COMMONWEALTH CORRIDOR FEASIBILITY STUDY: APPENDIX B

Virginia Department of Rail and Public Transportation

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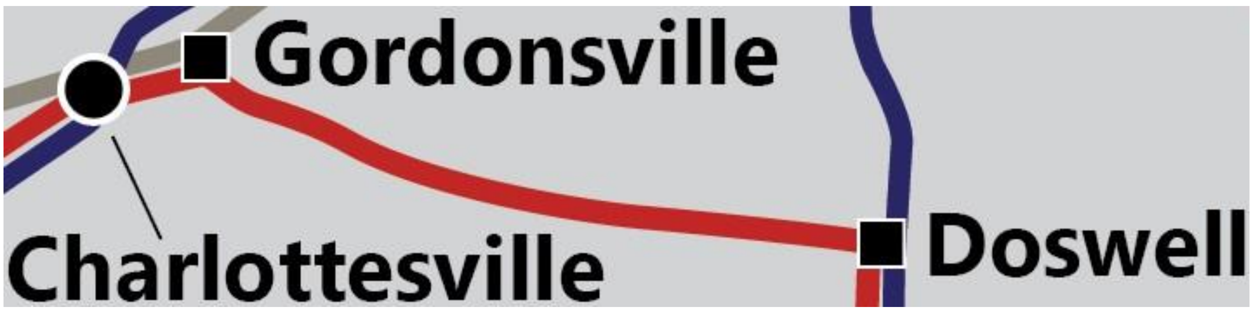
B. Appendix B: Charlottesville to Doswell Infrastructure Summary

B.1. Infrastructure Summary

The Charlottesville-Doswell segment of the Buckingham Branch Railroad is approximately 70 miles in length and consists of two smaller segments. The Charlottesville-Gordonsville segment at roughly 20 miles already hosts mixed passenger and freight operations at maximum speeds of 60mph and 40mph respectively. The Gordonsville-Doswell segment at roughly 50 miles currently only hosts freight operations at a maximum speed of 25mph though historically hosted passenger and freight operations at speeds up to 65mph and 50mph respectively. This report will expand on steps that could be taken to upgrade the infrastructure along the entire corridor to enable 79mph passenger operation without modifying the existing track alignment.



Overall, prior to any new passenger service the entire corridor should be inspected by hi-rail trip to verify existing conditions and help finalize what upgrades are necessary for initiating new Commonwealth Corridor passenger service across the segment. Below is a high-level summary of the initial steps to be taken, with further details provided in this section.

- Track, roadbed, and undergrade bridges/culverts should be fully inspected to determine current condition
    - Utilize ultrasonic rail testing to assist in determining status of existing rail
    - Identify ties, rail, and bridges/culverts to potentially be replaced or rehabilitated
    - Identify possible locations for drainage improvements, vegetation removal, and environmental impacts
- Track geometry should be verified through a new track geometry car run across the segment to confirm all existing curve locations, degree of curvature and superelevation
- The locations of critical assets and railroad physical characteristics such as begin-end points of bridges and key structures, physical mileposts, points-of-switch locations, clearance point locations off sidings and industry leads, and signal devices (absolute and intermediate signals) should be identified and located using survey-level Global Positioning Satellite (GPS) measurement, to accommodate installation of Positive Train Control
- Existing signal system elements should be inspected and verified to determine if upgrades or replacement are necessary, particularly to accommodate Positive Train Control
- Grade Crossings should be inspected and verified to determine the potential need for closure or upgrades
- After inspection, existing conditions should be evaluated against the needs of the desired operation
    - This step will finalize upgrade needs across the length of the corridor
    - Rail & Tie replacement and any bridge/culvert work
    - Drainage upgrades, vegetation removal, and environmental mitigation if required
    - Signal System upgrades & installation
        - New signal system will be required Gordonsville-Doswell

    - PTC will be required on the entire Charlottesville-Doswell segment if it is not already installed and active
  - Crossing upgrades and changes
  - Railroad maintenance records should be included in the evaluation
- Track alignment changes or addition of passing sidings or double-track location will require additional analysis of all surveyed infrastructure

Below approximates the quantity of each major infrastructure component in the overall Charlottesville-Doswell segment:

- 70 miles of rail (739,200 linear feet) and right-of-way
- 227,500 crossties/timbers
- 32 mainline turnouts
- 112 curves
- 19 bridges plus any identified culverts
- 20 miles of signaled track
- 78 grade crossings

B.2. Potential Operations

Trains do not necessarily operate at the engineered maximum design track speeds (upper bounds) as these are idealized values for a given track segment. Signal spacing and safe braking must be accounted for, along with other factors such as the desired type of operation, mixed traffic use, and multiple crossings in lower speed areas. For example, the last 2 miles approaching Charlottesville (curves between MP 180-182) have passenger speeds limited to 15mph, however the existing curves can accommodate passenger speeds of at least 50mph.

Additionally, acceleration and braking limit the effectiveness of short, higher-speed stretches between lower speed stretches. This is particularly common where a higher-speed (low degree of curvature) curve or short tangent stretch is bracketed by lower-speed (high degree of curvature) curves on either side. In this case it is better to maintain the lower speed continuously, which may also allow better infrastructure design. Curves 139-1 and 154-1 are examples of curves that can support 79mph operation but are bracketed by curves that only support 65mph operation. The superelevation and realistic speeds in Table 3 on page 14 are adjusted accordingly.

B.2.1. Operating Speeds

Potential operating speeds for the Charlottesville-Doswell corridor are estimated in Table B.1 with a maximum of 79mph passenger operation and based on the realistic speeds found in Table B.3. The speed transition points are approximate, and travel time does not take train-handling (acceleration/braking) into consideration. Some slower speed segment lengths were rounded up to partially offset this. These estimated operating speeds suggest an average speed of almost 70mph may be possible to cover the 70-mile segment, meaning it can be traversed in approximately 60 minutes. Even if the average speed was reduced to an average of 60mph, for example if some upgrades are not possible or are accomplished in a phased upgrade approach, the segment could still be traversed in 70 minutes.

A Train Performance Calculation (TPC) run should be simulated over the suggested infrastructure to confirm possible travel times. A simulation will include train-handling variables such as acceleration, braking, locomotive power, and engineer reactions to provide a more accurate estimation of travel time.

