Ten West Link 500 kV Transmission Project

Delaney – Colorado River 500 kV line
DCR Transmission, LLC

Phase 1 – Comprehensive Progress Report

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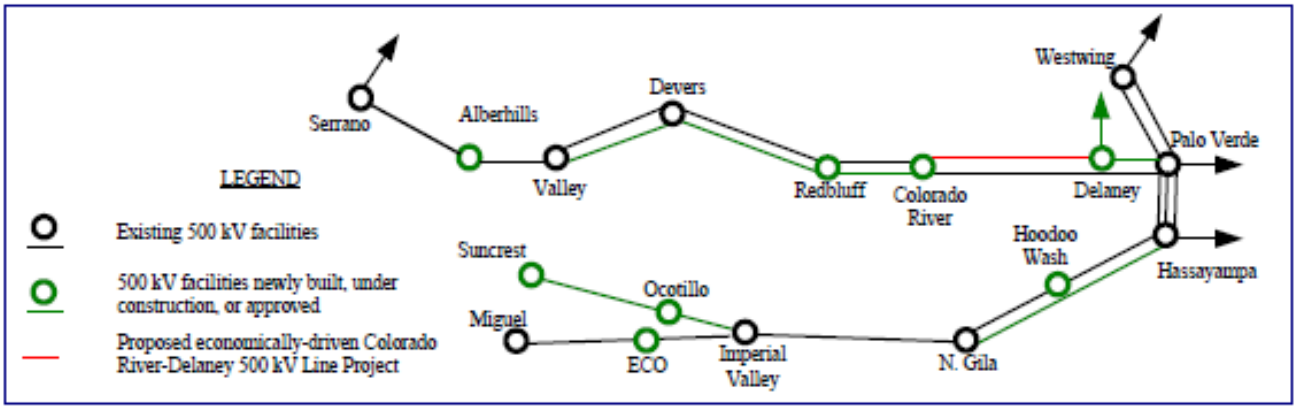
1. Executive Summary

DCR Transmission, LLC (DCRT or DCR Transmission) is developing the Ten West Link (TWL) Transmission Project, a high-voltage AC infrastructure project proposing to connect the Delaney 500 kV substation in Arizona with the Colorado River 500 kV substation in California via a 114 to 130-mile long series compensated transmission line. The TWL Project is expected to achieve full commercial operation by May 2021.

As a part of the 2013-2014 Transmission Planning Process (TPP), the California Independent System Operator (CAISO) identified an economically-driven need for a transmission interconnection between the 500 kV buses at Southern California Edison (SCE) owned Colorado River substation and the Arizona Public Service (APS) owned Delaney substation, as illustrated in the figure below. In addition to the economic benefits, the proposed project also provides policy-related and reliability benefits to the electrical customers in Arizona and California.

The Delaney-Colorado River 500 kV transmission line was approved by the CAISO Board of Governors at the July 8, 2014 Board meeting. On July 10, 2015, the CAISO selected DCRT as the approved project sponsor to develop, permit, finance, construct, own, operate and maintain this transmission line.

Ten West Link Transmission Project



This report serves as the Comprehensive Progress Report (CPR) required for completing Phase 1 of the WECC Path Rating Process for the TWL. This report presents study results that demonstrate the interconnected transmission system performs reliably and exceeds NERC Reliability Standards and WECC system performance criteria. The study includes post-transient/governor power flow contingency analysis and voltage stability analysis (+2.5% for N-2 contingencies, +5% for N-1 contingencies) as well as transient stability analysis. The report also provides an Affected Path Stress Test (10% test) and a Path Independence Test. The study demonstrates that the construction and interconnection of the TWL project will increase the ratings of WECC Path 46 and Path 49 by 1,050 MW and 550 MW, respectively. Both of these Path Rating increases do not result in any criteria violations under the NERC Reliability Standards and WECC criteria. DCR Transmission submits this CPR to the WECC Studies Subcommittee for a 60-day review and requests Phase 2A status in the WECC Path Rating Process.

2. Purpose

This report documents the study results required to complete Phase 1 of the WECC Path Rating Process for the TWL Project (a.k.a., the Delaney – Colorado River 500 kV line). The addition of this project will increase the existing WECC Path 46 (West of the River) rating from 13,400 MW to 14,450 MW (an increase of 1050 MW), as well as increase the existing WECC Path 49 (East of the River) rating from 10,100 MW to 10,650 MW (an increase of 550 MW).

The transition from Phase 1 to Phase 2 of the WECC Path Rating Process occurs once the Studies Subcommittee (StS) chair notifies the Reliability Assessment Committee (RAC), Operating Committee (OC), the StS and the project sponsor that all of the following items have been completed:

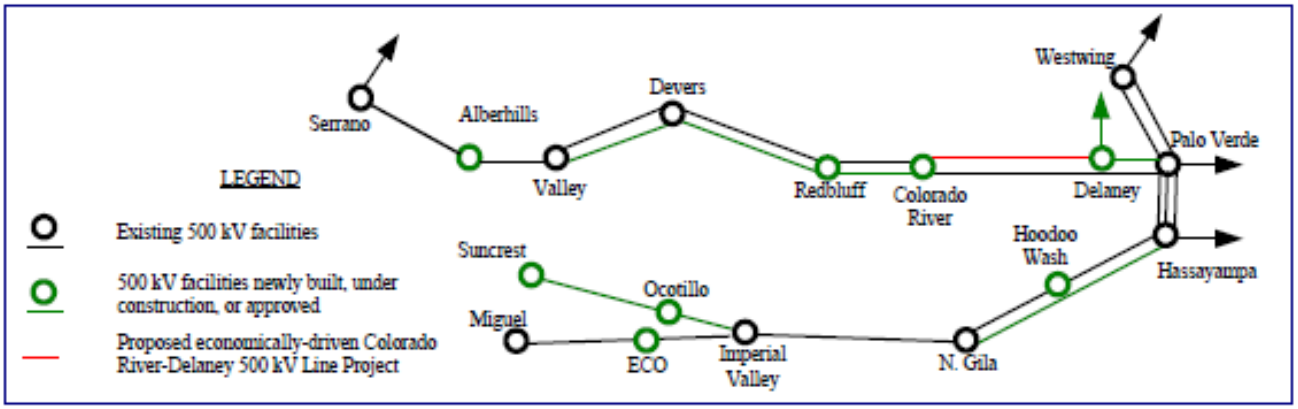
1. RAC has completed its assessment of the Project's conformity with the Project Coordination Review Objectives.
2. The project sponsor has submitted a full Project representation to WECC for inclusion in WECC base cases.
3. The project sponsor has distributed a Comprehensive Progress Report (CPR)[1] accompanied by a letter to StS and RAC requesting Phase 2 Status for the Project. StS and RAC members have 60 days to comment on the CPR by submitting a letter to the project sponsor with a copy to WECC staff.

This report is the Phase 1 CPR for the TWL Project. This Phase 1 study demonstrates that the TWL can achieve a Planned WECC Path 46 rating of 14,450 MW and a Planned WECC Path 49 rating of 10,650 MW. Both new path ratings do not result in criteria violations under the NERC Reliability Standards and WECC criteria. DCR Transmission, LLC submits this CPR to the WECC StS for a 60-day review and requests Phase 2A status in the WECC Path Rating Process.

2.1. Plan of Service

The TWL Project plan of service, as specified by the CAISO, is provided below. Figure 1 is a sketch showing the location of the TWL in relation to the existing transmission system.

Figure 1- Delaney-Colorado River 500 kV Transmission Project



[1] The Phase 1 studies and the CPR serve to provide a Planned Rating and their focus is on non-simultaneous performance. Known simultaneous effects should be addressed in the CPR, but the Phase 1 report is not required to fully resolve simultaneous interactions (known or new).

Key Transmission Line Functional Specifications, prescribed by the CAISO, for the Delaney-Colorado River 500 kV transmission line project are itemized below:

Overhead Line Construction

- Line Terminus 1: Colorado River 500 kV Bus (SCE owned)
- Line Terminus 2: Delaney Substation 500 kV Bus (APS)
- Nominal Phase-to-Phase Voltage: 500 kV
- Minimum Line Continuous Ampacity: 3,800 Amps (summer/winter)
- Minimum Line 4-Hour Emergency Ampacity: 5,200 Amps (summer/winter)
- Minimum Line 30-Minute Emergency Ampacity: 5,600 Amps (summer/winter)
- Approximate Line Impedance: (0.0012 to 0.0015) + j (0.027 to 0.033) p.u. on a 100 MVA base
- Approximate Line Length: 114 - 130 miles
- Approximate Series Compensation Level: 35%. Project Sponsor must include provisions to automatically bypass the series capacitor due to faults in the series capacitor. Project sponsor shall also include a means to isolate the series capacitor to facilitate maintenance.
- Location of Series Compensation: Approximately in the middle of the Colorado River – Delaney 500 kV line or equivalent compensation near the line termination station(s).
- Minimum Series Capacitor Continuous Ampacity: 2,700 Amps (summer/winter)
- Minimum Series Capacitor 30-Minute Emergency Ampacity: 3,645 Amps (summer/winter)

2.2. Planned Operating Date

The plan of service provides for the facilities to be operational by May 1, 2020.

