TRANSMISSION SERVICE REQUEST

Shiprock 345 kV to Navajo 500 kV

(TSR Arefs: 76248667, 76248674, 76248678, 76248680, & 76248685)

Desert Southwest Region

January 29, 2013
# TABLE OF CONTENTS

1 EXECUTIVE SUMMARY ........................................................................................................... 2

2 INTRODUCTION .......................................................................................................................... 6

3 RESULTS ..................................................................................................................................... 8

4 COST AND SCHEDULE ESTIMATES ......................................................................................... 12

5 CONCLUSIONS .......................................................................................................................... 14
1 EXECUTIVE SUMMARY

A Transmission Service Requesting Customer (Customer) has submitted to the Western Area Power Administration (Western) five requests for Point-to-Point Transmission Service that can be identified by their Aref numbers 76248667, 76248674, 76248678, 76248680, and 76248685. These Transmission Service Requests (TSRs), which range from 100 MW to 500 MW, each requested the Shiprock 345 kV station as its Point of Receipt (POR) and the Navajo 500 kV station as its Point of Delivery (POD). Because these five TSRs are for a Western transmission scheduling path that does not exist today, a Transmission Service Request (TSR) study was completed to obtain a high-level conceptual project that could modify the existing Western transmission system between the Shiprock 345 kV station and the Navajo 500 kV station in order to meet any of the five requests. This conceptual transmission project supports the delivery of additional schedules from any of the five TSRs.

Western’s Transmission Business Unit verified that there is insufficient ATC on the Colorado River Storage Project (CRSP) transmission system’s existing scheduling path from the Shiprock 345 kV station to the Navajo 230 kV station, which is adjacent the Navajo 500 kV station. Because there is insufficient ATC, the Shiprock 345 kV to Navajo 230 kV scheduling path would need to be modified. This modification could be done by rebuilding all of the existing Shiprock to Navajo 230 kV transmission line sections (including its three embedded load-serving stations) and/or by building a new Western-determined parallel line.

However, simply rebuilding the entire 183-mile line with each of its three embedded stations is not a valid option. Such an extensive rebuild of the existing single line 230kV system would approach or exceed the cost of a new line and would require more than one year of various construction outages of this system. This expected amount of extended construction outages to rebuild the single-line path would present an unacceptable operating risk for two primary reasons.

1) It would significantly disrupt the path’s through schedules --- especially given that this is Western’s only scheduling path between the northern and southern portions of its newly consolidated Rocky Mountain Region; and,

2) It would significantly disrupt the reliability and schedules to the path’s embedded loads; some of which are needed for the coal-fired Navajo Generating Station to which the TSRs are seeking an interconnection.

Therefore, the option of rebuilding the existing 230 kV transmission line would not seem practical compared to that for constructing a new parallel transmission line.
So, with respect to a new 230 kV transmission line project to meet any of the five TSRs, a list of the project’s major transmission facilities would include the following.

- **230 KV LINE** – A new single-circuit 230 kV transmission line would be constructed in parallel with (but not adjacent to) the nearly 200-mile existing single-circuit line between the Shiprock and Navajo stations. The new line is expected to have at least about a 600 MVA continuous rating to accommodate the amount of the TSR.

- **230 KV SERIES CAPACITORS** – A review of power flow studies for the existing 230 kV line, which has a high level of series compensation, indicates the expected need for a similar level of series compensation in a new parallel 230 kV line. The new line’s series capacitors are expected to have at least about a 600 MVA continuous rating to accommodate the amount of the TSR.

- **230 KV PHASE-SHIFTER** – A review of power flow studies for the existing 230 kV line, which has a 230 kV phase-shifting transformer at its west end, indicates an expected need for a similar 230 kV phase-shifting transformer in a new 230 kV line. The new phase-shifter is expected to have at least about a 600 MVA continuous rating to accommodate the amount of the TSR. The new 230 kV phase-shifting transformer would be installed in a new 230/500-kV station at the west end of the proposed new 230 kV line nearby the existing Navajo 500 kV station.

