North of John Day Path Retirement

Operations Planning

December 2020

Executive Summary

BPA Operations Planning has determined the North of John Day (NJD) path is no longer required for operating the bulk electric system (BES). The NJD path was established in 1997 as one of the major boundaries used in determining the stable and reliable operating nomogram for the Federal Columbia River Transmission System (FCRTS), California-Oregon Intertie (COI), Pacific DC Intertie (PDCI), and Hemingway-Summer Lake (Path 75). The COI/PDCI (y-axis) versus NJD (x-axis) nomogram (often referred to as the COI nomogram for short) became part of dispatcher standing order (DSO) 306 in 1997. The nomogram has been removed from DSO 306 in 2020 and BPA Operation is recommending the retirement of NJD (x-axis). This document summarizes the reasoning for retiring the COI nomogram and the need to retire the NJD path. It provides a brief overview of the system upgrades, resulting improvements in voltage stability limit, and improved operational procedures that call for the retirement of NJD.

From 1997 to present, BPA has completed several BES reinforcements. These reinforcements have significantly increased the system's voltage stability limit for all lines in service and planned outage conditions. As a result, a majority of the time the System Operating Limit (SOL) will be set by facility ratings (to prevent overloads) at levels comfortably below the heightened voltage stability limit. The greatly improved FCRTS, plus the development of the RC's Oregon Export IROL which provides enhanced determination, monitoring, and management of the system voltage stability limit, has allowed for the removal of the COI nomogram in DSO 306.

As of the 2020 winter season BPA Operations no longer determines the nomogram limits for all lines in service and scheduled outages. BPA Operations monitors and responds to the RC's Oregon Export IROL to manage voltage stability. The retirement of the nomogram and the NJD path is necessary to ensure optimal use of BPA Transmission resources and to provide coordinated operation of the voltage stability limit with the RC's OR Export IROL. BPA Operation is no longer using NJD to operate the FCRTS and is recommending that the path be retired.

History

The North of John Day path was established after the August 10, 1996 system disturbance. Analyses conducted after the disturbance to determine its cause found that a significant contributing factor was heavy loading and associated lack of reactive support in the Pacific Northwest's main transmission grid in southern Washington that included the 500 kV lines from the I-5 corridor, Hanford, and Lower Snake areas. This, in turn, lead to the system instability experienced on August 10, 1996. The NJD path was defined based on this analysis. Its purpose was to provide a reference for measuring the stress through this portion of the grid and the associated risk for voltage stability. Since flows on the COI, PDCI, and Path 75 all were major contributors to the flow over the NJD path, their interaction was what lead to the establishment of the COI nomograms.

The COI is defined as the three 500 kV lines leaving Oregon into California, Malin-Round Mountain 1&2 and Captain Jack-Olinda. This path is part of the Pacific AC Intertie (PACI), the larger AC transmission network built to transfer power to and from the Pacific Northwest and Pacific Southwest areas. The COI is such an important path on the PACI that, over time, it became common to discuss the transfer capability of the PACI by speaking to the COI limit. The Northwest AC Intertie (NWACI) is the PACI system north of COI. BPA sets limits for the NWACI and for many years, BPA applied these limits to the COI in coordination with the southern PACI operator. This was logical because the COI is

where the Northwest AC Intertie and Southwest AC Intertie come together to make the larger Pacific AC Intertie. In 2016 the California Independent System Operator (CAISO) discussed with BPA confusion being caused by BPA calling its NWACI limit the COI limit. The CAISO is the official transmission operator for the COI path. It was agreed by BPA and the CAISO that BPA would start referring to its limit as the NWACI limit and not the COI. This helped clear up the understanding of roles and responsibilities, with the CAISO the official transmission operator for the COI and BPA the official transmission operator for the NWACI. For the last three years of its use (spring 2017, 2018, and summer of 2019) the COI/PDCI vs. NJD nomogram was renamed to the NWACI/PDCI vs. NJD nomogram. *This paper will refer to the nomogram as the COI nomogram, because this was the name used for the majority of its active life.*

Major System Upgrades and New Operating Procedures

Major System Upgrades

In the last 22 years, BPA completed a number of significant BES upgrades. Figure 1 shows a one-line diagram of the Northwest 500 kV AC transmission system in the summer of 1997. Figure 2 shows a one-line diagram of the system as of the summer of 2019 and emphasizes in green major upgrades with their energization dates. Similarly, Table 1 provides a list of AC upgrades, including shunt capacitor additions and the important FACRI remedial action scheme (RAS). Figures 1, Figure 2 and Table 1 are not complete lists of BES upgrades, but are selected as the most noteworthy for improving the system performance and directly supporting the retirement of the NJD path.

Looking at the major upgrades over the last 22 years it can be seen they are located along the central/eastern Washington area and Lower Columbia River area. This is also where a very large amount of hydro generation is located, and now wind generation too. Even before the large increase in wind generation, the 1997 network was used to its stability limits when transferring the large quantity of hydro power to Northwest load and to the NWACI and PDCI. Given the large amount of generation and the growing demand for its transfer, the network required stability boundaries to define the safe operating region for the various demands that were placed on the transmission system. This nomogram was created in 1997, called the COI/PDCI vs. NJD nomogram, and was continuously updated through the last 22 years. The nomogram provided a necessary tool for operating the BES in order to guard against voltage instability.

With the 1997 system, the transfer of large amounts of power required transmission lines to operate well above their surge impedance loading (SIL). Above SIL, lines are inductive and require capacitive reactive power to balance inductance and maintain voltage stability. As the loading increases above SIL the capacitive compensation needed increases exponentially. Therefore, it was critical to limit the total demand (power transfers) on the system to ensure the loading increases seen after contingencies could be supported with the available increases in capacitive reactive power from switching shunt devices, SVC voltage boosting, and especially by increasing generation voltage boosting. The system demands continued to grow and BPA's Transmission Planning group developed the reinforcements necessary to meet the demands and provide a much needed increase in the transmission voltage stability limits.

The new lines built around the NJD area provide significant benefit. When a new line is energized it reduces the loading on the existing lines, which provides exponential reductions in the capacitive reactive power required by the network. All the new 500 kV lines listed provided this benefit. Additionally, significant capacitive support was added with the Bakeoven and Slatt series capacitors and various shunt capacitor installations.

The growing benefit of these projects was seen in the DSO 306 nomograms (Figures 3 to 11), showing increasing voltage stability limits as the projects were energized through the years. By 2012, BPAcompleted the Bakeoven series capacitors and Slatt shunt capacitor additions specifically to "square off the nomogram", establishing the capability to operate COI, PDCI, and Path 75 at WECC ratings [4800 MW north to south (N-S) for COI, 3100 MW N-S for the PDCI, and 550 MW west to east (W-E) for Path 75]while simultaneously transferring power to Northwest loads during summer peak demand hours.

