IMPACT ON THE NORTH ISLAND FREIGHT INFRASTRUCTURE IN THE EVENT OF A DISRUPTION OF THE PORTS OF AUCKLAND

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by

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ABSTRACT

This research provides an investigation into the impact on the North Island freight infrastructure, in the event of a disruption of the Ports of Auckland (POAL).

This research is important to New Zealand, especially having experienced the Canterbury earthquake disaster in 2010/2011 and the current 2012 industrial action plaguing the POAL. New Zealand is a net exporter of a combination of manufactured high value goods, commodity products and raw materials. New Zealand's main challenge lies in the fact of its geographical distances to major markets. Currently New Zealand handles approximately 2 million containers per annum, with a minimum of ~40% of those containers being shipped through POAL.

It needs to be highlighted that POAL is classified as an import port in comparison to Port of Tauranga (POT) that has traditionally had an export focus. This last fact is of great importance, as in a case of a disruption of the POAL, any import consigned to the Auckland and northern region will need to be redirected through POT in a quick and efficient way to reach Auckland and the northern regions. This may mean a major impact on existing infrastructure and supply chain systems that are currently in place.

This study is critical as an element of risk management, looking at how to mitigate the risk to the greater Auckland region. With the new Super City taking hold, the POAL is a fundamental link in the supply chain to the largest metropolitan area within New Zealand.

Key Words: Port Operations, Natural Disaster, Risk Management, Container Management, Multi Modal Transport Challenges.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS / ACRONYMS

AKL	Auckland
BOP	Bay of Plenty
CILTNZ	Chartered Institute of Logistics & Transport in New Zealand
CO_2	Carbon dioxide
EASTS	Eastern Asian Society for Transport Studies
ECMT	East Coast Main Trunk Line from Hamilton to Tauranga
g	Gram
GDP	Gross Domestic Product
ha	Hectare
HPV	High Performance Vehicle (NZTA)
hr	Hour
hrs	Hours
JIT	Just in Time
JOG	Waikato Regional Council Grant of Funding to KiwiRail to upgrade network to attract more regional volume onto rail. ($13mil grant)
kg	Kilogram
km	Kilometres
LE	Locomotive Engineer
MAF	Ministry of Agriculture and Forestry
mil	Millions
MoT	Ministry of Transport
NCR	Net Crane Rate
NLTP	National Land Transport Programmes
NZTA	New Zealand Transport Agency
OKA	Out of Kilter Algorithm
POAL	Ports of Auckland
POT	Port of Tauranga

SH	State Highway 1 or 2 or 27 or 29 as depicted by the numeral following the SH
STATS NZ	Statistics New Zealand
T / t	Tonnes
TEU≈	Twenty Foot Equivalent unit, twenty foot container, Container, slot
TRG	Tauranga

Note: where the word container is used in this document, it is specifically referring to Twenty Foot Equivalent Units or TEU≈ as reported, recorded and accounted for by all NZ Ports when aggregating annual volumes handled by the specific Ports.

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1. INTRODUCTION

1.1. Setting the Scene

New Zealand is a country made up of two main islands, which accommodate the main population and are the source of the country's gross domestic product. New Zealand is heavily reliant on efficient transport of commodities to allow the economy of the country to prosper. Sea freight accounted for 99.6% of trade volume in 2008 (NZ Shippers council, 2010).

New Zealand's North Island accounts for 72% of all containerised imports and exports to and from New Zealand, which is some 2,353,067 TEU (Twenty-foot equivalent units/containers). Ports of Auckland and Port of Tauranga account for 81% of the North Island container traffic or some 1,378,711 TEU. [See Appendix 7.1 for North Island Map detailing container exports by port and Appendix 7.2 for South Island Map detailing container exports by port].

The majority of the North Island containerised imports (70%) come through Ports of Auckland (POAL) and the majority of the North Island containerised exports (39%) exit the North Island through the Port of Tauranga (POT).

TABLE 1 - Summary of POAL & POT Container Volume for 2010. (POAL, 2010)

Summary of NZ, N/Island, & POAL / POT Container volume for 2010 in TEU≈					
Type	All of NZ	North Island	POAL / POT	as % of NZ Total	as % of N/Island
Total	2,353,067	1,700,225	1,378,711	59%	81%
Full Imports	553,532	430,972	373,059	67%	87%
Full Exports	795,488	561,673	427,491	54%	76%
Empty Imports	437,416	278,201	179,971	41%	65%
Empty Exports	185,069	140,258	119,519	65%	85%
Other	381,562	289,121	278,671	73%	96%

It stands to reason that both POAL and POT are a crucial part of the New Zealand North Island logistics infrastructure and any disruption at either port would have a fundamental impact on the country's economy.

New Zealand is home to some 65 volcanoes in various stages of their life ranging from active, to dormant, to extinct. We make up part of the Pacific Ring of Fire, which is some 44,000km in length and has a total of 452 volcanoes. New Zealand exists as a result of the Pacific Tectonic plate being subducted (going underneath) the Indo-Australian tectonic plate. We sit on the boarder between these two wrestling giants (GeoNet, 2011).

"A volcanic field that covers around 360km^2 under Auckland City includes 49 separate volcanoes, each of which is considered extinct. However, the field as a whole remains active. The last eruption was Rangitoto, around 600 years ago" (GeoNet, 2011).

Multiple natural disasters experienced globally in the last two years impacted on logistics and freight distribution in general, such as volcanic activity in the northern and southern hemisphere with ash clouds circulating over Europe and the United

Kingdom in the northern hemisphere and ash clouds circulating over Australia, New Zealand, Southern Africa and South America in the southern hemisphere. This phenomenon resulted in millions of passengers being stranded and billions of dollars of lost revenue to the global logistics industry. In Europe alone it is estimated that the cost to industry is up to €2.5bn and still counting (Sabbatt, 2010).

The recent earthquakes in Christchurch New Zealand in 2010 and 2011 and Tōhoku Japan in 2011 resulted in loss of life, property destruction, infrastructure failure and massive disruption to logistics networks. The loss of life is still being quantified, as is the total cost of these natural disasters. The current estimates run into the hundred of billions.

With these phenomena current and exposing the fragility of existing logistics infrastructure, the purpose of this investigation is to test the impact on the North Island infrastructure in the event of a prolonged disruption of the Ports of Auckland as a result of a natural disaster.

1.2. Aim

The aim of this investigation is to test the fragility of the New Zealand North Island Infrastructure in an attempt to determine if the whole infrastructure, including rail, is robust enough to cope with a major shift of import and export volume at short or little notice.

1.3. Objectives

The research will identify and discuss the existing infrastructure in place – available modes associated with capacities and constraints along the supply chain – and to identify whether it is possible to mitigate this risk through instituting load and discharge port changes requiring the redirection of marine vessels.

In particular this study will focus on:

- Similar analyses/studies that have been conducted in New Zealand or internationally.
- Identifying the infrastructure of POAL, POT, the feeder systems to/from these ports, e.g. road and rail.
- Assessing pressure points and analysing them in terms of fragility.
- Mitigation of pressure points by looking at various mode alternatives such as ports, road and rail.
- Testing whether the Out of Kilter Algorithm (OKA) modelling is appropriate and can be applied in this instance.
- Identifying whether/how hurdles such as economical, technical, geographical, human resource and environmental can be overcome.
- Efficiencies, timing of product delivery.
- Whether Just in Time (JIT) is still justified under resilience conditions.

1.4. Methodology

This research was conducted using the following process:

- Literature review of international case studies
- Compilation of data supplied by POAL/POT to the supply chain of vessels to/from the Ports of Auckland and Tauranga.
    - Shipping schedules
    - Port data on infrastructure availability, berth occupancy, crane availability and productivity
    - Container movements – imports/exports
    - Capacities available and saturation points
- Evaluation of the above data and assessment of what needs to be put in place in terms of infrastructure and operations to make it happen.
- Assessing whether a simulation model such as the OKA model is relevant and able to test a variety of scenarios.
- Identifying whether potential relocation of vessels planned to call POAL will be able to be diverted to POT, and under which conditions this can take place.

Some of the characteristics to be examined will be for example volumes, number of containers (total containers, full imports, full exports, empty imports, empty exports, other), immediate available capacity associated to various modes, infrastructural inhibitors and how these could be addressed, fixed asset capabilities and limitations of all sorts.

1.5. Scope and Limitations

Scope of the investigation:

- The scope of the investigation is limited to container trade, specifically the current volumes that are imported and exported through Auckland and Tauranga.
- Containers that were imported and exported through the two respective ports during the month of August 2010 will be used to perform modelling to determine impact on infrastructure. The reason for using volumes during August as opposed to any other month is that both Ports would be experiencing "normal" volume trade during this window, as this would be the tail end of the NZ export peak and the beginning of the NZ import peak. Both Ports, as being the most "sensible time" to model average numbers, agreed to this date.

Limitations of the investigation:

- It is assumed that both of the Ports of Auckland (Manakau and Waitamata) are totally inoperable for the purpose of this exercise, effectively ruling out the option of coastal shipping into and out of the POAL during this outage.
- Road, rail and supporting infrastructures will form the basis of the modelled solution.
- Modelling will be done in the first instance by spread sheeting and with the consideration of using an OKA Model. (Latest OKA update by Emeritus Professor for Transport, Kissling, Lincoln University, 2009). The OKA to be used was developed by Fulkerson in 1961. The out of kilter algorithm is an example of a primal-dual algorithm (Fulkerson, 1961).

1.6. Structure of Report

The first chapter concentrates on setting the scene, including identifying the objectives, outlining the methodology used and defining the scope and limitations of this report.

Next the Golden Triangle infrastructure and network reliability are discussed by investigating Ports, Road and Rail networks.

Chapter three is dedicated to International case studies in regards to the impact of natural disasters on Ports situated in Chile, Japan and New Zealand.

This is followed by a case study considering the impact on the North Island freight infrastructure in the event of a disruption of the Ports of Auckland.

Findings and the outcome are discussed in the conclusion.

2. OVERVIEW OF THE GOLDEN TRIANGLE INFRASTRUCTURE AND NETWORK RELIABILITY

2.1. Introduction

This chapter outlines information on reliability of ports, road & rail infrastructure and networks within the Golden Triangle of the North Island of New Zealand.

The Golden Triangle is an economic powerhouse existing between the three cities of Auckland, Hamilton and Tauranga, which produce more than one third of New Zealand's Gross Domestic Product (GDP) (Waikato Times, 2010).

Geographically, the most important feature from a transport perspective is the arrangement of New Zealand as two elongated main islands separated by a passage of water (Cook Strait). As a consequence of this layout, each island has complete and self-contained road and rail networks, linked with the other island via coastal shipping and inter-island road and rail ferries to form a national network, and with the outside world through gateways at international sea and to a lesser extent airports. Mountainous terrain and the distribution of population dictate the course that the land transport networks follow within each island (Bolland et al, 2005).

The movement of freight plays a vital role in sustaining and supporting economic development and thus contributes to the high quality of life experienced in New Zealand. The freight sector is an essential component of the export industry, linking areas of production to the ports and its costs contribute to the overall costs and competitiveness of New Zealand goods on world markets. An efficient freight industry can provide cost effective forms of transport to improve the overall competitiveness of New Zealand exports. The movement of freight influences almost all sectors of the economy and household activities and any loss of efficiency in the freight sector can have widespread impacts (Paling et al, 2008).

Transport networks are the fundamental critical infrastructure for the movement of people and goods in our globalised network economy. Transportation networks also serve as the primary conduit for rescue, recovery and reconstruction in disasters (Nagurney, 2011).

New Zealand as an isolated country is heavily reliant on efficient transportation across all modes to allow the economy to prosper.

2.2. Infrastructure Networks

New Zealand's transport networks are the lifeline of the country and its communities and are vital for response and recovery of the country and its economy after any major events such as earthquakes, floods or volcano eruptions. For this reason it is fundamental that our networks are resilient and that vital links maintain some form of functionality in the event of a natural disaster.

The Hawkes Bay earthquake of 1931 with a magnitude of 7.8 caused severe and widespread damage to buildings and the roads, railway line and Port of Napier (Brabhaharan, 2006).

The damages to lifelines resultant from this earthquake are documented and covered off in detail by Evans (2006). Evans advises that the failure of the key networks had a major impact on the response and recovery from the disaster including the restoration of power, as transformers could not be brought in due to infrastructure failure such as bridge collapse and massive Port damage.

The Christchurch earthquakes of September 2010 with a magnitude of 7.1 and 2011 of 6.3 also resulted in wide spread damage to the network infrastructure, however basic functionality was restored relatively quickly to the road, rail and Port infrastructure.

Some examples of contingency plans are as follows:

- Fonterra rerouted export stock via rail to Timaru Port to connect with the ship, which was also diverted to Timaru Port (Rural News Group, 2011).
- Z Energy reported that following the temporary closure of Port of Lyttelton a shipment of fuel was diverted to Timaru Port and an industry fleet of 24 truck tankers have been bridging the fuel into Christchurch on a continuous basis (Hill, 2011).

From the above two examples it can be determined that the road infrastructure into the Christchurch region was functional enough to allow fuel to be delivered by tankers and the rail network was operational allowing cargo to be rerouted from Christchurch to Timaru.

In the absence of general statistics on the "up time" or availability of the North Island logistics network infrastructure (roads, rail and ports), it would be fair to comment that the infrastructure is relatively robust and available for business. There are some obvious pinch points within the North Island such as:

- The Karangahake Gorge, which is traversed by SH2 between the Waikato and Bay of Plenty. This Gorge is susceptible to flooding, slips and black ice during the winter months, but it is invariably only closed for a matter of hours per event or remains open with a temporary speed restriction.
- The Kaimai Mountain pass on SH29 between the Waikato and Bay of Plenty. This mountain pass is susceptible to road accidents, which force closure from time to time, and occasional black frost during severe cold weather. In both cases the road is normally only closed for a few hours after which it is reopened, or the pass remains open with reduced passing lanes.
- The Desert Road section of SH1, crossing over a high mountain pass between Waiouru and Turangi in the middle of the North Island, can be very cold and wet in winter. Half a dozen times a year, the rain turns to snow on the Desert Road and it becomes impassable to traffic (Directions, 2011). In such cases there are alternate routes that can be taken to complete a journey.

The specific network in question, namely the road, rail and port infrastructure within the Golden Triangle has not been subjected to a natural disaster of such a nature as to render the network inoperable. Flooding over recent years has damaged small parts of the network, however no noticeable outage occurred that was not rectified within hours of the event. The network is thus “untested” in terms of a natural disaster.

2.3. North Island Ports

2.3.1. Overview

New Zealand’s North Island currently has six ports that handle containers from an import and export basis. They are, starting from the north and working down the eastern seaboard, North Port (Marsden Point), Ports of Auckland, Port of Tauranga, Port of Napier, Centre Port (Wellington) and Port of Taranaki (New Plymouth) on the western coast of the North Island (see fig.1). Of these six ports, Auckland and Tauranga are the main container ports servicing the Auckland, Waikato and Bay of Plenty regions – also referred to as the Golden Triangle. The most significant port in terms of container traffic handled and population density serviced is Auckland. North Port is discounted out of the equation, as it currently has no dedicated container handling facilities, infrastructure, systems and resources. Further to this North Port has no rail link connection to the main north/south trunk line. Port of Auckland and Tauranga both have well-established container handling operations supported by good infrastructure, systems and logistics capabilities. Between the two ports they currently handle 81% (Table 1) of all North Island container traffic. Port of Napier, Centre Port in Wellington and Port of Taranaki all have container handling facilities, infrastructure, systems and resources, albeit on a significantly smaller scale than Auckland and Tauranga. These three ports together only handle ~13% of the North Island imports and ~24% of the exports.

2.3.2. Ports of Auckland (POAL)

Ports of Auckland are New Zealand’s largest port in terms of containers throughput. POAL handles ~51% (Table 1) of the North Island container traffic. This is handled through two “on port” container terminals at POAL, namely Fergusson Container Terminal covering 32ha, which has a 610m berth and is serviced by 5 Post Panamax cranes. The second “on port” container terminal is Bledisloe Container Terminal covering some 14.5ha, which has a 260m berth and 3 ship to shore cranes. Both of these container terminals are serviced by >34 Straddle carriers. The port is serviced by road and rail.

