

## 6. TSUNAMI

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## 6.1 Summary

### Tsunami Hazard

Tsunami are typically generated as a result of displacement of ocean water due to landslides, earthquakes, volcanic eruptions and bolide impacts. Tsunami in Auckland can in general terms be categorised as:

- Distant source; > 3 hours travel time to NZ from sources such as South America and to a lesser extent Cascadia (North America) and the Aleutian islands.
- Regional source; 1-3 hours travel time to NZ from sources such as the Solomon Islands New Hebrides and the Tonga-Kermadec trench.
- Local Source < 60 minutes travel time to the nearest NZ coast. Activity on the southern end of the Tonga-Kermadec trench can cause tsunami to reach the Northland coast within 1 hour. Other sources can include submarine landslides or a slump in the continental shelf north of Northland.

Tsunami inundation modelling has been undertaken based on a maximum credible scenario of a 3 metre tsunami across the whole region, supplemented with more detailed modelling for a number of communities.

### Infrastructure Impacts from Uniform Hazard Scenario

The sectors most impacted by tsunami are roads and wastewater (coastal assets), ports and fuel (the Marsden Refinery being in an at-risk area). Communications, electricity and gas are expected to have limited and localised service impacts.

Recovery times for full restoration of services could be months to years for the worst affected sectors. Most affected utilities, except fuel, would be fully repaired or with temporary, alternative supplies / routes in place after one week.

#### Electricity

- Transpower's substations are all outside the inundation zone, though there are a number of towers and cables crossing low lying rivers and harbours. Impacts are expected to be relatively localised with short recovery times (days to weeks) once access is permitted in the area.
- Vector has a number of substations, cables, poles and pillars within inundation zones, with an estimated impact on supply to 2-4% of the population (up to 50,000 connections). Restoration of service could take up to 3-6 months with up to a year to restore full service.

#### Fuel

- The major impact for the fuel sector will arise from projected inundation of the Marsden Refinery. It could take weeks to months to establish an alternate supply (such as shipping refined fuel) and months to years for full recovery of the Refinery operations.

#### Gas

- Little or no impact predicted.

#### Telecommunications

- There will be some localised impacts to the cellular and landline network, with cellular impacts likely to be a degradation of capacity than a total loss of coverage in any given area. Power failure may have a significant impact as most households need power for their home phones.

#### Transport

- Roads on eastern shores are most at risk, however most also have easily accessible alternative routes. SH 16 and SH1 on approaches to the Harbour Bridge and across estuaries are likely to be inundated but NZTA estimate short recovery times once the water recedes. However it is worth noting that during the event major motorway evacuation routes are likely to be impassable and, if scour severely impacts the road and structures, recovery times could be weeks to months.
- Other key coastal transport assets likely to be impacted include the Ports of Auckland, Brittomart and Ferry Terminals with potentially months to years recovery times.

### **Water Supply**

- Local networks in North Shore and Orewa are most likely to be affected and the trunk supply into Orewa is on the Orewa Estuary Bridge with the potential to lose supply to the whole town. Recovery of the network will be dependent on the reinstatement of the bridge.

### **Wastewater**

- There are potentially significant impacts to the wastewater network arising from the inundation of coastal pump stations and trunk mains crossing bridges along the foreshore on pipebridges crossing estuaries. The recovery objective for week 1 is to divert overflows to safe watercourses with an estimated 6 months or more for full reconstruction of damaged infrastructure.

### **Stormwater**

- Coastal structures and pipelines expected to be damaged by scour and erosion with the worst service impacts expected if the old CBD / port outfalls are damaged which could significantly impact port and transport operations.

## 6.2 Tsunami Hazard

### Hazard Overview

Tsunami inundation mapping has been undertaken using a GIS-based attenuation model for a 3 metre tsunami across the whole region. This is considered to be a maximum credible scenario for much of the region.

Where additional modeling shows that the credible maximum scenario is greater than 3 metres, this layer has been combined with other modelled inundation extents. The additional modelling used was undertaken for selected communities on the east coast of the Auckland region. The communities modelled include:

- Omaha from Ti Point to Karamuroa Point
- Snells Beach from Puriri Place to Martins Bay
- Waiwera from Wenderholm Regional Park to Waiwera Hill Scenic Reserve
- Orewa/Whangaparoa from Hatfields Beach to Mollyhawk Reserve
- North Shore/Waitemata from Long Bay to Chelsea Bay
- Auckland Central from Ta Atatu Road/Northwestern Motorway intersection to Springcombe Road, St Heliers
- Auckland East from Clouston St, Glendowie to Chisbury Terrace Reserve.
- Excludes the Tamaki estuary upstream of Pakuranga Highway Bridge
- Beachlands/Maraetai from Jack Lachlan Drive Esplanade Reserve to Maraetai Point.
- Wharekawa/Whakatiwai from the Auckland region border to Kaiaua
- Selected bays and low-lying areas on Waiheke Island

This additional tsunami inundation modelling was undertaken for credible 'worst-case scenarios' from a distant source and a number of regional source scenarios. The following scenarios were represented:

#### Maximum Extent Distant Source

Inundation modeling is based on the maximum expected extent from a magnitude 9.5 earthquake occurring of the coast of South America, near the Peru coast. The tsunami has been modelled at a sea level of mean high water spring with an additional 50cm sea level rise. The results are considered to be conservative.

#### Maximum Extent Regional Source

Inundation modeling is based on the maximum expected extent from many modelled events generated in the Tonga-Kermadec Trench to the north east of Auckland. Many earthquakes with magnitudes between 9.2 and 8.8 were modelled to cover all credible scenarios. All tsunami were modelled at a sea level of mean high water spring and maximum extents are considered to be conservative.

The resulting map, using these scenarios and the 3 metre GIS scenario, provides a credible maximum tsunami inundation area for the entire region, excluding Great Barrier Island.

#### Limitations

- The polygons have been created from ESRI Grids and as a result may reflect a pixelated boundary when viewed at large scales.
- No erosion of coastal margins or topography is accommodated for in the modelling. The duration of tsunami events will generally exceed 8 hours. Therefore, locations susceptible to erosion such as beaches and sand spits may experience considerable erosion during a large event.

### General Infrastructure Impacts

The Auckland region has not experienced a significant tsunami event since the commencement of urban development. As such, it is difficult to accurately determine the potential damage a tsunami may cause. However, using knowledge of damage reported from historic international events allows general predictions of tsunami damage to be made. The main effects of a tsunami in the Auckland region arise from:

- inundation of coastal areas
- scour from incoming and receding debris laden water
- amplification in semi-enclosed harbours and estuaries
- increased turbulence and oversteepening of waves by opposing currents in the lower reaches of streams and rivers.

## 6.3 Energy

There is expected to be little impact on the energy sector from the effects of a tsunami. There may be some localised outages in the inundation zones although these are expected to be repaired relatively quickly. There are no impacts on the petroleum or gas network expected.

