Table 3 - Summary of Results from Load-Flow Simulations with all Substations in Service[11]

Normal Operation, Simultaneous Starts at Station

Case #	Location of Simultaneous Start	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3Bsmv	SMV Station	Titley ..... 52% Michilinda ..... 33% Baldwin ..... 28% Joseph ..... 45% Los Robles ..... 41% Yard ..... 50% Bus Center ..... 59% Irwindale ..... 48% Virginia ..... 35% Soldano ..... 37% Citrus 43%	Titley ..... <300% Michilinda ..... <300% Baldwin ..... <300% Joseph ..... <300% Los Robles ..... <300% Yard ..... <300% Bus Center ..... <300% Irwindale ..... <300% Virginia ..... <300% Soldano ..... <300% Citrus ..... <300%	594 VDC on the Southbound track, at Milepost 20.353 (near Monrovia station)
3Barc	Arcadia Station	Titley ..... 48% Michilinda ..... 32% Baldwin ..... 30% Joseph ..... 59% Los Robles ..... 52% Yard ..... 55% Bus Center ..... 46% Irwindale ..... 44% Virginia ..... 37% Soldano ..... 43% Citrus 38%	Titley ..... <300% Michilinda ..... <300% Baldwin ..... <300% Joseph ..... <300% Los Robles ..... <300% Yard ..... <300% Bus Center ..... <300% Irwindale ..... <300% Virginia ..... <300% Soldano ..... <300% Citrus ..... <300%	540 VDC on the Northbound track, at Milepost 20.491 (near Monrovia station)

11 Shaded lines indicate worst-case rms load for each substation for all 3B### runs.

Case #	Location of Simultaneous Start	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3Bmon	Monrovia Station	Titley 53% Michilinda 34% Baldwin 30% Joseph 54% Los Robles 53% Yard 57% Bus Center 42% Irwindale 42% Virginia 35% Soldano 41% Citrus 35%	Titley <300% Michilinda <300% Baldwin <300% Joseph <300% Los Robles <300% Yard <300% Bus Center <300% Irwindale <300% Virginia <300% Soldano <300% Citrus <300%	535 VDC on the Southbound track, at Milepost 20.353 (near Monrovia station)
3Bdua	Duarte Station	Titley 50% Michilinda 32% Baldwin 29% Joseph 48% Los Robles 39% Yard 50% Bus Center 61% Irwindale 48% Virginia 29% Soldano 39% Citrus 35%	Titley <300% Michilinda <300% Baldwin <300% Joseph <300% Los Robles <300% Yard <300% Bus Center <300% Irwindale <300% Virginia <300% Soldano <300% Citrus <300%	593 VDC on the Southbound track, at Milepost 20.353 (near Monrovia station)
3Birw	Irwindale Station	Titley 44% Michilinda 28% Baldwin 29% Joseph 49% Los Robles 43% Yard 41% Bus Center 45% Irwindale 61% Virginia 34% Soldano 38% Citrus 35%	Titley <300% Michilinda <300% Baldwin <300% Joseph <300% Los Robles <300% Yard <300% Bus Center <300% Irwindale <300% Virginia <300% Soldano <300% Citrus <300%	602 VDC on the Southbound track, at Milepost 20.353 (near Monrovia station)

Case #	Location of Simultaneous Start	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3Baza	Azusa Alameda Station	Titley..... 47% Michilinda ..... 29% Baldwin..... 29% Joseph..... 50% Los Robles ..... 44% Yard..... 46% Bus Center ..... 46% Irwindale ..... 62% Virginia ..... 41% Soldano..... 57% Citrus..... 41%	Titley ..... <300% Michilinda..... <300% Baldwin ..... <300% Joseph ..... <300% Los Robles..... <300% Yard ..... <300% Bus Center..... <300% Irwindale ..... <300% Virginia..... <300% Soldano..... <300% Citrus ..... <300%	570 VDC on the Southbound track, at Milepost 20.353 (near Monrovia station)

