Demand for Travel in the Wellington Region Following a Major Earthquake

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Executive Summary

This report investigates the role of transport after a major earthquake in the Wellington region. Travel patterns in the Wellington region are examined and the demand for travel after a major earthquake is predicted and analysed in the context of two earthquake scenarios. A major natural disaster that seriously degrades roading and infrastructure presents a serious problem to the functioning of the community. Increasing mobility in this period is necessary to facilitate emergency response efforts to restore essential services, which begins the integrative recovery process.

To predict the likely demand for travel in an emergency, travel patterns under normal conditions were examined using the 1997/1998 Land Transport Safety Authority Household Travel Survey data. Two earthquake scenarios were used (Prentice, 2005) to provide a realistic context. Scenario 1 is a moderate earthquake that registers a magnitude of a V-VI on The Modified Mercalli scale. Scenario 2 is a major earthquake caused by a rupture of the Wellington Fault with an expected magnitude of between 7.2 and 7.8 on the Richter scale.

The majority of trips are made by private vehicles (71.5%) in the Wellington region. Therefore, the number of people relying on private vehicles after an earthquake will be the primary problem, because many people will be less mobile due to the condition of the roading and infrastructure. The initial reaction to the earthquake will differ depending on time of the day. A daytime occurrence between 0800 and 1700 hours will result in a larger number of people away from home that will need to travel back home in the aftermath or travel to tend to their dependants. If the earthquake occurs between 2100 and 0800 hours, it is likely that individuals will be at home, therefore the need to travel home is decreased depending on the state of the individual's property after the earthquake.

Under both scenarios the initial demand for travel will be similar. However, the ability to travel under each scenario will differ. Under Scenario 1 localised damage to some principal, arterial and collector roads resulting in short to medium term road closure will limit the use of private vehicles and public transport. The implications for travel will be much more severe under Scenario 2. Heavy damage to many roads will severely limit the use of private vehicles and public transport.

Walking will become a very important travel mode after an earthquake since people will still be able to walk despite damage to the area. The worst-case scenario is when the most people are away from home. This is predicted to be a weekday at 1200 hours. At this time approximately 157, 000 people will be at work and will need to get home. Following a large earthquake approximately 142, 500 people will be left unable to use their primary mode of transport. Depending on the severity of the event, walking may be the only way to get home. Approximately 107, 000 people will likely be able to walk the distance get home, and approximately 35, 500 will not.

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1 Introduction

Society is connected through its infrastructure, by way of roads, railways and other physical networks that support it. A major natural disaster will seriously degrade such networks. This presents a substantial problem because the community's need for these networks is at its highest when the level of functioning is substantially diminished. The initial response (of both the public and emergency response teams) will revolve largely around mobility, which is essential to emergency response efforts to restore essential services, which begins the integrative recovery process. This purpose of this report is to investigate the role of transport after a major earthquake in the Wellington region. Travel patterns in the Wellington region are examined and the demand for travel after a major earthquake is examined under two scenarios.

To predict the likely demand for travel in an emergency, travel patterns under normal conditions must first be analysed. The first section of this report details travel mode and destination patterns in the Wellington region. The following section assesses travel patterns over time. The final section discusses the implications of these travel patterns in conjunction with two earthquake scenarios to predict the demand for travel in the region after these events.

The findings of this report will also provide the basis and context for the development of the Emergency Events Travel Analysis Survey (EETA) and the Emergency Events Information Needs Analysis (EEINA) survey. The EETA will investigate individuals' travel needs after a major earthquake assessing and the EEINA will investigate individuals' information needs after a similar event.