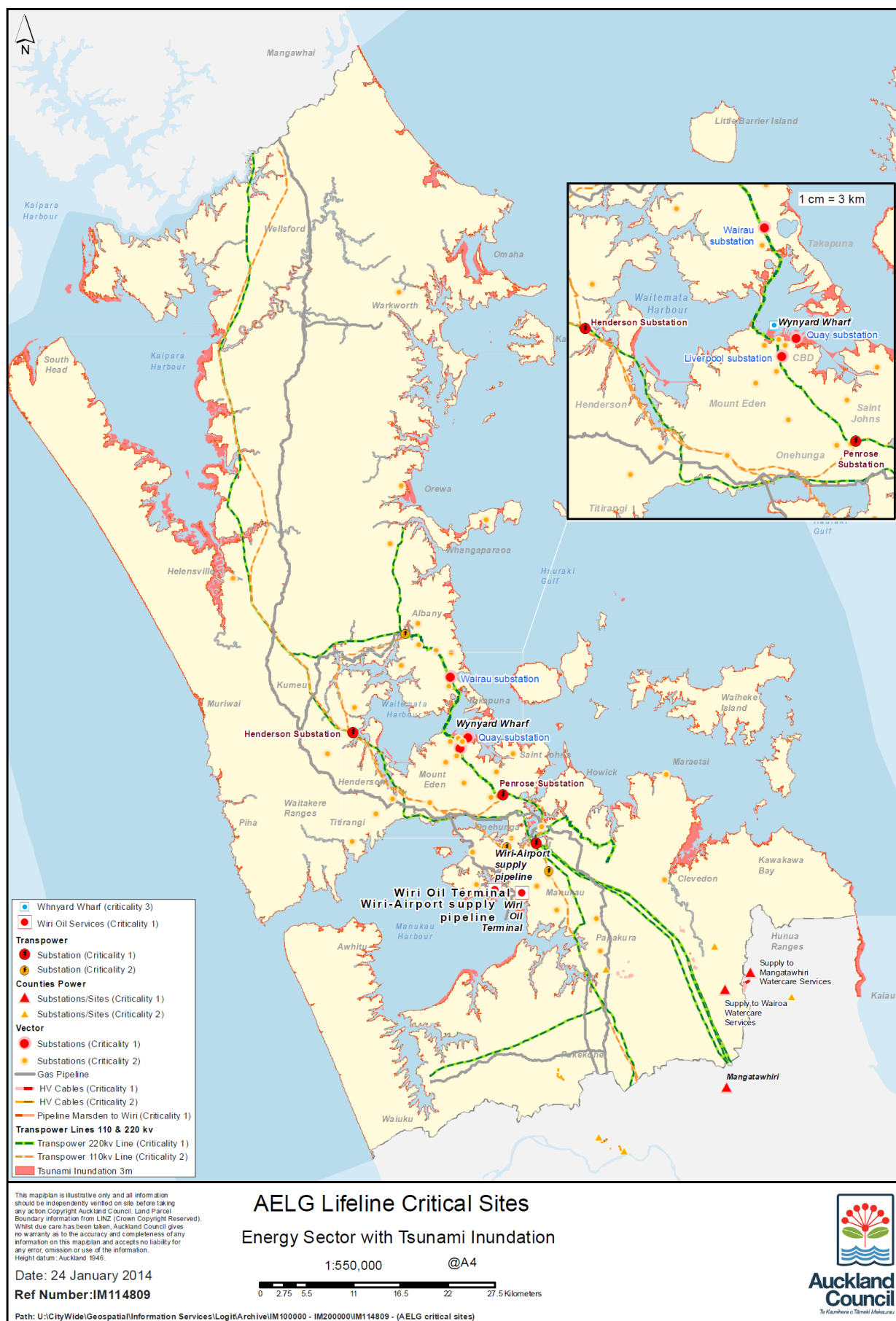
### Network and Service Impacts

#### Electricity

Counties Power expects little or no damage to it's network. The following table summarises impacts from Vector and Transport networks.

Network Assets at Risk of Tsunami	Expected Service Impacts
<p><b>Distribution</b></p> <ul style="list-style-type: none"> <li>▪ Ngatarunga Bay, Quay St, Northcote and Mangere West zone substations are all within the latest modelled inundation area</li> <li>▪ More than 700 hundred distribution substations are within the inundation area (including a significant proportion of the lower CBD)</li> <li>▪ More than 2500 service pillars within the inundation area</li> <li>▪ Some cable and/or poles potentially at risk from tsunami erosion</li> <li>▪ Risk to poles from floating debris is difficult to ascertain</li> <li>▪ The Hobson GXP, Zone Substation and Tunnel entrance are all just outside the inundation area. Because there are significant elements of this site that are below ground it is possible that tsunami effects could be experienced here, but it is difficult to ascertain what they might be.</li> </ul> <p><b>Bulk Transmission network</b></p> <ul style="list-style-type: none"> <li>▪ Otahuhu Site is adjacent to the Tamaki River</li> <li>▪ The new Hobson St Grid Exit Point adjacent to the Viaduct Basin</li> <li>▪ New Wairau Rd Grid Exit Point adjacent to the Wairau River / drain system</li> <li>▪ Cables installed in Fanshawe St and the Harbour Bridge</li> <li>▪ Cables and Towers crossing the Tāmaki River at Panmure</li> <li>▪ Henderson Otahuhu double circuit towers installed in the Whau River and adjacent to Henderson Creek</li> <li>▪ Number of towers installed in and around flat industrial areas of the Manukau Harbour</li> </ul>	<p><b>Distribution network</b></p> <ul style="list-style-type: none"> <li>▪ Many localized outages (individual pillars)</li> <li>▪ A significant number of wide-spread distribution outages (feeder outages due to switchgear failure)</li> <li>▪ A few wide-spread zone substation related outages – may be able to back feed with limited security</li> </ul> <p>For the ground mounted equipment (zone and distribution substations and pillars) this represents between 2 and 4% of the population.</p> <p>The tsunami hazard produces extremely clustered outage areas – particularly in the CDB, Orewa and Devonport along with a number of other smaller areas. Due to the potential overall scale it could take between 3 and 6 months to fully restore supply and potentially 12 months to restore to full security (assuming all areas are rebuilt). It is expected that we would be constrained by the availability of sufficient labour and equipment and that a Maximum Credible Event would have significant impacts in other areas of New Zealand. These timeframes could be modified if 'no rebuild' zone/s were established and/or by the potential use of temporary overhead circuits.</p> <p><b>Bulk Transmission network</b></p> <ul style="list-style-type: none"> <li>▪ According to all inundation modelling to date, none of Transpower's assets are at risk from inundation.</li> <li>▪ All new assets have been designed to mitigate against the minimum effects currently predicted.</li> <li>▪ Cables on bridges or towers in the tidal range could be damaged due to "projectile damage" of large floating debris (shipping)</li> <li>▪ Foundations could be undermined by scouring of the banks causing subsidence.</li> <li>▪ All this is expected to be localised based on the information currently available and unlikely to result in significant loss of supply.</li> </ul>

