West London Orbital

West London Economic Prosperity Board
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Transport for London

EVERY JOURNEY MATTERS

Introduction

1. **Mayor's Transport Strategy**
2. **WLO route**
3. **Delivery Approach**
4. Programme Plan
5. What do we need to do?
6. Key Risks

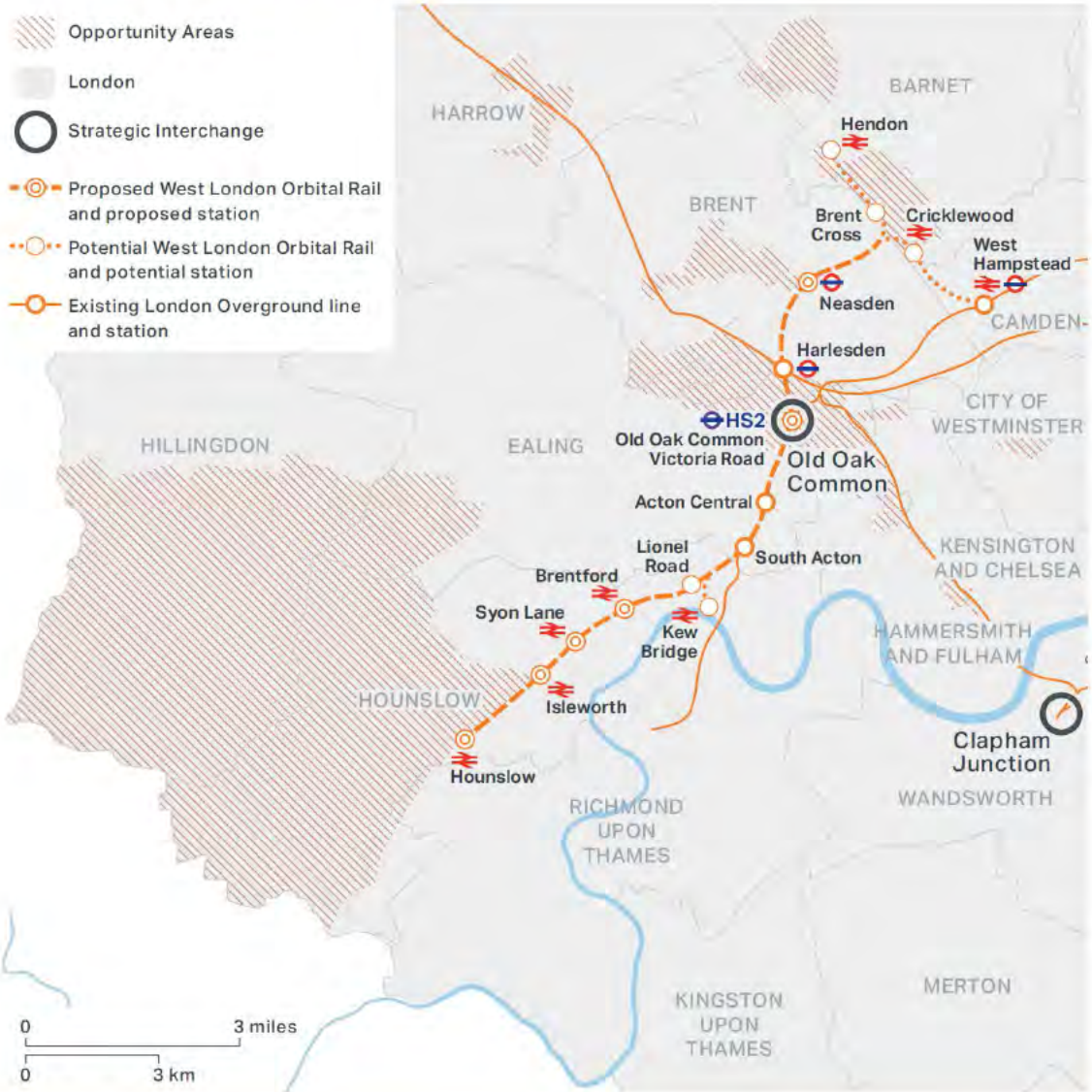
Mayor's Transport Strategy 2018

Proposal 88

The Mayor, through TfL, the West London Alliance boroughs and Network Rail, will work towards the delivery of a new London Overground 'West London Orbital' line connecting Hounslow with Cricklewood and Hendon via Old Oak, Neasden and Brent Cross.

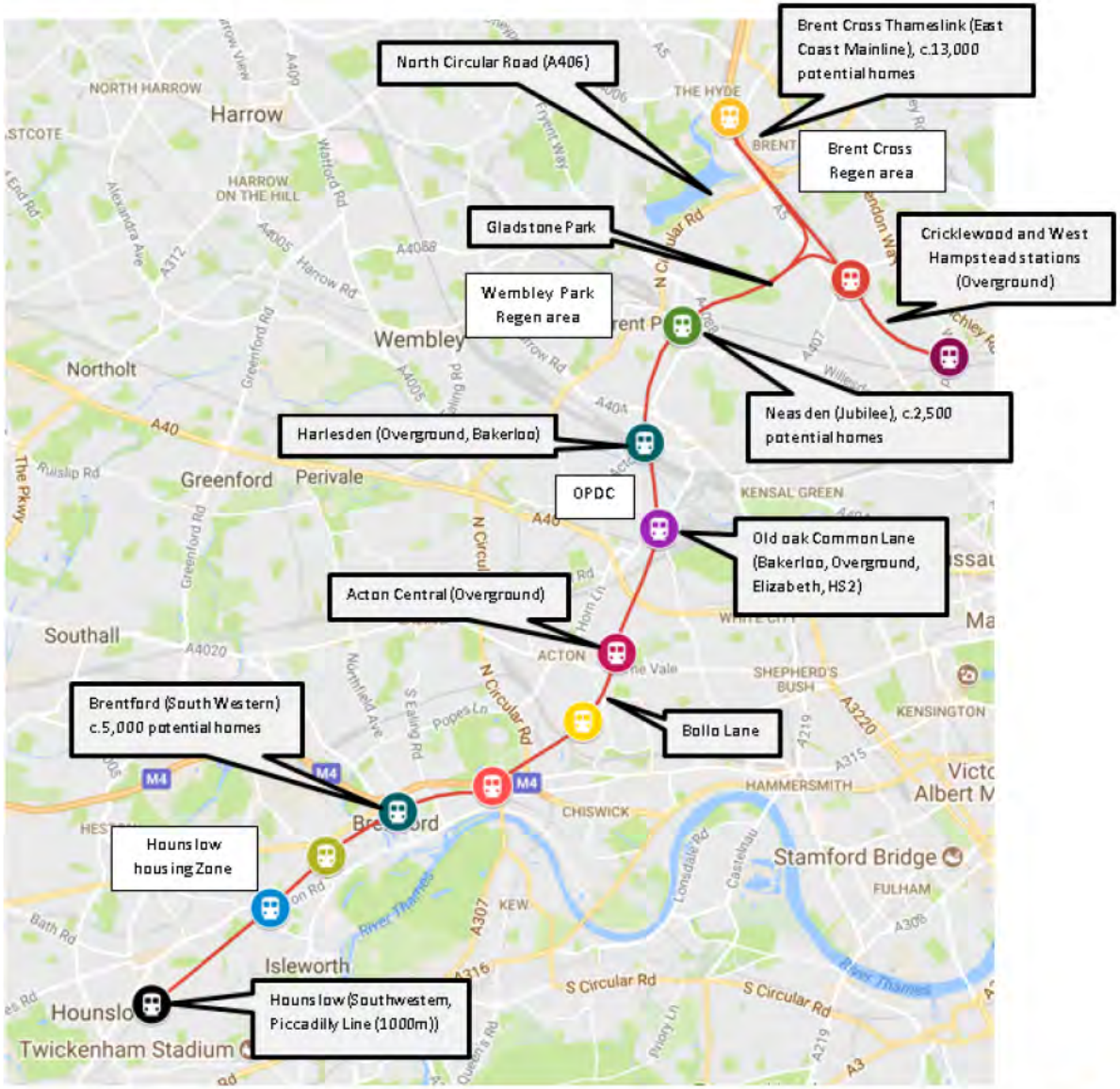
Possible connections to:

- Thameslink
- Jubilee Line
- Bakerloo Line
- Elizabeth Line
- Metropolitan Line
- Overground at West Hampstead, Harlesden
- National Rail at Brent Cross West(TBC), Brentford to Hounslow

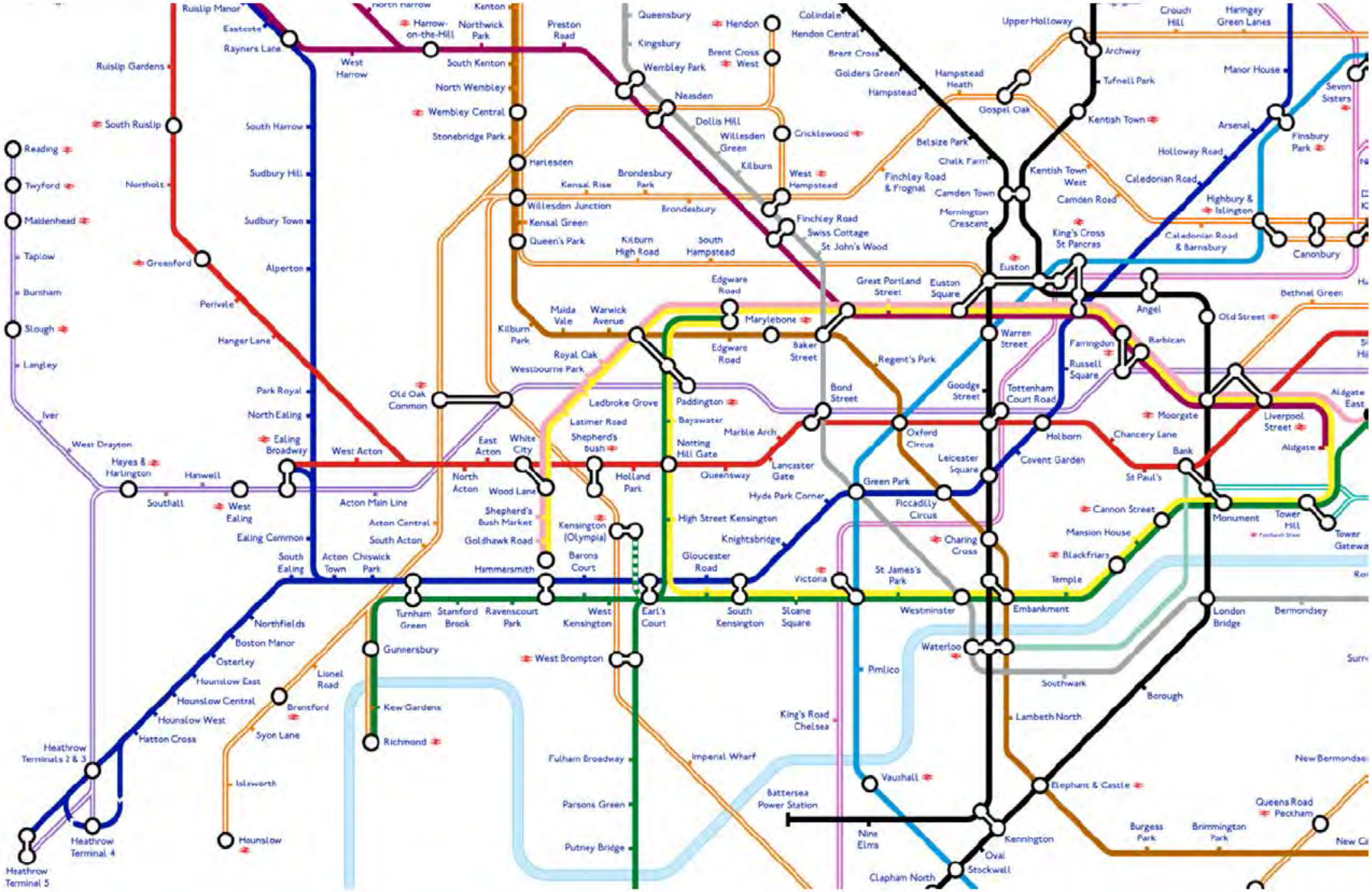


West London Orbital Route

WLO route including potential stations and links to and new housing sites



Connections to other lines



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Wide ranging public and political support

- Cross borough (and party) support across west London
- Mayor and deputy mayor support as demonstrate by the letter to the borough leaders and MTS press release
- Very positive local and regional press coverage
- Strong support with local residents
- Ongoing liaison, consultation and engagement will be necessary to ensure continued support

How can this be delivered?

Joined up working will be key

Three emerging strands:

1. Rail project (TfL led, significant council involvement)
2. Regeneration, place-making, complementary measures (council led, TfL support)
3. Funding development for preparatory planning (jointly led)

Governance: Project to be overseen by a cross-organisation programme board, with delivery led by a cross-agency delivery team

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West London Alliance
IMPROVING OUTCOMES FOR WEST LONDON

NetworkRail

Project Delivery Overview

Stage 1 - Current Phase (6 months up to Autumn 2018)
Review and Update existing work, confirm desired outcomes

Stage 2 - Next Phase (9-12 months)
Further Design work (GRIP 2), Business Case development and public consultation

Stage 3 - Future Phase (18-24 months)
Scheme development to single preferred option (GRIP 3 & 4) and more public consultation

Stage 4 - Future Phase (12-18 months)
Transport & Works Act Order (or similar) preparation and submission

Project Delivery – Immediate Deliverables

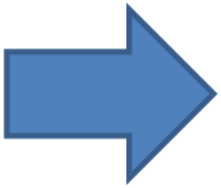
Review work undertaken to date including the published business case, technical feasibility and cost estimates and update as appropriate

Phase 1: 6-9 months work to review and update and develop current studies.

TfL commitment of c£230k to carry out this work

Key deliverables:

- Updated transport modelling and demand forecasting report
- Baseline technical report (including timetabling)
- Network Rail GRIP 1: Output definition report
- Funding and Financing study
- Land assembly report
- Consents strategy
- Development capacity study
- Communications and engagement plan



Updated Business Case Autumn 2018

Delivered by TfL working with local authorities and Network Rail

Key Risks

- Identifying funding for scheme development and construction (CIL, MCIL, TfL, GLA, DfT, Planning Delivery Fund, HIF 2 etc)
- Level crossings at Bollo Lane, Acton Wells 4-tracking, congestion along southern half of scheme
- Unlocking new opportunity areas in discussion with GLA
- Reducing any operating subsidy that is a characteristic of orbital infrastructure that does not cut across fare zones.

All have possible ways forward – no show-stoppers identified to date

What do councils now need to consider/do?

1. Continue to embed the scheme into Local Plans. Specifically:
    - Reg 18 and 19 consultations
    - Strategic narrative and vision/master planning around stations
    - Complementary measures
1. Work with GLA to secure funding contributions, e.g. HIF 2 funding when announced later in 2018.
2. Incorporate into Corporate Plans
3. Commence work on land assembly along the line – to be led by consultants via funding study (match funding from TfL being sought)
4. Be ready to contribute strategic input (officer time)
5. Prepare planning and transport functions for WLO-related applications and activity

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Network Strategy & Capacity Planning– Capability and Capacity Analysis

Hounslow - Old Oak Common Timetable Study Report

Arthur Velavs

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Toby Saint-Clair	Date 08/02/2017
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DOCUMENT ADMINISTRATION

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Reviewers			
Version	**Date**	**Reviewer(s)**	**Review Notes**
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Ref.	**Document Name**	**Date**
001	Hounslow – Old Oak Common Timetable Study Remit	07/2016
002	Brentford Community Stadium Exhibition (website)	-
003	Southern Rail Access to Heathrow Feasibility Study	12/2015
004	2018 Train Planning Rules v1	10/2016
005	Bplan (NR website)	10/2017

Stakeholders	
Name	**Company**
Jill Stone – Senior Development Manager	Network Rail – Network Strategy & Planning
Mark Frost – Head of Traffic & Transport	Hounslow Borough Council

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Abbreviations	
Acronym	**Meaning**
CP5	Control Period 5
CP6	Control Period 6
GWML	Great Western Main Line
GRIP	Guide to Rail Investment Process
HS2	High Speed 2
IRT	Indicative Running Time
ITSS	Indicative Train Service Specification
ITT	Indicative Timetable
LOROL	London Overground Operations Limited
NIM	National Infrastructure Model (NIM)
NLL	North London Line
SOAR	Sale Of Access Rights
SRAtH	Southern Rail Access to Heathrow
SRT	Sectional Running Time
TfL	Transport for London
tph	Trains per hour
TPRs	Timetable Planning Rules
TPS	Timetable Planning System
WTT	Working Timetable

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1. Introduction

1.1. Background

The Old Oak Common area in West London is due to undergo a transformational change over the coming decades, which will be triggered by the construction of one of the largest railway hubs in the country. The High Speed Two (HS2) project is proposing to construct the new station which would link HS2 to both the Great Western Main Line and Crossrail. On the back of this, Transport for London (TfL) is proposing to construct two new London Overground stations, allowing access from the Old Oak Common hub to the North London Line (NLL) and West London Line (WLL).

Situated only a few miles to the south west of Old Oak Common, Hounslow is well located to take advantage of this development. Hounslow Borough Council proposes a direct rail link between Hounslow and the projected NLL Old Oak Common station. The Council is also proposing a new railway station at Lionel Road to serve Brentford Football Ground.

The Council aspire to achieve four trains per hour (tph) between Hounslow and the proposed NLL Old Oak Common station, calling at existing stations and the new Lionel Road station.

1.2. Aims & Objectives

Though rail infrastructure exists between South Acton and Brentford in the form of Kew branch, it is solely used by freight services. The Capability & Capacity Analysis Team examined the suitability of using enhanced infrastructure between Hounslow and the proposed NLL Old Oak Common station to run passenger shuttle services. The aim of this study is identify the feasibility of providing four shuttle paths per hour in each direction between Hounslow and the NLL Old Oak Common station. Should this be unachievable, Capability & Capacity Analysis will advise on the changes necessary to allow implementation of the shuttle services. Capability & Capacity Analysis will further advise on the compatibility of the project with the existing network and wider service aspirations.

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1.3. Geographic Scope

Figure 1: Diagram illustrating the route between Hounslow and Willesden Junction (proposed location for NNL Old Oak Common station), including the proposed location of the new Lionel Road station

The Hounslow – Old Oak Common Timetable Assessment study has examined the section of track between Hounslow and Willesden High Level Junction, including the Hounslow Line (SW230), Kew branch (SW240/EA1330) and the North London Line (EA1310).

The study further examined interaction between the Hounslow Line (SW230) and the Main Line (SW210) to establish the best location of turnback for shuttle services.

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2. Assumptions & Methodology

2.1. Assumptions

Time period assumptions

The high peak hour is defined as trains arriving at London Waterloo between 08:00 and 08:59.

Train service assumptions

The baseline train service assumptions should be the end of the Control Period 6 (CP6) train service assumptions on the Windsor Lines and North London Line which are listed as the core service assumptions below.

The Wessex Route Study also outlines an alternative use of the Windsor Lines which should be tested as sensitivity. This is also outlined below.

Windsor Lines – core service assumptions

- High peak hour - 8tph stopping passenger trains in both directions between London Waterloo and beyond Feltham
    - 8tph consisting of the current 4tph that operate over the Hounslow Loop plus an additional 2tph provided in CP5 and 2tph provided in CP6
    - As a turnback is now no longer being provided at Hounslow by any current projects (Feltham Re-signalling or Wessex Capacity Programme) it is assumed that all additional services will operate to destinations beyond Feltham, for instance Windsor & Eton Riverside.
    - For the purposes of this study infrastructure beyond Feltham should not be modelled
- Off-peak – 6tph passenger trains in both directions between London Waterloo and beyond Feltham
    - 6tph consisting of the current 4tph that operate over the Hounslow Loop plus an additional 2tph that will be provided in CP5/ CP6 (off-peak service requirement to be agreed through the franchise)
    - 2tph freight paths to be assumed in addition to the 6tph passenger services
    - As a turnback is now no longer being provided at Hounslow by any current projects (Feltham Re-signalling or Wessex Capacity Programme) it is assumed that all additional services will operate to destinations beyond Feltham, for instance Windsor & Eton Riverside.
    - For the purposes of this study infrastructure beyond Feltham should not be modelled

Windsor Lines – sensitivity

The Wessex Route Study outlined an option to run semi-fast Windsor Line services via the Hounslow Loop in the high peak hour (assumed to be services from Reading) to achieve comparable journey times to those offered by services via Richmond.

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It is assumed that this will result in passengers from Feltham and beyond spreading out across Hounslow Loop and Richmond services thereby freeing up train passenger capacity on services via Richmond.

Assumptions are as follows:

- High peak hour - 8tph passenger trains in both directions between London Waterloo and beyond Feltham
    - 8tph consisting of 6tph stopping services and 2tph semi-fast services
    - 2tph semi-fast services to stop at Hounslow and Brentford only

North London Line– core service assumptions

Peak – 5tph passenger trains in both directions between Stratford and Richmond

1tph freight service (origin – destination as per today's WTT)

Off-peak – 4tph passenger trains in both directions between Stratford and Richmond

2-3tph freight services (origin – destination as per today's WTT)

Infrastructure assumptions in all scenarios

Assume infrastructure as per the end of CP5 with the following exceptions:

- Assume Old Kew Junction is doubled;
- Assume Kew branch is electrified;
- Assume a new station at Old Oak Common Lane as per TfL's GRIP 3 drawings (attached in Appendix A);
- Assume provision of a turnback in the Old Oak Common Lane station area.

Rolling Stock assumptions

Assume the following in terms of rolling stock:

- Assume the NLL services and the additional services to meet London Borough of Hounslow's aspirations are operated as Class 378 London Overground 5-car units (as per those operated by LOROL)
- Assume that current services that operate over the Hounslow Loop are as follows:
    - London Waterloo to London Waterloo services are 10-car Class 707 units
    - Weybridge to London Waterloo services are 10-car Class 707 units
    - Reading to London Waterloo services (sensitivity option only) are 10-car Class 458 units

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2.2. Methodology

2.2.1. Infrastructure Model Set-up

Sectional Running Time (SRT) is the official time it takes for a train to travel between two locations on the rail network. As the Kew branch is currently used by freight services only, there are no passenger SRTs connecting the SW230 (Hounslow line) and EA1310 (NLL) routes. Furthermore, the study assumes a number of proposed infrastructure upgrades which have no SRTs associated with them. In order to estimate these missing SRTs, the existing National Infrastructure Model (NIM) was updated in RailSys to derive the Indicative Running Times (IRTs) to be used as a substitute for SRTs.

A two-platform Lionel Road station has been added between Old Kew Junction and Kew East Junction. The location for this station was estimated based on the Brentford Community Stadium exhibition brochure and Google Maps. A two platform NLL Old Oak Common Station has been added between Acton Wells Junction and Willesden Junction High Level. The location for this station has been estimated based on the diagrams provided by Transport for London (TfL).

In order to illustrate the timetable for analysis, the same infrastructure upgrades have been made for the national model in the Train Planning System (TPS).

2.2.2. IRT calculation

The new RailSys infrastructure model was used to generate IRTs for Class 378 services travelling between Hounslow and the proposed NLL Old Oak Common station.

2.2.3. Timetable Assessment

A Timetable Planning System (TPS) project was created based on the Principal 2017 Production timetable. As there was no information available on the CP5/CP6 Hounslow Loop uplift, the timetable was examined to establish the potential time slots for additional services specified in the Indicative Train Service Specification (ITSS) for the South-Western Franchise. The decision was made to fit the additional franchise services around the existing Hounslow Loop services and the new shuttle services delivered as part of this study.

2.2.4. Infrastructure Assessment

Infrastructure was examined to establish whether it is possible to run 4tph or 2tph shuttle services between Hounslow and NLL Old Oak Common.

2.2.5. Recommendations

Based on the infrastructure analysis, recommendations were made for the best possible locations for turnback of the shuttle services. Further recommendations were made to improve the feasibility of delivery of the shuttle services and reduce performance risk.

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3. Project Findings

3.1. IRT calculation results

The following tables summarise the IRTs derived for Class 378 shuttle services running between Hounslow and NLL Old Oak Common stations:

Depart	Arrive	Stop type	IRT
Hounslow	Isleworth	stop to stop	2.5
Isleworth	Syon Lane	stop to stop	1.5
Syon Lane	Brentford	stop to stop	1.5
Brentford	Old Kew Junction	stop to pass	1
Old Kew Junction	Lionel Road	pass to stop	1.5
Lionel Road	Kew East Junction	stop to pass	0.5
Kew East Junction	South Acton Junction	pass to pass	1.5
South Acton Junction	South Acton	pass to stop	0.5
South Acton	Acton Central	stop to stop	1.5
Acton Central	Old Oak Common NLL	stop to stop	2.5
Total Journey Time (excluding dwell)			14.5

Table 1: Class 378 IRTs for services travelling from Hounslow to Old Oak Common NLL

Depart	Arrive	Stop type	IRT
Old Oak Common NLL	Acton Central	stop to stop	3
Acton Central	South Acton	stop to stop	1.5
South Acton	South Acton Junction	stop to pass	0.5
South Acton Junction	Kew East Junction	pass to pass	0.5
Kew East Junction	Lionel Road	pass to stop	1.5
Lionel Road	Old Kew Junction	stop to pass	1
Old Kew Junction	Brentford	pass to stop	2
Brentford	Syon Lane	stop to stop	1.5
Syon Lane	Isleworth	stop to stop	1.5
Isleworth	Hounslow	stop to stop	2
Total Journey Time (excluding dwell)			15

Table 2: Class 378 IRTs for services travelling from Old Oak Common NLL to Hounslow

To ensure validity, the derived IRTs have been compared to the SRTs of similar services currently operating along SW230 (Hounslow line) and EA1310 (NLL) routes. No significant differences were found.

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3.2. Timetable Assessment

3.2.1. Additional assumptions

The timetable was assessed to establish current capacity usage along the Hounslow – Old Oak Common NLL service path. Timetable Planning Rules (TPRs) were used to examine whether it is possible to compliantly plan the additional shuttle services as well as the CP6 uplift (increase from 18 to 20tph on the Windsor Lines, with 8tph on the Hounslow Loop). The prominent TPRs are headway, junction margin and turnround values.

A number of assumptions were made in relation to the new infrastructure. As there were no values for turnround times either at Hounslow or Old Oak Common NLL, the turnround time was assumed to be 4 minutes. The 4 minute turnround time was based on the "Minimum Turnround – Passenger Stock" table found in the Wessex section of the TPRs.

The minimum dwell time for Lionel Road was assumed to be the default 30 seconds, based on the minimum dwell of other non-major stations along the SW230 route (i.e. Syon Lane and Isleworth).

All shuttle services turning round at Hounslow and exiting Platform 2 in the Up direction conflict with Down Services entering Platform 2. To ensure compliance, the standard junction margin of 3 minutes was assumed for this move.

3.2.2. Peak hour definition

The high peak hour is defined as trains arriving at London Waterloo between 08:00 and 08:59. The average journey time between Hounslow and London Waterloo is approximately 40 minutes. In order for a service to arrive to London Waterloo between 08:00 – 08:59, this service needs to depart Hounslow between 07:20 – 08:20. This time frame was assumed to be the peak hour at Hounslow.

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3.3. Infrastructure assessment

3.3.1. Initial Assessment

Following the assessment of infrastructure along the Hounslow – Old Oak Common NLL route, Old Kew Junction was determined to be the most constraining point along the route. The doubling of Old Kew junction removed the single line conflict between Down and Up services travelling along the Kew branch. However, the crossing move between Up Hounslow services and Down Kew shuttle services remained a significant constraint. As a result, Old Kew Junction was used to determine the pattern of the Old Oak Common NLL – Hounslow shuttle services.

The second constraining point on Hounslow – Old Oak Common NLL route was determined to be South Acton Junction. Particularly, the issue was the crossing move between Down NLL services accessing Down Kew line and Up NLL services travelling to Richmond.

Since the two most constraining moves between Hounslow and Old Oak Common NLL were in the Down direction, this highlighted the Down Old Oak Common NLL – Hounslow route as a priority for developing the shuttle service pattern. The pattern was based around the Down crossing move at Old Kew Junction.

Extending the shuttle services beyond Hounslow would allow turnround on the SW210 route (i.e. Feltham or Whitton/Twickenham), but would also result in additional crossing moves between the SW230 (Hounslow line) and SW210 (Feltham/Twickenham line) routes. This would reduce the possibility of delivering the shuttle services. Therefore, the study initially concentrated on turning the shuttle services at Hounslow only, later examining the opportunities of turning the shuttle services around at Feltham, Whitton or Twickenham.

3.3.2. Viability of peak services

3.3.2.1. Journey Description

Shuttle services arrive into Platform 2, and after turning around for 4 minutes, they depart by crossing over to the Up Hounslow line at the North end of Hounslow. The resulting services arrive and depart Hounslow roughly 15 minutes apart within the peak hour. However, the arrival and departure timings in the shoulder peak hours differ from the peak hour due to the irregularity of the timetable in the morning hours.

The new Lionel Road station proves to be an advantage when timetabling in the areas of Old Kew Junction and South Acton Junction. It allows the shuttle services to extend dwell in the platform while waiting for an opportunity to make a compliant crossing at either junction. This is especially beneficial for NLL section of the route, as it allows shuttle services to arrive and depart the EA1310 (NLL) while avoiding conflicts at South Action Junction.

In order to turnround trains at Old Oak Common, a siding is necessary north of the station. The siding would be used to turn back shuttle services off the NLL while avoiding conflicts with other services. The preferred location of the sidings is north of the Old Oak Common NLL station, as this would potentially allow repurposing of the existing unused South West Sidings, and would require being looped onto the NLL.

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If minimum dwell at each station is included, the journey time between Old Oak Common NLL station and Hounslow is 25 minutes. Taking into account the 4 minute turnround time, an average return journey of the shuttle service would take just under 1 hour. This implies that at least 4 train units are necessary to run a 4tph shuttle service.

3.3.2.2. Journey Limitations

In order to fit four peak Hounslow – Old Oak Common paths into the assumed CP6 timetable, it is necessary to use minimum TPRs; junction margins and headways.

This enables four paths in the peak hours, with the 25 minute journey time described in the previous section. However, turning back shuttle services at Hounslow, with the addition of the CP6 uplift services, results in a 92% occupation of Platform 2. Such high occupation would not be accepted by the Sale Of Access Rights (SOAR) panel. Therefore, an additional platform or siding would be required at Hounslow to support the service proposition and to avoid the high occupation rate at Platform 2.

Additionally, the fact that all peak shuttle services have to be planned on minimum TPR values, headways and junction margins is a performance risk, which has the potential of causing significant secondary delay issues throughout the Wessex area. It means that if the shuttle service is delayed even slightly, it will affect other services travelling on the Hounslow line. This is a major problem, as these services have to join the highly congested SW210 (Feltham/Twickenham line) at particular times to avoid causing conflicts. The Hounslow Loop has a number of critical junctions, including Feltham Junction, Old Kew Junction and Barnes Junction. These junctions are very sensitive to changes due to congestion in the Hounslow Loop and Waterloo areas. Adding shuttle services as well as the CP6 uplift services to the Hounslow Loop, even when fully compliant, may result in breaking these junctions in the peak hours.

An additional platform or siding at Hounslow could enable the use of longer turnround times than the minimum of 4 minutes. However, in addition to an increase in journey time and the need for at least one additional unit (which would need to be accommodated on the network), this would also help mitigate delay for Hounslow – Old Oak Common journeys. It would not alleviate secondary delay spreading across the network due to the use of minimum junction margins.

