



I. Malta 230-115kV Transformer #2 Supporting Information

A. Background

The Dillon-Malta 115kV load-serving system extends from the Dillon Substation in the north to the Malta Substation in the south. The Dillon-Blue River 230kV, the Dillon-Cabin Creek 230kV, and the Dillon-Breckinridge-Alma-Malta 230kV transmission lines connect the Dillon Substation to points on the 230kV bulk transmission system. The Malta-Hopkins 230kV, the Malta-Basalt 230kV, the Malta-Tarryall 230kV, the Malta-Alma-Breckinridge-Dillon 230kV and the Malta-Mt. Elbert 230kV lines connect the Malta Substation to points on the 230kV bulk transmission system. The Dillon-Breckinridge-Alma-Malta 230kV transmission line parallels the Dillon-Climax-Malta 115kV system; however, because of the relatively high impedance path of the 115kV system, an outage of the parallel 230kV line does not tend to load up the 115kV system. The loads served from the 115kV system include the Climax 115kV load, the Dillon 115kV load, the Gilman 115kV load, the Leadville 115kV load, the Mayflower 115kV load and the Summit 115kV load. The Climax 115kV load is a new 40 MW load that is scheduled to go in-service in the 3Q/2011. The demand in the load-serving area varies seasonally (as modeled in the power flow base cases) with the highest demand occurring during the winter months.

B. Study Case Creation

Several study cases were developed to study the Malta-Climax-Dillon 115kV load-serving system. Table 17 represents the loads in five WECC operating cases in the 2011 time frame. Table 18 represents the load represented in the 2012-2016 Capital Budget base cases.

Table 17 Load Levels for the 2011 Operating Cases

Bus #	Bus Name	ID	2011HS		2011HSP		2011HW		2011LS		2011LW	
			MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
70114	CLIMAX 115.00	P3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70114	CLIMAX 115.00	IN	40.0	13.2	40.0	13.2	40.0	13.2	40.0	13.2	40.0	13.2
70155	DILLON 115.00	P3	5.6	2.3	3.4	1.3	12.9	6.5	3.9	1.6	8.4	3.8
70199	GILMAN 115.00	P1	2.4	0.5	1.5	0.3	4.4	1.0	1.7	0.3	2.9	0.6
70257	LEADVIL1 115.00	P1	1.3	-0.4	0.8	-0.3	2.9	-0.9	0.9	-0.3	1.9	-0.6
70257	LEADVIL1 115.00	NT	-2.8	-0.5	-1.7	-0.3	-2.8	-0.5	-2.0	-0.4	-1.8	-0.4
70258	LEADVIL2 115.00	P2	2.3	-1.1	1.4	-0.7	5.3	-2.3	1.6	-0.8	3.5	-1.6
70281	MAYFLOWR 115.00	P1	2.9	1.5	1.7	0.9	6.7	3.7	2.0	1.0	4.3	2.3
70281	MAYFLOWR 115.00	P2	3.9	-0.7	2.3	-0.5	8.9	-1.5	2.7	-0.5	5.8	-1.0
70418	SUMMIT1 115.00	P1	7.6	-0.6	4.6	-0.5	17.4	-0.2	5.3	-0.5	11.3	-0.6
70418	SUMMIT1 115.00	NT	-1.7	-0.8	-1.0	-0.5	-1.7	-0.8	-1.2	-0.6	-1.1	-0.5
	TOTAL		61.5	13.3	52.9	13.0	94.0	18.2	55.0	13.1	75.0	15.2

The loads listed for the 2013HS case were larger than expected for a summer on-peak case in the 2013 time frame. It is assumed that they



represent a future winter on-peak demand scenario. The 2013HS case has a TOT5 flow of 805 MW (west-to-east) and the combination of high demand and high TOT5 flow represented an extreme study scenario that was investigated in the study.

