Large Load Serving Study Report for La Plata Electric Association, Inc.

Alternatives

Addendum

San Juan Major Project

Tri-State Generation and Transmission Association

Power System Planning
December, 2008

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Introduction

This addendum report ("Addendum Report") documents the facility upgrades and additions required for several alternative system expansion configurations which were evaluated using powerflow studies in lieu of the preferred alternative which is described in the document entitled "Large Load Serving Study Report for La Plata Electric Association, Inc. San Juan Major Project", dated January of 2008 ("Study Report"). The preferred alternative proposal described in the Study Report consists of a 230 kV transmission line originating at the San Juan Generating Station 345 kV bus and going though the City of Farmington's ("COF") existing 115 kV Glade Tap Substation to terminate on the LPEA 115 kV loop at a new 230 kV substation called Iron Horse near Ignacio, Colorado All the power flow studies and cost evaluations for the alternatives were conducted in the same 2007-08 time frame as for the preferred alternative but were not formally memorialized until late 2008 in this report. Also included in this Addendum Report are planning cost estimates for all alternatives.

The projected loads used to study other alternatives were the same as described in the Study Report for the preferred alternative. The request from LPEA indicated the need to serve approximately 140 MW of new industrial load in LPEA's service area besides normal load growth in Southwestern Colorado. The conclusions of this report are presented in terms of that load level.

The main source for the existing 115 kV transmission system serving the LPEA service area is the 345-115 kV Hesperus Substation. Additional existing sources for the LPEA are a 115 kV transmission line from Lost Canyon Substation and a 115 KV line extending to Shiprock in New Mexico through the COF transmission system. Most of the LPEA load is now served from the existing Hesperus-Durango-Bayfield-Florida River 115 kV transmission loop.

As the new industrial load increases prior to construction of a new transmission line into the Bayfield area, Tri-State will rebuild its existing Durango-Bayfield 115 kV transmission line and it is likely that Tri-State's existing Hesperus to Durango 115 kV line will have to be uprated during this time. For the Hesperus-Durango-Bayfield-Florida River 115 kV loop, new reactive support is required to maintain acceptable voltage profiles. Initially, in conjunction with the Durango-Bayfield 115 kV transmission line construction, 22.5 MVARs of additional capacitor banks will be added in the Bayfield to Pagosa Springs area. In about 2012, Tri-State will add another 37.5 MVAR at the proposed Iron Horse 115 kV Substation. These changes along with other capacitor banks modeled in the power flows constitute the existing system used in this report.

To increase the load serving capability of the 115 kV loop and to avoid using all of the rated transfer capability on the limited TOT2A flow gate, an additional transmission line is required into the Bayfield area load center. Various transmission configurations were studied to serve the Southwest Colorado load requirements. While there are 345 kV variations of these configurations, a 230 kV voltage was expected to be sufficient and less costly to construct in order to provide for LPEA and the expected industrial load growth. The main system configurations are as follows:

- San Juan-Glade Tap-Iron Horse 230 kV
- Ojo East-Turley-Iron Horse 230 kV
- San Luis Valley-Chama-Iron Horse/Pagosa (115kV) 230 kV
- Curecanti-Montrose-Nucla-Florida River 230 kV

The Study Report described the results for the San Juan-Glade Tap-Iron Horse 230 kV system configuration as it is the preferred proposal at present. The Ojo East-Iron Horse option described in this addendum report is slightly more costly and has slightly less power transfer capability than the preferred option. The Ojo East alternative also appears to be less favorable based on initial discussions with PNM planning personnel in that it requires a new tap on PNM's northern New Mexico 345 kV system. The San Luis Valley-Iron Horse option provides about the same amount of power transfer capability but at more cost because of the longer distances, part of which would possibly be through new line corridors in national forests. The Rifle to Florida River option has significantly less power transfer capability and more cost than the preferred option.

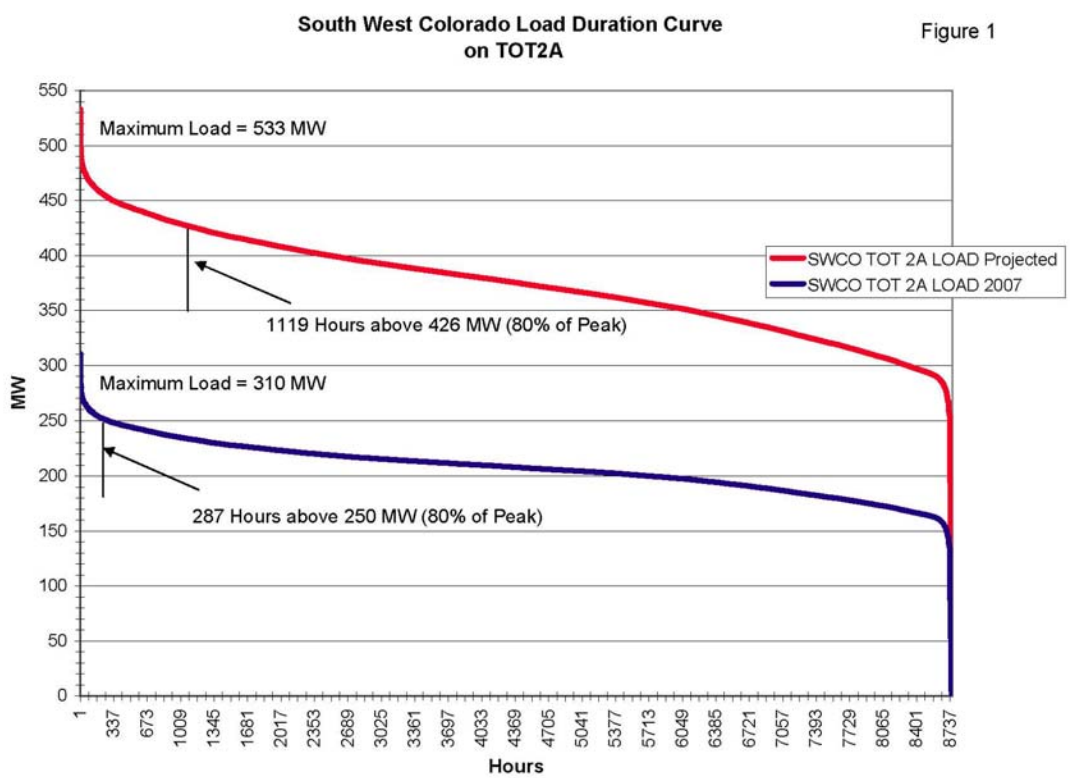
At present, the preferred proposal to provide relief to the existing transmission system has changed slightly with the southern termination expected to be at the WAPA Shiprock 345 kV bus rather than at the San Juan Generating Station 345 kV bus. At that location a 230 kV transmission line would originate and extend to a new 230 kV substation with phase shifting transformer northwest of the City of Farmington's ("COF") existing 115 kV Glade Tap Substation. The 230 kV line would then proceed to the northeast to terminate on the LPEA 115 kV loop at a new 230/115 kV substation called Iron Horse near Ignacio, Colorado. The original proposal is discussed in this Addendum Report as the above noted differences appear to be slight for modeling purposes and it was the subject of the original Study Report.

Load Projections

The aggregate load schedule used in this study is shown in Figure 1 of Appendix A in the Study Report. In this study of other transmission alternatives as well as the Study Report, the three Member systems, LPEA, Empire Electric Association, Inc. and San Miguel Electric Association are viewed as the aggregate load requirement in Southwestern Colorado.

These load projections for Empire and San Miguel are based on the Tri-State 2006 High Economic Forecast Projection. The LPEA load forecast used for the purposes of this study was as provided by LPEA. The LPEA supplied forecast is approximately 60 MWs higher in 2021 than the projections contained in the 2006 High Economic forecast for LPEA. Mainly, this difference is due to a lower projection for new industrial load in the Tri-State 2006 forecast which only included about 35 MW of new industrial load. Somewhat offsetting this difference was that no adjustment was made in the area load to account for the potential load of the Las Animas-La Plata irrigation project of the WAPA RM. No attempt was made in this study to adjust for potential new industrial load growth in the area served by White River Electric Association, Inc. north of Rifle, Colorado.

The existing Southwest Colorado peak hour load on TOT2A in 2007 was about 310 MW. With the addition of the 140 MW of new industrial load proposed by LPEA, the total Southwest Colorado load will severely impact the transfer capacity on TOT2A for the peak load hour in Southwest Colorado. The scale of this impact is shown in Figure 1 which compares projected 2021 hourly loads to the actual hourly loads in Southwestern Colorado in 2007. As indicated on Figure 1, the number of hours when the Southwest Colorado load on TOT2A is greater than 80 percent of the maximum is projected to increase by about 400 percent and the projected hourly loads will be greater than the actual recorded peak load in 2007 for almost the entire year.



Impact on TOT2A

As described in the Study Report, the service areas of LPEA, Empire and San Miguel cooperatives form the load area in Southwest Colorado served from TOT2A which is a restricted flow path recognized by the Western Electric Coordinating Council (WECC). Although Tri-State owns a portion of the TOT2A transfer capability, at a Southwestern Colorado load of 300 MW, the Tri-State share of the transfer capability virtually disappears and the Western share of the transfer capability becomes impacted.

The maximum Southwest Colorado load was about 300 MW in 2005. This corresponds to a transfer capability across TOT2A of about 350 MW according to the nomograph used in the Study Report.

Power Flow Study Methodology and Criteria

As was described in the Study Report, single contingency power flow analysis was performed using a 2016 summer case (WECC16HS1A) for each of the alternatives. This case included Tri-State's Springerville Unit 3 and, under the name of Sand Sage, two new 700 net MW units at Tri-State's proposed Holcomb, Kansas plant site with a 345 kV system connecting these units to Tri-State delivery points at Midway and Big Sandy in Colorado.

The 2016 summer base case was modified to extrapolate the 2016 loads in the control areas of Public Service Company of New Mexico (PNM), Public Service Company of Colorado (PSCo) and the Rocky Mountain area of the Western Area Power Administration (Western RM) to a level for the base year of 2021. Except for the facilities necessary to directly serve the LPEA load for each alternative, no new generation or transmission lines were added to the 2021 case above that included in the 2016 WECC base case.

