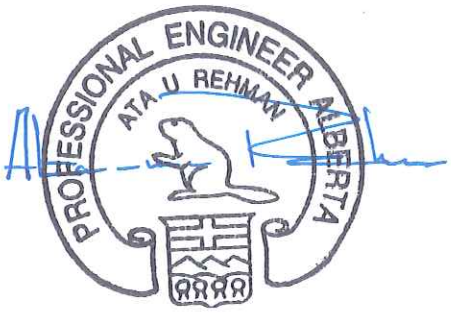
Engineering Study Report
AESO Project : RP-851

Date August 19, 2010



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APEGGA Permit to Practice P-08200

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LIST OF ATTACHMENTS

1.0 BACKGROUND

Trans Canada Corporation is proposing an expansion to extend the existing Keystone Pipeline Project currently under construction. The KXL Pipeline expansion will require additional Hardisty terminal pumping and storage facilities and four (4) transfer pumping stations along the Alberta pipeline section.

Table 1-1 below generally summarizes the approximate locations of the respective KXL pumping stations.

Table 1-1: Location of Keystone KXL Pipeline Pumping Stations

Station	Name	Location (LSD–SEC-TWP-RGE)*
PS 2	Lakesend East	3 – 14 – 39 – 6
PS 3	Monitor South	7 - 25 - 33 - 5
PS 4	Oyen South	16 – 20 – 27 - 4
PS 5	Blindloss South	16 – 20 – 21 - 2

*All land locations are West of the 4th Meridian.

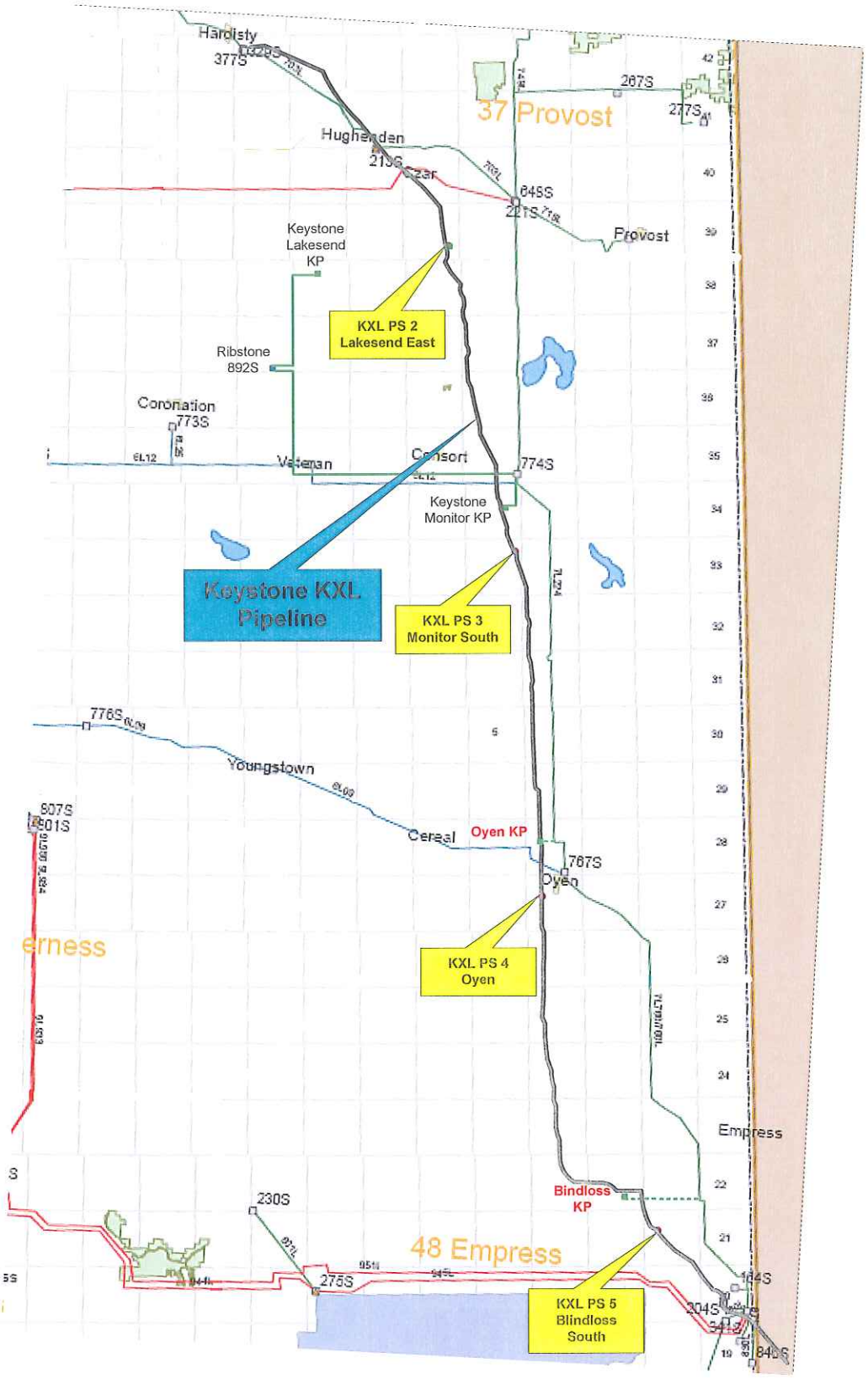
Table 1-2 below generally summarizes the service details for the respective KXL pumping stations.

		Load Development (MW)					
Station	Name	Stage 1	In-Service Date	Stage 2	In-Service Date	Stage 3	In-Service Date
PS 2	Lakesend East	1	2012-03-31	12	2012-11-01	15	Note 1.
PS 3	Monitor South	1	2012-04-28	12	2012-11-01	15	Note 1.
PS 4	Oyen South	1	2012-05-26	12	2012-11-01	15	Note 1.
PS 5	Blindloss South	1	2012-03-18	12	2012-11-01	15	Note 1.

