / 6)\} * g$$

where, A_L is lateral acceleration parallel to floor boards in g
THETA is the angle due to the actual superelevation = ARCSIN(E_a /G)
G = distance between rail head centers = 60 inches
PHI is the vehicle roll angle per 6 inches of unbalanced superelevation = 2.87 degrees per 6 inches of E_u.

The PHI value of 2.87 was derived from conventional coach data provided on page 21 of the report for the FRA entitled *Railroad Passenger Ride Safety*, revised April 1989.

Conventional non-tilting equipment has to be considered since either tilting or non-tilting equipment ultimately may be used. The tests reported indicated that both the LRC Coach (non-banking, with tilt capability cut out) and the Amfleet Coach reached 0.15 g of steady state lateral acceleration at 6 inches of unbalanced superelevation. By substituting these values into the above equation a PHI value of 2.87 is found calculated all values of actual superelevation up to 6 inches.

For prior projects, review of previous research and consultation with the FRA lead to the recommendation that 0.15 g should be the lateral acceleration limit. This analyses performed assumed that 0.15 g to be the lateral acceleration limit. Vehicle test data indicates that 0.15 g will be reached at 6 inches of unbalanced superelevation, therefore as long as unbalanced superelevation is limited to 5 inches, the lateral acceleration limit of 0.15 g will not be exceeded.

The PHI value is based upon available data for conventional non-tilting equipment. It is unlikely that new, non-tilting equipment will have a larger PHI coefficient, however, it might have a smaller value. A smaller PHI value would result in smaller lateral accelerations (good for passenger comfort) and in shorter comfort spiral lengths that would be based on a maximum jerk rate (jerk rate and comfort spiral are discussed in the following subsection). Consequently, spirals established based on the PHI value of 2.87 will be longer than necessary if the new non-tilting equipment has a smaller PHI. Therefore, the construction impacts resulting from shifts determined by the PHI value established for this report will be conservative.

The Comfort Spiral, Jerk, and Jolt

The comfort spiral transitions the passenger through a change in lateral acceleration (unbalanced superelevation) at a comfortable rate. Assuming that a vehicle's speed is constant, while traversing a spiral, unbalanced superelevation (lateral acceleration) changes linearly as the passenger travels along the spiral. This is because: degree of curvature changes linearly along a spiral; actual superelevation is introduced linearly along the spiral; and vehicle roll is linearly related to lateral acceleration. The change in lateral acceleration is referred to as jerk, with units of g per sec.

The jerk is computed by dividing the change in lateral acceleration (which is found by using the above equation and the change in unbalanced superelevation) by the time it takes for the passenger to travel over the spiral. The time is found by dividing the spiral length by the vehicle speed, with appropriate adjustments for units.

After a jerk rate has been established for a project, the minimum comfort spiral length can be computed by dividing the change in lateral acceleration by the jerk rate, and multiplying the quotient by the vehicle speed:

$L_s = A_L / J * V = A_L / 0.04 * 88 / 60 * V = 36.67 * A_L * V$

where, L_s is minimum comfort spiral length in feet

J is maximum jerk rate in g per sec

A_L is found from the earlier equation as a function of unbalanced superelevation.

AREA recommends 0.03 g per sec as a maximum jerk rate, when conditions permit. But where the cost of the realignment of existing tracks will be excessive the AREA recommends that the jerk rate should not exceed 0.04 g per sec. For this analysis a jerk rate of 0.04 g per sec for non-tilt train equipment was assumed.

The *Railroad Passenger Ride Safety* report, cited above, lists the lateral acceleration and jerk limits for several railroads. Jerk limits range from 0.03 to 0.1 g per sec. It is generally true that when a railroad accepts a higher jerk rate, it accepts a lower lateral acceleration. This is consistent with the observation reported in the same report that people are able to tolerate larger jolts when they are in a lower steady state lateral acceleration environment.

A jolt is also a rate of change of lateral acceleration per second, but it is considered as an occurrence that occurs in 1 second. A jolt is usually a response to a track irregularity. When jolts exceed 0.25 g per sec it is usually a sign that, for that speed, the track needs adjustment. The jerk through a spiral usually occurs over several seconds and, therefore, is not considered a jolt.

Usually back and forth car body rolling occurs when a track irregularity is encountered. The more violent the rolling the greater the jolt. When the jolt is measured as a lateral acceleration parallel to the floor boards, the position of the accelerometer affects the magnitude of the reading. In a double deck car, for the same track irregularity, a passenger on the lower level near the roll center of the car body will feel a smaller jolt than a passenger on the upper level.

The *Railroad Passenger Ride Safety* report also indicates that the researchers did not find any evidence that jerk is a comfort concern. This suggests that the comfort spiral could be shortened until the jerk is 0.25 g per sec. The problem with this approach is that the track has to be maintained in perfect condition. Any track irregularity would result in a total change in lateral acceleration that exceeds 0.25 g per sec.

The SNCF was found to have the highest limits, 0.15 g and 0.10 g per sec. Since comfort is a subjective feeling of the passenger, the SNCF may be recognizing that the French have a higher threshold to discomfort, or that they may be willing to tolerate a higher percentage of the passengers to be uncomfortable. Or, and perhaps more likely, SNCF has made a commitment to high quality track with tight maintenance tolerances for their high speed lines. (The British and American comfort criteria were established

at comfort limits where 50 percent of the passengers will be satisfied. The Japanese desire to have 90 percent of the passengers satisfied.)

Track Twist

If the track twist, the rate of introduction or removal of superelevation, is too large, safety is impaired. When computing the maximum allowable speed for the existing alignment, the analysis performed verified that the ratio of the existing spiral length to actual superelevation was equal to, or greater than, 62 for speeds below, and including, 90 miles per hour. For speeds above 90 miles per hour, the ratio would be equal to, or greater than, 83.

When the maximum allowable speed did not reach the proposed speed the spirals were lengthened and the actual superelevation adjusted, as necessary, to maximize the speed. A third alternative, decreasing the degree of curvature and adjusting spiral lengths and superelevation was not utilized in this study. Where these alignment changes were required the spiral lengths were changed to satisfy the appropriate actual superelevation runoff rate assumed for the Keystone Corridor. The new spirals also were checked for jerk. The actual superelevation was adjusted until the jerk criteria was satisfied. The following are the runoff rate criteria specified for by Amtrak:

Speed Range, miles per hour	Runoff per 31'
0 to 50	1/2"
51 to 70	3/8"
71 to 125	1/4"

Track Shifts

For this analysis, shifts between the existing and the proposed alignments were computed at 2 points: near each of the curve spiral points. A third possible point, near the mid-point of the curve was not calculated. The shifts near the curve spiral points were estimated as the difference between the spiral offsets, the "p" distance, for the proposed and existing spirals. At the curve's mid-point the difference in the external distances for the proposed and existing alignment would have been estimated to be the amount of shift required.

The estimated shifts were checked for an earlier NEC study by running several dummy cogos using typical alignment curve data, and calculating offsets. A range of intersection angles, radii, spiral lengths, and differential spiral lengths, when the existing spirals are unequal, were tested. For simple, spiral curves it was found that the estimated shifts were within 0.1 feet and that they were usually on the conservative side, i.e., 0.1-foot larger than actual. If the proposed alignment has a different intersection angle or a significantly different radius, the estimated shifts become less accurate.

Compound Curves

Compound curves (a combination of two or more curves connected by transition spirals) added another level of complexity to the analysis. Except for the following modifications, the method used to estimate the amount of shift was basically the same as for simple curves. The following labeling was used:

Existing Compound Curve
- A-spiral length between tangent and longer radius curve
- B-longer radius curve
- C-combining spiral length
- D-shorter radius curve
- E-spiral length between tangent and shorter radius curve

Proposed Compound Curve
- PA-spiral length between tangent and longer radius curve
- PB-longer radius curve
- PC-combining spiral length
- PD-shorter radius curve
- PE-spiral length between tangent and shorter radius curve.

Each curve in the compound curve was analyzed separately. For the first curve the following curve elements were used:

Existing
- A-spiral length
- B-curve radius
- E-C-spiral length

Proposed
- PA-spiral length
- PB-curve radius
- PE-PC-spiral length.

For the second curve the following curve elements were used:

Existing
- A+C-spiral length
- D-curve radius
- E-spiral length

Proposed
- PA+PC-spiral length
- PD-curve radius
- PE-spiral length.

From initial checks it was found that the external distance is very dependent upon the intersection angle, but that the difference in external distances is not very sensitive to the intersection angle. Therefore, using data from track geometry car graphs provided by Amtrak, it was assumed to be sufficient to divide the total intersection angle in the same proportion as the curve lengths.

Dummy COGO checks indicated that the largest shift found using the estimating method is similar to the largest found with the dummy COGO but the location of the peak shift may not be correctly represented. To check for impacts at specific locations dummy COGO should be used.

Basis for Existing Curve Data

As with any analysis, the results of the curve analyses performed were only as good as the quality of the available existing data. The best source of data is good mapping or surveyed data points of the existing tracks. Description of an alignment by degree of curvature is incomplete, it is similar to describing a line by its slope. The description of a curve is not complete until the Y intercept is known. Stringline data and track geometry car data also are not ideal sources of data. The degree of curvature is never uniform, always varying. The result is that data elements assumed to describe the alignment may vary greatly from the actual configuration. The variation cannot be determined without mapping or surveyed data points.

The existing data sources used to develop information for the analyses performed were as follows:

- Amtrak track geometry car charts;
- earlier work performed by various consultants for PaDOT; and
- track charts.

The track charts were used for general orientation, but not to define spiral lengths, curvature, etc. The previous work efforts was used for background information only; data on proposed curve speeds and previous recommendations were obtained from the reports developed by those studies.

Data relative to the existing superelevation, spiral lengths, curve lengths, and degree of curvature were primarily developed from an analysis of recent Amtrak Track Geometry Car Charts, which were the result of a round-trip run of the corridor.

Although there were possible inconsistencies in the track geometry car data, it was necessary to use them in most instances. The data was valuable for providing the spiral lengths, which were measured directly from the charts of the individual simple and compound curves.

The track geometry car chart data was reduced as follows. The track geometry produces strip charts with fluttering lines. A visual average was made for the degree of curvature and actual superelevation. If the data was not uniform, the curve was subdivided into a compound curve. The distance between uniform curvature data points was assumed to be spiral lengths. The distance between uniform actual superelevation data was not assumed to have any relationship to spiral length because actual superelevation may have been run off onto the tangents and into circular curves.

It was assumed that tracks 3 and 4 and sidings also will be shifted, as necessary, when either would be the inside track on a curve, and thus need to be shifted to maintain adequate clearance to the shifted inner tracks. The costs for this effort were included in the project estimate, but it was assumed that the magnitude of shifts and, therefore, impacts on adjacent right-of-way structures would be driven by the changes required to the high-speed tracks, tracks 2 and 3.

For each curve, the existing data from each source was tabulated. The source data was compared, curve by curve, and data type by data type. Finally, one set of existing data for each curve was selected and compiled. The compiled data is the most conservative.

Speeds

The existing speeds were taken from the existing Amtrak Employees Timetables. The proposed speeds were initially taken from the speeds proposed in earlier PaDOT studies. Proposed speeds have been established in multiples of 5 miles per hour.

When determining the maximum allowable speed within the criteria the speed is shown to the nearest downward five miles per hour.

The Spreadsheet

To facilitate the analysis a spreadsheet was developed that allows for the existing speed, degree of curvature, spiral and curve lengths, and superelevation to be input. The input was utilized to perform a variety of calculations. The spreadsheet determined the maximum speed obtainable given the existing alignment and actual superelevation, by only making soft changes, i.e., only changes to speed, unbalanced superelevation, and jerk. For this initial analysis no change to curvature, spiral lengths, and actual superelevation were made. In general it was assumed that the proposed curvature will remain unchanged.

For those instances when superelevation and spiral length changes were analyzed, the spreadsheet was used to determine the shifts associated with changes in actual superelevation and spiral lengths that would satisfy railroad and comfort criteria, and attain the proposed speeds. For the proposed alignment only the proposed speed and actual superelevation had to be input. Unbalanced superelevation, optimal spiral

lengths, and shifts were computed. "What if" questions about speeds were asked, and answered, by using different proposed speeds and superelevation for input. Limitations concerning the shift calculations were discussed earlier.

ANALYSIS PROCESS

The following questions for each curve were answered and the analysis proceeded as indicated.

1 What is the existing?:
- a. Amtrak curve number
- b. speed
- c. degree of curvature or radius
- d. actual superelevation[4]
- e. spiral length(s)

The following were computed:
- f. maximum speed with existing superelevation, not taking spiral length into consideration;
- g. unbalanced superelevation;
- h. steady state lateral acceleration to the passenger;
- i. minimum spiral length based on unbalanced superelevation;
- j. Minimum spiral length based on actual superelevation and railroad runoff rate criteria;
- k. Optimal spiral length as the maximum of (i) and (j); and
- l. spiral offset(s) and external.

2. Since it was assumed that the superelevation does not run onto the tangent and circular curve then the following were computed/developed:

- a. steady state jerk(s) based on optimal spiral length (k).
- b. track twist(s), rate of change of change in actual superelevation, i.e., ratio of existing spiral length to existing actual superelevation.
- c. list of bridges with no planned work.
- d. list of ballasted bridges.
- e. list of overhead bridges.
- f. list of bridges to be replaced.

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[4]Whether superelevation ran onto either the tangent or circular curve was not determined.

3. Assuming that the superelevation does not run onto the tangent and circular curve, then the following were computed/developed:

   a. if 2.b. was greater than 83, the highest speed that does not exceed 5 inches of unbalanced superelevation, nor exceed 0.15 g lateral acceleration, nor exceed 0.04 g per sec jerk was determined. The existing radius, superelevation, and spiral length(s) were to remain unchanged. This speed was considered as the highest speed attainable with no impacts, no shift, and not requiring an alignment change. Note: when the existing spirals were of unequal length, the shorter spiral was used to compute jerk. The analysis proceeded to 4.

   b. if 2.b. was greater than 62, the highest speed less than or equal to 90 miles per hour that does not exceed 5 inches of unbalanced superelevation, nor exceed 0.15 g lateral acceleration, nor exceed 0.04 g per sec jerk was determined. The existing radius, superelevation, and spiral length(s) were assumed to remain unchanged. This speed was assumed to be the highest speed with no impacts, no shift, and that did not require an alignment change. Note: when the existing spirals were of unequal length, the shorter spiral was used to compute jerk. The analysis proceeded to 4.

   c. if 2.b was less than 62 a spiral length change was required. The spreadsheet would report that an alignment change was required. The analysis would proceeded to 4.

4. Steps 1-3 were performed for all the curves, a curve list showing the highest speed determined in 3.a. and 3.b was developed. The proposed speed for each of these curves was listed. The curves whose highest speed met or exceeded their proposed speed were highlighted. The list was entitled *Highest Speeds for All Curves without Alignment Changes*. Proceed to 5.

5. For all curves that were not highlighted in 4 (i.e., those curves that will need alignment changes, and/or changes in superelevation, radius or spiral length-to achieve the proposed speed, without changing radius) increase actual superelevation in increments specified for the segment and speed, without exceeding 6 inches, until the proposed speed was reached without exceeding 5 inches of unbalanced superelevation or exceeding 0.40 g/sec jerk rate. If the proposed speed could not be achieved without exceeding the above limitations, the speed was decreased in 5 mph increments until the limitations were not exceeded. Proceed to 6.

6. If 1.g (maximum speed with existing superelevation, not taking spiral length into consideration) exceeded the speed calculated in step 5 by five or more mph the following steps were followed -

1. maximum speed was increased in five mph increments;
2. actual superelevation was increased in increments specified for the segment and speed, without exceeding 6 inches, until neither 5 inches of unbalanced superelevation or exceeding 0.40 g/sec jerk rate were exceeded.
3. 6.1 and 6.2 were repeated until a further five mph increase would require more than 6 inches of superelevation or the 0.40 g/sec jerk rate would be exceeded.
4. Using the superelevation that was determined to be necessary to achieve the maximum feasible speed, the shortest spiral length that satisfied Amtrak curve criteria and did not exceed the 0.04 g per sec jerk, was calculated. Spiral lengths were established as an integer multiple of either 31, 39, or 50 feet, depending upon the speed. Shifts to achieve the proposed alignment were calculated.
5. The impact of the proposed shifts on each bridge were evaluated. If the shifts exceeded the followings limits the bridge was considered to be impacted:

    - open deck bridges with no planned work-any shift or change in superelevation;
    - open deck bridges with through girders or through deck girders scheduled for tie replacement--6 inches;
    - open deck bridges with deck girders scheduled for tie replacement--1-foot;
    - open deck bridges scheduled for change to ballast--2 feet;
    - ballasted bridges--2 feet; and
    - overhead bridges--3 feet.

    Bridges listed for replacement were assumed to not be impacted by alignment changes.

A list all of the curves that required alignment changes to achieve the proposed or optimal speed was developed. It included: proposed speeds, curves requiring 6 inches or less of shift, and curves requiring between 6 inches and 3 feet of shift.

Appendix C
OPERATIONS ANALYSIS TO SUPPORT PROJECT GOALS

INTRODUCTION

The results of the Train Performance Calculator simulations that were performed in support of this supplement to the Transportation Plan are discussed in detail in this Appendix. Results for intercity, commuter, and freight trains are presented. The ability of the recommended improvements to support reliable, less than 90-minute intercity trip times, also is evaluated.

ABILITY TO MEET PROJECT GOALS

As agreed upon at meetings involving all the railroads, FRA, and PennDOT, operations analyses to assess the impact of the proposed projects on rail operations, and to help identify other additional improvements that will benefit future operations were performed. The analyses performed were:

- The Train Performance Calculator model, which assesses the performance of a single train over the route to measure trip time differences between the existing track configuration and the proposed configuration for a variety of train consists; and
- Manual analyses of existing and proposed 2015 schedules and operational requirements of high speed intercity and commuter trains to determine areas of operating conflicts and delays.

