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BEFORE THE UTAH UTILITY FACILITY REVIEW BOARD

PACIFICORP, doing business as ROCKY MOUNTAIN POWER, Petitioner vs. MIDWAY CITY, Respondent	DIRECT TESTIMONY OF CRAIG MICHAELIS Docket No. 20-035-03
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1 **Q: Please state your name, business address and present position.**

2 A: My name is Craig Michaelis. I am lead electrical engineer for Intermountain Consumer
3 Professional Engineers, Inc. My business address is 1145 East South Union Ave., Midvale,
4 Utah.

5
6 **Q: Please describe your education and business experience.**

7 A: I have worked for over 30 years in the electrical industry, including 15 years in the field as
8 an electrician. I have a bachelor's degree in computer science from the University of Utah
9 (1984) and a bachelor's degree in electrical engineering (1993), also from the University
10 of Utah. With ICPE I am responsible for our electrical engineers and designers.

11
12 **Q: What are your typical job duties?**

13 A: I am responsible for performing a wide range of services to ICPE clients, including studies,
14 load flow analysis, system planning, conceptual and detailed design, construction and
15 equipment specifications, equipment procurement, cost estimating, construction
16 management, project commissioning, and project inspection. Projects I have worked on
17 include utility and industrial substations, overhead and underground power distribution,
18 overhead to underground conversion, material handling, industrial facility power
19 distribution, generation and commercial facilities.

20
21 **Q: Are you familiar with the 46 kV Load Study performed by ICPE for Heber Light &
22 Power in 2018?**

23 A: Yes. A copy of the Study is attached as Exhibit ICPE-1.

24
25 **Q: What role did you have in performing that study?**

26 A: As lead electrical engineer I oversaw the project. I attended meetings internally at ICPE
27 and also with Heber Power discussing the project and its progress. I performed the final
28 review of the study results and the list of recommended improvements.

29
30 **Q: Please describe the methodology used to do modeling, prepare the report and provide
31 recommendations.**

1 A: A computer model of the electrical system was prepared using system data provided by
2 Heber Power. This model included substation locations, equipment nameplate data, line
3 locations, line sizes, and historical load data. Future system load projections were based on
4 load projections done in 2018 by Utility Financial Solutions LLC. The system was
5 studied in its current condition in 2018, as well as with five years of projected load growth
6 in 2022. The computer model was utilized to study how the Heber Power electrical system
7 would react to load growth as well as to various outage conditions that could occur. The
8 report explains how the Heber Power electrical system would respond to these conditions.
9 It showed that for some outage cases, Heber Power could have overloaded lines or
10 transformers and could have voltage issues or other problems. These issues would prevent
11 Heber Power from being able to provide power to all of their customers during these outage
12 conditions. The report provided recommended improvements that would help fix those
13 issues so that Heber Power can reliably provide power to its customers now and in the
14 future.

15
16 **Q: What does the column on pages 7-8 titled “2018 Base Case Line/Generation Out of**
17 **Service” describe?**

18 A: The table on pages seven and eight of the report summarizes the findings of the system
19 load study. The first column in the table lists various conditions that could occur on Heber
20 Power’s electrical system—from no outage to loss of a significant internal transmission
21 line combined with loss of all generation. These are essentially the “what if” scenarios that
22 we evaluate as part of the load flow study. By doing this analysis, we then can predict the
23 effect on the system in each of these scenarios. Those predicted effects are summarized in
24 the second column of the table.

25
26 **Q: What does the column on pages 9-10 titled “2022 Line/Generation Out of Service”**
27 **describe?**

28 A: The table on pages nine and ten describes the same “what if” scenarios as the previous
29 table, but for 2022 instead of 2018, assuming no major improvements are made to the
30 system.

1 **Q: What does the column on pages 11-12 titled “2022 After Improvements**
2 **Line/Generation Out of Service” describe?**

3 A: The report lists a number of suggested improvements in the table on pages four and five.
4 These are the improvements that we recommended to Heber Power as part of the study.
5 These improvements are intended to address the issues described in the table on pages nine
6 and ten. As with the preceding tables, this table lists a number of “what if” scenarios that
7 could occur on Heber Power’s electrical system and then describes the predicted effects of
8 each of these scenarios with the proposed improvements in place. As you can see, the table
9 on pages eleven and twelve shows that the electrical system would be much better able to
10 handle adverse events once the proposed improvements have been completed.
11

12 **Q: Were projected conditions in 2020 considered as part of the study?**

13 A: Conditions for 2020 were not specifically studied.
14

15 **Q: Why/why not?**

16 A: The system was studied in its current condition in 2018 as well as with five years of load
17 growth in 2022. The report shows that as load increases over time the Heber Power system
18 becomes less able to respond to possible outage conditions and therefore requires system
19 upgrades. The report did not attempt to predict specific conditions during 2020.
20

21 **Q: What does the report tell us about projected growth by the end of 2020?**

22 A: Our 46 kV Load Flow Study used the information from another study performed by an
23 outside consultant for Heber Power. We did not perform any analysis specific to 2020 as
24 the report addresses conditions in 2018 and in 2022. We know from the study that Heber
25 Power’s existing system likely cannot handle the projected demand in 2022. That said,
26 future projections are inherently imperfect. The projected 2022 peak load of 48.86 MW
27 may be more or less than the actual peak load in 2022. It’s very possible that a 48 MW
28 peak could happen in 2021 or perhaps not until 2023. A utility has to plan accordingly,
29 especially for large capital projects that take a long time to construct.
30

1 **Q: HLP currently has a proposed project to rebuild its 46 kV “south line” and add a**
2 **second point of interconnection. For each of the “proposed improvements” listed in**
3 **the chart on pages 4-5 that relate to rebuilding the south line and adding a second**
4 **point of interconnection, please describe why those improvements were**
5 **recommended by ICPE and what effect, if implemented, those improvements would**
6 **have on HLP’s system capacity and reliability.**

7 A: The first recommendation is to rebuild 46 kV lines with a 795 ACSR or larger conductor
8 to improve capacity. The 46 kV south line and the 46 kV tie lines are 4/0 ACSR conductor,
9 which is overloaded under heavy loads. For 2018, the 4/0 ACSR conductor is overloaded
10 if the north line experiences an outage and Heber Power’s internal generation is offline.
11 By 2022, the 4/0 ACSR conductor will be overloaded any time the north transmission line
12 is down. Heber Power relies on its two internal transmission lines—the north line and the
13 south line—to provide power to the various distribution substations throughout its service
14 territory. For the sake of reliability, each of these lines needs to be able to carry the load
15 of the system; otherwise, when one line is down for any reason (damage, wildlife, car
16 accident, repairs, maintenance) most or all of Heber Power’s electrical customers would
17 be without power. The upgrade to larger conductor will allow “N-1” reliability for Heber
18 Power’s transmission line, meaning that the system will still function even with the loss of
19 one of the 46 kV transmission lines.

20
21 The second recommendation is to rebuild PacifiCorp Interconnection to improve capacity
22 and reliability. Among other things, the interconnection is limited by 477 ACSR
23 conductor. By 2022—or potentially sooner—the interconnection point will be overloaded
24 during peak load times any time Heber Power’s internal generation is offline. Since this is
25 currently Heber Power’s only connection to the regional electrical grid, the entire Heber
26 Valley would be without power if this interconnection is overloaded or suffers an outage.
27 The proposed improvement involves upgrading the PacifiCorp feed that serves Heber
28 Power and also construction of a second point of interconnection. This second point of
29 interconnection would be fed by PacifiCorp from both the north and the south, providing
30 redundancy and extra capacity. Based on the load growth projections for Heber Power,

1 this interconnection upgrade is absolutely necessary to continue providing power to
2 customers in the Heber Valley.

3

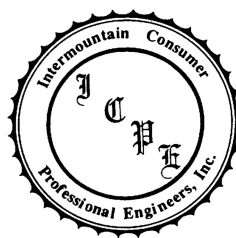
4 **Q: Does this conclude your direct testimony?**

5 A: Yes.

EXHIBIT ICPE-1

Heber Light & Power 46 kV Load Flow Study

June 2018



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SYSTEM STUDY

System Study Overview

This electrical system study report addresses study methods and results of load flow analysis of the Heber Light & Power 46 kV System. The study scope includes the Heber Light & Power 46 kV sub-transmission system. The 12.47 kV distribution portion of the system is not covered in this report, but will be studied as part of a separate report. Substations include Midway Substation, Provo River Substation, Heber Substation, Cloyes Substation, Jailhouse Substation and College Substation. Generators are located at Snake Creek Hydro, Lake Creek Hydro, Jordanelle Hydro and the Heber Plant.

The primary goal of the load flow was to study system loading including during N-1 outage conditions to help the Company to plan for future growth requirements including substation upgrades and 46 kV line upgrades. Recommendations for system improvements have been provided.

System Models and Assumptions

To perform the load flow analysis a system computer model was developed. Model development is discussed in the System Modeling section of this report. System model development and analysis were performed on Paladin DesignBase 4.0 software.

System modeling data was developed from Heber Light & Power provided system data. The model is based on the assumption that provided transformer data, generator data, system maps and data (conductor sizes, system configurations, line lengths, etc.) are reflective of actual field conditions.

Summary

The system load flow provides insight on substation transformer loading, line loading, and system voltage drop. The study includes analyzing N-1 outage conditions. An N-1 outage condition is the loss of a major system component such as a section of 46 kV line. Results and recommendations are discussed in the System Load Flow Analysis and Results section of this report.

SYSTEM LOAD FLOW ANALYSIS AND RESULTS

System load flow studies were performed for years 2018 and 2022. Overall system load projections are based on load projections done in 2018 by Utility Financial Solutions LLC. The load flow studies were utilized to assess line and transformer loading conditions and system voltage conditions. Tables shown below contain projected Heber Light & Power system load and projected peak circuit loads for years that were analyzed. The circuit and transformer load levels shown below are based on current circuit configuration.

Heber Light & Power– Projected System Peak Load		
Year	Heber Light & Power Load	
	MW	MVA
2018	44.63 MW	47.7 MVA
2022	48.86 MW	51.2 MVA

Substation Transformer	Recloser	2018		2022	
		Amps	kVA	Amps	kVA
Midway Transformer 10/12.5/14 MVA 46 kV – 12.47 kV	MW101	87	1,885	91	1,966
	MW102	215	4,644	219	4,726
	MW104	38	827	42	913
	Sub Total	341	7,355	352	7,605
Provo River 5 MVA (with fans) 46 kV – 12.47 kV	PR201	233	5,036	237	5,117
	PR202	26	556	30	638
	Sub Total	259	5,591	266	5,755
Heber T1 12/16/20 MVA 46 kV – 12.47 kV	HB302	352	7,613	383	8,261
	HB303	114	2,462	137	2,957
	Sub Total	466	10,075	519	11,218
Heber T2 12/16/20 MVA 46 kV – 12.47 kV	HB304	178	3,848	201	4,343
	HB305	79	1,710	83	1,792
	Sub Total	257	5,558	284	6,135
Cloyes 7.5/9.375 MVA 46 kV – 4.16 kV	CL401	34	737	38	829
	CL402	108	2,338	112	2,422
	CL403	-	-	-	-
	Sub Total	142	3,075	151	3,251
Jailhouse T1 10/12.5/14 MVA 46 kV – 12.47 kV	JH501	172	3,706	175	3,787
	JH503	44	954	48	1,036
	JH505	6	134	30	649
	Sub Total	216	4,659	223	4,823
Jailhouse T2 12/16/20 MVA 46 kV – 12.47 kV	JH502	382	8,252	405	8,752
	JH504	145	3,136	170	3,663
	JH505	6	124	30	649
	Sub Total	527	11,389	575	12,415
College (2) 12/16/120 MVA 46 kV – 12.47 kV	CO Circuits	-	-	-	-
	-	-	-	-	-
	Sub Total	-	-	-	-
Total	Amps	2,209	-	2,371	-
	kVA	-	47,702	-	51,202

The following table shows approximate transformer loading. The College Substation transformers are not included in the Total City numbers due to College Substation currently being out of service. When College Substation will be put back into service is unknown at this time. Loading on most transformers is at an acceptable level. It is not anticipated that new substations will be required over the next five years.

The Provo River transformer is out of capacity according to nameplate rating during peak load when Snake Creek Hydro generation is off. Transformer fans have been added that are not reflected on the nameplate which increases the transformer capacity, but it is unknown by how much. The Provo River transformer will need to be upgraded to a larger transformer. Until this can happen, Heber Light & Power may be able to decrease the load on the Provo River transformer by moving load to Midway circuits. This would only be a temporary solution.

Substation Transformer	2018		2022	
	%Base	%Total	%Base	%Total
Midway Transformer 10/12.5/14 MVA 46 kV – 12.47 kV	74%	53%	76%	54%
Provo River 5 MVA (with fans) 46 kV – 12.47 kV	112%	112%	115%	115%
Heber T1 12/16/20 MVA 46 kV – 12.47 kV	84%	50%	93%	56%
Heber T2 12/16/20 MVA 46 kV – 12.47 kV	46%	28%	51%	31%
Cloyes 7.5/9.375 MVA 46 kV – 4.16 kV	41%	33%	43%	35%
Jailhouse T1 10/12.5/14 MVA 46 kV – 12.47 kV	47%	33%	48%	34%
Jailhouse T2 12/16/20 MVA 46 kV – 12.47 kV	95%	57%	103%	62%
College (2) 12/16/120 MVA 46 kV – 12.47 kV	-	-	-	-
Total City (Excluding College which is currently out of service)	70%	47%	75%	50%

Proposed Improvements

Proposed system improvements are summarized in the following tables. A brief description and explanation of each improvement are given. A system map showing proposed improvements is in the appendix. For a more detailed explanation of load flow results see the Load Flow – Outage Cases section of the report.

Proposed System Improvements	
Proposed Improvement	Reason/Explanation
1. Rebuild 46 kV lines with 795 ACSR or larger conductor to improve capacity.	Outages of the North 46 kV line near Midway Substation require substations normally fed from the North 46 kV line to be fed across a 46 kV tie line from the South 46 kV line. The South 46 kV line and the 46 kV tie lines are 4/0 ACSR. The 4/0 ACSR line becomes overloaded during peak load in these cases. For 2018 this is only the case if generation is also offline. By 2022 the line will be overloaded during peak load any time the North 46 kV line near Midway substation is out of service. The following line sections are proposed to be rebuilt: 1. South 46 kV line from Midway Substation to the Heber Plant 46 kV tie line 2. Heber Plant 46 kV tie line 3. Heber Plant to College Substation (This portion has already been started) 4. Provo River 46 kV tie line The portion of the line work that has been started on the line to College Substation has 795 ACSR conductor. Heber Light & Power may want to install a larger conductor when rebuilding the South 46 kV and tie lines. Utility Financial Solutions, LLC created a Heber Light & Power load forecast in 2018 that showed approximately 70 MW of load by the year 2040. Installing a 795 ACSR line would not provide any future load growth beyond the 2040 load projection.
2. Rebuild PacifiCorp Interconnection to improve capacity and reliability.	The PacifiCorp Interconnection is limited by 477 ACSR conductor. By 2022 the 477 ACSR conductor will be overloaded during peak load any time Heber Light & Power generation is offline. Any time there is an outage by PacifiCorp the Heber Light & Power generation has to come offline because it is not large enough to carry the Heber Light & Power load. PacifiCorp must be able to serve Heber Light & Power's entire load after an outage since it takes time for Heber Light & Power Generation to be brought back into service. A detailed study of the PacifiCorp system that feeds Heber Light & Power should be performed by PacifiCorp. An outage of the PacifiCorp line that feeds Heber Light & Power will result in loss of power to the Heber Light & Power System. Heber Light & Power is fed from a single PacifiCorp 46 kV line out of Hales Substation. Heber Light & Power does not have enough generation to provide power on its own. A separate 46 kV line connecting Heber Light & Power to PacifiCorp's Silver Creek Substation would be required to ensure power was available during such an outage. Both PacifiCorp lines should connect to a ring bus at the new PacifiCorp Interconnection. It has been proposed to move the PacifiCorp Interconnection to a new substation location. The proposed location is shown on the system map in the appendix.

Proposed System Improvements	
Proposed Improvement	Reason/Explanation
3. Install a new 795 ACSR or larger 46 kV tie line between Jailhouse and College Substations.	For a loss of the South 46 kV line to the east of Cloyes Substation there is no way to restore power to the Jailhouse Substation. It is proposed to build a new 46 kV tie line between Jailhouse Substation and College Substation. This would create a loop so that these substations could be fed from the North 46 kV line or the South 46 kV line.
4a. Install a larger 12/16/20 MVA transformer at Provo River substation.	Provo River transformer is out of capacity according to nameplate rating during peak load when Snake Creek Hydro generation is off. Transformer fans have been added that are not reflected on the nameplate which increases the transformer capacity, but it is unknown by how much. It is proposed to replace the transformer with a larger 12/16/20 MVA transformer.
4b. Move load from the Provo River Substation to Midway Substation.	Until the transformer can be replaced, it is proposed that Heber Light & Power may be able to move some load to Midway circuits to help reduce the load on the Provo River transformer. This is only a temporary solution.

System Power Factor

Power factor for each Heber Light & Power circuit is shown below. Keeping a high power factor helps support voltage during system peak loading and during outage conditions. The need for power factor correction becomes more important as transformer and line loading levels increase. Improving power factor also reduces system losses. Power factor correction was not studied as part of this report. Any power factor correction necessary will be studied and discussed as part of a separate report studying the 12.47 kV distribution system.

