NER Impact During Bushing Failure

A Calculated Escape

Presented by:

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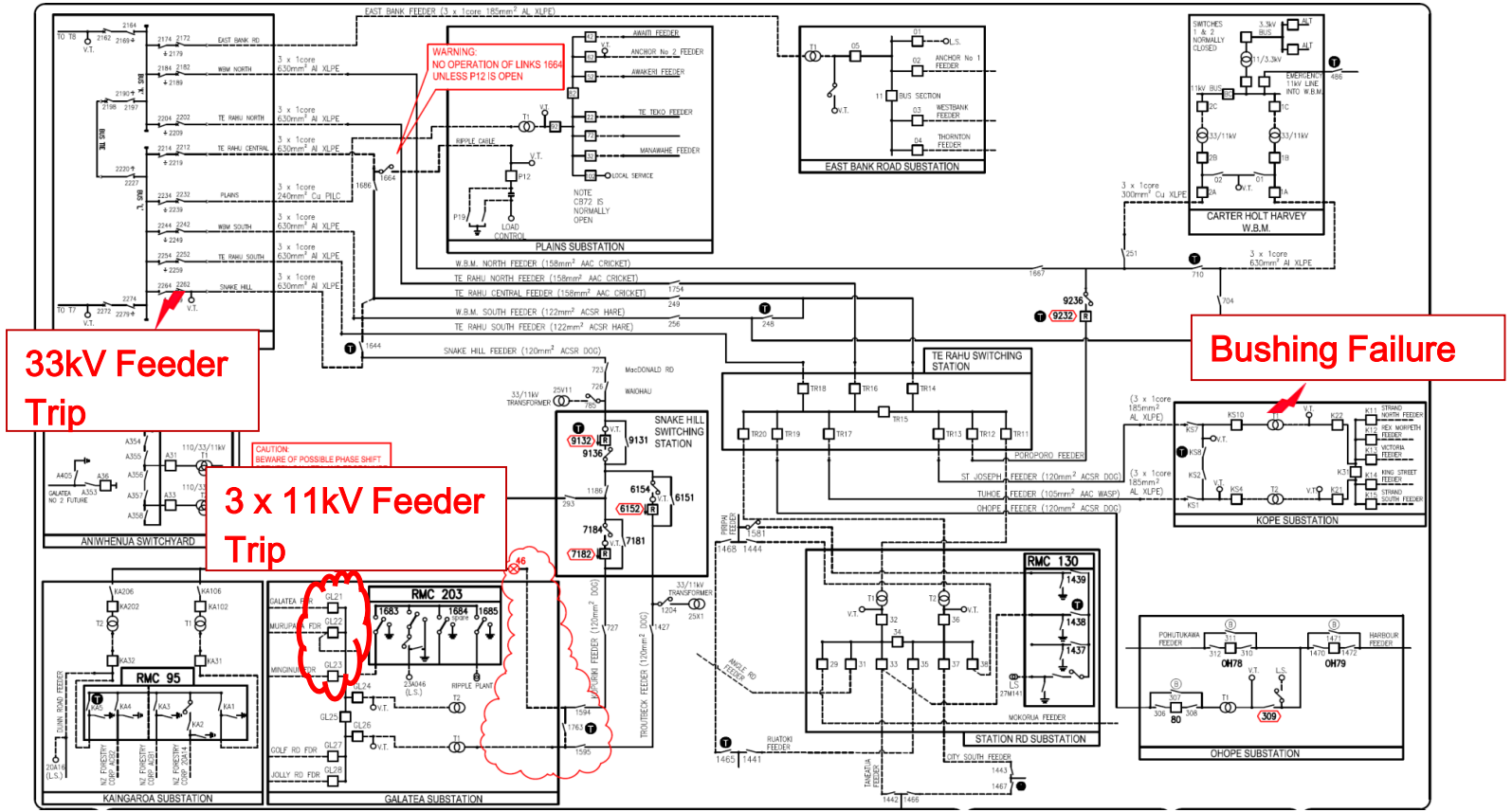
Overview

1. What Happened?
   - Faults in the grid
   - Transformer bushing failure
2. Root Cause
3. NERs
   - What is NER
   - How NERs helped
   - Issues and concerns of NERs
4. Lessons Learnt and Conclusion

