The Energy Queensland Group Final Project Assessment Report

8 October 2018

MCE Mount Crosby East – Establish new substation to replace Mount Crosby Substation (SSMTC)

Part of the Energy Queensland Group

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Executive summary

Description of the network risks

Mount Crosby Substation (SSMTC) is a dedicated customer substation providing supply to Seqwater's East Bank Raw Water Pumping Station (RWPS) and East Bank Water Treatment Plant (WTP) via 5 x 5MVA 33/5.5kV Energex owned transformers. The customer is equipped with a 5-section 5.5kV ring bus containing 800A transformer circuit breakers. The ring bus supplies 16 motors, the majority of which are started direct-on-line. This water treatment plant supplies 50 per cent of the drinking water in South East Queensland, benefiting 1.6 million customers.

Based on a Condition Based Risk Management (CBRM) analysis of the effect of current condition and ageing on the expected life of the asset, the following plant at SSMTC have been deemed to have reached retirement age as follows:

- 4 x 5MVA 33/5.5kV transformers (TR1/TR2/TR3/TR4);
- 2 x 50kVA station service transformers (TR8/TR9); and
- 2 x 33kV outdoor feeder circuit breakers (CB3682 and CB4202).

The cost to replace this equipment under a refurbishment project was estimated at $9.1 million at 2015/16 price.

In 2016, Seqwater informed Energex of their requirement for 1:10,000 AEP flood immunity for the critical electrical infrastructure at the Mount Crosby East Bank RWPS. This prompted a complete review of the scope of the project. This required the substation to be relocated to a higher position.

In October 2017 Seqwater formally informed Energex of their decision to upgrade their supply voltage level at the RWPS and WTP from 5.5kV to 11kV. This allowed Energex to use standard equipment for the proposed substation.

The proposed project to address the Energex equipment refurbishment requirements together with the customer's requirements is to establish a new 33/11kV substation, Mount Crosby East Zone Substation at a new location for a total cost of $20.04 million with the customer making a contribution of approximately $10.6 million. This capital contribution will be reconciled based on the actual cost of the project upon completion, subject to negotiated project variation cost-sharing.

Recommendation

It is recommended that Energex establish the new Mount Crosby East Zone Substation (SSMCE) and recover the existing Mount Crosby Zone Substation (SSMTC), for a total estimated cost of $20.04 million at 2018/19 prices. The customer will make an upfront capital contribution of approximately $10.6 million toward these works, to be reconciled as per the total actual cost of the project, less the escalated cost of the original project, subject to negotiated project variation cost-sharing. The target completion date for the recommended development is September 2020.

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1.0 EXISTING NETWORK

1.1 Introduction

Mount Crosby Substation (SSMTC) is a dedicated customer substation providing supply to Seqwater's East Bank Raw Water Pumping Station (RWPS) and East Bank Water Treatment Plant (WTP) via 5 x 5MVA 33/5.5kV Energex owned transformers. The customer is equipped with a 5-section 5.5kV ring bus containing 800A transformer circuit breakers. The ring bus supplies 16 motors, the majority of which are started direct-on-line. This water treatment plant supplies 50 per cent of the drinking water in South East Queensland, benefiting 1.6 million customers.

In March 2016, Energex was ready with the Feasibility Study for the project to replace four 33/5.5kV transformers and two 33kV circuit breakers at SSMTC for an estimated cost of $9.1M at 2015/16 prices, with an escalated cost of $9.4 million at 2018/19 prices. This was a refurbishment-driven project to replace assets that were deemed to reach retirement age.

In September 2016, Seqwater formally informed Energex of their flood immunity requirement of 1:1,000 AEP for existing infrastructure and 1:10,000 AEP for new critical electrical infrastructure at the Mount Crosby East Bank RWPS. This prompted a complete review of the scope of the project. Seqwater requested Energex to establish a new substation to supply the RWPS and WTP loads at a new site to meet the 1:10,000 AEP flood immunity requirement on the condition that the cost difference between the original replacement project and the new substation will be payable by Seqwater, subject to negotiated project variation cost-sharing. Energex assisted Seqwater in assessing a number of potential substation sites that satisfies the technical requirements of both organisations.

In October 2017, Seqwater formally informed Energex of their decision to upgrade their supply voltage level at the RWPS and WTP from 5.5kV to 11kV. This allows Energex to use standard equipment for the proposed new substation. It was also at this time that Seqwater finalised the site selection for the proposed substation.

Considering that the 33/5.5kV transformers TR1-TR4 have already reached retirement age and to mitigate the impacts of a failure of one of these transformers, an 8MVA 33/5.5kV transformer was purchased and delivered to the existing SSMTC as part of the contingency plan. This will allow the quick connection of this spare transformer in a contingency event.

Geographic and schematic views of the network area under study are provided in Figure 1 to Figure 3.