2 Data Sources

2.1 The 1997/1998 Land Transport Safety Authority Household Travel Survey

The primary data source analysed was the 1997/1998 Land Transport Safety Authority (LTSA) Household Travel Survey. The 2004/2005 data was not available at the time of writing. The travel survey sample comprised of approximately 14, 000 respondents from throughout NZ (with 1288 respondents from the Wellington region). Each respondent was asked a comprehensive set of questions about their travel patterns including distance travelled, trip destination, trip purpose, travel mode used etc. In the LTSA travel survey a trip is a component of travel to a destination. Travelling to work, for example, could comprise of a bus trip to the train station, a train trip to the city, and a walking trip the remaining distance to work. Although there was only one destination, it would be reordered as 3 trips. Travel mode refers to the type of transport used for a particular trip, e.g. private vehicle, bus or train. The travel survey data was weighted where necessary using population data from Statistics New Zealand.

2.2 Other Data Sources

Data was also obtained from Statistics New Zealand, the Department of Labour, and the Greater Wellington Regional City Council 2002/2003 Annual Report on the Regional Land Transport Strategy.

3 General Travel Behaviour in the Wellington Region

To predict the likely demand for travel in an emergency, travel patterns under normal conditions must first be assessed. Immediately following a major earthquake transport will be a key factor, because people will travel to make sure their family and friends are safe, to examine the level of damage to their property, and also to investigate the general level of damage (Peuler, 1988). There will be a higher emphasis on travel compared with normal circumstances because the usual forms of communication (landlines, cell phones, internet etc.) may be limited in a severe earthquake. Further, the demand for travel will differ depending on the time that the earthquake strikes. The following sub-section examines the main travel modes, and the unique characteristics of each. Particular attention is paid to the distance travelled on each mode, as this becomes important when examining the how far people may have to travel home.

3.1 Private Vehicles

Private vehicles are the dominant mode of transport in the Wellington region accounting for 71.5% of all trips. Vehicle drivers accounted for 45% of these trips, and vehicle passengers accounted for 26%. The majority of trips were between 1 and 4 km (48.6%), and only 12.3% were less than 1km, for both vehicle drivers and passengers. Further, the total distance driven in private vehicles has increased from 1990 to 1998 (LTSA, 1997/1998), with an associated 5% increase in car ownership from 1996 to 2001 (Statistics New Zealand, 2001, cited in, GWRC, 2002/2003). Seventy percent of people travel to work in the Wellington central city by private motor vehicle, a decrease from the previous several years. This difference was due to increases in walking, cycling and public transport (Statistics New Zealand, 2001, cited in, GWRC, 2002/2003).

Children under the age of 14 spend the most time travelling as passengers (time spent as a passenger decreases as age increases as would be expected). Due to safety concerns, the number of children driven to primary and secondary school has almost doubled from 1989/1990 to 1997/1998, with associated decreases in walking and cycling (LTSA, 1997/1998).

3.2 Walking

Walking was the second most frequently used mode of transport, accounting for 22.1% of all trips made in the Wellington region. This was the highest rate out of Otago, Auckland and Canterbury (LTSA, 1997/1998). Thirty-four percent of Wellingtonians stated that half or more of their trips could just as easily have been walked or cycled, while only 22% said that none of their trips could have been walked.

3.3 Public Transport

Public transport comprises 4.2% of all trips in Wellington. Buses account for the largest share (2.6%), followed by train (1.6%). The majority of bus trips (77%) are between 1km and 10km. Very few are less than 1km or over 15km, in contrast train trips are usually 3 to 4 times the distance travelled on buses (GWRC, 2002/2003). Train trips are relatively evenly distributed over distance; 21.7% are less than 10km; 20.7% are between 10 and 20km; 30% are between 20 and 30km and 28.1% are over 30km. The use of public transport from 2001 to 2003 increased by 3.8 - 5%, an increase of between 600, 000 to 700, 000 trips per year (GWRC, 2002/2003).

3.4 Cycling

Cycling comprises 1.3% of trips in the Wellington region. The majority of cycle trips (84.7%) are less than 5km, and almost half of these are less than 1km, and very few (5.6%) are over 10km.

3.5 Other Transport Modes

The use of transport modes such as ferry, plane and taxi are very infrequent accounting for only 0.97% of the total number of trips in the region.