NOTES:
1. All pump stations have an ultimate load projection of 25 MW, presently estimated to occur approximately 5 years after Stage 2 completion.

Figure 1-1 shows the proposed KXL pipeline routing and Alberta pumping station locations relative to existing area transmission system facilities.

Figure 1-1: Keystone Pipeline Alberta KXL Pump Station Locations



The addition of the Keystone and Keystone KXL Pipeline pump stations combined with other area load and wind generation growth were included in the southeastern Alberta regional transmission assessment comprising the Hanna (Area 42), Wainwright (Area 32), Alliance/Battle River (Area 36), Provost (Area 37) and Sheerness (Area 43) planning areas. The AESO subsequently applied and received approval for the Hanna Region Transmission Development to address identified deficiencies (http://www.aeso.ca/downloads/Hanna_NID_Filing_Aug14_Final.pdf).

Fortis Alberta advised that service to the Lakesend East and other KXL pumping stations cannot be accomplished utilizing area 25 kV distribution infrastructure (Fortis Alberta Keystone Pipeline PS2 Distribution Evaluation, Appendix A). A transmission supply proposal was requested for the Lakesend East pumping station. Discussions regarding supply security indicated that single-line extensions of, or taps from, existing area transmission circuits with single-transformer substations would be acceptable for all of the pipeline pumping stations provided the resulting configuration would not result in the simultaneous loss of sequential transfer pumping stations.

While a number of Lakesend East service connection alternatives are possible, only two (2) were given serious consideration. A 240 kV connection was eliminated due to substantially increased costs versus a lower voltage (i.e. 138 kV) connection since the supply security and reliability requirements offered by 138 kV connections were considered acceptable with substantially reduced environmental and visual impacts. Three (3) 138 kV connection arrangements were possible.

Alternative 1 involved constructing a dedicated 138 kV transmission line emanating from the Hansman Lake 650S substation to a 20/26.6/33.3 MVA 144-6.9 kV substation (Eyre 558S) at the Lakesend East pump station.

Alternative 2 involved constructing a new single-circuit transmission line tapping existing circuit 7L224 to a 20/26.6/33.3 MVA 144-6.9 kV substation (Eyre 558S) at the Lakesend East pump station.

Alternative 3 involved constructing a new double-circuit transmission line from existing circuit 7L224 to a 20/26.6/33.3 MVA 144-6.9 kV substation (Eyre 558S) at the Lakesend East pump station effectively providing two (2) lines of supply to the new substation.

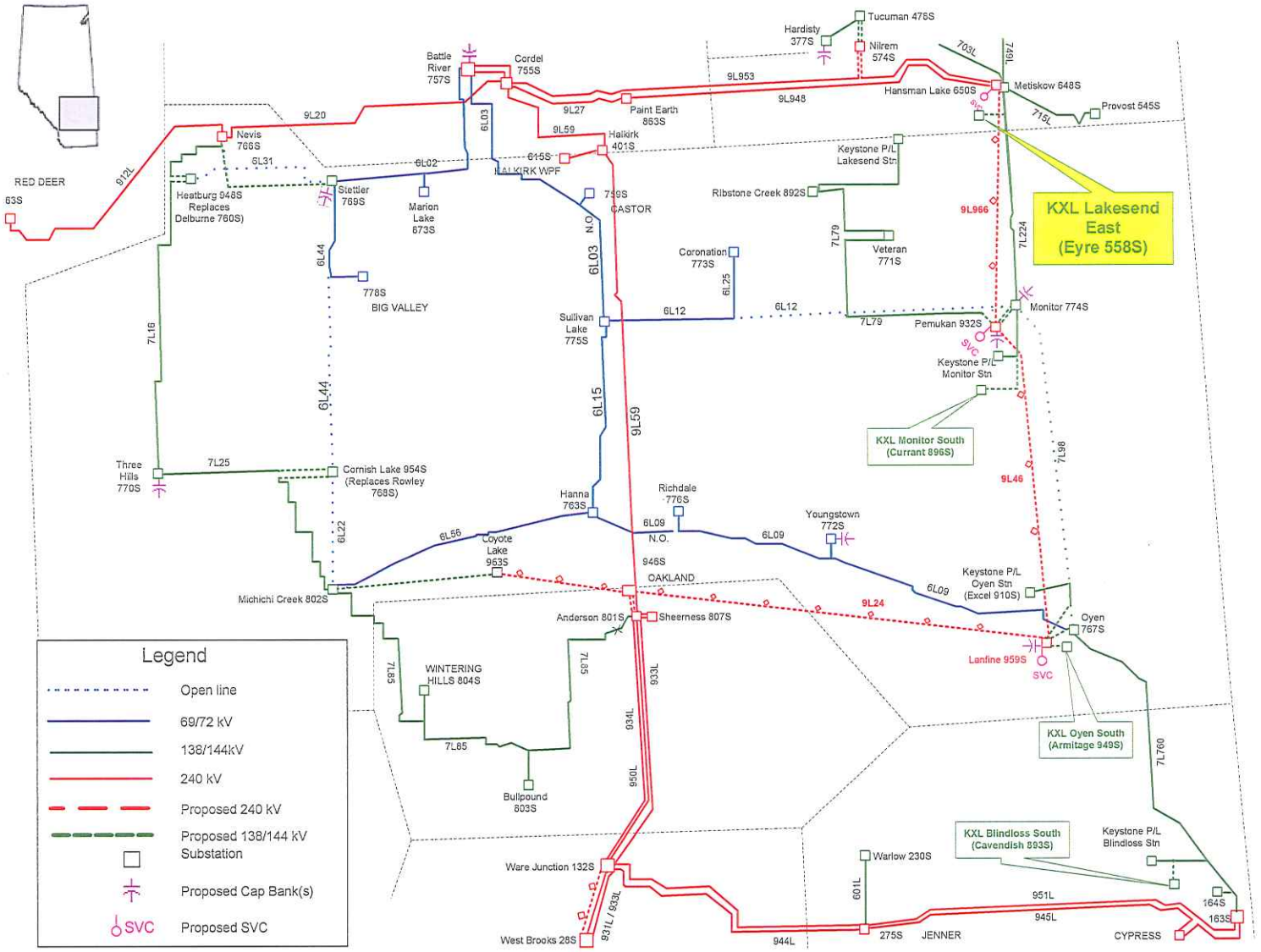
Alternative 3 was eliminated due to the anticipated incremental costs associated with such an arrangement and the AESO's proposed plan to open 7L224 to eliminate potentially damaging parallel flows following area 240 kV circuit contingencies. The resulting connection arrangement would then look very similar to the direct Hansman Lake 650S connection already contemplated (Alternative 1). Investment in the switching facilities required to realize the added flexibility of this connection arrangement could not be justified.

