

**Review of the
Greater Wellington Regional Council's**

**WELLINGTON REGIONAL PUBLIC
TRANSPORT PLAN 2014**

WELLINGTON CITY BUS SERVICES

**By Michael Flinn
Wellington
July 2016**

**Review of the
Greater Wellington Regional Council’s (GWRC’s)
WELLINGTON REGIONAL PUBLIC TRANSPORT PLAN
2014
WELLINGTON CITY BUS SERVICES**

By Michael Flinn

Michael Flinn is a Wellington based ex Wellington City Transport deputy general manager with a wide knowledge of Wellington’s passenger transport characteristics and requirements, and of bus operations overseas, particularly in the United Kingdom. He maintains an on-going and detailed interest in bus developments in the United Kingdom and elsewhere including a study trip to the United Kingdom last year.

This report is the result of analysing the extensive and dramatic changes proposed to be made to Wellington’s bus services by the Greater Wellington Regional Council in 2017.

This document is focused at providing independent and objective information for further debate and assessment, and has been purposely carried out independently of vested parties. It is not offered as professional advice to any of the stakeholders.

Since the publication of the Wellington Regional Public Transport Plan by GWRC in 2014 (identified further in the document as the “2014 Transport Plan”) for Wellington City bus services, further information has become available as a result of which there are VEHICLE and SERVICE issues that should be further reviewed before they are brought into effect in 2017.

My review is in two parts (1) Choice of Vehicles and (2) Service Changes.

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SUMMARY OF CONCLUSIONS

S1. CHOICE OF VEHICLES

- a) GWRC's decision to cease trolleybus operation in 2017 was made on inaccurate and incomplete information and should be reversed.
- b) Trolleybus operation should be continued in order to provide an affordable low pollution service until acceptable battery electric buses are available (possibly around 2020).
- c) Purchase of diesel electric versions of diesel buses (i.e. diesel electric hybrids) should be deferred.
- d) Purchase of double-deck buses should be deferred until after the final plan proposals are implemented in 2017/18 and, if warranted after evaluation, could be introduced on a steady basis as further old diesel buses are replaced.
- e) Conversion of trolleybuses to turbine-hybrid buses has been forced on NZ Bus by GWRC with the high risk that there will be insufficient time for rebuilding by 2017 with the compromise bus being second rate compared to the purpose-built trolleybus.
- f) A re-evaluation of the long term bus options, say in 2020, would provide a more reliable projection compared to the evaluation made in 2014 when several important options were at early development stages.

S2. SERVICE CHANGES

My conclusions are that under the proposed service changes:

- a) Passenger approval rating over several aspects is likely to fall significantly, as
 - i. about 15% of current passengers will be forced to change buses and will have to wait on their journey;
 - ii. for many the proposed services will give a worse perceived service;
- b) Interchange points at most locations will require upgraded facilities resulting in increased annual maintenance costs.
- c) Interchange transfers are highly dependent on the successful introduction of the new smartcard;
- d) Ratepayers will pay more:
 - i. The aim is to recover 55% of costs from fares;
 - ii. Government subsidy is currently about 25% of costs but is expected to reduce;
 - iii. Ratepayers can expect to meet reductions in subsidy and shortfalls in fare income.
- e) A phased introduction of service changes rather than one single change will be essential to avoid confusion if services, bus units and bus types are all changing at the same time. PTOM contracts would have to be adapted to handle progressive changes accordingly.

My report sets out some key issues that will arise with some of the proposed service changes and recommendations on how services could be amended to reduce these issues and improve on proposed services.

DETAILED SUMMARY

Since the publication of the Wellington Regional Public Transport Plan by GWRC in 2014 further information has become available as a result of which there are VEHICLE and SERVICE issues that should be further reviewed before they are brought into effect in 2017.

My review is in two parts (1) Choice of Vehicles and (2) Service Changes.

PART 1: CHOICE OF VEHICLES

D1.1 INTRODUCTION:

In 2013 GWRC hired a consultant (Price Waterhouse Coopers – PWC) to report on longer term options for vehicles over a forty year period. Information supplied to PWC advised that trolleybus operation would cease in 2017 as:

- a) It was the end of the operating contract period and the trolleybuses were at the end of their life; and
- b) The overhead power supply system was outdated and operation for much longer would require renewal of the system at a cost of over \$50 million.

Subsequently the 2014 Transport Plan was issued. It provides for trolleybus operation to cease in 2017 and for the 60 trolleybuses plus 68 old diesel buses to be replaced with GWRC's choice of diesel-electric hybrid buses in time for new operator contracts in 2017.

My evaluation considers the justification for ceasing trolleybus operation and the choice of replacement vehicles.

D1.2 TROLLEYBUSES:

Conclusions:

I conclude that GWRC's decision to cease trolleybus operation in 2017 was made on inaccurate and incomplete information and should be reversed.

I took the following key points into consideration:

- a) GWRC's decision to cease trolleybus operation was strongly influenced on information, now known to be flawed, that was contained in GWRC's DRAFT Transport Plan 2014 which stated that the trolleybus fleet was life expired, and that the direct current power supply system needed full replacement "in the medium term" at an estimated \$50 million cost;
 - b) Later corrected information is that the trolleybuses have, in fact, at least 5 to 10 years remaining life beyond 2014. And regarding the trolleybus direct current power supply system, an independent senior electrical engineer with extensive experience of direct current traction systems has identified that the power supply and overhead lines systems can be upgraded and continued for the remaining life of the trolleybuses (up to 10 years) at
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an annual cost a little above the recent annual costs of the overhead system alone. He also identifies that some substation equipment should be replaced and additional modern safety equipment fitted at a cost of about \$4.5million. This has not yet been investigated by the GWRC.

- c) If GWRC had recognised these facts regarding trolleybuses it would have recognised the benefits of retaining them and proper allowance for them could have been made in the NZTA PTOM contracts that are starting with a clean-sheet approach in 2017. GWRC should now to negotiate with NZTA over adapting the contracts to incorporate proposed future use of trolleybuses.
- d) GWRC must also carry out its own further work to confirm, and extend into a maintenance plan, the findings of the independent electrical engineer on the state of the power supply system¹.
- e) The current decision to replace all trolleybuses in 2017 with new hybrid buses is financially unsupportable (est. \$39 million for the new buses, plus financing costs, plus \$10 million for overhead removal costs).
- f) There is an absolutely clear pollution benefit from the use of trolleybuses over any diesel or any diesel hybrid option.

D1.3 CHOICE OF REPLACEMENT VEHICLES:

Conclusions:

D1.3.1 Diesel Electric Hybrids:

A lot of development is currently taking place which might eventually give benefits over current models;

But at present

- a) Extra cost over Diesels of approximately \$200,000 per bus;
- b) Low levels of Nitrous Oxides and Particles are obtained from Euro 5 and Euro 6 diesels and relatively small further reduction in emissions obtained from diesel electric hybrids in Wellington's situation is not worth the extra cost;
- c) Retention of trolley buses (no Nitrous Oxides, no Particle emissions, no CO₂ greenhouse gas emissions) is a better non-pollution option;
- d) Government 'Green Bus Funds' in England and Scotland are the reason diesel electric hybrids have been purchased there since 2011;
- e) Unladen weight greater by up to a ton due to batteries and electric motors; this will restrict passenger carrying capacity to keep within road weight limits;
- f) Battery life as yet unknown; reliability of electronics unknown; therefore unknown vehicle life.
- g) Given these uncertainties the contractor is likely to write off of the vehicle over a ten year contract period resulting in high annual charges to GWRC.

My conclusion is that purchase of diesel electric versions of diesel buses should be deferred.

¹ public submissions on the Draft Transport Plan GWRC hired a second consultant (Jacobs) to advise on aspects of trolleybuses and other options. By this stage GWRC had acknowledged that the trolleybuses life remaining was 5 – 10 years but the power system upgrade cost was still regarded as \$50 million. The consultants recognised the lack of skill and knowledge about the old equipment fitted in the substations and a lack of spares. However, the consultant did not investigate the equipment condition in any detail or suggest any review of the operations.

D1.3.2 Double-Deckers

- a) Introduction will require careful planning for both timetable and operational reasons;
- b) Replacing some single deck services with fewer double-deck services in the peak periods may seem to help congestion in the CBD but this advantage may be outweighed by longer loading/unloading times and a perceived deterioration in service due to longer gaps between services;
- c) Peak time in the CBD, which is when double-deckers higher capacity would be mostly utilised, is short and most double-deckers would probably only do one trip during each peak period.

My conclusion is that the ordering of double-deck buses should be deferred until after the final plan proposals are implemented in 2017/18 when travel patterns should be checked and, if warranted after evaluation, they could be introduced on a steady basis as further old diesel buses are replaced.

D1.3.3 Conversion of Trolleybuses to Turbine Hybrid Buses

(NZ Bus, the trolleybus owner, recently announced it was investigating converting the 60 existing trolleybuses to turbine hybrid buses.)

This is a high risk strategy for NZ Bus. There are no existing bus operations with this power supply in use and there is a need to do testing, evaluation and conversion in a limited period of time.

Overall such a rebuilding will provide a second rate bus compared to the continued use of these vehicles as trolleybuses.

Rebuilding of trolleybuses has been forced on NZ Bus by the GWRC trolleybus decision. Based on previous vehicle developments there is a low chance of success in the timescale available.

D1.3.4 Selection of Bus Types for the (longer term) Future

In early 2014 at GWRC's request PWC, as part of their consultancy project, looked at options including:

- a) Straight diesel buses
 - b) Trolleybuses
 - c) Duo trolleybus/diesel
 - d) Diesel electric hybrids
 - e) Battery electric,
 - f) Hydrogen fuel cells
- and/or combinations of some of these.

I found the timing of the study to be unfortunate as at the time of the study several options were in the early stages of overseas operation or were just starting to enter prototype or limited service evaluation. A later re-evaluation (say 2020) when the new options should be more developed and costs and benefits better understood, would give a more reliable guide for the longer term future. A later re-evaluation in 2020 would also fit with continuing trolleybus operation for a further five to ten years by which time affordable and service proven battery electric buses are more likely to have become available.

D1.3.5 Pollution:

There is no emission of carbon dioxide, nitrous oxides or particles from trolleybuses motors. The GWRC states that its goal is eventually to have battery-electric powered buses with no pollution – but with trolleybuses we already have this situation. It will be several years before viable battery-electric buses will be suitable for Wellington operation but in the meantime we have the next best thing.

PART 2: SERVICE CHANGES

D2.1 INTRODUCTION

Service changes consistent with implementation of the Wellington Region Public Transport Plan 2014 have been announced, all for introduction during 2017. My evaluation judges the likely impacts of the changes proposed compared to the objectives, stated below, of this Transport Plan.

Transport Plan 2014:

Objectives:

To improve value for money by:

- a) Improving the effectiveness and efficiency of the network;
- b) Improve reliability;
- c) Improve coverage;
- d) Improve connections;
- e) Improve access;
- f) Improve service levels;
- g) Ensure that capacity is matched to demand.

Noted:

There are many overlapping, low frequency point to point bus routes that offer low service levels.

The “*Transport Plan 2014*” built on the “*2011/2012 City Bus Network Review*” and incorporated findings from the ‘*2014 Public Transport Spine Study*’ which advocates core bus routes these being:

- a) North-South, Johnsonville to Island Bay via City & Newtown
- b) East-West, Karori to Seatoun via City, Kilbirnie and Miramar,

- both supporting a public transport spine from Johnsonville to Wellington Airport.

The “*2011/2012 City Bus Network Review*” had concluded that “hubbing” (having designated places where passenger interchanges would take place) could:

- a) reduce resources needed;
- b) reduce route duplication;
- c) allow resources to be redirected towards improving poorly serviced areas.

Conclusions:

My conclusions are that under the proposed changes:

- a) Passenger approval rating over several aspects is likely to fall significantly, as;
 - i. up to 15% of current passengers will be forced to change buses and will have to wait during their journey, and
 - ii. for many the proposed services will give a worse perceived service.
- b) Interchange points at most locations will require upgraded facilities resulting in increased annual maintenance costs.
- c) Interchange transfers are highly dependent on the successful introduction of the new smartcard;
- d) Ratepayers are likely to have to face an increased percentage of total costs as the NZTA subsidy is expected to reduce progressively from 25% to 20% of total costs, and GWRC aims for fares to recover 55% with the balance being met by ratepayers.

To keep fare revenues as high as possible I consider a phased introduction would be more effective than the apparent single change currently intended. PTOM contracts would have to be adapted to handle progressive changes accordingly.

D2.2 SPECIFIC SERVICES (SUMMARY)

The services examined include Core Routes, Victoria University Services, Karori and Western Suburbs Services, CBD Congestion and the Bus Rapid Transit (BRT) proposals.

D2.2.1 Core Routes

PROPOSED (10 minute inter-peak service) Johnsonville to Island Bay, Karori Park to Miramar & Seatoun via Hataitai, Railway Station to Lyall Bay.

Conclusions:

- a) Proposed services do not minimise bus changes by passengers.
- b) No justification seen for increasing the Johnsonville inter-peak services from current 15 mins to 10 mins;
- c) The following services should continue similar to present:
 - i. Current Karori Park to Lyall Bay route via Newtown;
 - ii. Railway Station to Island Bay via Newtown;
 - iii. Railway Station to Miramar and Seatoun via Hataitai,
- d) These services should be run by trolleybuses;
- e) GWRC needs to confirm the frequency level of these services based on operating costs, patronage, fare income, subsidy level and affordability;
- f) Either the Lyall Bay or Island Bay service should run via Taranaki St. & Massey University;
- g) Miramar/Seatoun buses should be routed via the Miramar Cutting (incl. a short length of new wiring for trolleybuses);
- h) Miramar Ave. to Miramar terminus loop service not favoured. Instead;
 - The proposed 10 minute inter-peak service to Miramar/Seatoun should alternate to give a 20 minute service direct to the Miramar terminus and to the Seatoun terminus.
- i) Alternate the 10 minute service from Karori Park to provide a 20 minute service to Seatoun and a 20 minute service to Lyall Bay in order to continue the direct Seatoun to Newtown link that has been in place for decades.

- j) Too few buses are proposed to service Newtown inter-peak (currently 23 buses per hour; proposed 12 buses per hour). See my proposals regarding retention of route 18 and extension of Mairangi route 22/23 services below.

D2.2.2 Victoria University Services

Conclusions:

- a) Withdrawal of route 18 is not justified (The Campus Connection - Miramar – Kilbirnie – Newtown – Massey Uni. – Ghuznee Street – Victoria Uni.(Kelburn Parade) – Kelburn – Karori). This service has high AM peak loadings and there is a need to minimise bus transfers by passengers.
- b) I propose Route 18 be retained and modified as follows:
 - i. Delete Miramar – Kilbirnie section and start service at Kilbirnie
 - ii. Delete Birdwood Street – Karori Park section and extend instead to Johnsonville as replacement for the current route 47 service (hourly service after 10am);
- c) I propose Route L (the replacement for the current route 21 Wrights Hill service) should be diverted down The Terrace to the Railway Station – CBD – Mt. Victoria to provide a service for Wrights Hill passengers to the CBD – hourly frequency remains sufficient rather than the half hourly proposed.

D2.2.3 Karori and Western Suburbs Services

Conclusions:

- a) Even upgraded bus stops at Karori tunnel will be inadequate for the numbers of passengers who will be forced to change buses there;
- b) New services should be investigated to reduce the need for passengers to transfer buses at Karori tunnel. Route L (replacement for Wrights Hill route 21) should be extended to Karori Park or Karori West;
- c) Mairangi inter-peak services, currently proposed to terminate at the Railway Station, should be extended through the CBD out to one or more of the southern or eastern suburbs through Newtown, to reduce the need for passengers to change buses.