A study conducted in 1997 of the Rangitoto island volcano forming part of the entry channel to the Ports of Auckland (see fig.2) and other volcanoes in the immediate Port vicinity, modelled up to 5 different scenarios resultant in natural disasters. The outcome of the study and scenario modelling was that a 5% likelihood of eruption within the next 50 years existed and that this would block the shipping channel, hence the need to plan ahead (Thull, 2011).

FIGURE 1 - View of Auckland, POAL wharves, shipping channel and Rangitoto volcano (POAL, 2011)

Ports of Auckland opened an inland port in East Tamaki February 2002. The East Tamaki inland port closed in 2007 following Fisher and Paykel's decision to move part of its production offshore (Ports of Auckland, 2008). Ports of Auckland opened an inland port at Wiri in October 2005, also offering full import and export processing and storage of containers. The facility is situated on 15ha of land in southern Auckland. The Wiri facility has good road links and is linked to Rail, albeit only with a link on the northern side, making south bound freight not possible without incurring shunting on the main north/south trunk line. The southern access link has yet to be established, however this would be relatively simple to do, but has to date not been required.

TABLE 2 - POAL Key Data Sheet (POAL 2010 & 2011)

POAL Key Data Sheet								
Terminal	Berth	Space Available	Throughput in TEU	Crane Data	Straddles	Logistics services		
Name	length	Current	Current	Number		Water	Road	Rail
Fergusson	610m	32ha		5 p/pmax	34	✓	✓	✓
Bledisloe	260m	14.5ha	867,368	3 ship/shore		✓	✓	✓
Wiri	N/A	15ha		2 x reach Stackers	none	✗	✓	✓

2.3.3. Port of Tauranga (POT)

Port of Tauranga is New Zealand's largest port by total tonnage imported and exported, handling in excess of ~14 million tonnes of freight (Port of Tauranga, 2010). POT is New Zealand's second largest port in terms of container throughput handling ~30% (Table 1) of the North Island container traffic. This is largely handled through the Sulphur Point Container Terminal covering some 39ha (with another 33ha unsealed available). The container terminal has a 600m berth with another 170m currently under construction. 24 straddle carriers service this container terminal. Sulphur point is serviced by a robust purpose built road infrastructure and rail.

The Mt Wharves falls outside the scope of this investigation, as they are dedicated to handling bulk and break-bulk cargo.

On the 5th June 1999 the Port of Tauranga opened New Zealand's first inland port in Southdown, an industrial suburb in the south of Auckland city. This facility is known as MetroPort and acts as an extension of the main Port of Tauranga, located some 200 km to the south east (Port of Tauranga, 2009). MetroPort is situated on 3.5ha of land and has 1450 ground slots. This facility has good road and rail links and can cater for 2 x 110 TEU≅ capacity trains on its two rail sidings totalling 780m (MetroPort Overview, 2011).

TABLE 3 - POT Key Data Sheet (POT 2010 & 2011)

POT Key Data Sheet								
Terminal	Berth	Space Available	Throughput in TEU	Crane Data	Straddles	Logistics services		
Name	length	Current	Current	No	No	Water	Road	Rail
Sulphur Point	600m	72ha	511,343	5 (4) p/pmax	24	✓	✓	✓
Mt Wharves	2000m	113ha	Break-bulk Wharves	Nil	nil	✓	✓	✓
MetroPort	N/A	8ha	113,000	6 Top lifters & 1 Reach stacker	nil	✗	✓	✓

2.3.4. Comparison of Ports of Auckland and Port of Tauranga

Table 4 below is a comparative between POAL and POT, highlighting what the two Ports have in common and what the points of differentiation are that exist between the two Ports.

TABLE 4 - Ports of Auckland and Port of Tauranga Comparative Fact Sheet

Ports of Auckland	Comparative relative to 2010	Port of Tauranga
1st	Market position containers	2nd
3rd	Market position volume	1st
867,368	TEU≈ per annum 2010	511,343
8 of which 5 are post Panamax	Ship to shore cranes	5 of which 4 are post Panamax
34	Straddle cranes	24
870 meters	Dedicated container berth	600 meters
49	~Container ship port calls for Aug 2010, 20 of which were common to both Ports	46
Wiri Inland Port	Inland Port provision	MetroPort Southdown
Road and Rail	Inland Port services	Road and Rail
Yes	Customs & MAF accredited	Yes
35,000	TEU≈ throughput per annum	113,000

2.4. Road Network

2.4.1. Introduction

The State Highways of New Zealand comprise a network of approximately 11,000km, which represent 12% of New Zealand's road network. These highways are funded and maintained by the Government through the NZTA. The balance or other 88% of the network is approximately 83,000km of Local Roads. These are funded and managed by individual Territorial Authorities (Rockpoint, 2009).

This section will remain focussed on State Highways, with specific interest in the section within the "Golden Triangle" which will have relevance to this investigation.

NZTA advise that heavy vehicles using the State Highway network grew by 3.4% in 2010 compared to 2009 (NZTA, 2009). If one drills down to a regional level, the Northland and Auckland region incurred 4% growth while the Waikato and Bay of Plenty incurred 3.7% growth during this period. The average annual growth of heavy vehicles using the State Highway network over the last decade is 3% (NZTA, 2009).

The National Land Transport Programmes (NLTP) planned investment in State Highways alone for the 2009 / 2012 period is ~$4.6 billion. This is made up of the following National Land Transport Programmes (NZTA, 2009):

- New and improved infrastructure for State Highways $3.075m
- Renewal of State Highways $633m
- Maintenance and operation of State Highways $897m

Road transport is not considered to be a solution for mass container aggregation between Auckland's two inland ports and POT. This view is supported by the Ministry of Transport (MoT) in a regulatory statement made in 2010 where MoT states that it is doubtful that road transport will ever play a major role in the transport of heavy cargo such as processed meat and dairy product, which are typical of the containerised export commodities carried by shipping lines (MoT, 2010). This study assumes that most of the long haul container feeder movements between hinterlands will be undertaken by rail or coastal shipping because the cargo is generally heavy and hence not efficient for trucking on the road.

The sheer scale of the task of moving an estimated 540,000 containers per annum in each direction by taking into account road weight restrictions will lend the operation towards rail, which is designed for just such voluminous movement of cargo. The New Zealand Transport Authority (NZTA) introduced new legislation in May 2010 allowing for vehicle dimension and mass amendment. This effectively allows for the road authorities to issue permits for high productivity vehicles (HPV's) of greater than 20 meters in length and over 44 tonnes in gross mass to operate on pre approved routes. It is apparent however that such permits will not be issued lightly in that the operator has to demonstrate that the road and equipment are suitable for the route being applied for. Further to this the operator is required to demonstrate that the vehicle's extra length and weight will provide significant productivity gains for the operation (MoT, 2010). In the case of container aggregation it is unlikely that an H permitted vehicle will move substantially more containers than a normal heavy vehicle, as the incremental weight of adding an additional container to an H permitted vehicle will inevitably result in the vehicle then exceeding even its "H" permissions. This is due to the indivisibility of a container. Through mixing and matching, H permitted vehicles may be able to load a combination of heavy and light containers, however as stated this will have little impact on the sheer volume of containers that will have to be moved.

2.4.2. The Golden Triangle road network

State Highways provide approximately 5,973km of network across New Zealand's North Island. The interregional strategic corridors of road and rail, such as State Highway 1 and 29, are classified as nationally strategic road corridors, whilst the North Island Main Trunk and East Coast Main Trunk are classified as nationally strategic rail corridors.

The economic prosperity of the regions, which make up the "Golden Triangle" depend on robust and resilient interregional transport connections.

These corridors cover the area between Auckland, Hamilton and Tauranga, New Zealand's "Golden Triangle" and give a number of options for the movement of freight. The main options are:

I. Tauranga via the Karangahake Gorge to Auckland (Route 1)
II. Tauranga via Kaimai Mountain Pass & Matamata to Auckland (Route 2)
III. Tauranga via the Kaimai Mountain Pass & Hamilton to Auckland (Route 3)

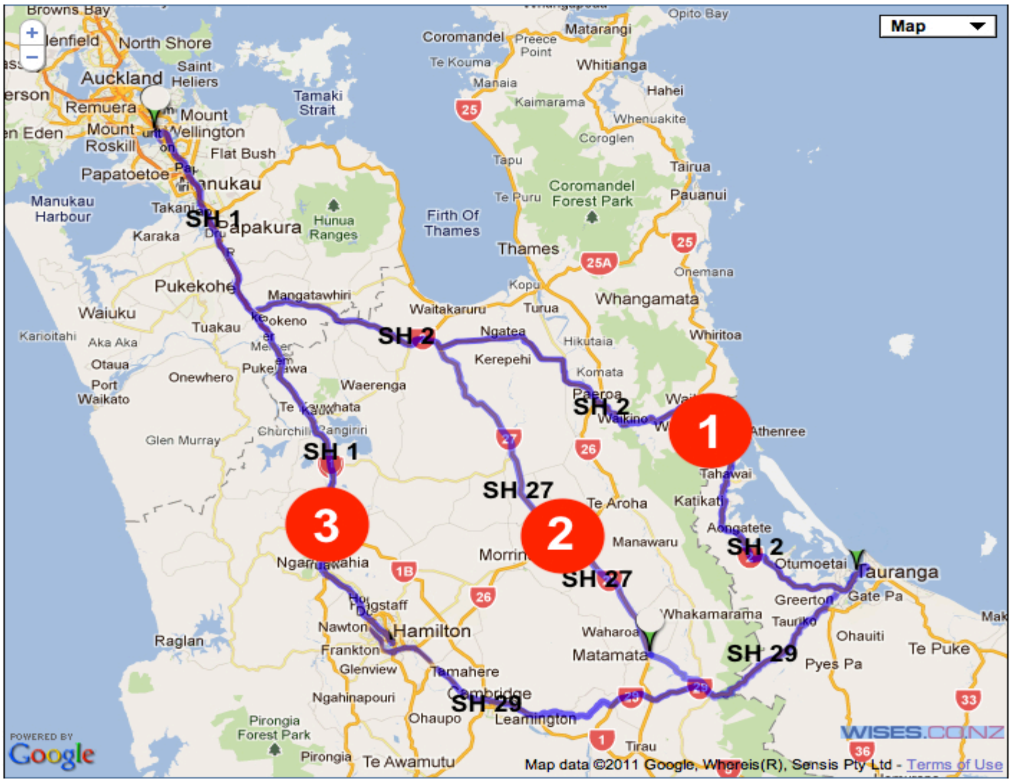

FIGURE 2 - Golden Triangle Road Route Network with three main options highlighted. (Wises Maps, December 2011 with Pixelmator overlay)

The following section will debate the pros and cons of these routes.

2.4.2.1. Route 1 (SH1/SH2) Tauranga – Karangahake – Auckland

This route starts at Port of Tauranga Sulphur Point Container Terminal and travels up through the Bay of Plenty on SH2, passing through the Kaimai/Mamaku Mountains at the Karangahake Gorge, joining SH1 at the Bombay Hills and continuing on to Auckland. This route is (as measured from start point and ending at the MetroPort in Southdown, Auckland) 198.3km. It takes approximately 3 hours to travel by truck. This route is favoured by trucking companies, as it is more fuel-efficient than the SH29 Option (Reid, 2011). This route is slow at peak times and prone to closing due to accidents and weather related incidents.

2.4.2.2. Route 2 (SH1/SH2/SH27/SH29) Tauranga – Matamata – Auckland

This route starts at the Port of Tauranga Sulphur Point Container Terminal and travels over the Kaimai/Mamaku Mountain pass on SH29, climbing up from sea level to ~499m above sea level at the apex of the crossing (Google Maps, 2011), turning on to SH27 at Matamata, joining SH2 for a short period to connect to SH1 at the Bombay Hills and continuing on to Auckland. This route is (as measured from the starting point and ending at the MetroPort in Southdown, Auckland) 206.6km. It takes approximately 3 hours to travel by truck and results in higher fuel consumption than the SH2 route (Reid, 2011). This route is the safest of the three options largely due to it bypassing town and school traffic.

2.4.2.3. Route 3 (SH29/SH1) Tauranga – Hamilton – Auckland

This route starts at the Port of Tauranga Sulphur Point Container Terminal and travels over the Kaimai/Mamaku Mountain pass on SH29 directly through Hamilton and then via SH1 to Auckland. This route is (as measured from the starting point and ending at the MetroPort in Southdown, Auckland) 225km. It takes approximately 3.5 to 3.75 hours to travel by truck. This route is the least favoured by logisticians due to the time that it takes to complete the journey. The delay is incurred by travelling further, but mainly by having to pass through the Hamilton Metropolis. This route is also the furthest of the three routes by approximately 20 km in each direction, adding 40 km to a round trip.

2.4.2.4. Route fragility

During the period selected for the case study (the month of August 2010) there was no road closures in the Waikato region traversed by the three routes (Green, 2012). For the same period in the Bay of Plenty region, one of the routes (SH1/2) was closed for two hours on 6th August 2010 in the Karangahake Gorge, to allow for an accident scene to be cleared (Potbury, 2012). This stretch of road is prone to closure in winter due to flooding, road accidents or a combination of black ice related incidents.

[The above Routes are highlighted on a full size map. See Appendix 7.12]

TABLE 5 - Golden Triangle road network route comparisons

Route Comparisons	SH1/2 via Karangahake	SH1/2/27/29 via Kaimai's	SH1/SH29 via Hamilton
Most fuel efficient route	✓	✗	✗
Quickest route	✓	✗	✗
Safest route	✗	✓	✗
Average travel time	3hours	3 hours	3.75 hours
Most congested at peak times	Very slow at peak times and around school closing time	No major congestion issues	Very slow passing Hamilton and Cambridge
Distance	198.3km	206.6km	225km
Route risk/fragility	Prone to closing due road accidents throughout the year and flooding, slips and ice in winter	Closes occasionally due to road accidents	Closes occasionally due to road accidents and flooding
Days experiencing closure in August 2010	One	Nil	Nil

2.5. Rail Network

2.5.1. Introduction

This section covers a historical overview of rail in New Zealand, The North and South Island. It specifically focuses on the Golden Triangle and gives an overview of the Human Resources (HR) side of operations.

2.5.2. Historical overview

"Rail has a history that involves periods in private ownership, as a government department, and as a government corporation. The first railway in New Zealand was opened in 1863. Lines were initially built by provincial governments and tended to be fragments of rail connecting ports to the hinterland. In 1876, these fragments were brought under central government control, and a century-long process began of joining them together into a single national network. Initially, moving people between urban centers was the primary motivation for creating this national network, while moving freight long distances was only a complementary use. Even today the most heavily used parts of the network involve relatively short distances (e.g. Auckland to Tauranga, or the West Coast to Christchurch), rather than the entire main trunk lines.

New Zealand's difficult topography, together with budget considerations, resulted in the adoption of a narrow-gauge track standard, which has constrained the average speed of rail services ever since. In addition, the country's small and highly dispersed population has mitigated the formation of economies of density (running more trains on existing tracks). Since rail has high fixed costs (the tracks, formations, signalling systems) and low variable costs, it tends to benefit more from economies of density than economies of network size" (National Infrastructure unit, 2009)

"The size of New Zealand's national rail network has changed little since the early 1990s, and is approximately 4,000km" (National Infrastructure Unit, 2009).