The two (2) remaining alternatives were considered feasible and include the same substation development. Differentiating factors include the respective points of connection, incremental costs of transmission line construction (22 km for Alt. 1 versus 16 km for Alt. 2), incremental switching facilities to achieve a Hansman Lake 650S connection (Alt 1) and perceived differences in expected performance.

Fortis Alberta ultimately elected to proceed with Alternative 2, the construction of approximately 16 km of 138 kV transmission line tapping existing circuit 7L224 to a 20/26.6/33.3 MVA 144-6.9 kV substation (Eyre 558S) at the Lakesend East pump station. Figure 1-2 is a regional transmission system one-line diagram showing the initial stage of Hanna Regional Transmission Development highlighting the proposed KXL pipeline Lakesend East pump station service connection. Future Keystone KXL pipeline pump station locations are also indicated for information purposes.

Attachment A contains more detailed single-line diagram representations of the proposed KXL Lakesend East pump station service connection development. The connecting transmission line will be constructed with 266.8 kcmil ACSR conductor to match existing circuit 7L224. The remaining KXL pipeline pump station service connections are indicated for information purposes only. Separate connection applications will be forwarded for each connection in due course.

Figure 1-3: Keystone KXL Lakesend East Pipeline Pump Station Connection



2.0 Criteria and Assumptions

The impact of the KXL pipeline Lakesend East and remaining KXL pipeline pump station connections has already been addressed from a regional perspective in the Hanna Region Transmission Development. This engineering report only deals with the specific alterations and augmentation of the local transmission network to accommodate Fortis Alberta's preferred connection for the KXL pipeline Lakesend East pump station in the context of the greater Hanna Region Transmission Development.

2.1 Load Forecast

All Keystone KXL pipeline pump station service load was included in the forecasted load development used for AESO Hanna Region Transmission study and reinforcement development including the KXL pipeline Lakesend East connection.

2.2 Generation Assumptions

No generation addition is proposed or included in the KXL pipeline Lakesend East or other pump station connections. Generation assumptions appearing in the AESO Hanna Region Transmission study and reinforcement development NID were used to assess the 2012 KXL pipeline Lakesend East pump station connection impacts.

2.3 Facility Ratings

Transmission facility ratings were reviewed and proposed upgrading, augmentation or mitigative measures have been addressed in the AESO's Hanna Region Transmission Development. Table 2.3-1 summarizes capability of new transmission line construction and circuit 7L224 comprising the KXL pipeline Lakesend East pump station service connection.

Table 2.3-1
Transmission Connection Ratings (MVA)

Element	From	To	Conductor	Summer	Winter
Tap	7L224	Eyre 558S	266.8 ACSR	120	146
7L224	Hansman Lake 650S	Monitor 774S	266.8 ACSR	120	146
Eyre 558S	138 kV bus	6.9 kV bus	N/A	20/26.6/33.3	

2.4 Reliability Criteria

AESO Planning Reliability Criteria was applied in the AESO Hanna Region Transmission study to test the performance of the area transmission system under Category A (i.e. all elements in service) and Category B (i.e. one element out-of-service) situations with due regard to radially connected loads. Category B contingencies also cover single element outage events while the most critical generator is out of service for maintenance or for commercial reasons, and the remaining generators in the system are dispatched according to the forecast merit order. AESO Reliability Criteria requires that the system remain stable, all equipment operate within applicable thermal and voltage limits and that all applicable performance standards are respected.

3.0 Impact Assessment

All anticipated Keystone and Keystone KXL pipeline loads were included in the load forecast utilized in the Hanna Region Transmission Development Study[1]. This study region comprised of Hanna-Area 42, Wainwright-Area 32, Alliance/Battle River-Area 36, Provost-Area 37 and Sheerness-Area 43 planning areas.. The HRTD steady-state and transient impact assessments included all Keystone and Keystone KXL pipeline pump station loads. Studies performed on the Stage 1 development proposed for completion in 2012 included the ultimate load forecast for the Keystone KXL pipeline pump stations thereby ensuring that the proposed reinforcement would be sufficient to satisfy this requirement until the second stage of development is completed (2017 presently proposed). The KXL pump station loads were connected to local 138 kV substation buses for steady-state and transient study purposes. Attachment B contains copies of power flows for Alternatives 1 & 3 Hanna Region Transmission Development for normal 2012 summer light, summer peak and winter peak cases studied showing the locations of the respective KXL pump station load connections used in the studies.

Hanna Region Transmission reinforcement developments are presently anticipated to be in place by August of 2012. TransCanada Corporation requested that connection facilities required to accommodate full operation at the respective pumping station locations be available to provide approximately 1 MW of construction power by the second quarter of 2012 (Table 1.0-1) in advance of some of the proposed 2012 Hanna Region Transmission reinforcement developments. None of the pumps will be operated prior to completion of associated critical elements of the Hanna Region Transmission reinforcement developments.

