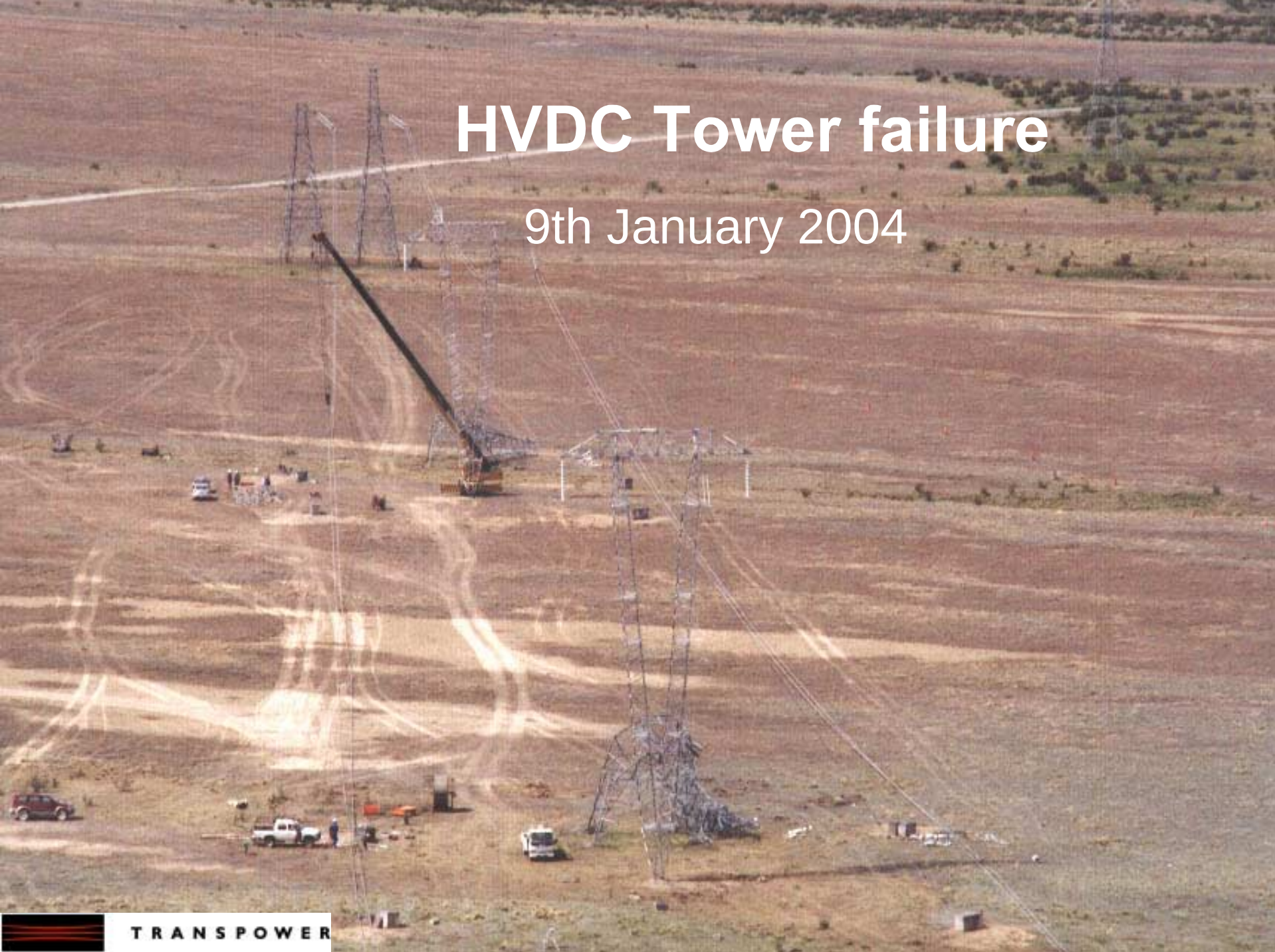
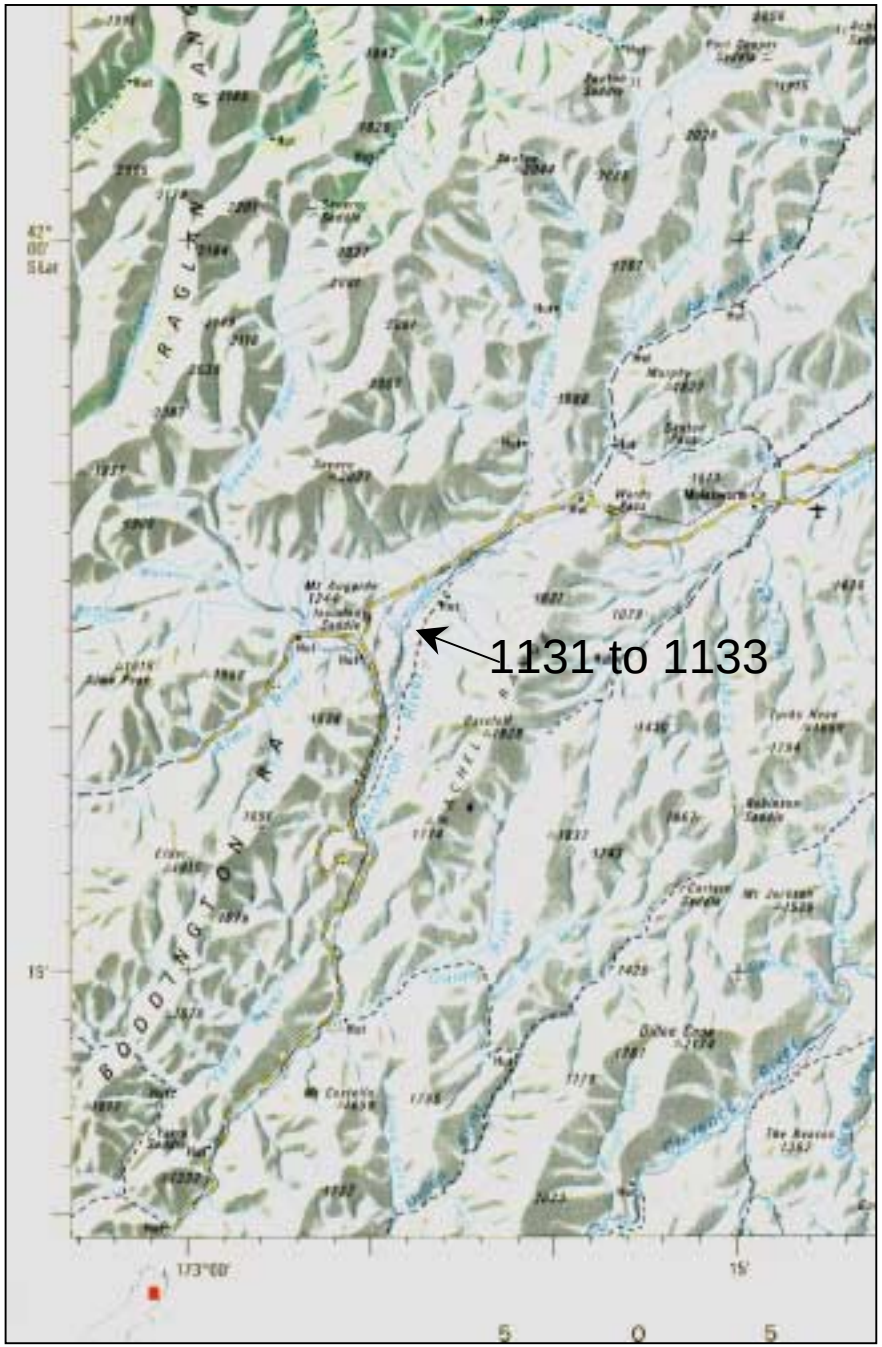