3. Study Methods

The sections below detail the Study methodology for performing the analysis for this report.

3.1. Base Case Development

The non-simultaneous base cases were developed from the most current WATS base case (WOR134007_6_2018c_CRY-PSTBs_n_v1.sav) dated, July 25, 2018. Prior to adding the Ten West Link Project, the WATS case was tested to ensure the case did not have any major reliability criteria violations. The Ten West Link Project was then added to the base case. Generation was re-dispatched, as necessary, to achieve path flows or other system conditions as specified for each case.

Additional base cases were developed with series capacitors bypassed on the Ocotillo – Suncrest 500 kV line and the Eco – Miguel 500 kV line.

The base cases used in this study were developed using GE PSLF (version 21.0_02).

Additional details regarding the approach used to develop each study base case are provided in the "Base Case Development" subsections of Section 4 in this report.

3.2. Post Transient Power Flow Analysis

Power flow contingencies were modeled with single element (N-1) outages and credible double element (N-2) outages to evaluate NERC/WECC category P1 through P7 performance. Transmission elements were monitored for thermal and voltage violations.

3.3. Post-Transient Voltage Stability

WECC requires that rated paths meet voltage stability criteria with flows increased to 102.5% and 105% of the path rating. For adequate reactive margin, 105% cases are required to converge for Category P1 contingencies, while 102.5% cases are required to converge for Category P7 contingencies.

3.4. Transient Stability

Single element (N-1) and double element (N-2) contingencies were simulated to evaluate NERC/WECC transient stability performance.

All transient stability simulations were performed to 20 seconds.

3.5. Affected Path Stress Test (10% Flow Test)

WECC requires using a screening test procedure to identify all paths potentially affected by the path under study. For the most severe contingency on the Path being studied, determine which other Paths have a flow increase of 10% or more post-contingency. The percent increase is calculated using the rating of each potentially affected Path.

3.6. Path Independence Test

WECC requires the use of two (2) screening tests to determine whether a Path is independent of another Path. The results of the tests will be provided to the Project Review Group (PRG) to aid in determining if a proposed Project is part of the same Path.

If the proposed Project is determined to be a subset of an existing Path, the project sponsor is required to re-rate the Path within the Path Rating Process. A project that is a subset of an existing Path is not precluded from defining a separate path or from seeking a separate Path Rating.

4. Study Results

4.1. Phase 1 Study Analysis, Path 46 (West of the River)

4.1.1. Base Case Development

The non-simultaneous base cases were developed from the most current WATS base case (WOR134007_6_2018c_CRY-PSTBs_n_v1.sav) dated, July 25, 2018. Navajo generation was modeled off-line in this base case. Prior to adding the TWL Project, the base case was evaluated using all of the power flow contingencies in Appendix A and determined to be within acceptable limits. The TWL Project was then added to the base case to evaluate its impacts.

WECC Path flows were tuned by varying area schedules, as necessary, between New Mexico (10), AZ (14), NVE (18), CFE (20) and the LA Basin (22, 24 and 26).

Base cases were developed with the Ocotillo – Suncrest 500 kV line and the Eco – Miguel 500 kV line series compensation: 1) In-Service and 2) Out-of-Service.

The West of the River path is defined as the sum of flows on the following lines:

- Eldorado* – Lugo 500 kV
- Eldorado* – Cima – Pisgah No.1 and No.2 230 kV
- Mohave* – Lugo 500 kV
- Julian Hinds – Mirage* 230 kV
- McCullough* – Victorville No.1 and No.2 500 kV
- Mead* – Victorville 287 kV
- Marketplace* – Adelanto 500 kV
- North Gila* – Imperial Valley 500 kV
- Palo Verde – Colorado River* 500 kV
- Delaney – Colorado River* 500 kV (*Proposed Transmission Line*)
- El Centro – Imperial Valley* 230 kV
- Ramon – Mirage* 230 kV
- Coachella – Mirage* 230 kV

4.1.2. Post-Transient Power Flow Analysis

Maximum West of the River flow for the pre-and post-project base cases are tabulated in the following table. These results show that with inclusion of the Ten West Link Project, the WECC Path 46 can be increased by 1,050 MW with or without the Ocotillo – Suncrest 500 kV and Eco – Miguel 500 kV series capacitors by-passed.

Table 1 Path 46, West of the River Maximum Path Flows

Case	Series Comp Bypass	Pre-Project WOR Flow (MW)	Post-Project WOR Flow (MW)	Delta (MW)
2020HW-WOR@13400B-r1CRY-PSTB-r1.sav		13,400	14,450	1,050
2020HW-WOR@13400B-r1CRY-PSTB-r1-SCbypassed.sav	x	13,400	14,450	1,050

A summary of limiting elements for both the pre-and post-project base cases are tabulated in the following table. It can be seen that the P0 thermal loading would no longer limit the path.

Table 2 Path 46, West of the River Thermal Loading, Percent Loading

						Series Comp† In-Service		Series Comp† By-Passed	
Category	Contingency	Affected Element	Area	Zone	Rating (Amps)	Pre-Project	Post-Project	Pre-Project	Post-Project
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP1 230 kV Line 1	22	227	2970	99.0	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP2 230 kV Line 2	22	227	2970	99.0	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 1	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 2	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 1	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 2	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP1 230 kV Line 1	22	227	2970	98.7	99.1	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP2 230 kV Line 2	22	227	2970	98.7	99.1	< 96%	< 96%
P1	B012_CR-PV_500	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	40.3	99.9	41.1	99.7
P1	B030_LUGO-VICTORVL_500	RINALDI 230 - RINALDI2 500 kV Transformer H	26	286	1593 MVA	98.5	102.1	98.2	101.5
P1	B040_HALLEN-ELDORADO_500	MEAD - MARKETPL 500 kV Line 1	14	191	3300	94.6	99.9	95.5	99.9
P6	C106_Eld-McCull_Lugo-Victorvl_500	RINALDI 230 - RINALDI2 500 kV Transformer H	26	286	1593 MVA	98.1	101.7	98.0	101.2
P6	C108_Lugo-Victorvl_Eldordo-Lugo_500_wRAS	RINALDI 230 - RINALDI2 500 kV Transformer H	26	286	1593 MVA	109.2	113.1	109.4	112.9
P7	C200_DEV-RBluff_500_1-2_wRAS	DIXIELAN - RTP1 92 kV Line 1	21	213	370	< 96%	< 96%	96.6	100.0
P7	C201_RBluff-CoRvr_500_1-2_wRAS	DIXIELAN - RTP1 92 kV Line 1	21	213	370	< 96%	< 96%	96.7	100.1
Extreme	C303_PV-WW_500_1-2	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	59.2	98.2	< 96%	< 96%

†Series Comp refers to the series capacitors for the Ocotillo – Suncrest 500 kV line and the Eco – Miguel 500 kV line.

Highlighted contingencies in Table 2 identify transmission elements that limit the West of River path flow.

The Rinaldi 500/230 kV H transformer exceeds its thermal limit in the pre-project case. This transformer may have a short-term rating or system adjustments after the first contingency might be able to mitigate this overload.

No post-transient voltage violations were identified as a result of adding the TWL Project.

A complete listing of thermal and voltage results is provided in Appendix B.

4.1.3. Post-Transient Voltage Stability

Cases were created with Path 49 path flows increased to 102.5% and 105% of the maximum transfer capability.

All contingencies converged, which indicates adequate reactive margin for the system.

4.1.4. Transient Stability Analysis

Transient stability study simulations identified that all contingencies were damped and conformed to the NERC Reliability Standards and WECC Regional Criteria.

Transient stability results are provided in Appendix D and plots are provided in Appendix E.