Substation Transformer	Recloser	Power Factor
Midway Transformer	MW101	0.98
	MW102	0.97
	MW104	0.93
Provo River	PR201	0.98
	PR202	0.98
Heber T1	HB302	0.74
	HB303	0.95
Heber T2	HB304	0.99
	HB305	0.98
Cloyes	CL401	0.87
	CL402	0.95
	CL403	-
Jailhouse T1	JH501	0.98
	JH503	0.97
	JH505	Assumed 0.97
Jailhouse T2	JH502	0.96
	JH504	0.95
	JH505	Assumed 0.97
College	CO Circuits	-

Load Flow – Outage Cases

Loss of 46 kV line sections and loss of Heber Light & Power generation was considered. Load flows were ran with 46 kV line sections out of service and with Heber Light & Power generation offline. The table below lists the results and discusses proposed system improvements. Results are based on projected peak (summer) load levels. During winter load levels the outages would not have as great of an effect.

An outage of the PacifiCorp system that feeds Heber Light & Power will result in loss of power. There is only one connection to the PacifiCorp 46 kV system and Heber Light & Power does not have enough generation to provide power for the city on its own.

This study only focuses on the Heber Light & Power 46 kV system. The ability of PacifiCorp to be able to provide power to Heber Light & Power during peak loads or outage conditions was not studied. The load flow results for the 12.47 kV distribution portion of the system will be detailed in a separate report.

The Comments/Results column of the following tables lists ways to restore load, if possible, during a line or generation outage. It also discusses proposed solutions if the outage creates problems. This study does not address the ability to move load from circuit to circuit at the 12.47 kV level. This will be studied in a separate report.

2018 Base Case Line/Generation Out of Service	Comments/Results
No Outage	System operates without issues.
Loss of all Generation	The Pacificorp Interconnection is limited by 477 ACSR conductor. This is nearing capacity during peak load and loss of all generation. Provo River transformer is out of capacity according to nameplate rating during peak load when Snake Creek Hydro generation is off. Transformer fans have been added that are not reflected on the nameplate which increases the transformer capacity, but it is unknown by how much. The transformer will need to be replaced. It is proposed to replace the transformer with a larger 12/16/20 MVA transformer. Until the transformer can be replaced, Heber Light & Power may be able to move some load to Midway circuits to help reduce the load on the Provo River transformer. This is only a temporary solution.
Loss of the North 46 kV line near Midway Substation	There is a tie line at the Provo River Substation that can be closed to feed the North 46 kV line from the South 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the North 46 kV line from the South 46 kV line. The system can operate with this outage. Voltage drop on the 46 kV system is more severe. Voltage regulation on the 12.47 kV side of transformers will have to tap higher to correct for this. The South 46 kV line is 4/0 ACSR. This line is nearing capacity up to where the tie line connects the North and South 46 kV lines.

2018 Base Case Line/Generation Out of Service	Comments/Results
Loss of the North 46 kV line near Midway Substation and loss of all generation	There is a tie line at the Provo River Substation that can be closed to feed the North 46 kV line from the South 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the North 46 kV line from the South 46 kV line. Voltage drop on the 46 kV system is very high. Voltage regulation at 12.47 kV may not be able to correct the voltage completely. The South 46 kV line is 4/0 ACSR. This line is overloaded up to where the tie line connects the North and South 46 kV lines. The South 46 kV line would need to be rebuilt with a larger conductor to allow the system to run with these outages. See notes above for the case of loss of all generation concerning the Provo River transformer.
Loss of the South 46 kV line near Midway Substation	There is a tie line at the Provo River Substation that can be closed to feed the South 46 kV line from the North 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the South 46 kV line from the North 46 kV line. There are no issues running with this outage.
Loss of the South 46 kV line near Midway Substation and loss of all generation	There is a tie line at the Provo River Substation that can be closed to feed the South 46 kV line from the North 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the South 46 kV line from the North 46 kV line. System can be run with these outages. See notes above for the case of loss of all generation concerning the Provo River transformer.
Loss of the North 46 kV line to the east of the tie line at the Heber Plant	There is a 46 kV tie line at Cloyes Substation that can be closed to feed Heber and College substations. Voltage drop on the 46 kV system is very high. Voltage regulation at 12.47 kV may not be able to correct the voltage completely. The South 46 kV line is 4/0 ACSR. This line is overloaded up to Cloyes Substation. The South 46 kV line would need to be rebuilt with a larger conductor to allow the system to run with these outages.
Loss of the South 46 kV line to the east of the tie line at the Heber Plant	There is a 46 kV tie line at Cloyes Substation that can be closed to feed Cloyes and Jailhouse substations. There are no issues running with this outage.
Loss of the South 46 kV line to the east of Cloyes Substation	There is no way to restore power to Jailhouse Substation. Consider adding a new 46 kV tie line between Jailhouse Substation and College Substation.
Loss of the 46 kV line to College Substation	A load flow for this case was not run due to College Substation currently being out of service. College Substation will come back into service in the future. There will be no way to restore power to College Substation for this outage. Consider adding a new 46 kV tie line between Jailhouse Substation and College Substation.

2022 Line/Generation Out of Service	Comments/Results
No Outage	System operates without issues. Voltage drop on the 46 kV system is higher than in the 2018 case due to the higher loads. Voltage regulation on the 12.47 kV side of transformers will have to tap higher to correct for this.
Loss of all Generation	The Pacificorp Interconnection is limited by 477 ACSR conductor. The 477 ACSR conductor is overloaded. The PacificCorp Interconnection would need to be rebuilt with a larger ampacity to allow the system to run with loss of all generation. Provo River transformer is out of capacity according to nameplate rating during peak load when Snake Creek Hydro generation is off. Transformer fans have been added that are not reflected on the nameplate which increases the transformer capacity, but it is unknown by how much. The transformer will need to be replaced. It is proposed to replace the transformer with a larger 12/16/20 MVA transformer. Until the transformer can be replaced, Heber Light & Power may be able to move some load to Midway circuits to help reduce the load on the Provo River transformer. This is only a temporary solution.
Loss of the North 46 kV line near Midway Substation	There is a tie line at the Provo River Substation that can be closed to feed the North 46 kV line from the South 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the North 46 kV line from the South 46 kV line. Voltage drop on the 46 kV system is very high. Voltage regulation at 12.47 kV may not be able to correct the voltage completely. The South 46 kV line is 4/0 ACSR. This line is overloaded up to where the tie line connects the North and South 46 kV lines. The South 46 kV line would need to be rebuilt with a larger conductor to allow the system to run with these outages.
Loss of the North 46 kV line near Midway Substation and loss of all generation	There is a tie line at the Provo River Substation that can be closed to feed the North 46 kV line from the South 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the North 46 kV line from the South 46 kV line. Voltage drop on the 46 kV system is very high. Voltage regulation at 12.47 kV may not be able to correct the voltage completely. The PacificCorp Interconnection is limited by 477 ACSR conductor. The 477 ACSR conductor is overloaded. The PacificCorp Interconnection would need to be rebuilt with a larger ampacity to allow the system to run with loss of all generation. The South 46 kV line is 4/0 ACSR. This line is overloaded up to where the tie line connects the North and South 46 kV lines. The South 46 kV line would need to be rebuilt with a larger conductor to allow the system to run with these outages. See notes above for the case of loss of all generation concerning the Provo River transformer.

2022 Line/Generation Out of Service	Comments/Results
Loss of the South 46 kV line near Midway Substation	There is a tie line at the Provo River Substation that can be closed to feed the South 46 kV line from the North 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the South 46 kV line from the North 46 kV line. There are no issues running with this outage.
Loss of the South 46 kV line near Midway Substation and loss of all generation	There is a tie line at the Provo River Substation that can be closed to feed the South 46 kV line from the North 46 kV line. Alternatively, there is a tie line at the Heber Plant that can be closed to feed the South 46 kV line from the North 46 kV line. The PacifiCorp Interconnection is limited by 477 ACSR conductor. The 477 ACSR conductor is overloaded. The PacifiCorp Interconnection would need to be rebuilt with a larger ampacity to allow the system to run with loss of all generation. See notes above for the case of loss of all generation concerning the Provo River transformer.
Loss of the North 46 kV line to the east of the tie line at the Heber Plant	There is a 46 kV tie line at Cloyes Substation that can be closed to feed Heber and College substations. Voltage drop on the 46 kV system is very high. Voltage regulation at 12.47 kV may not be able to correct the voltage completely. The South 46 kV line is 4/0 ACSR. This line is overloaded up to Cloyes Substation. The South 46 kV line would need to be rebuilt with a larger conductor to allow the system to run with these outages.
Loss of the South 46 kV line to the east of the tie line at the Heber Plant	There is a 46 kV tie line at Cloyes Substation that can be closed to feed Cloyes and Jailhouse substations. The system can be run with this outage. Voltage drop on the 46 kV system is very high. Voltage regulation at 12.47 kV will have to work harder to correct the voltage.
Loss of the South 46 kV line to the east of Cloyes Substation	There is no way to restore power to Jailhouse Substation. Consider adding a new 46 kV tie line between Jailhouse Substation and College Substation.
Loss of the 46 kV line to College Substation	A load flow for this case was not run due to College Substation currently being out of service. College Substation will come back into service in the future. There will be no way to restore power to College Substation for this outage. Consider adding a new 46 kV tie line between Jailhouse Substation and College Substation.

2022 After Improvements Line/Generation Out of Service	Comments/Results
No Outage	System operates without issues.
Loss of all Generation	There are no issues operating with this outage.
Loss of the North 46 kV line out of the new PacifiCorp Interconnection	There is a tie line at the Provo River Substation that can be closed to feed the North 46 kV line from the South 46 kV line. There are no issues operating with this outage.
Loss of the North 46 kV line out of the new PacifiCorp Interconnection and loss of all generation	There is a tie line at the Provo River Substation that can be closed to feed the North 46 kV line from the South 46 kV line. This tie line would need to be rebuilt with larger conductor to keep it from becoming overloaded during this outage.
Loss of the South 46 kV line out of the new PacifiCorp Interconnection	There is a tie line at the Provo River Substation that can be closed to feed the South 46 kV line from the North 46 kV line. There are no issues running with this outage.
Loss of the South 46 kV line out of the new PacifiCorp Interconnection and loss of all generation	There is a tie line at the Provo River Substation that can be closed to feed the South 46 kV line from the North 46 kV line. There are no issues operating with this outage.
Loss of the North 46 kV line to the east of the tie line at the Heber Plant	There is a 46 kV tie line between the Heber Substation and the rebuilt line to College Substation that can be closed to feed Heber Substation. There are no issues operating with this outage.
Loss of the South 46 kV line to the east of the tie line at the Heber Plant	There is a 46 kV tie line at Cloyes Substation that can be closed to feed Cloyes and Jailhouse substations. There are no issues operating with this outage.
Loss of the South 46 kV line to the east of Cloyes Substation	There is a new tie line between the Jailhouse and College Substations that can be closed to feed Jailhouse Substation. There are no issues operating with this outage.
Loss of the 46 kV line to College Substation	There is a new tie line between the Jailhouse and College Substations that can be closed to feed College Substation. A load flow for this case was not run due to College Substation currently being out of service. College Substation will come back into service in the future.

SYSTEM MODELING

To perform a comprehensive load flow a system computer model is necessary. System modeling data was developed from Heber Light & Power provided system data. The model is based on the assumption that provided transformer data, generator data, system maps and data (conductor sizes, system configurations, line lengths, etc.) are reflective of actual field conditions.

Substation transformer and generator data is shown below. Detailed model input data is shown in the appendix.

Heber Light & Power – Substation Transformer Data			
Transformer	MVA Rating	Voltage Rating	%Z @ Nominal
Midway	10/12.5/14 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.91%
Provo River	5 MVA (with fans)	46-12.47 kV Delta-Gnd-Y	Z1 = 6.55%
Heber T1	12/16/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.7%
Heber T2	12/16/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.05%
Cloyes	7.5/9.375 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.7%
Jailhouse T1	10/12.5/14 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 8.15%
Jailhouse T2	12/16/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 8.12%
College T1	12/16/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.67%
College T2	12/16/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.67%

Generator	Generator Rating	System Connection
Snake Creek Hydro	1.98 MW	To circuit PR201 at 12.47 kV
Lake Creek Hydro	1.5 MW	To Circuit JH502 at 12.47 kV
Jordanelle Hydro	13 MW	To Circuit HB302 at 12.47 kV
Heber Plant	13.756 MW	To 46 kV System

APPENDICES

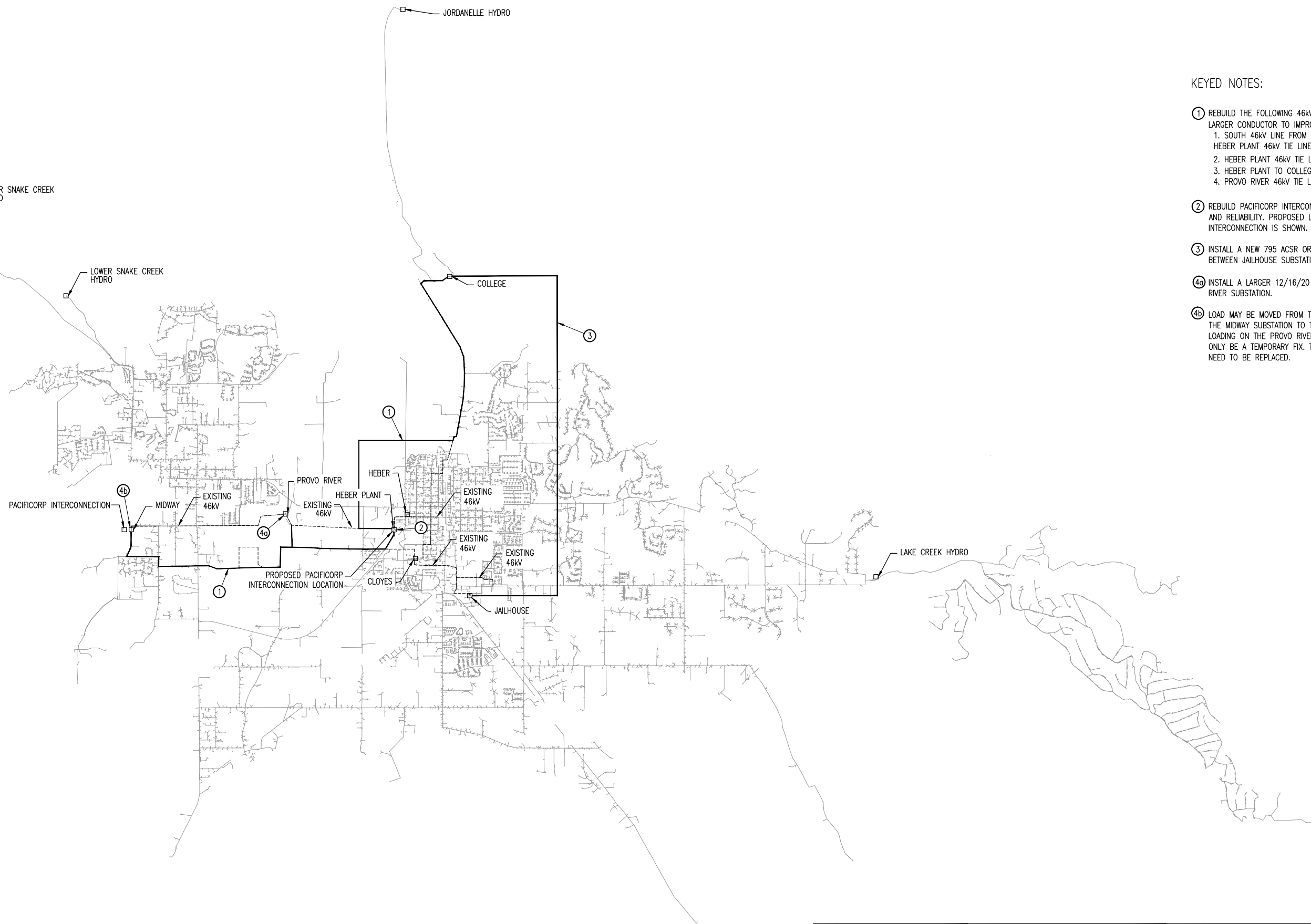
1. System Map
2. Load Flow Studies
3. Model Input Data

APPENDIX 1 – SYSTEM MAP



KEYED NOTES:

- ① REBUILD THE FOLLOWING 46KV LINES WITH 795 ACSR OR LARGER CONDUCTOR TO IMPROVE CAPACITY:
1. SOUTH 46KV LINE FROM THE MIDWAY SUBSTATION TO THE HEBER PLANT 46KV TIE LINE.
 2. HEBER PLANT 46KV TIE LINE.
 3. HEBER PLANT TO COLLEGE SUBSTATION.
 4. PROVO RIVER 46KV TIE LINE.
- ② REBUILD PACIFICORP INTERCONNECTION TO IMPROVE CAPACITY AND RELIABILITY. PROPOSED LOCATION OF NEW PACIFICORP INTERCONNECTION IS SHOWN.
- ③ INSTALL A NEW 795 ACSR OR LARGER 46KV TIE LINE BETWEEN JAILHOUSE SUBSTATION AND COLLEGE SUBSTATION.
- ④a) INSTALL A LARGER 12/16/20 MVA TRANSFORMER AT PROVO RIVER SUBSTATION.
- ④b) LOAD MAY BE MOVED FROM THE PROVO RIVER SUBSTATION TO THE MIDWAY SUBSTATION TO TEMPORARILY REDUCE THE LOADING ON THE PROVO RIVER TRANSFORMER. THIS WOULD ONLY BE A TEMPORARY FIX. THE TRANSFORMER WOULD STILL NEED TO BE REPLACED.