Reducing the frequency of the Hounslow – OOC services to two trains per hour in the peak would still require the use of minimum junction margins, with the associated risk of spreading delay. However, it would enable more space in the timetable in the hour to potentially recover from any delays. More detailed performance analysis would be required to determine how such a timetable would build up delay and recover.

Lastly, the timings of existing services in the Hounslow area differ between the peak and shoulder peak hours. Dwell times and arrival times at Hounslow station are different between the hours. As a result, an hourly consistent pattern cannot be achieved at Hounslow. Each hour needs to be adjusted to take into account the irregularities of the morning timetable. Such a timetable may be difficult to market.

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3.3.3. Viability of off-peak services

During the off-peak timetable the problems occur at the NLL end of the route. The crossing move at Old Kew Junction and occupation of Hounslow Platform 2 are less of an issue in the off-peak, because there are less services travelling along the Hounslow Loop. On the contrary, the main constraints to delivering the shuttle services are now located along the NLL, particularly in the area of Acton Wells Junction.

The off-peak timetable around Old Oak Common NLL station is highly irregular. The freight paths around Acton Wells Junction vary considerably between off-peak hours. For example, in today's timetable between 12:00 – 13:00 there are 5 freight services travelling Up the North London Line and 1 freight service travelling Down the Kew branch. In contrast, between 14:00 – 15:00 there are 3 freight services travelling Up the North London Line but 2 freight services travelling Down the Kew branch.

As a result, it is not possible to accommodate 4tph between Hounslow – Old Oak Common NLL during the off-peak time period between 12:00 – 13:00. The maximum number of shuttle services that can be achieved between Hounslow and the proposed Old Oak Common NLL station is 3tph. This is primarily due to the freight services using Acton Wells Junction to access Acton Main Line and the sidings. Furthermore, existing freight services that travel along the Kew branch, take up additional paths that could otherwise be used by shuttle services.

As the off-peak timetable is irregular, each off-peak hour varies in the maximum number of shuttle services possible and the times at which the services can be accommodated. This means achieving a symmetrical (clockface) standard hour timetable for shuttle services across all off-peak hours is impossible; to make the timetable work, each hour would need to be individually tailored. An irregular timetable creates operational complexity and is difficult to market.

It is important to note that the situation in the off-peak period is likely to deteriorate due to the future growth in demand for freight (especially as this service would not commence until at least 2026). The current freight forecasts for the NLL expect significant growth in freight services in the area of Acton Wells Junction. With more freight services using Acton Wells Junction, even fewer paths will be available for the shuttle services.

3.3.4. Windsor Lines –sensitivities analysis

The main difference between the core services assumption and the sensitivities option is that 2 out of 8 trains per hour are now semi-fast services that stop at Hounslow and Brentford only. This implies that the semi-fast services will travel faster between Brentford and Hounslow than the stopping services.

Because the semi-fast services stop at Hounslow, they will operate like other stopping services on approach to the station. Semi-fast services will be subject to the same slow headway and platform re-occupation margins at Hounslow as the stopping services. Furthermore, all existing services (including semi-fast services) also stop at Feltham. As a result, semi-fast services will interact with the Hounslow – Feltham section just like all other stopping services.

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With the addition of the shuttle services and the CP6 uplift services, the Hounslow – Feltham section becomes very congested. As there are more stopping services on the Hounslow Loop, the semi-fast services are likely to be pathed out to fit in with the stopping services. In this case, the sensitivities option of having 2 semi-fast services is unlikely to have any significant impact on the timetable. However, it will have an impact on the journey times of the semi-fast services which may impact the viability of the Wessex Route Study option.

3.3.5. Feltham Turnround

Extending the shuttle services to Feltham results in a number of new constraints, as the shuttle services now additionally interact with Hounslow Junction and Feltham Junction.

All current services stop at Feltham station. According to the TPRs, a Down shuttle service from Hounslow would require a 7 minute break in the SW210 line services to reach Feltham. Such large intervals are rare in the peak period timetable. The available intervals rarely align with other conditions necessary to run a full shuttle services as far as Feltham Junction. The situation is worsened by existing services with extended dwell at Hounslow Platform 2.

Due to heavy traffic along the SW210 lines in the peak hour, a bay platform is necessary at Feltham. The bay platform would be used to offload the passengers and turnround the shuttle services.

Following examination of the current peak timetable, this study concluded that after extending shuttle services to Feltham it is only possible to turnround 1 shuttle service per hour in the peak period. This would require a bay platform at Feltham.

3.3.6. Whitton/Twickenham Turnround

Extending the shuttle services to Whitton or Twickenham results in a number of new constraints, as the services now additionally interact with Hounslow Junction, Whitton Junction and Twickenham Junction.

Currently, turnround of shuttle services at Whitton is impossible. The existing infrastructure prevents running of compliant shuttle services from Whitton back to Hounslow after the service turns round.

Twickenham offers several turnround options in the form of an extra platform and multiple crossings. However, Twickenham is more congested then Whitton due to the SW245 route joining from Strawberry Hill.

Existing infrastructure at Twickenham allows turnround of services in either Platform 2 or Platform 3. However, due to additional services joining via the SW245 route, along with services on the SW210 route, both platforms are highly occupied during the peak hour. Several services have extended dwell at Platform 3. As a result, a bay platform is needed to offload and turn services around at Twickenham.

It is not possible to turnround any shuttle services at Twickenham in the peak hour. Extending the shuttle services beyond Hounslow introduces too many constraints along the route, which prevent

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the shuttle service from operating. For example, several Up SW210 services are semi-fast; they skip Whitton and continue on to Twickenham. Semi-fast services limit the number of shuttle services achievable on the SW210 route due to speed differentials. Furthermore, the additional Platform 3 is mostly occupied by Up services from the SW245 route, preventing the use of it for turnround of shuttle services.

3.3.7. Southern Rail Access to Heathrow interaction

The Southern Rail Access to Heathrow (SRAtH) Feasibility Study developed a range of indicative train service specifications (ITSS) which aim to serve London Heathrow from a number of locations in the UK south. The London Waterloo – Heathrow ITSS proposes that it is possible to achieve 2tph stopping services via Richmond and 2tph stopping services via Hounslow. The Feasibility Study does not provide any timings for these proposed services.

SRAtH has no impact on the Hounslow – Old Oak Common shuttle services in the context of this study. When implemented, SRAtH services will be part of the CP6 uplift and are therefore already accounted for in this study.

It is important to note that in this study the CP6 specification fits around the Hounslow – Old Oak Common shuttle services. If the timings of SRAtH services happen to be different from the CP6 paths identified in this study, there may be substantial impacts on the findings.

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4. Recommendations

Although it is technically possible to accommodate 4tph shuttle services between Hounslow and Old Oak Common in the peak hour, this poses an unacceptable performance risk with Hounslow Platform 2 being occupied for the majority of the hour. This would therefore require a new platform or siding on the south side of Hounslow

It is difficult to address the performance risk to the Wessex network caused by the necessary use of minimum TPRS (junction margins, headways etc). Grade separation of Old Kew Junction would be highly beneficial, as it is the main constraint along the shuttle service route. A grade separation at South Acton Junction would also alleviate the issue of planning on minimum junction margins. However, even the significant investment to alleviate the constraining junctions would not mitigate the risk arising from running on minimum headways.

The main constraint that prevents running shuttle services in the off-peak hours is the movement of freight at Acton Wells Junction. This constraint could be resolved by constructing a direct connection from South West sidings to Acton Main Line, effectively separating these freight services from the NLL.

This study recommends Hounslow as the best location for the shuttle service turnback. Extending shuttle services past Hounslow to turnround at Feltham, Whitton or Twickenham results in additional constraints, which prevent delivery of the shuttle services.

In order to turnaround trains at Old Oak Common, a siding is necessary north of the station. The siding would be used to turn back shuttle services off the NLL while avoiding conflicts with other services. The preferred location of the sidings is north of the Old Oak Common NLL station, as this would potentially allow repurposing of the existing unused South West Sidings.

This study also notes the potential benefit of a timetable recast of the Inner Wessex area. The current timetable features many irregularities between the hours, such as hourly services with different dwell times at Hounslow. A recast of the timetable would potentially allow standardisation of hours, allowing for an even hourly pattern of the shuttle services. Though this would still carry the aforementioned performance risk, due to the volume of services and their interaction on the Hounslow Loop.

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5. Conclusion

Though it is possible to achieve 4tph in the peak, this requires a new platform or siding at Hounslow and carries significant performance risk of spreading delay across the network, resulting from the necessary minimum TPRs (junction margins, headways etc). Reduction of the service frequency to 2tph in the peak would still require the use of minimum junction margins, with the associated risk of spreading delay. However, it would enable more space in the timetable in the hour to potentially recover from any delays. More detailed performance analysis would be required to determine how such a timetable would build up delay and recover.

It is difficult to address the performance risk to the Wessex network caused by the necessary use of minimum TPRS (junction margins, headways etc). Grade separation of Old Kew Junction would be highly beneficial, as it is the main constraint along the shuttle service route. A grade separation at South Acton Junction would also alleviate the issue of planning on minimum junction margins. However, even the significant investment to alleviate the constraining junctions would not mitigate the risk arising from running on minimum headways.

The major constraint in the off-peak timetable is the movement of freight services at Acton Wells Junction. The off-peak timetable is highly irregular, with some hours of the off-peak timetable may accommodate 2-4tph shuttle services whereas others may not (based on today's level of freight services). This situation is likely to worsen over time due to the forecast freight growth on the route. The main constraint that prevents running shuttle services in some hours is the movement of freight at Acton Wells Junction. This constraint could be resolved by constructing a direct connection from South West sidings to Acton Main Line, effectively separating these freight services from the NLL.

The irregularities in the peak Hounslow Loop timetable and the off-peak North London Line freight paths mean it would be almost impossible to achieve a consistent pattern of Hounslow – OOC services, with each hour needing to be adjusted to take into account the wider service structure. Such a timetable may be difficult to market.

The Windsor Line sensitivities option proposed by the Wessex Route Study makes little difference in regards to running shuttle services from Old Oak Common to Hounslow. However, semi-fast services will potentially perform like stopping services in the areas where semi-fast services interact with the shuttle services. This would increase the journey times of these semi-fast services, potentially affecting the viability of the Route Study option.

It is recommended that the new shuttles services turn round at Hounslow, at the Wessex end, and a siding north of OOC station at the North London Line end. The siding would be used to turn back shuttle services off the NLL while avoiding conflicts with other services.

This study found that the CP6 uplift services fit between the existing services and the proposed Hounslow – Old Oak Common shuttle services. If the actual CP6 timetable results in different pathing assumptions, the proposed shuttle service routes will potentially become invalidated. Therefore, in order to fully establish whether the shuttle services are feasible, more precise information on the CP6 timetable would be required. Until this is known, any timetable developed for

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the Hounslow shuttles will carry this risk.

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Network Strategy & Capacity Planning– Capability and Capacity Analysis

Hounslow - Old Oak Common Timetable Study Report

Arthur Velavs

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Stakeholders	
Name	**Company**
Jill Stone – Senior Development Manager	Network Rail – Network Strategy & Planning
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Abbreviations	
Acronym	**Meaning**
CP5	Control Period 5
CP6	Control Period 6
GWML	Great Western Main Line
GRIP	Guide to Rail Investment Process
HS2	High Speed 2
IRT	Indicative Running Time
ITSS	Indicative Train Service Specification
ITT	Indicative Timetable
LOROL	London Overground Operations Limited
NIM	National Infrastructure Model (NIM)
NLL	North London Line
SOAR	Sale Of Access Rights
SRAtH	Southern Rail Access to Heathrow
SRT	Sectional Running Time
TfL	Transport for London
tph	Trains per hour
TPRs	Timetable Planning Rules
TPS	Timetable Planning System
WTT	Working Timetable

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1. Introduction

1.1. Background

The Old Oak Common area in West London is due to undergo a transformational change over the coming decades, which will be triggered by the construction of one of the largest railway hubs in the country. The High Speed Two (HS2) project is proposing to construct the new station which would link HS2 to both the Great Western Main Line and Crossrail. On the back of this, Transport for London (TfL) is proposing to construct two new London Overground stations, allowing access from the Old Oak Common hub to the North London Line (NLL) and West London Line (WLL).

Situated only a few miles to the south west of Old Oak Common, Hounslow is well located to take advantage of this development. Hounslow Borough Council proposes a direct rail link between Hounslow and the projected NLL Old Oak Common station. The Council is also proposing a new railway station at Lionel Road to serve Brentford Football Ground.

The Council aspire to achieve four trains per hour (tph) between Hounslow and the proposed NLL Old Oak Common station, calling at existing stations and the new Lionel Road station.

1.2. Aims & Objectives

Though rail infrastructure exists between South Acton and Brentford in the form of Kew branch, it is solely used by freight services. The Capability & Capacity Analysis Team examined the suitability of using enhanced infrastructure between Hounslow and the proposed NLL Old Oak Common station to run passenger shuttle services. The aim of this study is identify the feasibility of providing four shuttle paths per hour in each direction between Hounslow and the NLL Old Oak Common station. Should this be unachievable, Capability & Capacity Analysis will advise on the changes necessary to allow implementation of the shuttle services. Capability & Capacity Analysis will further advise on the compatibility of the project with the existing network and wider service aspirations.

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1.3. Geographic Scope

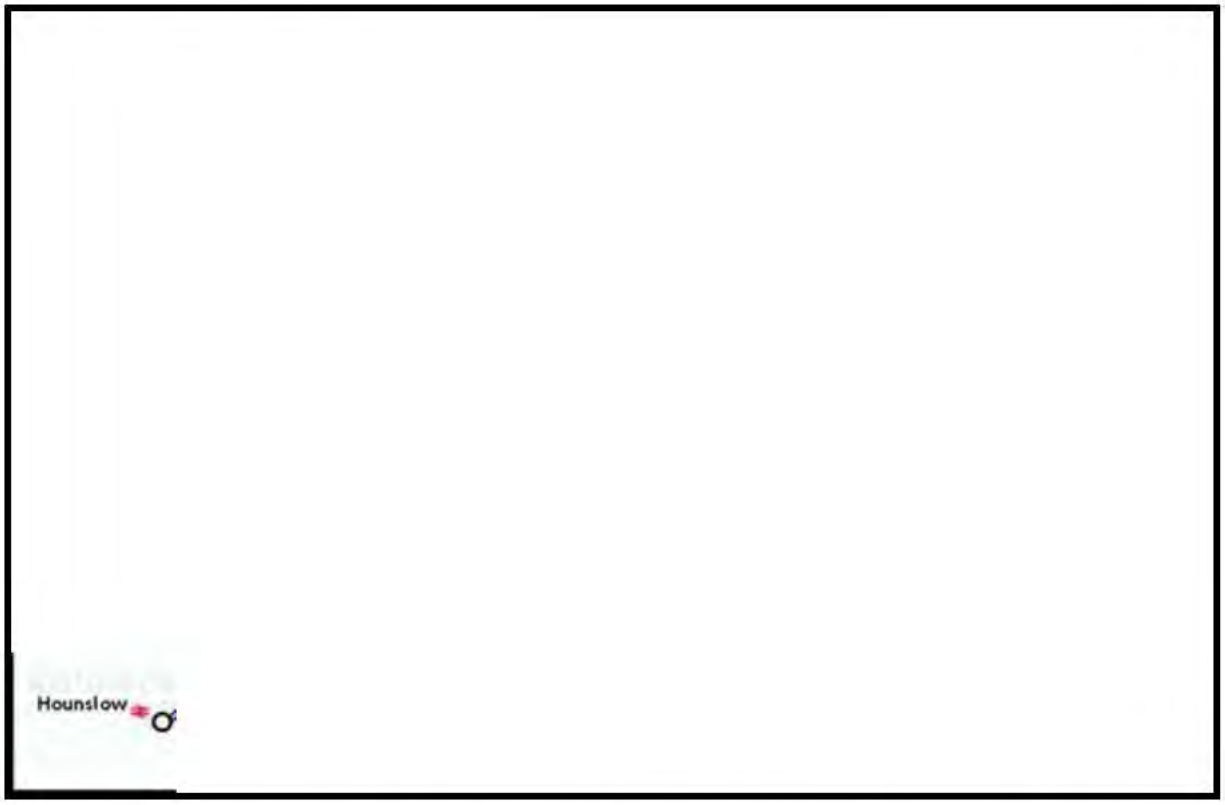

Figure 1: Diagram illustrating the route between Hounslow and Willesden Junction (proposed location for NNL Old Oak Common station), including the proposed location of the new Lionel Road station

The Hounslow – Old Oak Common Timetable Assessment study has examined the section of track between Hounslow and Willesden High Level Junction, including the Hounslow Line (SW230), Kew branch (SW240/EA1330) and the North London Line (EA1310).

The study further examined interaction between the Hounslow Line (SW230) and the Main Line (SW210) to establish the best location of turnback for shuttle services.

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2. Assumptions & Methodology

2.1. Assumptions

Time period assumptions

The high peak hour is defined as trains arriving at London Waterloo between 08:00 and 08:59.

Train service assumptions

The baseline train service assumptions should be the end of the Control Period 6 (CP6) train service assumptions on the Windsor Lines and North London Line which are listed as the core service assumptions below.

The Wessex Route Study also outlines an alternative use of the Windsor Lines which should be tested as sensitivity. This is also outlined below.

Windsor Lines – core service assumptions

- High peak hour - 8tph stopping passenger trains in both directions between London Waterloo and beyond Feltham
    - 8tph consisting of the current 4tph that operate over the Hounslow Loop plus an additional 2tph provided in CP5 and 2tph provided in CP6
    - As a turnback is now no longer being provided at Hounslow by any current projects (Feltham Re-signalling or Wessex Capacity Programme) it is assumed that all additional services will operate to destinations beyond Feltham, for instance Windsor & Eton Riverside.
    - For the purposes of this study infrastructure beyond Feltham should not be modelled
- Off-peak – 6tph passenger trains in both directions between London Waterloo and beyond Feltham
    - 6tph consisting of the current 4tph that operate over the Hounslow Loop plus an additional 2tph that will be provided in CP5/ CP6 (off-peak service requirement to be agreed through the franchise)
    - 2tph freight paths to be assumed in addition to the 6tph passenger services
    - As a turnback is now no longer being provided at Hounslow by any current projects (Feltham Re-signalling or Wessex Capacity Programme) it is assumed that all additional services will operate to destinations beyond Feltham, for instance Windsor & Eton Riverside.
    - For the purposes of this study infrastructure beyond Feltham should not be modelled

Windsor Lines – sensitivity

The Wessex Route Study outlined an option to run semi-fast Windsor Line services via the Hounslow Loop in the high peak hour (assumed to be services from Reading) to achieve comparable journey times to those offered by services via Richmond.

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It is assumed that this will result in passengers from Feltham and beyond spreading out across Hounslow Loop and Richmond services thereby freeing up train passenger capacity on services via Richmond.

Assumptions are as follows:

- High peak hour - 8tph passenger trains in both directions between London Waterloo and beyond Feltham
    - 8tph consisting of 6tph stopping services and 2tph semi-fast services
    - 2tph semi-fast services to stop at Hounslow and Brentford only

North London Line– core service assumptions

Peak – 5tph passenger trains in both directions between Stratford and Richmond

1tph freight service (origin – destination as per today's WTT)

Off-peak – 4tph passenger trains in both directions between Stratford and Richmond

2-3tph freight services (origin – destination as per today's WTT)

Infrastructure assumptions in all scenarios

Assume infrastructure as per the end of CP5 with the following exceptions:

- Assume Old Kew Junction is doubled;
- Assume Kew branch is electrified;
- Assume a new station at Old Oak Common Lane as per TfL's GRIP 3 drawings (attached in Appendix A);
- Assume provision of a turnback in the Old Oak Common Lane station area.

Rolling Stock assumptions

Assume the following in terms of rolling stock:

- Assume the NLL services and the additional services to meet London Borough of Hounslow's aspirations are operated as Class 378 London Overground 5-car units (as per those operated by LOROL)
- Assume that current services that operate over the Hounslow Loop are as follows:
    - London Waterloo to London Waterloo services are 10-car Class 707 units
    - Weybridge to London Waterloo services are 10-car Class 707 units
    - Reading to London Waterloo services (sensitivity option only) are 10-car Class 458 units

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2.2. Methodology

2.2.1. Infrastructure Model Set-up

Sectional Running Time (SRT) is the official time it takes for a train to travel between two locations on the rail network. As the Kew branch is currently used by freight services only, there are no passenger SRTs connecting the SW230 (Hounslow line) and EA1310 (NLL) routes. Furthermore, the study assumes a number of proposed infrastructure upgrades which have no SRTs associated with them. In order to estimate these missing SRTs, the existing National Infrastructure Model (NIM) was updated in RailSys to derive the Indicative Running Times (IRTs) to be used as a substitute for SRTs.

A two-platform Lionel Road station has been added between Old Kew Junction and Kew East Junction. The location for this station was estimated based on the Brentford Community Stadium exhibition brochure and Google Maps. A two platform NLL Old Oak Common Station has been added between Acton Wells Junction and Willesden Junction High Level. The location for this station has been estimated based on the diagrams provided by Transport for London (TfL).

In order to illustrate the timetable for analysis, the same infrastructure upgrades have been made for the national model in the Train Planning System (TPS).

2.2.2. IRT calculation

The new RailSys infrastructure model was used to generate IRTs for Class 378 services travelling between Hounslow and the proposed NLL Old Oak Common station.

2.2.3. Timetable Assessment

A Timetable Planning System (TPS) project was created based on the Principal 2017 Production timetable. As there was no information available on the CP5/CP6 Hounslow Loop uplift, the timetable was examined to establish the potential time slots for additional services specified in the Indicative Train Service Specification (ITSS) for the South-Western Franchise. The decision was made to fit the additional franchise services around the existing Hounslow Loop services and the new shuttle services delivered as part of this study.

2.2.4. Infrastructure Assessment

Infrastructure was examined to establish whether it is possible to run 4tph or 2tph shuttle services between Hounslow and NLL Old Oak Common.

2.2.5. Recommendations

Based on the infrastructure analysis, recommendations were made for the best possible locations for turnback of the shuttle services. Further recommendations were made to improve the feasibility of delivery of the shuttle services and reduce performance risk.

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3. Project Findings

3.1. IRT calculation results

The following tables summarise the IRTs derived for Class 378 shuttle services running between Hounslow and NLL Old Oak Common stations:

Depart	Arrive	Stop type	IRT
Hounslow	Isleworth	stop to stop	2.5
Isleworth	Syon Lane	stop to stop	1.5
Syon Lane	Brentford	stop to stop	1.5
Brentford	Old Kew Junction	stop to pass	1
Old Kew Junction	Lionel Road	pass to stop	1.5
Lionel Road	Kew East Junction	stop to pass	0.5
Kew East Junction	South Acton Junction	pass to pass	1.5
South Acton Junction	South Acton	pass to stop	0.5
South Acton	Acton Central	stop to stop	1.5
Acton Central	Old Oak Common NLL	stop to stop	2.5
Total Journey Time (excluding dwell)			14.5

Table 1: Class 378 IRTs for services travelling from Hounslow to Old Oak Common NLL

Depart	Arrive	Stop type	IRT
Old Oak Common NLL	Acton Central	stop to stop	3
Acton Central	South Acton	stop to stop	1.5
South Acton	South Acton Junction	stop to pass	0.5
South Acton Junction	Kew East Junction	pass to pass	0.5
Kew East Junction	Lionel Road	pass to stop	1.5
Lionel Road	Old Kew Junction	stop to pass	1
Old Kew Junction	Brentford	pass to stop	2
Brentford	Syon Lane	stop to stop	1.5
Syon Lane	Isleworth	stop to stop	1.5
Isleworth	Hounslow	stop to stop	2
Total Journey Time (excluding dwell)			15

Table 2: Class 378 IRTs for services travelling from Old Oak Common NLL to Hounslow

To ensure validity, the derived IRTs have been compared to the SRTs of similar services currently operating along SW230 (Hounslow line) and EA1310 (NLL) routes. No significant differences were found.

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3.2. Timetable Assessment

3.2.1. Additional assumptions

The timetable was assessed to establish current capacity usage along the Hounslow – Old Oak Common NLL service path. Timetable Planning Rules (TPRs) were used to examine whether it is possible to compliantly plan the additional shuttle services as well as the CP6 uplift (increase from 18 to 20tph on the Windsor Lines, with 8tph on the Hounslow Loop). The prominent TPRs are headway, junction margin and turnround values.

A number of assumptions were made in relation to the new infrastructure. As there were no values for turnround times either at Hounslow or Old Oak Common NLL, the turnround time was assumed to be 4 minutes. The 4 minute turnround time was based on the "Minimum Turnround – Passenger Stock" table found in the Wessex section of the TPRs.

The minimum dwell time for Lionel Road was assumed to be the default 30 seconds, based on the minimum dwell of other non-major stations along the SW230 route (i.e. Syon Lane and Isleworth).

All shuttle services turning round at Hounslow and exiting Platform 2 in the Up direction conflict with Down Services entering Platform 2. To ensure compliance, the standard junction margin of 3 minutes was assumed for this move.

3.2.2. Peak hour definition

The high peak hour is defined as trains arriving at London Waterloo between 08:00 and 08:59. The average journey time between Hounslow and London Waterloo is approximately 40 minutes. In order for a service to arrive to London Waterloo between 08:00 – 08:59, this service needs to depart Hounslow between 07:20 – 08:20. This time frame was assumed to be the peak hour at Hounslow.

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3.3. Infrastructure assessment

3.3.1. Initial Assessment

Following the assessment of infrastructure along the Hounslow – Old Oak Common NLL route, Old Kew Junction was determined to be the most constraining point along the route. The doubling of Old Kew junction removed the single line conflict between Down and Up services travelling along the Kew branch. However, the crossing move between Up Hounslow services and Down Kew shuttle services remained a significant constraint. As a result, Old Kew Junction was used to determine the pattern of the Old Oak Common NLL – Hounslow shuttle services.

The second constraining point on Hounslow – Old Oak Common NLL route was determined to be South Acton Junction. Particularly, the issue was the crossing move between Down NLL services accessing Down Kew line and Up NLL services travelling to Richmond.

Since the two most constraining moves between Hounslow and Old Oak Common NLL were in the Down direction, this highlighted the Down Old Oak Common NLL – Hounslow route as a priority for developing the shuttle service pattern. The pattern was based around the Down crossing move at Old Kew Junction.

Extending the shuttle services beyond Hounslow would allow turnround on the SW210 route (i.e. Feltham or Whitton/Twickenham), but would also result in additional crossing moves between the SW230 (Hounslow line) and SW210 (Feltham/Twickenham line) routes. This would reduce the possibility of delivering the shuttle services. Therefore, the study initially concentrated on turning the shuttle services at Hounslow only, later examining the opportunities of turning the shuttle services around at Feltham, Whitton or Twickenham.

3.3.2. Viability of peak services

3.3.2.1. Journey Description

Shuttle services arrive into Platform 2, and after turning around for 4 minutes, they depart by crossing over to the Up Hounslow line at the North end of Hounslow. The resulting services arrive and depart Hounslow roughly 15 minutes apart within the peak hour. However, the arrival and departure timings in the shoulder peak hours differ from the peak hour due to the irregularity of the timetable in the morning hours.

The new Lionel Road station proves to be an advantage when timetabling in the areas of Old Kew Junction and South Acton Junction. It allows the shuttle services to extend dwell in the platform while waiting for an opportunity to make a compliant crossing at either junction. This is especially beneficial for NLL section of the route, as it allows shuttle services to arrive and depart the EA1310 (NLL) while avoiding conflicts at South Action Junction.

In order to turn trains around at Old Oak Common, a siding is necessary north of the station. The siding would be used to turn back shuttle services off the NLL while avoiding conflicts with other services. The preferred location of the sidings is north of the Old Oak Common NLL station, as this would potentially allow repurposing of the existing unused South West Sidings. However, this would require infrastructure changes to join the southern end of South West Sidings to the South West Line and, more importantly, would require infrastructure alternations to the North London Line itself

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just north of the new Old Oak Common station to provide crossovers to access the South West Line from the station. The feasibility of this infrastructure is unknown and would need to be investigated.

Accessing the sidings is also difficult in some hours due to the number of freight movements on the North London Line. Finding four paths each way to access and egress the sidings will be challenging in hours with a high number of freight trains.

If minimum dwell at each station is included, the journey time between Old Oak Common NLL station and Hounslow is 25 minutes. Taking into account the 4 minute turnround time, an average return journey of the shuttle service would take just under 1 hour. This implies that at least 4 train units are necessary to run a 4tph shuttle service.

3.3.2.2. Journey Limitations

In order to fit four peak Hounslow – Old Oak Common paths into the assumed CP6 timetable, it is necessary to use minimum TPRs; junction margins and headways.

This enables four paths in the peak hours, with the 25 minute journey time described in the previous section. However, turning back shuttle services at Hounslow, with the addition of the CP6 uplift services, results in a 92% occupation of Platform 2. Such high occupation would not be accepted by the Sale Of Access Rights (SOAR) panel. Therefore, an additional platform or siding would be required at Hounslow to support the service proposition and to avoid the high occupation rate at Platform 2.

Additionally, the fact that all peak shuttle services have to be planned on minimum TPR values, headways and junction margins is a performance risk, which has the potential of causing significant secondary delay issues throughout the Wessex area. It means that if the shuttle service is delayed even slightly, it will affect other services travelling on the Hounslow line. This is a major problem, as these services have to join the highly congested SW210 (Feltham/Twickenham line) at particular times to avoid causing conflicts. The Hounslow Loop has a number of critical junctions, including Feltham Junction, Old Kew Junction and Barnes Junction. These junctions are very sensitive to changes due to congestion in the Hounslow Loop and Waterloo areas. Adding shuttle services as well as the CP6 uplift services to the Hounslow Loop, even when fully compliant, may result in breaking these junctions in the peak hours.

An additional platform or siding at Hounslow could enable the use of longer turnround times than the minimum of 4 minutes. However, in addition to an increase in journey time and the need for at least one additional unit (which would need to be accommodated on the network), this would also help mitigate delay for Hounslow – Old Oak Common journeys. It would not alleviate secondary delay spreading across the network due to the use of minimum junction margins.

Reducing the frequency of the Hounslow – OOC services to two trains per hour in the peak would still require the use of minimum junction margins, with the associated risk of spreading delay. However, it would enable more space in the timetable in the hour to potentially recover from any delays. More detailed performance analysis would be required to determine how such a timetable would build up delay and recover.

Lastly, the timings of existing services in the Hounslow area differ between the peak and shoulder

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peak hours. Dwell times and arrival times at Hounslow station are different between the hours. As a result, an hourly consistent pattern cannot be achieved at Hounslow. Each hour needs to be adjusted to take into account the irregularities of the morning timetable. Such a timetable may be difficult to market.

3.3.3. Viability of off-peak services

During the off-peak timetable the problems occur at the NLL end of the route. The crossing move at Old Kew Junction and occupation of Hounslow Platform 2 are less of an issue in the off-peak, because there are less services travelling along the Hounslow Loop. On the contrary, the main constraints to delivering the shuttle services are now located along the NLL, particularly in the area of Acton Wells Junction.