Table 4 - Summary of Results from Load-Flow Simulations for Contingency Operations[12]

Case #	Substation Out-of-Service	Adjacent Substations	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3B99	Titley	Craig & Michilinda	Michilinda 50%	Michilinda ..... <300%	565 VDC on the Southbound track, at Milepost 15.578 (near Sierra Madre Villa station)
			Baldwin 29%	Baldwin ..... <300%	
			Joseph 39%	Joseph ..... <300%	
			Los Robles 35%	Los Robles ..... <300%	
			Yard 45%	Yard ..... <300%	
			Bus Center 54%	Bus Center ..... <300%	
			Irwindale 41%	Irwindale ..... <300%	
			Virginia 29%	Virginia ..... <300%	
			Soldano 34%	Soldano ..... <300%	
			Citrus 32%	Citrus ..... <300%	
3B01	Michilinda	Titley & Baldwin	Titley 62%	Titley ..... <300%	528 VDC on the Northbound track, at Milepost 15.812 (near Sierra Madre Villa station)
			Baldwin 42%	Baldwin ..... <300%	
			Joseph 43%	Joseph ..... <300%	
			Los Robles 38%	Los Robles ..... <300%	
			Yard 48%	Yard ..... <300%	
			Bus Center 54%	Bus Center ..... <300%	
			Irwindale 57%	Irwindale ..... <300%	
			Virginia 35%	Virginia ..... <300%	
			Soldano 41%	Soldano ..... <300%	
			Citrus 37%	Citrus ..... <300%	
3B02	Baldwin	Michilinda & Joseph	Titley 54%	Titley ..... <300%	594 VDC on the Southbound track, at Milepost 20.353 (near Monrovia station)
			Michilinda 42%	Michilinda ..... <300%	
			Joseph 53%	Joseph ..... <300%	
			Los Robles 42%	Los Robles ..... <300%	
			Yard 50%	Yard ..... <300%	
			Bus Center 57%	Bus Center ..... <300%	
			Irwindale 49%	Irwindale ..... <300%	
			Virginia 35%	Virginia ..... <300%	
			Soldano 44%	Soldano ..... <300%	
			Citrus 37%	Citrus ..... <300%	

12 Shaded lines indicate worst-case rms load for each substation for all 3B## runs.

Case #	Substation Out-of-Service	Adjacent Substations	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3B03	Joseph	Baldwin & Los Robles	Titley.....44% Michilinda .....32% Baldwin.....45% Los Robles .....63% Yard.....45% Bus Center .....49% Irwindale .....47% Virginia .....37% Soldano .....39% Citrus.....36%	Titley.....<300% Michilinda .....<300% Baldwin.....<300% Los Robles .....<300% Yard .....<300% Bus Center.....<300% Irwindale.....<300% Virginia .....<300% Soldano.....<300% Citrus.....<300%	528 VDC on the Northbound track, at Milepost 18.808 (near Arcadia station)
3B04	Los Robles	Joseph & Yard	Titley.....45% Michilinda .....30% Baldwin.....30% Joseph.....67% Yard.....61% Bus Center .....50% Irwindale .....46% Virginia .....38% Soldano .....38% Citrus 33%	Titley.....<300% Michilinda .....<300% Baldwin.....<300% Joseph .....<300% Yard .....<300% Bus Center.....<300% Irwindale.....<300% Virginia .....<300% Soldano.....<300% Citrus.....<300%	525 VDC on the Southbound track, at Milepost 20.263 (near Monrovia station)
3B05	Yard	Los Robles & Bus Center	Titley.....43% Michilinda .....27% Baldwin.....27% Joseph.....43% Los Robles .....47% Bus Center.....66% Irwindale .....45% Virginia .....27% Soldano .....33% Citrus 31%	Titley.....<300% Michilinda .....<300% Baldwin.....<300% Joseph .....<300% Los Robles .....<300% Bus Center.....<300% Irwindale.....<300% Virginia .....<300% Soldano.....<300% Citrus.....<300%	579 VDC on the Southbound track, at Milepost 20.359 (near Monrovia station)