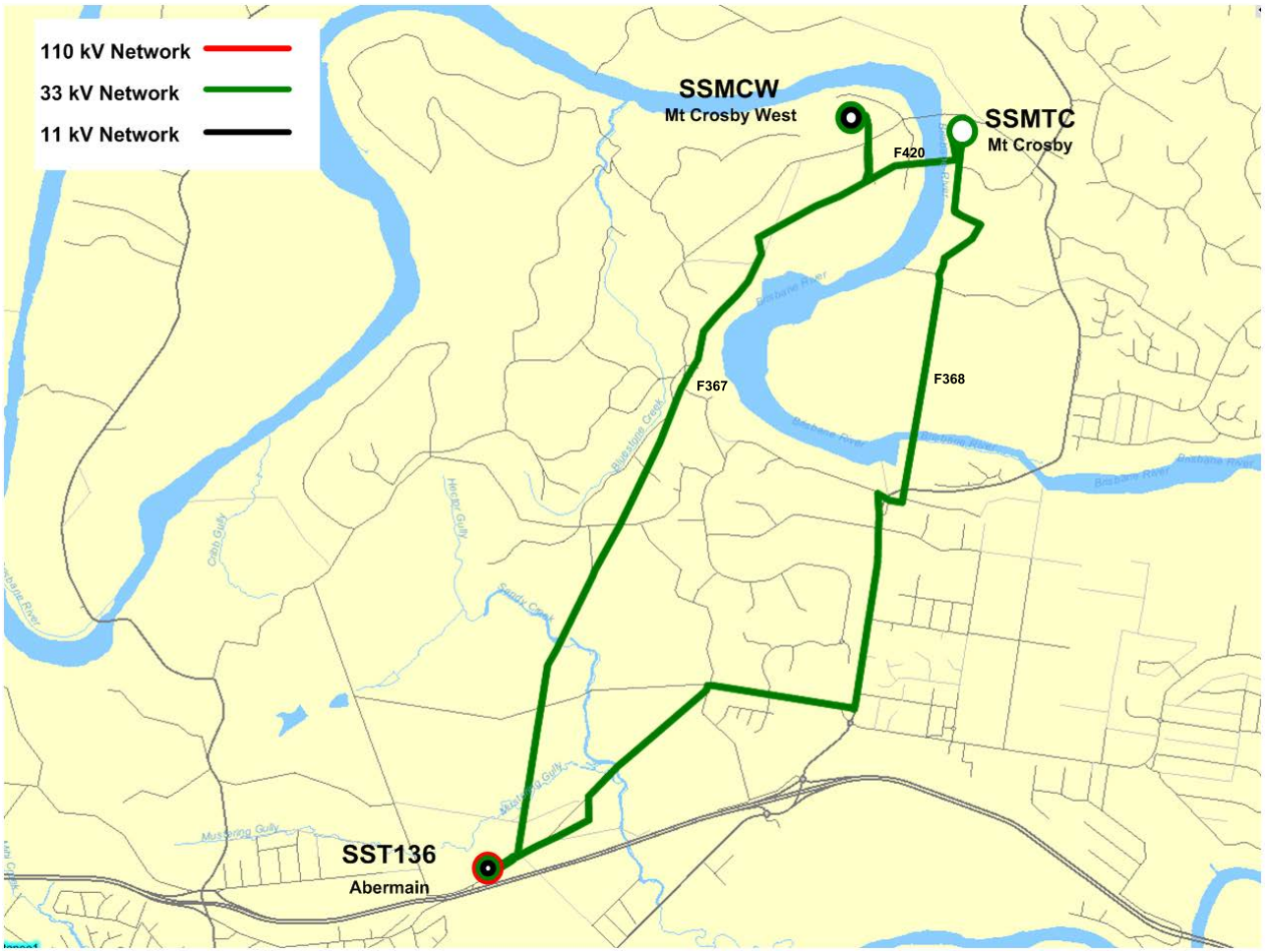

Figure 1: Existing network arrangement (geographic view)

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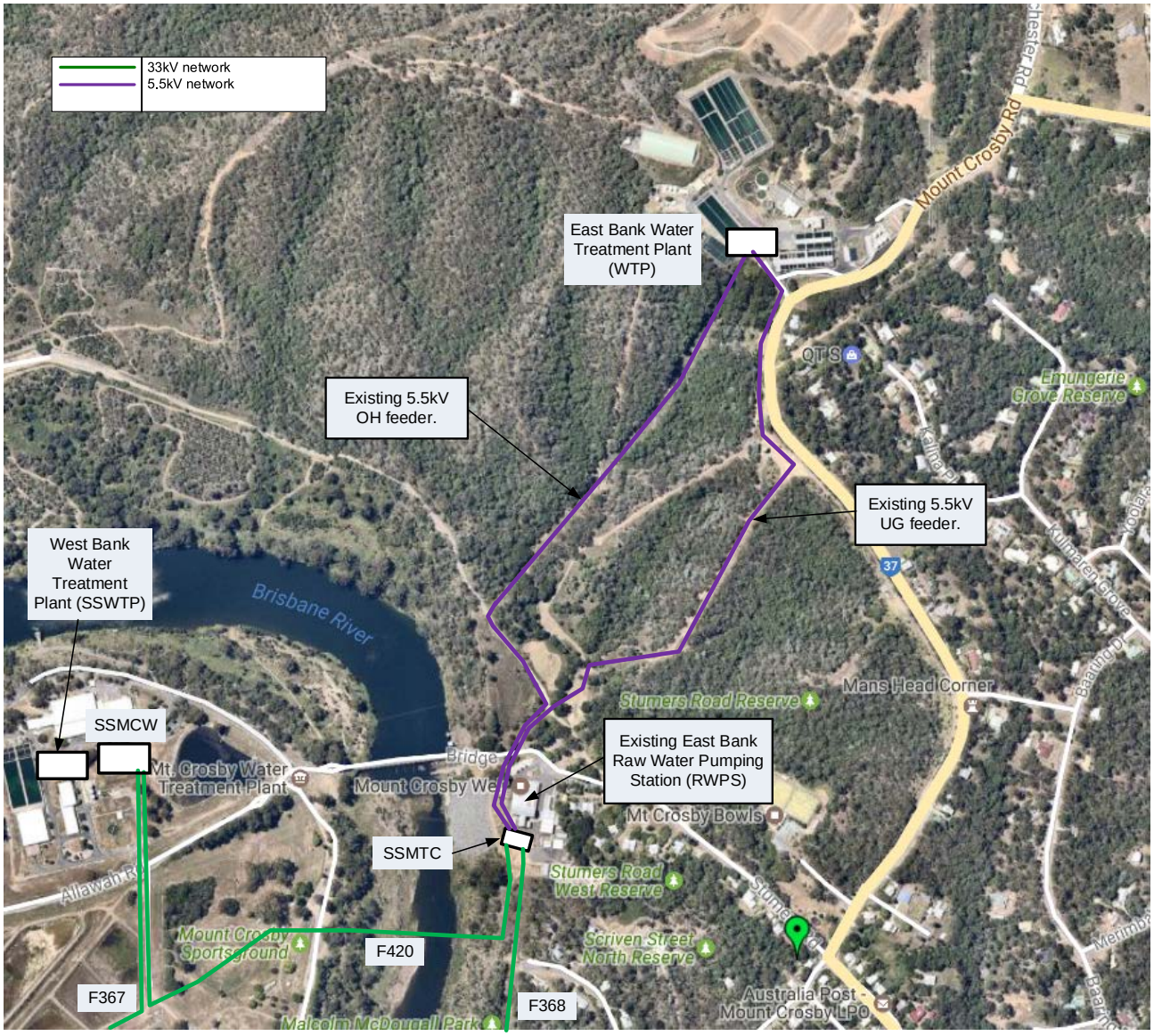


Figure 2: Existing network arrangement at SSMTC (geographic view)