4.0 Available Short Circuit Currents

Short circuit current levels for the Eyre 558S substation (KXL pipeline Lakesend East pump station service)are provided below[2]. The values were generated using topology and generation dispatch representations utilized for 2012 Hanna region transmission reinforcement Stage1 development system impact assessment studies. Other area substation levels can be obtained from the Hanna Region Transmission Development NID.

Table 4-1
Estimated Eyre 558S 2012 Available Short Circuit Current Levels
Post Hanna Region Transmission Stage 1 Development

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[1] The AESO filed the Hanna Region Transmission Development NID with AUC and received its approval(Proceeding ID .278 and Application No.1605359)

[2] Short circuit current calculation is based on modeling information provided to the AESO by third parties. Short circuit estimation is subject to change. The information provided in this study is not intended to be used as the sole source of information for electrical equipment specification and the design of public or worker safety-grounding systems.

Voltage (V_{bus},kV)	Voltage[1.]	Pos. Seq. $(R_1+jX_1)^2$	3-Ø-G (A)	Zero Seq. $(R_0+jX_0)^2$	L-G (A)
138	1.035	0.03969+j0.09513	4199	0.16265+j0.61389	1546

NOTES:

1. P.U. pre-fault voltage; $V_{base}= V_{bus}$
2. P.U. quantity, $MVA_{base}= 100$.
3. The AESO is currently in the process of verifying and validating the sequence impedance data for the AIES. The Line to Ground (L-G) 1-phase fault levels therefore has a tolerance of +/- 10%.

5.0 Summary and Conclusions

AESO studies for the existing system considering the addition of the Keystone and Keystone KXL Pipeline Projects combined with other area load and wind generation growth for the Hanna (Area 42), Wainwright (Area 32), Alliance/Battle River (Area 36), Provost (Area 37) and Sheerness (Area 43) planning areas indicated thermal, voltage and stability deficiencies. The existing system topology was incapable of accommodating most of the anticipated load growth in the area including the Keystone KXL pipeline pump station service requirements. The AESO investigated a number of reinforcement alternatives and subsequently applied for and received approval to proceed with Hanna Region Transmission (Reinforcement) Development. The proposed Hanna Region Transmission development addresses all forecasted load and wind generation development including the proposed Keystone KXL pipeline pump station service requirements.

Table 1-1 provides staged load developments for the Keystone KXL pipeline Lakesend East pump station service. The Hanna region transmission reinforcement Stage1 development (2012) included Keystone KXL pipeline Lakesend East pump station service stage 3 load development (2015) to ensure capability to serve Keystone KXL pipeline pump station services until Hanna region transmission reinforcement Stage2 development is completed (2017).

The existing Hanna region transmission is capable of providing the approximate 1 MW construction power requirement for the Lakesend East and all remaining Keystone KXL pump station services in advance of the Hanna Region Transmission Stage 1 Development completion.

ATTACHMENT A

Single Line Diagrams

KXL Pipeline Lakesend East Pump Station
Service Connection

Figure A-1: KXL Pipeline Lakesend East Pump Station Service Connection Development

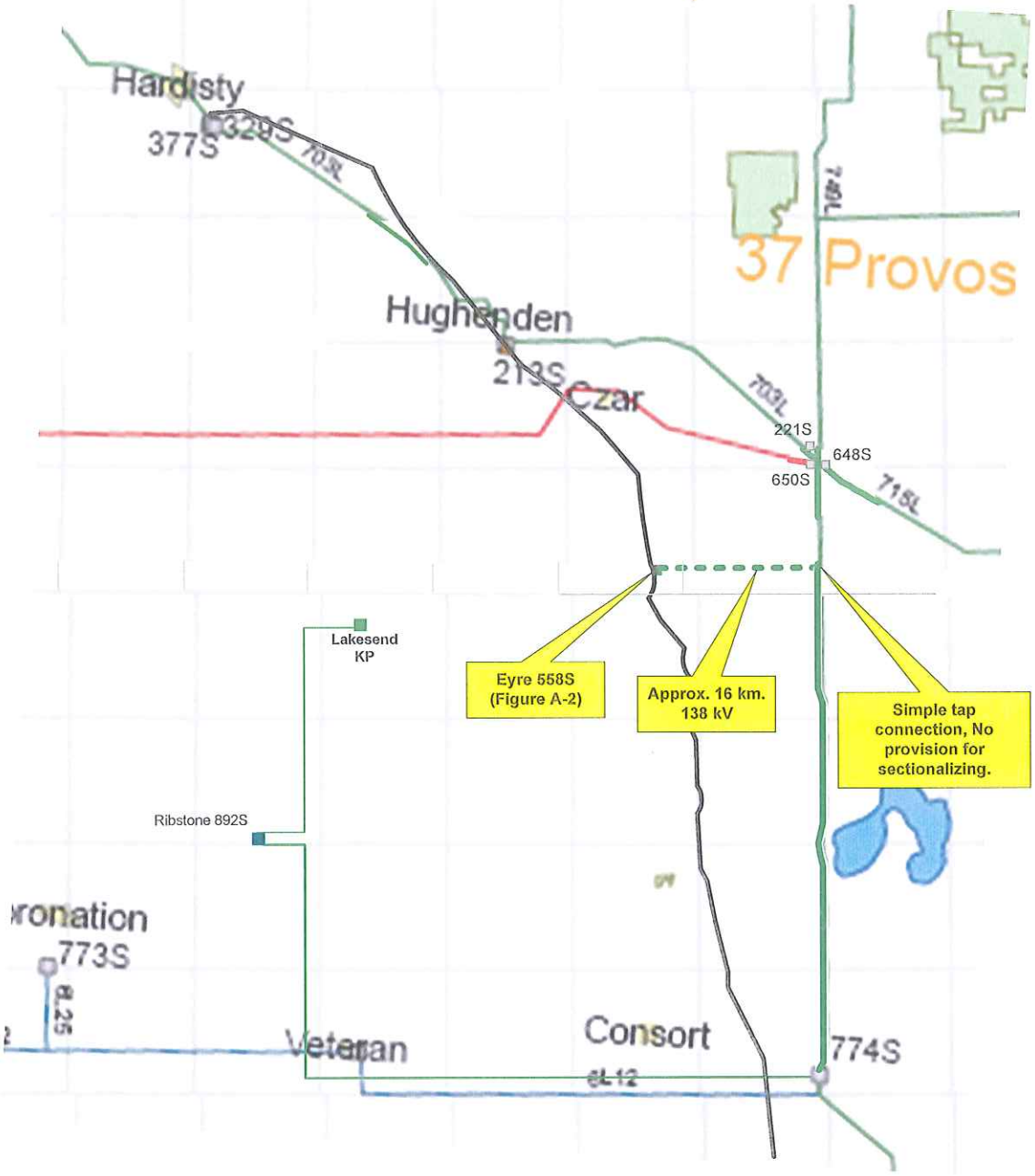
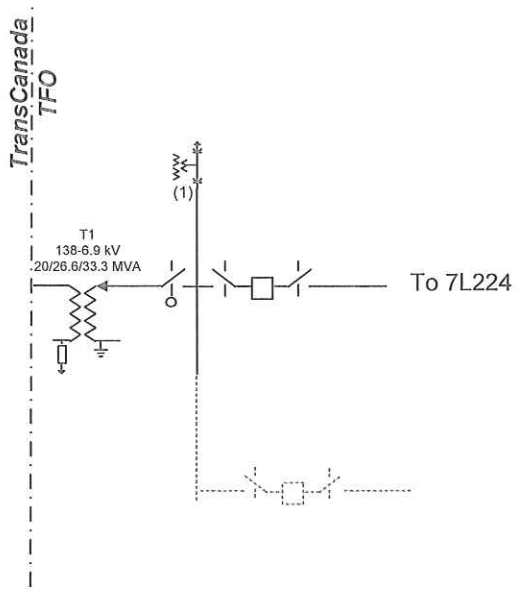