Case #	Substation Out-of-Service	Adjacent Substations	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3B06	Bus Center	Yard & Irwindale	Titley....43% Michilinda....27% Baldwin....26% Joseph....41% Los Robles....35% Yard....63% Irwindale....59% Virginia....29% Soldano....34% Citrus....31%	Titley....<300% Michilinda....<300% Baldwin....<300% Joseph....<300% Los Robles....<300% Yard....<300% Irwindale....<300% Virginia....<300% Soldano....<300% Citrus....<300%	551 VDC on the Southbound track, at Milepost 22.289 (near Duarte station)
3B07	Irwindale	Bus Center & Virginia	Titley....37% Michilinda....25% Baldwin....26% Joseph....44% Los Robles....40% Yard....40% Bus Center....63% Virginia....58% Soldano....50% Citrus....36%	Titley....<300% Michilinda....<300% Baldwin....<300% Joseph....<300% Los Robles....<300% Yard....<300% Bus Center....<300% Virginia....<300% Soldano....<300% Citrus....<300%	546 VDC on the Northbound track, at Milepost 24.604 (near Irwindale station)
3B08	Virginia	Irwindale & Soldano	Titley....35% Michilinda....24% Baldwin....25% Joseph....43% Los Robles....37% Yard....38% Bus Center....45% Irwindale....61% Soldano....60% Citrus....40%	Titley....<300% Michilinda....<300% Baldwin....<300% Joseph....<300% Los Robles....<300% Yard....<300% Bus Center....<300% Irwindale....<300% Soldano....<300% Citrus....<300%	663 VDC on the Southbound track, at Milepost 20.359 (near Monrovia station)

Case #	Substation Out-of-Service	Adjacent Substations	Substation rms Loads (% capacity)	Substation Peak Load (Maximum Peak)	Minimum Train Voltage & Location
3B09	Soldano	Virginia & Citrus	Titley.....33% Michilinda .....22% Baldwin.....28% Joseph.....41% Los Robles .....34% Yard.....37% Bus Center .....42% Irwindale.....63% Virginia .....54% Citrus.....51%	Titley.....<300% Michilinda .....<300% Baldwin.....<300% Joseph .....<300% Los Robles .....<300% Yard .....<300% Bus Center .....<300% Irwindale.....<300% Virginia .....<300% Citrus.....<300%	634 VDC on the Southbound track, at Milepost 25.880 (near Azusa Alameda station)
3B10	Citrus	Soldano	Titley.....35% Michilinda .....24% Baldwin.....25% Joseph.....43% Los Robles .....37% Yard.....37% Bus Center .....42% Irwindale.....52% Virginia .....44% Soldano.....69%	Titley.....<300% Michilinda .....<300% Baldwin.....<300% Joseph .....<300% Los Robles .....<300% Yard .....<300% Bus Center .....<300% Irwindale.....<300% Virginia .....<300% Soldano.....<300%	614 VDC on the Southbound track, at Milepost 26.889 (near Azusa Alameda station)

5.0 ANALYSIS OF PERFORMANCE WITHOUT ADDITIONAL SUBSTATIONS

5.1 Description

The following provides analysis of system performance and capacity if the substations at Michilinda and Soldano were not provided.

All other factors, data and requirements remain as per the main report.

5.2 Analysis

5.2.1 Simulation of Normal Operating Conditions

A series of traction power simulations were performed with all TP substations in service and with simultaneous starting of trains at full performance from each station, except terminal stations as follows:

- Simultaneous start from stations (Run series 3D###)[13].

The analysis indicated that even with all substations in service, the system cannot maintain traction voltage in compliance with Metro criteria. Specifically, for Run series 3Daza (simultaneous start from Azusa Alameda station), the minimum train voltage was 407 volts (see Figure 8). The latter case, in particular, reflects a voltage condition significantly below what Metro trains can accept and thus indicates that operation would be significantly affected, with trains shutting-down temporarily.