The off-peak timetable around Old Oak Common NLL station is highly irregular. The freight paths around Acton Wells Junction vary considerably between off-peak hours. For example, in today's timetable between 12:00 – 13:00 there are 5 freight services travelling Up the North London Line and 1 freight service travelling Down the Kew branch. In contrast, between 14:00 – 15:00 there are 3 freight services travelling Up the North London Line but 2 freight services travelling Down the Kew branch.

As a result, it is not possible to accommodate 4tph between Hounslow – Old Oak Common NLL during the off-peak time period between 12:00 – 13:00. The maximum number of shuttle services that can be achieved between Hounslow and the proposed Old Oak Common NLL station is 3tph. This is primarily due to the freight services using Acton Wells Junction to access Acton Main Line and the sidings. Furthermore, existing freight services that travel along the Kew branch, take up additional paths that could otherwise be used by shuttle services.

As the off-peak timetable is irregular, each off-peak hour varies in the maximum number of shuttle services possible and the times at which the services can be accommodated. This means achieving a symmetrical (clockface) standard hour timetable for shuttle services across all off-peak hours is impossible; to make the timetable work, each hour would need to be individually tailored. An irregular timetable creates operational complexity and is difficult to market.

It is important to note that the situation in the off-peak period is likely to deteriorate due to the future growth in demand for freight (especially as this service would not commence until at least 2026). The current freight forecasts for the NLL expect significant growth in freight services in the area of Acton Wells Junction. With more freight services using Acton Wells Junction, even fewer paths will be available for the shuttle services.

3.3.4. Windsor Lines –sensitivities analysis

The main difference between the core services assumption and the sensitivities option is that 2 out of 8 trains per hour are now semi-fast services that stop at Hounslow and Brentford only. This implies that the semi-fast services will travel faster between Brentford and Hounslow than the stopping services.

Because the semi-fast services stop at Hounslow, they will operate like other stopping services on

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approach to the station. Semi-fast services will be subject to the same slow headway and platform re-occupation margins at Hounslow as the stopping services. Furthermore, all existing services (including semi-fast services) also stop at Feltham. As a result, semi-fast services will interact with the Hounslow – Feltham section just like all other stopping services.

With the addition of the shuttle services and the CP6 uplift services, the Hounslow – Feltham section becomes very congested. As there are more stopping services on the Hounslow Loop, the semi-fast services are likely to be pathed out to fit in with the stopping services. In this case, the sensitivities option of having 2 semi-fast services is unlikely to have any significant impact on the timetable. However, it will have an impact on the journey times of the semi-fast services which may impact the viability of the Wessex Route Study option.

3.3.5. Feltham Turnround

Extending the shuttle services to Feltham results in a number of new constraints, as the shuttle services now additionally interact with Hounslow Junction and Feltham Junction.

All current services stop at Feltham station. According to the TPRs, a Down shuttle service from Hounslow would require a 7 minute break in the SW210 line services to reach Feltham. Such large intervals are rare in the peak period timetable. The available intervals rarely align with other conditions necessary to run a full shuttle services as far as Feltham Junction. The situation is worsened by existing services with extended dwell at Hounslow Platform 2.

Due to heavy traffic along the SW210 lines in the peak hour, a bay platform is necessary at Feltham. The bay platform would be used to offload the passengers and turnround the shuttle services.

Following examination of the current peak timetable, this study concluded that after extending shuttle services to Feltham it is only possible to turnround 1 shuttle service per hour in the peak period. This would require a bay platform at Feltham.

3.3.6. Whitton/Twickenham Turnround

Extending the shuttle services to Whitton or Twickenham results in a number of new constraints, as the services now additionally interact with Hounslow Junction, Whitton Junction and Twickenham Junction.

Currently, turnround of shuttle services at Whitton is impossible. The existing infrastructure prevents running of compliant shuttle services from Whitton back to Hounslow after the service turns round.

Twickenham offers several turnround options in the form of an extra platform and multiple crossings. However, Twickenham is more congested then Whitton due to the SW245 route joining from Strawberry Hill.

Existing infrastructure at Twickenham allows turnround of services in either Platform 2 or Platform 3. However, due to additional services joining via the SW245 route, along with services on the SW210 route, both platforms are highly occupied during the peak hour. Several services have extended

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dwell at Platform 3. As a result, a bay platform is needed to offload and turn services around at Twickenham.

It is not possible to turnround any shuttle services at Twickenham in the peak hour. Extending the shuttle services beyond Hounslow introduces too many constraints along the route, which prevent the shuttle service from operating. For example, several Up SW210 services are semi-fast; they skip Whitton and continue on to Twickenham. Semi-fast services limit the number of shuttle services achievable on the SW210 route due to speed differentials. Furthermore, the additional Platform 3 is mostly occupied by Up services from the SW245 route, preventing the use of it for turnround of shuttle services.

3.3.7. Southern Rail Access to Heathrow interaction

The Southern Rail Access to Heathrow (SRAtH) Feasibility Study developed a range of indicative train service specifications (ITSS) which aim to serve London Heathrow from a number of locations in the UK south. The London Waterloo – Heathrow ITSS proposes that it is possible to achieve 2tph stopping services via Richmond and 2tph stopping services via Hounslow. The Feasibility Study does not provide any timings for these proposed services.

SRAtH has no impact on the Hounslow – Old Oak Common shuttle services in the context of this study. When implemented, SRAtH services will be part of the CP6 uplift and are therefore already accounted for in this study.

It is important to note that in this study the CP6 specification fits around the Hounslow – Old Oak Common shuttle services. If the timings of SRAtH services happen to be different from the CP6 paths identified in this study, there may be substantial impacts on the findings.

3.3.8. Level Crossings

The proposed Hounslow – Old Oak Common services would run over three existing level crossings: Wood Lane on the Hounslow Loop and Bollo Lane (Kew Branch) and Churchfield Road on the North London Line.

A level crossing risk assessment would need to be undertaken on these crossings to understand what mitigations might be required to enable an increase in train service.

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4. Recommendations

Although it is technically possible to accommodate 4tph shuttle services between Hounslow and Old Oak Common in the peak hour, this poses an unacceptable performance risk with Hounslow Platform 2 being occupied for the majority of the hour. This would therefore require a new platform or siding on the south side of Hounslow

It is difficult to address the performance risk to the Wessex network caused by the necessary use of minimum TPRS (junction margins, headways etc). Grade separation of Old Kew Junction would be highly beneficial, as it is the main constraint along the shuttle service route. A grade separation at South Acton Junction would also alleviate the issue of planning on minimum junction margins. However, even the significant investment to alleviate the constraining junctions would not mitigate the risk arising from running on minimum headways.

The main constraint that prevents running shuttle services in the off-peak hours is the movement of freight at Acton Wells Junction. This constraint could be resolved by constructing a direct connection from the South West Line to Acton Main Line, effectively separating these freight services from the NLL.

This study recommends Hounslow as the best location for the shuttle service turnback. Extending shuttle services past Hounslow to turnround at Feltham, Whitton or Twickenham results in additional constraints, which prevent delivery of the shuttle services.

In order to turnaround trains at Old Oak Common, a siding is necessary north of the station. The siding would be used to turn back shuttle services off the NLL while avoiding conflicts with other services. The preferred location of the sidings is north of the Old Oak Common NLL station, as this would potentially allow repurposing of the existing unused South West Sidings. However, this would require infrastructure changes to join the southern end of South West Sidings to the South West Line and, more importantly, would require infrastructure alternations to the North London Line itself just north of the new Old Oak Common station to provide crossovers to access the South West Line from the station. The feasibility of this infrastructure is unknown and would need to be investigated.

This study also notes the potential benefit of a timetable recast of the Inner Wessex area. The current timetable features many irregularities between the hours, such as hourly services with different dwell times at Hounslow. A recast of the timetable would potentially allow standardisation of hours, allowing for an even hourly pattern of the shuttle services. Though this would still carry the aforementioned performance risk, due to the volume of services and their interaction on the Hounslow Loop.

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5. Conclusion

Though it is possible to achieve 4tph in the peak, this requires a new platform or siding at Hounslow and carries significant performance risk of spreading delay across the network, resulting from the necessary minimum TPRs (junction margins, headways etc). Reduction of the service frequency to 2tph in the peak would still require the use of minimum junction margins, with the associated risk of spreading delay. However, it would enable more space in the timetable in the hour to potentially recover from any delays. More detailed performance analysis would be required to determine how such a timetable would build up delay and recover.

It is difficult to address the performance risk to the Wessex network caused by the necessary use of minimum TPRS (junction margins, headways etc). Grade separation of Old Kew Junction would be highly beneficial, as it is the main constraint along the shuttle service route. A grade separation at South Acton Junction would also alleviate the issue of planning on minimum junction margins. However, even the significant investment to alleviate the constraining junctions would not mitigate the risk arising from running on minimum headways.

The major constraint in the off-peak timetable is the movement of freight services at Acton Wells Junction. The off-peak timetable is highly irregular, with some hours of the off-peak timetable may accommodate 2-4tph shuttle services whereas others may not (based on today's level of freight services). This situation is likely to worsen over time due to the forecast freight growth on the route. The main constraint that prevents running shuttle services in some hours is the movement of freight at Acton Wells Junction. This constraint could be resolved by constructing a direct connection from the South West Line to Acton Main Line, effectively separating these freight services from the NLL.

The irregularities in the peak Hounslow Loop timetable and the off-peak North London Line freight paths mean it would be almost impossible to achieve a consistent pattern of Hounslow – OOC services, with each hour needing to be adjusted to take into account the wider service structure. Such a timetable may be difficult to market.

The Windsor Line sensitivities option proposed by the Wessex Route Study makes little difference in regards to running shuttle services from Old Oak Common to Hounslow. However, semi-fast services will potentially perform like stopping services in the areas where semi-fast services interact with the shuttle services. This would increase the journey times of these semi-fast services, potentially affecting the viability of the Route Study option.

It is recommended that the new shuttles services turn round at Hounslow, at the Wessex end, and a siding north of OOC station at the North London Line end. The siding would be used to turn back shuttle services off the NLL while avoiding conflicts with other services. However, this would require infrastructure changes to join the southern end of South West Sidings to the South West Line and, more importantly, would require infrastructure alternations to the North London Line itself just north of the new Old Oak Common station to provide crossovers to access the South West Line from the station. The feasibility of this infrastructure is unknown and would need to be investigated.

Accessing the sidings is also difficult in some hours due to the number of freight movements on the North London Line. Finding four paths each way to access and egress the sidings will be

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challenging in hours with a high number of freight trains.

This study found that the CP6 uplift services fit between the existing services and the proposed Hounslow – Old Oak Common shuttle services. If the actual CP6 timetable results in different pathing assumptions, the proposed shuttle service routes will potentially become invalidated. Therefore, in order to fully establish whether the shuttle services are feasible, more precise information on the CP6 timetable would be required. Until this is known, any timetable developed for the Hounslow shuttles will carry this risk.

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WEST LONDON ORBITAL RAIL

TECHNICAL ANALYSIS AND CONCLUSIONS

SEPTEMBER 2017

WSP | PARSONS BRINCKERHOFF

WEST LONDON ORBITAL RAIL

TECHNICAL ANALYSIS AND CONCLUSIONS

West London Alliance

Report

Project no: 70034419
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EXECUTIVE SUMMARY

BACKGROUND

The West London Alliance is currently investigating ways of accommodating the additional passenger demand resulting from the growth of population and employment in the area and across London as a whole. This includes substantial additional housing planned along much of the corridor between Hounslow and West Hampstead/Hendon. An option to serve these developments in a sustainable way, consistent with the draft Mayor's Transport Strategy ambitions, is to restore rail passenger services on the Dudding Hill Line and the Kew – Acton link to provide a West London Orbital (WLO) rail service from Hounslow to West Hampstead and Hendon.

Figure 1 West London Orbital Rail Service

The Dudding Hill Line is an existing railway line in north-west London running from Acton to Cricklewood. The line itself has had no scheduled passenger service for over a century. It has no

stations, no electrification and a 30 miles per hour speed limit with semaphore signalling, and is lightly used by freight and very occasional passenger charter trains. It is roughly 4 miles long. Near the site of Old Oak Common, trains would join the existing North London Line, and then further south at Acton, use the link down to the Hounslow Loop to reach Brentford and Hounslow. We refer to this set of routes as the West London Orbital railway.

STUDY APPROACH

WSP was commissioned to carry out a feasibility study into the case for introducing a new passenger service using the West London Orbital railway. The study has assessed the case on the basis of consideration of the:

- Strategic options for the route
- Passenger demand assessment
- Operational and infrastructure analysis
- Assessment of the preferred option

STRATEGIC OPTIONS (CHAPTER 2)

The strategic options considered are heavy rail, tram, tram-train, bus rapid transit and conversion to highway. Each of these has been assessed against a multi-criteria sifting framework. The findings demonstrate that the line should remain part of the national rail network and not be a candidate for conversion to another mode. The retention of the Dudding Hill Line as a heavy rail line avoids the negative implications for freight and facilitates the realisation of benefits which the re-introduction of heavy rail passenger services has the potential to achieve, both in terms of transport connectivity and supporting the housing and economic growth agendas for the local areas. This conclusion was supported by the client group.

DEMAND ANALYSIS (CHAPTERS 3 & 4)

Demand modelling using TfL's LTS-PT model has been used to assess the implications of the restored passenger service. Three options were considered:

- **Option 1**. 4 trains per hour (tph) Hendon – Hounslow, calling at Hendon, Brent Cross/Staples Corner, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow
- **Option 2**. 4 tph West Hampstead – Hounslow, calling at West Hampstead, Cricklewood, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow
- **Option 3**. 4 tph West Hampstead – Hounslow and 4 tph Hendon – Hounslow, stops as above.

The forecasts from the demand analysis indicate that the introduction of WLO rail services will result in an increase in passenger kilometres, passenger hours and total passenger boardings on all rail services (including WLO). The results for Option 1 and Option 2 are similar. However, Option 3 (8 tph rather than 4 tph) is forecast to make a more significant impact on the rail network with the changes almost double of those for Option 1 or Option 2.

The improved connectivity and extra capacity provided by WLO passenger services on the public transport network in London is forecast to attract passengers from LUL lines such as the Northern, Jubilee, Central, District and Piccadilly as well as rail services currently operated by South West Trains and Great Western Railway. Additional passengers to the Elizabeth Line (Crossrail 1) are estimated to be attracted as a result of the WLO providing a direct connection between Old Oak Common (OOC) Victoria Road station and the main Old Oak Common station.

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OPERATIONS AND INFRASTRUCTURE ANALYSIS (CHAPTER 5)

The feasibility of delivering the rail services tested in the demand analysis was assessed, along with the associated capital cost implications. The analysis built upon previous work by TfL, Network Rail and WSP. The principal issues include:

- Construction of new stations at Harlesden and Neasden
- Construction of new platforms at Old Oak Common, Cricklewood, West Hampstead and Staples Corner/Brent Cross
- Platform turnround capability at Hounslow
- Capacity between Hounslow and Key East junction given the proposed increased use of that route by the new South Western franchise
- Bollo Lane level crossings given the very substantial increase in use of the Kew - Acton line
- Capacity between Acton and Old Oak Common, especially around Acton Wells junction
- Resignalling of Dudding Hill Line and Acton - Kew

Of these issues four-tracking around Acton Wells and identifying a satisfactory solution for the level crossings at Bollo Lane present the most significant challenges.

PREFERRED OPTION (CHAPTERS 6 & 7)

Derived from the findings from the demand analysis and the operations and infrastructure analysis the preferred option has been defined as:

- **Phase 1:** 4 trains per hour from West Hampstead to Hounslow, calling at West Hampstead, Cricklewood, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow
- **Phase 2:** additional 4 trains per hour from Hendon to Kew Bridge, calling at Hendon, Brent Cross/Staples Corner, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Kew Bridge

The outputs from the LTS-PT modelling, along with the capital and operating cost estimates have been used as inputs for the economic appraisal and an assessment of wider benefits and affordability.

STUDY FINDINGS

STRATEGIC RATIONALE

This study has confirmed the appropriateness of developing a heavy rail solution for the Hounslow to West Hampstead/Hendon corridor given its existing role as a freight route and the opportunity to provide connectivity across the wider rail network. Retention of the heavy rail corridor on the Dudding Hill Line section will also permit integration of the WLO services into London Overground operations and to support the further success of this brand.

The introduction of a high quality public transport service, integrated with the wider public transport network, will support the accommodation of forecast population and employment growth in West London in a manner consistent with the draft Mayor's Transport Strategy. The scheme will deliver significant connectivity and accessibility benefits by introducing new stations and new services. This will result in the attraction of existing public transport and highway users, as well as new users, contributing to relieving forecast crowding on LUL and national rail services, addressing highway congestion and supporting local environmental improvements.

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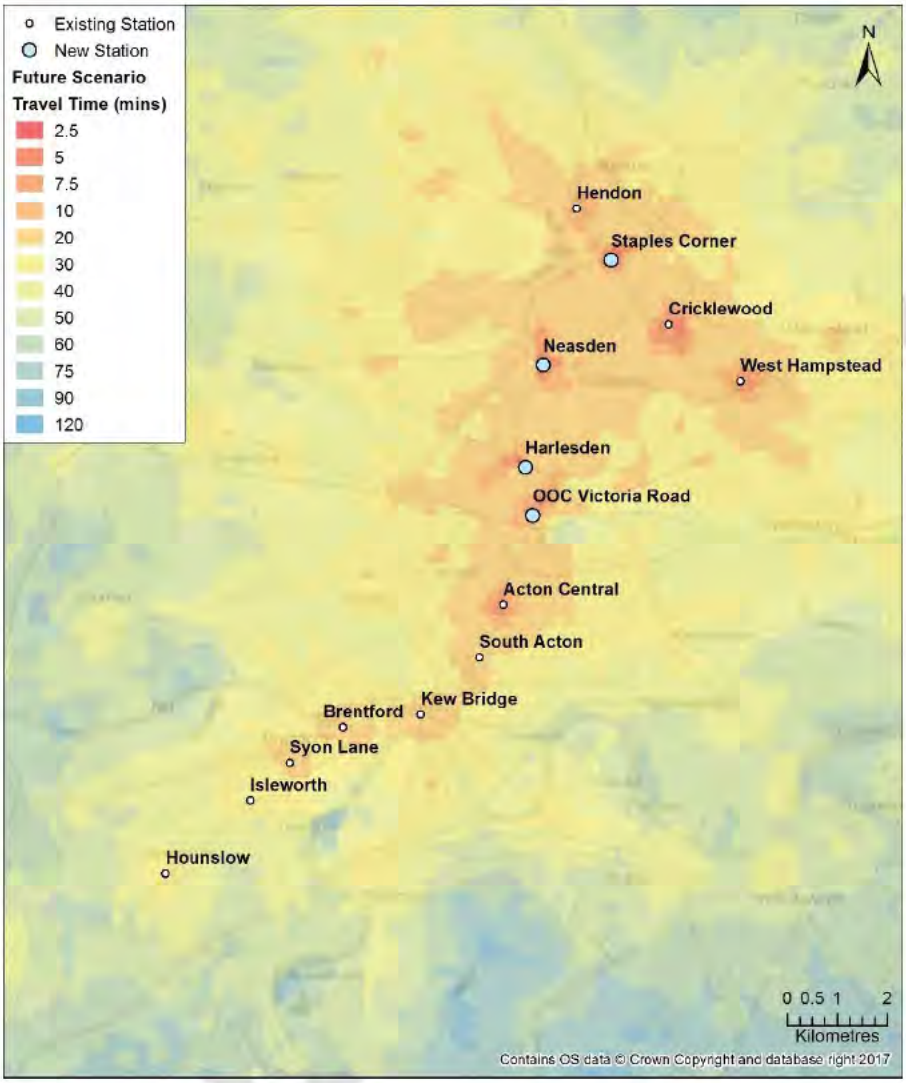
Within the areas benefitting from the significantly improved accessibility and connectivity are many sites identified by the emerging Strategic Housing Land Availability Assessments. In addition to serving these sites and the associated proposed housing, the introduction of WLO services will support an intensification of development facilitating increased numbers of housing units to be delivered on the sites.

Figure 2 Accessibility of new WLO stations



ECONOMIC CASE

The economic appraisal has been undertaken in line with TfL guidance with the forecast benefits (both uncrowded and crowded time in hours) for all public transport users converted into monetary values to estimate the social benefits of the scheme. Given the significant levels of demand forecast for the WLO and the journey time savings and crowding benefits delivered, the total social benefits exceed £30bn PV over the appraisal period.

The cost of delivering these benefits has been estimated for the capital and operating elements over the appraisal period. Together these amount to a net financial effect of £689m PV. The resulting benefit to cost ratio (BCR) if greater than 50:1.

Table 2 Summary of Economic Appraisal Results

ITEM	30 YEAR PV 2017
Journey time benefits	>£10bn
Crowding benefits	>£20bn
Total Social Benefits	**>£30bn**
Capital costs	£374m
Operating costs	£315m
Revenue	Not included
Net Financial Effect	**£689m**
Net Present Value	**>£30bn**
Benefit:Cost Ratio	**>50:1**

The high BCR reflects the significant benefits of the scheme to society through journey time savings and crowding benefits, and their realisation through better utilisation of existing infrastructure with selective capital investment.

COMMERCIAL & FINANCIAL CASES

For the purposes of this study it has been assumed that the proposed WLO services will be operated by London Overground and the development and implementation of the infrastructure will be led by TfL and Network Rail to ensure efficient and effective integration with the wider rail network and recognising current roles and responsibilities.

Initial analysis suggests an operating subsidy would be required as assumed WLO operating costs are estimated to exceed estimated WLO revenue. Further consideration of means to meet the 'gap' will need to be considered in order to confirm the affordability of WLO rail service operations. This consideration should address:

- Future TfL fares' policy for orbital travel, recognising the strategic nature of many of the trips (which can be made without crossing fare boundaries, in contrast with radial trips)
- Opportunities to harness future technology for ticketing and fares to most effectively manage demand across the network and price fares appropriately
- Future rolling stock choices, e.g. electric or battery, and implications for operating and whole-life costs

Further work will also be required to identify a funding proposition to confirm the affordability of implementing the scheme given its cost of over £250m. Initial analysis indicates that there is scope to derive a significant contribution towards this capital cost through funding from the Community Infrastructure Levy (CIL). With potentially 15,000 to 20,000 new homes planned in West London the associated value of the CIL could approach around £150m.

CONCLUSIONS

This study demonstrates that significant social benefits will result from the introduction of WLO rail services, which have been confirmed to be operationally feasible. The key technical challenges for scheme implementation have been identified with proposed solutions set out. At this stage the affordability of the scheme has not been confirmed, but plausible opportunities to achieve this have been identified providing confidence that it can be.

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1 INTRODUCTION

1.1 CONTEXT

1.1.1 The West London Alliance is currently investigating ways of accommodating the additional demand resulting from the growth of population and employment in the area and across London as a whole. This includes substantial additional housing planned along much of the corridor between Hounslow and West Hampstead/Hendon. An option to serve these developments in a sustainable way, consistent with the draft Mayor's Transport Strategy ambitions, is to restore passenger services on the Dudding Hill Line and the Kew – Acton link to provide a West London Orbital rail service from Hounslow to West Hampstead and Hendon.

Figure 1-1 West London Orbital Rail Services

1.1.2 The Dudding Hill Line is an existing railway line in north-west London running from Acton to Cricklewood. The line itself has had no scheduled passenger service for over a century. It has no stations, no electrification and a 30 miles per hour (48 km/h) speed limit with semaphore signalling, and is lightly used by freight and very occasional passenger charter trains. It is roughly 4 miles (6.4 km) long. Near the site of Old Oak Common, trains would join the existing North London Line, and then further south at Acton, use the link down to the Hounslow Loop to reach Brentford and Hounslow. We refer to this set of routes as the West London Orbital railway.

1.2 THIS DOCUMENT

1.2.1 WSP was commissioned to carry out a feasibility study into the case for introducing a new passenger service using the West London Orbital railway.

1.2.2 This document presents the approach and findings of the technical analysis undertaken and the conclusions drawn. It covers:

- Strategic options for the route
- Passenger demand assessment
- Operational and infrastructure analysis
- Assessment of preferred option
- Conclusions and recommendations for further work

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2 STRATEGIC OPTIONS

2.1 INTRODUCTION

2.1.1 The Dudding Hill Line is a 4-mile railway line between Cricklewood and Acton Wells. At the northern end connections are provided to the Midland Main Line, both to the north and south. At Acton Wells it joins the North London Line. From there, trains may proceed to the Great Western Main Line (Ealing), or continue along the North London Line towards Hounslow or Richmond. There are single-track link lines from the West Coast Main Line at Willesden and the Chiltern main line at Neasden.

2.1.2 The Dudding Hill Line is not an independent line: it links four main lines together, and by way of the North London Line, provides valuable links to the South Western network. It is an important freight artery, providing a means by which stone trains from the Mendips, for example, can operate to the West Coast or Midland Main Lines.

2.1.3 This study addresses the potential for the entire route from West Hampstead/Hendon to Hounslow, but the focus of this chapter is the currently under-utilised northern section, for which a range of options have been advanced, including conversion from heavy rail.

2.2 CONSIDERATION OF STRATEGIC OPTIONS

2.2.1 The Dudding Hill Line provides a corridor for freight, but currently does not see any passenger services (either public transport or private vehicles). The provision of these would provide improved accessibility, support economic and housing growth along the corridor and relieve passenger demand on adjacent rail and highway networks. A high level consideration has been undertaken into the merit of seeking to utilise the existing heavy rail infrastructure for passenger services along the corridor, or replace the freight alignment with alternative transport facilities. Passenger services last ran on the route in 1902.

2.2.2 The strategic options considered for passenger services are: heavy rail, tram, tram-train, bus rapid transit and conversion to highway. Each of these has been assessed against a multi-criteria sifting framework. The purpose of the framework is to support the differentiation between the options in order to inform the decision on the strategic option to proceed with. The framework was developed to enable a proportionate approach to be taken, cognisant of the information available and the stage of the project.

2.2.3 The framework addresses for each option, its:

- → **Suitability**: e.g. meeting the identified needs and objectives for the proposed scheme
- → **Feasibility**: e.g. delivery and operational issues
- → **Acceptability**: e.g. powers/consents, capital cost/affordability, stakeholder acceptability

2.2.4 Criteria for each of the above elements have been determined and the performance of each option against them has been assessed as positive, neutral or negative in comparison to the existing situation.

2.3 FINDINGS OF ASSESSMENT

2.3.1 The findings of the high level assessment of the strategic options are summarised in the table

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below. The extent of the contribution to or consistency with the criterion has been assessed. Green indicates the strongest performance, yellow intermediate and red the least.

Table 2-1 Summary of High Level Assessment of Passenger Service Strategic Options

2.3.2 While all the options, by enhancing the local transport network in West London, would contribute positively to the intent for the scheme, the greatest benefit is anticipated to arise from the heavy rail and tram-train options as they offer being part of the existing wider transport network (as does conversion to road), as well as providing the perceived permanency of fixed rails, which is attractive to developers, investors and the public due to the perceived greater value of these forms of public transport.

2.3.3 However, the most material differentiator between the heavy rail and tram-train options and the others is the ability of these passenger services to operate alongside the existing freight services on the line. With each of the other options freight movements could not take place on the line. Diverting freight services elsewhere does not appear feasible given geography and the utilisation of the rail network in the area. Constructing a new rail route for freight has been discounted.

2.3.4 Freight trains under some very limited circumstances can share tracks with passenger trams, but there are onerous safety considerations to be addressed, which it may not be possible to satisfactorily overcome. A line not dissimilar to the Dudding Hill line in Paris, called the Tangentielle Nord line, has seen part of the former Grande Ceinture line re-used for trams. The French authorities have not closed the Grande Ceinture, which, like the North London Line, is an important freight artery, but have built a separate tram alignment next to it. A similar option for the Dudding Hill line might be possible, but it would require significant land-take, would be expensive and present engineering challenges (and therefore has not been assessed further).

2.3.5 The incompatibility between maintaining the existing freight services and introducing trams, bus rapid transit or a highway arguably indicates that none of these options is suitable for further consideration, notwithstanding that all the options are feasible in terms of construction and operation. The least confidence for operational feasibility relates to tram-train, which is still being trialled on the South Yorkshire rail network.

2.3.6 The findings for the assessment of acceptability reinforce the conclusions on suitability of the options. While introducing tram or tram-trains may provide a lower cost alternative to re-introducing heavy rail passenger services (and compared to having to remove the rails and lay a new carriageway for bus rapid transit or cars), their acceptability to stakeholders such as TfL, GLA, Network Rail, freight operators and local authorities is expected to be poor and hence achieving the necessary approvals would be very challenging. Similarly, given the policy context of the draft Mayor's Transport Strategy, the construction of a new road and transfer of freight from rail to road would be anticipated to also be opposed by key stakeholders.

2.3.7 In conclusion, having considered potential strategic options for the introduction of passenger services along the Dudding Hill Line, the findings from the high level assessment demonstrate that the line should remain part of the national rail network and not be a candidate for conversion to another mode. The retention of the Dudding Hill Line as a heavy rail line avoids the negative implications for freight and facilitates the realisation of benefits which the re-introduction of heavy rail passenger services has the potential to achieve, both in terms of transport connectivity and supporting the housing and economic growth agendas for the local areas. This conclusion was supported by the client group.

2.3.8 In this study, therefore, we have sought to develop the optimum specification for delivering improvements to the line through heavy rail retention, and in delivering the level of service quality that has become synonymous with the London Overground brand.

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3 DEMAND ANALYSIS: APPROACH

3.1 APPROACH

3.1.1 In order to assess the implications of the restored passenger service we have used TfL's LTS-PT model. LTS-PT is a public transport model which covers the whole of London and predicts the demand on public transport mode (rail, underground, bus) and route that a person chooses to get to their destination, as well as the associated crowding impacts. The software platform for LTS-PT is Cube Voyager.

3.1.2 Travellers in London may respond in a number of different ways when they are faced with the introduction of a new passenger service including:

- Change their route to benefit from a faster and possibly less crowded passenger service
- Change the destination of some trips
- Change mode of travel, for example from road to rail
- Change the number of trips (trip generation and trip suppression)

3.1.3 Some of these responses will be more profound than others and TfL has a suite of models (LTS, HAM, LTS-PT) to assess all the above mentioned responses. However, to inform this feasibility study and to provide an initial indication of the demand on the re-introduced service, only the re-routing response has been assessed. This is considered to be the strongest response to the introduction of a new passenger service in London.

3.1.4 We should emphasise that LTS-PT is a reassignment model of public transport demand: it does not capture the transfer from private cars or induced demand growth, both of which we would expect to play a substantial role in a West London Orbital passenger service. As such, the results presented here are almost certainly underestimated.

3.1.5 Considering the constraints of the study timescales, it has not been possible to review base year LTS-PT model validation in the area of interest or undertake a detailed network audit. However, should the scheme be progressed to the next stage, we recommend a thorough review and a possible improvement of the accuracy of the public transport model in line with TfL and DfT guidance.

3.2 OPTIONS

3.2.1 For the demand modelling the following three options have been considered:

- **Option 1**. 4 tph Hendon – Hounslow, calling at Hendon, Brent Cross/Staples Corner, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow
- **Option 2.** 4 tph West Hampstead – Hounslow, calling at West Hampstead, Cricklewood, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow
- **Option 3.** 4 tph West Hampstead – Hounslow and 4 tph Hendon – Hounslow, stops as above.