The following assumptions were made in establishing these operating speeds:

- All necessary infrastructure upgrades within the existing alignment are complete including track, bridges, signals, PTC, and grade crossings.
- Passenger train operating parameters are:
    - Maximum 5” underbalance and 6” superelevation
    - Operating speeds are 5mph less than design speeds
    - Operating speeds are in increments of 5mph (except 79mph)
- Segment runs from the CSX connection at Doswell to Charlottesville station
    - Approximately MP 111.5 to MP 182.25, or 70.75 miles
- CSX connecting track at Doswell is limited to 15mph
- Speeds through Gordonsville (MP 160-161) can be increased to an average of 30mph
    - Combination of signal, turnout and curve adjustments may be required
- Speeds between MP 177.5 and MP 180.75 are limited to 50mph
- Speeds through Charlottesville (MP 180.75-182.25) can be increased to an average of 30mph
    - Track alignment supports this, speed is currently limited to 20mph due to no electric locks on hand-thrown turnouts and trespassing issues
- Any other local speed restrictions, should they exist, are removed

TABLE B.1: POTENTIAL OPERATING SPEEDS

Approximate MP		Passenger Speed (MPH)	Distance (miles)	Travel Time (min)
From	To			
111.50	112.00	15	0.50	2.00
112.00	132.75	79	20.75	15.76
132.75	133.25	65	0.50	0.46
133.25	137.25	79	4.00	3.04
137.25	139.25	65	2.00	1.85
139.25	140.75	79	1.50	1.14
140.75	141.25	65	0.50	0.46
141.25	146.00	79	4.75	3.61
146.00	146.50	70	0.50	0.43
146.50	149.75	79	3.25	2.47
149.75	150.00	70	0.25	0.21
150.00	153.90	79	3.90	2.96
153.90	155.50	65	1.60	1.48
155.50	157.25	79	1.75	1.33
157.25	157.50	65	0.25	0.23
157.50	159.50	79	2.00	1.52

Approximate MP		Passenger Speed (MPH)	Distance (miles)	Travel Time (min)
From	To			
159.50	160.00	65	0.50	0.46
160.00	161.00	30	1.00	2.00
161.00	165.25	79	4.25	3.23
165.25	165.50	70	0.25	0.21
165.50	168.50	79	3.00	2.28
168.50	168.75	70	0.25	0.21
168.75	172.25	79	3.50	2.66
172.25	172.75	65	0.50	0.46
172.75	177.50	79	4.75	3.61
177.50	180.75	50	3.25	3.90
180.75	182.25	30	1.50	3.00
Avg Speed, Total Distance & Time		**69.63**	**70.75**	**60.97**

B.3. Track, Roadbed & Bridges

Desired operation for passenger speeds of 79mph requires track infrastructure meet FRA Class IV standards. This class of track also allows freight trains to operate at speeds of up to 60mph. Current freight speeds in the Charlottesville-Gordonsville segment reach 40mph (FRA Class III) and in the Gordonsville-Doswell segment are a maximum of 25mph (FRA Class II).

B.3.1. Roadbed

With the track currently being maintained to FRA Class III standards on the Charlottesville-Gordonsville segment and FRA Class II standards on the Gordonsville-Doswell segment, which was historically maintained to Class III, it is likely full-depth reconstruction of the roadbed on the combined segments are not required. This will save significantly on cost and lead time prior to service startup. However, this should be confirmed as much as possible. Buckingham Branch maintenance staff should be consulted, and maintenance records and any available geometry car data should be reviewed and compared to identify specific locations where re-construction may be advisable, and a new geometry car run should be undertaken as well. This will aid in preventing future maintenance issues and ultimately provide for a safer track structure.

B.3.2. Rail & Ties

Existing rail will need to be evaluated for durability and remaining life expectancy. It is quite possible operations can commence on existing rail in some sections, while others may require new rail. Modern railroads have moved to continuous welded rail (CWR) as their standard for new installations and rail replacement. CWR provides a more durable rail structure, reducing track defects compared to jointed rail, reduces overall maintenance cost, and offers reduced noise and improved ride quality. The most common size in use today is 136LB CWR. Rail comes in both premium and standard carbon. Premium is highly suggested for use on passenger routes due the increased risks (and by extension, increased loss potential) associated with operating passenger trains.

If capital installation cost is a consideration a mix of both rail types may be an option while keeping risk minimized. Utilization of premium rail on curves will lessen the wear rate over time and be less susceptible to temperature fluctuations. Standard carbon rail in tangents may be sufficient. It can be more brittle and susceptible to breaking with temperature changes, however on tangent track this would be far less of an impact. It is common to for a train to be able to continue over a broken rail in tangent track, but very rare on a curve.

A suggested rail replacement approach could be to program rail replacement in phases over time as opposed to replacing all the rail at once if a sizeable portion of the existing rail is still in good condition. Utilization of an ultrasonic rail testing vehicle can help in determining the viability of existing rail by testing for internal defects and microscopic external defects. Rail head wear and gauge-face wear will also dictate need for replacement, and rail grinding may be utilized to re-establish a suitable rail profile on existing rail if inspection and testing shows the rail is still viable. Buckingham Branch Railroad has recommended all rail on the Gordonsville-Doswell segment be replaced prior to initiation of passenger service due to its current condition.

Existing tie, switch timber and bridge timber condition will also need to be evaluated and replaced as needed. Based on an assumption of 3,250 ties per mile, there are approximately 227,500 ties in the

Charlottesville-Doswell segment. Hardwood ties exist on the corridor and are sufficient for the desired operation. Concrete ties can be considered but are not necessary.

B.3.3. Special Trackwork

All turnouts should be included within the initial rail inspection and evaluation. While most turnouts will be traversed on the normal route, the wear on existing special trackwork may warrant replacement for higher-speed operations. Where possible, turnouts should be relocated from curves to tangent track to improve reliability and reduce maintenance. Based on review of aerial imagery cross-referenced with the most recently available track chart, there are approximately 32 turnouts on the mainline to be evaluated.

Turnouts that are traversed on the diverging route, such as the connecting wye tracks at Doswell and Gordonsville, should be evaluated for replacement with turnouts rated for higher speeds. These turnouts are currently likely low-speed 15 or 20mph turnouts given the proximity of the low-speed/high-curvature wye tracks. Increasing track speed to 30mph in these locations, which the curve evaluation at these locations shows is attainable, can provide significant travel time savings. Turnouts for passing sidings or start of double-track segments should also be considered for upgrades to 45mph or even 60mph turnouts depending on the nature of train operations. Consideration will need to be given for standard or movable-point frogs.

B.3.4. Curves

Railroad curvature is a limiting factor in track speed even if the track infrastructure is maintained to a higher FRA Class designation. Trains still need to be able to navigate curves safely. A combination of curve superelevation (Ea) and vehicle underbalance (Eu) limits dictate the maximum speed on any given curve. Spirals, the transition from tangent track to a superelevated curve, also need to be considered as part of curve design. Spirals are calculated in more detailed design and are not part of this analysis, however it should be noted that higher superelevations require longer spirals to make the transition.