D2.2.4 CBD Congestion

Conclusions:

- a) Only a proportion of PM peak trips through the CBD are full; most peak hour services need review;
- b) Retimed trips could be run without the need to resort to double-deck buses;
- c) A smoother flow of buses through the CBD at peak times is achievable by retiming departures from the Railway Station and Courtenay Place to stop the current practice of several being timed to go at the same time. As well the timing of express buses vs. timing of start/stop services needs review to ensure maximum use of express buses;
- d) Despite retention of trolleybuses as recommended, peak hour Johnsonville services could still be linked with Island Bay for that part of the Island Bay service that uses diesel buses, i.e. currently the express services routes 4 and 32. This would result in fewer peak hour trips Station-Courtenay Place and vice-versa.

D2.2.5 Bus Rapid Transit (BRT)

Comments:

- a) The Basin Reserve issue seems to have caused a hiatus in speeding up bus trip times;
- b) I suggest a trial service for a period by extending the Johnsonville inter-peak service as a limited stop service (reduced stops through CBD, then Hospital, Newtown shops, Kilbirnie shops only with possible extension to Rongotai Shopping, or the Airport)

D2.2.6 Non-Core and Weekend Services

Comments:

- a) While increased use of hubbing is provided for, a cutting back of this may be more acceptable to the majority of passengers and retain fare income (as hubbing will cause some passenger loss).
 - b) Increases planned in some service frequencies may not be justified by demand and should be reviewed.
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END OF DETAILED SUMMARY

Review of the GWRC Public Transport Plan 2014

Wellington City Bus Services

By Michael Flinn

Introduction

Since the publication of the GWRC Public Transport Plan in 2014 further information has become available as a result of which there are vehicle and service issues that should be further reviewed before they are brought into effect in 2017.

This narrative is in two parts, the first dealing with the choice of vehicles to be operated and the second the services that are to be changed resulting from the adoption of the Transport Plan 2014.

Several tables to support parts of the narrative are attached.

Part 1 CHOICE OF VEHICLES

1 BACKGROUND

In 2013 Greater Wellington Regional Council hired a consultant (PWC) to report on the longer term options for various bus types over a 40 year period.

Information supplied by GWRC to PWC was that in 2017 trolleybus operation would cease as:

- it was the end of the operating contract period and the trolleybuses were at the end of life, and
- the overhead power supply system was outdated, and
- operation for much longer would require renewal of that system at a cost of over \$50 million.

Information on the trolleybuses and infrastructure systems was published in the 2014 Draft Transport Plan for public consultation and this resulted in the “Wellington Regional Public Transport Plan 2014” recognising that the trolleybuses still had 5 to 10 years life left. This would mean operating until 2019-2024.

A review of the power supply system was not then followed up to see if that system could be extended at reasonable cost to match the trolleybus life. A private review has been carried out on the power supply by a professional engineer with extensive D.C. traction experience. His review outlines that the system life can be extended at a modest cost but the GWRC still has not yet done this review. Consequently, around \$30 million or more will be required to buy replacement buses and over \$10 million will be needed to pull down the existing overhead with other costs or losses on top of that.

The long term option recommendations were done on the information available in 2013 a date set by the need to use it for the 2014 Transport Plan but the alternatives to trolleybuses in the short term are not yet commercially acceptable or viable. Both the diesel electric hybrids and battery electric buses that GWRC wants to introduce are still under development and are not yet proven in service to be at an acceptable service level to replace the trolleybuses. (See table 11.) In the meantime, extended use of trolleybuses together with the replacement of older diesel buses would further reduce current pollution levels. In view of the development stage of most alternative bus types in 2013 a review of longer term bus replacement should be done around 2020 where the commercial viability of most options should be much clearer.

Details are set out below.

2. SELECTION OF VEHICLE TYPES

2.1 Trolleybuses

One of the major issues in the 2014 Transport Plan was the decision to cease trolleybus operation in 2017 and replace the 60 trolleybuses plus 68 old diesel buses with GWRC's choice of diesel electric hybrid buses in time for new operator contracts in 2017.

The Draft Transport Plan in 2014, which was issued earlier for public comment, contained two critical items which the GWRC claimed as its main reasons for intending to end trolleybus operations in 2017.

2.1.1 Draft Transport Plan 2014

a) First critical item:

The Draft Plan on pages 32 and 33 stated that the current trolley bus fleet was life expired and needed to be replaced in a short period of time.

As several submitters on the Plan explained, the trolleybuses were substantially new in the 2007 to 2009 period and by 2017 would be about half way through a normal bus life and immediate replacement was not justified. When the final Transport Plan was issued in 2014 it was confirmed that there was still between 5 and 10 years life remaining in the trolleybuses which would take them through until 2019 to 2024. This would equate to an average age of 11 to 16 years. This is shorter than the usual life of a trolleybus of 20 years or more but the new trolleybuses in 2007-9 included traction motors and various running gear items including axles from the previous trolleybus fleet as a cost cutting measure.

When the building contract for the current fleet of 60 trolleybuses was being explored by the then equivalents of the Regional Council, the Transport Agency and the bus operator (Stagecoach) around 2006, a period of 10 years was used as the basis for an operating contract. This did not mean that the trolleybus life would be 10 years because in fact the usual actual life of a trolleybus built to the standard of the current trolleybuses is 20 years or even more. The period of 10 years (to 2017) was not only used as the basis of the proposed operating contract between GWRC and the operator but this then set out the term for the support needed from the power supply contract (a contract between the operator and the power supply provider) and the overhead lines contract (between GWRC and Wellington Cable Car Ltd). It appears that over this period of 10 years the successors to the original parties have erroneously interpreted the 10 year term as the end point of trolleybus life and operation.

b) Second critical item:

The Draft Plan claimed that the Direct Current (DC) power supply system was old and needed full replacement "in the medium term" at an estimated cost of around \$50 million to replace the whole system. This cost would include around \$30 million for underground cabling and most of the rest on substation equipment.

Once the true facts about the age and condition of the trolleybuses had been recognised by the Regional Council then the subsequent question to arise was whether the current supply system could be extended for the "medium term" or for the estimated remaining life of the trolleybuses.

It appears that no detailed report on extending the power supply system life was sought by GWRC and still has not been sought. This review should have included further advice from the power supply contractor (Wellington Electricity). Advice from experienced rail and transit traction Direct Current (DC) supply organisations should also have been sought because as users of DC power have reduced in number and as the electricity industry has significantly changed in recent years, knowledge in DC traction power supply practices has become rare in Lines Companies.

Expertise is held at a high level in organisations that use DC traction power on a large scale such as Kiwirail and the Melbourne tram and rail operators. Wellington Electricity's public comments on the trolleybus replacement would appear to have been more of a sales push to provide the future charging systems for battery electric buses rather than on getting to grips with power supply issues for the trolleybuses. However, it is fair to say that since 2007 not all the requests to fund updates to the power supply system may have been met by GWRC or the operator so all parties have to bear some responsibility for the present situation. Cheaper short term fixes have taken preference over proper resourcing to cover the life of the trolleybuses. While the supply contract is between the operator (NZ Bus) and Wellington Electricity the Regional Council is the primary funder and has the role of overall transport management.

2.1.2 NZ Transport Agency and Public Transport Operating Model (PTOM) Contracts

Because of the Council's attitude towards the condition of the trolleybuses and the power supply system it did not, as far as is known, discuss with the NZ Transport Agency the extended operation of the trolleybuses beyond 2017 and its impact on tenders for the proposed PTOM Contracts. As the infrastructure needed to operate trolleybuses includes the power supply system and the overhead lines, preference would need to be given in the new PTOM contract scene to the trolleybus owner (NZ Bus) to operate in all or part of the overhead lines area for the remaining useful life of the trolleybuses which would clearly give a benefit to that owner over other operators. Given that the Regional Council did not even know the correct facts about the age and condition of the trolleybuses which were operated by one of its largest current contractors, it is clear that there was not a good relationship between the Council and the operator before the Draft Transport Plan was issued. This is clearly one of the influences on the Council's actions regarding trolleybus operation.

If the Regional Council had recognised the proper facts about these trolleybuses a "clean sheet" approach to the introduction of PTOM contracts by the Transport Agency would not have been assumed. Special dispensation would have been needed for an alternative type of contract for a five to ten year period to cover the rest of the usual life of the trolleybus fleet for which no other use is available. The current trolleybuses cost around \$600,000 per bus compared to a cost at that time of around \$350,000 to \$400,000 for a diesel bus and it is inconceivable that a life of less than 15 years was expected and approved by both the Transport Agency and Regional Council for funding in 2007 and they must have accepted that such a life was likely. The introduction of a new contract system (such as the PTOM contracts) must recognise and accept such longer term commitments where fixed infrastructure is in place.

2.1.3 Regional Council's Attitude to Trolleybuses

Looking back to June 2014, to statements made after the Transport Plan was issued, a picture of influences and attitudes toward trolleybuses is apparent. The GWRC Public Transport General Manager is then quoted as saying that two years earlier it had signalled it would be reviewing the long term future of trolleybuses because “the level of funding required to keep them going was starting to furrow the brows around the Council table and over at the NZ Transport Agency”. He also claimed that “there was little environmental argument for keeping the trolleys” when reduced emissions from new diesels was taken into account and according to their consultants for the Plan (PWC) “the trolleys were not equipped with modern technology”. NZ Bus CEO was quoted as saying that the consultant (PWC) did not talk to NZ Bus until the day before their report was issued.

In terms of signals that the trolleybus system was to be reviewed presumably made in 2012, I looked at the Wellington Regional Public Transport Plan 2011-2021 and there is no explicit mention of such a review. At that time the GWRC attitude in this Transport Plan was clearly expressed on page 20 where its Policy 5.2 “To support the use of vehicles that have a reduced impact on the environment” was to be reached in part by Method No 2 “Maintain and support the use of trolleybuses in Wellington City”. Further to that the Regional Land Transport Strategy (RTLS) was supported by this Transport Plan (Page 62) on Vehicles and Infrastructure in part by “Ensure more vehicles run on renewable fuels that are non-polluting including trolleybuses that have positive noise reduction and low emission benefits over diesel buses”.

Clearly there had been a complete change in attitude by GWRC by 2013 which was not discussed in the 2014 Draft Transport Plan but which should have been explicitly mentioned. The additional cost allied to the operation of trolleybuses is not identified in either the 2014 Draft Transport Plan (P 32) or the Transport Plan other than revealing that “from 2008/09 to 2012/13 the annual cost of maintenance of renewals of the overhead network has ranged from \$3.4 million to \$5.6 million”. Whether that was all or part of the “brow furrowing round the Council table or at NZTA” was not revealed. As far as I am aware the Technology fitted to the trolleybuses is modern and at a price that could be afforded and subsidised. Pollution forecasts are dealt with later but there is an absolutely clear pollution benefit from the use of trolleybuses over any diesel or diesel hybrid powered option.

2.1.4 Trolleybuses Longer Travel Times

Advice by GWRC to PWC on travel times being longer by trolleybus compared to diesel buses was that it was due to “overloading issues (power supply), de-polings and from being unable to pass each other”. These may be infrequent causes that delay trolleybuses but the main causes have always been slowing for points and other crossing gear plus slowing at curves.

2.1.5 Overall Unsatisfactory Trolleybus Review

Overall there is a very unsatisfactory situation as far as the trolleybus system review is concerned. Erroneous and/or insufficient information was issued in the Draft Plan for public consultation and when corrected no action was taken to check that other related issues were updated or reviewed for the final Plan. There appears to have been a lack of serious consultation with the relevant parties such as the main contractors before the Draft Plan was issued resulting in information in the Draft Plan for consultation being wrong.

The Regional Council wishes to introduce electric buses to operate in Wellington but with current progress on development of these vehicles it now appears to be at least five years before a suitable and affordable electric bus may be available here. The extended operation of trolleybuses until such vehicles become available will give substantial environmental advantages over any alternative type of bus now available.

2.1.6 Independent Review of Power Supply System²

While the Regional Council has not yet bothered to get a report on extending the life of the power supply system for trolleybus operation after 2017, a recent independent review by a professional engineer with extensive D.C. traction experience has been carried out on the power supply system and the condition of the overhead lines. This Report identifies that with proper management the power supply and overhead lines system could be upgraded and continued for 10 years (or the life of the trolleybuses) with an annual cost a little above the annual costs incurred in recent years to keep the overhead lines in good condition. This cost should be considered to be the price of keeping this low emission transport system continuing.

Compared to the cost of complete power supply equipment replacement (estimated at approximately \$50 million) or replacement of substation equipment only (\$16.5 million), the Report identifies that some of the substation equipment should be replaced and additional modern safety equipment fitted at a cost of around \$4.5 million (including equipment reconditioned and underground cables checked to establish their condition). This should provide a reliable and affordable power supply system for an extended period of trolleybus operation.

2.1.7 Costs of Trolleybus Replacement

If trolleybuses are replaced in 2017 there are seriously large costs to be met. Replacement of the 60 trolleybuses by diesel buses at \$450,000 each would cost \$27 million plus financing costs, or replacement by diesel hybrids at \$650,000 would cost \$39 million plus financing costs (all to be funded initially by bus operators) plus at least \$10 million (from GWRC) to dismantle and remove the overhead lines. This does not take into account the losses to NZ Bus for the prematurely shortened life of the trolleybuses or the shortened life of the overhead lines (funded by GWRC) where for instance about \$3 million has been spent between 2012 and 2015 on renewing substantial sections of the Karori Park line.

GWRC's Trolley Bus Decision Should Be Reversed

The Regional Council's decision on trolleybus operation was made on inaccurate and incomplete information and the Council's decision should be reversed. This would require a negotiation with the NZTA over the contract for the extended operation of trolleybuses and a revision of the contract units being used for post 2017 bus operations.

2.1.8 Trolleybuses Have Good Interior Design

The trolleybuses are specially laid out to best perform the start and stop role they are performing on the city's major routes. The front low floor section has 2 plus 1 seating giving an extra wide aisle for passenger circulation, both front and rear doors are wide for quick boarding and

² Independent Technical Analysis of the Wellington Trolleybus Electrical Infrastructure, author Allan Neilson. See <http://wellington.scoop.co.nz/?p=84962>

alighting and the low floor allows easy entry and exit for buggies as well as passengers. On the other hand 3 axle diesel buses also have a low floor section but with 2 plus 2 seating there is a narrow aisle making passenger circulation more difficult when standing passengers are carried and while the front door is wide the narrow rear door slows exiting passengers and extends trip times. Also double decker buses have known circulation problems in the area around the rear door and adjacent exit from the stairs from the upper floor level and are not ideal for busy start and stop operation.

2.1.9 Road User Charges - Trolleybuses

Recent discussions regarding electric vehicles have included suggestions that Road User Charges (RUC's) should be waived for electric vehicles. As a trolleybus is an existing electric vehicle the waiving of RUC's could provide a saving of \$500,000 or so p.a.

3 GWRC's REPLACEMENT PLANS

After the Plan was approved the Council announced that it proposed to replace the 60 trolleybuses and 68 old diesel buses with diesel electric hybrid buses with an extra cost of \$200,000 per bus over standard diesel buses.

3.1 Diesel Electric Hybrids (see Table New Bus Costs)

Diesel electric hybrid buses are relatively new and there is a lot of development currently taking place by a number of manufacturers which might eventually give benefits over current models after further operational experience. Introduction of such buses in Wellington at this time in such numbers is premature until further overseas operational experience of these buses confirms they may be suitable for Wellington conditions over a full life. Currently the extra cost of \$200,000 per bus is not competitive given the large reduction in Nitrous Oxides (NOx) and Particles obtained by new diesel engines conforming to Euro 5 and 6 specifications. Further emission reductions from hybrids are relative to the low levels achieved by the new diesels and the extra cost is not worth the small reduction in levels obtained. While the modern diesels reduce NOx and Particle emissions they do not reduce CO2 greenhouse gas emissions. In any case background air pollution levels are lower in Wellington than Northern Hemisphere cities and the need for Hybrids does not exist to the same extent. In many cities hybrids are generally considered to be a stop gap until full electric buses are available.

