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California Independent
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STEP Powerflow Screening Study Results

Presentation for STEP Group 06/20/2003

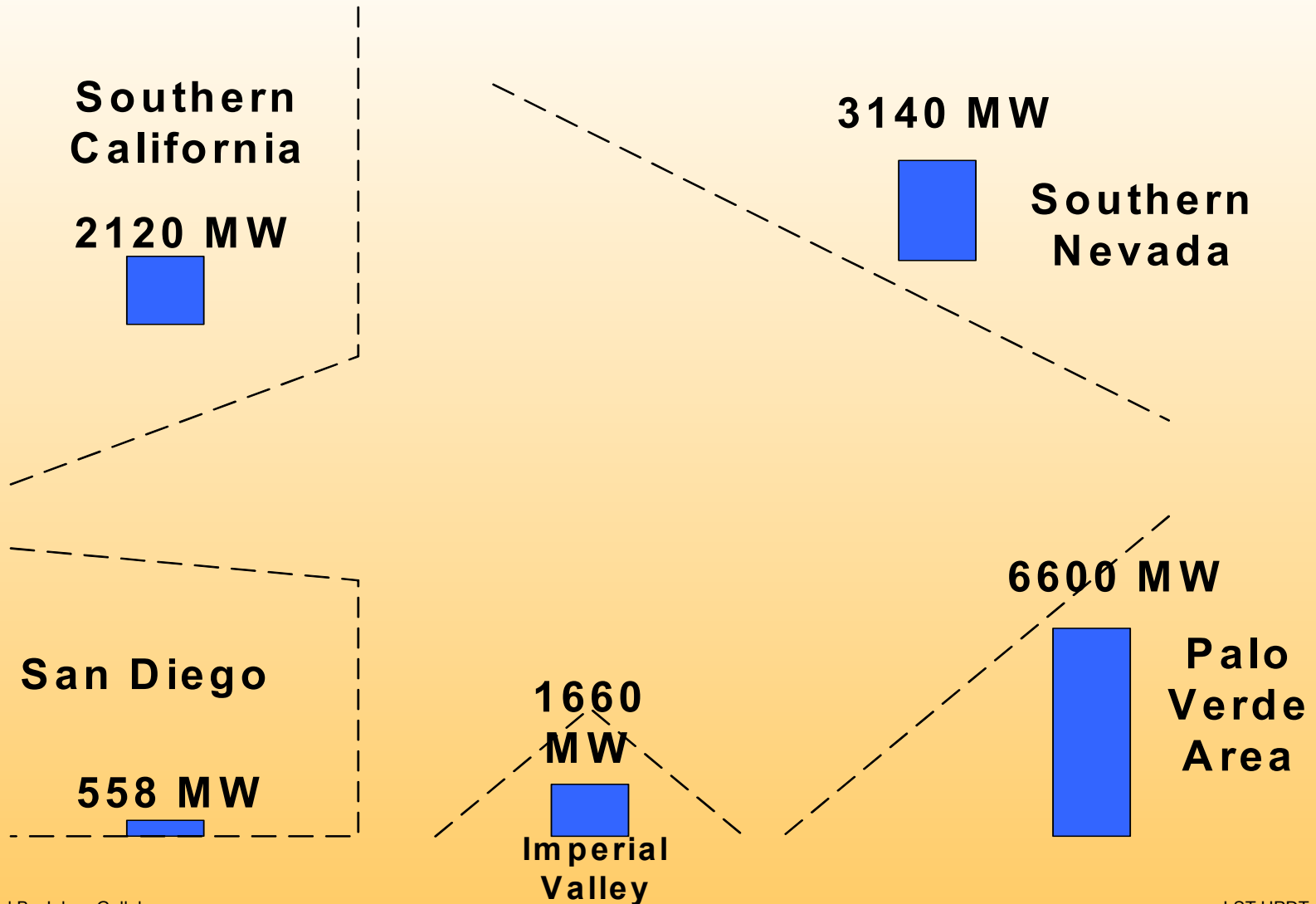
**Johan Galleberg
Grid Planning
California ISO**



- Study followed the STEP approved study plan (May 8, 2003)
- A realistic “maximum” flow 2007 heavy summer case was used in the studies performed
- The case was reviewed by the utilities in the Southwest region
- Generation modeled according to study plan



New generation modeled:



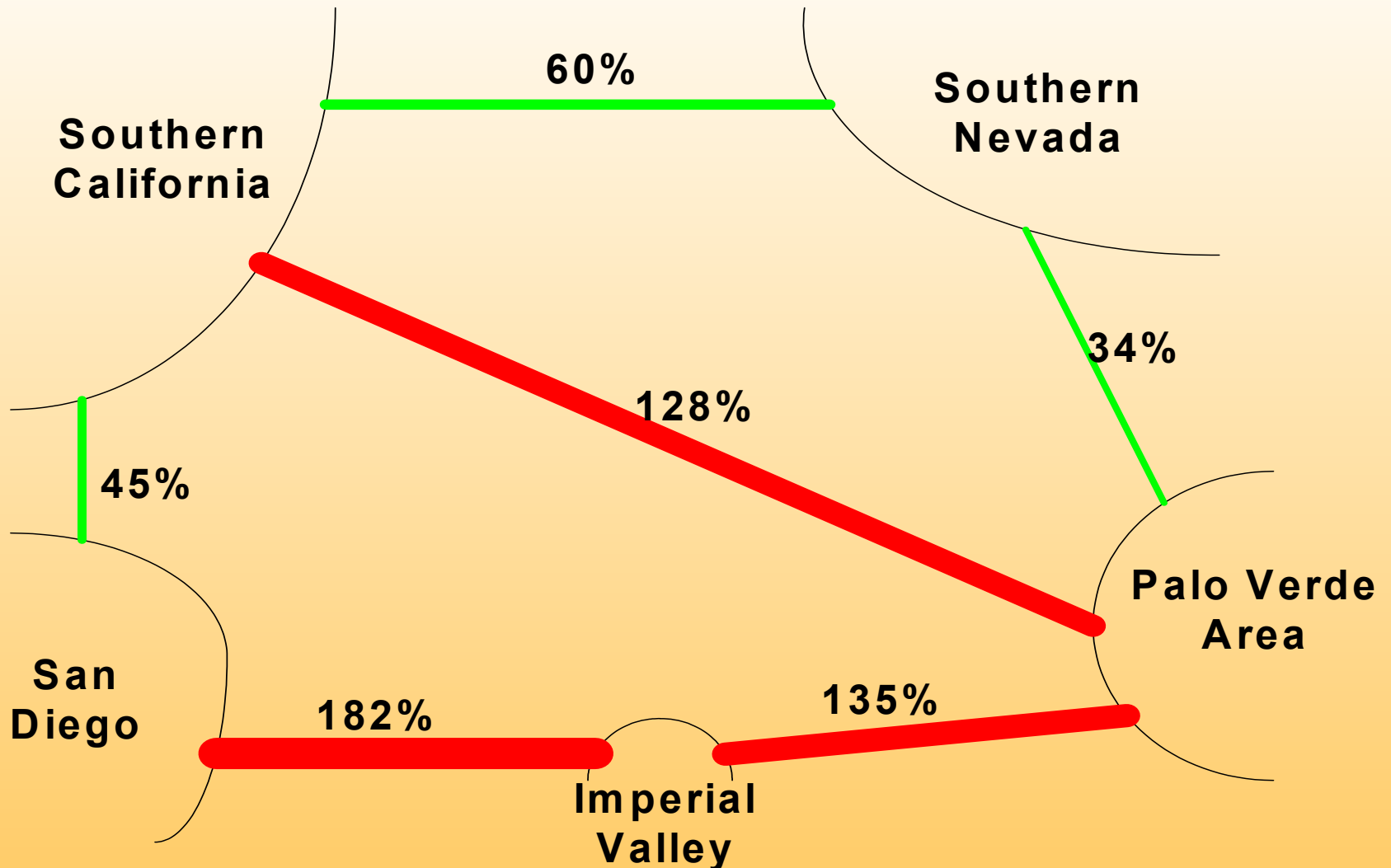


Removed Generation

- **Based on heat-rate, in-service year and announced retirements**
 - **About 1200 MW in SDG&E's area:**
 - **Southbay units, three Encina units and peaker units**
 - **About 5000 MW in SCE's area:**
 - **Mohave units, some of the older plants by the coast and peaker units**

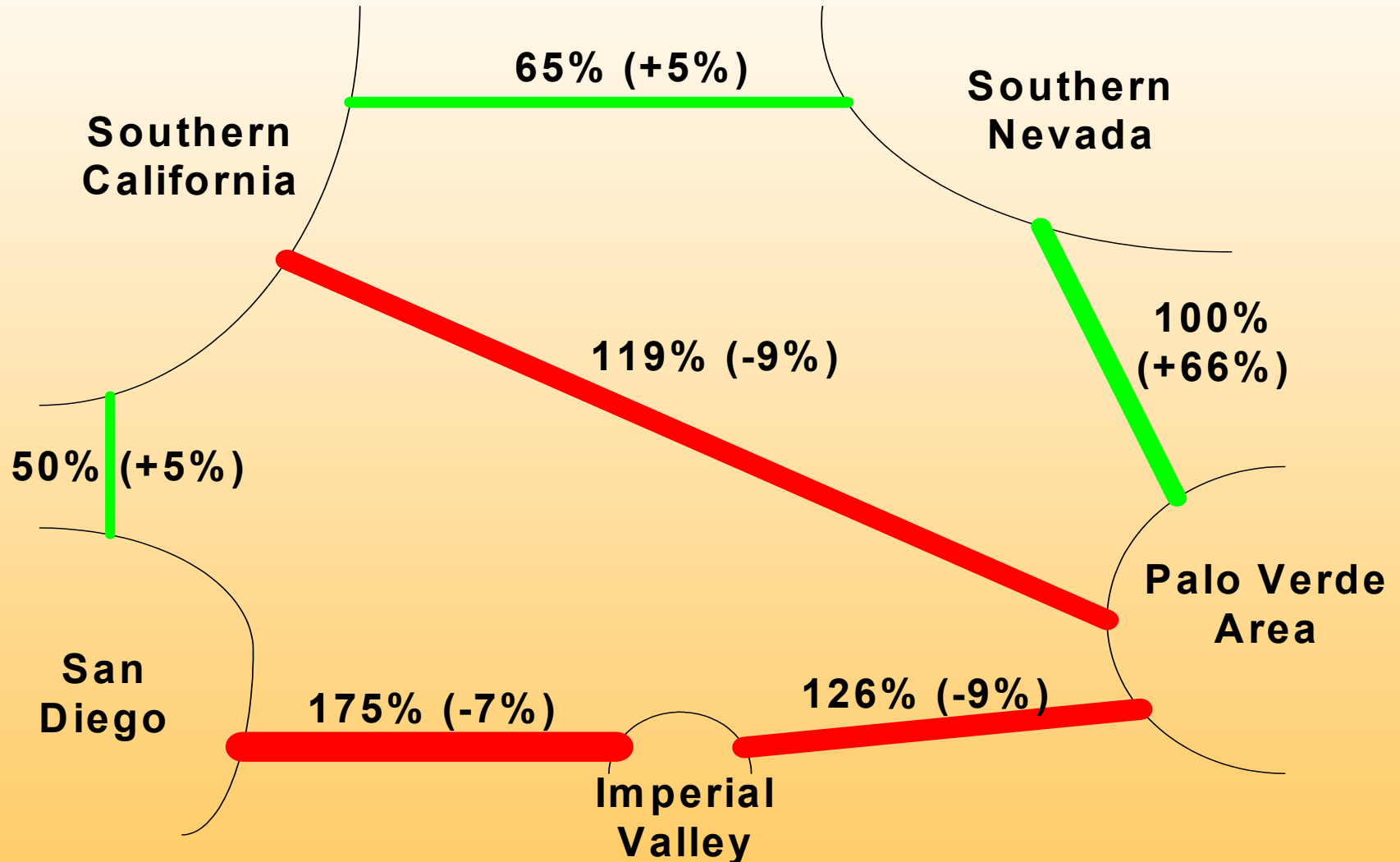


Flows in basecase (in % of thermal rating)





Maximized phase-shifters between Palo Verde area and Southern Nevada





Development of Projects (alternatives):

- Based on historic flow duration curves and projected future flow
- Based on input from STEP members
- Mileage based on existing lines or estimates
- Series compensation:
 - 0-80 miles: Not compensated
 - 80-150 miles: compensated in receiving end (50%)
 - 150 miles and longer: Compensated in both ends (50%)



What the study included:

- Normal overloads (N-0)
- Single contingencies of 500 kV lines (N-1)
- Post Transient analysis for a double unit outage of the two San Onofre units



What the study did not include:

- Impact on the lower voltage system (< 230 kV)
- N-2 contingency analysis (powerflow)
- Transient Stability
- Post Transient (except for SONGS double unit outage)



Parameters for each alternative

- Miles of new transmission lines
- Rating of new and existing series capacitors
- Number of new transformers/phase shifters
- Overloads (under normal and single line contingency conditions)
- Losses
- VAR support
- Flows across various WECC paths/interfaces
- Sufficient transfer capability requires at least one new line from the Palo Verde area into California and at least one new line into San Diego



Categorizing the 21 alternatives:

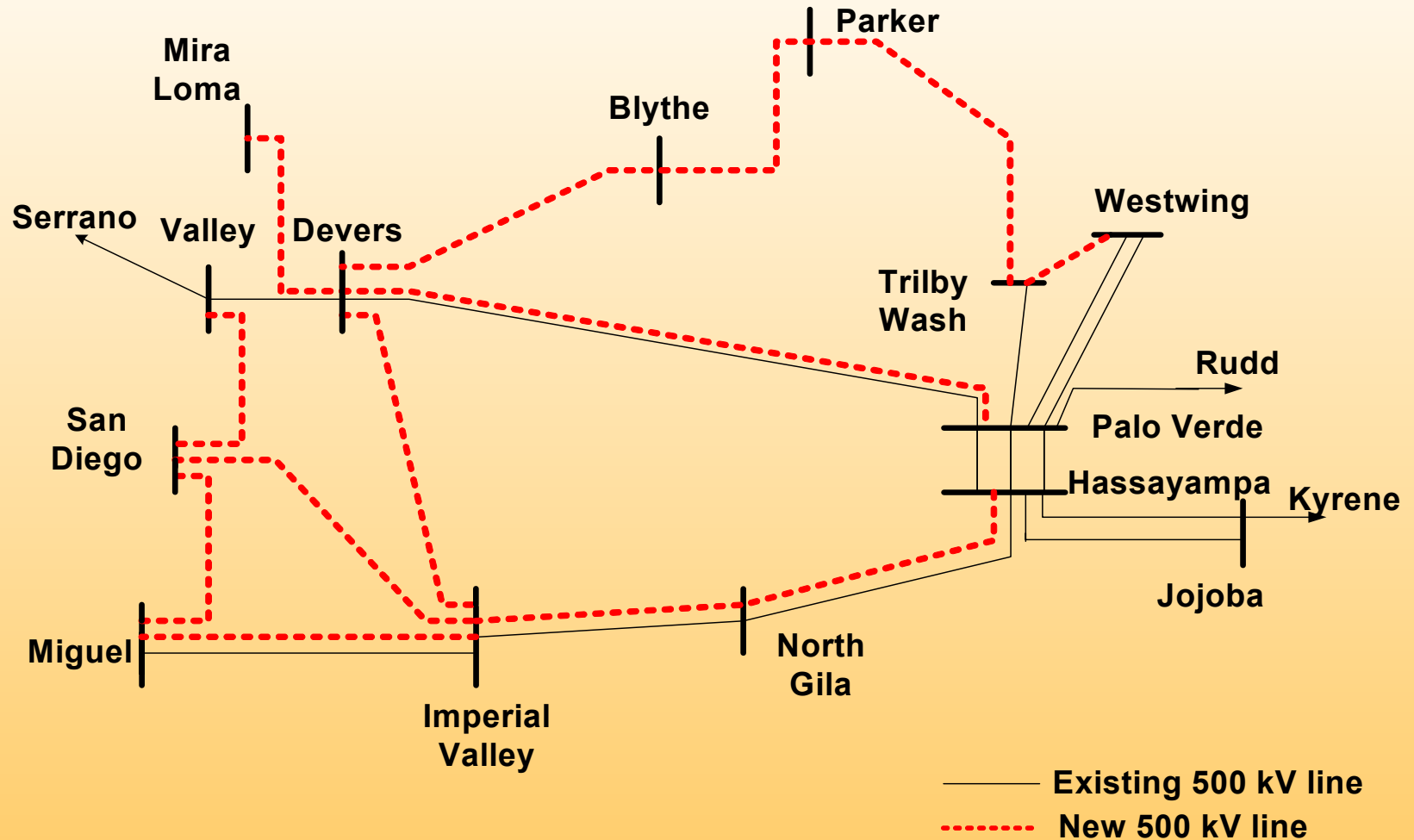
- 18 AC alternatives
 - 3 of these have been recommended for further studies by the STEP Study Working Group
- 3 DC alternatives
 - 2 of these have been recommended for further studies by the STEP Study Working Group



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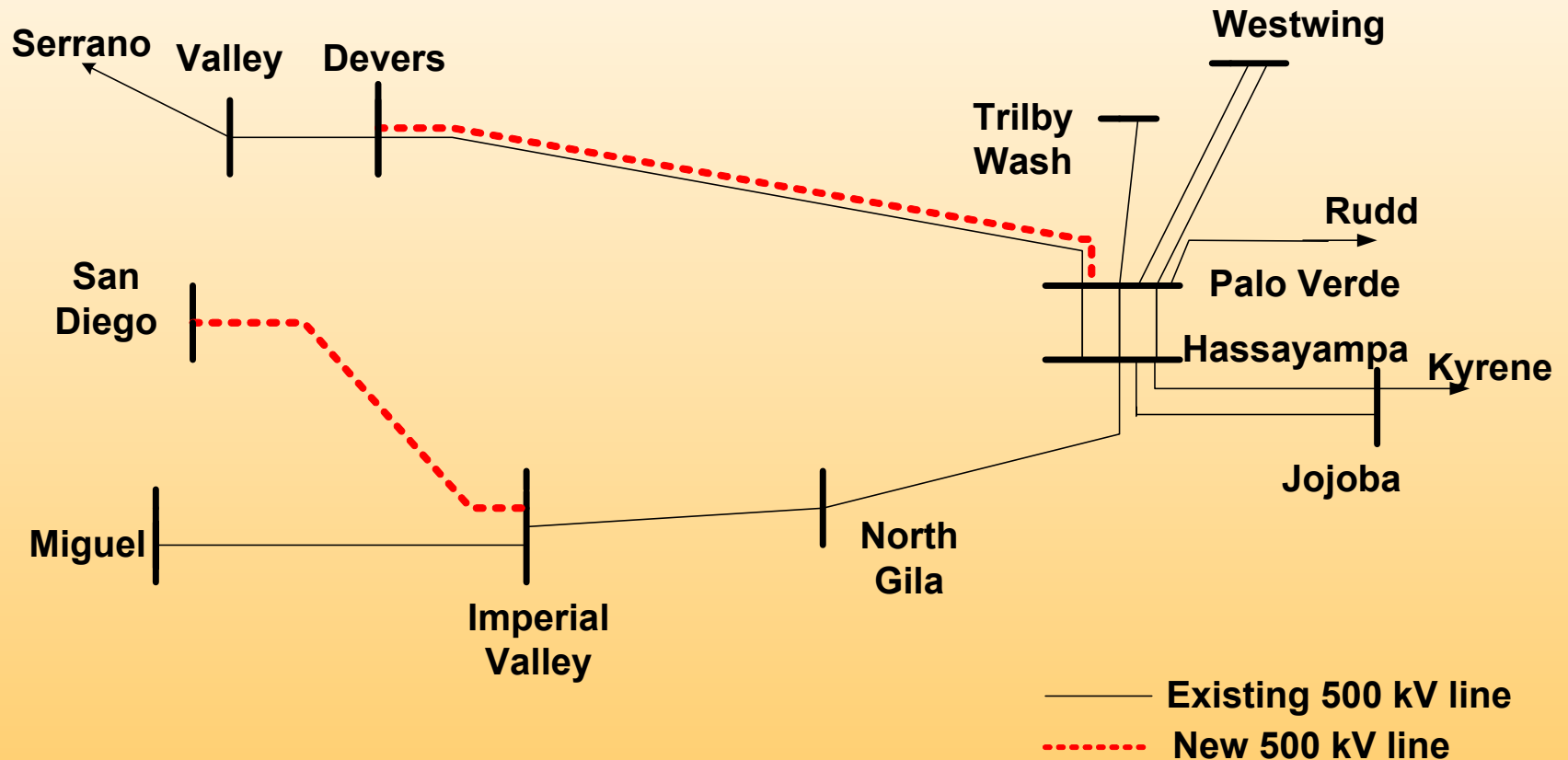
500 kV system (all 18 AC alternatives)





Recommended for further studies:

(Alt. 15 in screening study report)





Alternative 15 cont.