As described in the Study Report, the expected north-to-south transfer capability on TOT2A for only the Southwest Colorado 2021 load is about 260 MW. By including the capability of Tri-State's proposed Dulce Project, which could remove about 85 MW of LPEA load through a 115 kV system tapping the PNM 345 kV system near Gavilan, New Mexico, i.e. the Ojo East Substation, the transfer capability of TOT2A could be maintained at about 350 MW in 2021.

For the 2021 load case with the LPEA San Juan Project loads a north to south flow of 350 MW on TOT2A was made the objective to match the capabilities expected from the Dulce Project system. A south-to-north transfer capability of 300 MW was also assumed in the study. Although there is no defined rating for transfers to the north on TOT2A, it appears that schedules above this amount tend to heavily load the Shiprock 345-230 kV, 300 MVA transformer modeled in the WECC power flow case and also require a 60° or more phase shifting angle by the phase shifters proposed for the San Juan-Glade Tap-Iron Horse 230 kV alternative discussed in the Study Report. The system was also modeled with the TOT2A phase shifters off or deactivated which was the modeling status in the WECC 2016 HS base case.

For the purposes of this study, all projected loads were assumed to have a power factor of 0.95 lagging. While some loads in the LPEA service area can and do routinely operate at a higher power factor, this assumption provides an additional margin of error for estimating the extent of system improvements in that area.

The following standard planning criteria was used to evaluate system performance in this study:

Voltage	between 95% and 105% of nominal voltage
Voltage deviation	at most 5% change with any single element outage
Power flow	at most 80% of maximum rating under normal conditions
Outage power flow	at most 100% of maximum rating

The power flow analysis for this study was run utilizing Rev. 30.3 of Siemens/Power Technologies Inc. (PTI)'s Power System Simulator (PSS/E) software package. Individual power flows were run and plotted for specific outages on the local transmission system serving LPEA and for certain critical outages of high voltage transmission lines serving the local LPEA system for the 2021 base case modified with the Southwest Colorado load projections and transmission system changes as described for each alternative.

Existing Transmission System Serving LPEA

System Description

The main source for the existing transmission system serving the LPEA service area is at Hesperus Substation. This substation is supplied by the 345 kV line from Rifle to San Juan which is a major component of TOT2A. Transformation at Hesperus Substation consists of two 345-115 kV, 280 MVA transformers. As shown in the following Figure One, additional existing sources for the LPEA service area are a 115 kV transmission line from Lost Canyon Substation that terminates at Tri-State's Durango Substation and a 115 KV line between Hesperus and the Glade Tap Substation of the COF. This latter 115 kV line is also part of the transmission system comprising TOT2A. However, this 115 kV transmission line is normally operated open when significant power schedules are being transmitted on TOT2A. Several small hydro generating plants are located in the area such as the Vallecito, Bayfield and Tacoma power plants.

Most of the LPEA load is served from the Hesperus-Durango-Bayfield-Florida River 115 kV transmission loop although the Durango area is served by a second 115 kV loop between Hesperus-Bodo-Durango.

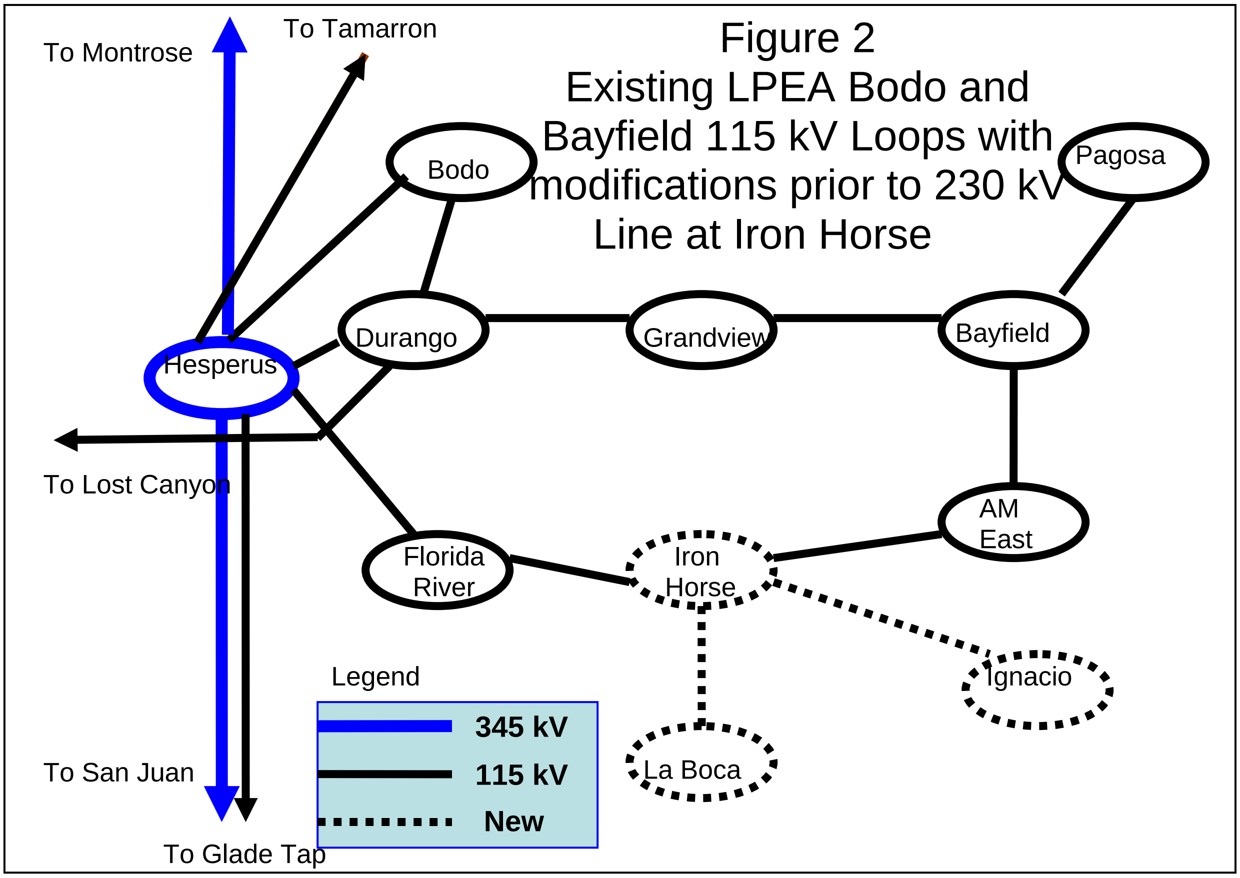


Figure 2
Existing LPEA Bodo and Bayfield 115 kV Loops with modifications prior to 230 kV Line at Iron Horse

As shown in Figure 4 of Appendix A in the Study Report, most of the new 115 kV substations proposed by LPEA to serve the existing and new industrial load growth will be concentrated east of Hesperus near Bayfield and Ignacio, Colorado. LPEA intends to add more 115 kV transmission lines in the area to serve the new load projections. As shown in Figure Two, these lines will be terminated at the Iron Horse 115 kV Switching Station on the LPEA transmission line between Florida River and AM East Substations. These changes will occur prior to the addition of a new transmission line by Tri-State.

The north side of the Hesperus-Durango-Bayfield-Florida River 115 kV loop is owned by Tri-State and will be rebuilt using 795 MCM ACSR conductor at a 100 °C rating to accommodate the expected load increases. The southern side of the loop, from Hesperus through Florida River and AM East substations to Tri-State’s Bayfield Substation is owned by LPEA and uses 795 MCM ACSR conductor at a 75 °C rating. From Bayfield Substation, Tri-State owns a radial 115 kV line that terminates at Pagosa Substation. This line is approximately 35 miles long and uses 397 MCM ACSR conductors at a 50 °C rating. In addition, the existing 50 °C thermal limit for the 397 conductor on the Hesperus to Durango line may have to be improved for the increased loads. The 115 kV transmission lines between Bodo and Durango or Bodo and Hesperus that are part of the Hesperus-Bodo-Durango 115 kV loop shown on Figure Two do not appear to require any modifications for the LPEA projected loads.

For the Hesperus-Durango-Bayfield-Florida River 115 kV loop, new reactive support is required to maintain acceptable voltage profiles with the large loads that are being proposed. Applied capacitive reactance near these loads raises the voltage under normal operating conditions, and lessens the voltage deviation under outage conditions that cause high power flow on one leg of the 115 kV loop system. Initially two 7.5 MVAR capacitor banks should be installed on the Pagosa 115 kV bus with a circuit switcher for protection. Also, the existing 7.5 MVAR capacitor banks on the 115 kV bus at Bayfield should be upgraded to 15 MVAR. By 2012, an additional 37.5 MVAR will be installed at Iron Horse Substation with or without a proposed new transmission line.

Existing Transmission System Serving LPEA

Study Results and Discussion

TOT2A Phase Shifters Off

Appendix B includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are not in use. The projected 2021 loads are used including the previously described industrial load increase. In all cases, the NLTC settings on the Hesperus 345-115 kV transformers have been set at .95 to provide a voltage boost to the 115 kV system, the Hesperus-Durango 115 kV line has been assumed to be rebuilt with 477 MCM ACSR conductor and the Durango-Bayfield 115 kV line has been rebuilt as previously described. 30 MVAR capacitor banks are assumed at Florida River and Pagosa Substations. 37.5 MVAR capacitor banks at Iron Horse and 22.5 MVAR capacitor banks at AM East Substation are also modeled along with an increase from 15 to 30 MVAR at Bayfield Substation.