4.2. Phase 1 Study Analysis, Path 49 (East of the River)

4.2.1. Base Case Development

The non-simultaneous base cases were developed from the most current WATS base case (WOR134007_6_2018c_CRY-PSTBs_n_v1.sav) dated, July 25, 2018. Navajo generation was modeled off-line in this base case. Prior to adding the TWL Project, the base case was evaluated using all of the power flow contingencies in Appendix A and determined to be within acceptable limits. The TWL Project was then added to the base case to evaluate its impacts.

WECC Path flows were tuned by varying area schedules, as necessary, between New Mexico (10), AZ (14), NVE (18), CFE (20) and the LA Basin (22, 24 and 26).

Base cases were developed with the Ocotillo – Suncrest 500 kV line and the Eco – Miguel 500 kV line series compensation: 1) In-Service and 2) Out-of-Service.

The EOR path is defined as the sum of flows on the following lines:

- Navajo* – Crystal 500 kV
- Moenkopi – Eldorado* 500 kV
- Liberty* – Peacock 345 kV
- Palo Verde* – Colorado River 500 kV
- Delaney* – Colorado River 500 kV (*Proposed Transmission Line*)
- Hassayampa* – Hoodoo Wash 500 kV
- Hassayampa* – N.Gila 500 kV
- Perkins* – Mead 500 kV

4.2.2. Post-Transient Power Flow Analysis

Maximum East of the River flow for the pre-and post-project base cases are tabulated in the following table. These results show that with inclusion of the Ten West Link Project, the WECC Path 49 can be increased by 550 MW with or without the Ocotillo – Suncrest 500 kV and Eco – Miguel 500 kV series capacitors by-passed.

Table 3 Path 49, East of the River Maximum Path Flows

Case	Series Comp Bypassed	Pre-Project EOR Flow (MW)	Post-Project EOR Flow (MW)	Delta (MW)
2020HW-EOR@10100-r1CRY-PSTB-r1.sav		10100	10,650	550
2020HW-EOR@10100-r1CRY-PSTB-r1-SCbypassed.sav	x	10100	10,650	550

A summary of limiting elements for both the pre-and post-project base cases are tabulated in the following table. A number of contingencies limit the EOR path flow.

Table 4 Path 49, East of the River Thermal Loading, Percent Loading

						Series Comp† In-Service		Series Comp† By-Passed	
Category	Contingency	Affected Element	Area	Zone	Rating (Amps)	Pre-Project	Post-Project	Pre-Project	Post-Project
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP1 230 kV Line 1	22	227	2970	99.0	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP1 230 kV Line 1	22	227	2970	99.3	99.8	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP2 230 kV Line 2	22	227	2970	99.3	99.8	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 1	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 2	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 1	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 2	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP1 230 kV Line 1	22	227	2970	99.0	99.5	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP2 230 kV Line 2	22	227	2970	99.0	99.5	< 96%	< 96%
P1	B012_CR-PV_500	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	41.1	99.3	41.9	100.0
P1	B019_CRY-MCCULLGH_500	MOENKOPI - ELDORDO 500 kV Line 1	14	141	2760	99.2	99.4	99.4	99.0
P6	C107_Cry-McCll_HA-Md_500	MOENKOPI - ELDORDO 500 kV Line 1	14	141	2760	99.7	100.0	99.8	99.7
P6	C108_Lugo-Victorvl_Eldordo-Lugo_500_wRAS	RINALDI 230 - RINALDI2 500 kV Transformer H	26	286	1593 MVA	107.9	105.5	109.8	102.7
P7	C303_PV-WW_500_1-2	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	60.1	98.3	60.8	99.3

†Series Comp refers to the series capacitors for the Ocotillo – Suncrest 500 kV line and the Eco – Miguel 500 kV line.

Highlighted contingencies in Table 4 identify transmission elements that limit the East of River path flow.

The Rinaldi 500/230 kV H transformer exceeds its thermal limit in the pre-project case. This transformer may have a short-term rating or system adjustments after the first contingency might be able to mitigate this overload.

Addition of the Project and stressing the case to maximum EOR flow resulted in voltage for some 230 kV buses in Area 21 (Imperial Irrigation District or IID) to drop below 0.9 per unit for loss of the Devers – Red Bluff No.1 and No.2 500 kV contingency. In the pre-project base case, the voltage levels at these buses were just above 0.90 per unit for this P7 contingency.

A complete listing of thermal and voltage results is provided in Appendix B.

4.2.3. Post-Transient Voltage Stability

Cases were created with Path 49 path flows increased to 102.5% and 105% of the maximum transfer capability.

All contingencies converged, which indicates adequate reactive margin for the system.

4.2.4. Transient Stability Analysis

Transient stability study simulations identified that all contingencies were damped and conformed to the NERC Reliability Standards and WECC Regional Criteria.

Transient stability results are provided in Appendix D and plots are provided in Appendix E.

5. Affected Path Flow Test (10% Flow Test)

WECC requires using a screening test procedure to identify all paths potentially affected by the path under study. For the largest credible contingency (loss of Devers – Red Bluff No.1 and No.2 500 kV lines) on the Path being studied, determine which other Paths have a flow increase of 10% or more post-contingency. Seven (7) WECC path flows increased greater than 10% for the WECC Path 46 base case and six (6) WECC path flows increased greater than 10% for the WECC Path 49 base case.

Table 5 WECC Path 46, Affected Path Flow Test (10% Test)

NUM	NAME	Post-Con 'Direction of + Flow	Pre-Con Flow (MW)	Post-Con Flow (MW)	Flow Change (MW)	Path Rating (+) (MW)	Path Rating (-) (MW)	10% Test (% Change)
1	ALBERTA - BRITISH COLUMBIA	W2E	-180.7	-141.6	39.1	1000	-1200	3.9%
2	ALBERTA - SASKATCHEWAN	W2E	0.1	0.1	0.0	150	-150	0.0%
3	NORTHWEST - CANADA	N2S	-1044.3	-843.3	201.0	3000	-3150	6.7%
4	WEST OF CASCADES - NORTH	E2W	8077.7	7941.9	-135.8	10200	-10200	-1.3%
5	WEST OF CASCADES - SOUTH	E2W	6226.4	6209.7	-16.7	7200	-7200	-0.2%
6	WEST OF HATWAI	E2W	1138.0	1174.7	36.7	4277	0	0.9%
8	MONTANA - NORTHWEST	E2W	1254.1	1265.7	11.6	2200	-1350	0.5%
9	WEST OF BROADVIEW	E2W	1728.9	1732.5	3.6	2573	0	0.1%
10	WEST OF COLSTRIP	E2W	2067.1	2067.4	0.3	2598	0	0.0%
11	WEST OF CROSSOVER	E2W	1625.5	1617.6	-7.9	2598	0	-0.3%
14	IDAHO - NORTHWEST	W2E	1179.8	1269.1	89.3	2400	-1200	3.7%
15	MIDWAY - LOS BANOS	S2N	2624.0	1808.0	-816.0	4800	-2000	-17.0%
16	IDAHO - SIERRA	N2S	-205.1	-190.9	14.2	500	-360	2.8%
17	BORAH WEST	E2W	1613.8	1707.9	94.1	2557	-1600	3.7%
18	MONTANA - IDAHO	N2S	97.1	96.2	-0.9	337	-256	-0.3%
19	BRIDGER WEST	E2W	2210.3	2259.5	49.2	2400	-600	2.0%
20	PATH C	N2S	428.4	474.5	46.1	1600	-1250	2.9%
22	SOUTHWEST OF FOUR CORNERS	E2W	1185.7	1318.6	132.9	2325	0	5.7%
23	FOUR CORNERS 345/500	345-2-500	0.0	0.0	0.0	1000	-1000	0.0%
24	PG&E - SPP	E2W	21.6	24.4	2.8	160	-150	1.8%
25	PACIFICORP/PG&E 115 KV INTERCON.	N2S	61.9	64.3	2.4	100	-45	2.4%
26	NORTHERN - SOUTHERN CALIFORNIA	N2S	-1201.8	-364.1	837.7	4000	-3000	20.9%
27	IPP DC LINE	N2S	1504.0	1504.0	0.0	2400	-1400	0.0%
28	INTERMOUNTAIN - MONA 345 KV	E2W	398.4	380.6	-17.8	1400	-1200	-1.3%
29	INTERMOUNTAIN - GONDER 230 KV	E2W	90.3	108.0	17.7	200	0	8.9%
30	TOT 1A	E2W	-298.4	-331.9	-33.5	650	0	-5.2%
31	TOT 2A	N2S	233.5	229.6	-3.9	690	0	-0.6%
32	PAVANT, INTRMTN - GONDER 230 KV	E2W	155.5	187.0	31.5	440	-235	7.2%
33	BONANZA WEST	E2W	-450.1	-494.3	-44.2	785	0	-5.6%
34	TOT 2B	N2S	-47.1	-33.2	13.9	780	-850	1.8%
35	TOT 2C	N2S	25.2	39.6	14.4	400	-580	3.6%