Table 6-1 Electricity Network: Vulnerability to Tsunami Hazard



**Figure 6-1: Energy Network Overlaid Tsunami Hazard Data**

## Petroleum

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>▪ Significant impact on Refinery with potentially long (weeks-months) recovery times until an alternative supply could be in place (such as shipping refined fuel to alternate locations) and years for full restoration.</li> <li>▪ Fuel offloading infrastructure could be impacted along the east coast of NZ.</li> <li>▪ Localised effects on service stations located within the inundation zones.</li> <li>▪ Wiri-Oil pipeline is unlikely to be affected, but will not be receiving fuel if the Refinery and / or pipeline is non-operational.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Significant disruption to fuel supplies in Northland and Auckland (and across the country as most eastern ports would be impacted).</li> </ul>

**Table 6-2: Petroleum Network: Vulnerability to Tsunami Hazard**

## Gas

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>▪ Little or no impact pipeline due to assets mainly being underground. Some damage may be sustained to local DRS installations due to movement of detritus.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Minimal. Some localised areas may be affected by loss of DRS installations.</li> </ul>

**Table 6-3: Gas Network: Vulnerability to Tsunami Hazard**

## Recovery Times

	Day 1	Week 1	Full Recovery
Electricity	Damage assessments and switching back of unaffected assets, switched out as a precaution	98%	Depends how much permanent repair and replacement required
Petroleum Fuels	100%	Depends on extent of damage to Refinery.	Depends on extent of damage to Refinery.
Gas	100%	100%	100%

**Table 6-4: Energy Network: Recovery Times**

## Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
Transpower	<ul style="list-style-type: none"> <li>▪ Substation Design Policy</li> <li>▪ Emergency Response Plan (Specific event- Flooding, inc Tsunami)</li> <li>▪ Transpower System Operator Contingency Plans for Supply Restoration</li> <li>▪ Transpower Emergency Management Plans, including possible rolling blackouts to manage load</li> <li>▪ Transpower Business Continuity Plan</li> </ul>	<ul style="list-style-type: none"> <li>▪ All newly designed assets must comply with this policy, which is intended to increase resilience.</li> <li>▪ Systematic assessment of impacts and resources available to address them</li> <li>▪ In the event of large scale supply loss, an approved plan for restoring supplies will begin depending on equipment availability.</li> <li>▪ In the event of demand exceeding capacity to supply, then an approved plan to manage load will be implemented.</li> <li>▪ Should Auckland based facilities put personnel and operations at risk, functions will relocate to pre-agreed fallback sites.</li> <li>▪ Where an extended loss of supplies results from Transpower's network, the National Communications manager will handle all responses to the media, usually via Senior Transpower Management.</li> </ul>
Vector-Electricity	<ul style="list-style-type: none"> <li>▪ Emergency Response Plan</li> </ul>	<ul style="list-style-type: none"> <li>▪ Systematic assessment of impacts and resources available to address them</li> </ul>

Sector	Planning undertaken	Specific Response Activities
Counties Power	<ul style="list-style-type: none"> <li>Assessed not to be directly at risk</li> </ul>	<ul style="list-style-type: none"> <li>Assessment of indirect impacts and respond where necessary</li> </ul>
Vector-Gas	<ul style="list-style-type: none"> <li>Full tsunami planning undertaken and specific plans prepared where applicable</li> </ul>	<ul style="list-style-type: none"> <li>Emergency response plans activated.</li> <li>Manpower and emergency spares/equipment mobilised</li> <li>Pipelines and network monitored and extent of damage/interruptions assessed</li> </ul>
NZRC (Pipeline)	<ul style="list-style-type: none"> <li>Activate our response plan</li> </ul>	<ul style="list-style-type: none"> <li>Negligible as negligible effect from Tsunami</li> </ul>
WOSL	<ul style="list-style-type: none"> <li>No tsunami data available for west coast</li> </ul>	<ul style="list-style-type: none"> <li>No tsunami data available for west coast</li> </ul>



## 6.4 Telecommunications

### Network and Service Impacts

Network Assets at Risk of Tsunami	Expected Service Impacts
<p>Chorus</p> <ul style="list-style-type: none"> <li>▪ “Active” Single / Double Bay and passive copper cross-connect cabinets that are within approximately the 500mm bathymetric contour of the inundation zone will fail. Non-pressurised distribution cables may fail at terminals that are damaged (pillars and pits). Older premises wiring will fail.</li> </ul> <p>Vodafone</p> <ul style="list-style-type: none"> <li>▪ Cell sites at low risk of impact</li> <li>▪ Fibre at low risk except possibly where it crosses road bridges. Major bridges include Pakuranga and Orakei Roads – loss of a fibre path traversing one of these bridges should not be service impact but would be a loss of redundancy on critical core backbone.</li> </ul> <p>Chorus</p> <ul style="list-style-type: none"> <li>▪ Likely to be localised failures in / near inundation areas, but no significant coastal facilities.</li> </ul> <p>Telecom</p> <ul style="list-style-type: none"> <li>▪ Minimal impact to Telecom cell sites, critical buildings are on high ground.</li> </ul> <p>Kordia</p> <ul style="list-style-type: none"> <li>▪ No risk from tsunami impact as all sites located on high ground.</li> </ul> <p>TeamTalk</p> <ul style="list-style-type: none"> <li>• No risk to conventional and trunked mobile radio services from tsunami impact as all sites are located either on high ground or atop high buildings and operate with independent back up power.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Localised impacts to the cellular and landline networks.</li> <li>▪ Due to the level of cellular coverage overlap in urban areas, this would likely represent a degradation of capacity and in-building coverage rather than a total loss of coverage in any given area.</li> <li>▪ A significant level of network congestion can be expected in the immediate aftermath of a tsunami and/or tsunami warning.</li> </ul> <p>No significant congestion or service degradation expected to mobile radio networks as capacity is generally allocated to specific customers</p>