2.5.3. National network overview

New Zealand rail infrastructure is some 4,000km long. KiwiRail currently operates approximately 960 trains per month. 590 of these would be in the North Island, 70 on the Rail ferry service between Islands and the balance of 300 in the South Island (KiwiRail, 2011). The National Infrastructure Unit describes the four main parts to the rail network as

- "A national freight network, carrying a range of goods but with a comparative advantage in the transport of bulk commodities such as coal, milk, logs, containers and steel. It also has a role in moving containerised import/export goods to and from major ports, long-distance transport of containerised goods, and general (inter-modal) freight between major cities.
- An interisland ferry service, which is part of the KiwiRail business primarily because of its strategic role in transporting rail across the Cook Strait, acting as a link in the national rail network. However, the bulk of interisland ferry revenue (79 per cent) comes from commercial road freight, passengers and their vehicles, rather than from rail.
- A long-distance passenger service, the primary focus of which is providing a domestic and international tourism experience.
- Two metropolitan passenger networks, in Auckland and Wellington, which are supported by ratepayer, taxpayer and road-user subsidies on the basis that reduced congestion and/or increased mobility of commuters brings social, economic and environmental benefits" (National Infrastructure Unit, 2009).

The design of New Zealand rail network is not conducive to double stacking of containers on wagons.

2.5.4. Overview of North Island freight rail network

The North Island is serviced by the main trunk line running down its spine from Auckland to Wellington. Auckland to Northland is serviced by a secondary line running from Auckland to Whangarei, which enjoys limited use due to the nature of the track and height maximum in the tunnels on the route, limiting the size of the rail wagon / unit / container size that can be used on this line.

The Auckland to Wellington Main Trunk is broken into three main sections from a train make up perspective as well as a "couplings" perspective. "Couplings", being a KiwiRail term, includes various aspects of the train composition including driver allocation and/or switch over:

- Auckland to Hamilton
- Hamilton to Palmerston North

- Palmerston North to Wellington

The Tauranga link branches out from Hamilton passing through the Kaimai/Mamaku mountain range rail tunnel towards the Bay of Plenty. This tunnel is 8.9 km long and was constructed between 1969 and 1977 (Jones, 2010). This is the longest rail tunnel in New Zealand. The Kaimai mountain range is a formidable logistics obstacle with limited transit points. This is the only rail link from the Waikato main trunk line to the Bay of Plenty.

2.5.5. Golden Triangle rail network

The "Golden Triangle" or Auckland/Hamilton/Tauranga route is approximately 224km long with 10 passing loops where trains can pull over and wait to cross with other oncoming trains.

The Waikato Region in conjunction with Central Government made ~$13m available to KiwiRail as part of the JOG Project for the upgrading of the Waikato rail network for the purposes of achieving mode shift and increasing the line capacity between the Waikato and the Port of Tauranga (Waikato Regional Council, 2006). Resultant from this project the number of passing loops has been increased from 8 to 10, including improving the length of 3 of the existing 8 loops. Details of the impact of the JOG Project are depicted in the table below.

TABLE 6 - Impact of JOG Project on Waikato/BOP passing loops

Current Loops	Region	New Loops	2006 Length	2011 Length	Timing
Ruakura	Waikato		742	900	Complete
-	Waikato	Eureka	-	900	Complete
Motomaho	Waikato		730	900	Complete
Morrinsville	Waikato		779	779	-
Kereone	Waikato		856	856	-
-	Waikato	Tamihana	-	900	Complete
Hemopo	Waikato		863	863	-
Whatakao	Waikato		870	870	-
Apata	BOP		474	900	Jul-12
Te Puna	BOP		917	917	-

Currently the East Coast Main Trunk line (ECMT) (the line between Hamilton and BOP) operates between 350 and 400 trains per week. 21 of these are POT – MetroPort trains. This is approximately 30% of the total rail loading throughout New Zealand. The ECMT employs 15% of the KiwiRail workforce. This stretch of the line only makes up 5% of the national total, however it conveys 8 million tonnes per annum, which is an incredible 50% of the total national rail freight demand.

The current train density on the ECMT is measured as 1.68 trains per hour. Modelling performed in conjunction with the KiwiRail planning department demonstrates that the ECMT can comfortably accommodate 2.7 trains per hour with the existing passing loops as outlined in table 6. In the event that the train density had to exceed 2.7 trains per hour, the Apata passing loop would become crucial in assisting to manage the added density above 2.7 trains per hour.

The "Golden Triangle" is the operational area as highlighted in Figure 10 (p.49), linking the Auckland Super City to the cities of Hamilton and Tauranga. Effectively this links the Bay of Plenty, Waikato and Auckland economic regions together from a rail perspective (Rae, 2011).

This Golden Triangle network carries mainly freight between Tauranga via Hamilton to Auckland and vice versa. Sections of this line are also used for bulk freight trains operating between the POT and the greater Waikato region, for example pulp, paper and logs from Kinleith to POT and Coal from POT to Huntly (Temperton, 2011).

Currently the POT is serviced by 3 MetroPort trains per day in both directions moving loaded import containers from POT to MetroPort and a combination of loaded and empty containers from AKL to TRG. The loaded containers are invariably for export emanating from the Waikato, Auckland or Northland regions, while the repositioned empty containers are for packing of export product in the Tauranga area and in some cases for repositioning to other New Zealand Ports such as Christchurch in the South Island.

TABLE 7 - Key details for Golden Triangle rail network

Auckland – Tauranga - Auckland	
Route distance single trip	224km
Route distance round trip	448km
Time taken to travel single trip	4.5 hours
Time taken to travel round trip	9 hours
Coupling point (Locomotive Engineer change over)	Te Rapa Hamilton
Possible trips per train per 24 hour period	3.7 subject to certain operational activities being performed at coupling points

2.5.6. Human resource consideration

The planning and make up of a train service is complex. A contributing factor to the complexity in planning a new service at KiwiRail, or making a change to any existing service, such as adding more trains to a network or reducing trains from a network, require human resource considerations.

These human resource factors involves a mixture of humanitarian considerations, as well as Inflexible impediments, that stem from historical employment agreements negotiated with the Union some years back.

The next section outlines a number of these:

- A 6 (six) weeks union consultation process for significant Locomotive Engineers roster changes. Obviously if these negotiations do not proceed amicably, the six-week period could become an eight or twelve week period or remain open ended. This does not bode well for flexibility or allow KiwiRail the opportunity to meet changing market requirements.

- Sourcing of Locomotive Engineers to operate new service from a limited pool of resources.
- Scheduling in a ~30 minute personal needs brake for the Locomotive Engineer (LE) after every 3 hours on duty. This is extremely complex and is done with some variation as it has to coincide with the train being positioned at a passing loop at the time of the personal needs brake, failing which the train would block the main trunk line for ~30 minutes reducing the network train density/efficiency.
- Ensuring that no LE is rostered on to work for more than 76 to 83 hours during any fortnight.
- No point-to-point operations are permissible. A LE is required to sign off of duty at his home depot where his shift started, hence the LE can not be scheduled to operate a train from Auckland to Tauranga and book off overnight in Tauranga returning with a train the following day. This results in the “coupling” that KiwiRail has to factor in to planning resources.

As seen by the above human resource considerations, planning for schedule changes or new services is a complex process. It is the intention of KiwiRail to attempt to address some of these issues during their next round of negotiations with the Union (Rae, 2011).

2.6. Road versus Rail

2.6.1. Introduction

This section compares the supply chains between road and rail operations. The comparative analysis highlights strengths and weaknesses of both modes.

2.6.2. Supply chain activity of a MetroPort/POT train

The supply chain activity of a MetroPort train is split into two sections due to the current operational methodology applied by KiwiRail of operating two separate trains, one south bound from MetroPort Auckland and one north bound from POT. The two trains meet each other in Te Rapa where they “couple” or swap over with the south bound crew swapping over to the north bound train and vice versa.

The following two tables, 11 and 12, are a flow chart breaking down the supply chain activity of both north and south bound MetroPort trains to allow for a detailed understanding of the timing of the various activities making up the supply chain. This stepped approach shows the time taken to complete each relevant activity.

TABLE 8 - Supply chain activity of a MetroPort train travelling MetroPort - Te Rapa - MetroPort

Supply chain activity of a MetroPort train travelling MetroPort - Te Rapa - MetroPort	
175 min	•Terminal Engineer makes up train & cargo manifest at MetroPort & refuels locomotive before Train Engineer comes on duty.
40 min	•LE comes on duty, receives briefing & travels to MetroPort from Depot via motor vehicle.
40 min	•LE signs for made up train from Terminal Engineer & reviews manifest & performs brake calculation and test
140 min	•Train departs from MetroPort for Te Rapa and travels for approximately 120km.
20 min	•Arrives in Te Rapa (coupling point) and swaps over with engineer of north bound train ex POT.
30 min	•LE takes personal needs break ~30 minutes.
40 min	•LE performs brake calculation and test for ~40 minutes.
140 min	•Train departs northbound to MetroPort and travels for approximately 120km.
30 min	•LE hands over train to Terminal Engineer & travels back to depot by motor vehicle.
120 min	•Include assumed time spent waiting for section to clear of traffic, waiting to pass oncoming trains at passing loops etc.
15 min	•LE completes administrative work for train.
615 min	•LE signs off after approximately 10.25 hours of continuous duty.
790 min	•Total supply chain time including train make up and manifest preparation and locomotive refuelling by Terminal Engineer.
Totals	•Containers moved = 106 Km travelled = 240 CO_2 generated on Route = 142g/km •

TABLE 9 - Supply chain activity of a MetroPort train travelling Sulphur Point - Te Rapa - Sulphur Point

Supply chain activity of a MetroPort train travelling Sulphur Point - Te Rapa - Sulphur point

145 min	•Terminal Engineer makes up train & cargo manifest at Sulphur Point before Train Engineer comes on duty.
75 min	•LE comes on duty, receives briefing & refuels locomotive. Travels to Sulphur Point from depot with Locomotive only travelling approximately 14km.
40 min	•LE signs for made up train from Terminal Engineer & reviews manifest & performs brake calculation and test.
120 min	•Train departs from Sulphur Point for Te Rapa and travels for approximately 104km.
20 min	•Arrives in Te Rapa (coupling point) and swaps over with engineer of south bound train ex MetroPort AKL.
30 min	•LE takes personal needs break ~30 minutes.
40 min	•LE performs brake calculation and test for ~40 minutes.
120 min	•Train departs south bound to Sulphur Point and travels for approximately 104km.
55 min	•LE hands over train to Terminal Engineer & travels back to depot with locomotive only.
120 min	•Include assumed time spent waiting for section to clear of traffic, waiting to pass oncoming trains at passing loops etc.
15 min	•LE completes administrative work for train.
635 min	•LE signs off after approximately 10.58 hours of continuous duty.
780 min	•Total supply chain time including train make up and manifest preparation and locomotive refuelling by Terminal Engineer.
Totals	•Containers moved = 106 Km travelled = 208 CO_2 generated on route = 142g/km

2.6.3. Supply chain activity of a MetroPort / POT road bridge

The supply chain activity of a MetroPort / POT road bridge has been dissected into table 13 below. This has allowed for the average time taken to perform a specific activity to be matched with the activity concerned.

The total time taken to complete one round trip in the supply chain is 9.25hrs for one truck to move 3 containers. For the purposes of these deliberations it is assumed that one truck will carry 3 X TEU≈ per round trip. The basis of this assumption is that the majority of containers travelling north bound will be loaded and hence heavy resulting in 1 x container per load. The bulk of the south bound volume is empty hence the weight allows for a truck to carry 2 x containers per load.

TABLE 10 - Supply chain activity of a road bridge operation between MetroPort and Sulphur Point POT

Supply chain activity of a road bridge operation between MetroPort and Sulphur Point POT	
20 min	•Driver comes on duty, performs pre driving check & takes instruction.
15 min	•Drive from depot to MetroPort ~20km.
20 min	•Load container & receive load manifest at MetroPort & update logbook.
180 min	•Depart from MetroPort and drive 198.3km via Sh1/SH2 to Sulphur Point at POT.
20 min	•Off load & Reload at Sulphur Point and perform administrative duty re manifests.(This is the ideal timing and is actually achieved by POT)
15 min	•Depart from Sulphur Point and drive for approximately 4km.
30 min	•Stop for personal needs/meal break.
180 min	•Depart from Tauranga and drive to MetroPort for approximately 198.3km via SH1/SH2.
20 min	•Off load & reload at MetroPort & receive manifest.
45 min	•Depart for Depot, refuel vehicle, hand over to new driver & sign off duty.
545 min	•Total time on duty 9.25hrs.
Totals	•Containers moved = 3 Km Travelled = 397 CO_2 generated on route = 16g/km •

2.6.4 Modal analysis

The road bridge supply chain is not as complex as the MetroPort rail operations supply chain. The mode comparison is summarised as per table 14 below.

From a supply chain activity timing perspective the actual time in motion (driving time) for both modes is vastly different to the total mode supply chain time to complete the round trip. Road driving time is 6 hours vs. a total supply chain time of 9.25 hours. In the case of rail the driving time is 8.75 hours vs. a total supply chain time of 26.25 hours. While road-driving time consumes 65% of the supply chain time, in the case of rail, only 33% of the total supply chain time is taken up by driving. This is as a result of the complexity of planning and making up a train service, which in this instance carries 212 TEU per round trip vs. the 3 carried by a single truck performing the same round trip.

TABLE 11 - Port of Tauranga / MetroPort Modal Comparison

POT / MetroPort modal comparison			
Activity	Measure	Mode	
		Road	Rail
Distances			
Round trip distance by mode	km	397	448
Daily km to move volume	km	154,433	4,928
Weekly km move volume	km	1,081,031	34,496
Monthly km to move volume	km	4,684,432	149,482
Annual extrapolation	km	56,213,180	1,793,778
Operational times			
Travelling time to complete round trip	hr	6	8.75
Total supply chain time to complete round trip	hr	9.25	26.25
Assets required			
Daily	Trucks / Trains	389	11
Weekly	Trucks / Trains	2723	77
Monthly	Trucks / Trains	11,800	334
Annual Extrapolation	Trucks / Trains	141,595	4,004
Fuel Consumption by mode by route			
Fuel consumed to complete 1 x round trip	Litres used	234	2400
Average fuel consumption Lit/100 on 1 x round trip	Lit/100km	59	536
Carbon Emissions by mode (CO_2)			
CO_2 generated grams per km for 1 x round trip	g/km	1,557.60	14,150.40
CO_2 generated kilograms per km for 1 x round trip	kg/km	1.5576	14.1504
CO_2 generated per route for 1 x round trip	kgs of CO_2	618	6,339
Total daily carbon generated per route	kgs of CO_2	240,545	69,733
Total weekly carbon generated per route	kgs of CO_2	1,683,814	488,132
Total monthly carbon generated per route	kgs of CO_2	7,296,471	2,115,223
Annual extrapolation of carbon generated per route	kgs of CO_2	87,557,649	25,382,679
Average carbon expended per TEU≈ per route	Kg/CO_2/TEU≈	206	30

Due to the volume capabilities of rail vs. road, it is unlikely that road bridging will play a major role in the movement of this container volume between MetroPort and POT. That does not imply that no cargo will be moved on road, as road will always play some role due to the nature of urgent cargo, perishable cargo as well as cargo arriving late for export.

Due to the lack of data available from the road transport industry, an assumption has been made that Road bridging will handle at least 5% of this volume transfer between POT and MetroPort.

In the event that Road bridging was used to handle all of these volumes the number of truckloads required on a daily basis running in each direction would be 389. This same volume could be moved by 11 trains.

2.6.4. Modal energy consumption and carbon production

The fuel consumed in the form of diesel oil has a huge variance between the modes with Rail using ~801,221 litres vs. road using ~2,763,815 to perform the same task over the course of August 2010. If road bridging was the mode of choice, this type of fuel consumption would drive complexity into the fuel and associated industries' supply chains. Delivery of fuel to the region would have to be ramped up with the supporting storage infrastructure to accommodate the extra stocks. The storage of one months' fuel supply would require 2,764m^3 of space.

The energy consumed would generate 7,296,241 kgs of CO_2 on road, where as rail would be 2,115,223 kgs of CO_2. This equates to a container contributing 206kgs of CO_2 on road vs. 30 kgs of CO_2 on rail.

The following factors were used in calculating the CO_2 emissions for road and rail transport between MetroPort and POT.