After 2012, BPA completed the PDCI upgrade project increasing the north to south (N-S) rating from 3100 MW to 3220 MW (3210 MW maximum power order on the Celilo DC bus). The new Celilo PDCI terminal operates with improved power factor, i.e. reduced capacitive demand, compared to the prior 4-terminal system. It also eliminated the 230 kV connected converters, moving much more of the AC power transfers to Celilo onto higher capacity 500 kV lines including the new Big Eddy-Knight 500 kV line. The PDCI upgrade is not listed in Table 1, but also added to the overall voltage stability limit increases. Furthermore, not listed in Table 1, but worth noting is the new synchrophasor (SP) RAS, which detects large contingency events and activates fast shunt switching at twelve 500 kV substations. SP RAS can be called a FACRI 2.0, detecting large contingencies and triggering the ability to rapidly deploy shunt switching to help maintain voltage levels and voltage stability. Lastly, BPA Operations continues to maintain reactive reserve requirements at the Upper Columbia and Lower Columbia hydro projects. As the power transfers increase the reactive reserves required increase. When the reactive reserve requirements cannot be provided the power transfers on the system (NWACI) are reduced to levels at which the reactive requirement can be provided.

The net benefit from the projects listed has improved the system voltage stability limits such that it is almost always expected that facility ratings (preventing overloads) will drive the maximum power transfer limits comfortably ahead of the voltage stability limits. This is true for all lines in service and for normally planned outage conditions. Furthermore and very importantly, these potential facility overloads are not a function of the loading over the NJD path.

Reliability Coordinator (RC), Oregon Export IROL

The continued monitoring of the voltage stability limit is still required and very important. BPA worked with the RC to establish a NWACI+P75 Northwest Export system operating limit (SOL), which was then converted into the Oregon Export IROL. The RC produces day ahead IROL limits and runs real-time voltage stability analysis to ensure the IROL is updated as needed with changing system conditions. The IROL has an operating procedure establishing a coordinated set of steps that major utilities will take to keep the system power transfers 300 MW below the IROL and to mitigate exceedances. The system upgrades and resulting voltage stability limit increases described above, were necessary to provide the transmission capacity to meet the growing demands and the Oregon Export IROL maintains and improves the determination, monitoring, and management of the system voltage stability limit.

BPA Dispatcher Standing Order (DSO) 306 COI/PDCI vs North of John Day Nomogram

For 22 years, TOOP had determined a COI nomogram defining the stable and reliable operating area for the Northwest BES system. The area boundaries used included:

1. NJD Path (x-axis)
2. COI and PDCI (y-axis)
3. Hemingway-Summer Lake (adjusting the nomogram regions with a series of lines).

Furthermore, in BPA's energy management system (EMS) additional adjustments to the nomogram were established:

A. Net Westside Load (WSLD) –The COI/PDCI nomogram (y-axis) was reduced by 1 MW for every 2 MW the WSLD exceeded the level that was assumed in the studies that established the nomogram limits.
B. TOT2 Total – the COI nomogram limit is reduced 1 MW for every 4 MW of flow over 1200 MW (N-S) on the TOT2 transmission path.
C. Klamath Cogen – the COI nomogram limit was reduced 1 MW for every 1 MW Klamath Cogen is less that what is assumed in studies that established the nomogram limits.

Figures 3 to 11 show examples of the nomogram for the summers of 1997, 1998, 2000, 2006, 2010, 2011, 2012, 2018 and 2019. The nomogram charts from 1998 to 2012 show a series of operating boundary lines for different flows on Path 75 (east-to-west and west-to-east directions). By the summer of 2012 the positive impact of many system reinforcements allowed the nomogram to be "squared off" to a single operating boundary in which the NJD, PDCI, COI, and Path 75 could operate simultaneously at WECC Path ratings during Northwest summer peak load hours.

In 2020 the COI nomogram was removed from DSO 306. The WSLD is no longer applied to adjust path limits. The TOT2 Total is still applied to the NWACI N-S total transfer capability (TTC) limit, but is planned for retirement. The Klamath Cogen is applied to the NWACI N-S TTC. As of 2020, BPA Operations no longer establishes the COI nomogram in DSO 306 or studies a NJD limit for normal outage planning. The NJD path has been set at a fixed TTC of 8,000 MW (this number can be increased, if needed) and Operations monitors the Oregon Export IROL to ensure voltage stability.

Conclusion

The BES upgrades and resulting voltage stability limit increases in combination with new Oregon Export IROL operating procedure permits the retirement of the DSO 306 COI nomogram and the NJD path. The NJD path is no longer considered a requirement for operating the transmission system. In fact, the retirement of the nomogram and the NJD path is necessary to ensure optimal use of BPA's transmission resources and to ensure coordinated operation of the voltage stability limit with the RC's OR Export IROL.

Table 1 Significant Main Grid AC Transmission Upgrades

Green: shunt cap. additions, the Slatt and John Day 230 kV are more for the wind, but also have AVR relays and would support post - contingency voltage if the system voltages go to the switch IN settings	
Gold: new line or series capacitor facilities	
Blue: new substation plus existing lines brought together at the substation	
RAS	
Project Name	**Energized Date**
FACRI	6/1/1997
LLL Voltage Stability Reactive Insert	6/1/1997
John Day 500kV G1SA&B	3/13/1997
Hanford 500kV G1SA&B	4/1/1997
Marion 500kV G1A&B	2/6/2001
Raver 500kV G1S1	10/5/2001
Ostrander 500kV G3SA/B	11/18/2004
Grand Coulee - Bell No 6 500kV line	12/1/2004
Hanford - Wautoma No 1 500kV line (was Hanford-Ostrander)	11/14/2005
Wautoma - Ostrander No 1 500kV line (was Hanford-Ostrander)	11/14/2005
Hanford - Wautoma No 2 500kV line (was Hanford-John Day)	11/17/2005
Wautoma - John Day No 1 500kV line (was Hanford-John Day)	11/17/2005
Wautoma Substation	12/5/2005
Schultz - Wautoma No 1 500kV line	12/5/2005
Wautoma - Rock Creek No 1 500kV line (was Wautoma-John Day)	7/25/2007
Rock Creek - John Day No 1 500kV line (was Wautoma-John Day)	7/25/2007
Rock Creek Substation	7/25/2007
John Day 230kV G2S1	12/20/2007
John Day 230kV G2S2	12/20/2007
Rock Creek 230kV G1S1	12/20/2007
Rock Creek 230kV G1S2	12/20/2007
Keeler 500kV G3	12/9/2010
Bakeoven Compensation Station	1/21/2011
Captain Jack 500kV G2	4/28/2011
Captain Jack 500kV G3	4/28/2011
Slatt 500kV G1	5/26/2011
Slatt 230kV G2S2	9/7/2011
Slatt 230kV G2S1	9/27/2011
McNary - John Day No 2 500kV line	11/2/2011
Little Goose - Central Ferry No 2 500kV line (was Little Goose-Lower Granite)	1/18/2012
Central Ferry Substation	1/19/2012
Central Ferry - Lower Granite No 2 500kV line (was Little Goose-Lower Granite)	1/19/2012
Central Ferry 500kV G1	10/24/2012
McNary 230kV G1S1	4/3/2014
McNary 230kV G1S2	4/3/2014
Central Ferry - Lower Monumental No 1 500kV line	11/3/2015
Knight Substation	11/13/2015
Big Eddy - Knight No 1 500kV line	11/13/2015
Wautoma - Knight No 1 500kV line (was Wautoma-Ostrander)	11/13/2015
Knight - Ostrander No 1 500kV line (was Wautoma-Ostrander)	11/13/2015
Slatt 230kV G3S1	3/1/2019
Slatt Series Capacitor	5/1/2019