In the meantime, trolleybuses emit no nitrous oxides (NOx) or particles in the operating area and emit no CO2 greenhouse gases as diesels do. Replacement of trolleybuses by diesels will increase air pollution through all these types but the replacement of old diesel buses with Euro 1 level engines by new diesels with Euro 5 or 6 engines will markedly reduce NOx's and particles but will not reduce greenhouse gas emissions. Double decker buses are usually fitted with larger engines than single decker buses so their pollution levels are higher. The reduction or elimination of NOx and Particle emissions in the operating areas such as Wellington's CBD is important as they are recognised as a health hazard and with the concentration of buses and other diesel powered vehicles in the CBD this makes it a higher hazard area than the overall Wellington area.

Diesel electric hybrids have lower fuel consumption than diesel buses because the hybrid diesel engine is used for battery charging rather than for propulsion. The fuel saving (and sometimes a smaller engine) provides a lower level of pollution compared to the straight diesel engine version.

Diesel Electric hybrids began to be introduced into service in 2011 in Europe and parts of UK and USA as a means of improving environmental pollution. In Europe and UK, European Union Emission Control Limits were being exceeded in a number of cities and measures had to be taken to reduce air pollution. The proposed bus contracting situation is more similar here to the UK so the background there is very relevant to consideration of hybrids here.

The main factor in getting contracted operators to order and operate diesel electric hybrids in England and Scotland due to the higher cost and unknown battery life has been the setting up by both Governments of what have been called “Green Bus Funds” (GBF). The Hybrids cost about GBP 100,000 more than ordinary diesels and the GBF’s initially provided 80% of this difference and although this level remains in Scotland it has been reduced to 50% in England to reflect lower fuel consumption. There is no similar scheme in Wales or Northern Ireland and there have been no sales of hybrids as a consequence in these countries. The English and Scottish governments have allocated specific funding levels for GBF’s and operators have to apply for funding for a specific numbers of buses and are required to quantify pollution savings expected to be achieved.

There are two types of diesel hybrids in service, series and parallel. Series Hybrids have a diesel engine driving a generator to charge a battery pack which drives the rear axle. The parallel Hybrids include a diesel motor with a drive as usual to the rear axle but the motor in addition drives a generator to charge a battery pack which can also drive the back axle. In some vehicles braking can generate power that can be used to additionally recharge the batteries. Some Hybrids have a smaller diesel fitted compared to similar diesel-only buses which can contribute to lower fuel consumption. Fuel savings (and reduced pollution emissions) vary from place to place but can be 25% or more.

There are a number of disadvantages for these hybrids. Firstly, there is an extra cost of around NZ\$200,000 per bus which in our contractual situation will have to be initially funded by the bus operator as there is no NZ Green Bus Fund. Secondly the additional equipment (batteries and electric motors) in hybrids means that the unladen weight is greater than a straight diesel by up to a tonne and that reduces the passenger numbers that can be carried. Several manufacturers are seeking to redesign vehicles to reduce the unladen weight. Thirdly there is the unknown life of the battery packs in either of the options. A life of about 5 years or so is predicted but most vehicles in service have not yet got to this stage and a new battery is expected to be an expensive item to replace. Fourthly is the unknown reliability of the electronics which control the recharging through the generator or the brakes and take control of the engine to start or stop charging and which will have to be reliable for daily operation for a minimum of 15 years. Until all these can be proved reliable through several years of operational experience, there is an unknown likely life of the current hybrids. Operation of any hybrid will require the ongoing supply of a selection of new types of equipment as well as the batteries.

Service trials are starting on flywheel fitted versions of diesel buses (initially developed by the Williams motor racing group) as an alternative to diesel electric hybrids which has a lower weight increase but several years of service will be required to prove such vehicles are suitable for 15 years or so competitive service.

While most of the English and Scottish hybrids have been bought using U.K. Green Bus Funds the serious pollution situation in London has led Transport for London (TfL) to decide that it will order 1000 diesel hybrids quite apart from the Green Bus Fund and allocate them to its operator contractors to reduce pollution in the worst areas first. In this way it is taking the financial risk as to how successful these buses will be over their anticipated life. The life is anticipated to be 14 years which is made up of a five year contract plus a 2 year good performance extension plus a second five year contract and a

second two year good performance extension. Transport for London faces a fine of GBP 236 million from the EU for exceeding nitrous oxide (NOX) and particle levels which is a good incentive to quickly reduce emission levels. Recent news from there is that some of these buses are having problems with 80 batteries in service and replacement batteries using different elements are to be fitted to all buses. Fortunately for TfL the batteries that failed are reported to be still under warranty and replacement batteries were available from stocks held for the bus building program.

Here in New Zealand the situation is different to UK. There is no equivalent of the European pollution control levels to be met, there is a lower level of air pollution, partly due in Wellington to the use of trolleybuses, and there is no high pollution crisis as is now evident in many northern hemisphere cities.

There is no government funding source such as the Green Bus Fund here so that the operator will have to fully fund new hybrids estimated to cost \$600,000 for 2 axle single-deck buses or \$650,000 for 3 axle single-deck buses. For 60 3 axle buses this would require new funding of \$39 million and for 68 2 axle buses another \$40.8 million to be found. With the permitted axle weights on roads lighter here than in Europe there will be uncertainty over passenger capacity and a new source of support and parts for the new equipment will need to be established and built up. There will be a lot of staff training required both on the technical side and on the driving side where the techniques of hybrid driving are different. GWRC contract terms are proposed to be between 2 and 10 years which will open up the contractor to a financial loss without a guarantee of a 15 year or so term to get a return through providing the buses to GWRC or another funder. Alternatively, a contractor will seek to recover the full cost over the contract length at a much higher annual cost.

If a contractor has a ten year contract the current uncertainty of battery life and with the uncertainty of any work for that vehicle after this time the contractor will aim to write off the cost of the bus over this time. This translates to a current charge to GWRC for 60 trolleybuses by the trolleybus contractor over a 15 year life of around \$4 M pa compared to a charge for 60 diesel hybrids of \$4.4 M pa but this increases to \$5.5 M pa over a 10 year life. This is a possible increase of \$1.5 M pa to be met primarily by fare payers and ratepayers.

The GWRC Plan also proposed to replace 68 old diesel buses currently run by contractors and the current charge of around \$2.2 million pa if replaced by hybrids at a total cost of \$40.8 million would be a charge of \$4.5 million p.a. for a 15 year life or a charge of \$5.8 million pa over a 10 year life. For a 10 year life this is a further increase of \$3.6 million pa on top of the increase to replace the trolleybuses, a total extra cost of over \$5million pa.

Recently a diesel hybrid bus was trialled in Wellington on its way to Sydney. Unfortunately, I was not able to see this vehicle to check the seating capacity and the standing capacity or see the Road User Charge weight. I am told that the standing capacity due to the extra weight was four or less which makes this vehicle useless for peak hour operation in Wellington conditions where similar sized diesel buses carry over 20 standing passengers at peak times. If no standing passengers could be taken for instance, three hybrid buses would be needed to replace two full diesel buses to move the same number of passengers.

At the current time diesel electric hybrids are not considered commercially viable in New Zealand for urban transit bus operation.

The International Association of Public Transport (UITP) (which has had Sir Peter Hendy the former Transport for London Commissioner for Transport as its Chairman) has a trolleybus committee which is actively working with manufacturers and suppliers to research improvements in trolleybuses and

components. Much research is taking place with one research option being investigated is the use of on-board batteries so that a trolleybus could travel over a part of a route without wiring and so for instance the Hataitai loop could be served by a trolleybus with its poles retracted at Hataitai, then on-board battery power would be used around the loop and poles then be rewired for the trip back to the CBD. Weight and cost would obviously be considerations when evaluating this and other options.

Diesel electric hybrid versions of diesel buses do not provide sufficient reductions in pollution plus a loss in passenger capacity to warrant the extra cost, and the purchase of any of these hybrids should be deferred.

3.2 Pollution (See Table 10, Pollution)

There are two types of air pollution from buses. Diesel engines emit carbon dioxide (a greenhouse gas) as well as health affecting emissions such as nitrous oxides and particles which have been linked to cancers. Upgrades to diesel engines for road vehicles have been legislated over the last decade or more and have now reached to what for bus engines is called Euro VI (or Euro 6) level. This standard will, no doubt, apply to new buses put into service soon and concentrates on reducing nitrous oxide and particle emissions to a low level. This is achieved by pre and after treatment of exhaust gases to a greater degree than previous versions with a requirement for these engines to run at hot temperatures to achieve the required low emission levels. A recent article in a UK transport magazine suggests that London Euro 6 engines, which are all to new designs, have to run at hot temperatures to reach required low pollution levels but after the morning peak they are still so hot that it is not possible to work on the engines before the evening peak. If this is so there are implications for a contractor as extra spare vehicles may be needed as maintenance cover.

Trolleybuses emit no carbon dioxide when operating but there may be some carbon dioxide generated by national grid generation. The current level of renewable generation for the national grid is claimed to be over 70% and this is rising over time. This is presumably based on total power generation capacity and therefore generation emitting greenhouse gases is only happening in cold periods where full generation is needed or when renewable generation equipment is undergoing upgrading. There is no emission of carbon dioxide, nitrous oxides or particles from trolleybus motors. The GWRC states that its goal is eventually to have battery electric powered buses with no pollution but with trolleybuses we already have this situation. It will be several years before viable electric buses will be suitable for Wellington operation but in the meantime we have the next best thing in trolleybuses. The use of diesel hybrid buses in Europe is considered to be an interim solution to reduce air pollution levels where pollution already exceeds acceptable levels. If and when battery electric buses are introduced here the pollution level will still depend on the renewable level of national grid generation which applies equally to all industrial, commercial and domestic electricity use.

Some idea on likely Nitrous Oxide, Particle and Carbon Dioxide pollution levels changes in the CBD can be made by comparing current CBD trips with proposed trips in the GWRC Plan. On weekdays between peak hours (9 AM to 4 PM) there are around 50 trips per hour in each direction over this 7 hour period. Of these around 23 trips are by trolleybuses and the remaining 27 are diesel trips. The proposed GWRC timetables has 33 diesel trips per hour in each direction which taken over a 7 hour day results in an increased number of diesel trips in the CBD in each direction from 189 to 231, an increase of 22%. With more diesel trips running through the CBD there can only be deterioration in air quality and increased noise levels. (See Table 6, CBD Information)

It is clear that there is no current Transport Agency Policy towards evaluating electric propulsion with other fuels for air pollution levels. In view of recent agreements on global pollution control limits the Government is expected to announce its proposed actions and targets and then as transport is a major carbon dioxide emitter it must be anticipated that the NZTA will give guidelines for funding organisations such as GWRC or operators such as Kiwi Rail when they are considering alternatives to diesel propulsion.

3.3 Double-decker Buses (see Table 2, Double-decker Requirement)

Recently the GWRC announced that it proposed to operate 50 double decker buses in Wellington including 10 diesel electric hybrids. No background as to the way these buses would be used was given but they could be used on a one for one replacement for 3-axle single decker buses running full peak hour trips or alternately on a replacement on a ratio basis for busy peak hour trips over a period of time. A comparison between bus types is that 2-axle diesel buses cost around \$400,000 each, have around 40 seats and can carry around 20 standing passengers, 3-axle single deck buses cost around \$450,000 each, carry around 50 seats and can carry around 20 standing passengers. Three-axle double decker buses (at an unknown cost) have around 90 seats and can carry 10 standing passengers at new increased legal vehicle weights. Diesel electric hybrid versions of each type will cost another \$200,000 per bus. Running fewer double decker trips than single decker trips in the PM peak may seem to help reduce congestion in the CBD but this is likely to be offset by longer loading times at bus stops.

Loading checks at peak hours on the current services proposed to become the proposed Route A (Johnsonville to Island Bay) shows that in both the AM and PM peaks there are a proportion of full trips (2-axle or 3-axle buses) but the busy time is short enough that if double decker buses were used on selective trips there would be little opportunity for each bus to be used for more than 1 trip in each peak period. This means that these buses will not recover enough income to meet the higher capital cost charge without fare increases. Similarly, the really busy period in each peak is around one hour and unless fewer double-deck buses are run than the current number of single-deck buses a fare increase is likely.

When the nature of the services is analysed replacement of say 4 single deck buses by 3 double-deck buses will result in longer gaps between trips which will be difficult to achieve without a perceived deterioration in service.

As an example the Johnsonville services on Route A come from Churton Park (AM peak frequency mainly 10 mins), Johnsonville West (AM peak frequency between 22 & 30 mins) and Granada/Paparangi (AM peak frequency mainly 15 mins) backed up by the Porirua service (AM peak frequency 10 or 20 mins) which all combine at the Johnsonville Hub before coming to the city. The proposal for Route A is for each of the first three services to have a 15 to 20 minute frequency combining to be a 5 to 10 minute service to the city. These frequencies were devised for a single deck based service which will need to be redefined for a double-deck service otherwise the proposed service will require fare increases if it is not modified. The Island Bay end of Route A has a different pattern of services in that the start/stop part (Route 1) has an all-day frequency of 12 mins (to be increased to 10 mins) and travels through Newtown past the Hospital and is primarily operated by trolleybuses. In peak hours two extra diesel operated routes are run including Route 32 from Houghton Bay round the coast to Island Bay then running with a minimum fare requirement along Adelaide Road to the city avoiding Newtown. Route 4 covers Owhiro Bay, Happy Valley Rd and the Frobisher/Severn St area in a loop before going

to the city also via Adelaide Rd. Currently the number of trips in the AM peak between 7 AM and 9AM is 24 from Johnsonville and 28 from Island Bay (Route 1, 10, Route 32, 8 and Route 4, 10). The operating pattern is similar in the PM peak so operating double-deck buses on either section with through running in the proposed Route A has to be carefully considered.

The introduction of double-deck buses on any route in Wellington needs careful planning for both timetable and operational reasons. Personally after looking at peak hour loadings on several routes I do not think they are needed now in Wellington. Wellington is a small city with a low density of housing on many routes so patronage is limited with parking one of the factors encouraging public transport use. All the purchase cost of double-deck buses has to be provided by the bus operator and just like trolleybuses the life will be at least 15 years. If a contract to operate them is for 5 to 10 years what assurance is there for operators that a vehicle will be able to earn revenue over its usual life? Operators are well aware of the trolleybus situation and will not want to sustain losses from this cause.

The ordering of double-deck buses should be deferred until after the final Plan proposals are implemented in 2017/18 and if warranted after services evaluation could be introduced on a steady basis when further older diesels are replaced.

3.4 Proposed Conversion of Trolleybuses to Turbine Hybrid buses.

NZ Bus recently announced that it is to immediately investigate the conversion of the current trolleybuses to turbine hybrid buses. This is not a surprise given that the GWRC appears to be so biased in its opinion towards operating trolleys that the Company sees no change likely from the Regional Council. The Company obviously considers that it has been forced into a position where it has to look at how it could use these vehicles for the rest of their reasonable life. To do this the company is taking a high risk in evaluating the conversion of existing buses including trolleybuses to be battery powered using turbines for recharging, with or without overnight charging. As there are no existing urban transit bus operations with this power supply in use there is a need to do the testing, evaluation and conversion in a limited period of time.