CO_2 emission calculations:

- Truck = 59 lit/100km (Reid, 2012)
- Train = 536 lit/100km Specific to DXR Locomotive used. (O'Donoghue, 2012)
- 1 x litre diesel burned emits 2.64kg of carbon [CO_2] (Spritmonitor, 2012)

Energy consumed / carbon released

- $2\ C_8H_{18} + 25\ O_2 \rightarrow 18\ H_2O + CO_2 = 2.64kg\ CO_2$

Road formula:

- (59/100)*(2.64/1) = 1.5576kg/km * 397km = 618kg/co_2 per round trip
- / 3TEU≈ per round trip = ~206kg/co_2/TEU≈

Rail formula:

- (536/100)*(2.64/1) = 14.1504kg/km * 448km = 6,339kg/co_2 per round trip
- / 212TEU≈ per round trip = ~30kg/co_2/TEU≈

CO_2 per tonne kilometre

- Due to no payload data being made available per container, it was not possible to perform a per/tonne/kilometre CO_2 factor, hence the results are reported on a per TEU≈ basis.

Road/Rail factor

- Road ~206kg/co_2/TEU≈ / Rail~30kg/co_2/TEU≈ factor 6.87
- Road generates 6.87 times more carbon per TEU≈ than what rail generates on this specific route.

Clearly rail has a much smaller impact in terms of carbon generation when compared to road. This is largely gained through the cargo capabilities of a train vs. a road operation resulting in a far more efficient usage of fuel in the rail operation.

It is fair to say that the environmental considerations would not play a deciding role in decision-making in the event of an emergency. The top priority for Logisticians would be to get the supply chain operational and the economy functioning as soon as possible. Only once the supply chain had been re-established would consideration be given to environmental concerns and ways to improve the interim supply chains' carbon footprint.

The outcome of this analysis would support a rail solution to the aggregation of this volume between POT and MetroPort.

3. INTERNATIONAL CASE STUDIES

3.1. Introduction

This chapter provides information on the relevance of ports and their vulnerability after a natural disaster and outlines three specific case studies, Chile, Japan and New Zealand and how they are impacted.

3.2. Overview of Ports

Ports are a country's gateway to the world and hugely important to allow trade and the economy to function and prosper. The main purpose of a port is to facilitate freight distribution by acting as an interface between maritime and land for imports and exports (DP World, 2010). They allow markets to expand for producers via exports, reduced prices from importing goods and services, increase quality and choices available for consumers and business. Ports allow importers to benefit from foreign resources and investments, exporters benefit from larger, more open markets, job growth in transportation and the distribution sectors (Bingham, 2007).

3.2.1. Sea Ports

New Zealand's nominal GDP was $189.2b in 2010. Exports accounted for $41,463b while imports cost 40,597b (Statistics NZ, 2010). If one considers that POAL and POT account for 54% of the country's container exports and 67% (Table 1) of the country's container imports, the ports and supporting network infrastructure robustness or fragility are a matter of national significance, with potential global impacts from an economic perspective.

The Port of Los Angeles soon discovered this when they realised the major economic backlash as a result of the devastation in Japan from the 2011 earthquakes and tsunamis half a world away. Approximately USD $35.3 billion in trade between Japan and the United States passed through the Port of Los Angeles in 2010. This represented 15% of the Port's annual trade and it accounts for an estimated 800 jobs in the Port of Los Angeles (NBC Los Angeles, 2011).

This demonstrates how interlinked our economies have become as a consequence of the globalisation and commoditisation of markets and products. Through this new world trend of Interlinking or Globalisation we assume international infrastructure fragility as part of our exposure.

While a port can be engineered to withstand various levels of earthquakes (PANC, 2009), it is much more difficult and costly to engineer tsunami protection into a port's design, which by nature of their business have a deep open channel to the ocean to allow the safe passage of vessels from international shipping lanes.

3.2.2. Inland Ports

An inland port could be described as a rail or barge terminal that is linked to a maritime terminal with regular inland transport services. An inland port is integrated with a maritime terminal and allows a more efficient access to the inland market both for inbound and outbound freight. To achieve this requires related logistical activities linked with the terminal, such as distribution centres, depots for containers, warehouses and logistical service providers (Rodrigue, 2006).

The North Island of New Zealand has two inland ports, both of which are situated in the greater Auckland region. POAL has the Wiri freight Hub that includes MAF and Customs functionality; hence for all intents and purposes it is an inland port as opposed to a freight hub (POAL, 2011). POT has MetroPort situated in Southdown, which also includes MAF and Customs functionality (POT, 2011). Both Inland ports are serviced by road and rail.

Inland ports are becoming more commonplace since the advent of containerisation, which has simplified cargo management. Most inland ports only deal in containerised cargo. The Tioga Group, while conducting a study of <29 inland ports and related developments, has found that although the projects or reasons for developing inland ports differ widely, they have one key element in common: The goal of developing economic activity around transportation infrastructure at inland ports (Tioga, 2006).

The port establishing an inland port, by default is expanding its hinterland. Intermodalism and the use of pipelines have distorted the original meaning of "hinterland" (Olukoju, 2006).

While this may be factually correct, inadvertently the Port companies, by establishing inland ports, are de-risking the supply chain for the shippers or cargo owners. By establishing these inland ports, they are by default releasing the "captivness" of the cargo to a specific port. By not being captive to a specific port, the cargo owner has the choice of switching to a different port in the event of a disruption of any kind at the normal port of entry or exit. As an example an importer or exporter can consign cargo from or to MetroPort or Wiri. Whether the cargo exits or enters NZ through POAL or POT is irrelevant, as long as the importer's / exporter's time and price criteria are met. Both MetroPort and Wiri are serviced by rail and road, which can access any port of choice of the shipper (Own industry experience, 2012).

Sydney Ports and Hutchison Port Holdings (HPH) recently made a joint announcement that HPH had been appointed operator of the Enfield Intermodal Logistics Centre (ILC), which is located 18 km from Port Botany. Lloyds List Publication advises that this ILC is expected to handle up to 300,000 TEU per annum, which represents some 40% of port related freight. This ILC will be serviced by rail moving containers to and from the Port. This is estimated to cut carbon emissions by over 1,000 tonnes per annum and save 6,5million truck kilometres over the same period. This facility will also provide much needed empty container storage for the Port (Sydney Ports, 2011).

Ports who are tsunami prone, should consider that one of the merits of developing an inland port is, that by default, they are de-risking their profile and that of their customers who own the cargo. Ports should give consideration to modelling the staging of receipt, delivery and storage of containers at an off-port locality, such as an inland port. This practice would effectively minimise damage and loss of cargo awaiting vessel arrivals/consignee collection. The modelling could focus on delivering containers to ship side and clearing containers from shipside on a just-in-time basis. In the event of a tsunami, the majority of cargo would be secure and could be diverted to a neighbouring port for the duration of the repairs or clean up of any damage to the original port.

3.3. Overview by Countries

The earthquakes affecting Chile in 2010, Japan and New Zealand in 2011 are recent events that have been selected due to their similarities and resultant supply chain disruption. The commonality shared by these events is that all three of these countries sit on the Pacific Rim of Fire and in each event the Ports infrastructure sustained damage with subsequent closures.

3.3.1. Chile

The earthquakes that struck Chile in February 2010 resulted in massive damage to the country's infrastructure leaving more than 1.5mil people displaced. The major port Valparaíso covering the capital city Santiago was forced to close to allow for the damage to be assessed (Barrionuevo, 2010). The port reopened 5 days later with approximately 30% operationability. Wharves had to be repaired, as did surrounding buildings. Valparaíso Port services Chile's largest city Santiago, which is 116km away (Chilean Government, 2011). Valparaíso is a crucial link in the country's trade and tourism business. Many passenger cruisers had to bypass their planned stops at Valparaíso due to port closure, damages as well as further infrastructure damage in Santiago. While damaged, the port reopened reasonably quickly to allow vital rescue and recovery related cargo as well as fuel supplies to continue flowing into Chile (Barrionuevo, 2010).

The port of Valparaíso services one of Chile's most important urban centres, Santiago. With nine universities, it is a centre for education. Its most important industries are culture, transport and tourism (World Port Source, 2011). During the 2007 year, the port handled 9.7mil tonnes of cargo. This was a combination of 6.3mil tonnes packed into ~845 thousand TEU≈ and 1.2mil tonnes of break-bulk cargo. [5.3mil tonnes were exports and 3.7mil tonnes were imports.] The port also handled 116 thousand passengers off of 48 cruise vessels. The main exports out of the Valparaíso region are wine, copper and fresh fruit (World Port Source, 2011). Chile is the world's third largest copper supplier with the copper mines situated north of Santiago (MSNBC, 2010).

The Chilean export port of Talcahuano (servicing a major manufacturing, petrochemical, forestry, fishing and trade hub) was also forced to close after roads and major bridges collapsed (MSNBC, 2010). Some 2mil metric tonnes of fish catch is at risk due to the unloading piers and equipment being severely damaged. This port services the city of Concepción, the third largest city in Chile. The port was also home to the ASMAR Shipyard, which builds commercial as well as military ships up to 50,000dwt (Shipyards Directory, 2012). The ASMAR shipyard was government owned and operated by the Chilean Navy (Pearce, 1980). The port was destroyed by the 15meter tsunami waves (LA Times, 2010). The port remains closed today, some 658 days later while a total rebuild has to take place. Agriculture in the region has been severely impacted firstly by earthquake damage and secondly by infrastructure devastation effectively blocking cargos from reaching export markets. Estimates for the repair of damages to infrastructure in Chile run into the hundreds of billions of US dollars (MSNBC, 2010). The shipyard alone suffered over $1b in damages (CSL, 2011).

FIGURE 3 - Map representing area impacted by Chilean earthquake and tsunami of 2010 (BBC, 2010)

Drifted and overturned vessels due to 2010 Chilean Earthquake and Tsunami (Talcahuano Port, Chile)

Damaged quaywall due to 2010 Chilean Earthquake and Tsunami (Talcahuano Port, Chile)

Drifted and overturned vessel due to 2010 Chilean Earthquake and Tsunami (Talcahuano Port, Chile)

Damaged warehouses due to 2010 Chilean Earthquake and Tsunami (Talcahuano Port, Chile)

FIGURE 4 - Vessel and Port Damage at Talcahuano Port, Chile (PIANC, 2009)

3.3.2. Japan

The Japanese earthquake & subsequent tsunamis of March 2011 devastated the port of Sendai servicing the Tōhoku Prefecture, which is one of the largest commercial centres in Japan. Whole towns were flattened by the tsunamis, which hit the area in waves (USGS, 2010). Most of the Sendai port infrastructure was badly damaged or washed away in the tsunami. The nearby Fukushima nuclear power plant, which was also damaged by the tsunami waves, resulted in radiation leaking out of the plant, causing further complications from a logistics perspective. The port was closed for more than 200 days before receiving the first container ship on 30 September 2011. This port closure had a dramatic impact on the commerce of the region and any search, rescue and recovery programmes (Fas, 2011).

FIGURE 5 - Sendai Port drift away containers and cargo handling equipment (Shibasake, 2011)

Manufacturers and exporters in the area such as refineries, steel industry, chemical plants, auto industry and the paper industry, have all had to rely on expensive trucking options on the few operable roads to enable their business import and export goods to flow (Gonorth, 2012). Alternate ports had to be used such as Tokyo, Yokohama, and Niigata. Loss of life as a result of the earthquake and subsequent complications is more than 17,000 people dead or missing and thousands more injured. The financial cost of the disaster is not yet fully quantified, but conservative estimates are in excess of $300b US (Globalworks, 2011).

As the third largest economy in the world, Japan's GDP at $5.5trillion, accounts for 8.7% of global GDP. The net impact of the disaster on global GDP is that it is expected to shave about a half percentage point off global economic growth with about half of that effect confined to Japan itself (CRS, 2011).

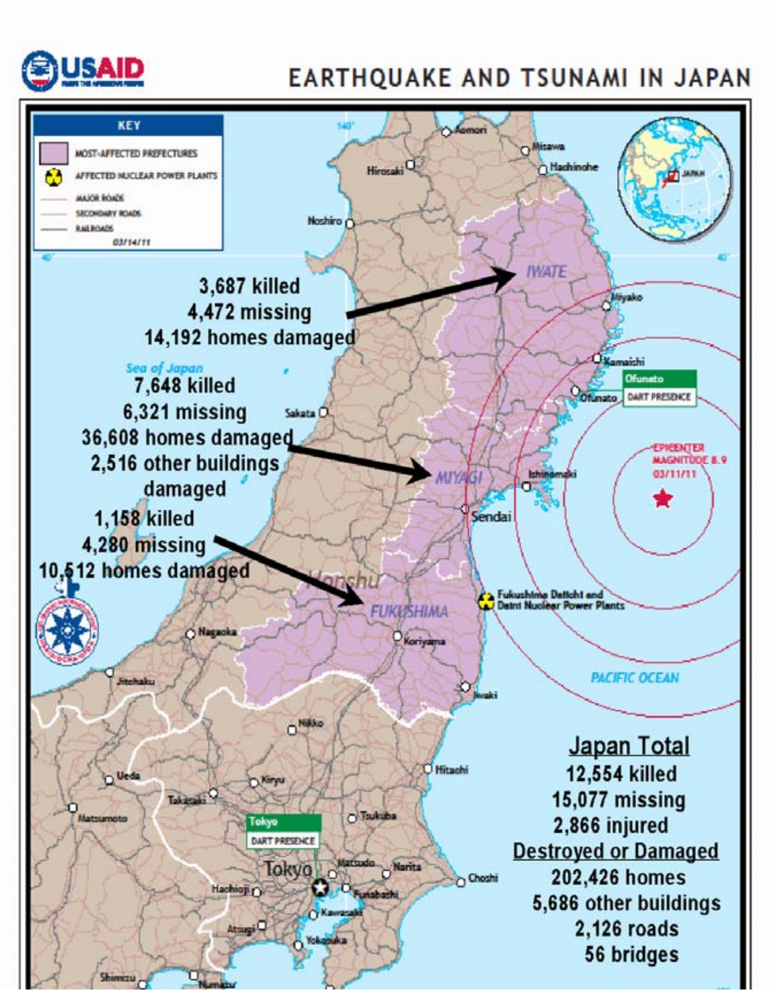

FIGURE 6 - Map representing area impacted by Japanese earthquake and tsunami of 2011 (FAS.org, 2011)

3.3.3. New Zealand

The 22 February 2011 Christchurch earthquake resulted in a port closure of 4 days (Pacifica, 2011). The earthquake caused extensive damage to wharves and other port equipment. The infrastructure around the port including roads, rail and the Lyttelton Tunnel was also damaged. The city of Christchurch sustained major damage to buildings, both in the city and the suburbs. One hundred and eighty one people perished and many hundreds were injured (TV3, 2011). The port recovered relatively quickly and reopened to limited operationability after only 4 days of closure (LPCC, 2011). The cost of the Christchurch earthquake is estimated at $30b, which is approximately 22 per cent of the country's GDP (STATS NZ, 2012).

Due to the regionalised nature of the Christchurch earthquake, the logistics industry were able to immediately use the neighbouring port of Timaru as a temporary alternative for the continuous flow of exports and imports from the region. Having this port in relative close proximity to Christchurch also allowed the fuel supplies to continue to flow into the region as well as emergency supplies and aid.