HVDC Tower failure
9th January 2004
TRANSPOWER

Location

- Isolation Saddle on Molesworth Station, approximately 1.5 hours north of Hanmer Springs
- Access via gravel road currently closed to public
- Elevation approximately 920 metres



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Weather conditions

- High winds caused by low pressure system that travelled up NZ
- Unusual system for January
- Extremely high winds encountered in Canterbury, Marlborough and lower North Island
- Very little rain associated with front

Details of Failure

- The HVDC line tripped at 4.02am on 9th January. Only Pole 2 was in service, with minimal transfer south to north
- Not known if the towers failed at this time - wind blown debris at a variety of sites could have caused the initial tripping
- Molesworth Station manager advised Transpower of damaged towers at 7:41am - “crumpled Meccano”
- Contractors reached site mid-morning and confirmed 3 towers had failed - 1131, 1132 and 1133

Tower 1131

- Heavy Suspension Tower on top of Isolation Saddle
- Modified to Akimbo arm during 1991 upgrade
- Strengthened to NZS4203 during 1991 upgrade

Tower 1132

- Heavy Suspension Tower located on Isolation Flat (valley floor)
- Modified to Akimbo arm during 1991 upgrade

Tower 1133

- Light Suspension Tower located on Isolation Flat (valley floor)
- Normal suspension insulators
- Strengthened in 1964 before commissioning

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Restoration of link

- First contractors arrived at site mid-morning Friday 9th January
- Emergency towers, heavy machinery including cranes and work crews on site early Saturday 10th January
- Ground cable employed and spliced in.

