Rail Freight Demand Forecasts for 2040/41 and 2050/51

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MDS Transmodal

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CONTENTS

EXECUTIVE SUMMARY

The Great British Railways Transition Team (GBR-TT) Strategic Freight Unit (SFU)[1] commissioned MDS Transmodal (MDST) to produce capacity-unconstrained rail freight demand forecasts for 2040/41 and 2050/51 under various scenarios, as an input to the development of the Rail Freight Growth Target, which will be a critical planning assumption of the under-development Long Term Strategy for Rail.

There were several key activities that acted as inputs to inform the modelling of demand:

- Identification of “core markets” to narrow the focus of the forecasts to the markets that will materially drive investment or access decisions;
- Scenario Planning to work alongside a stakeholder group to agree distinct, plausible future-based scenarios;
- Traffic Baseline Audit to understand the robustness of the base year for the forecasts

The market

In general, the choice to use rail simply represents an option to reduce unit costs and sometimes improve supply chain performance versus alternative options such as using road. It is therefore important to appreciate how relevant supply chains work and how rail can play a role. Reducing rail costs or increasing the costs of alternative options are likely to boost rail freight traffic.

The core markets for which detailed modelling has been conducted are intermodal containers and construction materials. Energy and Fuels has also been identified as a ‘core’ market, but has not been modelled in detail. Instead, broad brush assumptions on market changes have been applied.

Scenarios and assumptions

Four scenarios were agreed for each forecast year with each having a theme:

- Scenario 1: A road-reliant scenario where policy and investment choices favour road over rail
- Scenario 2: A TAG-compliant scenario which broadly reflects Business-As-Usual
- Scenario 3: A scenario where the rail infrastructure manager autonomously takes decisions to support rail freight
- Scenario 4: A Pro-rail scenario where policy and investment choices favour rail over road

Additionally a “backcast” scenario was agreed for 2011/12.

Scenario assumptions included changes to: Drivers’ wages, HGV purchase costs for net-zero vehicles, road congestion and road pricing, fuel resource cost and duty, track access charges for rail, tonnes per train, rail operational hours per week, end-to-end rail journey times, rail wagon lease costs, GDP, population, trade growth, port capacity, market assumptions for specific commodities - particularly around the reduction in the movement of carbon fuels.

[1] As of 2025 with the cessation of GBRTT the team is now part of the Network Rail Railfreight team.

Rail electrification or other zero-carbon operation was assumed to have no relative cost impact for freight operating companies. This could be achieved through technological advances and Government incentives.

Loading gauge (e.g. bridge heights) is assumed to be at least W8 on routes to intermodal container terminals, to allow the haulage of standard intermodal containers on standard or lowliner wagons. If loading gauge is below W8 such that more expensive well-wagons are required, it is assumed the FOC would be compensated for the extra cost.

A base year of 2021/22 (financial year) was chosen.

Modelling methods

Intermodal containers were forecast using the latest version of the GB Freight Model (GBFM v6.2), incorporating expected market growth, changes to costs (affecting mode share) and new rail-served warehousing sites improving the viability of using rail to/from those warehouses.

Region to region market growth assumptions for construction materials were based on the "Aggregate Minerals Survey" (British Geological Survey) and the "Aggregates demand and supply in Great Britain: Scenarios for 2035" (Mineral Products Association). GBFM v4 was used for the mode share modelling.

The modelling is conducted in tonnes, which are then translated into tonne kilometres and trains per weekday.

Summary results

Table E1 summarises the forecasts for each scenario. Table E2 disaggregates the tonne kms forecasts by Network Rail region. Detailed data describing these forecast outputs has been provided to the client.

Table E1: Unconstrained rail freight demand forecasts by scenario. Tonnes, tonne kms and trains per weekday

	Thousand Tonnes	Million Tonne kms	Trains per weekday
Base year 2021/22	82,830	18,181	465
2040/41 Sc1	82,709	20,394	574
2040/41 Sc2	111,253	26,520	644
2040/41 Sc3	158,844	39,888	887
2040/41 Sc4	208,698	58,567	1,206
2050/51 Sc1	90,705	22,579	630
2050/51 Sc2	131,810	32,314	766
2050/51 Sc3	196,462	51,242	1,108
2050/51 Sc4	283,789	80,179	1,676

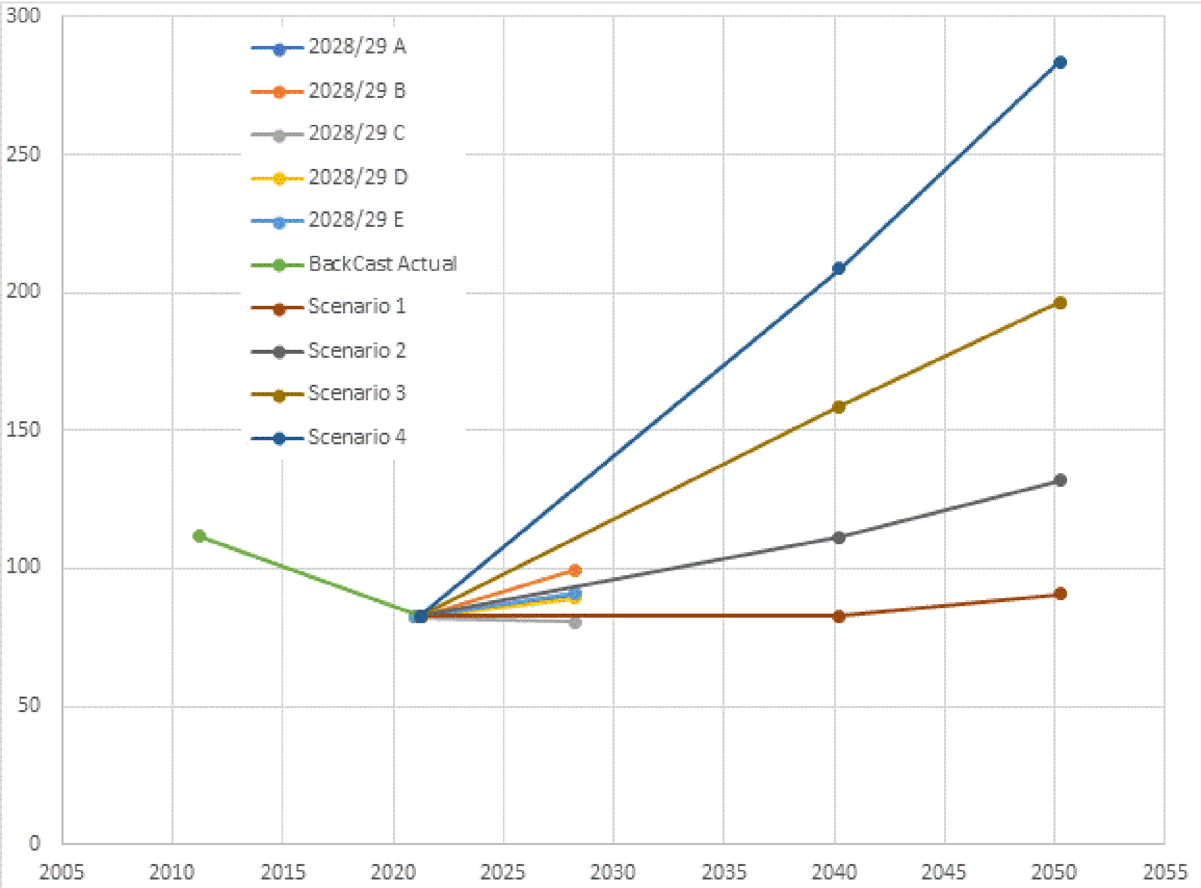
Table E2: Tonne kms by region by scenario. Million tonne kms

GBRTT Region	Eastern	North West & Central	Scotland	Southern	Wales & Western	Total	Growth from BY
Base year 2021/22	7,699	5,403	795	1,039	3,245	18,181	
2040/41 Sc1	8,424	6,227	1,331	1,039	3,373	20,394	12%
2040/41 Sc2	11,401	8,019	1,684	1,501	3,915	26,520	46%
2040/41 Sc3	15,485	12,257	2,451	3,692	6,004	39,888	119%
2040/41 Sc4	22,603	19,383	4,340	4,374	7,868	58,567	222%
2050/51 Sc1	9,304	7,048	1,486	1,311	3,431	22,579	24%
2050/51 Sc2	13,570	10,241	2,224	1,951	4,328	32,314	78%
2050/51 Sc3	19,822	16,032	3,583	4,587	7,218	51,242	182%
2050/51 Sc4	29,561	27,231	5,770	7,501	10,116	80,179	341%

These forecasts show a wide range of possible overall outcomes for the rail freight market – from broadly constant to a significant growth. In the higher-growth scenarios, the key findings are large increases in intermodal traffic (domestic, to-and-from the ports, and Channel Tunnel) and construction materials. These are counterbalanced by the end of the movement of carbon fuels by rail (coal and petroleum).

The graph below displays these 2040/41 and 2050/51 tonnage forecasts alongside the 2028/29 forecasts (produced in early 2023, with scenarios A-E).

Figure E1: 2040/41 and 2050/51 forecasts with earlier forecasts for 2028/29. All commodities. Million tonnes per year



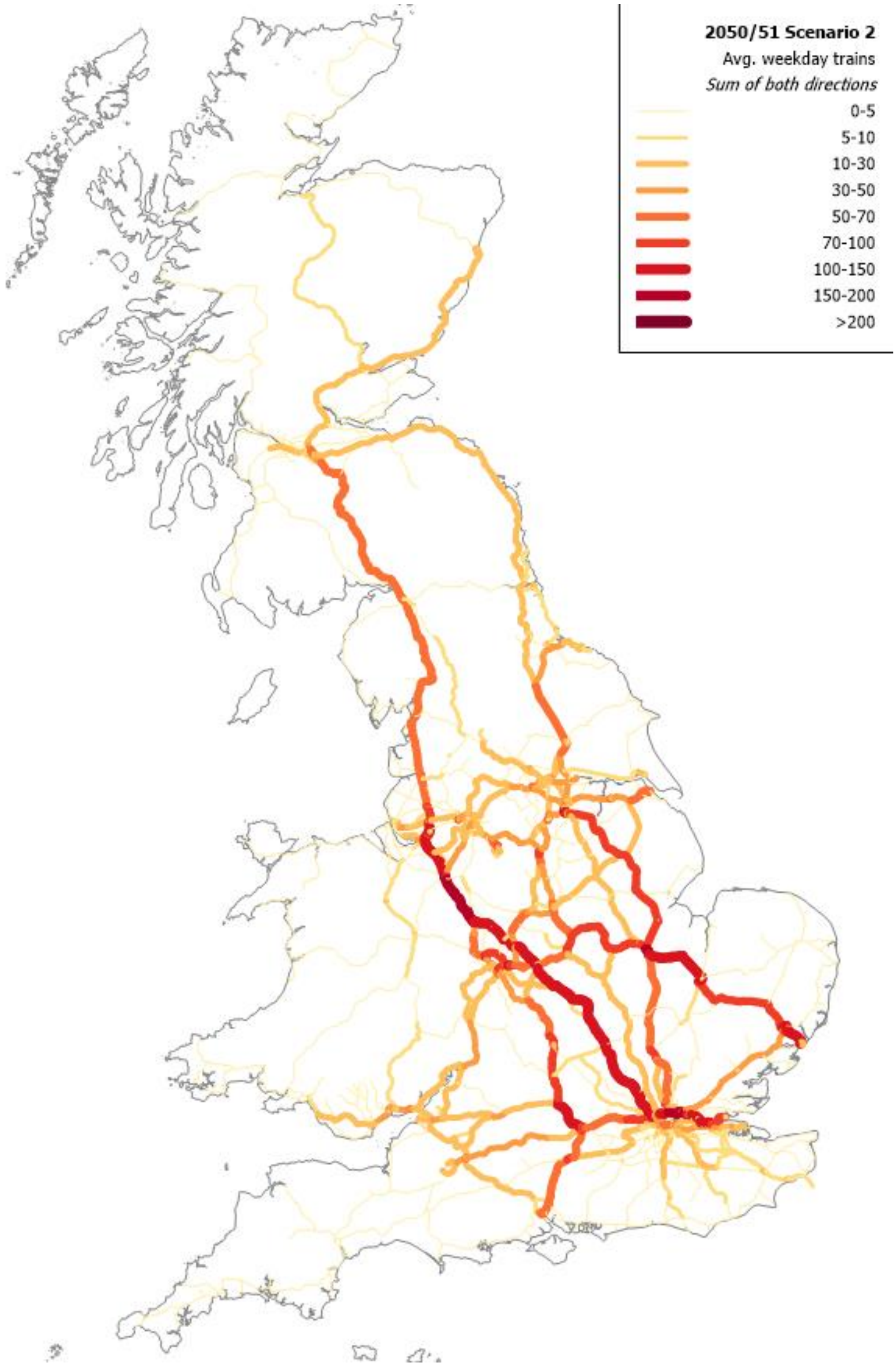
There are a number of significant differences between the assumptions and methods involved in producing these latest 2040/41 and 2050/51 forecasts as compared to the earlier 2021-based forecasts for 2028/29. These include:

- The 2028/29 forecasts were constrained by expected network capacity available for freight while the 2040/41 and 2050/51 forecasts were not constrained because the longer-term forecasts are intended to show demand rather than making a judgement of future network capacity and likely traffic.
- For the 2040/41 and 2050/51 forecasts, assumptions were arrived at following consulting a wide range of rail freight and non-rail freight stakeholders to broaden the perspectives.
- For the 2040/41 and 2050/51 forecasts the scenarios were not intended to have lows, highs or central themes – with each being its own separate standalone scenario
- For intermodal containers, a long-term approach was taken to choosing which terminal-to-terminal services would exist, which was not constrained by services in operation today.
- For construction materials, the region-to-region market was forecast based on exogenous market forecasts for the sourcing of aggregates by source-type, from the Mineral Products Association.

Rail assignment

The demand forecasts are assigned to the rail network. Figure E2 shows the assignment for 2050/51 scenario 2 in terms of freight trains per weekday.

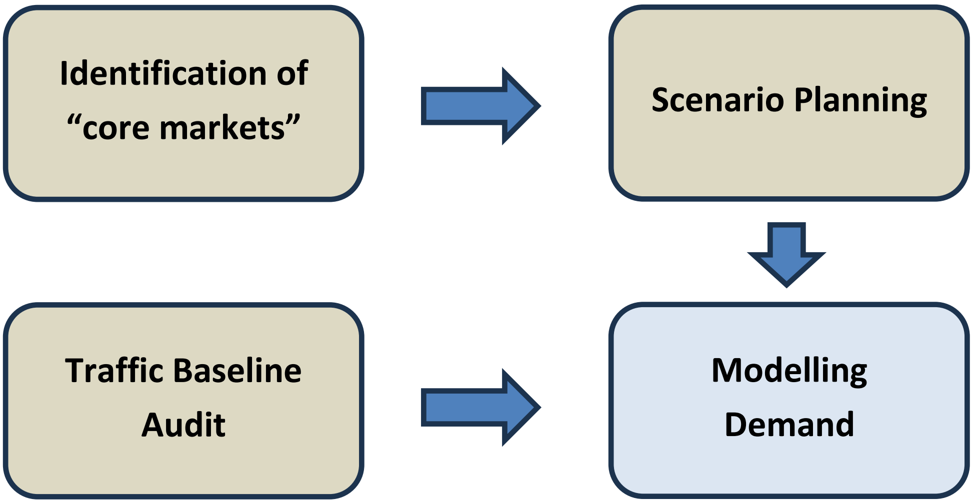
Figure E2



1. INTRODUCTION

In late 2022, the Great British Railways Transition Team (GBR-TT) Strategic Freight Unit (SFU) commissioned MDS Transmodal (MDST) to produce capacity-unconstrained rail freight demand forecasts for 2040/41 and 2050/51 under various scenarios, as an input to the development of the Rail Freight Growth Target, which will be a critical planning assumption of the under-development Long Term Strategy for Rail.

There were several key activities that acted as inputs to inform the modelling of demand:



- Identification of “core markets” (Steer with MDST) to narrow the focus of the forecasts to the markets that will materially drive investment or access decisions;[2]
- Scenario Planning (MDST and Steer) to work alongside a stakeholder group to agree distinct, plausible future-based scenarios;[3]
- Traffic Baseline Audit (Lindum Analytics with MDST) to understand the robustness of the base year for the forecasts;

This report describes the assumptions, methodology and results:

- Section 2 introduces the market for rail freight
- Section 3 describes the assumptions for these scenarios
- Section 4 describes how the base year traffics were established
- Section 5 describes the methods used and the models employed
- Section 6 explains the methods to translate from forecast tonnes to tonne kms and trains per weekday

[2] This is reported in a report by Steer on behalf of GBRTT: “Freight Futures Report”, 2023
[3] This is reported in the same report

- Section 7 summarises the results
- Section 8 describes the assignment of the forecasts to the rail network
- Section 9 describes the detailed outputs provided
- Section 10 discusses validation and quality assurance
- Section 11 concludes the report

2. THE MARKET FOR RAIL FREIGHT

It is important to recognise that the rail freight sector represents an option for cargo owners and their third party transport contractors within often complex and international supply chains. There are a few freight traffics that can be regarded as captive to rail, such as iron ore and coal between port and steel works (Scunthorpe is the only remaining example for rail in the UK) or where planning controls limit volumes by road (e.g. ex Peak District quarries and a cement plant). Otherwise, rail simply represents an option to reduce unit costs and sometimes improve supply chain performance. It is therefore important to appreciate how relevant supply chains work and how rail can play a role.

In the case of the **deep-sea container market**, where the goods arriving into Great Britain are most commonly carried in 40' long units (2 TEU) of 9'6" height and 8' width (12.20m x 2.90m x 2.44m), the majority of containers are discharged directly from very large ships that also serve major ports on Continental Europe. Britain represents around 15% of the cargo carried by these vessels, which can carry up to 24,000 TEU (twenty feet equivalent units). Only 4 ports in Britain currently have terminals that can receive such ships (Felixstowe, London Gateway, Southampton and Liverpool).

The long length of haul within Britain from the three southern ports and the fact that all the major ports are rail connected makes rail relatively competitive. Cargo owners have the choice of asking shipping lines to deliver containers directly to end destinations ('line haulage') or to collect containers themselves from the quayside ('merchant haulage'). It has generally suited the rail freight operating companies (FOC) to strike deals with the shipping lines (just nine lines now account for the great majority of the global market) in order to consolidate high volumes that can most easily justify regular trainload services to inland terminals. The inland terminals are generally owned or controlled by either a FOC or an aggregator who deals with the lines to offer FOC's trainload volumes. Aggregators will generally provide the local road delivery service from the inland rail terminal.

The motive for using very large ships is that of scale economies over long voyages. To maximise those scale economies, the lines are making increasing using of 'interlining' en-route, particularly from the main source of deep-sea containers into Europe, the Far East. In this way many more smaller markets can be served by large ships. For example, no ships from Japanese ports currently directly serve the UK; cargo from Japan will be transhipped at an intermediate port (say in the Middle East or Mediterranean) onto a ship that could have loaded in Shanghai and be calling in Felixstowe. One of the consequences of this practice is that deep-sea ships now make fewer direct calls to GB ports (only around half of services to North Europe now make a GB call) but the number of containers exchanged per call has increased considerably, making the regular flow of containers through stacking areas onto trains more difficult to manage.

An alternative approach which is directly in competition with rail is for lines to tranship at Continental ports to 'feeder' services that operate to regional ports in Great Britian such as on the Humber, Tees, Tyne, Forth, Severn, Mersey or Clyde. This approach cuts out the long inland haul within Britain and lends itself to local delivery from the regional port. This option limits the level of charges which rail operators can levy.

The shipping lines will balance these options in choosing whether to use rail; the lower the freight rates that rail can offer through improving asset utilisation and employing longer trains, the higher its market share will be.

The rail industry in Britian has been less successful in winning market share in **the Continent - GB intermodal market** despite the market being much larger (around double the scale) and there being a direct connection via the Channel Tunnel. There are several explanations for this.

- Cargo owners have the option of using direct door-to-door road haulage. The physical capacity of international road trailers can be marginally higher than a container and some cargo owners find it easier to load and discharge road trailers.
- Rail in Great Britain cannot accommodate these standard road trailers because of loading gauge restrictions, except along HS1 to Barking. There are cases where unaccompanied road trailers are transferred from long-distance trains at the Benelux ports and then shipped onto ro-ro ferries to GB ports for delivery in Britain by road. The competitiveness of this approach has recently been illustrated by one line that caters for piggyback trailers arriving at Calais choosing to open an unaccompanied ro-ro freight service from Calais to Tilbury to carry them forward into the GB market rather than make use of the Channel Tunnel.
- Where cargo owners do use containers, these are being carried on direct shipping services (again mainly from Benelux ports) to regional ports such as Thamesport, Tilbury, Immingham, Hull, Teesport, Grangemouth and Liverpool to reduce the cost of inland delivery. Intermodal services via the Channel Tunnel do operate but have not yet proved to be particularly price competitive. This may be a consequence of charges levied across France and through the Channel Tunnel.
- A particular example where a regional port has been able to extend its own hinterland in association with short-sea maritime operators has been Teesport in facilitating onward rail forwarding to Scotland, South Yorkshire and the Midlands.

In so far as purely **domestic unit load market opportunities** are concerned, experience to date suggests that a key requirement is one of scale because the main users are supermarkets whose requirements are for at least a daily service. One of the supermarkets has been able to fill trains on its own (subcontracting to a service provider) and to justify using rail over relatively short distances (Daventry to Barking and to Cardiff) while others use aggregators, notably to and from Scotland.

Some manufacturers are also examining opportunities in the domestic sector. A significant barrier to entry is one of switching current loading practices to road trailers into containers (with lower internal capacity) but this is being addressed, particularly where cargo is weight rather than volume constrained.

However, in each of these markets, the proximity of the intermodal rail terminal to the distribution shed is of crucial importance in reducing or eliminating the cost of road haulage delivery. The success of domestic services to and from the largest distribution park in the UK at Daventry illustrates this vividly. Our subsequent modelling illustrates the importance of rail linked clusters of warehouses to expand rail's share of the non-bulk market.

The other main rail freight opportunity for future growth lies in **aggregates** and other construction materials.

The **aggregates sector** is dominated by a handful of companies that are typically internationally owned and can therefore also exploit global experience in the use of rail. These companies do often face planning constraints that encourage them to use rail from their 'super quarries' to major existing terminals within urban areas; most particularly within London, Manchester and the West Midlands. However, the economies of using rail freight over longer distances, the increasing difficulty in gaining planning consent to exploit sand and gravel deposits in some areas and the absence of hard rock deposits in southern England means that rail is of increasing interest.

The key driver to expanding more traffic for rail is probably also the development of more distribution terminals in urban areas where trains can decant material loaded at quarries for local delivery to building sites and the development of added value (concrete batching etc.) at such urban sites, again reducing local haulage costs. Increasing gentrification of some urban environments to promote inner city residential development can provide a barrier for further movement of aggregates by rail, an issue that has also faced inland waterway traffic, particularly on the Thames.

It follows that, as in the case of the intermodal sector, the prospects for the further expansion of rail lies mainly with existing cargo owners and their carriers and for rail freight to be able to offer more cost effective solutions to companies that are already familiar with the rail freight sector.

For other rail freight sectors it is less easy to generalise.

For 'traditional' rail freight users in the steel, waste and other industrial sectors, the continuing use of rail will generally depend on those industries continuing to operate from existing sites. Threats to rail freight will come from their competitiveness or even existing sites of raw materials 'running out' (e.g. in the case of silica sand). Price elasticity in such cases will be relatively low.

These factors apply particularly in the case of the automotive sector, where changes from internal combustion to electricity will lead to new plants being developed, often close to port facilities; maritime services could inhibit rail's long term opportunity. Global industries are most logically located in port estates, whence inland distances to the main areas of domestic consumption are limited.

The use of **rail for express cargo** linked to on-line deliveries remains an opportunity providing that infrastructure and land use planning are tailored to market requirements. However, it is reasonably clear that rail cannot offer significant economies over and above 'double-deck' road haulage in the UK because there are, unlike on the Continent, no legal limits to the height of road trailers. It therefore follows that if rail freight is to offer advantages to the on-line delivery sector that this must be based on speed of delivery between major hubs serving dense urban communities. That speed will only be available if the distribution sheds from which goods are to be sourced are more or less integral with the rail services offered, more or less as the original Post Office services were designed but delivering to specialised rail based 'sub-hubs' where local delivery vans can be loaded and not to railway stations, which cannot easily be re-designed to cater for the scale of the opportunity now available.

3. ASSUMPTIONS

A consultation process was undertaken to establish:

- the core markets that forecasting should be focussed upon,
- what the themes of the scenarios should be,
- what the scenario inputs should include as parameters, and
- quantification of those parameter values

We consulted a wide range of rail freight and non-rail freight stakeholders when developing the scenarios to broaden the perspectives. This included DfT, Freightliner, GBRTT, Logistics UK, MDS Transmodal, National Highways, Network Rail, Rail Freight Group, Transport Scotland, Transport for Wales, Chartered Institute for Logistics and Transport, and independent experts.

This was an iterative process with several steps to refine the assumptions in line with the prevailing views.

The resulting core markets for which we have conducted detailed modelling are:

- Intermodal containers and
- Construction materials
- Note: Energy and Fuels has been identified as a 'core' market, but has not been explored in detail in this modelling as changes to the market are uncertain and difficult to model (e.g. the carriage of hydrogen).

These markets have been defined as 'core' because changes in market conditions would drive material policy and funding decisions in network capacity and investment. All freight markets were assessed against a criteria which included: network investment, terminal infrastructure, incentives & subsidy, and capacity allocation. Likewise, intermodal containers and construction materials were chosen because they are large sectors, (collectively representing 55% of tonnes and 66% of tonne kms in the base year), where there is an expectation of significant growth potential.

As discussed below, to narrow the focus of the work, other sectors have had much simpler assumptions applied, with some sectors just assumed to continue with the same traffics as the base year. This does not suggest that there will not be growth in these markets; rather, that any growth (or decline) in these markets is unlikely to materially change network capacity allocation decisions or the funding requirement. These other markets remain important to rail with decisions on which markets are core continuing to be assessed in future work.

Four scenarios were agreed for each year with each having a general theme:

- Scenario 1: A road-reliant scenario where policy and investment choices favour road over rail
- Scenario 2: A TAG-compliant scenario which broadly reflects Business-As-Usual (BAU)

- Scenario 3: A scenario where the rail infrastructure manager autonomously takes decisions to support rail freight
- Scenario 4: A Pro-rail scenario where policy and investment choices favour rail over road

Additionally a "backcast" scenario was agreed for 2011/12 – showing how the variables have changed over the last 10 years. Details of the backcast scenario results and analysis are given in section 10.3.

3.1. General assumptions

A table of general assumptions for each scenario is given in appendix 1

Scenario 2 is intended to represent a BAU-like scenario and therefore many of the changes in the parameters from the base year are based on the DfT's Transport Analysis Guidance (TAG) data book[4]. For scenarios 1, 3 and 4, variations of a plausible magnitude from TAG are chosen in line with the theme of the scenario.