B.3.4.1 Track Geometry

Design standards for track geometry will need to be set to determine the exact specifications required for operating speeds. For example, Amtrak standards on the Northeast Corridor require curves with no more than 5.5” superelevation, intercity equipment can operate at 5” underbalance, and curves must be designed for 5mph over the desired operating speed. MBTA in Boston authorizes a full use of 6” superelevation and does not require the 5mph buffer.

These design standards need to also consider the mixed use of the corridor as freight trains operate at different speeds and underbalance than passenger trains do. Favoring the design too heavily one way or the other could result in an overall impairment in operation for all parties. Additionally, long-term track wear and maintenance needs to be considered. Too much superelevation can result in excessive wear on the low rail of the curve from freight trains while too little can result in excessive wear on the high rail of a curve from passenger trains pushing against them at higher speeds.

B.3.4.2 Curve Identification & Speed Analysis

All curves in the combined Charlottesville-Gordonsville-Doswell segment are identified and tabulated in this document. These curves were calculated using GIS data imported into AutoCAD, utilizing the most recently available track chart as a cross-reference. The track chart is missing data on several curves, so the GIS data was utilized for curve analysis. The analysis assumes the track remains on the existing alignment and should be considered high-level for planning purposes. Further detailed engineering evaluation based on a track geometry inspection run should be conducted to determine the existing conditions and the requirements to improve them for the desired passenger operation.

Based on a combined review of the most recently available track chart and GIS data on the entire Charlottesville-Gordonsville-Doswell segment there are a total of 112 curves, including the curves on the wye connector with CSX at Doswell and toward the connecting NS track at Charlottesville. Utilizing GIS, some of the compound curves shown in the track chart are consolidated into a single, simple curve for ease of analysis in speed calculations. This resulted in trimming the 112 curves down to 100. In the subsequent tables, both curves are shown as having the same Degree of curvature.

Table B.2 provides potential maximums for train speeds assuming every curve was modified to either a 4" or 6" superelevation, for underbalance ratings of 1.5" (freight), 3", 4" and 5". This simply demonstrates maximum potential speeds on the line utilizing set maximums with no consideration for best design practices, over-design, or long-term maintainability.

TABLE B.2: MAXIMIZED CURVE SPEEDS

Curve MP	Degree of Curve	6" Ea, Max Speed by Eu (MPH)				4" Ea, Max Speed by Eu (MPH)			
		1.5"	3"	4"	5"	1.5"	3"	4"	5"
111-1 (CSX)	12.75	28	31	33	35	24	28	29	31
112-1	1.00	103	113	119	125	88	100	106	113
113-1	1.50	84	92	97	102	72	81	87	92
115-1	1.01	102	112	118	124	88	99	106	112
120-1	0.46	152	166	175	184	130	146	157	166
122-1	1.01	102	112	118	124	88	99	106	112
122-2	1.98	73	80	84	88	62	70	75	80
123-1	1.99	73	80	84	88	62	70	75	80
124-1	1.98	73	80	84	89	63	71	76	80
125-1	1.77	77	85	89	94	66	75	80	85
126-1	1.02	102	112	118	124	87	99	106	112
128-1	1.97	73	80	85	89	63	71	76	80
128-2	1.99	73	80	84	88	62	70	75	80
130-1	1.98	73	80	84	89	62	71	75	80

Curve MP	Degree of Curve	6” Ea, Max Speed by Eu (MPH)				4” Ea, Max Speed by Eu (MPH)			
		1.5”	3”	4”	5”	1.5”	3”	4”	5”
131-1	1.98	73	80	84	89	62	71	75	80
131-2	1.89	75	82	87	91	64	72	77	82
131-3	1.89	75	82	87	91	64	72	77	82
132-1	1.95	74	81	85	89	63	71	76	81
132-2	2.98	59	65	69	72	51	57	61	65
133-1	1.94	74	81	85	90	63	71	76	81
133-2	1.94	74	81	85	90	63	71	76	81
134-1	1.66	80	87	92	97	68	77	82	87
134-2	1.78	77	84	89	93	66	74	80	84
135-1	1.94	74	81	85	90	63	71	76	81
135-2	1.94	74	81	85	90	63	71	76	81
135-3	1.97	73	80	85	89	63	71	76	80
136-1	1.74	78	85	90	95	67	75	81	85
137-1	3.01	59	65	68	72	51	57	61	65
138-1	2.92	60	66	69	73	51	58	62	66
139-1	2.00	73	80	84	88	62	70	75	80
140-1	2.92	60	66	69	73	51	58	62	66
141-1	1.91	74	82	86	90	64	72	77	82
142-1	1.97	73	80	85	89	63	71	76	80
143-1	1.99	73	80	84	88	62	70	75	80
143-2	1.96	73	80	85	89	63	71	76	80
144-1	1.99	73	80	84	88	62	70	75	80
145-1	1.97	73	80	85	89	63	71	76	80
146-1	2.56	64	70	74	78	55	62	66	70
146-2	2.07	71	78	82	87	61	69	74	78
146-3	2.07	71	78	82	87	61	69	74	78
147-1	1.97	73	80	85	89	63	71	76	80
148-1	1.55	83	91	96	100	71	80	85	91
148-2	2.15	70	77	81	85	60	68	72	77
148-3	2.05	72	79	83	87	61	69	74	79
149-1	2.63	63	69	73	77	54	61	65	69

Curve MP	Degree of Curve	6” Ea, Max Speed by Eu (MPH)				4” Ea, Max Speed by Eu (MPH)			
		1.5”	3”	4”	5”	1.5”	3”	4”	5”
150-1	2.05	72	79	83	87	61	69	74	79
150-2	2.17	70	76	81	85	60	67	72	76
151-1	1.93	74	81	86	90	63	71	76	81
151-2	2.13	70	77	81	85	60	68	73	77
152-1	1.98	73	80	85	89	63	71	76	80
152-2	0.53	142	155	164	172	121	137	146	155
153-1	1.99	73	80	84	88	62	70	75	80
153-2	3.01	59	65	68	72	51	57	61	65
154-1	1.94	74	81	85	90	63	71	76	81
155-1	3.01	59	65	68	72	51	57	61	65
155-2	1.81	76	84	88	93	65	74	79	84
156-1	2.18	70	76	80	84	60	67	72	76
156-2	2.04	72	79	83	87	62	69	74	79
157-1	2.96	60	65	69	72	51	58	62	65
157-2	1.89	75	82	87	91	64	72	77	82
158-1	1.96	73	80	85	89	63	71	76	80
158-2	1.96	73	80	85	89	63	71	76	80
159-1	1.81	77	84	88	93	65	74	79	84
159-2	3.01	59	65	68	72	51	57	61	65
160-1	2.88	61	66	70	73	52	58	63	66
160-2	11.65	30	33	35	36	25	29	31	33
160-3	5.21	45	49	52	54	38	43	46	49
164-1	1.32	90	98	104	109	77	87	93	98
165-1	2.76	62	68	71	75	53	60	64	68
165-2	1.72	79	86	91	95	67	76	81	86
165-3	1.72	78	86	91	95	67	76	81	86
166-1	1.86	75	83	87	91	65	73	78	83
166-2	0.43	158	173	182	191	135	152	163	173
166-3	2.08	71	78	82	87	61	69	74	78
167-1	1.75	78	85	90	94	67	75	80	85
167-2	1.83	76	83	88	92	65	74	79	83

