SUSTAINABLE INFRASTRUCTURE DEVELOPMENT - A NEW ZEALAND EXPERIENCE

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Abstract:
Sustainable Infrastructure has been defined as "…Future friendly, resource efficient …. With pedestrian and public transport oriented systems…."[1] (Back ground paper, UN Expert Group Meeting, 2007)

Wide arrays of strategies are available to achieve the above. Creation of transport corridors, higher capacity transport modes, Increased levels of service and future proofing projects are four of them. Using these in an eco efficient manner will provide sustainable transport systems.

This paper concentrates on the surface transport strategies adopted in New Zealand. More specifically it wishes to provide an insight to the exclusive busway and buslane operation in New Zealand

Keywords: *Sustainable, Transport, Bus way, Bus Lanes*

1.0 Introduction

Sustainable infrastructure system has been defined as "one that facilitates the delivery of transport, energy and water services to support social and economic development in an integrated, eco-efficient and socially inclusive manner. It contributes to the achievement of the Millenium Development Goals and the reduction of green house emissions and the ecological footprint" [1] (Dr. David Ness, Background paper, UN Expert Group meeting, Bangkok, 11-13, June, 2007)

Alternatively, The Ministry of Economic Development, New Zealand has made the following definition about the Infrastructure in a Report to the Ministry of Economic Development, May 2004 [2]. This report has been compiled by Peter Clough, Ian Duncan, Doug Steel, Joanna Smith and John Yeabsley and reviewed by Brent Layton of NZIER.

Based on the McMillan Dictionary of Economic terms (1996) the above report defines the infrastructure as "The structural elements of an economy that facilitates the flow of goods and services between buyers and sellers".[2] The report then divides the infrastructure in to three categories.

- Economic Infrastructure (Physical assets)
- Social infrastructure (assets supporting a healthy workforce with adequate skills)
- Institutional infrastructure (legal system, culture and capital markets)

Both these definitions are complementary to each other. They have common characteristics. Both emphasize the need to be;

- eco-efficient
- Reducing green house gases
- Contributing to development goals.

In the context of transport, sustainability can be loosely defined as keeping the transportation of goods and passengers as long as possible without a reduction in the level of service. Alternatively, any effort

to increase the level of service or to lengthen the service period of transportation facilities with unchanged level of service will help make them sustainable.

There are consequences that humans are ready to live with, to enjoy a certain level of service in their current transport facilities. Any attempt to increase the level of service or lengthen the period of service will therefore increase the consequences that humans tolerate.

The impact of these consequences can be minimized or better managed if appropriate strategies are followed.

This paper attempts to highlight some strategies that have found success in minimizing the above consequences. Two case studies from New Zealand are used to highlight these strategies. This paper concentrates on the area of physical infrastructure and specifically transport sector.

2.0 The Current Situation

The world is facing an increase in population. Countries are finding it a struggle to keep and protect the populace. Noteworthy trend is that there is increase in urbanization parallel to this increase in population. Roberts, B. and Kanaley, T., report that "Urbanization in Asia involves around 44 million people being added to the population of cities every year." [3] (Sustainable Urban Development in Asia, Australian planner, Vol44, No1, March, 2007)

People are attracted towards the better living conditions offered by the urban centers. One adverse effect of the urbanization is the creation of slums or low income housing at the periphery of the cities.

This extra population is serviced by the limited transport services of the city. They share the road space, the rail space, vehicle space and recreation space. They produce increased tonnage of waste that needs to be disposed. They consume more energy and increased amounts of water.