- Second Palo Verde – Devers 500 kV line
 - Series capacitors identical to existing No. 1 line
- Imperial Valley – San Diego 500 kV line
 - Series capacitors in the San Diego end, 50 % compensated
- Second Devers 500/230 kV transformer
- Second Miguel 500/230 kV transformer
- One 500/230 kV transformer at Ramona (or Rainbow)
- Upgrade series capacitors on SWPL (up to 2000 A (N-0) and 2400 A (N-1))
- Additional voltage support is needed at Devers



Alternative 15 cont.

- No normal overloads
- 4 overloads under single contingency conditions:

Contingency	Overloaded element	Overload (%)	Possible mitigation
Devers – Valley 500 kV line	San Bernardino – Devers 230 kV line No. 1	129	Re-conductor
Miguel – Imperial Valley 500 kV line	ROA 230 – HRD 230 230 kV line	109	IV Gen. SPS
Miguel – Imperial Valley 500 kV line	RUM 230 – HRD 230 230 kV line	105	IV Gen. SPS
Miguel – Imperial Valley 500 kV line	RUM 230 – ROA 230 230 kV line	121	IV Gen. SPS



Where to terminate the line between Imperial Valley and San Diego ?

- May be determined by other factors
(environmental factors, land use etc.)
- At least 3 possible locations:
 - Miguel
 - Ramona (or somewhere east of Sycamore
Canyon)
 - Rainbow



Imperial Valley – Miguel No. 2

- Existing Substation at Miguel
 - May not be feasible to bring a second 500 kV line into Miguel
 - Will significantly overload the underlying transmission system at Miguel
 - Impacts from a double line outage of both Imperial Valley – Miguel lines would be very high
- => Not considered to be a good option



Imperial Valley - Ramona

- Need to construct a new double circuit tower line between Ramona and Sycamore Canyon (about 16 miles)
 - Need to add a new 230/138 kV transformer at Sycamore Canyon and loop in existing line
 - Does have some impacts on the lower voltage system at Sycamore Canyon
 - Overloads on CFE's system under an outage of Miguel – Imperial Valley can be mitigated by tripping generation at Imperial Valley
- ⇒ Needs to be studied further



Imperial Valley - Rainbow

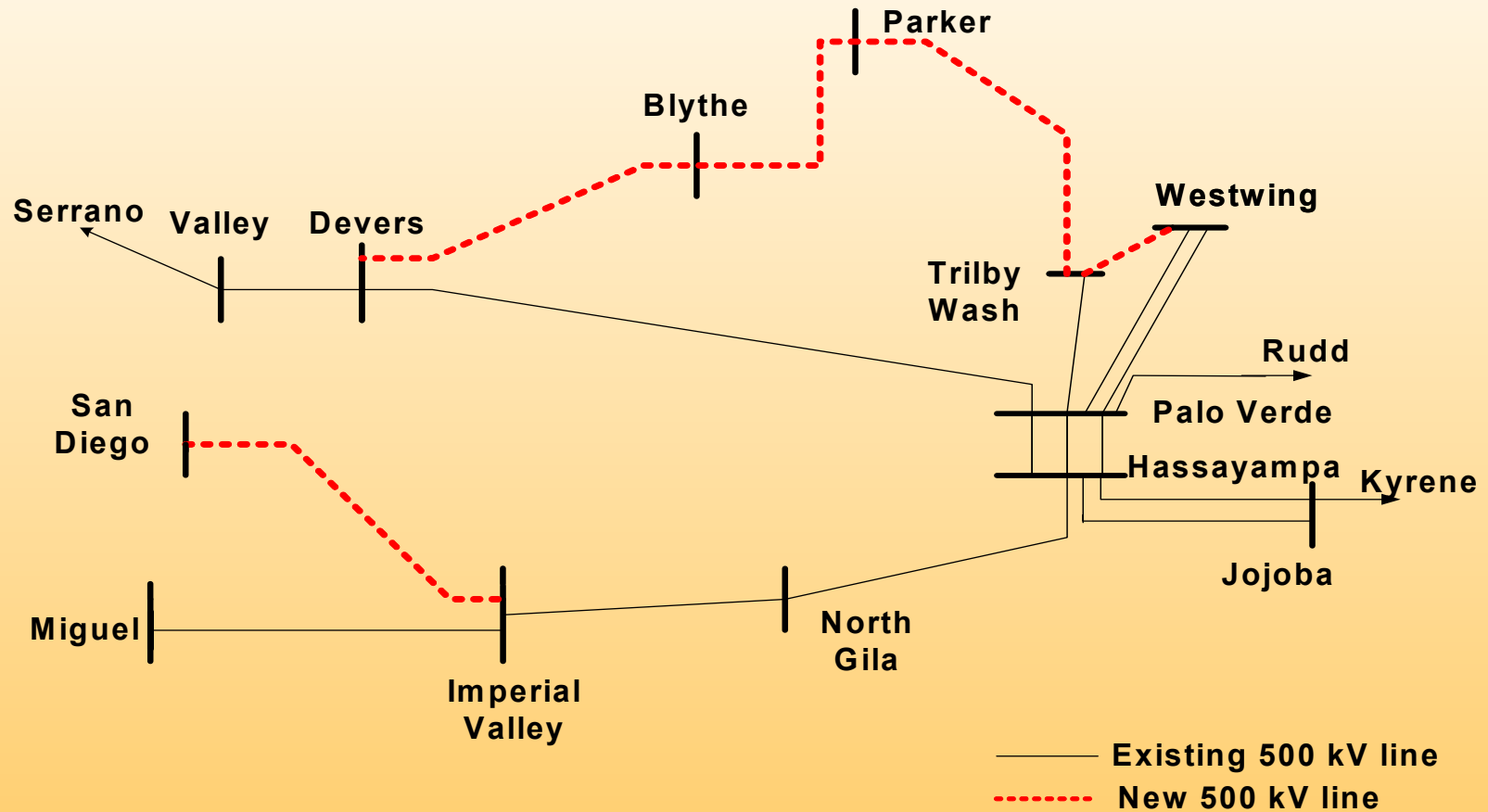
- Need to add a second 230 kV circuit on existing 230 kV line between Talega and Escondido
- A longer line than Imperial Valley – Ramona
- Causes higher import at Miguel Substation and therefore more impacts on underlying system at Miguel as compared to Imperial Valley – Ramona
- Overloads on CFE's system under an outage of Miguel – Imperial Valley are higher than with Imperial Valley – Ramona

=> Needs to be studied further



Recommended for further studies:

(Alt. 21 in screening study report)





Alt. 21 cont.