Table 6-5: Telecommunication Network: Vulnerability to Tsunami Hazard

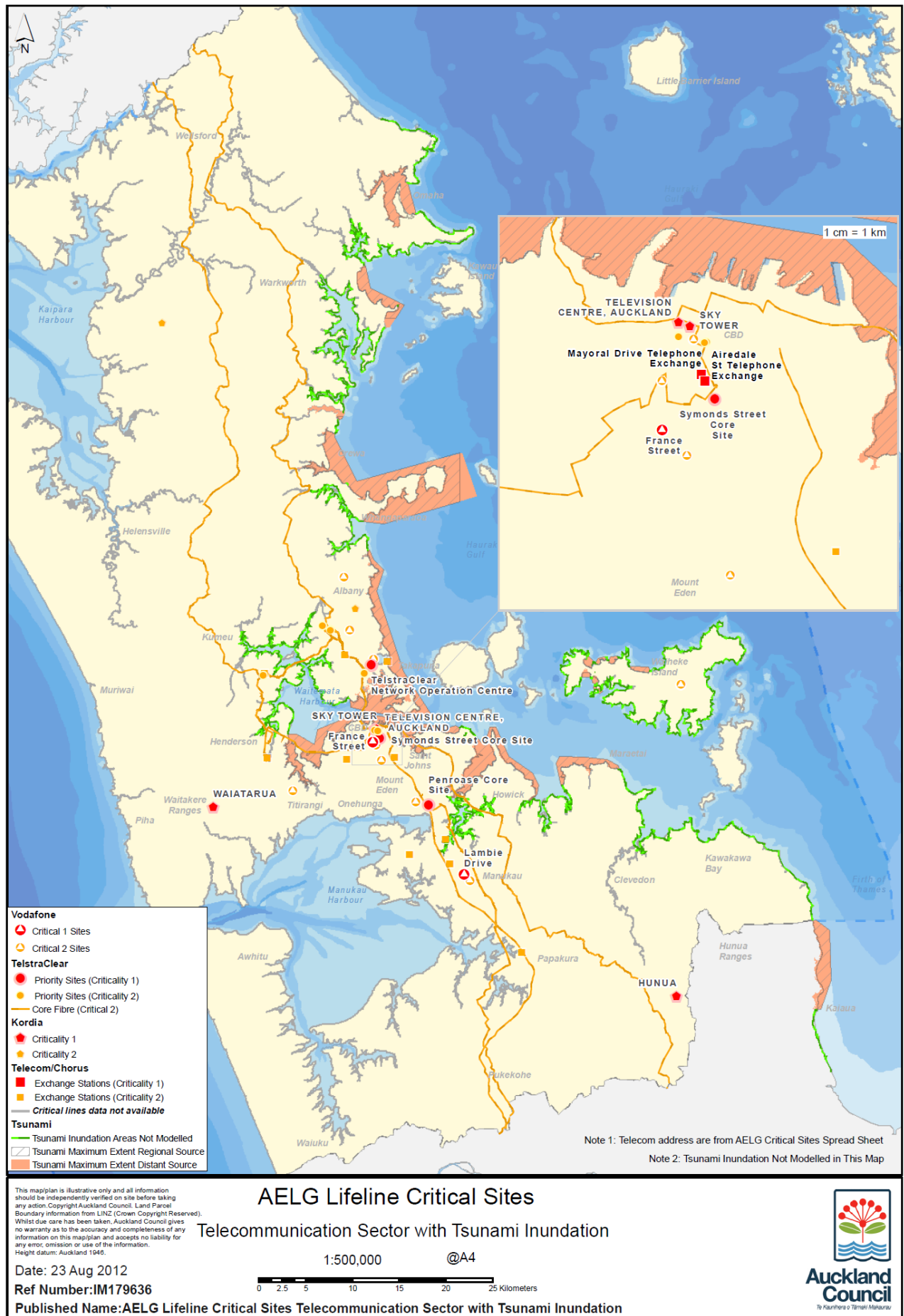


Figure 6-2: Telecommunications Network Overlaid Tsunami Hazard Data

## Recovery Times

	Day 1	Week 1	Full Service Restoration
Land lines	Localised impacts in inundation areas	Will depend on access to areas and availability of electricity supply.	
Cellular Networks	Localised impacts in inundation areas		

**Table 6-6: Telecommunication Network: Recovery Times**

## Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
Copper Telco Network	<ul style="list-style-type: none"> <li>Activate the Chorus Emergency Management Plan</li> </ul>	<ul style="list-style-type: none"> <li>Equipment alarms and Inbound reported fault volumes will drive our response.</li> </ul>
Mobile/Cellular Network	<ul style="list-style-type: none"> <li>Manage under Emergency Management Framework.</li> <li>Activate TEPF.</li> </ul>	<ul style="list-style-type: none"> <li>Review location of generators and re-deploy if warning time allows.</li> <li>Issue H&amp;S advice to staff. (Vodafone – head office on Viaduct Harbour Ave may need to be evacuated, would involve relocation of some business critical functions to alternate sites)</li> <li>Ask Group EOC to issue media advice to minimise phone use to essential purposes only and use txt in preference to voice communication.</li> </ul>
Fibre Telco Network	<ul style="list-style-type: none"> <li>Activate the Chorus Emergency Management Plan</li> </ul>	<ul style="list-style-type: none"> <li>The fibre network will be largely unaffected but sites will need to be inspected where inundation has flooded patch panels.</li> </ul>

**Table 6-7: Telecommunications Sector Response and Recovery Activities**

## 6.5 Transport

### Network and Service Impacts

A tsunami is expected to have a significant impact on the road network. However most coastal roads that would be closed by damage have enough redundancy to allow the networks as a whole to keep operating. A typical recovery profile of a vulnerable section of road following a tsunami would see the road closed by water during and immediately after the event. Capacity should be quickly restored as the water recedes and as long as there is no scouring, full capacity should be achieved within two days.

The Japan tsunami caused extensive damage to bridges and roads. The worst case scenario for Auckland is significant damage from scour and erosion to SH16 causeway and SH1 around Harbour Bridge and where it crosses estuaries to the south.

Other key coastal transport assets likely to be impacted include the Ports of Auckland, Brittomart and Ferry Terminals with potentially months to years recovery times.

### Road

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>Harbour Bridge approaches are likely to have temporarily reduced capacity during the event and the Victoria Park Tunnel will potentially flood. There is likely to be some physical damage to roads.</li> <li>Several sections of SH1 to the north of the city are likely to be affected where the road crosses rivers at low topographical points</li> <li>Equally sections of the SH 1 Southern motorway are in potential inundation areas where it crosses rivers e.g. at Tamaki and Papakura</li> <li>SH16 is shown to be inundated at Waterview (and detour routes are highly limited in capacity) through Helensville at the Kaipara River. The raising of the causeway will mitigate flooding and inundation during a tsunami event though overtopping is still possible.</li> <li>Tamaki Drive is in a high risk area. The tsunami waters will damage vehicles and cliffs as well as damaging or undermining the carriageway by scouring. However, there are enough alternative routes to avoid a significant effect on the road network.</li> <li>The Quay Street sea wall is at risk, and, if it collapsed, a number of lifeline utilities in the carriageway could also be impacted.</li> <li>Generally, only minimal scouring is expected around bridge embankments</li> <li>Bridges over long narrow estuaries may be more susceptible, due to the intensity/compression of the incoming surge</li> <li>Roads on eastern shores are the most vulnerable to damage from inundation and scouring, although most have easily accessible alternative routes should they become impassable.</li> </ul>	<ul style="list-style-type: none"> <li>Significant disruption to the State Highway network – impacted to the north south and west.</li> <li>The Northern Gateway has decreased the risk to SH 1 as the new alignment is further from the coast and at a higher level than the old.</li> <li>Several local coastal roads would be closed due to damage, but most of these areas have enough redundancy to allow the network as a whole to keep operating.</li> <li>Damage is likely on many of the local roads with culverts and bridges as receding waters could cause scouring. This increases delay in reopening the roads to full capacity.</li> </ul>