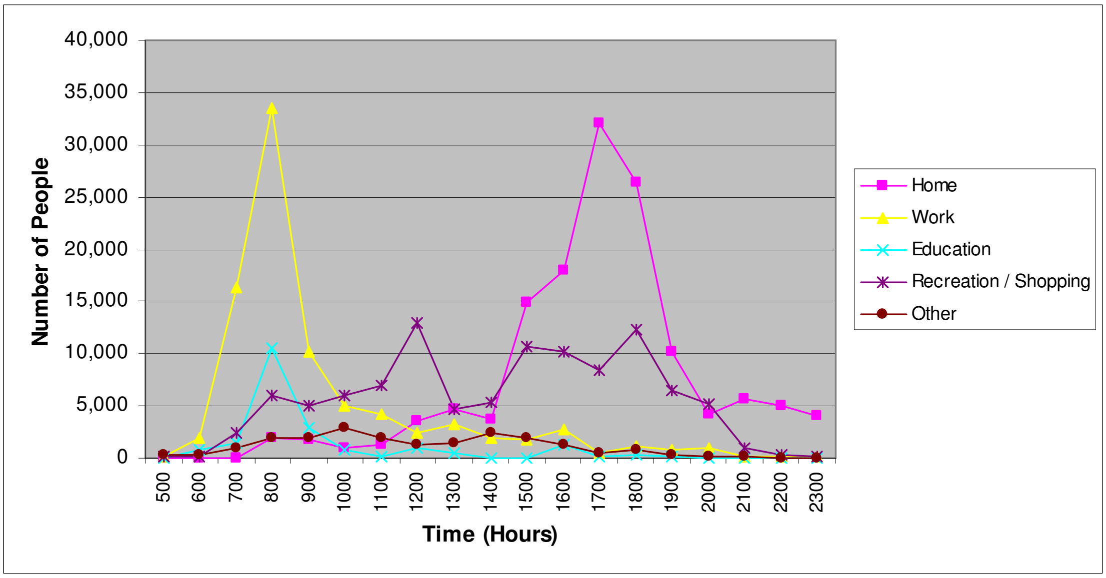
4 Temporal Travel Behaviour in the Wellington Region

4.1 Temporal Travel Patterns during the Week and Weekend

The following analysis examines travel patterns in the Wellington region over the course of the day and throughout the week. The demand for travel after an earthquake can be extrapolated from travel patterns under normal conditions using the LTSA travel survey data. As a disruption to infrastructure and roading will have different effects at different times of the day and week, a worst–case scenario approach was taken to pinpoint the time an earthquake would occur that would produce the greatest need for travel.

Figure 4.1.1 shows the number of people in-transit over the course of the day and the destinations they are travelling to. Weekdays were collapsed as they showed very similar patterns. Saturday and Sunday were examined separately as they showed unique travel patterns.