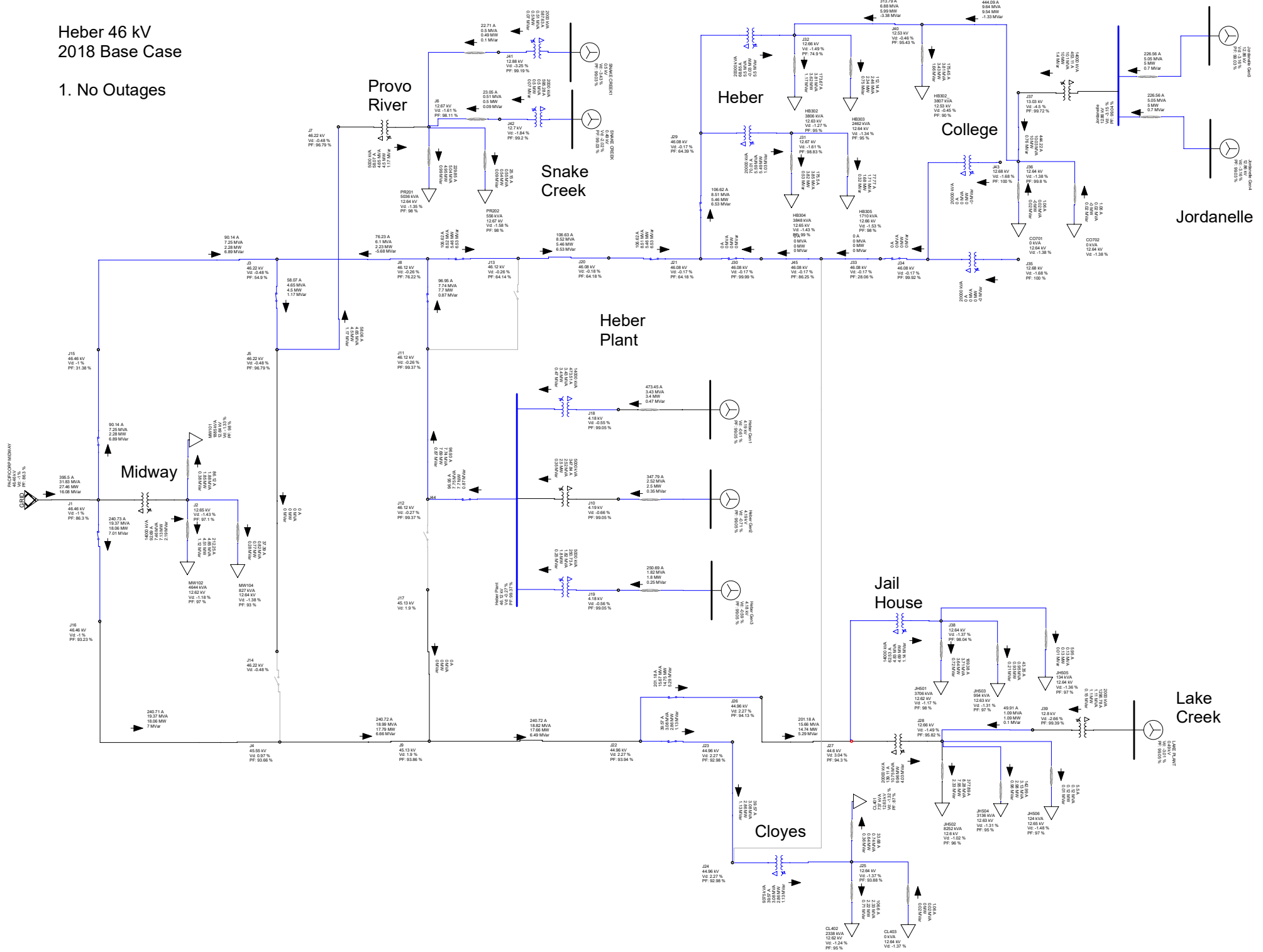


 Intermountain Consumer Professional Engineers, Inc. CONSULTING ENGINEERS 1140 S. 1000 E. SUITE 200 MIDVALE, UTAH 84047 PHONE (801) 255-1111 FAX 508-0088		Title: HEBER LIGHT & POWER ELECTRICAL 46KV SYSTEM STUDY PROPOSED IMPROVEMENTS													
CONFIDENTIAL															
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REVISIONS															
Proj. No: 034-031 Scale: NONE															

APPENDIX 2 – LOAD FLOW STUDIES

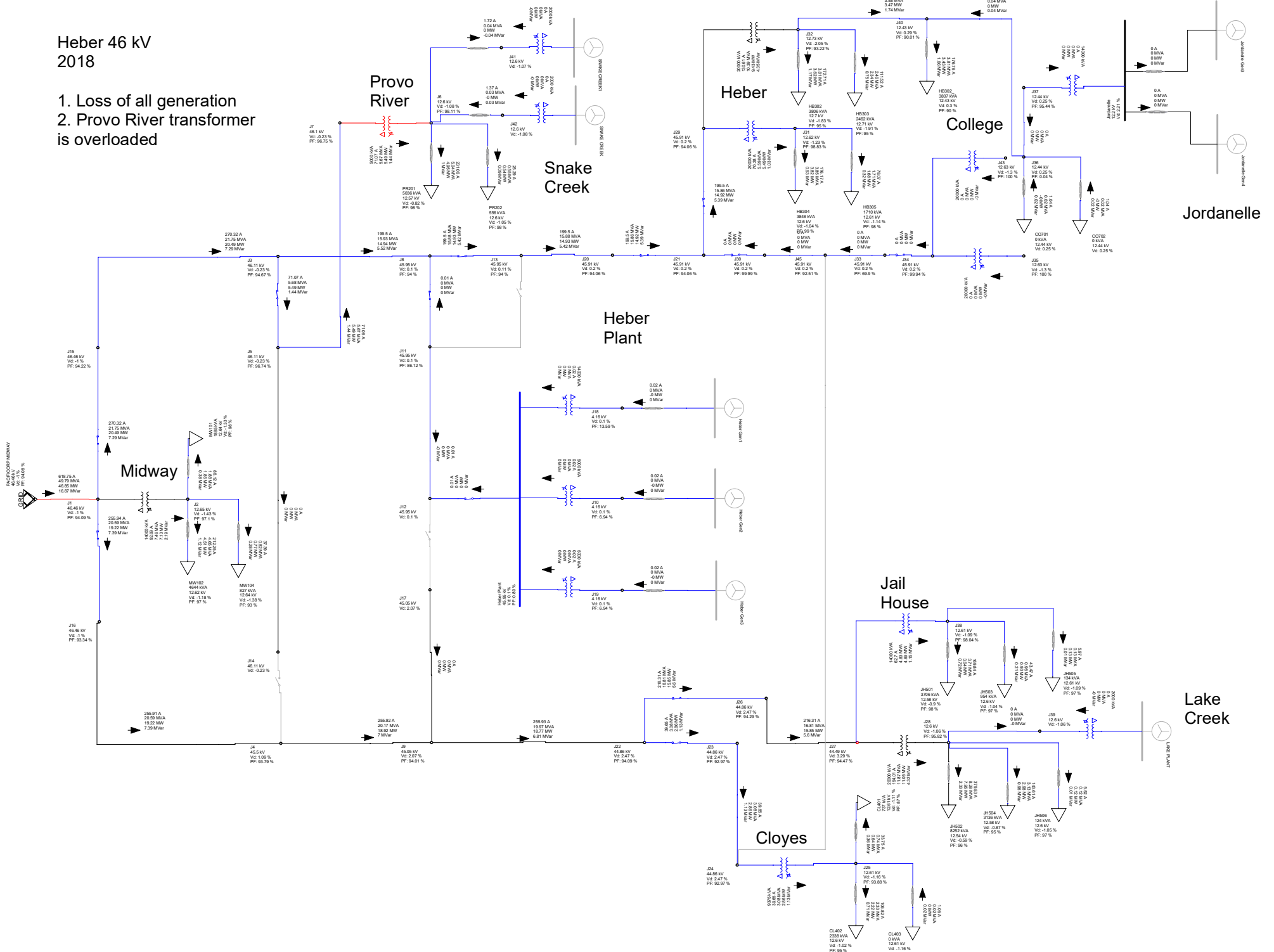
Heber 46 kV 2018 Base Case

1. No Outages



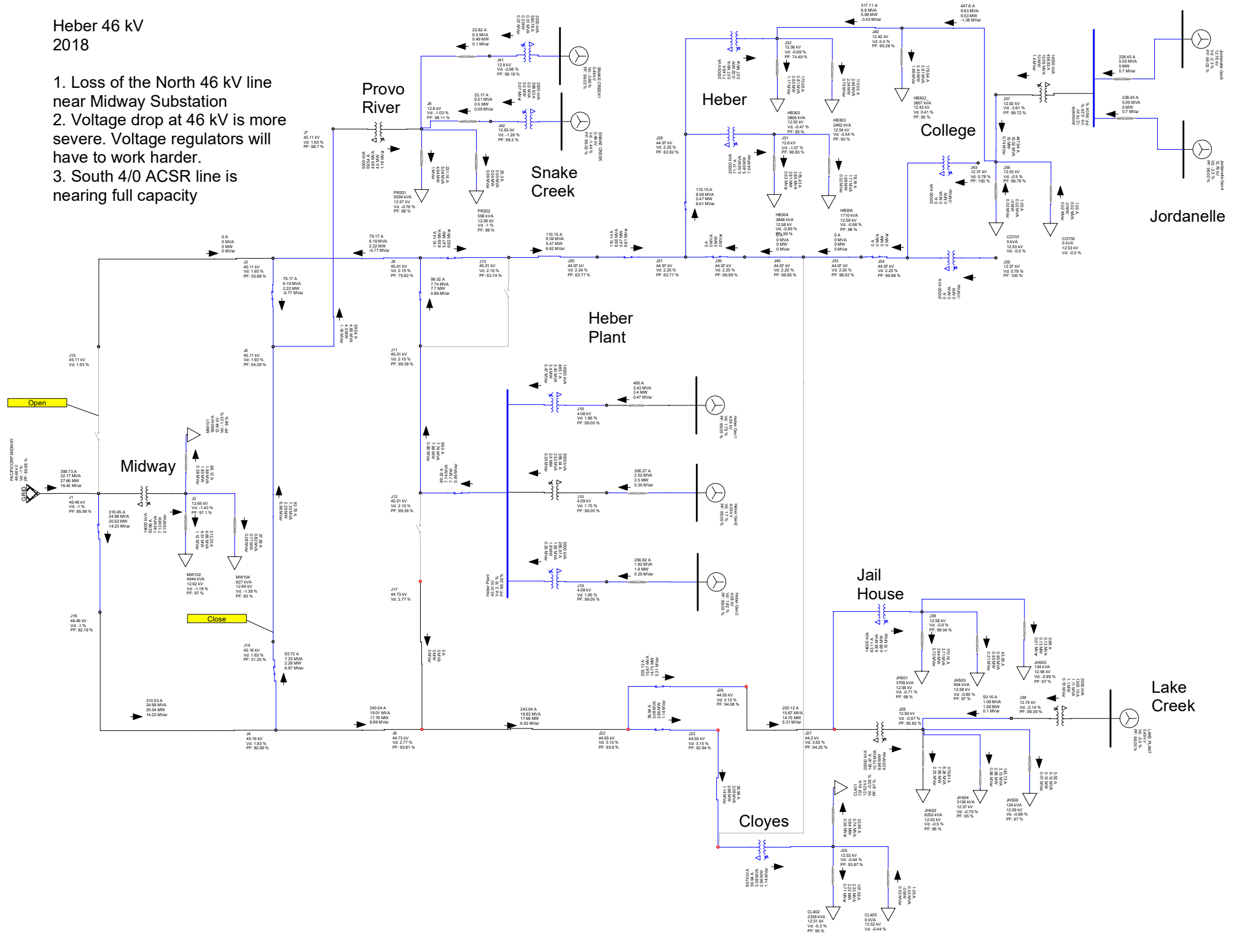
Heber 46 kV 2018

1. Loss of all generation
2. Provo River transformer is overloaded



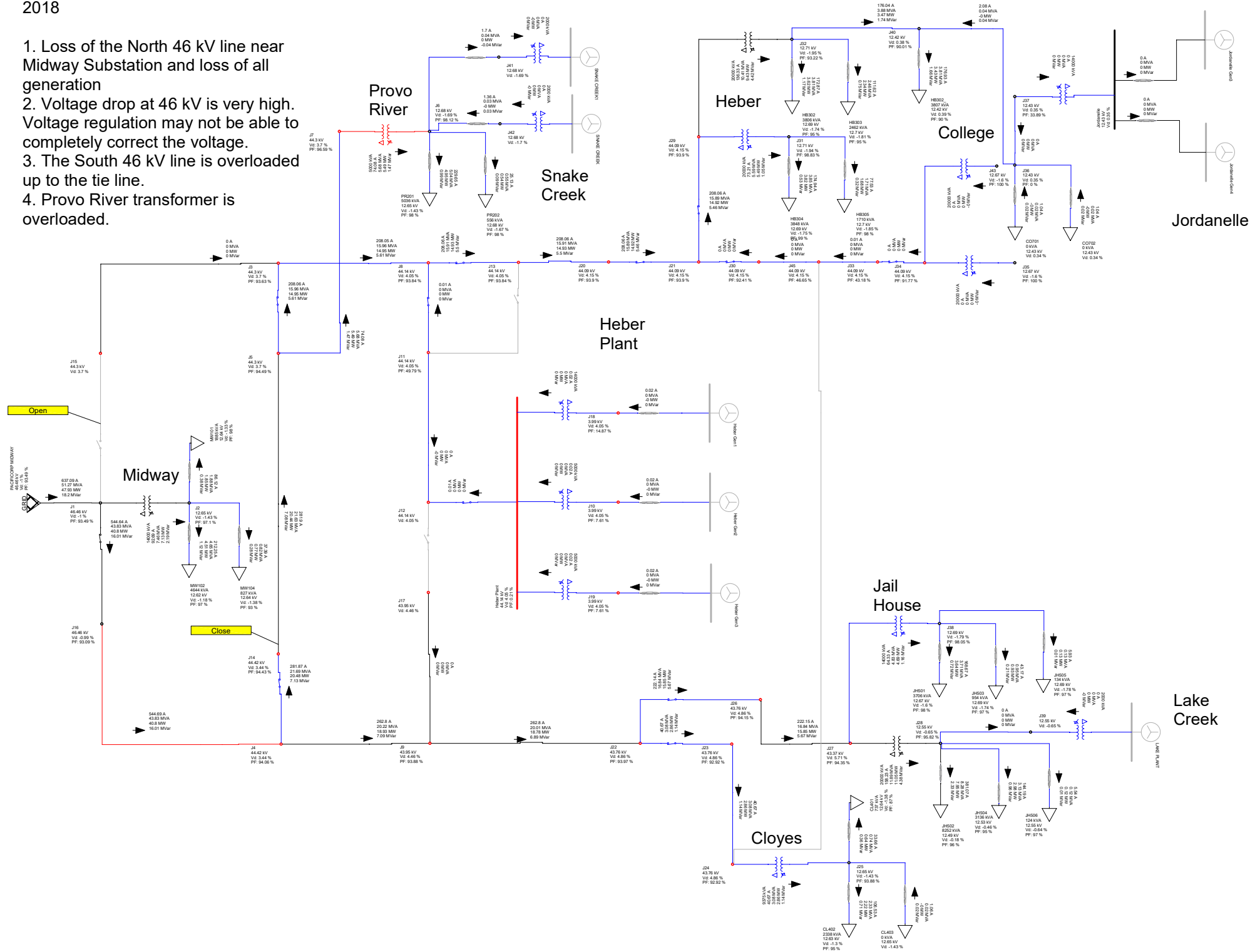
Heber 46 kV 2018

1. Loss of the North 46 kV line near Midway Substation
2. Voltage drop at 46 kV is more severe. Voltage regulators will have to work harder.
3. South 4/0 ACSR line is nearing full capacity

