Project
System Impact Study
Report

Transmission Planning Department

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Arizona Public Service

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I. Executive Summary

In 2004, Arizona Public Service (APS) received a generator interconnection request according to their Open Access Transmission Tariff from XXXXX (formerly known as XXXXXX). Under APS’s Standard Large Generator Interconnection Procedures (LGIP), XXXXXX applied for network resource interconnection service for the Project. However as allowed under APS’s LGIP, XXXXXX chose to forgo the interconnection Feasibility Study and initiate an interconnection System Impact Study. XXXXXX is planning to construct the Project south of the existing Four Corners generating station in northwest New Mexico.

Project is a two unit plant with a net capacity of 1,400 MW. As currently scheduled, the first unit is expected to be in-service in fall 2008 and the second unit will come on-line in spring 2009. XXXXXX would construct a new 500 kV switching station at the plant site and a second switching station (FCW) located near the existing Four Corners 500 kV switchyard. The two new switchyards would be connected by two 500 kV lines. Also, a third new 500 kV line would be built to connect the Four Corners 500 kV switching station to the new FCW switchyard. Additionally, XXXXXX requested that the study effort include the eastern portion of the Navajo Transmission Project (NTP) prior to the first unit being placed in-service. The portion of the NTP modeled for this study consisted of a new 500 kV line from the FCW switching station to a new 500 kV station called Red Mesa East (RME). RME would be located approximately 13 miles south of the existing Navajo 500 kV switchyard. At the RME switching station, the existing Navajo-Moenkopi 500 kV line would be folded into a new ring bus.

Initially, the Project required increased compensation on the Southern Navajo system in order that the output of the plant reached the intended locations. Consequently, most of the study effort of this SIS included a plan to increase the compensation of some of the series capacitors banks in the system. However since 2002, the Southern Navajo owners have been replacing the capacitor banks in the system due to age and have developed a plan to increase both the ampacity and compensation of the banks. The Navajo Engineering and Operations (E&O) Committee has recently approved implementation of the committees plan. As a result, a sensitivity analysis was subsequently performed and the results are included in this report. Table 1 displays the two series compensation upgrade projects used in this SIS.

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<th>Series Bank</th>
<th>Ampacity(1)</th>
<th>Compensation</th>
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<td>Navajo E&amp;O Model</td>
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<td>1137/1530 A</td>
<td>1750/2362 A</td>
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<td>C10 (NV-WW)</td>
<td>1137/1530 A</td>
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<td>C6 (MK-YP)</td>
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(1) First number and second numbers are the continuous and emergency ratings, respectively, of the capacitor bank.
**Figure 1**  
**Plan of Service**

<table>
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<tr>
<th>Project Elements</th>
<th>Responsibility</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Proj Plant &amp; 500 kV Switchyard</td>
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<tr>
<td>FC terminal Proj-FC 500 kV line</td>
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<td>RME-Proj 500 kV line &amp; 500 kV Switchyard</td>
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<tr>
<td>Replace FC 500/345 kV transformer</td>
<td>XXXX</td>
<td>$ 10 M</td>
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</tbody>
</table>

(1) Includes only the terminal costs at the Four Corners switchyard.  
(2) Includes only the RME switchyard costs.

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**System Impact Study Report**
Initial analyses demonstrated a need to add a special protection system (SPS) to allow the Project to interconnect with the existing system. These analyses revealed that a loss of the plant (i.e., either both units or both FCW-Proj lines) caused an overload on the existing Four Corners 500/345 kV transformer for the schedules studied. Tripping either the FCW-RME or FCW-Four Corners 500 kV lines mitigated the overload condition. Subsequent analysis assessing the impacts of interconnecting Project on Path 23 capability showed a need to replace the existing Four Corners 525/345 kV, 840 MVA transformer with a similarly rated unit but with a 125% emergency capability. With the replacement of the Four Corners transformer, there is no longer a need for the initially proposed SPS.

After the initial draft report of the SIS was completed, XXXXX asked to have the Four Corners West switching station removed from the plan of service. As a result, the terminals of the FCW-Four Corners and RME-FCW 500 kV lines will be terminated at the Project switching station. In addition, the Project switching station will be expanded to a breaker-and-a-half configuration. Subsequent studies of the most critical contingencies were re-examined and the results are documented in this report. Also, the change in scope is not expected to change either the SSR or fault duty results.

Using results from the various analyses and assessments performed to date, the plan of service for the Project including the replacement of the Four Corners 500/345 transformer is sufficient to maintain the present capacity of Path 22, Path 51 and the operating capability of the Four Corners Generating Station using the schedules provided by XXXXX and the assumed electrical system for the 2009 time frame. Results from the power flow, inadvertent flow, transient stability, and post-transient stability analyses show that the interconnection of Project does not violate WECC/NERC Planning Standards or local reliability criteria. Also, the fault duty analysis shows that the addition of the proposed facilities does not require replacement of breakers at the locations studied. Figure 1 shows the Plan of Service for Project and its associated transmission facilities. A brief description of each major element of the project’s POS is given below.

1. Project and 500 kV switching station

Construct a coal-fired plant south of the existing Four Corners Generating Station with two 835 MVA units providing a net output of 1,400 MW. A new 500 kV switchyard will be built at the site and two 850 MVA, 500/21 kV generating step-up transformers will interconnect the units with the switching station. Costs for the plant and the new switching station will be determined by XXXXX, who will be responsible for all expenses.

2. Project-Four Corners 500 kV line

Construct a new 500 kV terminal at the existing Four Corners 500 kV switchyard. Build a 19 mile, 500 kV, double-bundle 2156 kcm ACSR transmission line interconnecting the Project switching station and the new terminal at the existing Four Corners site. Cost of the new terminal at Four Corners in 2005 dollars is approximately $2,000,000 and is the
responsibility of XXXXX. Costs for the transmission line between Four Corners and Project switching stations will be the responsibility of XXXXX along with their determination.

3. Red Mesa East switching station and RME-Project 500 kV line

Construct a new 500 kV switching station (Red Mesa East) 13 miles south of the existing Navajo Generating Station. Fold-in the present Navajo-Moenkopi 500 kV transmission line into the new RME switchyard. Cost for a new 500 kV, 3-breaker ring bus is estimated at $11,000,000. Build a new 202 mile, 500 kV transmission line from the Project site to the new RME switching station using double-bundled, 2156 kcm ACSR conductor. One 500 kV, 150 Mvar line reactor with a circuit breaker will be located at each terminal of the line. Also, a new series capacitor bank will be located at the Project terminal of the line at approximately 32% compensation. Minimum size of the new series capacitor bank is tentatively set at 2,200 amp continuous and 2,970 amp emergency. Cost responsibility for the RME switching station and the RME-Project 500 kV line is currently unknown.