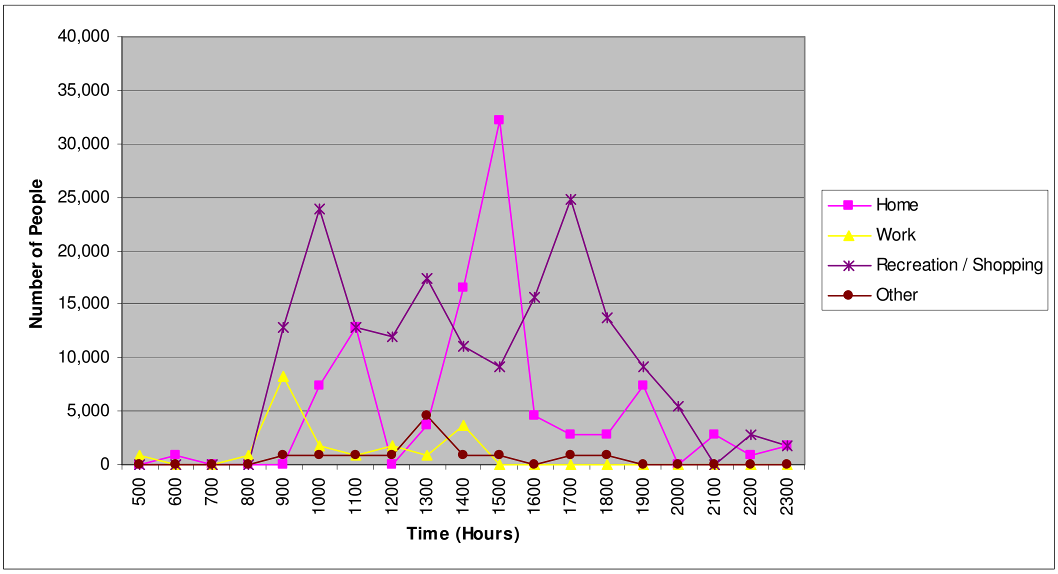
4.1.1 Number of people in-transit at various times on Weekdays



The two main travel destinations were work and home. The number of people in-transit to work peaks at 0800 hours, then steadily decreases until it plateaus at around 1000 hours. The number of people travelling home begins to rise at 1400 hours, steadily increasing till it peaks at 1700 hours. Those travelling for recreation and shopping purposes comprise the next largest group where the number of travellers peaks at 1200 with a second peak between 1500 and 1800 hours. The number of people travelling to a place of educational peaks at 0800 hours then decreases sharply. Travel to other destinations was comparatively much less frequent and are reasonably constant throughout the day.

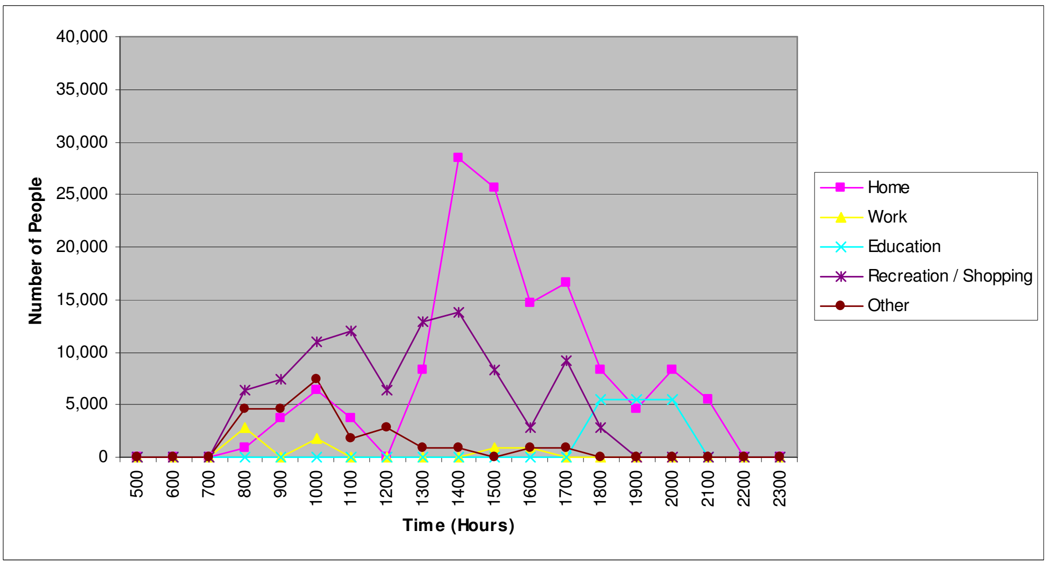
If an earthquake occurs at the peak time of 0800 hours 54, 200 people are predicted to be caught in-transit. If the event occurs at the second peak of 1700 hours 41, 900 people are expected to be caught in-transit. Figure 4.1.1 also illustrates that the largest number of people are away from home in the dip that occurs at 1200 between the two peak travel times. At this point most people are at work or other miscellaneous destinations, but have not yet begun their travel home. An earthquake during this period would produce the greatest demand for travel.