The choice of a turbine to power the proposed hybrid version would lead to higher CO2 emissions (compared to trolleybuses) from this bus depending on the fuel choice. Like other hybrid versions this option will depend on vehicle weight determining the passenger capacity. At this early stage NZ Bus implies that it intends to use two wheel hub motors powered by batteries which will be recharged by a turbine. This implies that in the trolleybuses the electric motor, the driveshaft and the back axle would be removed and new control equipment fitted. This is a major refit with no information at this stage as to the weight change which will determine the passenger capacity compared to 72 for trolleybuses and up to 75 for 3 axle diesel buses. Recharging power supply facilities for large numbers of buses is expensive and the cost and size of the batteries will be a compromise between operating time and weight. An unknown factor for some time will be the ability of the traction batteries to recharge at an acceptable rate and the ability of the turbine to be able to keep recharging the batteries to full level on a regular basis.

Overall such a rebuilding will provide a second rate bus compared to the continued use of these vehicle as trolleybuses.

Turbine Hybrid buses have been used for inner city circular services in Christchurch and Auckland with mixed success and had relatively short service lives. Development of the current trolleybuses took place

over several years and included the use of 3 development trolleybuses before the final design was completed. Development of diesel electric hybrid buses took several years and after initially trialling small diesel engines for recharging it was found that existing bus sized diesel engines were needed for long life and reliability.

Rebuilding of trolleybuses to be turbine powered has been forced on NZ Bus by GWRC actions with a low chance of success in the timescale available.

3.5 Selection of Bus Types for the Future

GWRC engaged consultants (PWC) to advise on selecting the most suitable bus types for the future so that information could be used for consultation in the Draft Transport Plan. This included options such as fleets of straight diesels, trolleybuses, duo trolleybus/diesel, diesel electric hybrids, battery electrics, hydrogen fuel cells and/or combinations of some of these. The evaluation period was over 40 years and as NZTA has introduced a 20 year maximum life for buses this evaluation covers at least two generations of buses.

The consultants were requested to do the evaluation in early 2014 on advice from GWRC that the trolleybus operation was to end in 2017 due to the end of the operating contract, the condition of the current trolleys (mentioned above) and the need to spend around \$50 million on replacing the power supply system within a few years even to keep the trolleys operating past 2017 (also see above). This 2014 timing was unfortunate as at that time several options evaluated were in the early stages of operation or were just starting to enter prototype or limited evaluation and a later re-evaluation (say in 2020) where the new options should be more developed and costs and benefits better understood would give a more reliable guide for the longer term future.

The fact that the trolleybus condition and the possibility of not needing to spend such large sums on continuing to operate trolleybuses for 5 to 10 years after 2014 would have no impact on the relative positions of the options over the 40 year period on the information available in 2014.

With updated information on the trolleybuses and options available to keep the power supply system continuing for 5 to 10 years this is a viable medium term option until affordable battery electric buses may become available within this period. This would continue the low emission benefits equivalent to battery electric buses particularly in the CBD. The biggest emission improvement possible in the next few years (as the consultant reported) is the replacement of older diesels with new diesels.

After public submissions on the Draft Transport Plan the GWRC engaged a second consultant (Jacobs) to advise on aspects of trolleybuses and other options. At that time the life remaining in the trolleybuses was acknowledged as 5 to 10 years and the cost to upgrade the power supply system was still around \$50 million. However, there was information that the overhead power had been tripping out with overloading being blamed. Also recognised by the consultants was the lack of skill and knowledge about the old equipment fitted in the substations and the lack of spares which could lead to extended time before supply could be restored. I understand that the consultant did not investigate the equipment condition in any detail or suggest any review of the power supply operations.

Part 2 SERVICE CHANGES

4 SERVICE CHANGES SUMMARY

The 2014 Transport Plan advised that the city bus network was reviewed in 2011/12. That review concluded that the network was complicated for users and was inefficient with duplicated services and under and over supplied services to some areas. The Plan stated that the 2011/12 review had found there are many overlapping, low frequency point to point bus routes that, while providing direct routes to the central business district (CBD), offer low service levels and in some cases do not offer evening and weekend services.

The Plan's objectives were to improve value for money by improving the effectiveness and efficiency of the network, improve reliability, coverage, connections, access and service levels and ensure that capacity is matched to demand. The 2011/12 Review had concluded that "hubbing" could reduce resources needed and reduce route duplication with resources redirected towards improving services to poorly serviced areas.

After the 2011/12 Review the Public Transport Spine Study was carried out. It was issued in 2014 and advocated core bus routes:

- a north to south spine from Johnsonville to Island Bay via the City and Newtown, and
- an east to west spine from Karori to Seatoun via the City, Kilbirnie and Miramar,

both of which were to support a public transport spine from Johnsonville to Wellington Airport.

The final piece in the jigsaw is the Bus Rapid Transit Plan which is intended to speed up bus journey times and provide "a modern, comfortable, first class travel experience". The change for this service was anticipated to be in place by 2021 by progressively introducing bus lanes, introduce a new bus network for the City and introduce new buses as the fleet is renewed (forecast growth by 2041 would indicate that 100 capacity buses would be needed by then).

This evaluation of the service changes is to measure the overall intentions in the 2014 Transport Plan with the services actually proposed and the impacts on passengers resulting from the proposed changes.

Recent surveys have given an approval rating for several aspects of Wellington public transport of over 80% but this is likely to fall significantly if some of the Transport Plan proposals are implemented. Passengers do not like changing from one bus to another and do not like waiting at bus stops for a bus to arrive. My estimate is that up to 15% of weekday passengers will be forced to change buses and will have to wait as a result of the Plan's proposals and that for many the proposed services will give a perceived worse service and satisfaction will fall significantly.

Currently the NZ Transport Agency (NZTA) provides a subsidy of about 25% of total running costs (expected to reduce in proportion towards 20%), GWRC aims for fares to recover about 55% of total running costs with GWRC ratepayers meeting the rest.

Some of the changed services will significantly affect some passengers, often by requiring a change of bus during their journey. Not only is this resented by passengers but the interchange point will in most locations require upgraded facilities which will then require additional annual maintenance costs for these facilities.

The Transport Plan is intended to cover a number of years but the service changes are all timed for introduction during 2017. If changes were introduced over a period of time this might mean variations

taking place during the new Public Transport Operating model (PTOM) contract periods or requiring shorter terms for some PTOM contracts. A new contract system should be flexible enough to cope with such changes. Each service should be reviewed on at least an annual basis to see that it is still matched to demand (which can often change) and some ability for change needs to be allowed for in the contracts.

Given that 55% of costs are to be recovered from fares and proposed interchange transfers are highly dependent on the successful use of a new smartcard (not yet under development contract), passenger reaction is very important. My approach is that evolution of services will be more effective than revolution and the comments below are based on observation of passenger loadings and the wish to keep fare revenue as high as possible by evolving current schedules rather than forcing radical change.

The services covered include Core routes, Victoria University services, Karori and western suburbs services, CBD congestion, and bus rapid transit (BRT) proposals.

5. SERVICE REVIEW

5.1 Core Routes (see tables 5, 7, 8 & 9)

The major proposed service change is to introduce a 10 minute inter-peak frequency on all core routes which GWRC lists as Johnsonville to Island Bay, Karori Park to Miramar and Seatoun, and Railway Station to Lyall Bay. The current inter-peak service frequencies are 15 mins to Johnsonville, Seatoun, & Miramar, 12 mins to Island Bay, and 10 mins from Karori Park to Lyall Bay.

GWRC promoted a north/south axis and an east/west axis for these routes and so proposed the Johnsonville to Island Bay service, a Karori Park to Miramar & Seatoun service via Hataitai, and a Railway Station to Lyall Bay service. This may be a geographical way of forming services but there are other factors that should also be used in arranging services including providing cross city links that result in minimising bus changes by passengers and reducing waiting times for passengers as much as possible. Outside of peak hours the popular destinations in the city apart from the CBD are Johnsonville shops, Wellington Hospital, Newtown shopping area, Kilbirnie shopping area and the airport. To reduce the need for passengers forced to change buses when using cross city core routes the current Karori Park to Lyall Bay route should continue as the demand between the western suburbs and Newtown and the Hospital will be greater than for Hataitai.

I can see no justification for increasing the frequency of the Johnsonville inter-peak services above the current 15 minute frequency as the current patronage levels do not warrant this. While there are promises of additional houses there in the future there is no guarantee that this will result in additional patronage. Once the buses leave Johnsonville Hub there is only one bus stop in Johnsonville before the next stop at the foot of Ngauranga Gorge followed by bus stops on the Hutt Road also served by Eastbourne buses or Khandallah buses with all of these stops being in commercial rather than residential areas. In addition there is a half hourly service from Newlands also serving the foot of Ngauranga Gorge and the Hutt Road to the Station. So the possible increase in patronage is limited to the Johnsonville suburbs and residents. The frequency change did not take into account the inter-peak 30 minute rail service from Johnsonville also run at this time and the amount of subsidy to that area has to be taken into account as a factor. If over a period of time patronage does pick up the next stage should be extra buses linking suburbs to the Hub with a choice of rail or bus to go further to the CBD with the proposed new smart card being available for free transfers.

The current service from Karori Park to Lyall Bay has an inter-peak service frequency of 10 minutes and seems to have a reasonable patronage level. From Karori it goes past the Hospital and through

Newtown on the way to Kilbirnie and provides far better cross city links for eastern, southern and western residents than the proposed Karori Park to Miramar and Seatoun service through Hataitai. This seems to me to be a far better linking for passengers than the proposed change and would retain the current route. With the retention of the trolleybuses as I have advocated there would then be trolleybus routes of Karori Pk. to Lyall Bay, Railway Station to Island Bay via Newtown and Railway Station to Miramar and Seatoun via Hataitai. Whether all these routes have a 10 minute frequency depends on operating costs, patronage and fare income and the subsidy level needed and affordable. It is up to GWRC to determine that information. Resulting from this network are several issues to be settled. One is which route goes via Taranaki St to Newtown, either the Lyall Bay service or the Island Bay service. Both services take about the same time, one service serves Courtenay Place and the other serves Massey University and Wellington High School on Taranaki Street.

The second issue is the route of the Miramar/Seatoun service after it leaves Cobham Drive at the foot of the airport. Currently trolleys go alongside the airport to Caledonia St and split left there at Hobart St to Miramar and right to Seatoun. That routeing was done after the airport was extended and before the Miramar Cutting area was redeveloped from a gas works to other commercial uses including a supermarket. If trolleybus operation is extended new wiring through the Miramar Cutting, which has been considered for some time, should be put up for a better service to bus patrons. This would allow the Miramar service to be quicker than now and provide a service from Seatoun through that busy area of Miramar. Wiring alongside the airport and on Caledonia St would be removed with new wiring from Miramar Avenue through the Cutting to Cobham Drive roundabout. This alteration would be in use for at least 5 years or more for the remaining life of the current trolleys.

The proposed Route C would not serve the section of route between Miramar Avenue and Miramar terminus which would be served by a short loop service. This loop will require passengers on this section to change buses at Miramar Avenue and wait for a connection to a route C bus. Such a loop would be unpopular with passengers and I would expect a fair proportion of passengers to walk to the interchange point instead.

I am also concerned that after decades of bus services from Seatoun to the city via Newtown travel patterns have been established and patrons for Newtown through to the Basin Reserve will be forced to change buses at Kilbirnie, with the GWRC advice to them being that the new smart card will allow free transfers (but not for cash payers) with no assurance on waiting times there other than a core 10 minute service from Lyall Bay.

I therefore suggest that there is a 20 minute service to Miramar via Hataitai (eliminating the proposed local loop in Miramar in the GWRC Plan) run in conjunction with a 20 mins service via Hataitai to Seatoun both running as far as Caledonia St (or Miramar Avenue) then splitting to their destinations. Further to this I would split the 10 mins service from Karori Pk. at Kilbirnie to provide a 20 mins service to Lyall Bay and a 20 mins service to Seatoun via Caledonia St or Miramar Avenue. While this probably provides too many buses to Seatoun it does in the meantime provide continued direct links to Newtown, reduces waiting time for patrons, reduces the number of passengers loading at Kilbirnie and will help reduce trip running times.

There is an issue with the number of buses serving Newtown inter-peak (9AM to 4PM) which is the busiest corridor into the CBD. Currently there are 23 trips in each hour between Newtown and the CBD in each direction but the new timetable proposes only 12 buses an hour in each direction. Apart from the inwards stops at the Riddiford/Hall St corner and the Hospital stop and the outwards Hospital stop

each of which will have a five minute combined frequency, all other stops in Newtown will have a 10 minute frequency.

The proposals scrap:

- a) the Mairangi to Houghton Bay/Southgate daily service (Route 22/23, 2 trips per hour),
- b) Khandallah to Strathmore, daily service (Route 43/44, 2 trips per hour),
- c) Seatoun daily service (Route 11) diverted via Hataitai (4 trips per hour),
- d) Miramar to Karori Park via the University weekday service (Route 18, 2 trips per hour) and
- e) Newtown Zoo to the Station weekday service (Route 10, 2 trips per hour).

These are replaced with proposed services

- a) to Island Bay Route A (6 trips an hour) and
- b) Lyall Bay Route F (6 trips an hour).

These services are intended to take most of the passengers from the cancelled services through Newtown but with such a reduction in proposed bus trips each trip must be expected to carry more passengers and is likely to be much slower due to additional boarding and alighting by passengers now forced to change buses.

In addition, the Zoo will lose a direct service from the CBD and a change at the Hospital to the link service there will be required to get to or from the Zoo.

I believe that as the Newtown to City corridor is the busiest in the city more trips should be provided to avoid extended trip travel times. This is covered below.

5.2 Victoria University Service changes

There is a major change to services to be provided for Victoria University students and staff with the withdrawal of Route 18 serving the eastern and southern suburbs through Newtown and the withdrawal of Route 17 serving Karori Main Road to the Terrace and Molesworth St. Changes to Routes 22 & 23 from Houghton Bay and Southgate through Newtown to the CBD, Kelburn and Mairangi will cancel these routes, leave only local routes through Newtown and only the Railway Station to Mairangi section left as a service.

Students and staff from the eastern and southern suburbs now using Routes 18 or 22/23 are expected to travel on one of the core routes, get off at either Courtenay Place or the Railway Station and catch a shuttle bus to the University at Kelburn. This is a major change for these services patrons leading to extended travel times for some of 15 minutes and complete withdrawal cannot be justified after looking at the level of patronage on these services. While Routes 18, 22 & 23 may not have high loadings between 10AM and 4PM they provide direct links from southern and eastern suburbs and some direct links should be retained to give assistance to Newtown trips on core routes and to reduce the numbers to be shuttled from either the Railway Station or Courtenay Place. To some of these passengers Route 18 is a “Bus Rapid Transit” service already in operation by taking a more direct route through Ghuznee St to Kelburn saving up to 15 minutes compared to CBD trips.

Route 18 provides a more direct trip from Miramar to Kilbirnie, Newtown, Taranaki St, and Ghuznee St to Kelburn and continues on to Karori Park. A well patronised AM peak service to Kelburn University up to 10 AM is followed by a quieter half hourly service for the rest of the day with some extra trips run in the PM peak. This service is run on weekdays all year round. The complete cancellation

of this bus route is considered unjustifiable due to the numbers travelling (around 350 passengers up to 10AM), the consequent likely further overloading of core routes and the longer travel times for passengers. Now that the Karori Campus has closed other options are available to provide a suitable replacement service. Instead of extending to Karori Park (see Karori services below) the route should be extended to Johnsonville as a replacement for current Route 47 (see below). Route 18 should start from Kilbirnie; have several peak hour trips until 10 AM then run as an hourly service through to Johnsonville. After 10 AM an hourly service would require 2 buses compared to the current requirement for 4 buses on route 18 for a half hour service and 2 buses on the hourly Route 47 service. Extra trips would be needed during the PM Peak. This revision will cut costs, will significantly reduce bus changes by passengers and reduce travel times compared to the proposed services. Options are to run this service only in University Semester periods during the year (between March and November) or daily throughout the year or a combination of both.