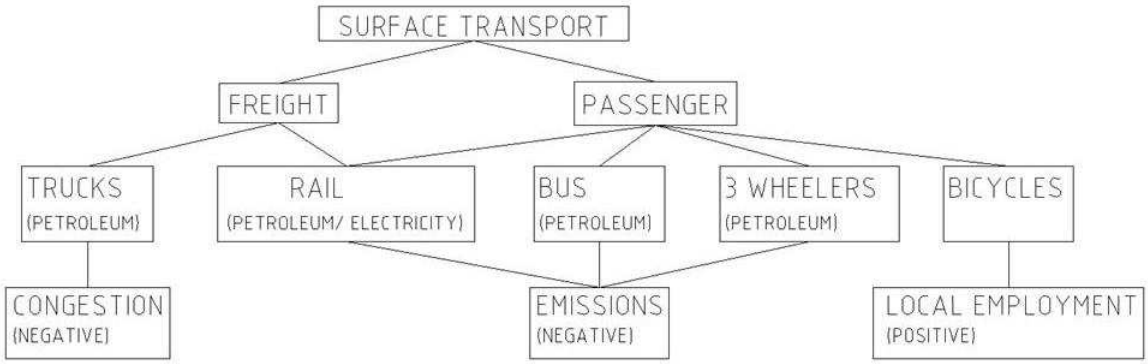


Figure 1 - *The Current Transport Scenario*

If better ways of managing are not implemented, all this extra pressure will result in unbearable environmental degradation and resource consumption.

An increase of services to meet these demands will release increased amounts of pollutants, waste products and will reduce the livable space. (i.e. environmental degradation and excessive resource consumption) The particular choice for the service increase can lock the consumption patterns for a long time. " Urban roads and freeways in preference to mass transit systems imply heavy fossil fuel demand for personal modes of transport and continued growth in greenhouse gas emissions" [1] (Dr. David Ness, Background paper, UN Expert Group meeting, Bangkok, 11-13, June, 2007)

In transport sector the symptoms of these adverse factors are;

- The congestion of road space

- Higher concentrations of pollutants
- Reduction of livable space

The higher concentration of pollutants is an example of environmental degradation. The congestion of road space and the reduction of livable space are the examples for higher resource consumption.

The livable spaces can be defined as the areas where people could reside safely, conveniently and with sufficient recreational spaces.

3.0 The Future Scenario

From this relatively unplanned chaos, it is better to move towards a better planned urbanization. Better planned urbanization will yield lower or managed environmental degradation and lower resource consumption. In a better planned urbanization the pressures on the infrastructure will be far less than that of an unplanned one.

In the transport sector, a better planned urbanization will yield

- Reduced congestion on the roads
- Lower concentrations of pollutants
- More land available for livable spaces.

4.0 Challenges of Getting There

If the increase in road and rail space can be achieved in an eco efficient and future friendly manner, the environmental degradation and the resource consumption can be minimized.

The first challenge is making the infrastructure eco efficient. Reduction of resource and energy consumption and emissions will make the infrastructure projects more eco efficient. Making the infrastructure eco efficient will also be consistent with the definition of Sustainable Infrastructure Development.

The second challenge is highlighted by the following statement. “Transport and urban infrastructures become traps if they can only operate on large footprints. In contrast, future friendly infrastructure-cities designed as resource efficient, with carbon neutral buildings and pedestrian and public transport oriented systems-can support a high quality of life with a small footprint” [4] (WWF,2006). Therefore, future proofing the transport projects (in terms of eco efficiency) during planning, can overcome this challenge.

5.0 Strategies to Meet the Challenges

Innovations to the current way of planning are needed to meet the above challenges. Ways to minimize ecological foot print and to make the transport projects future friendly needs to be discovered.

Transport corridors, higher capacity transport modes, increased levels of service (eco friendly), future proofing projects are a few strategies that will reduce the ecological foot print and make the transport projects more future friendly.

5.1 Transport corridors

This concept has been identified some time ago and is made use of increasingly. It is composed of combining or relocating different transport modes to flow in a fewer corridors. This concept will give the following advantages:

- More land will be freed for recreational and residential land use.

- Dissipation of pollutants will be concentrated at a fewer number of corridors and could be more economically and easily managed.
- Switching between the modes is made more convenient for the passengers.

These corridors tend to increase the service throughput by eliminating or minimizing the time lag between the loading and unloading. The time and the costs of travelling between the modes are also minimized.

Down side of these transport corridors is the production of higher concentrations of pollutants.

