NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Reliability Readiness Evaluation Report

Balancing Authority/Transmission Operator

Salt River Project

Scottsdale, Arizona

to ensure the reliability of the bulk power system

November 5–8, 2007

116-390 Village Blvd., Princeton, NJ 08540
609.452.8060 | 609.452.9550 fax
www.nerc.com

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Introduction and Evaluation Process

The North American Electric Reliability Corporation (NERC) Reliability Readiness Evaluation and Improvement Program is one of the commitments of NERC and the industry to strengthen the reliability of the North American bulk power system. The program conducts independent evaluations of balancing authorities, transmission operators, reliability coordinators, and other key entities that support the reliable operation of the bulk power system to assess their preparedness to meet their assigned reliability responsibilities. The evaluations identify strengths and areas for improvement in an effort to promote excellence in operations among these organizations.

Since its inception in 2004, NERC and the industry have been working collaboratively to enhance the program. The evaluation process is based on fundamental aspects of reliability: culture, operations, maintenance, planning, and training. Documents related to the program are available at http://www.nerc.com/.

The reliability readiness evaluation teams, each led by a NERC staff member and a regional co-leader, include industry volunteers with considerable expertise selected to provide representation from other interconnections, other regions, and neighboring operating entities. The teams also typically include representatives from the Federal Energy Regulatory Commission (FERC) staff.

The public version of the reliability readiness evaluation report contains the majority of the evaluation team's findings. Any discussion of findings pertaining to critical infrastructure will be contained in Appendix 1, a confidential appendix to the report that is sent privately to the evaluated entity and is not included in the public version of the report.

An evaluation team met on-site with Salt River Project (SRP) representatives on November 5–8, 2007. This report reflects the views and recommendations of the evaluation team regarding the readiness of SRP to meet its responsibilities as a balancing authority/transmission operator.

Evaluation Team

Darrell Piatt*	NERC
Anitha Neve*	Western Electricity Coordinating Council (WECC)
Xavier Baldwin	City of Burbank Water and Power
William Moojen	Snohomish Public Utility District No. 1
Phil Vavala	Potomac Electric Power Company
James (Jim) Hartwell	Northeast Power Coordinating Council
Paul Robb	FERC

*Team co-leader

Organization Profile

Salt River Project is two companies: the Salt River Project Agricultural Improvement and Power District, a political subdivision of the state of Arizona; and the Salt River Valley Water Users' Association, a private corporation. The Salt River Project Agricultural Improvement and Power District, hereafter referred to generically as SRP, is a non-profit company that serves electric power to over two million residents within a 2,900 square mile territory that includes the Phoenix metropolitan area, known as the "Valley," as well as several mining customers in the eastern service territory.

SRP has 54 interconnection points with 7 adjacent balancing authorities: Arizona Public Service Company (APS), Public Service Company of New Mexico, Tucson Electric Power Company, California Independent System Operator, Arlington Valley, New Harquahala Generating Company, and the Western Area Power Administration - Lower Colorado (WALC) (part of the Western Area Power Administration). These interconnection points occur at the 500, 230, 115, and 69 kV voltage levels. SRP owns and/or operates 1,349 miles of 500 kV lines, 369 miles of 230 kV lines, and 41 receiving stations at the 500, 230, and 115 kV voltage levels. SRP also operates 236 subtransmission substations and over 1,000 miles of 115 and 69 kV subtransmission lines. SRP is tightly interconnected with Arizona Public Service in serving the Valley area.

SRP currently operates or participates in 11 major power plants and numerous other generating stations — including thermal, nuclear, natural gas, and hydroelectric sources — with an installed generation capacity of 5,689 MW. SRP had a peak demand of 6,765 MW on July 21, 2006 with available resources totaling more than 8,100 MW to serve the peak.

SRP operates within the WECC Regional Entity and is in the Rocky Mountain Desert Southwest Reliability Coordinator (RDRC) operating footprint. SRP is registered with NERC as a balancing authority, distribution provider, planning authority, purchasing-selling entity, resource planner, load-serving entity, transmission owner, transmission operator, transmission planner, transmission service provider, generation owner, and generation operator. The System Operations organization contains Transmission and Generation Operations, Transmission System Planning (long range), Transmission Planning (short term), Computer Applications, Electronic Systems, and Power Accounting Services.

Executive Summary

The evaluation team found no significant operational problems and concluded that SRP has adequate facilities, processes, plans, procedures, tools, and trained personnel to perform the balancing authority/transmission operator functions necessary to maintain the safe and reliable operation of the bulk power system.

SRP is a public power company with a strong focus on providing customers with safe and reliable electric and water service within the context of affordable rates and environmental responsibility to support the rapid economic growth of its service territory. SRP is committed to using water and power resources wisely so as to benefit its water shareholders and electric customers while building and maintaining a strong partnership with communities that is serves. In this business environment, SRP has developed a strategic focus to define its forward-looking corporate posture, which it refers to as "*thinking in the future tense.*"

The team's positive observations recognize SRP's commitment to purchasing and installing computers, networks, and control systems that are relevant with respect to current control technology. The team also recognizes SRP's creative application of these systems and third-party software applications. Additionally, SRP practices and procedures add value to transmission operations, resulting in transmission system safety and reliability.

The team's recommendations generally identify the next area of opportunity for incremental improvement, not deficiencies. These areas of opportunity come from the broad level of experience and industry exposure that the team represents, and some of the recommendations represent areas that are already under consideration by SRP.