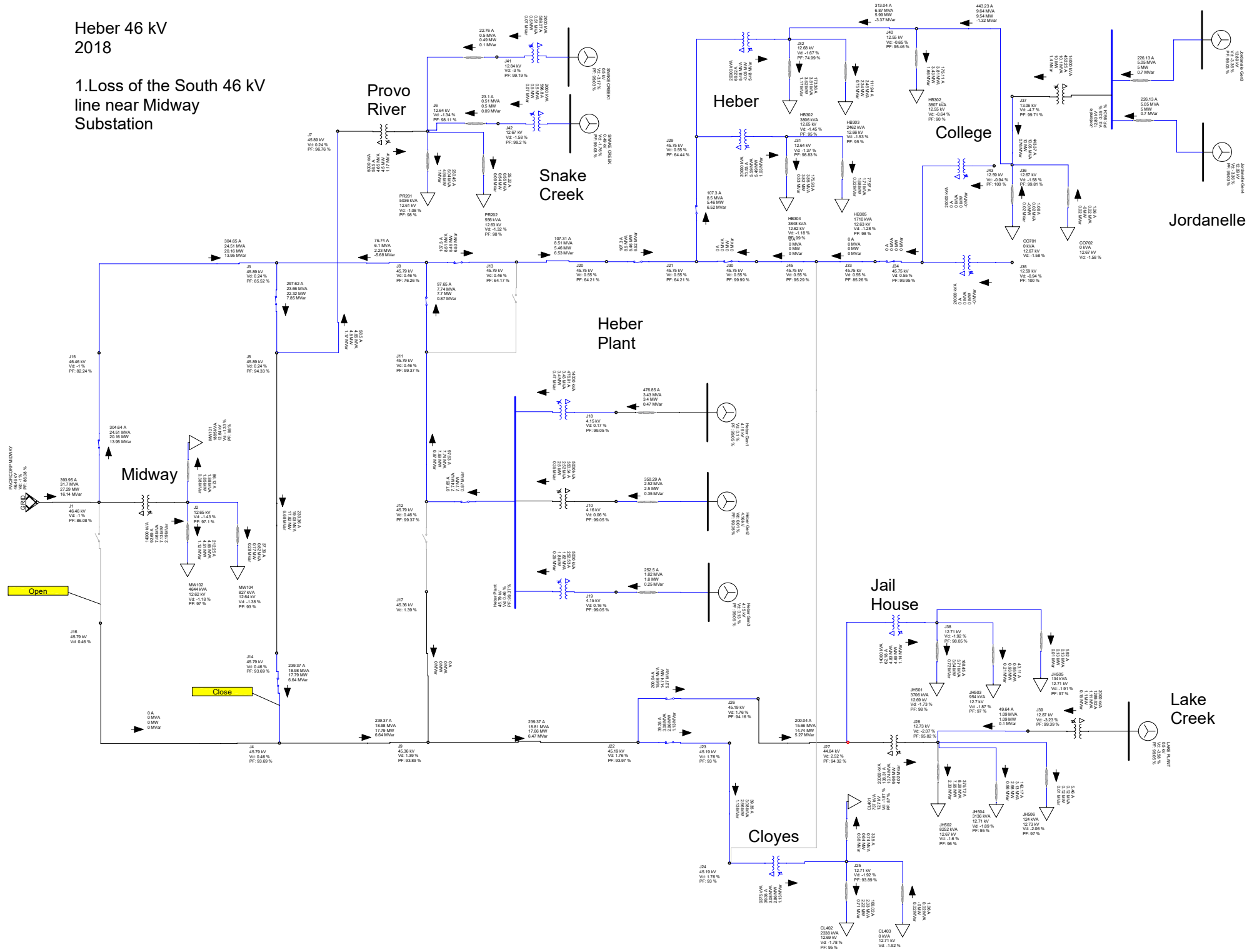


Heber 46 kV 2018

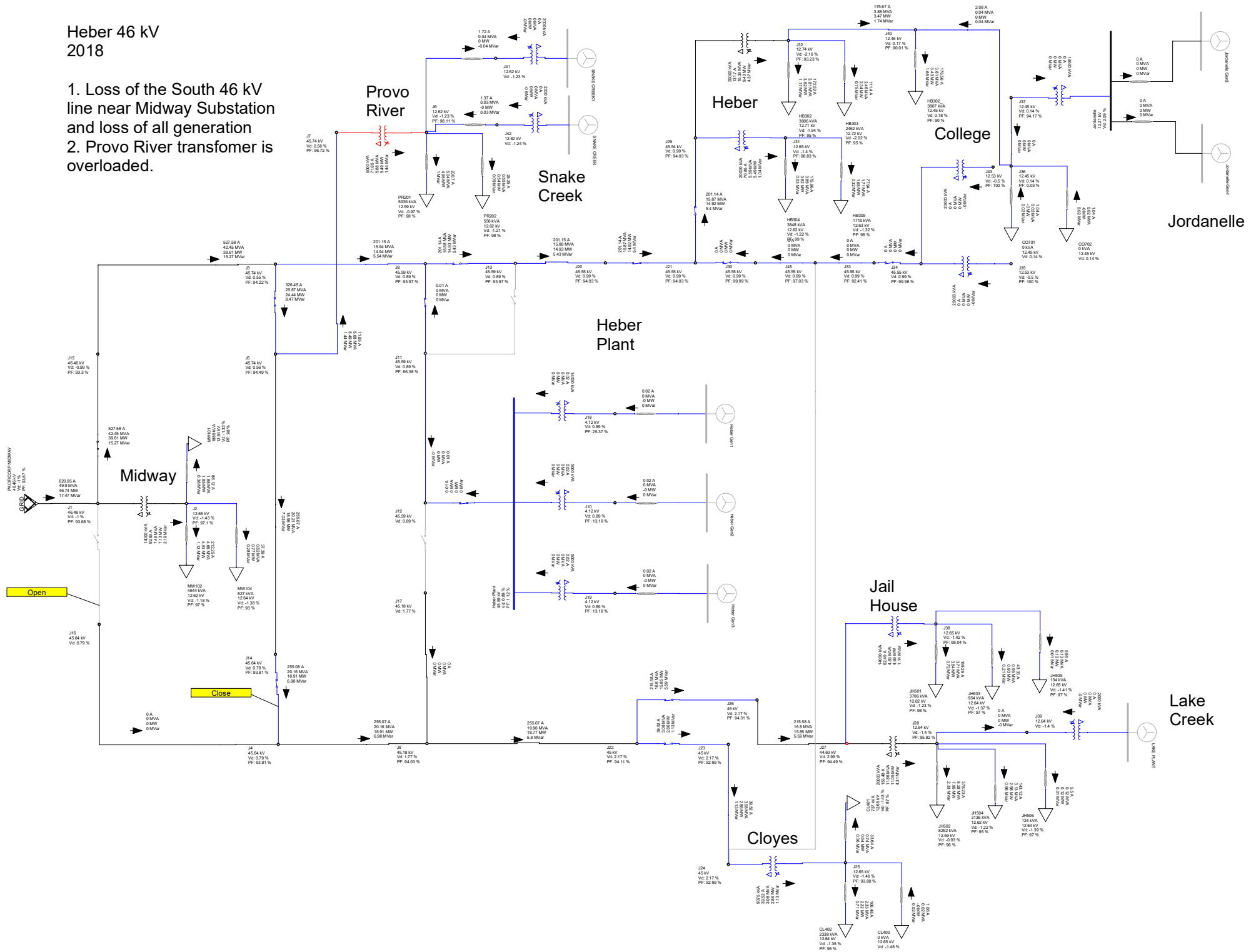
1. Loss of the North 46 kV line near Midway Substation and loss of all generation
2. Voltage drop at 46 kV is very high. Voltage regulation may not be able to completely correct the voltage.
3. The South 46 kV line is overloaded up to the tie line.
4. Provo River transformer is overloaded.



1.Loss of the South 46 kV line near Midway Substation

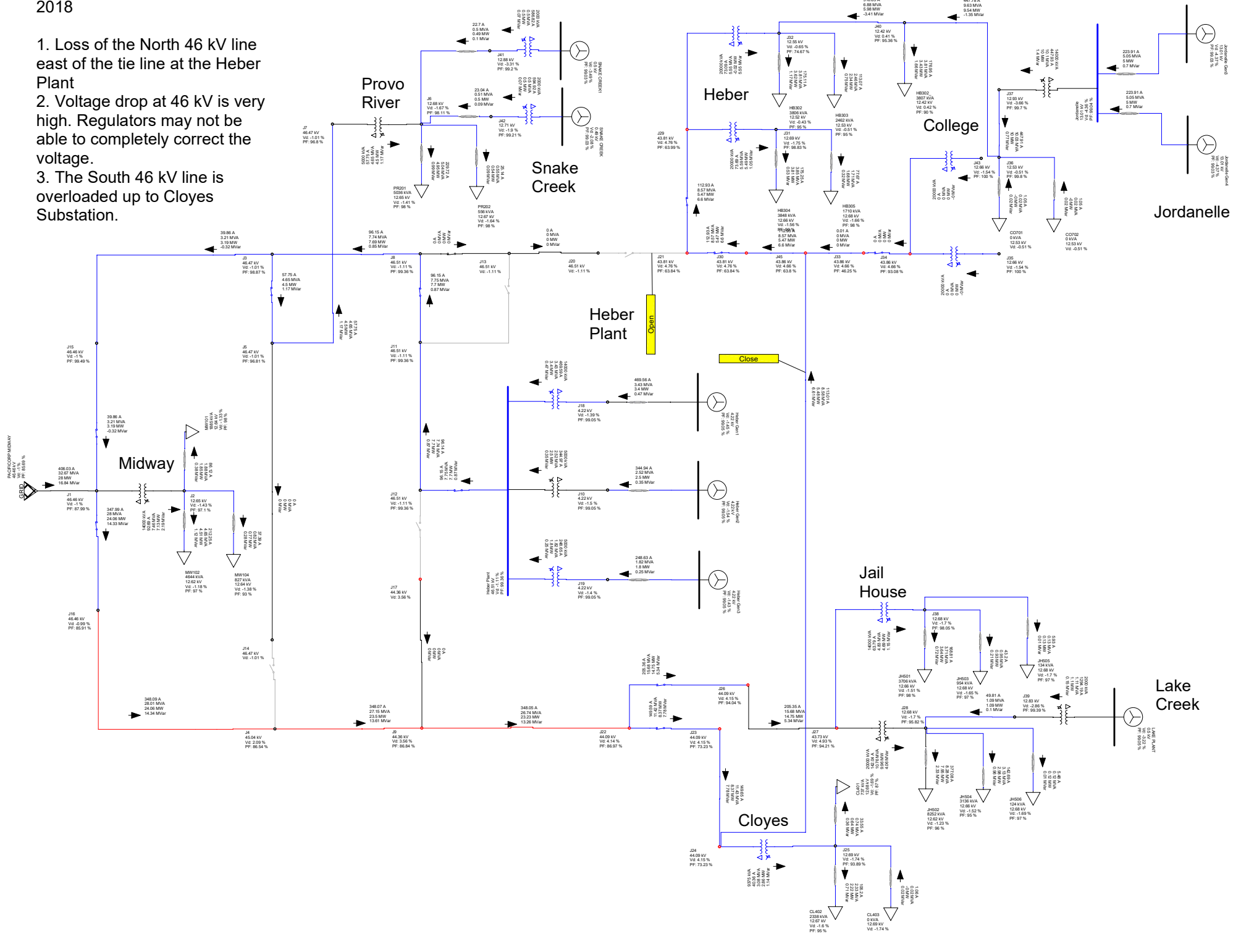


1. Loss of the South 46 kV line near Midway Substation and loss of all generation
2. Provo River transformer is overloaded.



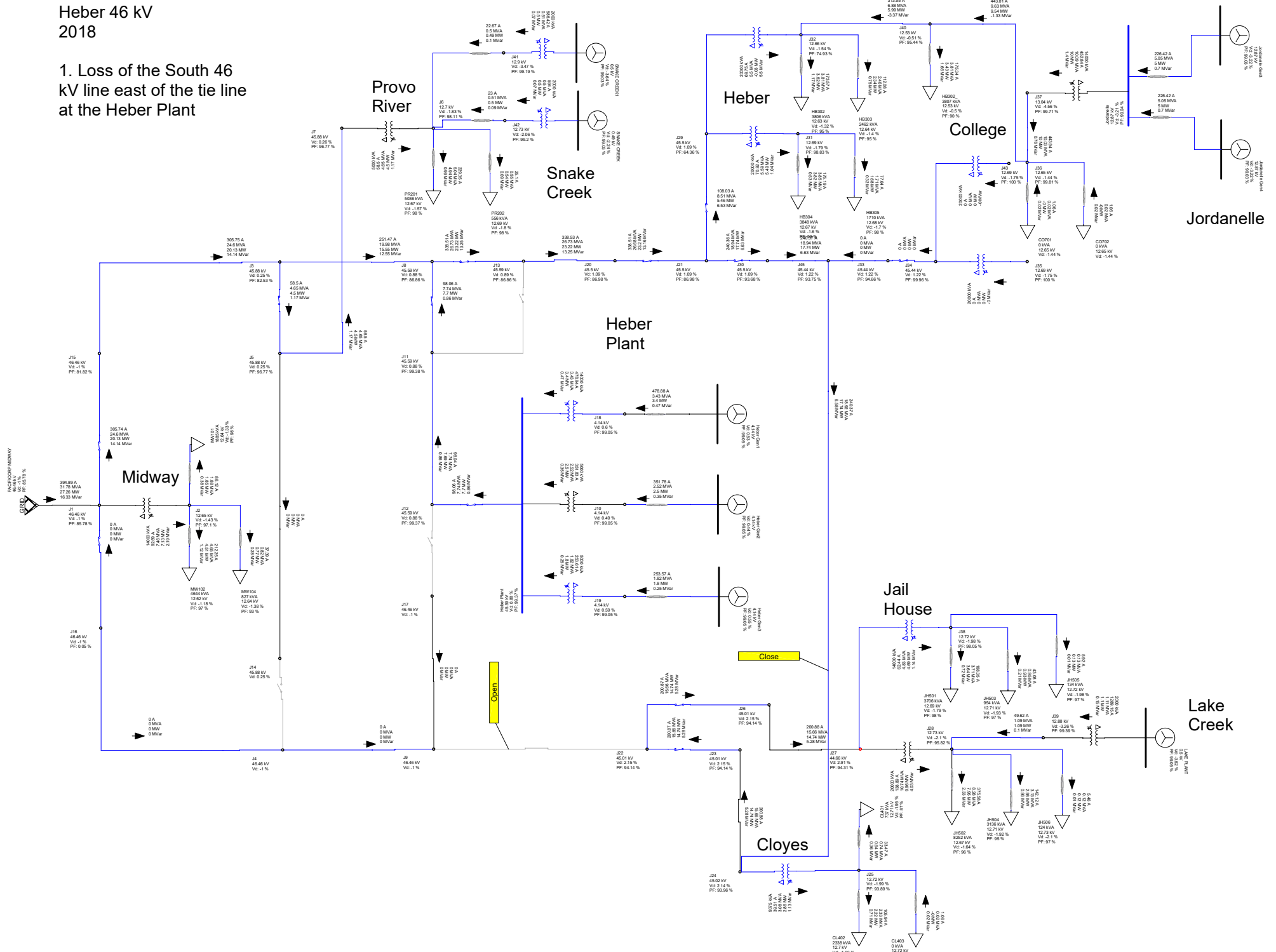
Heber 46 kV 2018

1. Loss of the North 46 kV line east of the tie line at the Heber Plant
2. Voltage drop at 46 kV is very high. Regulators may not be able to completely correct the voltage.
3. The South 46 kV line is overloaded up to Cloyes Substation.