Figure A-2: KXL Pipeline Lakesend East Pump Station Service Connection Development

Figure A-2
XL Lakesend East Pumpstation Supply
Eyre 558S Substation



LEGEND

Proposed

Future (Layout Planning Only)

ATTACHMENT B

2012 Hanna Region Transmission Development Study Power Flow Diagrams

KXL Pipeline Pump Station Load Connection

Figure B-1
KXL Pump Station Load Modeled
Alt 1&3 WP BR5 Off No Additional Wind
Hanna Region Transmission Development

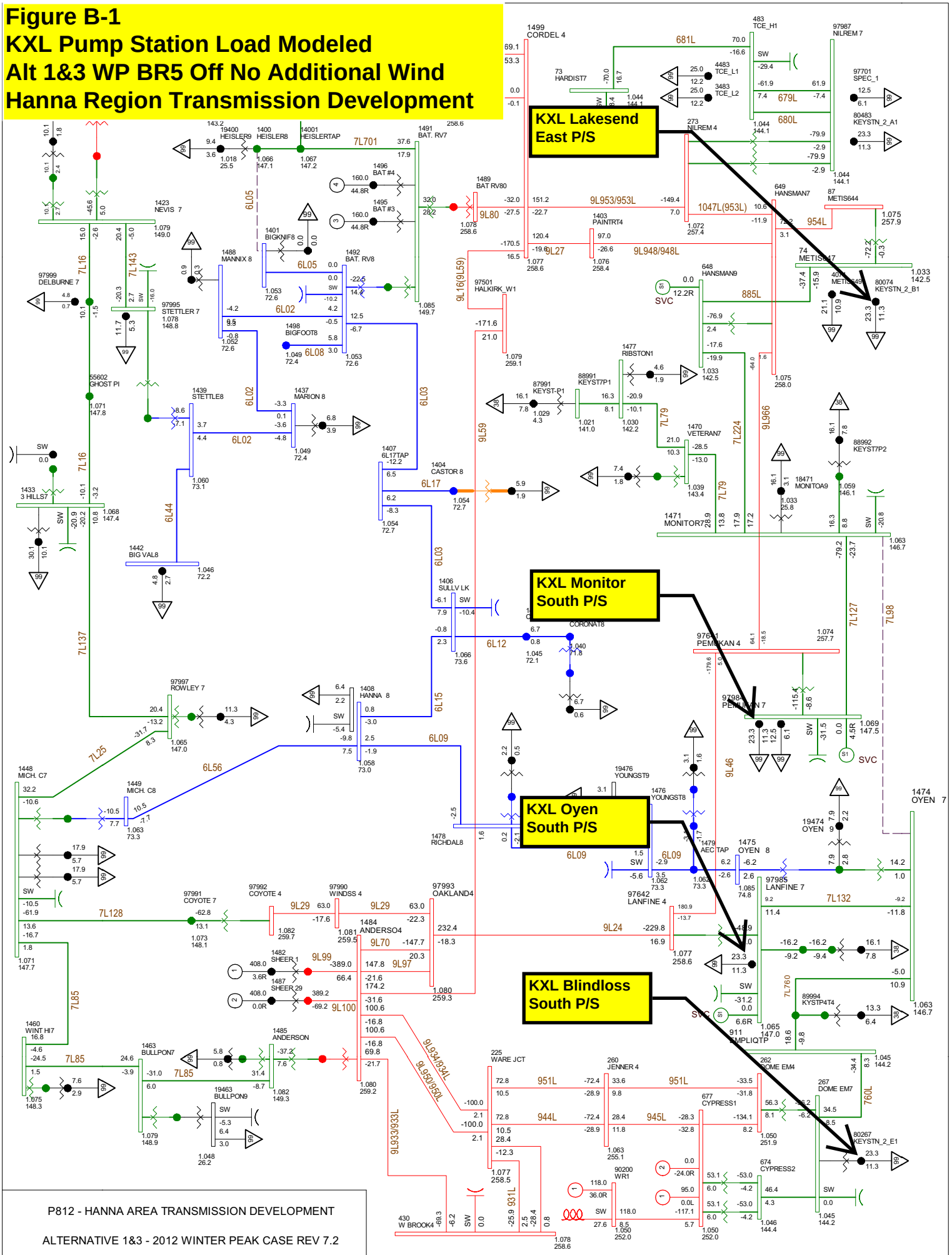
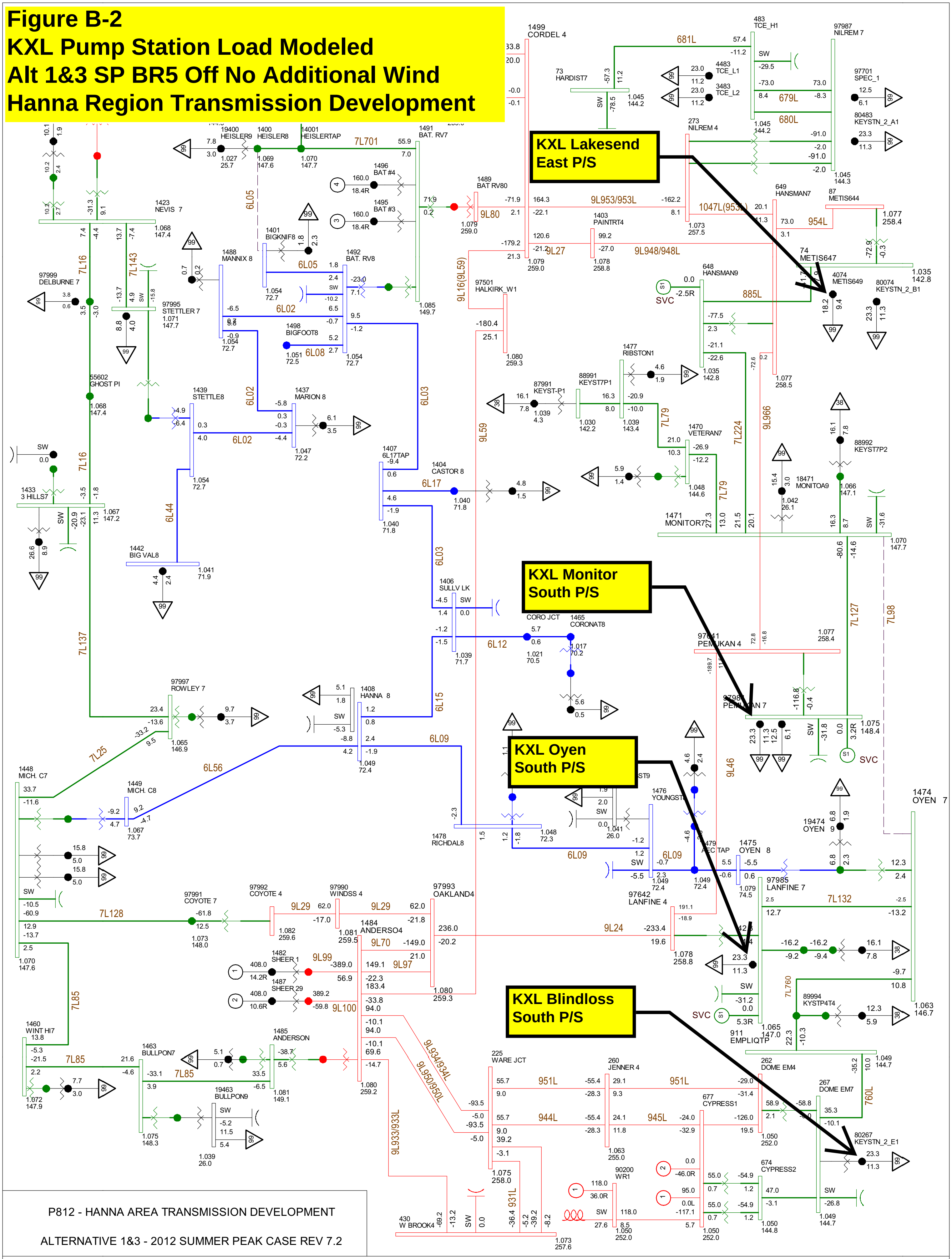


Figure B-2
KXL Pump Station Load Modeled
Alt 1&3 SP BR5 Off No Additional Wind
Hanna Region Transmission Development



P812 - HANNA AREA TRANSMISSION DEVELOPMENT

ALTERNATIVE 1&3 - 2012 SUMMER PEAK CASE REV 7.2

Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
100.0%RATEA
KV: <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

FIG 2012-ALT1&3-SP-1 (BR UNIT 5 OFF)
ALL ELEMENTS IN SERVICE
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D-2012-44

Figure B-3
KXL Pump Station Load Modeled
Alt 1&3 SL BR5 Off No Additional Wind
Hanna Region Transmission Development