Overall, the evaluation team identified 10 positive observations. In addition, the team offers 11 recommendations that, if implemented, will enhance SRP's ability to operate the bulk power system safely and reliably. The recommendations have been prioritized by the evaluation team and are listed accordingly.

Positive Observations

The evaluation team noted the following positive observations during the reliability readiness evaluation process:

1. Confidential information on computer systems and support redacted from public report. See discussion in Appendix 1.
2. Confidential information on computer systems and support redacted from public report. See discussion in Appendix 1.
3. SRP has developed and implemented the creative use of third-party software to display trended system data (Section 2.3).
4. Confidential information on power supply for control facilities redacted from public report. See discussion in Appendix 1.
5. SRP effectively uses phasor measurement units (PMU) and synchrophasors to monitor fault data and enhance the associated analysis (Section 3.2.1).
6. SRP has field tested its blackstart cranking paths to ensure operational validation (Section 2.4).
7. SRP enhances system operator training through actual system operation from the backup control center twice per year by each system operating shift team (Section 5.1).
8. SRP senior system management demonstrates a strong commitment to support and funds major projects to enhance transmission system operability and reliability (Section 1.2.2).
9. SRP has developed and implemented the use of a talent pool to support succession planning in managing the workforce demographic (Section 1.2.4).
10. SRP has demonstrated a strong commitment to support interconnected neighboring utilities, WECC, and NERC with safety, compliance, and reliability initiatives (Section 3.2.1).

Recommendations

The evaluation team offers the following recommendations:

1. Increase the integration of the state estimator and real-time contingency analysis tools into transmission system operations so they become essential analysis tools used to maintain and enhance system reliability (Section 2.3).
2. Purchase and incorporate the use of a dispatcher training simulator as a principal training delivery tool to enhance the learning experience and increase operational skills (Section 5.1).
3. Implement, as appropriate, a real-time or near-real-time dynamic stability analysis tool to monitor the transmission system voltage stability margin (Section 2.2.2).

4. Confidential information on plans for loss of control center redacted from public report. See discussion in Appendix 1.
5. Confidential information on plans for loss of control center redacted from public report. See discussion in Appendix 1.
6. Perform a job task analysis on all the system operator job classifications to fully focus the training requirements necessary to develop and strengthen the associated skill sets (Section 5.1).
7. Revise (and publish) the shift-change procedure into a checklist-driven process and specify the requirements associated with bringing a system operator back on-desk after an extended absence to ensure the operator is adequately prepared to fully assume the on-desk operating responsibilities (Section 2.2.3).
8. Implement a document management tool to identify document ownership, manage revision cycles, manage cataloguing, and verify system operator review and understanding of new and revised operating procedures (Section 2.2.3).
9. Confidential information on physical security redacted from public report. See discussion in Appendix 1.
10. Confidential information on plans for loss of control center redacted from public report. See discussion in Appendix 1.
11. Confidential information on power supply for control facilities redacted from public report. See discussion in Appendix 1.

Discussion

The reliability readiness evaluation team examined the following key areas during the evaluation. The detailed discussion that follows provides the foundation for the recommendations and positive observations the team identified. The report uses the generic term "system operator" to refer to all on-shift operating personnel responsible for executing the functions necessary to operate reliably and maintain the reliable operation of the bulk power system. This term will be used for the discussions unless additional specificity is required, such as *balancing* system operator or *transmission* system operator.

1. Culture

1.1 General

The corporate organization provides the necessary leadership and management for system operations to sustain high levels of safe, reliable operation.

SRP is a forward-looking organization with a strong strategic planning process that supports the corporate mission by implementing a strategic road map and setting goals for each business unit. The Transmission Business Segment's mission statement "*is to deliver an adequate and reliable supply of energy from chosen suppliers to customers within SRP's service territory…*" The System Operations department, as a part of the Transmission Business Segment, has specific objectives that include safety and system reliability as well as a focus on customer service and effective cost controls. Other key focus areas include proactive corporate citizenship, environmental responsibility, and active participation in industry organizations.

1.2 Organizational Effectiveness

1.2.1 Foundation for System Reliability

The organization's values and behaviors—modeled by its leaders and practiced by its members—serve to make system reliability a top priority.

SRP has a four-step strategic planning process: 1) assess and review current strategies against associated business results; 2) develop a new financial plan and budget; 3) define the new/revised corporate and operational objectives; 4) implement work plans and monitor progress. The updated strategic plan is integrated into each business unit, and all associated departments create departmental objectives to support the plan's implementation, resulting in individual responsibilities stated in each employee's annual performance plan. SRP provides talking point aids to managers and supervisors to foster communication of the updated strategic plan to all employees.

SRP defines its corporate mission in the *Salt River Project 2007 Annual Report* and other corporate documents available to SRP employees. In one document, a member of SRP's senior management states "*our workforce deserves full credit for SRP's successful fiscal year.*"

The System Operations department has four major categories in its *2007–2008 Objectives*. The first is safety and environmental; the second is budget; the third is performance, which includes system reliability as well as system reliability performance indicators; and the fourth is shareholder and customer satisfaction, which includes good customer service to those interconnecting to the transmission system.

1.2.2 Leadership and Management

Managers, by leadership, commitment, and example, establish and reinforce high standards of performance and align the organization to achieve safe, reliable system operation.