Power flow 21hsSJPSO2 is the base case. This case shows a flow of 234 MW into Southwest Colorado from the TOT2A' interface south of Montrose, Colorado and about 210 MW flowing north into Southwest Colorado from the TOT2A interface in Northwestern New Mexico. Along with the net generation of about 105 MW in Southwest Colorado this provides about 550 MW of input into Southwestern Colorado for the 2021 load projections. For this scenario the loading on the Northern New Mexico flow gate, WECC restricted Path 48, between San Juan and the Albuquerque area is about 1488 MW. The existing rating for this path is about 1800 MW. In this case approximately 97.5 MVAR of capacitors were modeled as being in use. This generally allowed for a voltage level of 116 kV or 1.01 pu at the substations on the Hesperus-Durango-Bayfield-Florida River 115 kV loop

Cases 21hsSJPSO3 through 21hsSJPSO13 deal with single contingency outages on the 115 kV system in the LPEA service area. Power flow 21hsSJPSO3 shows the modeling results for the single contingency outage of the Hesperus-Florida River 115 kV transmission line. To easily solve this case with acceptable system voltages, the projected load was reduced by 25 MWs at Florida River Substation and 135 MVARs of capacitors were needed. However, this still overloaded the rebuilt Durango-Bayfield transmission line. This rebuilt line should be capable of handling 229 MVA of power flow at nominal voltage. In this instance, the flow reaches 270 MVA without the additional 25 MW of load at Florida River Substation. To allow for such power flows the Durango-Bayfield transmission line would have to be capable of supporting 300 MVA. This would entail construction of a much larger 115 kV transmission line than normally constructed and rebuilding of the terminating and intermediate substations as equipment within the substations is generally rated for about 1200 amperes or 239 MVA. Power flow 21hsSJPSO8 finds results similar to case 21hsSJPSO3 for a single contingency outage of the Grandview-Bayfield 115 kV line. In this instance, the Bayfield load was reduced by 38 MW to easily solve the modeled case. Although power flow 21hsSJPS13 shows an overload of one for loss of one of the two Hesperus 345-115 kV autotransformers, the rating used in this power flow was 250 MVA rather than the maximum rating of 280 MVA at 65 °C.

Case 21hsSJPSO14 through 21hsSJPSO16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. The most significant outage case is 21hsSJPSO15 which loads the Glade Tap to El Paso Tap 115 kV line to 100 percent of its 85 MVA rating. However, case 21hsSJPSO15a shows this line can be opened with about a two percent decline in, but still satisfactory, voltages on the LPEA Hesperus-Durango-Bayfield-Florida River 115 kV loop.

TOT2A Phase Shifters On North

Appendix C includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed north with a 300 MW transfer across TOT2A. Local modeling of the LPEA 115 kV system is as previously described for the scenario with the phase shifters off.

Power flow 21hsSJPSN2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 6-16° to maintain the 300 MW north transfer In this scenario, approximately 276 MVA flows through the 300 MVA rated 345-230 kV autotransformer at Shiprock Substation.

Power flow 21hsSJPSN3 shows similar results to that for that scenario with the TOT2A phase shifters off. However, in this instance the loading on the Hesperus-Durango 115 kV transmission line has increased from 78 to 121 MVA between the phase shifters off and on-north scenarios. Power flow 21hsSJPSN8 finds results similar to 21hsSJPSO8 for a single contingency outage of the Grandview-Bayfield 115 kV line. Power flow cases 21hsSJPSN11 and 12 again show power flows on the Hesperus-Durango 115 kV transmission line well above the existing 85 MVA rating reinforcing the modeling of the line rebuilt as a requirement in these existing system cases. Power flow 21hsSJPS13 shows an overload of one for loss of one of the two Hesperus 345-115 kV autotransformers at its maximum rating of 280 MVA at 65 °C with a flow of 296 MVA.

Again, Cases 21hsSJPSN14 through 21hsSJPSN16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. The TOT2A phase shifters are locked in their pre-outage phase angle for these cases as is typically done for a TOT2A power flow study. This appears to have the most impact on the transfer capability for case 21hsSJPSNH15. In this instance, the Shiprock 345-230 kV transformer loads to 120 percent of its modeled rating of 300 MVA.

<u>TOT2A Phase Shifters On South</u>

Appendix D includes the selected power flow plots for outages on the LPEA 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed south with a 225 MW transfer across TOT2A. The San Juan and Shiprock phase shifters have a phase shifting angle of about 51-56° to maintain the 225 MW south transfer They have a maximum phase shifting angle of 60°, so not much more power can be transferred without meeting this limitation. Local conditions for the LPEA 115 kV system are as previously described for the phase shifters off scenario.

Power flow 21hsSJPSS2 is the base case. In this case, the flow on TOT2A' is about 689 MW to deliver 225 MW across TOT2A. The rating of TOT2A'is 690 MW so in this instance, only about 225 MW or less can be transferred across TOT2A to the south. This 225 MW peak hour transfer scenario would leave WAPA with about half of its allocation of the capacity on TOT2A and none for Tri-State or Xcel Energy. The actual allowable flow on TOT2A in this scenario is likely less than this estimate as it is without consideration of overloading the next critical element in an N-1, single contingency, analysis.

Power flow 21hsSJPSS3 shows line flow results similar to that for the scenarios with the TOT2A phase shifters off or pointed north. However, in this instance the voltage is depressed unless all capacitor banks scheduled for installation on the Hesperus-Durango-Bayfield-Florida River 115 kV loop are used and the Florida River Substation load is reduced by 25 MW. This is a total of 150 MVARs required to hold the voltage in the area to about .925 pu. At this point, the system is likely to enter voltage collapse if the Florida River load increment is added back onto the system. Besides the line overloads, this single contingency indicates the 115 kV system with the previously described improvements is incapable of serving the projected loads and meeting proscribed voltage reliability criteria. Primarily, this violation is because the existing system is incapable of withstanding a single contingency outage on the Hesperus-Durango-Bayfield-Florida River 115 kV loop without shedding load.

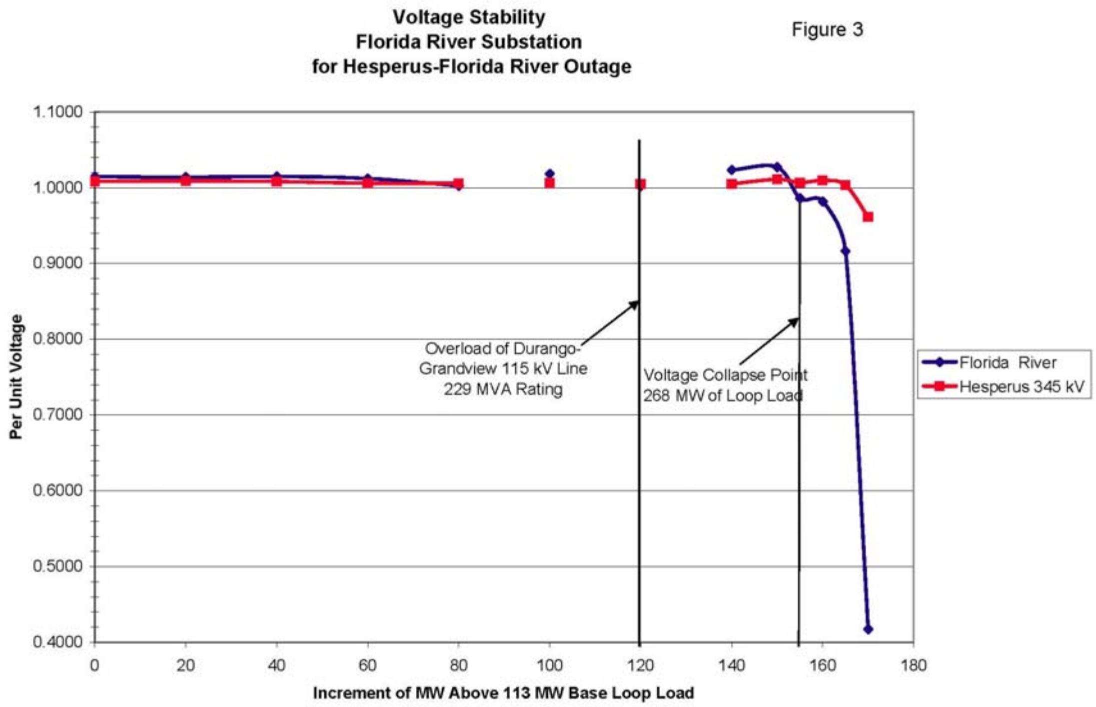
Power flow 21hsSJPSS7 and 8 find results again similar to that for the scenarios with the TOT2A phase shifters off or pointed north. Power flow cases 21hsSJPSN10 and 12 again show power flows on the Hesperus-Durango 115 kV transmission line well above the existing 85 MVA rating.

Cases 21hsSJPSS14 through 21hsSJPSS16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. Again, the TOT2A phase shifters are locked in their pre-outage phase angle for these cases. In this instance, outage case 21hsSJPSS14 which simulates the loss of the Grand Junction-Montrose 345 kV line indicates heavy loading on the Montrose 115 kV system as approximately 200 MVA flows from that 115 kV system to the Montrose-Hesperus 345 kV line to supply the Southwest Colorado area loads. To alleviate this situation, the Montrose-Hesperus line could be opened. This impact would be similar to that modeled in 21hsSJPSS16. For the loss of the Grand Junction-Montrose 345 kV line, there is only about 19 MW of transfer across TOT2A essentially indicating no available capacity across TOT2A for this contingency.