What Happened

Events of 20th June 2015



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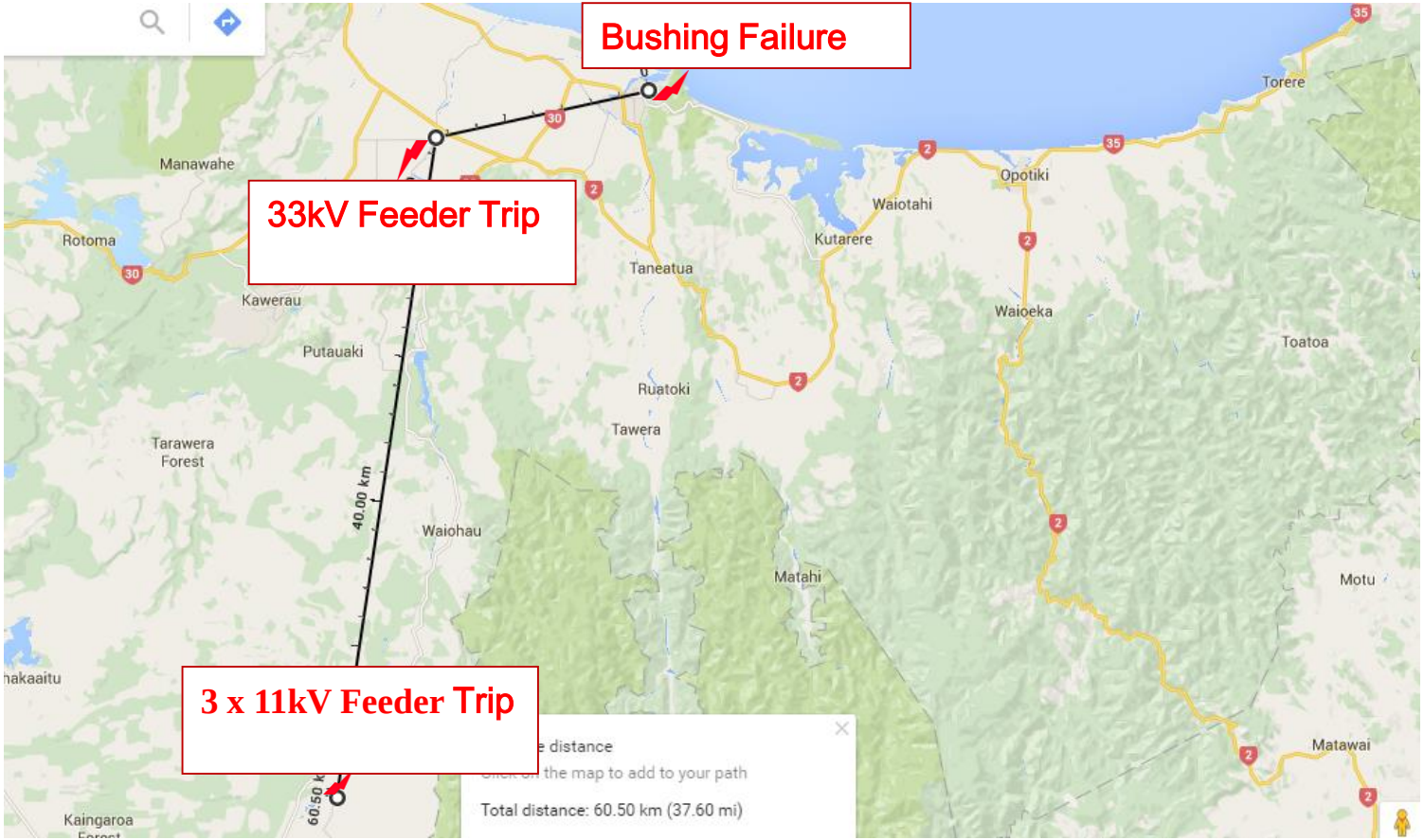
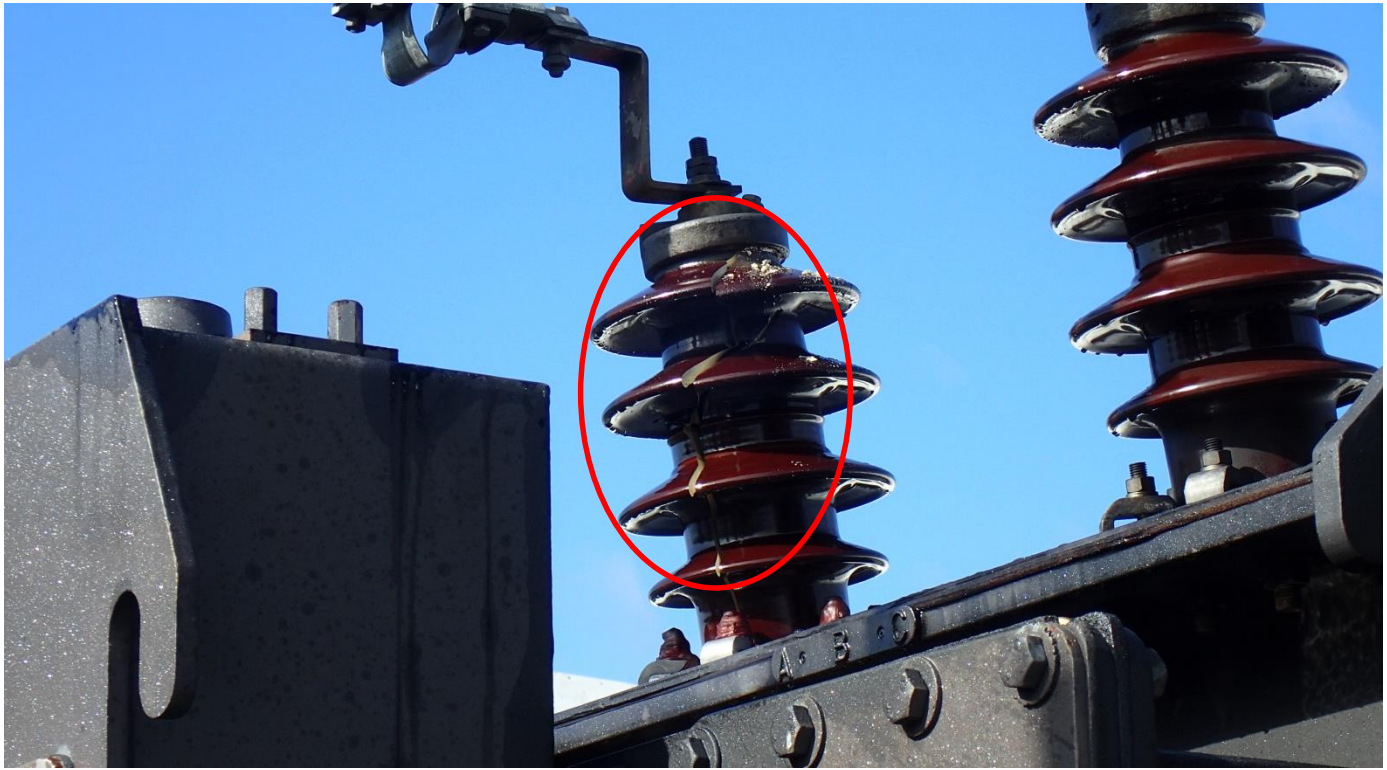