Table 18 Load Level for 2012-2016 Capital Budget Cases

Bus #	Bus Name	ID	2012HS		2013HS		2015HW		2016HS	
			MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
70114	CLIMAX 115.00	P3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70114	CLIMAX 115.00	IN	40.0	13.2	40.0	13.2	40.0	13.2	40.0	13.2
70155	DILLON 115.00	P3	7.6	3.9	19.2	10.5	19.2	0.7	5.4	2.2
70199	GILMAN 115.00	P1	1.9	0.4	8.2	1.9	4.6	1.0	1.4	0.3
70257	LEADVIL1 115.00	P1	1.7	-0.6	4.2	-1.3	4.1	-0.6	1.2	-0.4
70257	LEADVIL1 115.00	NT	-2.8	-0.5	-2.8	-0.5	5.1	-2.2	-2.8	-0.5
70258	LEADVIL2 115.00	P2	2.1	-1.0	7.8	-3.3	0.0	0.0	2.3	-1.1
70281	MAYFLOWR 115.00	P1	2.4	6.1	9.9	5.7	5.9	1.7	0.7	0.4
70281	MAYFLOWR 115.00	P2	1.9	-0.4	13.2	-2.0	4.6	-0.7	5.8	-1.0
70418	SUMMIT1 115.00	P1	8.1	0.6	26.0	0.8	20.0	3.2	7.3	-0.6
70418	SUMMIT1 115.00	NT	-1.9	0.3	-1.7	-0.8	-1.9	0.3	-1.7	-0.8
	TOTAL		60.9	21.9	124.0	24.2	101.6	16.5	59.6	11.6

Table 19 lists the study cases and the TOT5 (west-to-east) flows reflected in the study cases.

Table 19 TOT5 (west-to-east) Flow Levels for Study Cases

Study Case	TOT5 Flow (West-to-East)
11HS2A APPROVED OPERATING CASE	403
2011 HSP1 OPERATING CASE	395
2010-11 HW2A APPROVED OPERATING CASE	325
11LS1 OPERATING CASE	380
2010-11 LW1A APPROVED OPERATING CASE	588
BUDGET_2012HS	475
BUDGET_2013HS (Case probably represents future on-peak winter loads in the study area)	805
BUDGET_2014-15HW2A APPROVED BASE CASE	426
BUDGET_2016HS2 APPROVED BASE CASE	760

The Dillon-Malta 115kV load-serving system connects to the 230kV bulk transmission system by means of the Dillon 100 MVA 230-115kV transformer and the Malta 100 MVA 230-115kV transformer. In addition, there is a 115kV



connection to Poncha by way the Malta-Buena Vista-Ray Lewis-Poncha 115kV transmission line; however, this line provides much less support to the Dillon-Malta 115kV load-serving system. The transmission system carries the power flowing to serve loads in the study area along with a superimposed TOT5 flow. An outage of the Dillon 230-115kV transformer means the Malta 230-115kV transformer and Malta-Poncha 115kV line must carry all of the power needed for the loads in the study area plus losses. Similarly, an outage of the Malta 230-115kV transformer means the Dillon 230-115kV transformer and the Malta-Poncha 115kV line must carry all of the power needed for the loads in the study area plus losses. As Table 17 and Table 18 indicate, the study area demand is expected to exceed 100 MW in the 2015 on-peak winter time frame (102 MW) and is expected to be near the 100 MW level in the 2011 on-peak winter time frame (94.0 MW) due to the 40 MW load increase at the Climax 115kV bus. It is clear that the Dillon 230-115kV and Malta 230-115kV transformers could experience contingency overloads for the outage of either transformer as they individually serve the study area demand (near or exceeding 100 MW) under these outage conditions.

C. Study Results – 2011 Heavy Winter Study Case, TOT5=325 MW

The 2011 HW operating case was obtained with the Climax demand at 40 MW. The case was selected as winter represents the heaviest load period. Outages were simulated and the results listed in Table 20 below.

Table 20 2011HW Operating Case TOT5=325 MW

Case: 2010-11 HW2A Op Case			Ckt	Limiting Contingency	Rating	LnFlow	%O/L	V-Cont
HOPKINS	115.00-BASALT	115.00	1	BASALT 115.0-BASALT 230.0-T2	73.0	106.8	146.4	
HOPKINS	115.00-HOPKINS	230.00	T1	BASALT 115.0-BASALT 230.0-T2	100.0	122.1	122.1	
MALTA	115.00-MALTA	230.00	T1	DILLON 115.0-DILLON 230.0-T1	100.0	119.3	119.3	
MALTA	115.00-MALTA	230.00	T1	SANLSVLY 230.0-PONCHABR 230.0-1	100.0	107.5	107.5	
MALTA	115.00-MALTA	230.00	T1	DILLON 115.0-SUMTAP2 115.0-1	100.0	107.2	107.2	
MALTA	115.00-MALTA	230.00	T1	MAYFLOWR 115.0-SUMTAP2 115.0-1	100.0	107.2	107.2	

The results demonstrate that the outage of the Dillon 230-115kV transformer results in an overload of the Malta 230-115kV transformer of 119.3% of its 100 MVA rating. One alternative consists of adding a second 100 MVA 230-115kV transformer. A second alternative consists of replacing the Malta 230-115kV transformer with a larger transformer. Alternative #1 (add a second Malta 100 MVA 230-115kV transformer) is preferred as it provides a more reliable system under higher TOT5 flows and at high demand levels.