4. Replace the existing Four Corners 525/345 kV transformer

Replace the existing four single-phase 525/345 kV transformers at the Four Corners switching station with four new 525/345 kV, single-phase banks with a minimum 840 MVA continuous rating and a minimum 125% emergency rating. Impedance of the new transformer will not materially differ from the existing transformer bank. Cost for the replacement transformer is estimated to be $10,000,000 and is the responsibility of XXXXX.

II. Introduction

In 2004, Arizona Public Service received a network resource interconnection request from XXXXX (formerly known as XXXXX) to study a new two-unit, generation plant south of the existing Four Corners power plant. An agreement was signed to study the Project with a 1,400 MW net output and an expected in-service date of summer 2009. XXXXX also requested that APS proceed with a System Impact Study (SIS) and forgo the Feasibility Study for the new plant.

Located approximately 18 miles to the south of the existing Four Corners plant, Project will interconnect its new 500 kV transmission facilities with the existing Four Corners 500 kV transmission system. Project’s units would interconnect to a new 500 kV switching station at the plant site. This new switching station would then interconnect to a new 500 kV switching station (FCW) located to the west of the existing Four Corners 500 kV switchyard through two 500 kV transmission lines. A new line would interconnect this new switching station to a new 500 kV bay at the existing the Four Corners 500 kV switching station.
Additionally, XXXXX asked to have the eastern portion of the Navajo Transmission Project (NTP) studied along with the plant. However, XXXXX requested that two interconnection alternatives for NTP be assessed prior to the start of the SIS study to determine which option performed best. One NTP alternative that was studied included a 500 kV line extending from the FCW switching station to existing Moenkopi 500 kV switching station. A second alternative that was assessed was a new 500 kV transmission line originating from the FCW switchyard to a new 500 kV switching station (RME) located south of the Navajo power plant. At the RME site, the existing Navajo-Moenkopi 500 kV line would be folded into the new switching station. After an initial assessment was completed XXXXX chose to use the second alternative (see Figure 1) in the SIS.

Two review groups were formed in support of the SIS study effort. In order to determine the impacts of the Project on fault duties of the system expected for summer 2009, the Fault Study Group was formed. APS volunteered to perform the initial assessment on breakers and other equipment adjacent to the new plant. APS also requested that members of the group forward breaker interrupting ratings, substation configuration information and network equivalent data for modeling their respective systems.

In addition to the Fault Study Group, the Interconnection Study Group was formed to review the planning studies assessing impacts of the new plant and its transmission facilities on existing plants and transmission paths. APS also volunteered to perform the necessary studies and forward these to the members of the group.

In the spring of 2005, a study plan was finalized between members of the group and studies for the SIS report were started. Figure 2 shows the proposed Project, a segment of the Navajo Transmission Project and a portion of the transmission system in Northeast Arizona and Northwestern New Mexico.

XXXXX asked APS and the Four Corners Task Force to remove the Four Corners West switchyard from the plan of service after the SIS was completed. Consequently, the terminals of the FCW-Four Corners and RME-FCW 500 kV lines will be terminated at the Project switching station. In addition, the Project switching station will be expanded to a breaker-and-a-half configuration. The most critical contingencies for the interconnection were re-examined and the results documented in this report. Results from the previous studies which included the FCW switching station are also included in this report for the intent of future reference.

III. Study Assumptions

Study Cases

During the study plan development process it was decided to modify the WECC 2008 HS2-SA base case to represent the 2009 summer time frame. Two pre-project and two post-project cases were developed representing Mohave plant operating scenarios. Pre- and post-project cases included the several large projects expected to be in-service by the
2009 time frame (as discussed later). Also, the post-project cases were built with the intention to assess the impacts of the Project and all the associated transmission upgrades/additions against Path 22 and Path 51 ratings along with any impacts on the Four Corners Generating Station. For these cases, power flow and transient stability analyses were performed.

Additionally, four cases were then developed (two pre-project and two post-project) to assess the Navajo 7% generation margin performance with the Mohave scenarios. According to the methodology used in past Path 51 Operating Transfer Capability studies, only transient stability analyses were performed using the Navajo margin cases.

Post-transient analysis was performed on two of the original four 2009 summer cases. It was decided to perform the post-transient analysis on the Mohave out-of-service scenario since results would probably be more limiting than the Mohave in-service case on Path 22 performance. For both the pre and post-project scenarios both 2.5% and 5% flow margin cases were built stressing Path 22. Outages used in the original four cases were then run against these post-transient cases along with any previously identified SPS.

Each of the analyses was performed using the GE power flow program PSLF v13.1 under a Windows NT platform. Various power flow, transient stability and post-transient stability routines were used to perform the assessments.
A fault duty analysis was also performed to determine impacts to breakers in certain substations electrically adjacent to the Four Corners area and substations provided by the Fault Study Group. Using various modules, the Electrocon short circuit program CAPE (build 7/31/03) was used in the analysis.

Table 2 shows the cases compiled and used in the power flow, transient stability and post-transient stability analyses of the System Impact Study.

### Table 2

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<th>Case</th>
<th>Analysis</th>
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<th>Navajo E&amp;O SC Model</th>
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<th>Path 50</th>
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### Case Assumptions

A summer season was selected for studying the effects of the addition of the Project plant and its facilities due to high flows on Path 22 and Path 51 during the summer and the proximity of the plant to both paths and the Four Corners Generating Station.

As explained before, several planned projects were added to the cases to represent the 2009 summer time frame. Planned projects included the short-term EOR upgrades, the Harquahala-Devers project, the Southeast Valley project, the Springerville #3 and #4 additions, the Palo Verde-TS5 project, Mead-Harry Allen project and the EOR 9000+ project.

To construct the post-project cases, the data to model the Project plant and the transmission facilities associated with the project were added to the pre-project cases and are listed in Table 3. Twelve cases (Table 2), used in the original analysis, modeled the initial series capacitor upgrade plan. Eight additional cases were constructed using the new upgrade plan approved by the Navajo E&O committee. Table 3 (following page) also lists the new model for the series capacitor upgrade project.
IV. Study Methodology and Criteria

Methodology

As was mentioned before, power flow, transient stability and post-transient analyses were used to assess the effects of adding the Project and its associated transmission facilities. A review group was formed (see listing below) which drafted and finalized a study plan for the project. Although a listing of disturbances was included in the study plan, this listing does not contain all the disturbances that were simulated.