Any significant changes in parameters that represent a large proportion of costs are likely to have the biggest effects. The extent of the effects can be seen in gradual introduction of Scenario 4 – see section 10.1.

3.2. Intermodal Containers

3.2.1. Market

The domestic non-bulk market is assumed to grow in line with the average of GDP and population growth.

The overall unitised traffic coming through the ports and Channel Tunnel is assumed to grow in line with projected unitised trade growth, with each port's share based on the build out of specified container port capacity. Trade growth at large ports which are a long distance from their inland markets is likely to encourage high levels of rail traffic, while ports nearer to their inland markets are less likely to be so suited to a high rail mode share.

3.2.2. Cost changes

The magnitude of the impact of changes in the road and rail cost components is less clearcut. For each parameter, the impact of changes depends on how big a proportion the cost component is of the overall cost for that mode, and whether road and rail costs are of a similar magnitude such that there is active competition between the modes for a particular traffic.

The following tables give an indication of the proportion that each cost component makes up of the overall road and rail cost for a 200 km intermodal journey in the base year. The rail cost does not include any local road hauls at either end of the journey.

[4] https://www.gov.uk/government/publications/tag-data-book

Table 1: Proportion that each cost component makes up of the overall *ROAD* cost for a 200 km intermodal journey in the base year

Road cost component	% of total cost
Drivers' wages	33%
HGV tractor lease cost	9%
Fuel duty	17%
Diesel resource cost	14%
Other	27%
Total cost	**100%**

Table 2: Proportion that each cost component makes up of the overall *RAIL* cost for a 200 km intermodal journey in the base year

Road cost component	% of total cost
Drivers' wages	12%
Locomotive lease cost	21%
Wagon lease cost	12%
Fuel duty	2%
Diesel resource cost	9%
Track access charges (VUC)	7%
Terminals	30%
Other	7%
Total cost	**100%**

3.2.3. Rail served warehousing sites

As well as the general assumptions above applying to intermodal containers, there are also assumptions regarding the development of new or expanded rail served warehousing sites with on-site intermodal container terminals. If an intermodal container is destined for a warehouse on the same site as an intermodal terminal, there is no need for an onward road haul from rail terminal to final destination. This significantly improves the viability of using rail, encouraging a mode shift to rail. These intermodal terminals can also be used for off-site traffic.

Table A2.1 in appendix 2 describes the assumptions for each scenario in terms of the square meters of warehousing at each rail-served site.

3.3. Construction materials

The assumptions are detailed within the methods section for construction materials; section 5.2.

3.4. Steel industry

For the steel industry (metals, “other coal” & iron ore), our 2040/41 forecast rail traffics are unchanged from the base year, with “other coal” disappearing by 2050/51.

However we acknowledge that the nature of the industry may well change and this is a major source of uncertainty. The types of flow may switch from iron ore and other coal to more scrap metal going into a steel-making process with less need for coal, but we assume that the quantities by rail could be broadly similar, and to the same or similar sites.

In the base year (2021/22) there were: 3.5 million tonnes of iron ore + 1.6 million tonnes of "other coal" = 5.1 million tonnes carried by rail. There were 9 million tonnes of scrap metal exported (source: HMRC trade data), of which 0.5 million tonnes already travels by rail to the ports. Overall UK steel production is around 7.2 million tonnes per year. So there probably would be enough scrap metal exports to supply a UK steel industry similar to that of the present day if it was wholly reliant on scrap metal generated in the UK. If that were the case, then a fair proportion of that would probably go by rail.

If there is a sizeable switch from iron ore to scrap metal, then this would obviously affect the origins of traffics. However if the steelworks remained in the same places, the tonne kms in those regions may not be hugely changed, albeit a more dispersed market may drive lower volumes on individual flows, but the distances may be longer to counteract their effect on tonne kms.

There is also the possibility that iron ore may continue to be used, so the source of iron will not necessarily all be switching from ore to scrap metal

We have therefore kept our assumptions simple, with the aim of broadly representing both a continuation of iron ore based steel production or a change to the market:

- Metals traffics continue unchanged.
- Iron ore traffics continues unchanged
- Other coal traffics continues unchanged in 2040/41 but disappear by 2050/51

Currently, there is not enough information about changes in this market to confidently forecast how rail market demand may change. However, this should not preclude inclusion in future forecasts when there is more certainty about how the market may change.

3.5. Petroleum

Under current Government policy, new cars and vans must be fully zero emission at the tailpipe from 2035, with hybrids only from 2030. New Carbon-fueled large HGVs will not be able to be bought after 2040. Our assumption of a reduction in rail freight of 60% by 2040/41 and zeroing by 2050/51 reflects that approximate decline in likely demand. By 2050, volumes are expected to be so small that they won't warrant train loads. The rate at which the demand for petroleum transport changes is highly uncertain, depending on both Government policy and technological developments.

3.6. Biomass and Coal

3.6.1. Power station (ESI) coal

We remove all traffic for all future scenarios. This is because it is Government policy to phase out electricity production from coal.

3.6.2. Biomass

There is uncertainty around Government policy towards electricity production from biomass. There is also uncertainty around the technology and viability of Carbon Capture and Storage (CCS). Scenario 1 has a road-reliant theme so we remove all biomass traffic. We retain existing biomass traffic for the other scenarios. Future forecasts could include revised assumptions when there is more certainty in the industry's future.

3.6.3. Other Coal

We assume that by 2050/51 there will be substitutes for most current uses of coal, such that there isn't a market for the bulk transport of coal (i.e. there may be residual coal use, but it will not be important in a rail transport context). For 2040/41, we retain base year traffics. The extent of the phase out and in particular the timings of it are highly uncertain.

3.7. Other commodities

Chemicals, Industrial Minerals, Automotive, General Merchandise, Waste, Ore, Other and Network Rail Engineering, were not identified as core sectors and we retain base year traffics for all forecast scenarios. However these traffics could well change over the coming decades.

3.8. Rail assignment and routing

See section 8 for details.

4. ESTABLISHING BASE YEAR TRAFFICS

In order to base the forecasts in reality, it is important to accurately establish traffic for a "normalised" base year. This should represent traffic that would flow under "normal" circumstances. It should therefore ideally exclude unusual events such as

- strike days affecting the whole network,
- bad-weather affecting specific geographic areas,
- unusual several-months long industrial closures affecting specific traffics.

Similarly it should exclude periods of unusually high-volume traffic, such as where a construction project is generating high demand at a particular terminal.

However it is normal to have some abnormality. Therefore an ideal normalised base year would take average traffics from periods without unusual events and then scale them to overall long-term average traffics. Using a non-normalised base year of traffic would risk producing forecasts that had a similar skewed representation of traffic as the non-normalised base year traffic.

In practice it is challenging to reliably establish a truly normalised base year, so for these forecasts, this is done by estimating freight tonnages by origin and destination and commodity for a given recent year avoiding any significant periods of widespread disruption.

This enables a no-change scenario to be run – ensuring that the results match or closely match the base year. All other scenarios – including the Do-Minimum (BAU-style) scenario- then use this as a foundation.

A separate report describes and validates the analysis undertaken to establish the base year cargo tonnes traffic[5], but in brief the methodology is as follows:

- Select an appropriate recent 12 month period. This was chosen to be: Financial year 1st April 2021 to 31st March 2022.
- Gather the PALADIN data (Network Rail traffic data) for the period – particularly the weekly files "cnwg…" that detail the movements of all wagons: origin and destination by time (including tonnage carried by commodity).
- Group all movements for each wagon and then sort into time order.
- Avoid double-counting where there may be multiple records for some movements by going through the records and whenever the origin of a wagon changes, retain this record. Where the origin is unchanged, this is a repeat record for the same movement and is discarded.
- From all the retained records, select those where the journey starts in the time period of interest
- This represents a list of all rail freight cargo movements for the base year:
    - Origin terminal

[5] Rail Freight Demand Forecast Refresh, Report on GBR-TT "Baseline Tonnage Audit", April 2023

- Destination terminal
- Commodity or sector
- Tonnes

The results were validated and audited by Lindum Analytics with help from MDST, with Lindum Analytics recreating the process from scratch and comparing the results to other Network Rail data sources which have tonnages based on *train* movement origins and destinations rather than *cargo* origins and destination.

Tonnages were also validated by comparing to HMRC trade data through the ports[6] for certain traffics where they are known to be almost exclusively by rail, such as biomass from Liverpool, Immingham and Tyne.

The conclusions were that, overall, the data audit was successful in providing a good level of assurance that MDST's tonnage matrix is of a sufficient quality to be assumed "fit for purpose" as the start point for their demand forecast refresh work.

The methodology does, however, rely very heavily on the quality of the data going into it, as is the case with any data algorithm. Despite this, it was possible to identify a good close match between the tonnage figures for many high volume freight locations from the MDST approach compared to the analysis of the train-based tonnes data analysed by Lindum Analytics, and therefore to validate that the demand forecast work would be starting from a dataset that for the most part is as accurate as possible a representation of the base year.

[6] www.uktradeinfo.com/trade-data/

5. METHODS AND MODELS EMPLOYED

5.1. Intermodal containers

There are several stages to the GB Freight Model (GBFM) Version 6's representation of intermodal container movements, and modelling alternative scenarios. For the base year the method is:

- Establish origin zone to destination zone movements of cargo that would travel in a container if it was travelling by rail. This is done for port traffics and domestic traffic separately.
    - Domestic traffics are based on gravity models connecting relevant producer and consumer industries together via "supply" and "use" tables, along with the locations of warehouses. Overall traffic by commodity is constrained by that reported in the DfT's Continuing Survey of Road Goods Transport (CSRGT) plus Network Rail's traffic
    - Port traffics are based on HMRC trade data by port and ferry data by port. Inland distributions are based on gravity models connecting inland industries and warehouse locations, while satisfying an overall average length of haul target from CSRGT and Network Rail
- Build cost models for road and rail such that the cost of an origin to destination road journey, or terminal to terminal rail journey can be calculated.
    - These cost models are regularly validated against real world road and rail costs in the haulage industry.
- Input the base year intermodal rail services into the model: origin terminal by destination terminal.
- For each origin zone to destination zone movement, establish the minimum cost intermodal rail route incorporating:
    - the road haul from origin zone to origin rail terminal
    - the rail cost from terminal to terminal
    - the road haul from destination terminal to destination zone.
    - For origin or destination zones at a rail terminal (e.g. a port or a rail-served warehouse) there is no need for the road haul.
- For each OD movement, compare this to the direct-by-road cost, and choose a rail mode share accordingly using a Logit model.
- Add up all the modelled rail traffic for all ODs on each rail service and compare to the actual rail traffic in the base year.
- Calibrate by incremental additions or subtractions to costs where the modelled traffic level is respectively higher or lower than actual traffic until modelled and actual volumes approximately match. Because allocating all traffic from an OD to a particular service is not a continuous function (i.e. traffic can jump from one service to another if costs slightly change), it is not possible to get a perfect calibration.

Alternative scenarios can be represented by various changes such as:

- changing the market by changing the traffic in the OD matrices. E.g. future trade growth or having more warehousing space next to rail terminals.
- changing the rail mode share by changing the cost models. E.g. higher drivers' wages would increase costs per unit more for road than for rail. This would make rail more competitive and would therefore attract more traffic to rail.

The assumptions for each scenario are described in Section 3. The assumptions also involve additional intermodal terminals being built (many with associated warehousing), which require new services to be input into the model.

There are two main challenges with introducing new terminals into the model:

- Deciding which services should be included for each new terminal.
- Deciding what calibration values to allocate to these new services such that they don't compete unrealistically with similar parallel services.

5.1.1. Which services should be included

The process we adopt is to add services between each new terminal and all other intermodal terminals more than 160km away[7]. This overstates the realistic and viable level of connectivity, so after the model is run, any services receiving less than 60,000 tonnes per year (sum of both directions; significantly less than a full daily train) are considered non-viable and removed, whereupon the model is re-run for the second and final iteration.

However this potentially would bias traffic towards new terminals as compared to existing terminals, so all terminals are linked to all other terminals (existing or new, more than 160km away) for the first iteration, prior to being removed if receiving less than 60,000 tonnes.

This method is quite a departure from the representation of services in the base year – where they are chosen based on which services actually exist. Therefore there is a potential mismatch in the representation of the base year (just including those services that actually exist) and that for the forecasts (including services between all terminals in the first iteration).

To try to match up the forecast methodology with the traffic and approach in the base year, we have applied the forecast approach to the terminals in the base year; connecting all base year terminals >160km away for the first iteration (and then removing services with less than 60,000 tonnes). Due to the increased number of connections, this method results in overall more rail traffic than actually travels in the base year.

[7] At very short distances, intermodal container services are generally not viable on the rail network. This is partly because the financial cost is higher by rail, but also due to the convenience of using road. The cost models do not sufficiently represent the convenience of short distance road versus rail, and therefore we restrict the offering of short distance services to prevent the model from allocating short-distance traffic to rail. 160km is chosen as a cut-off because there are very few viable intermodal services less than 160km.

We therefore added a fixed £30 per unit cost to all services to reduce overall traffic to a level similar to the actual traffic in the base year. We arrived at this £30 through an iterative calibration process; effectively trial and error. This £30 is compensation for the fact that the model generates more terminal-to-terminal services (open to all customers) than exist in reality, from which the most attractive are cherry-picked.

The actual base year intermodal traffic is 18.3 million tonnes and 6.87 billion tonne kms. The equivalent modelled base year traffic with the extra £30 per unit cost calibration factor is 17.5 million tonnes and 7.27 billion tonne kms; 4% lower tonnes and 6% higher tonne kms. These are broadly consistent albeit the average length of haul from the model's outputs is slightly higher.

In this modelled representation of the base year (starting with all terminals being connected), the specific terminal to terminal connections that emerge are different from those in the actual base year. Most terminals retain similar volumes of traffic to the actual base year, however some of the specific connections between terminals are different.

We have always to remember that intermodal traffic can only be attracted if a Freight Operating Company (FOC) or aggregator takes the risk of operating a service between a given pair of terminals and such a service inevitably suppresses the chance of similar services running between competing terminals. Our methodology seeks to take into account the degree of 'randomness' in such a competitive environment and the issue of critical mass. This is a strategic model informing strategic decisions. It doesn't matter that Elderslie is forecast and not Coatbridge. However it does matter that Central Scotland to other regional markets are captured well.

5.1.2. What calibration values to allocate to these new services

Choosing the calibration values for these new services is not straightforward. For each new service, we aim to copy calibration values from existing nearby traffic-heavy services by taking a weighted average of calibration values of all existing services, with the formula for the weighting of the calibration factors from existing services as follows:

> *Weighting = Existing service tonnes / (Distance from existing service origin terminal to new service origin terminal PLUS Distance from existing service destination terminal to new service destination terminal PLUS 10km)*

This is done separately for port and inland-to-inland services.

This should mean that new services have calibration values that are consistent with those that "worked" for the calibrated base year.

As mentioned, there is a reasonably good match between intermodal tonnes and tonne kms in the modelled representation of the base year (starting with all terminals being connected) and the actual base year. However there are fewer modelled inland-to-inland tonnes and more tonnes to/from port terminals. This suggests that in the modelled base year, there are many services to and from ports that are being used for domestic traffic.

Limitations

This method of initially connecting all terminals to all other terminals is only suited to long term forecasting where we can potentially ignore current connections and assume that the market will fully adjust to the opportunities that new services offer - that may not be relevant or being taken advantage of now. This is too much of a departure from the present day real world to be credible for short term forecasts.

The huge demand growth forecast particularly for Scenario 4 is capacity unconstrained. To realise this traffic demand would require lots of extra network capacity to be made available to freight, along with upgrades to terminals. For many terminals this would not be practical and alternative facilities would be required. Even if sufficient network capacity ultimately is made available, there is a need for private sector investment to build the terminals and warehousing. This will only happen if there is confidence in the industry that network capacity will be available to make use of their investments.

The new terminals, particularly with associated on-site warehousing are responsible for a large amount of the growth forecast. If these are not built, demand would be lower. This can be seen to some extent in section 10.1 which shows the gradual introduction of the scenario components for 2050/51 Scenario 4. Scenario 4a includes market growth – with warehousing growth in line with population at existing sites. Scenario 4b includes the building of the assumed rail-served warehousing and other intermodal terminals.

5.1.3. Channel Tunnel intermodal

GBFMv6 models non-bulk cargo moved between European regions and British inland zones as follows:
To model the base year:

- GBFM estimates the non-bulk cargo moved between each European region and British inland zone.
- For each European region to British zone
  - The full-route transport cost is estimated including the inland legs plus the shipping (or Channel Tunnel) route. These costs are calculated based on road, rail and shipping cost models that include fuel costs, drivers' wages, HGV lease costs, ship charter rates, Channel Tunnel tolls etc.
  - The cargo is shared among the shipping and Channel Tunnel route options based on cost, with the cheapest end-to-end route getting the most traffic. This is done using a Logit model.
  - For example cargo from Cologne to Manchester could be shared between
    - Dover – Calais / ET shuttle driver-accompanied HGVs
    - Zeebrugge – Purfleet unaccompanied trailers
    - Rotterdam – Hull Lolo
    - and Channel Tunnel through-rail direct to the North West of England amongst various other route options.

- The total modelled traffic on each shipping route is compared to the known actual total traffic on each shipping route. Inevitably there are differences between the modelled traffic and the actual traffic.
- A calibration process resolves this: Routes with too little traffic are made cheaper. Routes with too much traffic are made more expensive. The model is re-run and again compared to actual traffics. This is repeated until the modelled traffic is close to the actual traffic on each route.
    - As mentioned above, when calibrating rail services within GB - only the lowest generalised cost rail service is chosen for each origin to destination, and flip-flopping can occur when calibrating. However, for international services (shipping and Channel Tunnel), traffic is shared between the routes with a continuous function, so "flip-flopping" is avoided. Therefore, a closer match to actual traffics can be achieved in this calibration.

From this calibrated modelled base, alternative scenarios can be tested in the model by changing the costs of shipping or Channel Tunnel services or inland transport. For example:

- Decarbonisation of HGVs and/or road pricing: If this were to effectively increase the cost of running HGVs, this could be input into the road cost model and would increase the inland costs. For the Cologne to Manchester example, the Dover – Calais route involves long distance inland hauls and would therefore become a lot more expensive. The Channel Tunnel through-rail route involves short inland road hauls to/from the rail terminals and would therefore only become slightly more expensive. Therefore, the Dover – Calais route would lose traffic and Channel Tunnel through-rail would gain traffic.
- Reducing Channel Tunnel through-rail tolls would attract more traffic to the route.
- Piggyback services can be introduced into the model as though they were unaccompanied-trailer ferry services.

There is a very competitive market for Cross channel crossings, and Channel Tunnel through-rail often currently loses out to sea crossings. If costs of using Channel Tunnel through-rail were to reduce and its level of service were to improve, the traffic volumes could be transformed, with much of the Central Europe to the British Midlands market captured and more.

In the base year, there are services through the tunnel to Dagenham, Daventry and Ditton (Widnes). For the future scenarios these services are retained with the cost changes affecting domestic and port rail freight services also affecting these Channel Tunnel services. In some scenarios, this may overstate the traffic on these specific services because if the market grew significantly in reality, services to other inland terminals would be introduced.

5.1.4. Zone labels

The model outputs its results in GBFM v6 zones (around 7000 in the country; mostly "Middle layer Super Output Areas" (MSOA) zones in England, but larger zones in Scotland and Wales). In order to identify which terminals relate to each zone, for each GBFMv6 zone in the forecasts, we give the terminal (Stanox code) with the most traffic in the base year. For example Felixstowe's zone's biggest tonnage Stanox code is Felixstowe North F.L.T., so that's what is stated for all zone 7130's (Felixstowe's) intermodal traffic.

5.2. Construction materials

Transport of construction materials is dominated by the movement of aggregates (crushed rock, sand and gravel) as mentioned in section 2. Aggregates are the main focus of the forecasting methodology but other construction materials are also assumed to grow in line with the forecast overall consumption of aggregates.

The forecasting approach is split into two components:

- Forecasting changes in the market; overall demand growth and changes in source types
- Forecasting changes in rail's mode share, using the GB Freight Model.

Each component generates growth scale factors. These can be applied one after the other – to the base year rail freight traffic.

5.2.1. Changes in the market

The British Geological Survey conducted the Aggregate Minerals Survey (AMS[8]) which gives the tonnes of aggregates transported from origin region to destination region in 2019 by type (Land-won sand and gravel (LWSG), Marine dredged sand and gravel (MSG) and Crushed rock (CR).

The Mineral Products Association (MPA) produce four supply scenarios[9] showing how the sourcing of aggregates could potentially change from a base year of 2021 up to 2035:

- Supply scenario 1. "Business as usual"
- Supply scenario 2. "Mind the gap: Offshoring sand & gravel supply"
- Supply scenario 3. "Substitution with crushed rock"
- Supply scenario 4. "Throwing the kitchen sink"

For each supply scenario, they give two aggregates demand intensity variants:

- a 'baseline' assumption whereby future aggregates intensity continues on the path it has followed since 2014
- a 'lower intensity' assumption which may be achieved through a combination of continuing improvement in resource efficiency, reducing waste, and greater substitution with other materials

The MPA supply scenarios were adopted and incorporated into the four scenarios for GBRTT as follows:

- GBRTT Sc1: Take Lower Intensity for MPA supply Sc2: Mind the gap: Offshoring sand & gravel supply
- GBRTT Sc2: Take mid-point of Baseline and Lower Intensity for MPA supply Sc2: Mind the gap: Offshoring sand & gravel supply
- GBRTT Sc3: Take mid-point of Baseline and Lower Intensity for MPA supply Sc4. This has a big increase in MSG and therefore needs port-based rail terminal capacity
- GBRTT Sc4: Take mid-point of Baseline and Lower Intensity for MPA supply Sc3. This has a big increase in crushed rock, much from rail-served super-quarries

This gives the following tonnages by source for 2035:

[8] "Collation of the results of the 2019 Aggregate Minerals Survey for England and Wales", OR/21/024, British Geological Survey 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1075214/AM2019_National_Collation-Final.pdf

[9] "Aggregates demand and supply in Great Britain: Scenarios for 2035", Mineral Products Association. https://mineralproducts.org/MPA/media/root/Publications/2022/Aggregates_demand_and_supply_in_GB_Scenarios_for_2035.pdf

Table 3: MPA scenario tonnages adopted for GBRTT scenarios 1-4 for 2035. Million tonnes

Type	2021	GBRTT Sc1	GBRTT Sc2	GBRTT Sc3	GBRTT Sc4
Crushed Rock (CR)	126	129	145	136	173
Land-won Sand & Gravel (LWSG)	43	29	33	21	21
Marine Sand & Gravel (MSG)	14	29	33	54	17
Recycled & Secondaries (RS)	70	90	90	90	90
Total	**253**	**277**	**300**	**301**	**301**

The MPA scenarios are to 2035, so these need to be extended to 2040 and 2050. We have used two extrapolation methods and then taken the average of those:

- Assume that the trends for each sector continue linearly from 2035 to 2040 and 2050
- Assume that the total tonnes trend continues linearly from 2035 to 2040 and 2050, but the market shares of the sources is retained at 2035 levels

This results in:

Table 4: GBRTT scenarios 1-4 for 2040 and 2050. Million tonnes

	2021	2040				2050			
Type	2021	Sc1	Sc2	Sc3	Sc4	Sc1	Sc2	Sc3	Sc4
Crushed Rock	126	132	152	141	186	137	166	152	213
Land-won Sand & Gravel	43	27	32	18	18	23	30	11	11
Marine Sand & Gravel	14	32	37	63	17	38	45	80	19
Recycled & Secondaries	70	95	96	96	96	105	108	108	108
Total	**253**	**286**	**316**	**317**	**317**	**303**	**349**	**351**	**351**
Total Not inc RS	**183**	**191**	**220**	**221**	**221**	**198**	**241**	**243**	**243**

Growth factors were then derived from 2021 to 2040 and 2050 for each scenario:

Table 5: Scale factors from 2021/22 to 2040/41 and 2050/51 for GBRTT scenarios 1-4.

	2040/41				2050/51			
Type	Sc1	Sc2	Sc3	Sc4	Sc1	Sc2	Sc3	Sc4
Crushed Rock	1.04	1.20	1.12	1.48	1.08	1.32	1.21	1.69
Land-won Sand & Gravel	0.63	0.73	0.41	0.41	0.53	0.69	0.26	0.26
Marine Sand & Gravel	2.29	2.62	4.48	1.24	2.74	3.22	5.71	1.37
Recycled & Secondaries	1.36	1.37	1.37	1.37	1.50	1.55	1.55	1.55
Total	**1.13**	**1.25**	**1.25**	**1.25**	**1.20**	**1.38**	**1.39**	**1.39**
Total Not inc RS	**1.04**	**1.20**	**1.21**	**1.21**	**1.08**	**1.32**	**1.33**	**1.33**

Notes:

- This ignores the quarter-year discrepancy between 2021 and 2021/22 etc, such that 2021 is taken to represent 2021/22, and 2040 and 2050 represent 2040/41 and 2050/51 respectively
- There is significant growth in MSG, particularly in scenario 3.

- There are significant declines for LWSG.

The 2021 MPA and 2019 AMS sources match up reasonably well but they are for different years. We used the 2021 MPA figures by source type (not including RS) as control totals to scale the 2019 AMS OD matrix. This is shown in appendix 3.

We applied the source type scale factors described above for each scenario with the following method: For each scenario:

- Scale up all the O-Ds by the **all-source** total growth excluding RS. Summing by destination region gives the target traffic to each destination region. For example 2040/41 scenario 1 is for the market excluding RS to grow by 4.2% (shown with less precision as 1.04 in the table above), so the aggregates to East Midlands grows by 4.2% from 23,621 to 24,603 thousand tonnes.
- Separately scale up all the O-Ds by the **source-specific** growth rate. This shows the default growth that would be applied if all traffics grew at the national rate for the source type.
- Inevitably these two approaches don't give a consistent result. For example, London receives large volumes of MSG, so in Scenario 1 (2040) scaling the Marine traffic by a factor of X 2.29 means that London ends up with much more traffic than the overall market growth rate of X 1.042 (+4.2%). Conversely the East Midlands receives no MSG; The scale factor of X 0.63 for LWSG (i.e. a very significant reduction), gives an overall decline, with the resultant traffic to East Midlands much lower than the target overall market growth rate of X 1.042.
- For regions receiving too much traffic, scale down their MSG until their overall traffic matches the all-source growth.
- For regions receiving too little traffic, add MSG. For each region, the source is manually chosen. We assume that all regions source their own MSG from ports in their region apart from:
  - East Midlands from East Coast ports
  - West Midlands from South West ports

For scenarios 1-3, there is considerable growth in MSG, so this gives the flexibility to move it between regions without any regions having a decline in MSG sourcing.