From western and northern suburbs services direct to the Kelburn University campus via Johnsonville, Khandallah, Ngaio, Crofton Downs and Wilton (Route 47) are cancelled and currently “selected trips” only are proposed by extending the Mairangi service (see later). Route 47 is currently a “semester only” service with an hourly frequency but it does offer a time saving of around 10 minutes compared to the proposed replacement. While the patronage is far less than the patronage on Route 18 the linking of both routes on an hourly frequency saves costs and reduces passenger travel times compared to the proposed service. This would also eliminate the overlap of Routes 18 and 47 between Karori Tunnel and John St., Newtown.

Other western suburbs services direct to the Kelburn University campus are substantially altered such as changes proposed for Route L (replacement service for current Wright’s Hill service (No 21) through Karori East). The proposed new service will divert this service past the Kelburn University campus direct to Courtenay Place then up Mt Victoria. This diversion is intended to be the only service from Karori to the Kelburn University campus and its trips are to be part of the shuttle proposed from Courtenay Place to the Kelburn University campus. The proposed new core service Route C goes direct along Karori Rd and Glenmore St to the City while proposed Route L covers the Wright’s Hill area before going through Kelburn along Ghuznee St to Courtenay Place and will require passengers to interchange at Karori Tunnel when necessary. The route change proposed for Route L reduces its usefulness to passengers other than those for the University as it does not directly serve the CBD and changes of bus will be needed at either Karori Tunnel or Courtenay Place. In periods when the University is not in session the route will be of little value to these passengers.

If services are provided to give direct links to Kelburn University from southern and eastern suburbs and Route L is diverted down the Terrace to the Station and CBD to Mt Victoria it will be possible to eliminate the Courtenay Place shuttle to the University and concentrate on a frequent Railway Station to University shuttle. Given that the current patronage levels on the outer parts of Route 20 (between Courtenay Place and Mt Victoria) and Route 21 (between Karori Mall, Wright’s Hill and Karori Tunnel) are modest between the peaks on the current hourly frequency, the half hourly frequency proposed for the new Route L is considered unnecessary and a hourly frequency remains sufficient for these sections

5.3 Karori and Western Suburbs services

Proposed Route L is offered as a replacement for Route 21 (Wrights Hill to Vogeltown) and Route 18 (Karori Park to Miramar) which will go past Kelburn, Kelburn University, Ghuznee St and Courtenay

Place to Mt Victoria. Route C goes from Karori Park via Karori Rd down Glenmore St and the CBD to Seatoun. Route 17 which is a peak hour service from Karori Park down Glenmore St to Molesworth St and the Railway Station, is cancelled. Consequently, the proposed services force passengers to change at Karori Tunnel if they for example are on Route L and want to go to the CBD or if they are on Service C and want to go to Kelburn University. The bus stop facilities at the Tunnel are currently inadequate for the transfer of numbers of passengers without new facilities at several bus stops. However, the current Zone boundary for cash fares is at the Karori end of Karori Tunnel (currently unmarked) with no or minimal waiting facilities at these stops but there are better facilities at the stops at the city end of the tunnel.

There are some peak hour passengers using Route 17 via Karori Rd to get from Karori to Kelburn University, the Terrace and Molesworth St so some peak hours replacement service should be investigated to eliminate the need for these passengers to interchange at the Tunnel by providing a suitable peak hour service to replace Route 17. Any buses on this Route could be part of the shuttle service from the between Kelburn University and the Railway Station. A new review is needed to provide routes and services that better serve Karori residents than the proposed services which significantly reduces the need for passengers to transfer at Karori Tunnel. To reduce tunnel transfers between the peak hours Route L should be extended to Karori Park or even Karori West as part of the revised hourly service and diversion to travel through the CBD.

Another western suburb service direct to the University which is substantially altered is Route 22/23 from Mairangi where this western leg is proposed to be stopped at the Railway Station to be part of the shuttle to the University. In the current timetable situation it is claimed that the Mairangi service is duplicating other routes especially on the southern end through Newtown but that situation will change as discussed above. At the western end of Routes 22 & 23 there are reasonable loadings to and from the University by staff and students and by residents of Northland and Kelburn going to the CBD where in the mornings after the peak there are loadings of between 6 and 15 proceeding through the CBD with further passengers boarding for journeys within the CBD or to go to the southern suburbs. Return journeys often carry good loads of University passengers from southern suburbs and CBD as well as locals returning to their suburbs.

I am aware that it is now proposed that the peak hour trips will be extended back to Courtenay Place rather than the Railway Station and that only “selected trips” will run beyond Mairangi to Johnsonville. Passengers having to get off at the Railway Station between the peak hours and in evenings and weekends who want to go through the CBD under the Plan’s proposals will be put off at the western side of the Terminal then have to proceed down to the subway before crossing under Lambton Quay and then ascending to Platforms A or B to catch a bus. This will delay each passenger by 5 to 10 minutes. Passengers include young children as well as elderly people beside the relatively fit people. On the way home the same manoeuvres must be gone through again with the expectation of an even longer wait for the Mairangi bus in a more exposed waiting area. It seems to me to be a better situation overall for the Mairangi service to be extended through the CBD out to one or more of the southern or eastern suburbs through Newtown (all trips could go to Kilbirnie with alternatives being Newtown Zoo or Houghton Bay) which could be run within a 120 minute round trip time. These trips would provide a direct link to the University, minimise changing between buses, minimise waiting time and spread the loadings through Newtown and the CBD. By running through the Lambton Terminal it could form part of the University Shuttle service with the Karori service from Mt Victoria.

5.4 CBD Congestion (see tables 3, 4 & 6)

Already mentioned in association with double-deck buses is the desire to reduce CBD congestion particularly in the PM peak between 5PM and 6PM. (see Table CBD). Between the peaks the number of trips per hour in each direction is 50 and there are normally few signs of congestion. Currently in the PM peak there are over 100 trips an hour between 5PM and 6PM in each direction between the Railway Station and Courtenay Place. The result is an extension of the through travel time from around 12minutes up to 20 minutes for some trips. Currently there are only a low proportion of trips that are full up and cannot take all potential passengers before leaving the CBD.

From my observations I believe that most peak hour services need to be reviewed and that will reduce the number of full buses without needing to go as far as introducing double-deck buses so that fewer trips need to be run. I believe that a smoother flow of buses through the CBD can be achieved by retiming departures from the Railway Station and Courtenay Place to stop the current practice of several being timed to go at the same time. The sequence of departures on linked services where express services are started at the same time as start/stop services also needs review, better spread departures and to ensure the maximum use of express buses to southern and eastern suburbs by their residents. (See Tables CBD South and CBD North).

With the retention of trolleybuses it would not be possible to link Johnsonville to Island Bay on Route A as in the Plan but it would be possible to link Johnsonville with Island Bay for that part of the service that uses diesel buses and so the Limited Stop/Express services (currently Routes 4 and 32) could be linked to peak hour Johnsonville trips. This would result in both peak hour periods having reduced numbers of trips between the Station and Courtenay Place and vice versa.

5.5 Bus Rapid Transit (BRT)

With the delay to a resolution of the traffic flows around the Basin Reserve there seems to be a hiatus in progress in attempting to speed up bus trip times. However there is a way of trialling a faster trip service between the Station and CBD through to Newtown to Kilbirnie by extending the Johnsonville inter-peak service as a limited stop service through Newtown to Kilbirnie with the option of extensions to the Rongotai Shopping Area or to the Airport. A faster limited stop service could be offered by reducing the stops used in the CBD, then stopping only at the Hospital, Newtown shops and Kilbirnie Shops, possibly saving at least 5 minutes over the core service trip times. This service would be a period trial to assess whether a speedier service is attractive to passengers and as a lead in to the eventual introduction of a generally faster BRT service.

5.6 Non-Core Routes and Weekend Services

Some of the non-core services are to be reduced from services through to the CBD to services which terminate at a “hub” requiring a change of bus to connect to the CBD. This includes the Strathmore end of Routes 43 & 44 which will terminate at Kilbirnie. The Houghton Bay and Southgate ends of Routes 22 & 23 will be replaced by services from Newtown, the first by a service (Route B) past the Zoo but the second by Route H a diversion of a service from Brooklyn via Owhiro Bay to Newtown. Also in this group is the Kowhai Park service which is replaced by Service J to Brooklyn. While peak hour services to the CBD are retained some inter peak evening and weekend services are altered. All these services are probably only moderately patronised but some are to be provided with increased frequencies and in some cases evening and weekend services.

Strathmore will get an unchanged service frequency of 30 minutes on weekdays inter-peak and daytime Saturdays and 60 minutes at other times. Houghton Bay and Southgate are currently served on weekdays inter-peak by a combined 30 minute service which divides at Riddiford St to give a 60 minute service to each terminus. It is replaced by proposed 30 minute services to each terminus from Newtown only. Daytime Saturday and Sunday services currently offer a half hourly service past the Zoo which later splits to provide an hourly frequency to each terminus. No weekday or weekend evening services go to Houghton Bay but an hourly service past the Zoo goes to Southgate during weekday and weekend evenings. The proposed replacement services to Southgate are provided by Route H which replaces part of Route 29 “Southern Shopper” service between Island Bay and Brooklyn via Owhiro Bay on which the weekday inter-peak frequency is usually around 1hr 20 minutes but the proposal is for a frequency of 30 minutes. Route 29 has peak hour trips which are continued but has no evening and weekend services but the proposal has a daytime Saturday frequency of 30 minutes and a 60 minute service for evenings, Saturday evenings and Sundays. So while Southgate has a similar service from Route H there are considerable frequency and service time increases for the Happy Valley Rd, Owhiro Bay and Frobisher St areas.

The other part of Route 29, the “Southern Shopper service, is between Brooklyn and the Newtown shopping area via Mornington, Kingston, part of the Vogeltown route and Britomart St. Proposals for Route I will cover part of this service by extending the buses from Kingston around the Vogeltown loop and Hutchison St to John St which is away from the Hospital and shops. Also the Kowhai Pk. to CBD service (Route 8) is replaced by a shuttle going only to Brooklyn shops (Route J). With a round trip travel time of 18 minutes on current timetables the proposed frequencies of 30 minutes on weekdays inter-peak and daytime Saturdays and of 60 minutes at evenings, Saturday evenings and Sundays will be met by one bus alone from Brooklyn, a not very efficient arrangement. Also the proposed extension of half of the Kingston buses (Route I) through the Vogeltown loop will require at least 15 minutes which will bring them back to Kingston at the same time as the next bus arrives at Kingston from the CBD at the proposed 15 minute frequency for weekdays inter-peak and daytime Saturday trips. Again this is considered not an efficient use of buses. Alternatively, the Kingston buses could all turn at Kingston and Kowhai Park could be served by new service from Newtown shops and Britomart St, Vogeltown loop, Kingston/Mornington and Brooklyn reusing part of the current “Southern Shopper route. This would be an hourly service similar to the current frequency to Kowhai Park and Vogeltown. This would still require transfers at either Brooklyn or Newtown for CBD passengers but would be more efficient and give better direct access to Newtown.

My concern at these proposed services and frequencies is that the frequencies are set up by the need to give reasonable connections to core routes to or from the CBD rather than the level of patronage. The 2012 Review endorsed by the Plan intended savings from “Hubbing” were to be directed towards improving services towards poorly serviced areas. Also the aim is to attain a recovery from fares of 55% of total costs. The earlier analysis of University services was one part of the change towards hubbing but would result in overloading of AM peak core services and increased travel times for students and staff. The pulling back of the changes proposed may reduce the savings assumed but will be more acceptable to the majority of these passengers and retain fare income.

There is a further time that has to be reviewed and that is daytime Saturday services. Table 8, Buses in Service, shows a comparison of buses required by the current and proposed services as far as can be calculated from details of the proposed services. The comparison is an indicative calculation based on either current timetabled trip times, or my calculation of travel times for new or amended routes but it does not take layovers or shift changes into account. The calculation of both alternatives gives a reasonable idea of changes in bus numbers required for services. On weekdays inter-peak a reduction

of 4 buses is indicated for core routes and a further reduction of 4 buses is indicated for non-core services. These implied savings would be reduced by changes suggested already.

On Saturdays during daytime, buses needed for core services are estimated to reduce by 4 but buses required for non-core routes increase by 7 due to newly introduced Saturday services or increased services on some of these routes. For similar reasons the number of buses required on Sundays for non-core services is expected to increase by 3. As the routes benefiting from the extra buses required for service have modest passenger loads the question is whether any increase in patronage can be expected from the increased number of trips to provide a sufficient fare increase to allow the 55% fare recovery aim to be reached. If the savings from hubbing are not attainable then the frequency of some of the non-core routes will need to be reviewed.

5.7 Changes to Services

If all the changes to services proposed in the Transport Plan were implemented at one time as is implied, the chances of extended confusion are high which would lead to a lack of confidence in the system and a loss of patronage and fare income. Large scale changes need to be introduced on a staged basis so that any issues can be dealt with within each stage before a further group of changes are made. A period of months should be considered during which changes are staged.

Michael Flinn

7 July 2016

SUMMARY OF TABLES ATTACHED:

Table 1	New Buses – Prices and Passenger Capacities
Table 2	Double-decker Requirements
Tables 3 & 4	Peak Hour bus trips in the CBD
Table 5	Peak Hour – Newlands, Johnsonville and Island Bay
Table 6	CBD Information
Tables 7 & 8	Indicative Number of Buses in Service
Table 9	Proposed Units in Transportation for PTOM Contracts
Table 10	Pollution
Table 11	Bus Motive Power Options

Review of GWRC Transport Plan 2014 -Wellington City Bus Services					TABLE 1	
(as in 2014 Transport Plan)					New Cost NZ (\$)	Capacity Passengers
2 axle diesel single deck					400,000	55
3 axle diesel single deck					450,000	75
2 axle diesel/electric hybrid single deck					600,000	53
3 axle diesel/electric hybrid single deck					650,000	72
3 axle diesel double deck (assumed cost)					550,000	100
3 axle diesel/electric hybrid double deck					750,000	95
Note 3 axle diesel double decker capacity of 100 passengers based on media reports						
Double Decker cost is my estimate but could be in the range \$550,000 to \$750,000 (Not Hybrids)						
Cost of new double decker alternatives						
No	Bus Cost				Funds Required	
50	550,000				27,500,000	
40	550,000				22,000,000	
10	750,000				7,500,000	
					29,500,000	

Table 2 – Page 1

Double Decker Requirement - Summary			Table 2					
This is a theoretical calculation of bus requirements if all trips were to be run by double deckers								
Route	Requirement for GWRC Proposals			Requirement to give Current Capacity				
	AM Peak	Interpeak	PM Peak	AM Peak	Interpeak	PM Peak		
Current trips at Peak Hours as GWRC proposals								
A Johnsonville to Island Bay	21	13	26	15	13	19		
G Newlands to Courtenay Place assumes single deckers to Miramar Heights	18	3	17	12	3	14		
F Station to Lyall Bay via Newtown	9	8	11	6	8	8		
Total	48	24	54	33	24	41		
Note Requirement numbers do not allow for layover time								