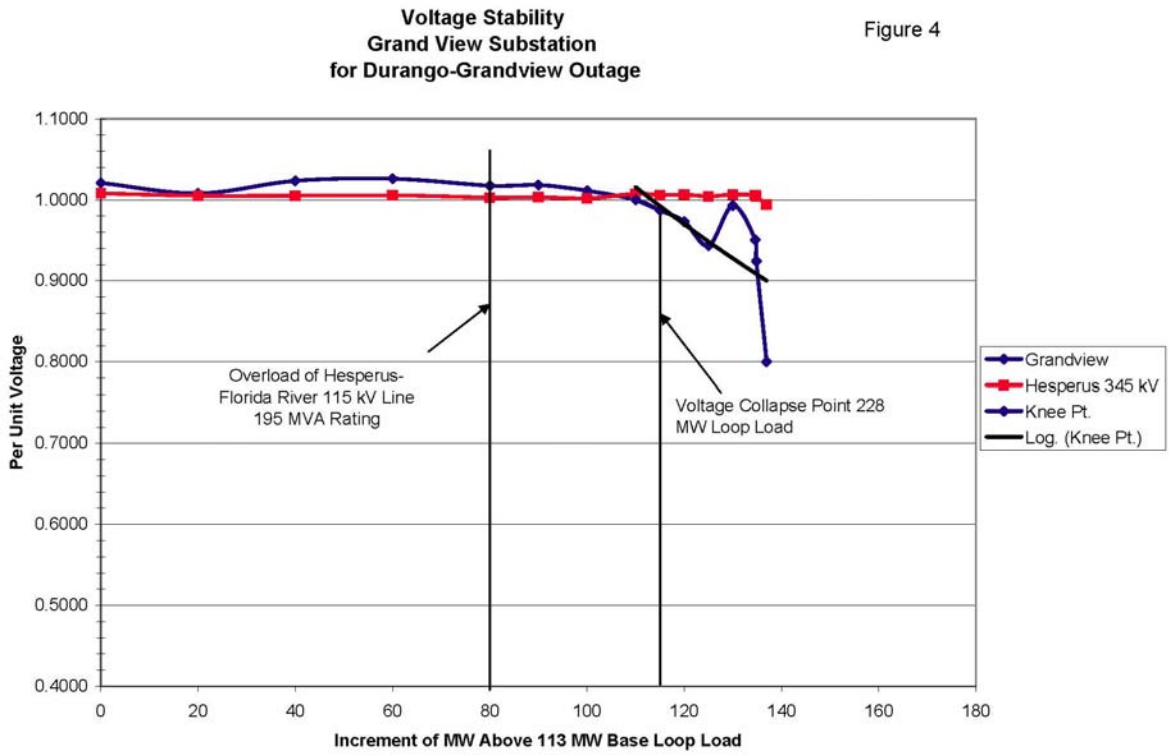
<u>Voltage Stability- TOT2A Phase Shifters Off</u>

Because of the difficulty of obtaining solutions when modeling the single contingency outage for either Hesperus legs of the Hesperus-Durango-Bayfield-Florida River 115 kV loop, a steady-state voltage stability analysis was run for these outages. The load on the loop was first reduced from the projected figure of 282 MW to 113 MW, a 60 percent reduction, at the corresponding 95 percent power factor and then increased in increments of 20, 10 and finally 5 MWs or less to determine when the voltage on the loop began to collapse.

The following graphs are PV (Power Load-Voltage) curves for the voltage at the critical bus, *i.e.* substation, versus the increment of load added to the substations on the Hesperus-Durango-Bayfield-Florida River 115 kV loop. Figure 3 is the first graph and is for the outage of the Hesperus-Florida River section of the loop and the corresponding voltage at Florida River Substation. In this instance, with use of the capacitor banks planned for installation on the loop, the voltage collapse point is extended to about 268 MW, although the rating of the rebuilt Durango-Bayfield transmission line is exceeded before the load reaches 223 MW. After the load increment reaches 155 MW, *i.e.* a total load of 268 MW, the voltage quickly collapses. As the projected maximum load is about 282 MW for the loop, the voltage collapse point should be at least 296 MW to meet single contingency reliability criteria.



The second graph, Figure 4, is for the outage of the Durango (Hesperus)-Grandview section of the loop and the corresponding voltage at Grandview Substation. In this instance, the voltage collapse point is at about 228 MW, although the rating of LPEA's Hesperus-Florida River transmission line is exceeded before the load reaches 193 MW. After the load increment reaches 115 MW, *i.e.* a total load of 228 MW, the voltage quickly collapses. Again, the voltage collapse point should be at least 296 MW to meet single contingency reliability criteria. The results shown in Figures 3 and 4 demonstrate why the power flow simulations for these outages were difficult to solve when modeling the existing system unless load reductions were used. As noted previously, use of the capacitor banks extends the load increment point at which voltage collapse occurs. But it also increases the voltage level at which this collapse takes place so that a more abrupt change occurs between a state of acceptable voltage and collapse.



Transmission System Expansion Options for LPEA

In order to increase the load serving capability of the LPEA system, an additional transmission line is required into the Bayfield area load center. As inferred in the TOT2A discussion, terminating a transmission line at Hesperus Substation without further upgrades to TOT2A merely uses all of the transfer capability on that limited flow gate. Additions to the existing facilities independent of the TOT2A transmission lines are needed.

Four basic transmission configurations were studied to serve the Southwest Colorado load requirements. While there are 345 kV variations of these configurations, a 230 kV voltage was expected to be sufficient to provide for LPEA and the expected industrial load growth. Theses system configurations are ranked as follows:

- San Juan-Glade Tap-Iron Horse 230 kV
- Ojo East-Turley-Iron Horse 230 kV

- San Luis Valley-Chama-Iron Horse/Pagosa (115kV) 230 kV
- Rifle-Curecanti (345 kV)-Montrose-Nucla-Florida River 230 kV

The Study Report describes the power flow results for the San Juan-Glade Tap-Iron Horse 230 kV system configuration. It was determined to be the preferred proposal. In this report the results for the remaining alternatives is documented. For the Ojo East-Iron Horse option it was determined to be slightly more costly with slightly less power transfer capability than the preferred option. The Ojo East alternative also appears to be less favorable based on initial discussions with PNM planning personnel in that it requires a new tap on PNM's northern New Mexico 345 kV system. The San Luis Valley-Iron Horse option provides about the same amount of power transfer capability but at more cost because of the longer distances, part of which may be through new line corridors in national forests. The Rifle to Florida River option has significantly less power transfer capability and more cost than the preferred option.

Each of the studied transmission alternatives was ranked from best to worst in capital dollars required per megawatt of load serving capability. The results of this ranking are presented in following Table One. Based on the technical and economic assumptions used in this study, the San Juan–Glade Area-Iron Horse 230-kV Transmission Line is the best transmission alternative for meeting the needs of the Project. This alternative results in the lowest investment of $487,000 per megawatt of increased load serving capability. Further, the San Juan–Glade Area-Iron Horse 230-kV is assumed in the cost estimates to be constructed as double circuit line from San Juan to at least the vicinity of Glade Road in New Mexico. Such construction would provide additional transmission capacity and flexibility for the area transmission system in the future while reducing the need for further line construction. While the first three alternatives all provide relief to the TOT2A restricted flow path at the desired LPEA load serving capability, the second alternative does so by increasing the loading on the Northern New Mexico restricted flow path.

Table One
Ranking of Alternative Options by Cost in 2008 Dollars

Rank	High Voltage Transmission Project Alternative for Connection to LPEA near Ignacio, Colorado	System Intact Load Serving Capability (MW)	Total Project Cost Including future New Mexico Service ($1000)	Initial Project Cost Required for LPEA/Southwest Colorado ($1000)	Projected Route Miles of 230 kV Line Required for LPEA/ Southwest Colorado	Initial Project Cost per MW of Delivery Capability ($1000)
1	230 kV San Juan-Glade Area-Iron Horse (Ignacio)	250	164,441	120,388	68	$482
2	230 kV Ojo East-Turley-Iron Horse (Ignacio)	250	177,864	156,214	110	$625
3	230 kV San Luis-Chama-Iron Horse/Pagosa	250	195,263	173,165	172	$693
4	230 kV Curecanti-	100	233,102	189,019	201	$ 1,891

Rank	High Voltage Transmission Project Alternative for Connection to LPEA near Ignacio, Colorado	System Intact Load Serving Capability (MW)	Total Project Cost Including future New Mexico Service ($1000)	Initial Project Cost Required for LPEA/Southwest Colorado ($1000)	Projected Route Miles of 230 kV Line Required for LPEA/ Southwest Colorado	Initial Project Cost per MW of Delivery Capability ($1000)
	Nucla-Florida River					

San Juan-Glade Tap-Iron Horse 230 kV System

System Description

The San Juan-Glade Tap-Iron Horse 230 kV system that was modeled in the power flow study is described in the Study Report and is not repeated in this Addendum Report.

Figure 2 in Appendix A provides a one-line diagram of the proposed San Juan-Glade Tap-Iron Horse 230 kV system. Essentially, this is a radial 230 kV line originating at the 230 kV bus at the San Juan Generating Station of PNM. Phase shifting transformers at Glade Tap or in close proximity to the existing Glade Tap Substation of the COF are used to control power flow on the 230 kV transmission line which connects the Iron Horse Substation near Ignacio, Colorado to the load in the Bayfield area and into the underlying 115 kV system of the COF at the existing Glade Tap Substation. Redundant transformers and phase shifters are assumed to provide the highest level of security.

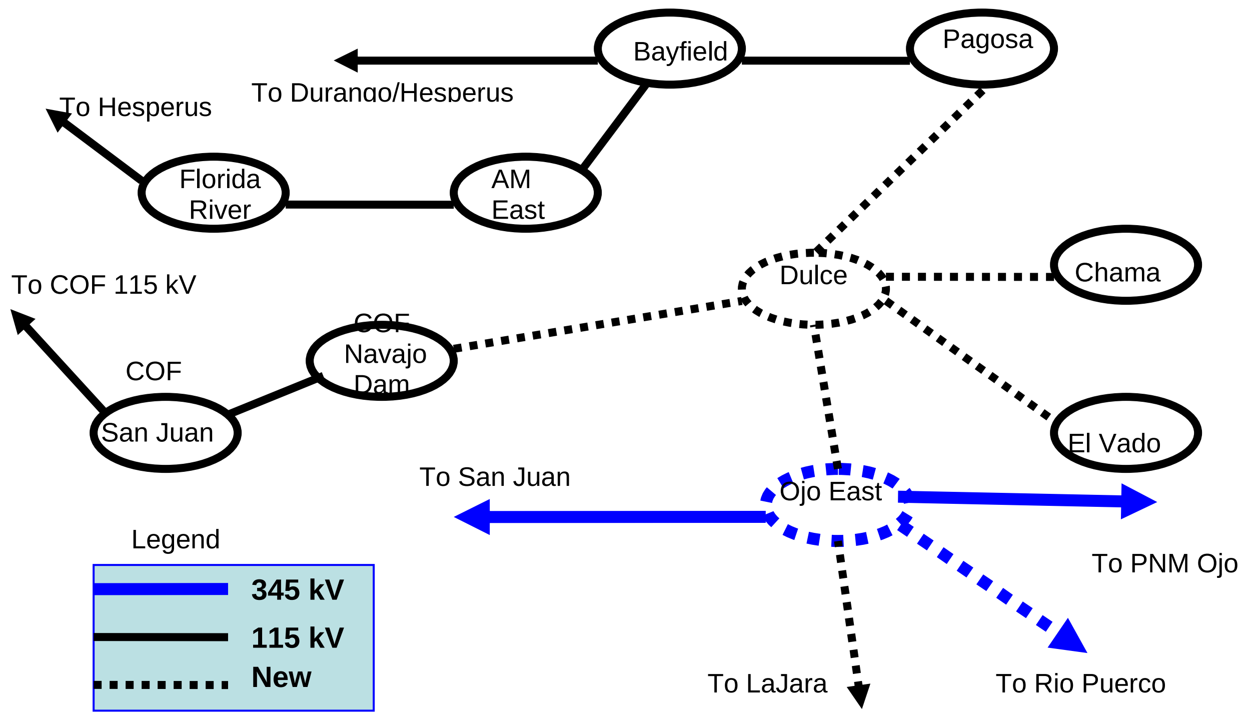
An estimate of the cost to construct this option is included as Table 1 in Appendix A. The initial cost to provide service to the LPEA and Southwest Colorado area is 122 million dollars. The total estimate which includes integrating Tri-State Member load in Northern New Mexico into this option is 167.5 million dollars.