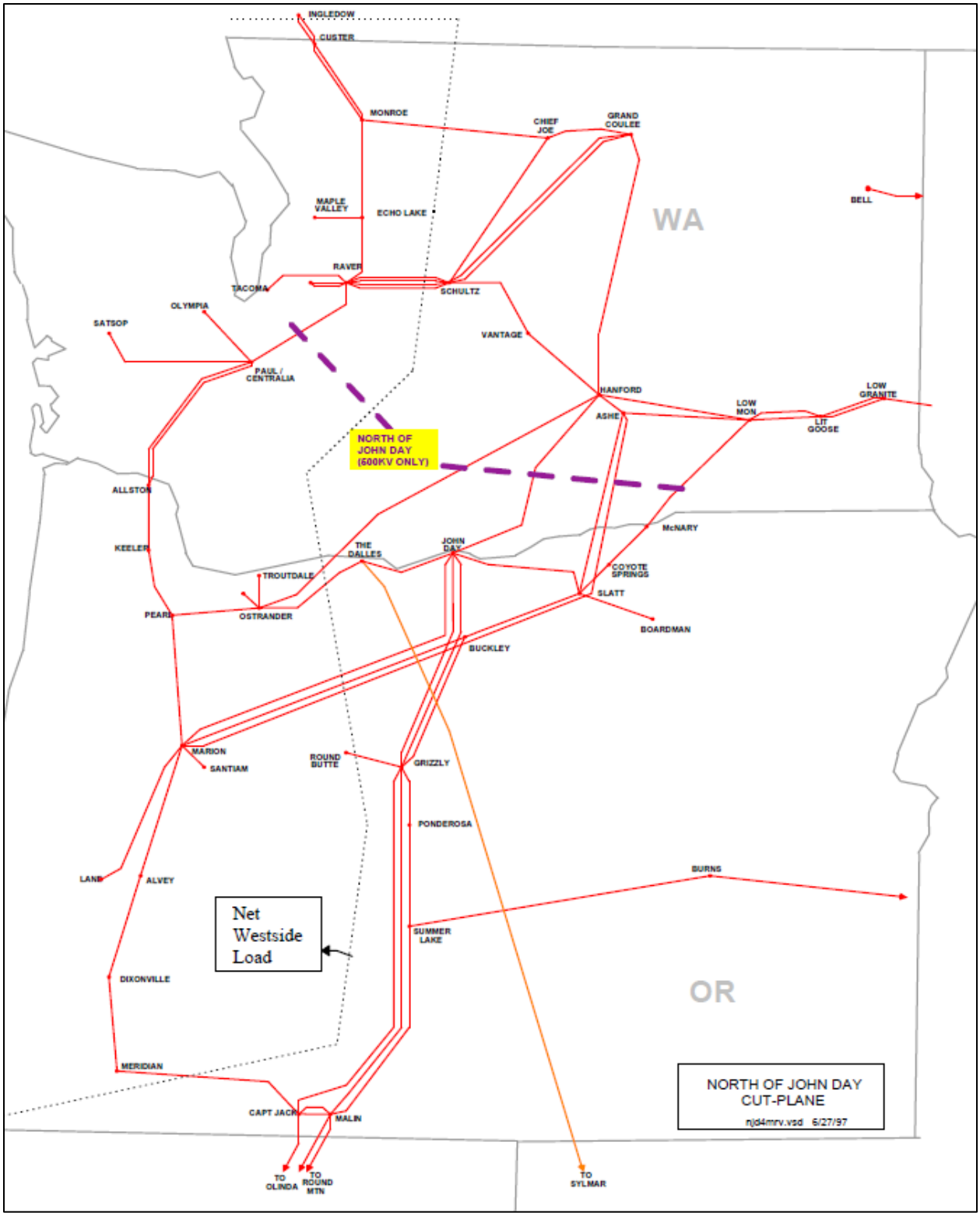

Figure 1 Summer 1997 System

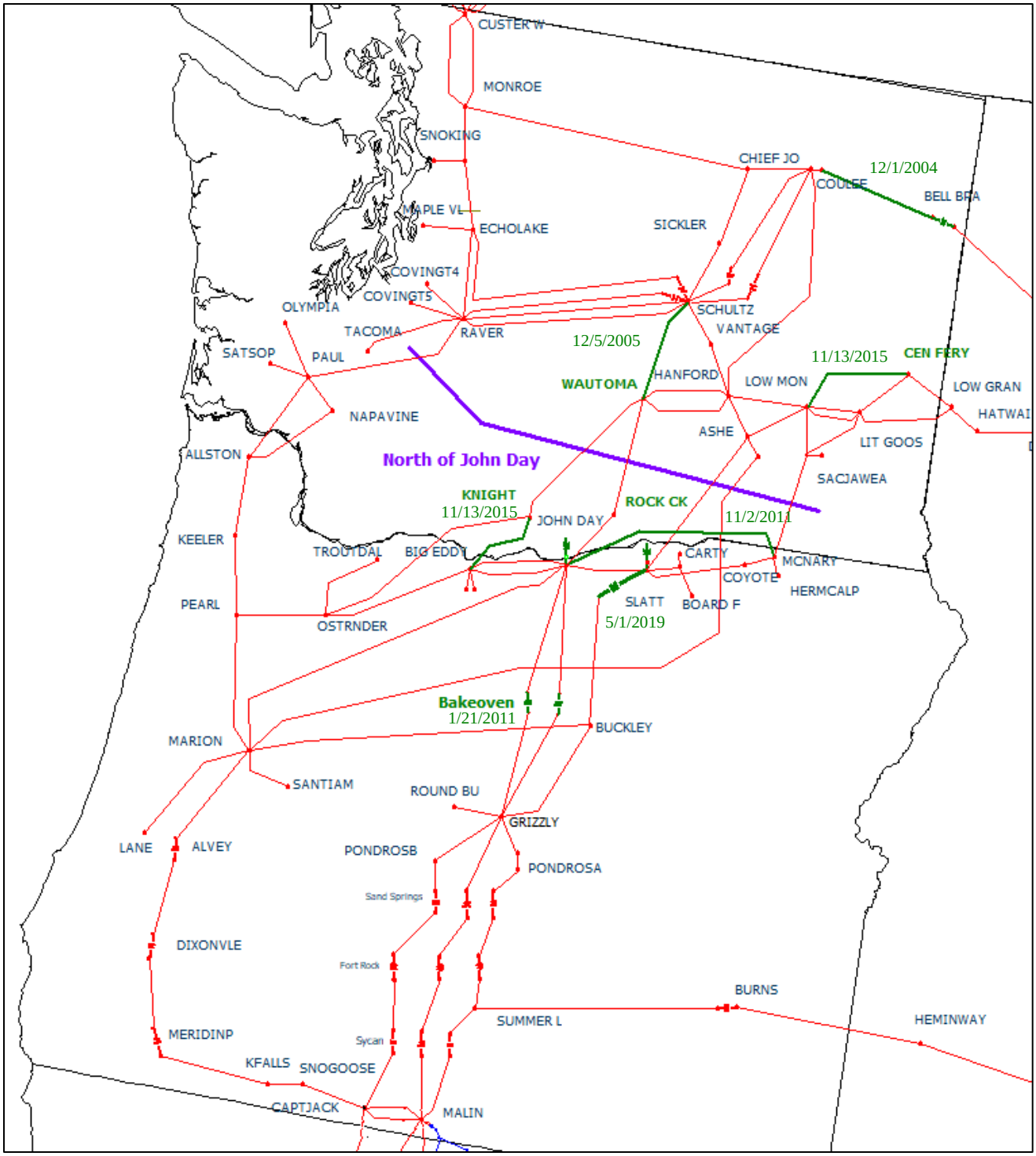

Figure 2 Summer 2019 System, Noting Major