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3.2.2 A new station at Lionel Road, which is situated just east of Brentford and north of Kew Bridge stations, has been the subject of previous extensive work. This work suggests there is a good case for the station. However, we have excluded it from the options above because it is not integral to the re-opening of the line: the line could be re-opened and perform well without Lionel Road. If Lionel Road station was constructed it would further increase the local regeneration benefits resulting from improved local rail services.

3.2.3 The West London Orbital passenger service options have been tested against the following baseline:

- Standard LTS-PT 2041 Reference Case (A141rc01a)

  This scenario includes HS2, but not Old Oak Common (OOC) or Brent Cross development.

- 2041 Maximum Growth Scenario without Crossrail 2 (A141rc20a)

  This scenario includes HS2 and additional trips associated with OOC and Brent Cross development, as well as other additional development across London. Given the commitment to these developments (e.g. the planned breaking ground for Brent Cross next year) this is deemed more representative of the anticipated scenario for West London in 2041.

3.2.4 The 2041 Reference Case and 2041 Maximum Growth scenario networks are the same, but the demand matrices are different.

3.2.5 The assessment has been undertaken for the AM (0700-1000) and PM (1600-1900).

3.3 STUDY LIMITATIONS

3.3.1 TfL's strategic public transport model LTS-PT was used for this study because it is the only London wide modelling tool available to assess the impacts and benefits of the proposed scheme. It is appropriate for providing a strategic overview of the range of benefits likely to be generated by the proposed schemes and therefore in forming one part of the wider assessment of the benefits and costs of the schemes.

3.3.2 Given the constrained timescales of the study, it has not been possible to review base year LTS-PT model validation in the area of interest or undertake a detailed network audit. Should the scheme be progressed to the next stage, we recommend a thorough review and a possible improvement of the accuracy of the public transport model in line with TfL and DfT guidance.

3.3.3 LTS-PT does not include modal transfer from car to rail: it is a public transport reassignment model. This means that the demand figures indicated here are lower than might be expected. The re-introduction of passenger services will alleviate congestion on the A406 North Circular Road, for instance, and this impact is not captured in the LTS-PT results.

3.3.4 Travellers in London may respond in a number of different ways when they are faced with the introduction of a new passenger line. To inform the feasibility study and to provide an initial indication of the demand on the re-introduced service, only the re-routing response has been assessed. This is considered to be the strongest response to the introduction of a new passenger service in London. Should the scheme be progressed to the next stage an assessment using the complete TfL's modelling toolkit (Highway and Public Transport assignment models, Demand Model) is recommended.

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4 DEMAND ANALYSIS: RESULTS

4.1 INTRODUCTION

4.1.1 This chapter presents the analysis of the modelled options. A range of model outputs have been generated from the LTS-PT model runs, including:

- → Summary statistics in a tabular form produced for each scenario and for differences between relevant scenarios
- → Flow difference plots
- → Charts showing boardings and alightings and line loading for each of the options

4.2 SUMMARY STATISTICS

4.2.1 Summary statistics at a global level for each AM and PM scenario modelled, as well as the difference with the associated baseline scenario are presented in Appendix A-1.

Baseline: Standard LTS-PT 2041 Reference Case (A141rc01a)

4.2.2 The introduction of West London Orbital passenger services is forecast to result in an increase in passenger kilometres, passenger hours and total passenger boardings on rail services (including WLO). The results for Option 1 and Option 2 are similar. However, Option 3 (8 tph rather than 4 tph) is forecast to make a more significant impact on the rail network with the changes almost double of those for Option 1 or Option 2. For example, in 2041 AM Option 1 is forecast to result in 5,556 additional rail boarders, Option 2 – 5,002 boardings and Option 3 – 12,834 boardings.

4.2.3 A reduction in passenger kilometres, passenger hours and total passenger boardings on LUL and buses indicates that the demand for the West London Orbital services is likely to be abstracted from LUL and bus services, providing crowding relief for them.

4.2.4 The WLO is estimated to improve connectivity and provide extra capacity on the public transport network in London resulting in lower levels of distance travelled, total boardings, journey times and crowding levels, above all in the north-western and south-western quadrants of London. The impact of Option 1 and Option 2 is estimated to be very similar, with Option 3, which assumes double the number of trains on the core section, showing more profound changes. The table below provides a summary across all public transport modes in London.

Table 4-1 Summary statistics. WLO Option Scenarios versus 2041 Reference Case

MODE	PEAK	DESCRIPTION	2041 TFL REF CASE	CHANGE IN USER BENEFITS		
		Scenario	A141rc01a	Option 1 minus RC	Option 2 minus RC	Option 3 minus RC
All PT	AM	Passenger Kms	85,795,810	-25,424	-22,445	-35,614
		Uncrowded Passenger Hours	115,348,652	-88,989	-77,060	-178,966
		Crowded Passenger Hours	154,400,839	-241,381	-210,768	-316,253
		Passenger Boardings	6,244,762	-1,957	-2,121	-1,605
	PM	Passenger Kms	89,635,043	-21,387	-17,409	-30,172

		Uncrowded Passenger Hours	120,021,714	-82,387	-70,612	-147,691
		Crowded Passenger Hours	154,108,212	-219,549	-190,719	-387,404
		Passenger Boardings	6,791,486	-2,268	-2,350	-1,779

Baseline: 2041 Maximum Growth Scenario without Crossrail 2

4.2.5 When tested against the Maximum Growth Scenario, the pattern of the results is similar as for the Reference Case Scenario. However, the additional trip generation associated with the Maximum Growth Scenario means changes are greater as summarised in Table 4-2.

Table 4-2 Summary statistics. WLO Option Scenarios versus 2041 Maximum Growth Scenarios

MODE	PEAK	*DESCRIPTION*	*2041 MAX GROWTH (MG)*	*CHANGE IN USER BENEFITS*		
		Scenario		Option 1 minus MG	Option 2 minus MG	Option 3 minus MG
All PT	AM	Passenger Kms	88,152,748	-26,651	-23,275	-37,204
		Uncrowded Passenger Hours	118,927,182	-90,796	-78,050	-155,426
		Crowded Passenger Hours	160,705,541	-242,933	-212,086	-447,184
		Passenger Boardings	6,485,584	-2,108	-2,262	-1,831
	PM	Passenger Kms	92,436,014	-22,333	-18,018	-32,261
		Uncrowded Passenger Hours	124,289,369	-88,546	-75,299	-155,144
		Crowded Passenger Hours	162,352,074	-252,329	-218,843	-436,387
		Passenger Boardings	7,068,359	-2,352	-2,443	-1,971

4.3 FLOW DIFFERENCE PLOTS

4.3.1 Differences in demand on the public transport network in the AM and PM between each option and its associated baseline scenario are presented in Appendix A-2. Increases in passenger volumes are shown in red with reductions in green.

4.3.2 The introduction of West London Orbital passenger services is forecast to attract passengers from LUL lines such as the Northern, Jubilee, Central, District and Piccadilly as well as rail services currently operated by South West Trains and Great Western Railway. With the WLO passenger services operating these national rail services are likely to witness lower levels of crowding, providing overall crowding relief to a broad range of other services.

4.3.3 A direct connection between Old Oak Common (OOC) Victoria Road station, which is considered as part of the WLO, and the main Old Oak Common station is estimated to attract additional passengers to the Elizabeth Line (Crossrail 1).

4.4 LINE LOADING BY STATION

4.4.1 Line loading, station boardings and alightings are detailed in Appendix A-3. This section summarises the findings of the analysis.

Baseline: Standard LTS-PT 2041 Reference Case (A141rc01a)

- In the AM (0700-1000) Option 1 is forecast to carry 6,064 passengers, Option 2 – 5,758 passengers and Option 3 – 12,646 passengers
- In the PM (1600-1900) Option 1 is forecast to carry 6,337 passengers, Option 2 – 6,146 passengers and Option 3 – 13,437 passengers
- The demand will vary by station with OOC Victoria Road being utilised the most. For example, in Option 1 in the AM 1,000 passengers are forecast to board the West London Orbital services and 2,823 to alight. In Option 2 these numbers are 952 and 2,479 passengers respectively and in Option 3 - 2,122 and 6,173 passengers.
- In the PM OOC Victoria Road demand is: Option 1 - 2,036 boarders and 1,579 alighters, Option 2 – 1, 889 and 1,478, Option 3 – 4,984 and 3,346. The majority of these passengers are those interchanging from/to the Elizabeth Line (Crossrail 1).

Baseline: 2041 Maximum Growth Scenario without Crossrail 2

- In the AM (0700-1000) Option 1 is forecast to carry 6,243 passengers, Option 2 – 5,920 passengers and Option 3 – 12,943 passengers
- In the PM (1600-1900) Option 1 is forecast to carry 6,659 passengers, Option 2 – 6,437 passengers and Option 3 – 13,992 passengers
- In the Maximum Growth Scenario WLO services are forecast to carry more passengers than in the Reference Case: on average 2.7% more in the AM and 4.6% in the PM
- The demand estimates vary by station with OOC Victoria Road being utilised the most. For example, in Option 1 in the AM 1,100 passengers are forecast to board West London Orbital services and 2,772 to alight. In Option 2 these numbers are 1,045 and 2,428 respectively and in Option 3 - 2,342 and 6,022.
- In the PM OOC Victoria Road demand is: Option 1 - 2,036 boarders and 1,748 alighters, Option 2 – 1, 884 and 1,618, Option 3 – 4,936 and 3,671. The majority of these passengers are those interchanging from/to the Elizabeth Line (Crossrail 1).

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5 OPERATIONS AND INFRASTRUCTURE ANALYSIS

5.1 INTRODUCTION

5.1.1 This study has drawn on a number of studies which have been completed over the past few years, including those by TfL and Network Rail. In this chapter we seek to build upon this work.

5.2 OPERATIONAL CONSIDERATIONS AND PREVIOUS WORK

5.2.1 Several studies into these issues have been prepared before, both by WSP and by Network Rail. The principal issues identified in relation to a service between Hounslow and Old Oak Common, which represented the geographical limits of these studies, included the following:

- Platform turnround capability at Hounslow
- Capacity between Hounslow and Key East junction given the proposed increased use of that route by the new South Western franchise
- The availability of Bollo Lane level crossings given the very substantial increase in use of the Kew - Acton line
- Capacity between Acton and Old Oak Common, especially around Acton Wells junction
- The need for a turnback facility at Old Oak Common

5.2.2 With the exception of the final point, all these issues are relevant to the operation of the proposed Dudding Hill Line service through to West Hampstead or Hendon. A turnback facility at Old Oak Common is not necessary if trains continue to West Hampstead or Hendon, and the cost of its construction will be saved.

5.2.3 On the section north of Old Oak Common, the principal requirements surround the construction of new stations at Harlesden and Neasden, and the construction of new platforms at Old Oak Common (linked to, but separate from, the proposed London Overground platforms), Cricklewood and West Hampstead, or if the northerly option were to be adopted, new platforms at Hendon and (as part of the planned new Thameslink station) at Staples Corner/Brent Cross.

5.2.4 An essential further element is re-signalling. The railway north of Old Oak Common is currently operated on an absolute block (AB) system, which relies on manual communication between signalmen. Whilst satisfactory for a relatively limited freight service of one or a maximum of two trains per hour, it would be unreliable and inadequate for a high-performing regular passenger service. An extract from Network Rail's Operational Rules states the following:

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Figure 5-1 Extract from Network Rail Operational Rules

EA 1360 DUDDING HILL JUNCTION TO ACTON WELLS JUNCTION			
TIMING POINTS INCLUDED	DOWN	UP	NOTES
Dudding Hill Junction to Acton Canal Wharf Junction	AB	AB	
Action Canal Wharf to Action Wells Junction	AB	AB	

EA 1330 SOUTH ACTON JUNCTION TO OLD & NEW KEW JUNCTIONS			
TIMING POINTS INCLUDED	DOWN	UP	NOTES
South Acton Junction to Kew East Junction	*	*	* TCB timed as AB (one train in section)
Kew East Junction to New Kew Junction	*	*	* TCB timed as AB (one train in section)
Kew East Junction to Old Kew Junction	*	*	* TCB timed as AB (one train in section)

5.2.5 In short, the signalling on both these stretches of currently freight-only line is inadequate for anything approaching the level of service being contemplated.

5.2.6 Details have been sought from Network Rail regarding the intended timescale and scope of re-signalling. There are no re-signalling schemes for the Dudding Hill section in the remainder of CP5 or CP6 (2014-19, and 2019-24 respectively). Network Rail is carrying out asset life extension works during CP6 with the potential of re-signalling in CP7 (2024-29).

5.2.7 Consistent with the demand forecasting, the service options we have assessed are as follows:

- 4 tph Hendon – Hounslow, calling at Brent Cross/Staples Corner, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow.
- 4 tph West Hampstead – Hounslow, calling at Cricklewood, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow
- 4 tph West Hampstead – Hounslow, calling at Cricklewood, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow *and*

  4 tph Hendon – Hounslow, calling at Brent Cross/Staples Corner, Neasden, Harlesden, OOC Victoria Road, Acton Central, South Acton, Brentford, Syon Lane, Isleworth, Hounslow.

5.2.8 The operating times have been provided by TfL and are reproduced below:

Table 5-1: Proposed stations, distances and run times

STATION		DISTANCE (MILES)	TIME (MINS)
West Hampstead	D	11.68	0
Cricklewood	A		2
	D	10.48	2.5
Neasden	A		4.5
	D	8.86	5
Harlesden	A		7.5
	D	7.5	8
Old Oak Common Victoria Road	A		15
	D	6.71	15.5
Acton Central	A		18.5

STATION		DISTANCE (MILES)	TIME (MINS)
	D	5.5	19
South Acton	A		22
	D	4.81	22.5
Brentford	A		25.5
	D	2.85	26
Syon Lane	A		29
	D	2.08	29.5
Isleworth	A		36.5
	D	1.38	37
Hounslow	A	0	39

5.2.9 We believe that it will be beneficial to increase the linespeed on the Hendon line (freight-only lines on the west side of the Midland Main Line) to permit a higher operating speed on the section from the end of the Dudding Hill line to either or both of Hendon or West Hampstead. At this stage of the assessment, however, we have not assumed this upgrade.

5.3 FURTHER OPTIONS CONSIDERED

OPERATION OF TRAINS TO THE CHILTERN LINE AT NEASDEN JUNCTION

5.3.1 This option has been suggested as a potential spur off the Dudding Hill Line, with trains operating from West Hampstead to Wembley, via a new link line at Neasden, then reversing on to an existing spur, and continuing their journey towards Hounslow. This option would require the construction of new infrastructure, with its associated significant cost, and introduce complexities for operating a regular high-performing service on to and off the Chiltern lines. There is very little capacity on what has become Chiltern's main line from London to Birmingham, which operates via Wembley. We believe connections between Neasden Jubilee line station and the new Dudding Hill Line station will provide a very good interchange and is the best way to address onward orbital journeys from locations on the Chiltern line to Amersham and Aylesbury. This option has not been assessed for its likely levels of demand because of these severe infrastructure and operational issues, and it has therefore not been developed further for this study.

CROSSRAIL TO TRING

5.3.2 In the past it has been proposed that some Crossrail trains operate to and from Tring. One option for the link between Old Oak Common and the West Coast Main Line is the use of the Dudding Hill Line. Should the line be used for this purpose in the future, it would be incompatible with the proposal to operate a service from Hounslow to West Hampstead/Hendon without very substantial enhancement work.

5.3.3 However, when the Crossrail link was being assessed the favoured option was a new alignment serving Park Royal, and this would not have any impact on the West London Orbital service. It is understood, though, that no more work is to be undertaken for the foreseeable future on options to extend Crossrail services to and from the West Coast Main Line.

PROVISION OF LINK FROM RUISLIP TO OLD OAK COMMON

5.3.4 The DfT is investigating the possibility of making greater use of the railway which currently runs from Ruislip to Old Oak Common and London, as a means to relieve capacity constraints at

Marylebone station. The intention is that trains may in future run from High Wycombe, Princes Risborough and Banbury to two new platforms at Old Oak Common, where passengers would transfer to Crossrail for their onward journey to different parts of London. One benefit of this proposal is to avoid a very costly and disruptive expansion of Marylebone, which would otherwise be necessary in light of continuing growth on the Chiltern lines.

5.4 INFRASTRUCTURE REQUIREMENTS

NEW STATIONS – NEASDEN, HARLESDEN

5.4.1 At a minimum, new stations would need to be provided at Neasden and Harlesden as they are integral to the re-opening of the northern stretch of line from Old Oak Common to West Hampstead/Hendon.

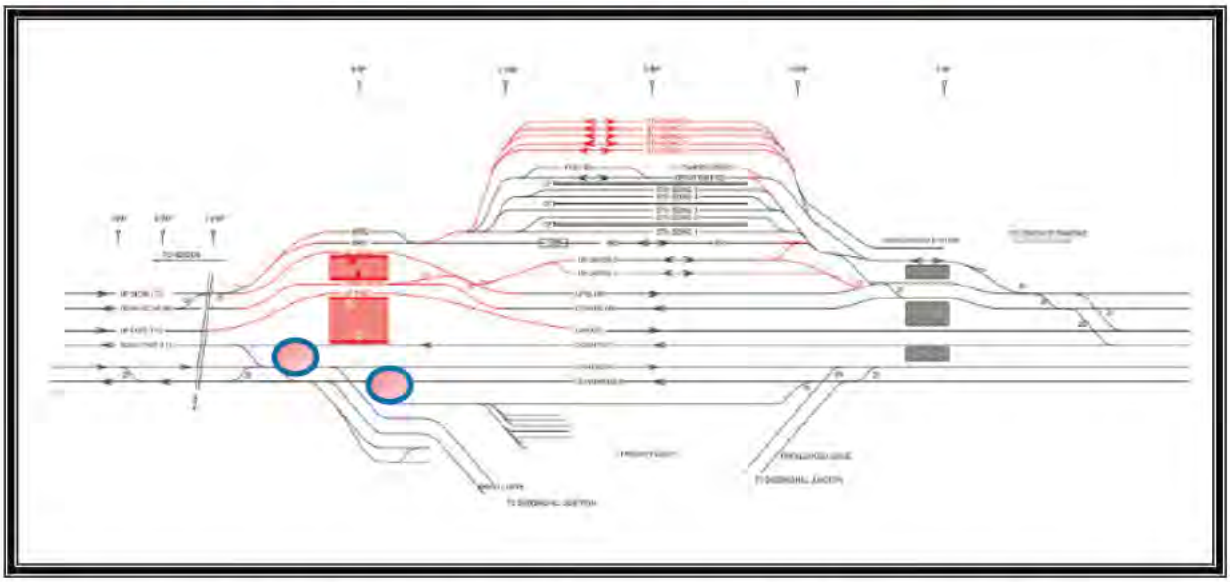
5.4.2 We have reviewed the costs provided by TfL for these stations and believe them to be appropriate. We do believe however, that possession costs could be lessened by combining works: for instance if the line was closed for a period of time, the new stations/platforms were installed at all the relevant locations, and the new signalling (see next point) installed, the cost would be for one possession, not several.

5.4.3 We believe that the costs of Neasden and Harlesden stations, both with 2 x 4-car platforms and associated facilities, will be in the order of £12m (spot cost).

NEW STATION – BRENT CROSS/STAPLES CORNER

5.4.4 A new station for Thameslink services is to be provided at Brent Cross/Staples Corner. This station is not required for passenger services to operate on the Dudding Hill Line. However, by serving Brent Cross/Staples Corner, WLO services would provide valuable access to the new development, and enhance the business case for the scheme. A phased approach for WLO could be considered with trains operating between West Hampstead and Hounslow initially and therefore not operating to Staples Corner.

Figure 5-2 Diagram of proposed stations in the Staples Corner/Brent Cross area



5.4.5 The figure above illustrates the Thameslink station location on the Midland Main Line. The Dudding Hill Lines are towards the bottom of the figure, and form the triangular junction. Two possible locations are indicated for platforms for the WLO service: both appear feasible at this

very early stage of development. The northern site may involve the need (and the cost) to purchase land. However, in both instances the platforms would be some distance away from those to be built to serve the Thameslink lines, and a lengthy footbridge would most probably need to be provided. The topology of the area and the railway junctions precludes providing platforms further south.

5.4.6 We have included a cost of £5m (spot cost) for the platforms in this location.

NEW PLATFORMS – WEST HAMPSTEAD, HENDON, CRICKLEWOOD, OLD OAK COMMON VICTORIA ROAD

5.4.7 New platforms will be needed at each of these stations. Consistent with the TfL analysis, two new platforms need to be provided at each of Cricklewood and Old Oak Common (which would be linked to, but slightly separate from, the London Overground North London Line station). We believe however, that West Hampstead and Hendon only require one new platform at each, based on a maximum of 4 trains per hour turning back at each. At both stations, the existing platform 4 would need to be converted to an island platform, with the removal of fencing and some limited construction work. This should lead to a substantial reduction in estimated costs, and we believe that £1m at each of Hendon and West Hampstead is the appropriate sum. It should be noted that no changes to the junction layout will be necessary at either Hendon or West Hampstead to permit the operation of trains into and out of the single platform at each location.

5.4.8 At Cricklewood, two new platforms will be needed, for by this stage of their journey, the trains will be operating on the correct line for their direction of travel. The platforms would be provided on the freight lines on the west of the railway. In TfL's analysis, it was assumed that the entire station would need to be made step-free, involving the provision of lifts to all platforms. West Hampstead, 2 minutes south of Cricklewood, was, within the last decade, made fully step-free after the installation of lifts and a new footbridge. We have included the full cost of step-free provision as the construction of two new platforms is clearly a material change to the station, but feel that at a later stage of work, it may be considered satisfactory for West Hampstead to be the recommended option for people needing lifts to access the platforms.

5.4.9 Two platforms will need to be constructed at the southern end of the Dudding Hill Line in the vicinity of Old Oak Common, on Victoria Road (at approximately the location marked with an oval on the figure below). It would clearly be of value if this station and the proposed North London Line station – situated directly next to it - were to be planned and marketed as one, with appropriate walkways, footbridge and signage. We have adopted TfL's cost estimate for this station, but in line with our recommendations about the possession costs noted above, believe that one possession should be implemented for all the station construction works and re-signalling, in the interest of cost efficiency. We have included a cost of £14m (spot cost) for the platforms at these locations.

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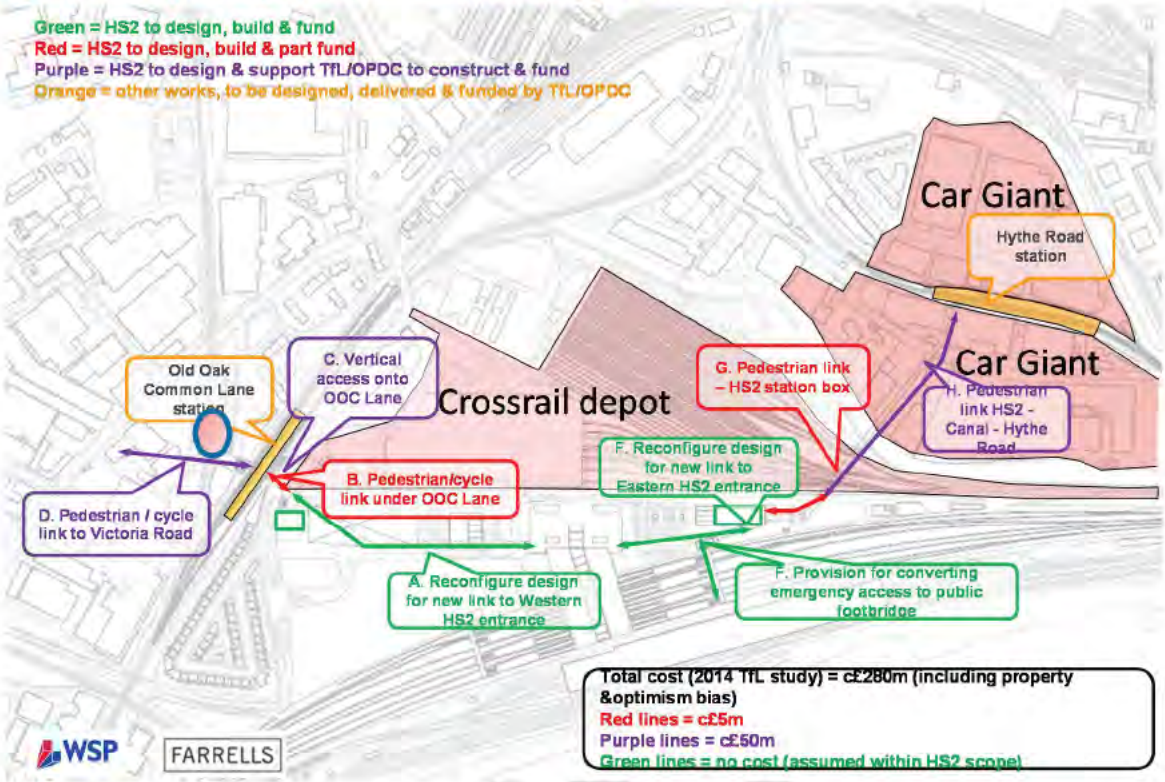
Figure 5-3 Diagram of proposed stations in the Old Oak Common area



HOUNSLOW, KEW BRIDGE AND LIONEL ROAD

5.4.10 The South Western franchise service on the Hounslow loop is changing as a result of the DfT's specification for the new franchise. It is expected that 8 trains per hour will operate; 4 West London Orbital trains can be accommodated provided that a turnback facility at Hounslow is provided along with the doubling of the Kew East junction.

5.4.11 Any West London Orbital service in excess of 4 trains per hour will not be able to operate to Hounslow, and we are assuming under this circumstance that any service above 4 tph will turn round at Kew Bridge or Lionel Road. Infrastructure modifications to the track and signalling will be necessary to permit this, and the disused platforms at Kew Bridge would need rebuilding.

5.4.12 Hounslow: plans were developed to serve South West Trains services. This involved the construction of a reversing siding to the west of the station. This scheme has been postponed for the foreseeable future. We believe that the alternative scheme of a new turnback platform would serve the role better, and deliver better punctuality. It would avoid any delays caused by the driver needing to check the trains for any left-behind passengers and would avoid frequent shunting moves. One platform would be adequate for 4 trains per hour. The necessary pointwork is in place to provide access to the new platform, which would be provided on the south side of the layout - a platform 3. We do not believe that there is any cost-effective way of running more than 4 trains per hour beyond Old Kew Junction and so, if the full service of 8 trains per hour is to operate, an alternative location needs to be found to turn the other 4 trains. We have included a cost of £5.4m (spot cost) for the construction of a new bay platform at Hounslow.

5.4.13 Kew Bridge/Lionel Road: if the option of 8 trains per hour is adopted, no more than four will be able to run all the way to Hounslow, and Network Rail has confirmed this in its own analysis. The reinstatement of the platforms on the Kew east spur, at Kew Bridge would provide one solution.

Another solution is for Lionel Road to be equipped with a turnback facility, probably an extra side platform. The use of the platforms at Kew Bridge will provide easy interchange with trains operated by the South Western franchise to Barnes, Clapham Junction and Hounslow. In addition, some signalling and trackwork will be necessary to allow reversal of trains at this location. We have allowed a total of £4m for the works at this station. We believe this cost will also be appropriate should enhanced facilities need to be provided at Lionel Road to allow the turn back of trains, as an alternative to Kew Bridge.

RE-SIGNALLING

5.4.14 We have assumed a figure of £8m (spot cost) for re-signalling the line between Cricklewood/ Hendon and Old Oak Common, and for Acton – Kew, to modern 3-minute headway colour light signalling. This is essential if the service pattern is to be 4 or 8 trains per hour in each direction, in addition to the freight traffic that uses the route.

5.4.15 The current signalling is on the 'absolute block' principle, involving manual communication between signalmen, and is inadequate for a railway with the proposed type of frequency and requirement for good punctuality.

5.4.16 While Network Rail is proposing re-signalling in CP7 (2024-29), so consistent with our assumption on the possible re-opening of the route, it would normally replace the signalling with 'modern equivalent form', in other words not adding any capacity to the route. The cost we have indicated is an estimate for the work for like-for-like re-signalling.

5.4.17 By the point of delivery, it may be that the Digital Railway concept will have been established nationally, and/or the North London Line will have been equipped with Automatic Train Operation equipment, which could easily be applied to the Dudding Hill Line as well. This would represent a step-change in capability and automate the process.

FOUR-TRACKING AROUND ACTON WELLS

5.4.18 Acton Wells Junction, being the most heavily-used junction on the East Anglia route, is confirmed to be a significant challenge for this project. Our construction team has direct experience with this area and with the previous, low-level enhancement of the two bridges at Acton Wells, which cost an order of magnitude of £10m. Quadrupling Acton Wells Junction, which includes new bridges and the likely addition of electrification, would be significantly more complicated than the previous works.

5.4.19 Just south of Old Oak Common station, the North London Line, by this point joined with the Dudding Hill Line, crosses the Central Line and the single track national rail route from Ruislip to Old Oak Common. Just south of this bridge is the junction used by freight trains running on to the Great Western Main Line at Acton. There is a section of about 350 metres which is two-track, and this acts as a significant bottleneck on the route today. Eight extra trains per hour (and almost certainly not even four) could not operate without a substantial upgrade of capacity.

5.4.20 For our study, we are including the cost of 4-tracking this section of route (marked in red on the figure below). Much of it will be an additional bridge, with some impact on light industrial land. We appreciate the impact to the local residents of further disruption on top of HS2 related works, and there are ways in which this disruption could be mitigated, such as the co-ordination of major activities.