5.2.2 Simulation of Contingency Operating Conditions

A series of traction power simulations were performed with each TP substation out of service as follows:

- Simultaneous start from nearest station (Run series 3D##)[14]

The analysis indicated that of the nine conditions simulated, all but two resulted in voltages below acceptable criteria. Moreover, two simulations showed very poor performance (likely to lead to frequent shut-down of LRVs due to low voltage) and two were highly unstable (voltages were too low to stabilize the system at any voltage). Table 5 provides a summary of the results. Figures 9 through 15 provide graphs of train voltage for these simulations.

13 "###" is a 3-letter variable, used to designate the station at which simultaneous start occurs.
14 "##" is a 2-number variable, used to designate the out-of-service substation.

Table 5 - Summary of Results from Load-Flow Simulations for Contingency Operations

Case #	Substation Out-of-Service	Adjacent Substations	Minimum Train Voltage & Location	Notes
3D99	Titley	Craig & Baldwin	174 VDC	Highly unstable
3D01	Baldwin	Titley & Joseph	410 VDC	Very poor
3D02	Joseph	Baldwin & Los Robles	520 VDC	Below Criteria
3D03	Los Robles	Joseph & Yard	523 VDC	Below Criteria
3D04	Yard	Los Robles & Bus Center	578 VDC	Acceptable
3D05	Bus Center	Yard & Irwindale	511 VDC	Below Criteria
3D06	Irwindale	Bus Center & Virginia	533 VDC	Acceptable
3D07	Virginia	Irwindale & Citrus	424 VDC	Very poor
3D08	Citrus	Irwindale	220 VDC	Highly unstable

Figure 8 - Train voltage for Case 3Daza (Simultaneous start from Azusa Alameda station)