Ojo East-Turley-Iron Horse 230 kV System

System Description

The very first alternative reviewed for serving the large load request of LPEA was the Ojo East to Iron Horse option. This option is a high voltage version of the Dulce Project which was in Tri-State's transmission budget as a long range planning option prior to the large load request of LPEA. The Dulce Project is further described in the report entitled: "Dulce Transmission Study, dated July of 2005. As illustrated in Figure 5, the Dulce Project consisted of construction of a 345-115 kV substation at the proposed Ojo East location near Gavilan, New Mexico. From that location a 115 kV transmission line would be constructed north to terminate at a sectionalized substation near Dulce, New Mexico. From the Dulce Substation 115 kV lines would be constructed to Tri-State Member substations at Chama and El Vado. Also, a 115 kV line was proposed from Dulce Substation to the COF system near the COF Navajo Dam Substation.

Figure 5 Dulce Project with PNM Ojo East-Rio Puerco 345 kV Additions



Modeling of the above described configuration for Dulce Project resulted in about 80 MW of power flow through the 345-115 kV autotransformer at Ojo East for system intact conditions with approximately 30 MW flowing into Pagosa Substation. The Tri-State transmission budget for 2006 included estimates for the Dulce Project north of and including Ojo East Substation of about $50 million. However, this did not include phase shifting transformers which are necessary to consistently transmit power in the desired direction relative to the TOT2A phase shifters. Inclusion of phase shifters would likely raise the investment amount to about $65 million.

The Ojo East-Turley-Iron Horse option assumed the same termination point on the PNM 345 kV system at Ojo East Substation as did the Dulce Project. As the Ojo East alternative to serve the LPEA large load request would increase the delivery at this location from less than 100 MW to about three times that amount, this possibility was less favorably viewed in initial discussions with PNM planning personnel. The timing for this alternative was also in question as it requires a new tap on PNM's northern New Mexico 345 kV system.

Figure 3 in Addendum Report Appendix A provides a one-line diagram of the proposed Ojo East-Turley-Iron Horse 230 kV system. Essentially, this is a radial 230 kV line originating at the 230 kV bus at the proposed Ojo East Substation of PNM. From that location, a 230 kV transmission line between Ojo East Substation and a new substation near the intersection of Pounds Mill Road and Highway 64 was modeled. At Pounds Mill

Substation, a 115 kV line was assumed to serve the Dulce-Chama areas and the 230 kV line continued west to about the vicinity of Turley, New Mexico and then north to Ignacio, Colorado to the proposed Iron Horse Substation. Phase shifting transformers and series compensation for the 230 kV line were assumed to be installed at Turley Substation to provide a constant input of 250 MW into the LPEA service area. A 125 MVAR series capacitor bank is modeled at Turley Substation to reduce the 230 kV line impedance seen by the phase shifting transformers. Approximately 25 MW was assumed to be scheduled into the Dulce/Chama area. As for all alternatives, the redundant transformers and phase shifters were assumed to provide the highest level of security on the 230 kV path to Iron Horse Substation.

Ojo East-Turley-Iron Horse 230 kV System

Facility Additions

The following major additions to the transmission system in the northern New Mexico area north to Iron Horse Substation comprise the Ojo East-Turley- Iron Horse 230 kV system:

- Construct the 345 kV Ojo East Substation with a five breaker ring bus and two 200 MVA 345-230 kV transformers and 165 MVAR of shunt capacitors;
- Install a three 230 kV breaker ring bus at the Ojo East Substation;
- Construct a single circuit 230 kV line from the 230 kV bus at Ojo East to Pounds Mill Substation (approximately 31 miles);
- Construct a 230 kV substation with 230 kV line breakers near Pounds Mill Road and Highway 64 and install a 200 MVA 230-115 kV transformer;
- Install a three breaker 115 kV ring bus and install two 7.5 MVAR switched capacitor banks with individual circuit switchers for each bank at Pounds Mill Substation;
- Construct a single circuit 230 kV line from Pounds Mill Substation to a new Turley Substation (approximately 51 miles);
- Install a 125 MVAR series capacitor with associated 230 kV circuit breakers at Turley Substation to allow for transfer of 250 MW to serve the LPEA loads;
- Install two 230 KV phase shifters with a capacity of 200 MVA with associated 230 kV circuit breakers at Turley Substation for parallel use to serve the LPEA loads;
- Install a 75 MVA, 230-115 kV transformer and a three breaker 115 kV ring bus and install two 7.5 MVAR switched capacitor banks with individual circuit switchers for each bank at Turley Substation;
- Construct a single circuit 230 kV line from the 230 kV bus at Turley Substation to the proposed Iron Horse Substation (approximately 28 miles);
- Install a 230 kV line circuit breaker and two 230-115 kV, 200-225 MVA autotransformers with circuit switchers at Iron Horse Substation;

- Construct additions to the 115 kV system serving LPEA as described for the San Juan-Glade Tap-Iron Horse 230 kV system in the Study Report.

Ojo East-Turley-Iron Horse 230 kV System

Study Results and Discussion

TOT2A Phase Shifters Off

Appendix E includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are not in use. In all cases, the NLTC settings on the Hesperus 345-115 kV transformers have been set at .95 to provide a voltage boost to the 115 kV system, the Hesperus-Durango 115 kV line has been uprated and the Durango-Bayfield 115 kV line has been rebuilt. These diagrams include the proposed Ojo East-Turley-Iron Horse 230 kV system. The Turley phase shifters are set to schedule 250 MW to LPEA. Approximately 275 MW is delivered at Ojo East for the LPEA and northern New Mexico loads.

Power flow 21hsSJPSOSIHsc2 is the base case. This case shows a schedule of 274 MW from the Ojo East 230 kV bus with approximately 247 MW of this schedule flowing into the LPEA system at Iron Horse Substation. Cases 21hsSJPSOSIHsc3 through 21hsSJPSOSIHsc13 deal with single contingency outages on the 115 kV system in the LPEA service area. Cases 21hsSJPSOSIHsc14 through 21hsSJPSOSIHsc15 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. (Not all of these cases were run for this scenario.) Some cases such as Cases 21hsSJPSOSIHsc6, 7 and 16 indicate overloads on the Hesperus-Durango-Bayfield-Florida River 115 kV loop. These case were run prior to the determination of the need to rebuild rather than just uprate the Durango-Bayfield 115 kV line and with a 128 MVA, 50 °C rating, rather than the subsequently determined 195 MVA, 75 °C rating, for the LPEA Hesperus-Florida River-AM East 115 kV line.

Case 21hsSJPSOSIHsc16 is interesting in that it shows for an outage on the 230 kV line supplying Iron Horse Substation, the LPEA load is thrown back onto the TOT2A system. This is similar to the results shown for Case Power flow 21hsSJPSO230SJGTIH17 in the Study Report. However, the miles of 230 kV line exposed to this potential outage is only about 70 for the San Juan-Glade Tap-Iron Horse alternative while for the Ojo East-Turley-Iron Horse alternative there are about 110 miles of 230 kV transmission line from the source at Ojo East to Iron Horse Substation.

Cases 21hsSJPSOIHsc20 through 23 review the impact of the loss of the 345 kV lines at Ojo East Substation. Case 21hsSJPSOIHsc20 indicates a drop in the 345 kV voltage to .93 per unit for the San Juan-Ojo East 345 kV line single contingency. Installation of 165 MVAR of capacitors on the 345 kV bus at Ojo East can bring the voltage for this outage back to almost the nominal value as shown in Case 21hsSJPSOIHsc21a. Because of the significance of these 345 kV lines to PNM, enough shunt capacitors were included in the cost estimate for this option to maintain the voltage near unity when this outage occurs. Also, this alternative places about 250 MW more on the WECC Path 48, Northern New Mexico, flow gate than does the San Juan-Glade Tap-Iron Horse 230 kV option. The existing simultaneous rating is about 1800 MW which is only about 70 MW more than the tabulated power flow in Case 21hsSJPSOSIHsc2. Because of the uncertainty of the impact of the Ojo East-Rio Puerco 345 kV project on the existing rating of this path, no additional cost for increasing the capacity on Path 48 was assigned to this alternative to serve the LPEA large load request in this report. However, if this alternative was pursued, cost responsibility for increasing the capability of Path 48 may possibly result.

TOT2A Phase Shifters On North

Appendix F includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed north with a 300 MW transfer across TOT2A. Local conditions for the LPEA 115 kV system are as previously described. These diagrams include the proposed Ojo East-Turley-Glade Tap-Iron Horse 230 kV system with a schedule of 250 MW to LPEA.