Train Performance Calculator Runs

A program of Train Performance Calculator (TPC) analyses was undertaken to evaluate the efficacy of the recommended track configuration and alignment to satisfy the recommended goal of regularly scheduled, safe, and dependable rail passenger service between Philadelphia and Harrisburg in less than 90 minutes. The results of the analyses to date are summarized in this Appendix.

Conditions for Simulations of "Goal Trains"

Goal trains are those scheduled to meet the recommended, less than 90-minute, trip time between Philadelphia and Harrisburg. TPC simulations of goal trains on the existing, and the upgraded, facility configurations were based upon the conditions described in the following subsections.

"Baseline" TPC Runs. Baseline TPC runs were performed with a train consist of four Amfleet cars powered by one F40PH diesel locomotive upon the existing facility configurations, i.e., prior to any improvements being made. Trip times to 30th Street Station were simulated. The Baseline conditions included:

- Existing Maximum Authorized Speeds (MASs); trains were limited to 90 miles per hour;
- Speed restrictions as shown on Amtrak's employee timetables that were in effect in spring of 1997;
- Positive stops and Civil speed restrictions were not enforced by the signal system in these simulations; and
- Six Intermediate stops - 1.0-minute dwell at Exton, Downingtown, Elizabethtown, and Harrisburg Airport[1]; and 2.0-minute dwell at Paoli and Lancaster.
- Several Train consists were evaluated:
  - four Amfleet cars powered by one F40PH diesel locomotive;
  - four Silverliner IV Electric Multiple Unit (EMU) vehicles;
  - two IC-3D Diesel Multiple Unit (DMU) vehicles ; and
  - four Amfleet cars powered by one AEM-7 locomotive.

TPC Runs - MAS Increased to 110 mph. Another set of TPC runs to determine the amount of time savings to be experienced after increasing MAS to 110 mph. Trip times to 30th Street Station were simulated. The following conditions were used:

- MAS was increased to 110 mph; speeds on individual curves were calculated using a spreadsheet previously described in Appendix C.
- Speed restrictions due to track conditions were assumed to be removed as the result of an intensive program to restore the line to a state of good repair. As in the Baseline case, positive stops and curve speeds were not enforced.
- Improvements to spiral length and superelevation of selected curves, to optimize speed for curves without changing curvature, were assumed.
- Six Intermediate stops - 1.0-minute dwell at Exton, Downingtown, Elizabethtown, and Harrisburg Airport; and 2.0-minute dwell at Paoli and Lancaster.
- Several Train consists were evaluated:
  - four Amfleet cars powered by one F40PH diesel locomotive;
  - four Silverliner IV Electric Multiple Unit (EMU) vehicles;
  - two IC-3D Diesel Multiple Unit (DMU) vehicles ;
  - four Amfleet cars powered by one AEM-7 locomotive; and

[1]A proposed station to provide rail access to the airport located east of Harrisburg, adjacent to the Keystone Corridor.

- S one generic Amtrak tilt train.[2,3]
- ! Speeds were set assuming three levels of unbalanced superelevation -
  - S 3 inches;
  - S 5 inches; and
  - S 9 inches[4].
- ! Concrete ties were assumed to be installed in stretches of 110 mph operation and on curves where unbalanced superelevation would exceed 5 inches.

TPC Runs - Intermediate stops decreased to two. A third set of TPC runs to determine the amount of time savings to be experienced from decreasing the number of intermediate train stops to two after increasing MAS to 110 mph. Trip times to 30th Street Station were simulated. The following conditions were used:

- ! MAS was increased to 110 mph; speeds on individual curves were calculated using a spreadsheet previously described in Appendix C.
- ! Speed restrictions due to track conditions were assumed to be removed as the result of an intensive program to restore the line to a state of good repair. As in the Baseline case, positive stops and curve speeds were not enforced.
- ! Improvements to spiral length and superelevation of selected curves, to optimize speed for curves without changing curvature, were assumed.
- ! Two intermediate stops (2.0-minute dwell) at Paoli and Lancaster.
- ! Several Train consists were evaluated:
  - S four Amfleet cars powered by one F40PH diesel locomotive;
  - S four Silverliner IV Electric Multiple Unit (EMU) vehicles;
  - S two IC-3D Diesel Multiple Unit (DMU) vehicles ;
  - S four Amfleet cars powered by one AEM-7 locomotive; and
  - S one generic Amtrak tilt train.

- ! Speeds were set assuming three levels of unbalanced superelevation -
  - S 3 inches;
  - S 5 inches; and
  - S 9 inches.

  These all assume that selected curves would be upgraded to 6 inches of actual superelevation (identified as E_a on the tables).
- ! Concrete ties were assumed to be installed in stretches of 110 mph operation and on curves where unbalanced superelevation would exceed 5 inches.

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[2]A hypothetical train capable of operating at nine inches of unbalanced superelevation.

[3]At the time the TPC runs were made, data on Amtrak's proposed high-speed trainset was not available, therefore the characteristics of a hypothetical trainset used in the 1995 analysis of New Haven to Boston improvements was utilized.

[4]Only the generic tilt train was simulated at nine inches of unbalanced superelevation.

TPC Simulations of increasing intermediate train stops to 14. A fourth set of TPC simulations to evaluate the impact of increasing the number of intermediate train stops to 14, after increasing MAS to 110 mph was performed. Trip times to 30th Street Station were simulated. The following conditions were used:

- MAS was increased to 110 mph; speeds on individual curves were calculated using a spreadsheet previously described in Appendix C.
- Speed restrictions due to track conditions were assumed to be removed as the result of an intensive program to restore the line to a state of good repair. As in the baseline case, positive stops and curve speeds were not enforced.
- Improvements to spiral length and superelevation of selected curves, to optimize speed for curves without changing curvature, were assumed.
- Fourteen intermediate stops - 1.0-minute dwell at Malvern, Exton, Whitford, Downingtown, Coatesville, Parkesburg, Leaman Place, Mount Joy, Elizabethtown, Middletown, and Harrisburg Airport; and 2.0-minute dwell at Ardmore, Paoli, and Lancaster.
- Several Train consists were evaluated:
  - four Amfleet cars powered by one F40PH diesel locomotive;
  - four Silverliner IV Electric Multiple Unit (EMU) vehicles;
  - two IC-3D Diesel Multiple Unit (DMU) vehicles ;
  - four Amfleet cars powered by one AEM-7 locomotive; and
  - one generic Amtrak tilt train.
- Speeds were set assuming three levels of unbalanced superelevation -
  - 3 inches;
  - 5 inches; and
  - 9 inches.

  These all assume that selected curves would be upgraded to 6 inches of actual superelevation (identified as E_a on the tables).
- Concrete ties were assumed to be installed in stretches of 110 mph operation and on curves where unbalanced superelevation would exceed 5 inches.
- Although positive stops and curve speeds were not enforced, signal system improvements compatible with the recommended speeds were assumed.

The runs with one AEM-7 locomotive, the Diesel Multiple Unit consists being investigated by PennDOT, and the generic Amtrak tilt train cars were made for comparison purposes. The TPC runs illustrate the running times that could be expected given the relevant performance and physical characteristics of these types of rolling stock.

Conditions used in the TPC simulations, including MASs, speeds through curves, and unbalanced superelevation, are all a function of track structures, equipment structural capacity, and crashworthiness and represent the collective best judgment of experienced rail operators. Before high-speed operations are introduced, however,

many of these conditions will have to be analyzed in greater detail, and tested to ensure the safety of the total system.

TPC Running Times and Schedule Times

TPC simulated running time is the best achievable time that may be expected of a given train operated over a railroad line with given physical characteristics. The TPC times reported in Tables C-1 through C-10 are therefore the most optimistic running times for each given train consist.

When train schedules are prepared using TPC simulated times as a basis for the train running times, it is necessary to add an allowance for minor operating irregularities, which may be expected to occur on a daily basis. Several terms are used for this allowance, the most common of which are "pad", "cushion time", or "slop". A discussion of the issue of the amount of pad that should be added to the TPC times is found in a later subsection. The addition of this allowance to the TPC running time will enable trains to perform reliably on a day-to-day basis. The pad also will enable trains to regain any lost time resulting from minor delays (i.e., temporary speed restrictions, diversions around maintenance work, etc.). Pad also provides for two additional components: the probability that not all of the configuration and alignment improvements incorporated into the model will prove physically feasible; and the realization that the model assumes that the train engineer operates the train in a consistent and precise manner in response to speed changes.

Description of the Goal Train Output Tables

The results of the TPC simulations are contained in Tables C-1 through C-10. The tables are organized to present the overall running times and time savings (compared with the Baseline TPC run) from Philadelphia to Harrisburg for the different train consists and facility configuration assumptions.

The running times and time savings to be achieved by various alternative train consists operating at 3 inches of unbalanced superelevation and present timetable speeds, before any facility improvements such as curve realignments are made are illustrated in Table C-1. The Baseline scenario is identified in the tables as the scenario with "1-F40PH + 4 Amfleet, 3" Eu, with 6 stops.

The running times and time savings to be achieved with 3 inches of unbalanced superelevation and an MAS of 110 are illustrated in Table C-2. The Baseline scenario is identified in the tables as the scenario with "1-F40PH + 4 Amfleet, 3" Eu, with 6 stops.

Table C-1
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
1997 Timetable Maximum Authorized Speeds
Six Intermediate Stops[5]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	54.67
4 Silverliner IV EMUs 3" Eu	1-48.1	4.1	56.72
2 IC-3D Flexiliner DMUs 3" Eu	1-49.0	3.2	56.27
1-AEM-7+4 Amfleet 3" Eu	1-47.4	4.8	57.11

Table C-2
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Maximum Authorized Speed to 110 mph
Six Intermediate Stops[6]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
1-F40PH+4 Amfleet 3" Eu - 6 Stop	1-37.6	14.6	62.85
4 Silverliner IV EMUs 3" Eu	1-32.3	19.8	66.42
2 IC-3D Flexiliner DMUs 3" Eu	1-31.3	20.9	67.16
1-AEM-7+4 Amfleet 3" Eu	1-26.6	25.6	70.79

[5]Intermediate stops: 1.0-minute dwell at Exton, Downingtown, Elizabethtown, and Harrisburg Airport; 2.0-minute dwell at Paoli and Lancaster.

[6]Intermediate stops: 1.0-minute dwell at Exton, Downingtown, Elizabethtown, and Harrisburg Airport; 2.0-minute dwell at Paoli and Lancaster.

The six intermediate stop running times and time savings (also compared with the Baseline TPC run) resulting from improvements to curve geometry to permit operation at 110 mph and curve speeds computed for 5 inches of unbalanced superelevation are shown in Table C-3. In all cases, selected curves would have upgraded actual superelevation of 6 inches. These tables also illustrate the trip time savings in comparison with the Baseline scenario.

Table C-3
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Curve Unbalance (Eu) to 5 Inches
Maximum Authorized Speed of 110 mph
Six Intermediate Stops (1.0-minute dwell at Exton, Downingtown, Elizabethtown, and Harrisburg Airport; 2.0-minute dwell at Paoli and Lancaster)

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
1-F40PH+4 Amfleet 5" Eu	1-34.1	18.1	65.13
4 Silverliner IV EMUs 5" Eu	1-29.0	23.2	68.88
2 IC-3D Flexiliner DMUs 5" Eu	1-27.0	25.2	71.47
1-AEM-7+4 Amfleet 5" Eu	1-22.5	29.7	74.36

The impact of using the generic Amtrak tilt train at 9 inches of unbalanced superelevation, with six intermediate stops, is shown in Table C-4.

The running times and time savings to be achieved by decreasing the number of stops to two, with 3 inches of unbalanced superelevation and an MAS of 110, are illustrated in Table C-5. The Baseline scenario is identified in the tables as the scenario with "1-F40PH + 4 Amfleet, 3" Eu, with 6 stops. The two intermediate stop running times and time savings (also compared with the Baseline TPC run), resulting from improvements to curve geometry to permit operation at 110 mph and curve speeds computed for 5 inches of unbalanced superelevation are shown in Table C-6. In all cases, selected curves would have upgraded actual superelevation of 6 inches. These tables also illustrate the trip time savings in comparison with the Baseline scenario.

Table C-4
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Curve Unbalance (Eu) to 9 Inches
Maximum Authorized Speed of 110 mph
Six Intermediate Stops[7]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
Amtrak Generic Tilt Train	1-16.0	36.2	80.68

Table C-5
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Decreasing Number of Stops
Maximum Authorized Speed of 110 mph
Two Intermediate Stops[8]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
1-F40PH+4 Amfleet 3" Eu	1-26.5	25.7	70.89
4 Silverliner IV EMUs 3" Eu	1-23.8	28.4	73.20
2 IC-3D Flexiliner DMUs 3" Eu	1-21.6	30.6	75.10
1-AEM-7+4 Amfleet 3" Eu	1-18.0	34.2	78.61

[7]Intermediate stops: 1.0-minute dwell at Exton, Downingtown, Elizabethtown, and Harrisburg Airport; 2.0-minute dwell at Paoli and Lancaster.

[8]Intermediate stops (2.0-minute dwell) at Paoli and Lancaster.

Table C-6
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Decreasing Number of Stops and Increasing Eu to 5"
Maximum Authorized Speed of 110 mph
Two Intermediate Stops[9]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 5" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
1-F40PH+4 Amfleet 5" Eu	1-23.7	27.5	74.17
4 Silverliner IV EMUs 5" Eu	1-21.2	30.0	76.47
2 IC-3D Flexiliner DMUs 5" Eu	1-17.9	33.3	79.78
1-AEM-7+4 Amfleet 5" Eu	1-14.7	36.5	83.14

The impact of using the generic Amtrak tilt train at 9 inches of unbalanced superelevation, with two intermediate stops, is shown in Table C-7.

Table C-7
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Decreasing Number of Stops and Increasing Eu to 9 Inches
Maximum Authorized Speed of 110 mph
Two Intermediate Stops[10]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
Amtrak Generic Tilt Train	1-07.0	43.2	91.51

The running times and time savings to be achieved by increasing the number of stops to fourteen, with 3 inches of unbalanced superelevation and an MAS of 110, are

[9]Intermediate stops (2.0-minute dwell) at Paoli and Lancaster.

[10]Intermediate stops (2.0-minute dwell) at Paoli and Lancaster.

illustrated in Table C-8. The Baseline scenario is identified in the tables as the scenario with "1-F40PH + 4 Amfleet, 3" Eu, with 6 stops. The fourteen intermediate stop running times and time savings (also compared with the Baseline TPC run), resulting from improvements to curve geometry to permit operation at 110 mph and curve speeds computed for 5 inches of unbalanced superelevation are shown in Table C-9. In all cases, selected curves would have upgraded actual superelevation of 6 inches. These tables also illustrate the trip time savings in comparison with the Baseline scenario.

Table C-8
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Number of Stops
Maximum Authorized Speed of 110 mph
Fourteen Intermediate Stops[11]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
1-F40PH+4 Amfleet 3" Eu	1-57.7	(2.0)	52.11
4 Silverliner IV EMUs 3" Eu	1-48.3	7.4	56.61
2 IC-3D Flexiliner DMUs 3" Eu	1-49.1	6.6	56.23
1-AEM-7+4 Amfleet 3" Eu	1-42.9	12.8	59.61

The impact of using the generic Amtrak tilt train at 9 inches of unbalanced superelevation, with fourteen intermediate stops, is shown in Table C-10.

TPC Results for the Goal Trains

The running times and time savings resulting from the facility configuration improvements and train stop assumptions are discussed in the following paragraphs.

[11]Intermediate stops 1.0-minute dwell at Malvern, Exton, Whitford, Downingtown, Coatesville, Parkesburg, Leaman Place, Mount Joy, Elizabethtown, Middletown, and Harrisburg Airport; 2.0-minute dwell at Ardmore, Paoli, and Lancaster.

Table C-9
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Number of Stops and Increasing Eu to 5"
Maximum Authorized Speed of 110 mph
Fourteen Intermediate Stops[12]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
1-F40PH+4 Amfleet 5" Eu	1-55.0	0.7	53.33
4 Silverliner IV EMUs 5" Eu	1-45.5	10.2	58.12
2 IC-3D Flexiliner DMUs 5" Eu	1-45.7	9.9	58.00
1-AEM-7+4 Amfleet 5" Eu	1-39.1	16.6	61.87

Table C-10
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Decreasing Number of Stops and Increasing Eu to 9 Inches
Maximum Authorized Speed of 110 mph
Fourteen Intermediate Stops[13]

Train Consist Eu	Running Time	Difference From Baseline	Average Speed
1-F40PH+4 Amfleet 3" Eu - 6 Stop **Baseline**	1-52.2	N/A	53.24
Amtrak Generic Tilt Train	1-32.2	22.8	66.00

[12]Intermediate stops 1.0-minute dwell at Malvern, Exton, Whitford, Downingtown, Coatesville, Parkesburg, Leaman Place, Mount Joy, Elizabethtown, Middletown, and Harrisburg Airport; 2.0-minute dwell at Ardmore, Paoli, and Lancaster.

[13]Intermediate stops 1.0-minute dwell at Malvern, Exton, Whitford, Downingtown, Coatesville, Parkesburg, Leaman Place, Mount Joy, Elizabethtown, Middletown, and Harrisburg Airport; 2.0-minute dwell at Ardmore, Paoli, and Lancaster.

Comparative simulated running times with various train consists showing effects of various train consists operating at 3 inches of unbalanced superelevation (Eu), the present (spring 1997) maximum authorized speeds, and six intermediate stops are shown in Table C-1. No changes in track configuration or state of good repair improvements were assumed for these runs. The impact of varying train consists ranges from 3 to 5 minutes. The utilization of diesel rather than electric locomotives increases trip times by 4.8 minutes. The use of DMUs rather than diesel locomotives reduces the TPC time by three minutes.