Table 3

<table>
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<th>Positive Sequence Modeling Data (1)</th>
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<th>B</th>
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<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Westwing-Yavapai series cap (4)</td>
<td>-</td>
<td>- .01028 pu</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Westwing-Navojo series cap (4)</td>
<td>-</td>
<td>- .01620 pu</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Navajo-Westwing series cap (4)</td>
<td>-</td>
<td>- .01620 pu</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Four Corners 525/345 kV, 840 MVA(5)</td>
<td>.000177 pu</td>
<td>.010594 pu</td>
<td>.006865 pu</td>
<td>.003131 pu</td>
<td>525.000 kV</td>
<td>345 kV</td>
</tr>
</tbody>
</table>

(1) Impedance values calculated on a 100 MVA base.
(2) Saturated, direct-axis reactance on an 835 MVA base.
(3) Initial model for the series capacitor upgrade project.
(4) Series capacitor model developed by the Navajo E&O committee.
(5) Impedance values calculated on a 100 MVA base for the existing unit.

Tables for all three types of assessments are included in this report. However due to their volume, Q-V nose curves and transient stability plots are not included in this report. For the transient stability analysis, both 3-phase faults with 3-pole operations and certain
single-line-to-ground faults were simulated. A remedial actions scheme identified in one analysis was assessed with successful operations in the other analyses.

**Interconnection Study Group**

- Nevada Power
- Western Area Power Administration
- El Paso Electric
- Tucson Electric Power
- PacifiCorp
- Arizona Public Service
- Public Service of New Mexico
- Salt River Project
- Southern California Edison

A study group was also formed (see listing below) to perform the fault duty analysis and a study plan was developed outlining the requirements for the analysis. A listing of monitored buses was developed for the study plan; however this list was later updated to accommodate suggestions made by review group members in the course of the study. Using the list, the fault duty analysis calculated both 3-phase and single-line-to-ground faults as well as X/R ratios. Results of the fault duty analysis were used to gauge the adequacy of breakers and other equipment in the adjacent areas as well as to inform members of the study group of future fault duty levels.

**Fault Study Group**

- Salt River Project
- Southern California Edison
- Public Service of New Mexico
- El Paso Electric
- Tucson Electric Power
- PacifiCorp
- Western Area Power Administration
- Arizona Public Service
- Texas-New Mexico Power

**Criteria**

For the Project SIS, two sets of criteria were used to assess system performance. For the power flow, transient stability and post-transient analyses, the Western Electricity Coordinating Council’s (WECC) and North American Electric Reliability Council (NERC) Planning Standards were used. WECC/NERC Planning Standards can be found in part I of the document “WECC Reliability Criteria”.

In addition to the WECC/NERC Planning Standards, the methodologies described in the WECC documents “Voltage Stability Criteria, Undervoltage Load Sheding Strategy, System Impact Study Report 12
and Reactive Power Reserve Monitoring Methodology” and “Summary of WECC Voltage Stability Assessment Methodology” were used in the reactive margin assessment (i.e. post-transient analysis). The second set of criteria used in the Project system impact study was APS’s own transmission reliability criteria. Arizona Public Service’s criterion includes the same guidelines found in the WECC/NERC Planning Standards along with criteria and ratings unique to APS’s transmission system.

For the fault duty analysis, study group members were asked to provide breaker duty information along with substation configuration data (i.e. for the current year – 2005) for the buses monitored in the analysis. Study group members also provided system equivalent information for updating APS’s fault duty model.

V. Study Results

Inadvertent flow assessment

As was mentioned earlier, XXXXX had originally asked to have two transmission options evaluated prior to the start of the System Impact Study for the Project. For Option #1, a single circuit, 500 kV series compensated transmission line would extend from the Four Corners West switching station to a location just south of the Navajo Generating Station. However, the new line from the FCW station would then parallel the right of way of the existing Navajo-Moenkopi 500 kV line and finally interconnect into a new bay at the existing Moenkopi switchyard. Option #2 included a single circuit, 500 kV series compensated transmission line extending from the new Four Corners West switchyard to a new 500 kV site just south of the Navajo Generating Station would be Option #1. At the new site, the Navajo-Moenkopi line would be folded into the new switching station.

An initial analysis was done in the fall 2004 that examined not only the two options but also other sensitivities. These sensitivities included use of different compensation levels, phase shifting transformers and various network configurations and their subsequent effects on loop flow upon EHV lines and paths in northern Arizona. Consequently, the result of these studies indicated the need for increasing the present compensation level for the Southern Navajo series capacitors regardless of which transmission option is ultimately constructed. Four of the five Southern Navajo series capacitors were chosen to be upgraded. Figure 2 shows the location of the affected banks and Table 1 shows the impedance changes for each bank.

After the initial inadvertent analysis was completed, XXXXX agreed to study Option #2 in the System Impact Study with the understanding that additional studies may be performed in the future to further refine compensation levels. For the SIS, the schedule for the plant would be split between central Arizona and the Las Vegas area with 1100 MW scheduled to the Phoenix area (Path 51) and 300 MW scheduled to southern Nevada (Navajo-Crystal).
As was mentioned earlier, the Navajo E&O Committee approved an upgrade project for the Southern Navajo series capacitors in late summer of 2005. Consequently, the upgrade project was substituted in the Inadvertent Flow analysis for the original model proposed for the Project. Sensitivities with and without the Perkins phase shifting transformers were performed in this last analysis. Also, sensitivities were also performed with and without the Mohave Generating Station at full output. Results of the analysis show little impact on lines and paths in northern Arizona and on Path 49 (East-of-the-River) independent of each sensitivity. Findings from the analysis using the latest model of Southern Navajo upgrades are found in Appendix A.

**Power flow analysis**

**Heavy summer scenario, Mohave out-of-service (prj_02g & prj_02jx) –**

Results from the heavy summer, pre-project case (prj_02g) show that the existing system in 2009 (Path 22) can be operated at its rating without violating NERC/WECC criterion or APS reliability criteria. Two of the most serious (but not limiting) outages for the pre-project case are shown below.

- Loss of the Coronado-Silver King 500 kV line caused the Cholla-Leupp 230 kV line to load to 723 amps (i.e. 100% of its emergency rating) and a 4.35% voltage drop at the Preacher Canyon 345 kV bus.

- A loss of the Four Corners-Moenkopi 500 kV line caused the Cholla-Preacher Canyon 345 kV line to load to 89% of its emergency rating of 1,310 amps and causes a 4.36% voltage drop on the Preacher Canyon 345 kV bus.

Several significant (but not limiting) outages were found in the post-project case (prj_02jx) and are listed below.

- An outage of the Navajo-Westwing 500 kV line caused the series capacitors on the Yavapai-Westwing 500 kV line to load to 1,642 amps or 100% of their emergency rating.