Table 6-11: Road Network: Vulnerability to Tsunami Hazard

## Rail

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>Brittomart Station is in the inundation zone.</li> </ul>	<ul style="list-style-type: none"> <li>No input from Kiwirail.</li> <li>Expect rail movements to stop and trains to be evacuated at safe stations rail network in inundation areas in a number of places.</li> </ul>

**Table 6-12: Rail Network: Vulnerability to Tsunami Hazard**

## Ports

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>All assets are low-lying and at risk of a tsunami event although it is unlikely that a single tsunami event will impact both Auckland &amp; Onehunga ports.</li> <li>Crane operation relies on electricity supply relies from Quay Street substation (in tsunami risk area).</li> <li>A major east coast event is also likely to impact Ports of Tauranga, the normal</li> </ul>	<ul style="list-style-type: none"> <li>Large event has potential to destroy key port infrastructure (eg, wharves, cranes, buildings, straddle carriers) and cut off electricity supply required to operate cranes.</li> <li>Minimal operations may be able to recommence (eg, vessels with own cranes may be able to discharge cargo but efficient cargo handling equipment will be unavailable)</li> </ul>

**Table 6-13: Ports: Vulnerability to Tsunami Hazard**

## Ferries

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>All ferry terminals</li> </ul>	<ul style="list-style-type: none"> <li>Closure of most ferry terminals until inspections and repairs can be undertaken.</li> </ul>

**Table 6-12: Ferry Network: Vulnerability to Tsunami Hazard**

## Airports

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>Road access to the Airport may be affected disrupting flights but Airport assets are not deemed to be at risk.</li> <li>Airport at Great Barrier island may be at threat for a very significant tsunami.</li> </ul>	<ul style="list-style-type: none"> <li>The Airport and Airlines monitor any NZ or worldwide tsunami's to review impacts on International and Domestic travel.</li> </ul>

## Recovery Times

	Day 1	Week 1	Full Recovery
Road	Coastal roads closed by flooding, small coastal roads closed by damage, but network as a whole keeps operating. Minimal scouring around bridge embankments but possible effects on bridges over long narrow estuaries.	50 – 80%	Most of the network is likely to be accessible. Only the coastal roads are likely to be affected and depending on the extent of damage, within 1 to 2 weeks full recovery is likely.
Rail			
Ports	Port completely inoperable	Ships with own cranes able to berth to discharge aid supplies.	At least 3 months (or up to 12 months if replacement gantry cranes were required)
Airport			

**Table 6-16: Transport Network: Recovery Times**

## Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
AT (Roads)	<ul style="list-style-type: none"> <li>Activate draft Auckland Region Tsunami Contingency Plan</li> <li>AELG Safe Routes Maps</li> <li>Auckland Transport Emergency Response Plan</li> <li>Contractor Emergency Response Plan</li> </ul>	<ul style="list-style-type: none"> <li>Mainly low lying coastal roads are likely to be inundated and closed till the water recedes unless the roads have been scoured.</li> <li>Operations staff will carry out inspections and close out unsafe roads.</li> <li>Detour routes will be created</li> <li>Contractors will provide assistance in terms of traffic management to emergency services</li> <li>Roads that have been scoured will be repaired and restored to fully operational state.</li> <li>A stock of Bailey Bridges is held in Palmerston North but there is likely to be high demand for these around the country in a major east coast tsunami event.</li> </ul>
AT (public transport)	<ul style="list-style-type: none"> <li>Activate draft Auckland Region Tsunami Contingency Plan</li> <li>AELG Safe Routes Maps</li> <li>Auckland Transport Emergency Response Plan</li> <li>Contractor Emergency Response Plan</li> <li>Public Transport Emergency Response Plan (to be developed)</li> </ul>	<ul style="list-style-type: none"> <li>Mainly low lying coastal roads are likely to be inundated and closed till the water recedes unless the roads have been scoured.</li> <li>Operations staff will carry out inspections and close out unsafe roads.</li> <li>Detour routes will be created</li> <li>Contractors will provide assistance in terms of traffic management to emergency services</li> <li>Roads that have been scoured will be repaired and restored to fully operational state.</li> </ul>
Joint Transport Operations Centre		
Auckland Council (stormwater)	<ul style="list-style-type: none"> <li>No specific Tsunami response and recovery plans in place.</li> </ul>	<ul style="list-style-type: none"> <li>Consider initial restoration of damaged outfalls and structures by "day-lighting". In some cases this may be a "best solution" and be made permanent and may require additional protection works to be undertaken.</li> </ul>
Auckland Airport	<ul style="list-style-type: none"> <li>Reviewed tsunami data for effect on Airport.</li> </ul>	<ul style="list-style-type: none"> <li>Discussions undertaken with Airlines for response including overseas events.</li> </ul>
Ports of Auckland	<ul style="list-style-type: none"> <li>Tsunami Emergency Plan</li> <li>Major Incident Management Plan</li> </ul>	<ul style="list-style-type: none"> <li>Notify Harbour Master and all ships of approaching event</li> <li>Harbour Master takes full control of all ships.</li> <li>Depending on advance warning period &amp; expected size of tsunami the following may occur: <ul style="list-style-type: none"> <li>Move Ships out to sea to minimise damage to ships and other property.</li> <li>Move floating plant to Viaduct Harbour</li> <li>Move mobile plant into shelter</li> <li>Move tugs to deep water in Inner Harbour</li> <li>Secure cranes and wedge wheels</li> <li>Breakdown and/or lash container stacks</li> <li>Move dangerous goods away from threat</li> </ul> </li> <li>After event perform initial visual inspection of damage sustained and threats to safety (eg, wharves, cranes, ships, buildings, dangerous goods cargo and container stacks)</li> <li>Commission detailed survey of all buildings, wharves and cranes ASAP</li> </ul>
KiwiRail		