However Scenario 4 does not have significant MSG growth because the growth is predominantly in CR. We have adopted a similar approach whereby the CR is increased or decreased to make up the difference instead of MSG. However where extra CR is required, because the changes are modest in percentage terms, this is achieved by scaling up existing sources rather than manually adding traffic from specific sources as is done for MSG.

This results in a region-to-region tonnage matrix by source type for 2021 and for each forecast scenario (plus the backcast year) from which 2021-to-forecast scenario scale factors can be derived. We applied these scale factors to the base year **rail** traffic to give a forecast of rail traffic prior to any consideration of changes in transport costs affecting road versus rail mode shares. We ignore the quarter-year discrepancy between 2021 and our base year of 2021/22, and assume that the derived growth rates from 2021 to 2040 and 2050 can be used to represent growth from 2021/22 to 2040/41 and 2050/51, respectively.

The manually added **inter**-regional MSG traffics (from East Coast ports to the East Midlands and South West ports to the West Midlands) are assumed to be of sufficient distance to be viable by rail given a rail connection at the port. The manually added **intra**-regional MSG traffics are assumed to be too short a haul to be viable by rail and are assumed to travel by road.

Other construction materials are assumed to grow in line with the overall aggregates market: "GM" (General Market).

Limitations

A weakness of this approach is that the growth rates to 2035 given in the MPA report are not broken down by region; the same national growth rate is applied to all regions for both supply and consumption. For example this implies that all Land-won Sand & Gravel sources will decline by 74% in 2050/51 for scenarios 3 and 4, whereas the reality will be that many sources stop production, while others have sufficient supplies to continue producing consistently up to 2050/51, or new sources will emerge. Similarly in reality different regions are likely to have different growth rates for consumption.

For scenarios 1-3, after applying the two separate growth methods (all-source growth rate and source-specific growth rate), the assumption that regions only adjust their MSG consumption to match the all-source growth rate is a simplification. In reality there will be other considerations based on local availability and costs.

For the extra MSG traffic added, there could be some intra-regional traffic that is suited to rail, and conversely some inter-regional traffic that is not suited to rail. Other ports and inland terminals could be chosen instead of Avonmouth to Walsall and Immingham to Ratcliffe power station.

5.2.2. Changes in rail's mode share

We represent changes that affect transport costs as affecting the road vs rail mode split for construction materials traffic.

GBFM version 4 can be run with its base year costs to produce an OD tonnage matrix by commodity and by mode (road or rail) at a county level. For each scenario there are assumptions about how much the components of transport cost are likely to change in terms of percentage change. The percent changes in cost components are input into GBFM v4's cost model. For each origin to destination GBFM works out the road and the rail costs and estimates the mode share accordingly. For example, if the road cost increased while rail costs stayed constant, this would encourage a mode shift from road to rail.

There are various factors that make changes in mode share less likely in reality than in the model. There are restrictions on HGV movements from many quarries which are not represented in the model. Such restrictions force the use of rail in the base year, thus meaning that the base year mode share is not purely a result of road and rail costs. Therefore changing the road and rail costs would have less of a real-world impact on mode choice than the model would predict. We take account of this limitation by inputting just half of the described scenario change into the model, to reduce the model's mode share response. The last leg; moving materials from local depot to a building site is unlikely to be possible by rail in most cases. For intra-county movements we therefore also halve the model's response.

The resulting model runs output equivalent OD matrices such that rail freight growth scale factors can be derived for construction materials by origin-to-destination region.

We applied these growth scale factors after having applied the market growth scale factors to arrive at our construction materials forecasts.

Limitations

The growth in rail carriage of aggregates over recent years has corresponded with a period when

- mean train lengths were extended (reducing real units costs)
- the proportion of the market served by rail linked quarries grew (so increasing the opportunity to use rail competitively)
- there has been some expansion in urban terminal capacity (as a response).

It has therefore been difficult to accurately determine the response of the market to road and rail cost changes alone. We have therefore taken a cautious approach to the risk of the model exaggerating mode share change in response to road and rail cost changes by halving the model's response for intra-county movements. We estimate that this factor could significantly impact on the level of growth forecasts for construction materials by around 10%, but the results do fit broadly with our expectations of how the market would respond, based on experience.

GBFM version 4's cost models are not up-to-date. However we have checked that each relevant cost component's proportion of the overall cost is similar to that of up-to-date cost models. Therefore applying percent changes to those cost components should produce an equivalent model response to if up-to-date cost models were being used.

5.2.3. New quarries

Scenarios 3 and 4 include new quarries at Horton in Ribblesdale and Bayston Hill. Horton in Ribblesdale's traffic is assumed to be split between Manchester and Leeds. We have allocated this to specific terminals in the cities (Weaste in Manchester and Stourton in Leeds), albeit different nearby terminals could be used instead. Similarly, Bayston Hill's traffic is assumed to be split between Birmingham and London, allocated to Walsall freight terminal and Hayes & Harlington sidings respectively.

These traffics are simply added to the rail forecast traffic.

5.3. Other commodities

Our approach to representing the Light logistics / Express freight market is described in appendix 4.

For other commodities, the definition of the scenario assumptions effectively defines the methodology:

- Power station (ESI) coal: Remove all traffic for all future scenarios
- Biomass: Retain base year traffics, apart from scenario 1, where all biomass traffic is removed
- Petroleum: For 2040/41, scale all traffics by multiplying by X 0.40 (i.e. a 60% reduction). For 2050/51, remove all traffic.
- Other Coal: For 2040/41, retain base year traffics. For 2050/51, remove all traffic.
- Chemicals, Industrial Minerals, Metals, Automotive, General Merchandise, Waste, Ore, Other and Network Rail Engineering: Retain base year traffics

6. METHODS TO TRANSLATE FROM FORECAST TONNES TO TONNE KMS AND TRAINS PER WEEKDAY

6.1. Translating tonnes to tonne km by NR region

The modelled outputs are in tonnes by origin, destination and commodity. However these need to be translated to *tonne kms*, and those tonne kms need to be split by NR region.

Each weekly wagon movement file ("cnwg") as described in section 4 has an associated "locn" file which details the en-route locations that each train takes. By combining these cnwg and locn files, the base year tonnes can be assigned to the rail network.

Once assigned, the tonnes on each link can be multiplied by the link length to give the overall tonne kms. By retaining the origin, destination and commodity information in the assignment, the tonne kms can be calculated for each origin by destination by commodity tonnage record in the base year. By noting which GBRTT region each link is in, the tonne kms can therefore be disaggregated into GBRTT region. Adding up all the assigned tonne kms in the base year gives a total figure of 17.90 billion tonne kms.

The Office of Rail and Road (ORR) publish rail freight tonne kms figures by quarter[10]. These show total rail freight tonne kms for 2021/22 was 18.18 billion tonne kms. This is 1.6% higher than our result from the assignment. Reasons for our assignment being slightly low include:

- If there are new Stanox codes for origins or destinations that are not included in our network, the assignment starts from the first recognised Stanox code which is often the junction where the terminal's branch line meets the main line. This slightly shortens the assigned traffic route.
- Occasionally there are some inconsistencies where there is no en-route information for a wagon movement in the relevant locn file, and these wagons are not assigned.
- Occasionally there are some glitches in the cnwg data where the origin and destination appear to be the same Stanox code. These occasional cnwg glitches are described in more detail in the report referenced in section 4.

As the difference is relatively small, we have simply scaled up all our calculated tonne kms (base year and forecasts) by 1.6% in order to match the published ORR total.

It is a similar process for the forecasts – relying on assignment to the network. Section 8 describes this process in more detail.

6.2. Translating to trains per weekday

[10] Table 1310 - Freight moved by commodity

6.2.1. Converting tonnes to trains

For previous forecasts, we have arrived at tonnes per train values for each commodity group, and applied these to all tonnes in those commodity groups for base year and forecasts. In many instances this gives a reasonably accurate representation of the numbers of trains. However train numbers would be overstated along routes with particularly heavy trains (such as limestone trains from the Mendips to London) and will be understated along routes with light trains.

To better represent the tonnes per train, we have calculated the tonnes per train in the base year for each separate origin to destination. To do this, we apply the following method:

- Establish the tonnes per train for each train at the beginning of its journey
- Find the first train that any cargo movement uses
- Attach the tonnes per train of the relevant train to the cargo movement.
- For any origin to destination, add up all the cargo movements in the year and take an average of the tonnes per train. This average is weighted on the gross tonnes of the cargo moved.
- For every origin to destination movement, find the equivalent tonnes per train for the reverse movement and take an average of these two directions. For most bulk flows, the return tonnes per train will be near zero, so the average will be around half of the loaded-direction tonnes per train. By using this average tonnes per train, the count of trains for bulk tonnes includes the empty return train.

For example, if the loaded direction had trains carrying 2,000 cargo tonnes, with empty returns, then the average tonnes per train would be 1,000. Applying this to 6,000 tonnes of cargo moved would result in 6 trains. In reality this would be the correct number of trains, but it would be 3 loaded trains plus 3 empty return trains.

For intermodal container journeys, the two directions are typically much more balanced. Taking the average of the two directions should again result in correct number of trains. For example if A-to-B trains carry 1,000 cargo tonnes and B-to-A trains carry 500 cargo tonnes, the average is 750 tonnes per train.

Applying this to 3,000 tonnes of cargo moved from A-to-B and 1,500 tonnes of cargo moved from B-to-A (4,500 tonnes in total) gives 6 trains. In reality this would be 3 trains in each direction. In the spreadsheet output it would appear as 4 trains from A-to-B and 2 trains from B-to-A.

So in both examples, the total number of trains should be reasonably accurate, but the directions may not be. It is therefore advised when quantifying trains, to add trains in both directions.

These tonnes per train are used to translate the base year tonnes into trains. For the forecasts, they are also used, albeit Scenario 1 has 10% fewer tonnes per train than the base year, while scenarios 3 and 4 have 5% more for both 2040/41 and 2050/51. These percentage scale-factors are applied to the base year tonnes per train to use in the forecasts.

In most “there-and-back” movements, the tare tonnes (weight of wagons ignoring any cargo) in the reverse direction will be similar to that in the loaded direction. For instances where there are very few trains in the reverse direction (less than 10%), the reverse direction tonnes per train could cause a distortion to the overall average tonnes per train. In these circumstances, we assume that the reverse direction is an empty train (zero tonnes).

For new origin-to-destinations journeys in the forecasts that do not have a base year equivalent, the market sector average tonnes per train is used.

For *forecast* intermodal traffics, many of the origin-to-destinations are different from the base year, so the average intermodal tonnes per train for base year intermodal traffics is used.

6.2.2. Converting annual trains to trains per weekday

In the base year we convert from annual trains into trains per weekday (Monday-Friday) by dividing by 297. This is based on analysis of freight movements for 5 separate non-bank-holiday weeks spaced out across the year (2021); these show that 87.7% of freight traffic is operating on weekdays[11]. Table 6 shows that there is variability throughout the week.

[11] To avoid e.g. a long train journey starting at 23:59 on a Friday evening being classified as a weekday train, traffic is represented by a count of the number of en-route location timings for freight trains, where the en-route location timings are grouped into weekdays and weekends.

Table 6: Average tonnes departing per day by day of the week (excluding bank holidays) throughout 2021

Day	Average tonnes departing
Mon	257,246
Tue	294,016
Wed	292,296
Thu	293,058
Fri	269,542
Sat	117,015
Sun	68,435

This shows that Tuesdays, Wednesdays and Thursdays are the busiest days of the week. Mondays and Fridays are around 90% of this, with Saturdays 40% and Sundays just 23%.

Dividing by 297 is used to translate the base year annual trains into trains per weekday. For the forecasts, this is also used. However scenario 1 has 5% fewer operational hours per week, while scenarios 3 and 4 have 5% more. We represent these changes as changes to the amount of traffic able to run at the weekend. Therefore a 5% increase in operational hours per week means the number of trains per weekday would be divided by 1.05. Therefore the conversion factor from annual to trains per weekday would become dividing by 312 instead of dividing by 297.

7. SUMMARY RESULTS AND COMMENTARY

7.1. Summary results

The following tables with associated graphs summarise the results in terms of tonnes, tonne kms and trains per weekday:

- Table 7 shows the tonnes by sector by scenario.
- Table 8 shows the equivalent in terms of tonne kilometres.
- Tables 9 – 13 break this down into GBRTT region with a separate table for each region.
- Table 14 summarises tonne kms by region.
- Table 15 summarises the results in trains per weekday.

The sectors (or commodities) are ordered with Intermodal and Construction at the top, followed by the other commodities for which there is a change from the base year. The bottom half of the table (from Automotive down) shows the commodities for which there is no change from the base year.

Table 7: Tonnes by sector by scenario. Thousand tonnes

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	15,834	22,876	29,433	47,534	81,726	26,794	37,767	65,477	109,422
Intermodal: Inland-Inland	2,104	504	2,030	4,368	15,646	569	3,299	8,686	30,558
Intermodal: Channel Tunnel	350	346	872	14,675	16,400	371	1,206	16,791	33,656
Intermodal: Piggyback	0	0	0	2,074	1,989	0	0	3,345	6,212
Construction materials	26,937	32,913	44,528	55,206	57,950	40,027	58,274	70,303	72,081
Biomass	8,320	0	8,320	8,320	8,320	0	8,320	8,320	8,320
ESI Coal	1,326	0	0	0	0	0	0	0	0
Petroleum	3,940	1,576	1,576	1,576	1,576	0	0	0	0
Coal Other	1,550	1,550	1,550	1,550	1,550	0	0	0	0
Postal / Light logistics	260	737	737	1,333	1,333	737	737	1,333	1,333
Automotive	207	207	207	207	207	207	207	207	207
Chemicals	15	15	15	15	15	15	15	15	15
Domestic Waste	1,778	1,778	1,778	1,778	1,778	1,778	1,778	1,778	1,778
Empty returns for containers carrying bulks	369	369	369	369	369	369	369	369	369
General Merchandise	425	425	425	425	425	425	425	425	425
Industrial Minerals	2,428	2,428	2,428	2,428	2,428	2,428	2,428	2,428	2,428
Iron Ore	3,540	3,540	3,540	3,540	3,540	3,540	3,540	3,540	3,540
Metals	7,296	7,296	7,296	7,296	7,296	7,296	7,296	7,296	7,296
Nuclear	28	28	28	28	28	28	28	28	28
Engineering	6,116	6,116	6,116	6,116	6,116	6,116	6,116	6,116	6,116
Other	5	5	5	5	5	5	5	5	5
Total	**82,830**	**82,709**	**111,253**	**158,844**	**208,698**	**90,705**	**131,810**	**196,462**	**283,789**
Growth from Base year		**0%**	**34%**	**92%**	**152%**	**10%**	**59%**	**137%**	**243%**

Figure 1: Tonnes by sector by scenario. Million tonnes

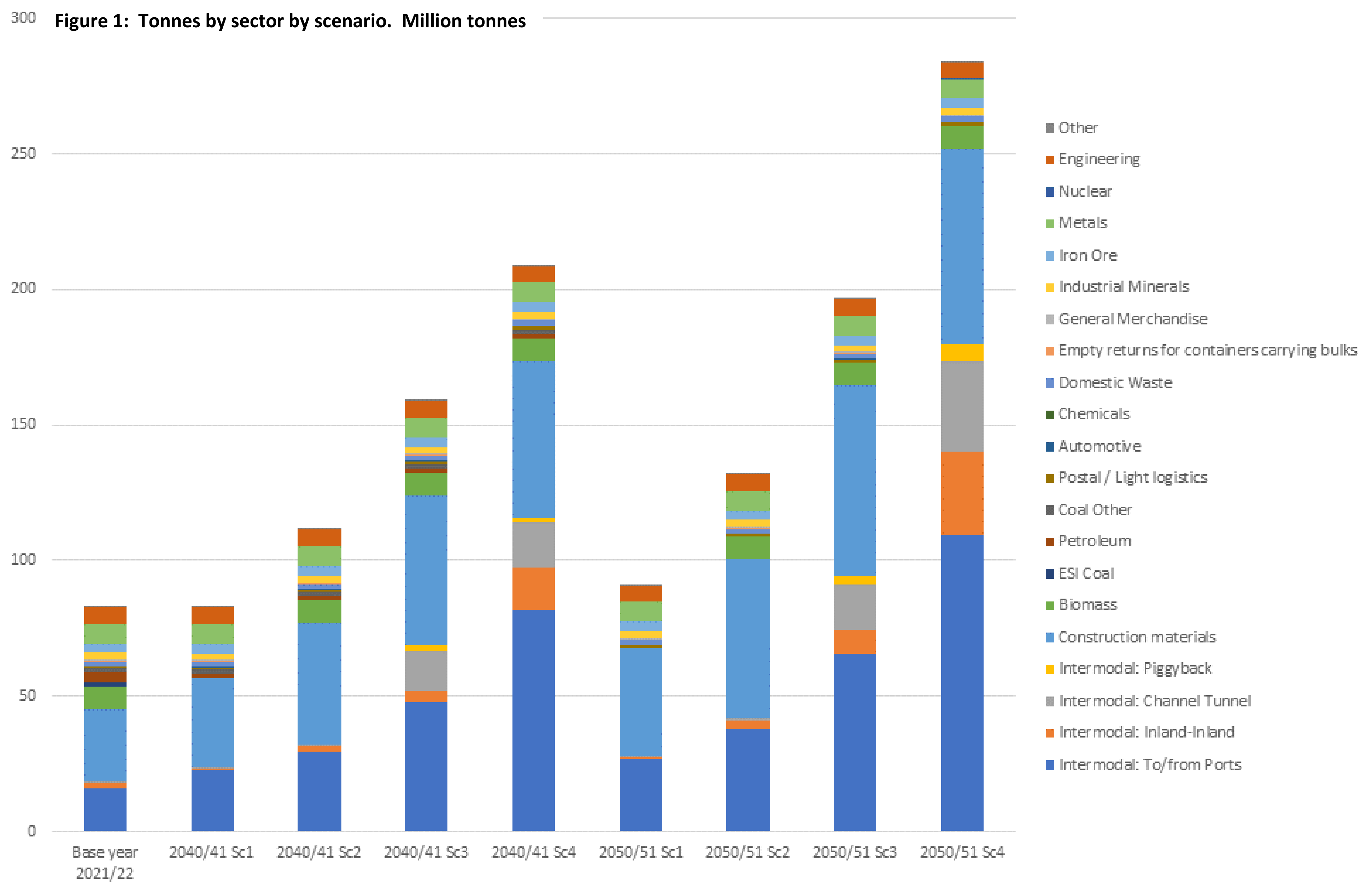


Table 8: Tonne KILOMETRES by sector by scenario. Million tonne kilometres

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	5,817	9,587	11,691	17,909	29,846	11,162	14,812	24,265	38,382
Intermodal: Inland-Inland	941	318	1,140	2,512	7,250	357	1,906	4,901	13,082
Intermodal: Channel Tunnel	91	100	209	3,964	4,850	111	308	4,563	9,696
Intermodal: Piggyback	0	0	0	196	193	0	0	317	592
Construction materials	5,076	5,976	7,912	9,553	10,675	7,070	10,253	11,976	13,207
Biomass	1,133	0	1,133	1,133	1,133	0	1,133	1,133	1,133
ESI Coal	190	0	0	0	0	0	0	0	0
Petroleum	924	370	370	370	370	0	0	0	0
Coal Other	164	164	164	164	164	0	0	0	0
Postal / Light logistics	94	237	223	382	382	237	223	382	382
Automotive	51	51	51	52	52	51	51	52	52
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	328	328	328	328	328	328	328	328	328
Empty returns for containers carrying bulks	72	72	72	72	72	72	72	72	72
General Merchandise	71	61	71	77	77	61	71	77	77
Industrial Minerals	356	283	283	283	283	283	283	283	283
Iron Ore	129	129	129	129	129	129	129	129	129
Metals	1,233	1,220	1,233	1,242	1,242	1,220	1,233	1,242	1,242
Nuclear	9	9	9	9	9	9	9	9	9
Engineering	1,384	1,377	1,384	1,389	1,389	1,377	1,384	1,389	1,389
Other	117	111	117	122	122	111	117	122	122
Total	18,181	20,394	26,520	39,888	58,567	22,579	32,314	51,242	80,179
Growth from Base year		12%	46%	119%	222%	24%	78%	182%	341%

Figure 2: Tonne KILOMETRES by sector by scenario. Billion tonne kilometres

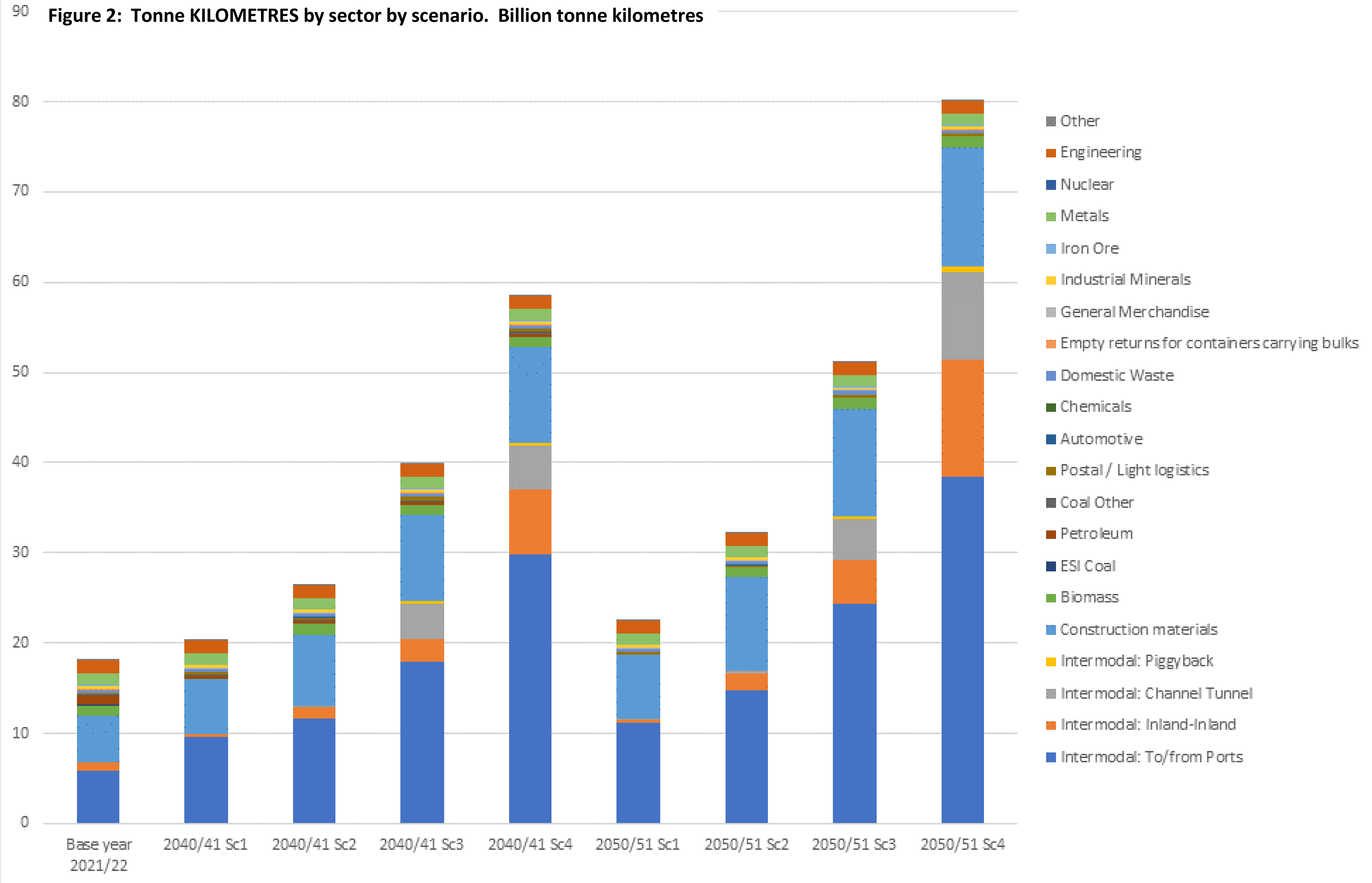


Table 9: Eastern Region Tonne KILOMETRES by sector by scenario. Million tonne kilometres

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	2,739	4,519	5,880	8,679	14,486	5,266	7,501	12,150	19,128
Intermodal: Inland-Inland	47	0	90	262	1,327	0	106	474	2,614
Intermodal: Channel Tunnel	1	8	19	371	437	9	29	436	897
Intermodal: Piggyback	0	0	0	21	20	0	0	34	63
Construction materials	1,733	2,080	2,733	3,376	3,556	2,451	3,495	4,189	4,322
Biomass	857	0	857	857	857	0	857	857	857
ESI Coal	190	0	0	0	0	0	0	0	0
Petroleum	457	183	183	183	183	0	0	0	0
Coal Other	56	56	56	56	56	0	0	0	0
Postal / Light logistics	26	44	41	131	131	44	41	131	131
Automotive	3	2	3	3	3	2	3	3	3
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	127	127	127	127	127	127	127	127	127
Empty returns for containers carrying bulks	30	30	30	30	30	30	30	30	30
General Merchandise	3	3	3	3	3	3	3	3	3
Industrial Minerals	195	144	144	144	144	144	144	144	144
Iron Ore	129	129	129	129	129	129	129	129	129
Metals	488	485	488	490	490	485	488	490	490
Nuclear	1	1	1	1	1	1	1	1	1
Engineering	571	568	571	572	572	568	571	572	572
Other	48	43	48	50	50	43	48	50	50
Total	7,699	8,424	11,401	15,485	22,603	9,304	13,570	19,822	29,561
Growth from Base year		9%	48%	101%	194%	21%	76%	157%	284%

Figure 3: <u>Eastern Region</u> Tonne KILOMETRES by sector by scenario. Billion tonne kilometres