The study determined that if a second Malta transformer is not added, 5 MW of load in the study area will need to be shed to bring the Malta 230-115kV transformer flow below 115% of its 100 MVA rating for an outage of the Dillon 230-115kV transformer.

A second Malta 100 MVA 230-115kV transformer was added to the study case. Outages were simulated. The results are listed in Table 21 below.

Table 21 2011HW Operating Case with the Malta 230-115kV #2 Transformer



Case: 11hw2ap-c-alt1.sav						
Monitored Element	Ckt	Limiting Contingency	Rating	LnFlow	%O/L	V-Cont
CRAIG 230.00-RIFLE WA 230.00	1	CRAIG 345.0-MEEKER 345.0-1	478.0	478.9	100.2	
HOPKINS 115.00-BASALT 115.00	1	BASALT 115.0-BASALT 230.0-T2	73.0	106.8	146.4	
HOPKINS 115.00-HOPKINS 230.00	T1	BASALT 115.0-BASALT 230.0-T2	100.0	122.0	122.0	

The addition of the second Malta 230-115kV transformer mitigates the contingency overload of the Malta 230-115kV #1 transformer and does not cause other system problems.

D. Future System – Summer - High Demand/ High TOT5 Flow

The Dillon-Malta 115kV load-serving system is highly dependant on the demand in the 115kV load-serving system and on the level of TOT5 flow (west-to-east) across western Colorado. The highest demands in the mountain areas occur during the winter season. To evaluate higher demand and higher TOT5 conditions, another study case was selected. The 2013HS budget case was used for the evaluation. The case displayed a TOT5 (west-to-east) flow of 813 MW and a TOT2A (north-to-south) flow of 75 MW. The load represented as the Climax 115kV bus is 45.6 MW and 15.0 MVAR. This assumes an expansion of load beyond the customer forecast of 40 MW and 13.2 MVAR. Outages were simulated and the results listed in Table 22 below.

Table 22 Criteria Violations for Case “2013hs_budget_1.sav”, TOT5=805.3 MW, Climax=45.6 MW

Case: 2013hs_budget_1.sav						
Monitored Element	Ckt	Limiting Contingency	Rating	LnFlow	%O/L	V-Cont
CLIMAX 115.00		MALTA 115.0-MALTA 230.0-T1				0.896
DILLON 115.00-DILLON 230.00	T1	MALTA 115.0-MALTA 230.0-T1	100.0	119.6	119.6	
DILLON 115.00-SUMTAP2 115.00	1	MALTA 115.0-MALTA 230.0-T1	85.0	102.3	120.3	
GOREPASS 138.00-HAYDEN 138.00	1	GOREPASS 230.0-HAYDEN 230.0-1	135.0	145.2	107.5	
HOPKINS 115.00-BASALT 115.00	1	HAYDEN 230.0-FOIDELCK 230.0-1	73.0	102.5	140.4	
MALTA 115.00-MALTA 230.00	T1	DILLON 115.0-DILLON 230.0-T1	100.0	158.2	158.2	
MALTA 115.00-MALTA 230.00	T1	MAYFLOWR 115.0-SUMTAP2 115.0-1	100.0	141.5	141.5	
MALTA 115.00-MALTA 230.00	T1	DILLON 115.0-SUMTAP2 115.0-1	100.0	141.4	141.4	
MALTA 115.00-MALTA 230.00	T1	MALTA 230.0-HARTSELT 230.0-1	100.0	134.0	134.0	
MALTA 115.00-MALTA 230.00	T1	TARRYALL 230.0-HARTSELT 230.0-1	100.0	132.5	132.5	
MALTA 115.00-MALTA 230.00	T1	BASE CASE	100.0	110.1	110.1	
MAYFLOWR 115.00-SUMTAP2 115.00	1	MALTA 115.0-MALTA 230.0-T1	85.0	98.5	115.9	
ROBIN1 115.00		MALTA 115.0-MALTA 230.0-T1				0.876
ROBIN2 115.00		MALTA 115.0-MALTA 230.0-T1				0.896
SUMMIT1 115.00		MALTA 115.0-MALTA 230.0-T1				0.745
SUMMIT1 115.00		MAYFLOWR 115.0-SUMTAP2 115.0-1				0.818
SUMMIT1 115.00		BASE CASE				0.875
SUMMIT2 115.00		MALTA 115.0-MALTA 230.0-T1				0.745
SUMMIT2 115.00		MAYFLOWR 115.0-SUMTAP2 115.0-1				0.818
SUMMIT2 115.00		DILLON 115.0-SUMTAP2 115.0-1				0.820
SUMMIT2 115.00		CLIMAX 115.0-LEADVIL1 115.0-1				0.836
SUMMIT2 115.00		BASE CASE				0.875