Compared to the timetable scheduled performance of two hours and five minutes for seven-stop Keystone trains, the six-stop Baseline TPC run represents more than an eleven percent pad (discussed in subsequent subsections).

Estimates of the time savings that may be achieved by increasing MAS to 110 mph, implementing an intensive state of good repair program, selectively increasing actual curve superelevation to 6 inches, selectively increasing spiral length on curves to satisfy design and comfort criteria as discussed in Appendix C are provided in Table C-2. Also included are track capacity improvements to improve trip time reliability and trip time improvements at Lancaster, Harrisburg Station, and the east of Overbrook Interlocking. These improvements provide total savings ranging from about 14.6 minutes to 25.5 minutes, compared with the Baseline. A diesel-hauled consist could potentially operate on a six-stop 1-hour 45-minute schedule. An AEM-7 (electric) hauled consist could achieve a 95-minute schedule between 30th Street and Harrisburg. Silverliners or DMUs could support a 1-hour 40-minute operation.

Estimates of the time savings that may be achieved by increasing MAS to 110 mph, implementing an intensive state of good repair program, increasing Eu to 5 inches, selectively increasing actual curve superelevation to 6 inches, selectively increasing spiral length on curves to satisfy design and comfort criteria as discussed in Appendix C are provided in Table C-3. Also included are track capacity improvements to improve trip time reliability, and trip time improvements at Lancaster, Harrisburg Station, and to the east of Overbrook Interlocking. These improvements provide total savings ranging from about 18.0 minutes to 29.7 minutes, compared with the Baseline. A diesel-hauled consist could potentially operate on a six-stop, 1-hour 40-minute schedule. An AEM-7 (electric) hauled consist could achieve an 90-minute schedule between 30th Street and Harrisburg. Silverliners and DMUs both could satisfactorily support a 95-minute operation.

The incremental effect of operating a generic tilt train at nine inches of unbalanced superelevation is illustrated in Table C-4. The generic trainset produced savings of 36.2 minutes and would should reliably operate a one-hour 25-minute schedule between Philadelphia and Harrisburg.

The incremental effect of decreasing the number of stops to two at three inches of unbalanced superelevation is illustrated in Table C-5. The improvement produces total savings ranging from about 23.7 minutes to 32.2 minutes, compared with the Baseline. Incremental savings from the six intermediate stop 3" Eu option range from 6.7 minutes (for the AEM-7 Option) to 9.1 minutes (for the diesel option). Minimizing the number of times the diesel must accelerate from a station stop has a significant impact on it operating performance.

The incremental effect of decreasing the number of stops to two at five inches of unbalanced superelevation is illustrated in Table C-6. The improvement produces total savings ranging from about 27.5 minutes to 36.4 minutes, compared with the Baseline 90 mph case. Incremental savings from the six intermediate stop 5" Eu option range from 6.7 minutes (for the AEM-7 Option) to 9.5 minutes (for the diesel option). Minimizing the number of times the AEM-7 must accelerate from a station stop has a less significant impact on it's operating performance than decreasing the number of diesel-hauled stops.

The incremental effect of decreasing the number of stops to two at nine inches of unbalanced superelevation is illustrated in Table C-7. The improvement produces total savings of 43.2 minutes, compared with the Baseline. The incremental savings from the six intermediate stop option is 7.0 minutes. Minimizing the number of times the generic tilt train must accelerate from a station stop has about the same impact on it's operating performance as decreasing the number of AEM-7-hauled stops.

The incremental effect of increasing the number of stops to 14 at 3 inches of unbalanced superelevation is illustrated in Table C-8. The increase in stops produces total savings ranging from about a loss of 2.0 minutes, for the diesel-hauled consist, to a savings of 12.8 minutes for the AEM-7 hauled consist, compared with the Baseline. Incremental time lost from the comparative six intermediate stop option range from 12.4 minutes (for the Silverliner 3" Option) to 16.6 minutes (for the diesel 3" Option). Increasing the number of times the diesel-hauled consist must accelerate from a station stop has a more significant impact on it's operating performance than increasing the number of electric-hauled stops.

The incremental effect of increasing the number of stops to 14 at 5 inches of unbalanced superelevation is illustrated in Table C-9. The increase in stops produces total savings ranging from about 0.7 minutes for the diesel-hauled consist to 16.6 minutes for the AEM-7 hauled consist, compared with the Baseline. Incremental time lost from the comparative six intermediate stop option range from 12.9 minutes (for the Silverliner 5" Option) to 17.3 minutes (for the diesel 5" Option).

The incremental effect of increasing the number of stops to 14, at nine inches of unbalanced superelevation, is illustrated in Table C-10. The increase in stops produces total savings of 22.8 minutes, compared with the Baseline. The incremental time loss

from the comparable 9-inch six intermediate stop option is 13.4 minutes. Minimizing the number of times the generic tilt train must accelerate from a station stop has about the same impact on it's operating performance as decreasing the number of AEM-7-hauled stops.

Speed Profile Graphs

Speed profile graphs comparing the performance of various train consists, train speeds, number of stops, and MAS are provided as Figures C-1 and C-2. The 29.7 minutes saved by having an electrified train operation, in place of a diesel operation, between Philadelphia and Harrisburg, restoring the track structure, signals, etc. to a state-of-good repair, and upgrading selected curves to six inches of actual superelevation is shown in Figure C-1. The effect of reducing the number of stops, with electrified operation, from six to two is shown in Figure C-2.

The vertical scale on each figure has been modified from the normal display in which speed on the vertical scale is uniform to a proportional scale in which the area under the curve created by the plot is equal to time. Since the scale between 0 and 25 mph would dominate the display and the distance traveled at speeds in that range is minimal that speed range is normally not plotted. When two TPC runs are plotted on the same chart, the revised scale enables the enhanced effect of trip improvements at lower speeds to be illustrated.

Performance of Commuter Trains

Budgetary limitations limited TPC runs to intercity trains.

Figure C-1: PHILADELPHIA 30TH ST TO HARRISBURG TIME SAVED

1 F40+4 AMCOACH Vs 1 AEM7+4 AMCOACH

1997 Time Table Speeds Vs 110-mph with 5" Eu

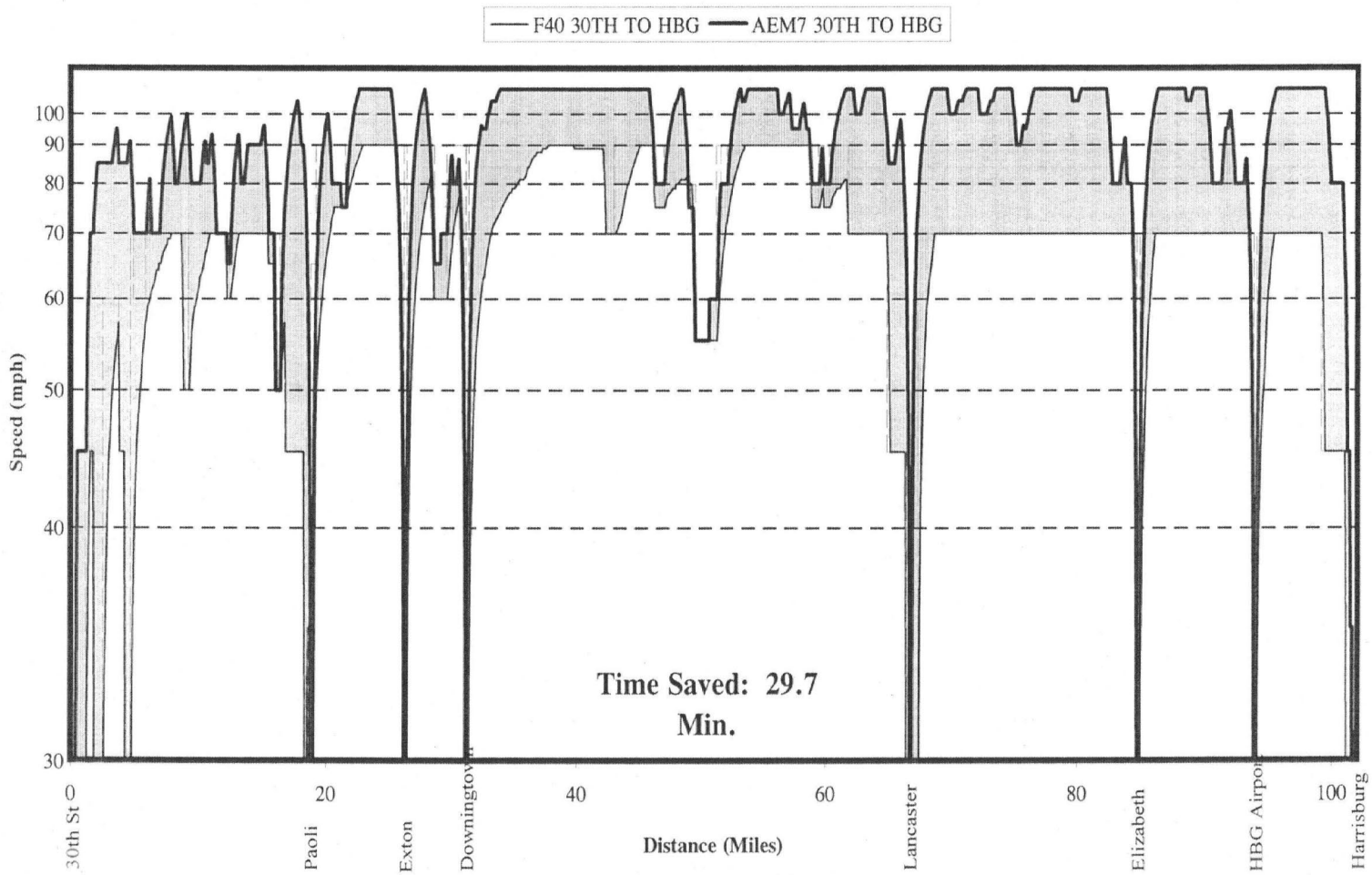


Figure C-2

PHILADELPHIA 30TH ST TO HARRISBURG TIME SAVED

1 AEM7+4 AMCOACH, 110-mph with 5" Eu

2 Stops Vs 6 Stops

2015 TRAFFIC LEVEL OPERATIONS

MONTE CARLO™ Simulations

When several services coexist on the same trackage, conflicts are likely. Delays from these conflicts can jeopardize the reliability of all services; therefore, a methodology is required that can measure the impact of these conflicts. With services as interrelated as those on the NEC and the Richmond Line, simulation of the entire interrelated system is the only valid methodology. That is not the case with the Keystone Corridor. The lack of intercity freight operations and the integrated nature of the intercity-commuter scheduling process lessens the need for a computerized analysis of train operations. Consequently, the MONTE CARLO™ simulation package was not applied to the Harrisburg corridor.

Therefore, in addition to the TPC model, manual analysis techniques were used to evaluate the effectiveness of individual projects initially considered necessary to achieve the trip time and reliability goals.

The purpose of the manual analyses was to provide information for each location analyzed as to:

- where delays potentially could occur;
- possible schedule changes to eliminate conflicts; and
- facility changes that could potentially eliminate conflicts.

Operations Evaluation Methodology

The starting point for the analyses were the existing corridor-wide facilities and the Year 2015 schedules, which were obtained from each entity (SEPTA, PennDOT, CR, and Amtrak).

The analyses attempted to determine for varying levels of service, at different times of the day whether commuter and intercity trains could be routed on regularly assigned tracks. If normal track assignments appeared infeasible, the potential for using other tracks to avoid delays was evaluated. If it appeared that, because of conflicting moves, no track was available, or if an interlocking was blocked, trains were assumed to wait until a route was available. The severity of potential operating problems was established based experience of the personnel performing the analyses.

Terminal operations in Philadelphia and Harrisburg were not simulated as part of the study. It was expected that the terminals could accommodate the projected traffic levels. The capacity of the terminals cannot be ignored, and the interface of intercity

and commuter passenger operations at the station and in the vicinity of the station are a potential problem ultimately that should be addressed by rail planners.

2015 Operations Between Philadelphia and Harrisburg

Achieving the running time goals under theoretical circumstances does not ensure meeting them in actual operations. The numerous interfaces with commuter trains between Philadelphia and Atglen affect trip times.

At several locations, where there was potential for delays, the first step was to determine if operating options could alleviate the perceived difficulties. When this process did not identify viable solutions, it was concluded that the delays could be minimized through configuration modifications. The recommended changes are documented in the body of this supplemental report.

TRIP TIME FINDINGS

Scheduling Pad

Background. In planning train schedules or analyzing the results of TPC runs, *pad* is defined as the difference between a published schedule time and the best achievable time between two terminals. When planning schedules, the amount of pad allows trains to incur small increments of delay en route and still maintain a high probability of on-time performance. When analyzing the results of TPC runs, two additional components of pad are considered: the expectation that not all of the configuration and alignment improvements incorporated into the model will prove physically feasible; and the expectation that the model assumes that every train engineer operates the train in a consistent and precise manner in response to required speed changes. These assumptions usually are too optimistic.

Traditionally, the most common way of adding pad to the schedule is to concentrate much of it toward the end of the run. The reason for this technique is that pad, which is distributed throughout a schedule and is consumed by waiting for scheduled departure times at intermediate stations, is unavailable to cover any delays that may occur toward the end of a run. Since, traditionally, the on-time performance of a train is measured by the time at the final terminal, many schedule makers and transportation supervisors prefer to have the pad allocated toward the end of the run.

In scheduling high-performance trains on a route with heavy commuter traffic, it may be more appropriate to distribute pad at the location(s) where delays are most likely to occur.

Pad Considerations. The amount of pad to be provided depends upon the nature of the railroad being operated. Traditionally, a percentage of the TPC is allotted for pad. Realistic estimates of pad cannot be made until a facility and schedules have been defined. Even then, determining the distribution of pad must be based on subjective evaluation and operating history.

Previous MONTE CARLO™ simulations for similar NEC studies have resulted in the conclusion that a pad in the range of 6 to 7 minutes, which represents 7-percent added to the TPC time for intercity trains in this corridor would be justified.

Achievement of Planned Keystone Corridor Improvements and Impact upon Pad. The TPCs expected that the presently projected curve speeds will be achieved. Experience has indicated that not all of these planned improvements will prove physically feasible and not all of the anticipated savings will be achieved in the real world. This is another reason why a pad of at least 7-percent is necessary during the planning phase of a project.

Pad Recommendations. For planning purposes it is better to overestimate pad than to underestimate it, unless doing so grossly distorts construction costs. Based on the FRA's previous analyses, a 6- to 7-minute (7-percent pad) is being used to determine whether or not a reliable less than 90-minute time between Philadelphia and Harrisburg is achievable.

Trip Time Goal Status

The TPC simulations have clearly indicated that completion of an extensive state of good repair program, the performance characteristics of the intercity rolling stock, and the amount of unbalanced superelevation, will be critical to achieving the trip time goal of less 90 minutes.

To determine whether a reliable intercity service of less 90 minutes can be operated, Table C-11 was prepared to summarize the overall running times for various alignment and train consist options. The results are shown for speeds computed for the three different unbalanced superelevation conditions and the 110 mph MAS option between Philadelphia and Harrisburg that have been simulated. The table also shows the amount of pad available for each run.

Using the 6- to 7-minute (7-percent) pad recommendation mentioned in the previous section, it is clear that only the six stop cases assuming electrified diesel-hauled operation in which 5 and 9 inches of unbalanced superelevation were used resulted in a run time that provides the recommended pad.

Table C-11
SIMULATED RUN TIMES
AND AVAILABLE PAD
Compared to 90-Minute Goal

Case	Simulated Run Time	Pad (minutes.)	Pad (% of TPC Time)
Baseline: 1-F40PH +4Amfleet, 3" Eu - 6 stop	107.2	N/A	N/A
110 mph/5" Eu/2 IC-3D/6 stops	87.0	3.0	3.4%
110 mph/3" Eu/1 AEM-7/6 stops	86.6	3.4	3.9%
110 mph/3" Eu/1 F40PH/2 stops	86.5	3.5	4.1%
110 mph/3" Eu/4 Silverliner IV EMUs/2 stop	83.8	6.2	7.5%
110 mph/5" Eu/1 F40PH/2 stops	83.7	6.3	7.6%
110 mph/5" Eu/1 AEM-7/6 stops	82.5	7.5	9.1%
110 mph/3" Eu/2 IC-3D/2 stops	81.6	7.4	10.2%
110 mph/3" Eu/AEM7/2 stops	78.0	12.0	15.4%
110 mph/5" Eu/2 IC-3D/2 stops	76.9	13.1	17.1%
110 mph/9" Eu/ Generic Tilt train/6 stops	76.0	14.0	18.4%
110 mph/5" Eu/AEM7/2 stops	73.7	16.3	22.0%
110 mph/9" Eu/ Generic Tilt train/2 stops	67.0	23.0	34.3%

Considering the above-mentioned uncertainties, and therefore applying the seven percent pad, only the electrified 110 mph six-stop options achieve the trip time goal of less than 90 minutes. Use of a train with tilt capabilities operating at 9-inches of unbalanced superelevation and a MAS of 110 mph, would enable a 6-stop 85-minute

schedule to be established, and might enable a limited number of 80-minute 6-stop trains to be operated.

It does not appear that IC-3D consists would support a 6-stop, 90-minute service (at 5" Eu), however, 6-stop 95-minute would appear to be possible. A two-stop 85-minute IC-3D schedule would appear feasible. IC-3D diesel-powered trains would only be operated between the lower level of 30th Street Station and Harrisburg. They would be restricted from operating into the underground Suburban Street Station.

It should be noted that a number of potential changes in the conditions upon which the TPC results are based might occur, which would further erode the amount of available pad. For example:

- There may still be some question as to whether all of the curve modifications that are assumed in the TPC runs are feasible, from an engineering standpoint;
- If a 110 mile-per-hour MAS cannot be achieved, there would be some increase in TPC running time;
- If an unbalanced superelevation lower than 5 inches must be used, the trip time would suffer; and
- Adding station stops beyond six would increase running time.