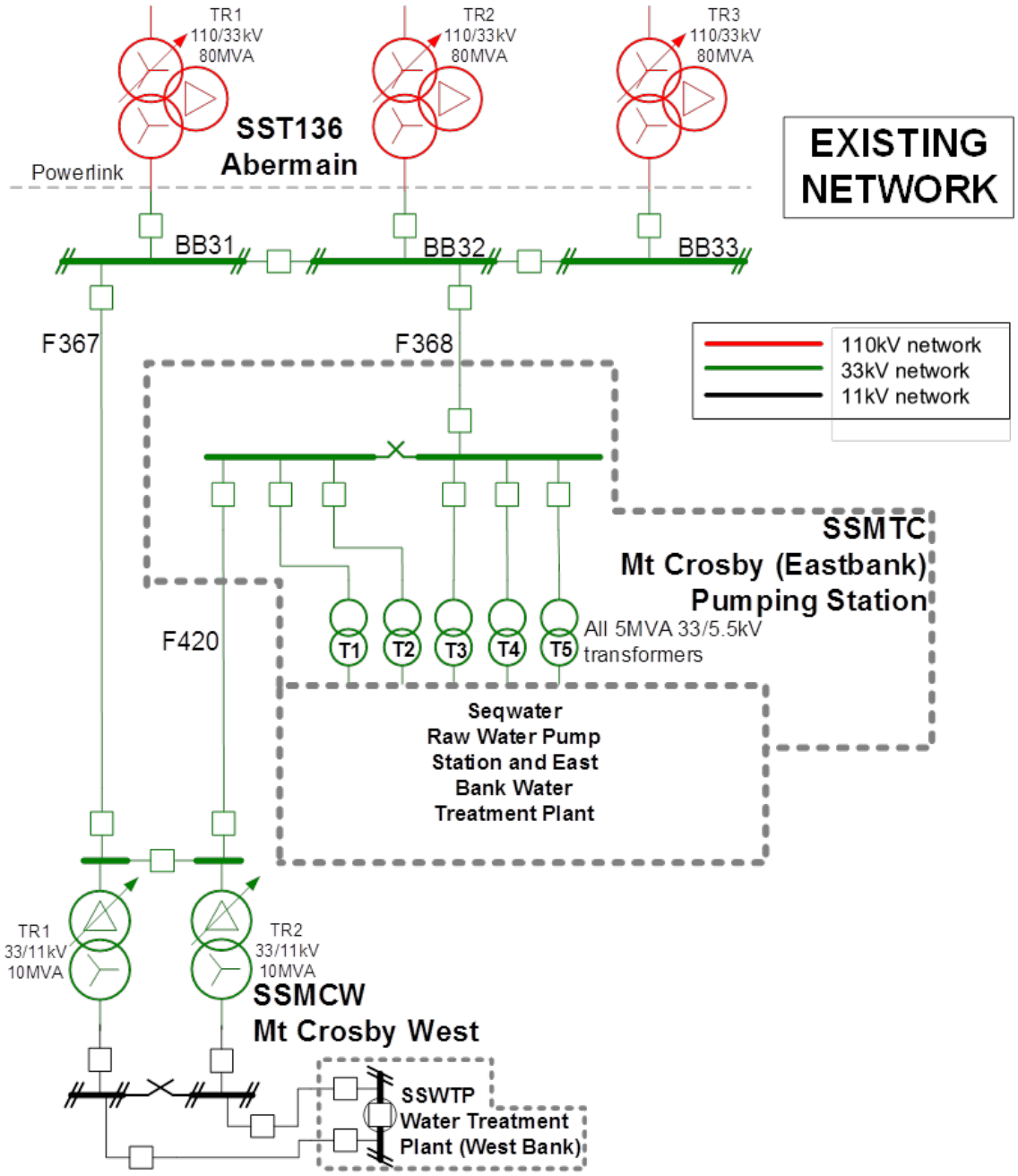


Figure 3: Existing network arrangement (schematic view)

1.2 Applied Service Standards

The Service Standards that are applicable to a consideration of supply constraints affecting this area of study are summarised below:

- As per *Joint Workings Protocol for Refurbishment and Replacement*, all electrical network assets that are in greatest need are identified and scheduled for refurbishment or replacement in sufficient time to prevent failure and to minimise the associated risks.

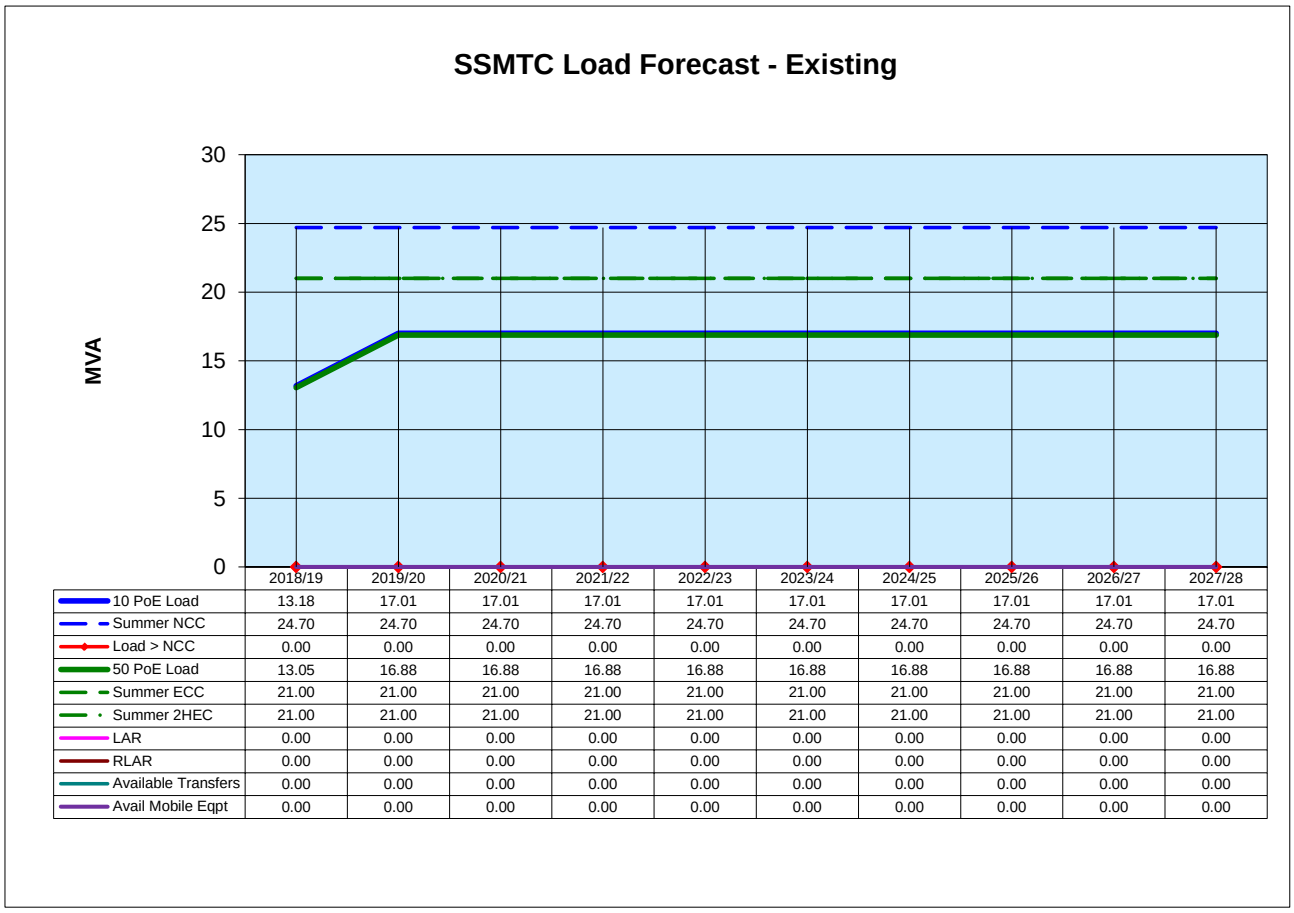
- Large Customer Connection
  - As per *Energex Policy Framework for Large Customer Connections*, upon request of a Large Customer, Energy Queensland shall construct connection assets to provide connection services.
- Risk framework
  - As per *Energex Network Risk Framework*, for risks in the tolerable range, the aim is to reduce all network risks to As Low As Reasonably Practicable (The ALARP principle, as represented by the ALARP range in tolerability scales).