NUM	NAME	Post-Con 'Direction of + Flow	Pre-Con Flow (MW)	Post-Con Flow (MW)	Flow Change (MW)	Path Rating (+) (MW)	Path Rating (-) (MW)	10% Test (% Change)
36	TOT 3	NE2SW	707.1	682.5	-24.6	1680	0	-1.5%
37	TOT 4A	SE2NW	288.1	319.1	31.0	810	0	3.8%
38	TOT 4B	W2E	96.5	91.8	-4.7	680	0	-0.7%
39	TOT 5	N2S	26.9	3.4	-23.5	1680	0	-1.4%
40	TOT 7	N2S	130.8	117.7	-13.1	890	0	-1.5%
41	SYLMAR - SCE	E2W	1190.8	1338.1	147.3	1600	-1600	9.2%
42	IID - SCE	S2N	0.0	0.0	0.0	600	0	0.0%
45	SDG&E - CFE	N2S	-0.7	12.1	12.8	408	-800	3.1%
46	WEST OF COLORADO RIVER (WOR)	E2W	14450.5	14165.4	-285.1	10000	-11200	-2.9%
47	SOUTHERN NEW MEXICO (NM1)	N2S	-82.0	-99.6	-17.6	1048	-1048	-1.7%
48	NORTHERN NEW MEXICO (NM2)	N2S	1224.6	1221.2	-3.4	1970	-1970	-0.2%
49	EAST OF COLORADO RIVER (EOR)	E2W	10170.6	9962.8	-207.8	9900	0	-2.1%
50	CHOLLA - PINNACLE PEAK	N2S	466.4	489.2	22.8	1200	0	1.9%
51	SOUTHERN NAVAJO	W2E	-1406.2	-2064.6	-658.4	2800	0	-23.5%
52	SILVER PEAK - CONTROL 55 KV	N2S	4.0	4.8	0.8	17	-17	4.7%
54	CORONADO - SILVER KING - KYRENE	E2W	529.9	619.3	89.4	1494	0	6.0%
55	BROWNLEE EAST	E2W	665.9	677.3	11.4	1915	0	0.6%
58	ELDORADO - MEAD 230 KV LINES	E2W	-178.6	-210.7	-32.1	1140	-1140	-2.8%
59	WALC BLYTHE - SCE BLYTHE 161 KV	W2E	5.6	77.5	71.9	218	0	33.0%
60	INYO - CONTROL 115 KV TIE	N2S	11.7	10.9	-0.8	56	-56	-1.4%
61	LUGO - VICTORVILLE 500 KV LINE	N2S	1605.7	2354.3	748.6	2400	-900	31.2%
62	ELDORADO - MCCULLOUGH 500 KV	N2S	1093.1	1071.9	-21.2	2598	-2598	-0.8%
65	PACIFIC DC INTERTIE (PDCI)	E2W	-394.2	-394.2	0.0	3100	-3100	0.0%
66	COI	N2S	432.7	969.0	536.3	4800	-3675	11.2%
71	SOUTH OF ALLSTON	S2N	346.2	401.0	54.8	3980	-1115	1.4%
73	NORTH OF JOHN DAY	N2S	989.3	1197.0	207.7	7700	-7700	2.7%
75	MIDPOINT - SUMMER LAKE	N2S	807.4	894.3	86.9	1500	-550	5.8%
76	ALTURAS PROJECT	S2N	1.6	2.7	1.1	300	-300	0.4%
77	CRYSTAL - ALLEN	S2N (Imp)	-217.7	-202.4	15.3	950	0	1.6%
78	TOT 2B1	W2E	18.3	6.9	-11.4	600	-600	-1.9%
79	TOT 2B2	N2S	28.8	26.3	-2.5	265	-300	-0.9%
80	MONTANA SOUTHEAST	N2S	-320.9	-386.5	-65.6	600	-600	-10.9%
81	SNTI-S.NEVADA TRAN INTERFACE	N2S	-476.9	-529.4	-52.5	4533	-3790	-1.2%
82	TOTBEAST	W2E	1473.3	1571.6	98.3	2465	0	4.0%
83	MATL	N2S	11.7	9.0	-2.7	325	-300	-0.8%
85	HAE + SNTI	N2S	1154.7	1335.4	180.7	6285	-4843	2.9%
101	PVEAST PALO VERDE EAST	E2W	3444.3	4416.4	972.1	9848	9848	9.9%
500	Southern CA Imports	Various	14622.3	14966.3	344.0	0	0	

Table 6 WECC Path 49, Affected Path Flow Test (10% Test)

NUM	NAME	Post-Con 'Direction of + Flow	Pre-Con Flow (MW)	Post-Con Flow (MW)	Flow Change (MW)	Path Rating (+) (MW)	Path Rating (-) (MW)	10% Test (% Change)
1	ALBERTA - BRITISH COLUMBIA	W2E	-180.7	-141.7	39.0	1000	-1200	3.9%
2	ALBERTA - SASKATCHEWAN	W2E	0.1	0.1	0.0	150	-150	0.0%
3	NORTHWEST - CANADA	N2S	-1044.9	-844.4	200.5	3000	-3150	6.7%
4	WEST OF CASCADES - NORTH	E2W	8089.8	7962.9	-126.9	10200	-10200	-1.2%
5	WEST OF CASCADES - SOUTH	E2W	6241.7	6224.7	-17.0	7200	-7200	-0.2%
6	WEST OF HATWAI	E2W	1172.7	1207.7	35.0	4277	0	0.8%
8	MONTANA - NORTHWEST	E2W	1266.9	1278.2	11.3	2200	-1350	0.5%
9	WEST OF BROADVIEW	E2W	1764.7	1766.3	1.6	2573	0	0.1%
10	WEST OF COLSTRIP	E2W	2092.7	2092.7	0.0	2598	0	0.0%
11	WEST OF CROSSOVER	E2W	1612.6	1608.2	-4.4	2598	0	-0.2%
14	IDAHO - NORTHWEST	W2E	1432.3	1510.2	77.9	2400	-1200	3.2%
15	MIDWAY - LOS BANOS	S2N	2169.9	1530.0	-639.9	4800	-2000	-13.3%
16	IDAHO - SIERRA	N2S	-124.5	-114.0	10.5	500	-360	2.1%
17	BORAH WEST	E2W	1946.6	2026.4	79.8	2557	-1600	3.1%
18	MONTANA - IDAHO	N2S	83.9	83.7	-0.2	337	-256	-0.1%
19	BRIDGER WEST	E2W	2391.0	2432.2	41.2	2400	-600	1.7%
20	PATH C	N2S	556.1	596.7	40.6	1600	-1250	2.5%
22	SOUTHWEST OF FOUR CORNERS	E2W	1641.2	1710.3	69.1	2325	0	3.0%
23	FOUR CORNERS 345/500	345-2-500	0.0	0.0	0.0	1000	-1000	0.0%
24	PG&E - SPP	E2W	20.9	24.0	3.1	160	-150	1.9%
25	PACIFICORP/PG&E 115 KV INTERCON.	N2S	60.9	63.4	2.5	100	-45	2.5%
26	NORTHERN - SOUTHERN CALIFORNIA	N2S	-735.5	-80.7	654.8	4000	-3000	16.4%
27	IPP DC LINE	N2S	1504.0	1504.0	0.0	2400	-1400	0.0%
28	INTERMOUNTAIN - MONA 345 KV	E2W	331.9	318.6	-13.3	1400	-1200	-0.9%
29	INTERMOUNTAIN - GONDER 230 KV	E2W	156.8	170.1	13.3	200	0	6.6%
30	TOT 1A	E2W	-402.2	-430.4	-28.2	650	0	-4.3%
31	TOT 2A	N2S	403.4	399.4	-4.0	690	0	-0.6%
32	PAVANT, INTRMTN - GONDER 230 KV	E2W	271.3	294.1	22.8	440	-235	5.2%
33	BONANZA WEST	E2W	-562.2	-599.0	-36.8	785	0	-4.7%
34	TOT 2B	N2S	-71.2	-59.3	11.9	780	-850	1.5%
35	TOT 2C	N2S	71.0	80.6	9.6	400	-580	2.4%
36	TOT 3	NE2SW	806.8	784.7	-22.1	1680	0	-1.3%
37	TOT 4A	SE2NW	415.3	441.2	25.9	810	0	3.2%
38	TOT 4B	W2E	93.7	90.1	-3.6	680	0	-0.5%
39	TOT 5	N2S	-239.8	-262.2	-22.4	1680	0	-1.3%
40	TOT 7	N2S	68.9	56.8	-12.1	890	0	-1.4%
41	SYLMAR - SCE	E2W	996.3	1073.3	77.0	1600	-1600	4.8%
42	IID - SCE	S2N	0.0	0.0	0.0	600	0	0.0%
45	SDG&E - CFE	N2S	0.4	11.9	11.5	408	-800	2.8%