AC Transmission Upgrades in Green

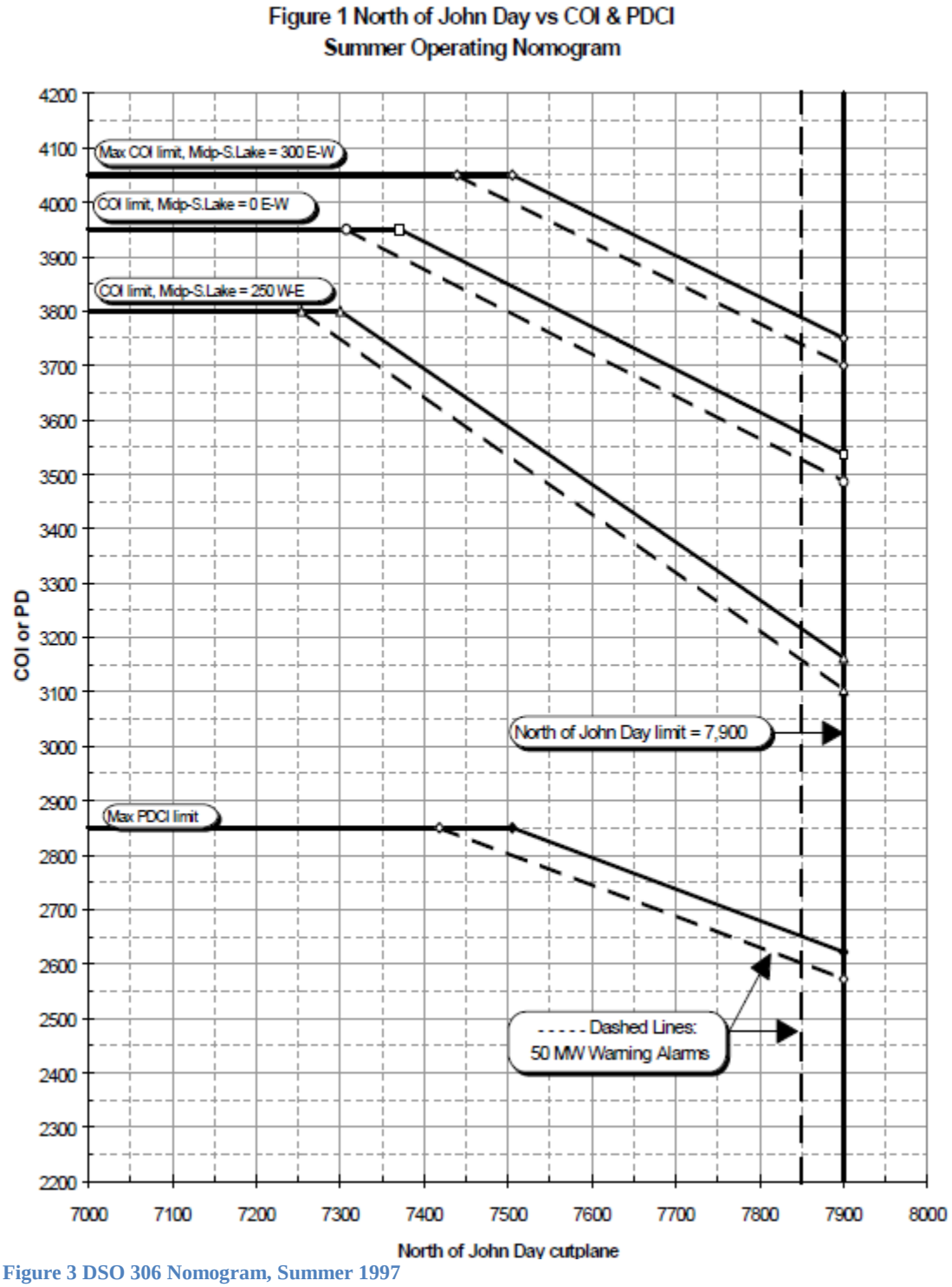

Figure 3 DSO 306 Nomogram, Summer 1997

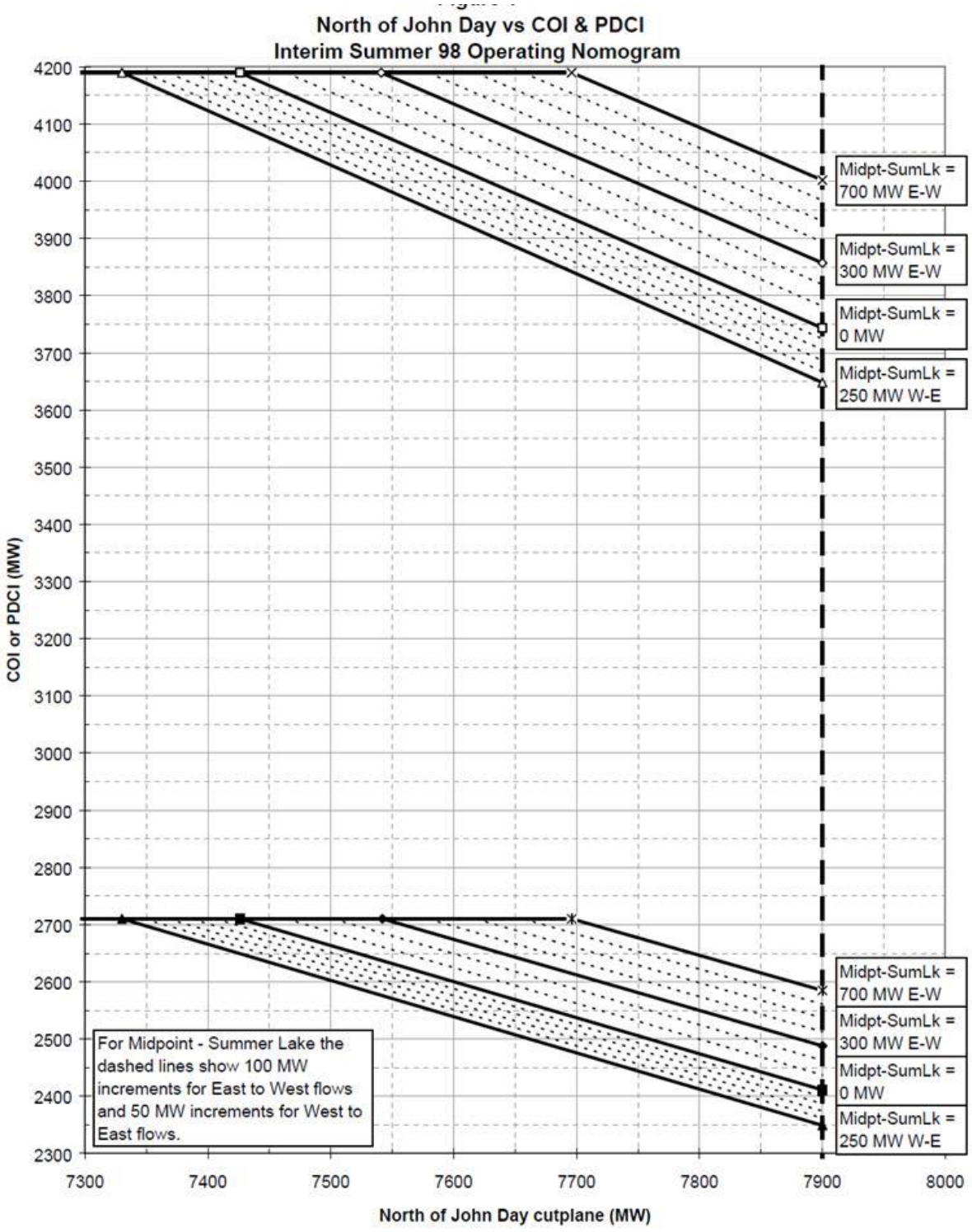