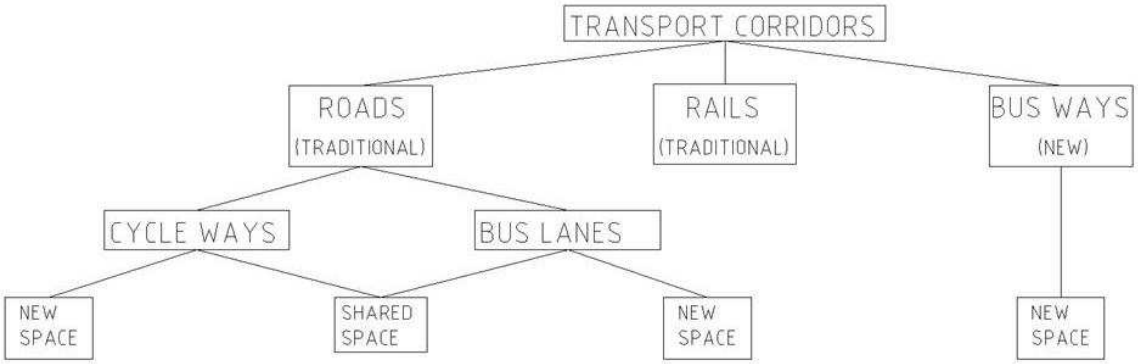


Figure 2 - *The concept of Transport Corridors*

This concept can be extended to include the networks of other services of energy and water within the same corridor.

5.2 Higher Capacity Transport modes

Busses, Trucks and the Trains are the conventional higher capacity transport modes. Increasing the use of these instead of the passenger car will help to increase the service throughput. Popularizing the use of these modes will lead to increased patronage. Some innovations to popularize these modes would be:

- Creating more accessible modal interfaces (modal interface-Railway station, Bus Station)
- Creating more convenient modal interfaces (more comfortable stations, better parking facilities etc.)
- Introducing more frequent trips
- Introducing faster trips between stations (segregating the passenger transport from the road transport mix - busways, monorails etc.)
- Introducing more comfortable vehicles (light rails, smaller busses etc.)

5.3 Increased levels of Service (eco friendly)

Mobility is inversely proportional to accessibility. Keeping mobility / accessibility ratio constant, it is still possible to increase the service throughput. This could be achieved by using higher capacity transport modes in higher mobility corridors. A number of innovations are being tried out and are being found acceptance.

- Busways
- Bus lanes
- HOV lanes
- Light rails

5.3.1 Busways

Exclusive busways are usually run between urban centers or between cities. No other vehicles or pedestrians are allowed on them. Bus Stations are located near the centers of Bus Trip catchment areas. Due to their exclusivity they do not face traffic congestions faced by the busses on normal roads. Therefore, they will be faster networks. They can throughput greater number of passengers more rapidly.

Bus Stations are designed to streamline the transfer from the land side to the vehicle side smoothly. Eco friendly designs help in minimizing the foot print and also in attracting more passengers. Free parking for the passengers can be an added incentive.

5.3.2 Bus Lanes

Bus lanes are exclusive lanes assigned for bus travel. These are usually assigned during the peak travel periods. The existing traffic lanes are rearranged to produce the bus lanes. The best location for the bus lanes are the lanes adjacent to the kerbs. However, there are median adjacent bus lanes in densely commercial city centers. (The freight trucks may occupy the kerb side for loading and unloading operations. Special accesses at higher frequencies may be available for the passengers to access the medians).

At times other than peak periods, these lanes may be opened for other traffic to use.

5.3.3 HOV Lanes

These are operated in situations where the high occupancy vehicles are relatively low in number compared to single occupancy vehicles. When the HOV lane is not congested, the high occupancy vehicles can move at greater speeds than the adjacent conventional lanes. This is an increase in the service throughput. The down side is that these require more disciplined drivers and more policing. Usually these are single directional and are separated from the other lanes. The entries/ exits are spaced out at suitable locations. Reversible HOV lanes are also operated occasionally. The main justification is the speed differential between the HOV lane and the adjacent lanes. A barrier between the HOV lane and the adjacent lane is highly desirable as this speed differential can be very high. These are used on freeways. [5]

5.3.4 Light Rails

Light rails are of two basic types. Running along urban streets sharing space with other traffic one type is known as Super Trams. They behave like trams with smaller number of cars and frequent stops.