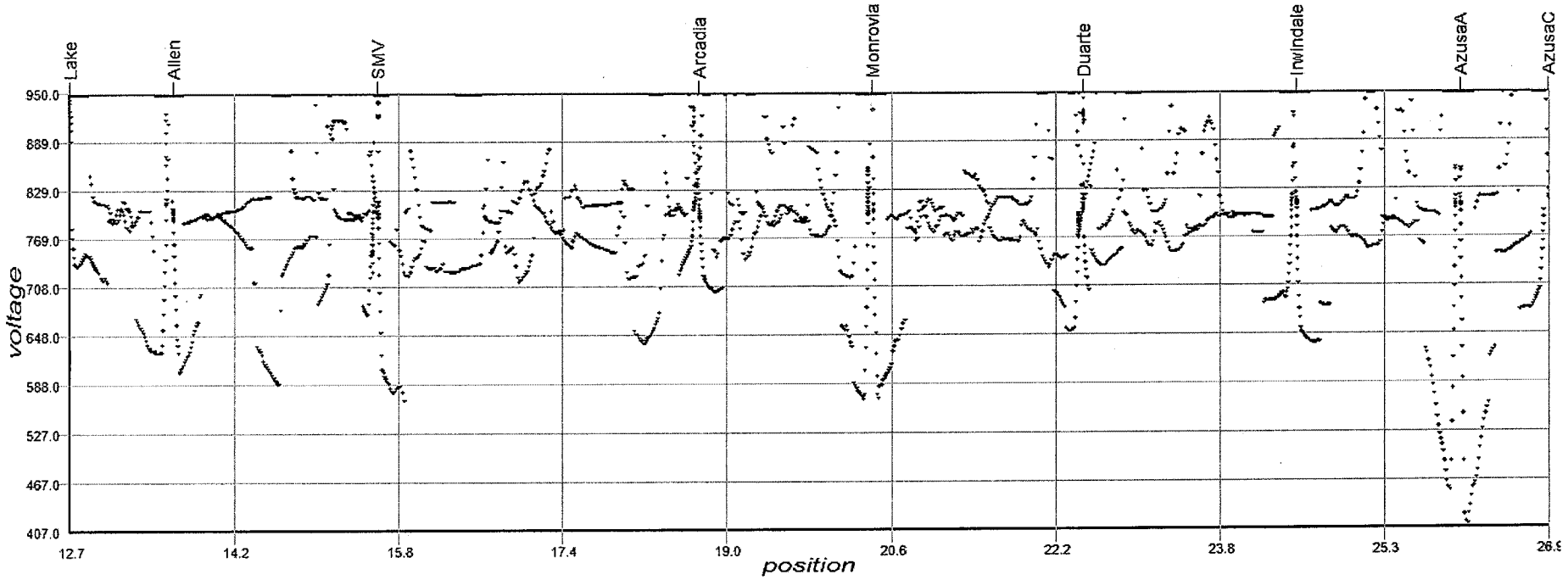

Figure 9 - Train voltage for Case 3D99 (Titley Substation out of service)

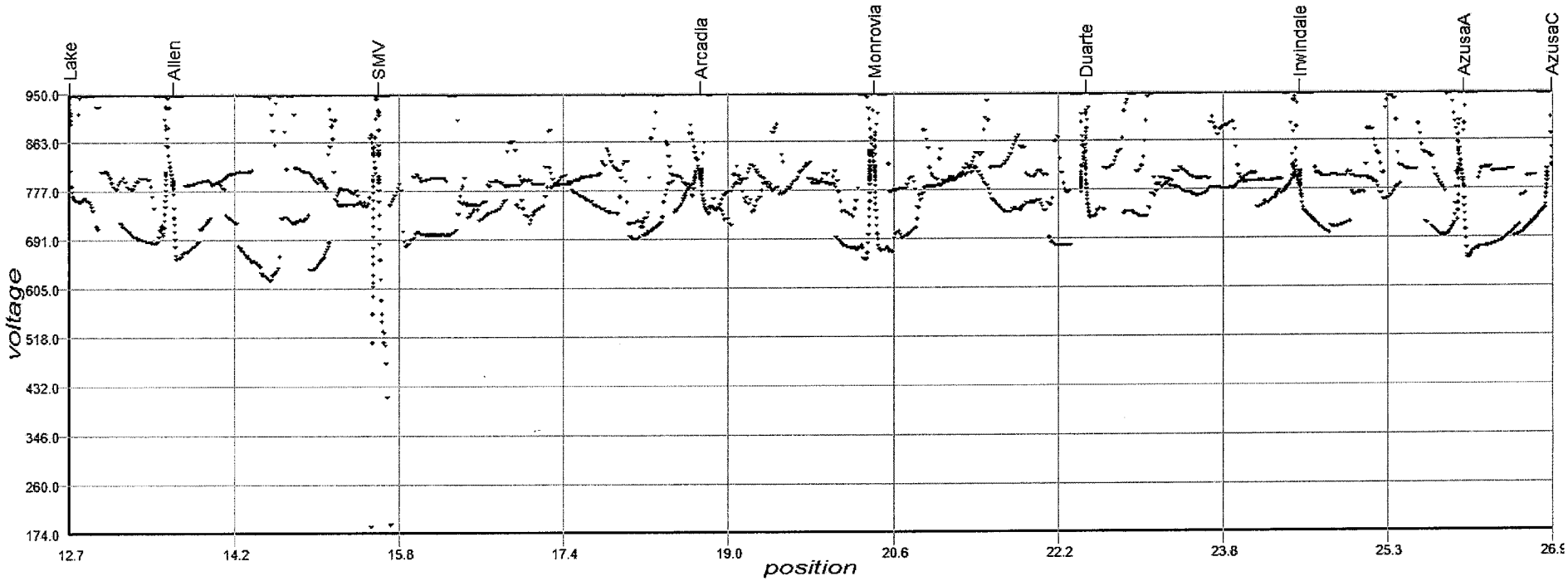

Figure 10 - Train voltage for Case 3D01 (Baldwin Substation out of service)