Table 2, Page 3

G	Areas served	Period	GWRC		Buses Required				AM Peak (mins)					
			Service proposed	Travel time (mins)		Max	Min	Avge	Trip No	Current Capacity	Current Service			
	Newlands to Courtenay Place		mins frequency	(a)	(b)	total								
	For double deckers only the section of route between Newlands and Courtenay Place has been considered													
	This includes the current services 52, 56, 57 & 58													
	Peak AM	5/10 m		35	50	85	17	9	11		4	22.5	15	
	Inter peak	30 m		50	50	100	3				5	30	20	
	Peak PM	5/10 m		50	45	95	19	9.5	13		6	37.5	25	
											7	45	30	
	AM Peak - No of trips 7am to 9am on average of 7.5 min frequency is 11											8	52.5	35
	AM Peak - No of trips 7am to 9am currently on services are:											9	60	40
											10	67.5	45	
		Route 52 Newlands dep		2							11	75	50	
		Route 56 Paparangi dep		6							12	82.5	55	
		Route 57 Woodridge dep		9							13	90	60	
		Route 58 Baylands dep		6							14		65	
		total		23							15		70	
											16		75	
	If proposed service is the same as the current service assume 23 trips are provided in the AM Peak from 7am to 9am											17		80
	This is an average frequency of 5 mins in this period. This would require 18 buses for this service											18		85
	However capacity of double deckers is 100 compared to 70 for a 3 axle single decker currently used on most trips													90
	Available capacity from 23 double deck trips is 2300 passengers compared to 1610 currently provided on 3 axle single deckers													
	To continue to provide the current AM Peak capacity on double deckers would require 16 double deck trips at an average frequency of 7.5 minutes													
	This would require 12 double deck buses for this service													
	PM Peak - No of trips 4 pm to 6 pm on average of 7.5 min frequency is 16					(16 x 7.5 m = 120 minutes)								
	PM Peak - No of trips 4 pm to 6 pm currently on services are:											Trip No	Current Capacity	Current Service
											1	0	0	
											2	8	5.7	
		Route 52 Newlands Courtenay Plce dep		1							3	16	11.4	
		Route 56 Paparangi Courtenay Plce dep		7							4	24	17.1	
		Route 57 Woodridge Courtenay Plce dep		7							5	32	22.8	
		Route 58 Baylands Courtenay Plce dep		6							6	40	28.5	
		total		21							7	48	34.2	
											8	56	39.9	
	If proposed service is the same as the current service assume 21 trips are provided in the PM Peak from 4 pm to 6 pm											9	64	45.6
	This is an average frequency of 5.7 mins in this period. This would require 17 buses for this service											10	72	51.3
	However capacity of double deckers is 100 compared to 75 for a 3 axle single decker currently used on most trips											11	80	57
	Available capacity from 21 double deck trips is 2100 passengers compared to 1470 currently provided on 3 axle single deckers											12	88	62.7
	To continue to provide the current PM Peak capacity on double deckers would require 15 double deck trips at an average frequency of 8 mins											13	96	68.4
	This would require 13 double deck buses for this service											14	104	74.1
											15		79.8	
											16		85.5	
	If the current Peak capacity level is to be provided from double deckers on Route G then 13 double deckers would be needed											17		91.2
	Inter peak service with a 30 minute frequency requires 3 double deckers with an hourly capacity of 3000													96.9
	compared with the current hourly capacity of 140 in each direction.													

Table 3, Page 1

Peak Hour Trips in the CBD from the Railway Station to Courtenay Place between 5PM and 6 PM											
CURRENT TIMETABLE						PROPOSED TIMETABLE 2017					
SUMMARY 5PM to 6PM Trips CBD from Railway Stn to Courtenay Plce						SUMMARY 5PM to 6PM Trips CBD from Railway Stn to Courtenay Plce					
To & Route	Rly Stn dep	Victoria St	Taranaki St	C Plce	To	To & Route	Rly Stn dep	Rly Stn dep	Victoria St	Taranaki St	C Plce
							Max No	Min No	MIN	MIN	MIN
Southern Suburbs						Southern Suburbs					
Island Bay 1	9			9		Island Bay A	12	6			6
Island Bay 4	4			4		Houghton Bay B1	2	2			2
Newtown Park 10	3		3			Southgate H2	3	3			3
Houghton Bay/Southgate	6			6		Houghton Bay Express A1	6	3			3
Houghton Bay Express 32	3			3		Owhiro Bay H1	3	3			3
	25	0	3	22			26	17	0	0	17
Eastern Suburbs						Eastern Suburbs					
Miama 2	6			6		Miramar/Seatoun C	12	6			6
Lyall Bay 3	7			7		Lyall Bay F	12	6		6	
Hataitai 5	3			3		Hataitai O	6	4			4
Lyall Bay 6	5			5		Lyall Bay F1	3	2			2
Seatoun 11	5		5			Scorching Bay Express C1	3	2			2
Rongotai via Hataitai 14	4			4		Moa Pt Express C2	3	2			2
Miramar Heights 24	3	3	via Wakefield St			Miramar North Express D1	6	3			2
Scorching Bay/Moa Pt 30	4			4		Strathmore Q1	3	3			3
N Miramar Express 31	4			4		Miramar Heights P	6	2			
Strathmore 43/44	4			4			54	30	0	6	21
	45	3	5	37							
Kingston Area						Kingston Area					
Kingston 7	8	8				Kingston I	12	6	6		
Kowhai Pk 8	4	4				Kowhai Pk J	4	2	2		
Aro St 9	3	3				Aro St/Highbury K	6	3	3		
Vogeltown 21	2		2				22	11	11	0	0
	17	15	2	0							
Central Area						Central Area					
Mt Victoria 20	2			2		Mt Victoria (via Taranaki St) L	0	0			3
From Johnsonville/Newlands						From Newlands					
Newlands 52	2			2		Newlands G	12	6			5
Johnsonville 54	2			2							
Granada 55	1			1							
	5	0	0	5							
From Eastbourne						From Eastbourne					
Eastbourne/Gracefield 81	5			5		Eastbourne	8	8			5
To Airport						To Airport					
Airport 91	6			6		Airport	6	3			3
Total Trips	105	18	10	77			128	75	11	6	54
							Avge	101.5			

Table 3, Page 2

DETAIL					
Trip Details 5PM to 6PM CBD Railway Stn to Courtenay Plce					
From & Route	Rly Stn dep	Victoria St	Taranaki St	C Plce	To
					Houghton Bay
	32 5.00			5.14	Kilbirnie
	11 5.00		5.10		Miramar
	2 5.00			5.12	Hataitai
	5 5.00			5.12	Lyll Bay
	6 5.00			5.12	Southgate
	22 5.00			5.14	Island Bay
	1 5.01			5.17	Mt Victoria
Highbury 20	5.01			5.12	Kingston
	7 5.03	5.11			Lyll Bay
Karori Pk 3	5.05B			5.19	Island Bay
	1 5.05			5.20	Island Bay
	4 5.05			5.20	Miramar
	2 5.05			5.17	North Miramar
	31 5.05			5.17	Seatoun
	11 5.05		5.15		Roseneath/Kilb
Wilton 14	5.05			5.20	Scorching Bay
	30 5.05			5.19	Houghton Bay
	23 5.05			5.19	
Newlands 52	5.05			5.15	Airport
Queensgate 91	5.05			5.18	Kingston
	7 5.09	5.17			Island Bay
	1 5.10			5.25	Houghton Bay
	32 5.10			5.24	Miramar
	2 5.10			5.22	Lyll Bay
	6 5.10			5.22	Kowhai Pk
	8 5.10	5.18			Aro St
	9 5.10	5.18			Vogeltown
K Mall	5.10B		5.20		
Johnsonville 54	5.11			5.20	Zoo
	10 5.12		5.25		Evans By/M Heights
	24 5.12	5.20W			
Gracefield 84	5.14			5.30	Kingston
	7 5.14	5.22			Airport
	91 5.15			5.28	Lyll Bay
Karori Pk 3	5.15B			5.29	Island Bay
	1 5.15			5.30	Moa Point
	30 5.15			5.29	Kingston
	7 5.18	5.26			Kilbirnie
	3 5.20			5.34	Kilbirnie
	11 5.20		5.30		Island Bay
	1 5.20			5.35	Island Bay
	4 5.20			5.35	Miramar
	2 5.20			5.32	Hataitai
	5 5.20			5.32	North Miramar
	31 5.20			5.32	Lyll Bay
	6 5.20			5.32	Kilbirnie
	14 5.20			5.35	Southgate
Mairangi 22	5.24B			5.38	Kingston
	7 5.24	5.32			Lyll Bay
Karori Pk 3	5.25B			5.39	Island Bay
	1 5.25			5.40	Kowhai Pk
	8 5.25	5.33			Seatoun
	11 5.25		5.35		Strathmore
Khandallah 44	5.25			5.39	Strathmore
	44 5.25			5.37	Houghton Bay
	23 5.25			5.39	Airport
Queensgate 91	5.25			5.38	
Grenada 55	5.25			5.35	Evans By/M Heights
	24 5.27	5.35W			
Eastbourne 83	5.27			5.43	
Gracefield 84	5.29			5.45	Island Bay
	1 5.30			5.45	Houghton Bay
	32 5.30			5.44	Miramar
	2 5.30			5.42	Lyll Bay
	6 5.30			5.42	Aro St
	9 5.30	5.38			Mt Victoria
Highbury 20	5.31			5.42	Zoo
	10 5.32		5.42		Kingston
	7 5.33	5.41			Lyll Bay
Karori Pk 3	5.35B			5.49	Island Bay
	4 5.35			5.50	North Miramar
	31 5.35			5.47	Scorching Bay
	30 5.35			5.47	Roseneath/Kilb
Wilton 14	5.35			5.50	

Table 3, Page 3

Newlands 52	5.35			5.45	
	91 5.35			5.48	Southgate
	22 5.36			5.50	Kowhai Pk
	8 5.40	5.48			Island Bay
	1 5.40			5.55	Hataitai
	5 5.40			5.52	Vogeltown
K Mall 21	5.40B		5.50		
Johnsonville 54	5.36			5.49	Kingston
	7 5.41	5.49			Evans By/M Heights
	24 5.43	5.51W			Airport
Queensgate 91	5.45			5.57	Lyllall Bay
Karori Pk 3	5.45B			5.59	Miramar
	2 5.45			5.57	Seatoun
	11 5.45		5.55		Strathmore
Khandallah 43	5.45			5.57	
Eastbourne 83	5.47			6.03	Kingston
	7 5.48	5.56			Houghton Bay
Mairangi 23	5.49B			6.01	Aro St
	9 5.50	5.58			Roseneath/Kilb
	14 5.50			6.05	Moa Point
	30 5.50			6.04	Island Bay
	1 5.50			6.05	Island Bay
	4 5.50			6.05	Lyllall Bay
	6 5.50			6.05	
Gracefield 84	5.51			6.06	Zoo
	10 5.52		6.03		Lyllall Bay
Karori Pk 3	5.53B			6.06	North Miramar
	31 5.55			6.07	Strathmore
Khandallah 44	5.55			6.07	Kowhai Pk
	8 5.55	6.03			Airport
	91 5.55			6.05	
W = via Wakefield St					

Table 4, Page 1

SUMMARY 5PM to 6PM Trips CBD from Courtenay Plce to Railway Station												
CURRENT TIMETABLE						PROPOSED TIMETABLE 2017						
SUMMARY 5PM to 6PM Trips CBD from Courtenay Plce to						SUMMARY 5PM to 6PM Trips CBD from Courtenay Plce to						
CURRENT TIMETABLE						PROPOSED TIMETABLE TRIPS						
To & Route	C Plce	Willis St	Brandon St	Lbtn Qy Nth	Rly Stn	To & Route	Plan Frequency	C Plce	Willis St	Brandon St	Lbtn Qy Nth	Rly Stn
	Taranaki St				Molesworth St							
							Max					
							Min					
Karori Pk 3	7		1		8	Karori Pk C	12					6
South Karori 3S	3				3	South Karori C3	3					2
Karori West 3W	3				3	Karori West C4	3					2
Karori Wrights Hill 21	3				3	Wrights Hill ex Mt Vic	0					0
	16		1		17		18					10
Mairangi 13,22,23	6				6	Mairangi, J ville (ex Station) M	4					3
						Mairangi ex Brandon St M1	4			4		3
Highbury 20	2				2		8					6
Khandallah 43,44,45	7		3		10	Khandallah ex Highbury K	6					3
Broadmeadows 46	2				2	Ngaio ex Brandon St K1	3			3		3
	9		3		12	Broadmeadows, J ville P	6					2
							15					8
Wilton 14	5		1		6	Wilton O	6					4
Newlands 52,56,57,58	10				10	Johnsonville A	12					6
Churton Pk, Johnsonville 54	6		2		8	Newlands, Johnsonville G						
Grenada 55	3				3	Johnsonville G1	4					2
Porirua 210	1				1	Woodridge G2	4					2
Johnsonville West 53	3				3	Baylands G3	4					2
	23		2		25	Churton Pk R, R1	3			3		2
							27					14
Eastbourne	7				7	Eastbourne 81-85	8					8
91 Queensgate ex Airport	3				3	Airport 91	6					3
91 Rly Stn ex Airport	3				3							
90 Stokes Valley	1				1	Stokes Valley	1					1
92/93 U Hutt Express	2				2	U Hutt Express	2					2
80 Wainui o Mata	3				3	Wainui o Mata	3					3
	19				19		6					6
Kingston, Aro St, Kowhai Pk		10			10							
Island Bay	5				5							
Miramar	3				3	Lyall Bay to Stn	12					6
Newtown Pk Zoo	3				3	Kingston to Stn	12					6
Seatoun	4				4							
Hataitai	3				3							
24 ex Miramar North	2				2							
	20	10			20							
Total	100	10	7		23		118					71
					117		Avge					94.5

Table 4, Page 2

CURRENT TIMETABLE						
From & Route	C Pice	Willis St	Brandon St	Lbtn Qy Nth	Rly Stn	To
45			5.05		5.09	Khandallah
22	5.00			5.16		Mairangi
54			5.05L		5.11	Churton Pk
43	5.00				5.11	Khandallah
81	5.00			5.16 M		Eastbourne
80	5.00				5.15	Wainui o mata
Aro St 9		5.05			5.15	
Hataitai 5	5.00				5.19	
3			5.10	5.15		Karori Pk
54	5.00				5.14	Churton Pk
56	5.00				5.20	Paparangi
90	5.00				5.15	Stokes Valley
92	5.00				5.15	U Hutt Express
93	5.00				5.15	U Hutt Express
14	5.02			5.17M		Wilton
3S	5.02			5.16		South Karori
3W	5.03			5.19		West Karori
Airport 91	5.06			5.20M		Upper Hutt
Lyll Bay 3	5.04			5.20		Karori Pk
21	5.05			5.20		Mall Karori
56	5.05				5.22	Jville/Nlds
55	5.05				5.20	Grenada
83	5.05				5.23	Eastbourne
Miramar 2	5.06				5.24	
Island Bay 1	5.08				5.26	
13	5.08			5.24		Mairangi
3			5.20	5.25		Karori Pk
Strathmore 44	5.09				5.20	Khandallah
Seatoun 11	5.11T				5.28	
Zoo 10	5.10T				5.25	
46	5.10				5.24	Broadmeadows
81	5.10			5.26 M		Eastbourne
Mt Victoria 20	5.10				5.21	Highbury
57	5.06				5.25	Newlands
80	5.10				5.25	Wainui o mata
Kingston 7		5.14			5.21	
Kilbirnie 14	5.12			5.27M		Wilton
3W	5.13			5.29		West Karori
Lyll Bay 3	5.14			5.30		Karori Pk
54	5.14				5.28	Churton Pk
43	5.15				5.26	Khandallah
Southgate 22	5.18			5.35		Mairangi
3	5.15			5.28		Karori Pk
Brooklyn 7		5.19			5.26	
85	5.15				5.31	Eastbourne
58	5.12				5.31	Newlands
211	5.15				5.25	Porirua
53	5.16				5.31	West J,ville
Airport 91	5.16			5.30M		
Island Bay 1	5.20				5.38	
45			5.25		5.30	Khandallah
3	5.19			5.35		Karori Pk
Mmar Hghts 24	5.19				5.35	
Aro St 9		5.28			5.35	
Kowhai Pk 8		5.28			5.35	
Kingston 7		5.29			5.36	
Hataitai 5	5.20				5.39	
56	5.18				5.37	Jville/Nlds
55	5.20				5.35	Grenada
14	5.22			5.37M		Wilton
Lyll Bay 3	5.24			5.40		Karori Pk
14		5.25L	5.32M			Wilton
57	5.24				5.41	Newlands
Miramar 2	5.26				5.44	
Airport 91	5.26			5.40 M		Queensgate, L H
Seatoun 11	5.27T				5.43	
Vogeltown 21	5.28T			5.36		Mall Karori
Strathmore 44	5.29				5.40	Khandallah
81	5.30			5.46 M		Eastbourne
Zoo 10	5.30T				5.45	
22	5.30			5.44		Mairangi
Lyll Bay 3	5.30			5.45		Karori Pk
58	5.30				5.47	Newlands
54	5.30				5.42	Churton Pk
80	5.30				5.45	Wainui o mata
Island Bay 1	5.32				5.50	
3S	5.32			5.46		South Karori
Airport 91	5.36			5.50M		