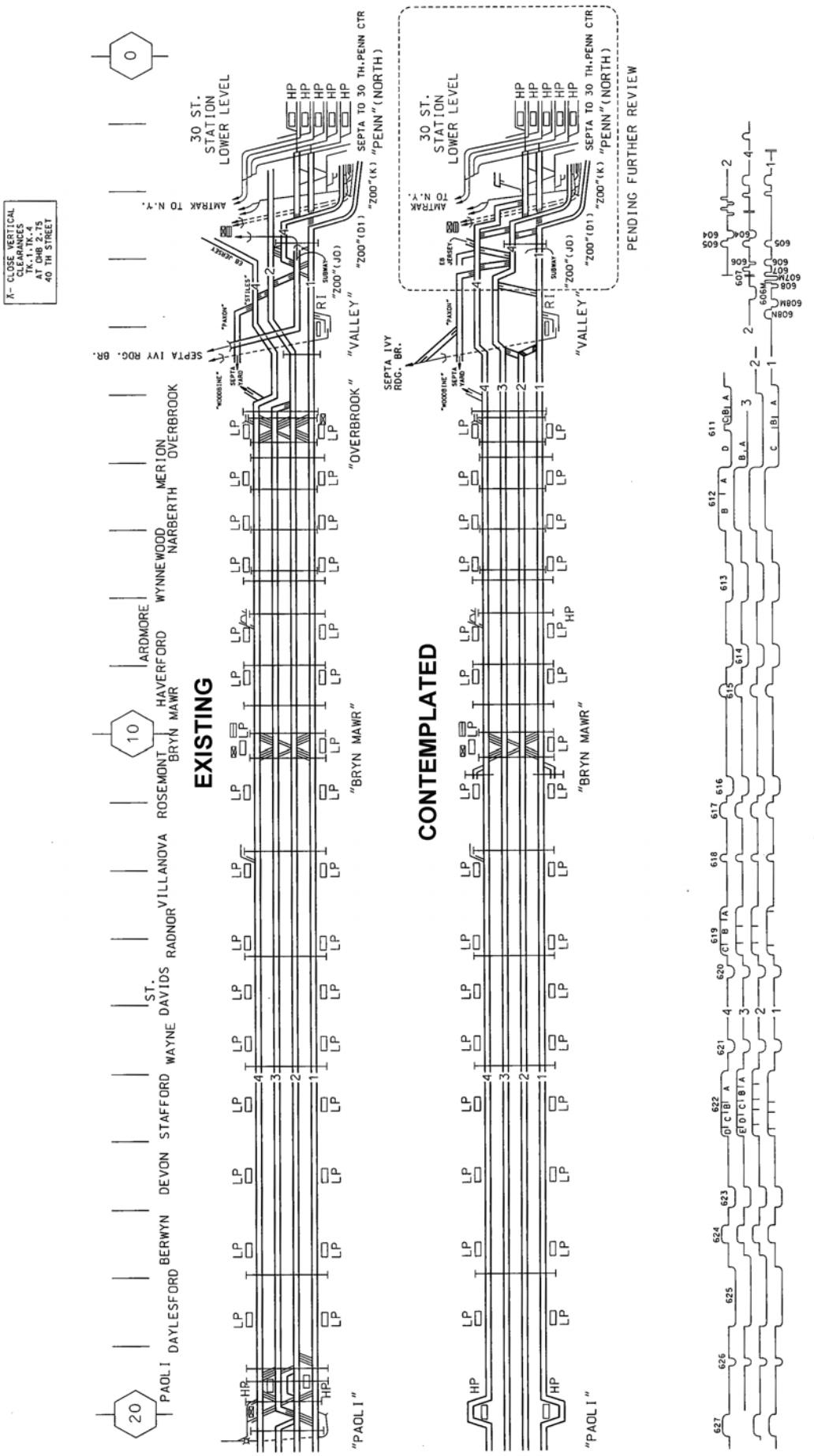
It is believed that an on-time performance of at least 90 percent should be established as a goal for Keystone Corridor train services.

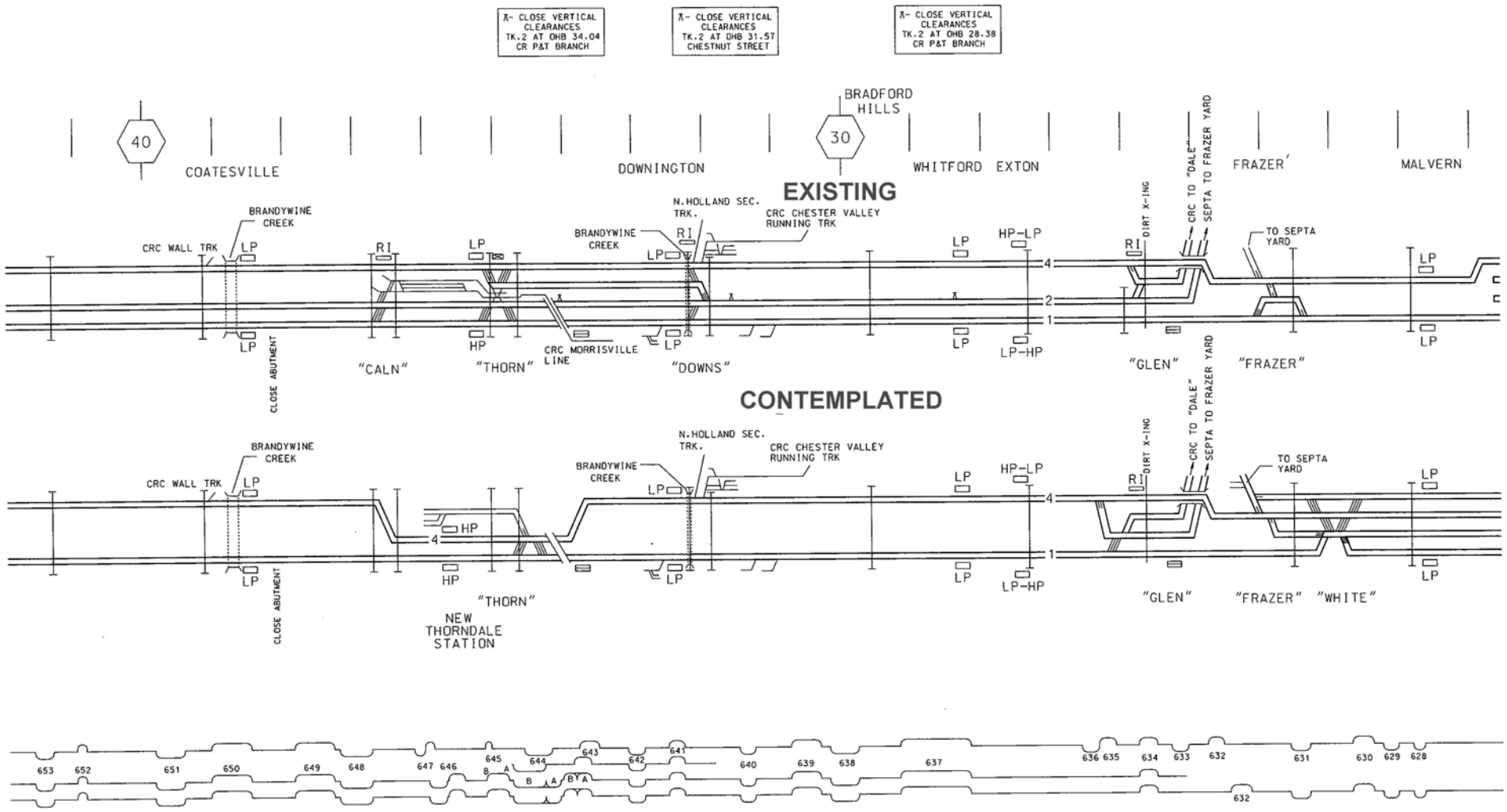
Track Capacity

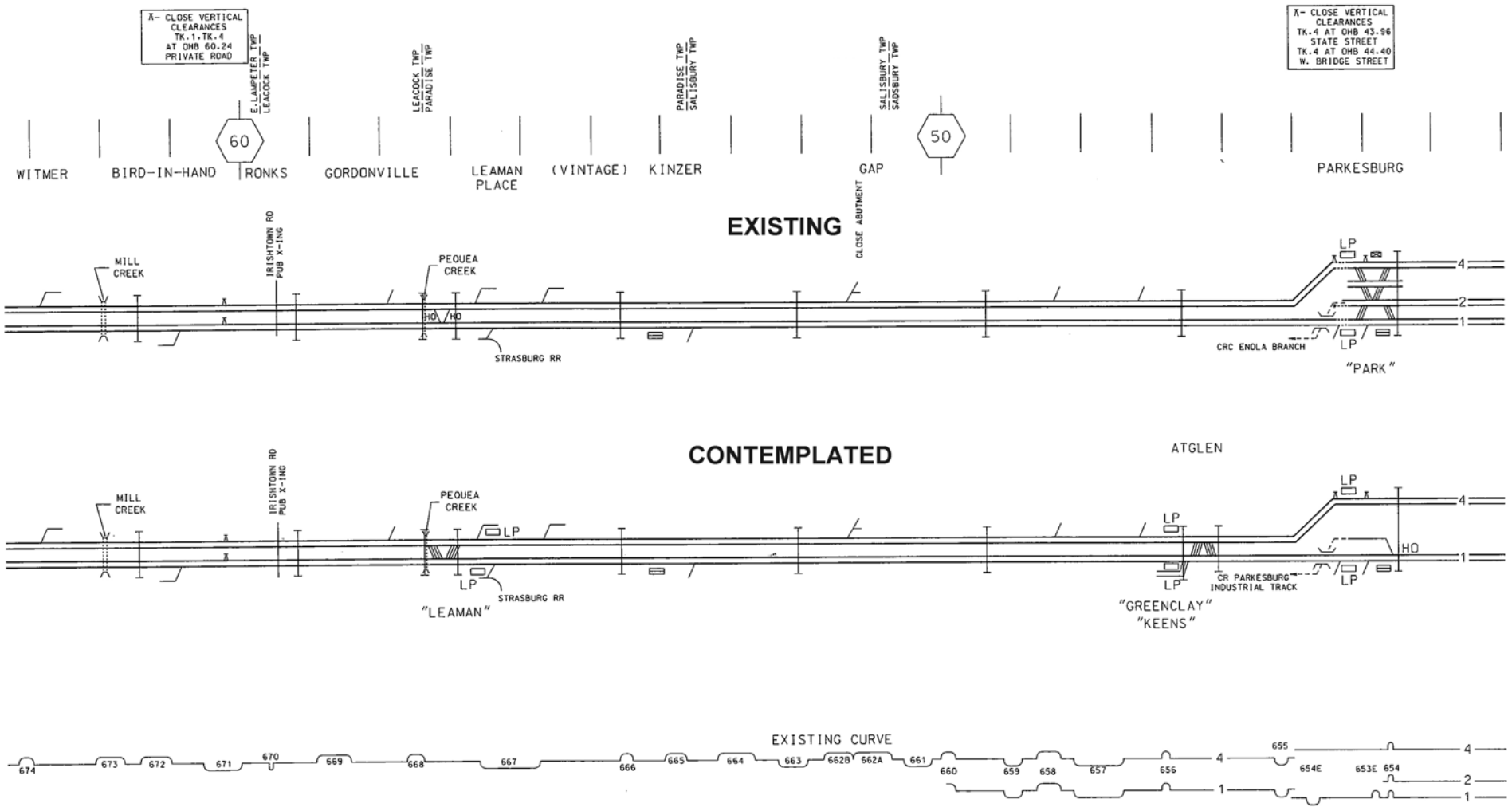
Goal trains most likely could be integrated into today's corridor schedule through schedule adjustments, with implementation of the state of good repair program, and the construction of the planned track and configuration improvements. However, given the 2015 schedules provided by corridor users, there is insufficient capacity and operating flexibility at certain station locations to accommodate all users during peak periods, if the recommended improvements at those locations are not implemented. The Overbrook to Philadelphia segment improvements also must be implemented, if trip time and capacity goals are to be satisfied.

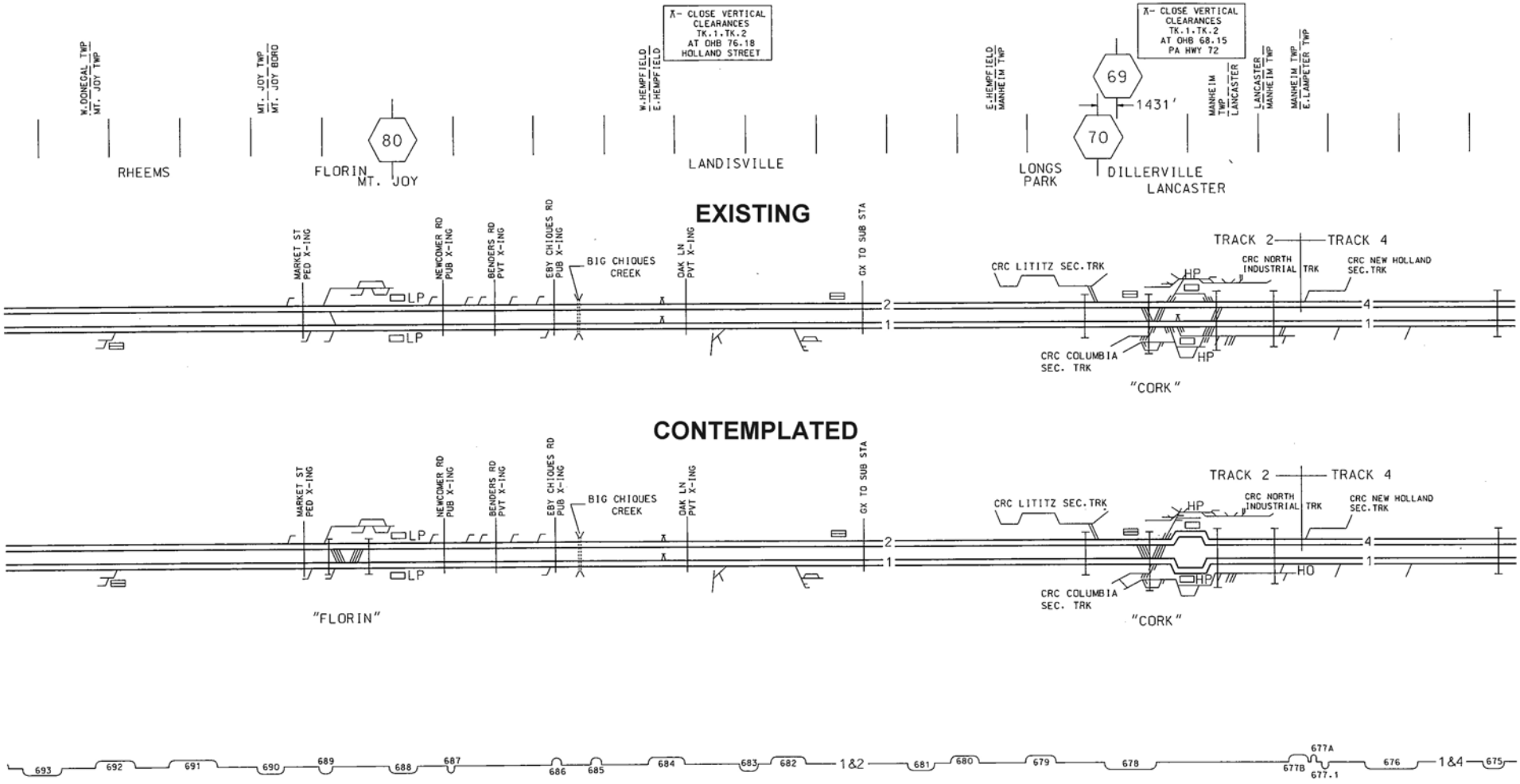
Insufficient capacity, resulting from lack of program implementation in these key locations, can be handled in two ways: reducing train frequencies and lengthening schedules to accommodate delay. Selection of either of these two options would be policy decisions, which would work against the project goals assumed for this study.