Bushing Failure
33kV Feeder Trip
3 x 11kV Feeder Trip
Manawahe
Rotoma
Kawerau
Putauaki
Tarawera Forest
Waiohau
Taneatua
Ruatoki
Tawera
Matahi
Kutarere
Waiotahi
Opotiki
Torere
Waioeka
Toatoa
Motu
Matawai
Kaingaroa
40.00 km
60.50 km
Total distance: 60.50 km (37.60 mi)

Trip 1 – RØ Bushing Failure at Kope T1

Bushing Failure

- Bucholz trip at 7am, 20th June 2015
- Trip reset
- Bushing failure at 11:30

Observations on Site

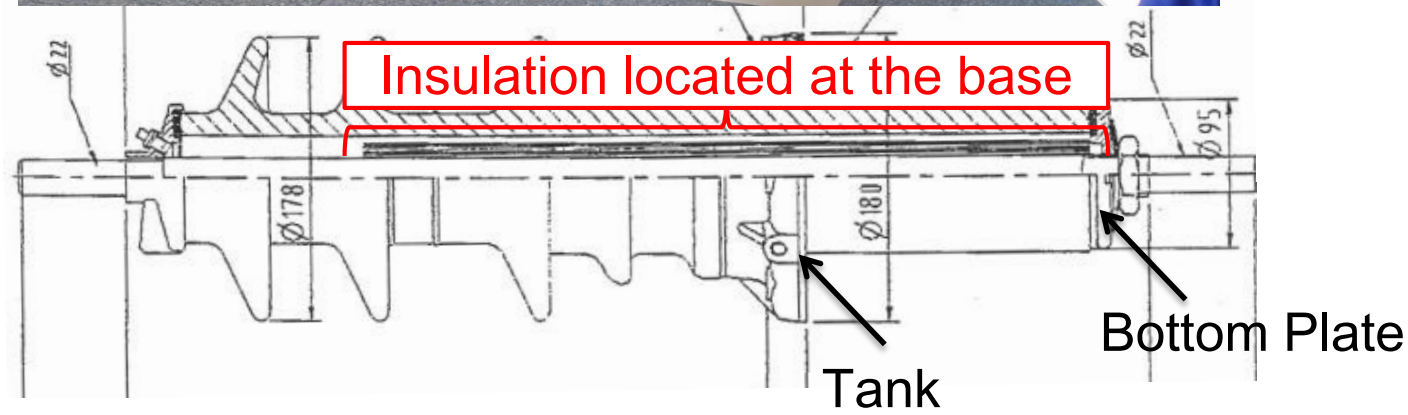


February 2013 Transformer Condition Assessment

Indication of glazing breaking due to tracking

- Bushing had been noted as a noisy bushing
- On inspection glazing cracks and marks on clamps and studs
- Bushing was tightened with self-amalgamating tape