1.3 Limitations of the existing network

1.3.1 Subtransmission network limitations

Substation capacity

SSMTC is equipped with 5 x 5MVA 33/5.5kV transformers. The substation capacity is limited by the transformers, providing a Normal Cyclic Capacity of 24.7MVA. The 10 year 10 PoE and 50 PoE load forecasts, and the existing Normal Cyclic Capacity (NCC), Emergency Cyclic Capacity (ECC), Two Hour Emergency Capacity (2HEC), Residual Load at Risk (RLAR), available transfers and available mobile equipment, are shown in Figure 4.



	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28
10 PoE Load	13.18	17.01	17.01	17.01	17.01	17.01	17.01	17.01	17.01	17.01
Summer NCC	24.70	24.70	24.70	24.70	24.70	24.70	24.70	24.70	24.70	24.70
Load > NCC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50 PoE Load	13.05	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88
Summer ECC	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Summer 2HEC	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
LAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Available Transfers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avail Mobile Eqpt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 4: Substation load forecast (existing network)

As outlined above:

- There are no capacity limitations at SSMTC within the planning horizon.

A Plant Overload Protection Software (POPS) scheme is not installed at SSMTC to automatically reduce load to below 2HEC in the event of a contingency condition.

Substation Load

The load duration and actual load curves for SSMTC are shown in Figure 5 and Figure 6. The peak load at SSMTC for 2017 was 12.2MVA.This is the load supplied at RWPS and WTP.