The second type runs in its own right of way with less frequent stops. They behave more like trains with a larger number of cars.

Light rails typically have a passenger carrying capacity in excess of 200 for each car. They offer large increase in service throughput. [6]

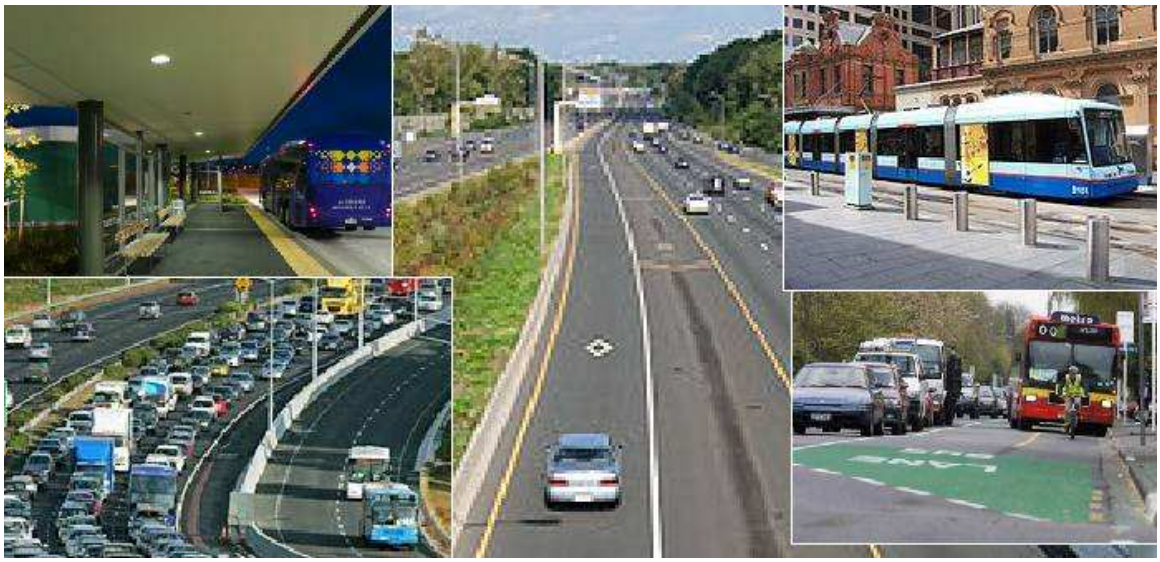


Figure 3 – *Clockwise from Top Left Corner, Light Rail, Bus Lane New Zealand, Middle - HOV Lanes, Northern Busway New Zealand, Bus Station-Northern Busway New Zealand*

5.4 Future proofing the Projects

Future proofing the transportation projects against more eco efficient methods will eliminate the trap of large eco footprints. Selecting for a busway, an alignment which is also suitable for a light rail will serve as an example of future proofing. Such an alignment will minimize the costs of retrofitting a light rail at a future date.

6.0 New Zealand Experience

New Zealand has been trying a few of these innovative strategies pursuant to the Ministry of Economic Development policy, and others are in the pipe line. New Zealand is a country with one fourth of her population in the city of Auckland. This imposes a huge pressure on the transport network of Auckland. Therefore it is no surprise that most of the projects where these strategies are tried out is around Auckland.

Two projects highlighting above strategies are the Northern Busway and the Bus lanes. Northern busway is known as a huge success story with its use increasing by 20%, in one month alone. The bus lanes on the other hand have some criticisms leveled against them. But both are contributing to an increased throughput.

There are investigations being planned for a light rail link in the Auckland Central Business District.