- Westwing - Trilby Wash – Parker – Blythe - Devers instead of a second Palo Verde - Devers No. 2 500 kV line
 - Series capacitors at Devers and Parker
- Imperial Valley – San Diego 500 kV line
 - Series capacitors in the San Diego end, 50 % compensated
- Second 500/230 kV transformer at Devers and Miguel
- One 500/230 kV transformer at Blythe, Parker and Ramona (or Rainbow)
- Upgrade series capacitors on SWPL (up to 2100 A (N-0) and 2500 A (N-1))
- Additional voltage support is needed at Devers



Alternative 21 cont.

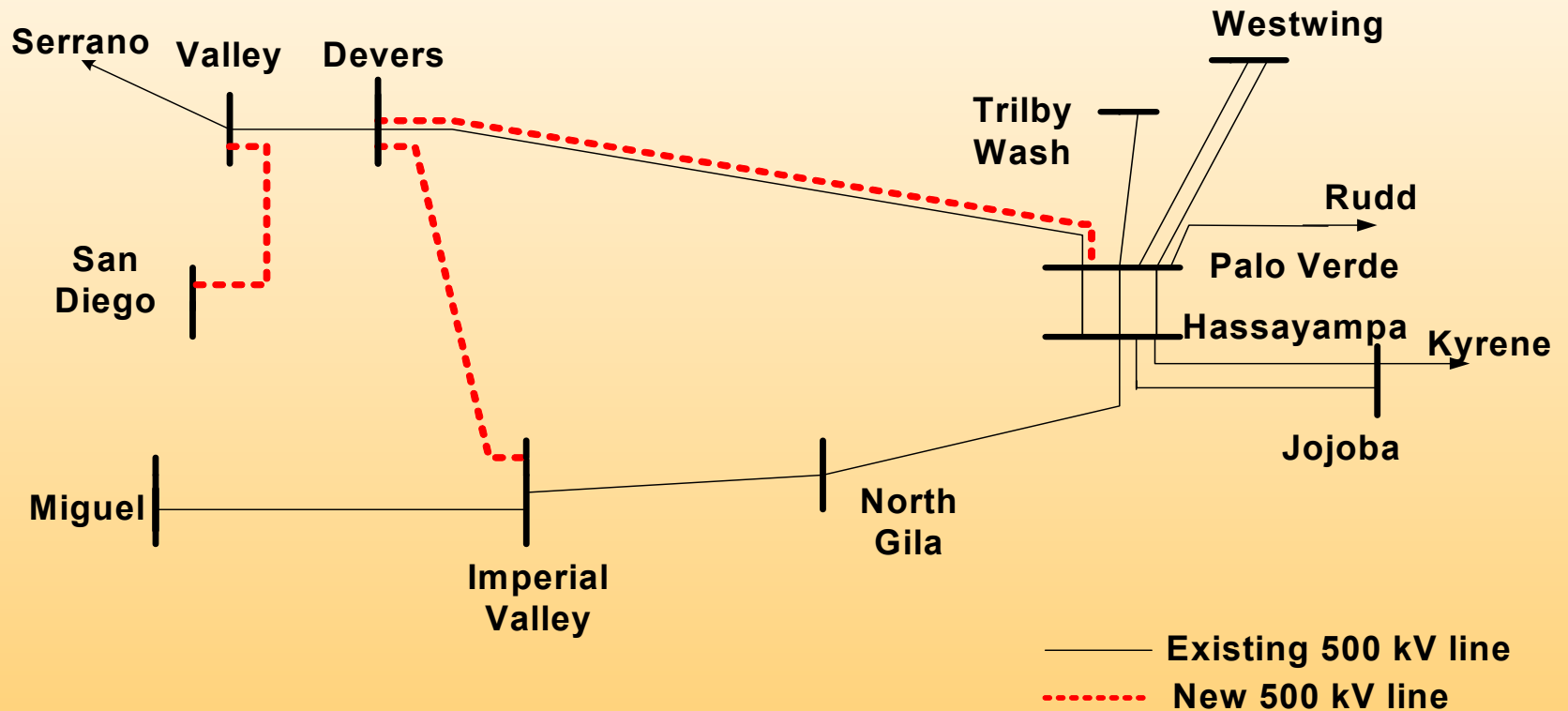
- No normal overloads
- 7 overloads under single contingency conditions:

Contingency	Overloaded element	Overload (%)	Possible mitigation
Devers – Valley 500 kV line	San Bernardino – Devers 230 kV line No. 1	123	Re-conductor
Palo Verde – Devers 500 kV line	Palo Verde – Trilby Wash 500 kV line	104	??
Park500-Trilby Wash 500 kV line	Parker –N. HAVASU 230 kV #1 line	110	??
Park500-Trilby Wash 500 kV line	N. HAVASU-TOPOCK 230 kV #1 line	110	??
Miguel – Imperial Valley 500 kV line	ROA 230 – HRD 230 230 kV line	107	IV Gen. SPS
Miguel – Imperial Valley 500 kV line	RUM 230 – HRD 230 230 kV line	103	IV Gen. SPS
Miguel – Imperial Valley 500 kV line	RUM 230 – ROA 230 230 kV line	119	IV Gen. SPS



Recommended for further studies:

(Alt. 19 in screening study report)





Alternative 19 cont.

- Second Palo Verde – Devers 500 kV line
 - Series capacitors identical to existing No. 1 line
- Imperial Valley – Devers 500 kV line
 - Series capacitors in the Devers end, 50 % compensated
- Second 500/230 kV transformer at Devers and Miguel



Alternative 19 cont.

- One 500/230 kV transformer at Rainbow
- Upgrade series capacitors on SWPL (up to 2200 A (N-0) and 2700 A (N-1))
- Phase shifter at Rainbow (set to hold about 980 MW)
- Phase shifter at Devers on Devers - Imperial Valley line (set to hold about 1000 MW)
- Additional voltage support is needed for an outage of Miguel – Imperial Valley 500 kV line



Alternative 19 cont.

- No normal overloads
- 9 overloads under single contingency conditions:



Alternative 19 cont.