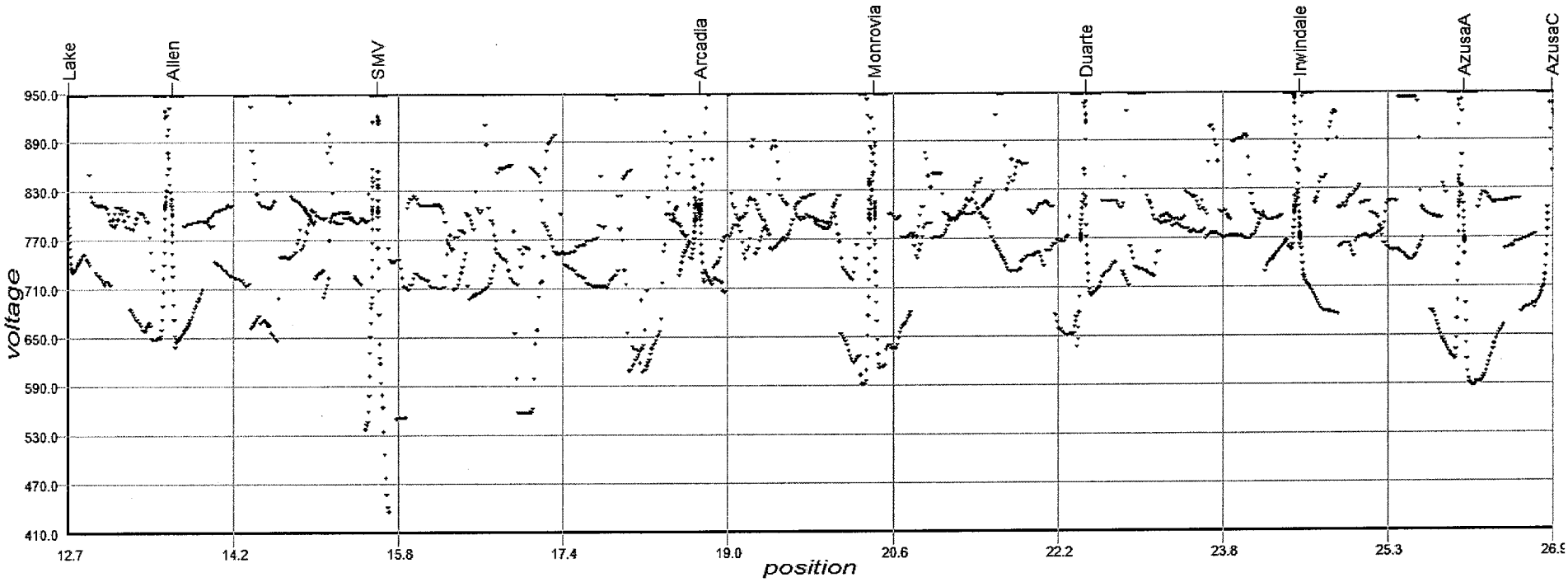

Figure 11 - Train voltage for Case 3D02 (Joseph Substation out of service)