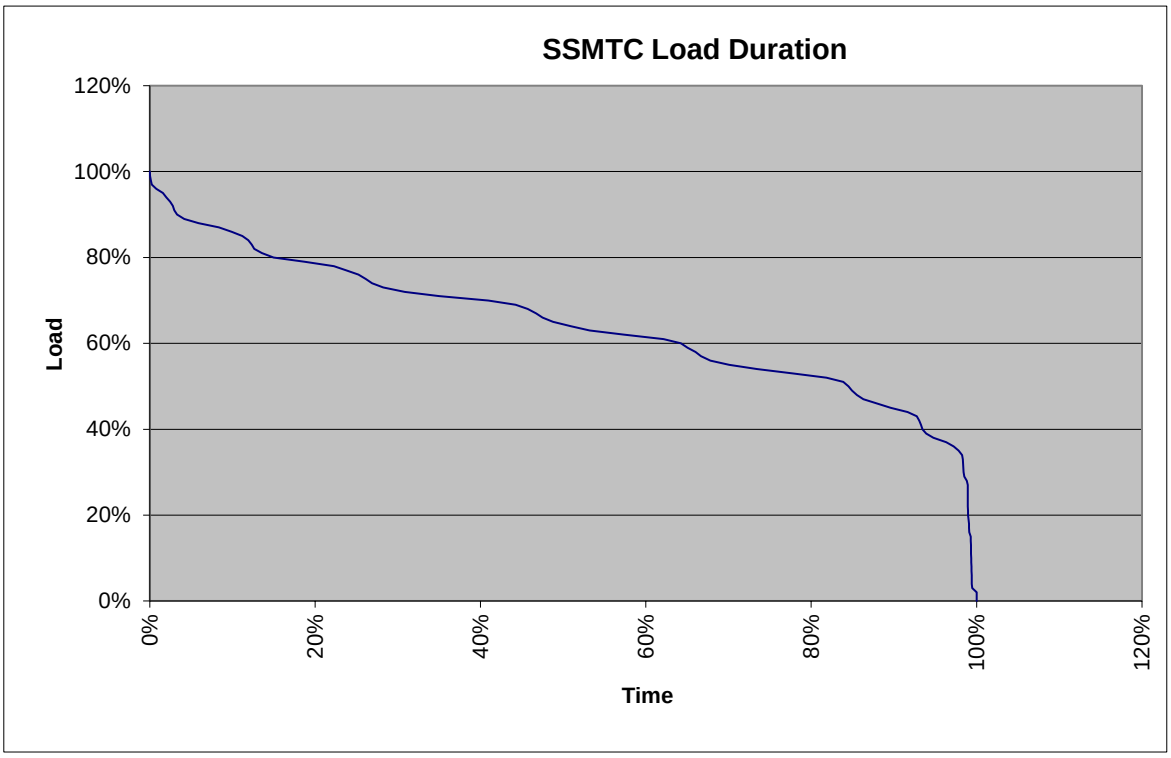


Figure 5: Substation load duration curve

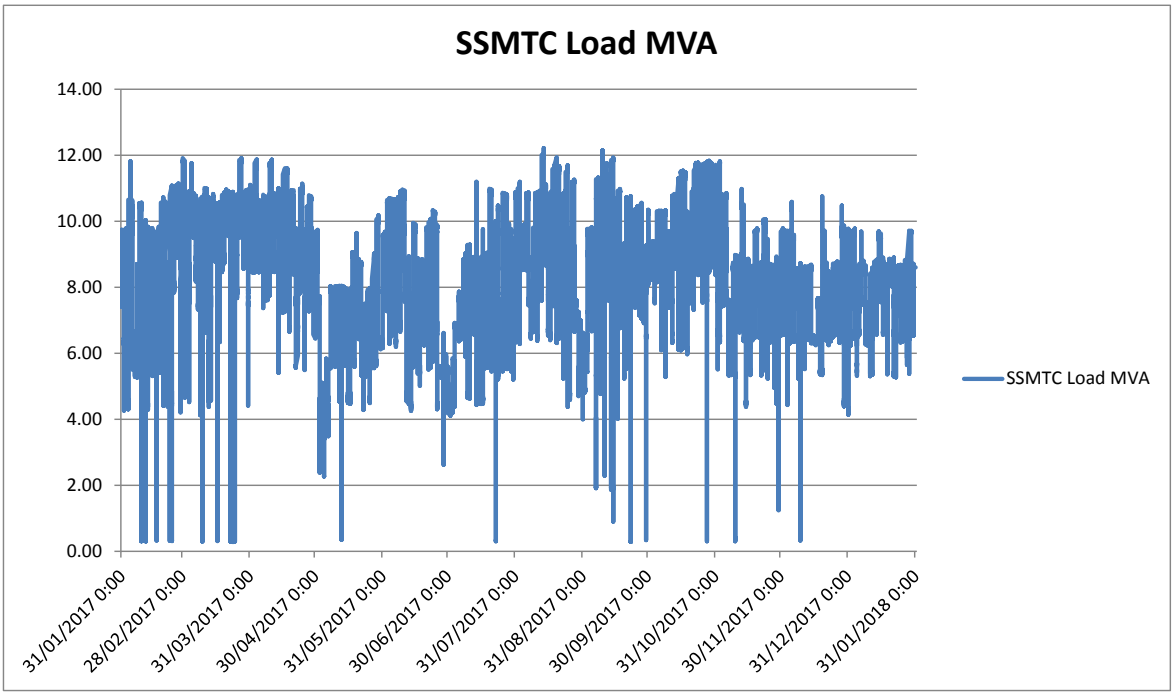


Figure 6: Substation actual load curve – SSMTC

Substation condition

Based on a Condition Based Risk Management (CBRM) analysis of the effect of current condition and ageing on the expected life of the asset, the following have been deemed to reach retirement age as follows:

- 33/5.5kV transformers TR1 to TR4 due to transformer condition; and
- 33kV CBs CB3682 and CB4202 due to mal-operation and potential bushing failures;

33/11kV transformers

The 33/5.5kV transformer TR1 was manufactured by Tyree in 1966, while transformers TR2 to TR4 were manufactured by Tyree in 1947. All these transformers are fitted with AEI tap changers, which are considered to have good reliability.

Transformer TR1 has been consistently in the 'moderate to wet insulation' range and has a trend of increasing saturation of water in oil. Insulation age analysis indicates a stable degredation of insulation. TR1 has been deemed to have reached retirement age in 2016.

Transformer TR2 is consistently in the 'extremely wet insulation' range. Saturation of water in oil also has an increasing trend. Low breakdown voltage occurred in the latter part the life of the transformer indicating that the oil quality in the transformer was contaminated. TR2 has been deemed to have reached retirement age in 2014.

Transformer TR3 is consistently in the 'extremely wet insulation' range. Saturation of water in oil also has an increasing trend. Breakdown voltage was below 30kV in 2014, which indicates that the dielectric strength is in the 'P1 Action' range. TR3 has been deemed to have reached retirement age in 2014.

Transformer TR4 is consistently in the 'extremely wet insulation' range. Saturation of water in oil also has an increasing trend. Breakdown voltage was below 30kV in 2014, which indicates that the dielectric strength is in the 'P1 Action' range. TR4 has been deemed to have reached retirement age in 2014.

Transformer TR5 is relatively young, with a year of manufacture of 1979. The CBRM states that this transformer is expected to reach retirement age in 2039.

Figure 7 to Figure 11 show photos of transformers TR1 to TR5.

Figure 7: 5MVA 33/5.5kV Transformer TR1

Figure 8: 5MVA 33/5.5kV Transformer TR2

Figure 9: 5MVA 33/5.5kV Transformer TR3

Figure 10: 5MVA 33/5.5kV Transformer TR4

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Figure 11: 5MVA 33/5.5kV Transformer TR5

33kV circuit breakers

The 33kV circuit breaker CB3682 is AEI type LG1C/44 manufactured in 1962. This type of circuit breaker is known to be slow to operate, which can lead to protection issues during faults. This type of CB is no longer being manufactured. They are maintenance intensive, requiring an intrusive maintenance following six fault operations, as per the Energex Maintenance Policy. As per the CBRM analysis, this 33kV circuit breaker is deemed to have reached retirement age in 2016.

The 33kV circuit breaker CB4202 is Westinghouse EMAILEED 345GC manufactured in 1952. Bulk oil circuit breakers of this type are known to be slow to operate, which can lead to protection issues during faults. This type of CB is no longer being manufactured. Energex, and two other Distribution Network Service Providers, have identified a recurring defect in EMAILEED 345GC circuit breakers, which involves leaks in the pitch-filled bushings. They are maintenance intensive, requiring an intrusive maintenance following six fault operations, as per the Energex Maintenance Policy. As per the CBRM analysis, this 33kV circuit breaker is deemed to reach retirement age in 2020.

1.4 Customer requirements

Seqwater is the sole customer being supplied by the existing substation SSMTC. The substation supplies load at the East Bank RWPS and WTP. In addressing the identified limitations at SSMTC, Seqwater have the following requirements:

- Establish a new substation to meet flood immunity requirement of 1:10,000 AEP for the new critical electrical infrastructure.
- Full N-1 capacity to supply the full load of the RWPS and WTP during contingency conditions.
- Added security with the provision of a mobile substation connection.
- Supply voltage at 11kV.
- All 11kV feeder reticulation to be owned and maintained by Energex.
- Provision for a third 25MVA 33/11kV transformer in the future.