4.1.2 Number of people in-transit at various times on Saturdays



Travel patterns differ on Saturdays as fewer people travel to work, with recreation and shopping taking up a relatively larger proportion of travel activity (Figure 4.1.2). The majority of shopping and recreation takes place between 1000 hours and 1800 hours. The peak time for travelling home on Saturdays occurs at around 1500 hours. An earthquake would have different effects on travel demand on Saturday compared to during the week as fewer people are at work, instead people are more likely to be away from home for shopping and recreation activities. Further, people are likely to be away from home later when compared with a weekday (although this is a small proportion of people). Between 1000 and 1700 hours there is a reasonably constant amount of travel with an average of 28, 200 people in-transit.

4.1.3 Number of people in-transit at various times on Sundays



There are fewer people in transit on Sundays compared with Saturdays. The peak time occurs between 1300 and 1700 hours. Travel patterns on Sundays are fairly similar to Saturdays except that almost all people are home by 2200 hours on a Sunday (Figure 2.4.3), whereas there are still people in-transit to social events and people travelling home up until and after midnight on Saturdays. Also the peak for travelling home occurs an hour earlier compared with Saturdays.

To obtain an estimate of the total number of people who will likely need to travel home, a cumulative total of how many people have reached their destination by a certain time was calculated. For this analysis only work and home were examined as they were the two major destinations. An 'other' category was omitted due to difficulties associated with an over inflated estimate as a result of multiple trip counting.

4.1.4 People at work and home by various times across weekdays and weekends

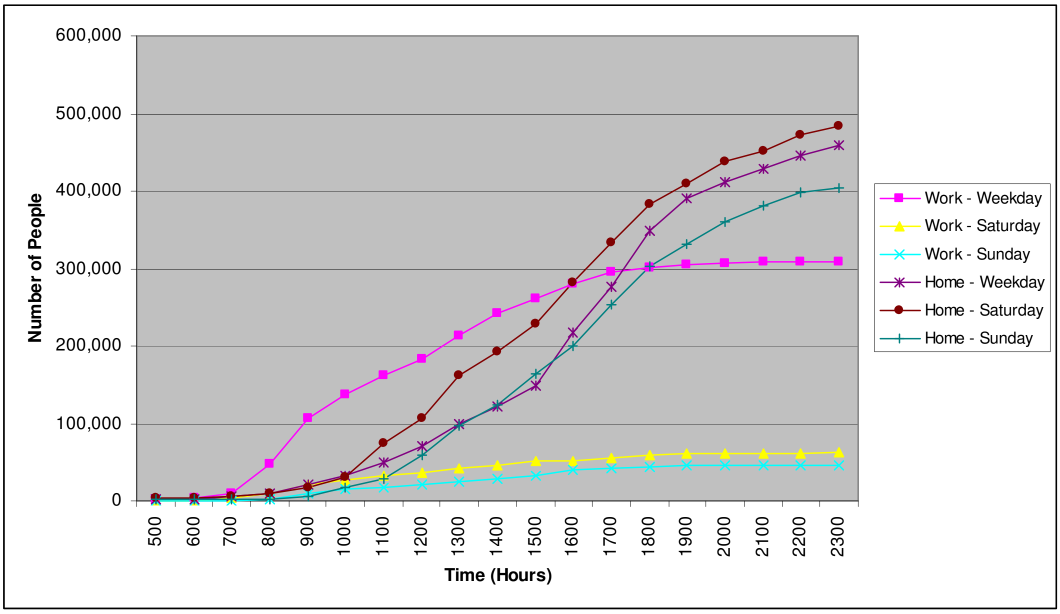


Figure 4.1.4 shows the number of people who have reached their destination by a given point during the day, over the course of the week. Again, weekdays were collapsed. Those arriving at work during the week rises sharply from 0700 to 0930 and continues to increase steadily until 1800 hours where it asymptotes. The number of people returning home shows the largest increase from 1300 to 1800 hours. Saturday and Sunday show a similar trend for those travelling to work, except that fewer people work in the weekend. Based on Figure 4.1.4, fewer people appear to return home on Sundays. This could possibly be because more people stay at home, thus no trips away or to home were recorded.