Under the category of performance in the SRP System Operations department *2007–2008 Objectives* document is a requirement for each supervisor above a certain salary grade to have a written and signed development plan. This requirement assigns the supervisor with performance criteria that support the SRP strategic performance objectives.

In the opinion of the system operator interviewed by the evaluation team, the commitment by SRP leadership to a high level of performance is evident in the goal linkage in the annual performance plans, the desire of the supervisors to listen and respond to the ideas and concerns of the employees, and the resourcing of the operating needs in the way of equipment and associated training. The commitment to reliability and safety in all areas of system operations is evident not only in writing but also in practice. This commitment is further reinforced as topic areas in company meetings and periodic reports to all employees indicating corporate performance in the annual plans and goals.

SRP's senior leadership and management have supported a number of projects that have significantly enhanced SRP's ability to operate in a more efficient manner. Projects such as the new energy management system (EMS), new network hardware, the large portfolio of operating tools, and the new backup control center project are examples of a commitment to staying abreast of technology and advancing the enterprise. The evaluation team commends SRP's senior system management for demonstrating a strong commitment to support and fund major projects to enhance transmission system operability, safety, and reliability.

1.2.3 Corporate Oversight and Monitoring

Line management is used to strengthen reliability and improve performance. System reliability is kept under constant scrutiny through techniques such as self-assessments, performance indicators, and periodic management meetings.

SRP prepares a summer-preparedness study that addresses loads, resource margins, fuel supplies, maintenance status, and emergency preparedness. This report is presented to the general manager's staff and the SRP Board each year at the beginning of the summer season. In addition, the Transmission Business Segment presents the status of system performance to the general manager's staff three times per year. Included in these presentations is the status of the corporate goal areas for which this business segment is responsible. During the summer peak season, a weekly system update is provided to the general manager's staff to ensure a shared understanding of system performance. Also, SRP management provides periodic corporate goal

performance reports to employees to ensure uniform understanding of the status of the strategic goals.

According to SRP management, system performance is discussed in almost every one-on-one meeting between senior management personnel. The general manager provides an overview to small groups of SRP employees annually so as to promote discussion and increase understanding and a shared commitment to these goals. Employees are encouraged to provide candid feedback and observations regarding ways to improve SRP's operations. In keeping with this theme, SRP has implemented a "Power of Ideas" program to enable employees to share ideas, provide feedback, and make any other observations that could potentially improve corporate performance.

1.2.4 Human Resources

Personnel resource needs are anticipated and individuals are systematically recruited, developed, and assigned positions in the system operations organization.

SRP Transmission and Generation Operations is currently staffed to accommodate a planned loss of a dispatcher or system operator by bringing a replacement employee into a training position one year in advance. In general, a trainee can complete the initial system operator training and obtain the required NERC certification in that period. This is due in part to the fact that the primary candidate pool resides within SRP generation plant operations. The initial training program is discussed in Section 5 of this report.

SRP's staffing policy not only supplements the needs created by the retirement or loss of qualified operating personnel, but it provides a fully qualified relief shift to facilitate the release of a system operator or dispatcher from on-desk responsibilities to attend training. The success of this staffing policy has resulted in adoption of similar policies in other areas of operating support.

1.2.5 Corporate Communications

System operations communications inform and engage both corporate and system operations employees so they can contribute to the strategic priorities of the organization.

As discussed, SRP has a strong commitment to effective communications up and down the organization. The management team in system operations actively solicits the input and ideas of system operators as well as other support personnel. The managers hold "tailboard" meetings each weekday that involve both the day and evening shift personnel. Quarterly system operator meetings are held to review departmental as well as corporate performance. These meetings often serve as a venue for problem solving or idea development regarding process improvements or opportunities to utilize new tools.

A number of corporate documents provide the status of corporate or departmental goal performance. The corporate communications strategy incorporates both verbal and written communication; however, the most powerful impact of the strategy is when actions are consistent with the other elements of communication. As a result of the interviews conducted

during this evaluation, it is the opinion of the evaluation team that SRP works hard to communicate consistently in both word and deed.

2. Fundamentals of Operations

2.1 General

Operations personnel monitor and control the system in a manner that ensures safe, reliable operation.

SRP has an effective system of communications for and with the system operators and operating support personnel. An operations manager is usually present at shift change to facilitate communications during shift change, and SRP uses a third-party software program for the system operations log. This program includes access to several databases, providing archival and retrieval functionality. Additionally, SRP uses the WECC Messaging System to monitor and communicate a number of events and circumstances related to the interconnected bulk power operations within the interconnection. SRP uses Lotus Notes for operating policies, procedures, and practices as well as other information related to system status. SRP also uses the intercontrol center communications protocol (ICCP) to exchange system operating data within WECC.

2.2 Operational Focus

2.2.1 Operational Safety

System operation activities are conducted in a manner that maintains high levels of safety and reliability for all system conditions.

SRP clearly has a strong safety-first emphasis, encouraging safety both at work and home. Safety is a goal area that is incorporated into performance evaluations as well as the incentive pay plan; SRP also has safety recognition programs. A monthly safety review is distributed to inform employees about safety issues and safety performance. In the *2007–2008 Organizational and Departmental Goals and Objectives for Transmission and Generation Operations*, safety is listed as the first performance goal and includes metrics that will be used to evaluate performance in this key area. The *Power, Construction and Engineering Services Fiscal Year 2008 Business Plan* provides the safety metrics for this department. A picture on this same corporate document shows a SRP work group receiving the 2007 President's Trophy for safety.