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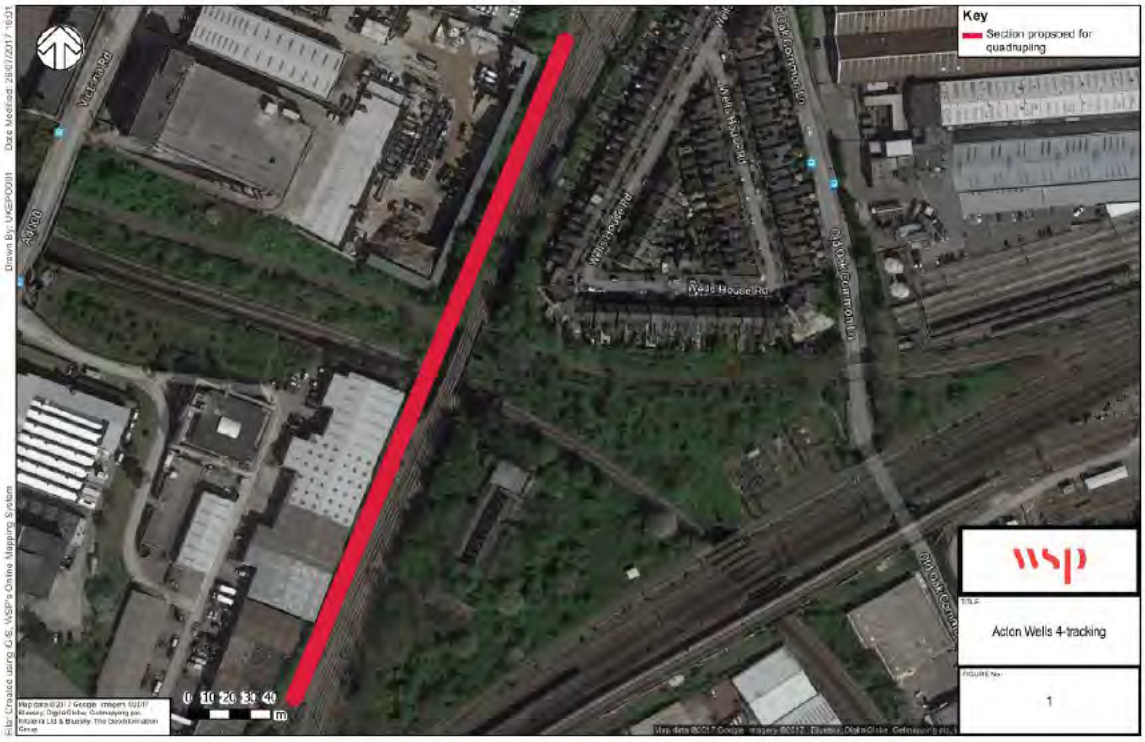
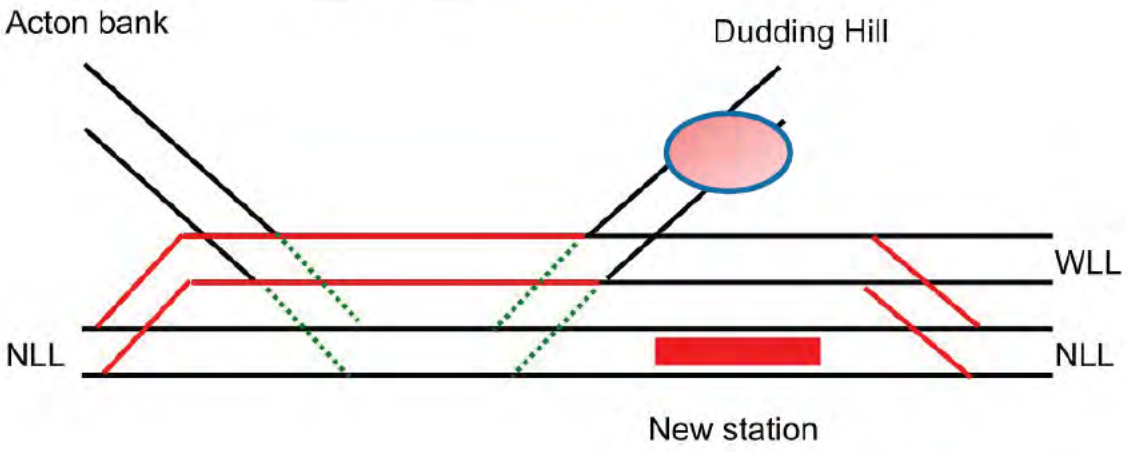
Figure 5-4 Diagram of proposed four-tracking in the Acton Wells area



5.4.21 This infrastructure is appropriate for the proposals at this time, however over the coming decade as both passenger and freight services evolve, the scope of infrastructure capacity enhancements should be kept under review. In the diagram below, it is assumed that there are 5 passenger trains per hour in each direction on the lower pair of tracks and 8 on the upper pair. The majority of freight traffic (an average of 3 trains per hour) will go on the upper pair of tracks and then head towards Acton, with 1 train per hour on the lower pair of tracks. The remaining two-track section to South Acton, and the junction in particular, will remain a capacity constraint, but with a notional capacity of 20+ trains per hour, it should be able to accommodate 14 in each direction.

Figure 5-5: Diagram of proposed track layout in the Acton Wells area



5.4.22 Acton Wells Junction was recently renewed in Christmas 2015. The entire track system was replaced and local upgrades were made to the signalling and overhead line. The proposed layout

will require a new underbridge that spans the Wycombe single and the Central line. The Central line is now designated as a night tube route and possessions are very scarce. The Wycombe single could potentially be removed as part of the HS2 works associated with Old Oak Common. The site around Acton Wells has a high level of contamination from Japanese Knotweed, which requires specialist handling, clearance, and ongoing management.

5.4.23 The bridge construction will be very challenging and will require temporary land take of the surrounding commercial properties. The existing under bridges, which cross the Wycombe single and the Central line have had recent repair, but are classified as being in "poor condition" by Network Rail. Consideration should be given to replacing these bridges at the same time as the other works are undertaken; economies of scale might be achieved with possessions and infrastructure costs if this is accomplished as a joined-up programme with Network Rail.

5.4.24 There are a number of HV routes that run adjacent to and below the tracks that will potentially need to be relocated. It is also likely that the overhead line electrification would need to be moved or duplicated on the new tracks in Acton Wells junction, as it would allow more effective capacity planning for the electric rolling stock services.

5.4.25 Possessions on this route are extremely rare and are limited to Christmas and six hour Saturday night closures. Access for machines and personnel is through either the Ikea Car park on the Dudding Hill Lines or through the redundant EWS shed off of Old Oak Common Lane.

5.4.26 Upgrading and quadrupling of Acton Wells will be very challenging, but enhancing the capacity of Acton Wells will allow segregation of the many competing services in the area, with significant capacity increases, and would most likely be very popular with all of the railway stakeholders, including freight companies and Network Rail. This may attract pooled capital investment contributions. A more detailed scoping analysis of electrification, HV relocation, track layout, and access planning will be needed to better inform cost estimates. However, a high level estimate for capital and possession costs is £45m (spot cost).

DOUBLING KEW EAST CURVE AND POTENTIAL GRADE SEPARATION

5.4.27 Network Rail has undertaken timetable analysis for the route from Hounslow to Old Oak Common. The analysis assumed the doubling of Old Kew junction, as that location was deemed to be the most tightly constrained of the entire route.

5.4.28 The doubling of the junction is a relatively straightforward construction activity. However, there would be some significant enabling works to be carried out such as the relocation of location cases, troughing routes and power supplies. It is anticipated that no additional land would be required as the limit of development would be within the limits of deviation for Network Rail. A bank holiday weekend would provide a sufficient duration to install and commission the double junction. We estimate a figure of £4.6m (spot cost) for doubling the junction.

5.4.29 If the junction was to be grade separated with a single line viaduct, it will need to be approximately 400m based on a 1:30 gradient in length and will more than likely extend beyond the Network Rail boundary. The capital cost of such a flyover, with ballasted rail and turnouts, would be of the order of £8.5m (in addition to the above cost). To reduce the impact on the operational railway, offline construction will need to be considered, which may result in further acquisition of land. The duration of construction will depend upon possession and land availability, but would be approximately 18 – 24 months.

5.4.30 There would be the opportunity to integrate required possessions with the Hounslow works and potentially the Bollo Lane works (described below).

BOLLO LANE LEVEL CROSSINGS

5.4.31 There are two level crossings just south of South Acton station, one on the North London Line

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and one on the line from South Acton to Kew, collectively termed the Bollo Lane level crossings. The operation of a much more intensive service on the latter of these routes will lead to greatly increased level crossing down time, with all the disruption that that causes to local traffic, as well as increased safety concerns.

5.4.32 Given the close proximity with the level crossing on the North London Line, and the fact that there are some small industrial units between the two crossings, it is not feasible to only seek to replace the level crossing affected by the proposed introduction of passenger services on the Dudding Hill Line. However, closure of the Bollo Lane level crossings will present significant challenges as there are not clearly viable infrastructure solutions.

5.4.33 Elevating the railway over the road will be expensive and create significant disruption to the railway and local environment. It would likely require the purchase of some properties. Placing the railway beneath the existing road appears feasible, but again will be very disruptive to the railway as a considerable amount of closures will be required to carry out the work.

5.4.34 The most affordable solution would be to permanently close the two level crossings and provide bridges to maintain access and permeability for pedestrians and cyclists, with associated re-planning. Highway traffic would have to be re-routed and the surrounding network upgraded to accommodate additional traffic. Such proposals may be unacceptable to local stakeholders.

5.4.35 Further investigation and work will be required before a more detailed scope can be determined, which would include consideration of the traffic impacts of closure, volumes of HGVs using alternative routes (and what these routes are) and, of course, the cost impacts.

5.4.36 For the purposes of this study we have included a figure of £30m to provide a solution, but at this stage it has not been defined. Such a solution would permit the West London Orbital trains to operate, but also provide a wide range of other benefits for the local road network and local communities, by removing the severance and safety issues of interfacing with the rail network.

CHURCHFIELD ROAD CROSSING (ACTON)

5.4.37 There is a level crossing just north of Acton Central station which will see significantly increased downtime following the introduction of the West London Orbital services. Subject to modelling/local consultation, closure could be considered, and we have assumed a cost of £5m representing an estimated cost for a footbridge with ramps.

ELECTRIFICATION, ROLLING STOCK CHOICES, DEPOTS AND STABLING

5.4.38 At this stage we are assuming that the railway will be operated by diesel traction, or possibly battery or hybrid traction. While the Kew – Acton and Dudding Hill Line sections are not electrified, all the rest of the line is and battery technology may have developed sufficiently by the time of opening to be a viable option. Therefore, potential subsequent phases of the enhancement plans could electrify the non-electrified sections.

5.4.39 Depot and stabling facilities need to be provided, regardless of the choice of rolling stock. We recommend use of the facilities at Cricklewood for stabling, either in the triangle between the north- and south-facing Dudding Hill curves, or on the other side of the Midland Main Line. At present there is sufficient capacity for a small fleet of 4-car multiple units; this may have changed by the time of implementation, but should be included in ongoing plans for the development of the site. Fuelling, cleaning and minor maintenance could be undertaken here. An alternative location could be the south west sidings at Willesden, which see very little use.

5.4.40 Depot facilities are harder to identify for diesel rolling stock in the London area. There are very clearly cost efficiencies in sub-contracting the maintenance to a depot which is already there (and preferably currently services diesel trains), rather than a depot solely for the small fleet of trains necessary for this new service. Options include:

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- Wembley depot, which is used by Chiltern for its entire fleet of rolling stock. It is a small depot, but is closest to the route.
- Reading depot, which will retain a small fleet of diesel rolling stock for the non-electrified routes in the Thames Valley operated by GWR. There would probably be capacity at Reading depot, but it would require operation of empty coaching stock trains to and from Reading (approximately 34 miles from Acton) on a regular basis.
- Salisbury depot, which is known to be capacity constrained and a considerable distance from the route. The depot current maintains SWT's fleet of class 158/9s, which operate from Waterloo to Exeter.
- Selhurst depot, which would create a complex journey, albeit not too lengthy, for units to travel to this depot. It currently services class 171s operated by GTR, and deployed on the Uckfield and Brighton – Ashford services. The depot probably has capacity.
- Willesden depot, where the diesel facilities are to be withdrawn after the electrification of the Gospel Oak – Barking route, but there may be scope to reinstate them at a modest cost.

5.4.41 At this stage it would be inappropriate to be definitive about the choice of depot as matters will evolve between now and the implementation date. For the purposes of the study we have included a capital cost of £5m for the provision of capital equipment for diesel rolling stock at a location, and access charges would need to be paid on an ongoing basis to the operator of the depot.

5.5 PROPOSED INFRASTRUCTURE ENHANCEMENT COSTS

5.5.1 The table below provides a summary of the estimated capital costs associated with the proposed new service.

Table 5-2 Infrastructure Capital Cost Estimates

ITEM	SPOT COST PROPOSED	COMMENTS
West Hampstead 2 new platforms (4-car)	£1m	If conventional rolling stock is used, only one platform needed, as an extension of current platform 4.
Cricklewood 2 new platforms (4-car)	£5.5m	Extend subway to new platform or add AFA lift and footbridge; cost estimate is based on step-free access to the newly built platform, will be similar in either case.
Hendon 2 new platforms (4-car)	£1m	Only one platform needed, as an extension of current platform 4.
Brent Cross/ Staples Corner	£5m	£5m increment on new station to be provided for Thameslink on the Midland Main Lines.
Neasden new station (4-car)	£18m	We agree with the construction costs provided by TfL, but by taking the possessions at the same time, we believe a cost saving of £800,000 can be made.
Harlesden new station (4-car)		
OOC Victoria road new platforms (4-car)		
Re-signalling of Dudding Hill line and Acton - Kew	£8m	Efficiencies could be found if re-signalling is combined with other possessions for the stations, but signalling project costs are often underestimated. Cost of data exchange and expanded Kew Bridge East scope added as minimum.
Quadrupling of Acton Wells Junction area	£45m	The required scope would be larger than considered in the initial report, due to anticipated renewals of existing bridges, site complications, and new electrification needed.
Bollo Lane level crossing replacement	£30m	Significant further work will be necessary to determine the scope of this.
Acton level crossing	£5m	Removal, and replacement with a footbridge.
Kew Bridge or Lionel Road turnback	£4m for each	Turnback facilities and refettling work necessary for turnback of 4tph (in addition to Hounslow).

Old Kew Junction doubling	£4.6m	In line with TfL report.
Old Kew Junction flyover	£8.5m	400m single track viaduct, ballasted track, and turnouts.
Hounslow bay platform	£5.4m	Bay platform to turn back 4 tph.
Depot facilities	£5m	Capital cost of necessary equipment.
Total	**£146m**	**Excludes risk/contingency and optimism bias.**

5.5.2 Given the early stage in the development of the scheme and the uncertainties and challenges described above, in line with guidance we have included a risk/contingency allowance of 80%. This produces a total capital cost of £263m.

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6 PREFERRED OPTION

6.1 INTRODUCTION

6.1.1 Based on the demand forecasting and analysis of operational and infrastructure requirements for the three options described in Chapter 3, conclusions were drawn to inform the specification of the preferred option to be assessed. The conclusions were:

- Option 3 (4 tph West Hampstead – Hounslow and 4 tph Hendon – Hounslow) attracts a higher level of demand and therefore higher total benefits (reduced passenger distance and passenger hours) when compared with Option 1 (4 tph Hendon – Hounslow) and Option 2 (4 tph West Hampstead – Hounslow).
- Old Oak Common is central to the demand profile on the route, and it appears feasible to construct a station on the Dudding Hill lines at Brent Cross/Staples Corner.
- With appropriate enhancements to the railway, the assumed level of service can be accommodated, but providing in excess of 4 trains per hour to Hounslow, on top of the South West Trains service, is deemed prohibitively expensive.
- The preferred option should seek to deliver the benefits of option 3 (or as much of them as possible) for the most economical level of capital costs, e.g. a turnback at Kew Bridge and potentially with a phased introduction.

6.1.2 Based on these conclusions a preferred scenario has been developed and agreed with the client group. The preferred option is specified as:

- Phase 1 – 4 trains per hour from West Hampstead to Hounslow.
- Phase 2 – additional 4 trains per hour from Hendon to Kew Bridge.

6.1.3 The run times are the same as assumed in the initial demand modelling for Options 1 to 3.

6.2 DEMAND MODELLING

6.2.1 The LTS-PT model has been used to undertake demand and benefit forecasting for the preferred option, consistent with the initial options modelling. A range of model outputs have been generated, including summary statistics, flow difference plots, new services line loading, boardings and alightings.

SUMMARY STATISTICS

6.2.2 Summary statistics at a global level for each AM and PM scenario modelled, as well as the difference with the associated baseline scenario are presented in Appendix B-1.

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Baseline: Standard LTS-PT 2041 Reference Case (A141rc01a)

6.2.3 The introduction of West London Orbital passenger services is forecast to result in an increase in passenger kilometres, passenger hours and total passenger boardings on rail services (including WLO) of 9,374 in the AM and 9,327 in the PM. A reduction in passenger kilometres, passenger hours and total passenger boardings on LUL and buses indicates that the demand for the West London Orbital services is likely to be abstracted from LUL and bus services, providing crowding relief for them.

6.2.4 The WLO is estimated to improve connectivity and provide extra capacity on the public transport network in London resulting in lower levels of distance travelled, total boardings, journey times and crowding levels, above all in the north-western and south-western quadrants of London. The table below provides a summary across all public transport modes in London.

Table 6-1 Summary statistics. WLO Preferred Option versus 2041 Reference Case

MODE	PEAK	*DESCRIPTION*	*2041 TFL REF CASE*	*CHANGE IN USER BENEFITS*
		Scenario	A141rc01a	Preferred Option minus RC
All PT	AM	Passenger Kms	85,795,810	-33,096
		Uncrowded Passenger Hours	115,348,652	-140,143
		Crowded Passenger Hours	154,400,839	-317,792
		Passenger Boardings	6,244,762	-1,827
	PM	Passenger Kms	89,635,043	-26,986
		Uncrowded Passenger Hours	120,021,714	-119,500
		Crowded Passenger Hours	154,108,212	-308,646
		Passenger Boardings	6,791,486	-1,913

Baseline: 2041 Maximum Growth Scenario without Crossrail 2

6.2.5 When tested against the Maximum Growth Scenario, the pattern of the results is similar as for the Reference Case Scenario. However, the additional trip generation associated with the Maximum Growth Scenario means changes are greater as summarised in Table 6-2.

Table 6-2 Summary statistics. WLO Option Scenarios versus 2041 Maximum Growth Scenarios

MODE	PEAK	*DESCRIPTION*	*2041 MAX GROWTH (MG)*	*CHANGE IN USER BENEFITS*
		Scenario	A141rc01a	Preferred Option minus MG
All PT	AM	Passenger Kms	88,152,748	-34,613
		Uncrowded Passenger Hours	118,927,182	-129,397
		Crowded Passenger Hours	160,705,541	-370,356
		Passenger Boardings	6,485,584	-2,010
	PM	Passenger Kms	92,436,014	-28,444

	Uncrowded Passenger Hours	124,289,369	-126,955
	Crowded Passenger Hours	162,352,074	-351,499
	Passenger Boardings	7,068,359	-2,028

FLOW DIFFERENCE PLOTS

6.2.6 Differences in demand on the public transport network in the AM and PM between each option and its associated baseline scenario are presented in Appendix B-2. Increases in passenger volumes are shown in red and reductions in green.

6.2.7 The introduction of West London Orbital passenger services is forecast to attract passengers from LUL lines such as the Northern, Jubilee, Central, District and Piccadilly as well as rail services currently operated by South West Trains and Great Western Railway. With the WLO passenger services operating these national rail services are likely to witness lower levels of crowding, providing overall crowding relief to a broad range of other services.

6.2.8 A direct connection between Old Oak Common (OOC) Victoria Road station, which is considered as part of the WLO, and the main Old Oak Common station is estimated to attract additional passengers to the Elizabeth Line (Crossrail 1). However, the number of passengers transferring at the OOC between the WLO services and the Elizabeth Line drops by around 25% in comparison with Option 3 as the WLO Hounslow-Hendon service gets truncated to Kew Bridge providing less frequent connection to/from Hounslow.

LINE LOADING BY STATION

6.2.9 Line loading, station boardings and alightings are detailed in Appendix B-3. This section summarises the findings of the analysis.

Baseline: Standard LTS-PT 2041 Reference Case (A141rc01a)

- → The WLO services are forecast to carry 9,504 passengers In the AM (0700-1000) and 10,165 passengers in the PM (1600-1900).
- → The demand will vary by station with OOC Victoria Road being utilised the most. For example, in the AM 1,537 passengers are forecast to board the West London Orbital services and 4,660 to alight. In the PM these numbers are 3,917 and 2,428 passengers respectively. The majority of these passengers are those interchanging from/to the Elizabeth Line (Crossrail 1).

Baseline: 2041 Maximum Growth Scenario without Crossrail 2

- → The WLO services are forecast to carry 9,758 passengers In the AM (0700-1000) and 10,623 passengers in the PM (1600-1900).
- → In the Maximum Growth Scenario WLO services are forecast to carry more passengers than in the Reference Case: on average 2.7% more in the AM and 4.5% in the PM.
- → The demand will vary by station with OOC Victoria Road being utilised the most. For example, in the AM 1,682 passengers are forecast to board the WLO services and 4,593 to alight. In the PM these numbers are 3,916 and 2,669 passengers respectively. The majority of these passengers are those interchanging from/to the Elizabeth Line (Crossrail 1).

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7 ASSESSMENT OF PREFERRED OPTION

7.1 INTRODUCTION

7.1.1 A preliminary assessment to support a decision on whether or not to proceed with the development of the scheme has been undertaken drawing upon the outputs of the demand forecasting and capital cost estimates, supported by further analysis.

7.2 ECONOMIC APPRAISAL

7.2.1 The economic appraisal has been undertaken in line with TfL guidance (as set out in the Business Case Development Manual, March 2017). The forecast benefits (both uncrowded and crowded time in hours) for all public transport users have been converted into monetary values based upon TfL's values of time for rail users in work time and for commuting and other journey purposes.

7.2.2 The forecast benefits have been profiled over a 30-year appraisal period from 2026 to 2055. The profiling captures:

- Value of time growth (from BCDM)
- Background demand growth to 2041 (from LTS-PT model)
- Build-up factor of 50% in years 2026-2028 prior to introduction of 8 tph services from 2029
- Discounting at 3.5% for next 30 years and then at 3%

7.2.3 Substantial benefits are forecast to arise from the journey time improvements provided by the WLO rail services, notably by accessing the Elizabeth Line at OOC Victoria Road and for journeys within the corridor which cannot currently be made directly (with travel time savings of up to 20 to 30 minutes). In total the value of the travel time benefits for the appraisal period exceed £10bn PV.

7.2.4 In addition, very significant benefits are forecast to be experienced not only by those using the WLO rail services, but by those experiencing less crowded travel conditions on other routes on the national rail network. In total the value of the crowding relief benefits for the appraisal period exceed £20bn PV.

7.2.5 Set against these social benefits (i.e. economic welfare rather than financial) are the costs of the scheme, both capital and operating. The capital costs have been described in Chapter 5 with a total cost including 80% risk identified as £263m. In line with appraisal practice, an optimism bias uplift of 64% reflecting the early stage of scheme development has been applied for the assessment. It is assumed that there will be real growth inflation on this current year estimate of 1.5% per annum until scheme opening. This produces a discounted capital cost estimate for the appraisal of £374m PV.

7.2.6 Forecast operating costs have been estimated on the basis of consistency with standard industry assumptions. They are estimated to be (in current prices):

- £8.611m p.a. for Phase 1 from 2026
- £15.247m p.a. for the full service from 2029

7.2.7 As with the capital costs, real growth inflation (1% p.a. in line with revenue) has been assumed. Over the life of the appraisal period the total operating cost is estimated to be £315m PV, including optimism bias uplift.

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7.2.8 For the purposes of this preliminary economic appraisal, and reflecting the results from LTS-PT being based on trip reassignment and hence largely redistribution of revenue, we have not included revenue in the appraisal as the net effect on the overall case will be negligible. However, as discussed below, we have forecast estimated revenue for the WLO rail services in order to inform consideration of the anticipated operating position.

7.2.9 The resulting indicative benefit to cost ratio for the proposed WLO services is very high (over 50:1). This reflects the very substantial social benefits received by both users of the WLO rail services and users of the wider public transport network from the journey time and capacity improvements introduced. These benefits are derived from infrastructure that largely exists and therefore mitigates the cost requirements of the scheme.

Table 7-1 Summary of Economic Appraisal Results

ITEM	30 YEAR PV 2017
Journey time benefits	>£10bn
Crowding benefits	>£20bn
Total Social Benefits	**>£30bn**
Capital costs	£374m
Operating costs	£315m
Revenue	Not included
Net Financial Effect	**£689m**
Net Present Value	**>£30bn**
Benefit:Cost Ratio	**>50:1**

7.3 OPERATING POSITION

7.3.1 For the purposes of this study it has been assumed that the WLO rail service would be operated as a London Overground concession. Indicative revenue has been estimated on the basis of assuming that all additional rail boarders forecast in LTS-PT provide a yield of £1 for WLO rail services recognising that many trips are likely to be 'discounted' due to the use of travelcards, season tickets, capped fares etc. and as legs of multi-legged journeys. This produces an estimated revenue when the 8 tph service has commenced operation of around £9m (in current prices). This compares to an operating cost estimate of around £15m.

7.3.2 The requirement for an operating subsidy is standard for much of the rail network, but further consideration of means to meet the 'gap' between the forecast revenue and operating cost will need to be considered in order to confirm the affordability of WLO rail service operations. This consideration should address:

- → Future TfL fares' policy for orbital travel, recognising the strategic nature of many of the trips (which can be made without crossing fare boundaries, in contrast with radial trips)
- → Opportunities to harness future technology for ticketing and fares to most effectively manage demand across the network and price fares appropriately
- → Future rolling stock choices, e.g. electric or battery, and implications for operating and whole-life costs

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7.4 WIDER BENEFITS

ACCESSIBILITY

7.4.1 Through the provision of new direct high quality public transport links and integration with the wider national rail network and LUL network, the introduction of WLO rail services will deliver a step change in accessibility to and from the corridor between Hounslow and West Hampstead/Hendon.

7.4.2 Figures 7-1 and 7-2 illustrate the extent of the catchments for the new stations by time band in the 'with' and 'without' scenarios for WLO rail services. As can be seen, the introduction of WLO rail services significantly increases the areas accessible within 'reasonable' travel times (e.g. within 20 and 30 minutes) of these currently under-served locations.

7.4.3 Figure 7-3 shows the walk-in catchment for each of the stations served by the proposed services. It also presents the PTAL score for each station location in the absence of the scheme. The majority of the stations are scored as 3 or 4. (It should be noted that the baseline does not fully capture the large scale development around Old Oak Common, due to the forecast year available. It is therefore anticipated that the eventual baseline PTAL for the Old Oak Common (Victoria Road) will be considerably higher than shown in this analysis).

7.4.4 PTAL is a standardised measure used by TfL, which combines information about the proximity of public transport services and the morning peak frequencies. The PTAL scores have been produced from WebCAT PTAL output, which takes the closest point to the station. As this can be up to 100m from the platforms or station entrance, a manual adjustment was made. Figure 7-4 shows the effect on the PTAL score of introducing the scheme.

Figure 7-1 Accessibility in without WLO rail services scenario

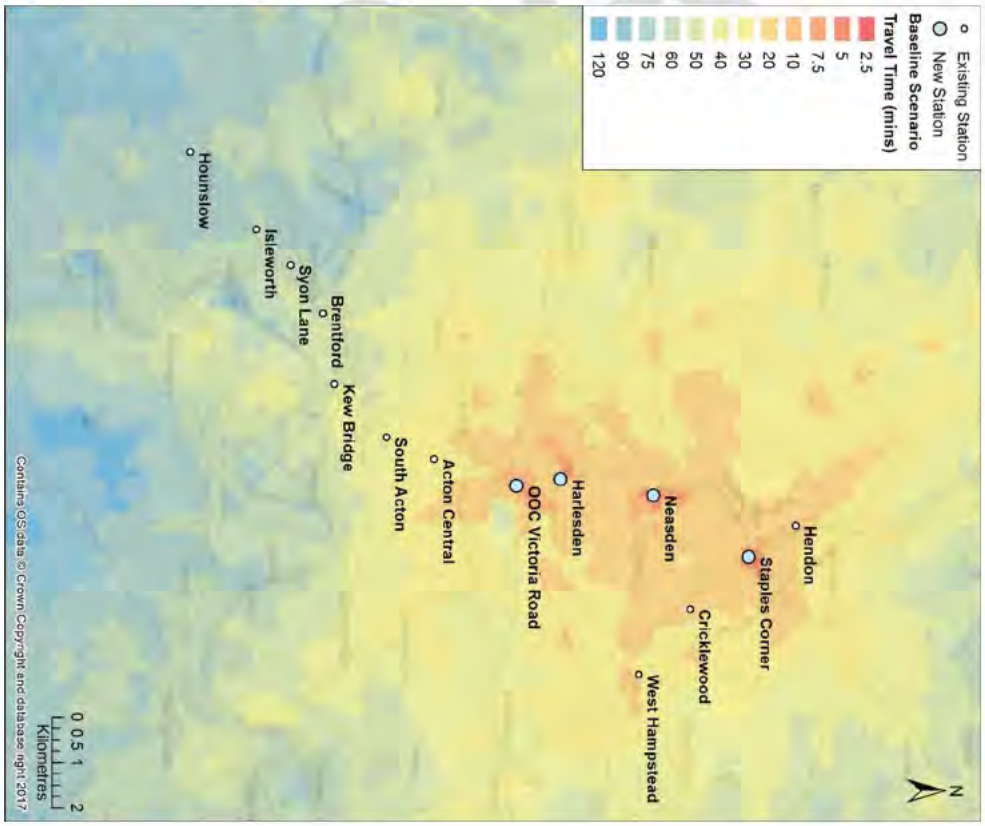


Figure 7-2 Accessibility in with WLO rail services scenario

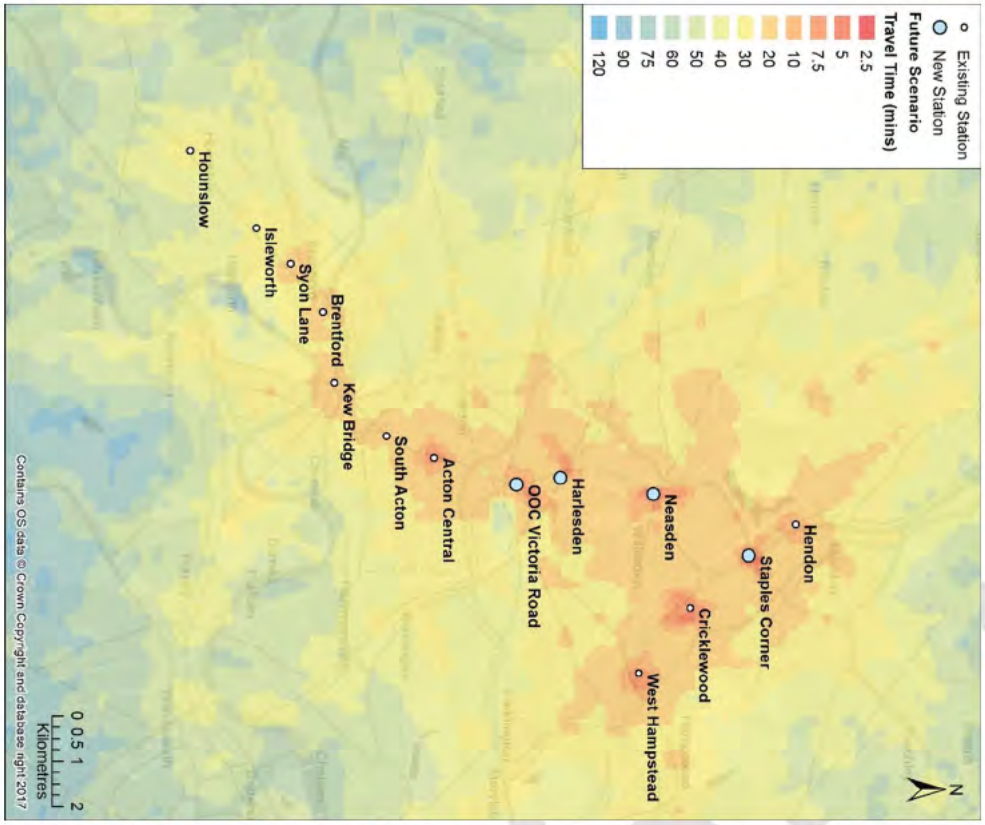


Figure 7-3 PTAL scores without WLO rail services

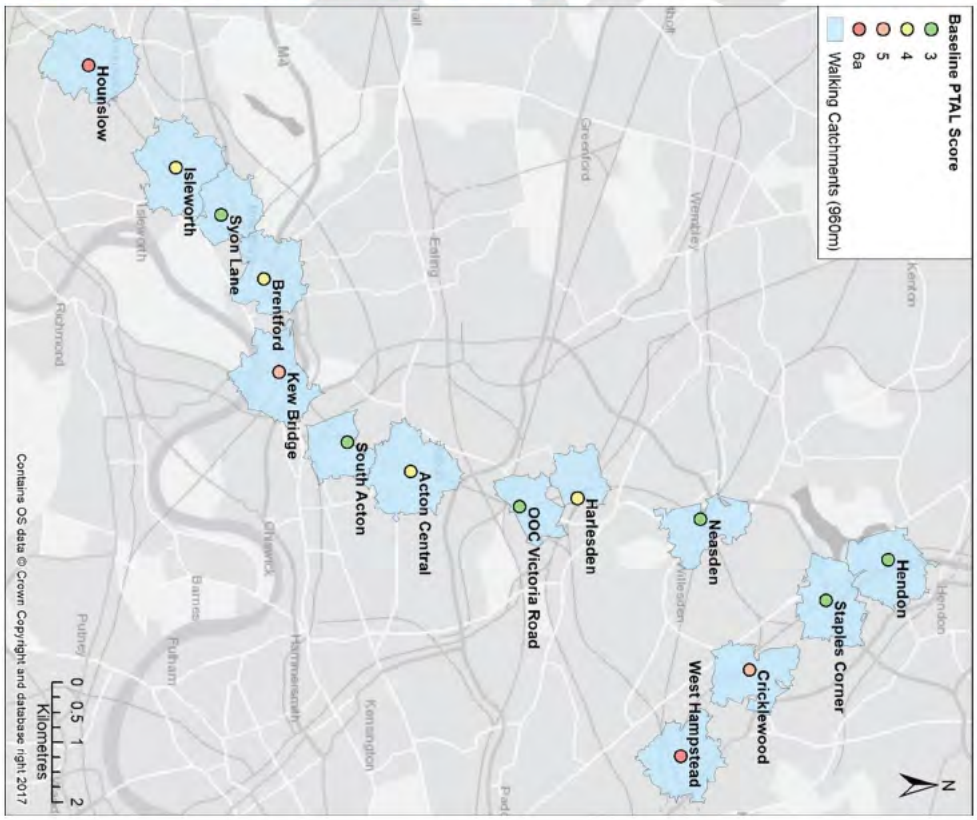


Figure 7-4 PTAL scores with WLO rail services

7.4.5 The results of the PTAL analysis illustrated in Figures 7-3 and 7-4 demonstrate an increase in score for nine of the 14 stations. All six of the stations with a score of 3 without WLO rail services gain a score of 4 after its introduction. Both Isleworth and Harlesden stations are promoted to a score of 5.