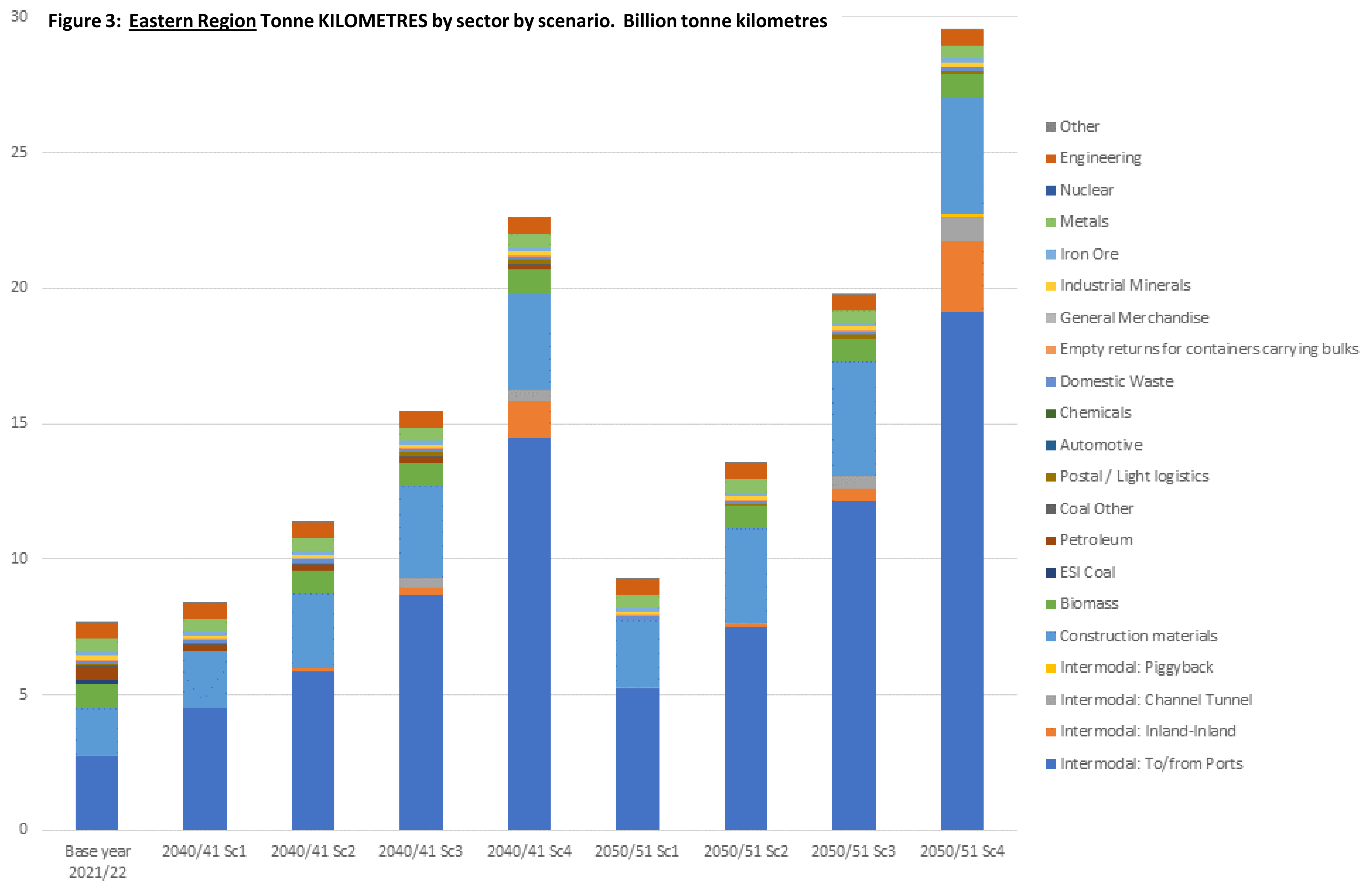


Table 10: North West & Central Region Tonne KILOMETRES by sector by scenario. Million tonne kilometres

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	2,289	3,448	3,910	4,937	8,648	3,994	4,874	6,551	10,688
Intermodal: Inland-Inland	594	225	735	1,333	3,646	253	1,181	2,538	6,145
Intermodal: Channel Tunnel	42	65	119	2,183	2,843	74	181	2,487	5,445
Intermodal: Piggyback	0	0	0	0	0	0	0	0	0
Construction materials	1,228	1,466	1,952	2,439	2,882	1,739	2,736	3,126	3,623
Biomass	277	0	277	277	277	0	277	277	277
ESI Coal	0	0	0	0	0	0	0	0	0
Petroleum	39	16	16	16	16	0	0	0	0
Coal Other	19	19	19	19	19	0	0	0	0
Postal / Light logistics	51	156	148	201	201	156	148	201	201
Automotive	28	28	28	29	29	28	28	29	29
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	126	126	126	126	126	126	126	126	126
Empty returns for containers carrying bulks	26	26	26	26	26	26	26	26	26
General Merchandise	29	25	29	32	32	25	29	32	32
Industrial Minerals	76	55	55	55	55	55	55	55	55
Iron Ore	0	0	0	0	0	0	0	0	0
Metals	178	172	178	182	182	172	178	182	182
Nuclear	6	6	6	6	6	6	6	6	6
Engineering	379	378	379	380	380	378	379	380	380
Other	16	16	16	17	17	16	16	17	17
Total	5,403	6,227	8,019	12,257	19,383	7,048	10,241	16,032	27,231
Growth from Base year		15%	48%	127%	259%	30%	90%	197%	404%

Figure 4: North West & Central Region Tonne KILOMETRES by sector by scenario. Billion tonne kilometres

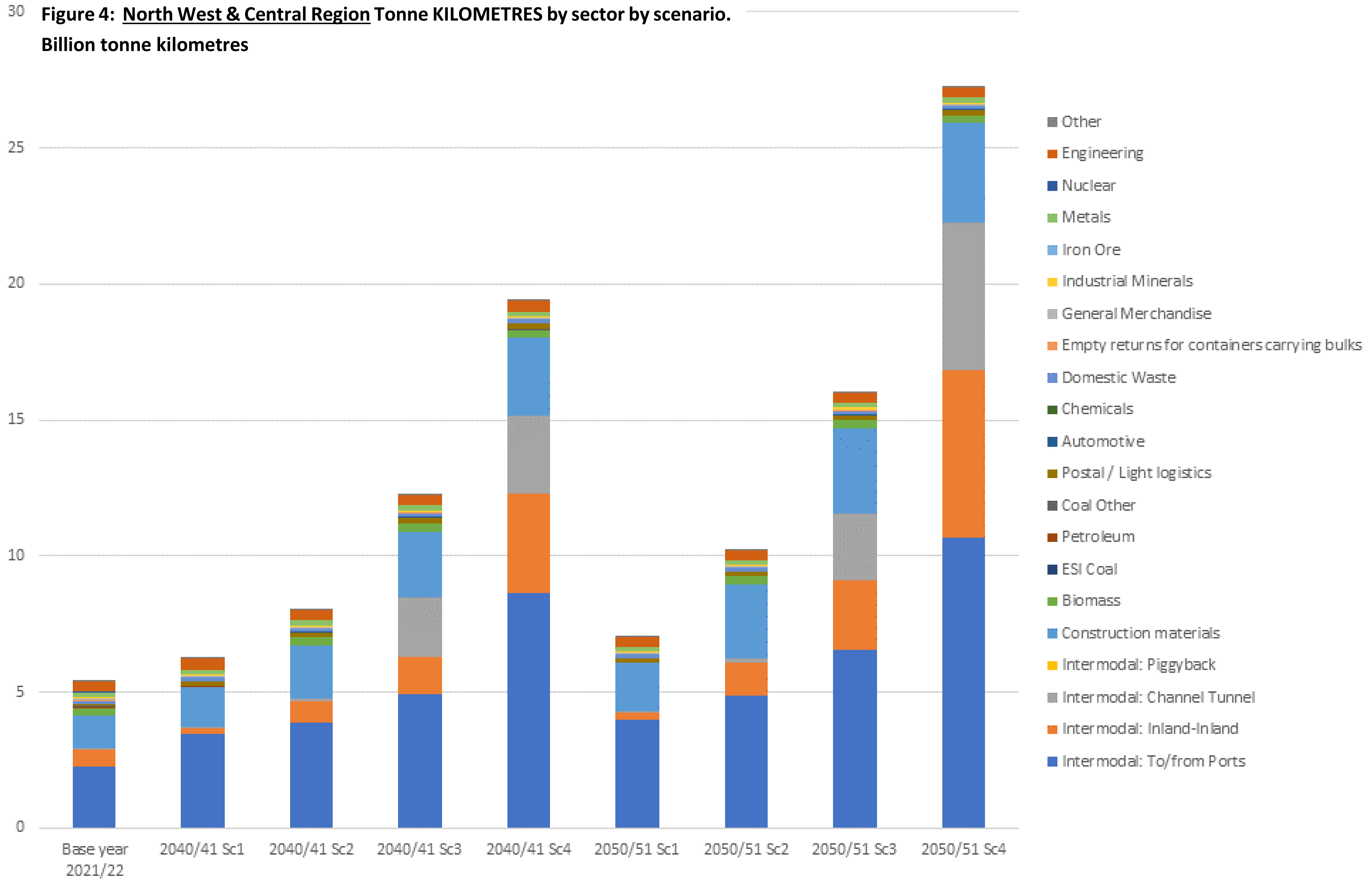


Table 11: Scotland Region Tonne KILOMETRES by sector by scenario. Million tonne kilometres

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	197	911	1,014	1,363	2,035	1,059	1,261	1,695	2,301
Intermodal: Inland-Inland	274	106	330	715	1,926	121	607	1,496	3,062
Intermodal: Channel Tunnel	0	0	0	0	0	0	0	0	0
Intermodal: Piggyback	0	0	0	0	0	0	0	0	0
Construction materials	88	90	119	133	140	103	156	173	189
Biomass	0	0	0	0	0	0	0	0	0
ESI Coal	0	0	0	0	0	0	0	0	0
Petroleum	52	21	21	21	21	0	0	0	0
Coal Other	0	0	0	0	0	0	0	0	0
Postal / Light logistics	18	37	34	50	50	37	34	50	50
Automotive	1	1	1	1	1	1	1	1	1
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	0	0	0	0	0	0	0	0	0
Empty returns for containers carrying bulks	0	0	0	0	0	0	0	0	0
General Merchandise	0	0	0	0	0	0	0	0	0
Industrial Minerals	58	58	58	58	58	58	58	58	58
Iron Ore	0	0	0	0	0	0	0	0	0
Metals	8	8	8	8	8	8	8	8	8
Nuclear	2	2	2	2	2	2	2	2	2
Engineering	85	84	85	86	86	84	85	86	86
Other	12	12	12	13	13	12	12	13	13
Total	795	1,331	1,684	2,451	4,340	1,486	2,224	3,583	5,770
Growth from Base year		67%	112%	208%	446%	87%	180%	351%	626%

Figure 5: <u>Scotland Region</u> Tonne KILOMETRES by sector by scenario. Billion tonne kilometres

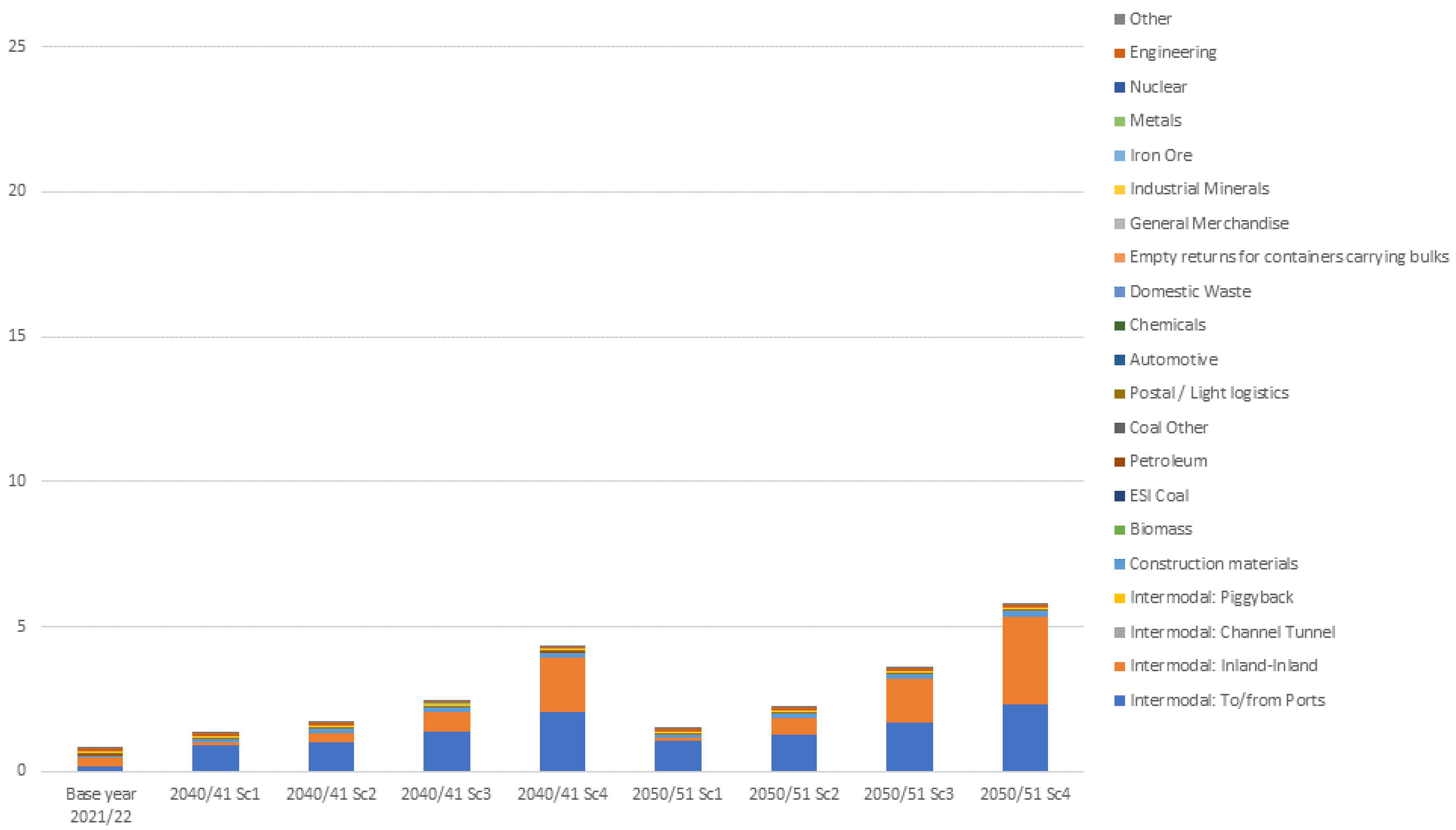


Table 12: Southern Region Tonne KILOMETRES by sector by scenario. Million tonne kilometres

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	265	299	376	635	1,052	353	490	827	1,383
Intermodal: Inland-Inland	1	0	0	6	32	0	0	8	76
Intermodal: Channel Tunnel	47	30	79	1,593	1,727	33	110	1,787	3,625
Intermodal: Piggyback	0	0	0	225	209	0	0	356	669
Construction materials	428	428	754	933	1,054	648	1,064	1,315	1,454
Biomass	0	0	0	0	0	0	0	0	0
ESI Coal	0	0	0	0	0	0	0	0	0
Petroleum	10	4	4	4	4	0	0	0	0
Coal Other	1	1	1	1	1	0	0	0	0
Postal / Light logistics	0	0	0	0	0	0	0	0	0
Automotive	12	11	12	12	12	11	12	12	12
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	2	2	2	2	2	2	2	2	2
Empty returns for containers carrying bulks	1	1	1	1	1	1	1	1	1
General Merchandise	38	32	38	41	41	32	38	41	41
Industrial Minerals	2	2	2	2	2	2	2	2	2
Iron Ore	0	0	0	0	0	0	0	0	0
Metals	27	23	27	30	30	23	27	30	30
Nuclear	0	0	0	0	0	0	0	0	0
Engineering	189	188	189	190	190	188	189	190	190
Other	16	16	16	16	16	16	16	16	16
Total	1,039	1,039	1,501	3,692	4,374	1,311	1,951	4,587	7,501
Growth from Base year		0%	45%	255%	321%	26%	88%	342%	622%

Figure 6: Southern Region Tonne KILOMETRES by sector by scenario. Billion tonne kilometres

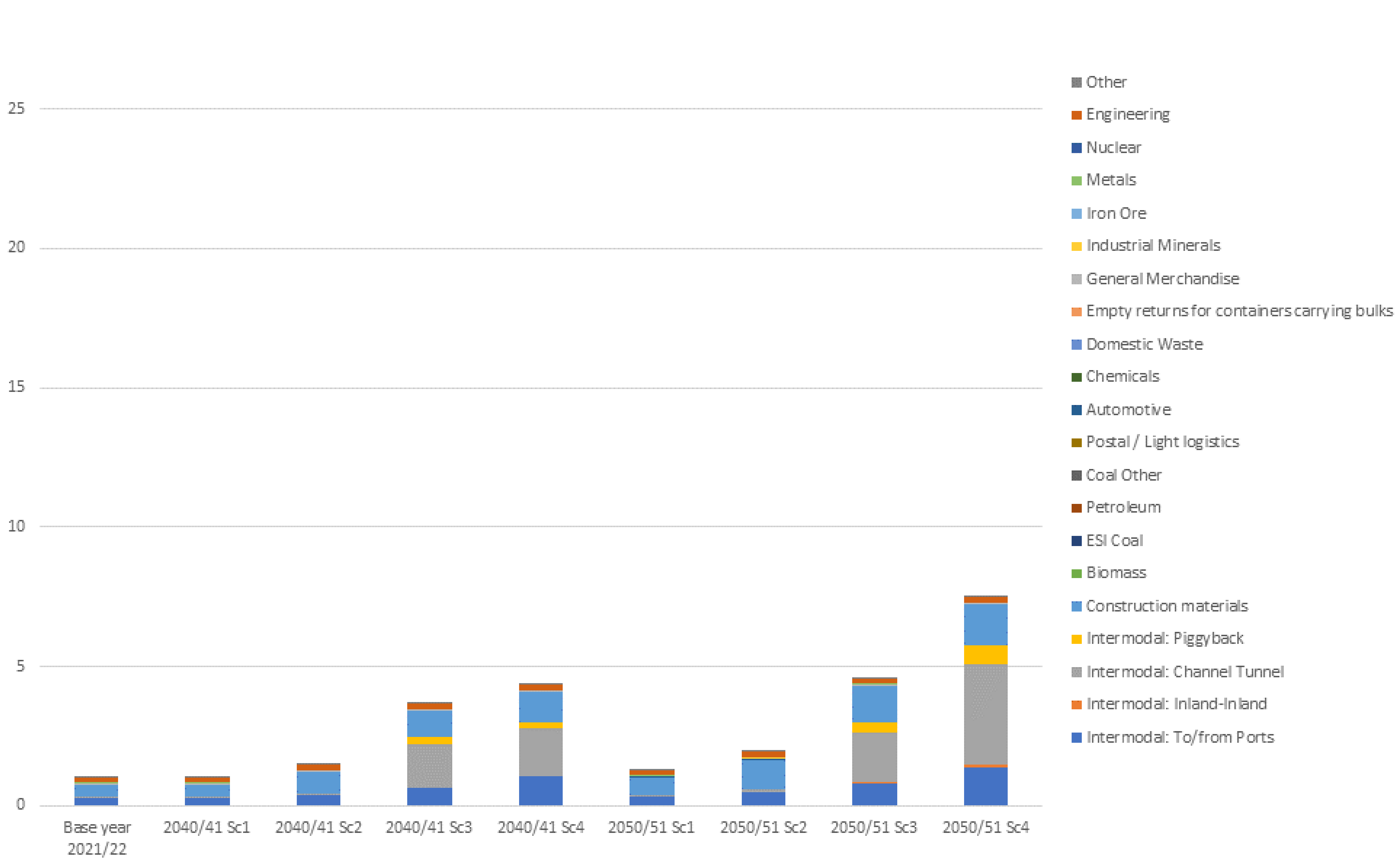


Table 13: Wales & Western Region Tonne KILOMETRES by sector by scenario. Million tonne kilometres

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	330	393	490	2,178	3,602	467	664	3,058	4,945
Intermodal: Inland-Inland	24	0	0	79	148	0	24	147	713
Intermodal: Channel Tunnel	0	0	0	0	0	0	0	0	0
Intermodal: Piggyback	0	0	0	0	0	0	0	0	0
Construction materials	1,600	1,911	2,353	2,673	3,043	2,129	2,802	3,173	3,619
Biomass	0	0	0	0	0	0	0	0	0
ESI Coal	0	0	0	0	0	0	0	0	0
Petroleum	366	146	146	146	146	0	0	0	0
Coal Other	88	88	88	88	88	0	0	0	0
Postal / Light logistics	0	0	0	0	0	0	0	0	0
Automotive	7	7	7	7	7	7	7	7	7
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	74	74	74	74	74	74	74	74	74
Empty returns for containers carrying bulks	16	16	16	16	16	16	16	16	16
General Merchandise	0	0	0	0	0	0	0	0	0
Industrial Minerals	23	23	23	23	23	23	23	23	23
Iron Ore	0	0	0	0	0	0	0	0	0
Metals	532	531	532	532	532	531	532	532	532
Nuclear	1	1	1	1	1	1	1	1	1
Engineering	160	158	160	161	161	158	160	161	161
Other	25	24	25	26	26	24	25	26	26
Total	3,245	3,373	3,915	6,004	7,868	3,431	4,328	7,218	10,116
Growth from Base year		4%	21%	85%	142%	6%	33%	122%	212%

Figure 7: Wales & Western Region Tonne KILOMETRES by sector by scenario. Billion tonne kilometres

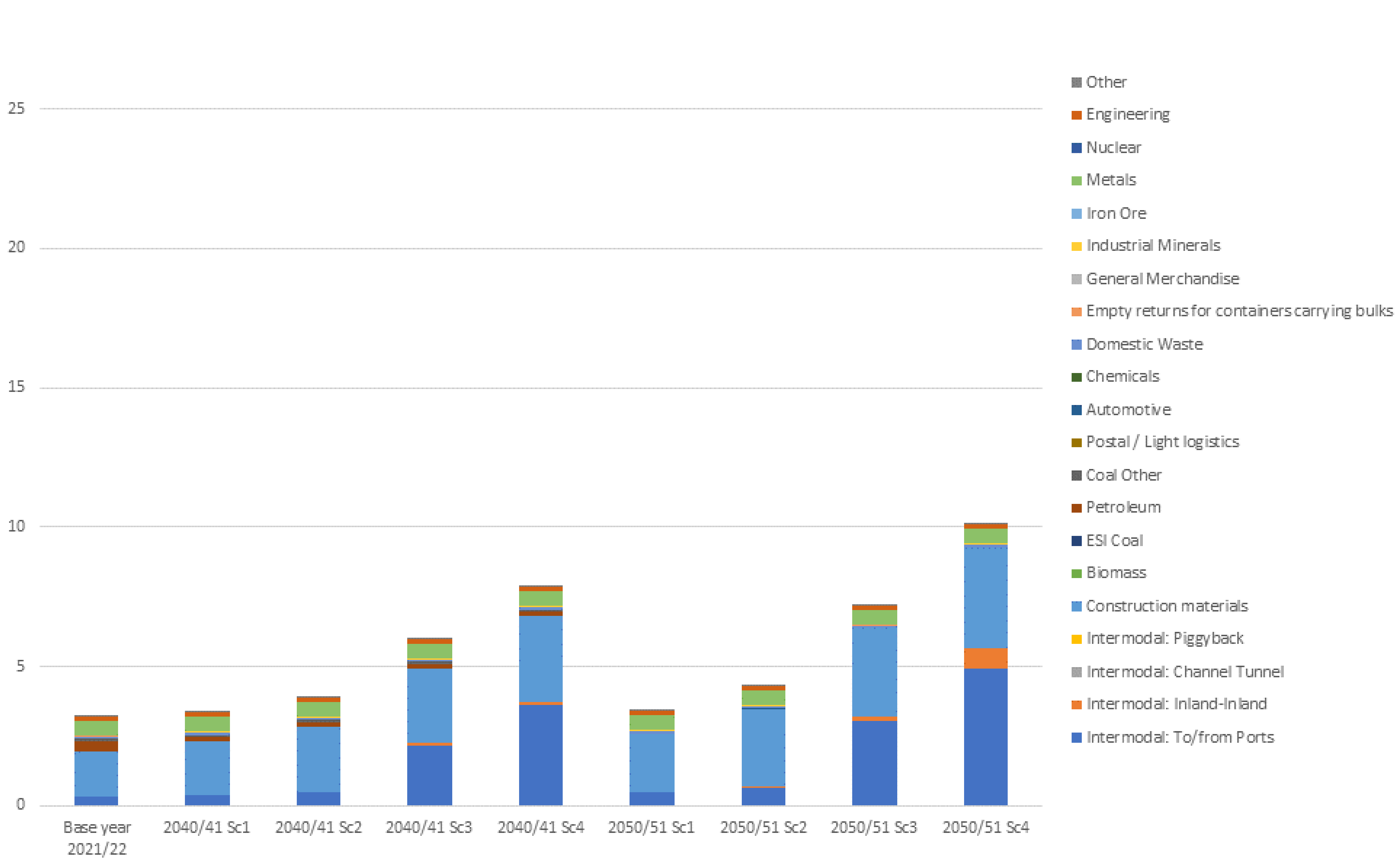


Table 14: Tonne kms by region by scenario. Million tonne kms

GBRTT Region	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Eastern	7,699	8,424	11,401	15,485	22,603	9,304	13,570	19,822	29,561
North West & Central	5,403	6,227	8,019	12,257	19,383	7,048	10,241	16,032	27,231
Scotland	795	1,331	1,684	2,451	4,340	1,486	2,224	3,583	5,770
Southern	1,039	1,039	1,501	3,692	4,374	1,311	1,951	4,587	7,501
Wales & Western	3,245	3,373	3,915	6,004	7,868	3,431	4,328	7,218	10,116
Total	18,181	20,394	26,520	39,888	58,567	22,579	32,314	51,242	80,179
Growth from Base year		12%	46%	119%	222%	24%	78%	182%	341%