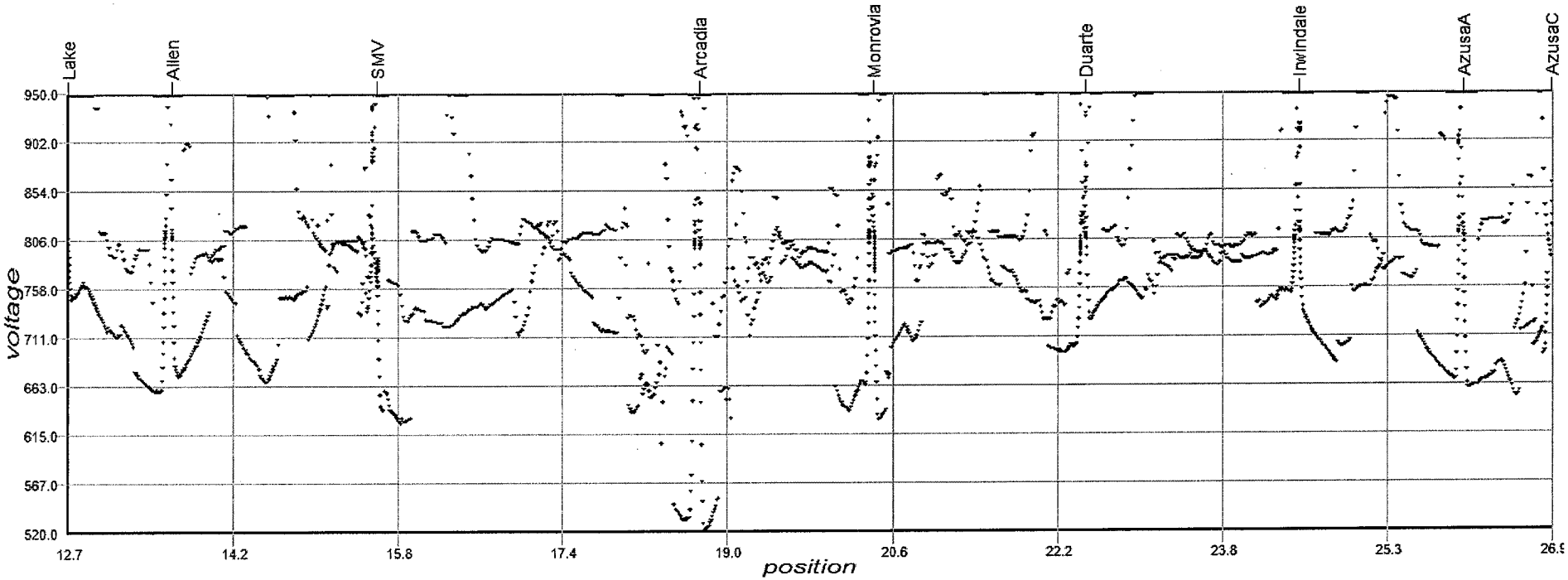

Figure 12 - Train voltage for Case 3D03 (Los Robles Substation out of service)