6.1 Bus Lanes

According to Auckland City Council website there are 19 roads with bus lanes. All of them are operated at peak hours (i.e. 7-9AM and 4-6PM). Motor cycles and bicycles are permitted on them as they do not infringe on the capacity of the bus lane. Outside the peak hours other vehicles are permitted the use of these. Wellington and Christchurch are other cities operating bus lanes in New Zealand.

The road space was reallocated by permitting the busses to use the outermost lanes during peak hours. The rationale was that uncongested bus lanes increase the speed of busses. These conform to all three strategies enumerated above.

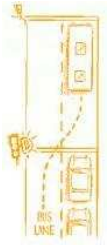
The start and the ends of bus lanes are clearly sign posted. The start sign additionally carries the operating times. The pavement of the bus lanes are marked in green at both the start and at the end. These colored areas carry a logo “BUS LANE” in white to avoid any ambiguity.

Very stiff penalties are imposed for unauthorized use of the bus lanes. The use of bus lanes are monitored by video cameras. Private vehicles turning off the main road are permitted the use of 50m. of the bus lane immediately prior to the turning.

To further facilitate bus movement there are proposals for bus priority measures. Bus advance, bus bypass, bus boarder, signal pre-emption are being considered actively as bus priority measures. [7] [8](Courtesy of Auckland City Council Web site.)

6.1.1 Bus Advance

These enable the busses to get to the front of a queue. Additional set of signals are mounted approximately 50m. in advance of the normal signals, where the general traffic is halted. The bus can then move to the front of the queue and the first to move when green lights on.



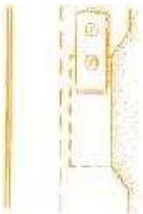
6.1.2 Bus bypass

These are special lanes that allow busses to move around the waiting traffic at an intersection. As shown in the illustration, busses are allowed to move along a left turn only lane and get to the limit line at the intersection

6.1.3 Bus Boarder

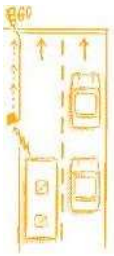
These intrude in to a traffic stream allowing the busses to stop (to pick-up passengers) without going off stream.

The trailing vehicles will have to wait behind the bus when that is stopped. Advantage is that no time is lost in finding headways to move into a traffic stream, as from a bus bay. This is the exact reverse of a bus bay.



6.1.4 Signal Pre-emption

These detect when a bus is approaching, and allows the bus through the intersection without any hindrance. The detectors on the road (linked to the signal) send the message to the signal, of the approaching bus. If the current phase is red then green phase is brought forward to allow the bus through. If the current phase is green, next phase is further delayed until the bus has passed.



6.2 Busway

The Northern Busway is an exclusive, two lane two way roadway for busses. The terminii for this project are Akoranga and Constellation Drive bus stations. Akoranga bus station is the southernmost bus station on this line. Between the Akoranga Bus Station and the Constellation Drive bus station there are 8.5 kms. of busway. The busway has been located adjacent and to the east of the State Highway 1 (Motorway). Stage 1 of this project is using the motorway between Constellation drive and the Albany bus stations. This has been in operation from November 2005.

There are four Bus Stations in this line. The Smales Farm and The Sunnynook are the other two Bus stations. They are serviced by the local bus services making the passenger transfer smoother.

The busway in practice fits with the strategies outlined in this paper. By being adjacent to the motorway it fits with the strategy of Transport corridors. Being a busway upholds the next two strategies of high capacity transport modes and increased levels of service.

Transit New Zealand (currently part of New Zealand Transport Agency-NZTA), North Shore City Council, Auckland City Council and the Auckland Regional Transport Authority (ARTA) collaborated to bring the Busway into fruition. There was a total of 12 years spent in planning the busway from inception of proposals to the awarding of the earthwork contract in 2003. Various options were assessed and the final alignment was accepted by the Transit New Zealand in 2001. Further design work was undertaken and developed by OPUS, Beca and Aurecon (formerly, Connell-Wagner), all primary consultants in New Zealand. In November 2005 the first two busway stations were opened. The busway was opened for operations with all stations in February 2008.