A root cause analysis performed to evaluate each event (regardless of the nature — human error or not), its cause, the actions required to fix or prevent a future event, training opportunities, and the need to publish a new or revised policy or procedure. The lessons learned are shared with all employees, and often the presentation is made by an involved employee so as to increase each employee's commitment to safety. SRP also uses a safety training observation program to foster and encourage safe behavior. Unsafe behavior is first addressed by coaching and training. Chronic unsafe behavior is not tolerated. See Section 5.2.1 of this report for additional discussion on this topic.

2.2.2 Operational Decision-Making

Operational decisions are reached using a systematic and thorough approach that supports safe, reliable, and efficient system operations.

SRP system operators are authorized to take any actions necessary to provide for the safe and reliable operation of the interconnected transmission system, up to and including the dropping of firm load. This authority is documented in the system operator's job descriptions as well as in *AOP OP 1000 – Emergency Operation Authority*, signed by the manager, system operations. This authority is also recognized by the interconnected neighbors as indicated in the neighboring system questionnaires received as part of this readiness evaluation. The system operator interviewed as part of this evaluation was very confident in both his authority and his ability to operate the transmission system in a safe and reliable manner.

SRP has good wide-area view capabilities with the EMS model, which extends one to two buses into adjacent balancing authority and interconnected transmission system areas. SRP also has visibility of generation values for the neighboring balancing authorities that can be displayed on EMS summary screens or on one-line diagrams. The wide-area view with the associated data, in the opinion of the evaluation team, provides to the system operator all the information needed to establish a good context of situational awareness on a real-time or near-real-time basis.

The SRP alarm system that is part of the new EMS has nine different alarm-severity levels with color and audible capabilities, and SRP uses all nine levels. Additionally, the system has a number of sorting and filtering options for managing alarms. SRP uses an area of responsibility concept for breaking the alarms down into classes for alarm management. Alarms can also be viewed on the event-log viewer, which can export the alarm data into Excel for quick and concise display of all alarm or event data. The EMS alarm system has a "heartbeat" monitoring system to monitor the health of the alarm processor. If a problem is detected, the system will send a page to the computer applications person who is on call.

SRP uses three frequency monitoring points as input sources for the EMS. The primary control center only accepts two frequency monitoring points that serve as EMS inputs for system control functions so that if one source fails the EMS automatically switches to the second source. There are 27 frequency monitoring points on SRP transmission system, but only 21 frequency monitoring points are available for display. All the monitored system frequency points are time-error corrected by an arbiter clock.

The SRP frequency monitoring points are widely dispersed and can be displayed as tabular EMS display or in the "Process Book," a trending application extensively used by the system operators. The frequency monitoring performed by SRP is, in the opinion of the evaluation team, adequate in indicating potential islanding, actual islanding, and the extent of an islanding condition. SRP does not use a wide-area geographic display of system frequencies; the evaluation team believes this application should be considered but does not put it forward as a recommendation.

SRP maintains system voltage within a plus or minus five percent range. Automatic and manually operated devices are used to control system voltage and prevent potentially low-voltage conditions. The automatic devices consist of shunt capacitors on the 230, 115, and 69

kV systems as well as shunt reactors and a static var controller connected on the 115 kV systems. In addition, 66 percent of the 12 kV distribution capacitors are automatically controlled to maintain unity power factor for the distribution feeder. The manual controlled devices consist of shunt capacitors on the 230 kV system and 22 percent of the 12 kV distribution capacitors. The majority of the reactive resources required to reliably operate the SRP system are the var supplied by the generators on the system.

SRP coordinates voltage levels with neighboring balancing authority areas according to the *Arizona Security Monitoring Manual.* This document specifies that there will be minimum reactive flow between balancing authority areas at the points of interconnection. When violations occur, there is notification and discussion concerning the cause and possible solutions.

During the summer peak-loading period, SRP requires Valley generation to run so as to provide the necessary reactive support. The SRP system operators monitor Valley loads and generation to determine the reactive margins to stay prepared for the next-worst contingency. Multiple reactive reserve screens on the EMS provide summaries of both static and dynamic reactive reserves.

Due to the large amount of transmission-dependent load served by SRP and APS in the Phoenix metropolitan area, coupled with the reactive component of residential air-conditioning, the evaluation team recommends that SRP implement, as appropriate, a real-time or near-real-time dynamic stability analysis tool to monitor the transmission system voltage stability margin.

All SRP generators have automatic voltage regulation (AVR), with the exception of one small hydro unit for which the real and reactive power output is fixed based on a fixed water order. If a SRP generating unit is in dispatch or on-line at minimum power and the AVR is not in the automatic mode, the system operator receives an alarm and the plant operator is contacted to investigate the occurrence. SRP has a carefully followed policy regarding the operation of AVRs regarding notification, maximum out-of-service times, and other operating criteria. Additionally, all SRP generators are required to be equipped with power system stabilizers that must remain in service at all times during the operation of the generating unit. This is a WECC requirement, and if the power system stabilizers are not operational on an in-service generator the system operator receives an alarm and follows similar procedures to those associated with the AVRs.

SRP is a founding member and administrator of the Southwest Reserve Sharing Group, which is discussed further in Section 4 of this report. The SRP operating reserve is defined by the greater of a defined percentage of load or the largest unit in dispatch. SRP's EMS has an operating reserve screen that displays SRP's distribution of operating reserves and the reserve requirement by unit. This display also shows ramp rates and the area control error (ACE). ACE is visible on the board display and on most EMS displays.