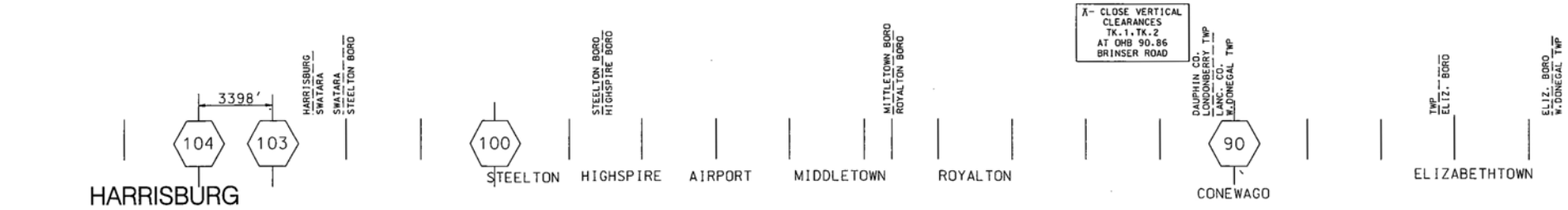
APPENDIX D
TRACK CHARTS



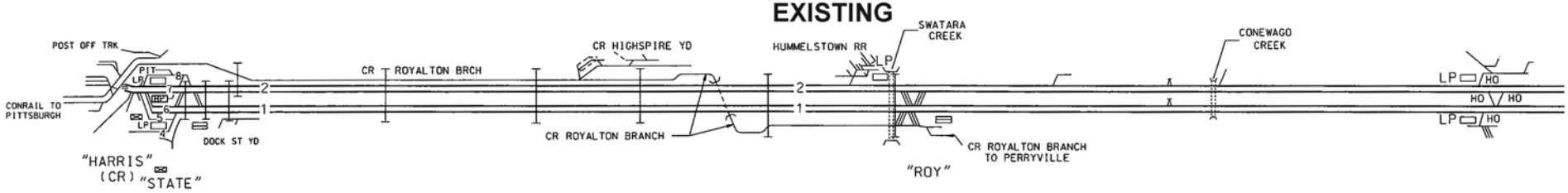

X- CLOSE VERTICAL CLEARANCES TK.2 AT OHB 34.04 CR P&T BRANCH
X- CLOSE VERTICAL CLEARANCES TK.2 AT OHB 31.57 CHESTNUT STREET
X- CLOSE VERTICAL CLEARANCES TK.2 AT OHB 28.38 CR P&T BRANCH
40
COATESVILLE
DOWNINGTON
BRADFORD HILLS
30
WHITFORD EXTON
FRAZER'
MALVERN
EXISTING
BRANDYWINE CREEK
CRC WALL TRK
LP
RI
HP
HP-LP
N.HOLLAND SEC. TRK.
CRC CHESTER VALLEY RUNNING TRK
CRC MORRISVILLE LINE
DIRT X-ING
CRC TO "DALE"
SEPTA TO FRAZER YARD
TO SEPTA YARD
CLOSE ABUTMENT
"CALN"
"THORN"
"DOWNS"
"GLEN"
"FRAZER"
CONTEMPLATED
NEW THORNDALE STATION
"WHITE"


X- CLOSE VERTICAL CLEARANCES TK.1,TK.4 AT OHB 60.24 PRIVATE ROAD
X- CLOSE VERTICAL CLEARANCES TK.4 AT OHB 43.96 STATE STREET TK.4 AT OHB 44.40 W. BRIDGE STREET
E.LAMPETER TWP
LEACOCK TWP
LEACOCK TWP
PARADISE TWP
PARADISE TWP
SALISBURY TWP
SALISBURY TWP
SADSBURY TWP
60
50
WITMER
BIRD-IN-HAND
RONKS
GORDONVILLE
LEAMAN PLACE
(VINTAGE)
KINZER
GAP
PARKESBURG
EXISTING
CLOSE ABUTMENT
MILL CREEK
IRISHTOWN RD PUB X-ING
PEQUEA CREEK
HO
HO
STRASBURG RR
LP
4
2
1
CRC ENDLA BRANCH
LP
"PARK"
CONTEMPLATED
ATGLEN
MILL CREEK
IRISHTOWN RD PUB X-ING
PEQUEA CREEK
LP
LP
STRASBURG RR
"LEAMAN"
LP
4
HO
1
LP
LP
CR PARKESBURG INDUSTRIAL TRACK
"GREENCLAY"
"KEENS"
EXISTING CURVE
674
673
672
671
670
669
668
667
666
665
664
663
662B
662A
661
660
659
658
657
656
4
1
655
654E
653E
654
4
2
1

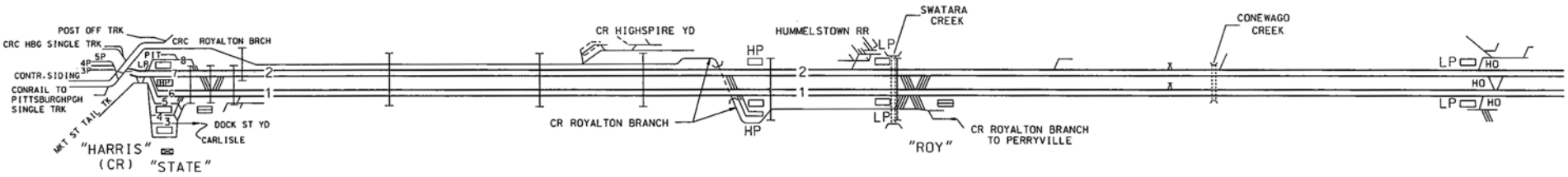

W. DONEGAL TWP
MT. JOY TWP
MT. JOY TWP
MT. JOY BORO
W. HEMPFIELD
E. HEMPFIELD
E. HEMPFIELD
MANHEIM TWP
MANHEIM TWP
LANCASTER
LANCASTER
MANHEIM TWP
E. LAMPETER TWP
X- CLOSE VERTICAL CLEARANCES TK.1.TK.2 AT OHB 76.18 HOLLAND STREET
X- CLOSE VERTICAL CLEARANCES TK.1.TK.2 AT OHB 68.15 PA HWY 72
80
69
70
1431'
RHEEMS
FLORIN
MT. JOY
LANDISVILLE
LONGS PARK
DILLERVILLE
LANCASTER
EXISTING
MARKET ST PED X-ING
NEWCOMER RD PUB X-ING
BENDERS RD PVT X-ING
EBY CHIQUES RD PUB X-ING
BIG CHIQUES CREEK
OAK LN PVT X-ING
GX TO SUB STA
LP
TRACK 2
TRACK 4
CRC LITITZ SEC. TRK
CRC NORTH INDUSTRIAL TRK
CRC NEW HOLLAND SEC. TRK
HP
CRC COLUMBIA SEC. TRK
"CORK"
CONTEMPLATED
"FLORIN"
HO
693
692
691
690
689
688
687
686
685
684
683
682
1&2
681
680
679
678
677A
677B
677.1
676
1&4
675

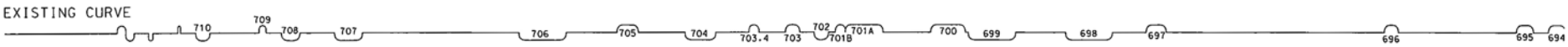


EXISTING



CONTEMPLATED





APPENDIX E
ASSUMED TRAIN SCHEDULES—2015

Note: Sixteen pages of schedules follow.

"DH" means "deadhead" or nonrevenue moves.

WESTBOUND											
	Train	DH	DH	DH	DH	DH	Amtk 601	Hbg Cmtr	Hbg Cmtr	7607	DH
		Fra-Atg	Fra-Th	Fra-Th	Fra-Th	Fra-Atg	30h-500	HLan1	HLan3	Sub-Cyn	Fra-Atg
	MP										
New York Penn Station											
30th Street Station LL											
Suburban Station	0.0						5:00 AM			5:40 AM	
30th Street Station UL	0.0						5:03 AM				
Powelton Yard	0.5										
Zoo-D1	1.4						5:08 AM				
Zoo-JO	1.9									5:46 AM	
Overbrook	5.4										
Ardmore	8.5									*To*	
Bryn Mawr	10.1									*Cynwyd*	
Paoli	19.9						5:27 AM				
Malvern	21.6						5:30 AM				
Frazer Yard	23.9	4:57 AM	5:11 AM	5:28 AM	5:41 AM	5:43 AM					6:11 AM
Exton	27.5						5:36 AM				
Whitford	28.3						5:38 AM				
Downingtown	32.4						5:43 AM				
Thorn	35.0		5:46 AM	6:03 AM	6:16 AM						
Coatesville	38.4						5:48 AM				
Parksburg	44.2						5:53 AM				
Atglen	47.0	5:32 AM				6:18 AM					6:46 AM
Leaman Place	55.6						6:03 AM				
Lancaster	68.0						6:13 AM	6:15 AM	6:45 AM		
Mt. Joy	80.1						6:22 AM	6:30 AM	7:00 AM		
Elizabethtown	86.8						6:28 AM	6:38 AM	7:08 AM		
Middletown	94.7							6:49 AM	7:19 AM		
H'burg Airport	97.0						6:38 AM	6:52 AM	7:22 AM		
Harrisburg	104.6						6:45 AM	7:00 AM	7:30 AM		
EASTBOUND											
	Train	6612	514	516	Amtk	694	518	520	4206	9524	622
		PowSub	Th-Sub	MalSub	h30-500	CynSub	Atg-Sub	Bry-Sub	MalSub	Th-Sub	CynSub
	MP										
Harrisburg	104.6				5:00 AM						
H'burg Airport	97.0				5:08 AM						
Middletown	94.7										
Elizabethtown	86.8				5:17 AM						
Mt. Joy	80.1										
Lancaster	68.0				5:32 AM						
Leaman Place	55.6										
Atglen	47.0						5:45 AM				
Parksburg	44.2						5:47 AM				
Coatesville	38.4						5:52 AM				
Thorn	35.0		5:06 AM				5:55 AM			6:24 AM	
Downingtown	32.4				5:58 AM		6:00 AM			6:29 AM	
Whitford	28.3						6:05 AM			6:34 AM	
Exton	27.5				6:04 AM		6:07 AM			6:36 AM	
Frazer Yard	23.9			5:40 AM					6:24 AM		
Malvern	21.6		5:24 AM	5:47 AM			6:13 AM		6:31 AM	6:42 AM	
Paoli	19.9		5:28 AM	5:51 AM	6:12 AM		6:17 AM		6:35 AM	6:46 AM	
Bryn Mawr	10.1	*From*	5:48 AM	6:11 AM		*From*	6:37 AM	6:45 AM	6:55 AM		*From*
Ardmore	8.5	*Yard*	5:52 AM	6:15 AM		*Cynwyd*		6:49 AM			*Cynwyd*
Overbrook	5.4		6:00 AM	6:23 AM				6:57 AM			
Zoo-JO	1.9					6:42 AM					7:19 AM
Zoo-D1	1.4				6:27 AM						
Powelton Yard	0.5	5:39 AM									
30th Street Station LL	0.0										
30th Street Station UL			6:10 AM	6:33 AM			6:53 AM	7:07 AM	7:11 AM	7:20 AM	
Suburban Station	0.0	5:48 AM	6:15 AM	6:38 AM	6:35 AM	6:52 AM	6:58 AM	7:12 AM	7:16 AM	7:25 AM	7:29 AM
New York Penn Station											

WESTBOUND										
	Train	**Amtk**	**Hbg Cmtr**	**DH**	**501**	**503**	**DH**	**Hbg Cmtr**	**Amtk**	**Hbg Cmtr**
		30h-600	**HLan5**	**Sub-Bry**	**Sub-Mal**	**Sub-Th**	**Sub-Bry**	**HLan7**	**30h-700**	**HLan9**
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	**0.0**	6:00 AM		6:05 AM	6:15 AM	6:45 AM	6:57 AM		7:00 AM	
30th Street Station UL	**0.0**	6:03 AM			6:20 AM	6:50 AM			7:03 AM	
Powelton Yard	**0.5**									
Zoo-D1	**1.4**	6:08 AM							7:08 AM	
Zoo-JO	**1.9**									
Overbrook	**5.4**				6:29 AM	6:59 AM				
Ardmore	**8.5**				6:36 AM	7:06 AM				
Bryn Mawr	**10.1**			6:30 AM	6:40 AM	7:10 AM	7:22 AM			
Paoli	**19.9**	6:25 AM			7:03 AM	7:33 AM			7:25 AM	
Malvern	**21.6**				7:06 AM	7:36 AM				
Frazer Yard	**23.9**									
Exton	**27.5**	6:33 AM							7:33 AM	
Whitford	**28.3**									
Downingtown	**32.4**	6:38 AM							7:38 AM	
Thorn	**35.0**					7:51 AM				
Coatesville	**38.4**									
Parksburg	**44.2**									
Atglen	**47.0**									
Leaman Place	**55.6**									
Lancaster	**68.0**	7:06 AM	7:15 AM					7:45 AM	8:06 AM	8:15 AM
Mt. Joy	**80.1**		7:30 AM					8:00 AM		8:30 AM
Elizabethtown	**86.8**	7:20 AM	7:38 AM					8:08 AM	8:20 AM	8:38 AM
Middletown	**94.7**		7:49 AM					8:19 AM		8:49 AM
H'burg Airport	**97.0**	7:28 AM	7:52 AM					8:22 AM	8:28 AM	8:52 AM
Harrisburg	**104.6**	7:35 AM	8:00 AM					8:30 AM	8:35 AM	9:00 AM
EASTBOUND										
	Train	**Amtk**	**HLan2**	**Flyer**	**9002**	**526**	**9528**	**Amtk**	**HLan4**	**4208**
		h30-600	**HBG. Comtr**	**Th-Sub**	**Bry-Sub**	**MalSub**	**Atg-Sub**	**hbgnyp-630**	**HBG. Comtr**	**CynSub**
	MP									
Harrisburg	**104.6**	6:00 AM	6:15 AM					6:30 AM	6:45 AM	
H'burg Airport	**97.0**	6:08 AM	6:24 AM					6:38 AM	6:54 AM	
Middletown	**94.7**		6:27 AM						6:57 AM	
Elizabethtown	**86.8**	6:17 AM	6:38 AM					6:47 AM	7:08 AM	
Mt. Joy	**80.1**		6:46 AM						7:16 AM	
Lancaster	**68.0**	6:32 AM	7:00 AM					7:02 AM	7:30 AM	
Leaman Place	**55.6**									
Atglen	**47.0**						6:41 AM			
Parksburg	**44.2**						6:43 AM			
Coatesville	**38.4**						6:48 AM			
Thorn	**35.0**			6:36 AM			6:51 AM			
Downingtown	**32.4**	6:58 AM					6:56 AM	7:28 AM		
Whitford	**28.3**						7:01 AM			
Exton	**27.5**	7:04 AM					7:03 AM	7:34 AM		
Frazer Yard	**23.9**					*6:56 AM*				
Malvern	**21.6**			6:54 AM		7:03 AM	7:09 AM			
Paoli	**19.9**	7:12 AM		6:58 AM		7:07 AM	7:13 AM	7:42 AM		
Bryn Mawr	**10.1**				*7:16 AM*	7:27 AM				*From*
Ardmore	**8.5**				7:20 AM			7:54 AM		*Cynwyd*
Overbrook	**5.4**				7:28 AM					
Zoo-JO	**1.9**							7:59 AM		7:45 AM
Zoo-D1	**1.4**	7:27 AM								
Powelton Yard	**0.5**									
30th Street Station LL	**0.0**									
30th Street Station UL					7:38 AM	7:43 AM	7:47 AM			
Suburban Station	**0.0**	7:35 AM		7:38 AM	7:43 AM	7:48 AM	7:52 AM			7:55 AM
New York Penn Station								9:29 AM		
								NY subwy		

WESTBOUND										
	Train	**9691**	**DH4005**	**505**	**507**	**DH**	**Hbg Cmtr**	**6613**	**509**	**615**
		Sub-Cyn	**Sub-Bry**	**Sub-Th**	**Sub-Th**	**Sub-Bry**	**HLan11**	**Sub-Pow**	**Sub-Th**	**Sub-Cyn**
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	**0.0**	*7:04 AM*	7:12 AM	7:15 AM	7:28 AM	7:38 AM		7:41 AM	7:45 AM	7:50 AM
30th Street Station UL	**0.0**			7:20 AM	7:33 AM				7:50 AM	
Powelton Yard	**0.5**							7:49 AM		
Zoo-D1	**1.4**									
Zoo-JO	**1.9**	7:10 AM						*To Yard*		7:56 AM
Overbrook	**5.4**			7:29 AM	7:42 AM				7:59 AM	
Ardmore	**8.5**	*To*		7:36 AM	7:49 AM				8:06 AM	*To*
Bryn Mawr	**10.1**	*Cynwyd*	7:37 AM	7:40 AM	7:53 AM	8:03 AM			8:10 AM	*Cynwyd*
Paoli	**19.9**			8:03 AM	8:16 AM				8:33 AM	
Malvern	**21.6**			8:06 AM	8:19 AM				8:36 AM	
Frazer Yard	**23.9**									
Exton	**27.5**				8:24 AM					
Whitford	**28.3**									
Downingtown	**32.4**				8:29 AM					
Thorn	**35.0**			8:21 AM	8:34 AM				8:51 AM	
Coatesville	**38.4**									
Parksburg	**44.2**									
Atglen	**47.0**									
Leaman Place	**55.6**									
Lancaster	**68.0**						8:45 AM			
Mt. Joy	**80.1**						9:00 AM			
Elizabethtown	**86.8**						9:08 AM			
Middletown	**94.7**						9:19 AM			
H'burg Airport	**97.0**						9:22 AM			
Harrisburg	**104.6**						9:30 AM			
EASTBOUND										
	Train	**9004**	**9530**	**Flyer**	**7532**	**534**	**9626**	**9536**	**9538**	**9008**
		Bry-Sub	**MalSub**	**Th-Sub**	**Th-Sub**	**Bry-Sub**	**CynSub**	**Mal-Sub**	**Atg-Sub**	**Bry-Sub**
	MP									
Harrisburg	**104.6**									
H'burg Airport	**97.0**									
Middletown	**94.7**									
Elizabethtown	**86.8**									
Mt. Joy	**80.1**									
Lancaster	**68.0**									
Leaman Place	**55.6**									
Atglen	**47.0**								7:16 AM	
Parksburg	**44.2**								7:18 AM	
Coatesville	**38.4**								7:23 AM	
Thorn	**35.0**			7:06 AM	*7:11 AM*				7:26 AM	
Downingtown	**32.4**				7:16 AM				7:31 AM	
Whitford	**28.3**				7:21 AM				7:36 AM	
Exton	**27.5**				7:23 AM				7:38 AM	
Frazer Yard	**23.9**		*7:13 AM*							
Malvern	**21.6**		7:20 AM	7:24 AM	7:29 AM			7:36 AM	7:44 AM	
Paoli	**19.9**		7:24 AM	7:28 AM	7:33 AM			7:40 AM	7:48 AM	
Bryn Mawr	**10.1**	7:35 AM	7:44 AM			7:48 AM	*From*	8:00 AM		8:10 AM
Ardmore	**8.5**	7:39 AM				7:52 AM	*Cynwyd*			8:14 AM
Overbrook	**5.4**	7:47 AM				8:00 AM				8:22 AM
Zoo-JO	**1.9**						*8:08 AM*			
Zoo-D1	**1.4**									
Powelton Yard	**0.5**									
30th Street Station LL	**0.0**									
30th Street Station UL		7:57 AM	8:00 AM		8:07 AM	8:10 AM		8:16 AM	8:22 AM	8:32 AM
Suburban Station	**0.0**	8:02 AM	8:05 AM	8:08 AM	8:12 AM	8:15 AM	8:18 AM	8:21 AM	8:27 AM	8:37 AM
New York Penn Station										