Table 4, Page 3

CURRENT TIMETABLE						
From & Route	C Pice	Willis St	Brandon St	Lbtn Qy Nth	Rly Stn	To
CURRENT TIMETABLE						
From & Route	C Pice	Willis St	Brandon St	Lbtn Qy Nth	Rly Stn	To
3W	5.33			5.49		West Karori
46	5.35				5.49	Broadmeadows
3	5.35			5.50		Karori Pk
83	5.35				5.50	Eastbourne
56	5.36				5.53	Jville/Nlds
53	5.35				5.50	West J,ville
13	5.38			5.51		Mairangi
45			5.45		5.53	Khandallah
Hataitai 5	5.40				5.59	
43	5.40				5.51	Khandallah
Lyll Bay 3	5.40			5.55		Karori Pk
55	5.40				5.55	Grenada
57	5.42				5.58	Newlands
Kingston 7		5.46			5.54	
Aro St 9		5.47			5.55	
Seatoun 11	5.42				5.58	
Kilbirnie 14	5.42			5.57M		Wilton
Island Bay 1	5.44				6.02	
81	5.45			5.58 M		Eastbourne
Houghton By 23	5.46			5.58		Mairangi
Mt Victoria 20	5.45				5.56	Highbury
54	5.45				5.58	Churton Pk
Miramar 2	5.46				6.04	
Airport 91	5.46			6.00M		Queensgate, L H
Strathmore 44	5.49				6.00	Khandallah
Mmar Hgts 24	5.49				6.05	
Kingston 7		5.56			6.02	
Kowhai Pk 8		5.57			6.05	
Zoo 10	5.50T				6.05	
Lyll Bay 3	5.50			6.05		Karori Pk
58	5.48				6.04	Jville/Nlds
56	5.54				6.10	Newlands
3S	5.52			6.06		South Karori
14	5.52			6.07M		Wilton
Island Bay 1	5.56				6.14	
53	5.55				6.10	West J,ville
Airport 91	5.56				6.09	
Vogeltown 21	5.58T			6.06		Mall Karori
Seatoun 11	5.58T				6.13	
Total	100	10	7	41	76	C Pice 5.00PM Rte 92 & 93 based on observation not timetable
			117		117	
				26		
				15		

L = Lambton Quay east stop
M = Molesworth St stop
T = joins CBD at Taranaki St

Table 5, Page 1

Bus Timetable Johnsonville and Newlands to City					Current Timetables				
Current Timetables					Current Timetables				
A Johnsonville / Newlands to Courtenay Place					Courtenay Place to Newlands and Johnsonville				
Peak Hour Services merging at Newlands Park or Johnsonville Stn after 7AM arriving at Wellington Stn until around 9AM					Departures from Courtenay Place				
AM Peak Service Inwards 7AM to 9AM					PM Peak services between 4PM and 6PM				
ex Johnsonville	Ex Newlands	Arr Wellington Stn	Route No		Route No	to Johnsonville	to Newlands		
Johnsonville Stn	Newlands Park				Courtenay Plce dep	via J Stn	via Nlands Pk		
	7.00		7.18	57		54	4.05LQ		
	7.05		7.21	54		54	4.00		
		7.05	7.23	58		57		4.00	
						58		4.06	
	7.10		7.25	55		56		4.12	
		7.10	7.31	56		54	4.15		
	7.15		7.34	54		211	4.15		
		7.14	7.34	57		57		4.18	
	7.20		7.35	53		58		4.24	
		7.18	7.41	58		54	4.30		
		7.22	7.46	56		56		4.30	
	7.25		7.40	55		54	4.35LQ		
		7.26	7.49	57		57		4.35	
	7.25		7.49	54		55	4.40		
	7.27		7.46	211		58		4.40	
		7.30	7.53	58		54	4.45		
	7.37		7.56	211 to Basin Reserve		56		4.45	
	7.40		7.55	55		57		4.50	
		7.34	7.58	56		53	4.55		
	7.35		8.02	54		58		4.55	
		7.38	8.05	57 to Basin Reserve		54	5.00		
	7.50		8.05	53		56		5.00	
	7.55		8.10	55		54	5.05 ex L Quay		
		7.42	8.11	58		55	5.05		
	7.57		8.16	211 to Basin Reserve		57		5.06	
	7.45		8.13	54		58		5.12	
		7.46	8.16	56 to Basin Reserve		54	5.14		
		7.50	8.21	57		211	5.15		
	7.55		8.22	54		53	5.16		
		7.54	8.25	58		56		5.18	
	8.10		8.25	55		55	5.20		
	8.12		8.27	53		57		5.24	
		7.58	8.27	56		54	5.30		
	8.05		8.30	54		58		5.30	
		8.02	8.32	57		53	5.35		
		8.06	8.35	58		56		5.36	
	8.17		8.36	211		55	5.40		
		8.10	8.37	56		57		5.42	
		8.15	8.40	57		54	5.45		
		8.20	8.43	58		58		5.48	
		8.25	8.47	56		56		5.54	
	8.25		8.47	54		53	5.55		
	8.35		8.50	53					
	8.40		8.55	55					
		8.35	8.56	57					
		8.52	9.08	52					
	8.55		9.15	54					
Summary	Trips J Stn	Trips Nlds	Route No		Summary (2 hours)	Route No			
	4		53			53	4		
	9		54			54	11		
	6		55			55	4		
	4		211			211	2		
		1	52			52		0	
		7	56			56		7	
		8	57			57		7	
		7	58			58		7	
Total	23	23	46				21	21	42
						LQ dep Lambton Quay			
Timetables	52, 56, 57, 58	dated 16/11/2015	Newlands		Timetables	52, 56, 57, 58	dated 16/11/2015	Newlands	
	54	dated 21/3/2016	Churton Pk			54	dated 21/3/2016	Churton Pk	
	53	dated 21/11/2011	Johnsonville West			53	dated 21/11/2011	Johnsonville West	
	55	dated 28/11/2010	Granada, Paparangi			55	dated 28/11/2010	Granada, Paparangi	
	211	dated 16/11/15	Johnsonville, Porirua			211	dated 16/11/15	Johnsonville, Porirua	

Table 5, Page 2

B Current Timetables Island Bay to Railway Stn AM Peak 7am to 9AM				Current Timetables Railway Stn to Island Bay PM Peak services between 4PM and 6PM			
Route No	Island By dep	Rly Stn arr	Molesworth St arr	Route No	Rlwy Stn Dep.		
1	7.00	7.35		1	4.04		
32E	7.09		7.38	4	4.05		
1	7.12	7.47		1	4.16		
4	7.21W		7.46	32E	4.20		
1	7.24	7.59		1	4.28		
4	7.25W	7.52		4	4.30		
32E	7.29		8.00	1	4.40		
4	7.31W		7.56	32E	4.40		
1	7.36	8.15		1	4.50		
32E	7.44	8.19		4	4.50		
4	7.46W		8.17	1	4.57		
1	7.48	8.27		32E	5.00		
4	7.52W	8.22		1	5.01		
32E	7.54	8.29		1	5.05		
4	7.54W		8.27	4	5.05		
32E	7.59	8.34		1	5.10		
1	8.00	8.41		32E	5.10		
4	8.05		8.42	1	5.15		
4	8.07W		8.39	1	5.20		
1	8.12	8.51		4	5.20		
32E	8.19	8.53		1	5.25		
4	8.21W		8.52	1	5.30		
1	8.24	9.03		32E	5.30		
4	8.30	9.06		4	5.35		
32E	8.34	9.07		1	5.40		
1	8.37	9.16		1	5.50		
1	8.49	9.26		4	5.50		
				1	6.00		
Summary (2 hours)				Summary (2 hours)			
Route		No of trips		Route		No of trips	
1		10		1		16	
4		10		4		7	
32E		7		32E		5	
		27				28	
W dep Adelaide Rd at Wakefield Park, timetabled time							
32E Express starting from Houghton Bay							
Routes							
1 Island Bay to Railway Stn (stopping service via Newtown)							
4 Fast service from Owhiro Bay via Adelaide Rd							
32E Express Service from Houghton Bay via Newtown, Minimum Fare 3 Zones, non stop Adelaide Rd to Courtenay Place							

Table 7, Page 1

Indicative Number of Buses In Service			
Calculation of the number of buses needed for service , not taking into account layover times or shift change requirements			
Calculation based on travel times and frequencies.			
Current Weekday Interpeak (9AM to 4PM, taken around 2PM)			
Major Routes			
	Round Trip	Frequency	Buses
Current Route	Travel Time mins	mins	Required
1 Station to Island Bay	71	12	6
2 Station to Miramar	83	15	6
3 Karori Park to Lyall Bay	113	10	12
10 Station to Newtown Park Zoo	53	30	2
11 Station to Seatoun	85	15	6
54/53/55 Churton Pk/Johnsonville to Courtenay Plce	82	30/60	6
Total			38
Proposed Equivalent Weekday Interpeak services			
Proposed Route			
A Johnsonville to Island Bay	126	10	13
C Karori to Seatoun	118	10	12
F Station to Lyall Bay	75	10	8
Total			33
Indicative reduction in buses in operation			5
Round Trip Travel Times are based on Current Timetables			
Proposed Service C Karori Pk to Seatoun			
	Period	Current Service	
Areas served		mins frequency	Travel time (mins)
Karori Park to Seatoun			(a) (b) total
	Peak AM	10 m	64 63 127
	Inter peak	10 m	54 62 116
	Peak PM	10 m	66 66 132
	This covers the 10 min service only. Extra trips run in peak hours are:		
	AM Peak		4
	PM Peak		6
The timeable is based on single deck buses with a passenger capacity of around 70 passengers			
Current Service			
	Period	Current Service	
Areas served		mins frequency	Travel time (mins)
Karori Park to Lyall Bay			(a) (b) total
	Peak AM	10 m	54 58 112
	Inter peak	10 m	51 57 108
	Peak PM	10 m	58 57 115
	Peak Hour extras		6
Alternative Services			
Railway Stn to Lyall Bay			
	Peak AM	10 m	34 42 76
	Inter peak	10 m	36 40 76
	Peak PM	10 m	42 45 87
	Peak Hour extras		
Railway Station to Island Bay			
	Peak AM	10 m	34 40 74
	Inter peak	10 m	36 35 71
	Peak PM	10 m	40 40 80
Summary (10 Minute frequency)			
			Peak AM Inter peak Peak PM
Karori Park to Seatoun {C}			13 12 14
Railway Stn to Lyall Bay (3)			8 8 9
Railway Station to Island Bay (1)			8 8 8
	Sub total		29 28 31
	Peak Hour Extras		10 10
Kingston (7) (10m/15m/10m)			6 4 6
Total			45 32 47

Table 8, Page 1

Summary of Indicative Numbers of Buses Required and CBD Trips per Hour - CURRENT and PROPOSED													
Summary covers Weekday Interpeak (9AM to 4PM) and mid day requirements on Saturday and Sunday													
	Monday to Friday Interpeak				Saturday				Sunday				
	Buses Req	CBD Trips			Buses Rec	CBD Trips			Buses Req	CBD Trips			
Core Routes (see below)													
CURRENT SERVICES	38	25			28	18			22	14			
PROPOSED SERVICES	34	18			24	11			22	12			
Variation	-4	-7			-4	-7			0	-2			
Non Core Routes (see below)													
CURRENT SERVICES	26	15			15	9			14	8			
PROPOSED SERVICES	22	8			22	8			17	7			
Variation	-4	-7			7	-1			3	-1			
All Services													
CURRENT SERVICES	64	40			43	27			36	22			
PROPOSED SERVICES	56	26			46	19			39	19			
Variation	-8	-14			3	-8			3	-3			
Round Trip times are based wherever possible on Current Services Timtabled times.													
This table excludes services to Eastbourne, Newlands & the Airport where there is no change to service frequencies or CBD trips at the above times													
The Table shows indicative numbers of buses needed to cover the routes over the calculated travel times and timetabled frequencies. Layover times are not included.													
Actual bus numbers needed will only be decided when detailed timetables are prepared													
A Core Route Linkings CURRENT SERVICE													
Destination	Route No	Monday to Friday Interpeak				Saturday				Sunday			
		Rd Trip Time	Frequency	No Of Buses	CBD Trips	Rd Trip Time	Frequency	No Of Buses	CBD Trips	Rd Trip Time	Frequency	No Of Buses	CBD Trips
		(mins)	(mins)		p hr	ex Station (mins)	(mins)	(max)	p hr	ex Station (mins)	(mins)	(max)	p hr
Island Bay	1	71	12	6	5	80	15	6	4	64	15	5	4
Miramar	2	83	15	6	4	81	15	6	4	84	20	5	3
Karori/Lyall	3	113	10	12	6	103	15	7	4	96	15	6	4
Newtown Zoo	10	53	30	2	2								
Seatoun	11	85	15	6	4	85	15	6	4	82	30	3	2
Johnsonville	53-55	82	30/60	6	4	80	30	3	2	70	60	3	1
Total				38	25			28	18			22	14
B Core Route Linkings PROPOSED SERVICE													
Destination	Route No	Monday to Friday Interpeak				Saturday				Sunday			
		Rd Trip Time	Frequency	No Of Buses	CBD Trips	Rd Trip Time	Frequency	No Of Buses	CBD Trips	Rd Trip Time	Frequency	No Of Buses	CBD Trips
		(mins)	(mins)		p hr	ex Station (mins)	(mins)	(max)	p hr	ex Station (mins)	(mins)	(max)	p hr
A Johnsonville to Island Bay	A	126	10	13	6	139	15	10	4	112	15	9	4
C Karori Pk to Seatoun via Hataitai	C	118	10	12	6	116	15	8	3	104	15	7	4
F Wellington Stn to Lyall Bay via New F	F	75	10	8	6	69	15	5	4	64	15	5	4
R Churton Pk to Johnsonville	R	27	30	1	0	30	30	1	0	22	30	1	0
Total				34	18			24	11			22	12
Major Routes Change in Bus Numbers/CBD Trips													
				-4	-7			-4	-7			0	-2
C NON Core Route Linkings CURRENT SERVICE													
Destination	Route No	Monday to Friday Interpeak				Saturday				Sunday			
		Rd Trip Time	Frequency	No Of Buses	CBD Trips	Rd Trip Time	Frequency	No Of Buses	CBD Trips	Rd Trip Time	Frequency	No Of Buses	CBD Trips
		ex Station (mins)	(mins)		p hr	ex Station (mins)	(mins)	(max)	p hr	ex Station (mins)	(mins)	(max)	p hr
Khandallah		42				40				41			
Strathmore		71				78				58			
	43/44	113	30	4	2	118	30/60	4	2	99	30/60	4	2
Mairangi		45				30				30			
Houghton Bay/Southgate		65				57				61			
	22/23	110	30	4	2	87	30/60	4	2	91	30/60	4	2
Wilton		31				32				31			
Hataitai		54				44				44			
Rongotai (ex Hataitai)		20				18				18			
	14	105	30	4	2	94	30	4	2	93	30	4	2
Highbury via Kelburn		33											
Mt Victoria		45											
	20	78	60	2	1								
Vogelton, Farnham St loop	21	51											
Karori Mall via Glenmore St	21	33											
		84	60	2	1								
Miramar Heights via Evans Bay	24	94	60	2	1								
Johnsonville to John St	47	84	60	2	0								
Sub Total				20	9		30	12	6		30	12	6
Aro St	9	35	30	2	2								
Kingston	7	52	20	3	3	48	20	3	3	40	30	2	2
Kowhai Pk	8	49	60	1	1								
Total				26	15			15	9			14	8
All Listed Services - Current Services -Total Buses/CBD trips													
				64	40			43	27			36	22
J Round trip John St to Johnsonville													
CBD Trips Trips in one direction over one hour													
Rd Trip Time Round trip travel time, suburban terminus to Railway Station (in minutes) (DOES NOT INCLUDE LAYOVER TIME AT TERMINALS)													