Transformer Bushing



Transformer Bushing Failure – Root Cause

NOTICE NO DAMAGE TO INSULATION

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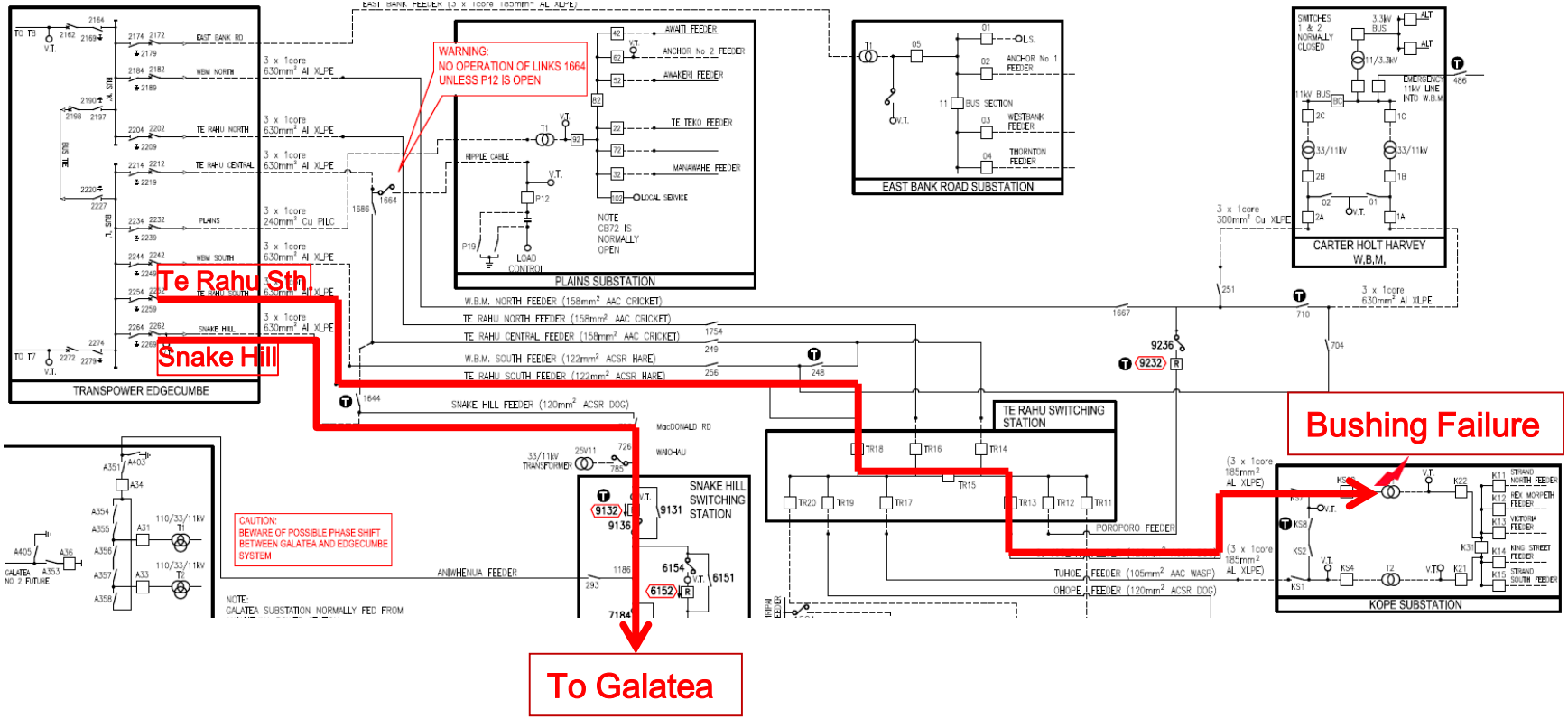
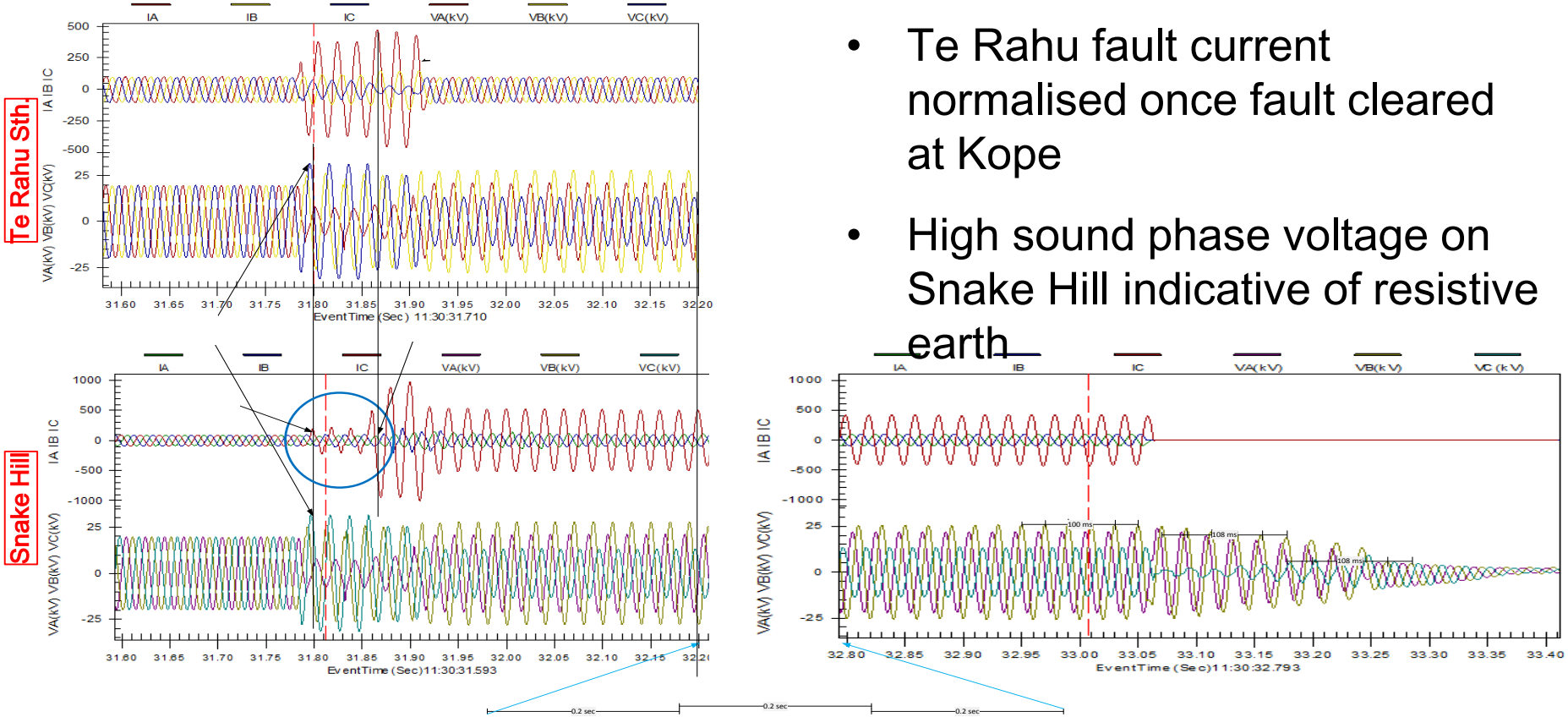
Trip 2 – Cross Country Earth Fault

33 kV Simultaneous Cross Country Earth Fault



33 kV Simultaneous Cross Country Earth Fault



- Te Rahu fault current normalised once fault cleared at Kope
- High sound phase voltage on Snake Hill indicative of resistive earth