Curve MP	Degree of Curve	6” Ea, Max Speed by Eu (MPH)				4” Ea, Max Speed by Eu (MPH)			
		1.5”	3”	4”	5”	1.5”	3”	4”	5”
168-1	2.71	62	68	72	76	53	60	64	68
168-2	2.71	62	68	72	76	53	60	64	68
168-3	0.95	105	116	122	128	90	102	109	116
169-1	1.59	82	89	94	99	70	79	84	89
170-1*	0.10	327	358	377	396	280	316	338	358
171-1	2.12	71	77	82	86	60	68	73	77
172-1	2.98	59	65	69	72	51	57	61	65
173-1	1.98	73	80	85	89	63	71	76	80
174-1	1.90	75	82	86	90	64	72	77	82
175-1	0.79	116	127	134	141	99	112	120	127
175-2	1.56	82	90	95	100	71	80	85	90
176-1	0.87	110	121	127	134	94	106	114	121
176-2	2.00	73	80	84	88	62	70	75	80
176-3	1.08	99	109	115	120	85	96	102	109
177-1	1.76	77	85	90	94	66	75	80	85
177-2	4.71	47	52	55	57	40	46	49	52
178-1	4.80	47	51	54	57	40	45	48	51
178-2	4.46	49	53	56	59	41	47	50	53
179-1	4.26	50	54	57	60	42	48	51	54
179-2	3.09	58	64	68	71	50	56	60	64
179-3	4.92	46	51	53	56	39	45	48	51
179-4	4.00	51	56	59	62	44	49	53	56
179-5	4.24	50	55	58	60	43	48	51	55
180-1	3.49	55	60	63	67	47	53	57	60
180-2	5.04	46	50	53	55	39	44	47	50
180-3	1.68	79	87	92	96	68	77	82	87
181-1	3.99	51	56	59	62	44	50	53	56
181-2	1.97	73	80	85	89	63	71	76	80
181-3	1.97	73	80	85	89	63	71	76	80
181-4	1.97	73	80	85	89	63	71	76	80
181-5	3.01	59	65	68	72	51	57	61	65

Curve MP	Degree of Curve	6” Ea, Max Speed by Eu (MPH)				4” Ea, Max Speed by Eu (MPH)			
		1.5”	3”	4”	5”	1.5”	3”	4”	5”
182-1	3.37	56	61	65	68	48	54	58	61
182-2	1.87	75	83	87	91	64	73	78	83
182-3	1.12	97	107	113	118	83	94	101	107
182-4	1.75	78	85	90	94	67	75	80	85
182-5 (NS)*	12.75	28	31	33	35	24	28	29	31

*Curve 170-1 is likely an angle point. A small value has been estimated for degree of curvature as this "curve" will easily accommodate 79mph operation. The NS connecting curve was not able to be measured, however it was assumed to be roughly equivalent to the CSX connecting curve.

Table B.3 provides a more realistic look at each curve tailored for 79mph passenger operation with consideration of freight traffic sharing the line. Superelevation is set so the design speed is for a 5” underbalance passenger train is 84mph or greater (i.e., design speed 5mph faster than intended maximum operating speed). This provides some balance between the passenger trains operating at a higher underbalance and freight trains operating at a 1.5” underbalance. In locations where 84mph is not possible trains will have to operate at reduced speed through those curves, with a 5mph minimum buffer between operating speed and maximum design speed.

TABLE B.3: SUGGESTED SUPERELEVATION AND CURVE SPEEDS

Curve MP	Degree of Curve	Superelevation (Ea)	Passenger Eu=5” (MPH)		Freight Eu=1.5” (MPH)	
			Max	Operate	Max	Operate
111-1 (CSX)	12.75	0	23	20	12	10
112-1	1.00	0.5	88	79	53	40
113-1	1.50	3	87	79	65	40
115-1	1.01	1	92	79	59	40
120-1	0.46	0	124	79	68	40
122-1	1.01	0.5	88	79	53	40
122-2	1.98	5.25	85	79	69	40
123-1	1.99	5.25	85	79	69	40
124-1	1.98	5.25	86	79	69	40
125-1	1.77	4.5	87	79	69	40
126-1	1.02	0.5	87	79	53	40
128-1	1.97	5	85	79	68	40
128-2	1.99	5.25	85	79	69	40
130-1	1.98	5.25	85	79	69	40

Curve MP	Degree of Curve	Superelevation (Ea)	Passenger Eu=5" (MPH)		Freight Eu=1.5" (MPH)	
			Max	Operate	Max	Operate
131-1	1.98	5.25	85	79	69	40
131-2	1.89	4.75	85	79	68	40
131-3	1.89	4.75	85	79	68	40
132-1	1.95	5	85	79	68	40
132-2	2.98	5.5	70	65	57	40
133-1	1.94	5	85	79	69	40
133-2	1.94	5	85	79	69	40
134-1	1.66	3.5	85	79	65	40
134-2	1.78	4.125	85	79	67	40
135-1	1.94	5	85	79	69	40
135-2	1.94	5	85	79	69	40
135-3	1.97	5	85	79	68	40
136-1	1.74	4	85	79	67	40
137-1	3.01	5.5	70	65	57	40
138-1	2.92	5.5	71	65	58	40
139-1	2.00	3	75	65	56	40
140-1	2.92	5.5	71	65	58	40
141-1	1.91	4.75	85	79	68	40
142-1	1.97	5	85	79	68	40
143-1	1.99	5.25	85	79	69	40
143-2	1.96	5	85	79	68	40
144-1	1.99	5.25	85	79	69	40
145-1	1.97	5	85	79	68	40
146-1	2.56	5.5	76	70	62	40
146-2	2.07	5.5	85	79	69	40
146-3	2.07	5.5	85	79	69	40
147-1	1.97	5	85	79	68	40
148-1	1.55	3	85	79	64	40
148-2	2.15	6	85	79	70	40
148-3	2.05	5.5	85	79	69	40
149-1	2.63	5.5	75	70	61	40