Due to method of coding trips in the LTSA travel survey, multiple trips to the same destination by the same person are unavoidably captured in figure 4.1.4. For example, if an individual travels to work, then leaves for lunch returns afterward, they would be counted as travelling to work in the morning, then travelling again after lunch. However, the peak time where the largest number of people are away from home can be derived from Figure 4.1.1, thus avoiding the point at which multiple trips contaminate the data. This peak time where most people are away from home can be observed as the bottom of a u-shape on Figure 4.1.1 at 1200. This peak at 1200 hours can then be used as a reference point on Figure 4.1.4 and extrapolated out to obtain the number of people who are at work by this time. At 1200 hours approximately 157, 000 people have arrived at work. This represents the worst-case scenario as the largest number of people will have to travel to get home than at any other time. The weekday scenario is also further complicated by the fact that many people will have to collect children from school as well as travel home, which is not the case in the weekends. However, this is dependant on seasonal variations due to school holidays.

According to the Wellington Regional Labour Market Report (2004) 247, 500 people were employed in the Wellington region. The previous estimate of the number of people at work at peak time appears to be an acceptable estimate as it should be lower than the maximum number of people working as differing shifts, part-time work, sick days, annual leave etc. would decrease the working population.

The population of Wellington as of 2004 was 451, 700. The number of people returning home based on the graph appears to be higher than the true population. This was due to the aforementioned limitation of multiple trip counting.

5 Earthquake Scenarios

To provide a realistic context for which to study earthquake related behaviour, Prentice (2005) created two earthquake scenarios based in the Wellington region. Each scenario describes the magnitude, geological characteristics of the earthquake, and provides a damage forecast. This allows the demand for travel to be investigated in the context of two situations where the ability to travel due to infrastructure damage differs.

5.1 Scenario 1: Moderate earthquake

Scenario 1 is a moderate sized earthquake that produces substantial shaking in Wellington Region. The cause could be a small local earthquake, or a larger distant earthquake that registers a magnitude of a V-VI on The Modified Mercalli scale (a measure of shaking intensity). There is an estimated 90% probability of such an earthquake occurring in the next 50 years.

Under this scenario approximately 96% of residential buildings will suffer slight to no damage. However, the area in and around Lower Hutt Valley, 2% to 4% of households will suffer extensive or complete damage.

Under Scenario 1 there will be localised damage to some principal, arterial and collector roads. There will be severe damage where there is high risk from slope failure, liquefiable soils, or close proximity to a fault rupture, which will result in short to medium term road closure. However, there should still be access to most areas (with the possible exception of Karori) using unaffected roads. There will likely be some damage to State Highway 2 (the only arterial route between Wellington and Lower Hutt) due to slope failure and lateral spreading resulting in possible road closure for several days. This will be most likely to occur on the section between Wellington and Petone (Brabhaharan, 1999, cited in Prentice, 2005).

Railway services will experience substantial disruption, with many sections closed. There will be some localised damage due to track misalignment, with slips causing addition damage. Return to basic service will take up to 6 weeks, but return to full service will take several months. The Wellington airport will likely be closed for a short time while the paved surfaces are repaired (Centre for Advanced Engineering, 1991, cited in Prentice, 2005).

5.2 Scenario 2: Major earthquake

Scenario 2 is a major earthquake caused by a rupture of the Wellington Fault centred on the Wellington-Hutt Valley segment of the Wellington Fault. This would produce an expected magnitude of between 7.2 and 7.8 on the Richter scale. There is an estimated 10% probability of such an earthquake occurring in the next 50 years.