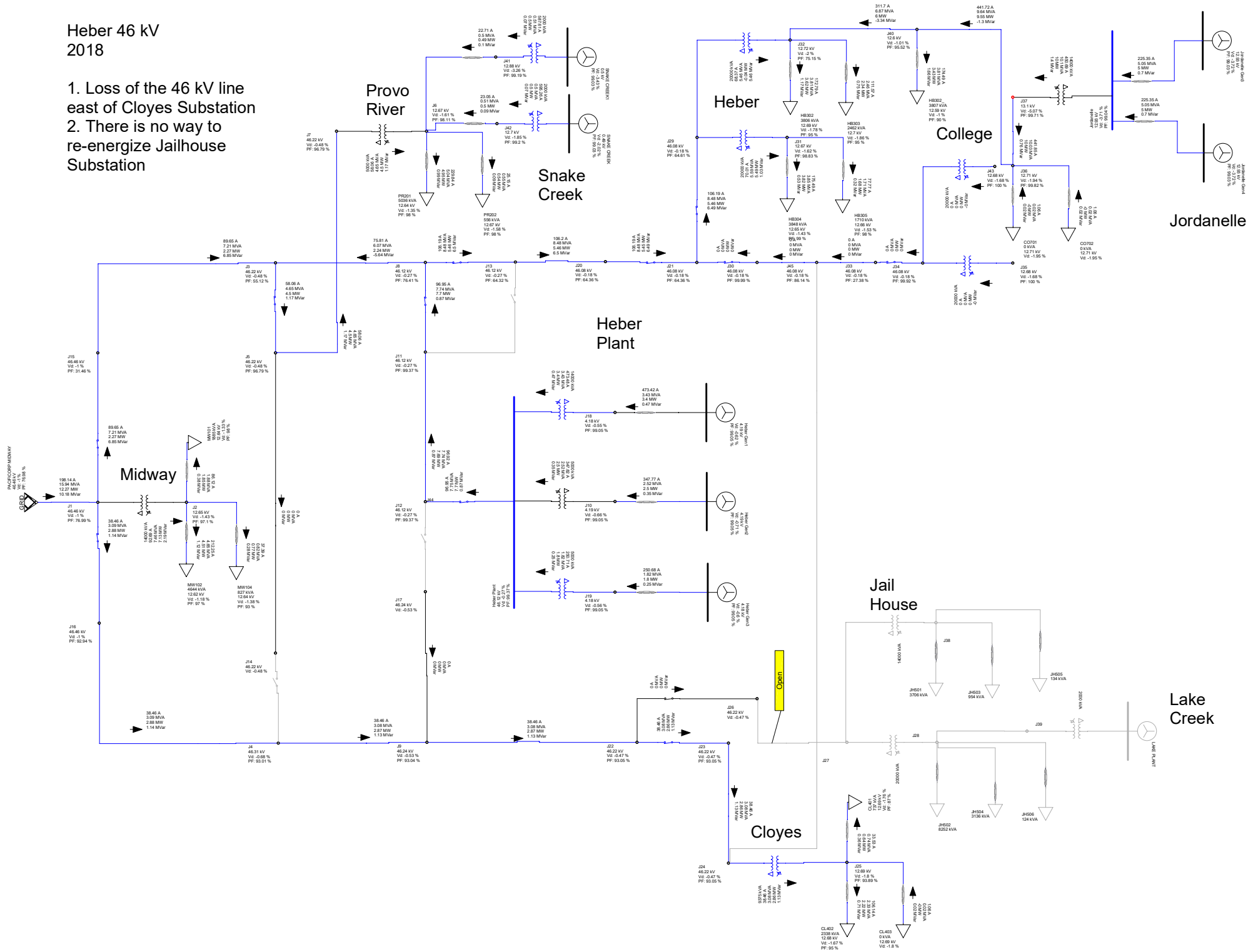


Heber 46 kV 2018

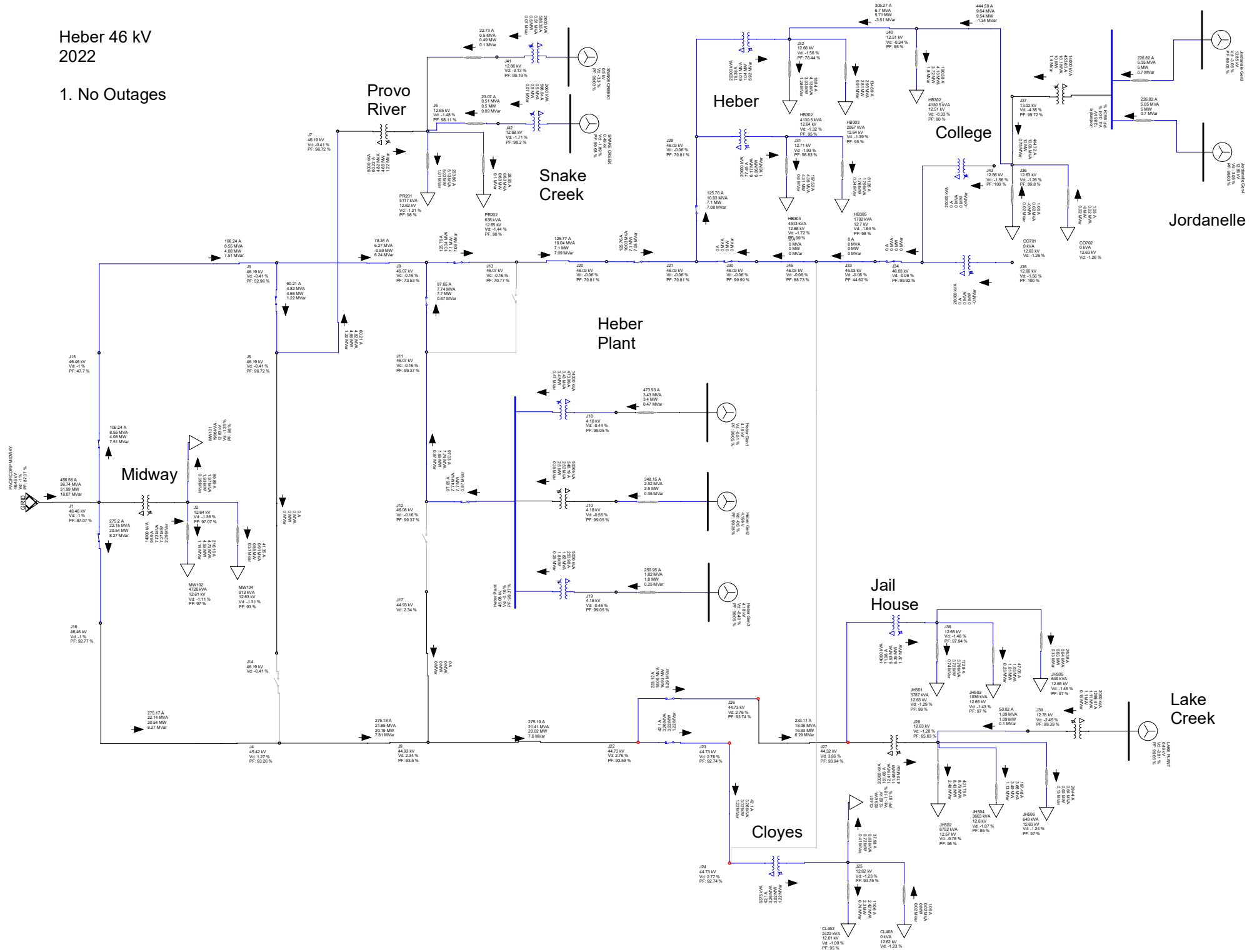
1. Loss of the South 46 kV line east of the tie line at the Heber Plant



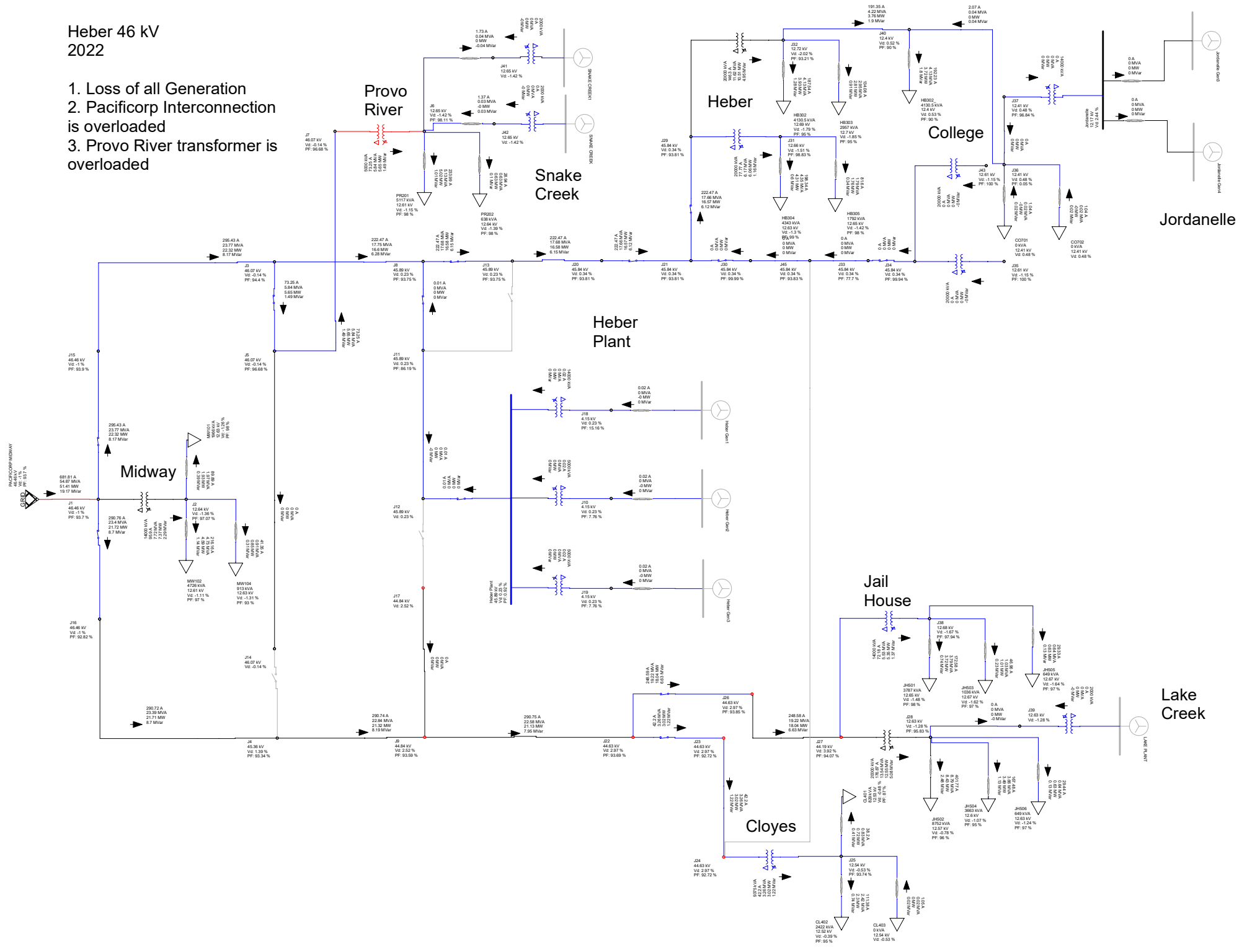
1. Loss of the 46 kV line east of Cloyes Substation
2. There is no way to re-energize Jailhouse Substation



1. No Outages

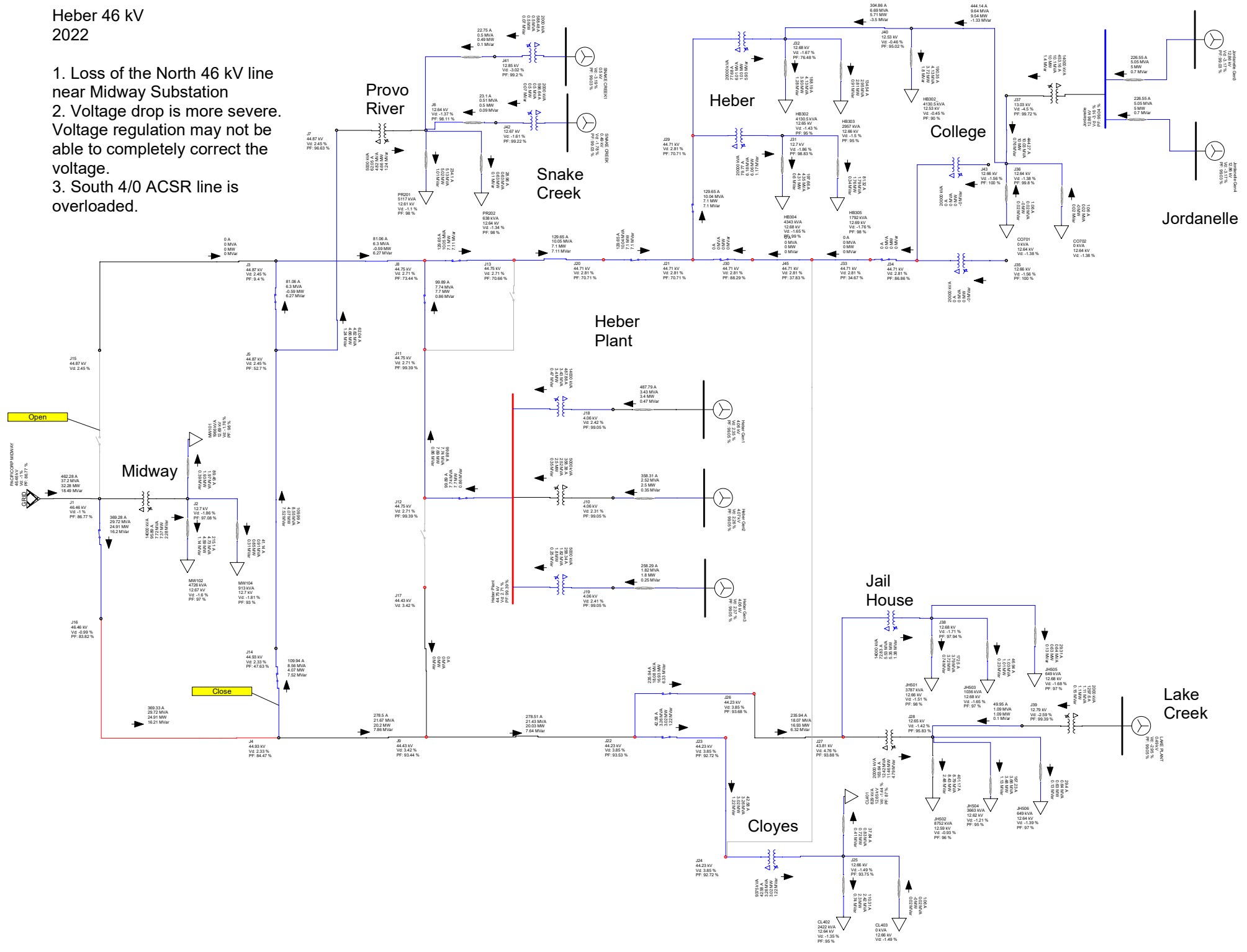


1. Loss of all Generation
2. Pacificorp Interconnection is overloaded
3. Provo River transformer is overloaded



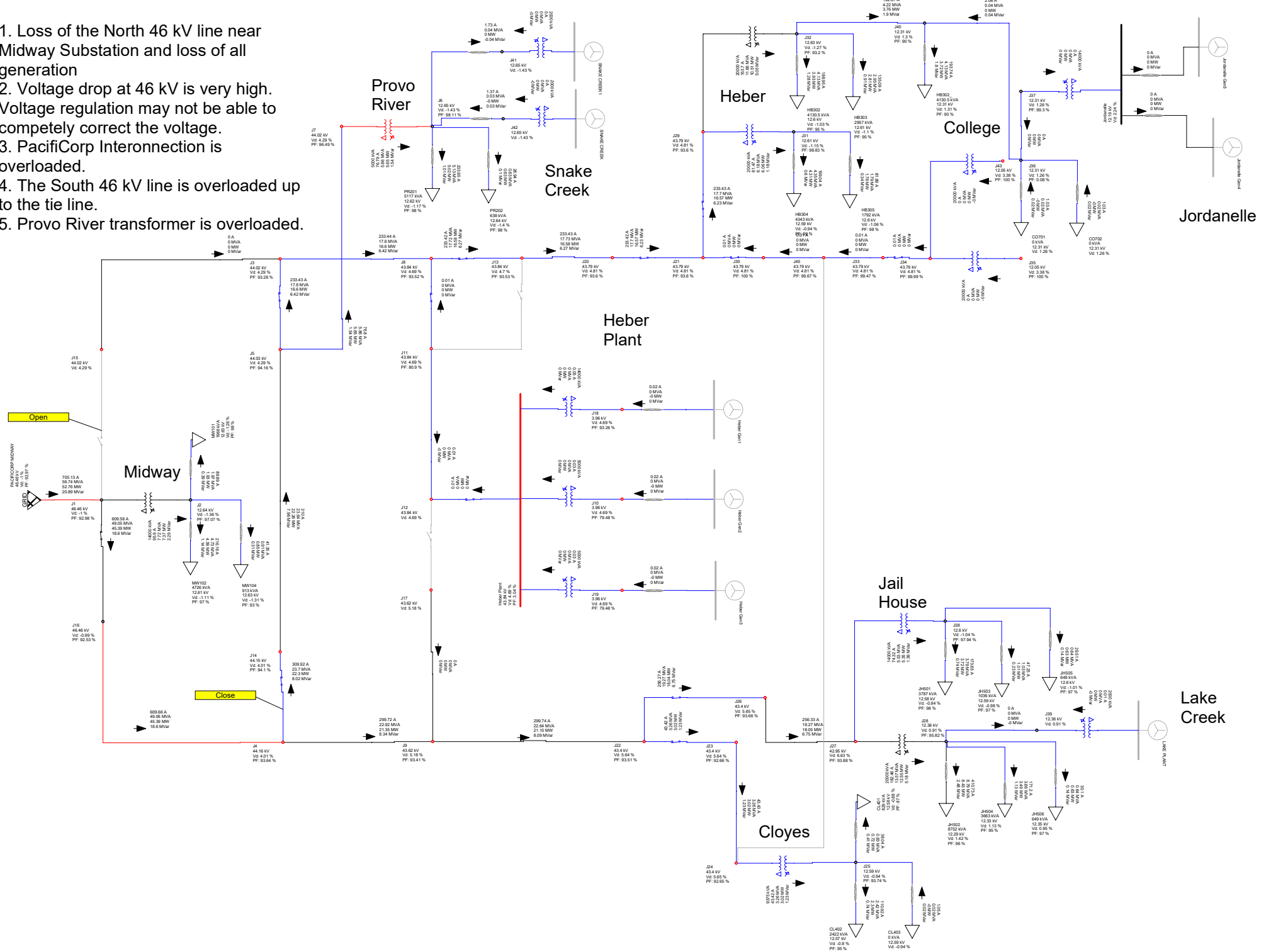
Heber 46 kV 2022

1. Loss of the North 46 kV line near Midway Substation
2. Voltage drop is more severe. Voltage regulation may not be able to completely correct the voltage.
3. South 4/0 ACSR line is overloaded.



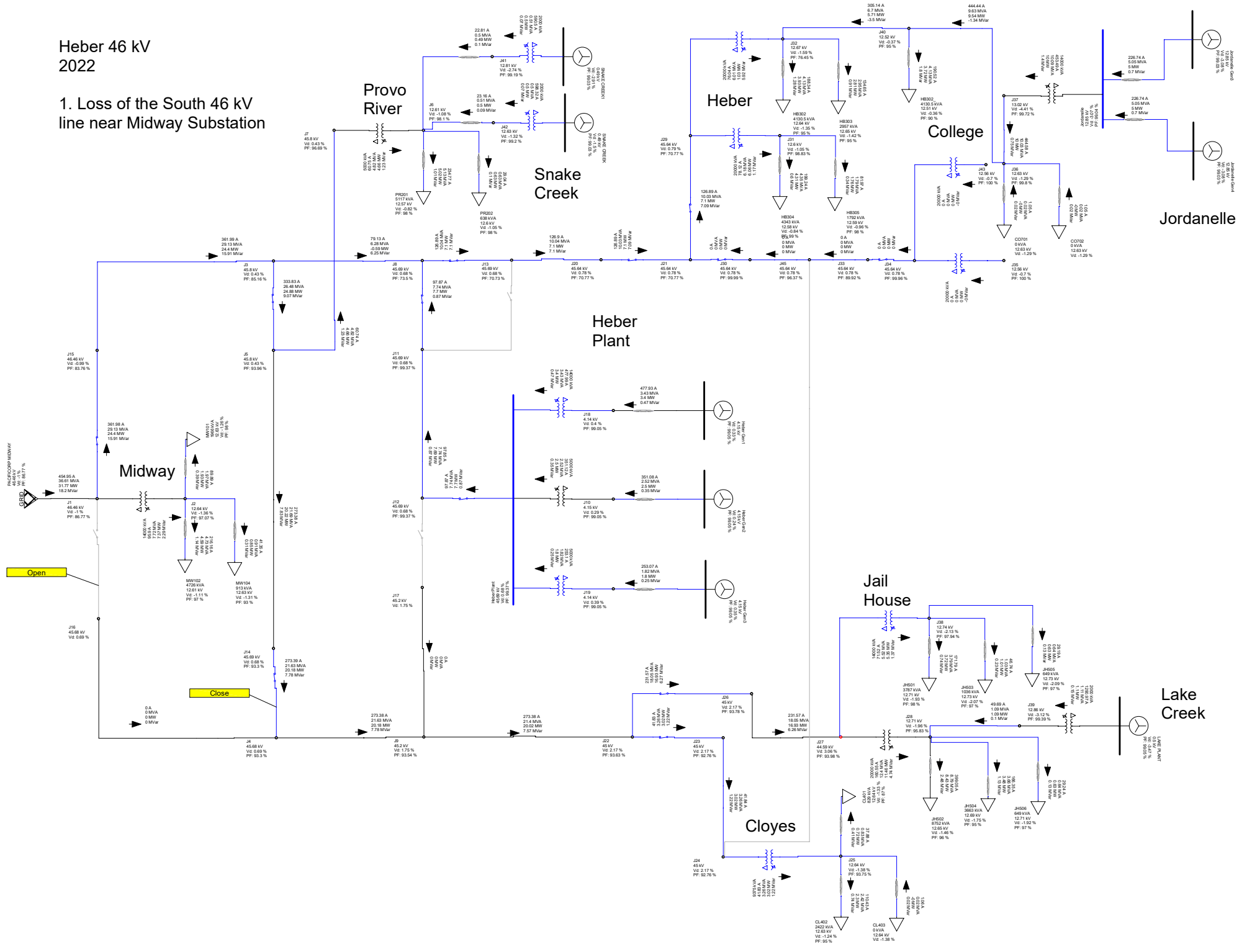
Heber 46 kV
2022

1. Loss of the North 46 kV line near Midway Substation and loss of all generation
2. Voltage drop at 46 kV is very high. Voltage regulation may not be able to completely correct the voltage.
3. PacifiCorp Interconnection is overloaded.
4. The South 46 kV line is overloaded up to the tie line.
5. Provo River transformer is overloaded.