Curve MP	Degree of Curve	Superelevation (Ea)	Passenger Eu=5” (MPH)		Freight Eu=1.5” (MPH)	
			Max	Operate	Max	Operate
150-1	2.05	5.5	85	79	69	40
150-2	2.17	6	85	79	70	40
151-1	1.93	4.875	85	79	68	40
151-2	2.13	6	85	79	70	40
152-1	1.98	5	85	79	68	40
152-2	0.53	0	116	79	63	40
153-1	1.99	5.25	85	79	69	40
153-2	3.01	5.5	70	65	57	40
154-1	1.94	3	76	65	57	40
155-1	3.01	5.5	70	65	57	40
155-2	1.81	4.375	85	79	68	40
156-1	2.18	6	84	79	70	40
156-2	2.04	5.5	85	79	69	40
157-1	2.96	5.5	71	65	58	40
157-2	1.89	4.75	85	79	68	40
158-1	1.96	5	85	79	68	40
158-2	1.96	5	85	79	68	40
159-1	1.81	4.25	85	79	67	40
159-2	3.01	5.5	70	65	57	40
160-1	2.88	0	49	40	27	25
160-2	11.65	0	24	15	13	10
160-3	5.21	0	37	30	20	15
164-1	1.32	2.5	90	79	65	40
165-1	2.76	6	75	70	62	40
165-2	1.72	3.75	85	79	66	40
165-3	1.72	3.75	85	79	65	40
166-1	1.86	4.5	85	79	67	40
166-2	0.43	1.3	145	79	96	40
166-3	2.08	5.5	85	79	69	40
167-1	1.75	4	85	79	67	40
167-2	1.83	4.25	85	79	67	40

Curve MP	Degree of Curve	Superelevation (Ea)	Passenger Eu=5" (MPH)		Freight Eu=1.5" (MPH)	
			Max	Operate	Max	Operate
168-1	2.71	6	76	70	62	40
168-2	2.71	6	76	70	62	40
168-3	0.95	1.5	98	79	67	40
169-1	1.59	3.25	86	79	65	40
170-1*	0.10	0	267	79	146	40
171-1	2.12	5.75	85	79	69	40
172-1	2.98	5.5	70	65	57	40
173-1	1.98	5	85	79	68	40
174-1	1.90	4.75	85	79	68	40
175-1	0.79	0	95	79	52	40
175-2	1.56	3	85	79	64	40
176-1	0.87	0	90	79	49	40
176-2	2.00	5.25	85	79	69	40
176-3	1.08	0.5	85	79	51	40
177-1	1.76	4	85	79	66	40
177-2	4.71	5.25	55	50	45	40
178-1	4.80	5.5	55	50	45	40
178-2	4.46	5	56	50	45	40
179-1	4.26	4.75	57	50	45	40
179-2	3.09	3	60	50	45	40
179-3	4.92	5.5	55	50	45	40
179-4	4.00	4.25	57	50	45	40
179-5	4.24	4.75	57	50	45	40
180-1	3.49	3.5	58	50	45	40
180-2	5.04	6	55	50	46	40
180-3	1.68	0.5	68	50	41	40
181-1	3.99	1	46	30	29	25
181-2	1.97	0.5	63	30	38	25
181-3	1.97	0.5	63	30	38	25
181-4	1.97	0.5	63	30	38	25
181-5	3.01	0.5	51	30	30	25

Curve MP	Degree of Curve	Superelevation (Ea)	Passenger Eu=5" (MPH)		Freight Eu=1.5" (MPH)	
			Max	Operate	Max	Operate
182-1	3.37	0.5	48	30	29	25
182-2	1.87	0.5	64	30	39	25
182-3	1.12	0.5	83	30	50	25
182-4	1.75	0.5	67	30	40	25
182-5 (NS)*	12.75	0	23	15	12	10

*Curve 170-1 is likely an angle point. A small value has been estimated for degree of curvature as this "curve" will easily accommodate 79mph operation. The NS connecting curve was not able to be measured, however it was assumed to be roughly equivalent to the CSX connecting curve.

B.3.5. Curve Re-Alignment

Sharper curves do not allow for higher speeds, even with maximum superelevation and underbalance parameters applied. A total of 32 of the 112 curves cannot support 79mph operation with these maximums applied. However, several of these sharper curves, such as in Gordonsville and through Charlottesville, are likely not worth evaluating for re-alignment. They might be geographically limited as they are in Gordonsville, or the maximum speed is driven by other factors as in Charlottesville.

In addition to applying operational considerations when curve re-alignment is considered, right-of-way limitations must be identified. Curve re-alignments will adjust the alignment within the right-of-way which means additional right-of-way may need to be required to provide appropriate room for the new alignment. This may be more evident in locations where double-track exists, or potential future double-track is desired.

From a high-level, there are several stand-alone curves that re-aligning may benefit the operation. These curves are located within a small stretch of lower speed in a larger segment of higher speed. The single curves where operating speed is 79mph that are limited to either 65 or 70mph are 132-2, 146-1, 149-1, 157-1, 165-1, 168-1 & 2 (compound curve), and 172-1. Each curve re-aligned eliminates a lower speed restriction, and these curves should be looked at first.

Subsequently, there are two blocks of curves with 65mph speeds that can be evaluated. Each block includes one curve that is already capable of 79mph operation but is reduced in operating speed due to being bracketed. These two curve blocks are 137-1, 138-1, 139-1, 140-1 and 153-2, 154-1, 155-1.

Curves that support desired operating speeds but are at or near the maximum engineering specification limits could also be considered for re-alignment to ease the curve, provide a small amount of reliability buffer, and reduce future maintenance needs. Examples of such curves include, but are not limited to, 148-2, 150-2, 151-2, 156-1, 171-1, and 180-2.

The block of curves between MP 177 and MP 180 are already limited in speed and are probably not worth considering significant re-alignment outside of 180-2 mentioned above. The alignment follows the Rivanna River through this stretch and includes undergrade bridges. While improving speeds is always desirable, the cost/benefit through this stretch may dictate other locations take priority.

B.3.6. Undergrade Bridges & Culverts

Like track infrastructure, all undergrade structures should be inspected to determine their current condition. Since all the identified bridges are in the Charlottesville-Gordonsville segment and already host higher-speed trains, it is likely these bridges are in a serviceable condition. It is important to identify any short-term needs so that they can be accounted for and addressed prior to service startup, rather than trying to replace a bridge after new service has started. A full list of the 19 undergrade bridges as identified through a combination of aerial imagery and the most recently available track chart can be found in Table B.4.