There will be a significantly greater level of damage under Scenario 2 than under Scenario 1. Fourteen percent of residential and 25% of commercial properties will be extensively or completely damaged. It is estimated that between 35-40% of households will be displaced immediately following the event, which should drop to 25-30% within 2 months as recovery efforts are made.

Under Scenario 2 bridges, tunnels and viaducts in close proximity to the Wellington fault will suffer moderate to extensive damage. While these may not collapse, they will move and are expected to be impassable (Johnstone et al. 1995, cited in, Prentice, 2005). Many roads will be blocked by debris from buildings. Further, trolley bus wires will collapse or sag making certain roads impassable. Cobham drive will suffer severe damage, which could affect access to the airport. Churchill Drive, leading to Johnsonville and also north out of the city on State Highway 1, will likely experience a moderate degree of damage that would prevent access to it. It is likely that the Hutt River bridges will be damaged such that access will be restricted between west and east sides of the city. Damage to State Highway 2 will be more severe under Scenario 2, and it is expected to be cut off at several points (due to the failure of the Thorndon overbridge) with slope failure and lateral spreading, resulting in restricted access for several weeks (Centre for Advanced Engineering, 1991, cited in Prentice, 2005).

Damage to railway systems will be more widespread under Scenario 2, resulting in significant misalignment of tracks near the fault line, on the common section of State Highways 1 and 2. Between Ngauranga and Petone significant landslides will cause further damage. Basic service will likely be restored in 2 to 3 months, but normal service will not be restored for approximately 12 months. Wellington airport will require up to 4 days to return to a basic level of service, due to substantial damage to the runway (Centre for Advanced Engineering, 1991, cited in, Prentice, 2005).

6 Predicted Demand for Travel after a Major Earthquake

6.1 Travel Patterns in Wellington

Several key travel patterns in the Wellington region were identified which will have important implications after a major natural disaster. The majority of trips are made by private vehicles (71.5%) in the Wellington region making people will be very reliant on the roading infrastructure after an earthquake, therefore the number of people in private vehicles will be the primary problem.

Walking is the next most frequent mode of transport with nearly a quarter of all trips made on foot, which puts less pressure on infrastructure compared with other modes of travel. If the emergency event occurs during school hours, a large number of children will be reliant on private transport to get home. The increased use of public transport means that the likely suspension of these services after a severe event will leave some people without transport, or seeking alternative modes of travel, most likely walking.

The initial reaction to the earthquake will differ depending on time of the day. If it occurs during the between 0800 and 1700 hours, a larger number of people will be away from home who will need to travel back home in the aftermath. Also, people may need to travel to tend to their dependants, get food, water, emergency supplies etc. If the earthquake occurs between 2100 and 0800 hours, it is likely that individuals will be at home, therefore the need to travel home will be greatly reduced. Travel patterns differ on Saturdays as fewer people travel to work, and recreation and shopping take up a relatively larger proportion of travel activity.

If the earthquake occurs during the week at the peak time of 0800 hours, 54, 200 people are expected to be caught in-transit. If the event occurs at the second peak of 1700 hours 41, 900 people are expected to be caught in-transit. As such, a large number of people will be forced to abandon their vehicles due to the impassability of certain roads. This will exacerbate the blockage caused by debris on the road from damaged structures. Some of these abandoned vehicles will need to be removed by tow trucks, which may not be able to access the areas where they are needed.

6.2 Implications for Travel under Scenario 1

Under both scenarios the initial demand for travel will be similar, however, the ability to travel under each scenario differs. Under Scenario 1 localised damage to some principal, arterial and collector roads resulting in short to medium term road closure will have implications for private vehicles and public transport. The use of private and public transport will be restricted to undamaged and unblocked roads. Due to the large number of private vehicles, the flow of traffic will likely result in congestion due to bottlenecks on useable roads. Buses services are unlikely to provide normal service also due to road blockages.