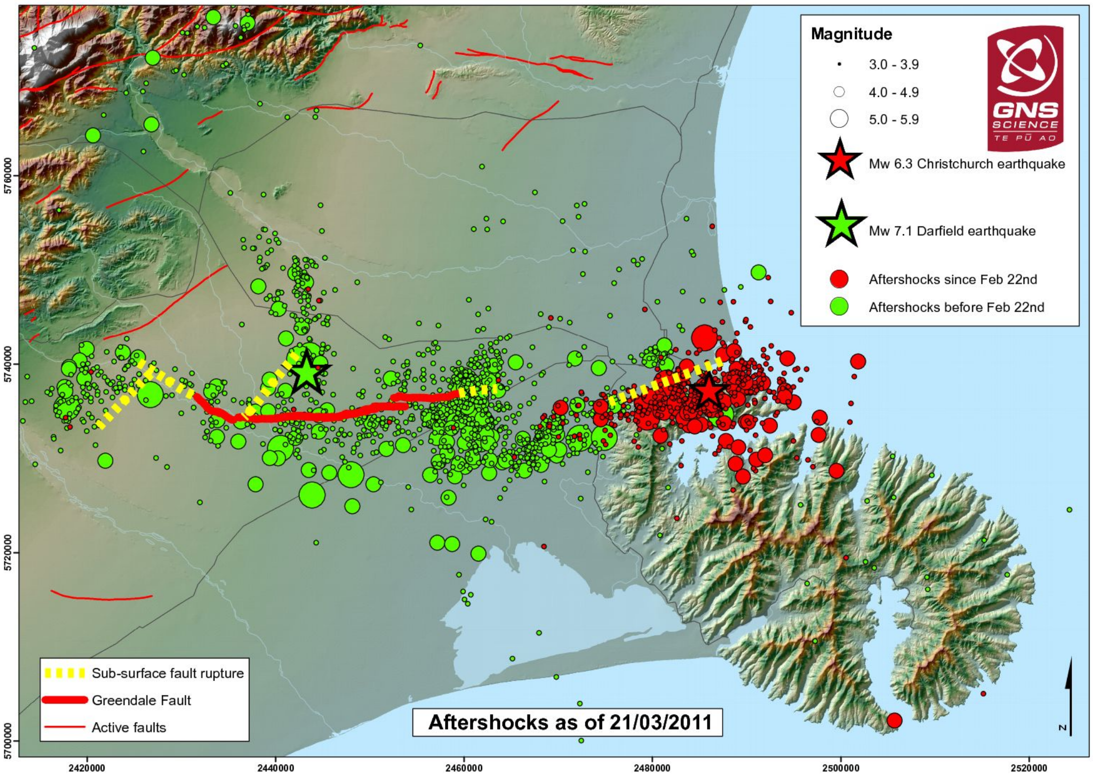

FIGURE 7 - Map representing area of impact of Christchurch earthquake of 2011 (GeoNet, 2011)

3.3.4. Summary

In table 12 below is a comparison of natural disasters resulting in the closures of 4 international ports. It is interesting to note that all four of the ports had to close, however Valparaíso and Lyttelton managed to reopen after 5 & 4 days respectively. Both of these ports experienced relatively small tsunamis, or no tsunamis. The two ports that were hit by large tsunamis after the earthquakes remained closed for extended periods. Sendai, hit by 10-meter waves, had to close for more than seven months and Talcahuano, which was overwhelmed by 15-meter waves, was damaged to such an extent that the wharves and surrounding buildings have to be rebuilt. The port remains closed more than a year after the waves first hit.

It is apparent after conducting this research, that the destructive force of large tsunamis is far more catastrophic to ports and immediate surrounds infrastructure than the earthquake alone. The tsunamis affecting Sendai port in Japan and Talcahuano port in Chile appear to have had the effect of converting the severe damage caused by the earthquake, which can be reasonably localised, into total devastation having a far greater impact on the region. This statement is supported by the reasonably quick recovery of Valparaíso port in Chile and Lyttelton Port of Christchurch New Zealand of 5 and 4 days respectively, where no or relatively small tsunamis were experienced after the earthquakes.

TABLE 12 - Example of recent port closures due to natural disasters

Country	Event	Result	Infrastructure	City	Port	Closed	Reopened	Days closed
Chile	Earthquake Feb 2010 followed by Tsunami of 1.29 meters	Catastrophe – loss of life and massive damage to property	Massive damage to property, major bridges, rail network	Santiago the largest city in Chile	Valparaíso	27-Feb-10	3 March 10 limited operations resumed ~30% functionality.	5
Chile	Earthquake Feb 2010 followed by Tsunami waves of 15 meters	Catastrophe – loss of life and massive damage to property	Massive damage to property and wharves. Buildings around the port have collapsed	Concepción the third largest city in Chile	Talcahuano	27-Feb-10	Currently being rebuilt – remains closed	658 as at 1 Dec 11 and still counting
Japan	Earthquake March 2011 followed by devastating Tsunami waves of 10 meters which vaporised whole towns	Catastrophe – huge loss of life and property devastation	Infrastructure was totally destroyed	Tōhoku region, largest commercial centre	Sendai	11-Mar-11	30 Sept 11 first container ship. Partial reopening earlier only for strategic fuel deliveries and emergency supplies.	200
New Zealand	Earthquake Feb 2011	Catastrophe – loss of life and property damage	Infrastructure badly damaged	Christchurch	Lyttelton	22-Feb-11	26-Feb-11	4

4. OVERVIEW OF AUCKLAND/TAURANGA

4.1 Introduction

The assumption is the POAL is closed for the month of August 2010 as a result of some disaster (natural or man made).

This chapter highlights the impact on the road, rail, POT infrastructure and supporting systems, when the total load of all containers normally handled by POAL during August 2010 are diverted to POT. The volume is applied to the supply chain from the time that the vessel arrives at the POT, the marine/land transfer through to making the container available for collection at MetroPort in Southdown, Auckland. All activities between these two supply chain points are analysed and discussed with the results of the simulations reported.

4.2 Setting the Scene

It is a fact that for many years New Zealand Ports have not reported container volumes through to Statistics New Zealand (STATS NZ) as part of statutory reporting. Currently STATS NZ only requires NZ Ports to report on commodities imported/exported as well as the actual tonnage of such imports and exports as part of statutory reporting. The outcome of this current recording system does not allow accurate details on container movements.

Ports competing against each other for the same container business from the various shipping lines plying the New Zealand import/export trade exacerbate this situation. Information has traditionally been withheld or supplied with creative rounding up or down to protect the port supplying the data as Ports have traditionally viewed this as proprietary information.

At the start of the research, consideration was given to using the OKA model to assist with predicting the various network flows. After realising the lack of the total availability of data, as well as the political influences where land availability required discussion, it soon became evident that it would be pointless to use the OKA Model, as the data required for input was not forthcoming. After the available data was considered, it was established that simple simulation would be possible using Excel spread sheeting as a tool and the more complex modelling of the OKA was pointless due to the lack of the required data.

Resulting from these current statutory reporting practices, it is not uncommon to encounter reports or seminar presentations with varying interpretations of New Zealand container import and export volumes.

The container import/export data used in this dissertation has two sources, namely Ports of Auckland and Port of Tauranga. Both Ports were approached for data to allow this risk analysis project. Both Ports agreed to this. The following data was supplied:

- POAL
    - A summary of all container trade in the New Zealand Market for the 2010 calendar year to serve as an industry overview.

    - Specific data relating to container imports and exports through the POAL for the month of August 2010.
- POT
    - Specific data relating to container imports and exports through POT, including the MetroPort for the month of August 2010.

As discussed in chapter 1, under Scope and Limitations in section 1.6, it was agreed to utilise the container volumes for August 2010, as this would reflect a normal operating month for both Ports. This was agreed to by both POAL and POT.

For the purposes of clarity, the following explanations are supplied for container, restow and tranship:

- Where the word container is used in this document, it is specifically referring to Twenty Foot Equivalent Units or TEU≈ as reported, recorded and accounted for by all NZ Ports when aggregating annual volumes handled by the specific Ports.
- Restow means that the container is offloaded from the vessel for the purposes of balancing the load to the stow plan of the vessel. It is standard practice to attempt to load all of the heaviest containers nearer the bottom of the vessel, as this gives the vessel stability in heavy seas and does not result in the vessel becoming top-heavy. When the ship planner works out the stow plan they also have to factor in the destination of the container as it would not be cost effective to unpack the entire vessel at the first discharge port to access a heavy container in the bottom of the stow. This process does result in a certain amount of restowing at most ports where a vessel loads and discharges containers. Ports traditionally account for this activity as part of the container volumes that are handled and they reported as such.
- Tranship means that a container is transferred from one shipping lane to another shipping lane to enable the container to reach its destination. An example of this in New Zealand could be a feeder shipping service or a coastal shipping service repositioning a container from Port of Nelson to POAL where the container will be transhipped to an international service, which does not call at Nelson. This practice opens up regional ports to the rest of the world and enables exporters to ship the cargo from the nearest regional port to their production facility. This practice is also accounted for by ports as part of the container volume that they handle

4.2.1 Ports of Auckland volume for August 2010

POAL handled 71,453 containers during the month of August 2010 as summarised in table 13 below. Of this volume only 30,248 were physically imported and 21,561 made up the total of the exports. The balance of 19,644 containers is a combination of restow and tranship.

Restow and tranship volumes accounted for 26% of all container movements at the POAL during August 2010.

TABLE 13 - Ports of Auckland Container Volume for August 2010

POAL Container volume August 2010	
Type	POAL
Imports	30,248
Exports	21,561
Tranship	18,329
Restow	1,315
Total	71,453

4.2.2 Port of Tauranga volume for August 2010

POT handled 49,503 containers during the month of August 2010 as summarised in table 14 below. Of this volume only 18,723 were physically imported and 23,489 made up the total of the exports. The balance of 7,291 containers is a combination of restow and tranship. Restow and tranship volume accounted for 13% of all container movements at the POT during August 2010. This is equal to 37% of the restow and tranship volume that POAL handled during the same period. Obviously if the POAL volume is added to the POT volume, this will seriously challenge the POT shore operations.

TABLE 14 - POT Container Volumes for August 2010

POT Container volume August 2010	
Type	POT
Imports	18,723
Exports	23,489
Tranship	6,357
Restow	934
Total	49,503

4.2.3 Combining both Ports' volumes for August 2010

The consolidated volumes as depicted in Table 15 below, for both POAL and POT for the month of August 2010 total 120,956 containers. All of these containers have to be handled at shipside, however the imports make up 48,917 containers and the Exports total 45,050 containers. Transhipped or restowed containers contribute 26,935 of the total or 20%.

TABLE 15 - Total August 2010 Container volume to be worked by POT

Total Container workload for Port of Tauranga for August 2010			
Type	POAL	POT	Total
Imports	30,248	18,723	48,971
Exports	21,561	23,489	45,050
Tranship	18,329	6,357	24,686
Restow	1,315	934	2,249
Total	71,453	49,503	120,956

4.2.4 Feasibility of Port of Tauranga picking up the task

To assess the feasibility of the POT having the capability of picking up the task of handling POAL volumes on top of their existing volumes, it is necessary to segment the activities into some sort of logical order to enable iterations to be run.

4.2.5 Determination of vessels to be handled

Multi purpose vessels were removed from the data, as they load a mixture of containers and bulk cargos, and normally berth at General Wharves and not Container Wharves. POAL handled 49 container vessels and POT handled 46 container vessels for the month of August 2010. This totals to 95 container vessel port calls (Table 16). Of these 95 vessels, 20 were common to both ports. If the 20 common vessels were deducted from the total this would leave 75 vessels to be handled. [Appendix 7.3]

For the purpose of this assessment the total of 95 vessels will be used as it is highly likely that the POT would still have to handle the 20 vessels twice due to the common practice of these shared vessels arriving at POAL to discharge the majority of the import cargo into New Zealand, followed by various NZ port calls in an attempt to fill the vessel with export cargo. These voyages normally culminate in POT as the last call where the majority of the cargo is loaded and the vessel is finalised before departing the New Zealand seaboard for international destinations.

TABLE 16 - Summary of total container vessels to be serviced by POT

PORT	Vessels Serviced
POAL	49
POT	46
Total	**95**
Vessels in common	20
If common vessels were discounted out	75

In the interests of continuing to fill the vessels and distribute the empty containers after the import cargo has been unpacked, it is probable that this practice would continue with the exception of POAL being replaced with POT as the first and last port call.

Accordingly 95 container vessel port calls will be used in the assessment of the POT capabilities during the month of August 2010.

4.2.6 Berth occupancy and capabilities

POT had a 600m-vessel berth at Sulphur Point Container Terminal as at August 2010. The berth is currently being extended by 200m to enable three vessels to be worked at most times. The 600m berths will be used to assess the POT capabilities to handle the POAL volumes, as this was the prevailing status quo at that time.

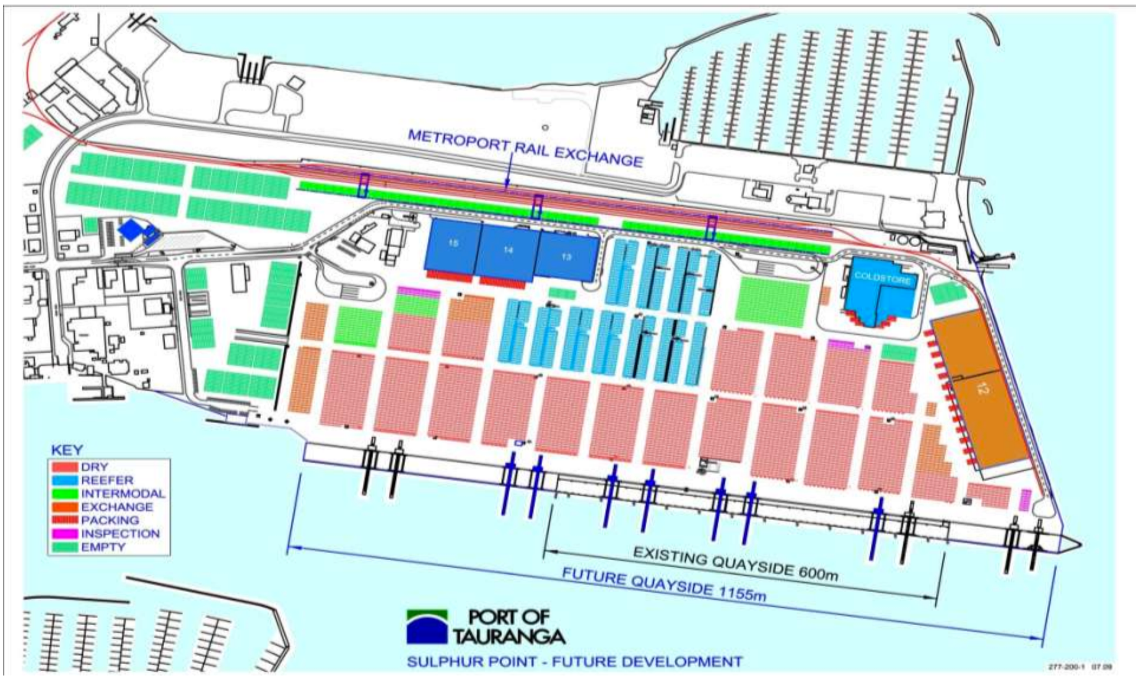

FIGURE 8 - Port of Tauranga - Sulphur Point Container Berths

During the month of August the POT Sulphur Point berth occupancy was 43.52% while resource utilisation to service the berths was 33.14%. This leaves an average of 10.38% idle time at the berth while the vessel is not being worked. This is the time that vessels use for vessel husbandry and awaiting tidal windows to allow for safe departure.

4.2.7 Times, reasons and assumptions

Assumed Berth SPACE Occupancy factor. For the purposes of these iterations, assumptions have had to be made on the number of berths occupied. The assumption derived at is 2.3 berths used on average @ 24 hours for the 31 days of August 2010. Due to limited data being supplied in different format by the two Ports, not including the vessel length, vessel draft, the number of container exchanges per vessel, tidal windows, and berth activity/maintenance down time, assumptions had to be made. This assumption is based on diagrammatic berth occupancy slides extracted from various presentations made by the POT depicting that the berth occupancy to service the vessels calling for the specific period was 2.3 berths used on average at any given time (McColgan, 2011). [Appendix 7.4]

Assumed Maximum Berth TIME Availability factor. The total number of hours available for berthing at Sulphur Point is calculated as follows:

24 hours x 2.3 ~berths space required x 31 days of August 2010 = 1,711 possible hours to work vessels per month.