Contingency	Overloaded element	Overload (%)	Possible mitigation
Devers – Valley 500 kV	San Bernardino – Devers 230 kV line No. 1	150	Re-conductor or Devers - Mira Loma 500 kV
Devers – Valley 500 kV	San Bernardino – Devers 230 kV line No. 2	107	Same as above
Devers – Valley 500 kV	Devers – Vista No.1 230 kV line	112	Same as above
Devers – Valley 500 kV	Devers – Vista No.2 230 kV line	105	Same as above
Miguel – Imperial Valley 500 kV	Devers – Valley SC 500 kV line	101	Same as above
Miguel – Imperial Valley 500 kV	ROA 230 – HRD 230 230 kV line	133	IV Gen.SPS and cross-trip of Tijuana-Otay Mesa 230 kV line. Additional VAR support
Miguel – Imperial Valley 500 kV	RUM 230 – HRD 230 230 kV line	129	Same as above
Miguel – Imperial Valley 500 kV	RUM 230 – ROA 230 230 kV line	145	Same as above
Miguel – Imperial Valley 500 kV	HRD 230 – MTP #1 & 2 230 kV line	109	IV Gen. SPS



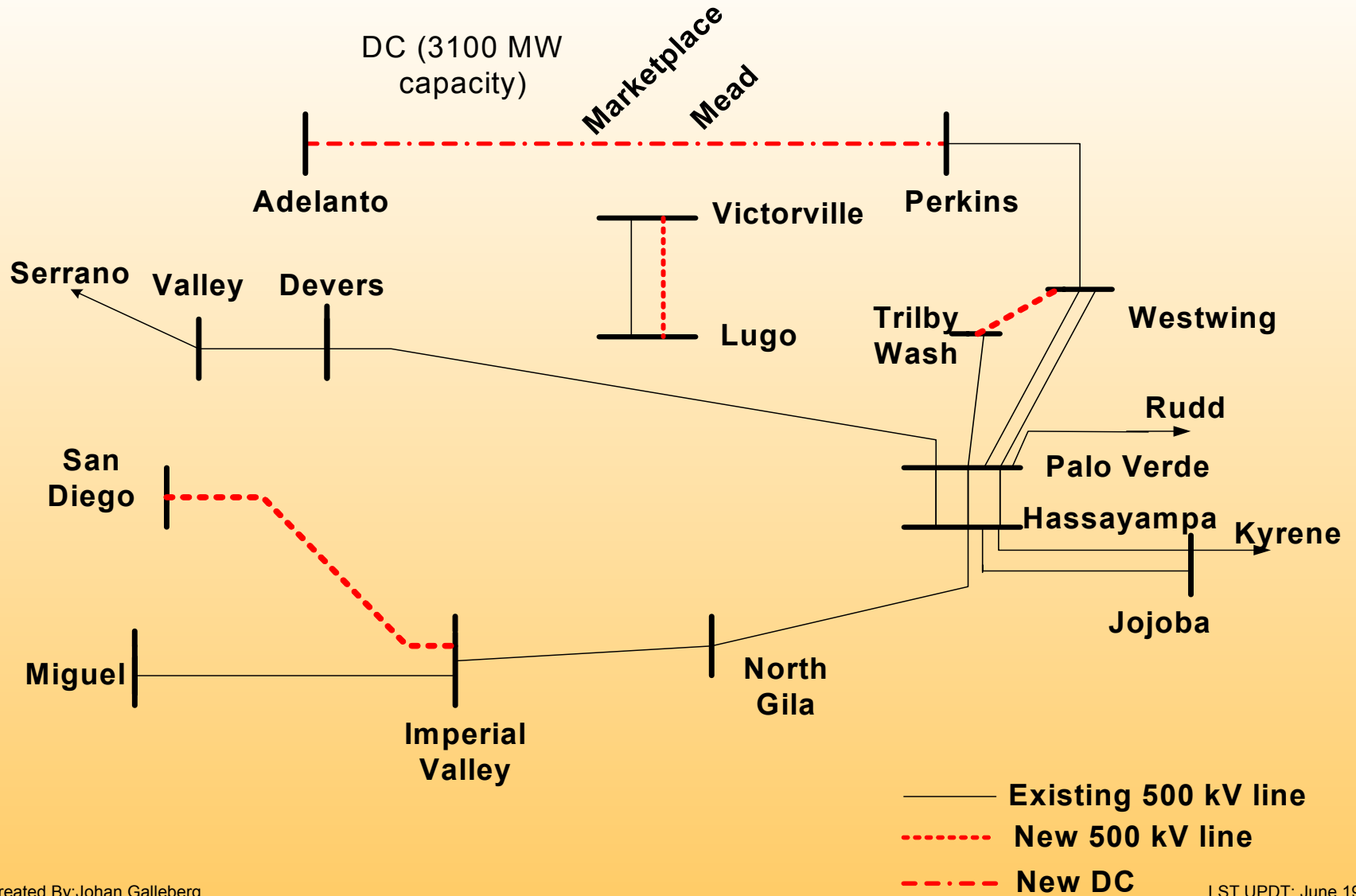
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DC Alternatives



Recommended for further studies (Alt. 11 in screening study report):





Alternative 11 cont.

- Convert existing Perkins – Mead – Marketplace – Adelanto 500 kV AC line into DC
- Imperial Valley – San Diego 500 kV line
 - Series capacitors in the San Diego end, 50 % compensated
- Lugo – Victorville No. 2 500 kV line
- Trilby Wash – Westwing 500 kV line
- Second Miguel 500/230 kV transformer
- One 500/230 kV transformer at Ramona (or Rainbow)
- Upgrade existing series capacitors
 - SWPL; up to 1800 A (N-0) and 2600 A (N-1)
 - Palo Verde – Devers to 2500 A (N-1)



Alternative 11 cont.

- No normal overloads
- 7 overloads under single contingency conditions:

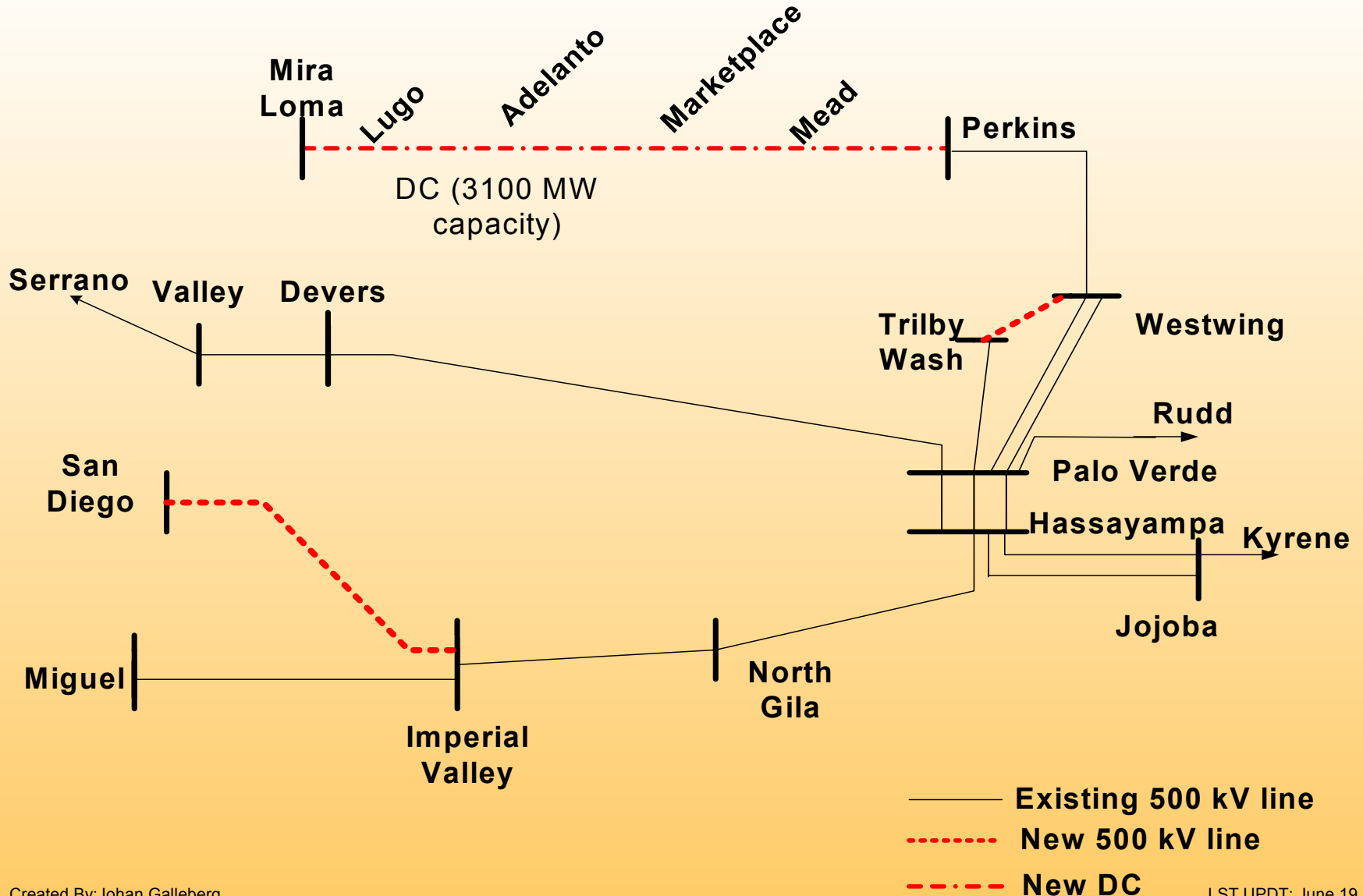
Contingency	Overloaded element	Overload (%)	Possible mitigation
Adelanto –Victorville 500 kV No.1 or 2	Adelanto-Victorville 500 kV No. 2 or 1	115	??
Miguel – Imperial Valley 500 kV line	ROA 230 – HRD 230 230 kV line	126	IV Gen. SPS & cross-trip Otay Mesa – Tijuana 230 kV
Miguel – Imperial Valley 500 kV line	RUM 230 – HRD 230 230 kV line	121	(IV Gen. SPS)
Miguel – Imperial Valley 500 kV line	RUM 230 – ROA 230 230 kV line	138	IV Gen. SPS & cross-trip Otay Mesa – Tijuana 230 kV
Lugo-Victorville No. 2 500 kV line	Lugo-Victorville No. 1 500 kV line	120	Upgrade wave traps to 3600 A
Lugo-Mira Loma No.2 500 kV line	Lugo-Mira Loma No. 3 500 kV line	112	Lugo- Mira Loma No.4 or Re-conductor (?)
Lugo-Mira Loma No. 3 500 kV line	Lugo-Mira Loma No. 2 500 kV line	106	Lugo- Mira Loma No.4 or Re-conductor (?)



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Recommended for further studies (Alt. 13 in screening study report):





Alternative 13 cont.

- Convert existing Perkins – Mead – Marketplace – Adelanto 500 kV AC line to DC and extend the DC line south with termination at Mira Loma Substation
- Imperial Valley – San Diego 500 kV line
 - Series capacitors in the San Diego end, 50 % compensated
- Trilby Wash – Westwing 500 kV line
- Second Miguel 500/230 kV transformer
- One 500/230 kV transformer at Ramona (or Rainbow)
- Upgrade existing series capacitors
 - SWPL; up to 1800 A (N-0) and 2700 A (N-1)
 - Palo Verde – Devers to 2600 A (N-1)



Alternative 13 cont.

- No normal overloads
- 4 overloads under single contingency conditions:

Contingency	Overloaded element	Overload (%)	Possible mitigation
Miguel – Imperial Valley 500 kV line	ROA 230 – HRD 230 230 kV line	124	IV Gen. SPS & cross-trip Otay Mesa – Tijuana 230 kV
Miguel – Imperial Valley 500 kV line	RUM 230 – HRD 230 230 kV line	119	IV Gen. SPS
Miguel – Imperial Valley 500 kV line	RUM 230 – ROA 230 230 kV line	136	IV Gen. SPS & cross-trip Otay Mesa – Tijuana 230 kV
Palo Verde- Westwing 500 kV line No. 1 or 2	Palo Verde – Trilby Wash	103	Future line