- A loss of both Project units caused the Four Corners 500/345 kV transformer to load to 934 MVA or 111% of its present emergency rating. Use of a SPS to trip either the FCW-RME or the Four Corners-FCW 500 kV lines caused the flow through the transformer to decrease to 66% or 554 MVA of its emergency rating. Alternately, bypassing of the FCW series capacitors reduced the flow through the transformer to 844 MVA or 100% of its emergency rating. However, replacement of the existing Four Corners transformer with a unit having a minimum emergency rating of 1050 MVA resulted in an acceptable overload for this outage without the need for a SPS.
An outage of the Navajo-Crystal 500 kV line loaded both banks of the Navajo-Westwing 500 kV series capacitors to 1,535 amps or 100% of their emergency ratings.

Loss of the Moenkopi-Yavapai 500 kV line loads both Navajo-Westwing series capacitors to 1,593 amps or 104% of their emergency rating. Because the Navajo-Westwing banks are part of the group of four series capacitors that will be upgraded to higher compensation levels, this outage is not strictly deemed to be limiting for this analysis.

An outage of the FCW-RME 500 kV line caused the Four Corners-Moenkopi 500 kV line to load to 2172 amps or 120% of its continuous rating. By-passing the series capacitors in the Four Corners-Moenkopi line caused the current to drop to 1,902 amps.

No other credible disturbances were found to violate any existing line or equipment emergency ratings for either the pre- or post-project cases. Additionally, no other credible outages that were taken caused unacceptable voltage dips. Appendix B contains the results for the prj_02g and prj_02jx power flow analyses.

**Heavy summer scenario, Mohave in-service (prj_02g2 & prj_02j2x)** –

For the pre-project peak load case (prj_02g2) with the Mohave plant in-service, power flow results show that the anticipated system for 2009 (Path 22) does not adversely violate WECC/NERC Planning Standards nor APS reliability criteria. From the study results, the most limiting outages for the prj_02g2 case are listed below.

- An outage of the Coronado-Silver King 500 kV line caused the Cholla-Leupp 230 kV line to load to 100% of its emergency rating and a voltage drop of 4.39% on the Preacher Canyon 345 kV bus.

- As a result of the loss of the Four Corners-Moenkopi 500 kV line, the Cholla-Preacher Canyon 345 kV line loaded to 89% of its emergency rating and caused a 4.22% voltage drop on the Preacher Canyon 345 kV bus.

Results from the post-project case (prj_02j2x) show that only one disturbance restricted output of the Project. Although an SPS was employed to mitigate the impact of this disturbance, the recommendation to replace the Four Corners 500/345 transformer eliminated the need to the SPS and all disturbances for this case were acceptable. Other critical disturbances are listed below.

- For a loss of the Navajo-Westwing 500 kV line, the Yavapai-Westwing series capacitor bank loaded to 100% of its emergency rating (1645 amps).

- The Four Corners 500/345 kV transformer loaded to 111% or 933 MVA for an outage simulating a breaker failure disturbance and loss of both Project units. A SPS
simulating tripping of either the FCW-RME or the Four Corners-FCW 500 kV lines caused the flow through the transformer to decrease to 66% or 554 MVA of its emergency rating. By-passing the FCW series capacitors reduced flow through the transformer to 844 MVA or 100% of its emergency rating. As before, the proposed new Four Corners transformer with a minimum 125% emergency rating mitigates the need for a SPS due to this outage.

- Loss of the Navajo-Crystal 500 kV line loaded both banks of the Navajo-Westwing 500 kV series capacitors to 100% of their emergency rating.

- For an outage of the Moenkopi-Yavapai 500 kV line, both banks of the Navajo-Westwing series capacitors loaded to 1,595 amps or 104% of their emergency rating. As before, since these banks are scheduled to be upgraded this restriction is not considered to be a limitation.

- Loss of the FCW-RME 500 kV line caused the Four Corners-Moenkopi 500 kV line to load to 2170 amps or 119% of its continuous rating. By-passing the series capacitors in the Four Corners-Moenkopi line caused the current to drop to 1,900 amps.

As was the case for the Mohave out-of-service scenario, no other credible disturbances were found to violate existing line or equipment emergency ratings or to cause unacceptable voltage dips. Results for the prj_02g2 and prj_02j2x cases are found in Appendix B.

**Heavy summer scenario, Series capacitor sensitivity (prj_02jxy & prj_02j2y)**

Study results from a post-project case (prj_02jxy) modeling the new Southern Navajo series capacitor upgrades with the Mohave plant off-line show that the addition of the Project does not violate either WECC/NERC Planning Standards or APS reliability criteria. A listing of the five disturbances identified in the post-project case (prj_02jx) modeling the initial series capacitor project are given below utilizing the Navajo E&O series capacitor project.

- An outage of the Navajo-Westwing 500 kV line caused the series capacitor on the Yavapai-Westwing 500 kV line to load to 1,513 amps or 64% of its planned emergency rating.

- A loss of both Project units caused the Four Corners 500/345 kV transformer to load to 745 MVA or 89% of its existing emergency rating. The replacement of the existing transformer with a unit capable of 125% overload capacity reduces the impact of an effective outage of both Project units.

- An outage of the Navajo-Crystal 500 kV line loads the RME-Moenkopi 500 kV series capacitor to 2,266 amps or 76% of its emergency rating.
- Loss of the Moenkopi-Yavapai 500 kV line loads both Navajo-Westwing series capacitors to 1,548 amps, or 66% of their planned emergency rating.

- The Four Corners-Moenkopi 500 kV line to load to 2005 amps or 110% of its continuous rating for loss of the FCW-RME 500 kV line. By-passing the series capacitors in the Four Corners-Moenkopi line caused the current to drop to 1,761 amps.

A review of the four most significant disturbances using the Navajo E&O series capacitor model reveals an improvement over the results using the initial series capacitor model.

Findings from the power flow analysis on the post-project case with the Mohave plant in-service (prj_02j2y) revealed that the addition of the Project plant does not violate either WECC/NERC Planning Standards or APS reliability criteria. Results of the five most significant disturbances from the post-project case (prj_02j2x) with the initial series capacitor model are listed below with the Navajo E&O series capacitor model as comparison.

- For a loss of the Navajo-Westwing 500 kV line, the Yavapai-Westwing series capacitor bank loaded to 64% of its proposed emergency rating (2362 amps).

- The Four Corners 500/345 kV transformer loaded to 89% or 750 MVA (current emergency rating) for an outage simulating a breaker failure disturbance and loss of both Project units. With the replacement of the existing Four Corners transformer, the overload that results from loss of both Project units will be further reduced.

- Loss of the Navajo-Crystal 500 kV line loads the RME-Moenkopi 500 kV series capacitor to 76% of its emergency rating.