Figure 8: Tonne KILOMETRES by region by scenario. Billion tonne kilometres

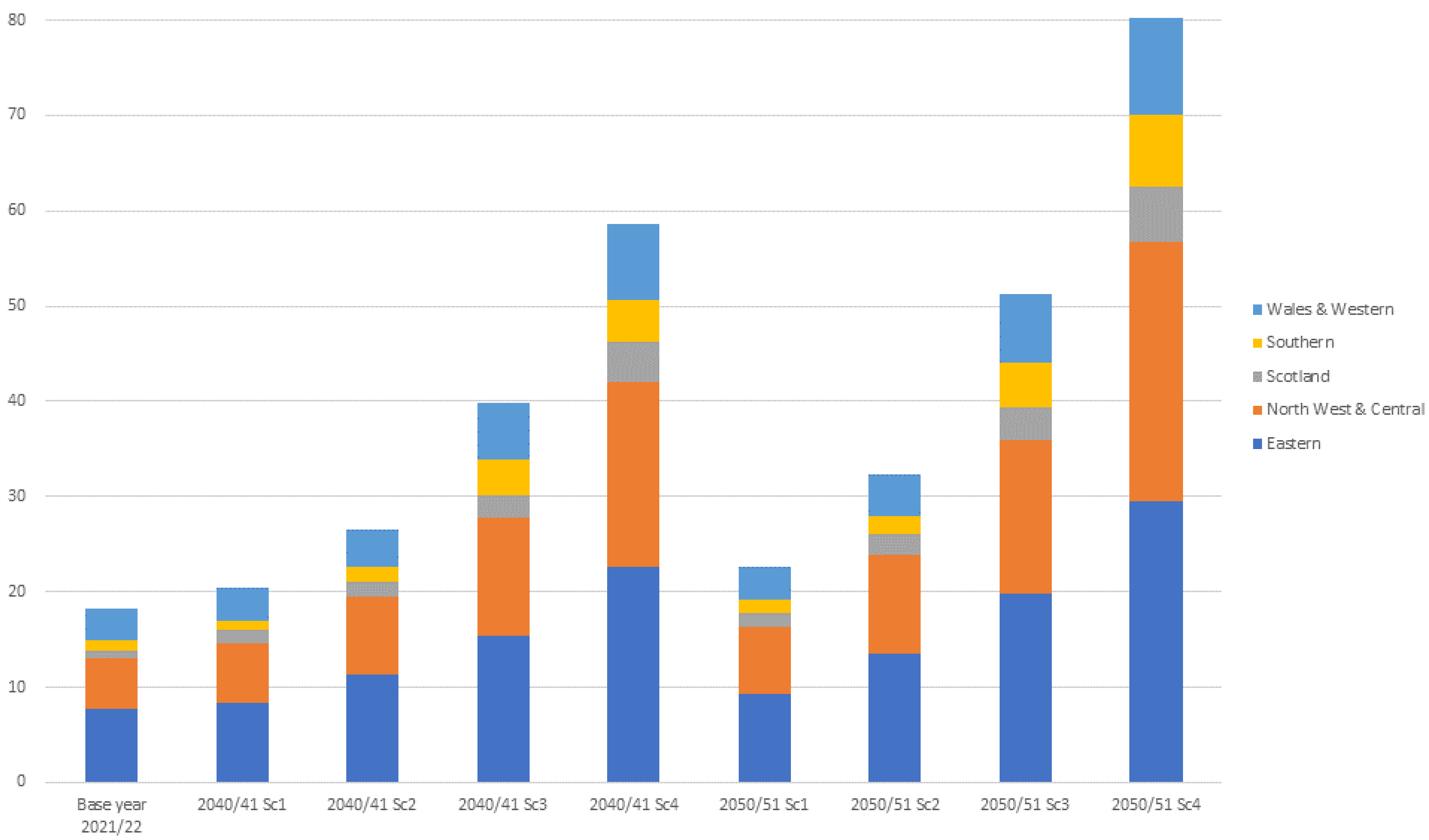
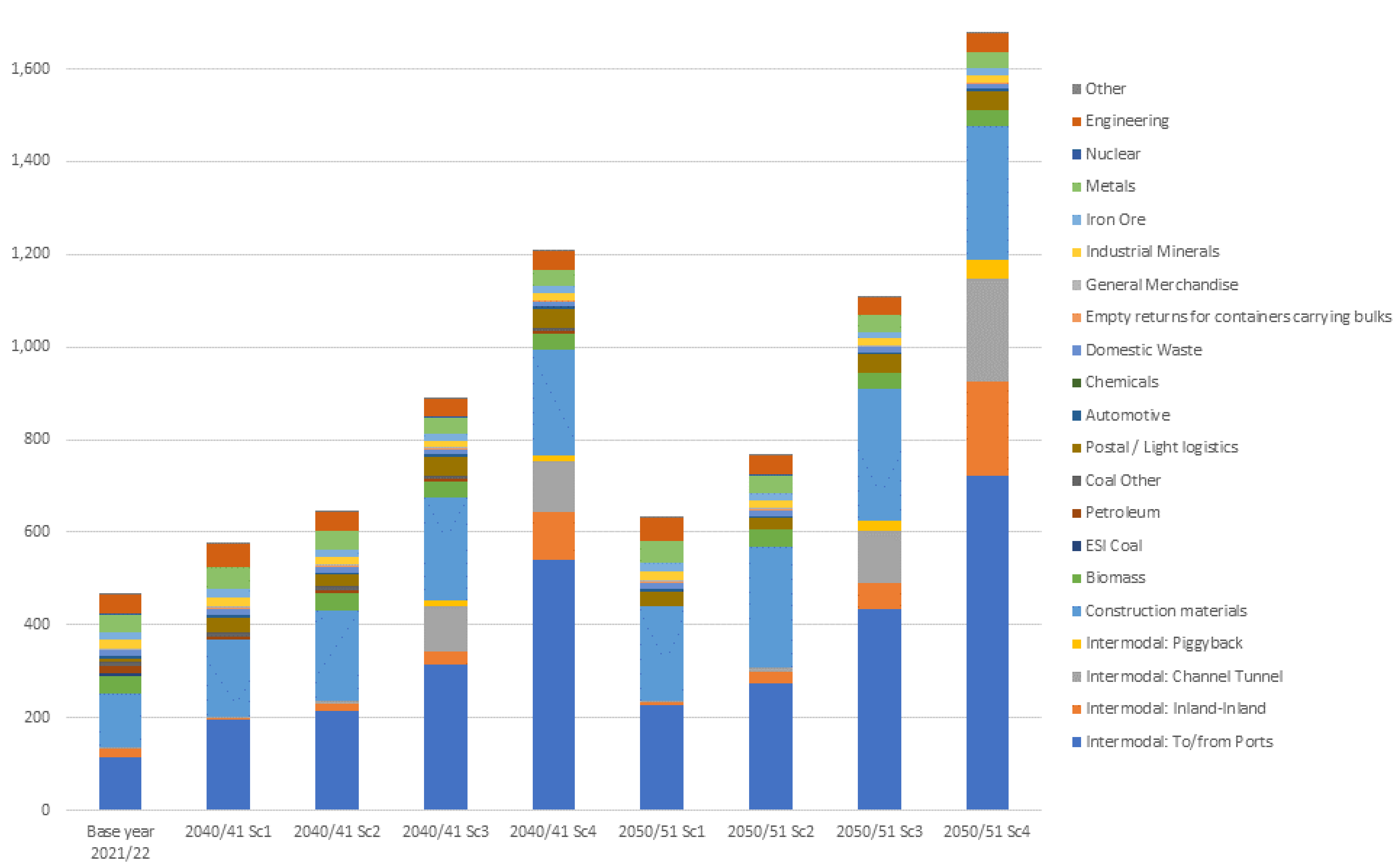


Table 15: Trains per weekday by sector by scenario.

Sector	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Intermodal: To/from Ports	114	195	214	314	540	228	275	433	723
Intermodal: Inland-Inland	19	4	15	29	103	5	24	57	202
Intermodal: Channel Tunnel	2	3	6	97	109	3	9	111	223
Intermodal: Piggyback	0	0	0	14	13	0	0	22	41
Construction materials	117	166	196	222	229	205	259	286	288
Biomass	37	0	37	34	34	0	37	34	34
ESI Coal	5	0	0	0	0	0	0	0	0
Petroleum	16	7	6	6	6	0	0	0	0
Coal Other	8	9	8	7	7	0	0	0	0
Postal / Light logistics	9	29	25	41	41	29	25	41	41
Automotive	6	7	6	5	5	7	6	5	5
Chemicals	0	0	0	0	0	0	0	0	0
Domestic Waste	11	12	11	10	10	12	11	10	10
Empty returns for containers carrying bulks	3	3	3	2	2	3	3	2	2
General Merchandise	3	3	3	3	3	3	3	3	3
Industrial Minerals	16	19	16	15	15	19	16	15	15
Iron Ore	16	18	16	14	14	18	16	14	14
Metals	40	46	40	36	36	46	40	36	36
Nuclear	1	1	1	1	1	1	1	1	1
Engineering	42	49	42	38	38	49	42	38	38
Other	0	0	0	0	0	0	0	0	0
Grand Total	**465**	**574**	**644**	**887**	**1,206**	**630**	**766**	**1,108**	**1,676**
Growth from Base year		**23%**	**39%**	**91%**	**159%**	**36%**	**65%**	**138%**	**260%**

Figure 9: Trains per weekday by sector by scenario



7.2. Commentary

Many sectors (Automotive, Chemicals, Domestic Waste, Empty returns for containers carrying bulks, General Merchandise, Industrial Minerals, Iron Ore, Metals, Nuclear, Engineering, and Other) are not modelled and are assumed to remain broadly constant; see section 3 describing the selection of the core and non-core markets. These make up 22 million tonnes (27% of the total in the base year) and 3.8 billion tonne kms (21% of the total in the base year).

The results for some other commodities:

- Biomass (8.3 million tonnes and 1.1 billion tonne kms in the base year)
- ESI Coal (1.3 million tonnes and 0.2 billion tonne kms in the base year)
- Petroleum (3.9 million tonnes and 0.9 billion tonne kms in the base year)
- Coal Other (1.6 million tonnes and 0.2 billion tonne kms in the base year)
- Postal / Light logistics (0.3 million tonnes and 0.1 billion tonne kms in the base year)

are largely defined by their assumptions. They collectively make up 15 million tonnes (19% of the total in the base year) and 2.5 billion tonne kms (14% of the total in the base year).

The remainder

- Intermodal containers (18 million tonnes and 6.8 billion tonne kms in the base year)
- Construction materials (27 million tonnes and 5.1 billion tonne kms in the base year)

are modelled in detail and are discussed in sections below.

7.2.1. Scenario 1

Scenario 1 has a road-reliant theme. There are some assumptions that do push growth:

- in the market such as:
    - Trade growth of over 50% by 2050/51 (same for all scenarios)
    - GDP growth (TAG compliant assumption)
    - Construction materials market growth
    - A modest increase in rail-served warehousing (based on committed planning developments which are currently being built)
- in rail's mode share versus road such as:
    - HGV and train drivers wages increasing by nearly 40% by 2050/51 (having a much greater detrimental effect on road costs than on rail). This is a substantial increase but is 10% below the 50% increase expected in TAG.
    - Increased diesel resource costs by 27% (having a much greater detrimental effect on road costs than on rail). This is consistent with TAG.
    - Increased fuel duty for road and decreased fuel duty for rail. This is consistent with TAG.

However many of the road and rail cost changes encourage some switch from rail to road such as:

- Increased Variable Usage Charge
- Introduced Freight Specific Charge (FSC) for bulk rail freight
- Reduced tonnes per train
- Reduced rail operational hours per week, reducing productivity
- Slower rail journey times

along with some commodity specific changes to markets such as Biomass, ESI Coal, Petroleum and "Coal Other" all disappearing by 2050/51.

In overall tonnes, these factors largely cancel each other out, with tonnes increasing by just 10% in 2050/51 and 24% in tonne kms. Construction materials and port-based intermodal containers both become a larger share of total rail freight. Inland-to-inland intermodal tonnes is significantly reduced, albeit the modelled representation of the base year is already lower than the actual base year traffic.

7.2.2. Scenario 2

Scenario 2 has a more neutral Business-As-Usual theme with many assumptions in line with DfT's TAG. Key differences from Scenario 1 include:

- A doubling of HGV tractor lease costs compared to existing diesels in 2050/51 due to electrification
- A higher growth in HGV and train drivers wages; in line with TAG
- No bulk FSC introduced
- No worsening of tonnes per train, rail operational hours per week, rail journey times
- More rail-served warehousing
- Larger market growth in construction materials

Overall tonnage growth is boosted to 59% in 2050/51 and 78% in tonne kms.

7.2.3. Scenario 3

Compared to Scenario 2, Scenario 3 has various attributes that boost rail freight including:

- A higher growth in HGV and train drivers wages
- Slower road speeds
- Improvements in rail cost components:
    - Reduced rail fuel duty
    - Tonnes per train
    - Rail operational hours per week
    - Rail journey times
    - Wagon lease costs
    - Channel Tunnel toll halved
- Increased market size:
    - Higher GDP and population growth

- A new light logistics / Royal Mail hub at Doncaster
- Piggyback introduced through the Channel Tunnel
- More sourcing of aggregates from the seabed.
- Additional rail-served warehousing sites
- Additional intermodal container terminals (without on-site warehousing)
- New quarries

Overall tonnage growth is boosted to 137% in 2050/51 and 182% in tonne kms, particularly led by intermodal with a large growth for Channel Tunnel traffics.

7.2.4. Scenario 4

Scenario 4 has a pro-rail theme, with several factors that encourage rail freight over and above scenario 3 including:

- Much more rail-served warehousing
- Road pricing, covering non-user costs such as congestion

There is the same market size for construction materials but the focus is on growth in crushed rock from large super-quarries rather than growth in marine sand and gravel. Both sources have potential for rail.

Overall growth is boosted to 243% in 2050/51 and 341% in tonne kms, particularly led by intermodal with a very large growth for Channel Tunnel traffics, including piggyback. Road pricing is responsible for much of this extra intermodal growth.

7.2.5. Regional differences

The regional impact varies by scenario:

- Southern starts from a low base and has modest growth but is boosted by Channel Tunnel growth in scenarios 3 and 4. Apart from Channel Tunnel, there isn't much intermodal in Southern, and most of the assumed new rail-served warehousing sites would generate trains passing through other areas rather than Southern.
- Scotland typically has higher growth than other regions albeit from a low base – largely led by large growth in intermodal
- Wales & Western has a lower-than average growth for all scenarios.

7.2.6. Intermodal containers

The overall growth rate forecast for intermodal container tonnes from the actual base year traffic to 2050/51 is:

- Scenario 1: 52% in tonnes and 70% in tonne kms
- Scenario 2: 131% in tonnes and 149% in tonne kms
- Scenario 3: 416% in tonnes and 397% in tonne kms
- Scenario 4: 883% in tonnes and 802% in tonne kms

These are very substantial growth rates. However the market for intermodal containers is huge – effectively including all currently-road non-bulk cargo movements, plus potentially some bulk movements too - for example: FMCGs (Fast Moving Consumer Goods). According to the DfT's latest CSRGT (Continuing Survey of Road Goods Transport[12], total annual tonnes by road in the year July 2021 – June 2022 was 1.646 billion tonnes, over half of which is non-bulk. Given some market growth to 2050/51, intermodal would still be a small fraction of this even in Scenario 4.

Channel Tunnel intermodal containers

The growth for scenarios 3 and 4 is very large, much fuelled by road pricing (Scenario 4) and the halving of the toll, along with the introduction of Piggyback services and the other factors that favour rail, particularly in scenario 4. Despite the huge percentage growth rates, we believe this is plausible because at the moment Channel Tunnel through-rail is not very competitive and gets a very small proportion of the cross-Channel market. If it were to become competitive (as modelled in scenarios 3 & 4) it could capture a large proportion of the market – the model results for scenario 4 suggest that it would capture around 20% of the likely overall 2050/51 non-bulk Europe – Britain market. To put into context, this is a similar percentage to the original forecasts made for Channel Tunnel when it was being built.

7.2.7. Construction materials

As mentioned in section 5.2, the Construction materials forecast is split into 2 components:

- Forecasting changes in the market; overall demand growth and changes in source types
- Forecasting changes in rail's mode share, using the GB Freight Model.

The table below shows the forecasts split into these 2 stages so that the impacts of different assumptions can be seen more easily.

[12] https://www.gov.uk/government/collections/road-freight-domestic-and-international-statistics

Table 16: Construction materials forecasts by type and scenario, initially showing market growth ONLY, then also incorporating cost-based mode share changes too. Thousand tonnes

	Base year 2021/22	2040/41 Sc1	2040/41 Sc2	2040/41 Sc3	2040/41 Sc4	2050/51 Sc1	2050/51 Sc2	2050/51 Sc3	2050/51 Sc4
Market growth ONLY									
Crushed Rock	18,405	19,213	22,175	20,599	30,893	19,952	24,310	22,212	36,034
Other Construction	6,191	6,449	7,444	7,489	7,489	6,693	8,157	8,223	8,223
Land-won Sand & Gravel	282	177	207	116	116	150	194	72	72
Marine Sand & Gravel	2,059	2,799	3,216	4,156	2,561	3,093	3,707	4,971	2,829
Marine Sand & Gravel Extra services	0	4,827	5,465	11,789	0	6,395	7,334	15,829	0
New Quarry	0	0	0	400	400	0	0	400	400
Total	26,937	33,464	38,507	44,548	41,458	36,283	43,703	51,707	47,558
Market AND Mode-share based growth									
Crushed Rock	18,405	18,942	25,272	26,052	41,742	21,673	31,961	30,897	51,518
Other Construction	6,191	6,263	8,442	9,320	10,133	7,225	10,757	11,702	12,393
Land-won Sand & Gravel	282	181	261	173	200	180	323	135	146
Marine Sand & Gravel	2,059	2,700	5,089	7,473	5,475	4,554	7,899	11,340	7,624
Marine Sand & Gravel Extra services	0	4,827	5,465	11,789	0	6,395	7,334	15,829	0
New Quarry	0	0	0	400	400	0	0	400	400
Total	**26,937**	**32,913**	**44,528**	**55,206**	**57,950**	**40,027**	**58,274**	**70,303**	**72,081**

There is growth in construction materials rail traffic in all scenarios, both when considering the market changes alone and when including the cost-based mode share changes too. With just the market changes, Scenario 3 has the most rail traffic. This is largely due to the extra Marine sand and gravel traffics assumed to be by rail in this scenario. Despite that, Crushed rock remains the largest type by rail in this and all scenarios, with it being particularly dominant in Scenario 4. The cost-based mode share changes impact on the rail traffic. In Scenario 1 in 2040/41, they show a decline from the market growth only result. For all other scenarios, the cost-based mode share changes boost the rail traffic.

8. RAIL ASSIGNMENT AND ROUTING

8.1. Introduction

It can be easier to visualise the impact of these forecasts by assigning the base year and forecast traffic to the rail network. It is often more meaningful to describe the number of freight trains per day on each route, as well as the tonnage.

8.2. Method

All freight trains using the network are assigned to the network for each of the 365 days separately in the base year 2021/21. For each wagon on each individual train, the traffic is scaled up in line with the origin to destination by commodity tonnage forecasts. This ensures that for each train, the routing and the tonnes per train are maintained in the forecasts unless actively changed - i.e. base year routings are assumed to continue, apart from where they are actively re-routed - see below.

Once a freight train assignment has been made for each day in the base year and each forecast scenario and year, they can be averaged to give a daily average for each year. There are fewer freight trains on Saturdays, Sundays and on bank holidays, so to give a more representative picture of the typical weekday traffic volumes, all Saturdays, Sundays and bank holidays are discarded when calculating the daily average.

The maps show the routes that the trains actually take in the base year; primary routes as well as timetabled secondary and diversionary routes. For example for trains from Southampton to the West Midlands and beyond, the main route is via Winchester with many trains, and the main diversionary route is via Laverstock junctions with just a handful of trains. For all commodities, because the base year assignments include the diversionary routes, these same diversionary routes are included in the forecasts by default.

The exception to this is for new forecast intermodal services, because there are no base year trains to scale up – see below.

8.3. Routing assumptions

TransPennine Route Upgrade (TRU)

TRU (the TransPennine route via Huddersfield) is assumed to be complete by 2040/41. This enables intermodal trains to run between Northern container ports (Liverpool, Hull, Immingham and Teesport) and inland terminals on the other side of the Pennines, so these are now included in the forecasts. Note that this assignment work was done after the main work, so the scenarios were slightly adjusted to include these TransPennine intermodal services, and it's only the tonne kms results in this report that are updated to reflect this inclusion of TransPennine intermodal services.

Other trains have not been re-routed to the TRU route. There could be an argument that Felixstowe to Trafford Park trains (and similar routes) should switch to the TRU route given the new capacity available and the likelihood that the West Coast Main Line (WCML) may become capacity constrained. However, we have kept to the existing routes for such services – using the WCML.

East West Rail (EWR)

EWR is assumed to be in place by 2040/41. The Western section between Oxford and Milton Keynes is due to open in 2025. This section would make some journeys from South and West of Oxford to Daventry (and other proposed sites in the Northampton area) more direct. Such traffic is therefore routed via this Western section of EWR.

Traffic between Oxford and Nuneaton could potentially switch to this Western section of EWR too. However there isn't a clear benefit of such a rerouting, so we have left such trains on their existing route via Banbury.

When the Eastern section is built to complete the EWR route, there is the scope to run freight trains along its full length. The largest freight opportunity would be to divert trains between East Anglia (predominantly Felixstowe) and the West Midlands, North West and Scotland, onto EWR, thus relieving:

- the route through London; Great Eastern Main Line (GEML), North London Line (NLL) and Southern WCML
- and the cross-country route via Ely, Peterborough and Leicester to the WCML.

However this is reliant on an East-to-North chord being built at Bletchley, which is currently not included in the scope of the EWR project. Therefore (apart from using the Western section as described above), freight opportunities for EWR are largely limited to diverting trains between Ipswich and Didcot, from the via-London route. We have diverted such forecast freight trains onto EWR.

East Coast Main Line (ECML); Peterborough - Doncaster

Capacity is limited on the 2-track sections of the ECML between Peterborough and Doncaster, with high-speed express passenger trains catching up with slow-speed freight trains - making timetabling challenging. Switching freight trains to the less-used route via Lincoln relieves the ECML. We therefore route at least 75% of such forecast trains that travel between Peterborough and Doncaster, via Lincoln, as per the 2020 freight routing report[13].

Ipswich - Nuneaton

Freight trains between East Anglia (predominantly Felixstowe) and the West Midlands, North West and Scotland, can route via London (GEML, NLL and WCML) or via the cross country route (via Ely, Peterborough and Leicester). Such freight trains travelling through London use up valuable capacity,

[13] "Routeing of rail freight forecasts. A study for Network Rail by MDS Transmodal", August 2020 https://www.networkrail.co.uk/wp-content/uploads/2020/08/Routeing-of-rail-freight-forecasts.pdf

so it is preferable for the majority to use the cross-country route instead, for the route section between Ipswich and Nuneaton. We route 70% of such trains via the cross-country route in line with the 2020 freight routing report.

Ashford - Wembley

Freight trains between the Channel Tunnel and Wembley can route via Maidstone or via Tonbridge and Redhill. As per the 2020 routing report, we route at least 70% via Tonbridge.

Other possible re-routings based on capacity constraints; not included

This work is intended to show unconstrained demand, so on the whole we have avoided more radical re-routings. However if there are no network upgrades, there are likely to be capacity challenges in various places across the network such as the WCML North of where HS2 trains join it.

For the Northern WCML, to avoid long 2-track sections, we could have considered re-routing via the Settle - Carlisle route and potentially the Kilmarnock route. Similarly on the Northern ECML, there is an option to route some trains via Stockton, and potentially via a re-instated Leamside branch line to Newcastle.

New forecast intermodal services

By default routes for new forecast intermodal services are assumed to be along the shortest path between origin and destination sites, along a route with a loading gauge of at least W8. Diversionary routes are not considered. However for various terminal to terminal flows, we have stipulated specific en-route ‘via-points’, to ensure that those routes are more realistic with a preference for:

- W10 routes,
- avoiding reversing movements where practical
- avoiding congested areas where practical

The routing of each origin-to-destination train that we have assumed can be seen in the detailed GIS data showing the origins and destinations of trains on each rail link.

Electrification

One of the downsides in the short-to-medium term of some of these routing decisions is that they often involve transferring trains from electrified routes to currently-non-electrified routes. Most of these routing decisions are for capacity reasons; reducing the number of freight trains on busy predominantly-passenger routes – which are normally the routes that are electrified.

There is an implicit assumption that either:

- The routes will be electrified,
- Locomotives will be available that can travel along these routes using battery or other low-carbon technologies,

- Or it will remain acceptable to run diesel trains along these routes.

8.4. Tonnes per train

Most trains are scaled up or down as per the forecast % change in the cargo tonnage from the base year. This means that as well as the route of each base year train being retained, the tonnes per train of each train is also retained.

This applies to scenario 2 where the assumption is that tonnes per train does not change. However scenario 1 assumes a 10% decrease and scenarios 3 and 4 assume a 5% increase in tonnes per train. These % changes are applied to all trains such that for example for scenario 4 the number of trains needed to carry the cargo is scaled down by X 1/1.05.

Forecast new intermodal services that are not in the base year are added to the assignment. The average tonnes per train in the dominant cargo direction is found for existing intermodal services. This is applied to the dominant cargo direction for each new service in scenario 2. It is adjusted for scenarios 1, 2 and 4 as per the previous paragraph. For each new intermodal terminal-to-terminal service, the number of trains in the non-dominant direction is set to match the dominant direction.

8.5. Operational hours per week

As each individual base year train is scaled up or down for the forecasts based on the tonnage, this implicitly retains the base year operational hours per week, and no further changes are required for scenario 2. However scenarios 3 and 4 assume a 5% increase in operational hours per week. This is assumed to reflect increased running at the weekend. Therefore to accommodate a set number of trains per week, the number of trains *per weekday* (Monday to Friday) is scaled down by X 1/1.05. Scenario 1 assumes a 5% *decrease* in operational hours per week, so the number of trains *per weekday* is scaled up by X 1/0.95.

8.6. Maps

Figures 10-18 show freight trains per (non-bank holiday) weekday (sum of both directions) for:

- Base year actual trains 2021/2
- 2040/41 Scenario 1
- 2040/41 Scenario 2
- 2040/41 Scenario 3
- 2040/41 Scenario 4
- 2050/51 Scenario 1
- 2050/51 Scenario 2
- 2050/51 Scenario 3
- 2050/51 Scenario 4

Zoomable pdf versions of these maps are also provided with labels showing the volumes.