2.2.3 Operational Alignment

Organizational structure supports safe and reliable system operation.

SRP has the appropriate interconnection agreements in place for the transmission lines that interconnect to the SRP transmission system. In addition, SRP has agreements with the Electrical District No. 4, Pinal County, Arizona; Mesquite Power, LLC; United States Department of Interior, Bureau of Indian Affairs, San Carlos Irrigation Project; and Gila River Indian Community Utility Authority to provide balancing area services to these load-serving entities.

RDRC provides reliability coordinator services to SRP in accordance with the *WECC Reliability Coordinator Plan* and the *RDRC Reliability Coordinator Empowerment Agreement*. No reliability coordinator functions have been delegated to SRP by RDRC, nor has SRP delegated any balancing authority/transmission operator authority to another entity on a permanent basis. During a transition from the primary control center to the backup control center, SRP delegates its balancing authority/transmission operator authority to APS — usually between 20 and 30 minutes.

SRP has a comprehensive, well-documented body of operating policies, procedures, and practices. The documents reside on two clustered servers operating in a Lotus Notes environment. These servers operate on the SRP corporate network, with connectivity available in the primary as well as the backup control center via firewalls and the virtual private network servers. System operators are notified of updates to existing or new policies, procedures, and practices via Microsoft Outlook, and this application tracks whether the system operator has read and acknowledged understanding of the new or revised document. After reviewing these document management practices, the evaluation team recommends that SRP implement a document management tool to identify document ownership, manage revision cycles, manage cataloguing, and verify system operator review and understanding of new and revised operating procedures.

SRP has a procedure for managers to be present at the morning and afternoon system operator shift changes. Information is exchanged in both verbal and written format. In the opinion of the evaluation team, this process is adequate but can be improved. The evaluation team recommends that SRP revise (and publish) the shift-change procedure into a checklist-driven process and specify the requirements associated with bringing a system operator back on-desk after an extended absence to ensure the operator is adequately prepared to fully assume the on-desk operating responsibilities.

Outage coordination is discussed in Section 4 of this report. The documentation for generation outage coordination is given in *AGC OP 10201* and transmission outage coordination in *PDO OP 46205*. All outages are reviewed by the night shift. The night shift usually prepares the switching order, and the order is reviewed again by the day shift before being dispatched.

2.3 Managing System Configuration

Power system configuration is carefully designed, analyzed, maintained, and controlled throughout the life of the infrastructure, ensuring that system and equipment margins are understood, considered in decision-making, and managed consistent with design and system requirements.

SRP has a complete portfolio of operating tools to enable its system operators to operate the transmission and generation system in a safe and reliable manner. SRP has the NERC calculation package, outage-scheduling program, tagging applications, trending applications, multiple weather sources, lightning-detection program, event-log viewer, Lotus Notes applications, and the reserve sharing system. Additionally, SRP has webSAS, an Internet tool that WECC uses to implement the unscheduled flow reduction procedure, and WebTrans, an Internet-based tool to facilitate the management of the wholesale transmission market.

SRP has a number of other applications as part of the EMS package, including a state estimator, real-time contingency analysis, and dispatchers' load flow program. SRP also has PI Archiver for archiving operating data and trending, a load-shed program, and the save-case snapshot program that saves each hourly operating case for up to 21 days. The SRP system operators also have Process Book, which is used for trending applications. The system operators have developed and implemented a number of creative applications using this software product, and the evaluation team commends this innovation. In the opinion of the evaluation team, SRP has an excellent set of operating tools and effectively uses these tools to operate the system in a safe and reliable manner.

SRP has experienced some problems with the state estimator and real-time contingency analysis tools associated with the new EMS. The evaluation team recommends that SRP expedite a remedy. Further, the team recommends that SRP increase the integration of the state estimator and real-time contingency analysis tools into transmission system operations so that they become essential analysis tools used to maintain and enhance system reliability.

SRP has a good real-time display of its transmission and generation system on a dynamic mapboard driven by the EMS. This is a "no light board," meaning that for a normal operating condition or status no lights are lit. SRP is still installing incremental improvements on this board associated with the increased capability of the new EMS.

SRP manages transmission system congestion on the bulk power system in the SRP system footprint. SRP primarily uses the WECC Rated System Path Methodology for determining the total transfer capability of a rated transmission path. The only SRP path in the WECC Path Rating Catalog is Path 54, the Coronado—Silverking 500 kV transmission line.

There are no interconnection reliability operating limits (IROLs) in the SRP transmission footprint. Security operating limits (SOLs) are identified in the annual Valley operating study along with the associated mitigation procedures. The SOLs are reported to the reliability coordinator and posted on WECCNet.

SRP has three special protection schemes/remedial action schemes (SPS/RASs) — two are generator tripping schemes and one is a load tripping scheme. The status all three SPS RAS are visible in EMS; however, these are stand-alone systems and do not depend on EMS inputs for operation. The relay maintenance on these three SPS/RASs is performed by SRP with documentation maintained in the relay maintenance management program.

2.4 Emergency Preparedness

The organization is prepared to manage and mitigate the impact of system emergencies in order to preserve the reliability of the system and to protect the interests of the public.