SUPPORTING GROWTH

7.4.6 The demand forecasting and economic appraisal demonstrate the very significant benefits to the forecast public transport users in 2041, based on TfL's current assumptions. In West London there are ambitions to deliver additional significant housing and the provision of high quality public transport and good accessibility is seen as providing an opportunity to increase the density of developments and potentially open up new sites.

7.4.7 PTAL scores are used in the Housing Density Matrix in the London Plan to set out recommended housing densities for developments. As indicated in the extract from the London Plan below, (and assuming 'Urban' setting for West London), the range of expected densities around the stations served by the scheme would increase to up to 700 habitable rooms per hectare and up to 260 units per hectare in the most accessible locations.

Figure 7-5 Recommended Housing Densities in the London Plan

Setting	Public Transport Accessibility Level (PTAL)		
	0 to 1	2 to 3	4 to 6
Suburban	**150-200 hr/ha**	**150-250 hr/ha**	**200-350 hr/ha**
3.8-4.6 hr/unit	35-55 u/ha	35-65 u/ha	45-90 u/ha
3.1-3.7 hr/unit	40-65 u/ha	40-80 u/ha	55-115 u/ha
2.7-3.0 hr/unit	50-75 u/ha	50-95 u/ha	70-130 u/ha
Urban	**150-250 hr/ha**	**200-450 hr/ha**	**200-700 hr/ha**
3.8-4.6 hr/unit	35-65 u/ha	45-120 u/ha	45-185 u/ha
3.1-3.7 hr/unit	40-80 u/ha	55-145 u/ha	55-225 u/ha
2.7-3.0 hr/unit	50-95 u/ha	70-170 u/ha	70-260 u/ha
Central	**150-300 hr/ha**	**300-650 hr/ha**	**650-1100 hr/ha**
3.8-4.6 hr/unit	35-80 u/ha	65-170 u/ha	140-290 u/ha
3.1-3.7 hr/unit	40-100 u/ha	80-210 u/ha	175-355 u/ha
2.7-3.0 hr/unit	50-110 u/ha	100-240 u/ha	215-405 u/ha

Figure 2.1: Recommended housing densities in the London Plan

hr = habitable rooms
u = a dwelling unit, i.e. a flat or a house
ha = hectare

7.4.8 Assuming an increase in density around the stations where the PTAL score increased to 4 or above in the with WLO rail services scenario, the recommended increase in the number of units within the walk-in catchments of the stations could be around 200 units on the basis of the London Plan guidance. If the effect of the improved accessibility is extended to a one mile radius, the result could be over 300 additional units.

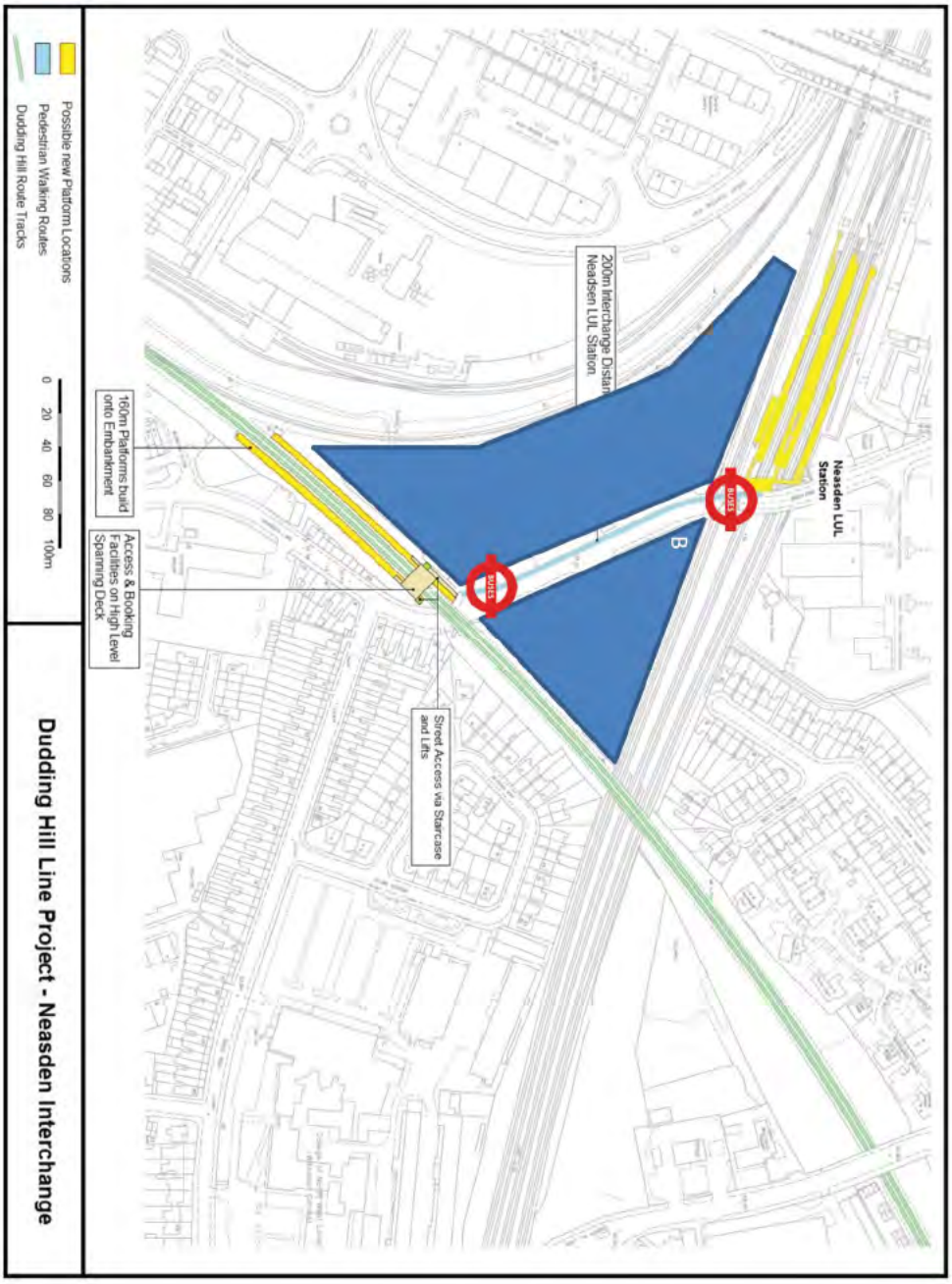
7.4.9 These indicative estimates however, are likely to be very conservative and developers will be keen to exploit the full commercial potential of the sites and seek to provide the highest densities they can. If this was to produce densities at some locations consistent with the 'Central' setting the level of additional units could approach around 1,000 units.

7.4.10 The above estimates are purely illustrative and do not reflect the current usage and densities in the areas which would benefit from the WLO rail services. Based on the emerging Strategic Housing Land Availability Assessments for the West London boroughs many identified sites will benefit from the introduction of the WLO rail services. This could potentially, subject to finalisation of site identification, developer appetite and local policies enable the intensification of housing development to potentially deliver 15,000 to 20,000 units.

7.4.11 The results of the demand forecasting indicate that in 2041 the WLO rail services will provide sufficient capacity to accommodate further significant growth on rail demand arising from further housing and employment development along the corridor.

OPPORTUNITIES FOR OVER-SITE DEVELOPMENT

Figure 7-6 Illustrative concept for OSD at Neasden



7.4.12 One potential way to support both the densification of development in the corridor and to raise funding to assist in addressing the scheme affordability, is to pursue opportunities for over-site development (OSD) at the WLO stations, which themselves are only likely to be cost effective if constructed to a material density.

7.4.13 A new station at OOC Victoria Road provides a good opportunity for a relatively dense OSD structure, along with increased public space and thoroughfare provision. This could complement the OPDC development masterplan. There is also precedent for OSD of reasonable density at Neasden. The new station at Harlesden offers limited potential for OSD, given its low density surroundings and lack of immediate proximity to an employment centre, but there is some space in the local area to enable a more ambitious vision when the future OPDC starts to regenerate the adjacent surroundings, so a longer-term masterplan could enable viable OSD.

7.4.14 The likely timescale for the delivery and operation of the WLO rail services, combined with TfL's ambitions for development of its sites via its Property Partnership Framework, would be the ideal timing and climate in which to bring forward plans for new transport-oriented development and new or rejuvenated town centres.

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8 CONCLUSIONS & RECOMMENDATIONS

8.1 BACKGROUND

8.1.1 The Dudding Hill line running from Acton to Cricklewood, has been identified as providing the opportunity for transport investment to support the sustainable growth of population and employment in the area. The line is currently lightly used by freight and very occasional passenger charter trains. The re-introduction of passenger services on the Dudding Hill Line and the Kew – Acton link to provide a West London Orbital (WLO) rail service from Hounslow to West Hampstead and Hendon would provide an efficient and effective means to serve the proposed developments for the corridor between Hounslow and West Hampstead/Hendon.

8.1.2 This study has confirmed the appropriateness of developing a heavy rail solution for the corridor given its existing role as a freight route and the opportunity to provide connectivity across the wider rail network. Retention of the heavy rail corridor on the Dudding Hill Line section would also permit integration of the WLO services into London Overground operations and to support the further success of this brand.

8.1.3 The preferred WLO service is based upon the findings from demand forecasting for different service options and analysis of the operations and infrastructure implications of delivering the options. The preferred WLO service, agreed with the client group, is the phased introduction of:

- → 4 trains per hour from West Hampstead to Hounslow (from 2026)
- → Additional 4 trains per hour from Hendon to Kew Bridge (from 2029)

8.2 THE CASE FOR THE PREFERRED OPTION

8.2.1 The results of the demand forecasting (using TfL's LTS-PT model) demonstrate a forecast increase in passenger kilometres, passenger hours and total passenger boardings on rail services (including WLO) of around 9,500 in both the AM and the PM periods. A reduction in passenger kilometres, passenger hours and total passenger boardings on LUL and buses indicates that the demand for the WLO services is likely to be abstracted from LUL (notably Northern, Jubilee, Central, District and Piccadilly lines) and bus services, providing crowding relief for them.

8.2.2 The value of the passenger benefits, when quantified in line with TfL guidance, more than offsets the estimated capital costs for the scheme and the cost of operating the services (producing a benefit to cost ratio above 50:1). This strong economic appraisal result is supported by the additional unquantified benefits that would arise from the transfer of highway trips to rail services, e.g. from the A406 North Circular Road (which are not included in the demand forecasting), and supporting the local housing and employment agendas and the draft Mayor's Transport Strategy.

8.2.3 Demonstrating the implications of the introduction of the WLO rail service, PTAL analysis identifies a significant increase in the accessibility provided. Of the 14 stations served by the WLO services, nine improve by a PTAL score. On the basis of this increase in scores and the London Plan's guidance on associated densities for housing developments, the WLO rail service could support significant additional units subject to finalisation of site identification through the Strategic Housing Land Availability Assessments process, developer appetite and local policies.

8.2.4 The assessment of the preferred option indicates a strong value for money case, encompassing both quantified and unquantified benefits.

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8.3 DELIVERABILITY OF THE PREFERRED OPTION

8.3.1 While the introduction of WLO rail services is anticipated to provide significant benefits for West London, and beyond, the delivery of the scheme presents some very significant challenges. As identified in the study these relate to the affordability of the scheme and the technical feasibility of implementing it.

8.3.2 The capital cost estimate for the scheme is around £150m, with an additional 80% risk assumed at this initial stage of scheme development. Given the magnitude of this cost estimate, significant funding sources will need to be identified in order to achieve scheme affordability. Initial analysis indicates that there is scope to derive a significant contribution towards this capital cost through funding from the Community Infrastructure Levy (CIL). With potentially 15,000 to 20,000 new homes planned in West London the associated value of the CIL could approach around £150m.

8.3.3 While there is an existing rail corridor, which serves freight trains, to accommodate the introduction of frequent passenger services requires capacity enhancements and the closure of level crossings. The most challenging enhancement is the quadrupling of track around Acton Wells. This will be technically difficult both in regards to the works required, including the construction of a new bridge, and given the very limited availability of possessions in which to undertake the work. However, such are the benefits to the rail industry if a solution can be delivered, that funding contributions towards it may be forthcoming. Similarly, the delivery of a satisfactory solution at Bollo Lane, where the existing level crossings will need to be closed, will potentially create significant disruption while the construction works are underway. Stakeholder and public acceptability will be influential in shaping the solutions.

8.3.4 Once operating, the option has been designed to best utilise the capacity available and necessary infrastructure resulting in the proposal to run 8 trains per hour on the core section between Neasden and South Acton, with 4 tph for the sections to the north and south. The currently forecast revenue for WLO rail services will not fully offset the forecast operating costs, but opportunities in relation to innovative fares policy and operating practices offer areas for consideration to close the gap.

8.4 RECOMMENDATIONS

8.4.1 A strong economic case has been demonstrated for the introduction of operationally feasible WLO rail services using the Dudding Hill Line. This supports the rationale for developing the scheme further, with a focus on the identified technical challenges for the implementation of the scheme, i.e. for Acton Wells and Bollo Lane.

8.4.2 Subject to the development of viable solutions, the strength of the case should be revisited on the basis of revised cost estimates and more detailed demand forecasting, incorporating a full run through the TfL model suite to capture forecast mode transfer. It would also be an opportunity for a thorough review and a possible improvement of the accuracy of the public transport model in line with TfL and DfT guidance.

8.4.3 In the expectation that the case for the scheme will remain strong, and with refined capital cost estimates, a funding proposal should be developed cognisant of the scope for developer contributions and the requirements for incorporating the services within London Overground in a manner that addresses the currently forecast operating deficit.

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Appendix A

DEMAND ANALYSIS. OPTIONS 1 - 3

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APPENDIX A-1

GLOBAL STATISTICS

This section presents key model statistics at a global level for each AM Peak and PM peak scenario modelled, as well as differences in those model statistics between each scheme scenario and its associated baseline scenario.

Baseline: **Standard LTS-PT 2041 Reference Case (A141rc01a)**

Mode	Peak	*Description*	*2041 TfL Ref Case*	*Dudding Hill Option 1*	*Dudding Hill Option 2*	*Dudding Hill Option 3*	*Difference*		
		Scenario	A141rc01a	A141DH01a	A141DH02a	A141DH03a	A141DH01a-A141rc01a	A141DH02a-A141rc01a	A141DH03a-A141rc01a
Rail	AM	Passenger Kms	61,984,155	62,016,662	62,012,664	62,059,289	32,507	28,509	75,134
		Uncrowded Passenger Hrs	57,719,229	57,777,414	57,770,667	57,817,208	58,185	51,438	97,979
		Crowded Passenger Hrs	77,959,930	77,986,499	77,979,181	78,132,445	26,569	19,251	172,514
		Passenger Boardings	1,937,480	1,943,036	1,942,482	1,950,314	5,556	5,002	12,834
	PM	Passenger Kms	63,991,947	64,030,999	64,028,295	64,077,715	39,052	36,348	85,769
		Uncrowded Passenger Hrs	57,473,633	57,542,266	57,537,479	57,617,507	68,633	63,845	143,874
		Crowded Passenger Hrs	73,205,216	73,276,088	73,269,513	73,362,298	70,872	64,297	157,082
		Passenger Boardings	1,996,416	2,001,814	2,001,511	2,009,314	5,398	5,095	12,898
LUL	AM	Passenger Kms	16,267,356	16,225,889	16,230,396	16,185,807	-41,466	-36,960	-81,549
		Uncrowded Passenger Hrs	29,182,762	29,104,438	29,112,603	29,028,623	-78,324	-70,159	-154,139
		Crowded Passenger Hrs	43,191,304	43,026,123	43,045,825	42,863,924	-165,182	-145,479	-327,380
		Passenger Boardings	2,272,048	2,267,928	2,268,300	2,264,134	-4,120	-3,748	-7,914
	PM	Passenger Kms	16,552,743	16,509,536	16,514,085	16,469,409	-43,207	-38,658	-83,334
		Uncrowded Passenger Hrs	30,074,167	29,992,731	30,000,849	29,915,406	-81,436	-73,318	-158,762
		Crowded Passenger Hrs	41,269,408	41,106,803	41,121,782	40,949,028	-162,605	-147,627	-320,381
		Passenger Boardings	2,416,620	2,412,513	2,412,830	2,408,901	-4,108	-3,791	-7,720
Bus	AM	Passenger Kms	6,749,006	6,732,698	6,735,147	6,720,018	-16,308	-13,859	-28,988
		Uncrowded Passenger Hrs	26,478,568	26,410,056	26,420,524	26,356,202	-68,512	-58,044	-122,366
		Crowded Passenger Hrs	30,735,987	30,633,814	30,651,975	30,575,417	-102,173	-84,012	-160,569
		Passenger Boardings	1,852,325	1,848,954	1,848,970	1,845,825	-3,370	-3,355	-6,500
	PM	Passenger Kms	8,199,665	8,182,581	8,184,708	8,167,247	-17,084	-14,957	-32,418
		Uncrowded Passenger Hrs	30,291,568	30,222,305	30,230,735	30,159,154	-69,263	-60,833	-132,414
		Crowded Passenger Hrs	36,796,301	36,669,085	36,689,483	36,572,932	-127,216	-106,818	-223,369
		Passenger Boardings	2,177,500	2,173,966	2,173,870	2,170,569	-3,534	-3,630	-6,931

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Mode	Peak	*Description*	*2041 TfL Ref Case*	*Dudding Hill Option 1*	*Dudding Hill Option 2*	*Dudding Hill Option 3*	*Difference*		
		Scenario	A141rc01a	A141DH01a	A141DH02a	A141DH03a	A141DH01a-A141rc01a	A141DH02a-A141rc01a	A141DH03a-A141rc01a
DLR	AM	Passenger Kms	632,655	632,502	632,523	632,453	-153	-132	-202
		Uncrowded Passenger Hrs	1,538,078	1,537,752	1,537,793	1,537,667	-326	-285	-411
		Crowded Passenger Hrs	1,899,277	1,898,692	1,898,759	1,898,507	-585	-518	-770
		Passenger Boardings	147,849	147,826	147,829	147,824	-23	-20	-25
	PM	Passenger Kms	701,112	700,968	700,975	700,931	-144	-137	-181
		Uncrowded Passenger Hrs	1,695,600	1,695,290	1,695,307	1,695,233	-310	-293	-367
		Crowded Passenger Hrs	2,080,741	2,080,177	2,080,211	2,080,072	-563	-529	-669
		Passenger Boardings	162,406	162,383	162,383	162,381	-23	-23	-25
Tram	AM	Passenger Kms	162,639	162,635	162,635	162,629	-4	-4	-10
		Uncrowded Passenger Hrs	430,015	430,004	430,004	429,986	-11	-11	-29
		Crowded Passenger Hrs	614,341	614,331	614,332	614,294	-10	-9	-48
		Passenger Boardings	35,061	35,061	35,061	35,060	0	0	-1
	PM	Passenger Kms	189,577	189,573	189,571	189,568	-4	-5	-9
		Uncrowded Passenger Hrs	486,745	486,735	486,732	486,722	-10	-13	-22
		Crowded Passenger Hrs	756,547	756,511	756,505	756,480	-36	-42	-67
		Passenger Boardings	38,543	38,543	38,542	38,542	0	-1	-1
All PT	AM	Passenger Kms	85,795,810	85,770,385	85,773,364	85,760,195	-25,424	-22,445	-35,614
		Uncrowded Passenger Hrs	115,348,652	115,259,663	115,271,591	115,169,686	-88,989	-77,060	-178,966
		Crowded Passenger Hrs	154,400,839	154,159,458	154,190,072	154,084,586	-241,381	-210,768	-316,253
		Passenger Boardings	6,244,762	6,242,806	6,242,642	6,243,157	-1,957	-2,121	-1,605
	PM	Passenger Kms	89,635,043	89,613,656	89,617,634	89,604,871	-21,387	-17,409	-30,172
		Uncrowded Passenger Hrs	120,021,714	119,939,327	119,951,102	119,874,022	-82,387	-70,612	-147,691
		Crowded Passenger Hrs	154,108,212	153,888,664	153,917,493	153,720,809	-219,549	-190,719	-387,404
		Passenger Boardings	6,791,486	6,789,219	6,789,137	6,789,708	-2,268	-2,350	-1,779

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Baseline: **2041 Maximum Growth Scenario without Crossrail 2**

Mode	Peak	*Description*	*2041 TfL Max Growth*	*Dudding Hill Option 1*	*Dudding Hill Option 2*	*Dudding Hill Option 3*	*Difference*		
		Scenario	A141rc20a	A141DH04a	A141DH05a	A141DH06a	A141DH04a-A141rc20a	A141DH05a-A141rc20a	A141DH06a-A141rc20a
Rail	AM	Passenger Kms	63,543,061	63,577,045	63,572,735	63,620,409	33,984	29,673	77,347
		Uncrowded Passenger Hrs	59,261,438	59,322,964	59,315,636	59,392,105	61,526	54,198	130,667
		Crowded Passenger Hrs	80,539,375	80,583,136	80,571,795	80,652,649	43,761	32,420	113,275
		Passenger Boardings	2,009,641	2,015,302	2,014,719	2,022,622	5,662	5,078	12,981
	PM	Passenger Kms	65,808,704	65,851,019	65,847,597	65,898,022	42,315	38,892	89,318
		Uncrowded Passenger Hrs	59,357,651	59,429,049	59,423,219	59,506,059	71,399	65,569	148,409
		Crowded Passenger Hrs	76,530,731	76,601,652	76,593,474	76,682,476	70,921	62,743	151,745
		Passenger Boardings	2,077,290	2,083,114	2,082,734	2,090,696	5,823	5,444	13,406
LUL	AM	Passenger Kms	16,651,343	16,607,306	16,612,485	16,567,202	-44,037	-38,857	-84,141
		Uncrowded Passenger Hrs	29,861,747	29,778,544	29,788,007	29,702,773	-83,203	-73,740	-158,974
		Crowded Passenger Hrs	44,507,659	44,331,416	44,353,861	44,170,433	-176,243	-153,798	-337,226
		Passenger Boardings	2,334,658	2,330,290	2,330,723	2,326,505	-4,367	-3,934	-8,152
	PM	Passenger Kms	17,064,166	17,017,429	17,022,776	16,976,105	-46,738	-41,391	-88,061
		Uncrowded Passenger Hrs	30,975,294	30,887,517	30,897,181	30,808,234	-87,777	-78,113	-167,060
		Crowded Passenger Hrs	43,170,281	42,990,865	43,009,032	42,825,111	-179,416	-161,249	-345,170
		Passenger Boardings	2,493,211	2,488,706	2,489,093	2,484,970	-4,505	-4,118	-8,241
Bus	AM	Passenger Kms	7,020,708	7,004,258	7,006,737	6,990,477	-16,450	-13,971	-30,231
		Uncrowded Passenger Hrs	27,493,659	27,424,854	27,435,407	27,366,943	-68,805	-58,252	-126,716
		Crowded Passenger Hrs	32,489,132	32,379,296	32,398,924	32,266,761	-109,836	-90,208	-222,371
		Passenger Boardings	1,927,422	1,924,039	1,924,033	1,920,782	-3,383	-3,389	-6,640
	PM	Passenger Kms	8,516,962	8,499,199	8,501,582	8,483,609	-17,762	-15,380	-33,353
		Uncrowded Passenger Hrs	31,405,075	31,333,233	31,342,630	31,268,921	-71,842	-62,445	-136,154
		Crowded Passenger Hrs	39,115,825	38,972,718	38,996,175	38,873,642	-143,107	-119,650	-242,184
		Passenger Boardings	2,263,218	2,259,570	2,259,473	2,256,103	-3,648	-3,745	-7,114

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Mode	Peak	*Description*	*2041 TfL Max Growth*	*Dudding Hill Option 1*	*Dudding Hill Option 2*	*Dudding Hill Option 3*	*Difference*		
		Scenario	A141rc20a	A141DH04a	A141DH05a	A141DH06a	A141DH04a-A141rc20a	A141DH05a-A141rc20a	A141DH06a-A141rc20a
DLR	AM	Passenger Kms	772,475	772,332	772,362	772,305	-142	-113	-170
		Uncrowded Passenger Hrs	1,873,801	1,873,502	1,873,562	1,873,427	-298	-239	-374
		Crowded Passenger Hrs	2,543,780	2,543,195	2,543,313	2,542,971	-584	-466	-809
		Passenger Boardings	178,172	178,152	178,156	178,152	-19	-16	-20
	PM	Passenger Kms	853,060	852,920	852,927	852,909	-140	-133	-151
		Uncrowded Passenger Hrs	2,054,730	2,054,424	2,054,440	2,054,426	-306	-290	-304
		Crowded Passenger Hrs	2,754,186	2,753,524	2,753,564	2,753,519	-662	-622	-667
		Passenger Boardings	195,390	195,368	195,367	195,369	-22	-23	-21
Tram	AM	Passenger Kms	165,161	165,155	165,155	165,151	-6	-6	-10
		Uncrowded Passenger Hrs	436,538	436,521	436,520	436,509	-17	-18	-29
		Crowded Passenger Hrs	625,596	625,566	625,562	625,543	-30	-34	-53
		Passenger Boardings	35,692	35,692	35,692	35,692	0	0	0
	PM	Passenger Kms	193,122	193,115	193,115	193,109	-8	-8	-13
		Uncrowded Passenger Hrs	496,620	496,601	496,600	496,585	-19	-19	-35
		Crowded Passenger Hrs	781,050	780,987	780,986	780,938	-64	-64	-112
		Passenger Boardings	39,250	39,249	39,249	39,249	-1	-1	-1
All PT	AM	Passenger Kms	88,152,748	88,126,096	88,129,473	88,115,544	-26,651	-23,275	-37,204
		Uncrowded Passenger Hrs	118,927,182	118,836,386	118,849,132	118,771,756	-90,796	-78,050	-155,426
		Crowded Passenger Hrs	160,705,541	160,462,607	160,493,455	160,258,357	-242,933	-212,086	-447,184
		Passenger Boardings	6,485,584	6,483,476	6,483,322	6,483,753	-2,108	-2,262	-1,831
	PM	Passenger Kms	92,436,014	92,413,681	92,417,996	92,403,753	-22,333	-18,018	-32,261
		Uncrowded Passenger Hrs	124,289,369	124,200,823	124,214,070	124,134,226	-88,546	-75,299	-155,144
		Crowded Passenger Hrs	162,352,074	162,099,745	162,133,231	161,915,686	-252,329	-218,843	-436,387
		Passenger Boardings	7,068,359	7,066,006	7,065,916	7,066,387	-2,352	-2,443	-1,971

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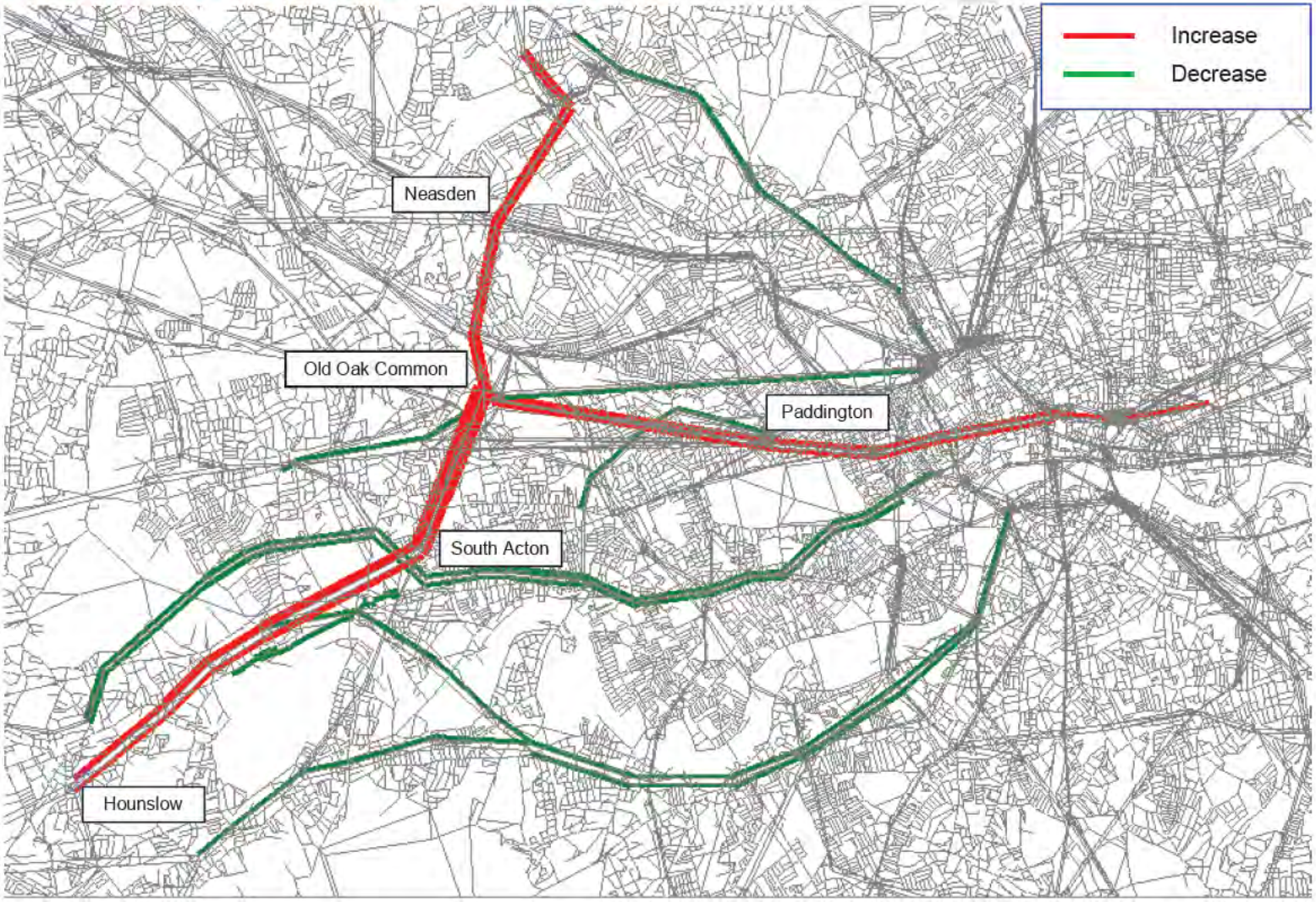
APPENDIX A-2