Figure 4 DSO 306 Nomogram, Summer 1998

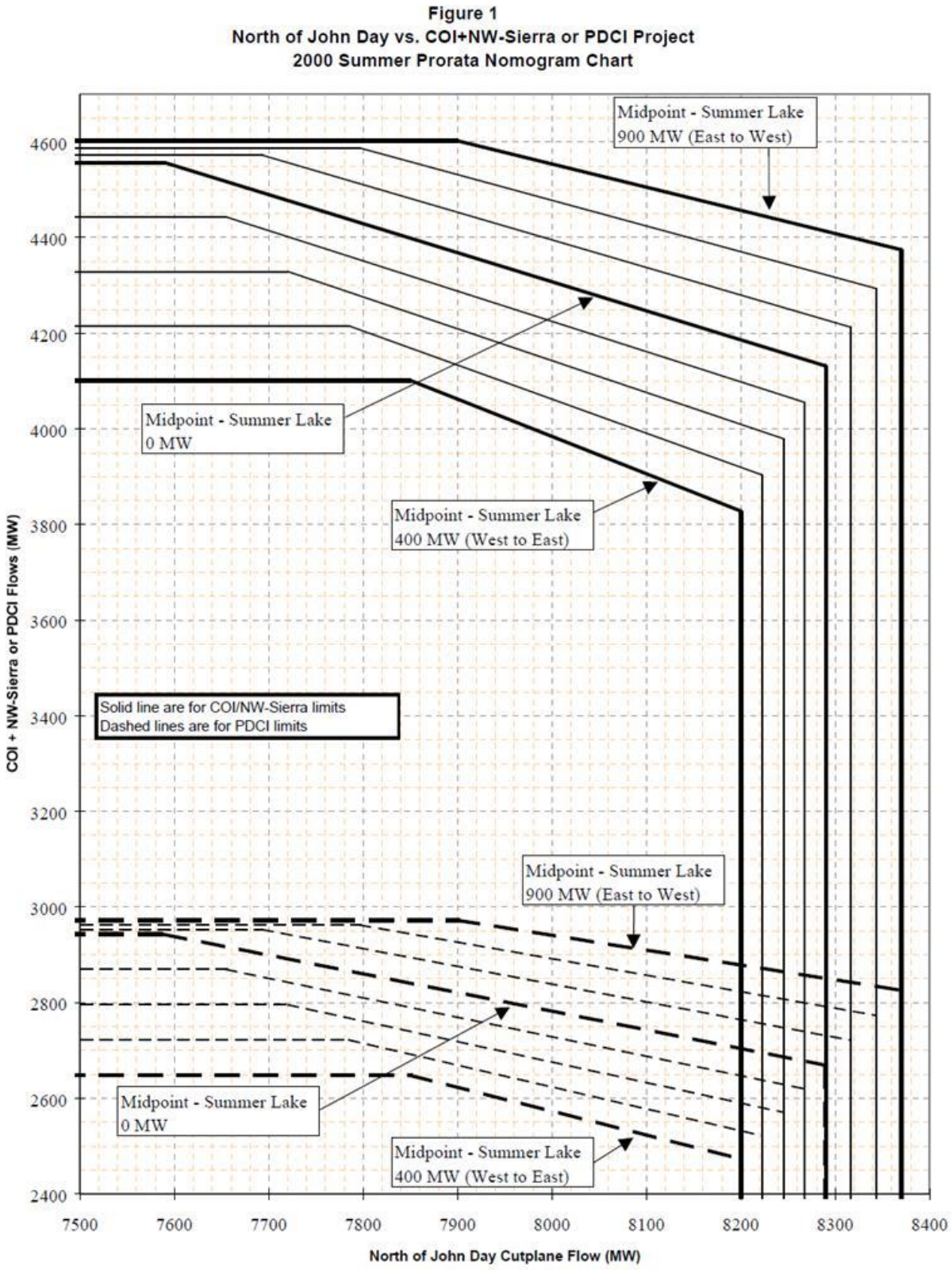

Figure 5 DSO 306 Nomogram, summer 2000

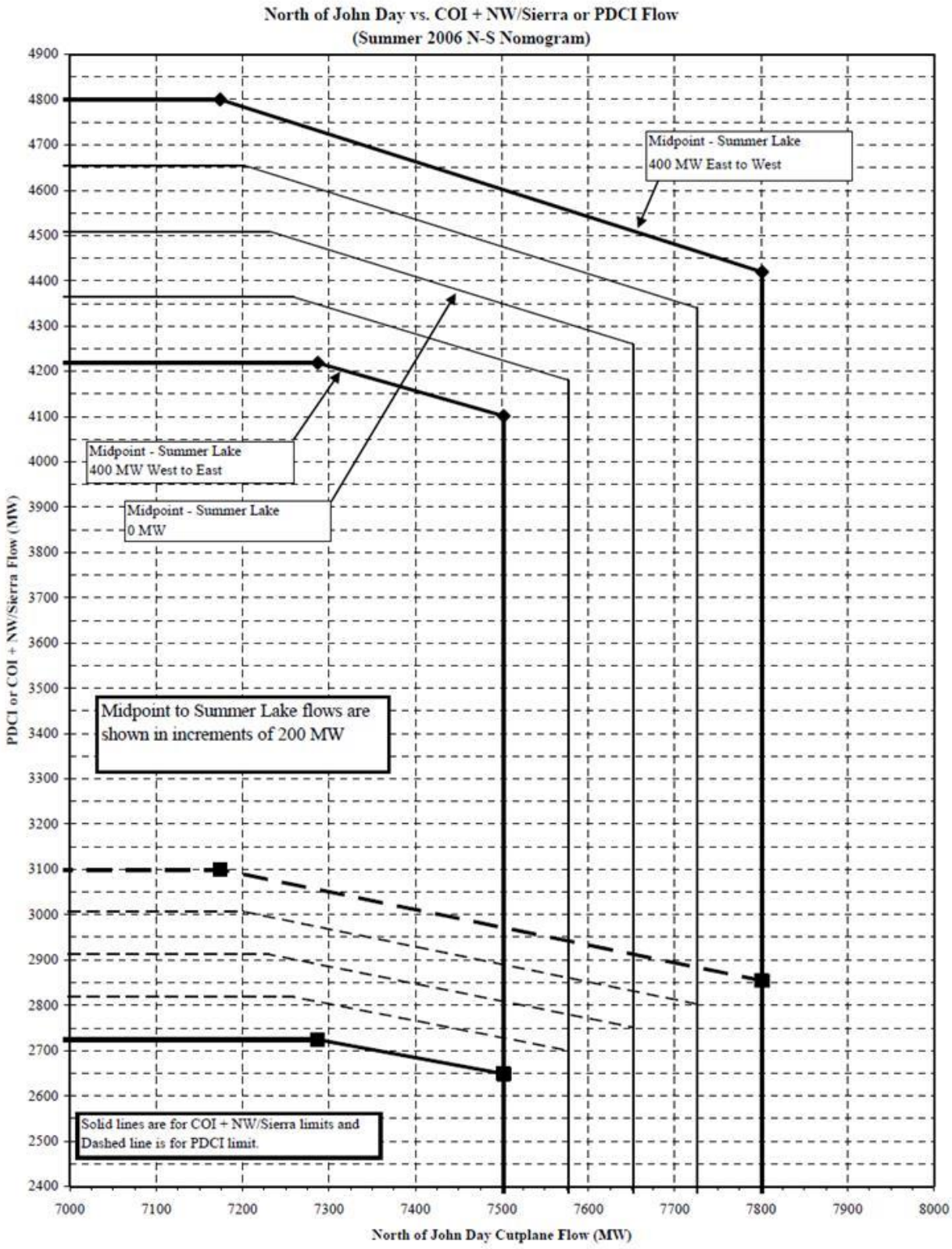