SRP's capacity and emergency plan is current and readily accessible to the system operators. The plan covers all the areas required to be addressed and is activated when it is apparent that minimum Southwest Reserve Sharing Group spinning reserves cannot be maintained during the next operating hour or for several subsequent hours during a peak load period. If the capacity emergency alert continues, SRP will activate the *AGC OP 14601 – Pre-Load Shedding Checklist* and the rotating blackout procedure will be ready for implementation. If conditions continue to deteriorate and a Level 3 Alert is declared, the Crisis Management Team is activated and assembled in the emergency operations center. In the opinion of the evaluation team, this reflects good planning and careful documentation in this critical area by SRP.

The blackstart restoration plan is part of *PDO OP 41001 – SRP System Restoration Plan.* The reliability coordinator, RDRC, handles overall restoration coordination, which includes synchronizing cross-jurisdictional islands. SRP has operationally validated one of its blackstart cranking paths. The evaluation team commends SRP for this significant initiative to verify that the identified path can and will perform as planned.

The reliability coordinator conducts system restoration tabletop exercises annually in which each balancing authority participates using its own system restoration plan. The reliability coordinator introduces "what if "scenarios each year to expand the scope and effectiveness of this training. The training also requires considerable communications between the interconnected balancing authorities, which is an additional benefit. All SRP system operators are required to participate in the drill.

SRP has an underfrequency load shedding (UFLS) program with a defined number of steps for shedding a specified percentage of peak load per step in accordance with the WECC requirements. The UFLS program is reviewed and updated on an annual basis by the SRP System Protection department. SRP also uses automatic load restoration that initiates when the frequency returns to predefined setting; load restoration is accomplished in two percent of system load increments at five minute intervals.

SRP has a manual load shedding program that uses the EMS load shedding program. The amount of load to be shed is specified, and the system operator inputs the parameters of load to be shed, the number of steps, and the duration (if it's a rolling load shed). The program will open and close substation breakers to execute the process. There is the possibility of some overlap between the UFLS and the manual load shedding program; however, SRP believes that due to the size of its system and large number of substations, the impact would not compromise the desired result from either program.

SRP has implemented the WECC off-nominal frequency trip requirements for all the generation in the SRP footprint. This program is in effect for one of the systems that SRP provides with balancing area services.

The Palo Verde nuclear power plant is in the APS footprint, and the agreement for critical bus voltage support is with APS. Due to the close connected arrangement between APS and SRP on the 500 kV system, close coordination between the two utilities is required to control and maintain the critical bus voltage. In keeping with this requirement, SRP monitors the Palo Verde critical bus voltage. Also, SRP models the plant load in its transmission studies and performs a duplicate final safety analysis report, which is updated each year. The evaluation team believes this teamwork is a key element in the safe and reliable operation of the interconnected transmission system.

3. Fundamentals of Maintenance

3.1 General

Maintenance is conducted by skilled personnel to achieve safe, reliable control center equipment and system performance.

SRP has recently installed a new EMS as well as network hardware in the primary control center. This system has been designed and installed so as to provide for a strong level of redundancy, enabling routine maintenance to be performed with no interruption of the control functions. The core system, for example, consists of three pairs of servers with redundant power supplies. All the consoles are designed so as to fail over to the alternate network if a problem occurs.

SRP's primary supervisory control and data acquisition (SCADA) network consists of multiple SONET rings (fiber optic networks). The ring topology is configured with redundant power supplies and several levels of redundancy on the critical nodes.

The SRP organizational structure is such that computer applications and electronic systems support is part of System Operations. This provides for close coordination and communications by operations and operations support personnel to facilitate maintenance and emergency response to system problems.

3.2 Equipment Reliability

3.2.1 Equipment Performance

The organization achieves high levels of equipment reliability. Equipment problems that impact reliability are resolved in a thorough and timely manner.

To ensure that maintenance is effective, SRP has a system availability goal of 99.98 percent; the present EMS availability level is 99.99 percent. To ensure that equipment performance remains at a high level, SRP uses a number of monitoring techniques to identify problems in order to make repairs prior to any degradation of operational capability.

Critical cyber network communication interfaces are monitored by an Internet control message protocol (ICMP). If the interface does not respond to an ICMP request, the HostCheck issues a system log message that is kept locally on the hardware management console and reported to a remote IBM customer support center. Also, a message is e-mailed to the SRP computer infrastructure support group.

EMS applications have computer-based monitoring systems that automatically generate a page and an e-mail in the event that a problem is detected. The telecommunication systems are monitored continuously, and the radio systems and ring down lines are tested annually to check for signal strength and clarity.
SRP has a number of digital fault recorders and sequence of events recorders to monitor the performance of the transmission system during contingency conditions. These devices validate the design and performance of the protective relaying systems. All recorders are time synchronized by digital clocks that receive a time data signal from satellites. It should be noted that at the time of this evaluation, WECC had no installation requirements for disturbance monitoring equipment. In 2003, SRP entered into a disturbance monitoring agreement with WECC for the installation of this equipment.

SRP participates in a voluntary WECC program to install phasor measurement units (PMUs) and synchrophasors. The data concentrator for this data is located in an APS substation. SRP has been assisting neighboring utilities in the region with the interpretation of PMU data and any associated recommendations for the outages that are being analyzed. SRP has been involved with this technology since 1990 and has actively funded some of the research efforts. More recently, SRP has been working on establishing Ethernet-based synchrophasors for system operator visibility and other applications, such as post-event analysis and line impedance verification. The evaluation team commends SRP for its active role in the deployment of the PMU and synchrophasor technology and for assisting neighboring utilities in utilizing this technology to enhance reliability.