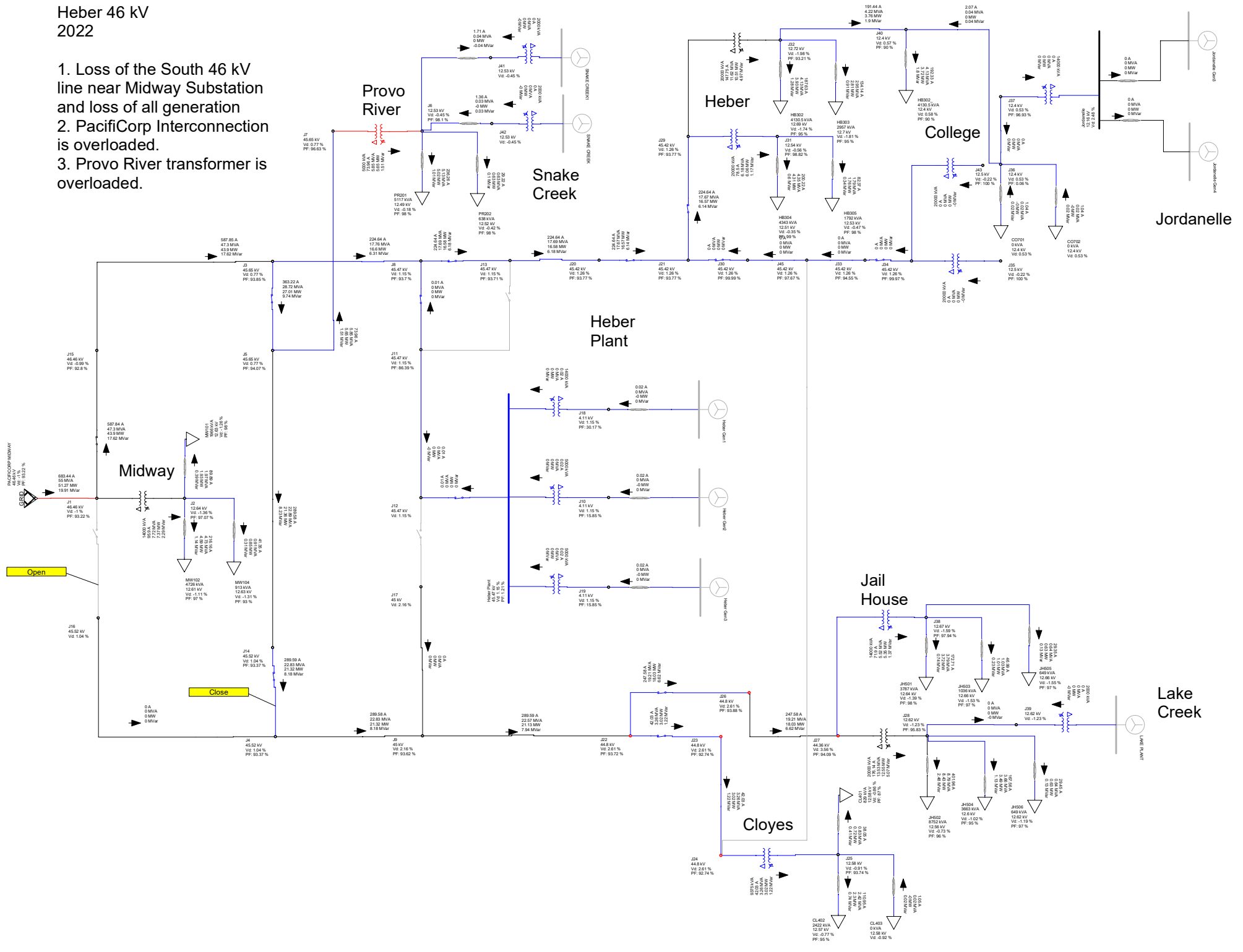
Heber 46 kV 2022

1. Loss of the South 46 kV line near Midway Substation



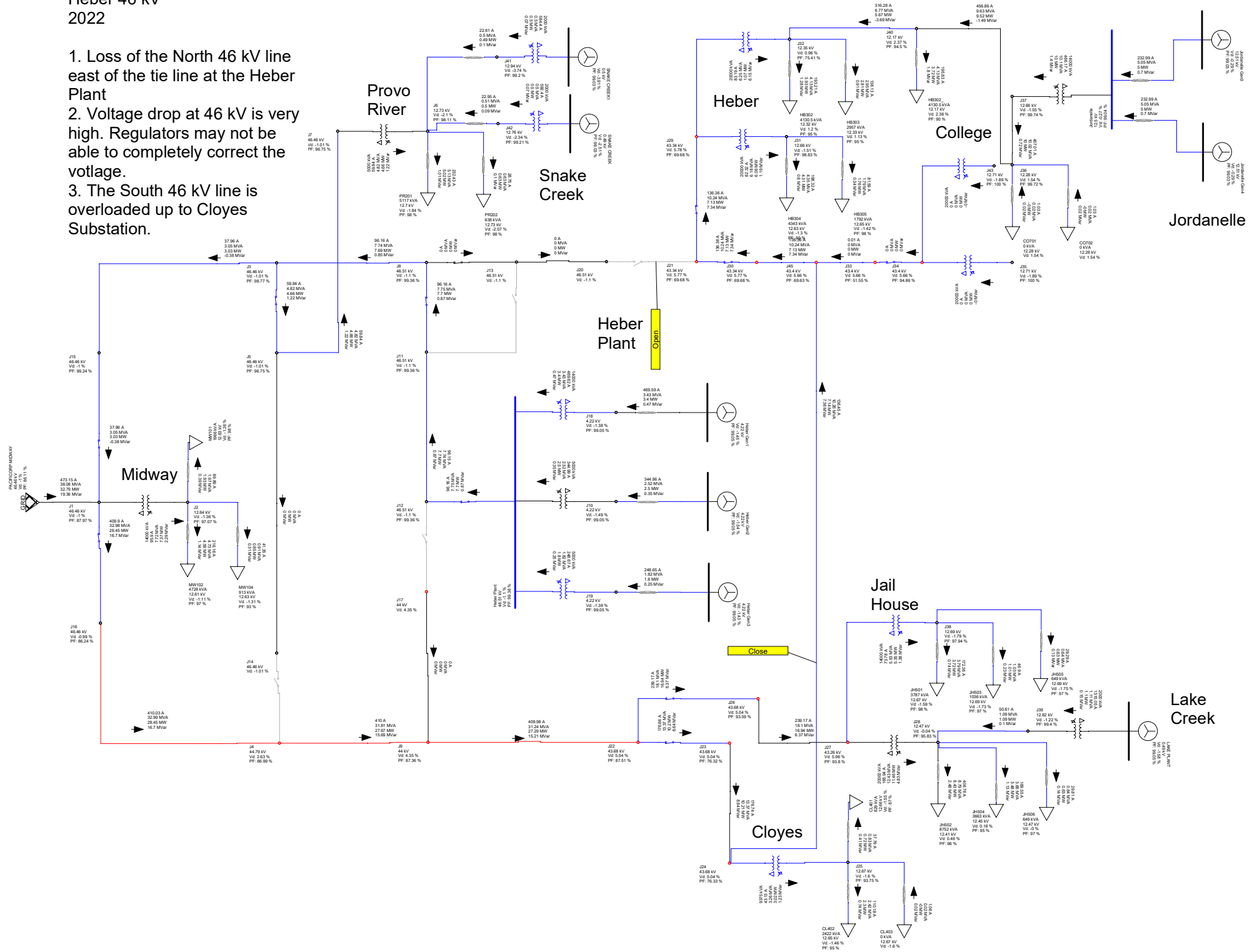
Heber 46 kV 2022

1. Loss of the South 46 kV line near Midway Substation and loss of all generation
2. PacifiCorp Interconnection is overloaded.
3. Provo River transformer is overloaded.

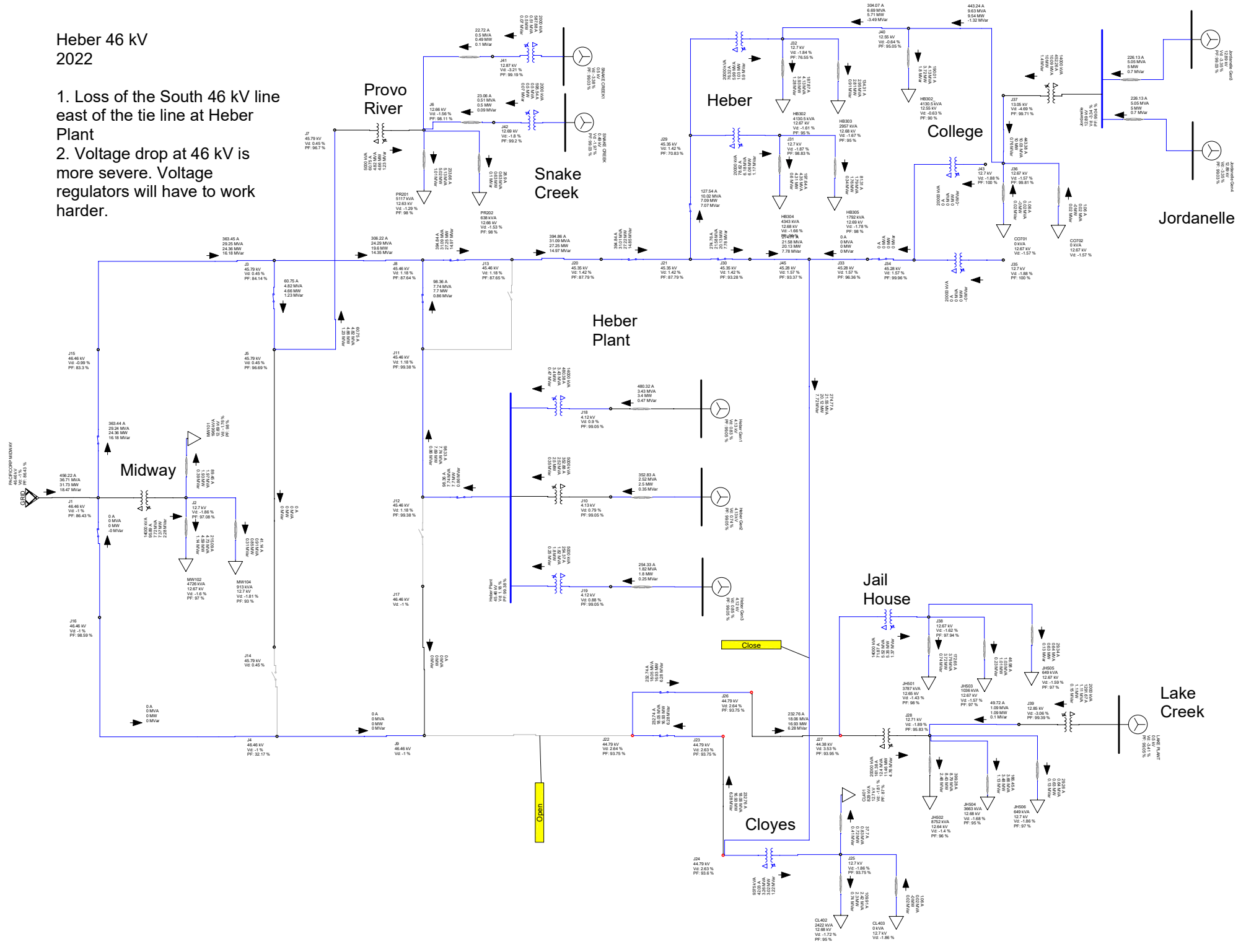


Heber 46 kV
2022

1. Loss of the North 46 kV line east of the tie line at the Heber Plant
2. Voltage drop at 46 kV is very high. Regulators may not be able to completely correct the voltage.
3. The South 46 kV line is overloaded up to Cloyes Substation.

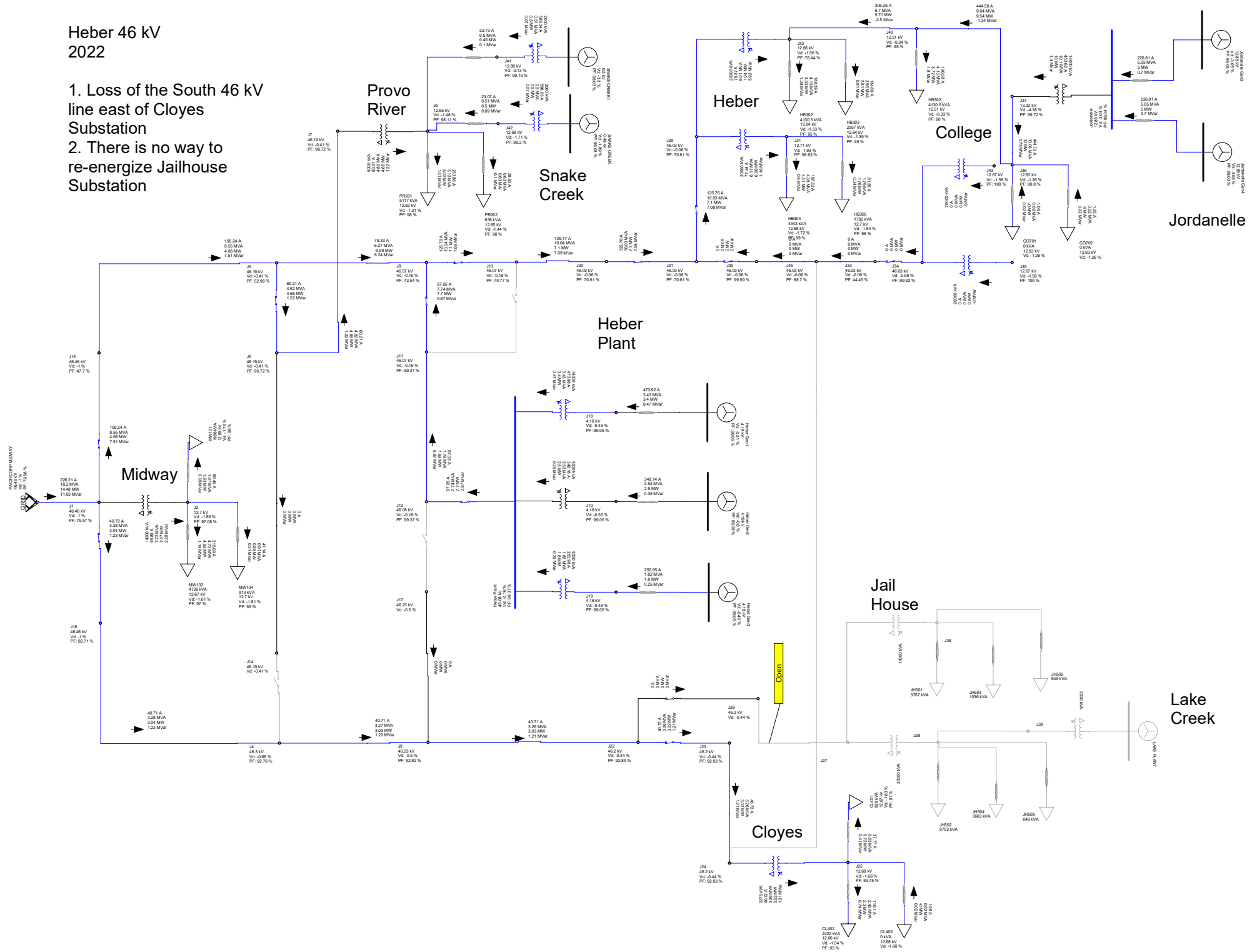


1. Loss of the South 46 kV line east of the tie line at Heber Plant
2. Voltage drop at 46 kV is more severe. Voltage regulators will have to work harder.