Table 8, Page 2

D NON Core Route Linkings PROPOSED SERVICE													
Destination	Route No	Monday to Friday Interpeak				Saturday				Sunday			
		Rd Trip Time ex Station	Frequency (min)	No Of Buses	CBD Trips p hr	Rd Trip Time ex Station	Frequency (min)	No Of Buses Max	CBD Trips p hr	Rd Trip Time ex Station	Frequency (min)	No Of Buses Max	CBD Trips p hr
Highbury, Aro St to Khandallah	K	94	30	3	2	94	30/60	3	2	94	60	2	1
Johnsonville, Mairangi, Railway Stn	M	72	30	3	0	72	30/60	3	0	72	60	2	0
Wilton to Hataitai	O	85	30	3	2	85	30	3	2	85	30/60	3	2
Karori Mall, Kelburn, C Plce, Mt Vic	L	70	30	3	0	70	30/60	3	0	70	60	2	0
subtotal				12	4			12	4			9	3
Broadmeadows to Miramar Hights	P	150	60	2	2	150	60	2	2	150	60	2	2
Strathmore, to Kilbirnie	Q	24K	30	1	0	22	30/60	1	0	28	60	1	0
Newtown to Houghton Bay	A1	33N	30	2	0	33N	30/60	2	0	33N	60	1	0
Newtown, Southgate, Brooklyn	H	65N	30	2	0	65N	30/60	2	0	65N	60	1	0
Vogeltown, Kingston, Railway Stn	I	70	30	2	2	70	30/60	2	2	70	30/60	2	2
Kowhai Park to Brooklyn	J	18B	30	1	0	18B	30/60	1	0	18B	60	1	0
Total No of Buses				22	8			22	8			17	7
B Round Trip Time from Brooklyn Shops to Kowhai Pk & return													
K Round Trip time from Kilbirnie to Strathmore & return													
N Round trip time from Newtown to Houghton Bay/Brooklyn & return													
Non Core Routes - Comparison of Buses required Current to Proposed				-4	-7			7	-1			3	-1
All Listed Services - Proposed Services - Total Buses/CBD Trips				56	26			46	19			39	19
Change to Buses Required Core and other Routes and CBD Trips				-8	-14			3	-8			3	-3

Table 9

Proposed Units in Transport Plan for PTOM Contracts		Alternative - Trolleybus Retention	
Units	Routes	Units	Routes
Unit 1 North - South	A Churton Pk, Johnsonville , CBD, Island Bay A1 Houghton Bay, CBD, Station (M-F Peak Hrs) B Houghton Bay - Newtown local service B1 Houghton Bay, Newtown, CBD Station (M- F Peak Hours) R Churton Pk - Johnsonville local service R1 Churton Pk, Johnsonville - Brandon St (M-F Peak Hrs)	Trolleybus Unit	A(Part) CBD,Island Bay C Karori CBD, Hataitai, Kilbirnie, Miramar - Seatoun F Lyall By/Rongotai, Kilbirnie, Newtown, CBD - Station F1 Lyall Bay, Hataitai, CBD - Station (M-F Peak Hr service) I Station, Wills/Victoria Sts, Brooklyn - Kingston/Vogeltown
Unit 2 East - West	C Karori CBD, Hataitai, Kilbirnie, Miramar - Seatoun C1 Scorching Bay Seatoun, CBD- Station (M- F Peak Hour Express) C2 Moa Point, Seatoun, CBD - Station (M-F Peak Hour Express) C3 South Karori, Karori, CBD -Coutenay Place (M-F Peak Hrs) C4 Karori West, Karori, CBD -Coutenay Place (M-F Peak Hrs) C5 Beacon Hill Shuttle, peak hour local service D Miramar - Miramar Shops, local service, daily D1 Miramar North, Miramar, CBD - Station (M-F Peak Hour Express) Q Strathmore Pk, Miramar - Kilbirnie ,local service, daily Q1 Strathmore Pk, Miramar, Kilbirnie, Hataitai, CBD - Station (M-F Peak hour service)	Unit 1 North - South	A1 Houghton Bay, CBD, Station (M-F Peak Hrs) B Houghton Bay - Newtown local service B1 Houghton Bay, Newtown, CBD Station (M- F Peak Hours) R Churton Pk - Johnsonville local service R1 Churton Pk, Johnsonville - Brandon St (M-F Peak Hrs) A (Part) Johnsonville,CBD
Unit 3 University	L Karori, Kelburn, Te Aro, Courtenay Plce - Mt Victoria, daily service M Johnsonville, Crofton Downs, Wilton,Kelburn - Station local daily service M1 Mairangi, Northland, Glenmore St - Brandon St (M-F Peak Hrs)	Unit 2 East - West	C1 Scorching Bay Seatoun, CBD- Station (M- F Peak Hour Express) C2 Moa Point, Seatoun, CBD - Station (M-F Peak Hour Express) C3 South Karori, Karori, CBD -Coutenay Place (M-F Peak Hrs) C4 Karori West, Karori, CBD -Coutenay Place (M-F Peak Hrs) C5 Beacon Hill Shuttle, peak hour local service D Miramar - Miramar Shops, local service, daily D1 Miramar North, Miramar, CBD - Station (M-F Peak Hour Express) Q Strathmore Pk, Miramar - Kilbirnie ,local service, daily Q1 Strathmore Pk, Miramar, Kilbirnie, Hataitai, CBD - Station (M-F Peak hour service)
Unit 4 Khandallah & Aro Valley	K Highbury, Aro Valley, Willis/Victoria St, Station, Ngaio - Khandallah, local daily service K1 Ngaio - Brandon St (M-F, Peak Hr Service) P Johnsonvill, Broadmeadows, Khandallah, CBD, Evans Bay - Mapuia , local daily service	Unit 3 University	L Karori, Kelburn, Te Aro, Courtenay Plce - Mt Victoria, daily service M Johnsonville, Crofton Downs, Wilton,Kelburn - Station local daily service M1 Mairangi, Northland, Glenmore St - Brandon St (M-F Peak Hrs)
Unit 5 Central	O Wilton, Wadestown, CBD, Roseneath - Hataitai, local daily service	Unit 4 Khandallah & Aro Valley	K Highbury, Aro Valley, Willis/Victoria St, Station, Ngaio - Khandallah, local daily service K1 Ngaio - Brandon St (M-F, Peak Hr Service) P Johnsonvill, Broadmeadows, Khandallah, CBD, Evans Bay - Mapuia , local daily service
Unit 6 Taranaki	F Lyall By/Rongotai, Kilbirnie, Newtown, CBD - Station F1 Lyall Bay, Hataitai, CBD - Station (M-F Peak Hr service)	Unit 5 Central	O Wilton, Wadestown, CBD, Roseneath - Hataitai, local daily service
Unit 7 Brooklyn & Owhiro Bay	H Newtown, Southgate, Qwhiro By - Brooklyn local daily service H1 Owhiro Bay, Brooklyn, Willis/Victoria Sts -Station (M-F Peak Hr service) H2 Southgate, Newtown,CBD - Station (M-F Peak Hr Service) I Station, Wills/Victoria Sts, Brooklyn - Kingston/Vogeltown J Kowhai Pk - Brooklyn, local daily service J1 Kowhai Pk, Brooklyn, Willis/Victoria Sts - Station (M-F Peak Hr service)	Unit 6 Taranaki	F Lyall By/Rongotai, Kilbirnie, Newtown, CBD - Station F1 Lyall Bay, Hataitai, CBD - Station (M-F Peak Hr service)
Unit 8 Newlands	G Johnsonville, Woodridge, Newlands, CBD - Courtenay Place G1 Johnsonville, Newlands - Courtenay Place (M- F Peak Hrs only) G2 Woodridge, Newlands - Courtenay Place (M- F Peak Hrs only) G3 Baylands, Newlands - Courtenay Place (M- F Peak Hrs only)	Unit 7 Brooklyn & Owhiro Bay	H Newtown, Southgate, Qwhiro By - Brooklyn local daily service H1 Owhiro Bay, Brooklyn, Willis/Victoria Sts -Station (M-F Peak Hr service) H2 Southgate, Newtown,CBD - Station (M-F Peak Hr Service) J Kowhai Pk - Brooklyn, local daily service J1 Kowhai Pk, Brooklyn, Willis/Victoria Sts - Station (M-F Peak Hr service)
Airport (Current Commercial Service)	E Airport Flyer, (daily exempt service)	Unit 8 Newlands	G Johnsonville, Woodridge, Newlands, CBD - Courtenay Place G1 Johnsonville, Newlands - Courtenay Place (M- F Peak Hrs only) G2 Woodridge, Newlands - Courtenay Place (M- F Peak Hrs only) G3 Baylands, Newlands - Courtenay Place (M- F Peak Hrs only)
		Airport (Current Commercial Service)	E Airport Flyer, (daily exempt service)

Table 10, Page 1

Pollution (NOx & Particles)		Pollution (CO2)	
Pollution Scale		Pollution Scale	
HIGH ↓	Pollution Levels Northern Hemisphere	HIGH ↓	Diesel Engines Euro 1 to Euro 6
	Pollution Levels New Zealand		Hybrid Fuel Economy Savings
	Euro 1 Diesel		Euro diesel emission controls not targeted at CO2
	Euro 2 Diesel		
	Euro 3 Diesel		
	Euro 4 Diesel		
	Euro 5 Diesel		
	Euro 5 Diesel Electric Hybrid		
	Presumed Fuel Consumption of Hybrid 25% less		
↑	Euro 6 Diesel	↑	
LOW	Euro 6 Diesel Electric Hybrid	LOW	
0	Presumed Fuel Consumption of Hybrid 25% less	0	
	Trolleybus or Electric Bus		Trolleybus or Electric Bus
	Nil Pollution on Site, around 80% of National Grid power from renewables		CO2 not emitted on site, around 80% of National Grid power from Renewables

Table 11

BUS MOTIVE POWER OPTIONS – Comparison of various types and attributes

This table (2 pages) provides an outline of the main types of motive power that can be used in buses intended for use in city transit use generally with a focus on Wellington. Costs of buses are indicative only.

Common Name	Description / Power source	Technology status/ Cost per bus	Emissions	Advantages	Disadvantages
<u>Diesel Bus</u>	Diesel engine provides direct drive. (A non-electric option)	Mature & proven /\$400k-\$450k new	High	<ul style="list-style-type: none"> - Cheaper capital costs - Operating costs dependent on price of diesel. - Readily available in marketplace - Cheaper than hybrids to operate - 15 year proven lifetime expectancy 	<ul style="list-style-type: none"> - High emissions, - Costly to lower NOX and particles, and CO2 emissions (Improvements not reducing CO2) - Noise - Operating costs dependent on price of diesel. - Maintenance cost higher than electric motors.
<u>Electric Bus</u> (Hybrid option with diesel engine)	Battery drives electric motor. Diesel engine charges battery or provides an additional direct drive. (A partial electric option)	Developing /\$600k - \$650k new	Moderate, compared to diesel bus	<ul style="list-style-type: none"> - Use of battery designed to cut down diesel fuel use - Reduces fuel use and emissions - Drive wheel located electric motors ensures lighter mechanical components (if provided). - Potentially smaller diesel motor if for generator only. 	<ul style="list-style-type: none"> - Higher capital cost (\$600/\$650k) - Weight of batteries reduces passenger capacity - Reliability of components over longer operating life unknown - Battery maintenance and replacement costs
<u>Electric Bus</u> (Hybrid option with turbine engine) (eg Wright-speed)	Battery drives electric motor. On-board Turbine engine charges battery (A partial electric option)	Early stages of development for urban transport. New/ modification costs unknown	Moderate to Low (depending of fuel used for turbine generator, and use of charging stations)	<ul style="list-style-type: none"> - Potentially lower emissions compared to any diesel option. - Turbine use can be reduced if battery charging stations used as well. 	<ul style="list-style-type: none"> - Technology in early stages of use. - Costs not quantified for new or existing vehicle modifications - Battery maintenance and replacement costs - Turbines usually lower efficiency than new diesels - Turbines may have high operating costs. - Additional layover time for battery charging may be required? - Weight of additional batteries (if needed) may reduce passenger capacity?

Common Name	Description / Power source	Technology status/ Cost per bus	Emissions	Advantages	Disadvantages
Electric Bus (Battery only)	Battery drives electric motor. 100% re-charging from grid power supply. (An all electric option)	Developing /\$900k new Early stages in Europe (1 st big order for 50 due to start in London late 2016)	Zero or Low emissions	- Zero tailpipe emissions - Low total emissions (depending on power grid renewable %) - Lower maintenance costs (less moving parts) but this is off-set by need to replace batteries periodically. - Electric motors <u>if located</u> in each drive wheel may reduce overall weight	- Considerably higher purchase costs (say \$900k) - Distance run between battery re-charge stops is limited, so longer running times may require greater battery capacity and weight. - Heavy battery weight (eg. to gain higher running distance between charges) will reduce passenger capacity. - Higher life operating costs due to need for periodic replacement of batteries. - Battery management/maintenance costs. - Needs suitable charging systems located at depots and some layover bus stations - Additional layover time for battery re-charging may be required – (additional vehicles may be required to cover these layover times) - High mains power inputs needed to charge fleet of buses (expensive to install and capacity problems may exist at some sites?)
Trolleybus	Power from overhead wires (with on-board battery for short off-wire operation) (An all electric option)	Mature / proven. Extended distance battery use under development	Zero tailpipe / Low total from grid	- Zero tailpipe emissions - Low total emissions (depending on power grid renewable %) - 20 to 25 year lifetime expectancy - Economical long term operating costs particularly for high density routes. - Battery recharged from overhead - Long infrastructure lifetime.	- Fixed overhead wires and power supply infrastructure - Higher capital costs (but over longer lifetime) - New buses expensive - Captive to wired routes (except for limited runs under battery power) - Battery maintenance and replacement costs (particularly if off-wire running distances not properly managed)

Notes re Batteries. Battery technology for heavy commercial vehicles is advancing but all types have limitations on life expectancy. 5-7 years is often claimed for in city use but operating experience shows that practically this may not be realistic at this stage, particularly for intensive service use. The service life for most types of batteries (including Lithium Iron) is generally dependent on the following factors;

- Charging rates – regular fast charging can stress the battery and reduce battery life.
- Depth of discharge – regular deep discharging (that uses up the bulk of battery capacity) significantly reduces battery life
- Operating environment – e.g. heat build-up can limit battery life, auxiliary loads (eg air con) can contribute to greater battery discharge.

Lithium-iron batteries need carefully designed “battery management systems” to ensure power output is optimised.

AEN 19/6/2016