Power flow 21hsSJPSNIHsc2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 35 to39° to maintain the 300 MW north transfer while the Glade Tap phase shifting angle is 65° to maintain a schedule to LPEA. As 60° could be the likely maximum angle for the Turley phase shifter, the power transfer to LPEA would probably only be about 240 MW, similar to the value shown in case 21hsSJPSN230SJGTIH2 in the Study Report, rather than the 247 MW shown in the power flow diagram. Case 21hsSJPSNIHsc6 shows a maximum angle of 75° on the Turley phase shifter for the LPEA local 115 kV single contingency loss of the Iron Horse-AM East 115 kV line. If a maximum phase shift angle of 60° is used, the power transfer would likely be similar to the 210 MW flow shown in case 21hsSJPSN230SJGTIH6 in the Study Report. The impact of the limit on the phase shifting angle is shown in the following Table Two for the Ojo East and San Juan 230 kV alternatives:

Table Two
Comparison of Phase Shift Angle and Power Transfer

Case	Outage	Ojo East-Iron Horse PS Angle	Turley-Iron Horse MW	San Juan-Iron Horse PS Angle	Coyote Gulch-Iron Horse MW
2	System Normal	64.8 °	250	60.0 °	240
3	Florida River-Hesperus	66.0 °	250	60.0 °	240
6	Iron Horse-AM East	75.0 °	249	60.0 °	209
7	Durango-Grandview	60.8 °	250	57.5 °	249

The above tabulated data indicates that for single contingencies on the 115 kV system near the Iron Horse 230 kV source when the TOT2A phase shifters are pointed north, consideration should be given as to whether a higher maximum angle for the phase shifters needed for this project than the 60° angle used for the San Juan-Glade Tap-Iron Horse 230 kV option in the Study Report is desirable.

Cases 21hsSJPSNIHsc14 through 21hsSJPSNIHsc15 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. The TOT2A phase shifters are locked in their pre-outage phase angle for these cases. Cases 21hsSJPSNIHsc20 through 23 review the impact of the loss of the 345 kV lines at Ojo East Substation. Case 21hsSJPSNIHsc20 indicates a drop in the 345 kV voltage to .95 per unit at Ojo East Substation for the San Juan-Ojo East 345 kV line single contingency even with use of the 165 MVAR of capacitors.

<u>TOT2A Phase Shifters On South</u>

Appendix G includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed south with a 350 MW transfer across TOT2A. Local conditions for the LPEA 115 kV system are as previously described. These diagrams include the proposed Ojo East-Turley-Glade Tap-Iron Horse 230 kV system with a schedule of 250 MW to LPEA.

Power flow 21hsSJPSSIHsc2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 42 to 44° to maintain the 350 MW south transfer while the Turley phase shifting angle is -4° to maintain a schedule to LPEA. With the TOT2A south scenario another 50 MW of power flow is placed on the WECC Path 48 flow gate as compared to when the TOT2A phase shifters are off. Cases 21hsSJPSNIHsc14 through 21hsSJPSNIHsc16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. Again, the TOT2A phase shifters are locked in their pre-outage phase angle for these cases.

As shown by case 21hsSJPSSIHsc16, the existing TOT2A system could supply the LPEA requirements through Hesperus for this contingency but the TOT2A transfer capability would be reduced by about 100 MWs from the initial schedule of 350 MWs to maintain a limit of 690 MWs on TOT2A south of Montrose, Colorado, *i.e.* TOT2A'. Cases 21hsSJPSSIHsc20 through 23 review the impact of the loss of the 345 kV lines at Ojo East Substation. Case 21hsSJPSSIHsc20a indicates a drop in the 345 kV voltage to .945 per unit at Ojo East Substation for the San Juan-Ojo East 345 kV line single contingency even with use of the 165 MVAR of capacitors.

As noted, Figure3 in Appendix A provides a one-line diagram of the proposed Ojo East-Turley-Iron Horse 230 kV system. An estimate of the cost to construct this option is included as Table 2 in Appendix A. The initial cost to provide service to the LPEA and

Southwest Colorado area is 156 million dollars. The total estimate which includes integrating Tri-State Member load in Northern New Mexico into this option is 178 million dollars.

San Luis Valley-Chama-Iron Horse 230 kV System

System Description

Figure 4 in Addendum Report Appendix A provides a one-line diagram of the proposed San Luis-Chama-Iron Horse 230 kV system. Essentially, this is a radial 230 kV line originating at the 230 kV bus at the San Luis Substation located north of Alamosa, Colorado. From that location, a 230 kV transmission line between San Luis Substation and a new substation near Chama, New Mexico was modeled. Generally, this line was assumed to proceed in a southern direction to the Colorado border and then proceed west to Chama. To do so, portions of the corridor would likely be in the Carson National Forest. At Chama Substation phase shifting transformers and a 75 MVA, 230-69 kV transformer was assumed to serve the Dulce-Chama areas. Approximately 25 MW was assumed to be scheduled into the Dulce/Chama area.

From Chama Substation the 230 kV line was assumed to continue in a northwesterly direction to about the vicinity of Trujillo, Colorado where a 150 MVA, 230-115 kV transformer was assumed to source a new 115 kV line connected to Tri-State's Pagosa Substation. This portion of the route may partly pass through the San Juan National Forest. Tri-State's existing Pagosa to Bayfield transmission line was assumed to be reconductored to accommodate the possible power flow from the Trujillo transformer. . A 175 MVAR series capacitor for the 230 kV line were assumed to be installed at Trujillo Substation to provide a constant input of 250 MW into the LPEA service area. The 230 kV line was assumed to proceed west from the proposed Trujillo Substation to terminate at the proposed Iron Horse Substation. Redundant transformers and phase shifters were assumed to provide the highest level of security.

San Luis Valley-Chama-Iron Horse 230 kV System

Facility Additions

The following major additions to the transmission system from San Luis Substation through northern New Mexico to Iron Horse Substation comprise the San Luis-Chama-Iron Horse 230 kV system:

- Add another 230 kV circuit breaker in an assumed five breaker ring bus at San Luis Substation with 90 MVAR of 115 kV shunt capacitors;
- Construct a single circuit 230 kV line from the 230 kV bus at San Luis Substation to the proposed Chama Substation (approximately 84 miles);

- Install two 230 KV phase shifters with a capacity of 200 MVA with associated 230 kV circuit breakers at Chama Substation for parallel use to serve the LPEA loads;
- Construct a 230 kV distribution substation with 230 kV line switches near Lumberton, New Mexico to serve the Dulce area loads;
- Construct a single circuit 230 kV line from the 230 kV bus at the proposed Chama Substation to the proposed Trujillo Substation (approximately 51 miles);
- Install a 175 MVAR series capacitor with associated 230 kV circuit breakers at Trujillo Substation to allow for transfer of 250 MW to serve the LPEA loads;
- Install a 150 MVA, 230-115 kV transformer and a three breaker 115 kV ring bus and install a 15 MVAR and two 7.5 MVAR switched capacitor banks with individual circuit switchers for each bank at Trujillo Substation;
- Construct a single circuit 115 kV line from Trujillo Substation to Pagosa Substation (approximately 9 miles);
- Reconductor the existing Tri-State 115 kV line from Pagosa Substation to Bayfield Substation (approximately 39 miles);
- Construct a single circuit 230 kV line from the 230 kV bus at Trujillo Substation to the proposed Iron Horse Substation (approximately 36 miles);
- Install a 230 kV line circuit breaker and two 230-115 kV, 200 MVA autotransformers with circuit switchers at Iron Horse Substation;
- Construct additions to the 115 kV system serving LPEA as described for the San Juan-Glade Tap-Iron Horse 230 kV system in the Study Report.

San Luis Valley-Chama-Iron Horse 230 kV System

Study Results and Discussion

TOT2A Phase Shifters Off

Appendix H includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are not in use. In all cases, the NLTC settings on the Hesperus 345-115 kV transformers have been set at .95 to provide a voltage boost to the 115 kV system, the Hesperus-Durango 115 kV line has been uprated and the Durango-Bayfield 115 kV line has been rebuilt. These diagrams include the proposed San Luis-Chama-Trujillo-Iron Horse 230 kV system. The Trujillo phase shifters are set to schedule 250 MW to LPEA. Approximately 286 MW is delivered at San Luis Substation for the LPEA and northern New Mexico loads.

Power flow 21hsSJPSOSLCHTIH2 is the base case. This case shows a schedule of 286 MW from the San Luis 230 kV bus with approximately 170 MW of this schedule flowing into the LPEA system at Iron Horse Substation, 72 MW being delivered at the Pagosa Substation 115 kV bus, and 25 MW of delivery into the 115 kV system in northern New Mexico. Cases 21hsSJPSOSLCHTIH3 through 21hsSJPSOSLCHTIH13 deal with single contingency outages on the 115 kV system in the LPEA service area. Cases 21hsSJPSOSLCHTIH14 through 21hsSJPSOSLCHTIH16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. Case 21hsSJPSOSLCHTIH17 is interesting in that it shows for an outage on the 230 kV line between Trujillo and Iron Horse Substation, approximately 160 MW of the schedule to LPEA can still be maintained through the Pagosa Substation 115 kV system. However, for outages on the 230 kV system beyond Trujillo, the LPEA load is thrown back onto the TOT2A system. This is similar to the results shown for Case Power flow 21hsSJPSO230SJGTIH17 in the Study Report.

While the miles of 230 kV line exposed to this potential outage is only about 70 for the San Juan-Glade Tap-Iron Horse alternative the line length between San Luis Substation and Iron Horse Substation is estimated at about 172 miles of 230 kV transmission line. With the previously noted Pagosa 115 kV path, the 36 miles of line between Trujillo and Iron Horse Substations does not risk all of the transfer. However, the transfer is dependent on the availability of transmission lines beyond San Luis Substation for this alternative. Cases 21hsSJPSOSLCHTIH20 through 22 review the impact of the loss of the 230 kV lines that provide a source to San Luis Substation as well as the availability of two 230 kV lines between Walsenburg Substation and Xcel's Comanche Generating Station. Loss of either the Walsenburg to San Luis, case 21hsSJPSOSLCHTIH20, or the Poncha to San Luis, case 21hsSJPSOSLCHTIH21, 230 kV lines reduces the transfer capability by about 30 MW.