Figure 6 DSO 306 Nomogram, summer 2006

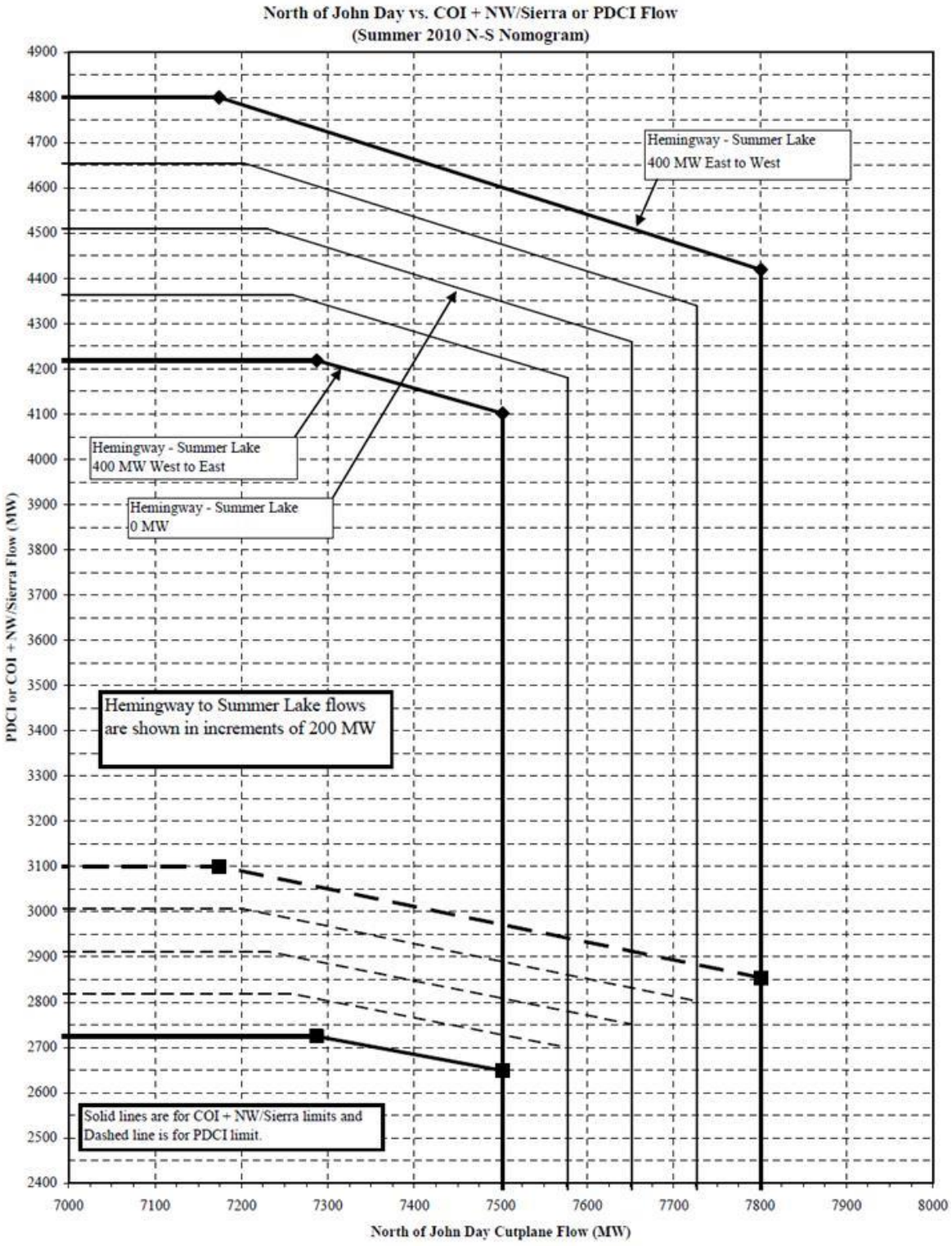

Figure 7 DSO 306 Nomogram, summer 2010