- **NAVAJO-END 230/500-KV SUBSTATION** – Unless arrangements can be made to fit a new 230/500-kV transformer into the existing Navajo 500 kV station, a new 230/500-kV transformer would be installed at the same new station as the new phase-shifting transformer at the west end of the proposed new 230 kV line. The new 230/500-kV transformer is expected to have at least about a 600 MVA top continuous rating to accommodate the amount of the TSR.

- **NAVAJO 500 KV TIE LINE** – Unless arrangements can be made to fit a new 230/500-kV transformer into the existing Navajo 500 kV station, a new 500 kV tie line (less than 2 miles long) of 2156 kcm ACSR in two conductors/phase bundles would be built from a new line bay within the existing Navajo 500 kV station to the proposed new 230/500-kV substation at the west end of the proposed new 230 kV line.

- **NAVAJO 500 KV BAY** – Build a new 500 kV bay within the Navajo 500 kV station for the new 500 kV tie line (or for the new 230/500-kV transformer, if arrangements can be made to fit the new transformer into the existing Navajo 500 kV station).
• SHIPROCK 230/345-KV TRANSFORMER – A new 230/345-kV transformer would be installed at the existing Shiprock station. A new 230/345-kV transformer is expected to have at least about a 600 MVA top continuous rating to accommodate the amount of the TSR.

• SHUNT REACTORS – A review of power flow studies for the existing 230 kV line indicates the expected need for new shunt reactors on the system. However, the number of shunt reactors, their respective voltages, and their respective sizes are yet to be determined.

The high-level conceptual cost estimate for the project’s major transmission facilities is at least about $382 million. Excluding activities for lands, environmental, non-Western interconnections, and path rating processes required by WECC or its subregional transmission planning groups; the project will take about 4 to 6 years (following the signing of an engineering/construction agreement with Western) until the project’s construction is completed and the project is placed into service. However, because of the project’s unique location, lands and environmental activities could add an uncertain number of additional years to the project’s estimated schedule.

The following items were not included in this TSR study, but would be required before a new Shiprock 345 kV to Navajo 500 kV transmission line project could become operational.

- Regional NERC/WECC processes for transmission facility planning, rating, and reporting (such as the WECC significant facility additions reporting processes, the WECC project rating processes, and so on).

- Subregional WestConnect transmission planning processes similar to those instituted by WECC.

- Official request to the owners of the Navajo Generation and Transmission system to interconnect the proposed 230 kV transmission line project to the existing Navajo 500 kV station via a new 230/500-kV transformer within the Navajo 500 kV station or via an alternative new short 500 kV tie line to the station.

- Interconnection Studies required by the Navajo Generating Station owners and/or by the Navajo 500 kV Transmission System owners to interconnect to its existing Navajo 500 kV Station.

- Cost estimates for environmental studies.

- Cost estimates for land acquisitions.
Full identification and resolution of any and all possible adverse system impacts on non-Western systems (such as Arizona Public Service Company, Salt River Project, and so on).

In addition, based upon Western’s experience, a new single-circuit 230 kV transmission line between the existing Shiprock 345 kV station and the existing Navajo 500 kV station would have these additional challenges.

- In order to meet interconnected system performance criteria for a single contingency outage of the project line itself, the project would very likely be required to operate within a yet to be determined operating nomogram that, depending on interconnected system conditions, would restrict the project from operating at a MW level that could adversely impact the reliability of the interconnected system and/or to implement a new generation-tripping Remedial Action Scheme (RAS) that would automatically mitigate any adverse system impacts created by the project’s single line outage. The primary adverse system impacts of concern caused by the outaged project line would be to parallel systems under interconnected system rating conditions for this portion of the interconnected system. (The parallel system ratings of concern would include the Four Corners transmission system.) So, a likely need for a new operating nomogram and/or a new generation-tripping RAS may lead to the conclusion to construct a second new single-circuit transmission line in order to avoid having to institute a new restrictive operating nomogram and/or a new generation-tripping RAS.