- For an outage of the Moenkopi-Yavapai 500 kV line, both banks of the Navajo-Westwing series capacitors loaded to 1,551 amps or 66% of their emergency rating.

- An outage of the FCW-RME 500 kV line caused the Four Corners-Moenkopi 500 kV line to load to 2008 amps or 110% of its continuous rating. By-passing the series capacitors in the Four Corners-Moenkopi line caused the current to drop to 1,763 amps.

From a review of the most critical disturbances modeling the Navajo E&O series capacitor project demonstrates a consistent improvement as compared to the initial series capacitor upgrade project. Results for the prj_02jxy and prj_02j2y cases are found in Appendix B.

Heavy summer scenario, Path 23 500 to 345 kV sensitivity (prj_02f2 & prj_02k3) –

Analysis of the pre-project scenario (prj_02f2) revealed that the expected system for 2009 does not violated WECC/NERC Planning Standards nor APS reliability criteria.
Flows through the Four Corners 500/345 kV transformer (Path 23) were 592 MW in the case. Listed below are the few more limiting disturbances from the prj_02f2 case.

- An outage of the Four Corner-Moenkopi 500 kV causes the flow through the Four Corners 500/345 kV transformer to load to 756 MVA or 90% of its emergency rating.
- A trip of the Four Corners Unit #4 caused the transformer to load to 100% of its present emergency rating.

With the addition of the Project facility, results from the post-project scenario (prj_02k3) show that flow through Path 23 is limited to approximately 441 MW. However, no planning standards or reliability criteria were violated at this flow level. A listing of some of the more limiting disturbances is given below.

- Post-disturbance flows through the Four Corners 500/345 kV transformer reached 760 MVA for an outage of Four Corners Unit #4.
- Loss of the FCW-RME 500 kV line caused the flow through the Four Corners transformer to reach 100% of its emergency rating.
- For a loss of the Four Corners-Moenkopi 500 kV line Path 23 loaded to 94% of its present emergency rating.

No other disturbances were found to violate any existing line or facility ratings for either the pre- or post-project cases. In addition, no voltage dips were found to be unacceptable. A more complete listing of the study results are found in Appendix B.

Heavy summer scenario, FCW sensitivity (prj_02jxr & prj_02j2r) –

Results from the post-project case prj_02jxr which models the new Southern Navajo series capacitor upgrades with the Mohave plant off-line show and without the FCW switching station revealed that the addition of the Project does not violate either WECC/NERC Planning Standards or APS reliability criteria. A listing of the four disturbances identified for this case utilizing both the Navajo E&O series capacitor project and the removal of the FCW switching station.

- Loss of the Navajo-Westwing 500 kV line caused the series capacitor on the Yavapai-Westwing 500 kV line to load to 1,512 amps or 64% of its emergency rating.
- An outage of the Four Corners-Moenkopi 500 kV line caused the Moenkopi series capacitors (Moenkopi-RME 500 kV) to load to 81% of their emergency rating.
- The Four Corners 500 kV series capacitors loaded to 1949 amps for an outage of the Project-RME 500 kV line. By-passing the capacitors dropped the current to 1,714 amps.
- Outage of the Moenkopi-Yavapai 500 kV line caused the Navajo-Westwing series capacitors to load to 66% of their emergency rating.

A review of the post-project case (prj_02j2r) with the Southern Navajo Upgrade Project and without the FCW switching station (w/ Mohave in-service) found no violations of either WECC/NERC Planning Standards or APS reliability criteria. Below is a listing of the most critical disturbances found in the analysis.

- A contingency of the Project-RME 500 kV line loads the Four Corners series capacitors to 1952 amps. Subsequent by-passing of the capacitors drops the current to 1,716 amps.

- Loss of the Four Corners-Moenkopi line caused the Moenkopi-RME 500 kV line to load to 2040 amps or 80% of its emergency rating.

- An outage of the Navajo-Westwing 500 kV line loaded the Moenkopi-RME line to 74% of its post-disturbance capacity.

For both post-project cases, the post-disturbance flows decreased slightly as a result of the new plan of service without the FCW switching station. An expanded listing of study results for both cases can be found in Appendix B.

**Transient stability analysis**

**Heavy summer scenario, Mohave out-of-service (prj_02g & prj_02jx) –**

For the pre-project peak load case, transient stability results show that the anticipated system in 2009 (Path 22) is able to operate at its present capability and does not violate the WECC/NERC Planning Standards nor APS reliability criteria for the adjacent systems. As a result of the analysis, the three most critical credible disturbances are provided below.

- Largest transient frequency dip for the case was 59.58 Hz at the EL_VADO1 4.2 kV bus for a 3-phase fault on the FOURCORN 345 kV bus and loss of the Four Corners-Cholla 345 kV line.

- An outage of the Coronado-Silver King 500 kV as a result of a 3-phase fault on the CORONADO 500 kV bus caused a transient voltage dip of 11.70% at the PRECHCYN 345 kV bus and a frequency dip of 59.70 Hz at the NEWMN4G2 13.8 kV bus.

- A 3-phase fault on the NAVAJO 500 kV bus and loss of the Navajo-Moenkopi 500 kV line caused a 59.55 Hz frequency dip on the NAVAJO 3 26.0 kV bus.

From a review of the transient stability plots for the prj_02g case, all disturbances resulted in positive damping.
Results of the post-project case show that with the addition of the Project plant and its transmission facilities no WECC/NERC Planning Standards or APS reliability criterion are violated. Listed below are the results of the more significant outages for the post-project (prj_02jx) case.

- Loss of the Four Corners-Cholla 345 kV line due to a 3-phase fault on the FOURCORN 345 kV bus caused a 59.62 Hz frequency dip on the EL_VADO1 4.2 kV bus.

- A 3-phase fault on the CORONADO 500 kV bus and a loss of the Coronado-Silver King 500 kV line caused a frequency dip of 59.73 Hz on the NEWMN4G2 13.8 kV bus.

- An outage of the Navajo-RME 500 kV line due to a 3-phase fault caused the frequency on the NAVAJO 2 26 kV bus to drop to 59.56 Hz.

- Initially an outage of the Project plant in the power flow analysis caused an overload of the Four Corners 500/345 kV transformer. A SPS that trips the FCW-RME 500 kV line relieves the overload and was subsequently simulated in the transient stability analysis with no further violations.

A review of the transient stability plots for the post-project case revealed positive damping for all disturbances including those with the SPS modeled. Results for both the prj_02g and prj_02jx transient stability analyses can be found in Appendix C.

**Heavy summer case, Mohave in-service (prj_02g2 & prj_02j2x) –**

Results from the transient stability simulations for the prj_02g2 case show that the expected system for 2009 including Path 22 does not violate WECC/NERC Planning Standards nor APS reliability criteria for the nearby systems. From the pre-project simulations, the three most limiting disturbances are shown below.