Damage to State Highway 2 (the only arterial route between Wellington and Lower Hutt) could possibly result in road closure for several days, which would have serious implications for the large volume of traffic from those commuting to work from the Hutt Valley to Wellington city and vice versa. This would lead to a large number of people displaced that will need to seek temporary accommodation, or attempt to walk the large distance home, made more dangerous by debris and the possibility of aftershocks. Substantial disruption of railway services will displace people that have to travel large distances (as large distances tend to be travelled via rail as opposed to bus). Airport closure will restrict the travel in and out of the city for a short time. Based on Scenario 1, up to 18, 000 people will have the additional need to travel as their residential properties have been completely destroyed. Survivors will then need to travel to find alternative accommodation. If the event occurs during the day, people will need to travel home, then will have an additional need to travel due to the devastation of their home.

6.3 Implications for Travel under Scenario 2

The implications for travel will be much more severe under Scenario 2. Bridges, tunnels and viaducts in close proximity to the Wellington fault will suffer moderate to extensive damage, and many roads will be blocked by debris from buildings and fallen trolley bus wires. Damage to the Hutt River bridges will likely restrict travel between the west and east sides of Lower Hutt, resulting a large number of people being displaced. Damage to State Highway 2 will likely be cut off at several points resulting in restricted access for several weeks. Heavy damage to roads will severely limit the use of private vehicles (and buses). Again, this is a major problem due to the reliance on private vehicles, but exacerbated due to the higher level of damage to infrastructure. Rail will be disrupted for 2 to 3 months causing long distance travel difficulties. Air travel in or out of the city will not be possible for at least 4 days. These blockages and disruptions will delay the recovery effort.

Fourteen percent of residential properties will be extensively or completely damaged, leaving up to 63, 000 people with the additional need to travel as their residential properties will be completely destroyed. The implications are the same for Scenario 2 as they are for Scenario 1, as survivors will need to travel to find accommodation.

6.4 Demand for Travel after an Earthquake

As previously stated, walking will be very important after an earthquake, as people will still be able to walk despite damage to infrastructure. Therefore, assessing whether or not people will be able to get home is key. The predicted worst-case-scenario is when the most people are away from home which is during the week at 1200 hours. At this time approximately 157, 000 people will be at work and will need to get home.

6.4.1 Demand for Travel for those at Work trying to get Home

Mode of transport	% of people that use the mode	Number of people Displaced	Number of people facing a walk home	
			Under 10km	Over 10km
Private Vehicles	71.48	130,737	99,366	31,371
Cycle	1.26	2,305	2,174	130
Public Transport	4.20	7,682	4,266	3,416
Other	0.97	1,774	1,252	523
Total		142,497	107,058	35,440

Table 6.4.1 shows that of those that work, following a large earthquake approximately 142, 500 will be left not able to use their primary mode of transport. Depending on the severity of the event, walking may be the only way to get home. If 10km is taken as the maximum distance for what constitutes a walkable distance home, approximately 107, 000 people will be able to get home, and approximately 35, 500 will not be able to. There will be individual differences such that some individuals will be able to walk further home, and other will not be able to walk 10km. These estimates are conservative in that they only include those people at work, though it does constitute the bulk of the need for travel in the region.

6.5 Conclusion

This report investigated the role of transport after a major natural disaster in the Wellington region. As people will be very reliant on roading infrastructure following a major earthquake, the number of people who use private vehicles will be the primary problem, due to the decreased level of mobility. Walking will become very important as the ability to use private transport, or public transport may be severely restricted, especially under Scenario 2. The initial travel response will differ depending on time of the day. If the event occurs between 0800 and 1700 hours on a weekday, there will a large number of people who will need to travel home. They also may need to travel to tend to their dependants. Approximately 107, 000 people should be able to walk home, and approximately 35, 500 may not be able to if there is certain damage to roading prohibiting the use of vehicles.

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