NUM	NAME	Post-Con 'Direction of + Flow	Pre-Con Flow (MW)	Post-Con Flow (MW)	Flow Change (MW)	Path Rating (+) (MW)	Path Rating (-) (MW)	10% Test (% Change)
46	WEST OF COLORADO RIVER (WOR)	E2W	13554.2	13242.5	-311.7	10000	-11200	-3.1%
47	SOUTHERN NEW MEXICO (NM1)	N2S	-81.8	-100.1	-18.3	1048	-1048	-1.7%
48	NORTHERN NEW MEXICO (NM2)	N2S	1219.2	1215.0	-4.2	1970	-1970	-0.2%
49	EAST OF COLORADO RIVER (EOR)	E2W	10650.4	10418.1	-232.3	9900	0	-2.3%
50	CHOLLA - PINNACLE PEAK	N2S	555.7	538.2	-17.5	1200	0	-1.5%
51	SOUTHERN NAVAJO	W2E	-1407.6	-2066.3	-658.7	2800	0	-23.5%
52	SILVER PEAK - CONTROL 55 KV	N2S	4.5	5.2	0.7	17	-17	4.1%
54	CORONADO - SILVER KING - KYRENE	E2W	612.1	589.9	-22.2	1494	0	-1.5%
55	BROWNLEE EAST	E2W	620.6	635.9	15.3	1915	0	0.8%
58	ELDORADO - MEAD 230 KV LINES	E2W	-157.3	-187.9	-30.6	1140	-1140	-2.7%
59	WALC BLYTHE - SCE BLYTHE 161 KV	W2E	2.0	62.3	60.3	218	0	27.7%
60	INYO - CONTROL 115 KV TIE	N2S	12.6	12.2	-0.4	56	-56	-0.7%
61	LUGO - VICTORVILLE 500 KV LINE	N2S	1308.4	1974.1	665.7	2400	-900	27.7%
62	ELDORADO - MCCULLOUGH 500 KV	N2S	832.8	807.3	-25.5	2598	-2598	-1.0%
65	PACIFIC DC INTERTIE (PDCI)	E2W	-394.1	-394.2	-0.1	3100	-3100	0.0%
66	COI	N2S	700.6	1261.0	560.4	4800	-3675	11.7%
71	SOUTH OF ALLSTON	S2N	353.7	413.3	59.6	3980	-1115	1.5%
73	NORTH OF JOHN DAY	N2S	1032.3	1262.4	230.1	7700	-7700	3.0%
75	MIDPOINT - SUMMER LAKE	N2S	993.5	1072.5	79.0	1500	-550	5.3%
76	ALTURAS PROJECT	S2N	0.6	1.9	1.3	300	-300	0.4%
77	CRYSTAL - ALLEN	S2N (Imp)	-228.3	-209.9	18.4	950	0	1.9%
78	TOT 2B1	W2E	38.1	28.2	-9.9	600	-600	-1.7%
79	TOT 2B2	N2S	33.1	31.2	-1.9	265	-300	-0.7%
80	MONTANA SOUTHEAST	N2S	-589.4	-641.7	-52.3	600	-600	-8.7%
81	SNTI-S.NEVADA TRAN INTERFACE	N2S	-1226.8	-1315.2	-88.4	4533	-3790	-2.0%
82	TOTBEAST	W2E	1614.1	1708.4	94.3	2465	0	3.8%
83	MATL	N2S	11.8	9.1	-2.7	325	-300	-0.8%
85	HAE + SNTI	N2S	-251.0	-136.4	114.6	6285	-4843	1.8%
101	PVEAST PALO VERDE EAST	E2W	3445.7	4549.9	1104.2	9848	9848	11.2%
500	Southern CA Imports	Various	14202.2	14203.2	1.0	0	0	

6. Path Independence Test

WECC requires the use of two (2) screening tests to determine whether the Path being rated is independent of another Path. The results of the tests are submitted to the PRG to aid in determining whether a proposed Project should be included as part of (or a subset of) another Path.

If the proposed Project is determined to be a subset of an existing Path, the project sponsor is required to re-rate the existing Path within the Path Rating Process. A project that is a subset of an existing Path is not precluded from defining a separate path or from seeking a separate Path Rating.

Path Independence Test 1 results did have three (3) paths with a percent flow greater than 25-40%. As a result, based on test 1 results, the Project does meet this test criterion and may need to be included as a subset of these existing Paths. Therefore, the Project will likely have to re-rate these existing Paths (subject to a final PRG determination) as part of its Path rating studies.

Table 7 Path Independence Test 1 Results

Test 1	Add Project, then Schedule Flow	Increase (MW)	200
	Pick up > 25-40%, Sub-Set of the Path.		
	Pick up < 25-40%, Not part of Path, independent rating can be achieved.		

Path Num	Path Name	Pre-Increase Flow (MW)	Post-Increase Flow (MW)	% Flow Change
46	WEST OF COLORADO RIVER (WOR)	13,399	13,586	93.6
49	EAST OF COLORADO RIVER (EOR)	10,141	10,329	94.1
51	SOUTHERN NAVAJO	-1,318	-1,365	-23.4
61	LUGO - VICTORVILLE 500 KV LINE	1,343	1,395	25.8

Path Independence Test 2 results did not have any percent flow calculations greater than 55%. As a result, based on test 2 results, the Project does not meet this test criterion.

Table 8 Path Independence Test 2 Results

Test 2	Add Project, then determine % flow change
	Pick up > 55%, deemed sub-set of the Path.
	Pick up < 55%, independent rating can be achieved.

Path Num	Path Name	Pre-Increase Flow (MW)	Post-Increase Flow (MW)	% Flow Change
46	WEST OF COLORADO RIVER (WOR)	13,346	13,398	0.4
49	EAST OF COLORADO RIVER (EOR)	10,101	10,140	0.4
51	SOUTHERN NAVAJO	-1,465	-1,318	-10.0
61	LUGO - VICTORVILLE 500 KV LINE	1,476	1,343	-9.0

7. Study Conclusions

The Phase 1 study results demonstrate that with inclusion of the TWL Project, the system adheres to the NERC TPL-001-4 performance requirements for power flow, post-transient governor power flow analysis, reactive margin analysis and transient stability analysis. Following is a summary of the WECC Path 46 and 49 path flows for the various cases that were developed.

Table 9 WECC Path 46 West of the River Case Path Flows

Case	Series Comp Bypass	Pre-Project WOR Flow (MW)	Post-Project WOR Flow (MW)	Delta (MW)
2020HW-WOR@13400B-r1CRY-PSTB-r1.sav		13,400	14,450	1,050
2020HW-WOR@13400B-r1CRY-PSTB-r1-SCbypassed.sav	x	13,400	14,450	1,050

Table 10 WECC Path 49 East of the River Case Path Flows

Case	Series Comp Bypass	Pre-Project EOR Flow (MW)	Post-Project EOR Flow (MW)	Delta (MW)
2020HW-EOR@10100-r1CRY-PSTB-r1.sav		10,100	10,650	550
2020HW-EOR@10100-r1CRY-PSTB-r1-SCbypassed.sav	x	10,100	10,650	550

Based on these study results, the TWL Project can be reliably interconnected to the existing system. In addition, the Path 46 path rating can be increased by 1,050 MW and the Path 49 path rating can be increased by 550 MW.

Comments provided during the 60-day comment period will be addressed to complete Phase 1 of the WECC Path Rating Process. The comments and any follow up responses will be attached to the report at the end of the 60-day comment period.