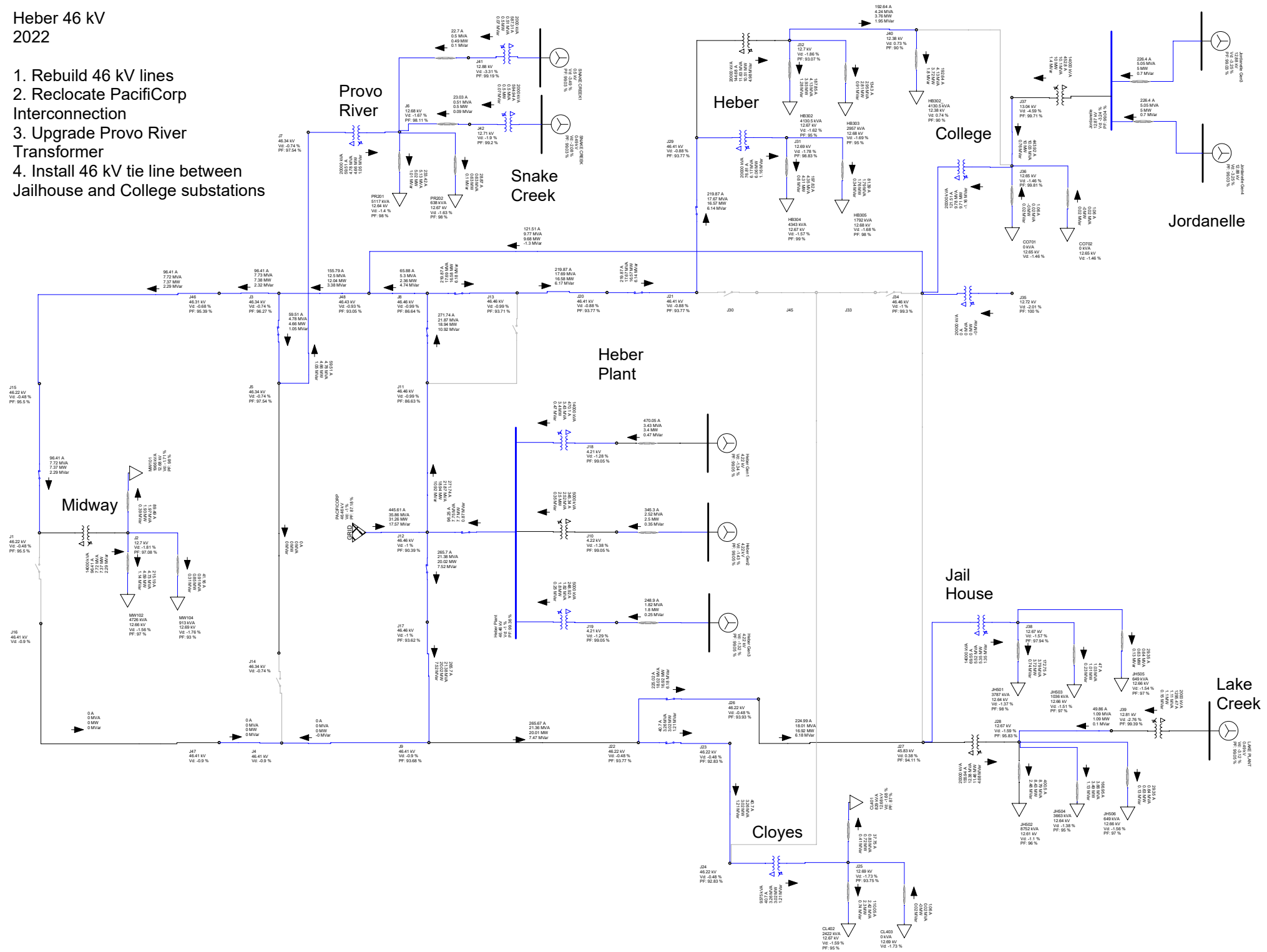
Heber 46 kV 2022

1. Loss of the South 46 kV line east of Cloyes Substation
2. There is no way to re-energize Jailhouse Substation



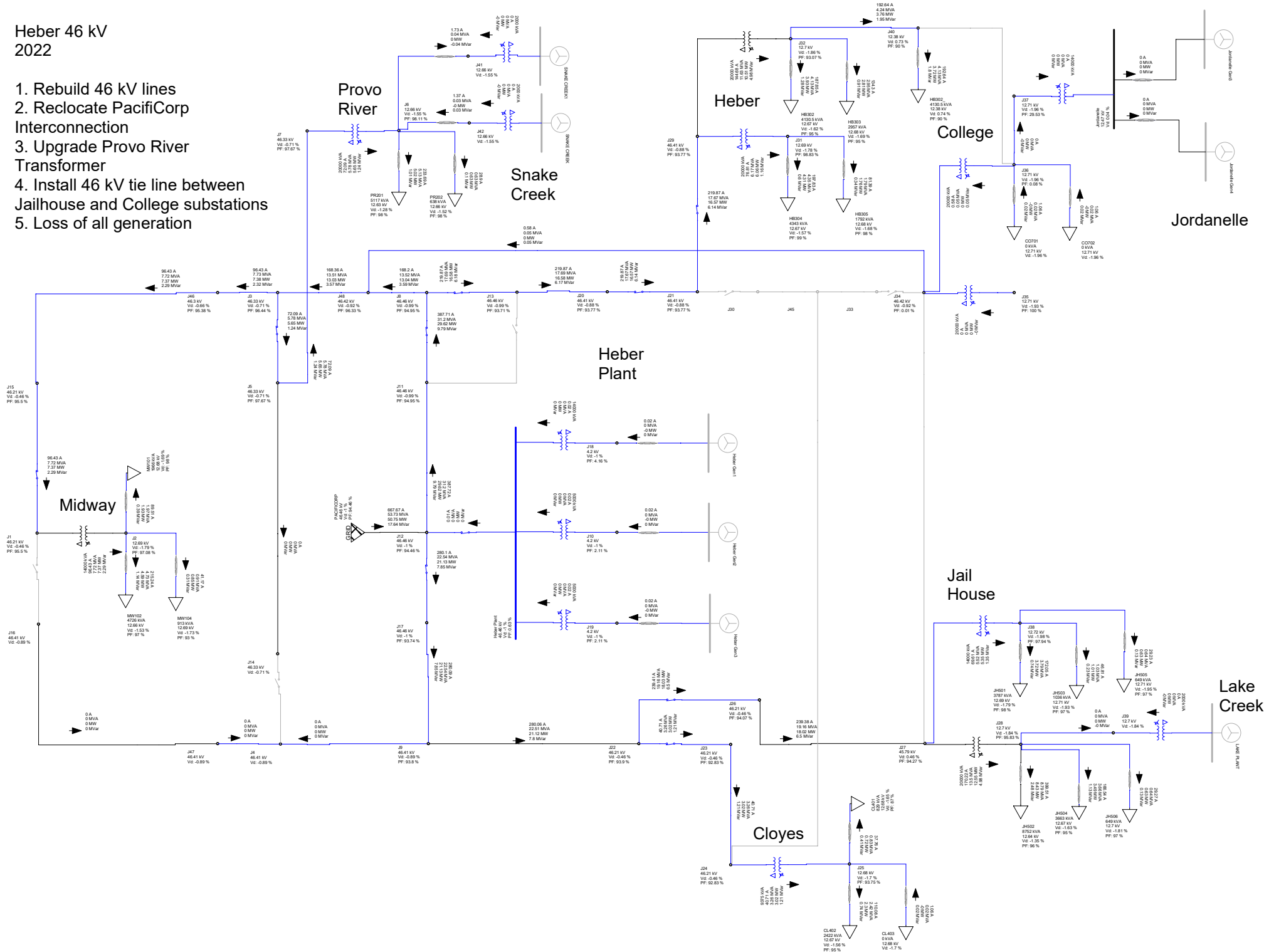
Heber 46 kV
2022

1. Rebuild 46 kV lines
2. Relocate PacifiCorp Interconnection
3. Upgrade Provo River Transformer
4. Install 46 kV tie line between Jailhouse and College substations



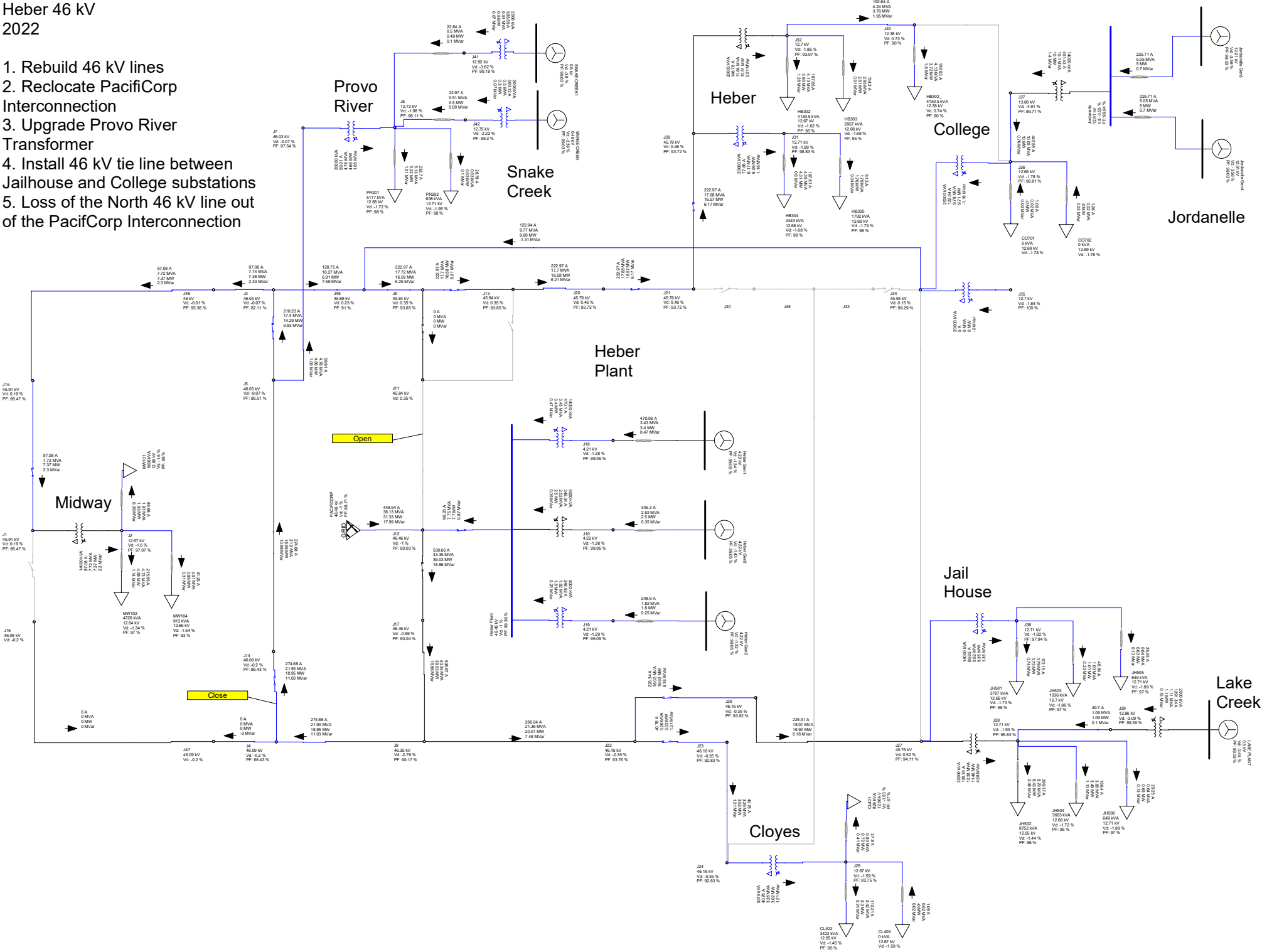
Heber 46 kV
2022

- 1. Rebuild 46 kV lines
- 2. Reclocate PacifiCorp Interconnection
- 3. Upgrade Provo River Transformer
- 4. Install 46 kV tie line between Jailhouse and College substations
- 5. Loss of all generation



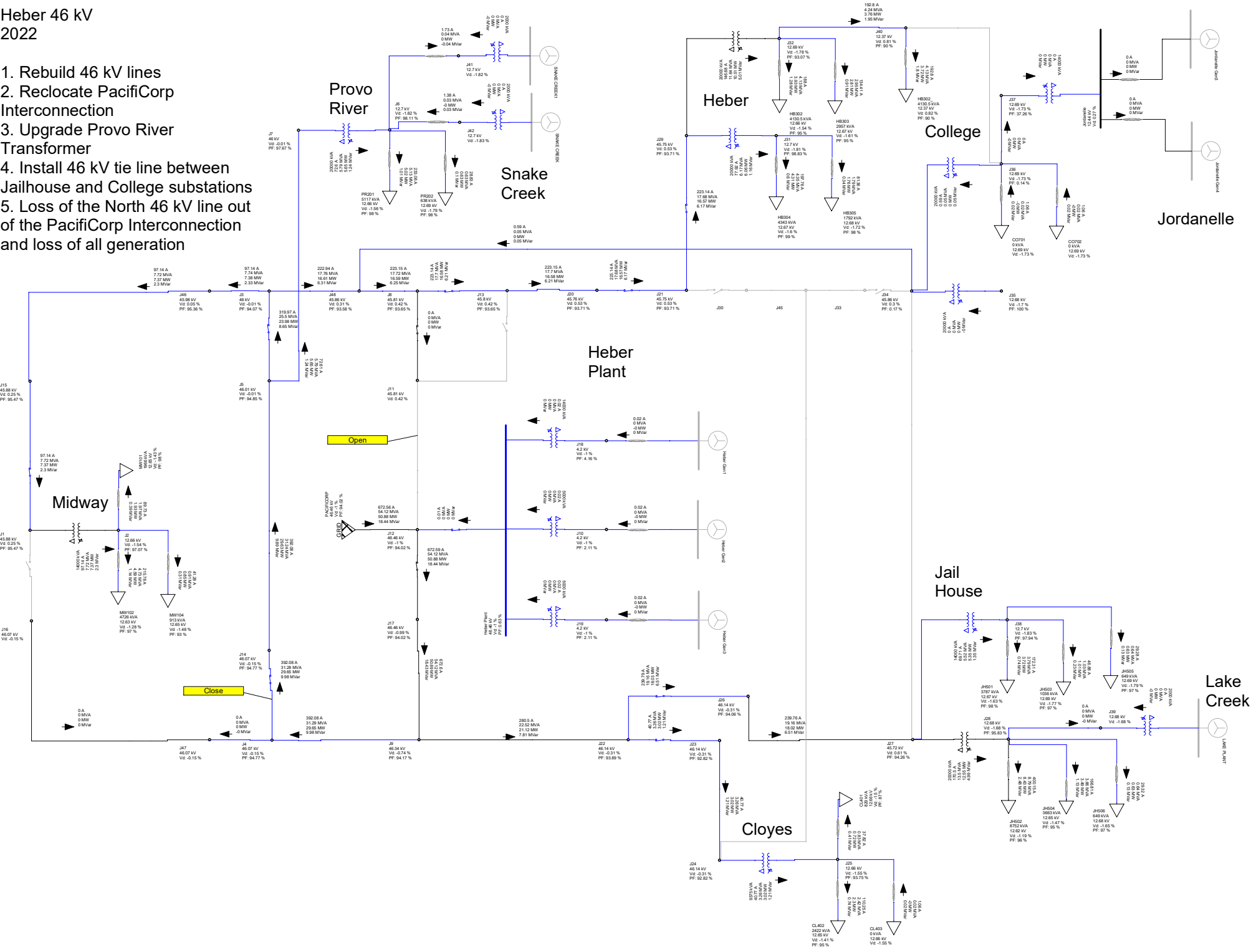
Heber 46 kV
2022

1. Rebuild 46 kV lines
2. Relocate PacifiCorp Interconnection
3. Upgrade Provo River Transformer
4. Install 46 kV tie line between Jailhouse and College substations
5. Loss of the North 46 kV line out of the PacifiCorp Interconnection



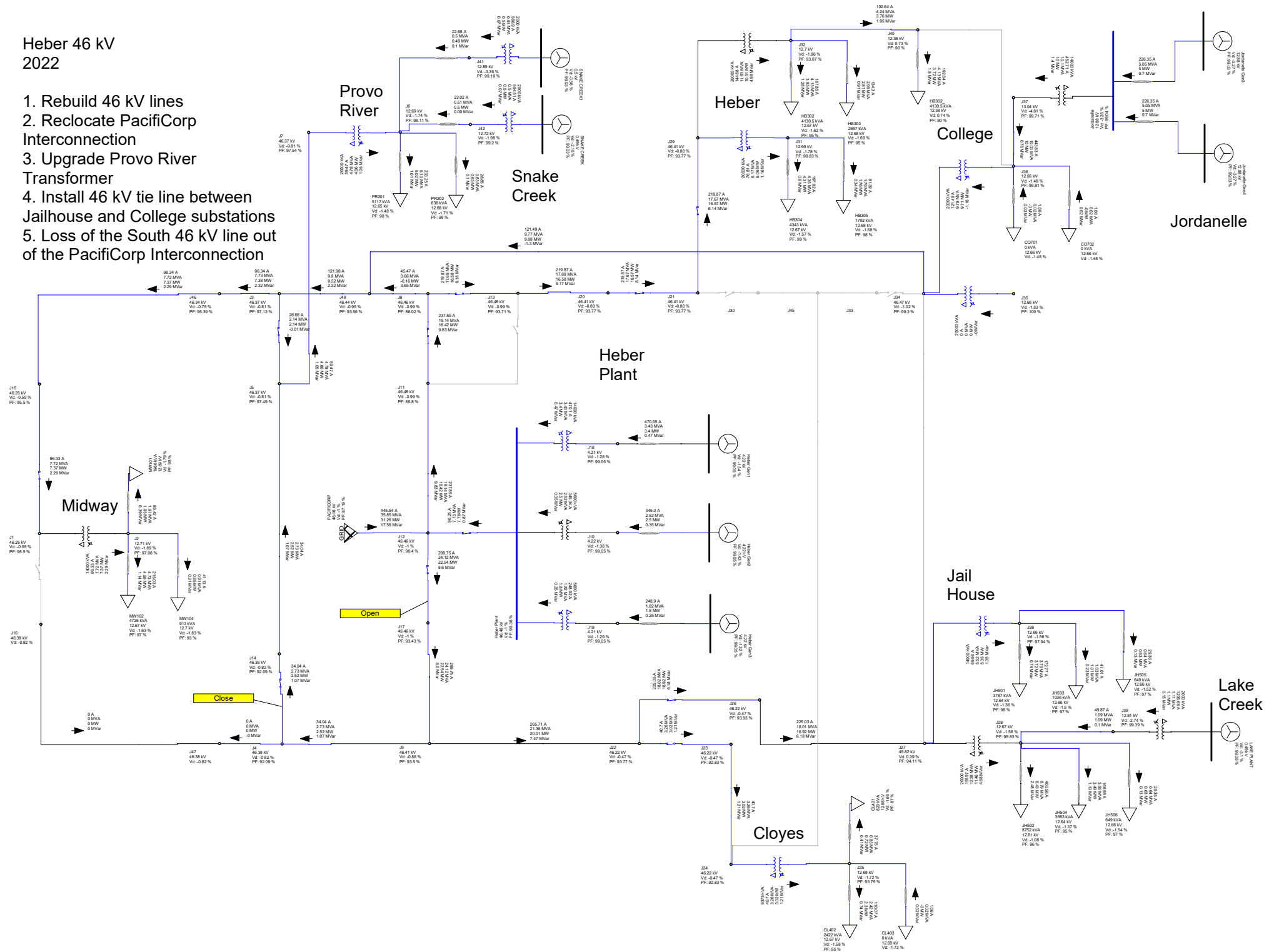
Heber 46 kV
2022

- 1. Rebuild 46 kV lines
- 2. Relocate PacifiCorp Interconnection
- 3. Upgrade Provo River Transformer
- 4. Install 46 kV tie line between Jailhouse and College substations
- 5. Loss of the North 46 kV line out of the PacifiCorp Interconnection and loss of all generation