1.5 Impact of doing nothing

The “do nothing” option is not acceptable as the following do not comply with the applied service standards detailed in section 2.3:

- Continuous operation of existing 33kV bulk oil CBs that have been deemed to reach retirement age at SSMTC poses an ongoing low level risk to Energex personnel safety due to the potential for in service failure of the assets.
- Continuous operation of existing 33kV bulk oil CBs that have been deemed to reach retirement age at SSMTC poses an ongoing low level risk to customer supplied by SSMTC (major customer, large scale business).
- Continuous operation of existing 33/5.5kV transformers that have been deemed to reach retirement age at SSMTC poses an ongoing moderate level risk to the customer due to the reduced capacity and reliability of supply for an extended duration in the event of transformer failure contingency scenario.
- Continuous operation of existing 33/5.5kV transformers that have been deemed to reach retirement age at SSMTC poses an ongoing low level business risk to Energex personnel safety due to the potential for in service failure of the assets.
- Continuous operation of existing 33/5.5kV transformers that have been deemed to reach retirement age at SSMTC poses an ongoing moderate level risk to the envoronment due to the potential for in service failure of the assets.
- Large Customer requirements for supply will not be met.

2.0 OPTIONS ANALYSIS

Energex was involved in the assessment of possible sites for the proposed new substation.

2.1 Alternative options rejected

For clarity, the following alternative options were considered but rejected as they were not practicable alternatives for the reasons indicated in Table 1.

Alternative option	Reasons for being rejected
Replace 33/5.5kV TRs and 33kV CBs at existing SSMTC	– Does not meet the flood immunity requirements of the customer of 1:1,000 AEP for existing infrastructure and 1:10,000 AEP for new critical electrical infrastructure. – Does not meet the requirement of the customer for supply voltage of 11kV.
Establish a new 33/11kV substation with 3 x 25MVA transformers	– The customer requested this network arrangement. However, as explained to the customer, this would not achieve their idea of N-2 reliability as there are only two 33kV feeders supplying the substation. This would not be a cost-effective option.
Non-regulated asset solution	– The project refurbishes/replaces existing assets. No capacity limits occur for non-network options to address. – The proposed solution results in an incidental augmentation using standard building blocks or a modern day equivalent. A non-network solution for this incidental increase in capacity is not economically viable.

Table 1: Alternative options rejected

2.2 Network options

In addition to the following option that has been assessed as meeting the applied service standards and customer requirements, no other practically feasible and economically equivalent option has been identified in this analysis.

2.2.1 Option 1: Establish new Mount Crosby East Zone Substation

This option involves establishing a new zone substation at Mount Crosby with 2 x 33kV feeder bays, 2 x 33kV transformer bays, 2 x 25MVA 33/11kV transformers, 3-bus x 11kV switchboard, establishment of 4 x 11kV feeders to the new RWPS customer substation (SSWPT) and 2 x 11kV feeders to the WTP substation (SSETP) and provision for a mobile substation connection. Details of Option 1 are discussed in greater detail in latter sections of this report.

Figure 12 and Figure 13 provide geographic and schematic diagrams for Option 1.

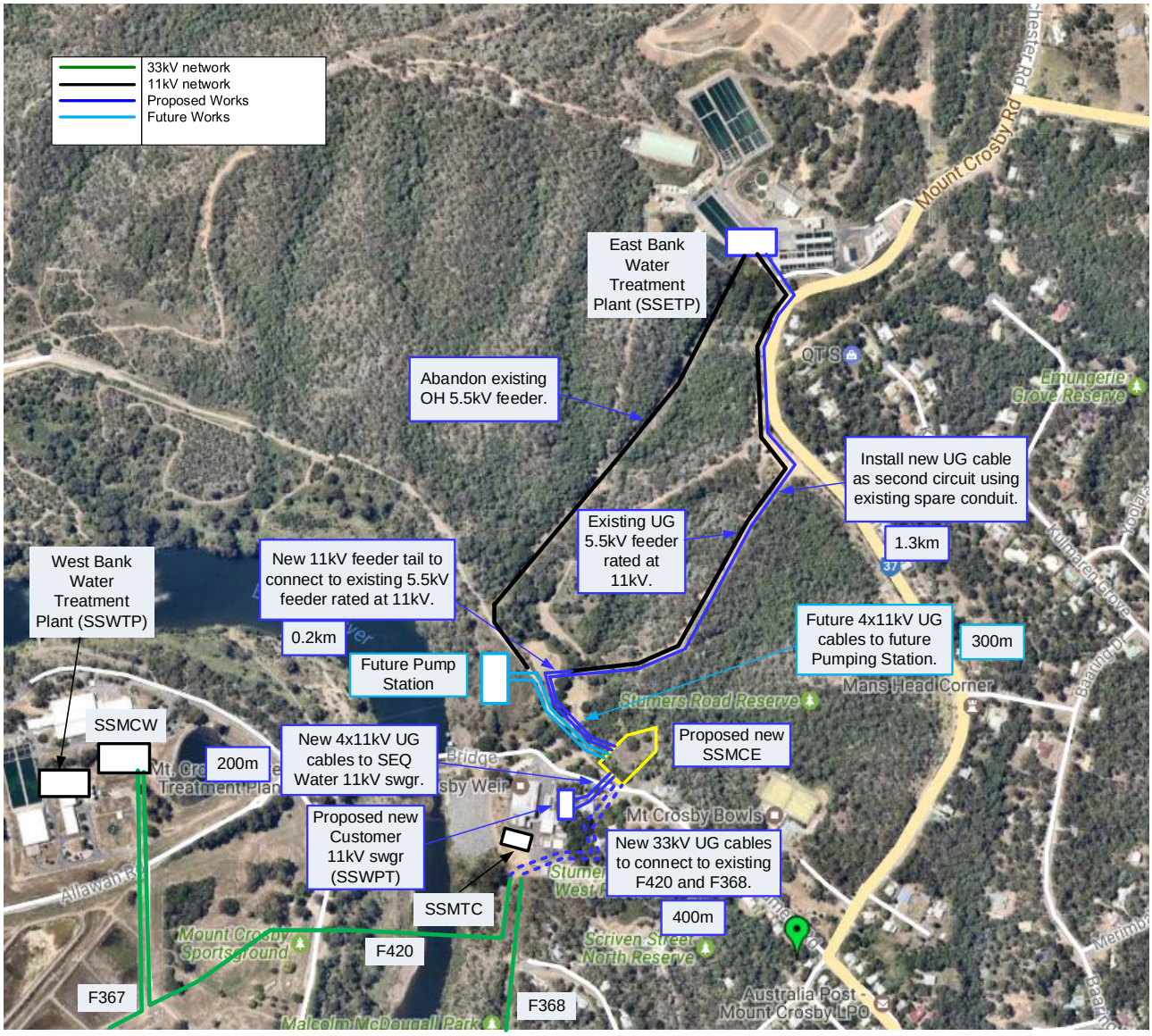

Figure 12: Proposed network arrangement (geographic view)

2.3 Non-Network options assessment

In order for a non-network solution to address the identified limitations, it should be able to maintain supply to the pumping station and water treatment plant load of Seqwater as the existing network assets reach retirement age. It should also be able to meet the requirements of Seqwater for the reliability and security of supply to these loads.