WESTBOUND										
	Train	DH	Amtk	Flyer	Hbg Cmtr	513	6617	515	6619	Hbg Cmtr
		Sub-Bry	30h-800	Sub-Th	HLan13	Sub-Pao	Sub-Pow	Sub-Pao	Sub-Pow	HLan15
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	0.0	7:56 AM	8:00 AM	*8:04 AM*		8:18 AM	8:21 AM	8:45 AM	8:50 AM	
30th Street Station UL	0.0		8:03 AM			8:23 AM		8:50 AM		
Powelton Yard	0.5						8:29 AM		8:58 AM	
Zoo-D1	1.4		8:08 AM							
Zoo-JO	1.9						*To Yard*		*To Yard*	
Overbrook	5.4					8:32 AM		8:59 AM		
Ardmore	8.5					8:39 AM		9:06 AM		
Bryn Mawr	10.1	8:21 AM				8:43 AM		9:10 AM		
Paoli	19.9		8:27 AM	8:29 AM		9:06 AM		9:33 AM		
Malvern	21.6		8:30 AM	8:32 AM		9:09 AM		9:36 AM		
Frazer Yard	23.9					9:20 AM		9:47 AM		
Exton	27.5		8:36 AM							
Whitford	28.3		8:38 AM							
Downingtown	32.4		8:43 AM							
Thorn	35.0			8:47 AM						
Coatesville	38.4		8:48 AM							
Parksburg	44.2		8:52 AM							
Atglen	47.0									
Leaman Place	55.6		9:03 AM							
Lancaster	68.0		9:13 AM		9:15 AM					
Mt. Joy	80.1		9:22 AM		9:30 AM					
Elizabethtown	86.8		9:28 AM		9:38 AM					
Middletown	94.7		9:35 AM		9:49 AM					
H'burg Airport	97.0		9:38 AM		9:52 AM					10:22 AM
Harrisburg	104.6		9:45 AM		10:00 AM					10:32 AM
EASTBOUND										
	Train	Flyer	Amtk	HLan6	HLan8	540	628	9010	542	6630
		Th-Sub	h30-700	HBG. Comtr	HBG. Comtr	Th-Sub	CynSub	Bry-Sub	Mal-Sub	PowSub
	MP									
Harrisburg	104.6		7:00 AM	7:15 AM	7:45 AM					
H'burg Airport	97.0		7:08 AM	7:24 AM	7:54 AM					
Middletown	94.7		7:11 AM	7:27 AM	7:57 AM					
Elizabethtown	86.8		7:18 AM	7:38 AM	8:08 AM					
Mt. Joy	80.1		7:24 AM	7:46 AM	8:16 AM					
Lancaster	68.0		7:34 AM	8:00 AM	8:30 AM					
Leaman Place	55.6		7:43 AM							
Atglen	47.0									
Parksburg	44.2		7:54 AM							
Coatesville	38.4		7:58 AM							
Thorn	35.0	7:38 AM				7:42 AM				
Downingtown	32.4		8:04 AM							
Whitford	28.3		8:08 AM							
Exton	27.5		8:10 AM							
Frazer Yard	23.9									
Malvern	21.6	7:56 AM	8:16 AM			8:00 AM			8:29 AM	
Paoli	19.9	8:00 AM	8:20 AM			8:04 AM			8:33 AM	
Bryn Mawr	10.1					8:24 AM	*From*	8:35 AM	8:53 AM	*From*
Ardmore	8.5						*Cynwyd*	8:39 AM	8:57 AM	*Yard*
Overbrook	5.4							8:47 AM	9:05 AM	
Zoo-JO	1.9						8:42 AM			
Zoo-D1	1.4		8:37 AM							
Powelton Yard	0.5									9:14 AM
30th Street Station LL	0.0									
30th Street Station UL						8:40 AM		8:57 AM	9:15 AM	
Suburban Station	0.0	8:40 AM	8:45 AM			8:45 AM	8:52 AM	9:02 AM	9:20 AM	9:23 AM
New York Penn Station										

WESTBOUND										
	Train	**Hbg Cmtr**	**Amtk 43**	**Hbg Cmtr**	**517**	**6623**	**D6011**	**519**	**Amtk**	**6625**
		HLan17	**nyppgh-0745**	**HLan19**	**Sub-Pao**	**Sub-Pow**	**Sub-Pow**	**Sub-Th**	**30h-1000**	**Sub-Pow**
	MP									
New York Penn Station			7:45 AM							
30th Street Station LL			9:15 AM							
Suburban Station	**0.0**				9:15 AM	9:25 AM	9:42 AM	9:45 AM	10:00 AM	10:03 AM
30th Street Station UL	**0.0**				9:20 AM			9:50 AM	10:03 AM	
Powelton Yard	**0.5**					9:33 AM	9:50 AM			10:11 AM
Zoo-D1	**1.4**		9:18 AM						10:08 AM	
Zoo-JO	**1.9**					*To Yard*	*To Yard*			*To Yard*
Overbrook	**5.4**				9:29 AM			9:59 AM		
Ardmore	**8.5**		9:23 AM		9:36 AM			10:06 AM		
Bryn Mawr	**10.1**				9:40 AM			10:10 AM		
Paoli	**19.9**		9:35 AM		10:03 AM			10:33 AM	10:27 AM	
Malvern	**21.6**				10:06 AM			10:36 AM	10:30 AM	
Frazer Yard	**23.9**				10:17 AM			10:47 AM		
Exton	**27.5**							10:41 AM	10:36 AM	
Whitford	**28.3**								10:38 AM	
Downingtown	**32.4**		9:51 AM					10:46 AM	10:43 AM	
Thorn	**35.0**							10:51 AM		
Coatesville	**38.4**								10:48 AM	
Parksburg	**44.2**								10:52 AM	
Atglen	**47.0**									
Leaman Place	**55.6**								11:03 AM	
Lancaster	**68.0**	10:15 AM	10:21 AM						11:13 AM	
Mt. Joy	**80.1**	10:30 AM							11:22 AM	
Elizabethtown	**86.8**	10:38 AM							11:28 AM	
Middletown	**94.7**	10:49 AM							11:35 AM	
H'burg Airport	**97.0**	10:52 AM	10:47 AM	11:22 AM					11:38 AM	
Harrisburg	**104.6**	11:00 AM	10:55 AM	11:32 AM					11:45 AM	
			to PGH							

EASTBOUND										
	Train	**Amtk**	**HLan10**	**544**	**Amtk**	**HLan12**	**HLan14**	**546**	**6632**	**548**
		h30-800	**HBG. Comtr**	**Pao-Sub**	**hbgnyp-830**	**HBG. Comtr**	**HBG. Comtr**	**Th-Sub**	**PowSub**	**Pao-Sub**
	MP									
Harrisburg	**104.6**	8:00 AM	8:15 AM		8:30 AM	8:45 AM	9:15 AM			
H'burg Airport	**97.0**	8:08 AM	8:24 AM		8:38 AM	8:54 AM	9:24 AM			
Middletown	**94.7**		8:27 AM			8:57 AM	9:27 AM			
Elizabethtown	**86.8**	8:17 AM	8:38 AM		8:47 AM	9:08 AM	9:38 AM			
Mt. Joy	**80.1**		8:46 AM			9:16 AM	9:46 AM			
Lancaster	**68.0**	8:32 AM	9:00 AM		9:02 AM	9:30 AM	10:00 AM			
Leaman Place	**55.6**									
Atglen	**47.0**									
Parksburg	**44.2**									
Coatesville	**38.4**									
Thorn	**35.0**							9:11 AM		
Downingtown	**32.4**	8:58 AM			9:28 AM			9:16 AM		
Whitford	**28.3**							9:21 AM		
Exton	**27.5**	9:04 AM			9:34 AM			9:23 AM		
Frazer Yard	**23.9**			8:49 AM						9:48 AM
Malvern	**21.6**							9:29 AM		
Paoli	**19.9**	9:12 AM		9:01 AM	9:42 AM			9:33 AM		10:00 AM
Bryn Mawr	**10.1**			9:21 AM				9:53 AM	*From*	10:20 AM
Ardmore	**8.5**			9:25 AM	9:54 AM			9:57 AM	*Yard*	10:24 AM
Overbrook	**5.4**			9:33 AM				10:05 AM		10:32 AM
Zoo-JO	**1.9**				9:59 AM					
Zoo-D1	**1.4**	9:27 AM								
Powelton Yard	**0.5**								10:14 AM	
30th Street Station LL	**0.0**									
30th Street Station UL				9:43 AM				10:15 AM		10:42 AM
Suburban Station	**0.0**	9:35 AM		9:48 AM				10:20 AM	10:23 AM	10:47 AM
New York Penn Station					11:29 AM					
					NY subwy					

WESTBOUND										
	Train	Hbg Cmtr	521	523	6627	Hbg Cmtr	525	Hbg Cmtr	527	6629
		HLan21	Sub-Pao	Sub-Pao	Sub-Pow	HLan23	Sub-Pao	HLan25	Sub-Th	Sub-Pow
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	0.0		10:15 AM	10:45 AM	10:49 AM		11:15 AM		11:45 AM	11:49 AM
30th Street Station UL	0.0		10:20 AM	10:50 AM			11:20 AM		11:50 AM	
Powelton Yard	0.5				10:57 AM					11:57 AM
Zoo-D1	1.4									
Zoo-JO	1.9				*To Yard*					*To Yard*
Overbrook	5.4		10:29 AM	10:59 AM			11:29 AM		11:59 AM	
Ardmore	8.5		10:36 AM	11:06 AM			11:36 AM		12:06 PM	
Bryn Mawr	10.1		10:40 AM	11:10 AM			11:40 AM		12:10 PM	
Paoli	19.9		11:03 AM	11:33 AM			12:03 PM		12:33 PM	
Malvern	21.6		11:06 AM	11:36 AM			12:06 PM		12:36 PM	
Frazer Yard	23.9		11:17 AM	11:47 AM			12:17 PM		12:47 PM	
Exton	27.5								12:41 PM	
Whitford	28.3									
Downingtown	32.4								12:46 PM	
Thorn	35.0								12:51 PM	
Coatesville	38.4									
Parksburg	44.2									
Atglen	47.0									
Leaman Place	55.6									
Lancaster	68.0	11:15 AM						12:15 PM		
Mt. Joy	80.1	11:30 AM						12:30 PM		
Elizabethtown	86.8	11:38 AM						12:38 PM		
Middletown	94.7	11:49 AM						12:49 PM		
H'burg Airport	97.0	11:52 AM				12:22 PM		12:52 PM		
Harrisburg	104.6	12:00 PM				12:32 PM		1:00 PM		

EASTBOUND										
	Train	550	6634	HLan16	Amtk	552	HLan18	HLan20	HLan22	554
		Pao-Sub	PowSub	HBG. Comtr	h30-1000	Pao-Sub	HBG. Comtr	HBG. Comtr	HBG. Comtr	Th-Sub
	MP									
Harrisburg	104.6			9:45 AM	10:00 AM		10:15 AM	10:45 AM	11:15 AM	
H'burg Airport	97.0			9:55 AM	10:08 AM		10:24 AM	10:55 AM	11:24 AM	
Middletown	94.7				10:11 AM		10:27 AM		11:27 AM	
Elizabethtown	86.8				10:18 AM		10:38 AM		11:38 AM	
Mt. Joy	80.1				10:24 AM		10:46 AM		11:46 AM	
Lancaster	68.0				10:34 AM		11:00 AM		12:00 PM	
Leaman Place	55.6				10:43 AM					
Atglen	47.0									
Parksburg	44.2				10:54 AM					
Coatesville	38.4				10:58 AM					
Thorn	35.0									11:11 AM
Downingtown	32.4				11:04 AM					11:16 AM
Whitford	28.3				11:08 AM					11:21 AM
Exton	27.5				11:10 AM					11:23 AM
Frazer Yard	23.9	10:22 AM				10:52 AM				
Malvern	21.6				11:16 AM					11:29 AM
Paoli	19.9	10:34 AM			11:20 AM	11:04 AM				11:33 AM
Bryn Mawr	10.1	10:54 AM	*From*			11:24 AM				11:53 AM
Ardmore	8.5	10:58 AM	*Yard*			11:28 AM				11:57 AM
Overbrook	5.4	11:06 AM				11:36 AM				12:05 PM
Zoo-JO	1.9									
Zoo-D1	1.4				11:37 AM					
Powelton Yard	0.5		*11:15 AM*							
30th Street Station LL	0.0									
30th Street Station UL		11:16 AM				11:46 AM				12:15 PM
Suburban Station	0.0	11:21 AM	11:24 AM		11:45 AM	11:51 AM				12:20 PM
New York Penn Station										

WESTBOUND										
	Train	**Hbg Cmtr**	**Amtk**	**Hbg Cmtr**	**529**	**9693**	**531**	**6631**	**533**	**Hbg Cmtr**
		HLan27	**30h-1200**	**HLan29**	**Sub-Bry**	**Sub-Cyn**	**Sub-Pao**	**Sub-Pow**	**Sub-Th**	**HLan31**
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	**0.0**		12:00 PM		12:15 PM	12:20 PM	12:45 PM	12:49 PM	1:15 PM	
30th Street Station UL	**0.0**		12:03 PM		12:20 PM		12:50 PM		1:20 PM	
Powelton Yard	**0.5**							12:57 PM		
Zoo-D1	**1.4**		12:08 PM							
Zoo-JO	**1.9**					12:26 PM		*To Yard*		
Overbrook	**5.4**				12:29 PM		12:59 PM		1:29 PM	
Ardmore	**8.5**				12:36 PM	*To*	1:06 PM		1:36 PM	
Bryn Mawr	**10.1**				12:40 PM	*Cynwyd*	1:10 PM		1:40 PM	
Paoli	**19.9**		12:27 PM		1:03 PM		1:33 PM		2:03 PM	
Malvern	**21.6**		12:30 PM		1:06 PM		1:36 PM		2:06 PM	
Frazer Yard	**23.9**				1:17 PM		1:47 PM		2:17 PM	
Exton	**27.5**		12:36 PM						2:11 PM	
Whitford	**28.3**		12:38 PM							
Downingtown	**32.4**		12:43 PM						2:16 PM	
Thorn	**35.0**								2:21 PM	
Coatesville	**38.4**		12:48 PM							
Parksburg	**44.2**		12:52 PM							
Atglen	**47.0**									
Leaman Place	**55.6**		1:03 PM							
Lancaster	**68.0**		1:13 PM	1:15 PM						
Mt. Joy	**80.1**		1:22 PM	1:30 PM						
Elizabethtown	**86.8**		1:28 PM	1:38 PM						
Middletown	**94.7**		1:35 PM	1:49 PM						
H'burg Airport	**97.0**	1:22 PM	1:38 PM	1:52 PM						2:22 PM
Harrisburg	**104.6**	1:32 PM	1:45 PM	2:00 PM						2:32 PM
EASTBOUND										
	Train	**6636**	**556**	**Amtk**	**HLan24**	**558**	**9694**	**6638**	**D9598**	**Amtk**
		PowSub	**Pao-Sub**	**hbgnyp-1130**	**HBG. Comtr**	**Pao-Sub**	**CynSub**	**PowSub**	**Pao-Sub**	**h30-1200**
	MP									
Harrisburg	**104.6**			11:30 AM	11:45 AM					12:00 PM
H'burg Airport	**97.0**			11:38 AM	11:55 AM					12:08 PM
Middletown	**94.7**									12:11 PM
Elizabethtown	**86.8**			11:47 AM						12:18 PM
Mt. Joy	**80.1**									12:24 PM
Lancaster	**68.0**			12:02 PM						12:34 PM
Leaman Place	**55.6**									12:43 PM
Atglen	**47.0**									
Parksburg	**44.2**									12:54 PM
Coatesville	**38.4**									12:58 PM
Thorn	**35.0**									
Downingtown	**32.4**			12:28 PM						1:04 PM
Whitford	**28.3**									1:08 PM
Exton	**27.5**			12:34 PM						1:10 PM
Frazer Yard	**23.9**		11:52 AM			12:22 PM			12:30 PM	
Malvern	**21.6**									1:16 PM
Paoli	**19.9**		12:04 PM	12:42 PM		12:34 PM			12:42 PM	1:20 PM
Bryn Mawr	**10.1**	*From*	12:24 PM			12:54 PM	*From*	*From*	1:02 PM	
Ardmore	**8.5**	*Yard*	12:28 PM	12:54 PM		12:58 PM	*Cynwyd*	*Yard*		
Overbrook	**5.4**		12:36 PM			1:06 PM				
Zoo-JO	**1.9**						1:13 PM			
Zoo-D1	**1.4**			12:59 PM						1:37 PM
Powelton Yard	**0.5**	12:14 PM						1:14 PM		
30th Street Station LL	**0.0**			1:07 PM						
30th Street Station UL			12:46 PM			1:16 PM				
Suburban Station	**0.0**	12:23 PM	12:51 PM			1:21 PM	1:23 PM	1:23 PM	1:27 PM	1:45 PM
New York Penn Station				2:37 PM						