3.2.2 Work Management

Work activities, including corrective, elective, and preventive maintenance, surveillance testing, and modifications, are managed effectively to support safe, reliable operation during both outage and routine periods.

All energy management, data communication, and voice communication systems are continuously monitored, and problems trigger both e-mails and pages to the appropriate maintenance and repair personnel, who are available to respond 24 hours per day, 7 days per week. If a system operator detects a problem, it is reported using SRP's "report a problem" system. The system will indicate the severity level of the problem, therefore determining the level of response to the problem. The required response time on an emergency ticket is 15 minutes. The work orders associated with these trouble reports are managed in a SRP work management system. The new EMS and network hardware are still under warranty, and arrangements for vendor response are in place.

Once each quarter, SRP performs maintenance upgrade patches and firewall upgrades to the EMS hardware. Routine maintenance is performed by scheduling the required EMS and network outages with all three dispatching groups, if they are affected, early in the work week and early in the work day when vendor support and internal staffing are at the highest levels. The upgrades to the Cisco data switches and routers are performed based on security issues. The data in the state estimator are updated manually, and SRP has a designated employee with the responsibility to keep the state estimator model current with system changes. The state estimator has a "bad data" summary display that shows a comparison between real-time data and state

estimator solution data, keying on deviation levels. These events are addressed immediately to identify and remedy the problem.

System operators compare primary and secondary real-time values and end-of-hour values to detect metering errors. Metering errors are usually evident when a larger than expected deviation between real-time and end-of-hour integrated load and excessive inadvertent accumulation are viewed for one or more hours of operation. SRP compensates for metering errors by biasing the "manual offset" on the ACE calculation display in the EMS. Transmission tie-line metering is tested annually and maintained as needed.

The SRP transmission system frequency transducers used for the EMS control functions are calibrated on an annual basis. Frequency transducers on the 500 kV systems are maintained on a two-year cycle, and those on the 230 and 115 kV systems are maintained on a four-year cycle. These maintenance cycles are managed using Cascade, a relay maintenance management tool and database.

4. Fundamentals of Operational Planning

Operational planning provides the technical information and support necessary for safe, reliable system operation.

SRP is a participating member of the Central Arizona Transmission Study Extra High Voltage Group, Southwest Area Transmission Regional Planning Group, and the WestConnect Regional Planning Group. In addition to participating on regional planning committees, SRP works closely with interconnected neighbors to coordinate transmission and operational planning.

SRP transmission planning is accomplished using a power system load-flow tool that incorporates in-house developed software for the front-end data preparation. SRP uses the current WECC joint bulk summer base case, deleting Arizona area from this base case and replacing it with the previous year's detailed study, known as the Valley operating study. SRP loads, generation, interchange schedules, system configuration and equipment ratings are updated and placed in the current year Valley operating study. The model is then sent to APS so that its data can be updated in the model before being sent to WALC, Tucson Electric Power, and Southwest Transmission Cooperative for updating their system data. The new study case is then run to validate the expected operating parameters before being released to the transmission system owners and operators in the state of Arizona.

Using the current year Valley operating study, SRP and APS transmission planners jointly develop post-transient and thermal nomograms by lowering the generation and looking for voltage and/or var limit violations. These nomograms are used by the system operators to validate unit commitment and reactive requirements for the most critical contingency. The thermal nomograms are used to ensure that voltage deviation for the most severe single contingency does not exceed the specified limit.

The daily operating studies are performed by the RDRC. The RDRC builds a case to reflect the area load, the next day's generation, the scheduled outages, planned interchange schedules, and the next day's system peak load. SRP checks these cases for thermal and voltage problems. In

the event a potential problem is identified, a conference call is initiated to discuss and resolve the issue.

SRP's transmission planning can perform near-real-time studies if needed, and real-time contingency analysis is run by the system operators on the day shift on a limited basis. The state estimator and real-time contingency analysis system model development for the new EMS has experienced problems in modeling phase shifter operations, and the converged cases represent some inaccuracies. Work to remedy this situation is in progress. If a contingency case is needed, the RDRC can run the case and send the results to SRP. For various critical facilities, SRP performs pre-contingency monitoring to enable the system operators to address a potential problem for pre-identified contingencies.

The SRP day-ahead energy resource plan is developed by SRP's supply and trading group. The group develops the day-ahead load forecast using projected weather conditions and historical load data and then develops the day-ahead hourly load projection. The resource plan is then developed, taking into account unit outages and/or derates. The day-ahead load forecast and capacity plan are sent to the balancing authority system operators for the construction of the unit commitment plan for the next day. This plan is routinely modified on a real-time basis as the load forecasts are adjusted and weather patterns develop.

SRP is a founding member of the Southwest Reserve Sharing Group and serves as the group's administrator, with one full-time employee dedicated to this function, and hosts the group's software on its computer system. The administrator runs the reserve scheduling system and provides front-line support 24 hours per day, 7 days per week. Procedural guidance for this operation is documented in *AGC OP 13202* and *AGC OP 14303*. SRP is prepared to respond to requests for spinning or non-spinning reserves from other balancing authorities. SRP supplies spinning reserves to various entities resulting from the sale of reserves by the SRP marketing affiliate.

SRP uses Lotus Notes as the basis for scheduling transmission and/or generation outages via a Web-browser interface. Generation outages are to be submitted a minimum of 30 days in advance; SRP's marketing function assesses the impact of the outage and sends approvals via e-mail. Transmission outage requests are reviewed and approved by the outage coordinator as per *PDO OP 46205*. Often, the request requires additional assistance from transmission planning for a study, outage priority evaluation involving transmission operations management, and coordination with interconnected neighbors.