Figure 10

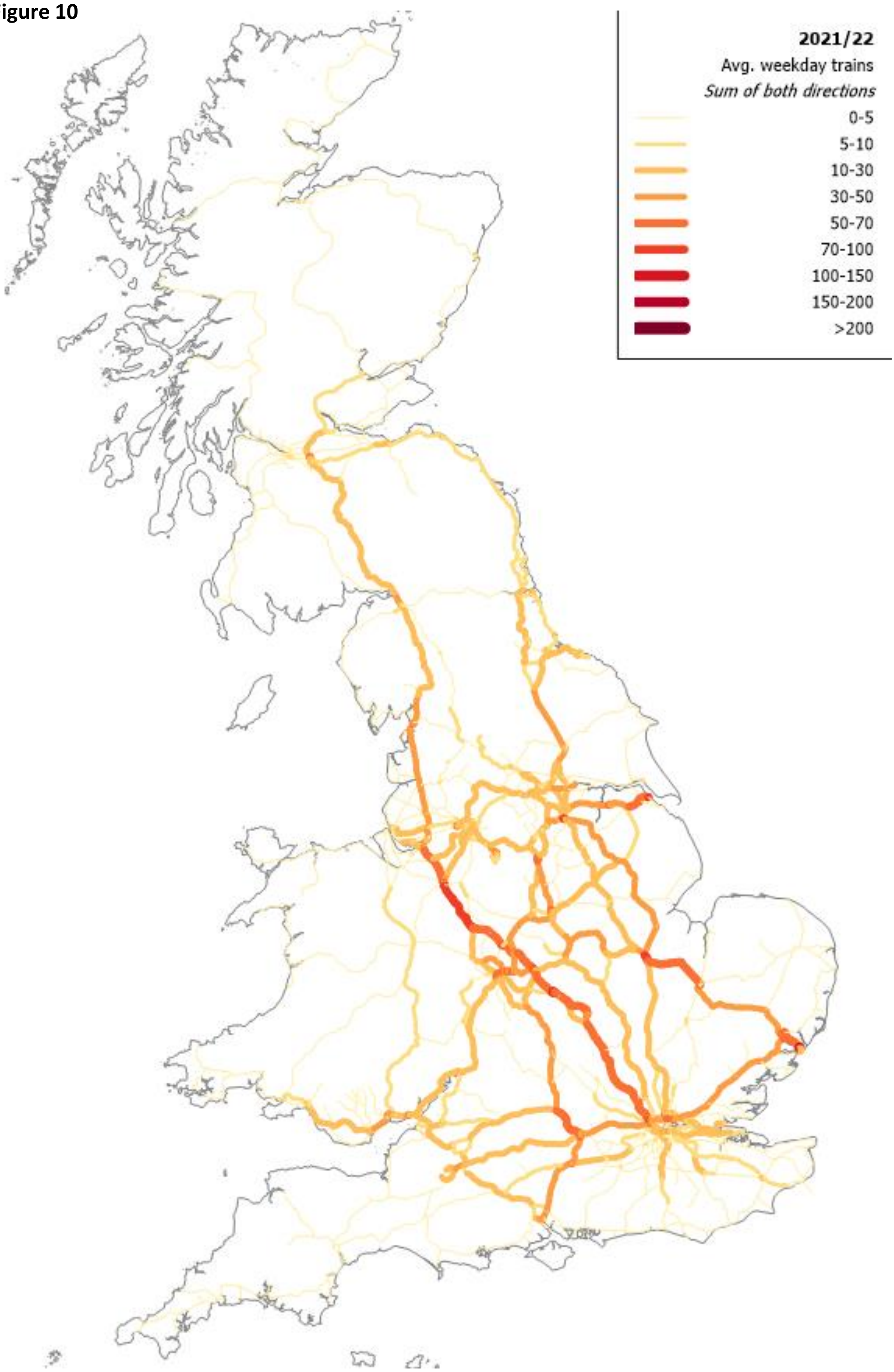

2021/22
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 11

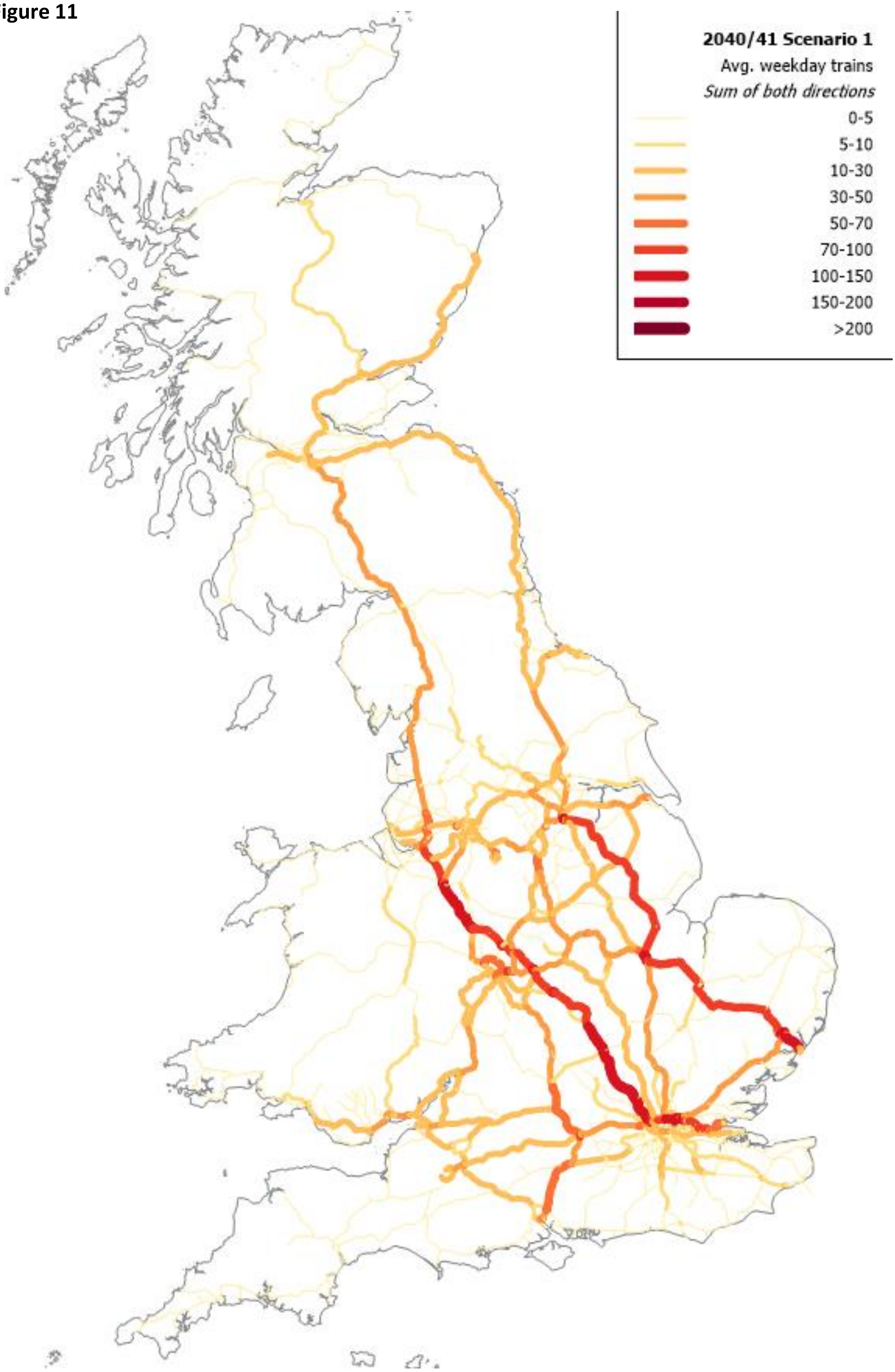

2040/41 Scenario 1
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 12

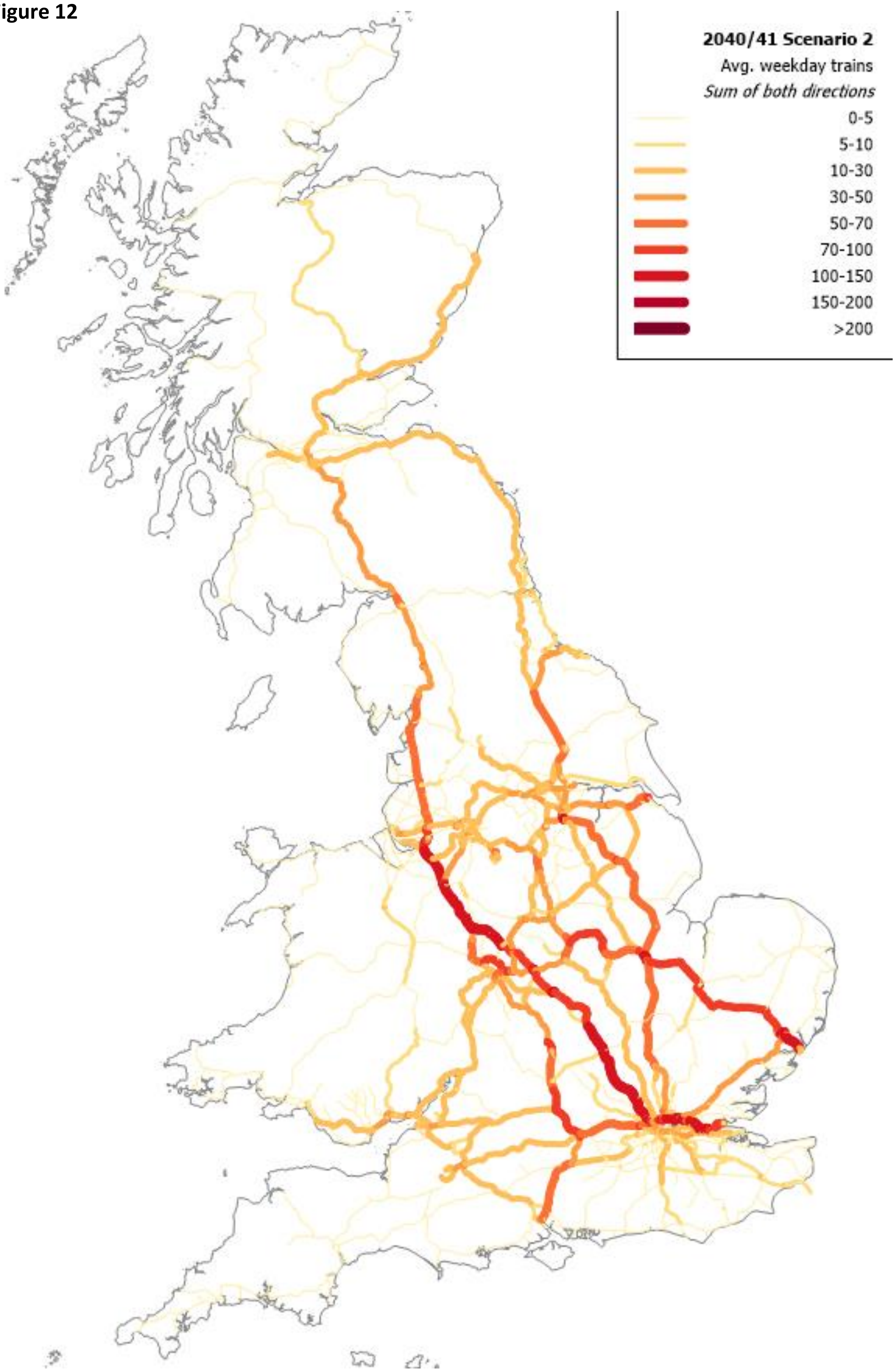

2040/41 Scenario 2
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 13

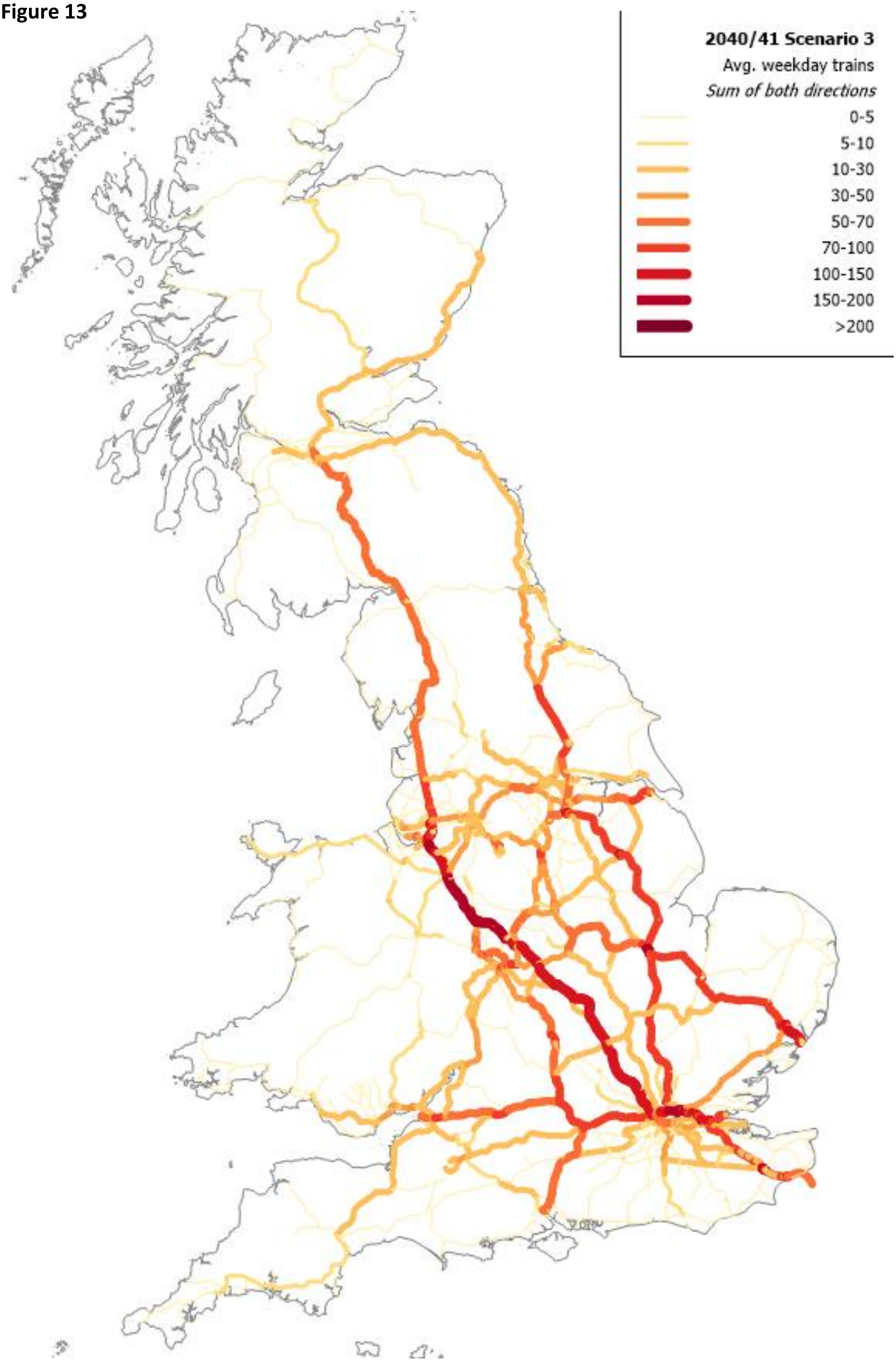

2040/41 Scenario 3
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 14

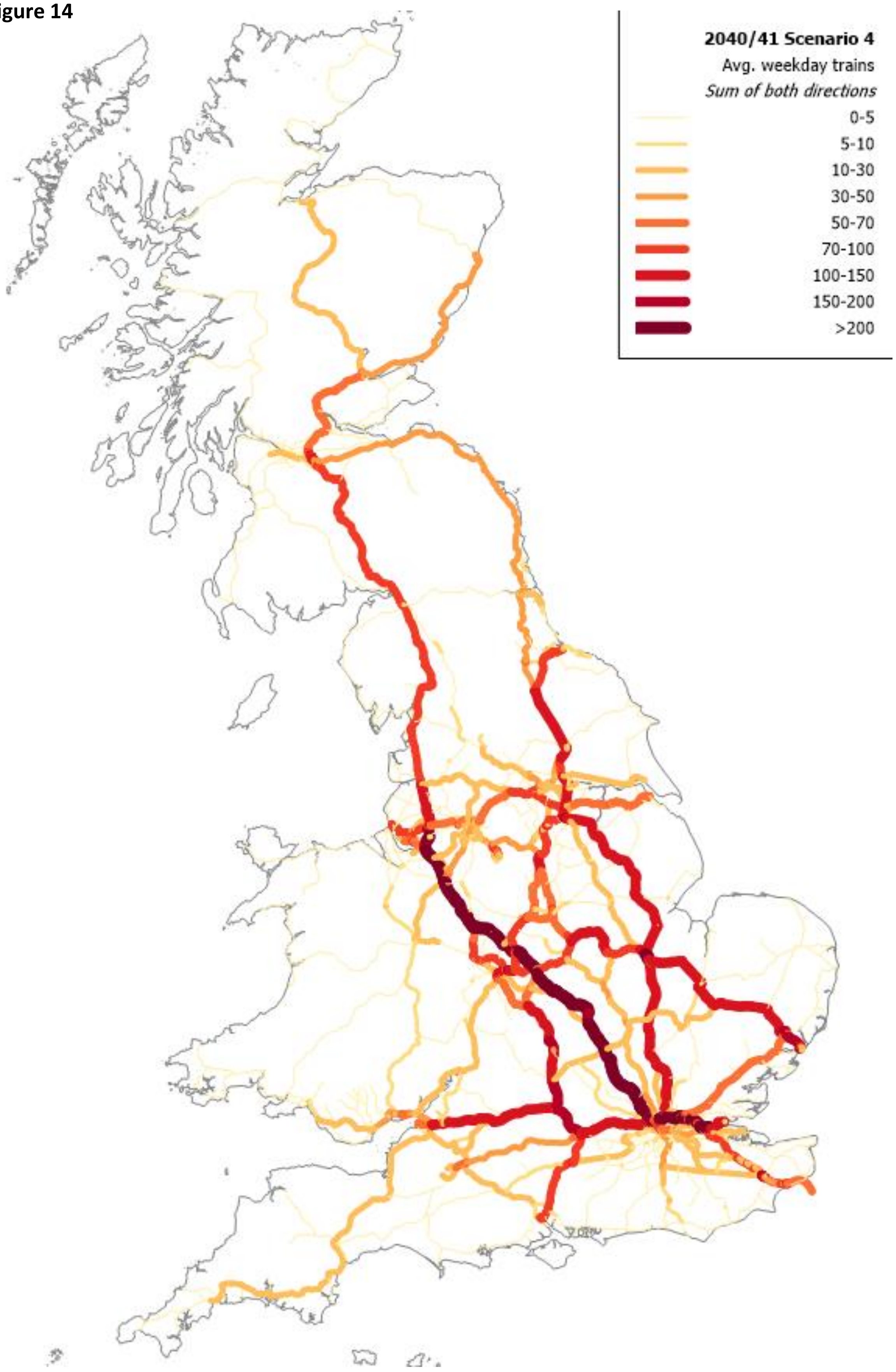

2040/41 Scenario 4
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 15

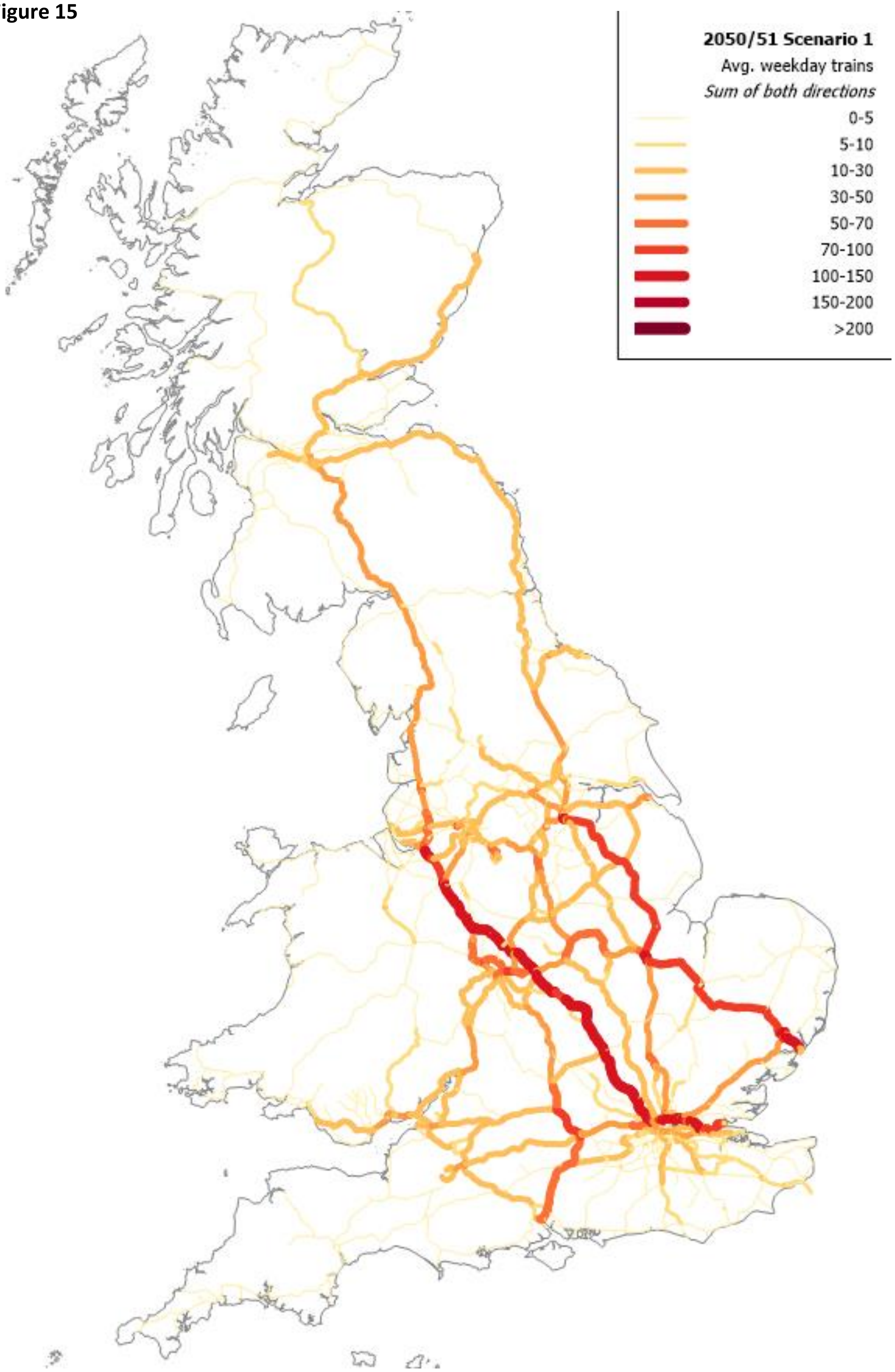

2050/51 Scenario 1
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 16

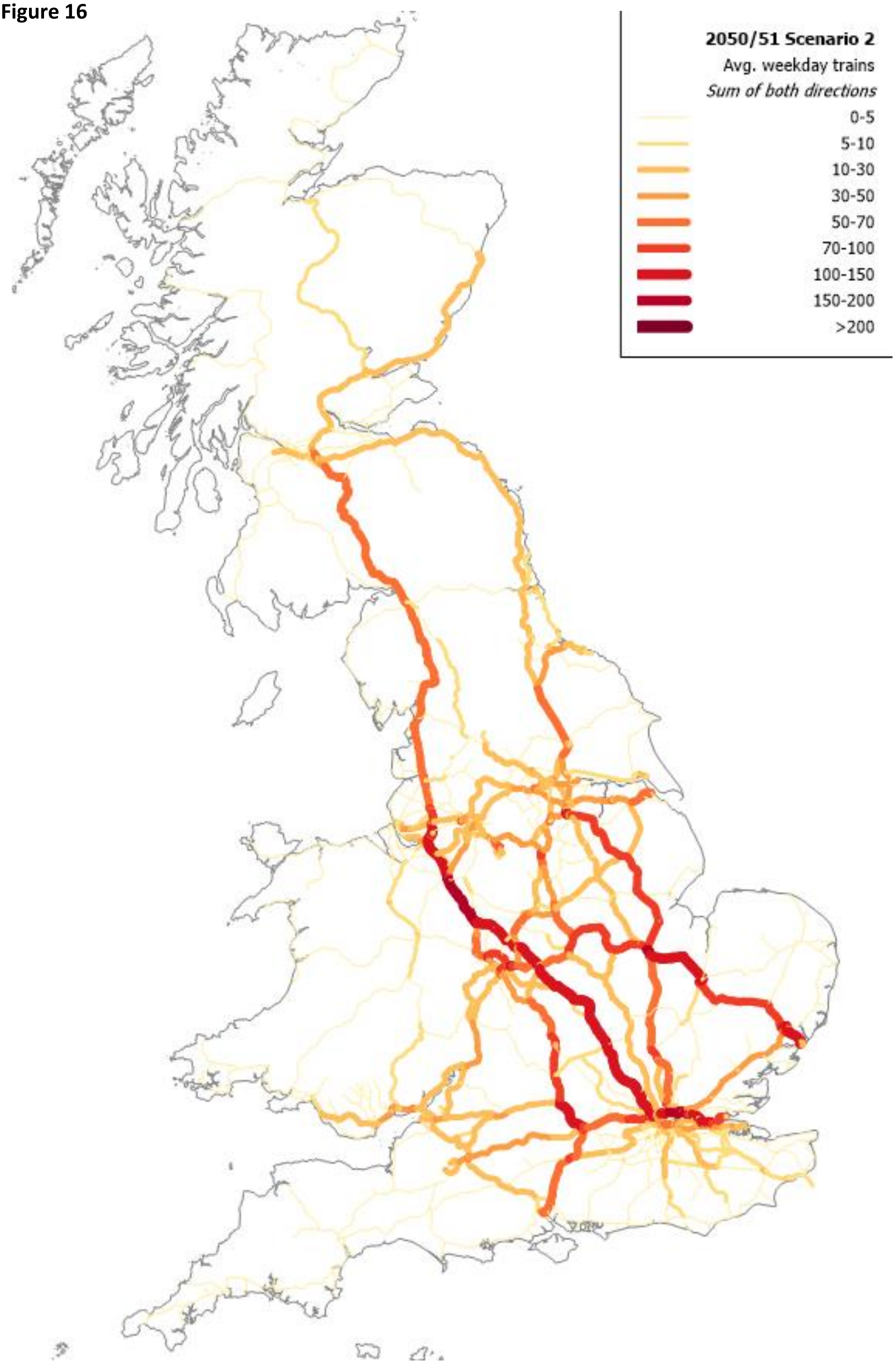

2050/51 Scenario 2
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 17

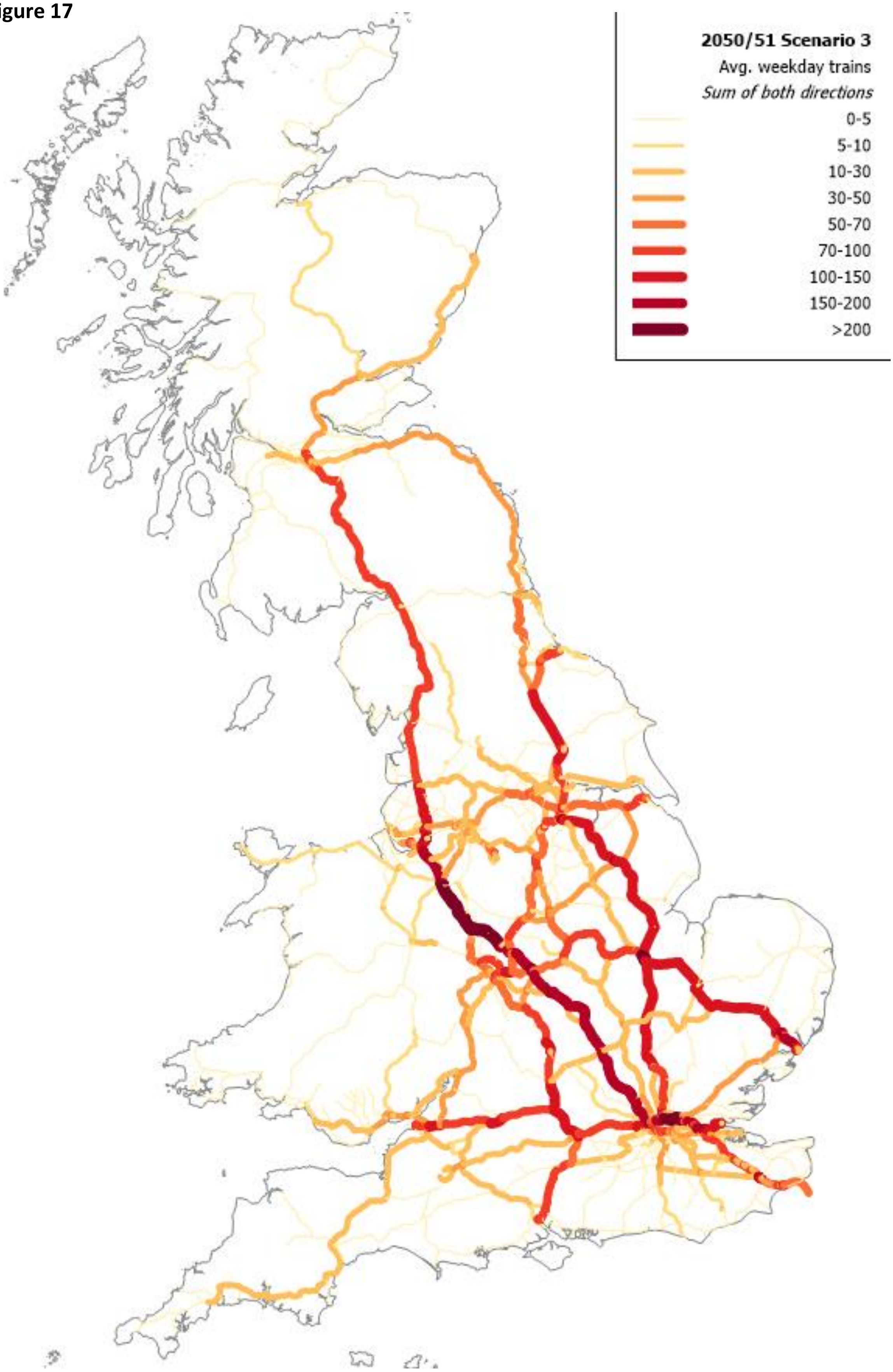
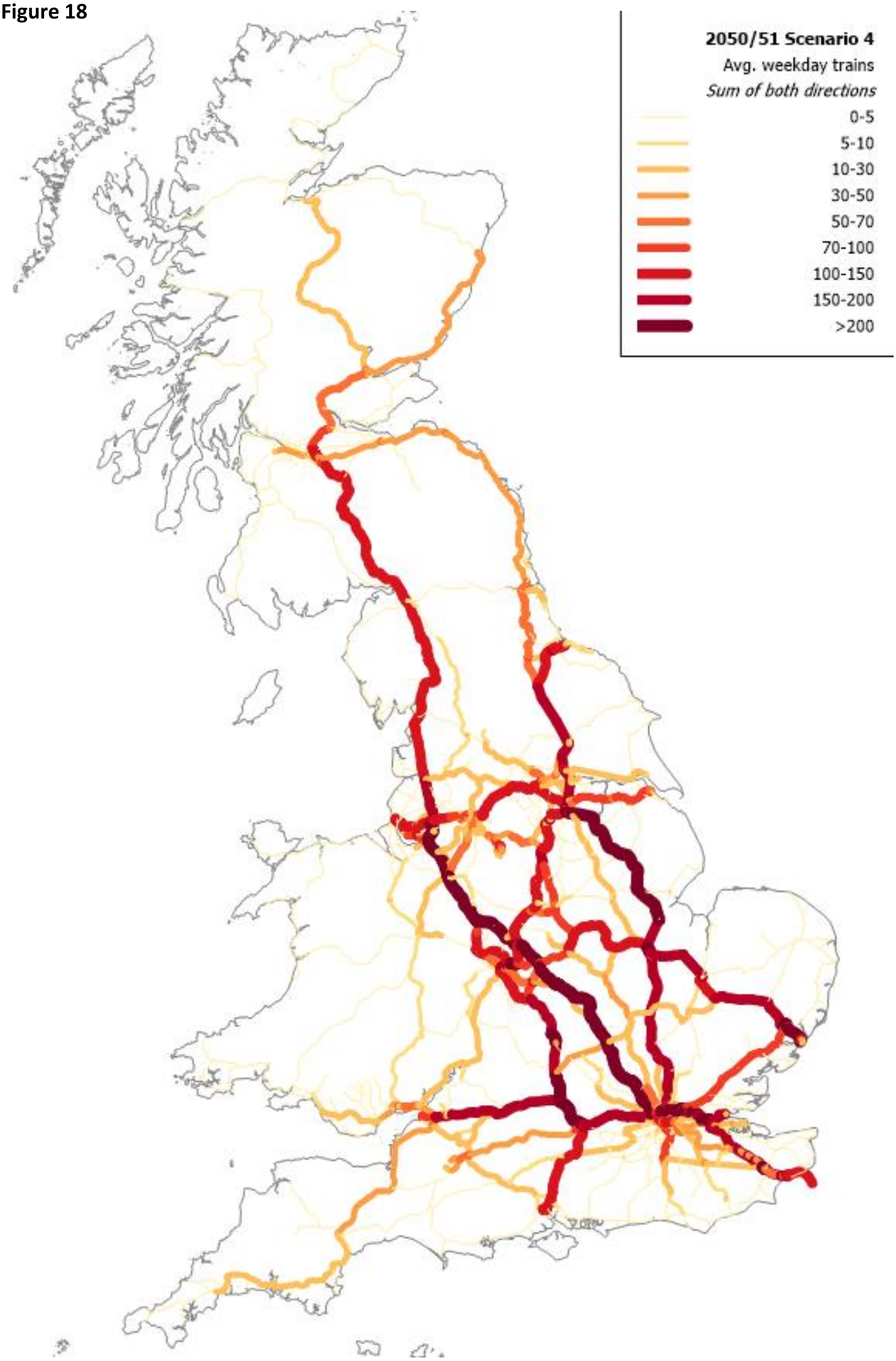

2050/51 Scenario 3
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

Figure 18


2050/51 Scenario 4
Avg. weekday trains
Sum of both directions
0-5
5-10
10-30
30-50
50-70
70-100
100-150
150-200
>200

8.7. Tonne kms by region

The rail assignment program can be set up to assign tonnes instead of trains. This has been done for the full base year including weekends and bank holidays to give annual tonnages. When the tonnes on each link are multiplied by the link's length that gives the output of annual tonne kms. By overlaying the Network Rail regions map on top of the network, the region that each link is in can be determined, such that the tonne kms can be allocated to regions.

The tonne km in the summary results section were derived from these tonnes assignments.

9. DETAILED OUTPUTS DESCRIPTION

9.1. Origin – destination database-style spreadsheet

We have produced detailed outputs for:

- Base year 2021/22 (actual traffic)
- Main scenarios: 2040/41 and 2050/51 for scenarios 1, 2, 3 and 4.
- The gradual introduction of 2050/51 scenario 4: 4a, 4b, 4c, 4d and 4e (equivalent to 4), and the 2040/41 equivalent of 4d
- 2021/22 Modelled representation of base year for intermodal containers only; starting with services between all base year terminals as per the method for representing long term forecast intermodal scenarios
- 2011/12 Backcast Actual
- 2011/12 Backcast Modelled

These outputs are within a spreadsheet in a database style such that a pivot table is a suitable method for analysis.

The fields provided are:

- Scenario
- Origin Stanox code
- Origin Name
- Origin NUTS1
- Destination Stanox code
- Destination Name
- Destination NUTS1
- OriginName_DestinationName
- Commodity TOPS code
- Commodity name
- Commodity group
- Construction Type: CR, GM, LWSG, MSG, MSG_Extra, NewQuarry
- Tonnes (annual)
- Total tonne kms (annual)
- Total tonne kms (annual) by region:
    - Eastern
    - North West & Central
    - Scotland
    - Southern
    - Wales & Western
- Trains (annual)
- Trains per weekday

Tonnes and trains results generated from the analysis of this data should be consistent with the tables in this report. However the tonne kms tables in this report are derived from the rail assignments (which incorporate actual rail distances and routing assumptions). The results are very similar but do have small differences.

9.2. Trains database (as a spreadsheet)

Detailed database-style spreadsheet showing the average number of trains per weekday on each network link by origin, destination and commodity group, with a GIS and pdf map to look-up the link IDs.

10. VALIDATION AND QA

10.1. Gradually introducing Scenario 4 through iterations

The four scenarios modelled all have many parameters that are changed together. This is useful when wishing to test a complex scenario, but makes it difficult to isolate the effect of changing any one parameter on its own.

To investigate how individual parameters impact on the results, it is better to introduce each parameter change separately and re-run the model in order to gradually build up the full scenario. The results of subsequent model runs can be compared to determine the impact of each parameter change.

2050/51 Scenario 4 is the scenario with the most traffic. We have therefore chosen this scenario to iteratively introduce the parameter changes from the base year, one theme at a time, with scenarios 4a to 4e:

a) Market growth:
   i. Population
   ii. GDP
   iii. Trade forecasts associated with specific container ports
   iv. Warehouse growth in line with population.
   v. Overall Construction market growth
b) Add market changes:
   i. Warehouse developments with on-site rail terminals
   ii. Other intermodal terminals
   iii. Construction changes in source, origin and destination, new quarries
c) Add cost changes:
   i. Affects road vs rail competition
   ii. Excluding rail industry improvements
   iii. Excluding road pricing
d) Add rail industry improvements, including Channel Tunnel and Light Logistics
e) Add road pricing. This is the final step; equal to scenario 4

These scenarios 4a-4e show the impact of each group of parameter changes separately

Table 17: Gradually introducing 2050/51 Scenario 4. Thousand tonnes. "Sc4e" equals full scenario 4.

	Thousand tonnes						% change from previous iteration				
Sector	**Base year 2021/22**	**2050/51 Sc4a**	**2050/51 Sc4b**	**2050/51 Sc4c**	**2050/51 Sc4d**	**2050/51 Sc4e**	**2050/51 Sc4a**	**2050/51 Sc4b**	**2050/51 Sc4c**	**2050/51 Sc4d**	**2050/51 Sc4e**
Intermodal: To/from Ports	15,834	28,790	46,797	68,320	73,734	109,422	82%	63%	46%	8%	48%
Intermodal: Inland-Inland	2,104	3,234	4,198	8,711	11,397	30,558	54%	30%	108%	31%	168%
Intermodal: Channel Tunnel	350	770	707	1,091	14,864	33,656	120%	-8%	54%	1262%	126%
Intermodal: Piggyback	0	0	0	0	2,770	6,212					124%
Construction materials	26,937	35,778	47,558	66,720	67,241	72,081	33%	33%	40%	1%	7%
Biomass	8,320	8,320	8,320	8,320	8,320	8,320	0%	0%	0%	0%	0%
ESI Coal	1,326	0	0	0	0	0	-100%				
Petroleum	3,940	0	0	0	0	0	-100%				
Coal Other	1,550	0	0	0	0	0	-100%				
Postal / Light logistics	260	737	737	737	1,333	1,333	183%	0%	0%	81%	0%
Automotive	207	207	207	207	207	207	0%	0%	0%	0%	0%
Chemicals	15	15	15	15	15	15	0%	0%	0%	0%	0%
Domestic Waste	1,778	1,778	1,778	1,778	1,778	1,778	0%	0%	0%	0%	0%
Empty returns for containers carrying bulks	369	369	369	369	369	369	0%	0%	0%	0%	0%
General Merchandise	425	425	425	425	425	425	0%	0%	0%	0%	0%
Industrial Minerals	2,428	2,428	2,428	2,428	2,428	2,428	0%	0%	0%	0%	0%
Iron Ore	3,540	3,540	3,540	3,540	3,540	3,540	0%	0%	0%	0%	0%
Metals	7,296	7,296	7,296	7,296	7,296	7,296	0%	0%	0%	0%	0%
Nuclear	28	28	28	28	28	28	0%	0%	0%	0%	0%
Engineering	6,116	6,116	6,116	6,116	6,116	6,116	0%	0%	0%	0%	0%
Other	5	5	5	5	5	5	0%	0%	0%	0%	0%
Total	**82,830**	**99,835**	**130,524**	**176,107**	**201,867**	**283,789**	**21%**	**31%**	**35%**	**15%**	**41%**

Figure 19: Gradually introducing 2050/51 Scenario 4. Million tonnes. "Sc4e" equals full scenario 4

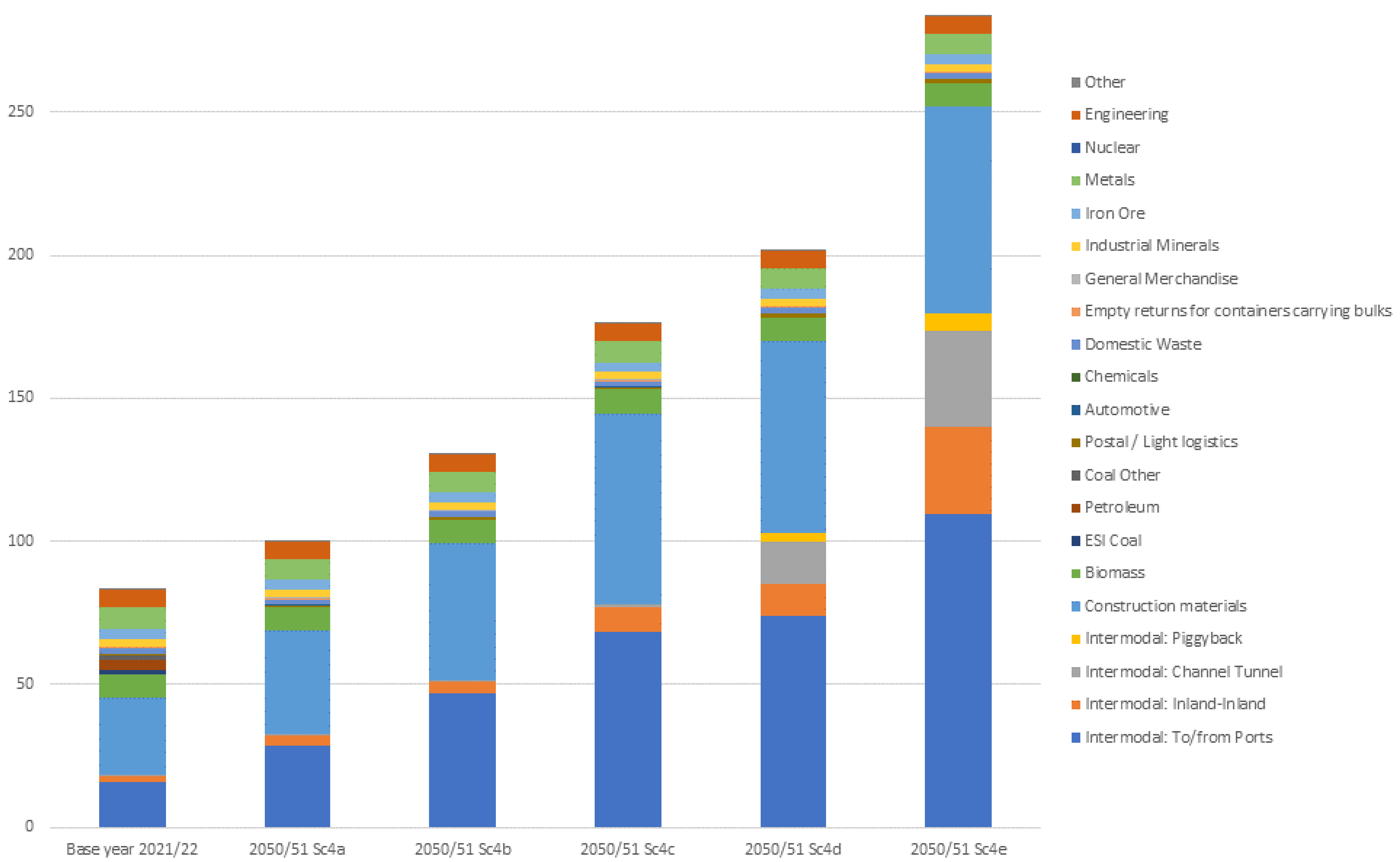
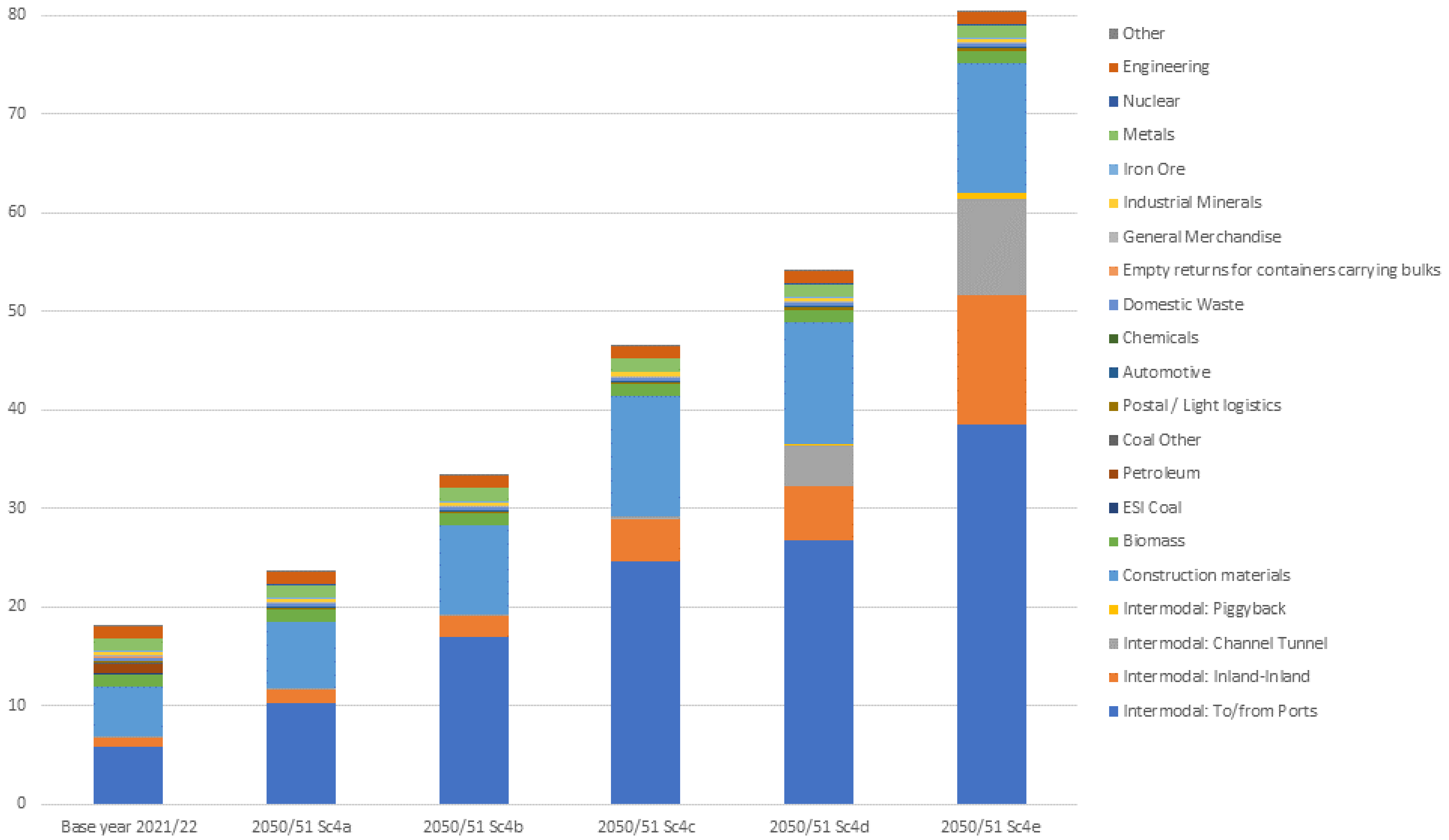


Table 18: Gradually introducing 2050/51 Scenario 4. Million tonne KILOMETRES. "Sc4e" equals full scenario 4.

	Million tonne kilometres						% change from previous iteration				
Sector	**Base year 2021/22**	**2050/51 Sc4a**	**2050/51 Sc4b**	**2050/51 Sc4c**	**2050/51 Sc4d**	**2050/51 Sc4e**	**2050/51 Sc4a**	**2050/51 Sc4b**	**2050/51 Sc4c**	**2050/51 Sc4d**	**2050/51 Sc4e**
Intermodal: To/from Ports	5,835	10,222	17,037	24,588	26,694	38,504	75%	67%	44%	9%	44%
Intermodal: Inland-Inland	943	1,413	2,116	4,317	5,547	13,124	50%	50%	104%	29%	137%
Intermodal: Channel Tunnel	91	185	166	289	4,070	9,727	103%	-10%	74%	1309%	139%
Intermodal: Piggyback	0	0	0	0	265	594					124%
Construction materials	5,066	6,729	9,005	12,273	12,361	13,249	33%	34%	36%	1%	7%
Biomass	1,141	1,141	1,141	1,141	1,141	1,141	0%	0%	0%	0%	0%
ESI Coal	210	0	0	0	0	0	-100%				