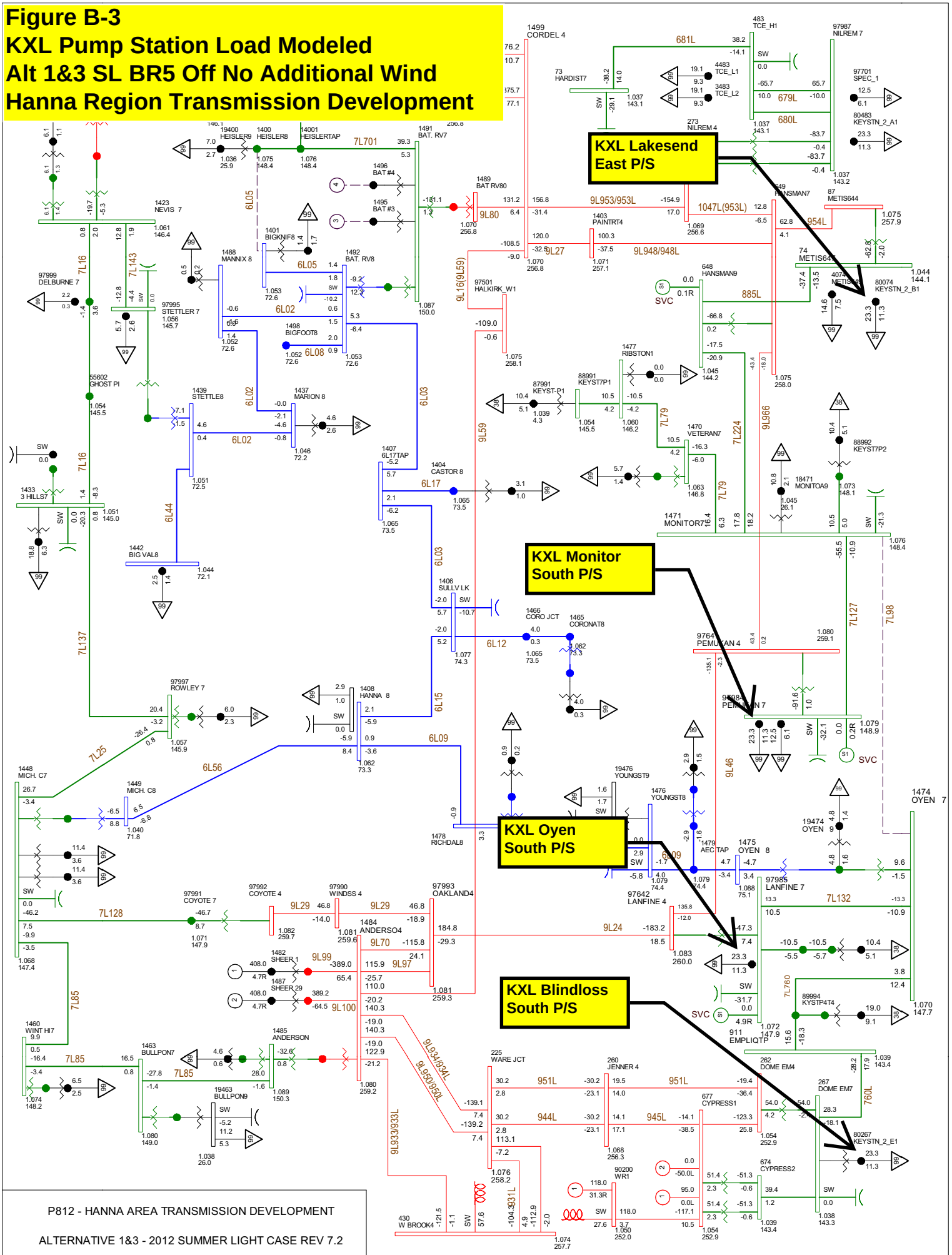
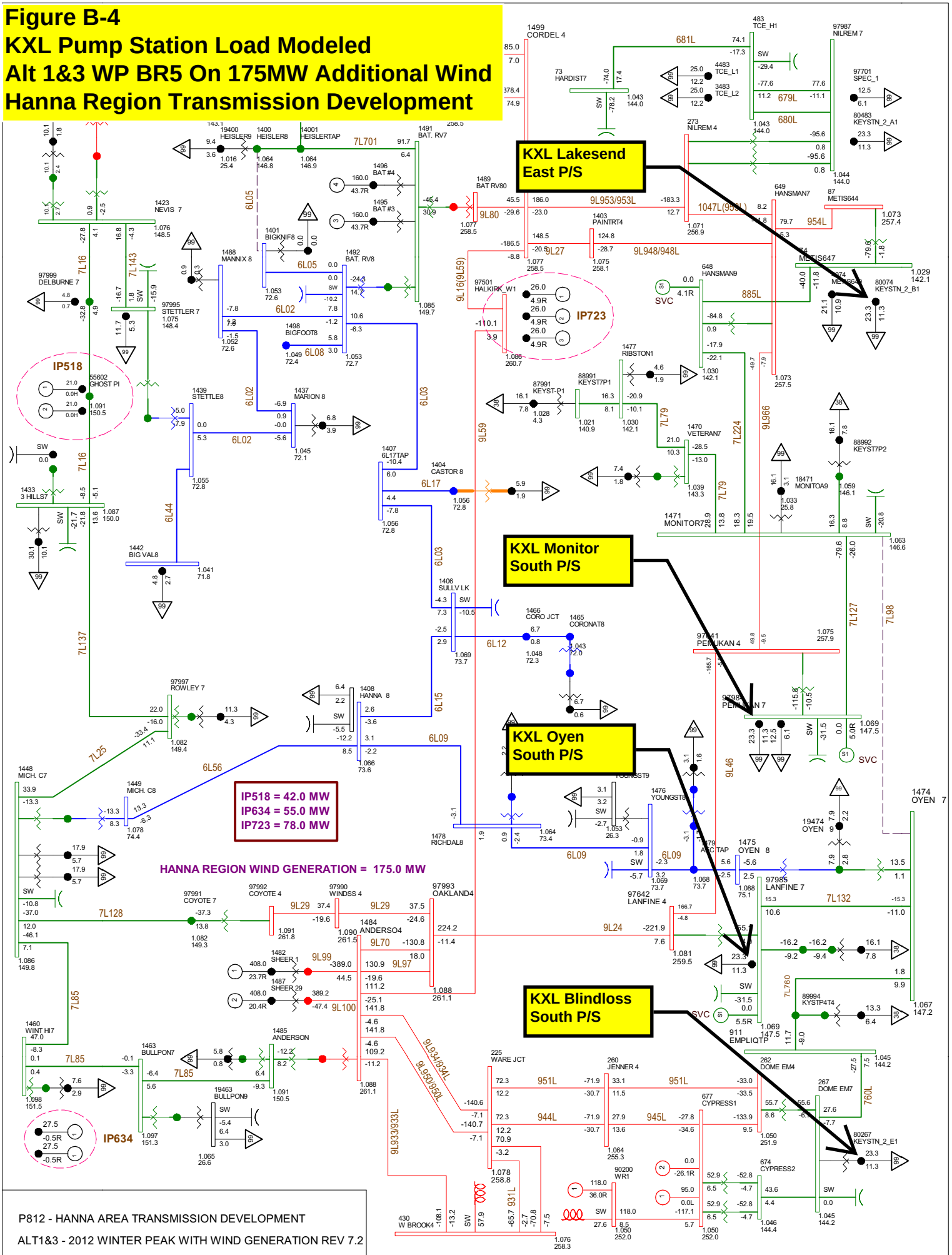