- However, although a double-circuit transmission line generally has a much lower installed cost per MW-mile than two independent single-circuit transmission lines; NERC transmission reliability requirements require a double-circuit line to pass the requirement for a simultaneous double-circuit line outage of itself. On the other hand, two independent single-circuit transmission lines that do not have any of the common failure modes specified in the NERC reliability requirements (i.e., bus section fault, non-bus-tie breaker fault, any fault together with a stuck non-bus-tie breaker, or delayed fault clearing due to a failure of a non-redundant relay) would not be required to pass a simultaneous forced double contingency outage of each of two independent single-circuit transmission lines.

- Because of its much higher MW capacity, preliminary high-level transmission cost estimates for a 345 kV or a 500 kV transmission circuit indicate that it could be a better value on a cost per MW-mile basis than a 230 kV circuit. However, a new single-circuit 345 kV or 500 kV project line would suffer from the same exposure to its own single
contingency line outage. So, this may also lead to a conclusion to construct two new independent single-circuit transmission lines rather than only one.

- Western’s relatively new consolidated Rocky Mountain operating region is the consolidation of its Desert Southwest operating region and (what is now) the northern portion of its consolidated Rocky Mountain operating region. However, today the only Western transmission asset connecting the northern and southern portions of its consolidated Rocky Mountain operating region is a single-circuit 230 kV transmission line between the existing Shiprock and Glen Canyon stations. Therefore, a 345 kV or a 500 kV transmission expansion between the Shiprock and Navajo systems would seem to be a much better modification to Western’s consolidated Rocky Mountain operating region than only the addition of a single-circuit 230 kV transmission line.

2 INTRODUCTION

A Transmission Service Requesting Customer (Customer) has submitted to the Western Area Power Administration (Western) five requests for Point-to-Point Transmission Service that can be identified by their Aref numbers 76248667, 76248674, 76248678, 76248680, and 76248685. These Transmission Service Requests (TSRs), which range from 100 MW to 500 MW, each requested the Shiprock 345 kV station as its Point of Receipt (POR) and the Navajo 500 kV station as its Point of Delivery (POD). Because these five TSRs are for a Western transmission scheduling path that does not exist today, a Transmission Service Request (TSR) study was completed to obtain a high-level conceptual project that could modify the existing Western transmission system between the Shiprock 345 kV station and the Navajo 500 kV station in order to meet any of the five requests.

Western’s Transmission Business Unit verified that there is insufficient ATC on the Colorado River Storage Project (CRSP) transmission system’s scheduling path from the Shiprock 345 kV station to the Navajo 230 kV station, which is adjacent the Navajo 500 kV station. Because insufficient ATC was available, options to rebuild the existing line or to build a new parallel line were explored. However, upgrading the entire 183-mile single-circuit line with each of its three embedded stations would require such an extensive rebuild of the existing single 230kV line path that it is expected to require more than one year of various construction outages of the existing path. Moreover, rebuilding the existing 183-mile line could cause many adverse system impacts. These anticipated adverse impacts to preserving reliable interconnected system operation are summarized immediately below.

Operation of the embedded load-serving systems would be at increased operating risk. The electric railroad that carries coal to the nearly 2400 MW Navajo power plant is fed from the Navajo 230 kV station, which is an embedded station on the 183-mile line. The Navajo 230 kV station is also connected to the 13.8 kV bus at the Navajo power plant. This interconnection is
used solely for providing start-up and emergency auxiliary power and energy to the Navajo Generating Station and transfers are limited to a maximum of 70 MW. Various NTUA loads, and in particular the Peabody Mines, are fed from the Kayenta 230 kV station, which is an embedded station near the middle of the 183-mile line. Various NTUA loads, including mining loads, are fed from the Long House Valley 230 kV station. The customer-funded upgrades to the existing Kayenta and Long House Valley 230 kV stations to improve transmission system reliability for the NTUA system would provide much less reliability improvement.