TABLE B.4: UNDERGRADE BRIDGES

Milepost	Road/Waterway Crossing	Bridge Type	Bridge Length (ft)	# of Spans
160.5*	Main Street	Through Plate Girder	100	2
161.9	Baker's Creek	Deck Plate Girder	34	1
163.2	Patton Creek	Deck Plate Girder	34	1
163.8	Patton Creek	I-Beam Stringer	34	1
166.6	Mechunk Creek	Through Plate Girder	88	2
167.5	Turkey Creek	Through Plate Girder	40	1
167.8	Creek	Through Plate Girder	34	1
167.9	Creek	Through Plate Girder	44	1
168.3	Mechunk Creek	Through Plate Girder	44	1
168.4	Creek	Through Plate Girder	29	1
170.8	Mechunk Creek	Through Plate Girder	88	2
170.9	Creek	Through Plate Girder	34	1
171.7	Creek	Through Plate Girder	120	3
172.2	Jack's Creek	Deck Plate Girder	34	1
178.4	Creek	Deck Plate Girder	23	1
179.5	Rivanna River	Deck Plate Girder	386	5
179.8	Moore's Creek	Deck Plate Girder	386	4
180.5	Franklin Street	I-Beam Stringer	25	1
181.6*	4th Street	Box Beam Girder	29	1

*Bridges are in 2-track territory

Culverts were not listed on the track charts provided, and we were unable to concretely identify any utilizing aerial imagery. Existing railroad records should be examined to determine if there are indeed any culverts, and inspectors should be on the lookout for them when inspection of the segment is conducted.

Should passing sidings or double tracking be considered in the future, bridge and culvert locations will need to be evaluated for the ability to add additional bays to the bridge or lengthen the culverts.

B.3.7. Other Right-of-Way and Maintenance Considerations

The addition of passenger service and higher speeds brings additional items for consideration both for installation and long-term maintenance.

- Drainage improvements
- Vegetation control and removal
- Consideration of possible environmental impacts
- Fencing in certain areas to limit trespassing with higher-speed trains (include access gates)
- Rail lubricators to reduce the wear on the high rail of curves
- Rail grinding program to maintain rail profile
- Overhead clearances may be reduced with an increase in superelevation
    - There are only 8 overhead structures on the corridor
    - Undercutting may be an option if clearances are impacted

Operational considerations will need to include further discussions with CSX and Buckingham Branch to understand their current operations and reasons for existing speed restrictions and limitations. The carriers may be able to offer improvement suggestions to the benefit of all parties, particularly when considering locations of potential passing sidings or double tracking. Additionally, any historic local restrictions on train speeds will need to be researched and evaluated. Modernized AHWD and improved fencing may allow for removal of such restrictions.

B.4. Signals & Positive Train Control

With new passenger service bringing an increase in train frequency and train speed, the addition of signals and Positive Train Control (PTC) is not only a prudent measure to provide for safe and efficient train operations but is required under federal regulations. Passenger train operation at speeds above 59mph requires broken rail detection (49 CFR 236.1005(a)(5)), which a signal system provides. Any new passenger serviced initiated after December 31st, 2020 requires a Positive Train Control (PTC) system be installed and made operative prior to service commencing (49 CFR 236.1005(b)(6)).

B.4.1. Signal System

The Charlottesville-Gordonsville segment currently has a Centralized Traffic Control (CTC) system combined with a wayside Automatic Block Signal (ABS) system. This segment already supports 60mph Amtrak passenger train operation. The Gordonsville-Doswell segment is not signalized, operating under dark territory rules without any existing passenger traffic. Both segments are dispatched out of the Buckingham Branch control center.

The existing signal system on the Charlottesville-Gordonsville segment is likely sufficient to support passenger trains operating at 79mph since it already supports 40mph freight trains. It may also be sufficient to support a level of increased train frequency. The same style signal system should be extended and installed along the Gordonsville-Doswell segment. Both the existing and new signal systems should be reviewed and designed considering the following:

- Block spacing for safe braking of passenger and freight trains operating at their respective maximum speeds

- Block spacing for desired train frequency but considering mixed passenger and freight traffic
- Existing locations that have fixed signals that are unlikely to change
  - Examples include the NS diamonds at Charlottesville and the wye tracks at both Gordonsville and Doswell
- Potential siding and/or double-track locations

B.4.2. Positive Train Control

With PTC being required prior to the start of new service, a PTC system will need to be selected, installed, and made operative over the combined Charlottesville-Gordonsville-Doswell segment. This will require the Buckingham Branch railroad to equip their locomotives with PTC as well.

There are two main types of PTC in use in the United States. They are:

- Advanced Civil Speed Enforcement System II (ACSES or ACSES II)
  - Primarily used on the Amtrak Northeast Corridor and connecting commuter lines
- Interoperable Electronic Train Management System (I-ETMS)
  - Primary system used by all seven Class I freight railroads, including NS and CSX

Due to the overall proposed Commonwealth Corridor operating over both NS and CSX mainline track with CTC and PTC, it is likely I-ETMS will be the best choice for a PTC system on the combined segment. This will allow existing equipment and any new equipment purchased for this service to have a single system installed, which will be easier on both procurement and train operation. It will also:

- Streamline compatibility with existing systems
  - Infrastructure connections at Charlottesville with the NS and Doswell with the CSX
  - CSX locomotives are already equipped with I-ETMS
  - Amtrak maintains a pool of locomotives equipped with I-ETMS
- Ensure new installations on Buckingham Branch locomotives are regionally compatible

B.5. Grade Crossings

There are a total of 83 at-grade crossings in the combined Charlottesville-Gordonsville-Doswell segment, of which 46 are public and 37 are private. The crossings are all highway-rail crossings, except for 1 public pathway crossing which is paired with a street but considered a separate crossing. A complete list of grade crossings can be found in Table 5.

The USDOT's Highway-Rail Crossing Handbook, 3rd Edition | FRA (dot.gov), a joint document by the FRA and FHWA, states the following regarding high-speed Rail:

> *Special consideration should be given to highway-rail crossings on high-speed passenger train routes. The potential for a catastrophic collision injuring many passengers demands special attention. This not only includes dedicated routes with train speeds over 79mph, but also other passenger routes over which trains may operate at speeds higher than freight trains.*

The proposed operation will result in passenger trains operating at maximum speeds that are double that of freight trains, and more than triple current train speeds in the Gordonsville-Doswell segment. Special consideration should be given to crossings on this segment as outlined in the Highway-Rail

Crossing Handbook, under which the proposed service would be categorized as a Tier I Feeder service – passenger service on a mixed-use (passenger and freight) track with speeds not exceeding 90mph.

FRA encourages review of at-grade crossings for elimination as the first and best choice. Removing a grade crossing entirely, either through consolidation, grade separation, or outright closure, creates the safest possible condition. The proposed increase in train speed and frequency over this segment should prompt review of all crossings for necessity and alternatives, including the potential for channelization curbs or four-quadrant gates.

Grade crossing evaluation was completed utilizing the FRA Grade Crossing database (Highway/Rail Crossing Database Files | FRA (dot.gov)).