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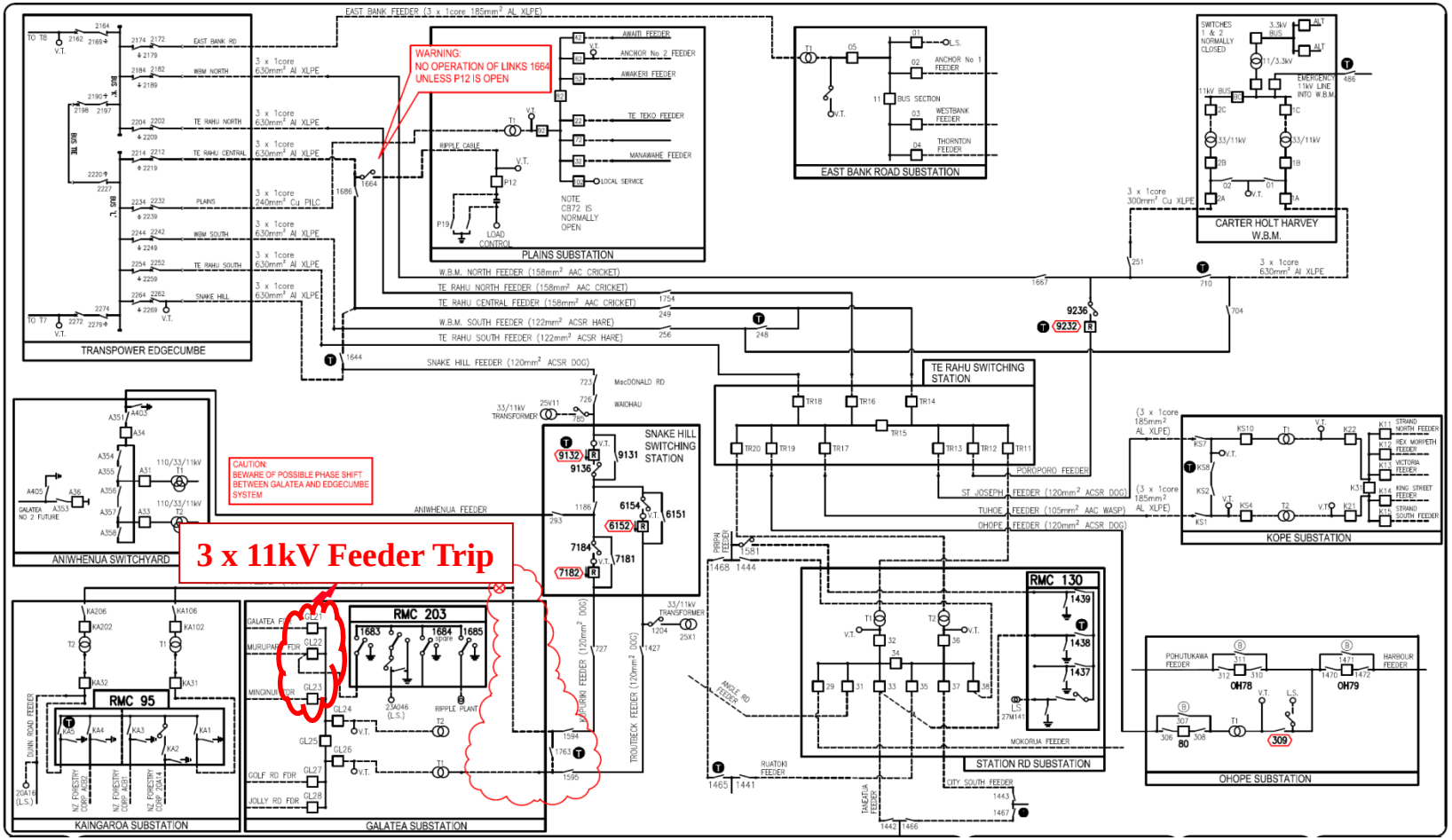
Trip 3 – Under Frequency