- Loss of the Four Corners-Cholla 345 kV as a result of a 3-phase fault on the FOURCORN 345 kV bus caused the largest transient frequency dip for the case at 59.58 Hz on the EL_VADO1 4.2 kV bus.

- A 3-phase fault on the CORONADO 500 kV bus and the resulting trip of the Coronado-Silver King 500 kV line caused a frequency minimum of 59.70 Hz on the NEWMN4G2 13.8 kV bus and a transient voltage dip of 11.79% at the PRECHCYN 345 kV bus.

- An outage of the Navajo-Moenkopi 500 kV line due to a 3-phase fault on the Navajo 500 kV bus caused a 59.55 Hz frequency dip on the NAVAJO 3 26 kV bus.
An inspection of the transient stability plots showed that all disturbances simulated demonstrated positive damping.

With the addition of the Project and its transmission facilities, the post-project case transient stability simulations show no violations of WECC/NERC Planning Standards or APS reliability criteria. Results of the more critical disturbances for the prj_02j2x case are listed below.

- An outage of the Four Corners-Cholla 345 kV line due to a 3-phase fault on the FOURCORN 345 kV bus caused the frequency to drop to 59.61 Hz.

- Loss of the Coronado-Silver King 500 kV line due to a 3-phase fault on the CORONADO 500 kV bus caused a voltage dip of 11.08% on the PRECHCYN 345 kV bus and a frequency dip of 59.73 Hz on the NEWMN4G2 13.8 kV bus.

- A 3-phase fault on the NAVAJO 500 kV bus and subsequent loss of the Navajo-RME 500 kV line caused a frequency dip of 59.56 Hz on the NAVAJO 2 26 kV bus.

- Loss of the Project plant in the power flow analysis caused an overload on the Four Corners 500/345 kV transformer. A special protection system which trips the FCW-RME 500 kV line eliminates the overload in the power flow analysis and was simulated in the transient stability analysis. Results of the SPS operation revealed no violations.

The transient stability plots for the post-project cases demonstrated positive damping for simulations. Summary transient stability results for both the pre- and post-project cases can be found in Appendix C.

Navajo margin case, Mohave out-of-service (prj_02n & prj_02nx) –

For the pre-project case, transient stability results show that the expected transmission system for 2009 is capable of operating at its present ability and does not violate either WECC/NERC or APS reliability criteria. Three disturbances with the largest deviations are listed below.

- An outage of the Four Corners-Cholla 345 kV line due to a 3-phase fault caused a transient frequency dip of 59.58 Hz on the EL_VADO1 4.2 kV bus.

- A 3-phase fault on the CORONADO 500 kV loss and subsequent loss of the Coronado-Silver King 500 kV line caused a voltage dip on the PRECHCYN 345 kV bus of 11.76% and a frequency dip of 59.70 Hz on the NEWMN4G2 13.8 kV bus.

- Loss of the Navajo-Moenkopi 500 kV line as a result of a 3-phase fault on the NAVAJO 500 kV bus caused a 59.50 Hz frequency dip on the NAVAJO 3 26 kV bus.
All disturbances from the prj_02n pre-project case resulted in positive damping.

The addition of the Project power plant and its transmission facilities resulted in no WECC/NERC or APS criteria violations in the Navajo margin post-project, transient stability assessment. Results of the most significant post-project (prj_02n2x) disturbances are given below.

- Loss of Four Corners-Cholla 345 kV line as a result of a 3-phase fault on the FOURCORN 345 kV bus caused a frequency dip of 59.61 Hz on the EL_VADO1 4.2 kV bus.

- A 3-phase fault on the CORONADO 500 kV bus and loss of the Coronado-Silver King 500 kV line caused a 11.10% voltage dip on the PRECHCYN 345 kV bus and a drop in frequency to 59.73 Hz on the NEWMN2G2 13.8 kV bus.

- As a result of a 3-phase fault on the Navajo-RME 500 kV bus, a frequency dip of 59.51 Hz was recorded on the NAVAJO 2 26 kV bus.

- A SPS was simulated, which modeled tripping of the FCW-RME 500 kV line for loss of both Project units, and demonstrated acceptable performance. It was later determined that the SPS is no longer needed due to the replacement of the Four Corners 500/345 kV transformer.

A review all transient stability plots for the Navajo margin post-project case revealed positive damping for all simulated disturbances. Appendix D contains the results for both the prj_02n and prj_02nx cases.

**Navajo margin case, Mohave in-service (prj_02n2 & prj_02n2x)** –

Transient stability results for the Navajo margin, pre-project case with Mohave in-service demonstrated that the expected system for 2009 will be able to operate at rated conditions without violating WECC/NERC Planning Standards or APS reliability criteria. Below are the three most critical credible disturbances determined in the analyses.

- An outage of the Four Corners-Cholla 345 kV due to a 3-phase fault on the FOURCORN 345 kV bus caused a transient frequency dip of 59.58 Hz.

- A 3-phase fault on the CORONADO 500 kV bus and loss of the Coronado-Silver King 500 kV line caused a 11.86% voltage dip at PRECHCYN 345 kV bus and a frequency dip of 59.70 Hz on the NEWMN4G2 13.8 kV.

- Loss of the Navajo-Moenkopi 500 kV resulting from a 3-phase fault on the NAVAJO 500 kV bus caused a 59.50 Hz frequency dip on the NAVAJO 3 26 kV bus.

Transient stability plots from the prj_02n2 case show that the all disturbances demonstrated positive damping.
Study results from the post-project Navajo margin case (prj_02n2x) with the addition of the Project and its transmission facilities show that no WECC/NERC Planning Standards or APS planning criteria were violated. The most significant disturbances for the prj_02n2x case are given below.

- Loss of the Coronado-Silver King 500 kV line resulting from a 3-phase fault caused a voltage dip of 11.15% on the PRECHYN 345 kV bus and a frequency dip of 59.73 Hz on the NEWMN4G2 13.8 kV bus.

- A 3-phase fault on the FOURCORN 345 kV bus and loss of the Four Corners-Cholla 345 kV line resulted in a transient frequency dip of 59.61 Hz on the EL_VADO1 4.2 kV bus.

- An outage of the Navajo-RME 500 kV line due to a 3-phase fault on the Navajo 500 kV bus caused a frequency dip of 59.51 Hz.

- Power flow analysis indicated that a SPS was needed to trip the FCW-RME 500 kV line for a loss of both Project units. A simulation was run that verified the SPS caused no violations in the transient analysis. With the replacement of the existing Four Corners 500/345 transformer, the SPS will longer be needed.