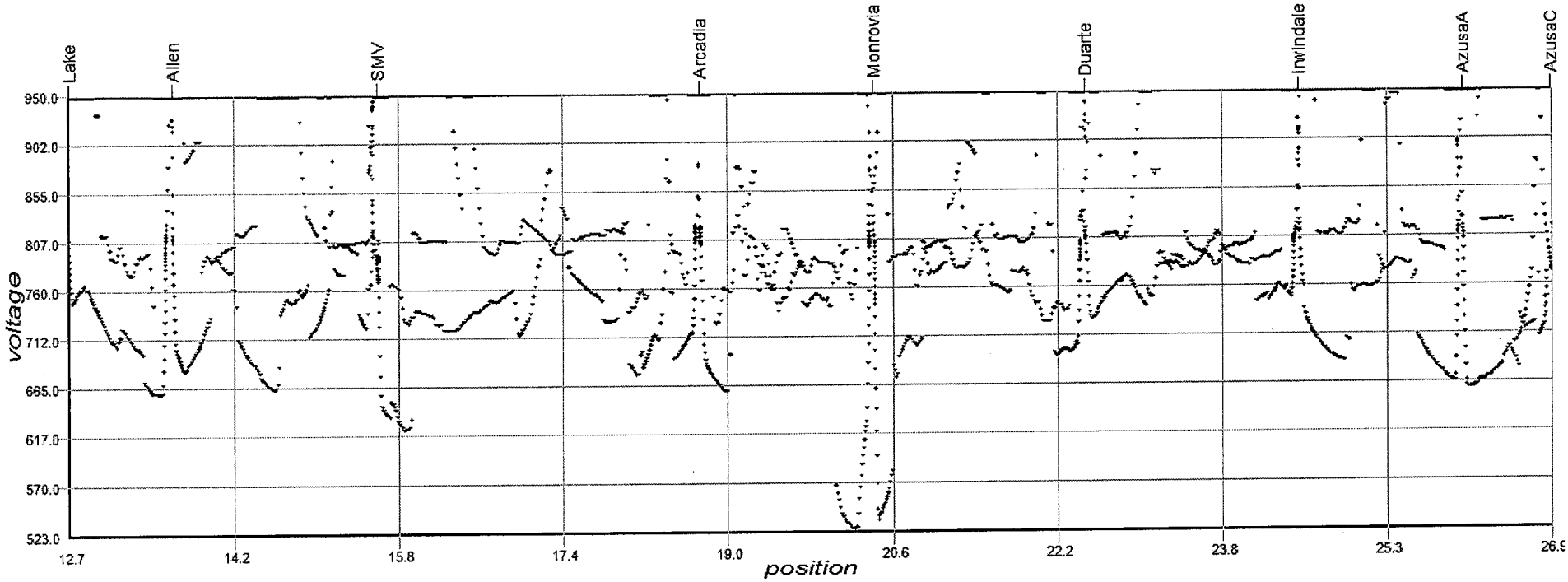

Figure 13 - Train voltage for Case 3D05 (Bus Center Substation out of service)

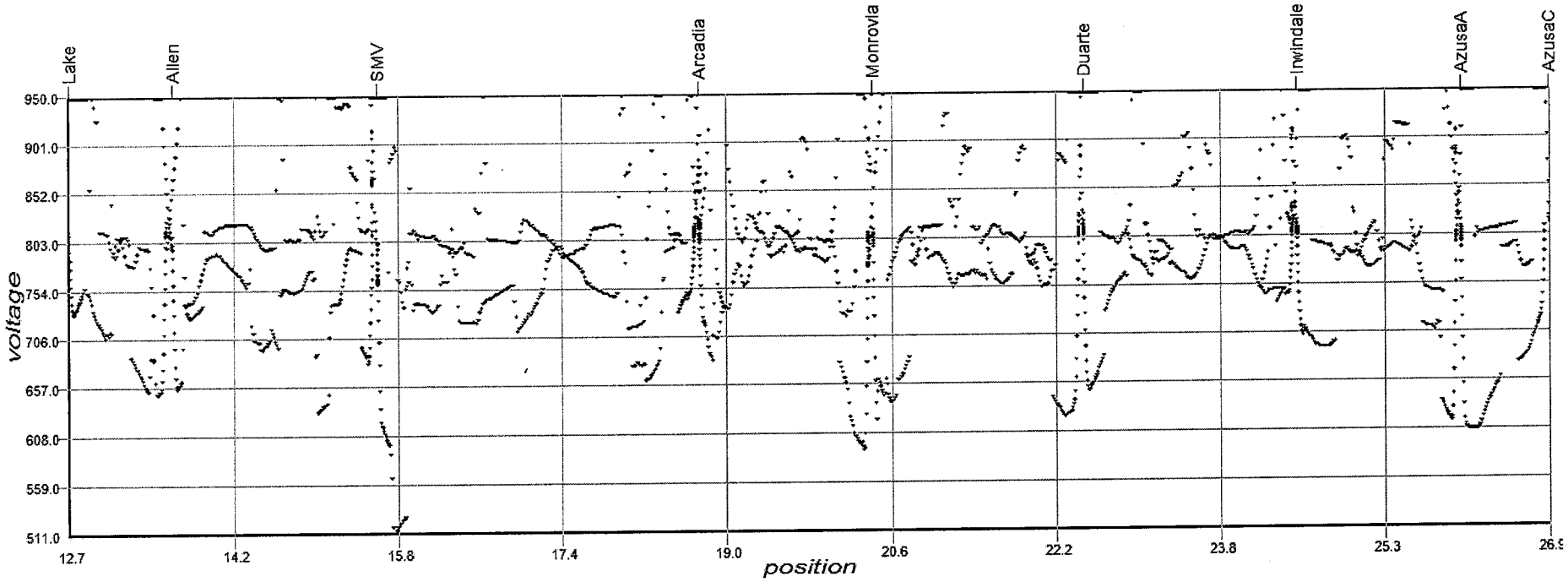

Figure 14 - Train voltage for Case 3D07 (Virginia Substation out of service)