Operation of the newly consolidated Rocky Mountain Region would be at increased operating risk. The only Western scheduling path that connects its newly consolidated Rocky Mountain northern system with its southern system is the Shiprock/Glen Canyon 230 kV line. This single 230 kV line path has been so important to Western’s system operation that its nearly 200-mile line has been upgraded and operated with improved reactive power compensation, including a special advanced reactive power compensation system at the Kayenta Station which can series compensate the nearly 200-mile line by over 70%. A significant amount of shunt compensation has been installed and operated within the stations at each end of the nearly 200-mile line. A 350 MVA 230 kV phase-shifter has been installed and operated at the Glen Canyon end of the 200-mile line. And, a special fast automatic remedial operating action scheme has been installed in its Kayenta Advanced Series Compensation System to support the reliable operation of the neighboring systems, particularly the Four Corners/southwest path.

Operation of the large neighboring systems would be at increased operating risk. Parallel neighboring 500 kV and 345 kV systems with very significant large coal-fired power plants (such as Four Corners, Cholla, Coronado, Springerville) could be adversely impacted at times by the inadvertent flows created by schedule adjustments that would need to be made if this nearly 200-mile line were taken out of service for extended construction outages. There could be an increased possibility of the Four Corners generation dropping scheme being invoked.

In addition to the adverse system impacts, there are other significant issues with rebuilding the existing line. The existing right-of-way (ROW) is for 230 kV but has only about 125 feet. Through previous discussions with the Navajo Tribe, a new or wider ROW would be required for an uprated voltage. The existing steel towers do not have the capability to be upgraded to carry additional conductor weight or to accommodate increased phase spacing. Upgrading the line to operate at a higher voltage level would require replacement of all existing equipment (towers, conductor, insulators, and so on).

The amount of extended construction outages to rebuild the single-line path would not seem practical compared to the construction of a new parallel line. This report describes the high-level conceptual cost and schedule estimates for a project line with its major transmission facilities that would be needed to accommodate any of the five Transmission Service Requests (TSRs).
3 RESULTS
Without sufficient ATC on the existing 230 kV line between the Shiprock 345 kV station and the Navajo 230 kV station, to meet any of the Transmission Service Requests (TSRs), a new 230 kV line project would need to be built from the Shiprock 345 station to the Navajo 500 kV station. The new 230 kV line project, illustrated in Figure 1 on page 11, would be about 183 miles long and would include the construction of the following major transmission facilities:

- Install new 600 MVA Shiprock 230/345-kV transformer.
- Build new 183-mile 230 kV line from Shiprock to Navajo (1272kcm ACSS conductor).
- Install new series reactive compensation station in new 230 kV line.
- Install yet-to-be determined shunt reactive compensation.
- Build new 230/500-kV substation at west-end of new line nearby Navajo station.
- Install new 600 MVA 230/500-kV transformer in new 230/500-kV substation.
- Install new 600 MVA 230 kV phase-shifter in new 230/500-kV substation.
- Build new 500 kV tie line from new 230/500-kV substation to Navajo 500 kV station.

The following items were not included in this TSR study, but would be required before a new 230 kV transmission line project between Shiprock 345 kV and Navajo 500 kV could become operational.

- Regional NERC/WECC processes for transmission facility planning, rating, and reporting (such as the WECC significant facility additions reporting processes, the WECC project rating processes, and so on).
- Subregional WestConnect transmission planning processes similar to those instituted by WECC.
- Official request to the owners of the Navajo Generation and Transmission system to interconnect the proposed 230 kV transmission line project to the existing Navajo 500 kV station via a new 230/500-kV transformer within the Navajo 500 kV station or via an alternative new short 500 kV tie line to the station.
- Interconnection Studies required by the Navajo Generating Station owners and/or by the Navajo 500 kV Transmission System owners to interconnect to its existing Navajo 500 kV Station.
- Cost estimates for environmental studies.
- Cost estimates for land acquisitions.
Full identification and resolution of any and all possible adverse system impacts on non-Western systems (such as Arizona Public Service Company, Salt River Project, and so on).

In addition, based upon Western’s experience, a new single-circuit 230 kV transmission line between the existing Shiprock 345 kV station and the existing Navajo 500 kV station would have these additional challenges.