Transient stability plots for the prj_02n2x demonstrated positive damping for all disturbances including those employing special protection systems. Summary results for both the pre- and post-project cases are found in Appendix D.

Navajo margin case, Series capacitor sensitivity (prj_02ny & prj_02n2y) –
Simulation results for the Navajo margin, pre-project case with Mohave in-service revealed that the anticipated system for 2009 will be able to operate at rated conditions without violating WECC/NERC Planning Standards or APS reliability criteria. Below are the three most critical credible disturbances found in the analyses.

- An outage of the Four Corners-Cholla 345 kV due to a 3-phase fault on the FOURCORN 345 kV bus caused a transient frequency dip of 59.61 Hz.

- A 3-phase fault on the CORONADO 500 kV bus and loss of the Coronado-Silver King 500 kV line caused a 4.28% voltage dip at MOENKOPI 500 kV bus and a frequency dip of 59.71 Hz on the NEWMN4G2 13.8 kV.

- Loss of the Navajo-Moenkopi 500 kV resulting from a 3-phase fault on the NAVAJO 500 kV bus caused a 59.62 Hz frequency dip on the NAVAJO 226 kV bus.

All disturbances from the prj_02ny case demonstrated positive damping.

Finding using the post-project Navajo margin case (prj_02n2y) with the addition of the Project and its plan of service demonstrated no WECC/NERC Planning Standards or APS
planning criteria were violated for N-1 disturbances. The most significant disturbances for the prj_02n2y case are given below.

- Loss of the Coronado-Silver King 500 kV line resulting from a 3-phase fault caused a voltage dip of 4.45% on the MOENKOPI 500 kV bus and a frequency dip of 59.71 Hz on the NEWMN4G2 13.8 kV bus.

- A 3-phase fault on the FOURCORN 345 kV bus and loss of the Four Corners-Cholla 345 kV line resulted in a transient frequency dip of 59.61 Hz on the EL_VADO1 4.2 kV bus.

- An outage of the Navajo-RME 500 kV line due to a 3-phase fault on the NAVAJO 3 26 kV bus caused a frequency dip of 59.50 Hz.

- Originally, power flow analysis indicated that a SPS was needed to trip the FCW-RME 500 kV line for a loss of both Project units. A simulation was run that verified the SPS caused no problems in the transient analysis. However as noted earlier, the proposed SPS will no longer be needed due to the replacement of the Four Corners transformer.

Plots of outage simulations for the prj_02n2y case revealed positive damping for all disturbances including those employing special protection systems. Summary results for both the pre- and post-project cases are found in Appendix D.

**Post-transient stability analysis**

**Heavy summer reactive margin cases (prj_02gb/c and prj_02jxb/c)** –

Findings from the heavy summer reactive margin analyses show that the Project can interconnect near the Four Corners switching station and schedule to southern Nevada (300 MW) and central Arizona (1100 MW) without violating WECC reactive margin criteria or local criteria. For the analysis, four buses were monitored (Pinnacle Peak 230 kV, Kyrene 230 kV, Silver King 230 kV and Westwing 230 kV) in central Arizona and their reactive margin limits were recorded for category B and C disturbances. Disturbances simulated in the reactive margin analysis were identical to those assessed in the power flow and transient stability portions of the SIS. Shown below is a comparison of the 4 most restrictive credible disturbances relative to pre- and post-project performance.

- For loss of the Cholla-Saguaro 500 kV line, the change of the reactive margin for the Pinnacle Peak 230 kV bus is 91 Mvar.

- Loss of the Cholla-Pinnacle Peak #1 345 kV line causes a 95 Mvar dip in reactive capability between the pre- and post-project cases.
An outage of the Coronado-Silver King 500 kV line in the post-project case caused the reactive margin to drop to 1945 Mvar @ .70 pu on the Pinnacle Peak 230 kV bus.

The reactive margin dropped to 722 Mvar @ .70 pu on the Silver King 230 kV bus for loss of the Browning-Silver King 500 kV line in the post-project case.

From a review of the post-transient results the majority of the disturbances resulted in increased margins between the pre- and post-project cases. A complete summary of results for both the pre- and post-project reactive margin analysis can be found in Appendix E.

Fault duty analysis

As was mentioned previously, a Fault Study Group (FSG) was formed to coordinate the fault duty calculation effort for the Project System Impact Study. Participating companies of the FSG are listed in the Study Methodology and Criteria section of this report.

A study plan was drafted and data was collected from the FSG members. APS volunteered to perform the actual calculations and to distribute the results for the SIS. System equivalent data, bus configurations, fault locations and breaker data were collected and used in the assessment. APS subsequently updated it’s short-circuit database with the FSG’s modifications for the 2009 summer time frame. Projects described earlier for the 2009 period were also added to the database. A second database was built using the newly created database but with the Project.

Using the CAPE program, APS determined both 3-phase and single-line-to-ground faults on the pre- and post-project databases. In addition, X/R ratios were calculated for each location to determine the effects of dc offset currents. Table A in Appendix F shows the pre-project, post-project and differential fault duties along with X/R ratios. Fault duties in Table A are determined directly from the CAPE program and have not been adjusted according to X/R ratio multipliers.

A review of the table in Appendix F shows that fault duties at the Four Corners 345 kV bus exceeds the minimum breaker ratings on 14 of the 15 breakers at the sub in the pre-project case. Because of their age, APS and the other joint owners of the substation will begin replacing breakers starting in 2006 with units that have 50 kA interrupting ratings that can be upgraded in the future to 63 kA. As a result of the pre-existing conditions, the Project plant is not responsible for the replacement of the Four Corners 345 kV breakers.

Symmetrical fault duties at APS’s Pinnacle Peak 230 kV substation also exceeded the minimum breaker ratings for a significant number of 230 kV breakers for the 2009 summer pre-project case. APS will be considering several options to mitigate these overloads. Some options could include reconfiguring bus sections, implementation of special protection systems and breaker replacements. However due to the pre-existing
conditions, Project will not be responsible for reducing or accommodating excessive fault duties seen at the Pinnacle Peak 230 kV substation.

As was mentioned before, XXXXX requested that the FCW switching station be removed from the interconnection after the SIS report was completed. Consequently, the fault calculations were re-performed and the findings confirmed that the Project plant and its related facilities do not require replacement of any existing breakers. As mentioned before, a summary of the study’s results can be found in Appendix F.

**Sub-synchronous resonance analysis**

APS’s Technical Projects Engineering group performed screening analyses on the Navajo and Four Corners Generating Stations as a result of the addition of the eastern portion of the NTP and the changes in Southern Navajo series capacitors. Changes to the Southern Navajo series capacitors, which were approved by the Navajo E&O committee, were modeled in APS’s screening studies. Conclusions from both screening studies are provided below.