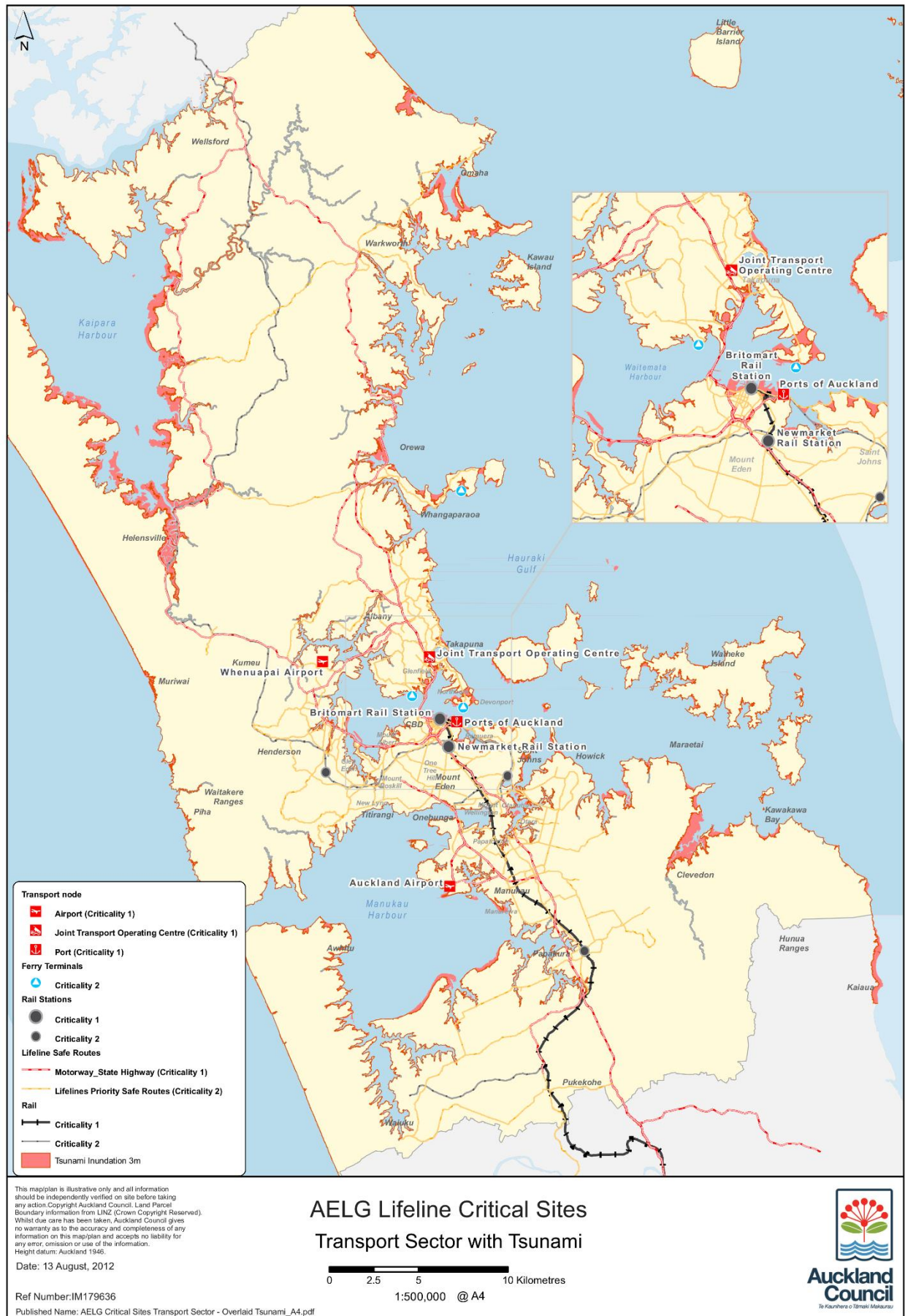


Figure 6-3: Transport Network Overlaid Tsunami Hazard Data

## 6.6 Water and Waste

Most of the Water Services are located underground and are unlikely to be severely damaged. However, where pipes cross bridges there may be damage due to the failure of the bridge. North Shore and Orewa are the most vulnerable areas for both water supply and wastewater. Critical infrastructure such as pumping stations and treatment plants are at risk from inundation where they're located in low lying areas on the coast. Sewers laid along North Shore beaches foreshore are most vulnerable.

The stormwater network elements that will be impacted by a Tsunami event are the coastal outfalls together with any waterways that are in low lying coastal areas in the area of impact..

Full service recovery is highly dependent on location and North Shore coastal areas are expected to be without a wastewater network for at least six months.

### Network and Service Impacts

#### Water

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>Local networks most impacted</li> <li>Trunk supply into Orewa is located on Orewa Estuary Bridge. Pipe subject to damage or failure dependent upon bridge.</li> </ul>	<ul style="list-style-type: none"> <li>Orewa reservoir has 2-4days storage. Water restrictions. However, local area may well be evacuated – lower demand.</li> </ul>

**Table 6-8: Water Supply Network: Vulnerability to Tsunami Hazard**

#### Wastewater

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>North Shore and Whangaparaoa are most vulnerable areas.</li> <li>Large sewer systems laid along the foreshore of a number of beaches and estuaries on the North Shore carry approximately 30% of waste to Rosedale.</li> <li>Pumping stations at risk of damage from inundation. Pumps destroyed if still operational, may need to switch off.</li> <li>Sewers at risk where they cross bridges - E.g. Whau Creek.</li> <li>Loss of facilities from structural and equipment damage due to inundation.</li> <li>Impacts from loss of power supply.</li> <li>Trunk and network reticulation damage from debris blockage, fracture, wash out etc.</li> </ul>	<ul style="list-style-type: none"> <li>Loss of service in localised areas due to damage, loss of power supply.</li> <li>Restriction or Loss of access to sites for repairs.</li> <li>North Shore trunk systems along foreshore and estuaries will take some time to reinstate.</li> <li>Clearance of debris in waterways, stream beds and estuaries to allow overland flow paths and prevent flooding or ponding.</li> <li>Debris blockage of designed sewer overflow points.</li> <li>Public health risk from potential contamination of water supplies.</li> <li>Clearance of blockages in trunk and network sewers will take substantial resources and time.</li> <li>Overflows to environment.</li> </ul>

**Table 6-9: Wastewater Network: Vulnerability to Tsunami Hazard**



## Stormwater

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>Coastal stormwater outfalls and pipelines are vulnerable to blockage (by sediment, building debris and marine detritus) and structural damage or complete loss due to scour and erosion. Some materials may be flushed well up pipelines and also open channels such as Wairau Stream.</li> <li>Waterways will be impacted by debris blockage in low lying coastal areas swept by tsunami surge. Pipe inlets are likely to be blocked, especially where these are fitted with grills.</li> <li>Old brick pipes in areas such as Queen Street are most vulnerable to damage from surge of tsunami waters.</li> </ul>	<ul style="list-style-type: none"> <li>If the large, old outfalls in the CBD and port area collapse (see earthquake section 5.6) considerable disruption to the port and transport operations may result.</li> <li>Reinstatement of impacted streams, pipelines, pipe entries, catchpits and outfalls needs to be quickly completed after tsunami to reduce flooding risk from next precipitation.</li> <li>Comprehensive waterway and pipe clearance programmes may be required quickly after the event to mitigate flooding risk and allow recovery.</li> </ul>

**Table 6-10: Stormwater Network: Vulnerability to Tsunami Hazard**

## Solid Waste

Network Assets at Risk of Tsunami	Expected Service Impacts
<ul style="list-style-type: none"> <li>Waiheke Transfer Station</li> <li>Devonport Transfer Station</li> <li>Visy MRF</li> <li>Waitakere Transfer Station</li> <li>Silverdale Transfer Station</li> <li>Whitford Landfill</li> <li>Papakura Transfer Station</li> <li>Waiuku Transfer Station</li> </ul>	<ul style="list-style-type: none"> <li>Closure of transfer stations with customers diverted to nearest alternative.</li> </ul>