3 x 11kV Feeder Trip
WARNING:
NO OPERATION OF LINKS 1664
UNLESS P12 IS OPEN
CAUTION:
BEWARE OF POSSIBLE PHASE SHIFT
BETWEEN GALATEA AND EDGECUMBE
SYSTEM
NOTE
CB72 IS
NORMALLY
OPEN
TRANSPOWER EDGECUMBE
PLAINS SUBSTATION
EAST BANK ROAD SUBSTATION
CARTER HOLT HARVEY
W.B.M.
TE RAHU SWITCHING
STATION
SNAKE HILL
SWITCHING
STATION
ANIWHENUA SWITCHYARD
KAINGAROA SUBSTATION
GALATEA SUBSTATION
KOPE SUBSTATION
OHOPE SUBSTATION
STATION RD SUBSTATION
RMC 203
RMC 95
RMC 130
EAST BANK FEEDER (3 x 1core 185mm² AL XLPE)
W.B.M. NORTH FEEDER (158mm² AAC CRICKET)
TE RAHU NORTH FEEDER (158mm² AAC CRICKET)
TE RAHU CENTRAL FEEDER (158mm² AAC CRICKET)
W.B.M. SOUTH FEEDER (122mm² ACSR HARE)
TE RAHU SOUTH FEEDER (122mm² ACSR HARE)
SNAKE HILL FEEDER (120mm² ACSR DOG)
ANIWHENUA FEEDER
ST JOSEPH FEEDER (120mm² ACSR DOG)
TUHOE FEEDER (105mm² AAC WASP)
OHOPE FEEDER (120mm² ACSR DOG)
MOKORUA FEEDER
CITY SOUTH FEEDER
TROUTBECK FEEDER (120mm² DOG)
MURUPARA FEEDER (120mm² DOG)
ANGLE RD FEEDER
RUATOKI FEEDER
TANGERUA FEEDER
AWATU FEEDER
ANCHOR No. 2 FEEDER
AWAKERI FEEDER
TE TEKO FEEDER
MANAWAHE FEEDER
LOCAL SERVICE
ANCHOR No 1 FEEDER
WESTBANK FEEDER
THORNTON FEEDER
BUS SECTION
EAST BANK RD
WBM NORTH
TE RAHU NORTH
TE RAHU CENTRAL
PLAINS
WBM SOUTH
TE RAHU SOUTH
SNAKE HILL
3 x 1core 630mm² Al XLPE
3 x 1core 240mm² Cu PILC
3 x 1core 300mm² Cu XLPE
(3 x 1core 185mm² AL XLPE)
MacDONALD RD
WAIOHAU
33/11kV TRANSFORMER
RIPPLE CABLE
RIPPLE PLANT
LOAD CONTROL
DUNN ROAD FEEDER
NZ FORESTRY CORP AG31
NZ FORESTRY CORP AG32
NZ FORESTRY CORP 20A14
GALATEA FDR
MURUPARA FDR
MINGINUI FDR
GOLF RD FDR
JOLLY RD FDR
POHUTUKAWA FEEDER
HARBOUR FEEDER
OH78
OH79
80
309
STRAND NORTH FEEDER
REX MORPETH FEEDER
VICTORIA FEEDER
KING STREET FEEDER
STRAND SOUTH FEEDER
SWITCHES 1 & 2 NORMALLY CLOSED
EMERGENCY 11kV LINE INTO W.B.M.
11kV BUS
3.3kV BUS
11/3.3kV
33/11kV
ALT
V.T.
L.S.

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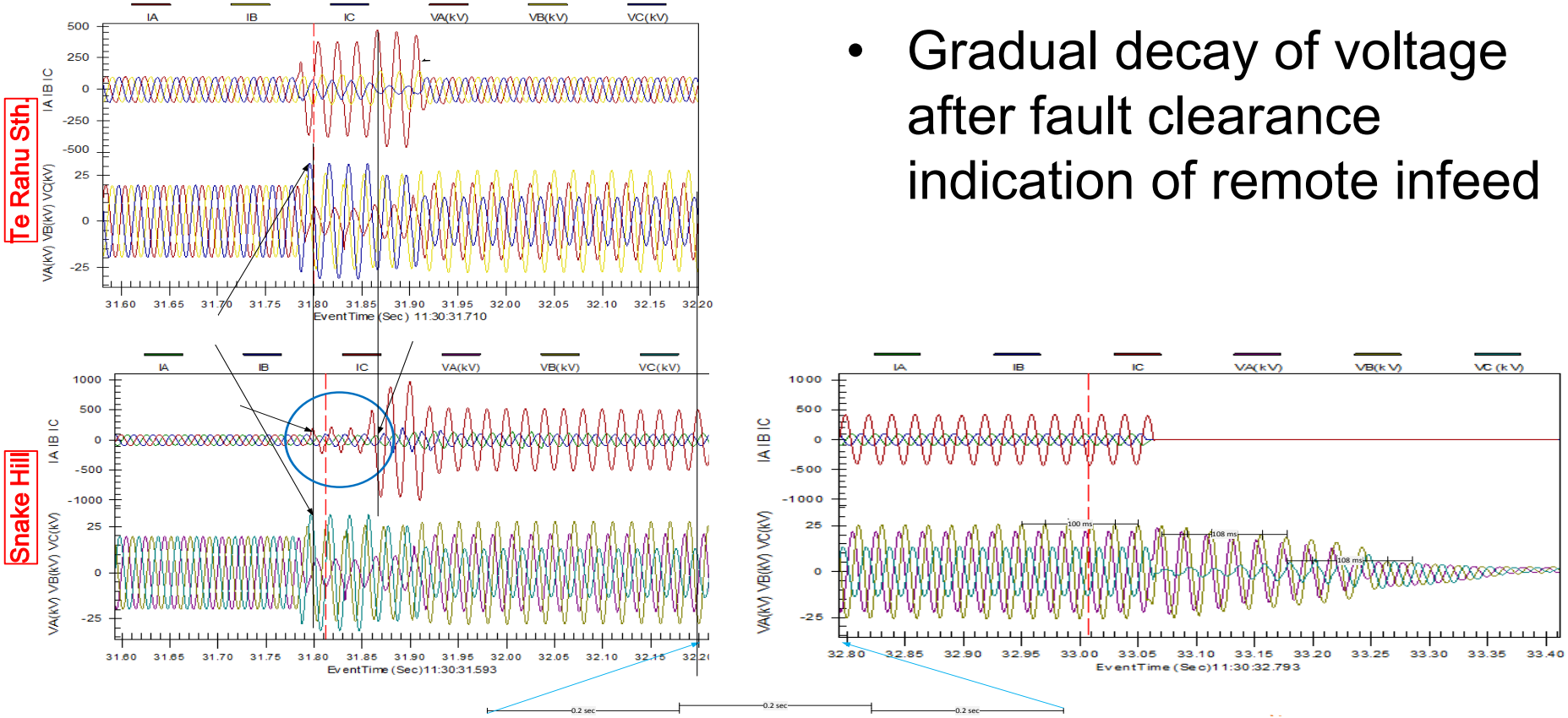
Trip – 3 Under-frequency