Figure B-4
KXL Pump Station Load Modeled
Alt 1&3 WP BR5 On 175MW Additional Wind
Hanna Region Transmission Development



P812 - HANNA AREA TRANSMISSION DEVELOPMENT

ALT1&3 - 2012 WINTER PEAK WITH WIND GENERATION REV 7.2

Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
100.0%RATE
KV: <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

FIG 2012-ALT1&3-WIND-WP-2 (BR UNIT 5 ON)
ALL ELEMENTS IN SERVICE
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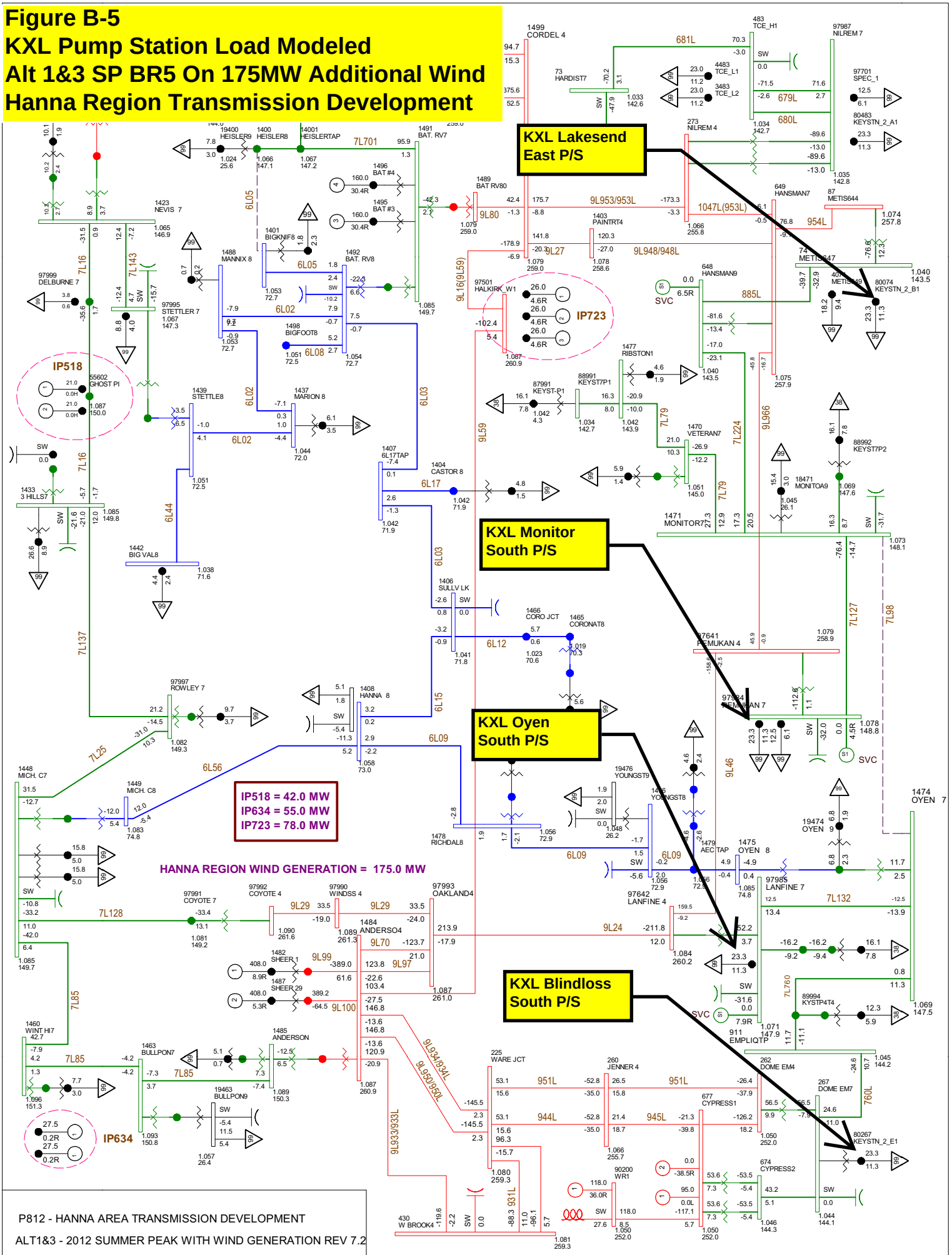
Figure B-5
KXL Pump Station Load Modeled
Alt 1&3 SP BR5 On 175MW Additional Wind
Hanna Region Transmission Development



P812 - HANNA AREA TRANSMISSION DEVELOPMENT

ALT1&3 - 2012 SUMMER PEAK WITH WIND GENERATION REV 7.2

Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
100.0%RATEA
KV: <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >500.000

FIG 2012-ALT1&3-WIND-SP-2 (BR UNIT 5 ON)
ALL ELEMENTS IN SERVICE
SUN, JUL 26 2009 15:46

D-2012-186

Figure B-6
KXL Pump Station Load Modeled
Alt 1&3 SL BR5 On 175MW Additional Wind
Hanna Region Transmission Development