WESTBOUND									
	Train	**Hbg Cmtr**	**Hbg Cmtr**	**Amtk**	**535**	**6635**	**Amtk**	**Hbg Cmtr**	**Amtk**
		HLan33	**HLan35**	**nyphbg-1220**	**Sub-Pao**	**Sub-Pow**	**30h-1400**	**HLan37**	**NYPChi-1255**
	MP								
New York Penn Station				12:25 PM					12:55 PM
30th Street Station LL				1:55 PM					2:25 PM
Suburban Station	**0.0**				1:45 PM	1:49 PM	2:00 PM		
30th Street Station UL	**0.0**				1:50 PM		2:03 PM		
Powelton Yard	**0.5**					1:57 PM			
Zoo-D1	**1.4**			1:58 PM			2:08 PM		2:28 PM
Zoo-JO	**1.9**					*To Yard*			
Overbrook	**5.4**				1:59 PM				
Ardmore	**8.5**			2:03 PM	2:06 PM				2:33 PM
Bryn Mawr	**10.1**				2:10 PM				
Paoli	**19.9**			2:15 PM	2:33 PM		2:27 PM		2:45 PM
Malvern	**21.6**				2:36 PM		2:30 PM		
Frazer Yard	**23.9**				2:47 PM				
Exton	**27.5**						2:36 PM		
Whitford	**28.3**						2:38 PM		
Downingtown	**32.4**			2:31 PM			2:43 PM		3:01 PM
Thorn	**35.0**								
Coatesville	**38.4**						2:48 PM		
Parksburg	**44.2**						2:52 PM		
Atglen	**47.0**								
Leaman Place	**55.6**						3:03 PM		
Lancaster	**68.0**	2:15 PM		3:01 PM			3:13 PM	3:15 PM	3:31 PM
Mt. Joy	**80.1**	2:30 PM					3:22 PM	3:30 PM	
Elizabethtown	**86.8**	2:38 PM					3:28 PM	3:38 PM	
Middletown	**94.7**	2:49 PM					3:35 PM	3:49 PM	
H'burg Airport	**97.0**	2:52 PM	3:22 PM	3:27 PM			3:38 PM	3:52 PM	3:57 PM
Harrisburg	**104.6**	3:00 PM	3:32 PM	3:35 PM			3:45 PM	4:00 PM	4:05 PM
				to PGH					to chi
EASTBOUND									
	Train	**HLan26**	**HLan28**	**560**	**6640**	**562**	**564**	**566**	**6642**
		HBG. Comtr	**HBG. Comtr**	**Pao-Sub**	**PowSub**	**Pao-Sub**	**Pao-Sub**	**Th-Sub**	**PowSub**
	MP								
Harrisburg	**104.6**	12:15 PM	12:45 PM						
H'burg Airport	**97.0**	12:24 PM	12:55 PM						
Middletown	**94.7**	12:27 PM							
Elizabethtown	**86.8**	12:38 PM							
Mt. Joy	**80.1**	12:46 PM							
Lancaster	**68.0**	1:00 PM							
Leaman Place	**55.6**								
Atglen	**47.0**								
Parksburg	**44.2**								
Coatesville	**38.4**								
Thorn	**35.0**							2:11 PM	
Downingtown	**32.4**							2:16 PM	
Whitford	**28.3**							2:21 PM	
Exton	**27.5**							2:23 PM	
Frazer Yard	**23.9**			12:52 PM			1:52 PM		
Malvern	**21.6**							2:29 PM	
Paoli	**19.9**			1:04 PM		1:54 PM	2:04 PM	2:33 PM	
Bryn Mawr	**10.1**			1:24 PM	*From*	2:14 PM	2:24 PM	2:53 PM	*From*
Ardmore	**8.5**			1:28 PM	*Yard*	2:18 PM	2:28 PM	2:57 PM	*Yard*
Overbrook	**5.4**			1:36 PM		2:26 PM	2:36 PM	3:05 PM	
Zoo-JO	**1.9**								
Zoo-D1	**1.4**								
Powelton Yard	**0.5**				2:14 PM				3:21 PM
30th Street Station LL	**0.0**								
30th Street Station UL				1:46 PM		2:36 PM	2:46 PM	3:15 PM	
Suburban Station	**0.0**			1:51 PM	2:23 PM	2:41 PM	2:51 PM	3:20 PM	3:30 PM
New York Penn Station									

WESTBOUND										
	Train	**537**	**539**	**6637**	**541**	**Hbg Cmtr**	**Hbg Cmtr**	**Hbg Cmtr**	**Amtk**	**Hbg Cmtr**
		Sub-Pao	**Sub-Pao**	**Sub-Pow**	**Sub-Th**	**HLan39**	**HLan41**	**HLan43**	**nyphbg-1435**	**HLan45**
	MP									
New York Penn Station									2:35 PM	
30th Street Station LL										
Suburban Station	**0.0**	2:15 PM	2:45 PM	2:49 PM	3:15 PM					
30th Street Station UL	**0.0**	2:20 PM	2:50 PM		3:20 PM					
Powelton Yard	**0.5**			2:57 PM						
Zoo-D1	**1.4**								4:05 PM	
Zoo-JO	**1.9**			*To Yard*						
Overbrook	**5.4**	2:29 PM	2:59 PM		3:29 PM					
Ardmore	**8.5**	2:36 PM	3:06 PM		3:36 PM				4:10 PM	
Bryn Mawr	**10.1**	2:40 PM	3:10 PM		3:40 PM					
Paoli	**19.9**	3:03 PM	3:33 PM		4:03 PM				4:22 PM	
Malvern	**21.6**	3:06 PM	3:36 PM		4:06 PM					
Frazer Yard	**23.9**	3:17 PM	3:47 PM		4:17 PM					
Exton	**27.5**				4:11 PM					
Whitford	**28.3**									
Downingtown	**32.4**				4:16 PM				4:38 PM	
Thorn	**35.0**				4:21 PM					
Coatesville	**38.4**									
Parksburg	**44.2**									
Atglen	**47.0**									
Leaman Place	**55.6**									
Lancaster	**68.0**					3:45 PM	4:15 PM	4:45 PM	5:08 PM	5:15 PM
Mt. Joy	**80.1**					4:00 PM	4:30 PM	5:00 PM		5:30 PM
Elizabethtown	**86.8**					4:08 PM	4:38 PM	5:08 PM		5:38 PM
Middletown	**94.7**					4:19 PM	4:49 PM	5:19 PM		5:49 PM
H'burg Airport	**97.0**					4:22 PM	4:52 PM	5:22 PM	5:34 PM	5:52 PM
Harrisburg	**104.6**					4:30 PM	5:00 PM	5:30 PM	5:42 PM	6:00 PM
									NY subwy	
EASTBOUND										
	Train	**Amtk**	**HLan30**	**HLan32**	**Amtk**	**HLan34**	**568**	**HLan36**	**6644**	**6596**
		Chinyp-1250	**HBG. Comtr**	**HBG. Comtr**	**h30-1400**	**HBG. Comtr**	**Th-Sub**	**HBG. Comtr**	**PowSub**	**Pow-Sub**
	MP									
Harrisburg	**104.6**	12:50 PM	1:15 PM	1:45 PM	2:00 PM	2:15 PM		2:45 PM		
H'burg Airport	**97.0**	12:58 PM	1:24 PM	1:55 PM	2:08 PM	2:24 PM		2:55 PM		
Middletown	**94.7**		1:27 PM		2:11 PM	2:27 PM				
Elizabethtown	**86.8**		1:38 PM		2:18 PM	2:38 PM				
Mt. Joy	**80.1**		1:46 PM		2:24 PM	2:46 PM				
Lancaster	**68.0**	1:24 PM	2:00 PM		2:34 PM	3:00 PM				
Leaman Place	**55.6**				2:43 PM					
Atglen	**47.0**									
Parksburg	**44.2**				2:54 PM					
Coatesville	**38.4**				2:58 PM					
Thorn	**35.0**						2:41 PM			
Downingtown	**32.4**	1:54 PM			3:04 PM		2:46 PM			
Whitford	**28.3**				3:08 PM		2:51 PM			
Exton	**27.5**				3:10 PM		2:53 PM			
Frazer Yard	**23.9**									
Malvern	**21.6**				3:16 PM		2:59 PM			
Paoli	**19.9**	2:10 PM			3:20 PM		3:03 PM			
Bryn Mawr	**10.1**						3:23 PM		*From*	*From*
Ardmore	**8.5**	2:22 PM					3:27 PM		*Yard*	*Yard*
Overbrook	**5.4**						3:35 PM			
Zoo-JO	**1.9**									
Zoo-D1	**1.4**	2:27 PM			3:37 PM					
Powelton Yard	**0.5**								3:53 PM	4:08 PM
30th Street Station LL	**0.0**	2:30 PM								
30th Street Station UL							3:45 PM			
Suburban Station	**0.0**				3:45 PM		3:50 PM		4:02 PM	4:19 PM
New York Penn Station		4:00 PM								

WESTBOUND										
	Train	**543**	**6641**	**Amtk**	**9547**	**549**	**Flyer**	**9551**	**553**	**9647**
		Sub-Mal	**Sub-Pow**	**30h-1600**	**Sub-Atg**	**Sub-Bry**	**Sub-Th**	**Sub-Th**	**Sub-Bry**	**Sub-Cyn**
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	**0.0**	3:45 PM	3:49 PM	4:00 PM	4:08 PM	4:15 PM	4:30 PM	4:35 PM	4:40 PM	4:43 PM
30th Street Station UL	**0.0**	3:50 PM		4:03 PM	4:13 PM	4:20 PM		4:40 PM	4:45 PM	
Powelton Yard	**0.5**		3:57 PM							
Zoo-D1	**1.4**			4:08 PM						
Zoo-JO	**1.9**		*To Yard*							4:49 PM
Overbrook	**5.4**	3:59 PM				4:29 PM			4:54 PM	
Ardmore	**8.5**	4:06 PM				4:36 PM			5:01 PM	*To*
Bryn Mawr	**10.1**	4:10 PM			4:26 PM	4:40 PM		4:55 PM	5:05 PM	*Cynwyd*
Paoli	**19.9**	4:33 PM		4:25 PM	4:48 PM		4:55 PM	5:19 PM		
Malvern	**21.6**	4:36 PM			4:51 PM		4:58 PM	5:22 PM		
Frazer Yard	**23.9**	4:47 PM								
Exton	**27.5**			4:33 PM	4:57 PM					
Whitford	**28.3**				4:59 PM					
Downingtown	**32.4**			4:38 PM	5:04 PM					
Thorn	**35.0**				5:09 PM		5:13 PM			
Coatesville	**38.4**				5:13 PM					
Parksburg	**44.2**				5:18 PM					
Atglen	**47.0**				5:23 PM					
Leaman Place	**55.6**									
Lancaster	**68.0**			5:06 PM						
Mt. Joy	**80.1**									
Elizabethtown	**86.8**			5:20 PM						
Middletown	**94.7**									
H'burg Airport	**97.0**			5:28 PM						
Harrisburg	**104.6**			5:35 PM						
EASTBOUND										
	Train	**HLan38**	**570**	**6572**	**HLan40**	**574**	**6648**	**578**	**6650**	**D6018**
		HBG. Comtr	**Pao-Sub**	**Pow-Sub**	**HBG. Comtr**	**Pao-Sub**	**PowSub**	**Pao-Sub**	**PowSub**	**Bry-Sub**
	MP									
Harrisburg	**104.6**	3:15 PM			3:45 PM					
H'burg Airport	**97.0**	3:24 PM			3:54 PM					
Middletown	**94.7**	3:27 PM			3:57 PM					
Elizabethtown	**86.8**	3:38 PM			4:08 PM					
Mt. Joy	**80.1**	3:46 PM			4:16 PM					
Lancaster	**68.0**	4:00 PM			4:30 PM					
Leaman Place	**55.6**									
Atglen	**47.0**									
Parksburg	**44.2**									
Coatesville	**38.4**									
Thorn	**35.0**									
Downingtown	**32.4**									
Whitford	**28.3**									
Exton	**27.5**									
Frazer Yard	**23.9**		3:19 PM			3:52 PM		4:13 PM		
Malvern	**21.6**									
Paoli	**19.9**		3:31 PM			4:04 PM		4:25 PM		
Bryn Mawr	**10.1**		3:51 PM	*From*		4:24 PM	*From*	4:45 PM	*From*	4:52 PM
Ardmore	**8.5**		3:55 PM	*Yard*		4:28 PM	*Yard*	4:49 PM	*Yard*	
Overbrook	**5.4**		4:03 PM			4:36 PM		4:57 PM		
Zoo-JO	**1.9**									
Zoo-D1	**1.4**									
Powelton Yard	**0.5**			4:36 PM			4:53 PM		5:04 PM	
30th Street Station LL	**0.0**									
30th Street Station UL			4:13 PM			4:46 PM		5:07 PM		
Suburban Station	**0.0**		4:18 PM	4:47 PM		4:51 PM	5:02 PM	5:12 PM	5:13 PM	5:17 PM
New York Penn Station										

WESTBOUND										
	Train	**7555**	**9557**	**9019**	**Hbg Cmtr**	**Amtk**	**Flyer**	**Hbg Cmtr**	**9559**	**561**
		Sub-Th	**Sub-Mal**	**Sub-Bry**	**HLan47**	**30h-1700**	**Sub-Th**	**HLan49**	**Sub-Atg**	**Sub-Mal**
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	**0.0**	4:47 PM	4:53 PM	4:57 PM		5:00 PM	5:05 PM		5:08 PM	5:15 PM
30th Street Station UL	**0.0**	4:52 PM	4:58 PM	5:02 PM		5:03 PM			5:13 PM	5:20 PM
Powelton Yard	**0.5**									
Zoo-D1	**1.4**					5:08 PM				
Zoo-JO	**1.9**									
Overbrook	**5.4**			5:11 PM						
Ardmore	**8.5**			5:18 PM						
Bryn Mawr	**10.1**		5:13 PM	5:22 PM						5:35 PM
Paoli	**19.9**	5:12 PM	5:37 PM			5:25 PM	5:30 PM		5:33 PM	5:59 PM
Malvern	**21.6**	5:15 PM	5:40 PM				5:33 PM		5:36 PM	6:02 PM
Frazer Yard	**23.9**									
Exton	**27.5**	5:20 PM				5:33 PM				
Whitford	**28.3**									
Downingtown	**32.4**	5:25 PM				5:38 PM				
Thorn	**35.0**	5:30 PM					5:48 PM		5:51 PM	
Coatesville	**38.4**								5:54 PM	
Parksburg	**44.2**								5:59 PM	
Atglen	**47.0**								6:03 PM	
Leaman Place	**55.6**									
Lancaster	**68.0**				5:45 PM	6:06 PM		6:15 PM		
Mt. Joy	**80.1**				6:00 PM			6:30 PM		
Elizabethtown	**86.8**				6:08 PM	6:20 PM		6:38 PM		
Middletown	**94.7**				6:19 PM			6:49 PM		
H'burg Airport	**97.0**				6:22 PM	6:28 PM		6:52 PM		
Harrisburg	**104.6**				6:30 PM	6:35 PM		7:00 PM		

EASTBOUND										
	Train	**Amtk**	**4598**	**D8020**	**Amtk**	**HLan42**	**580**	**HLan44**	**4656**	**DH**
		Pghnyp-1550	**CynSub**	**Bry-Sub**	**h30-1600**	**HBG. Comtr**	**ThSub**	**HBG. Comtr**	**CynSub**	**Bry-Sub**
	MP									
Harrisburg	**104.6**	3:50 PM			4:00 PM	4:15 PM		4:45 PM		
H'burg Airport	**97.0**	3:58 PM			4:08 PM	4:24 PM		4:54 PM		
Middletown	**94.7**				4:11 PM	4:27 PM		4:57 PM		
Elizabethtown	**86.8**				4:18 PM	4:38 PM		5:08 PM		
Mt. Joy	**80.1**				4:24 PM	4:46 PM		5:16 PM		
Lancaster	**68.0**	4:24 PM			4:34 PM	5:00 PM		5:30 PM		
Leaman Place	**55.6**				4:43 PM					
Atglen	**47.0**									
Parksburg	**44.2**				4:54 PM					
Coatesville	**38.4**				4:58 PM					
Thorn	**35.0**						4:41 PM			
Downingtown	**32.4**	4:54 PM			5:04 PM		4:46 PM			
Whitford	**28.3**				5:08 PM		4:51 PM			
Exton	**27.5**				5:10 PM		4:53 PM			
Frazer Yard	**23.9**									
Malvern	**21.6**				5:16 PM		4:59 PM			
Paoli	**19.9**	5:10 PM			5:20 PM		5:03 PM			
Bryn Mawr	**10.1**		*From*	5:17 PM			5:23 PM		*From*	5:40 PM
Ardmore	**8.5**	5:22 PM	*Cynwyd*				5:27 PM		*Cynwyd*	
Overbrook	**5.4**						5:35 PM			
Zoo-JO	**1.9**		5:30 PM						5:50 PM	
Zoo-D1	**1.4**	5:27 PM			5:37 PM					
Powelton Yard	**0.5**									
30th Street Station LL	**0.0**	5:30 PM								
30th Street Station UL							5:45 PM			
Suburban Station	**0.0**		5:40 PM	5:42 PM	5:45 PM		5:50 PM		6:00 PM	6:05 PM
New York Penn Station		7:00 PM								