It had a cost greater than NZ $300 millions. This cost was shared by the collaborators. The Stage 1 of Northern busway project (An express bus service between Albany and Auckland CBD) has produced following benefits. These were expected to increase post commissioning the Busway in 2008.

Benefits of the Busway

Daily reduction of Car trips	500 approx.
Annual savings in fuel	40000 liters
Annual reduction Carbon dioxide	>1000 tonnes
Annual reduction of Carbon Monoxide	13.6 tonnes
Annual reduction of fine diesel particles	0.14 tonnes
Annual reductn of car Travel	3.94million kms.

The daily use of the Northern busway is over 7000 passengers according to ARTA. This can be translated to a daily reduction of 3100 car trips assuming a car occupancy of 1.2 persons per car. In the first two months the use has grown by 7%, and in 2009 may it has shown a growth of 20%.

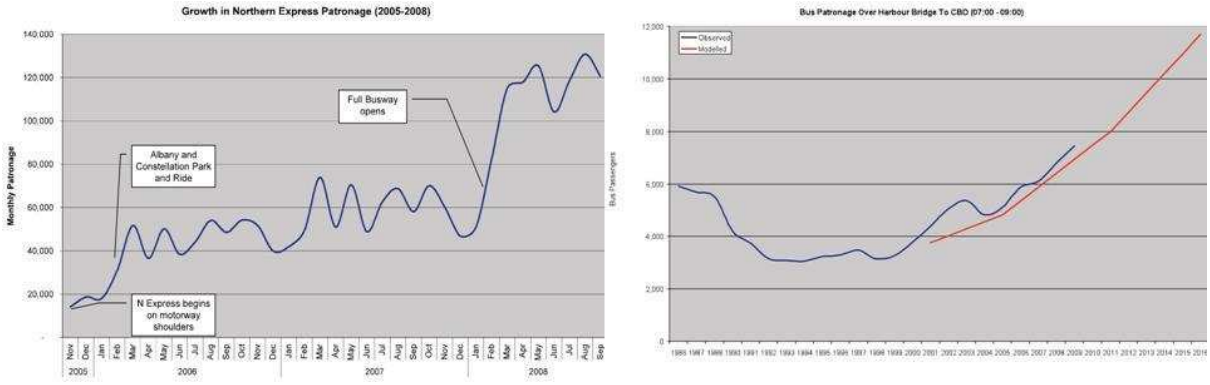


Figure 4 *The increased patronage and the patronage increasing rate of the Busway. (Courtesy of a Presentation to New Zealand Society of Sustainability Engineering and Science, 3rd July 2009) [9]*

The northern busway is being planned to be extended another 18kms. to Silverdale from constellation drive. NZTA has commissioned Zormac consultants with Aurecon for this study in 2008. It has been found that continued use of the eastern side of motorway is favorable except near the Albany station. Due to its orientation and to optimize retro fitting work, it was decided to cross the motorway by means of a tunnel before the Albany station. Once past the Albany station the busway extension reverts back to the eastern side of the motorway and remains on the eastern side until Sliverdale.

Maps showing the location of bus stations and the extensions proposed are in appendix A. [10] [11]

7.0 Concluding Remarks

The following conclusions are drawn from the above case studies:

- Busways grouped together with other transport corridors and Bus lanes increase the service throughput without adversely affecting the livable spaces.
- Higher utilization of busways and bus lanes indicate that they are eco-efficient transport projects.
- To increase operational efficiency between modes, combining stations for the transport modes should be considered.
- To attract more patronage of public transport better parking facilities adjacent to stations of the transport modes should be considered.
- Public transport priority measures should be adopted to attract more patronage.
- Aligning land use and transport is a sustainable transport outcome.
- To ensure sustainability of transport projects energy use and emissions needs to be reduced

All the above conclusions underline the acceptance and popularity of public transport systems in New Zealand. The higher acceptance and the use of public transport systems in New Zealand reflects that correct strategies have been adopted. The sustainability of the transport system will be improved by the public transport systems due to their smaller ecological footprints.