There are no other substations in the area that can supply the Seqwater load at the East Bank when the existing substation assets reach retirement age. Embedded generation to supply the load continuously and provide reliable and secure supply is not practicable. Seqwater will not entertain a load curtailment agreement at this site due to its importance.

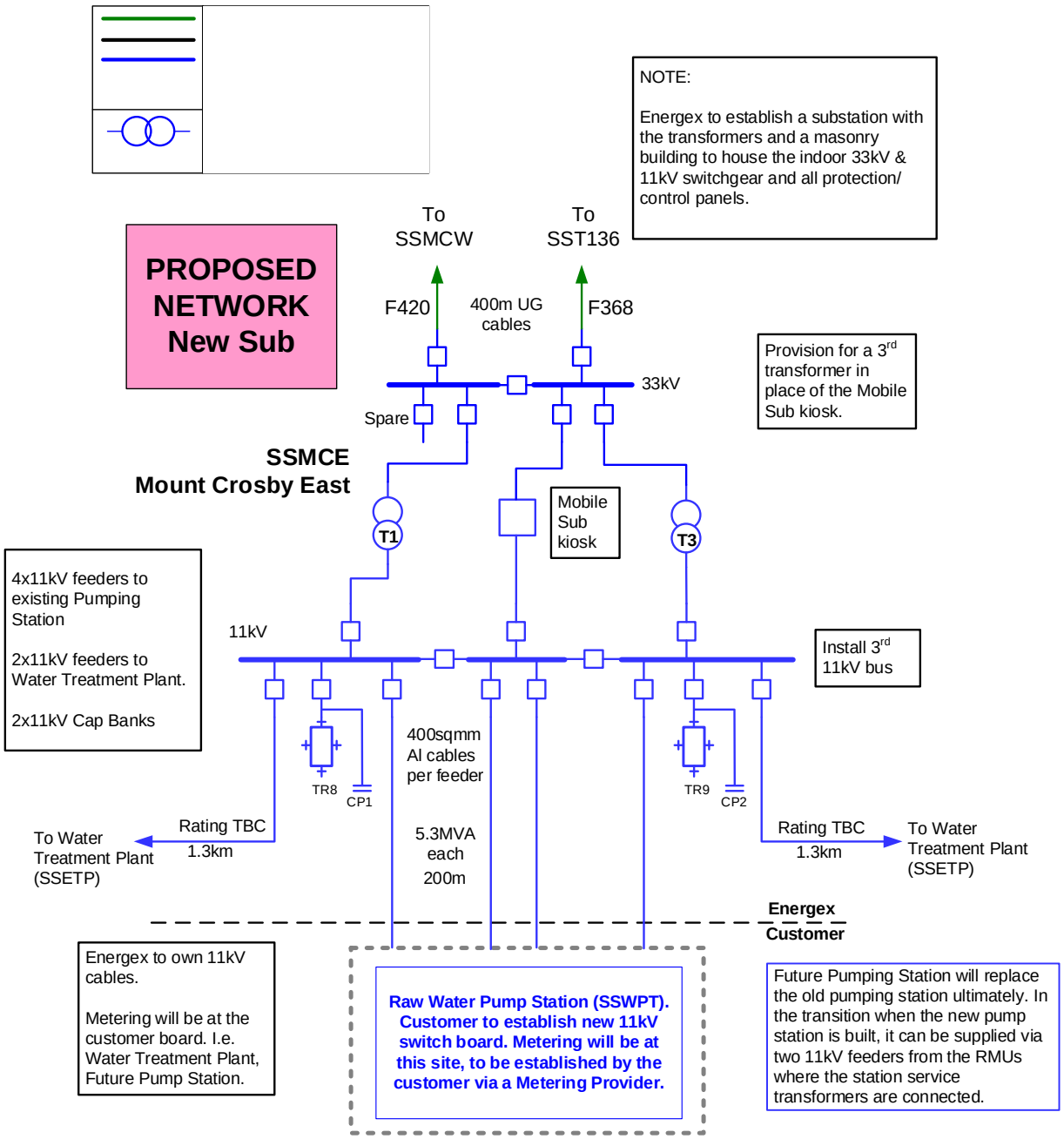

Figure 13: Proposed network arrangement (schematic view)

3.0 RECOMMENDED DEVELOPMENT (OPTION 1)

3.1 Scope of proposed works

3.1.1 Description of works

To address the limitations at Mount Crosby, it is proposed to establish the new Mount Crosby East Zone Substation (SSMCE). Works include:

- installation of a masonry building to house the 33kV indoor switchgear including 2 x bus sections with 1 x bus section CB, 2 x transformer CBs, 2 x 33kV feeder CBs, 1 x 33kV CB for the mobile substation kiosk and 1 x spare 33kV CB;
- installation of an 11kV indoor switchroom inside the masonry building including 3 x bus sections with 2 x bus section CBs (2000A each), 3 x transformer CBs (2000A), 8 x feeder CBs (1250A each);
- installation of 2 x 25MVA 33/11kV transformers;
- installation of 2 x 4.4MVAR capacitor banks;
- establishing 4 x 11kV UG feeders to the new customer switchboard at the RWPS (SSWPT);
- establishing a second 11kV UG feeder to the existing customer board at the WTP (SSETP);
- establishing 2 x 33kV UG feeder tails to connect the OH 33kV feeders from SSMTC to the new SSMCE substation;
- upgrading protection at SST136 and SSMCW;
- recovering and scrapping of 33/5.5kV transformers TR1 to TR5 and the spare 33/5.5kV transformer used for contingency;
- recovering and scrapping of 7 x 33kV CBs and 10 x 33kV disconnectors, outdoor bus stuctures; and
- remediation of the old SSMTC site.

With the proposed works to establish the new SSMCE Zone Substation, Seqwater has committed to the following:

- Provision and preparation of a site suitable and ready for the construction of the proposed substation, according to Energex requirements.
- Civil works to upgrade Stumers Road to be suitable for access to the proposed substation and crossing of the 33kV and 11kV UG cables.

- Civil works for the conduits for the 33kV and 11kV UG cables.
- Civil works to upgrade the driveway on the east side of the RWPS into a heavy haulage road.
- Engage a metering provider to establish metering at the new RWPS (SSWPT) 11kV switchgear building and the existing WTP (SSETP).
- Transfer ownership of the existing 5.5kV cable, rated at 11kV, from Seqwater to Energex.
- Payment of the cost difference between the original project to replace transformers and CBs in situ and the proposed establishment of the new substation, subject to negotiated project variation cost-sharing.