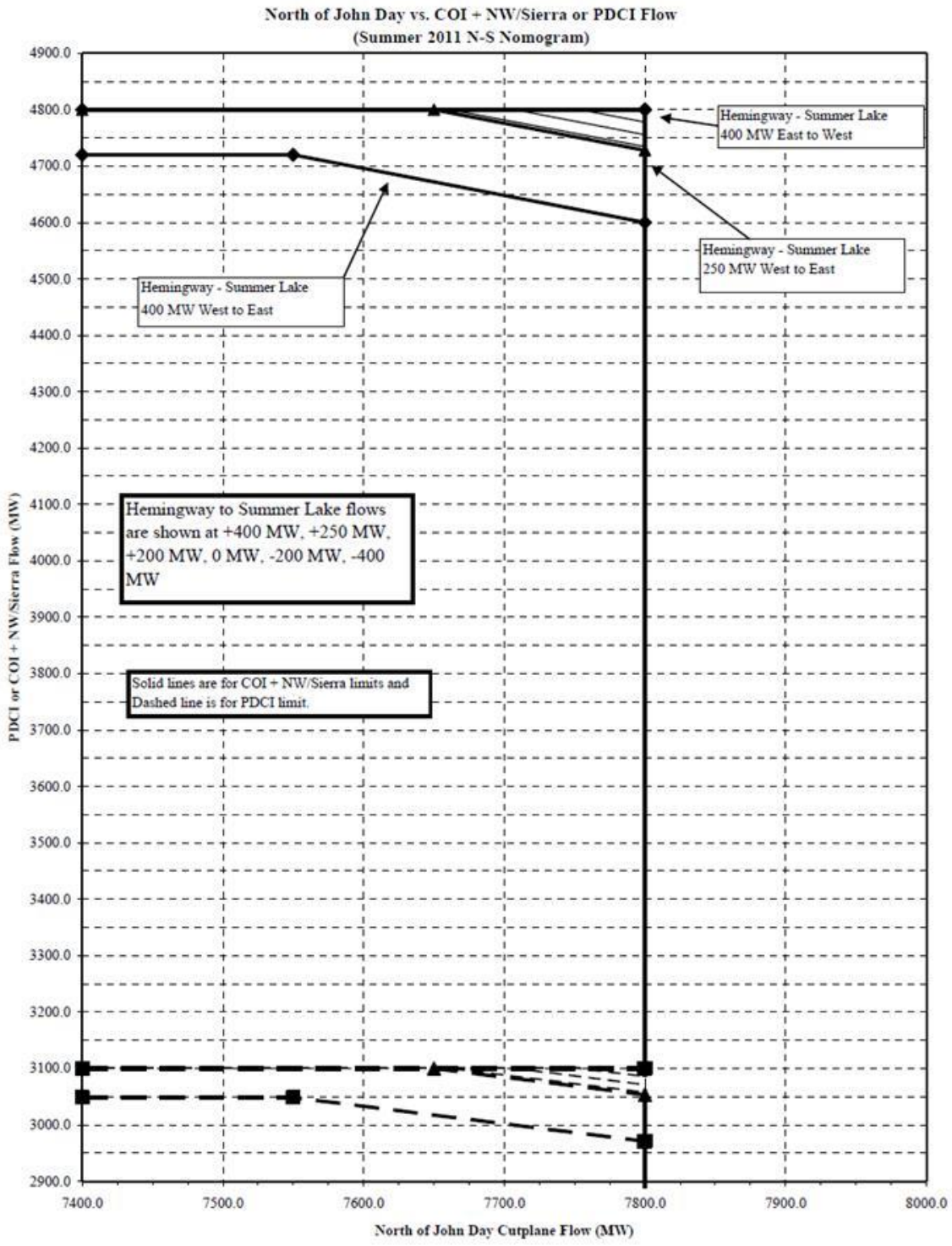

Figure 8 DSO 306 Nomogram, summer 2011

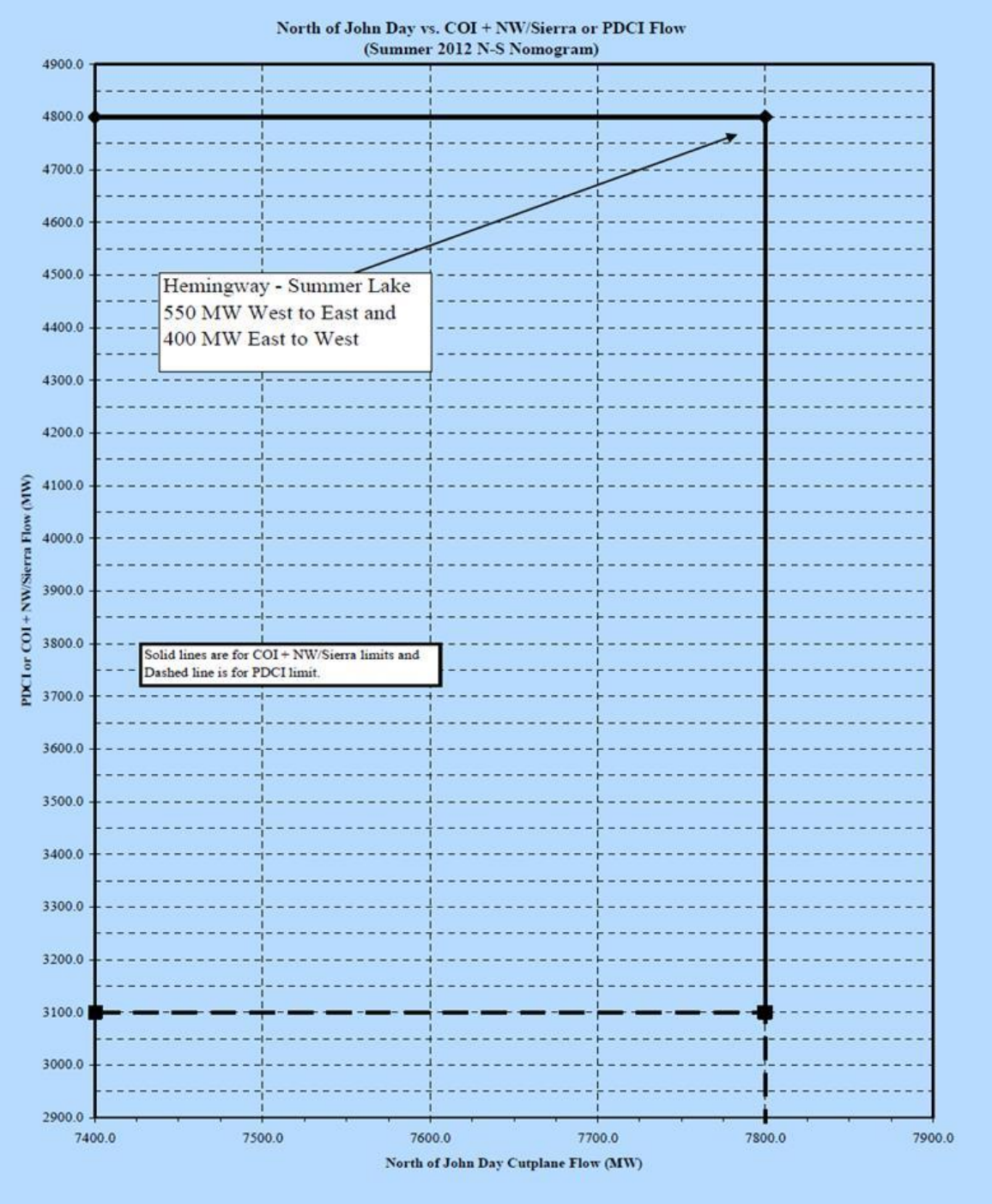

Figure 9 DSO 306 Nomogram, summer 2012