- Gradual decay of voltage after fault clearance indication of remote infeed

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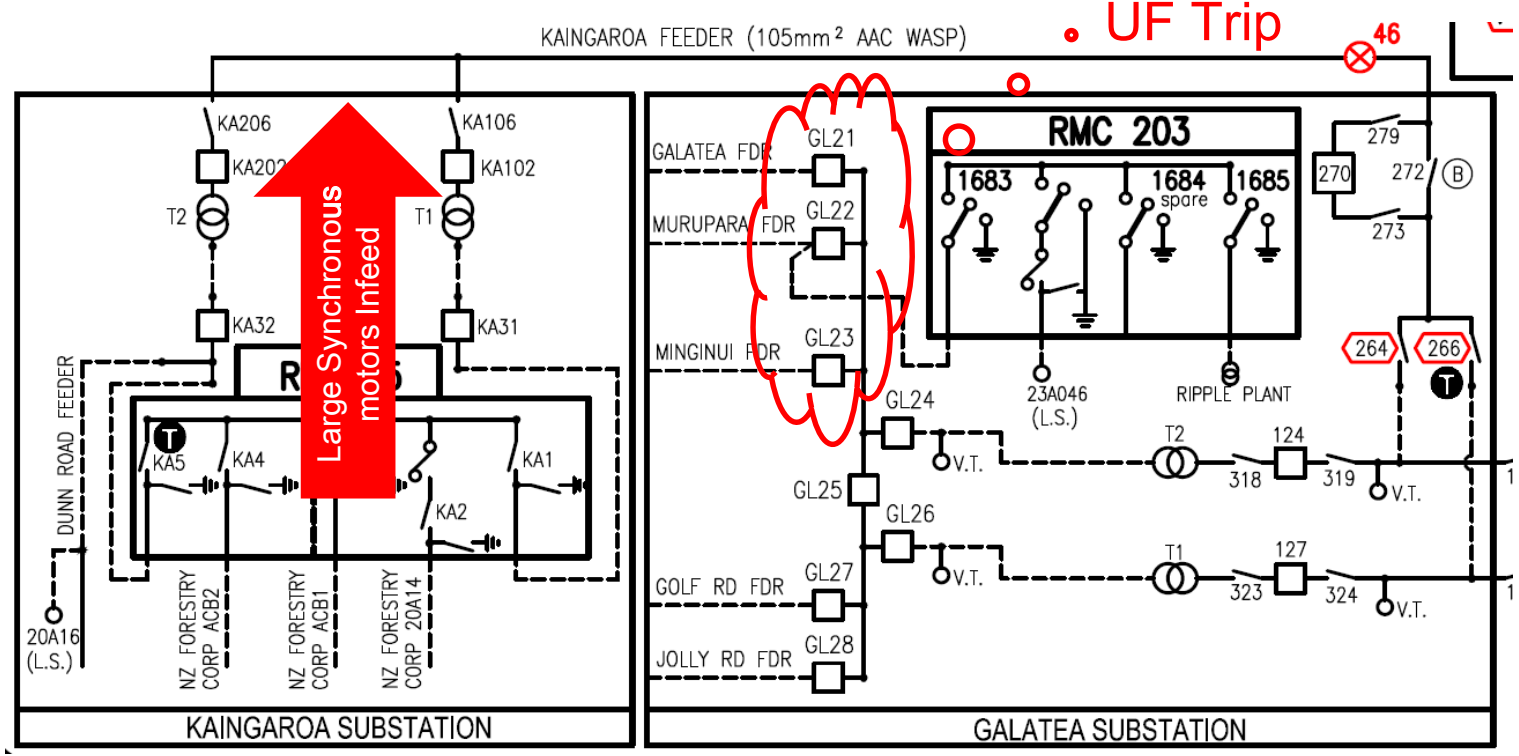
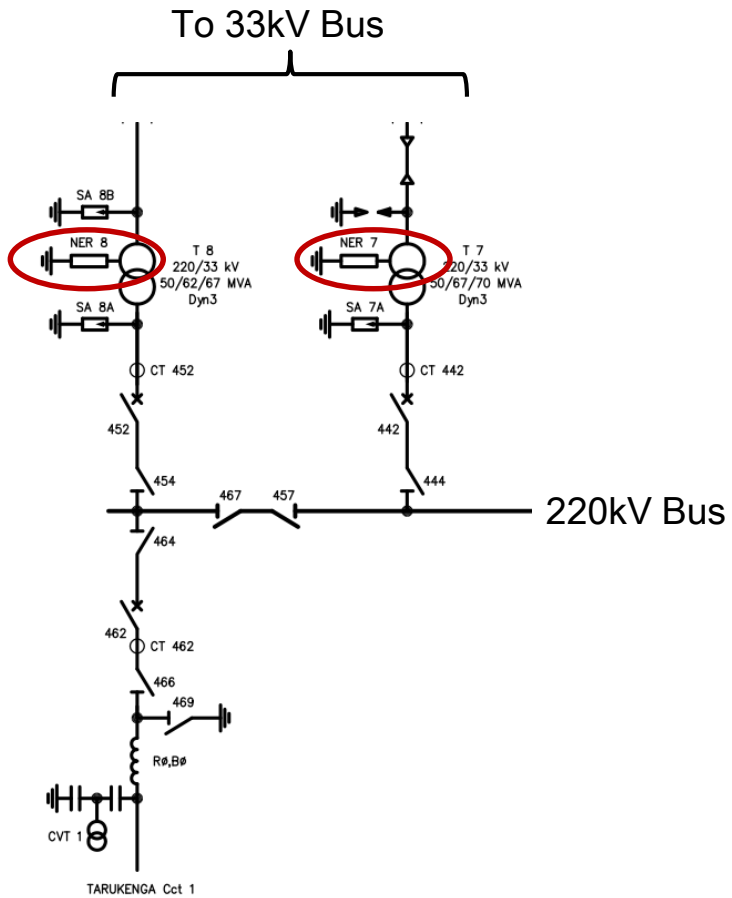