4.2.8 Wharf operations

Wharf activities drive the speed at which the berth cranes can operate and have a large impact on the number of crane moves per hour. The congestion density on wharf has a direct correlation to the berth crane productivity as measured in net crane rate or crane moves per hour (NCR). Ports are normally not forthcoming in sharing Wharf congestion information due to its potential to allow analysts to unravel other propriety information by utilising this denominator. In the case of the POT, previous graphic representation of port congestion and subsequent escalating impact on crane productivity slides presented at a BOP Risk Symposium (McColgan, 2011) have been used to determine an average ratio of port congestion and subsequent flow on berth crane impact. Optimal operations to allow NCR to achieve 33 lifts per hour can be equated to a range between 1 to 3.49 containers stored per ground slot with a limited ground slot allocation of 4615 currently in existence at Sulphur Point. Incremental increases in containers stored per ground slot over and above 3.49 directly impacts the speed with which the straddle crane services can feed the berth crane. This is as a result of the congestion factor driving the number of re-handles per container. The simple rule is, the more containers stored per ground slot in excess of 3.4, the higher the number of container re-handles and the slower a straddle can feed to and clear from the berth crane.

4.2.9 Scenario options

Table 17 below depicts the normal operating month experience by POT during August 2010 reflected as actual. The combined volumes of POAL and POT have been included after factoring in the above assumptions on container volumes, vessel numbers, berth occupancy and capabilities, timing assumptions with congestion ratios, and wharf activities.

TABLE 17 – Port of Tauranga Berth Occupancy Iteration

Aug-10		NCR Crane moves/hr.	Cranes Per Vessel	~work hrs	~berth hrs	No of Ships	No of TEU's	Work / Berth Variance	Berth occupancy assuming 2.3 berths		
									Actual	possible	as a %
Actual	POT	32.8	2.3	10.75	14.25	46	49,503	3.50	656	1,711	38.31%
Combined	POT & POAL	28	2.3	12.50	14.75	95	120,956	2.25	1,401	1,711	81.90%

It becomes evident that the added congestion of the POAL volumes will drive down the POT shore crane moves per hour from 32.8 to 28. This represents a slow down of feeding the shore cranes by 4.8 containers per crane per hour or 15%. Extrapolated out over the 2.3 cranes servicing each vessel is a total slowdown of 11.04 containers per hour. If this was further extrapolated over the average of 12.5 hours to work each vessel, it then totals 138 containers per vessel or 13,110 containers over the 95 vessels serviced during the month.

The number of hours required to work a vessel increases from the August actual average of 10.75 to 12.50. This is 1.75 hours extra per vessel or an increase of hours worked of 16% per vessel. Over a month this is 166.25 hours or 1995 hours per annum.

The total number of hours that a vessel is alongside has a nominal increase of .50 of an hour. While this looks small in isolation, it also adds up to 47.5 hours per week of lost sailing time to the shipping industry. This would equate to 570 hours in a year. To put this into perspective it is 23.75 days of sailing time in a year. This is sufficient time for a vessel to sail from New Zealand to China and halfway back again. (23.75 days @ US $10,000 per day = $237,500 in daily charges).

During this time the berth occupancy rate would increase from the August 2010 average of 38.31% to a robust 81.90%. This would indicate that the berths would not be completely maxed out, however any added vessel volume would drive further productivity losses with the current wharf support structure and resourcing.

It is evident that the POT would cope with the volume increase on a short to medium term basis, from a shipping volume, berth occupancy and wharf activities perspective, however the glaring loss of productivity would drive rapid decision making in relation to increasing the available ground slots together with a combination of initiatives to reduce the average container dwell time in the port.

4.3 Rail capabilities

This section looks at the rail freight capabilities to determine if rail is the logical mode to bridge the POT with the Auckland region via the MetroPort, situated in Southdown Auckland. This will be a critical element in enabling the supply chain to remain functional throughout the POAL outage.

4.3.1 Volumes adjusted for rail Imports / Exports

The combined volumes to be handled by POT will have to be adjusted before being applied to a rail scenario. The reasoning for this is not all of the consolidated volume will be leaving POT, or consigned for/from the Auckland region as the POT has existing services with a widespread geographical area. These comprise the Bay of Plenty, Waikato, King Country and existing Auckland volume.

TABLE 18 - Determining volume to be railed

Determining container volumes to be railed between TRG - AKL - TRG		
Imports		**48,971**
POT		
Imports	18,723	
Current North bound M/Port	5,788	
Deduct Balance of cargo not for M/Port	**12,935**	36,036
Assume deduct 5% road transport	1,802	
Balance of cargo for North bound operation		**34,234**
Exports		**45,050**
POT		
Exports	23,489	
Less current southbound M/Port	7,717	
Deduct balance of exports from BOP	**15,772**	29,278
Assume deduct 5% road transport	1,464	
Balance of cargo for South bound operation		**27,814**

After adjusting the volumes to remove no rail cargo, the remaining volume to be serviced by rail is:

- Imports = 34,234 containers
- Exports = 27,814 containers

The imbalance between the imports and exports of 6,420 containers is not viewed as an obstacle, as logic dictates that if 34,234 containers are transported from POT to Auckland, then 34,234 containers will have to be repatriated from Auckland to POT to be packed in the Bay of Plenty as exports or repatriated as empty containers to another NZ port for the purposes of being packed for export. This factor will automatically balance the train volume north and south bound.

4.3.2 North bound trains

During the month of August 2010, KiwiRail operated an average of 2 dedicated MetroPort trains per day, in each direction, on behalf of the POT. Each train has 106TEU capacity which at the time was the optimum mix per MetroPort train in terms of handling capability at both ends where the train is loaded / stripped. This was sufficient to clear the container volume consigned in both directions.

Over and above the 2 x MetroPort trains per day, KiwiRail operates a further 2 general market / cargo trains per day between Southdown, Auckland and POT. On these trains KiwiRail offer a container rail service to shipping lines who are not contracted to the POT to use the dedicated MetroPort trains and as such require the service to repatriate empty containers from the Auckland region (ex POAL arriving in NZ as full Imports) to the Tauranga region to allow the empty containers to be used for packing of export product. Any empty slots on these trains are offered on a priority basis – first to POT and then to the open market.

This situation works in reverse for the dedicated MetroPort trains, which are operated by KiwiRail for MetroPort. Should MetroPort have any empty slots on their dedicated trains then MetroPort will on a priority basis first offer the slots to KiwiRail to enable KiwiRail the opportunity to sell the empty slots to their customers, followed by offering the slots to the open market. Invariably this tight duopoly situation results in very few slots being offered direct to the open market and it enables the two operators to legally control the market as well as the container rail price between POT – Auckland – POT.

TABLE 19 - Trains required to service combined POAL and POT volumes

Trains required to service combined volume of POAL and POT						
Volume per train		Containers	No of trains required in each direction		
TEU≈/train		Volume/ month	Per Month	Per Week	Per Day
106	Current Maximum per network	34,234	323	75	11
115	Future situation as & when new locomotive power is released and all new passing loop extensions are complete to allow train length increase.	34,234	298	69	10
120		34,234	285	66	9
150		34,234	228	53	8

As depicted in table 19, KiwiRail would have to operate 11 x 106TEU MetroPort trains per day in each direction to clear the combined volumes of both Ports of 34,234 containers north bound as well as south bound. This represents a jump from the current 4 trains per day (2 x MetroPort and 2 x KiwiRail General Market) to 11 trains per day. This extrapolates out to 75 trains per week, or 323 trains per month or 3,876 trains per calendar year in each direction.

The next assessment will be to test if the network can cope with an extra 7 trains per day in each direction or a total of an extra 14 trains per day over an above the existing 8 per day currently being operated.

4.3.3 South bound trains

South bound trains have been modelled from Auckland to POT using the export volume of 27,814 as calculated in table 15-volume determination. Modelling south bound trains is not going to contribute value, due to the natural balancing discussed under 4.3.1.

4.3.4 Network density (Trains per hour on network)

The network density can be described as the maximum number of trains that can access a specific part of the rail infrastructure referred to as the network during a specific period.

The network in question is the line from MetroPort Southdown in Auckland to POT, Sulphur Point Container Terminal. This is highlighted in red on the map in figure 10 below as making up the Golden Triangle rail network.

The maximum density that the network can absorb is 2.7 trains per hour (Rae, 2011) with current passing loops and combination of double and single tracking.

During August 2010, the network handled 1.75 trains per hour (Rae, 2011) leaving a latent capacity of 0.95 trains per hour that the network can still absorb before reaching saturation.

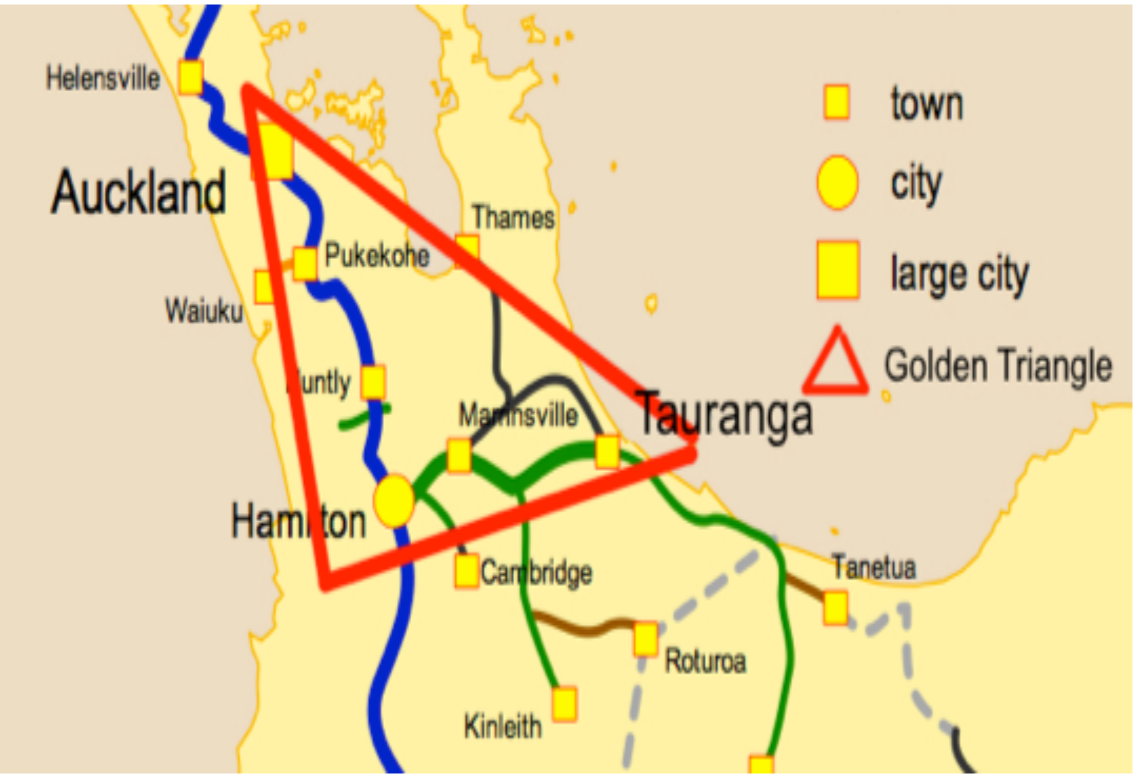

FIGURE 9 - Map Depicting Golden Triangle Rail Network (KiwiRail, 2011)

With this information the following calculations can be made as depicted in table 20 below, where the current total trains per 24-hour day is calculated as 42 out of a possible 65. This leaves 23 slots available to add on extra trains per 24-hour day.

As per the simulation done in 4.3.2 an additional 14 trains per day (7 north bound and 7 south bound) will be required to supplement the current 8 trains per day (4 x north bound and 4 x south bound) lifting the total number of MetroPort / POT trains per day to 22, split evenly with 11 running in each direction.

The network can comfortably accommodate the additional trains without exceeding the maximum sweet spot of 2.7 trains per hour on the network. By moving the density from 1.75 to 2.33 trains per hour the network would still have approximately 14% latent capacity remaining.

TABLE 20 - Network Train Density Calculations

Network Train density (trains per hour on network)				
	Per hour	Per 24 hr day	Per Week	Per Month
Capacity	2.70	65	454	1,966
Actual	1.75	42	294	1,274
Available	0.95	23	160	692
Proposed	2.33	56	392	1,699

4.3.5 Port of Tauranga / MetroPort train stripping and loading ability on 106 TEU trains

The last segment in the proposed supply chain is to assess the ability of the receiving and despatching areas to handle the new volume of cargo onto and off of the trains. The turn around time of the trains will be an important factor in the success of the operation, and this will determine if the entire workload can be carried by rail.

At POT Sulphur Point the average time as at August 2010 to strip and load a MetroPort train was 4 hours. The Port believe that this time could be improved on to an average of 3 hours (McColgan, 2012) as this reduced time had been achieved with stripping and loading of full trains previously.

At MetroPort the average time, during the same period to strip and load a train was 3 hours. MetroPort are comfortable that this can be done at an average time of 2½ hours as this has been achieved in the past.

TABLE 21 - POT / MetroPort Train Turn Around Time

POT / MetroPort Train stripping & Loading ability on 106 TEU Trains		
Activity	POT	MetroPort
	Hrs	Hrs
Current time to service trains	3.00	2.50
Max trains possible / 24 hr day at existing average	8.00	9.60
Require trains per 24 hr day	11	11
Shortfall every 24 hrs at existing times	-2.65	-1.05
Theoretical improvement required per train per 24 hrs	0.75	0.25
Theoretical time required per train @ 11 trains per 24 hrs	2.25	2.25
Adjust down for contingency	0.25	0.25
Proposed time to simulate	2.00	2.00
Total improvement required	1.00	0.50

Using the existing times and applying the new train volumes it is evident that POT would require 33 hours to strip and load 11 trains. The requirement is for this task to be performed within a 24-hour period. POT would have to shave 9 hours off of the task and reduce the average time to strip and load a train from 3 hours to 2 hours. The 2-hour time per train will allow for an extra ~11 minutes contingency (extra) per train as a buffer in the event that the time is required for unplanned events. This represents a 33% improvement required per train to allow for the new volume of 11 trains per day to be processed.

The situation is slightly less frenetic at MetroPort where 27.5 hours would be required to perform the same task. MetroPort's 2.50 hours to strip and load a train would have to reduce by ½ and hour per train to allow for the 11 trains per day to be processed. This would require a total reduction of 3½ hours over the 24-hour period. This represents a 25% improvement required per train to allow for the new volume of 11 trains to be processed every day. The 2 hour time limit per train would also include the same extra ~11 minute contingency per train in the event of unplanned delays.

5 CONCLUSION / OUTCOME

Currently the POAL has experienced 8 closures during the last two and a half months (December 2011 to 20 February 2012). These closures have been as a result of industrial action. More industrial action is planned with the next closure starting on Friday 24th February 2012 and due to continue for a period of three consecutive weeks, up to Friday 16th March 2012.

The vulnerability of the New Zealand export supply chain should not be underestimated. A supply chain is only as robust as its weakest link. These links in the supply chain are constantly subjected to varying weather phenomenon, natural disasters such as earthquakes or tsunamis and man made disasters such as pollution, industrial action, or financial crisis.

This demonstrates that the risk to the greater Auckland supply chain is real. In this instance the industry has always had two weeks notice to prepare for the industrial action resulting in POAL's closure. In the event of a natural disaster, industry will not enjoy this luxury of two weeks to implement contingency planning.

During this period the POT has risen to the occasion and handled the majority of the import volumes and vessels turned away from POAL. While the supply chain is still working, albeit much slower than normal, it is clear the POT and KiwiRail would need more time to prepare, plan and ramp up services to cope with this type of volume on an on-going basis.