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Restoration of link

- Emergency structures erected and conductor transferred Sunday 11th
- Line returned to service 17:00hrs Monday 12th (3½ days from identification)

Impact of failure

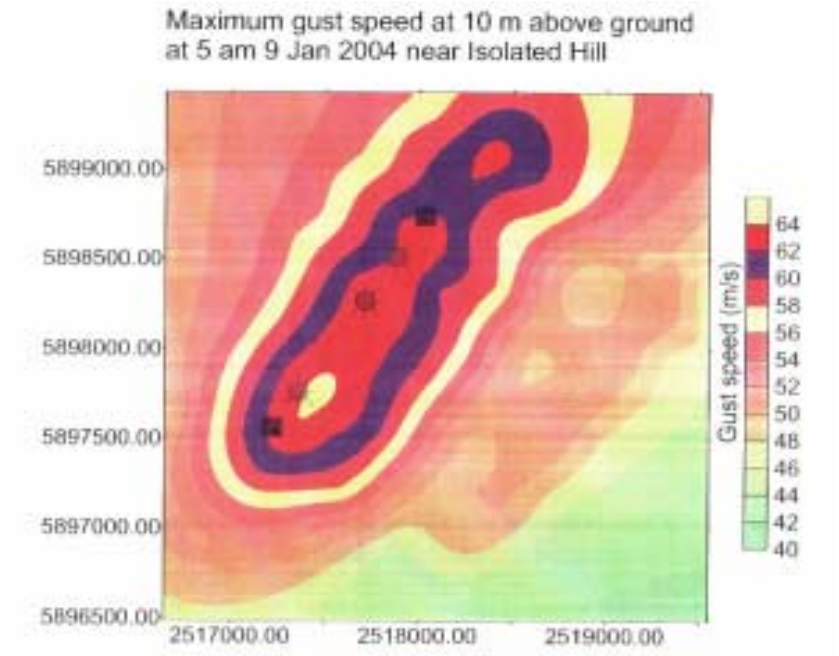
- **Friday:**
  - ⇨ Minimal load on HVDC at the time but scheduled for 800MW transfer north later in day. Lower than normal loads as people still on holiday
  - ⇨ Load made up from Huntly unit outage deferred, and extra generation from New Plymouth, Otahuhu Open Cycle Gas Turbines
  - ⇨ Separation of North Island and South Island prices. (NI elevated, SI depressed)
- **Saturday/Sunday:**
  - ⇨ Minimal impact, with almost no pricing separation
- **Monday:**
  - ⇨ More people back at work - higher loads. Huntly river heating limit forced cutback. Greater separation of NI and SI prices
  - ⇨ Significant demand response to higher prices. Vector shed 60 MW load at peak. Norske Skog, PanPac, Winstones cut operations. Extra cogeneration from Glenbrook

Investigation - Design Criteria

- Line designed in early 1960s for wind speed of 30 metres/sec, 110 km per hour
- During construction line was strengthened to 40m/s, 145 kph
- During DC5 HVDC upgrade in 1991, line was strengthened to NZS4203
  - ⇨ 1 in 50 year, 3-second gust modified using topographical factors
  - ⇨ Approx 51m/s used at these sites (180km/hr)

Investigation- Weather data

- NIWA modelling suggests 64m/s, (230 km/h), at ground level, tower 1131
- Conductors experienced 71m/s, (255 km/h)
- Wind event = return period of 1300 yrs



Investigation - Mode of Failure

- Windward Akimbo at 1131 appears to have broken under compression loading
- Tower 1131 is thought to have failed first
- Release of conductor at 1132 induced torsion on tower –failed due to wind load
- Tower 1133 (light suspension) failed under direct wind loading
- Armless angles at Towers 1130 & 1134 held
- All towers failed with classical tension / compression buckling

Investigation - Metallurgical Tests

- Metallurgical testing done by SGS (Auckland)
- Samples show nothing untoward
- Failures are all ductile caused by overloading
- No steel fatigue is evident
- Steel was above specified tensile strength

Investigation - Conclusions

- Wind speeds experienced were well above those the structures were designed or strengthened to
- Failure appears to be straight overloading
- Structures appear to have failed classically with no other factors obvious at this stage
- Orographic “lee-effect” was predominant cause of high wind speed