**Navajo Generating Station**

(taken from the report **SSR Impact of the Project On Navajo Units SSR**)

- *The Project has the impact of increasing the undamping of Navajo units torsional modes for several system conditions.*

- *Navajo units are protected against SSR by static filter, SEDC, and SSR relay. As long as the SSR protection is in service and properly maintained, the Project is not expected to have significant impacts on the torsional interaction problems of the Navajo units.*

- *These screening type studies can not be used to determine the transient torque impact of the Project. In view of the presence of static filter, the Project is not expected to have any significant transient torque impact but that remains to be verified.*

Appendix G contains a complete copy of the Navajo SSR screening study report.

**Four Corners Generating Station**

(taken from the conclusions of the report **SSR Impact of the Project On Four Corners Units**)

- *The Project does not have any significant negative impact on Four Corners unit 5 SSR problems except when the unit is radial to Red Mesa. Such low probability problems can be protected by operating procedures and relays.*

- *Four Corners units 1 to 4, San Juan units, and the Palo Verde units are electrically far from the Project and are expected to be impacted even less.*
A copy of the entire of the report of the SSR analysis for Four Corners unit 5 can be found in Appendix H.

VI. Other Studies, Guidelines and Standards

SSR studies

In addition to the screening studies performed on the Navajo and Four Corners Generating Stations, XXXXX will be responsible for assessing the impact on its own generators susceptibility to SSR conditions as a result of their facilities and the interconnecting network.

WECC guidelines

If XXXXX becomes a member of the WECC, the Project will be required to comply with the standards outlined in WECC Minimum Operating Reliability Criteria. Three standards that pertain directly to governor operation and voltage regulator operation are listed below.

Item 1.C.2 Governors. To provide an equitable and coordinated system response to load/generation imbalances, governor droop shall be set at 5%. Governors shall not be operated with excessive deadbands, and governors shall not be blocked unless required by regulatory mandates.

Item 2.B.5 Generators. Generating units 10 MVA and larger shall be equipped with automatic voltage control equipment. All generating units with automatic voltage control equipment shall normally be operated in voltage control mode. These generating units shall not be operated in other control modes (e.g. constant power factor control) unless authorized to do so by the host control area. The control mode of generating units shall be accurately represented in operating studies.

Item 2.B.6 Automatic voltage control equipment. Automatic voltage control equipment on generating units, synchronous condensers, and static var compensators shall be kept in service to the maximum extent possible with outages coordinated to minimize the number out of service at any one time. Such voltage control equipment shall operate at voltages specified by the host control area operator.

Item 2.B.7 Power system stabilizers. Power System Stabilizers on generators shall be kept in service to the maximum extent possible and shall be properly tuned in accordance with WECC requirements.
In regards to Item 2.B.7, a further description on a generator’s applicability to PSS installation and operation can be found in WECC’s *Policy Statement on Power System Stabilizers*.

In addition, the Project generators may be subject to WECC’s fault and post-fault duty voltage standard (*Low Voltage Ride Through Standard*).

**Power factor requirements**

According to Article 9 of APS’s Large Generator Interconnection Procedures, an interconnecting generator shall maintain a power factor at the point of interconnection (i.e. the Project 500 kV bus) with the range of .95 leading to .95 lagging. With a plant net output of 1400 MW, each unit of Project are required to be capable of generating or absorbing a minimum of 230 Mvars plus reactive losses incurred by the GSU transformers.

**VII. Network Service Assessment**

With the addition of the eastern portion of the Navajo Transmission Project, approximately 1500 MW of firm transmission capacity will become available between the Project and the Southern Navajo transmission system. It is assumed this capacity will be available to the Project owners.

At present, the participants of the Southern Navajo transmission system are Arizona Public Service, Salt River Project, Bureau of Reclamation and Tucson Electric Power. For the summer of 2009 time frame (as of 2/27/06), the available transmission capacity of the Southern Navajo system is approximately 169 MW. However, the Southern Navajo participants have proposed uprating the path through the WECC three-phase ratings process. Studies are underway to determine the incremental capacity for upgrading the southbound rating of Path 51. Although no final rating has been determined, initial study results indicate the upgrade could add another 1030 MW of available transmission capacity. Consequently, total southbound available capacity could be as large as 1199 MW.

As early as 2008, the owners of the Navajo-Crystal, Moenkopi-Eldorado and Mead-Perkins lines anticipate an increase of approximately 1,245 MW to their lines. The addition to the Navajo-Crystal line may be as large as 415 MW of available transmission capacity.

**VIII. Conclusions**

Based on the results from the various analyses and assessments completed to date, the facilities outlined for the Project (at a net output of 1,400 MW) meets or exceeds WECC/NERC Planning Standards and APS reliability criterion for the
2009 time frame. Facilities associated with the Project include those shown in Figure 1 as well as the special protection system described earlier in this report.

With the plant operating at its scheduled output of 1,400 MW, the Four Corners West path (Path 22) and the Southern Navajo path (Path 51) can operate at their present accepted ratings without adverse impacts. In addition, the Four Corners Generating Station can operate at its current net capability of 2,060 MW with the plant at its scheduled output of 1,400 MW.
Appendix A

Inadvertent Flow Summary Results
## Appendix B
Power Flow Results

<table>
<thead>
<tr>
<th>B1.</th>
<th>Summary table for prj_02g</th>
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<tbody>
<tr>
<td>B2.</td>
<td>Summary table for prj_02jx</td>
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<tr>
<td>B3.</td>
<td>Summary table for prj_02g2</td>
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<tr>
<td>B4.</td>
<td>Summary table for prj_02j2x</td>
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<tr>
<td>B5.</td>
<td>Summary table for prj_02jxz</td>
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<td>B6.</td>
<td>Summary table for prj_02j2z</td>
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<tr>
<td>B7.</td>
<td>Summary table for prj_02jxr</td>
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<tr>
<td>B8.</td>
<td>Summary table for prj_02j2r</td>
</tr>
</tbody>
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Appendix C
Transient Stability Results

C1. Summary table for prj_02g
C2. Summary table for prj_02jx
C3. Summary table for prj_02g2
C4. Summary table for prj_02j2x
Appendix D
Navajo Margin Transient Stability Results

D1. Summary table for prj_02n
D2. Summary table for prj_02nx
D3. Summary table for prj_02n2
D4. Summary table for prj_02n2x
D5. Summary table for prj_02ny
D6. Summary table for prj_02n2y
Appendix E
Post-transient Stability Results

E1. Summary table for prj_02gb and prj_02ge
E2. Summary table for prj_02jxb and prj_02jxc
Appendix F
Fault Duty Results
Appendix H
Four Corners Generating Station SSR Results