- In order to meet interconnected system performance criteria for a single contingency outage of the project line itself, the project would very likely be required to operate within a yet to-be-determined operating nomogram that, depending on interconnected system conditions, would restrict the project from operating at a MW level that could adversely impact the reliability of the interconnected system and/or to implement a new generation-tripping Remedial Action Scheme (RAS) that would automatically mitigate any adverse system impacts created by the project’s single line outage. The primary adverse system impacts of concern caused by the outaged project line would be to parallel systems under interconnected system rating conditions for this portion of the interconnected system. (The parallel system ratings of concern would include the Four Corners transmission system.) So, a likely need for a new operating nomogram and/or a new generation-tripping RAS may lead to the conclusion to construct a second new single-circuit transmission line in order to avoid having to institute a new restrictive operating nomogram and/or a new generation-tripping RAS.

- However, although a double-circuit transmission line generally has a much lower installed cost per MW-mile than two independent single-circuit transmission lines; NERC transmission reliability requirements require a double-circuit line to pass the requirement for a simultaneous double-circuit line outage of itself. On the other hand, two independent single-circuit transmission lines that do not have any of the common failure modes specified in the NERC reliability requirements (i.e., bus section fault, non-bus-tie breaker fault, any fault together with a stuck non-bus-tie breaker, or a delayed fault clearing due to a failure of a non-redundant relay) would not be required to pass a simultaneous forced double contingency outage of each of two independent single-circuit transmission lines.

- Because of its much higher MW rating, preliminary high-level transmission cost estimates for a 345 kV or a 500 kV transmission circuit indicate that it could be a better value on a cost per MW-mile basis than a 230 kV circuit. However, a new single-circuit 345 kV or 500 kV project line would suffer from the same exposure to its own single
contingency line outage. So, this may also lead to a conclusion to construct two new independent single-circuit transmission lines rather than only one.

- Western’s relatively new consolidated Rocky Mountain operating region is the consolidation of its Desert Southwest operating region and (what is now) the northern portion of its consolidated Rocky Mountain operating region. However, today the only Western transmission asset connecting the northern and southern portions of its consolidated Rocky Mountain operating region is a single-circuit 230 kV transmission line between the existing Shiprock and Glen Canyon stations. Therefore, a 500 kV transmission expansion between the Shiprock and Navajo systems would seem to be a much better modification to Western’s consolidated Rocky Mountain operating region than only the addition of a single-circuit 230 kV transmission line.
Figure 1

230 kV Transmission Line Project
(Shiprock 345 kV to Navajo 500 kV)
4 COST AND SCHEDULE ESTIMATES

A high-level conceptual cost estimate for the major facilities in the building of a new 230 kV transmission line project to meet any of the five Transmission Service Requests (TSRs) from the Shiprock 345 kV station to the Navajo 500 kV station is summarized in Table 1 below. Both the cost and schedule conceptual estimates are high-level, appropriate to a TSR study, and would be refined in the Facility Study phase.

The high-level conceptual cost estimate does not include estimates of any activities for land, environmental, interconnection, or path rating requirements.

Table 1 – Conceptual Cost Estimate of 230 kV Transmission Line Project

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est’d $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>new Shiprock 345/230-kV Transformer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>new 345/230-kV transformer (600 MVA) addition to Shiprock station</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>new 345kV transformer bay addition to Shiprock station</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>new 230kV transformer bay addition to Shiprock station</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est’d $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>new Shiprock/Navajo 230kV Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>new 230kV line section between Shiprock and Kayenta stations</td>
<td>105</td>
<td>158</td>
</tr>
<tr>
<td>new 230kV line section between Kayenta and Long House Valley stations</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>new 230kV line section between Long House Valley and Navajo stations</td>
<td>58</td>
<td>87</td>
</tr>
<tr>
<td>Total</td>
<td>183</td>
<td>275</td>
</tr>
</tbody>
</table>
new 230kV Series Capacitor Station  

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est'd $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>new 230kV Series Capacitor Station about midway along the new Shiprock/Navajo 230kV line (nearby Kayenta station) with about 70% series reactive compensation</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

new Navajo-end 500/230-kV Substation  

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est'd $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>new Navajo-end 500/230-kV substation nearby Navajo station includes 500/230-kV transformer (600 MVA) and its bays</td>
<td>-</td>
<td>24</td>
</tr>
<tr>
<td>new 230kV phase-shifter (600 MVA) in new 500/230-kV substation connected in series with the proposed 230/500-kV transformer (600 MVA)</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>51</td>
</tr>
</tbody>
</table>