The weak links discovered in the supply chain during this simulation are:

- Space constraints (shortage of developed ground slots) at POT and MetroPort. This drives inefficiencies in the stacking and storage of containers, with the resultant slowing down of the shore operations due to congestion. The flow-on effect is double and triple handling of containers. POT and MetroPort have space available and they are racing ahead with the development of more ground slots, however this development takes time and is better suited to a systematic ramp up as opposed to doubling overnight.
- A shortage of straddle cranes to cope with the extra volume at such short notice. POT have ordered a further six new straddle cranes as part of their growth plan. These straddles are still some months away. Consideration should have been given to relocating straddle cranes from POAL to POT to assist with the extra volumes during this period.
- Insufficient available infrastructure to handle sustainable rail exchange at POT. In response to this, POT have sought board approval to increase the rail spurs as well as tar sealing between the spurs to allow access for multiple rake loading, as opposed to loading one rake at a time. The POT has also taken delivery of a reach stacker, which will allow them to reach over one loaded rake to load a second rake.
- Lack of available trained human resources. This is a fundamental challenge, as without the required resources, all the new machinery will stand idle. It takes time and spare equipment to recruit and train resources. While this recruitment is now underway, the benefits of this will be downstream. In the interim the existing

resources are being overworked, which in itself is not a sustainable situation. This is an issue for both the POT as well as KiwiRail.

- Potential rail network saturation. KiwiRail have the locomotives and the wagon fleet to implement the required number of trains per day. The simulation works on the network, however this will drive the network close to capacity with the resultant decrease in time available to close the network for the required on-going maintenance, or to cope with any operational issues such as breakdowns or derailments.

Logisticians in New Zealand, as well as most other countries, constantly perform a juggling act to keep supply chains flexible, alive and working. This is not a simple task and takes years of experience, an in-depth industry knowledge and enduring supply chain failure or collapse, to learn how to navigate the fluid global supply and distribution streams.

A key link in the New Zealand supply chain is international shipping companies or lines. The majority of these lines are subject to decision making in the northern hemisphere and while they maintain offices in New Zealand, they have very little or no decision making authority. They are driven by commercial reality and business seasonality's and will not hesitate to unilaterally change services. Exporters and importers in New Zealand have very little influence over this situation.

The POT will have to do some work on the loading and stripping of MetroPort trains, as this is a potential area where the supply chain could hesitate and become blocked. If a backlog were allowed to build up, the only resolution would be to bring road bridging in to relieve the pressure on the operations. This in turn would probably manifest itself as a backlog in another area, as suddenly the POT would have to handle the extra volume of trucks, while continuing normal operations. There would be no margin for error in the system, making the supply chain that much more fragile or prone to fail.

It is clear why trucking plays such an important role in the New Zealand logistics scene. The supply chain is heavily reliant on the trucking industry, with the result that industry in New Zealand is vocally advocating rail as a future option or link in the supply chain. A level of discomfort exists within industry regarding the monopoly situation currently enjoyed by the trucking industry.

No amount of risk planning will make a supply chain untouchable, however risk planning does allow for a quick recovery, as most of the options are explored as part of a risk/crisis plan and can be adapted to suit in times of crisis management.

Over time, supply chains have evolved from a stock situation to a just in time supply basis driven by a plethora of reasons, with the common denominator, or most important consideration, being the reduction of working capital employed in the supply chain. This has effectively reduced the safety margins that businesses have traditionally operated with, in terms of stock levels or time to market.

An example of this would be a Trans Tasman supply chain, where the consignee holds one week's safety stock in Australia, as the supply chain is one week from the source, being New Zealand (there are three weekly sailings from New Zealand to Australia). In the event of severe weather on the Tasman, which can delay a vessel by up to six days, or a port closure in Australia due to industrial action, the supply chain is severely exposed to risk and will potentially run out. Part of risk planning should include modelling of minimum stock holdings as a safety net for such events.

It is interesting to note that when the POAL and POT import / export container volumes are grouped together, they come close to balancing each other out. This is a factor worth further investigation and could possibly take cost out for Port companies as well as the importers and exporters. It would involve closer collaboration between the Ports, which is unlikely as they compete directly with one another.

The relevance of this study is underpinned by the current situation where POAL has been sporadically closed for extended periods due to industrial action. While the contingency supply chain via POT to MetroPort has handled this situation with a fair degree of aplomb, it is evident that POT would not be able to sustain the current level of volume that this situation has forced on to them. This highlights that the POAL is a crucial link in the New Zealand supply chain, as is the POT. New Zealand Inc. would benefit from further modelling including the reverse situation where POT closes and POAL has to form part of the contingency plan.

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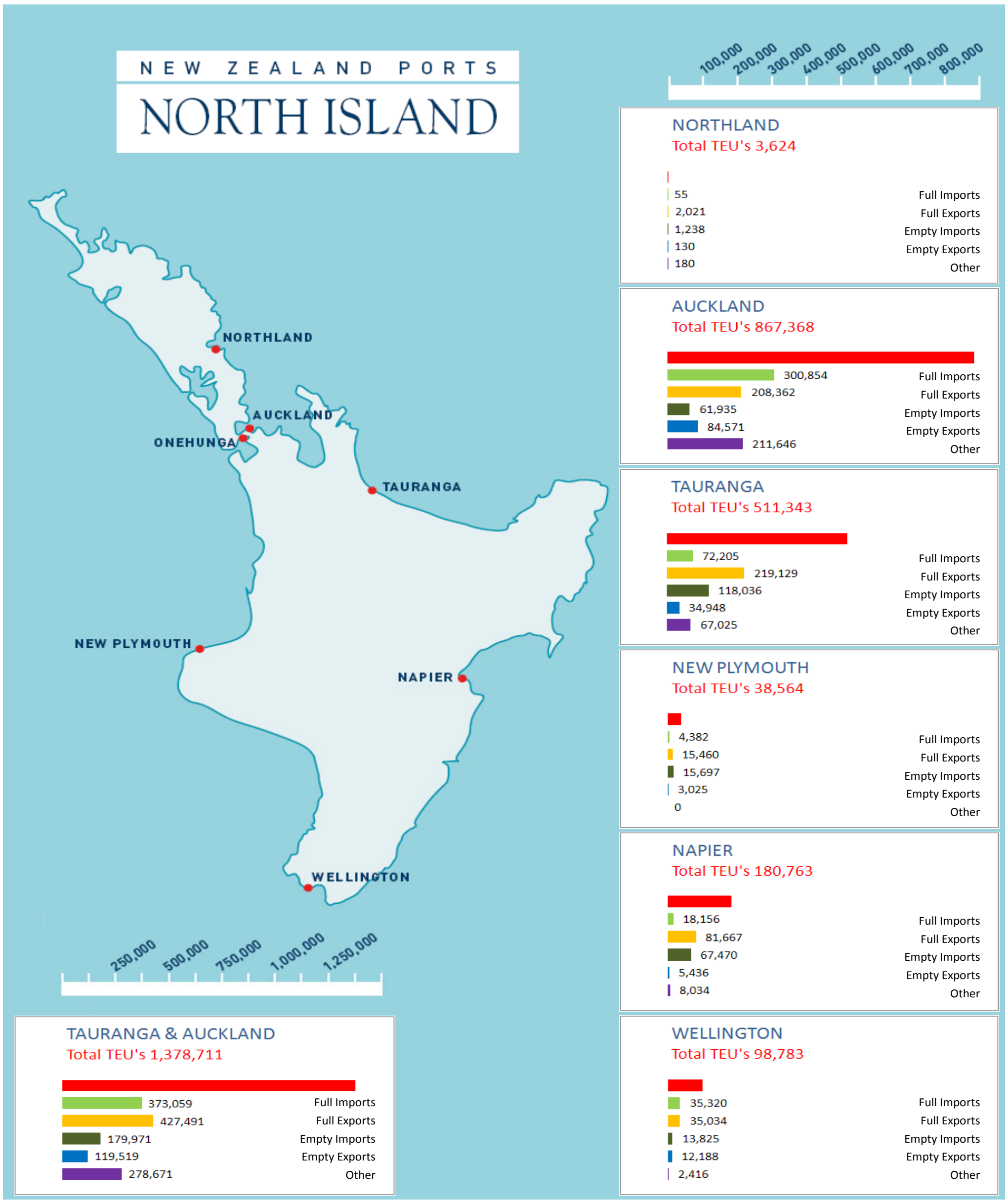
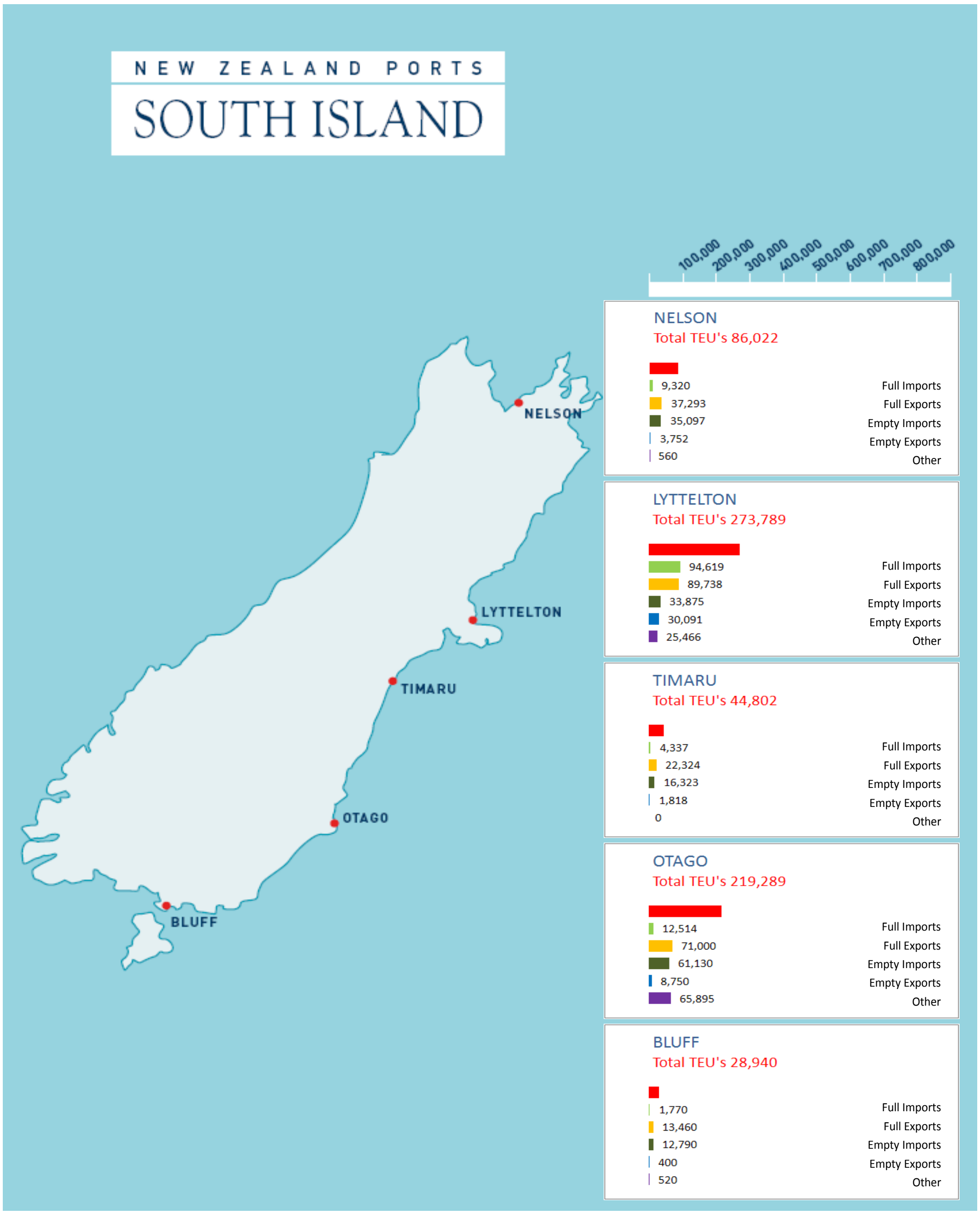
7 APPENDICES

7.1 New Zealand North Island map with container ports and actual TEU≈ volumes for Year Ended 2010 (POAL, 2011)



Actual Volumes in TEU for the Year ended June 2010
Source: Ports of Auckland

7.2 New Zealand South Island map with container ports and actual TEU≈ volumes for Year Ended 2010 (POAL, 2011)



Actual Volumes in TEU for the Year ended June 2010
Source: Ports of Auckland

7.3 Sorting of container vessel port calls between POAL & POT during August 2010.

Sorting of vessel port call between POAL and POT			
1	MOL SPARKLE	AKL	
2	ACX DIAMOND	TRG	
3	AMUR RIVER	TRG	
4	ANIARA	AKL	
5	ANL BINBURRA	TRG	
6	ANL BINDANA	TRG	1
7	ANL BINDANA	AKL	
8	ANL BIRRONG	TRG	1
9	ANL BIRRONG	AKL	
10	ANTWERP	AKL	
11	ASIAN LILY	AKL	
12	AUSTRALIA EXPRESS	AKL	
13	BUNGA RAYA DUA BELAS	AKL	
14	BUXLINK	TRG	1
15	BUXLINK	AKL	
16	CALIFORNIA MERCURY	TRG	1
17	CALIFORNIA MERCURY	AKL	
18	CAP BEATRICE	AKL	
19	CAP BEAUFORT	TRG	1
20	CAP BEAUFORT	AKL	
21	CAP BLANCHE	AKL	
22	CAP BON	AKL	
23	CAP BYRON	TRG	1
24	CAP BYRON	AKL	
25	CAP CAPRICORN	AKL	
26	CAP CLEVELAND	TRG	1
27	CAP CLEVELAND	AKL	
28	CAP MANUEL	TRG	1
29	CAP MANUEL	AKL	
30	CAPITAINE WALLIS	TRG	
31	CAPITAINE WALLIS	TRG	1
32	CAPITAINE WALLIS	AKL	
33	CMA CGM LETOILE	TRG	
34	COSCO FUZHOU	TRG	
35	COSCO FUZHOU	TRG	
36	FORUM PACIFIC	AKL	
37	FRIO HELLENIC	TRG	
38	HANSA VISBY	TRG	
39	HS WAGNER	TRG	1
40	HS WAGNER	AKL	
41	ITAJAI EXPRESS	TRG	
42	JPO SCORPIUS	TRG	1
43	JPO SCORPIUS	AKL	
44	JRS PEGASUS	AKL	
45	KOTA DARJAH	AKL	
46	KOTA PEKARANG	TRG	1
47	KOTA PEKARANG	AKL	
48	KOTA PERMATA	TRG	1
49	KOTA PERMATA	AKL	
50	KOTA RATU	AKL	
51	MAERSK ABERDEEN	AKL	
52	MAERSK DANVILLE	AKL	
53	MAERSK DENTON	AKL	
54	MAERSK DUFFIELD	AKL	
55	MAERSK FUKUOKA	TRG	
56	MAERSK FUKUOKA	TRG	1
57	MAERSK FUKUOKA	AKL	
58	MAERSK JENAZ	AKL	
59	MAERSK RADFORD	AKL	
60	MARFRET SORMIOU	TRG	
61	MOL SPARKLE	TRG	
62	MSC BRASILIA	TRG	
63	MSC KRITTIKA	TRG	1
64	MSC KRITTIKA	AKL	
65	MSC PALERMO	TRG	
66	MSC SARDINIA	TRG	
67	MSC TASMANIA	TRG	
68	NATALIE SCHULTE	TRG	
69	NORFOLK GUARDIAN	AKL	
70	OCEAN BRIGHT	TRG	
71	OCEAN BRIGHT	TRG	1
72	OCEAN BRIGHT	AKL	
73	OOCL MELBOURNE	TRG	1
74	OOCL MELBOURNE	AKL	
75	PARANAGUA EXPRESS	TRG	1
76	PARANAGUA EXPRESS	AKL	
77	PATRICIA SCHULTE	TRG	1
78	PATRICIA SCHULTE	AKL	
79	ROYAL KLIPPER	TRG	
80	SCHELDE TRADER	AKL	
81	SKY APOLLO	TRG	
82	SKY JUPITER	TRG	
83	SOFRANA TOURVILLE	AKL	
84	SOUTHERN EXPRESS	AKL	
85	SOUTHERN FLEUR	AKL	
86	SOUTHERN REEF	AKL	
87	SOUTHERN TIARE	AKL	
88	SPIRIT OF ENDURANCE	TRG	
89	SPIRIT OF ENDURANCE	TRG	
90	SPIRIT OF ENDURANCE	TRG	
91	SPIRIT OF ENDURANCE	TRG	1
92	SPIRIT OF ENDURANCE	AKL	
93	TALISMAN	AKL	
94	TURTLE BAY	TRG	
95	VEGA GOTLAND	AKL	
95	Total ships		20 Common ships

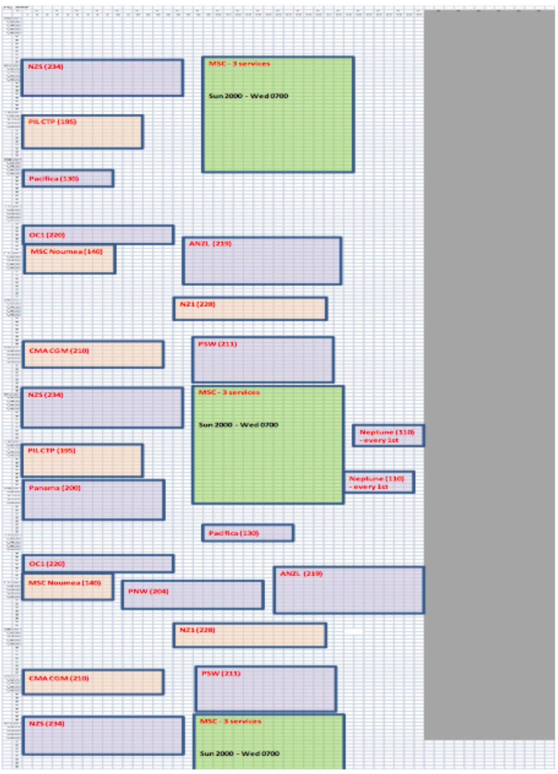
PORT	Vessels Serviced
POAL	49
POT	46
Total	**95**
Vessels in common	20
if common vessels were discounted out	75

7.4 Proforma berth booking schedule from Port of Tauranga with modelling of POAL and POT vessels with a resultant 2.3 berths used on average.