B.5.1. Public Crossings

Modern public highway grade crossings for Tier 1 Feeder passenger train operation should include Automatic Highway Warning Devices (AHWD) with advanced warning signs, gates, lights and bells that are ideally driven by Constant Warning Time (CWT) train detection. CWT provides the same amount of warning time to the public regardless of the speed the train is traveling. This is a critical safety component, so the public does not get impatient with abnormally long crossing wait times when slower trains are operating, which can lead to the public ignoring the warning devices.

Based on the FRA grade crossing data, crossings on the combined Charlottesville-Gordonsville-Doswell segments are nearly all up to modern standards for passenger service, with a handful of exceptions.

- All public crossings have AHWD with a minimum of flashing lights and bells
    - 43 of 46 crossings have CWT train detection
    - 1 crossing shows having "none" however the crossing has gates and lights, so it likely has a method of train detection.
    - 2 crossings show as having train motion detection
- 44 of 46 crossings have 2-Quadrant Gates
    - The two crossings without gates are a paired street/pedestrian crossing (listed as separate crossings) at Ellisville Drive in Louisa.
- There is a 3-crossing partial Quiet Zone in Gordonsville and a 5-crossing full Quiet Zone in Charlottesville. These are the only Quiet Zones in the combined segments.

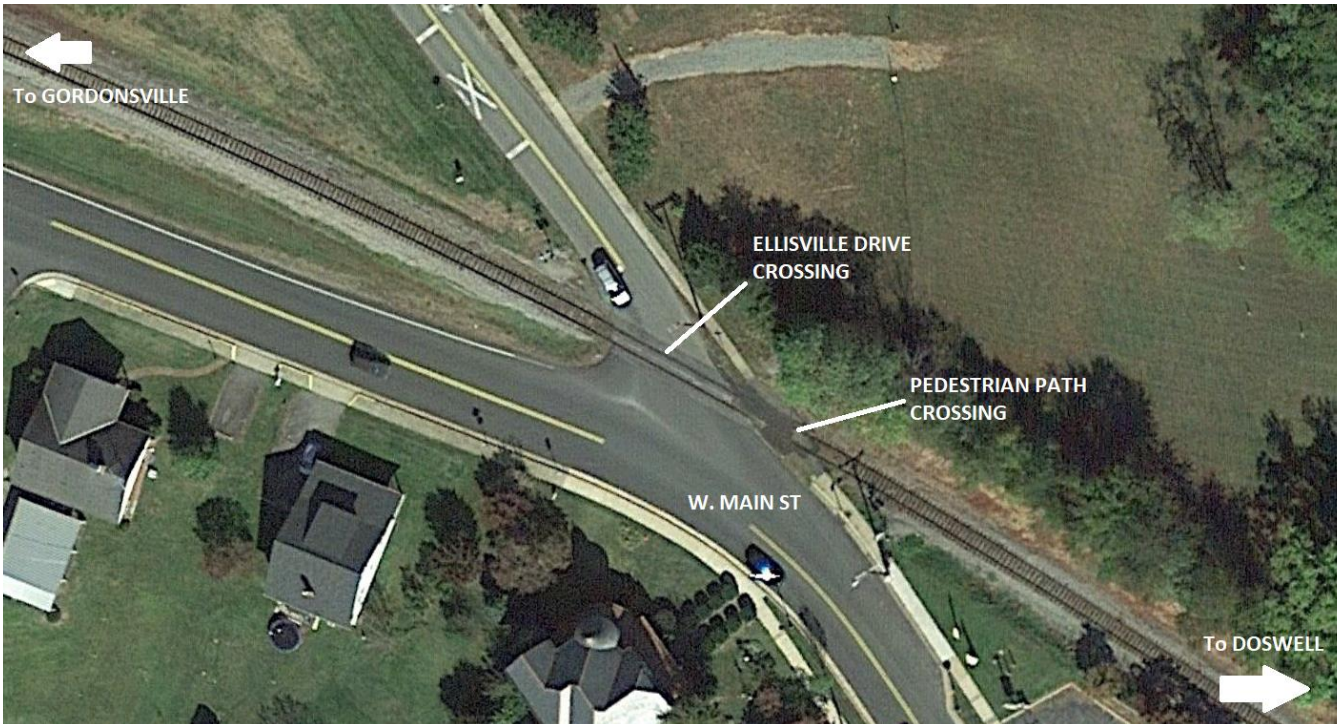
For the public crossings on this corridor, the following should be completed at minimum prior to implementing new passenger service:

- The condition of all crossing should be field confirmed.
- All crossings should be evaluated for possible consolidation, grade separation or closure
    - Potential future passing siding locations may be limited by crossing frequency, as stopped trains may result in blocked crossings
- All public crossings not using CWT should be upgraded to use CWT if feasible
    - CWT may not be appropriate in some areas, depending on train operations.
- Existing CWT crossings should have their train detection circuits extended for the maximum desired train speed
- Ellisville Drive and the adjacent pedestrian path should be consolidated into 1 crossing with a sidewalk, and gates should be installed. Traffic control signals and highway modifications may need to be considered at this location due to the intersection with West Main St. adjacent to the crossing. Further engineering analysis is recommended to determine the appropriate solution at this location. See Figure

B.1 below. Buckingham Branch Railroad has indicated these two crossings are planned to receive gates in the near future.

- Current Quiet Zones may need re-evaluation due to change in train frequency and speed.
- Prior to increase in train speed and initiation of train service a robust public outreach campaign should be held in the communities along the segments. Operation Lifesaver should be engaged to assist in this messaging.

FIGURE B.1: ELLISVILLE DRIVE & PEDESTRIAN PATHWAY



B.5.2. Private Crossings

The proposed operation on the combined Charlottesville-Gordonsville-Doswell segments does not prompt the need for AHWD at private crossings, however it is preferred under Tier I passenger service as noted in the Highway-Rail Crossing Handbook. At minimum, it is recommended all private crossings have at least passive warning devices – crossbucks, stop signs and/or yield signs.

- 35 of 37 crossings are farm or residential crossings
  - 6 Farm crossings, 29 Residential crossings
  - 1 Industrial Crossing within the Luck Stone Corporation quarry in Charlottesville
  - 1 Commercial Crossing serving a utility/power substation in Bumpass
- Only 3 of the 37 private crossings reflect having any warning devices in the FRA database
  - The crossing within the Luck Stone Corporation quarry is fully equipped with AHWD including 2-quadrant gates and CWT train detection while 2 crossings are listed as having crossbucks
  - A cursory review of online street-view imagery reveals several crossings have passive warning devices that are not recorded on the crossing inventory form.

For the private crossings on this corridor, the following should be completed at minimum prior to implementing new passenger service:

- The condition of all crossings should be field confirmed.
- All crossings should be evaluated for possible consolidation, grade separation or closure
    - Potential future passing siding locations may be limited by crossing frequency, as stopped trains may result in blocked crossings
    - This may involve researching existing agreements between landowners and the railroad and/or engaging landowners to alter or re-route their residential access
- Private crossings should be evaluated to see if AHWD are needed
- Private crossings not needing AHWD should have passive warning devices installed if they do not have them already.