KAINGAROA FEEDER (105mm² AAC WASP)
UF Trip
46
KA206
KA202
KA106
KA102
T2
T1
KA32
KA31
Large Synchronous motors Infeed
KA5
KA4
KA1
KA2
DUNN ROAD FEEDER
20A16 (L.S.)
NZ FORESTRY CORP ACB2
NZ FORESTRY CORP ACB1
NZ FORESTRY CORP 20A14
KAINGAROA SUBSTATION
GALATEA FDR
MURUPARA FDR
MINGINUI FDR
GOLF RD FDR
JOLLY RD FDR
GL21
GL22
GL23
GL24
GL25
GL26
GL27
GL28
RMC 203
1683
1684
spare
1685
279
270
272
B
273
264
266
23A046 (L.S.)
RIPPLE PLANT
V.T.
T2
124
318
319
T1
127
323
324
GALATEA SUBSTATION

Theory

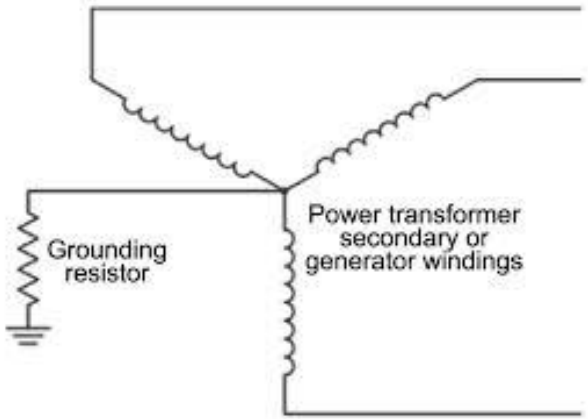
Neutral Earthing Resistor

Two NERs recently installed at Edgecumb by Transpower



What is NER?

- Connected between ground and neutral
- Low resistance NERs
  - Permit only 200A to 1200A
  - Used for large electrical systems
- High resistance NERs
  - Limit the fault current to very low as less than 50A to 100A
  - Used in mining etc.



What is NER?

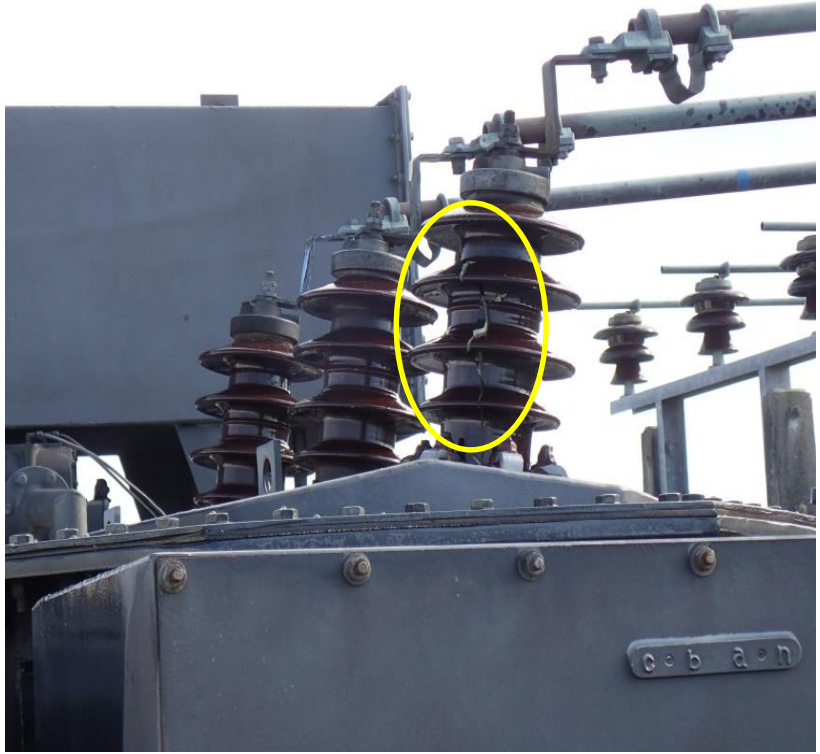
- Three elements are considered when sizing the earthing resistors:
  - Voltage (V)
  - Current (I)
  - Time (t)

$$R = \frac{V}{I \times \sqrt{3}}$$

How NERs Helped

- Limited Fault Current
  - <1000A with NERs
  - 15 to 20kA without NERs

- Limited Energy Released
  - Could have been explosive or transformer catching fire without NERs
  - Now only cracks on porcelain



Severe Damages

Issues and Concerns of NERs

- Difficulty in Finding Fault Location
  - Energy of fault arc is negligible
  - Insulation is likely to be self-restored

- Sound Phase Voltage Rise During Earth Faults
  - Displaced to full line-to-line voltage
  - Need to take it into consideration when doing design

Conclusion

Lessons Learnt and Conclusion

- NERs
  - Limited the fault current
  - Prevented causing severe damage
  - Caused cross country fault
- Failures
  - Failures happen
  - Treat the fault like a crime scene
  - Prior history usually a good indication for cause of fault
  - Take the time to investigate the root cause
  - Horizon has stopped live streamlining

Thank You!

And

Questions?