Table 22 lists the potential criteria violations in the study area around Climax. The Malta 230-115kV 100 MVA transformer overloads to 110.1% of its 100 MVA rating under system intact conditions. The Climax demand is shown in the case as 45.6 MW and 15.0



MVAR. This exceeds the forecast demand of 40.0 MW. The Climax demand was reduced to 40.0 MW. Table 2 shows the demand levels for loads in the case. The total demand on the Dillon-Malta 115kV load-serving system in the case is 124.0 MW, 30 MW higher than the 94.0 MW demand level in the 2011HW operating case that was evaluated earlier. Outage simulations were conducted on the case. The results are listed in Table 23 below.

Table 23 Criteria Violations for the Dillon-Malta 115kV Load-Serving System (124 MW), TOT5=805 MW, Climax=40 MW

Case: 2013hs_budget_2								
Monitored Element	Ckt	Limiting Contingency	Rating	LnFlow	%O/L	V-Cont		
DILLON 115.00-DILLON 230.00	T1	MALTA 115.0-MALTA 230.0-T1	100.0	115.2	115.2			
DILLON 115.00-SUMTAP2 115.00	1	MALTA 115.0-MALTA 230.0-T1	85.0	97.5	114.7			
GOREPASS 138.00-HAYDEN 138.00	1	GOREPASS 230.0-HAYDEN 230.0-1	135.0	145.1	107.5			
GRANGER 69.000		BASE CASE						1.062
HOPKINS 115.00-BASALT 115.00	1	HAYDEN 230.0-FOIDELCK 230.0-1	73.0	102.3	140.1			
HOPKINS 115.00-BASALT 115.00	1	WOLCOTT 230.0-FOIDELCK 230.0-1	73.0	88.5	121.2			
MALTA 115.00-MALTA 230.00	T1	DILLON 115.0-DILLON 230.0-T1	100.0	153.1	153.1			
MALTA 115.00-MALTA 230.00	T1	MAYFLOWR 115.0-SUMTAP2 115.0-1	100.0	136.1	136.1			
MAYFLOWR 115.00-SUMTAP2 115.00	1	MALTA 115.0-MALTA 230.0-T1	85.0	94.2	110.8			
MILL 115.00-METTLER 115.00	1	BLUERIVR 230.0-GOREPASS 230.0-1	123.5	125.0	101.2			
ROBIN1 115.00		MALTA 115.0-MALTA 230.0-T1						0.890
SUMMIT1 115.00		MALTA 115.0-MALTA 230.0-T1						0.766
SUMMIT1 115.00		MAYFLOWR 115.0-SUMTAP2 115.0-1						0.829
SUMMIT1 115.00		BASE CASE						0.881
SUMMIT2 115.00		MALTA 115.0-MALTA 230.0-T1						0.766
SUMMIT2 115.00		MAYFLOWR 115.0-SUMTAP2 115.0-1						0.829
SUMMIT2 115.00		BASE CASE						0.881

The reduction in Climax demand to 40 MW reduced the system intact flow on the Malta 230-115kV transformer to 107.0% of its 100.0 MVA rating. In addition, at the TOT5 level of approximately 805 MW (west-to-east), system intact low bus voltages may occur at the the Summit1 115kV bus (0.88 p.u.), and the Summit2 115kV bus (0.88 p.u.). In addition, an outage of the Malta 230-115kV transformer results in the Dillon 230-115kV transformer flow of 115.2% of its 100 MVA rating and an overload of the Dillon-SummitTap 115kV branch of 114.7% of its 85 MVA rating. The Dillon-SummitTap 115kV branch (Ckt #8174) is 8.31 miles and composed of 2-636 kcmil, 1-1750 kcmil, and 1-4/0 conductor, the latter with a rating of 85 MVA. A second Malta 230-115kV 100 MVA transformer was added to the case and outages were simulated. Table 24 lists the criteria violations.