Seqwater is providing Energex the site of the proposed new substation across Stumers Road and Bridge Street from the RWPS. They will do the civil works to prepare this site to be suitable for construction of the new substation according to Energex requirements. The intersection will be upgraded in the process. Seqwater will also upgrade the driveway to access the rear of the RWPS. This will become a heavy haulage road suitable for use in the recovery of plant and equipment from the existing SSMTC. The existing driveway access from the front of the RWPS is not suitable for heavy haulage due to the pipes crossing underneath.

It was confirmed by Seqwater that the existing 5.5kV UG cable and the existing joints from the RWPS to the WTP is rated at 11kV. There are spare conduits for a second 11kV cable and a fibre optic cable to the WTP. Energex will establish the second 11kV cable to supply the WTP. The existing Seqwater-owned 5.5kV OH feeder to the WTP will be abandoned.

Seqwater will establish a new 11kV substation at the RWPS (SSWPT) where the 4 x 11kV feeders from the new SSMCE substation will be terminated.

Due to the importance of the RWPS and WTP loads, Seqwater requires the higher reliability and security of supply. The proposed substation will have 2 x 25MVA 33/11kV transformers. There will be no interruption of supply for a contingency condition where one transformer is out of service. Furthermore, Seqwater required a connection kiosk for the deployment of a mobile substation for a prolonged outage of one of the 25MVA transformers.

As Seqwater will be converting the RWPS pump motors from 5.5kV to 11kV and cutting over to the new 11kV switchboard, the transition will be done over an estimated period of 73 weeks. During the transition, the proposed new 33/11kV substation SSMCE will be energised and supplying load while the existing 33/5.5kV substation SSMTC is still operational. Metering will be done at both 5.5kV and 11kV during the transition period.

Figure 14 to Figure 16 shows additional diagrams for the recommended works.

Figure 14: Proposed network arrangement (geographic view)

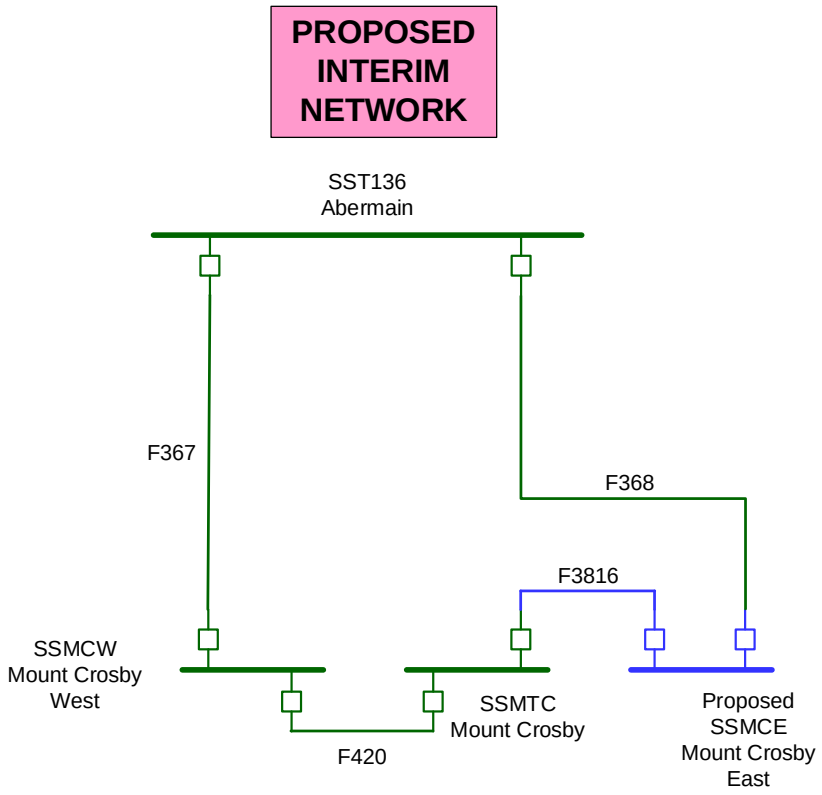

Figure 15: Proposed 33kV interim network arrangement (schematic view)

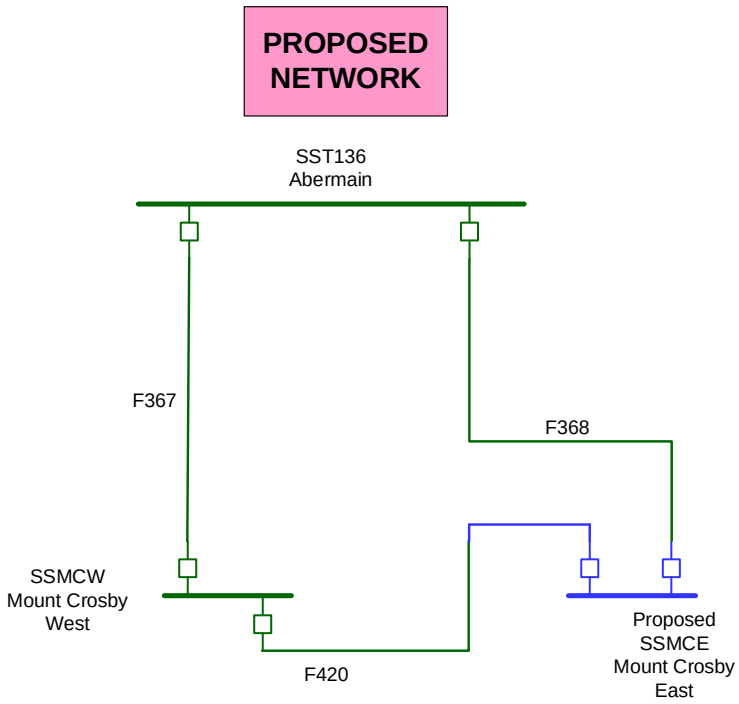

Figure 16: Proposed 33kV ultimate network arrangement (schematic view)

4.0 RECOMMENDATION

It is recommended that Energex establish the new Mount Crosby East Zone Substation (SSMCE) and recover the existing Mount Crosby Zone Substation (SSMTC), for a total estimated cost of $20.04 million at 2018/19 prices. The customer will make an upfront capital contribution of approximately $10.6 million toward these works, to be reconciled as per the total actual cost of the project, less the escalated cost of the original project, subject to negotiated project variation cost-sharing. The target completion date for the recommended development is September 2020.