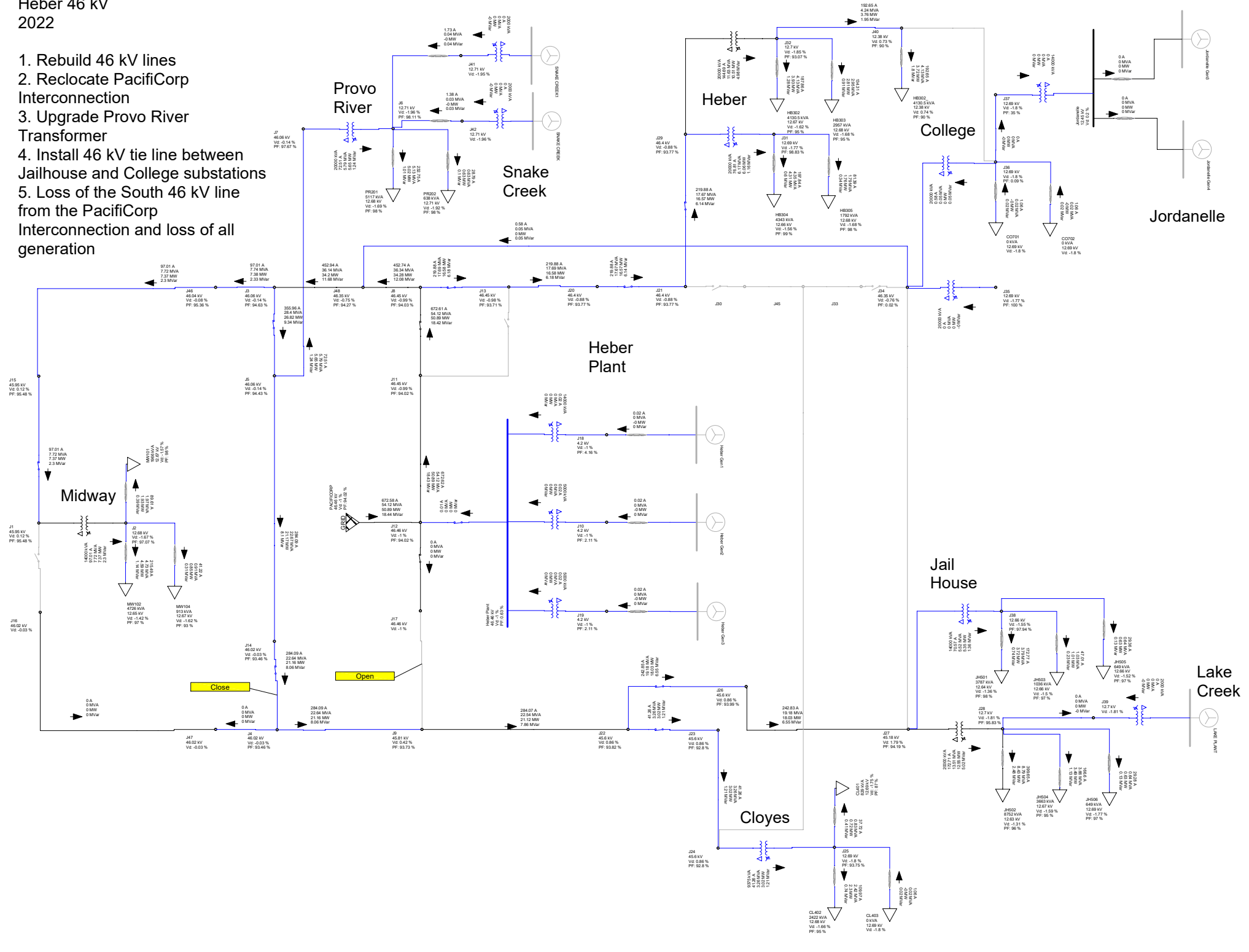
Heber 46 kV 2022

1. Rebuild 46 kV lines
2. Relocate PacifiCorp Interconnection
3. Upgrade Provo River Transformer
4. Install 46 kV tie line between Jailhouse and College substations
5. Loss of the South 46 kV line out of the PacifiCorp Interconnection



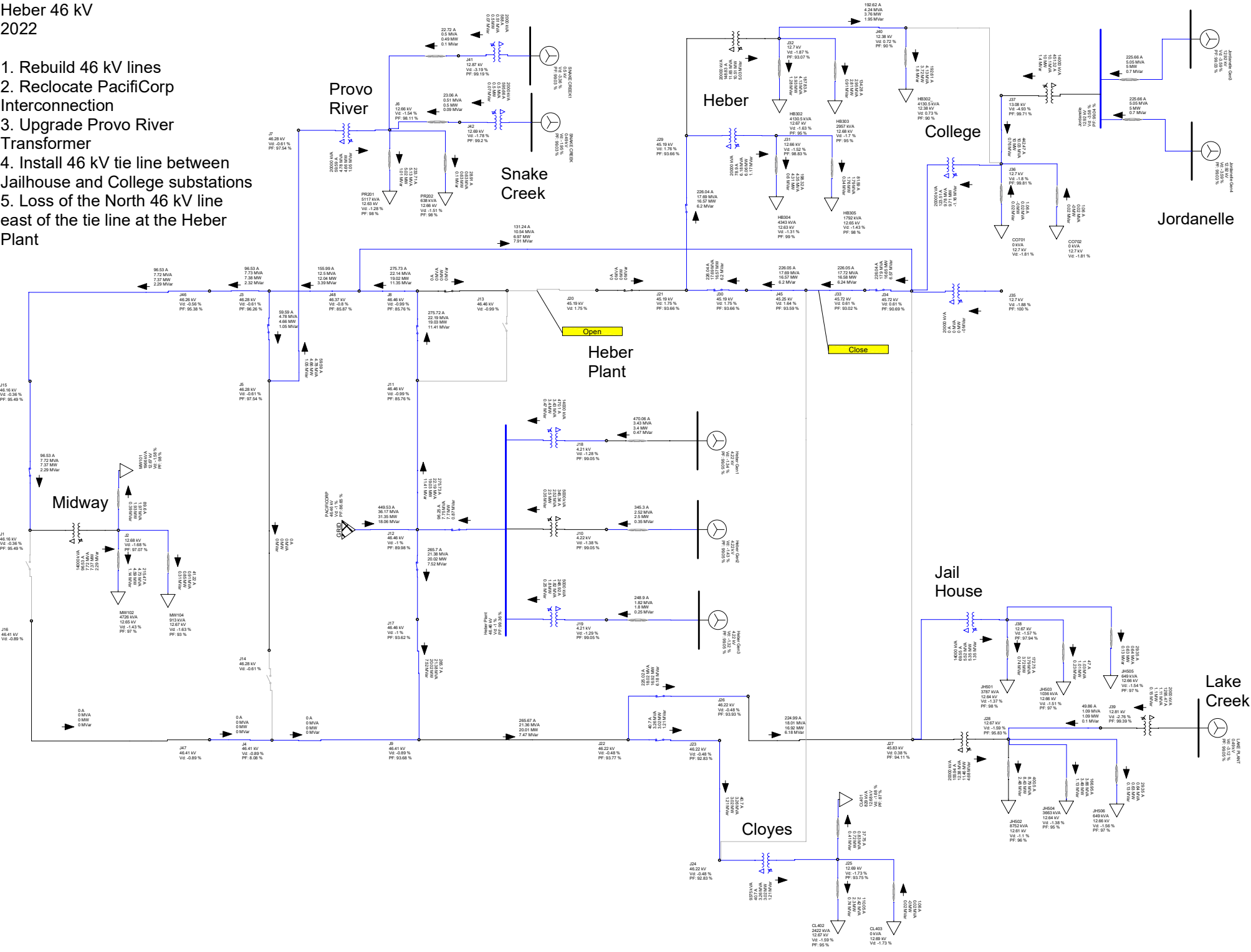
Heber 46 kV 2022

1. Rebuild 46 kV lines
2. Relocate PacifiCorp Interconnection
3. Upgrade Provo River Transformer
4. Install 46 kV tie line between Jailhouse and College substations
5. Loss of the South 46 kV line from the PacifiCorp Interconnection and loss of all generation



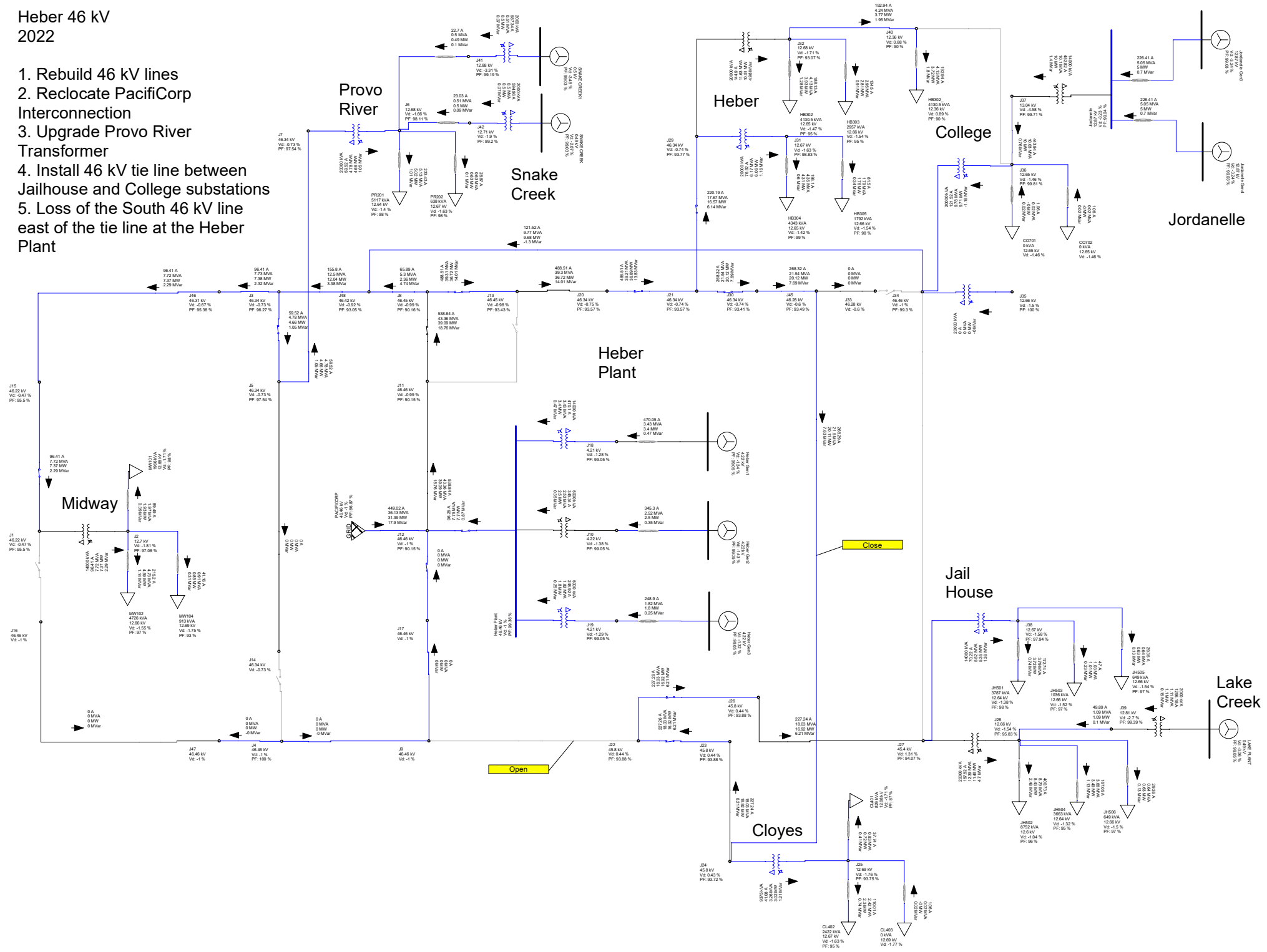
Heber 46 kV
2022

- 1. Rebuild 46 kV lines
- 2. Relocate PacifiCorp Interconnection
- 3. Upgrade Provo River Transformer
- 4. Install 46 kV tie line between Jailhouse and College substations
- 5. Loss of the North 46 kV line east of the tie line at the Heber Plant

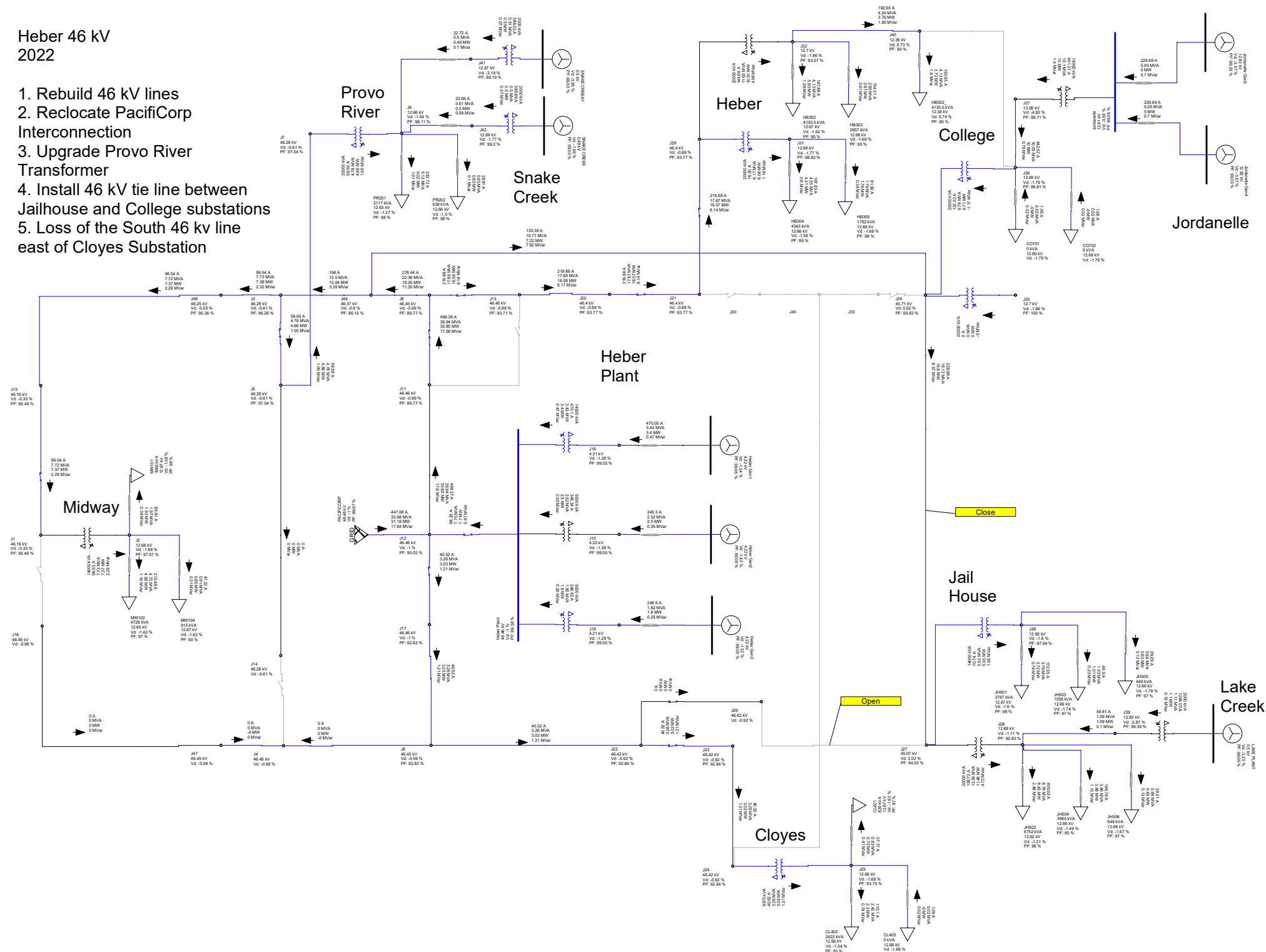


Heber 46 kV
2022

1. Rebuild 46 kV lines
2. Relocate PacifiCorp Interconnection
3. Upgrade Provo River Transformer
4. Install 46 kV tie line between Jailhouse and College substations
5. Loss of the South 46 kV line east of the tie line at the Heber Plant



1. Rebuild 46 kV lines
2. Relocate PacifiCorp Interconnection
3. Upgrade Provo River Transformer
4. Install 46 kV tie line between Jailhouse and College substations
5. Loss of the South 46 kv line east of Cloves Substation



APPENDIX 3 – MODEL INPUT DATA

Heber 46 kV 2018 Base Case

1. Input Data