Appendix A – Post-Transient Contingency Lists

The following is an itemized list of contingencies simulated for the path rating increase with inclusion of the Delaney-Colorado River 500 kV Transmission Project (in the east-to-west direction):

Select Transmission Line Outages (P1) ***- Power Flow Analysis***

1. Hassayampa-North Gila 500 kV
2. Hassayampa-Hoodoo Wash 500 kV
3. Hoodoo Wash-North Gila 500 kV
4. Imperial Valley – North Gila 500 kV
5. Imperial Valley – Highline 500 kV
6. Highline – North Gila 500 kV
7. Highline 500/230 kV Transformer
8. Imperial Valley – Eco 500 kV
9. Eco – Miguel 500 kV (w/RAS)
10. Imperial Valley – Ocotillo 500 kV
11. Ocotillo – Suncrest 500 kV
12. Colorado River-Palo Verde 500 kV
13. Delaney – Colorado River 500 kV (*Project contingency*)
14. Colorado River – Red Bluff No.1 500 kV
15. Red Bluff – Devers No.1 500 kV
16. Devers – Valley No.1 500 kV
17. Valley – Serrano 500 kV
18. Navajo-Crystal 500 kV
19. Crystal-McCullough 500 kV
20. Crystal-Harry Allen 500 kV
21. Harry Allen-Lenzie 500 kV
22. Harry Allen-Mead 500 kV
23. Lenzie-Northwest 500 kV
24. Adelanto-Victorville 500 kV
25. Eldorado-Lugo 500 kV (w/RAS)
26. Eldorado-McCullough 500 kV
27. Eldorado-Moenkopi 500 kV
28. Four Corners-Moenkopi 500 kV
29. Lugo-Mohave 500 kV
30. Lugo-Victorville 500 kV
31. Marketplace-Adelanto 500 kV
32. Marketplace-McCullough 500 kV
33. McCullough-Victorville 500 kV
34. Mead-Marketplace 500 kV
35. Mead-Victorville 287 kV

36. Moenkopi-Cedar Mt 500 kV
37. Cedar Mt-Yavapai 500 kV
38. Navajo-Moenkopi 500 kV
39. Perkins-Mead 500 kV
40. Harry Allen – Eldorado 500 kV
41. PDCI bi-pole outage
42. Eldorado 500/230 kV Transformer #5 (w/RAS)
43. Harry Allen 500/230 kV Transformer
44. Devers 500/230 kV Transformer
45. Mead 500/230 kV Transformer

Select Overlapping Outages (P6) - *Power Flow Analysis*

100. Colorado River-Palo Verde 500 kV & Harquahala-Hassayampa 500 kV
101. Delaney-Colorado River 500 kV & Julian Hinds-Mirage 230 kV
102. Colorado River-Red Bluff 500 kV & Julian Hinds-Mirage 230 kV
103. Eldorado-Lugo 500 kV & Eldorado-Mohave 500 kV (w/RAS)
104. Eldorado-Lugo 500 kV & Eldorado-Pisgah-Cima 230 kV (w/RAS)
105. Eldorado-Mohave 500 kV & Eldorado-Pisgah-Cima 230 kV
106. Eldorado-McCullough 500 kV & Lugo-Victorville 500 kV
107. Harry Allen-Mead 500 kV & Crystal-McCullough 500 kV
108. Lugo-Victorville 500 kV & Eldorado-Lugo 500 kV (w/RAS)
109. Lugo-Mohave 500 kV & Eldorado-Lugo 500 kV (w/RAS)
[WECC exception, no longer considered a credible contingency]
110. Moenkopi-Eldorado 500 kV & Eldorado-McCullough 500 kV
111. Ocotillo-Suncrest 500 kV & Eco-Miguel 500 kV (w/RAS)

Select Common-Mode Outages (P7) - *Power Flow Analysis*

200. Red Bluff-Devers 500 kV No. 1 & 2 (w/RAS)
201. Colorado River-Red Bluff 500 kV No. 1 & 2 (w/RAS)
202. Adelanto-Victorville 500 kV No. 1 & 2
203. IPPDC bi-pole outage
204. McCullough-Victorville 500 kV No. 1 & 2
205. Navajo-Moenkopi 500 kV & Navajo-Dugas 500 kV

Select NERC Extreme Events - *Power Flow Analysis*

300. Hassayampa-North Gila 500 kV & Hassayampa-HoodooWash 500 kV
301. Hassayampa-North Gila 500 kV & HoodooWash-North Gila 500 kV
302. Palo Verde-Westwing 500 kV No. 1 & 2
303. Palo Verde Generation – Trip two Units (w/RAS)

Select Transmission Line Outages (P1) ***– Transient Stability Analysis***

1. Hassayampa-North Gila 500 kV, 4 cycle clearing
2. Hassayampa – Hoodoo Wash 500 kV, 4 cycle clearing
3. Hoodoo Wash – North Gila 500 kV, 4 cycle clearing
4. Imperial Valley – North Gila 500 kV, 4 cycle clearing
5. Colorado River – Palo Verde 500 kV, 6 cycle clearing
6. Delaney – Colorado River 500 kV, 6 cycle clearing (*Project contingency*)
7. Eldorado – Moenkopi 500 kV, 6 cycle clearing
8. Eldorado – Lugo 500 kV, 6 cycle clearing
9. Lugo – Mohave 500 kV, 6 cycle clearing
10. Harry Allen – Mead 500 kV, 4 cycle clearing

Select Overlapping Outages (P6) ***– Transient Stability Analysis***

11. Harry Allen – Mead 500 kV & Crystal – McCullough 500 kV, 4 cycle clearing

Common-Mode Outages (P7) ***- Transient Stability Analysis***

12. Palo Verde – Delaney 500 kV & Palo Verde – Colorado River 500 kV, 6 cycle clearing
13. Red Bluff – Devers 500 kV No. 1 & 2, 6 cycle clearing

Select NERC Extreme Events ***- Transient Stability Analysis***

14. Hassayampa-North Gila 500 kV & Hassayampa-HoodooWash 500 kV, 4 cycle clearing
15. Hassayampa-North Gila 500 kV & HoodooWash-North Gila 500 kV, 4 cycle clearing
16. Palo Verde Generation – Trip two Units (No RAS)

Appendix B – Post-transient Power Flow Study Results

Table B-1 Phase 1 WECC Path 46 (West of the River) Power Flow (Thermal) Results

						Series Comp† In-Service		Series Comp† By-Passed	
Category	Contingency	Affected Element	Area	Zone	Rating (Amps)	Pre-Project	Post-Project	Pre-Project	Post-Project
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP1 230 kV Line 1	22	227	2970	99.0	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP2 230 kV Line 2	22	227	2970	99.0	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 1	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 2	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 1	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 2	22	227	1484	99.1	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP1 230 kV Line 1	22	227	2970	98.7	99.1	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP2 230 kV Line 2	22	227	2970	98.7	99.1	< 96%	< 96%
P1	B012_CR-PV_500	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	40.3	99.9	41.1	99.7
P1	B012_CR-PV_500	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	117.8	87.6	< 96%	< 96%
P1	B030_LUGO-VICTORVL_500	RINALDI 230 - RINALDI2 500 kV Trans H	26	286	1593 MVA	98.5	102.1	98.2	101.5
P1	B040_HALLEN-ELDORADO_500	MEAD - MARKETPL 500 kV Line 1	14	191	3300	94.6	99.9	95.5	99.9
P6	C106_Eld-McCull_ Lugo-Victorvl_500	RINALDI 230 - RINALDI2 500 kV Trans H	26	286	1593 MVA	98.1	101.7	98.0	101.2
P6	C108_Lugo-Victorvl_ Eldordo-Lugo_500_wRAS	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	105.7	96.1	< 96%	< 96%
P6	C108_Lugo-Victorvl_ Eldordo-Lugo_500_wRAS	RINALDI 230 - RINALDI2 500 kV Trans H	26	286	1593 MVA	109.2	113.1	109.4	112.9
P7	C200_DEV-RBluff_500_1-2_wRAS	DIXIELAN - RTP1 92 kV Line 1	21	213	370	< 96%	< 96%	96.6	100.0
P7	C200_DEV-RBluff_500_1-2_wRAS	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	98.3	99.5	< 96%	< 96%
P7	C201_RBluff-CoRvr_500_1-2_wRAS	DIXIELAN - RTP1 92 kV Line 1	21	213	370	< 96%	< 96%	96.7	100.1
P7	C201_RBluff-CoRvr_500_1-2_wRAS	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	98.3	99.4	< 96%	< 96%
Extreme	C303_PV-WW_500_1-2	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	59.2	98.2	< 96%	< 96%

†" Series Comp" refers to the Eco – Miguel 500 kV and Ocotillo – Suncrest 500 kV series compensation.