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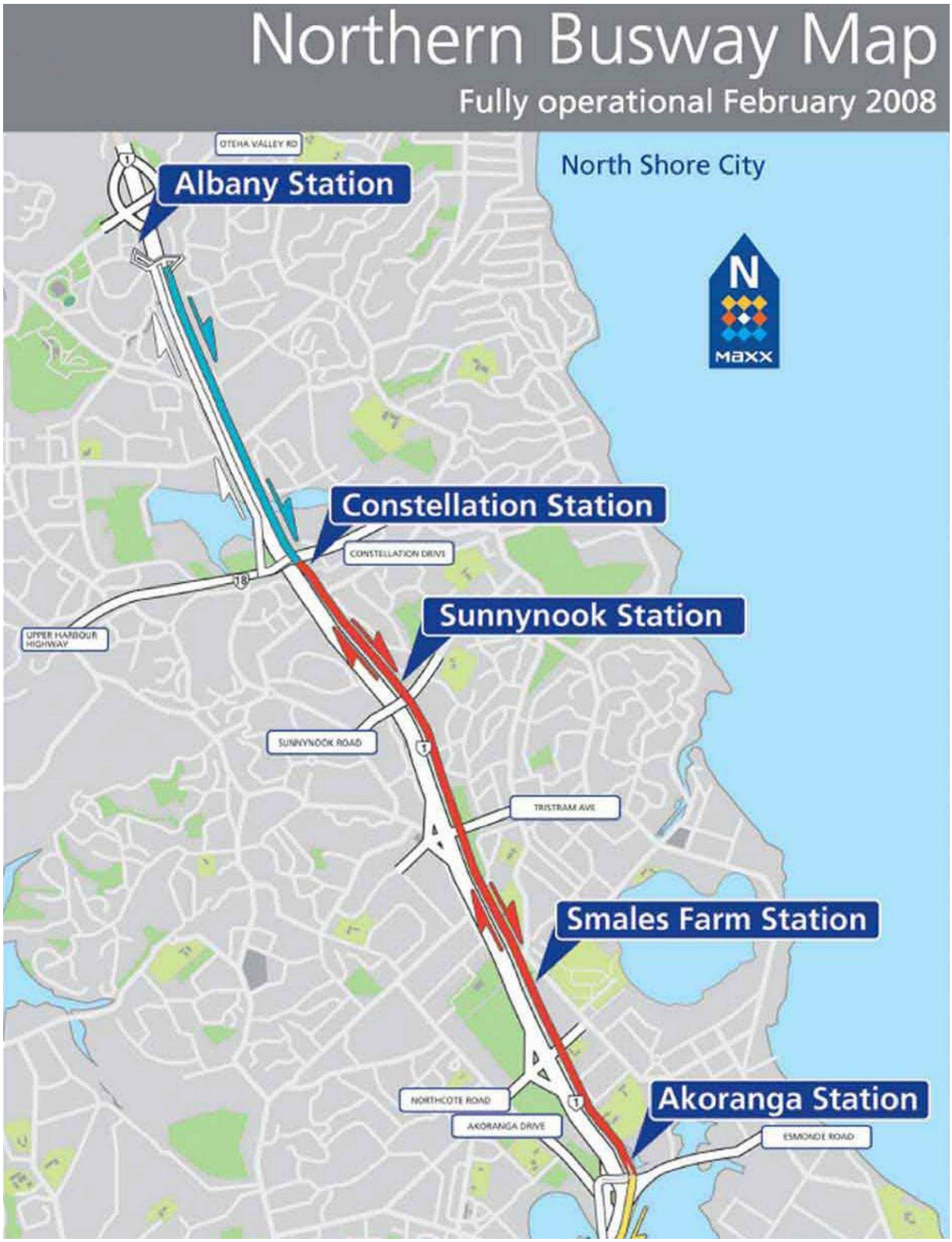
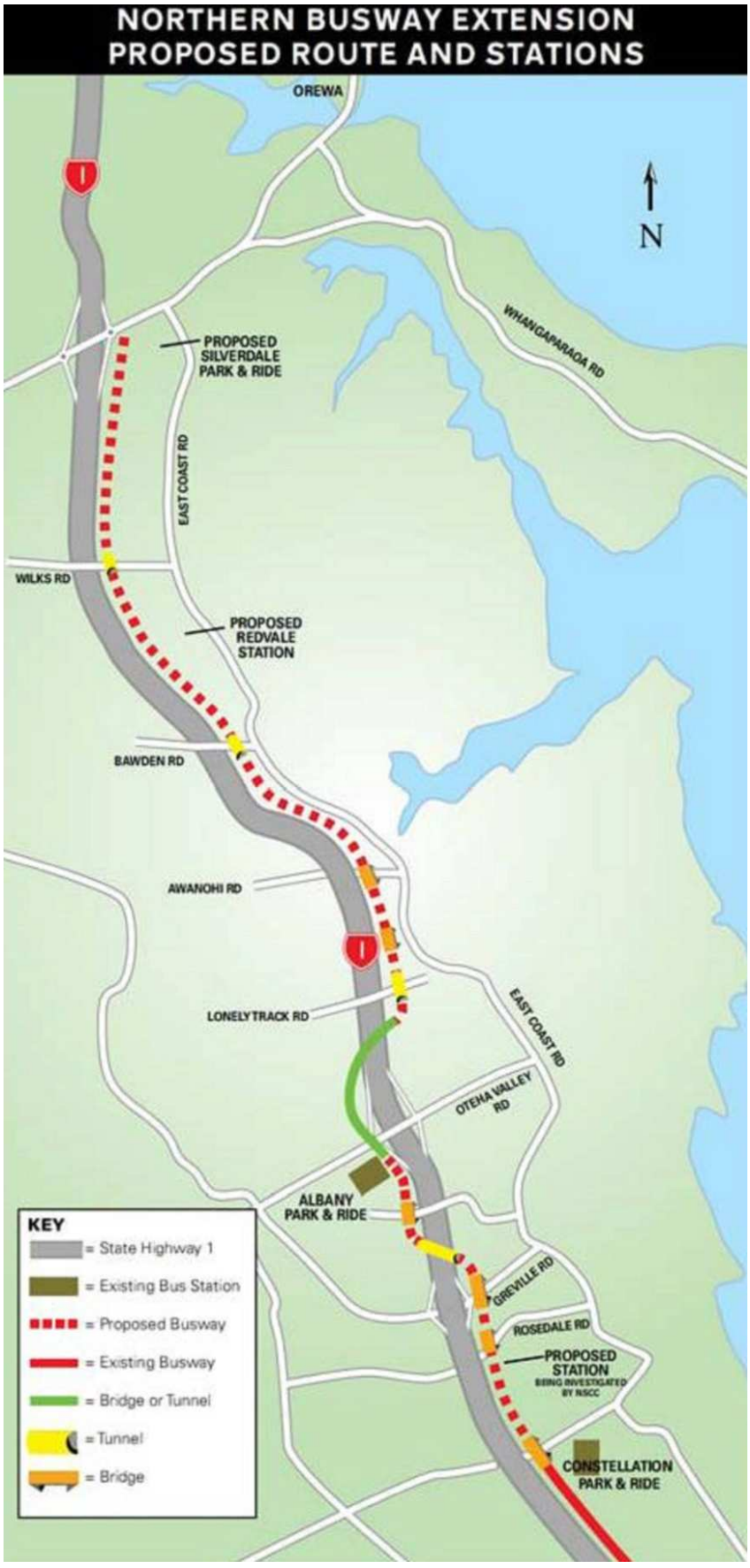
APPENDIX A



LOCATION PLAN OF THE NORTHERN BUSWAY



LOCATION PLAN OF THE PROPOSED EXTENSION TO THE NORTHERN BUSWAY