Petroleum	960	0	0	0	0	0	-100%				
Coal Other	166	0	0	0	0	0	-100%				
Postal / Light logistics	100	229	229	229	372	372	128%	0%	0%	62%	0%
Automotive	54	54	54	54	54	54	0%	0%	0%	0%	0%
Chemicals	0	0	0	0	0	0	0%	0%	0%	0%	0%
Domestic Waste	331	331	331	331	331	331	0%	0%	0%	0%	0%
Empty returns for containers carrying bulks	72	72	72	72	72	72	0%	0%	0%	0%	0%
General Merchandise	113	113	113	113	113	113	0%	0%	0%	0%	0%
Industrial Minerals	363	363	363	363	363	363	0%	0%	0%	0%	0%
Iron Ore	128	128	128	128	128	128	0%	0%	0%	0%	0%
Metals	1,254	1,254	1,254	1,254	1,254	1,254	0%	0%	0%	0%	0%
Nuclear	10	10	10	10	10	10	0%	0%	0%	0%	0%
Engineering	1,271	1,271	1,271	1,271	1,271	1,271	0%	0%	0%	0%	0%
Other	70	70	70	70	70	70	0%	0%	0%	0%	0%
Total	**18,181**	**23,584**	**33,360**	**46,503**	**54,117**	**80,377**	**30%**	**41%**	**39%**	**16%**	**49%**

Figure 20: Gradually introducing 2050/51 Scenario 4. BILLION tonne KILOMETRES. "Sc4e" equals full scenario 4



Despite introducing very different themes, each iteration has a broadly similar percentage impact on the results from the previous iteration albeit the final step (introducing road pricing) is the largest, particularly for intermodal. This is because intermodal rail traffic is very price sensitive – in active competition with road, so significantly increasing the cost of road gives rail a large market share boost of the huge non-bulk cargo market which currently mostly moves by road.

Note that rail assignment was not carried out on these iterative scenarios, so the tonne kms given above are derived from multiplying the tonnes by rail distances estimated by a simpler method which does not incorporate routing and actual rail distances along the network.

10.2. Road comparison for intermodal container terminal developments in new areas

GBFM produces outputs showing the potential for rail freight traffic on each intermodal service. However it can be helpful to put this into context separately from the model, by comparing with existing non-bulk road traffics along the same routes.

The DfT's Continuing Survey of Road Goods Transport (CSRGT) is a survey of HGV keepers, whereby they fill in a diary of all movements of an HGV for one week. This details the origin and destination NUTS3 zone for each movement, and the cargo and tonnage carried.

For practical reasons this is not a complete survey of all HGVs, so there is a need to scale up the approximately 0.1% sample of HGV movements to represent an estimate for all HGV movements. The scaling up process inevitably results in some "lumpiness" of the outputs if the data is highly disaggregated. There are also confidentiality issues whereby individual movements could potentially be identified if the data is analysed in a highly disaggregated format.

There are some intermodal container terminals included in the assumptions that are in areas that are currently not served by intermodal container rail services.

This section shows the annual non-bulk road tonnes lifted[14] along corridors paralleling potential intermodal services serving these sites to give an indication of the likely market available to them.

The road and rail cost models for 2040/41 scenario 3 are used to estimate what the indicative cost would be for road and rail to/from each region. Where rail is cheaper than road, this suggests that rail services may be viable for some of this traffic. These rail costs assume that one end is rail-connected such as a port or a rail-served warehouse, but the other end requires a local road haul.

[14] Source: CSRGT data for full year July 2021 to June 2022, provided by the DfT, subject to confidentiality rules on its use

The tonnage for the other end NUTS 1 regions where rail is cheaper than road are totalled to give a rough indication of the likely traffic potentially viable by rail.

Table 19: Existing non-bulk road traffic to + from the NUTS2 region of selected terminals

Terminal & its NUTS2	Other end region NUTS1	Annual road tonnes (Thousand) to + from terminal's NUTS2	Rail cheaper than road? With terminal's NUTS2 road total (Thousand tonnes)	Most traffic rail-served at terminal
Spalding, Lincolnshire	North East	735	Yes	No
	North West	2,534	Yes	
	Yorks and Humber	3,232	No	
	East Midlands	22,525	No	
	West Midlands	1,235	No	
	East of England	5,313	No	
	London	1,220	No	
	South East	2,009	Yes	
	South West	792	Yes	
	Wales	*	Yes	
	Scotland	467	Yes	
	Total	**40,246**	**6,720**	
Hull Docks, East Yorkshire and Northern Lincolnshire	North East	1,875	No	Yes
	North West	7,393	No	
	Yorks and Humber	34,678	No	
	East Midlands	6,569	No	
	West Midlands	3,478	Yes	
	East of England	3,180	Yes	
	London	*	Yes	
	South East	596	Yes	
	South West	638	Yes	
	Wales	968	Yes	
	Scotland	1,321	Yes	
	Total	**61,010**	**10,495**	
Immingham Docks, East Yorkshire and Northern Lincolnshire	North East	1,875	Yes	Yes
	North West	7,393	No	
	Yorks and Humber	34,678	No	
	East Midlands	6,569	No	
	West Midlands	3,478	Yes	
	East of England	3,180	Yes	
	London	*	Yes	
	South East	596	Yes	
	South West	638	Yes	

	Wales	968	Yes	
	Scotland	1,321	Yes	
	Total	**61,010**	**12,370**	
Salfords (North of Gatwick Airport), Surrey, East and West Sussex	North East	*	Yes	No
	North West	*	Yes	
	Yorks and Humber	*	Yes	
	East Midlands	968	Yes	
	West Midlands	2,015	Yes	
	East of England	2,468	No	
	London	2,395	No	
	South East	23,112	No	
	South West	833	Yes	
	Wales	*	Yes	
	Scotland	*	Yes	
	Total	**32,790**	**4,815**	
Port Talbot, West Wales and The Valleys	North East	*	Yes	No
	North West	2,421	Yes	
	Yorks and Humber	906	Yes	
	East Midlands	1,349	Yes	
	West Midlands	3,130	No	
	East of England	1,100	Yes	
	London	*	Yes	
	South East	904	Yes	
	South West	3,766	Yes	
	Wales	24,807	No	
	Scotland	*	Yes	
	Total	**38,574**	**10,637**	
St Austell, Cornwall and Isles of Scilly	North East	*	Yes	No
	North West	*	Yes	
	Yorks and Humber	*	Yes	
	East Midlands	*	Yes	
	West Midlands	*	Yes	
	East of England	*	Yes	
	London	*	Yes	
	South East	*	Yes	
	South West	12,432	No	
	Wales	1,269	Yes	
	Scotland	*	Yes	
	Total	**15,057**	**2,625**	
Exeter Riverside,	North East	*	Yes	No

Devon	North West	*	Yes	
	Yorks and Humber	*	Yes	
	East Midlands	1,307	Yes	
	West Midlands	1,928	Yes	
	East of England	*	Yes	
	London	*	Yes	
	South East	912	Yes	
	South West	24,109	No	
	Wales	1,105	Yes	
	Scotland	*	Yes	
	Total	**30,348**	**6,239**	
Sunderland Port, Northumberland and Tyne and Wear	North East	20,590	No	No
	North West	2,271	Yes	
	Yorks and Humber	4,740	No	
	East Midlands	1,132	Yes	
	West Midlands	1,686	Yes	
	East of England	*	Yes	
	London	*	Yes	
	South East	*	Yes	
	South West	*	Yes	
	Wales	*	Yes	
	Scotland	2,016	Yes	
	Total	**33,789**	**8,459**	
Tyne Dock, Northumberland and Tyne and Wear	North East	20,590	No	Yes
	North West	2,271	Yes	
	Yorks and Humber	4,740	No	
	East Midlands	1,132	Yes	
	West Midlands	1,686	Yes	
	East of England	*	Yes	
	London	*	Yes	
	South East	*	Yes	
	South West	*	Yes	
	Wales	*	Yes	
	Scotland	2,016	Yes	
	Total	**33,789**	**8,459**	
Holyhead Port, West Wales and The Valleys	North East	*	Yes	
	North West	2,421	No	
	Yorks and Humber	906	Yes	
	East Midlands	1,349	Yes	
	West Midlands	3,130	Yes	Yes

	East of England	1,100	Yes	
	London	*	Yes	
	South East	904	Yes	
	South West	3,766	Yes	
	Wales	24,807	No	
	Scotland	*	Yes	
	Total	**38,574**	**11,346**	

Notes:

- Source: CSRGT July 2021 to June 2022
- "*" indicates that traffic volumes surveyed are below the threshold for reporting while ensuring confidentiality. The totals include these small volumes

The potential terminals at the unitised ports (Hull Docks, Immingham Docks, Tyne Dock, Holyhead Port) would also have their port traffics available to them, some of which may not appear in CSRGT due to being hauled by overseas-registered hauliers. If the terminal is at the port, there would be no need for a road haul, thus making the movement more viable by rail.