Table B-2 Phase 1 WECC Path 49 (East of the River) Power Flow (Thermal) Results

						Series Comp† In-Service		Series Comp† By-Passed	
Category	**Contingency**	**Affected Element**	**Area**	**Zone**	**Rating (Amps)**	**Pre-Project**	**Post-Project**	**Pre-Project**	**Post-Project**
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP1 230 kV Line 1	22	227	2970	99.0	99.4	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP1 230 kV Line 1	22	227	2970	99.3	99.8	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE - SYCAMORE TP2 230 kV Line 2	22	227	2970	99.3	99.8	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 1	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP1 - SUNCREST TP1 230 kV Line 2	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 1	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SYCAMORE TP2 - SUNCREST TP2 230 kV Line 2	22	227	1484	99.4	99.9	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP1 230 kV Line 1	22	227	2970	99.0	99.5	< 96%	< 96%
P1	B008_IV-ECO_500	SUNCREST - SUNCREST TP2 230 kV Line 2	22	227	2970	99.0	99.5	< 96%	< 96%
P1	B012_CR-PV_500	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	< 96%	< 96%	98.3	66.8
P1	B012_CR-PV_500	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	41.1	99.3	41.9	100.0
P1	B019_CRY-MCCULLGH_500	MOENKOPI - ELDORDO 500 kV Line 1	14	141	2760	99.2	99.4	99.4	99.0
P1	B028_FOURCORN-MOENK	STRAWBTP - TONTO 69 kV Line 1	14	841	326	98.7	104.2	< 96%	< 96%
P1	B030_LUGO-VICTORVL_500	RINALDI 230 - RINALDI2 500 kV Trans H	26	286	1593 MVA	< 96%	< 96%	99.1	94.0
P6	C106_Eld-McCull_Lugo-Victorvl_500	RINALDI 230 - RINALDI2 500 kV Trans H	26	286	1593 MVA	< 96%	< 96%	99.0	94.1
P6	C107_Cry-McCll_HA-Md_500	MOENKOPI - ELDORDO 500 kV Line 1	14	141	2760	99.7	100.0	99.8	99.7
P6	C108_Lugo-Victorvl_ Eldordo-Lugo_500_wRAS	RINALDI 230 - RINALDI2 500 kV Trans H	26	286	1593 MVA	107.9	105.5	109.8	102.7
P7	C200_DEV-RBluff_500_1-2_wRAS	DIXIELAN - RTP1 92 kV Line 1	21	213	370	< 96%	< 96%	98.2	97.3
P7	C200_DEV-RBluff_500_1-2_wRAS	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	98.3	99.9	101.0	100.7
P7	C201_RBluff-CoRvr_500_1-2_wRAS	DIXIELAN - RTP1 92 kV Line 1	21	213	370	< 96%	< 96%	98.4	97.5
P7	C201_RBluff-CoRvr_500_1-2_wRAS	MIRAGE - J.HINDS 230 kV Line 1	24	949	896	98.4	100.0	101.2	100.7
P7	C303_PV-WW_500_1-2	DELANEY - PALOVRDE 500 kV Line 1	14	141	3000	60.1	98.3	60.8	99.3

†" Series Comp" refers to the Eco – Miguel 500 kV and Ocotillo – Suncrest 500 kV series compensation.

Table B-5 Phase 1 WECC Path 46 (West of the River) Power Flow (Voltage) Results

					Pre Project: SC† By-Passed			Post Project: SC† By-Passed		
Cat	Contingency	Bus	Area	Zone	Vpre (pu)	Vpost (pu)	Vdev (%)	Vpre (pu)	Vpost (pu)	Vdev (%)
P7	C200_DEV-RBluff_1-2	CALIPAT_SS 230	21	213	0.9904	0.9168	-7.4	0.9937	0.8928	-10.2
P7	C200_DEV-RBluff_1-2	C3-TAP 230	21	213	0.9867	0.9128	-7.5	0.9901	0.8889	-10.2
P7	C200_DEV-RBluff_1-2	HUDSON_RANCH 230	21	213	0.9918	0.9183	-7.4	0.9950	0.8944	-10.1
P7	C200_DEV-RBluff_1-2	MIDWAY230 230	21	212	0.9850	0.9110	-7.5	0.9884	0.8871	-10.3
P7	C200_DEV-RBluff_1-2	MIDWAY 92	21	212	0.9772	0.9155	-6.3	0.9798	0.8906	-9.1
P7	C200_DEV-RBluff_1-2	IPP-97 230	21	213	0.9904	0.9168	-7.4	0.9937	0.8928	-10.2
P7	C200_DEV-RBluff_1-2	MIDWAY_1 230	21	213	0.9904	0.9168	-7.4	0.9937	0.8928	-10.2
P7	C200_DEV-RBluff_1-2	MIDWAY_2 230	21	213	0.9904	0.9168	-7.4	0.9937	0.8928	-10.2
P7	C201_RBluff-CoRvr_1-2	CALIPAT_SS 230	21	213	0.9904	0.9181	-7.3	0.9937	0.8942	-10.0
P7	C201_RBluff-CoRvr_1-2	C3-TAP 230	21	213	0.9867	0.9141	-7.4	0.9901	0.8903	-10.1
P7	C201_RBluff-CoRvr_1-2	HUDSON_RANCH 230	21	213	0.9918	0.9197	-7.3	0.9950	0.8958	-10.0
P7	C201_RBluff-CoRvr_1-2	MIDWAY230 230	21	212	0.9850	0.9124	-7.4	0.9884	0.8885	-10.1
P7	C201_RBluff-CoRvr_1-2	MIDWAY 92	21	212	0.9772	0.9167	-6.2	0.9798	0.8921	-8.9
P7	C201_RBluff-CoRvr_1-2	IPP-97 230	21	213	0.9904	0.9181	-7.3	0.9937	0.8942	-10.0
P7	C201_RBluff-CoRvr_1-2	MIDWAY_1 230	21	213	0.9904	0.9181	-7.3	0.9937	0.8942	-10.0
P7	C201_RBluff-CoRvr_1-2	MIDWAY_2 230	21	213	0.9904	0.9181	-7.3	0.9937	0.8942	-10.0

†" Series Comp, SC" refers to the Eco – Miguel 500 kV and Ocotillo – Suncrest 500 kV series compensation.

Table B-6 Phase 1 WECC Path 49 (East of the River) Power Flow (Voltage) Results

					Pre Project: SC† By-Passed			Post Project: SC† By-Passed		
Cat	Contingency	Bus	Area	Zone	Vpre (pu)	Vpost (pu)	Vdev (%)	Vpre (pu)	Vpost (pu)	Vdev (%)
P7	C200_DEV-RBluff_1-2	CALIPAT_SS 230	21	213	0.9888	0.9097	-8.0	0.9951	0.8995	-9.6
P7	C200_DEV-RBluff_1-2	C3-TAP 230	21	213	0.9850	0.9058	-8.0	0.9915	0.8956	-9.7
P7	C200_DEV-RBluff_1-2	MIDWAY230 230	21	212	0.9833	0.9040	-8.1	0.9899	0.8938	-9.7
P7	C200_DEV-RBluff_1-2	MIDWAY 92	21	212	0.9759	0.9085	-6.9	0.9809	0.8978	-8.5
P7	C200_DEV-RBluff_1-2	IPP-97 230	21	213	0.9888	0.9097	-8.0	0.9951	0.8995	-9.6
P7	C200_DEV-RBluff_1-2	MIDWAY_1 230	21	213	0.9888	0.9097	-8.0	0.9951	0.8995	-9.6
P7	C200_DEV-RBluff_1-2	MIDWAY_2 230	21	213	0.9889	0.9097	-8.0	0.9951	0.8995	-9.6
P7	C201_RBluff-CoRvr_1-2	C3-TAP 230	21	213	0.9850	0.9063	-8.0	0.9915	0.8965	-9.6
P7	C201_RBluff-CoRvr_1-2	MIDWAY230 230	21	212	0.9833	0.9046	-8.0	0.9899	0.8947	-9.6
P7	C201_RBluff-CoRvr_1-2	MIDWAY 92	21	212	0.9759	0.9091	-6.8	0.9809	0.8988	-8.4

†" Series Comp, SC" refers to the Eco – Miguel 500 kV and Ocotillo – Suncrest 500 kV series compensation.

Appendix C – Power Flow Plots

Power Flow Plots are provided in separate .pdf document.