Table 24 Criteria Violations for the Dillon-Malta 115kV Load-Serving System with the Malta 230-115kV Transformer #2 Added



Case: 2013hs_budget_3.sav						
Monitored Element	Ckt	Limiting Contingency	Rating	LnFlow	%O/L	V-Cont
CLIMAX 115.00-LEADVIL1 115.00	1	LEADVIL2 115.0-MALTA 115.0-1	74.0	76.5	103.3	
GOREPASS 138.00-HAYDEN 138.00	1	GOREPASS 230.0-HAYDEN 230.0-1	135.0	144.8	107.2	
HENDERPS 115.00-PORTAL 115.00	1	BLUERIVR 230.0-DILLON 230.0-1	80.0	110.3	137.8	
HENDERPS 115.00-PORTAL 115.00	1	CABINCRK 230.0-DILLON 230.0-1	80.0	83.4	104.2	
HOPKINS 115.00-BASALT 115.00	1	HAYDEN 230.0-FOIDELCK 230.0-1	73.0	103.1	141.3	
HOPKINS 115.00-HOPKINS 230.00	T1	HAYDEN 230.0-FOIDELCK 230.0-1	100.0	100.3	100.3	
MILL 115.00-METTLER 115.00	1	BLUERIVR 230.0-GOREPASS 230.0-1	123.5	124.8	101.0	
SUMMIT1 115.00		CLIMAX 115.0-LEADVIL1 115.0-1				0.846
SUMMIT1 115.00		BASE CASE				0.885
SUMMIT2 115.00		CLIMAX 115.0-LEADVIL1 115.0-1				0.846
SUMMIT2 115.00		BASE CASE				0.885

The addition of the Malta 100 MVA 230-115kV transformer #2 eliminated a number of violations that could occur at this high TOT5 transfer flow (805 MW). System intact bus voltage violations still occur at Summit1 115kV bus (0.89 p.u.), and the Summit2 115kV bus (0.89 p.u.). There is a load at the Summit1 bus of 27.7 MW and 1.6 MVAR; therefore, this system intact bus voltage of 0.89 p.u. must be corrected.

The base case models the SummitTap2 -Summit2 115kV tie open. This is how the system is operated at present. The Summit2 115kV bus voltage is 0.88 p.u. with an angle of 79.3 degrees and the SummitTap2 115kV bus voltage is 1.005 p.u. with an angle of 95.7 degrees. This represents an angular separation of approximately 16 degrees and a voltage difference of 15%. With the SummitTap2-Summit2 115kV tie open, the Summit1 load is served from a long radial 115kV line from Robinson Rack (Circuit #9188) of 17.64 miles using 1-477 kcmil, 1-336 kcmil, and 1-4/0 kcmil conductor along different portions of the line, the 1-4/0 kcmil conductor limiting the line rating to 85 MVA. The voltage drop on this radial line is approximately 10%. Closing the SummitTap-Summit2 115kV tie in the power flow case (along with closing the RobinsonRack bus tie) increased the Summit1 115kV bus voltage from 0.88 p.u. to 1.01 p.u. Opening the Summit1-RobinsonRack 115kV line at Summit (with the Robinson Rack bus tie closed) resulted in acceptable voltages in the Climax area.

E. Conclusion

For the near term, two alternatives were considered. They consist of the following:

- o Alternative 1 Add a Malta 100 MVA 230-115kV transformer with terminations
- o Alternative 2 Replace the Malta 100 MVA 230-115kV #1 transformer with a 175 MVA transformer

The study determined that if a second Malta transformer is not added (or the Malta 100 MVA 230-115kV transformer is not replaced with a larger transformer), 5 MW of load in the study area will need to be shed to bring the Malta 230-115kV transformer flow below 115% of its 100 MVA rating for an outage of the Dillon 230-115kV transformer

In the long term, as demand increases in the load-serving area under higher TOT5 flows, additional system upgrades may be needed. The system may need to be re-



configured to serve the Summit1 load from the SummitTap (close the SummitTap-Summit2 115kV tie) and open the Summit1-Robinson Rack 115kV branch at Summit1. Alternatively, voltage support may be required at summit. In addition, system upgrades between Climax and Leadville may be required.