TOT2A Phase Shifters On North

Appendix L includes the selected power flow plots for outages on the LPEA 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed north with a 300 MW transfer across TOT2A. Local conditions for the LPEA 115 kV system are as previously described. These diagrams include the proposed San Luis-Chama-Trujillo-Iron Horse 230 kV system with a schedule of 250 MW to LPEA.

Power flow 21hsSJPSNSLCHTIH2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 17 to 22° to maintain the 300 MW north transfer while the Chama phase shifting angle is 56° to maintain the schedule to LPEA. A maximum 60° phase shifting angle was assumed for the Chama phase shifter. Case 21hsSJPSNSLCHTIH4 through 6 shows the maximum angle of 60° was achieved on the Chama phase shifter for the LPEA local 115 kV single contingencies near Iron Horse Substation.

Cases 21hsSJPSNSLCHTIH14 through 21hsSJPSNSLCHTIH16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. The TOT2A phase shifters are locked in their pre-outage phase angle for these cases. Case 21hsSJPSNSLCHTIH15 shows an overload of the 300 MVA 345-230 kV transformer at Shiprock Substation, which does not occur for the San Juan-Glade Tap-Iron Horse alternative but may do so if the termination is moved from San Juan to

Shiprock. Case 21hsSJPSNSLCHTIH18 indicates the need to open the source to the Tierra Amarillo, *i.e.* El Vado, area 69 kV system when the 230 kV line is out-of-service between Chama and Trujillo Substations to prevent power trying to flow west to the San Juan area and overloading the 69 kV system.

<u>TOT2A Phase Shifters On South</u>

Appendix J includes the selected power flow plots for outages on the existing115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed south with a 350 MW transfer across TOT2A. Local conditions for the LPEA 115 kV system are as previously described. These diagrams include the proposed San Luis-Chama-Trujillo -Iron Horse 230 kV system with a schedule of 250 MW to LPEA.

Power flow 21hsSJPSSSLCHTIH2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 57 to 59°, near their maximum of 60°, to maintain the 350 MW south transfer while the Chama phase shifting angle is -22° to maintain a schedule to LPEA. Cases 21hsSJPSSSLCHTIH14 through 21hsSJPSSSLCHTIH16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. Again, the TOT2A phase shifters are locked in their pre-outage phase angle for these cases.

Case 21hsSJPSSSLCHTIH17 demonstrates that an outage of the Trujillo-Iron Horse section of the 230 kV line from San Luis Substation still allows about two-thirds of the schedule to be delivered to LPEA. As shown by case 21hsSJPSSSLCHTIH18 the existing TOT2A system could supply the LPEA requirements through Hesperus for the single contingency loss of the 230 kV line between San Luis and Trujillo but the TOT2A transfer capability would be reduced by about 100 MWs from the initial schedule of 350 MWs to maintain a limit of 690 MWs on TOT2A south of Montrose, Colorado, *i.e.* TOT2A'.

Cases 21hsSJPSOSLCHTIH20 through 22 demonstrate the impact of the loss of the 230 kV lines that provide a source to San Luis Substation as well as the availability of two 230 kV lines between Walsenburg Substation and Xcel's Comanche Generating Station. For the TOT2A phase shifters pointed south scenario, the loss of the Walsenburg to San Luis 230 kV line, case 21hsSJPSSSLCHTIH20, reduces the transfer capability by about 60 MW due to voltage regulation considerations in the San Luis Valley. This would imply the need to add more shunt capacitor banks in this area to increase the transfer capacity but this adjustment was not made in the cost estimate for this alternative.

As previously noted, Figure 4 in Appendix A provides a one-line diagram of the proposed San Luis-Chama-Trujillo -Iron Horse 230 kV system. An estimate of the cost to construct this option is included as Table 3 in Appendix A. The initial cost to provide service to the LPEA and Southwest Colorado area is 173 million dollars. The total estimate which includes integrating Tri-State Member load in Northern New Mexico into this option is 195 million dollars.

Rifle-Curecanti (345 kV)-Montrose-Nucla-Florida River 230 kV System

System Description

Figure 5 in Addendum Report Appendix A provides a one-line diagram of the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system. Essentially, this is a radial 230 kV line originating at the 230 kV bus at Curecanti Substation located east of Montrose, Colorado. A 230 kV transmission line from Curecanti Substation to a point southwest of Montrose, Colorado was assumed to be built on an existing 115 kV transmission line corridor. A 100 MVA, 230-115 kV transformer and a 230 kV ring bus was assumed to be installed at or near the Tri-State's existing South Canal Substation to provide a source for the 115 kV loads normally served by that substation. Southwest of Montrose, the 230 kV line was assumed to be built in Tri-State's existing 115 kV line corridor to Nucla and then through Tri-State's existing Cahone and Empire Substation to terminate on a new 230 kV substation near LPEA's existing Florida River Substation. South of Empire Substation, near the existing Lost Canyon 230-115 kV Substation, the 230 kV line was assumed to be a double circuit configuration with one side operated at 115 kV so that the existing 115 kV line between Lost Canyon and Durango Substations as well as between Hesperus and Florida River Substations could be maintained. The existing Nucla, Cahone, and Empire 115 kV substations south of Montrose were assumed to be sourced from 100 MVA, 230-115 kV transformer and a 230 kV ring bus at each location. Series compensation of 224 MVARs for the 230 kV line were assumed to be installed at Empire Substation to provide a reduced impedance on this transmission line for power input into the LPEA service area.

South of Curecanti Substation, connections were avoided between this proposed 230 kV transmission line and the existing TOT2A transmission lines to provide an independent path for delivery of power to LPEA. No phase shifting transformers were used for this alternative as it originates and terminates north of the TOT2A boundary and because of the high expected cost for this alternative. An assumption of double circuit construction was used on some portions of this alternative because of existing corridors appearing to be at least partially within national forests and the need to maintain 115 kV sources. No 115 kV transmission line was assumed between Iron Horse and the proposed 115 kV Turley Substation for this alternative. However, segments of the Turley to Dulce/Chama area transmission system included in the estimates for the San Juan-Glade Tap-Iron Horse 230 kV alternative were included in the cost estimates for this alternative to ensure a reasonable comparison to the other alternatives for service to Northern New Mexico loads. For this alternative, the Turley area transmission system was assumed to be served through a wheeling arrangement with the COF although no costs were assigned for this assumption.

Rifle-Curecanti (345 kV)-Montrose-Nucla-Florida River 230 kV System

Facility Additions

The following major additions to the transmission system from Curecanti through to Iron Horse Substation comprise the Curecanti-Montrose-Nucla-Iron Horse 230 kV system:

- Add another 230 kV circuit breaker into a six breaker ring bus at Curecanti Substation;
- Construct a single circuit 230 kV line from the 230 kV bus at Curecanti Substation to the existing South Canal Substation (approximately 18 miles);
- Install a 100 MVA, 230-115 kV transformer and a three breaker 230 kV ring bus and re-use existing 115 kV line breakers at South Canal Substation;
- Construct a single circuit 230 kV line from the existing South Canal Substation to Nucla Substation (approximately 62 miles);
- Install a 100 MVA, 230-115 kV transformer and a three breaker 230 kV ring bus and re-use an existing 115 kV line breaker at Nucla Substation;
- Construct a single circuit 230 kV line from the existing Nucla Substation to Cahone Substation (approximately 44 miles);
- Install a 100 MVA, 230-115 kV transformer and a three breaker 230 kV ring bus and re-use an existing 115 kV line breaker at Cahone Substation;
- Construct a single circuit 230 kV line from the existing Cahone Substation to about 1.5 miles from Empire Substation and then a double circuit 230/115 kV line to Empire Substation (approximately total 20 miles);
- Install a 224 MVAR series capacitor with associated 230 kV circuit breakers at Empire Substation to allow for a transfer of up to 250 MW to serve the LPEA loads;
- Install a 100 MVA, 230-115 kV transformer and a three breaker 230 kV ring bus and install three 15 MVAR and two 7.5 MVAR switched capacitor banks with individual circuit switchers for each bank at Empire Substation;
- Construct a single circuit 230 kV line from Empire Substation to the vicinity of Lost Canyon Substation, about 9 miles, and then a double circuit 230/115 kV line to the vicinity of Shenandoah Substation, approximately 26 miles, from that location construct a single circuit 230 kV line to about the vicinity of Hesperus Substation, about 5 miles, and then a double circuit 230/115 kV line to terminate at Florida River, approximately 17 miles, (total length approximately 57 miles);
- Install a 230 kV line circuit breaker and two 230-115 kV, 200 MVA autotransformers with circuit switchers at Florida River Substation;
- Uprate from a 75 °C to 100 °C thermal limitation the existing LPEA 115 kV line from Florida River Substation to the proposed Iron Horse 115 kV Substation (approximately 13 miles);
- Construct Iron Horse Substation as a 115 kV substation with a four breaker ring bus;
- Construct additions to the 115 kV system serving LPEA as described for the San Juan-Glade Tap-Iron Horse 230 kV system in the Study Report.

Rifle-Curecanti (345 kV)-Montrose-Nucla-Florida River 230 kV System

Study Results and Discussion

TOT2A Phase Shifters Off

Appendix K includes the selected power flow plots for outages on the LPEA 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are not in use. In all cases, the NLTC settings on the Hesperus 345-115 kV transformers have been set at .95 to provide a voltage boost to the 115 kV system, the Durango-Bayfield 115 kV line has been rebuilt but the Hesperus-Durango 115 kV line was not uprated These diagrams include the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system. In this instance, the proposed 230 kV line is a part of TOT2A' as it replace the existing Montrose to Nucla 115 kV line. Its impact is included within the TOT2A data.