Appendix D – Transient Stability Results

Table D-1 Phase 1 WECC Path 46 (West of the River) Transient Stability Results

Contingency Number	*Contingency Description*	*NERC Category*	*VOLTAGES THAT DO NOT RECOVER TO 80% OF INITIAL VOLTAGE WITHIN 20 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 80% OF INITIAL VOLTAGE FOR MORE THAN 2.00 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 70% OF INITIAL VOLTAGE FOR MORE THAN 30 cycles (BES LOAD BUSES)*	*Positively Damped?*
Series Compensation† In-Service.						
1	B001_HAA-NGILA_500	P1	None	None	None	Yes
2	B002_HAA-HoodooWash_500	P1	None	None	None	Yes
3	B003_HoodooWash-NG_500	P1	None	None	None	Yes
4	B004_NGila-IV_500	P1	None	None	None	Yes
5	B005_PV-CR_500	P1	None	None	None	Yes
6	B006_Delaney-ColRiver_500	P1	None	None	None	Yes
7	B007_Moenkopi-Eldorado_500	P1	None	None	None	Yes
8	B008_Eldordo-Lugo_500	P1	None	None	None	Yes
9	B009_Mohave-LUGO_500	P1	None	None	None	Yes
10	B010_HAllen-Mead_500	P1	None	None	None	Yes
11	C011_HA-Md_Cry-McCll_500	P6	None	None	None	Yes
12	C012_PV-Delaney_ColRvr_500	P7	None	None	None	Yes
13	C013_RBluff-CoRvr_500_1-2	P7	None	None	None	Yes
14	C014_HAA-NGILA_HDWSH500	Extreme	None	None	None	Yes
15	C015_HAA-NG/HAA-HDWSH	Extreme	None	None	None	Yes
16	C016_HAA-NG/HDWSH-NG	P7	None	None	None	Yes
Series Compensation† By-Passed.						
1	B001_HAA-NGILA_500	P1	None	None	None	Yes
2	B002_HAA-HoodooWash_500	P1	None	None	None	Yes

Contingency Number	*Contingency Description*	*NERC Category*	*VOLTAGES THAT DO NOT RECOVER TO 80% OF INITIAL VOLTAGE WITHIN 20 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 80% OF INITIAL VOLTAGE FOR MORE THAN 2.00 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 70% OF INITIAL VOLTAGE FOR MORE THAN 30 cycles (BES LOAD BUSES)*	*Positively Damped?*
3	B003_HoodooWash-NG_500	P1	None	None	None	Yes
4	B004_NGila-IV_500	P1	None	None	None	Yes
5	B005_PV-CR_500	P1	None	None	None	Yes
6	B006_Delaney-ColRiver_500	P1	None	None	None	Yes
7	B007_Moenkopi-Eldorado_500	P1	None	None	None	Yes
8	B008_Eldordo-Lugo_500	P1	None	None	None	Yes
9	B009_Mohave-LUGO_500	P1	None	None	None	Yes
10	B010_HAllen-Mead_500	P1	None	None	None	Yes
11	C011_HA-Md_Cry-McCll_500	P6	None	None	None	Yes
12	C012_PV-Delaney_ColRvr_500	P7	None	None	None	Yes
13	C013_RBluff-CoRvr_500_1-2	P7	None	None	None	Yes
14	C014_HAA-NGILA_HDWSH500	Extreme	None	None	None	Yes
15	C015_HAA-NG/HAA-HDWSH	Extreme	None	None	None	Yes
16	C016_HAA-NG/HDWSH-NG	P7	None	None	None	Yes

†" Series Comp, SC" refers to the Eco – Miguel 500 kV and Ocotillo – Suncrest 500 kV series compensation.

Table D-2 Phase 1 WECC Path 49 (East of the River) Transient Stability Results

Contingency Number	*Contingency Description*	*NERC Category*	*VOLTAGES THAT DO NOT RECOVER TO 80% OF INITIAL VOLTAGE WITHIN 20 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 80% OF INITIAL VOLTAGE FOR MORE THAN 2.00 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 70% OF INITIAL VOLTAGE FOR MORE THAN 30 cycles (BES LOAD BUSES)*	*Positively Damped?*
Series Compensation† In-Service.						
1	B001_HAA-NGILA_500	P1	None	None	None	Yes
2	B002_HAA-HoodooWash_500	P1	None	None	None	Yes
3	B003_HoodooWash-NG_500	P1	None	None	None	Yes
4	B004_NGila-IV_500	P1	None	None	None	Yes
5	B005_PV-CR_500	P1	None	None	None	Yes
6	B006_Delaney-ColRiver_500	P1	None	None	None	Yes
7	B007_Moenkopi-Eldorado_500	P1	None	None	None	Yes
8	B008_Eldordo-Lugo_500	P1	None	None	None	Yes
9	B009_Mohave-LUGO_500	P1	None	None	None	Yes
10	B010_HAllen-Mead_500	P1	None	None	None	Yes
11	C011_HA-Md_Cry-McCll_500	P7	None	None	None	Yes
12	C012_PV-Delaney_ColRvr_500	P7	None	None	None	Yes
13	C013_RBluff-CoRvr_500_1-2	P7	None	None	None	Yes
14	C014_HAA-NGILA_HDWSH500	P7	None	None	None	Yes
15	C015_HAA-NG/HAA-HDWSH	P7	None	None	None	Yes
16	C016_HAA-NG/HDWSH-NG	P7	None	None	None	Yes
Series Compensation† By-Passed.						
1	B001_HAA-NGILA_500	P1	None	None	None	Yes
2	B002_HAA-HoodooWash_500	P1	None	None	None	Yes
3	B003_HoodooWash-NG_500	P1	None	None	None	Yes
4	B004_NGila-IV_500	P1	None	None	None	Yes
5	B005_PV-CR_500	P1	None	None	None	Yes
6	B006_Delaney-ColRiver_500	P1	None	None	None	Yes

Contingency Number	*Contingency Description*	*NERC Category*	*VOLTAGES THAT DO NOT RECOVER TO 80% OF INITIAL VOLTAGE WITHIN 20 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 80% OF INITIAL VOLTAGE FOR MORE THAN 2.00 SECONDS (BES LOAD BUSES)*	*VOLTAGE DIPS BELOW 70% OF INITIAL VOLTAGE FOR MORE THAN 30 cycles (BES LOAD BUSES)*	*Positively Damped?*
7	B007_Moenkopi-Eldorado_500	P1	None	None	None	Yes
8	B008_Eldordo-Lugo_500	P1	None	None	None	Yes
9	B009_Mohave-LUGO_500	P1	None	None	None	Yes
10	B010_HAllen-Mead_500	P1	None	None	None	Yes
11	C011_HA-Md_Cry-McCll_500	P7	None	None	None	Yes
12	C012_PV-Delaney_ColRvr_500	P7	None	None	None	Yes
13	C013_RBluff-CoRvr_500_1-2	P7	None	None	None	Yes
14	C014_HAA-NGILA_HDWSH500	P7	None	None	None	Yes
15	C015_HAA-NG/HAA-HDWSH	P7	None	None	None	Yes
16	C016_HAA-NG/HDWSH-NG	P7	None	None	None	Yes

†" Series Comp, SC" refers to the Eco – Miguel 500 kV and Ocotillo – Suncrest 500 kV series compensation.

Appendix E – Transient Stability Plots

Transient Stability Plots are provided in a separate .pdf document.

Appendix F – Schedule

Task #	Task Description	Date
1	PRG review of non-simultaneous Study Base Case	May 2017
2	Submit Phase 1 CPR draft report to PRG members	June 20,2017
3	Phase 1 CPR draft report comments due	July 11, 2017
4	Submit final Phase 1 Comprehensive Progress Report to TSS and PCC	July 18, 2017
5	TSS and PCC comments due back	September 15, 2017
6	Address comments and inform TSS of Phase 1 completion	September 21, 2017
7	Finalize PRG for Phase 2	September 28, 2017
8	Revised Non-Simultaneous Study Base Case received from PRG	August 2018
9	Submit final Phase 1 Comprehensive Progress Report to TSS and PCC	September 2018
10	TSS and PCC comments due back	November 2018
11	Development of PRG for WECC Phase 2 Studies	November 2018
12	Approved WECC Phase 2 Study Plan	November 2018
13	Approved Foundational Base Case	November 2018
14	Approved WECC Phase 2A Status	December 2018
15	Begin WECC Phase 2B Studies	January 2019
16	WECC Phase 2B Studies Completed	May 2019
17	Draft WECC Phase 2B Report to PCC/TSS for Review	June 2019
18	Approved WECC Phase 3 Status	August 2019

Appendix G – Peer Review Group Roster

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