FLOW DIFFERENCE PLOTS

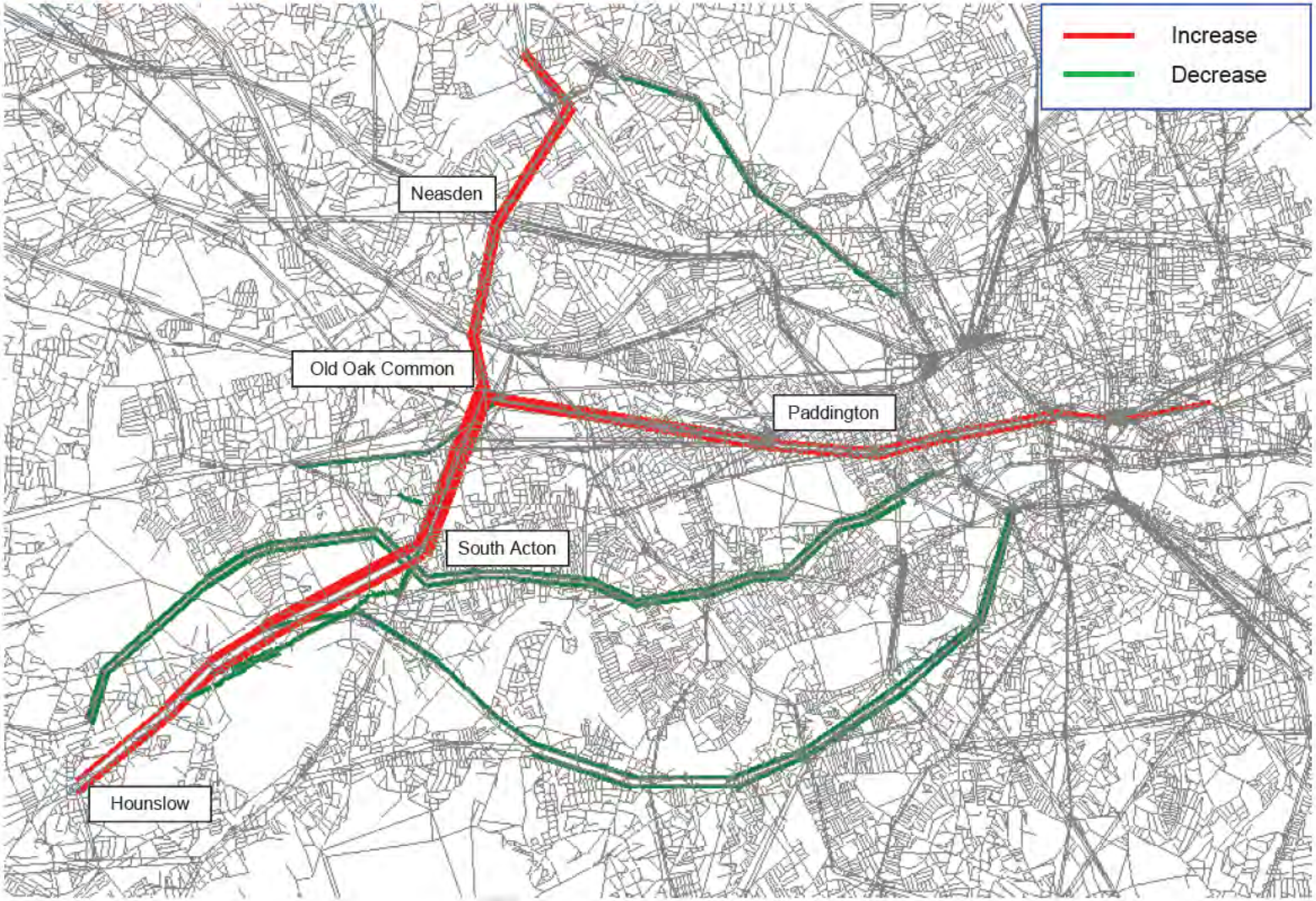
This section displays public transport network plots showing differences in demand on the public transport network in the AM and PM between each scheme option and its associated baseline scenario.

Baseline: **Standard LTS-PT 2041 Reference Case (A141rc01a)**

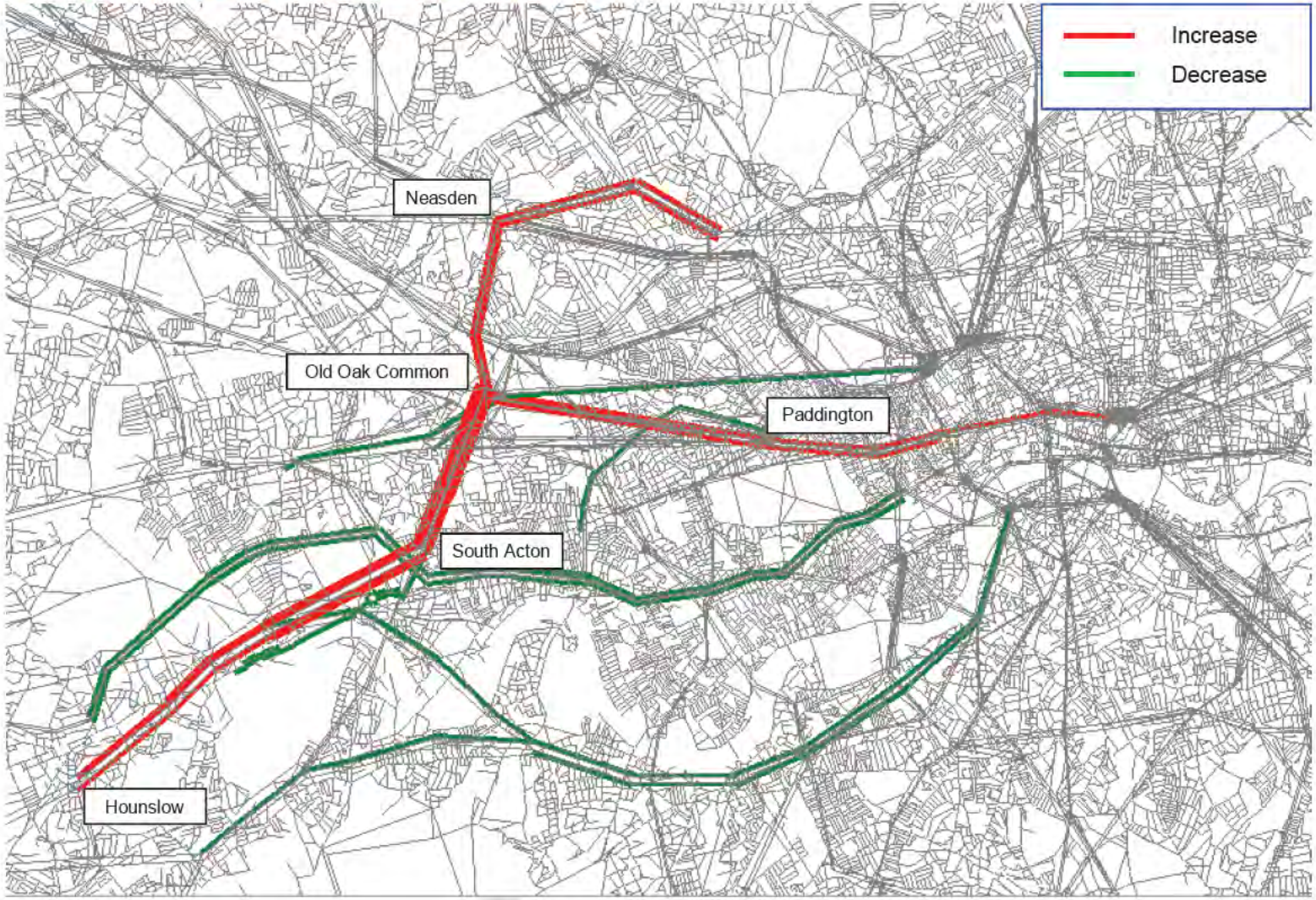
Passenger flow difference Option 1 minus Reference Case, AM



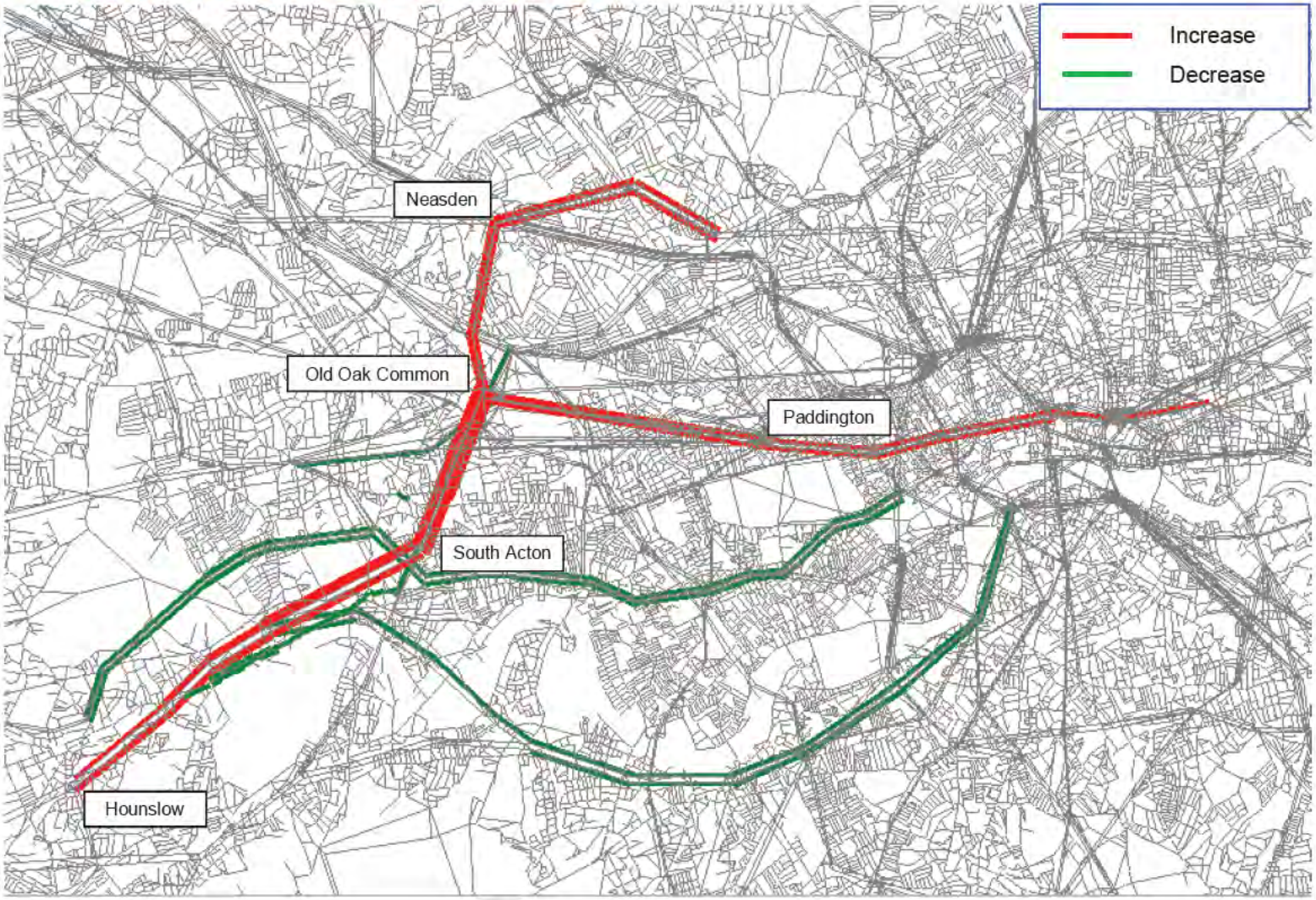
Passenger flow difference Option 1 minus Reference Case, PM



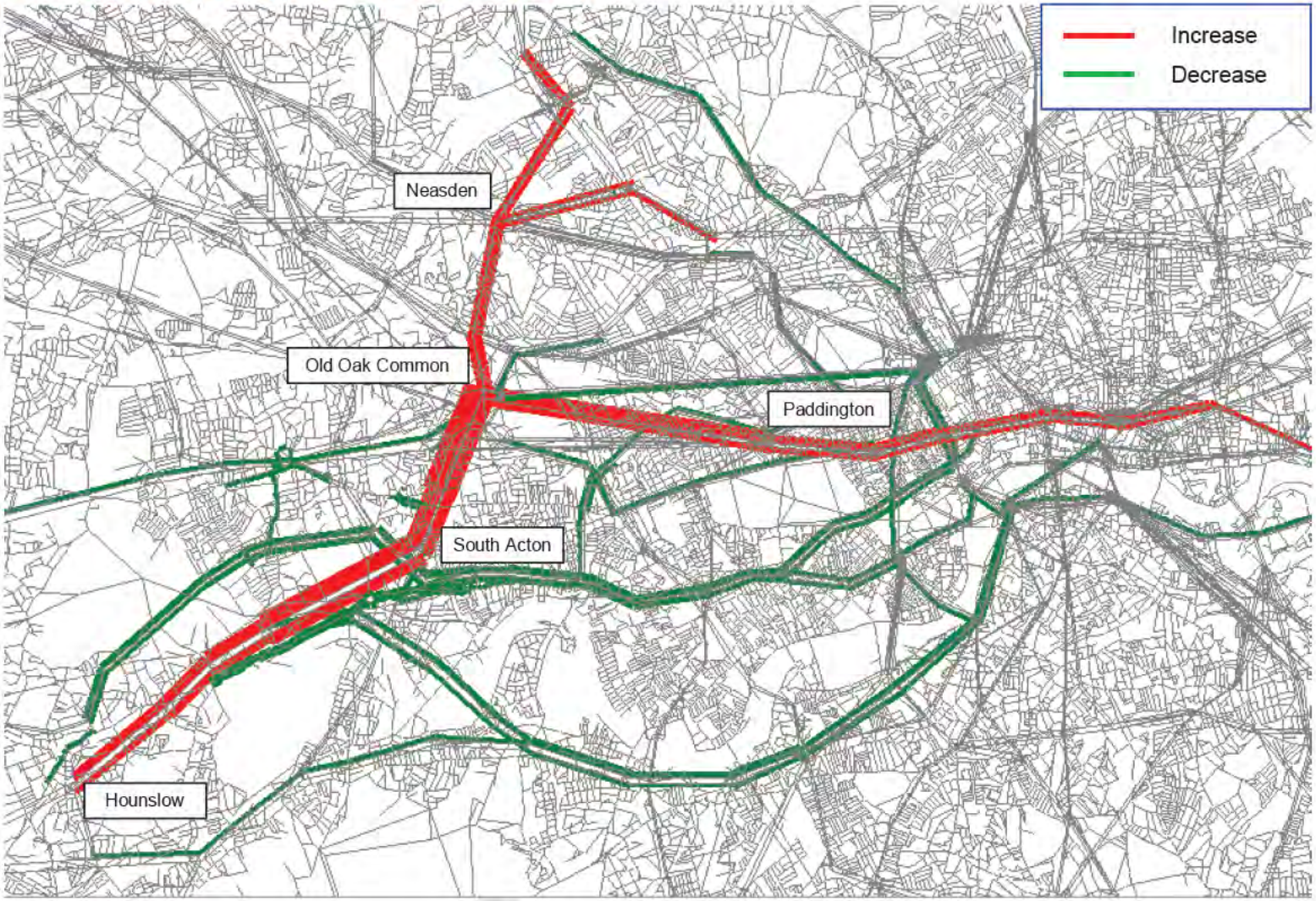
Passenger flow difference Option 2 minus Reference Case, AM



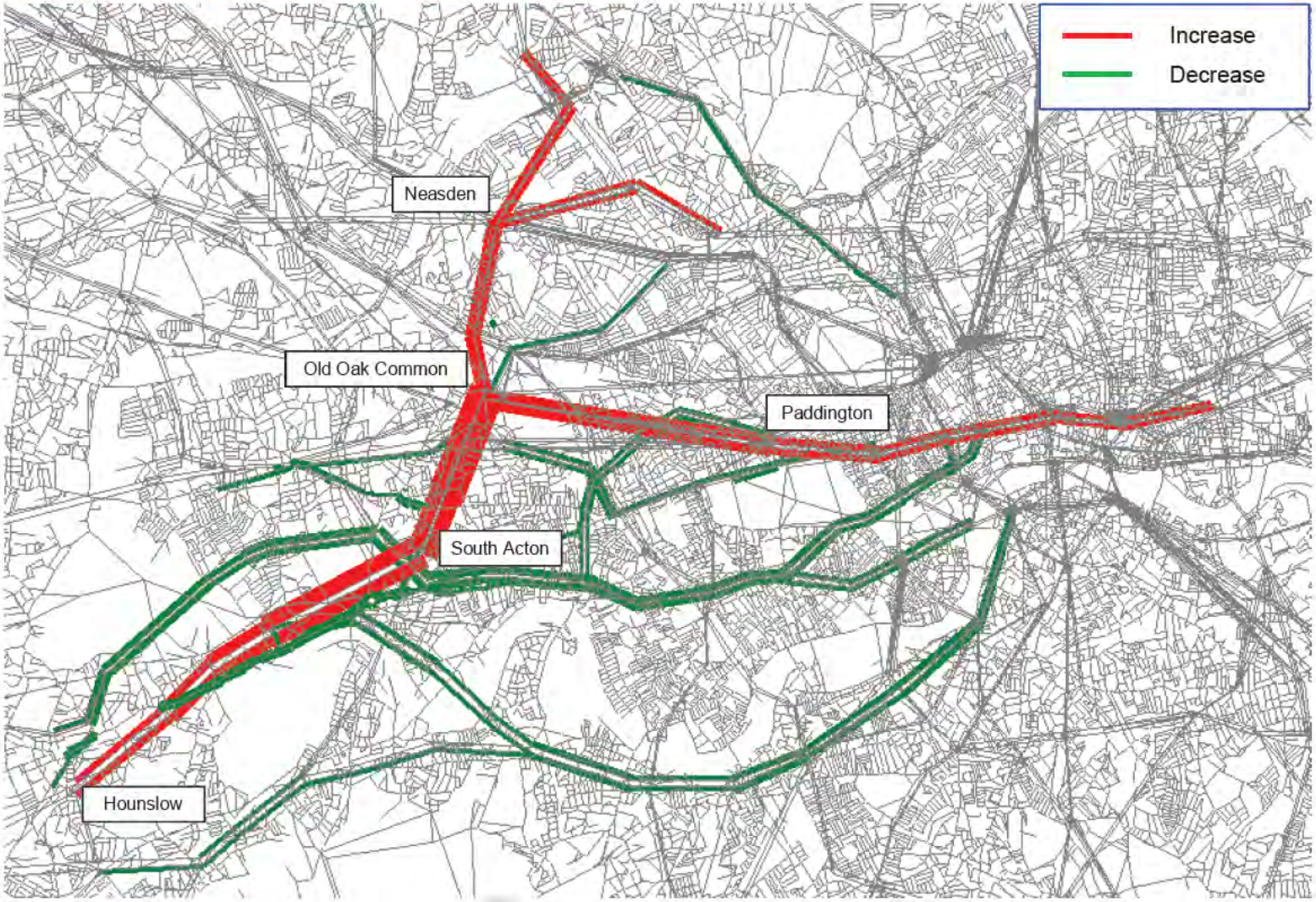
Passenger flow difference Option 2 minus Reference Case, PM



Passenger flow difference Option 3 minus Reference Case, AM

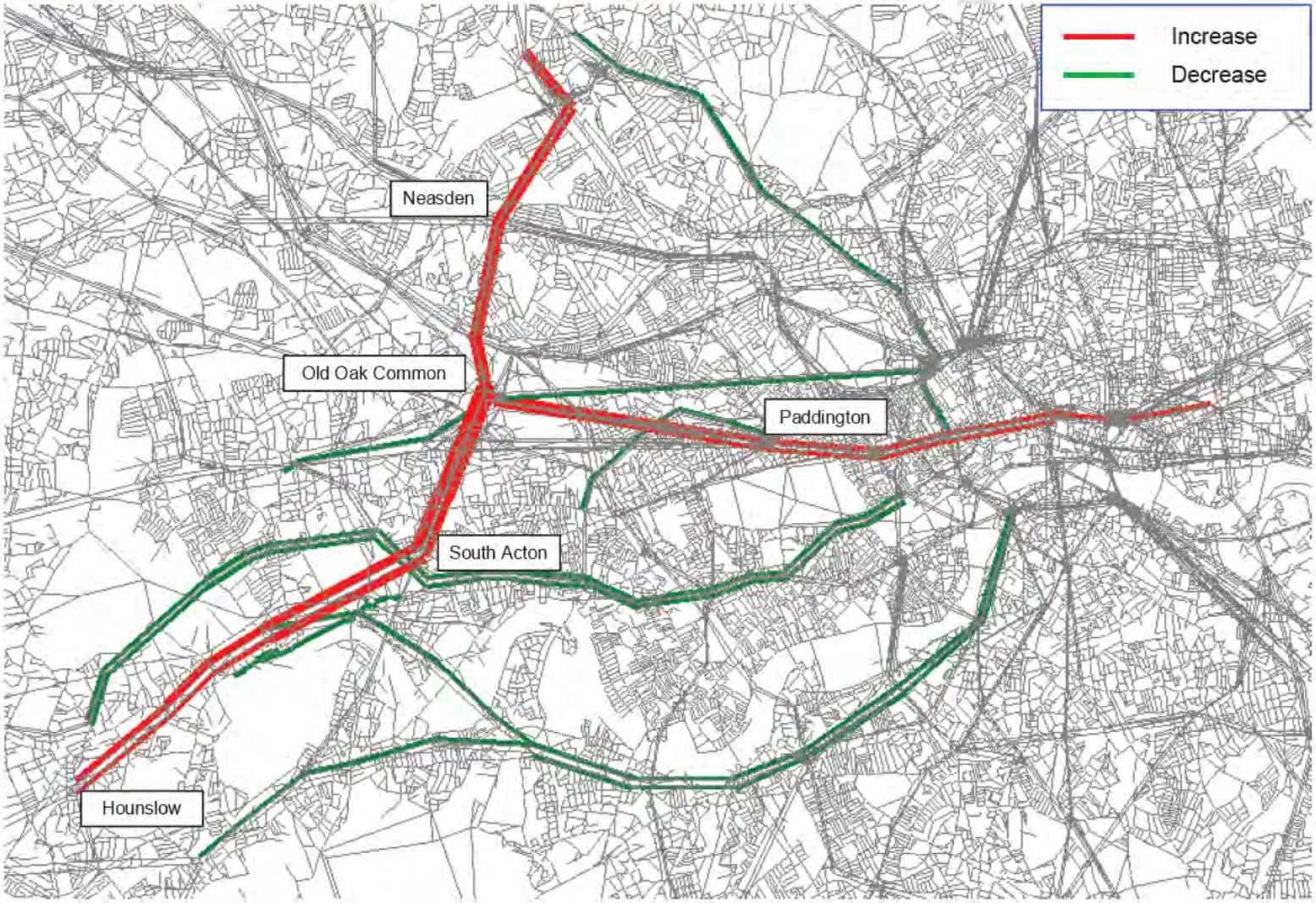


Passenger flow difference Option 3 minus Reference Case, PM

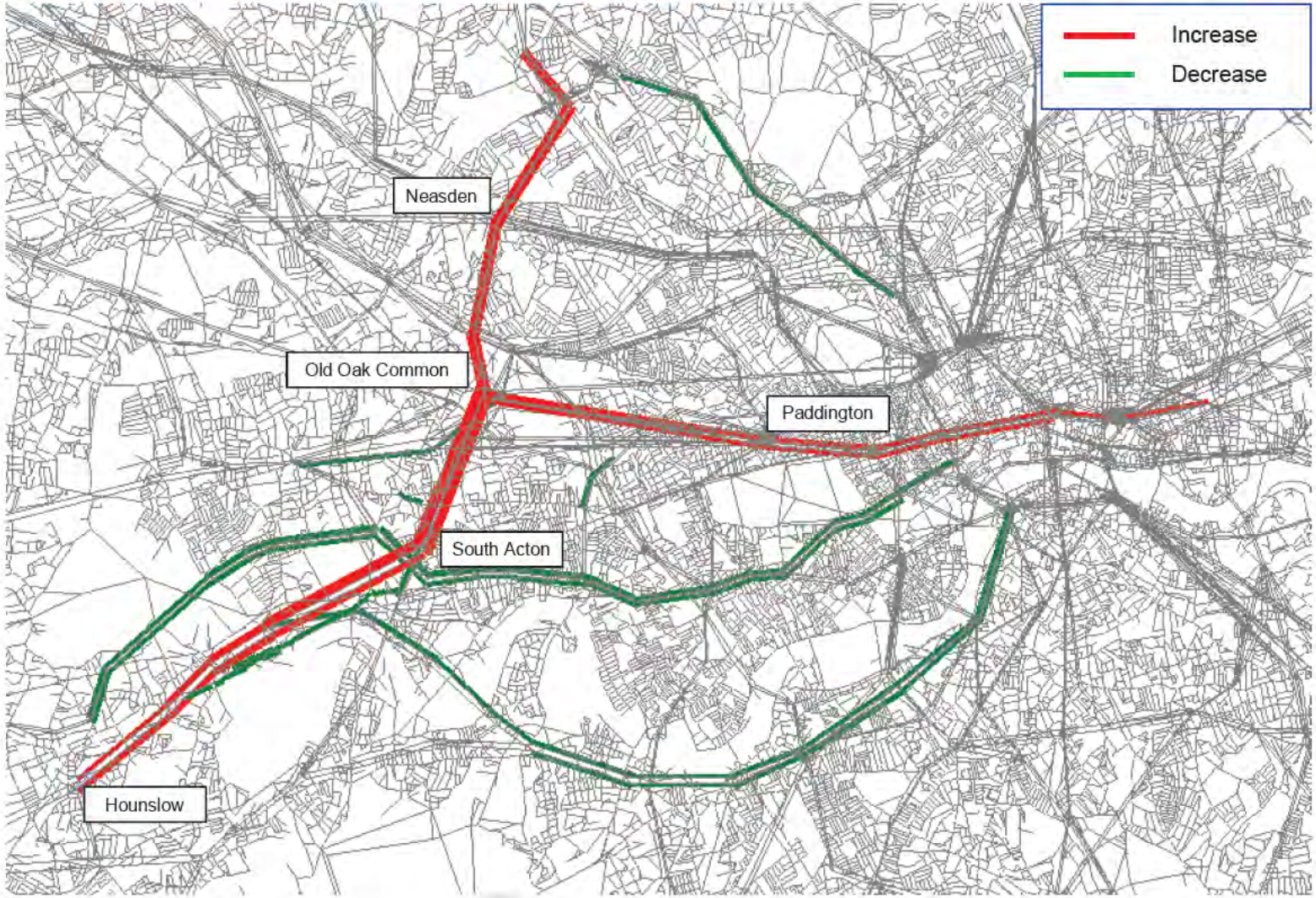


Baseline: **2041 Maximum Growth Scenario without Crossrail 2**

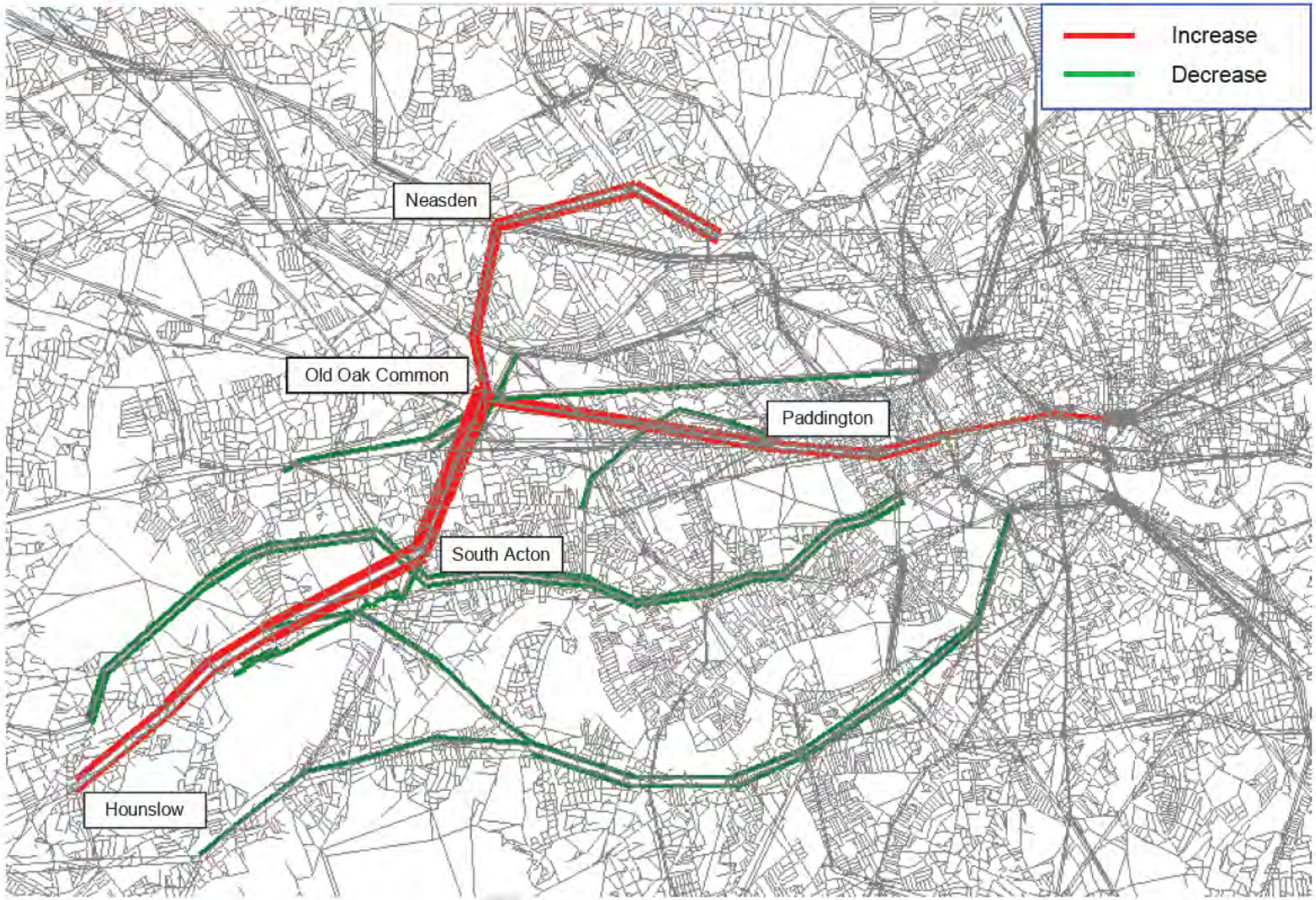
Passenger flow difference Option 1 minus Maximum Growth Scenario, AM