**Table 6-15: Solid Waste: Vulnerability to Tsunami Hazard**

## Recovery Times

	Day 1	Week 1	Full Recovery
Water supply	Situation assessment identify options for ensuring service continuity	Systems reconfigured to maximum extent possible. Repairs to major assets in progress where accessible and where service restoration possible. Orewa pipe bridge recovery 1-2 weeks.	Services restored to extent possible. Anticipate mainly local networks affected.
Wastewater	Situation assessment identify options for ensuring service continuity	Overflow diversions to safe water course or estuary/marine environment in place.	Reconstruction of major sewers and structures damaged commenced. Min. six months recovery along North Shore foreshore.
Stormwater	Inspection, damage reporting and prioritisation for recovery. Initial response on rescue.	Major outlets cleared of debris and flowing. Major inlets and grills cleared.	Pipes cleaning, reinstatement as required to completion and full service restored – 6 months to 4 years.

**Table 6-6: Water Network: Recovery Times**

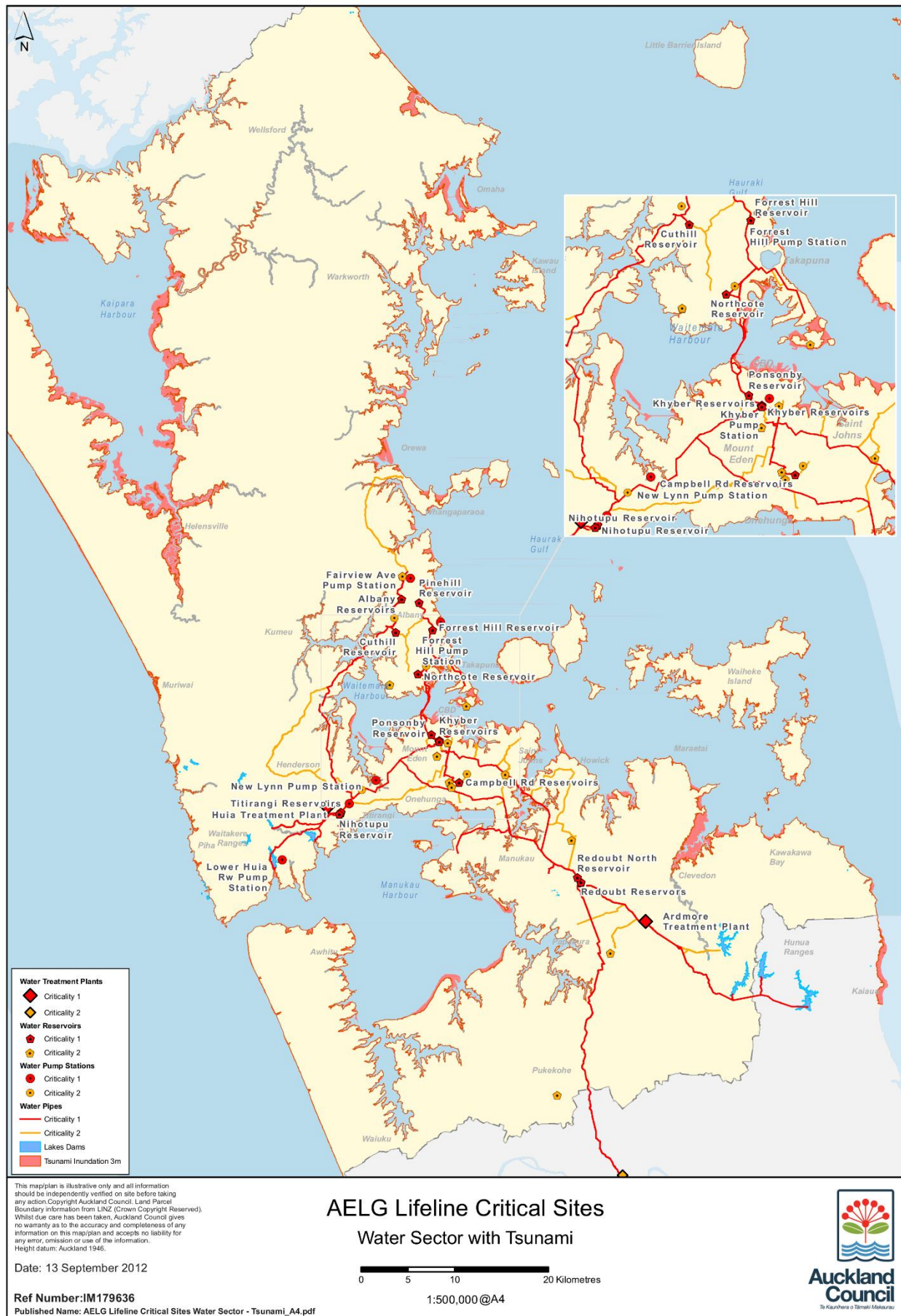


Figure 6-4: Water Supply Network Overlaid Tsunami Hazard Data