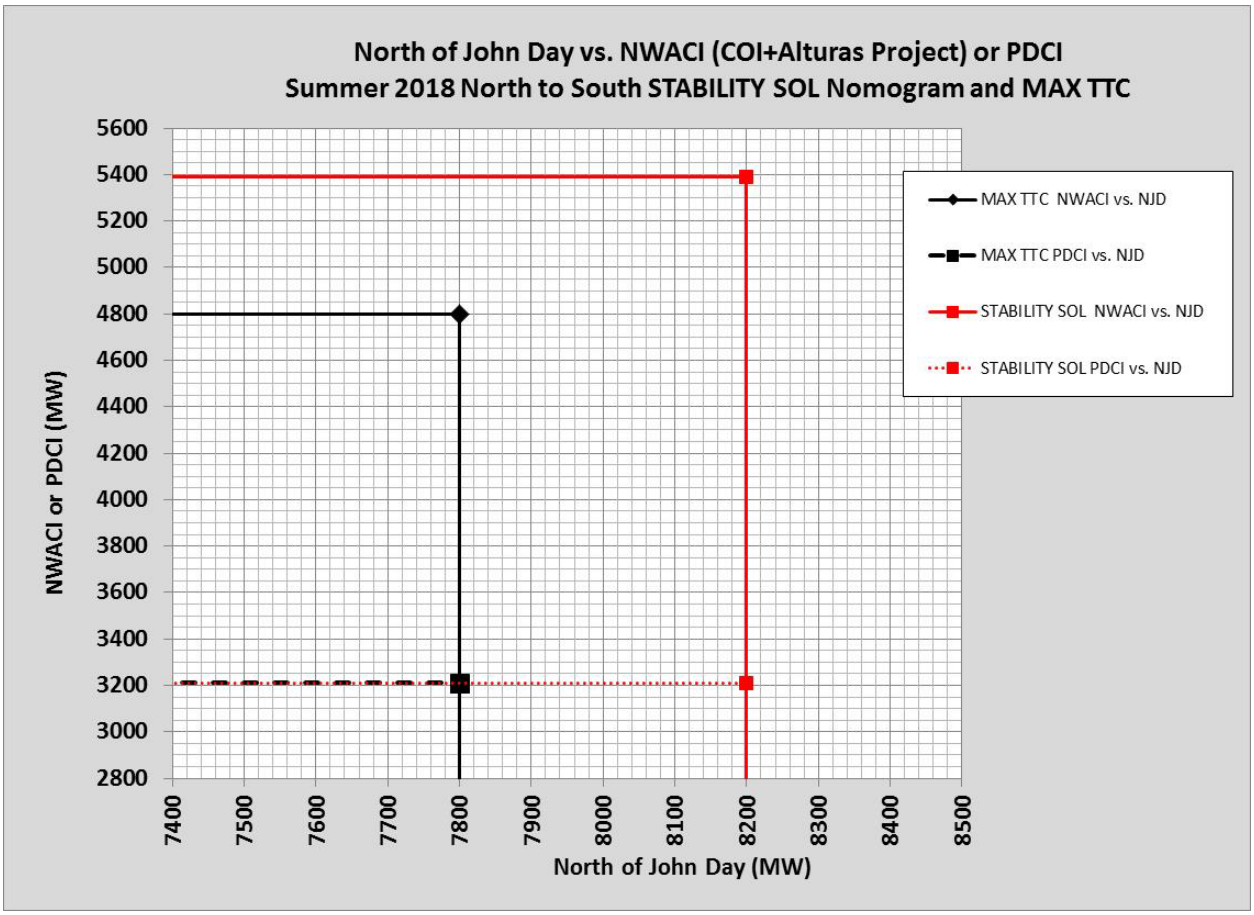

Figure 10 DSO 306 Nomogram, summer 2018

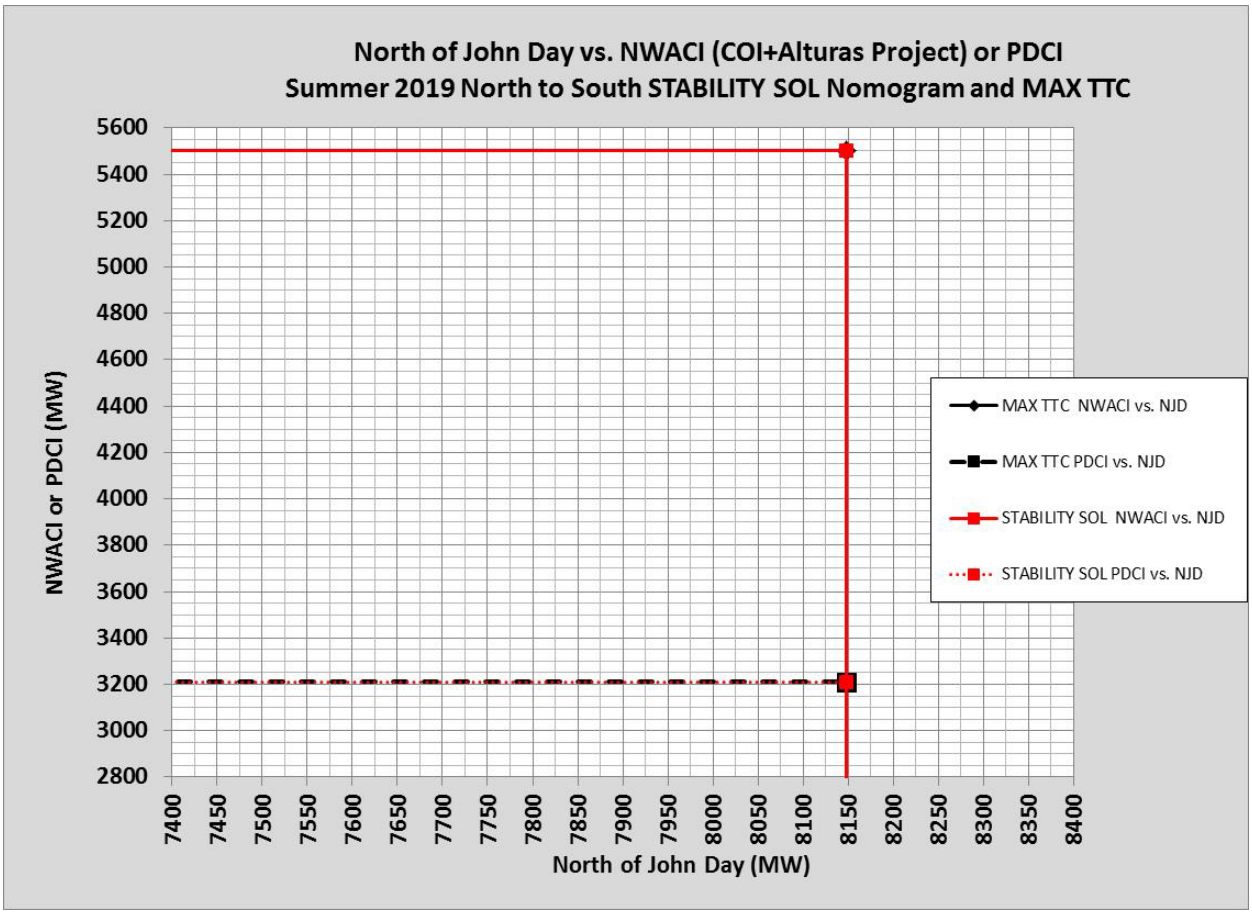

Figure 11 DSO 306 Nomogram, summer 2019