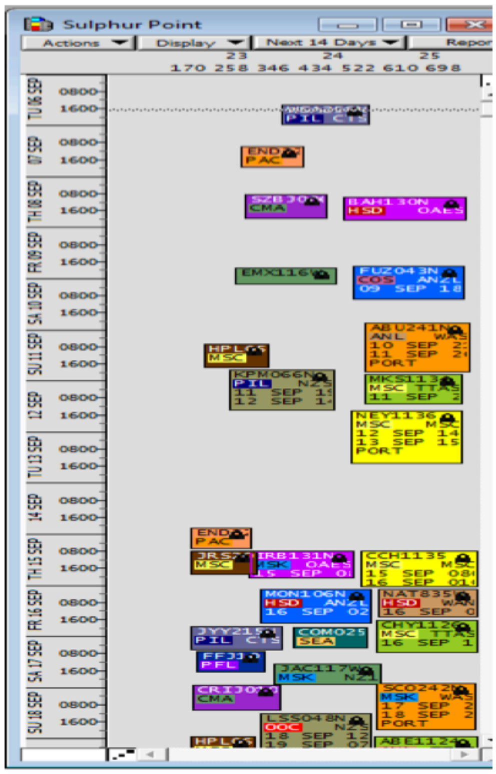
Proforma

POAL Vessels

Proforma

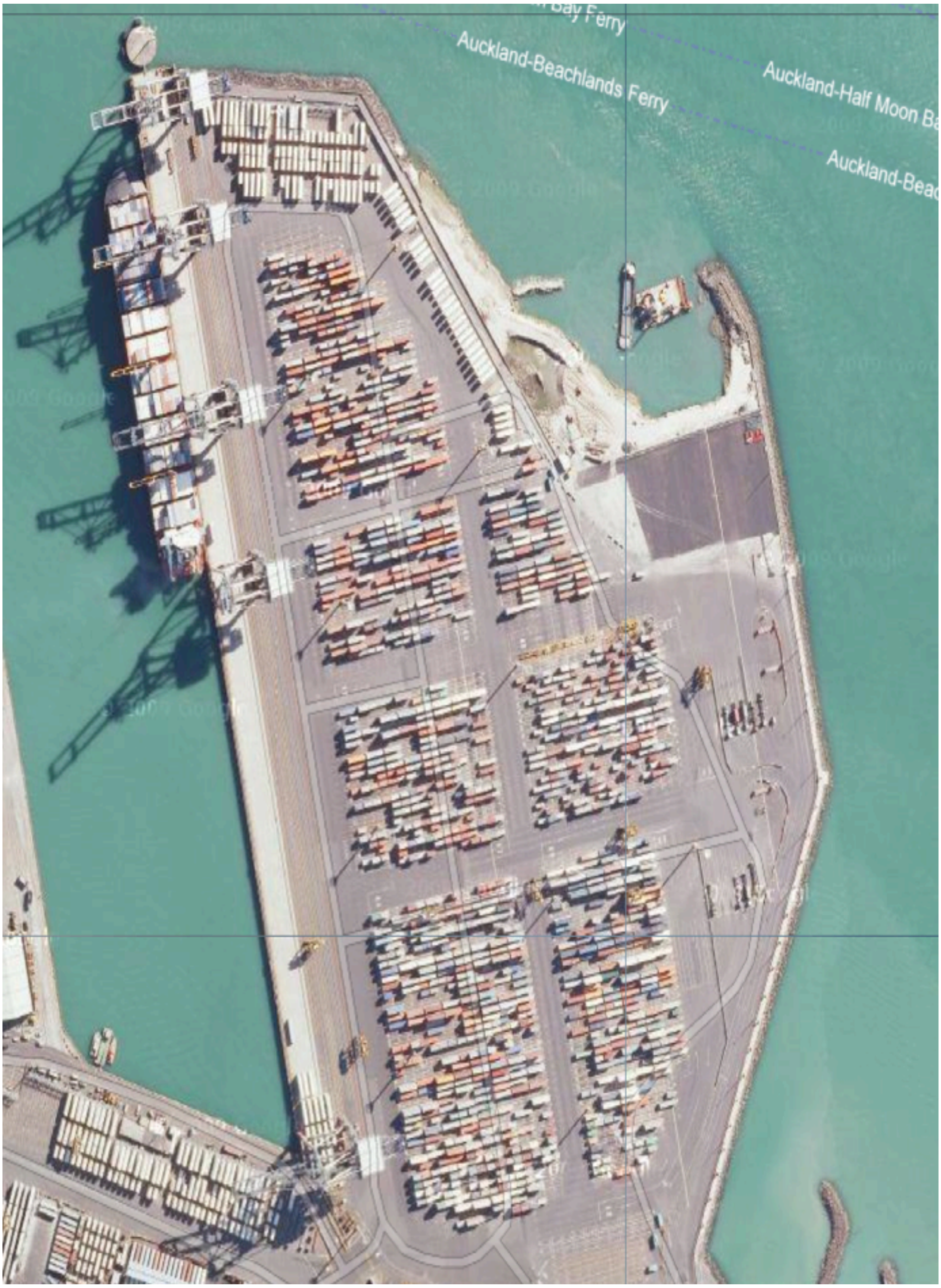


Actual

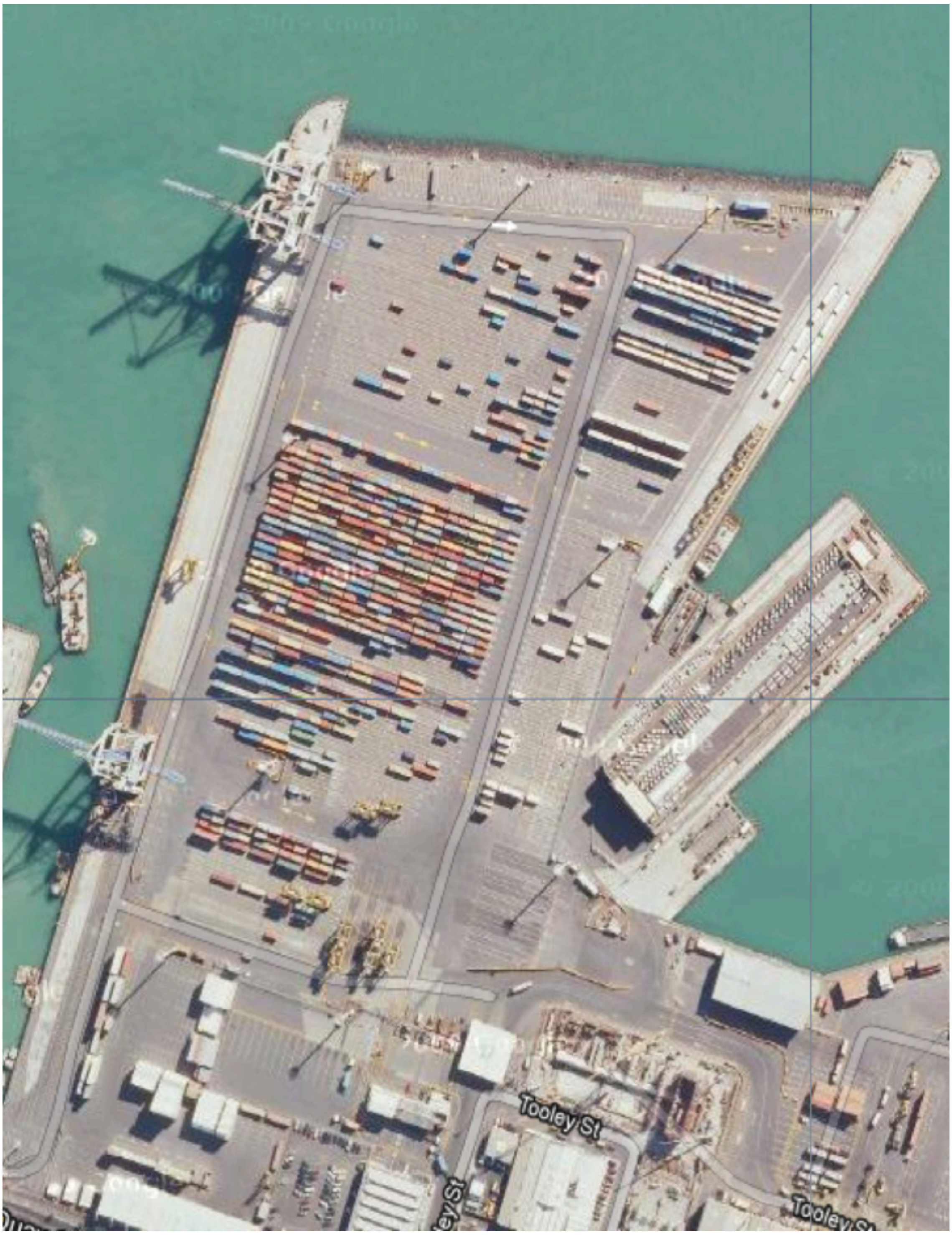


Source McColgan M. (2011)

7.5 Aerial picture: Fergusson Container Terminal, POAL. (Google Earth, 2011)

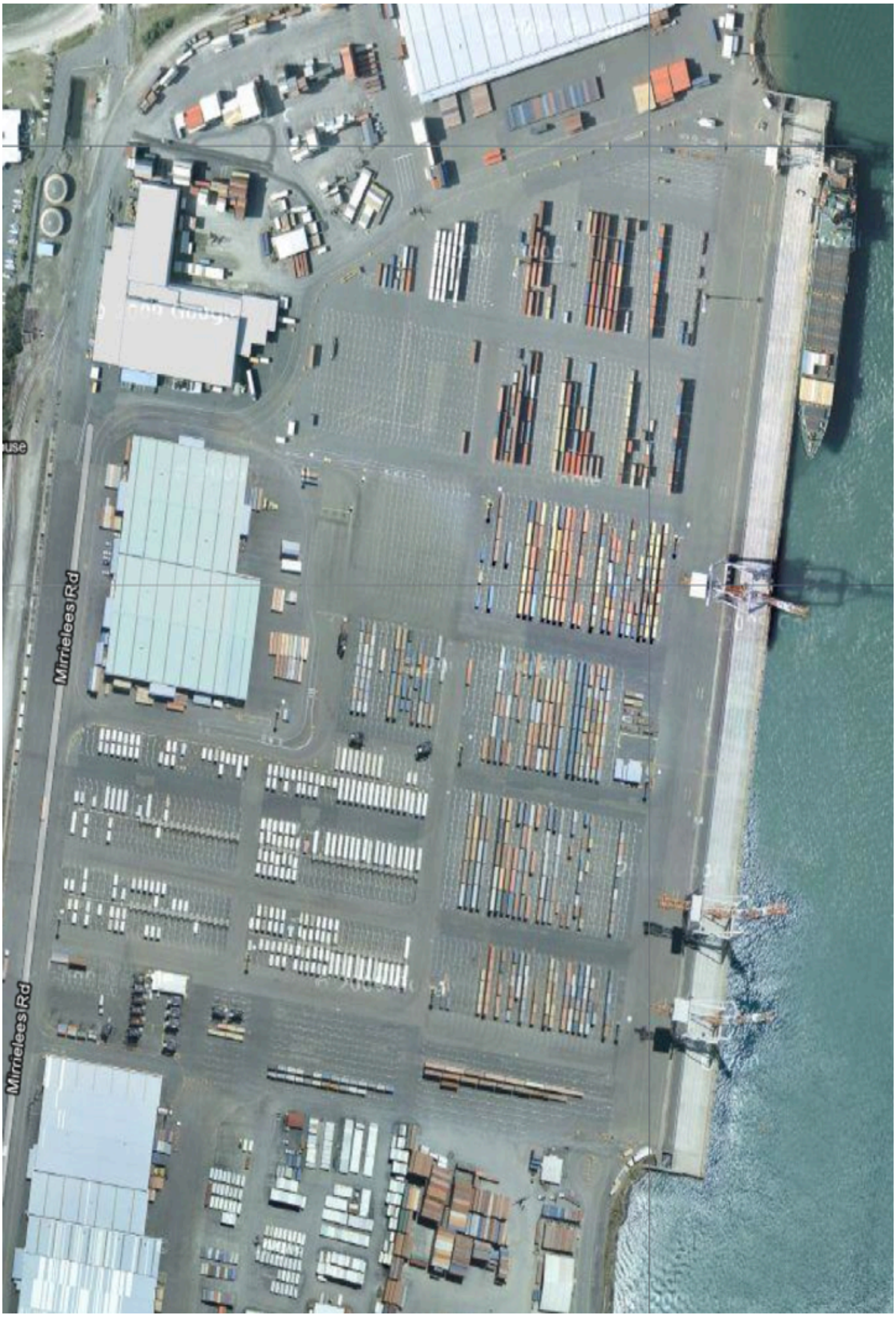


7.6 Aerial Picture: Bledisloe Container Terminal, POAL. (Google Earth, 2011)



7.7 Aerial Picture: Wiri Inland Port, POAL Manukau. (Google Earth, 2011)

7.8 Aerial Picture: Sulphur Point Container Terminal POT. (Google Earth, 2011)



7.9 Aerial Picture: MetroPort, Southdown Auckland. POT. (Google Earth, 2011)

7.10 Aerial picture: MetroPort with Auckland City in the background. (POT, 2011)

7.11 **Map of New Zealand North Island Rail Network with Golden Triangle highlighted on the map in Red. (Map supplied by KiwiRail and modified with Apple Pixelmator to include Golden Triangle.)**

7.12 Golden Triangle Road Route Network with three main options highlighted. (Wises Maps, December 2011 with Apple Pixelmator overlay to include all three routes on the one map.)