Navajo 500kV – new station Tie Line  

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est'd $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>new 500kV tie line from existing (joint ownership) Navajo 500kV Station to new 230/500-kV substation (near Navajo Station)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Navajo 500kV Station  

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est'd $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed 500kV tie line bay addition to existing (joint ownership) Navajo 500kV Station</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

**Grand Total**  

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles</th>
<th>Est'd $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Total</td>
<td>185</td>
<td>382</td>
</tr>
</tbody>
</table>
Excluding activities for lands, environmental, non-Western interconnections, and path rating processes required by WECC or its subregional transmission planning groups; the project will take about 4 to 6 years following the signing of an engineering/construction agreement with Western until the project’s construction is completed and the project is placed into service. However, because of the project’s unique location; lands and environmental activities could add an uncertain number of additional years to the project’s estimated schedule. Western will work with the customer’s schedule to coordinate the project’s in-service date. In addition, the total duration for the project can be reduced by up to 12 months, if the Customer chooses to complete the design and procurement processes in parallel with the environmental process. This would be done at the risk to the Customer should something be discovered during the environmental process that would require design changes in the project’s major facilities.

5 CONCLUSIONS

This study was performed to document what major facility additions would be needed to meet any of five Point-to-Point Transmission Service Requests (TSRs), which range from 100 MW to 500 MW. The five TSRs can be identified by their Aref numbers 76248667, 76248674, 76248678, 76248680, and 76248685. Each of the five TSRs has its Point of Receipt (POR) at the Shiprock 345 kV station; and its Point of Delivery (POD) at the Navajo 500 kV station. To meet any of these five requests, the following major facilities would be necessary in the construction of a new 230 kV transmission line project between the Shiprock 345 kV station and the Navajo 500 kV station.

- Build a new 230 kV transmission line (about 183 miles) from the Shiprock 230 kV station to a new 230/500-kV substation nearby the existing Navajo 500 kV station.

- Expand the Shiprock station with a new 230/345-kV (600 MVA) transformer.

- Build a new 230 kV series capacitor station (near Kayenta) for about 70% series compensation of the new line.

- Build a new 230/500-kV substation near the Navajo 500 kV station that would include a new 230/500-kV (600 MVA) transformer and a new 230 kV (600 MVA) phase-shifter.

- Build a new 500 kV bay in the existing Navajo 500 kV station to connect a new short 500 kV tie line between the new 230/500-kV substation and existing Navajo 500 kV station.

- Install yet-to-be determined shunt reactive compensation.
The high-level conceptual cost estimate for the project’s major transmission facilities is at least about $382 million. Excluding activities for lands, environmental, non-Western interconnections, and path rating processes required by WECC or its subregional transmission planning groups; the project will take about 4 to 6 years following the signing of an engineering/construction agreement with Western until the project’s construction is completed and the project is placed into service. However, because of the project’s unique location, lands and environmental activities could add an uncertain number of additional years to the project’s estimated schedule.

If the project line were constructed as an ehv circuit (either 345 kV or 500 kV) instead of a 230 kV circuit, then there could be station facility cost savings of about $60 million by possibly avoiding the need for a phase-shifter, series compensation, and one of the two transformers (either at the Shiprock 345 kV station or at the Navajo 500 kV station). However, the increased cost of only the circuit portion of an ehv line (either 345 kV or 500 kV) compared to only the circuit portion of a 230 kV line would be about $0.5 million to $1 million more per mile. So, the estimated increased cost for only the circuit portion of a new 183-mile 345 kV or 500 kV circuit (without its estimated station facility costs) of at least $90 million compared to a new 183-mile 230 kV circuit would exceed the estimated $60 million station facility savings. This increased cost for an ehv line may be recovered if the ehv line alternative could obtain a correspondingly higher path rating.