5. Fundamentals of Training

5.1 General

Training in both specific job-related skills and broader technical fundamentals is used to provide highly skilled, knowledgeable personnel for safe, reliable operations, and to achieve performance improvement.

SRP has a defined training program for new and experienced system operators. SRP has a dedicated training staff of a training supervisor and two training analysts. The training

curriculum consists of in-house-developed training courses, vendor-supplied courses, and regional training seminars. SRP is presently reviewing the purchase of a dispatcher training simulator (DTS) to work in conjunction with the new EMS that it recently purchased. The evaluation team recommends that SRP purchase and incorporates a DTS as a principal training delivery tool to enhance the learning experience and increase operational skills.

SRP system dispatchers/operators do not rotate desks. They usually start in the system dispatcher position, which requires NERC certification with the balancing, interchange, and transmission operator credential. The system operator is the highest operator position, and personnel must meet a series of criteria to advance to this classification. The criteria includes

1. NERC certification at the appropriate credential;
2. a minimum of five years experience as a system dispatcher;
3. strongly demonstrated leadership ability;
4. experience as an on-the-job mentor/trainer, subject matter expert, and training instructor;
5. cross training in another position;
6. managing a project assigned by transmission generations operations management.

In this process, a system dispatcher accumulates points that correspond to a matrix associated with advancement to the system operator position. This process does not happen automatically, but it is the product of a strong attitude of involvement in the continuous improvement process.

System operator trainees entering this career field have varying levels of electric utility experience. Initially, the new system operator trainee shadows a system operator for several weeks so as to get a good feel for the activities and routines associated with the system operator career. After this, the trainee must complete several weeks of classroom instruction on the basic subject areas of system operations. These courses are developed and delivered in a mode recommended in the NERC *Continuing Education Program Administrative Manual*. The basic classroom instruction consists of 117 hours for balancing and interchange operators and 109 hours for transmission operators.

Upon completion of classroom training, the trainee moves into an on-the-job training phase for approximately 10 weeks. In this phase, the trainee is assigned to an instructor/mentor who uses a checklist to ensure that each required area of instruction is covered and understood. The progress of the trainee is reviewed and evaluated by the training supervisor and management on a regular basis.

The final assessment of trainee's readiness to begin operation as an independent system operator with on-desk responsibilities begins with the instructor/mentor sign-off as ready for advancement. At this point, the trainee is assigned to a senior system operator for a final evaluation of the trainee's operational readiness. Upon recommendation by the senior system operator, the final upgrade decision is made by the responsible manager. This initial training period takes approximately one year, and SRP has a defined process for addressing situations where the trainee is not making satisfactory progress. During this initial training period, the

trainee must take and pass the examination to become a NERC-certified operator, which is required for all system operators.

Continuing training for experienced system operators consists of in-house-developed courses, regional training seminars, emergency operations drills, backup control center drills, and personal development courses available through the corporate training department. SRP also uses cross-training and special project assignments to promote continuing development. Each system operator completes approximately 55 continuing education hours each year.

SRP evaluates the training program by assessing operator performance in several key areas, such as load forecasting and switching operations, using a monthly index-based review. The initial training program is evaluated by area managers as they assess the progress of the trainees. Continuing training incorporates peer evaluations and includes evaluation by the area managers, and the training recipients. Each course is evaluated by the class participants via a course feedback process.

SRP has not completed a job task analysis on each of the system dispatcher/operator operating positions; however, software has been purchased to perform job task analyses for these positions and modify the training curriculum and program administration as needed. The evaluation team finds that SRP's management is committed to a training program dynamic focused on continuous improvement and operating excellence.

5.2 Organizational Effectiveness

5.2.1 Human Performance

Personnel select and apply appropriate human error prevention techniques commensurate with the importance of assigned tasks to minimize the frequency and consequences of events.

SRP management carefully monitors a number of operating performance indices to determine if deficiencies are emerging that could potentially impact reliability and/or safety. Results of this review are used to determine necessary changes, such as additional training, new or modified tools, procedural or policy guidance, or an adjusted mode of operation to reshape attitudes, increase understanding, and increase operating efficiencies.

SRP also uses a disturbance analysis report process as a quality management program that is modeled after similar programs in the semi-conductor industry. Significant disturbances are evaluated by a disturbance analysis team that assesses the sequence of events, all applicable data, and root causes related to the event. The team sends a report to management identifying not only the causal factors, but recommendations for prevention and potential improvement. This same approach is used to develop and communicate specific performance targets that may be included in system operator performance reviews.

SRP does not have a specific course on human error prevention; however, training classes and instruction on operating tools are designed and delivered to emphasize the proper and accepted behaviors while explaining improper and unacceptable actions and their consequences. The

disturbance analysis report program is administered in this same context in order to imbed human error prevention in SRP's overall approach to operational safety and reliability.

SRP has a safety training observation program (STOP) designed to foster safe behavior. Unsafe behavior is addressed by additional training, coaching, and counseling depending on the nature of the observed behavior. If unsafe behavior appears to be chronic, SRP will take the necessary steps to remove the employee from that particular position.

APPENDIX 1: Critical Infrastructure

The following discussion will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.

APPENDIX 2: Entity Participants

The following will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.

APPENDIX 3: Documents Reviewed

The following will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.