Power flow 21hsSJPSOCFR2 is the base case. Approximately 84 MW is delivered at Florida River Substation for the LPEA loads. The TOT2A line flows for this case are very similar to that for case 21hsSJPSO2 for the existing system. Essentially, about 25 MW of flow is transferred north of TOT2A for this alternative compared to the previously described existing system scenario. This alternative does unload the existing 345 and 230 kV lines which are part of TOT2A by moving approximately 65 MW relative to the existing system case onto the Montrose to Nucla line corridor. Cases 21hsSJPSOCFR3 through 21hsSJPSOCFR13 deal with single contingency outages on the 115 kV system in the LPEA service area. Cases 21hsSJPSOCFR14 through 21hsSJPSOCFR16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. (Not all of these cases were run for this scenario.) Case 21hsSJPSOCFR4, 5, and 10 show the need to uprate the Durango-Hesperus 115 kV line for this alternative. Case 21hsSJPSOCFR7 and 8 show the need to uprate the Florida River-Rock Ranch-Iron Horse 115 kV line for this scenario. An alternative would be to move the 230 kV source at Florida River further east to Iron Horse Substation. This would save some substation costs but increase the cost for line construction by adding another 13 miles of likely double circuit 230 kV transmission line for this alternative. Case 21hsSJPSOCFR15 for the outage of the Montrose-Hepsperus 345 kV line does show an additional 40 MW being delivered to Florida River Substation through the Curecanti-Montrose-Nucla-Iron Horse 230 kV system so this alternative does provide some support to the existing TOT2A system for contingencies.

Case 21hsSJPSOSLGUCFR2 is a base case, i.e. system intact, power flow diagram for the addition to the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system of a 230 kV line from the previously noted San Luis Substation to a new Gunnison 230 kV Substation on WAPA's existing Midway-Curecanti 230 kV line. This was reviewed in the study to determine if providing additional power flow capability to Curecanti Substation would significantly improve the power flow over the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system. While it did add a modest ten percent increase to the power delivered at Florida River Substation compared to Case

21hsSJPSOCFR2, it also would add an estimated 52 million dollars to the cost of this alternative.

Case 21hsSJPSORC345CFR2 is a base case, i.e. system intact, power flow diagram for the addition to the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system of the rebuilding of WAPA's existing Rifle-Curecanti 230 kV line to 345 kV operation and installation of a 345-230 kV transformer at Curecanti Substation. Again, this was reviewed to determine if providing additional power flow capability to Curecanti Substation would significantly improve the power flow over the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system. This addition only added a few MW of increased power delivery at Florida River Substation compared to Case 21hsSJPSOCFR2. It would add an estimated 88 million dollars to the cost of this alternative.

The line length between Curecanti and Florida River Substation is estimated at about 201 miles of 230 kV transmission line as compared to about 70 miles of 230 kV line exposed to a potential outage for the San Juan-Glade Tap-Iron Horse alternative.

<u>TOT2A Phase Shifters On North</u>

Appendix L includes the selected power flow plots for outages on the LPEA 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed north with a 300 MW transfer across TOT2A. Local conditions for the LPEA 115 kV system are as previously described. These diagrams include the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system.

Power flow 21hsSJPSNSOCFR2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 12 to 18° to maintain the 300 MW north transfer. In this case, the 230 kV input at Florida River Substation is about the same as described for the case with the TOT2A phase shifters off.

Cases 21hsSJPSNCFR3 through 21hsSJPSNCFR13 deal with single contingency outages on the 115 kV system in the LPEA service area. Cases 21hsSJPSNCFR14 through 21hsSJPSNCFR16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. The results for these cases are very similar to that found with the TOT2A phase shifters off.

<u>TOT2A Phase Shifters On South</u>

Appendix M includes the selected power flow plots for outages on the existing 115 kV system and the high voltage, 345 and 230 kV, system serving LPEA when the TOT2A phase shifters at Shiprock and San Juan are pointed south with a 250 MW transfer across TOT2A. Local conditions for the LPEA 115 kV system are as previously described. These diagrams include the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system.

Power flow 21hsSJPSSCFR2 is the base case. The San Juan and Shiprock phase shifters have a phase shifting angle of about 51 to 55°, near their maximum of 60°, to maintain a 255 MW south transfer. In this instance, the power delivered at 230 kV to Florida River Substation has increased by about 40 MW compared to case 21hsSJPSOCFR2 with the TOT2A phase shifters off. The tabulated power flow on TOT2A' is 710 MW which is above its existing 690 MW limitation even though only 250 MW is delivered across TOT2A. Power flow 21hsSJPSSCFR2a demonstrates that the power delivered to Florida River on the Curecanti-Montrose-Nucla-Florida River 230 kV system declines by about 30 MW if the series compensation is removed. Cases 21hsSJPSSCFR3 through 21hsSJPSSCFR13 deal with single contingency outages on the 115 kV system in the LPEA service area. Case 21hsSJPSSCFR4, 5, and 10 again reinforce the need to uprate the Durango-Hesperus 115 kV line for this alternative. For case 21hsSJPSSCFR4 the rebuilt Durango-Bayfield 115 kV is slightly overloaded on the Durango to Grandview section of this line. Consistently for these cases, TOT2A' exceeds its 690 MW limit even with only about 250 MW delivered across TOT2A. Case 21hsSJPSSCFR7 and 8 show the need to uprate the Florida River-Rock Ranch-Iron Horse 115 kV line for this scenario. Cases 21hsSJPSSCFR14 through 21hsSJPSSCFR16 tabulate the results of an outage on various sections of the 345 kV line component of the TOT2A transmission system. Again, the TOT2A phase shifters are locked in their pre-outage phase angle for these cases.

Case 21hsSJPSSLGUCFR2 is a base case, i.e. system intact, power flow diagram for the addition to the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system of a 230 kV line from the previously noted San Luis Substation to a new Gunnison 230 kV Substation on WAPA's existing Midway-Curecanti 230 kV line. While it did add a few MW to the power delivered at Florida River Substation compared to Case 21hsSJPSSCFR2, it also significantly increases the cost of this alternative.

Case 21hsSJPSSRC345CFR2 is a base case, i.e. system intact, power flow diagram for the addition to the proposed Curecanti-Montrose-Nucla-Florida River 230 kV system of the rebuilding of WAPA's existing Rifle-Curecanti 230 kV line to 345 kV operation and installation of a 345-230 kV transformer at Curecanti Substation. Again, this addition only added a few MW of increased power delivery at Florida River Substation compared to Case 21hsSJPSSCFR2 but at a significantly greater cost for this alternative.

Figure 5 in Appendix A provides a one-line diagram of the proposed San Juan-Glade Tap-Iron Horse 230 kV system. An estimate of the cost to construct this option is included as Table 4 in Appendix A. The initial cost to provide service to the LPEA and Southwest Colorado area is 189 million dollars. The total estimate which includes integrating Tri-State Member load in Northern New Mexico into this option is 233 million dollars.

Impact on Other Transmission

The primary interest in monitoring the impacts of the proposed transmission system for the LPEA area on critical transmission paths was the Northern New Mexico flow gate. This was an important consideration as alternatives to the preferred option included connecting to PNM's 345 kV system at the proposed Ojo East Substation near Gavilan, New Mexico. Connection to the Path 48 transmission system at that location and providing a power schedule of 275 MW to LPEA and other Tri-State northern New Mexico Member loads through a high voltage substation near Turley, New Mexico would increase the base case loading on Path 48 by about 260 MW and put the peak load flow close to the existing path rating of 1800 MW. This rating limitation on Path 48 was an initial consideration in gauging the amount of power that could be transferred into the LPEA area from the south. The preferred alternative has significantly less impact on Path 48 as shown in Table Three.

Other critical paths impacted by TOT2A were also monitored as shown in Table Three. The flows shown on Path 30, TOT1A, differ from the tabulations shown on the power flow diagrams because the sum used on the diagram designated data tabulation for the Rangely to Meeker 138 kV line as described in the WECC Path Rating Catalogue. However, this line does not exist in the power flow case as it has been changed by the addition of two substations, i.e. buses, for new industrial loads in the area served by White River Electric Association, Inc. north of Rifle, Colorado. No load was shown on these new buses in the power flow case. For TOT2B, the phase shifters at Pinto Substation and Sigurd Substation were off in the WECC 2016 HS base case and left in that mode for this study. For TOT2C, the phase shifters at Harry Allen Substation were set for importing 196 MW to the north in the WECC 2016 HS base case and left in that mode for this study. Under these conditions, no significant impact was found for these flow gates in the study.

Table 3
Base Case with 2021 Loads
Loading on Selected Critical Transmission Paths

Path 31 TOT2A North-South Power Flow Scenario	Path 30 TOT1 East-West (650 MW Limit) Load Level	Path 35 TOT2C North-South (300 MW Limit) Load Level	Path 36 TOT3 North-South (1605 MW Limit) Load Level	Path 48 Northern New Mexico (1800 MW Limit) Load Level	Paths 78&79 TOT2B South-North (600 MW Limit) Load Level
Existing System					
226 MW	-17 MW	-196 MW	1226 MW	1547 MW	263 MW
-210 MW	215 MW	-198 MW	1107 MW	1488 MW	86 MW
-301 MW	251 MW	-196 MW	1086 MW	1480 MW	53 MW
San Juan-Iron Horse Alternative					
351 MW	107 MW	-196 MW	1185 MW	1515 MW	200 MW
29 MW	245 MW	-196 MW	1100 MW	1474 MW	71 MW
-302 MW	372 MW	-196 MW	1019 MW	1441 MW	-48 MW
Ojo East-Iron Horse Alternative					
350 MW	41 MW	-196 MW	1196 MW	1779 MW	211 MW
9 MW	224 MW	-196 MW	1102 MW	1735 MW	71 MW
-301 MW	372 MW	-196 MW	1024 MW	1704 MW	-45 MW
San Luis-Iron Horse Alternative					
350 MW	-65 MW	-196 MW	1283 MW	1586 MW	307 MW
-136MW	172 MW	-196 MW	1165 MW	1497 MW	121 MW
-300 MW	245 MW	-196 MW	1130 MW	1476 MW	62 MW
Curecanti-Florida River Alternative					
255 MW	-25 MW	-196 MW	1229 MW	1551 MW	271 MW
-183MW	206 MW	-197 MW	1111 MW	1491 MW	93 MW
-300 MW	262 MW	-196 MW	1080 MW	1479 MW	48 MW