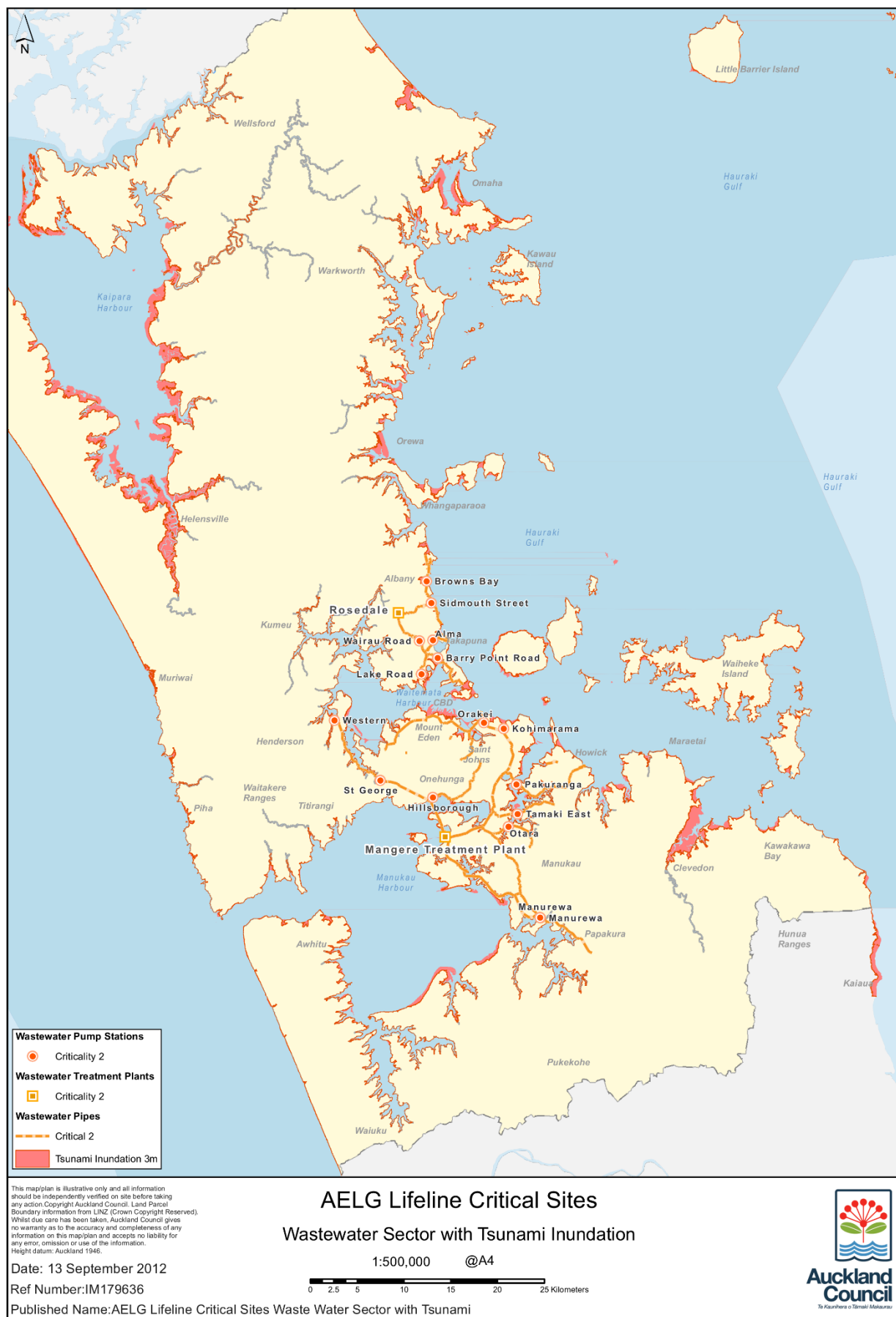


Figure 6-5: Wastewater Network Overlaid Tsunami Hazard Data

## Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
Watercare	<ul style="list-style-type: none"> <li>▪ Activate Watercare Operations Incident Management plan</li> <li>▪ Assess public health risk</li> </ul>	<ul style="list-style-type: none"> <li>▪ Situation assessment and system reconfiguration to maximum extent possible.</li> <li>▪ Implement public health risk management plan</li> <li>▪ Localised water supply restrictions imposed and emergency supplies required.</li> </ul>
Stormwater	<ul style="list-style-type: none"> <li>▪ No specific Tsunami response and recovery plans in place.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Consider initial restoration of damaged outfalls and structures by “day-lighting”. In some cases this may be a “best solution” and be made permanent and may require additional protection works to be undertaken.</li> </ul>

## 6.7 Other Critical Community Sectors

There are no critical 1 or 2 community sites in the inundation zone.

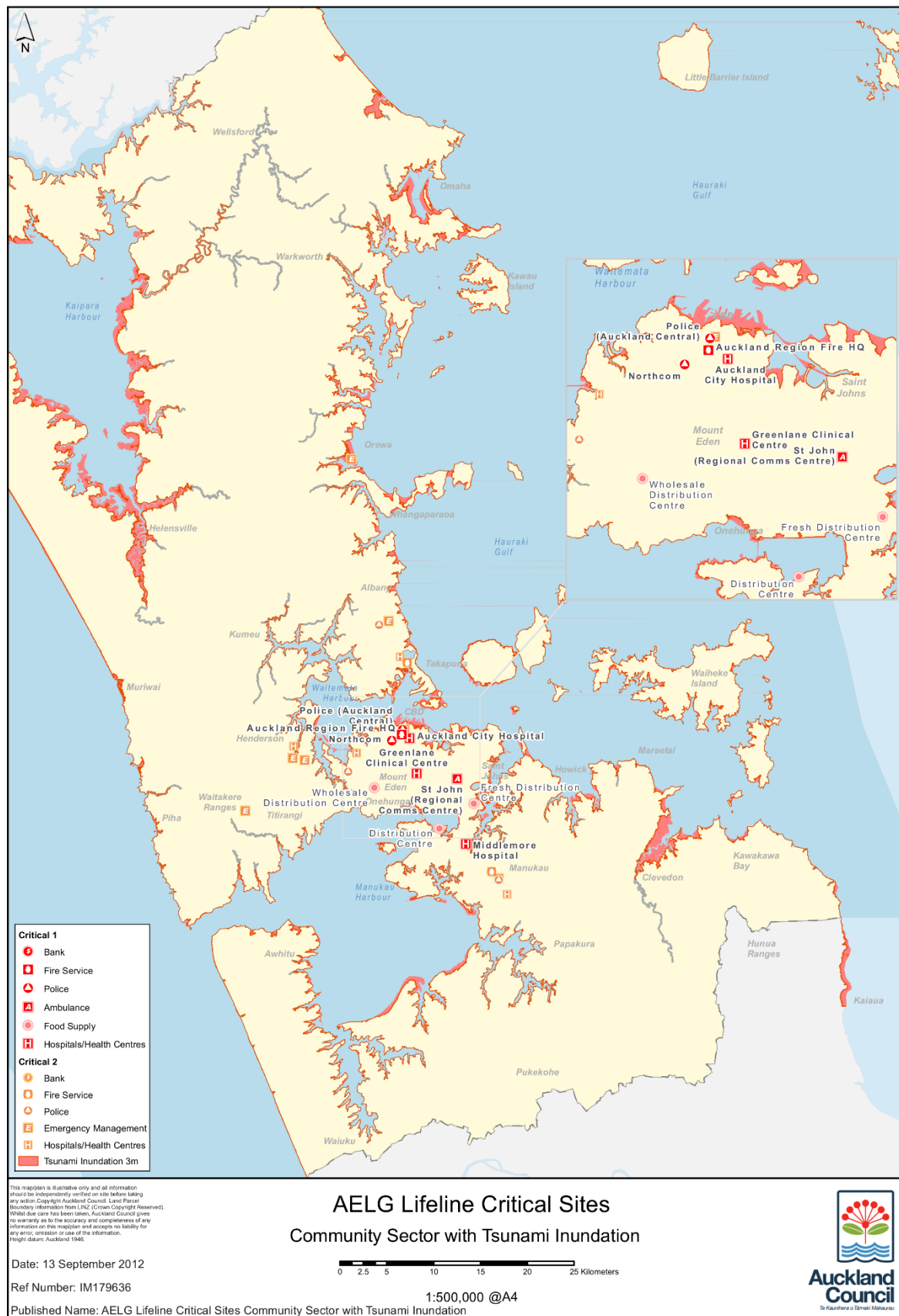


Figure 6-6: Critical Community Sites Overlaid Tsunami Hazard Data