Summary

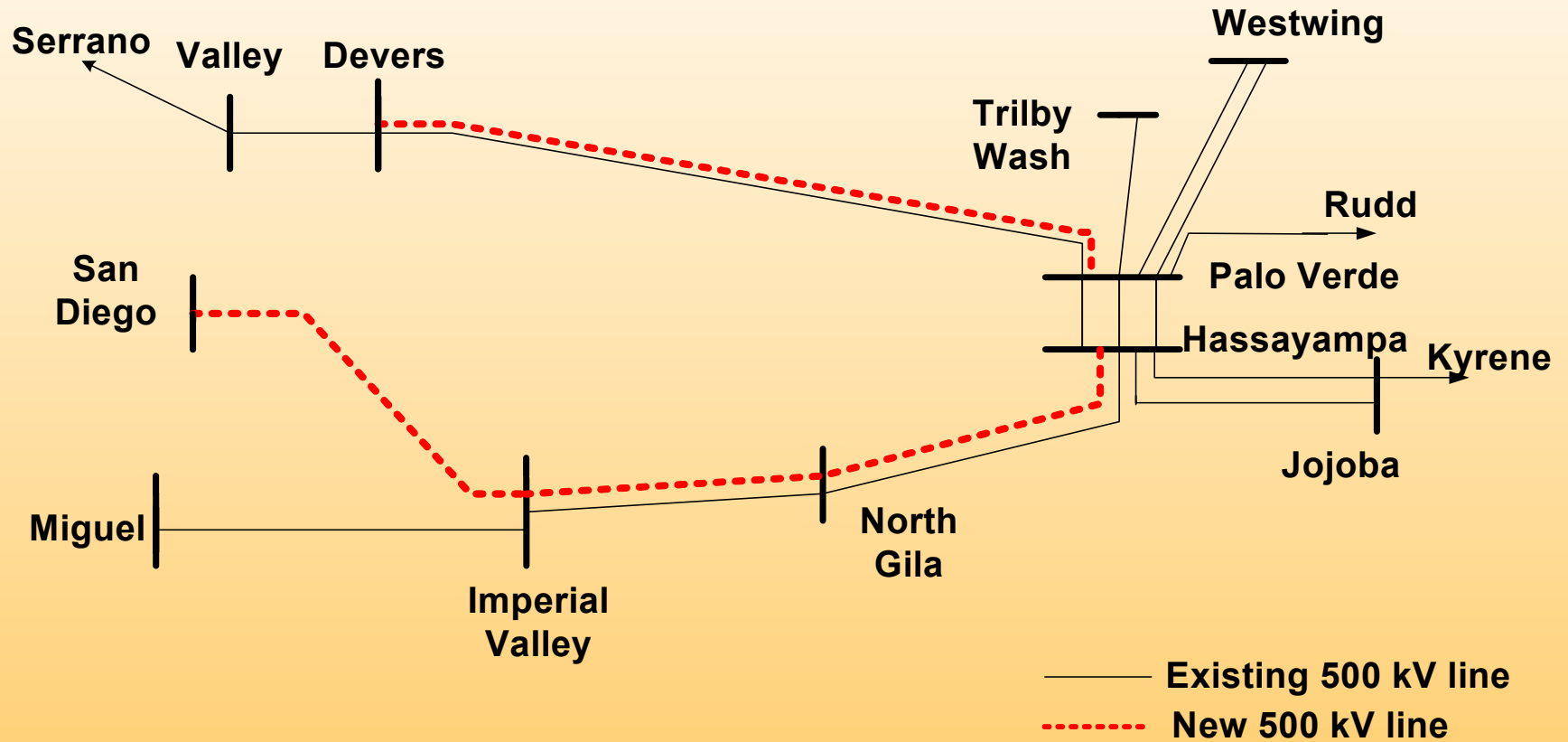
	(DC)		(AC)		
	11	13	15	19	21
Miles of new 500 kV lines	203	188	358	398	423
Miles of new 230 kV lines	51	51	16	51	16
Miles of DC lines	473	519	0	0	0
# of new 500 kV lines	2	1	2	3	5
# of new 500/230 kV transformers needed	2	2	3	3	5
# of new 500 kV lines with series capacitors	1	1	2	2	3
# of existing 500 kV lines with upgraded series cap.	4	4	3	3	3
# of new phase shifters	0	0	0	2	0
# of overloaded 230 kV lines (N-0)	0	0	0	0	0
# of overloaded 230 & 500 kV lines (N-1)	7	4	4	10	7
Losses 500 kV lines Southwest (MW)	315	278	395	419	405
Additional VAR support needed (MVAR)	1250	650	1250	1900	1100
EOR Flow (MW)	7590	7580	7350	7348	7223
South of Lugo Flow (MW)	6270	6523	4994	5048	5064
Miguel Import (MW)	2387	2362	2314	2412	2321



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Alt. 2 in screening study report

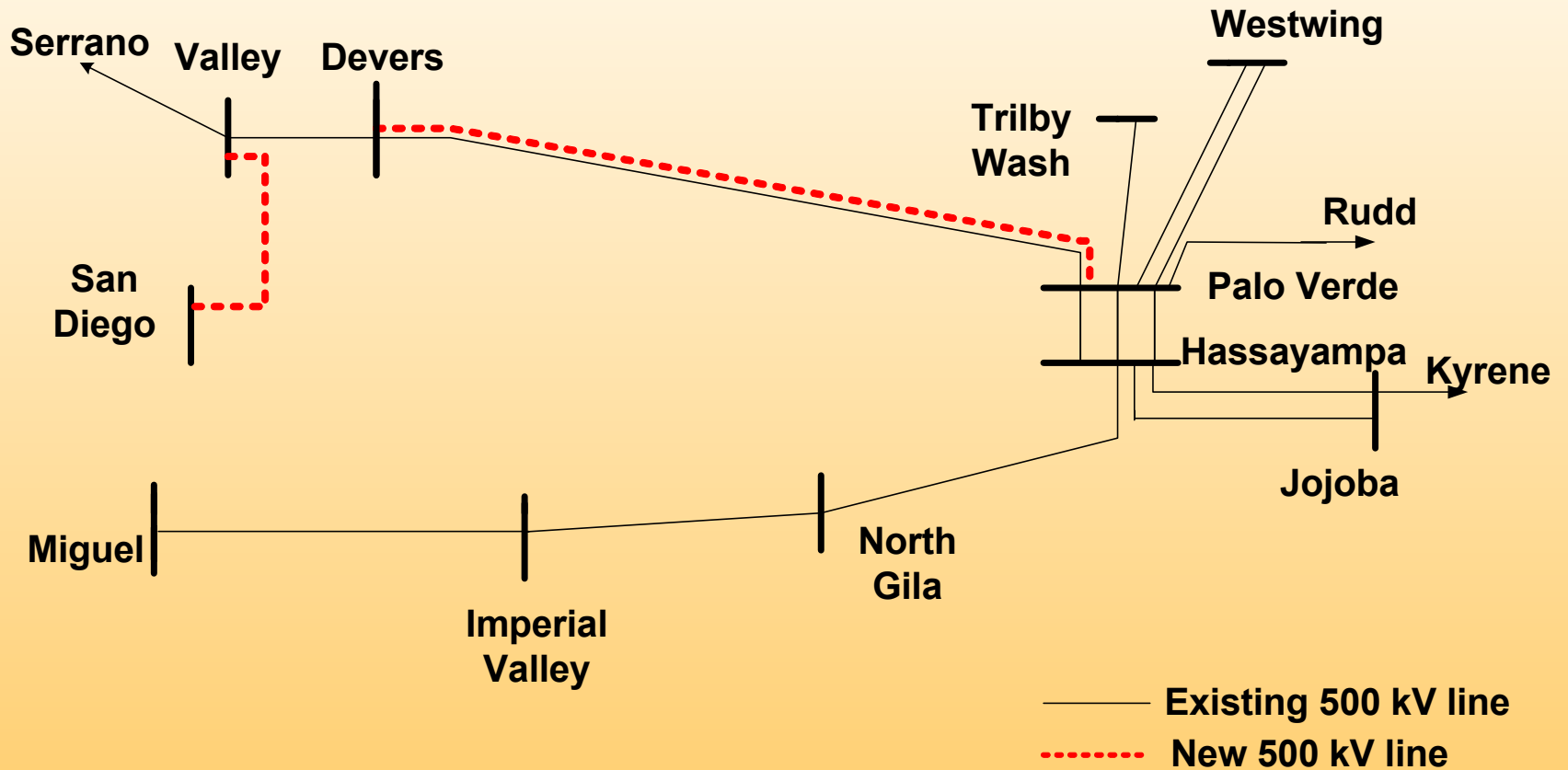




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Alt. 9 in screening study report





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Alt. 8 in screening study report