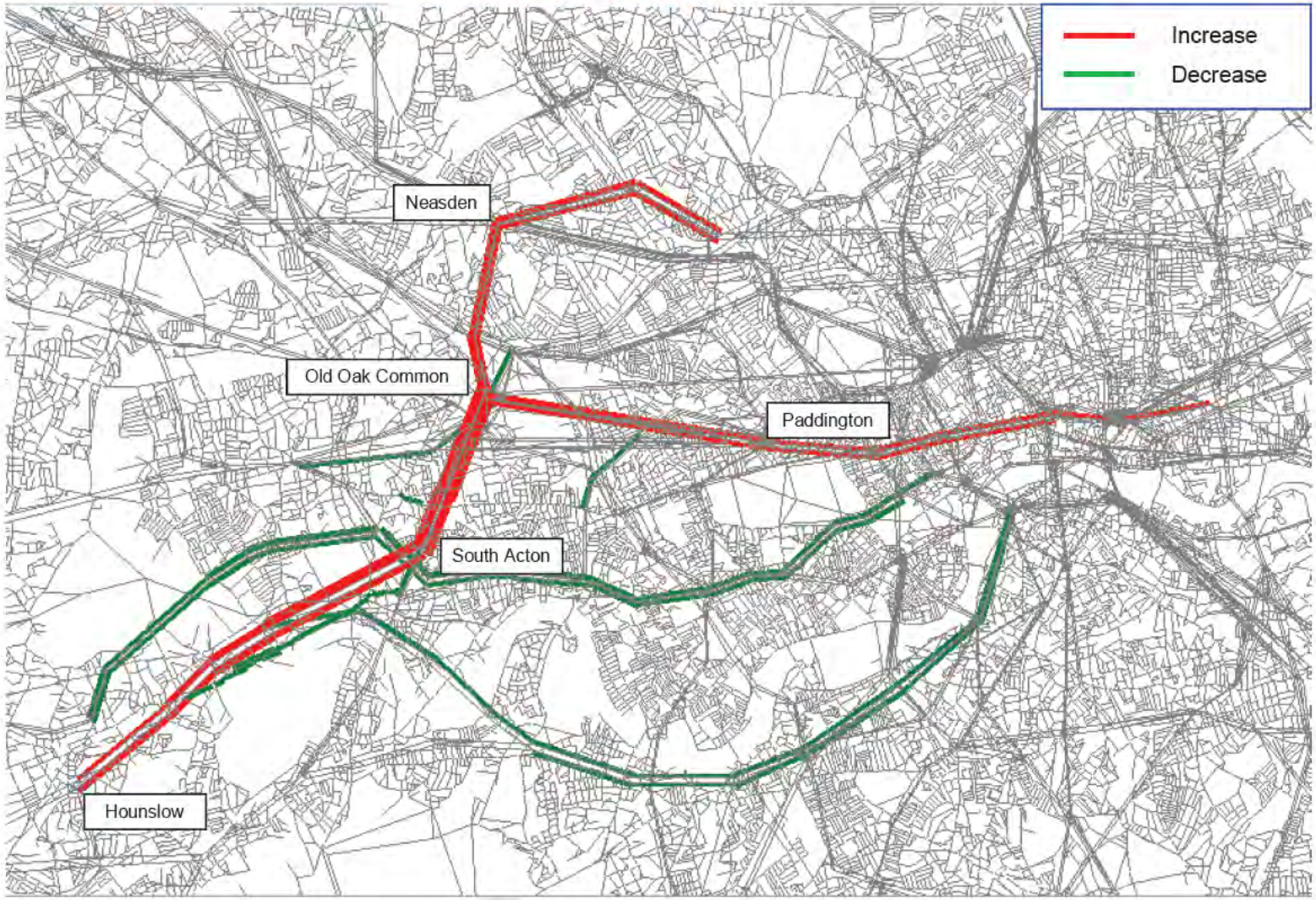
Passenger flow difference Option 1 minus Maximum Growth Scenario, PM



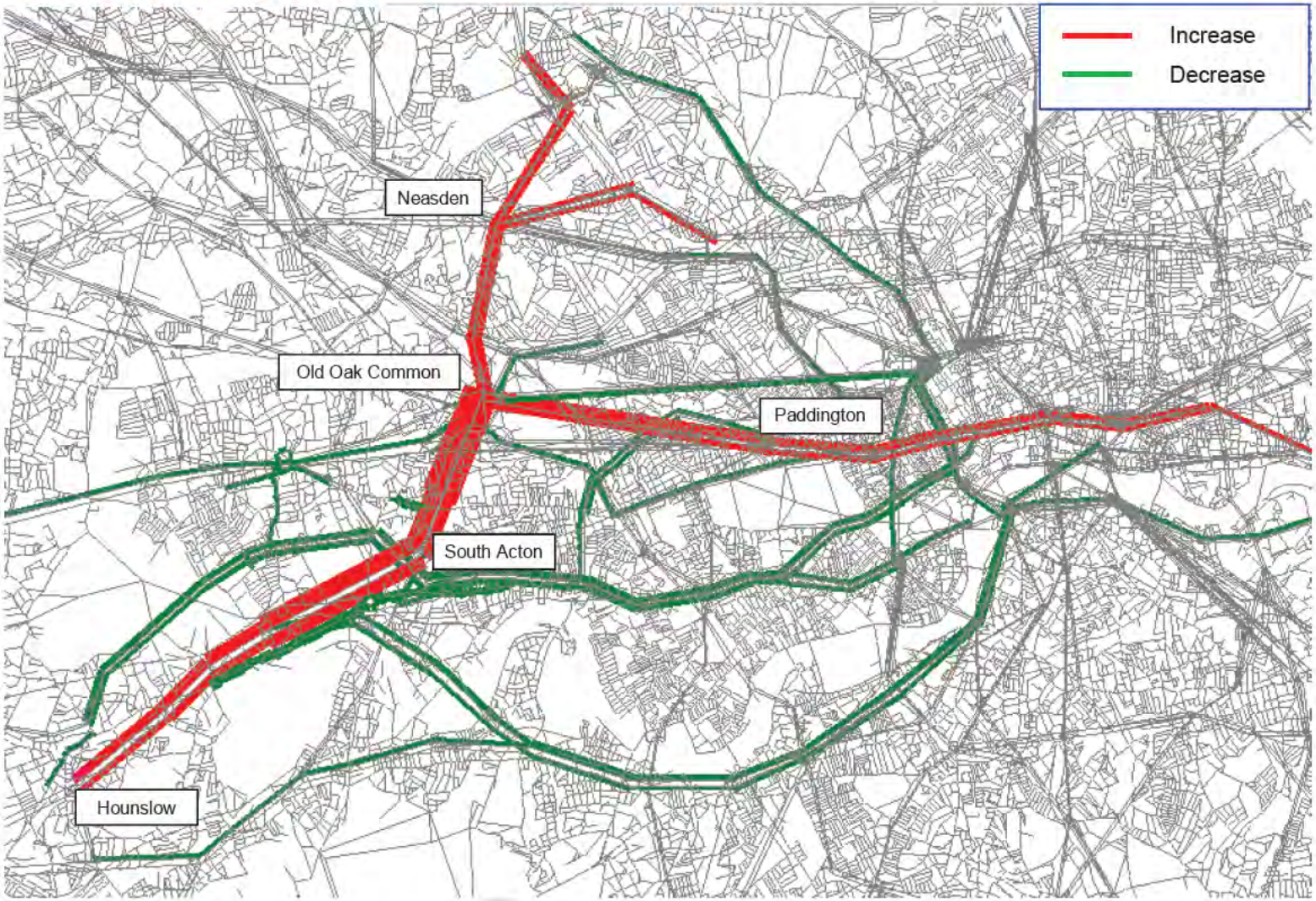
Passenger flow difference Option 2 minus Maximum Growth Scenario, AM



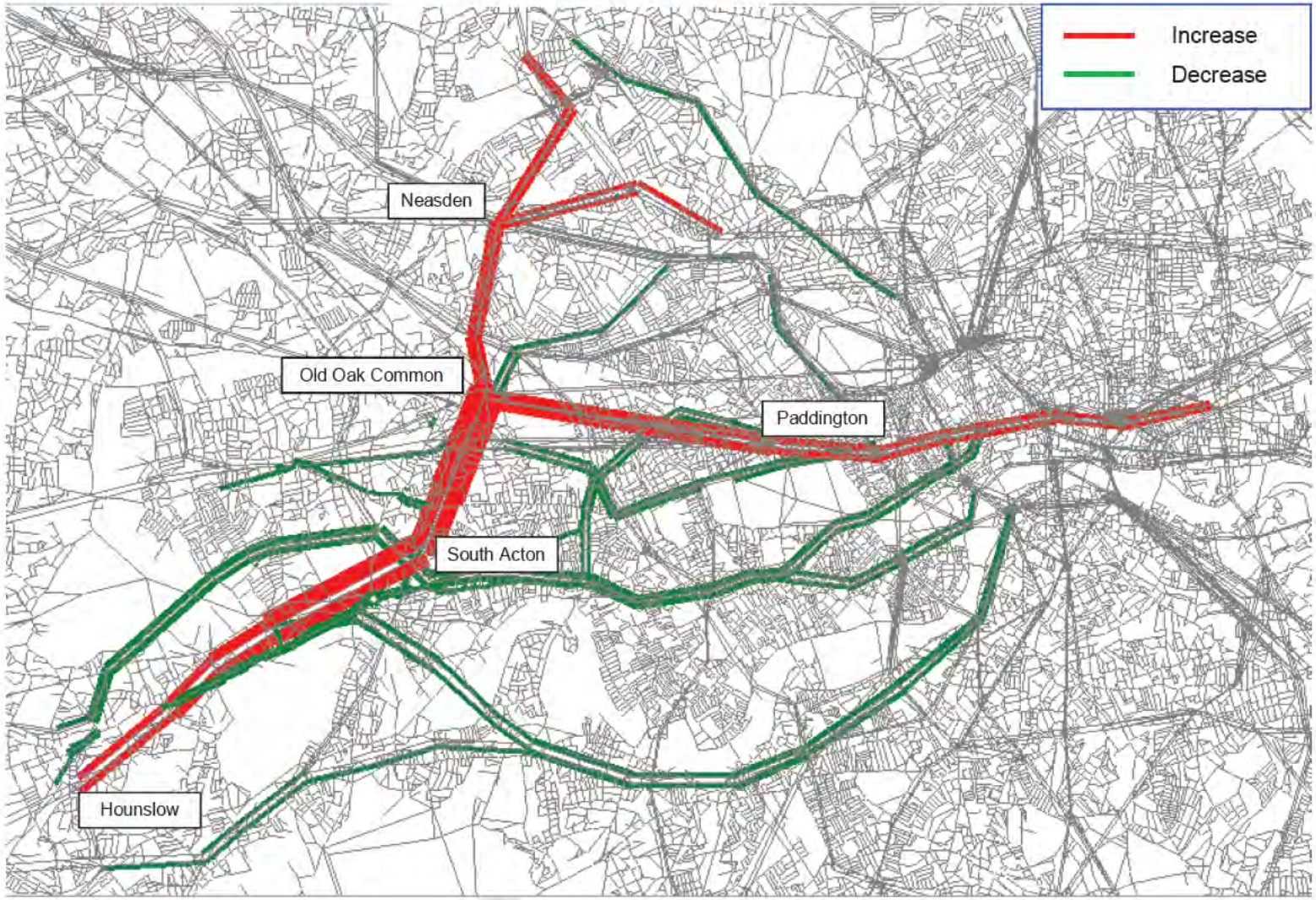
Passenger flow difference Option 2 minus Maximum Growth Scenario, PM



Passenger flow difference Option 3 minus Maximum Growth Scenario, AM



Passenger flow difference Option 3 minus Maximum Growth Scenario, PM



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APPENDIX A-3

WLO LINE LOADING, BOARDINGS AND ALIGHTINGS

Baseline: **Standard LTS-PT 2041 Reference Case (A141rc01a)**

Option 1

					AM			PM		
Direction	From	To	NAME	LONGNAME	Demand	Board	Alight	Demand	Board	Alight
Southbound	Hendon	Staple's Corner	DH001D	HENDON-HOUNSLOW	976	976	0	411	411	0
	Staple's Corner	Neasden	DH001D	HENDON-HOUNSLOW	995	20	0	427	16	0
	Neasden	Harlesden	DH001D	HENDON-HOUNSLOW	1226	246	-15	550	149	-25
	Harlesden	OOC Victoria	DH001D	HENDON-HOUNSLOW	1299	112	-39	606	81	-25
	OOC Victoria	Acton Central	DH001D	HENDON-HOUNSLOW	1800	950	-449	2245	1762	-123
	Acton Central	South Acton	DH001D	HENDON-HOUNSLOW	1769	232	-263	2036	207	-417
	South Acton	Brentford	DH001D	HENDON-HOUNSLOW	1743	142	-169	1703	102	-434
	Brentford	Syon Lane	DH001D	HENDON-HOUNSLOW	1145	45	-642	1546	176	-333
	Syon Lane	Isleworth	DH001D	HENDON-HOUNSLOW	646	13	-512	1334	57	-269
	Isleworth	Hounslow	DH001D	HENDON-HOUNSLOW	333	23	-336	830	59	-562
Northbound	Hounslow	Isleworth	DH002U	HOUNSLOW-HENDON	1005	1005	0	546	546	0
	Isleworth	Syon Lane	DH002U	HOUNSLOW-HENDON	1451	500	-54	898	401	-49
	Syon Lane	Brentford	DH002U	HOUNSLOW-HENDON	1792	381	-40	1441	559	-16
	Brentford	South Acton	DH002U	HOUNSLOW-HENDON	2148	459	-103	2288	910	-63
	South Acton	Acton Central	DH002U	HOUNSLOW-HENDON	2444	378	-82	2336	204	-156
	Acton Central	OOC Victoria	DH002U	HOUNSLOW-HENDON	2779	496	-161	2390	346	-292
	OOC Victoria	Harlesden	DH002U	HOUNSLOW-HENDON	455	50	-2374	1209	274	-1455
	Harlesden	Neasden	DH002U	HOUNSLOW-HENDON	410	19	-63	1146	55	-118
	Neasden	Staple's Corner	DH002U	HOUNSLOW-HENDON	326	17	-101	880	22	-289
	Staple's Corner	Hendon	DH002U	HOUNSLOW-HENDON	312	0	-14	851	0	-29

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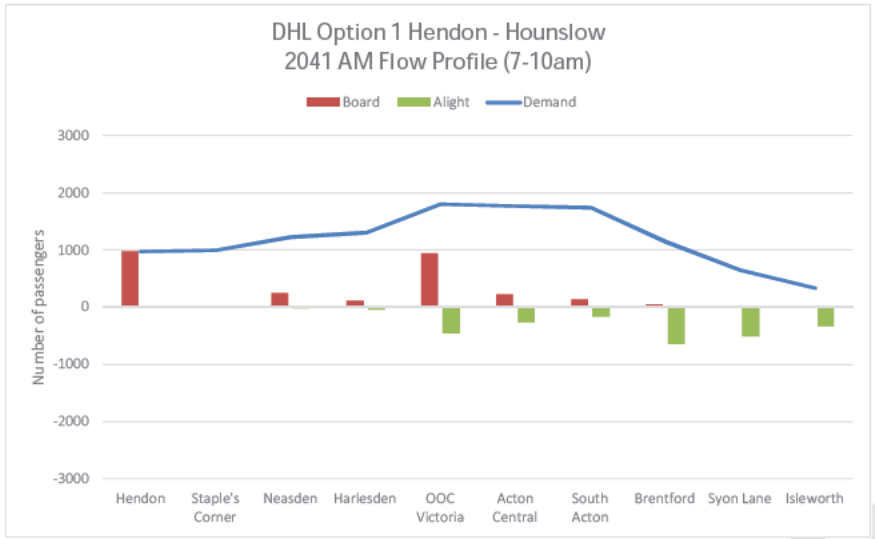
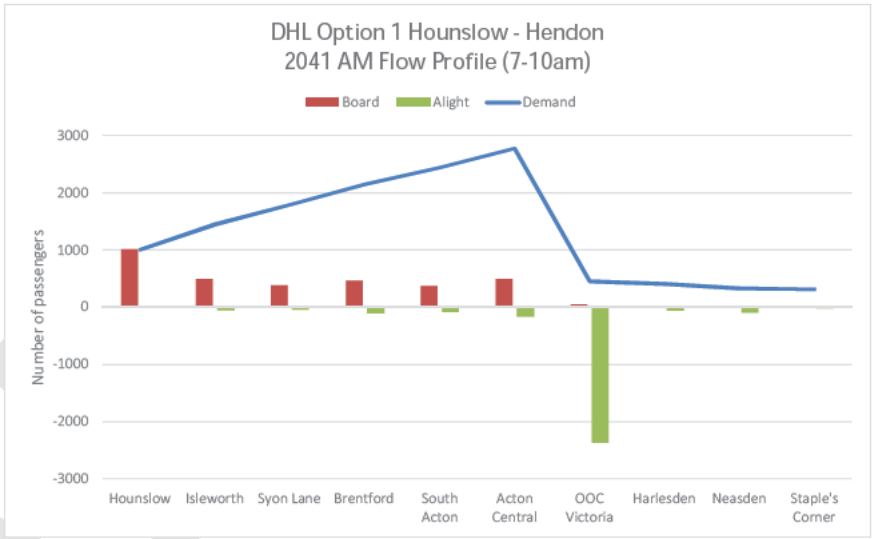
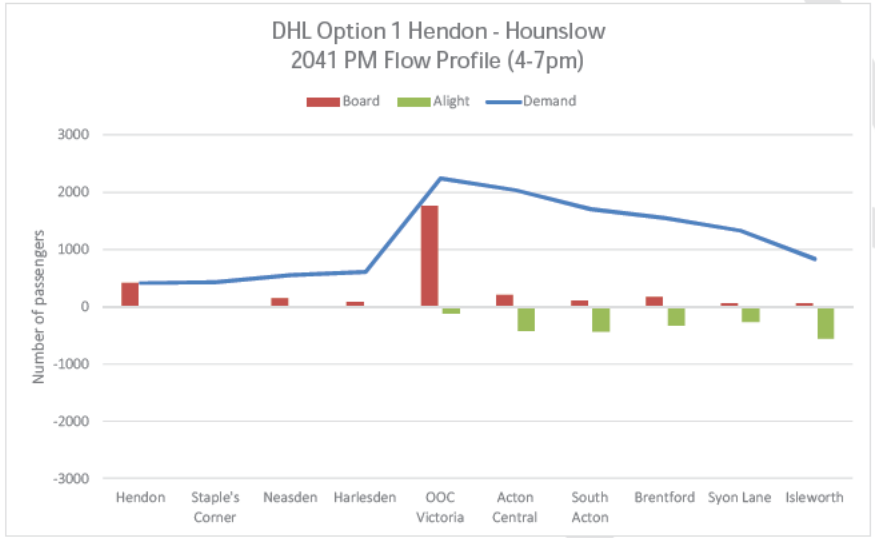
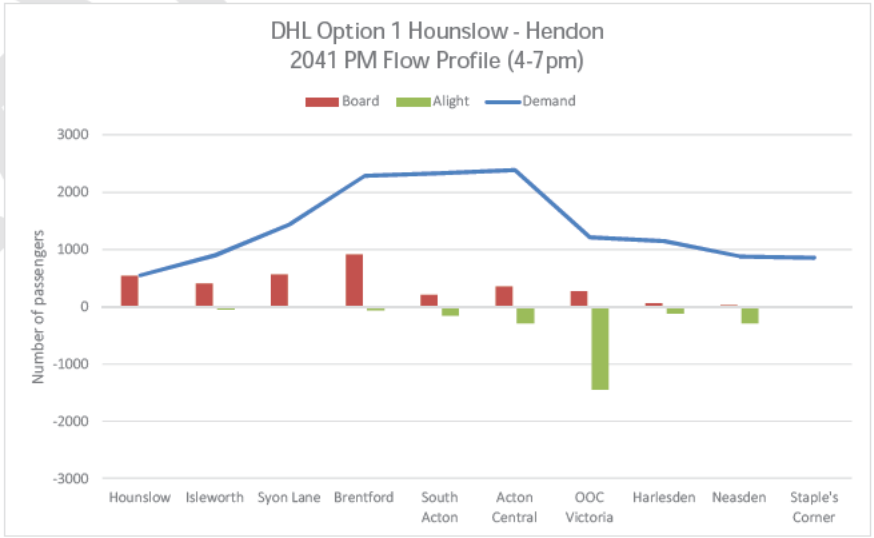

DHL Option 1 Hendon - Hounslow
2041 AM Flow Profile (7-10am)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
Hendon
Staple's Corner
Neasden
Harlesden
OOC Victoria
Acton Central
South Acton
Brentford
Syon Lane
Isleworth


DHL Option 1 Hounslow - Hendon
2041 AM Flow Profile (7-10am)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
Hounslow
Isleworth
Syon Lane
Brentford
South Acton
Acton Central
OOC Victoria
Harlesden
Neasden
Staple's Corner


DHL Option 1 Hendon - Hounslow
2041 PM Flow Profile (4-7pm)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
Hendon
Staple's Corner
Neasden
Harlesden
OOC Victoria
Acton Central
South Acton
Brentford
Syon Lane
Isleworth


DHL Option 1 Hounslow - Hendon
2041 PM Flow Profile (4-7pm)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
Hounslow
Isleworth
Syon Lane
Brentford
South Acton
Acton Central
OOC Victoria
Harlesden
Neasden
Staple's Corner

Option 2

					AM			PM		
Direction	From	To	NAME	LONGNAME	Demand	Board	Alight	Demand	Board	Alight
Southbound	West Hampstead	Cricklewood	DH003D	WESTHAMPSTEAD-HOUNSLOW	525	525	0	343	343	0
	Cricklewood	Neasden	DH003D	WESTHAMPSTEAD-HOUNSLOW	733	212	-3	425	85	-4
	Neasden	Harlesden	DH003D	WESTHAMPSTEAD-HOUNSLOW	980	259	-13	564	160	-20
	Harlesden	OOC Victoria	DH003D	WESTHAMPSTEAD-HOUNSLOW	1059	115	-36	636	83	-11
	OOC Victoria	Acton Central	DH003D	WESTHAMPSTEAD-HOUNSLOW	1820	901	-140	2281	1694	-50
	Acton Central	South Acton	DH003D	WESTHAMPSTEAD-HOUNSLOW	1818	215	-217	2063	202	-420
	South Acton	Brentford	DH003D	WESTHAMPSTEAD-HOUNSLOW	1803	124	-140	1726	95	-432
	Brentford	Syon Lane	DH003D	WESTHAMPSTEAD-HOUNSLOW	1177	45	-671	1560	176	-342
	Syon Lane	Isleworth	DH003D	WESTHAMPSTEAD-HOUNSLOW	666	13	-523	1344	57	-273
	Isleworth	Hounslow	DH003D	WESTHAMPSTEAD-HOUNSLOW	336	23	-353	830	59	-574
Northbound	Hounslow	Isleworth	DH004U	HOUNSLOW-WESTHAMPSTEAD	1005	1005	0	555	555	0
	Isleworth	Syon Lane	DH004U	HOUNSLOW-WESTHAMPSTEAD	1458	506	-54	920	414	-49
	Syon Lane	Brentford	DH004U	HOUNSLOW-WESTHAMPSTEAD	1805	387	-40	1471	568	-16
	Brentford	South Acton	DH004U	HOUNSLOW-WESTHAMPSTEAD	2173	471	-103	2340	932	-63
	South Acton	Acton Central	DH004U	HOUNSLOW-WESTHAMPSTEAD	2473	375	-75	2386	187	-141
	Acton Central	OOC Victoria	DH004U	HOUNSLOW-WESTHAMPSTEAD	2832	512	-153	2420	308	-273
	OOC Victoria	Harlesden	DH004U	HOUNSLOW-WESTHAMPSTEAD	544	51	-2339	1187	194	-1428
	Harlesden	Neasden	DH004U	HOUNSLOW-WESTHAMPSTEAD	485	4	-63	1094	25	-118
	Neasden	Cricklewood	DH004U	HOUNSLOW-WESTHAMPSTEAD	394	12	-102	813	7	-288
	Cricklewood	West Hampstead	DH004U	HOUNSLOW-WESTHAMPSTEAD	324	3	-73	570	1	-244

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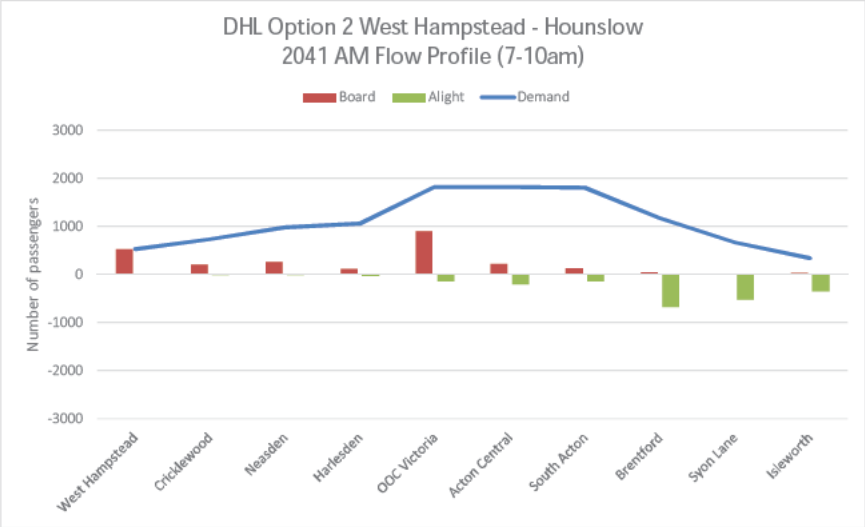
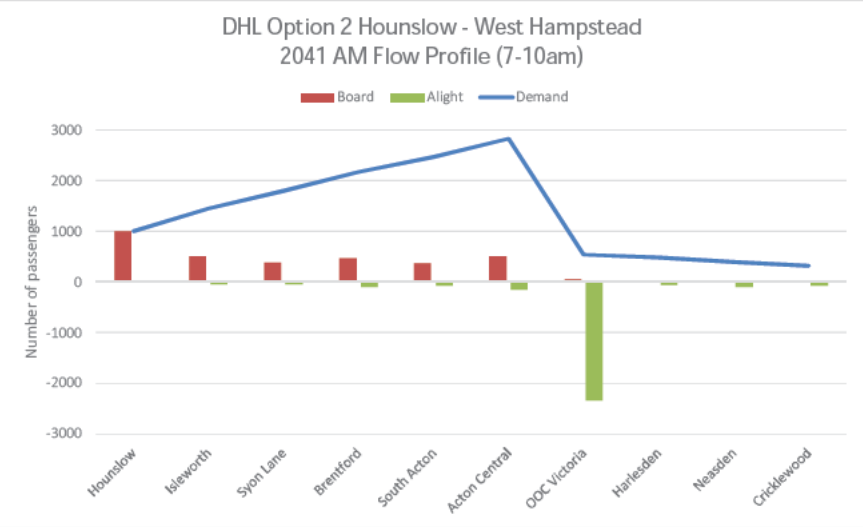
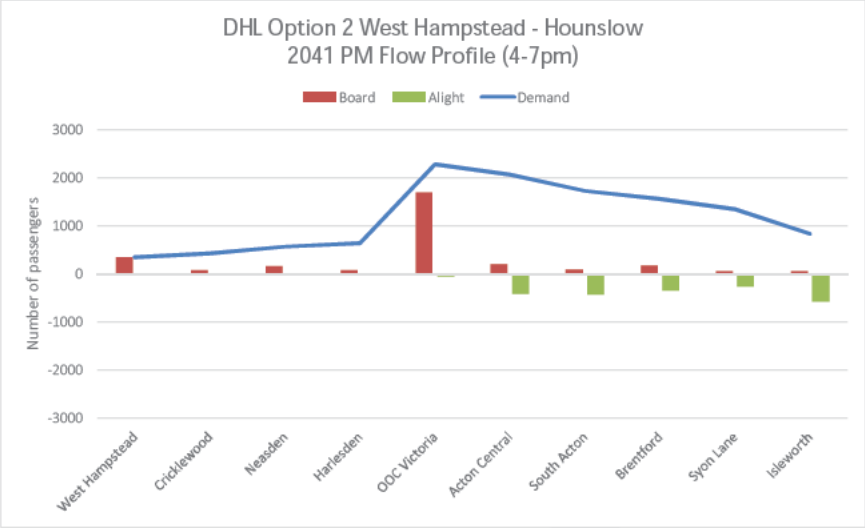
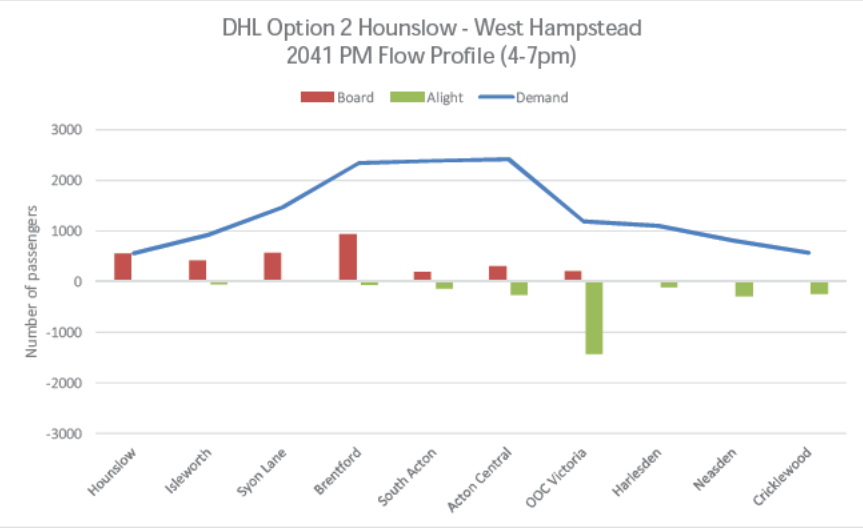

DHL Option 2 West Hampstead - Hounslow
2041 AM Flow Profile (7-10am)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
West Hampstead
Cricklewood
Neasden
Harlesden
OOC Victoria
Acton Central
South Acton
Brentford
Syon Lane
Isleworth


DHL Option 2 Hounslow - West Hampstead
2041 AM Flow Profile (7-10am)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
Hounslow
Isleworth
Syon Lane
Brentford
South Acton
Acton Central
OOC Victoria
Harlesden
Neasden
Cricklewood


DHL Option 2 West Hampstead - Hounslow
2041 PM Flow Profile (4-7pm)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
West Hampstead
Cricklewood
Neasden
Harlesden
OOC Victoria
Acton Central
South Acton
Brentford
Syon Lane
Isleworth


DHL Option 2 Hounslow - West Hampstead
2041 PM Flow Profile (4-7pm)
Board
Alight
Demand
Number of passengers
3000
2000
1000
0
-1000
-2000
-3000
Hounslow
Isleworth
Syon Lane
Brentford
South Acton
Acton Central
OOC Victoria
Harlesden
Neasden
Cricklewood