WESTBOUND										
	Train	**655**	**Hbg Cmtr**	**9021**	**Flyer**	**7563**	**9565**	**659**	**9023**	**Amtk**
		Sub-Cyn	**HLan51**	**Sub-Bry**	**Sub-Th**	**Sub-Th**	**Sub-Mal**	**Sub-Cyn**	**Sub-Bry**	**30h-1800**
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	**0.0**	5:18 PM		5:21 PM	5:33 PM	5:36 PM	5:39 PM	5:47 PM	5:50 PM	6:00 PM
30th Street Station UL	**0.0**			5:26 PM		5:41 PM	5:44 PM		5:55 PM	6:03 PM
Powelton Yard	**0.5**									
Zoo-D1	**1.4**									6:08 PM
Zoo-JO	**1.9**	5:24 PM						5:53 PM		
Overbrook	**5.4**			5:35 PM					6:04 PM	
Ardmore	**8.5**	*To*		5:42 PM				*To*	6:11 PM	
Bryn Mawr	**10.1**	*Cynwyd*		5:46 PM			5:57 PM	*Cynwyd*	6:15 PM	
Paoli	**19.9**				5:58 PM	6:01 PM	6:19 PM			6:25 PM
Malvern	**21.6**				6:01 PM	6:04 PM	6:22 PM			
Frazer Yard	**23.9**			6:10 PM			6:32 PM			
Exton	**27.5**					6:09 PM				6:33 PM
Whitford	**28.3**									
Downingtown	**32.4**					6:14 PM				6:38 PM
Thorn	**35.0**				6:16 PM	6:19 PM				
Coatesville	**38.4**									
Parksburg	**44.2**									
Atglen	**47.0**									
Leaman Place	**55.6**									
Lancaster	**68.0**		6:45 PM							7:06 PM
Mt. Joy	**80.1**		7:00 PM							
Elizabethtown	**86.8**		7:08 PM							7:20 PM
Middletown	**94.7**		7:19 PM							
H'burg Airport	**97.0**		7:22 PM							7:28 PM
Harrisburg	**104.6**		7:30 PM							7:35 PM
EASTBOUND										
	Train	**D7658**	**582**	**Amtk**	**HLan46**	**HLan48**	**7662**	**584**	**DH**	**DH**
		CynSub	**Mal-Sub**	**h30-1700**	**HBG. Comtr**	**HBG. Comtr**	**CynSub**	**Th-Sub**	**AtgFra**	**Bry-Pow**
	MP									
Harrisburg	**104.6**			5:00 PM	5:15 PM	5:45 PM				
H'burg Airport	**97.0**			5:08 PM	5:24 PM	5:54 PM				
Middletown	**94.7**				5:27 PM	5:57 PM				
Elizabethtown	**86.8**			5:17 PM	5:38 PM	6:08 PM				
Mt. Joy	**80.1**				5:46 PM	6:16 PM				
Lancaster	**68.0**			5:32 PM	6:00 PM	6:30 PM				
Leaman Place	**55.6**									
Atglen	**47.0**								5:32 PM	
Parksburg	**44.2**									
Coatesville	**38.4**									
Thorn	**35.0**							5:41 PM		
Downingtown	**32.4**			5:58 PM				5:46 PM		
Whitford	**28.3**							5:51 PM		
Exton	**27.5**			6:04 PM				5:53 PM		
Frazer Yard	**23.9**		5:21 PM						6:07 PM	
Malvern	**21.6**		5:28 PM					5:59 PM		
Paoli	**19.9**		5:32 PM	6:12 PM				6:03 PM		
Bryn Mawr	**10.1**	*From*	5:52 PM				*From*	6:23 PM		6:32 PM
Ardmore	**8.5**	*Cynwyd*	5:56 PM				*Cynwyd*	6:27 PM		
Overbrook	**5.4**		6:04 PM					6:35 PM		
Zoo-JO	**1.9**	6:04 PM					6:33 PM			
Zoo-D1	**1.4**			6:27 PM						
Powelton Yard	**0.5**									6:47 PM
30th Street Station LL	**0.0**									
30th Street Station UL			6:14 PM					6:45 PM		
Suburban Station	**0.0**	6:14 PM	6:19 PM	6:35 PM			6:43 PM	6:50 PM		
New York Penn Station										

WESTBOUND										
	Train	Hbg Cmtr	573	663	Amtk		575	667	Amtk	Hbg Cmtr
		HLan53	Sub-Th	Sub-Cyn	nyphbg-1708	HLan55	Sub-Pao	Sub-Cyn	30h-1900	HLan57
	MP									
New York Penn Station					5:08 PM					
30th Street Station LL										
Suburban Station	0.0		6:14 PM	6:22 PM			6:45 PM	6:52 PM	7:00 PM	
30th Street Station UL	0.0		6:19 PM				6:50 PM		7:03 PM	
Powelton Yard	0.5									
Zoo-D1	1.4				6:38 PM				7:08 PM	
Zoo-JO	1.9			6:28 PM				6:58 PM		
Overbrook	5.4		6:28 PM				6:59 PM			
Ardmore	8.5		6:35 PM	*To*	6:43 PM		7:06 PM	*To*		
Bryn Mawr	10.1		6:39 PM	*Cynwyd*			7:10 PM	*Cynwyd*		
Paoli	19.9		7:02 PM		6:55 PM		7:33 PM		7:27 PM	
Malvern	21.6		7:05 PM				7:36 PM		7:30 PM	
Frazer Yard	23.9									
Exton	27.5								7:36 PM	
Whitford	28.3								7:38 PM	
Downingtown	32.4				7:11 PM				7:43 PM	
Thorn	35.0		7:20 PM							
Coatesville	38.4								7:48 PM	
Parksburg	44.2								7:52 PM	
Atglen	47.0									
Leaman Place	55.6								8:03 PM	
Lancaster	68.0	7:15 PM			7:41 PM				8:13 PM	8:15 PM
Mt. Joy	80.1	7:30 PM							8:22 PM	8:30 PM
Elizabethtown	86.8	7:38 PM							8:28 PM	8:38 PM
Middletown	94.7	7:49 PM							8:35 PM	8:49 PM
H'burg Airport	97.0	7:52 PM			8:06 PM	8:22 PM			8:38 PM	8:52 PM
Harrisburg	104.6	8:00 PM			8:13 PM	8:32 PM			8:45 PM	9:00 PM
					NY subwy					
EASTBOUND										
	Train	DH	DH	7696	586	Amtk	588	Amtk	HLan50	D7666
		Th-Fra	Th-Fra	CynSub	Th-Sub	h30-1800	Th-Sub	pghnyp-1810	HBG. Comtr	CynSub
	MP									
Harrisburg	104.6					6:00 PM		*6:10 PM*	6:15 PM	
H'burg Airport	97.0					6:08 PM		6:18 PM	6:24 PM	
Middletown	94.7								6:27 PM	
Elizabethtown	86.8					6:17 PM			6:38 PM	
Mt. Joy	80.1								6:46 PM	
Lancaster	68.0					6:32 PM		6:44 PM	7:00 PM	
Leaman Place	55.6									
Atglen	47.0									
Parksburg	44.2									
Coatesville	38.4									
Thorn	35.0	5:48 PM	6:07 PM		*6:20 PM*		6:42 PM			
Downingtown	32.4					6:58 PM		7:14 PM		
Whitford	28.3									
Exton	27.5					7:04 PM				
Frazer Yard	23.9	6:07 PM	6:26 PM							
Malvern	21.6				6:38 PM		7:00 PM			
Paoli	19.9				6:42 PM	7:12 PM	7:04 PM	7:30 PM		
Bryn Mawr	10.1			*From*	7:02 PM		7:24 PM			*From*
Ardmore	8.5			*Cynwyd*	7:06 PM		7:28 PM	7:42 PM		*Cynwyd*
Overbrook	5.4				7:14 PM		7:36 PM			
Zoo-JO	1.9			7:13 PM						7:43 PM
Zoo-D1	1.4					7:27 PM		7:47 PM		
Powelton Yard	0.5									
30th Street Station LL	0.0							7:50 PM		
30th Street Station UL					7:24 PM		7:46 PM			
Suburban Station	0.0			7:23 PM	7:29 PM	7:35 PM	7:51 PM			7:53 PM
New York Penn Station								9:20 PM		

WESTBOUND										
	Train	**577**	**DH**	**DH**	**Hbg Cmtr**	579	**671**	**Hbg Cmtr**	**Amtk**	**581**
		Sub-Th	**Sub-Th**	**Sub-Th**	**HLan59**	**Sub-Mal**	**Sub-Cyn**	**HLan61**	**nyphbg-1829**	**Sub-Th**
	MP									
New York Penn Station									6:29 PM	
30th Street Station LL									8:19 PM	
Suburban Station	**0.0**	7:15 PM				7:45 PM	7:48 PM			8:15 PM
30th Street Station UL	**0.0**	7:20 PM				7:50 PM				8:20 PM
Powelton Yard	**0.5**									
Zoo-D1	**1.4**								8:22 PM	
Zoo-JO	**1.9**						7:54 PM			
Overbrook	**5.4**	7:29 PM				7:59 PM				8:29 PM
Ardmore	**8.5**	7:36 PM				8:06 PM	*To*		8:27 PM	8:36 PM
Bryn Mawr	**10.1**	7:40 PM				8:10 PM	*Cynwyd*			8:40 PM
Paoli	**19.9**	8:03 PM				8:33 PM			8:39 PM	9:03 PM
Malvern	**21.6**	8:06 PM				8:36 PM				9:06 PM
Frazer Yard	**23.9**		6:33 PM	6:52 PM						
Exton	**27.5**	8:11 PM								9:11 PM
Whitford	**28.3**									
Downingtown	**32.4**	8:16 PM							8:55 PM	9:16 PM
Thorn	**35.0**	8:21 PM	5:48 PM	6:07 PM						9:21 PM
Coatesville	**38.4**									
Parksburg	**44.2**									
Atglen	**47.0**									
Leaman Place	**55.6**									
Lancaster	**68.0**							9:15 PM	9:25 PM	
Mt. Joy	**80.1**							9:30 PM		
Elizabethtown	**86.8**							9:38 PM		
Middletown	**94.7**							9:49 PM		
H'burg Airport	**97.0**				9:22 PM			9:52 PM	9:48 PM	
Harrisburg	**104.6**				9:32 PM			10:00 PM	9:56 PM	
EASTBOUND										
	Train	**Amtk**	**HLan52**	**HLan54**	**592**	**7698**	**DH**	**DH**	**DH**	**HLan56**
		h30-1900	**HBG. Comtr**	**HBG. Comtr**	**Th-Sub**	**CynSub**	**AtgFra**	**Th-Sub**	**AtgFra**	**HBG. Comtr**
	MP									
Harrisburg	**104.6**	7:00 PM	6:45 PM	7:15 PM						7:45 PM
H'burg Airport	**97.0**	7:08 PM	6:54 PM	7:24 PM						7:55 PM
Middletown	**94.7**	7:11 PM	6:57 PM	7:27 PM						
Elizabethtown	**86.8**	7:18 PM	7:08 PM	7:38 PM						
Mt. Joy	**80.1**	7:24 PM	7:16 PM	7:46 PM						
Lancaster	**68.0**	7:34 PM	7:30 PM	8:00 PM						
Leaman Place	**55.6**	7:43 PM								
Atglen	**47.0**						6:22 PM		7:26 PM	
Parksburg	**44.2**	7:54 PM								
Coatesville	**38.4**	7:58 PM								
Thorn	**35.0**				7:42 PM		6:35 PM	6:51 PM	7:39 PM	
Downingtown	**32.4**	8:04 PM								
Whitford	**28.3**	8:08 PM								
Exton	**27.5**	8:10 PM								
Frazer Yard	**23.9**						6:54 PM	7:10 PM	7:58 PM	
Malvern	**21.6**	8:16 PM			8:00 PM					
Paoli	**19.9**	8:20 PM			8:04 PM					
Bryn Mawr	**10.1**				8:24 PM	*From*				
Ardmore	**8.5**				8:28 PM	*Cynwyd*				
Overbrook	**5.4**				8:36 PM					
Zoo-JO	**1.9**					8:43 PM				
Zoo-D1	**1.4**	8:37 PM								
Powelton Yard	**0.5**									
30th Street Station LL	**0.0**									
30th Street Station UL					8:46 PM					
Suburban Station	**0.0**	8:45 PM			8:51 PM	8:53 PM				
New York Penn Station										

WESTBOUND										
	Train	583	Amtk	585	Hbg Cmtr	Hbg Cmtr	587	589	591	6681
		Sub-Pao	30h-2100	Sub-Th	HLan63	HLan65	Sub-Th	Sub-Th	Sub-Th	Sub-Pow
	MP									
New York Penn Station										
30th Street Station LL										
Suburban Station	0.0	8:45 PM	9:00 PM	9:15 PM			10:15 PM	11:15 PM	12:15 AM	12:20 AM
30th Street Station UL	0.0	8:50 PM	9:03 PM	9:20 PM			10:20 PM	11:20 PM	12:20 AM	
Powelton Yard	0.5									12:28 AM
Zoo-D1	1.4		9:08 PM							
Zoo-JO	1.9									*To Yard*
Overbrook	5.4	8:59 PM		9:29 PM			10:29 PM	11:29 PM	12:29 AM	
Ardmore	8.5	9:06 PM		9:36 PM			10:36 PM	11:36 PM	12:36 AM	
Bryn Mawr	10.1	9:10 PM		9:40 PM			10:40 PM	11:40 PM	12:40 AM	
Paoli	19.9	9:33 PM	9:27 PM	10:03 PM			11:03 PM	12:03 AM	1:03 AM	
Malvern	21.6	9:36 PM	9:30 PM	10:06 PM			11:06 PM	12:06 AM	1:06 AM	
Frazer Yard	23.9	9:47 PM								
Exton	27.5		9:36 PM	10:11 PM			11:11 PM			
Whitford	28.3		9:38 PM							
Downingtown	32.4		9:43 PM	10:16 PM			11:16 PM			
Thorn	35.0			10:21 PM			11:21 PM	12:21 AM	1:22 AM	
Coatesville	38.4		9:48 PM							
Parksburg	44.2		9:52 PM							
Atglen	47.0									
Leaman Place	55.6		10:03 PM							
Lancaster	68.0		10:13 PM			10:15 PM				
Mt. Joy	80.1		10:22 PM			10:30 PM				
Elizabethtown	86.8		10:28 PM			10:38 PM				
Middletown	94.7		10:35 PM			10:49 PM				
H'burg Airport	97.0		10:38 PM		10:22 PM	10:52 PM				
Harrisburg	104.6		10:45 PM		10:32 PM	11:00 PM				

EASTBOUND										
	Train	HLan58	594	HLan60	Amtk	HLan62	596	HLan64	HLan66	598
		HBG. Comtr	Th-Sub	HBG. Comtr	h30-2100	HBG. Comtr	Th-Sub	HBG. Comtr	HBG. Comtr	Th-Sub
	MP									
Harrisburg	104.6	8:15 PM		8:45 PM	9:00 PM	9:15 PM		9:45 PM	10:15 PM	
H'burg Airport	97.0	8:24 PM		8:55 PM	9:08 PM	9:24 PM		9:55 PM	10:24 PM	
Middletown	94.7	8:27 PM			9:11 PM	9:27 PM			10:27 PM	
Elizabethtown	86.8	8:38 PM			9:18 PM	9:38 PM			10:38 PM	
Mt. Joy	80.1	8:46 PM			9:24 PM	9:46 PM			10:46 PM	
Lancaster	68.0	9:00 PM			9:34 PM	10:00 PM			11:00 PM	
Leaman Place	55.6				9:43 PM					
Atglen	47.0									
Parksburg	44.2				9:54 PM					
Coatesville	38.4				9:58 PM					
Thorn	35.0		8:43 PM				9:41 PM			10:41 PM
Downingtown	32.4		8:48 PM		10:04 PM		9:46 PM			10:46 PM
Whitford	28.3		8:53 PM		10:08 PM		9:51 PM			10:51 PM
Exton	27.5		8:55 PM		10:10 PM		9:53 PM			10:53 PM
Frazer Yard	23.9									
Malvern	21.6		9:01 PM		10:16 PM		9:59 PM			10:59 PM
Paoli	19.9		9:05 PM		10:20 PM		10:03 PM			11:03 PM
Bryn Mawr	10.1		9:25 PM				10:23 PM			11:23 PM
Ardmore	8.5		9:29 PM				10:27 PM			11:27 PM
Overbrook	5.4		9:37 PM				10:35 PM			11:35 PM
Zoo-JO	1.9									
Zoo-D1	1.4				10:37 PM					
Powelton Yard	0.5									
30th Street Station LL	0.0									
30th Street Station UL			9:47 PM				10:45 PM			11:45 PM
Suburban Station	0.0		9:52 PM		10:45 PM		10:50 PM			11:50 PM
New York Penn Station										

WESTBOUND				
	Train			
	MP			
New York Penn Station				
30th Street Station LL				
Suburban Station	**0.0**			
30th Street Station UL	**0.0**			
Powelton Yard	**0.5**			
Zoo-D1	**1.4**			
Zoo-JO	**1.9**			
Overbrook	**5.4**			
Ardmore	**8.5**			
Bryn Mawr	**10.1**			
Paoli	**19.9**			
Malvern	**21.6**			
Frazer Yard	**23.9**			
Exton	**27.5**			
Whitford	**28.3**			
Downingtown	**32.4**			
Thorn	**35.0**			
Coatesville	**38.4**			
Parksburg	**44.2**			
Atglen	**47.0**			
Leaman Place	**55.6**			
Lancaster	**68.0**			
Mt. Joy	**80.1**			
Elizabethtown	**86.8**			
Middletown	**94.7**			
H'burg Airport	**97.0**			
Harrisburg	**104.6**			
EASTBOUND				
	Train	**DH**	**DH**	**DH**
		Th-Sub	**Th-Sub**	**Th-Sub**
	MP			
Harrisburg	**104.6**			
H'burg Airport	**97.0**			
Middletown	**94.7**			
Elizabethtown	**86.8**			
Mt. Joy	**80.1**			
Lancaster	**68.0**			
Leaman Place	**55.6**			
Atglen	**47.0**			
Parksburg	**44.2**			
Coatesville	**38.4**			
Thorn	**35.0**	11:36 PM	12:36 AM	1:36 AM
Downingtown	**32.4**			
Whitford	**28.3**			
Exton	**27.5**			
Frazer Yard	**23.9**	11:55 PM	12:55 AM	1:55 AM
Malvern	**21.6**			
Paoli	**19.9**			
Bryn Mawr	**10.1**			
Ardmore	**8.5**			
Overbrook	**5.4**			
Zoo-JO	**1.9**			
Zoo-D1	**1.4**			
Powelton Yard	**0.5**			
30th Street Station LL	**0.0**			
30th Street Station UL				
Suburban Station	**0.0**			
New York Penn Station				