TABLE B.5: GRADE CROSSINGS

Order (E-W)	Street	Railroad Milepost	Crossing Type	Train Detection	Warning Devices*
1	DOSWELL RD	111.93	Public	Constant Warning Time	AW, G, L, B
2	PRIVATE RD	112.62	Private	None	
3	PRIVATE RD	113.16	Private	None	
4	PRIVATE RD	113.50	Private	None	
5	MT HOPE CHURCH RD	114.20	Public	Constant Warning Time	AW, G, L, B
6	NEW MARKET MILL	114.58	Public	Motion Detection	AW, G, L, B
7	PRIVATE RD	115.88	Private	None	
8	VERDON RD	115.95	Public	Constant Warning Time	AW, G, L, B
9	PRIVATE RD	116.68	Private	None	
10	PRIVATE RD	117.34	Private	None	
11	NOEL RD	117.64	Public	Constant Warning Time	AW, G, L, B
12	PRIVATE RD	117.95	Private	None	
13	PRIVATE RD	119.53	Private	None	
14	HEWLETT ROAD	119.76	Public	Constant Warning Time	AW, G, L, B
15	LANDORA BRIDGE RD	120.44	Public	Constant Warning Time	AW, G, L, B
16	HARTLEY RD	121.08	Public	Constant Warning Time	AW, G, L, B
17	PRIVATE RD	121.66	Private	None	
18	PRIVATE RD	122.34	Private	None	
19	TEMAN RD	122.82	Public	Constant Warning Time	AW, G, L, B
20	PRIVATE RD	123.83	Private	None	
21	BEAVERDAM SCHOOL	124.10	Public	Constant Warning Time	AW, G, L, B
22	BEAVERDAM RD	124.44	Public	Constant Warning Time	AW, G, L, B
23	TYLER STATION RD	127.21	Public	Constant Warning Time	AW, G, L, B

Order (E-W)	Street	Railroad Milepost	Crossing Type	Train Detection	Warning Devices*
24	BUMPASS RD	129.35	Public	Constant Warning Time	AW, G, L, B
25	COLEMANS LN	130.12	Private	None	XB
26	PRIVATE RD	130.78	Private	None	
27	POTTIESVILLE RD	131.30	Public	Constant Warning Time	AW, G, L, B
28	PRIVATE	133.76	Private	None	
29	GARRETTS MILL RD	134.27	Public	Constant Warning Time	AW, G, L, B
30	FREDERICKS HALL	134.62	Public	None	AW, G, L, B
31	WOODLEY LN	135.02	Private	DC (Direct Current)	XB
32	PRIVATE	135.40	Private	None	
33	PRIVATE	135.88	Private	None	
34	PRIVATE RD	137.36	Private	None	
35	MICA RD	138.85	Public	Constant Warning Time	AW, G, L, B
36	PRIVATE	139.60	Private	None	
37	PRIVATE	139.95	Private	None	
38	FIFTH ST	140.37	Public	Constant Warning Time	AW, G, L, B
39	E FIRST ST	140.71	Public	Constant Warning Time	AW, G, L, B
40	CHOPPING RD	142.17	Public	Constant Warning Time	Y, AW, G, L, B
41	PRIVATE	142.89	Private	None	
42	PRIVATE	143.27	Private	None	
43	CHALK LEVEL RD	143.89	Public	Constant Warning Time	Y, AW, G, L, B
44	PRIVATE RD	145.14	Private	None	
45	FREDERICKSBURG AV	146.44	Public	Constant Warning Time	AW, G, L, B
46	CHURCH AV	146.55	Public	Constant Warning Time	AW, G, L, B
47	CUTLER AV	146.67	Public	Constant Warning Time	AW, G, L, B
48	ELLISVILLE DR	146.78	Public	Constant Warning Time	Y, AW, L, B
49	ELLISVILLE	146.78	Public	Constant Warning Time	Y, AW, L, B
51	PRIVATE RD	147.71	Private	None	
52	RANGE RD	148.05	Public	Constant Warning Time	AW, G, L, B
53	PRIVATE	148.18	Private	None	
54	PRIVATE	148.36	Private	None	

Order (E-W)	Street	Railroad Milepost	Crossing Type	Train Detection	Warning Devices*
55	PRIVATE	148.57	Private	None	
56	KENTS MILL RD	149.32	Public	Constant Warning Time	Y, AW, G, L, B
57	OAKLAND RD	150.46	Public	Constant Warning Time	XB, AW, G, L, B
58	PRIVATE	151.13	Private	None	
59	PRIVATE	151.85	Private	None	
60	PRIVATE	152.60	Private	None	
61	DUNKUM STORE RD	154.18	Public	Constant Warning Time	AW, G, L, B
62	DOCTORS RD	155.50	Public	Constant Warning Time	AW, G, L, B
63	PRIVATE	156.22	Private	None	
64	PRIVATE	156.49	Private	None	
65	PRIVATE	157.16	Private	None	
66	OLD LOUISA RD	159.01	Public	Motion Detection	AW, G, L, B
67	S MAIN ST	160.24	Public	Constant Warning Time	AW, G, L, B
68	DEPOT ST	160.33	Public	Constant Warning Time	AW, G, L, B
69	HIGH ST	160.71	Public	Constant Warning Time	AW, G, L, B
70	KLOCKENER RD	162.36	Public	Constant Warning Time	XB, AW, G, L, B
71	PRIVATE	163.12	Private	None	
72	PRIVATE	163.48	Private	None	
73	LINDSAY RD	165.24	Public	Constant Warning Time	AW, G, L, B
74	CAMPBELL RD	170.32	Public	Constant Warning Time	AW, G, L, B
75	PRIVATE RD	171.40	Private	None	
76	KESWICK RD	174.39	Public	Constant Warning Time	AW, G, L, B
77	HUNT CLUB RD	174.64	Public	Constant Warning Time	AW, G, L, B
78	PRIVATE	176.98	Private	Constant Warning Time	G, L, B
79	CARLTON RD	180.82	Public	Constant Warning Time	AW, G, L, B
80	2ND ST	181.63	Public	Constant Warning Time	AW, G, L, B
81	1ST ST	181.68	Public	Constant Warning Time	AW, G, L, B
82	5TH ST	181.99	Public	Constant Warning Time	AW, G, L, B
83	7TH ST	182.10	Public	Constant Warning Time	AW, G, L, B

*Y = Yield Sign(s), XB = Cross Buck Sign(s), AW = Advanced Warning Sign(s), G = 2-Quadrant Gates,
L = Flashing Lights, B = Bells