A daily train from origin to destination can typically be sustained efficiently if rail tonnes are at least around 100,000 tonnes per year. However much of the tonnage identified would not be going to the same destinations or would require a more on-demand service than rail can provide, so the true cargo available to rail would be much lower than indicated. The implication is that cargo within the terminal's NUTS2 region would use the terminal. However some NUTS2 regions such as "West Wales and The Valleys" are too large for this assumption to be valid.

10.3. Backcasting

One means of validation is to run a "backcast". This backcasting exercise used the same baseline year as the forecasts (2021/22), but used actual *historic* input assumptions to describe a previous year: 2011/12. The model's rail freight traffic outputs were compared to the actual historic traffic volumes.

This backcasting was carried out for intermodal and construction materials. Other commodities had commodity-specific assumptions, so there is no modelling methodology to test.

The actual and modelled 2011/12 outputs are included in the main data output file.

10.3.1. Intermodal containers

The equivalent methodology as used for the forecasts was used for the backcasts; initially starting with all terminals connected over the 160km threshold, and then removing those services that had insufficient traffic to warrant a viable frequent service.

Several terminals have been built or developed to have services since 2011/12:

- London Gateway
- East Midlands Gateway
- Doncaster iPort
- Tinsley
- Masborough
- Seaforth

These were removed from the 2021/22 list of terminals when setting up the 2011/12 services. However there are several terminals that were operational in 2011/12 that have since closed or no longer have services:

- Grain (Thamesport)
- Selby
- Rugby

These terminals were added to the 2021/22 list of terminals when setting up the 2011/12 services.

The right-most column of table A1.1 in appendix 1 describes the changes from 2021/22 needed to represent 2011/12 in terms of input assumptions. For example the diesel resource cost was 13.6% more expensive in 2011/12 than in 2021/22.

These backcast assumptions were input into the model and the forecasting methodology followed to arrive at a modelled representation of 2011/12, that can be compared to actual 2011/12 traffic.

Table 20 shows:

- Actual 2011/12 intermodal container rail traffic; generated using the same methodology as described in section 5.1.
- Modelled 2011/12 intermodal container rail traffic
- Actual 2021/22 intermodal container rail traffic for comparison.
- Actual non-bulk *road* traffic for 2011/12 and 2021/22 as sourced from CSRGT[15] such that the rail mode share can be estimated.

Table 20: Intermodal containers tonnes: Actual and modelled 2011/12 rail traffic, along with actual and modelled 2021/22 rail traffic. Plus non-bulk road traffic for comparison. Million tonnes

	Actual 2011/12	Modelled 2011/12	Actual 2021/22	Modelled 2021/22
Rail tonnes	18.1	18.6	18.3	17.5

[15] We have considered road commodities: *Food products, Textiles and textile products; leather and leather products, Wood products, Chemical products, Glass, Cement and other non-metallic mineral products, Machinery and equipment, Transport equipment, Furniture, Mail, Parcels, Empty containers, pallets and other packaging, Household and office removals, Grouped goods, Unidentifiable goods, Other goods* - to be non-bulk such that if they were to travel by rail, they would be in an intermodal container.

Road tonnes	906		1,016	
Rail mode share	2.0%		1.8%	

Sources:

- PALADIN data from Network Rail processed by MDS Transmodal
- DfT CSRGT for road tonnes. Table RFS0129 for 2011 used to represent 2011/12. RFS0104 for July 2021 – June 2022 used to represent 2021/22. The CSRGT methodology changed between 2011 and 2021 such that the 2 road tonnes figures are not necessarily directly comparable.

Overall there has been little change between 2011/12 and 2021/22 in the traffic of intermodal containers by rail in either the actual results or the modelled results. Backcasting is most effective when there are large changes in an input parameter that is used as a significant explanatory variable for a model, while there is little else changing in the scenario. The model is limited in the number of variables that are represented, while there have been several changes that have happened since 2011/12. Brexit is a good example albeit the trade changes are represented in the model inputs.

Rail carries a very small percentage of the non-bulk market in both years.

Because the modelling methodology does not perfectly replicate the base year in terms of the services operating, there are some discontinuities when comparing traffics on specific services. However most of the main terminals have a reasonably close match between actuals and modelled. Table 21 shows the top five terminals for actual tonnes (origin plus destination tonnes) and their 2011/12 actual and modelled tonnages.

Table 21: Top 5 terminals for actual tonnes (origin plus destination million tonnes). 2011/12 actual and modelled tonnages

Terminal	Actual	Modelled	Modelled / Actual
Felixstowe	8.04	8.63	1.07
Southampton	4.14	3.16	0.76
Trafford Park	2.82	2.25	0.80
Coatbridge	2.70	1.85	0.69
Lawley St	2.41	0.82	0.34
Sub-total	**20.10**	**16.71**	**0.83**

Note that Lawley St's modelled traffic is below the actual traffic. In the model, nearby Rugby attracts lots of traffic that would likely otherwise go to Lawley St. Similarly some of Coatbridge's actual traffic is using Elderslie in the model.

Because there isn't much change in traffic between the base year and the backcast year, and the model's methodology does not accurately reflect intermodal container traffic in the base year, this is not a particularly effective validation test and demonstration of robustness for the model.

10.3.2. Construction materials

The equivalent methodology as used for the forecasts was used for the backcasts. Instead of growth by source type being based on the various forecast scenarios in the MPA report mentioned in section 5.2[16], the actual tonnage supplied by source type in 2011/12 was taken from the MPA's figure 2:

Table 22: Aggregates supply tonnage (million) in GB for 2011 and 2021, and resultant scale factor for backcasting

Source	2011	2021	Scale factor from 2021 to 2011
Crushed Rock	91	126	0.72
Land-won Sand & Gravel	44	43	1.02
Marine Sand & Gravel	11	14	0.76
Recycled & Secondaries	62	70	0.89
Total	**208**	**253**	**0.82**

Note: Ignoring the quarter-year discrepancy between 2011 and 2011/12, and 2021 and 2021/22

Forecast scenarios 1-3 balanced supply growth with demand growth in each region by adjusting the Marine Sand & Gravel (MSG) supply. However forecast scenario 4 didn't have large growth in MSG, so the Crushed Rock was varied instead. For the backcasting, this scenario 4 approach with varying the Crushed Rock was used.

Changes in the cost components of the cost models were then used to backcast mode shares.

The 2011/12 model results are shown in the table below and compared to actual 2011/12. The modelling method for construction materials describes changes from the base year, so there isn't a separate modelled version of 2021/22.

Table 23: Construction materials tonnes by rail: Actual and modelled 2011/12 rail traffic with comparison, along with actual 2021/22 rail traffic. Million tonnes

	Actual 2011/12	Modelled 2011/12	Modelled - Actual	Modelled / Actual	Actual 2021/22
Crushed Rock	12.28	12.98	0.70	1.06	18.40
Land-won Sand & Gravel	0.22	0.31	0.09	1.42	0.28
Marine Sand & Gravel	1.47	2.23	0.76	1.52	2.06
General Market	3.56	5.18	1.62	1.45	6.19
Total	17.53	20.70	3.17	1.18	26.94

Source for actuals: PALADIN data from Network Rail processed by MDS Transmodal

[16] "Aggregates demand and supply in Great Britain: Scenarios for 2035", Mineral Products Association. https://mineralproducts.org/MPA/media/root/Publications/2022/Aggregates_demand_and_supply_in_GB_Scenarios_for_2035.pdf

The total backcast modelled tonnes is 20.7 million tonnes, compared to the base year (2021/22) of 26.9 million tonnes; 23% lower. The actual 2011/12 tonnes was 17.5 million tonnes; 35% lower than the base year, so the backcast modelled tonnes is higher than the actual 2011/12 traffic.

Looking at it the other way around and considering 2011/12 as the starting point, actual growth was 54% while modelled growth was 30%. This extra actual growth may be due to a decline in supply from non-rail connected sites so mode share to rail is 'forced' AND new distribution terminal capacity has been put in.

Each construction material type is slightly higher in the modelled backcast when compared to actual 2011/12. This is particularly the case for the general market, which includes nearly 2 million tonnes of "Sugarstone" from the Peak District in the base year but under 100,000 tonnes in actual 2011/12.

Apart from general growth in most construction material types, as defined by the MPA data, there isn't a major change in the market between 2011/12 and 2021/22 that we would expect the modelling methodology to pick up to be able to conclude that the methodology is representing the market correctly. Some of the major changes there have been (e.g. growth in Sugarstone) would not be directly picked up by our modelling methodology anyway.

Like intermodal, because there isn't much change in traffic between the backcast year and the base year apart from market growth and some changes in traffics that are not directly modelled, this is not a particularly effective validation test and demonstration of robustness for the model.

10.4. Commentary and comparison to the 2028/29 forecasts

In 2022 MDS Transmodal produced short term forecasts for 2028/29, with a base year of 2021. There are several significant differences about the approaches to the two pieces of work, with resulting significant differences in the outcomes.

10.4.1. Deciding upon suitable assumptions

For 2028/29, the assumptions were decided upon by a process of MDST suggesting some potential assumptions, which were then discussed in a consultation process involving phone or video calls with individual stakeholders in the industry. The objective was to glean insights into the stakeholders' views by giving them something to react to, while giving them the confidence that they could speak freely because the conversation was with one MDST representative only. Most stakeholders already had some level of relationship or familiarity with the MDST representatives. The consultation process resulted in some adjustments to the suggested assumptions.

The consultation process to establish the assumptions for these latest 2040/41 and 2050/51 forecasts is described in a report by Steer on behalf of GBRTT: "Freight Futures Report", 2023, and involved consulting a wide range of rail freight and non-rail freight stakeholders to broaden the perspectives. This included DfT, Freightliner, GBRTT, Logistics UK, MDS Transmodal, National Highways, Network

Rail, Rail Freight Group, Transport Scotland, Transport for Wales, Chartered Institute for Logistics and Transport, and independent experts. The focus was more on public sector and trade bodies rather than those in the industry. Group discussion sessions were used to establish views. Subsequent discussions within the team arrived at how best to take on these stakeholder views in a pragmatic way.

10.4.2. Concept behind the choice of scenarios

For 2028/29, there were 4 scenarios ranging from low to high market growth, and favouring and disfavouring rail relative to road, plus a central scenario:

	Low market growth	High market growth
Factors which favour rail relative to road	Scenario A	Scenario B
Factors which disfavour rail relative to road	Scenario C	Scenario D
Neither favouring or disfavouring rail relative to road	Scenario E: Central	

For the latest 2040/41 and 2050/51 forecasts the scenarios were not intended to have lows and highs or central themes – with each being its own separate standalone scenario. However Scenario 1 did take on many characteristics of a road-reliant theme and Scenario 4 took on many characteristics of a pro-rail theme.

10.4.3. Traffic assignment and Capacity constraint

For 2028/29, demand forecasts were made for the various scenarios. These were then transformed into paths per hour along routes and through junctions by assigning them to the network.

Once assigned to the network, these demand forecasts were compared to expected future capacity available to freight through junctions. Where demand exceeded expected capacity, the forecasts were suppressed to fit into this expected capacity.

The result was to supress 21.5% of tonne kms demand in scenario B, but just 6.6% in scenario C.

For the latest 2040/41 and 2050/51 forecasts, no capacity constraint has been conducted; they are forecasts of demand based on defined costs to the user.

10.4.4. Intermodal containers

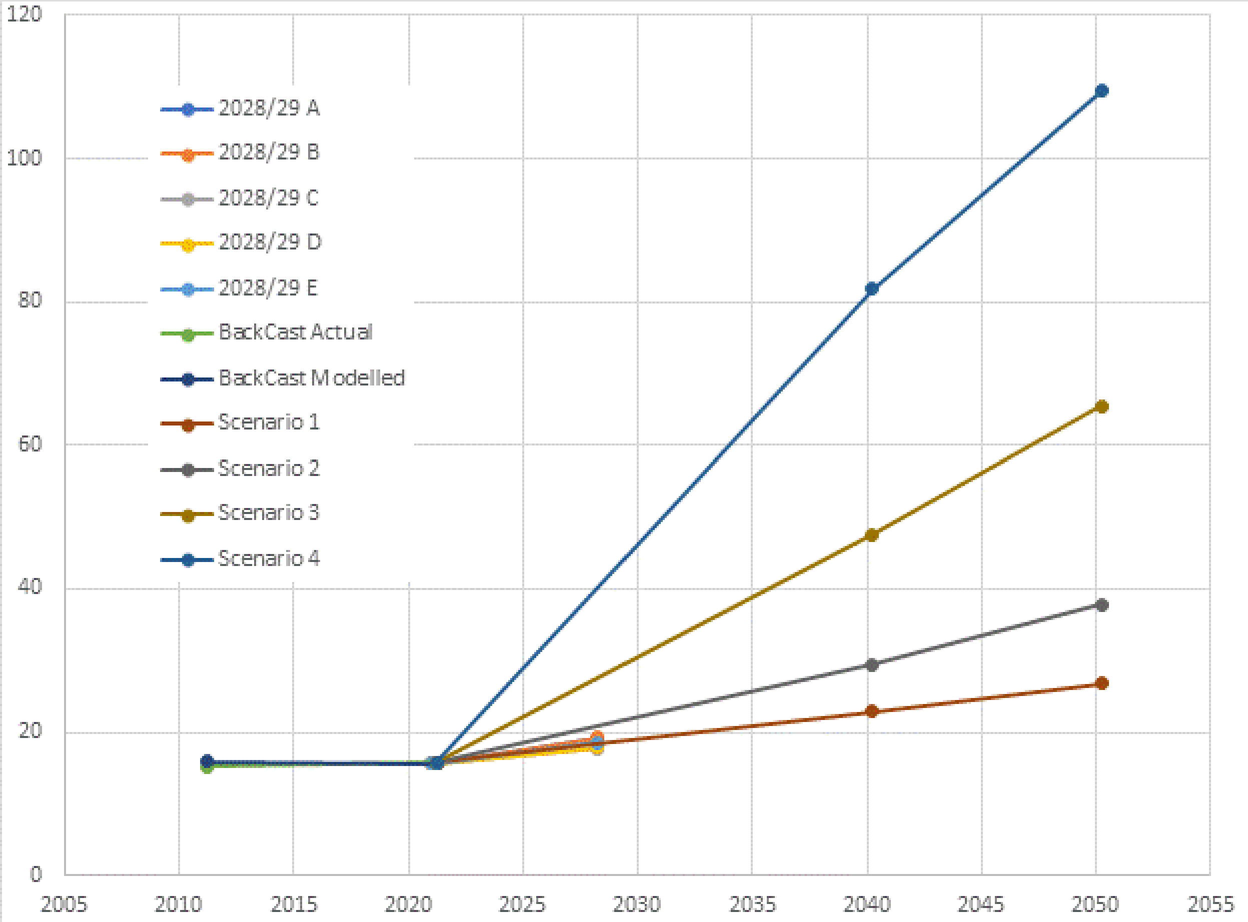
For the latest 2040/41 and 2050/51 forecasts, a long term approach was taken to choosing which terminal to terminal services would exist. This was based on initially assuming that all terminals were connected to all other terminals more than 160km away, and then removing those services that had less than 60,000 tonnes per year (sum of both directions). This was done to enable new terminals to be introduced and compete fairly with existing established connections. It ignored inertia in the industry (which is often a legitimate modelling assumption in the long term).

The 2028/29 could not be so readily considered long term. Therefore existing services were used for forecasts, along with adding additional services to and from new terminals.

Figures 21-23 show plotted on the same graph:

- 2028/29 forecasts for scenarios A-E after capacity constraint
- 2040/41 and 2050/51 latest demand forecasts for scenarios 1-4
- along with their base year traffics
- and 2011/12 actual and backcasting modelled results
- For
    - Intermodal. To/from Ports
    - Intermodal. Inland-Inland
    - Intermodal. Channel Tunnel

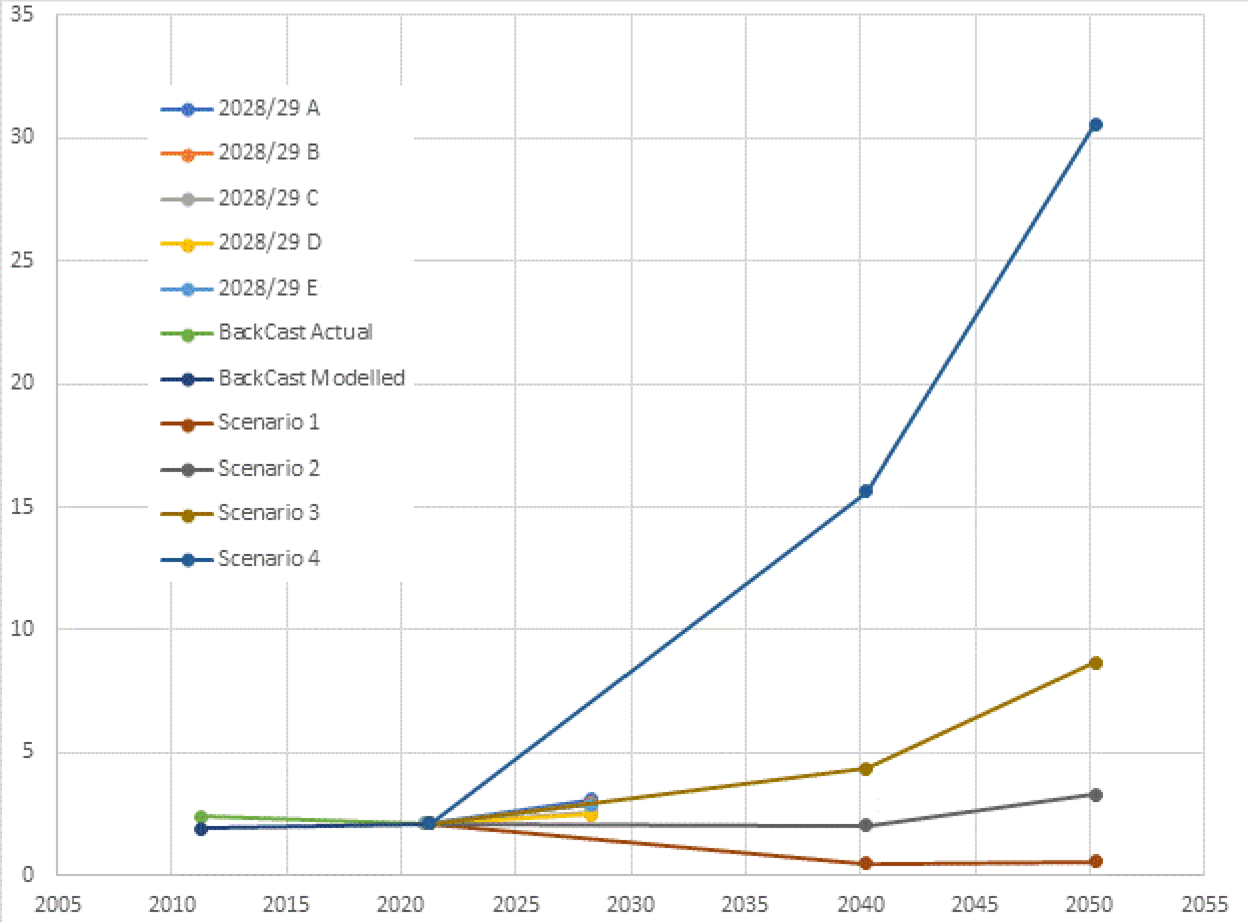
Figure 21: Comparison of latest forecasts with earlier forecasts for 2028/29 tonnes. Intermodal. To/from Ports. Million tonnes per year



Over the past 10 years Intermodal traffic to/from the ports has remained stable. The capacity constrained forecasts for 2028/29 maintained this relative stability, albeit with slightly more traffic in scenario B (high market growth and factors that favour rail) than in scenario C (low market growth and factors that disfavour rail).

The latest forecasts show similar growth for scenario 1 and slightly more for scenario 2. However scenarios 3 and 4 show much more significant growth as there is a major shift from road to rail along with projected trade growth.

Figure 22: Comparison of latest forecasts with earlier forecasts for 2028/29 tonnes. Intermodal. Inland – Inland. Million tonnes per year

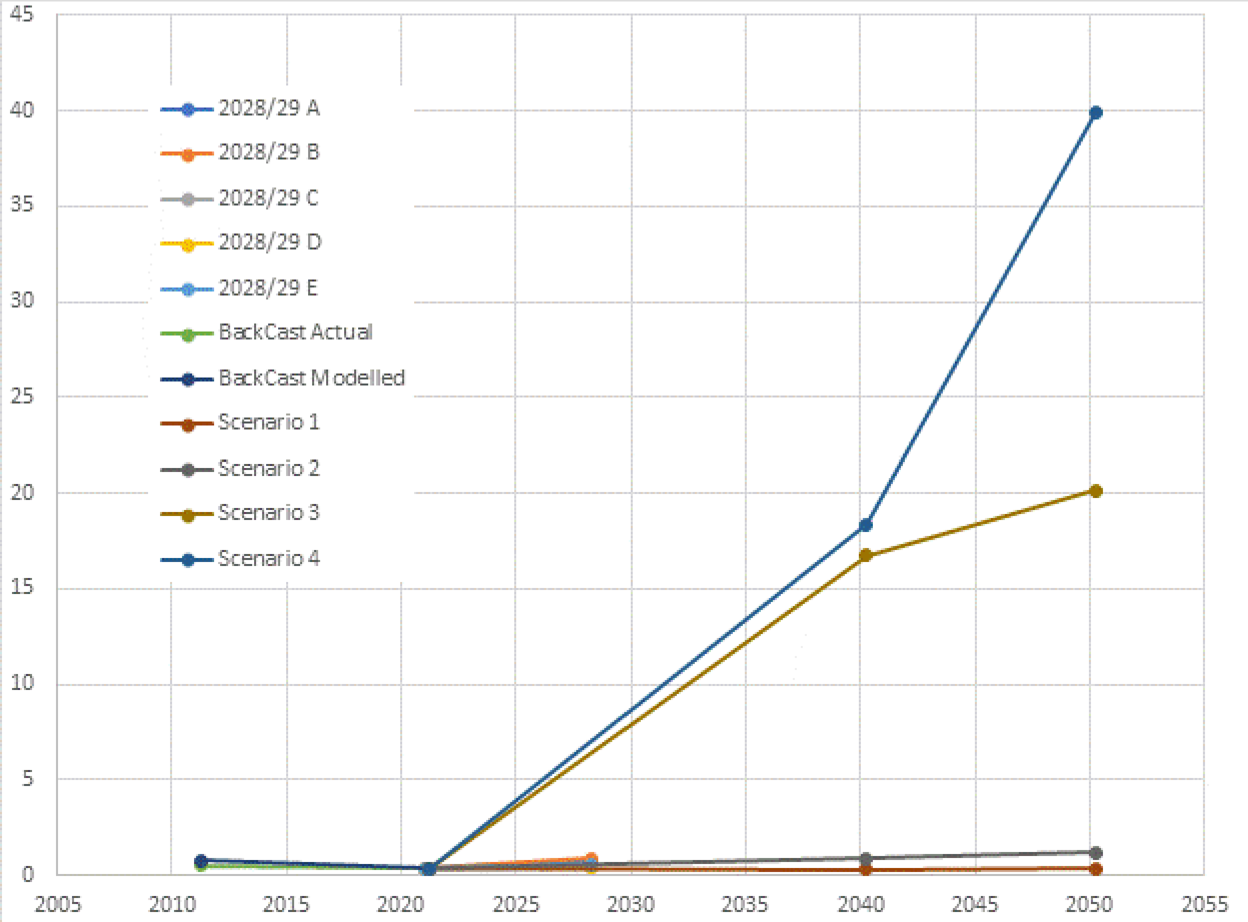


Over the past 10 years inland-to-inland Intermodal traffic has remained reasonably stable. The capacity constrained forecasts for 2028/29 showed some growth, particularly for scenarios A (up 45%) and B.

The latest forecasts show a decline for scenario 1 as the road-reliant impacts kick in. Note that in the forecasts, there is also a tendency for more use to be made of port terminals such as Tilbury for domestic traffic, so more *forecast* domestic traffic will actually appear as to/from ports, contributing to its large growth.

Scenario 3 shows a large growth and scenario 4 is very pro-rail with a very large growth.

Figure 23: Comparison of latest forecasts with earlier forecasts for 2028/29 tonnes. Intermodal. Channel Tunnel. Million tonnes per year



The capacity constrained forecasts for 2028/29 showed some modest growth from a low base.

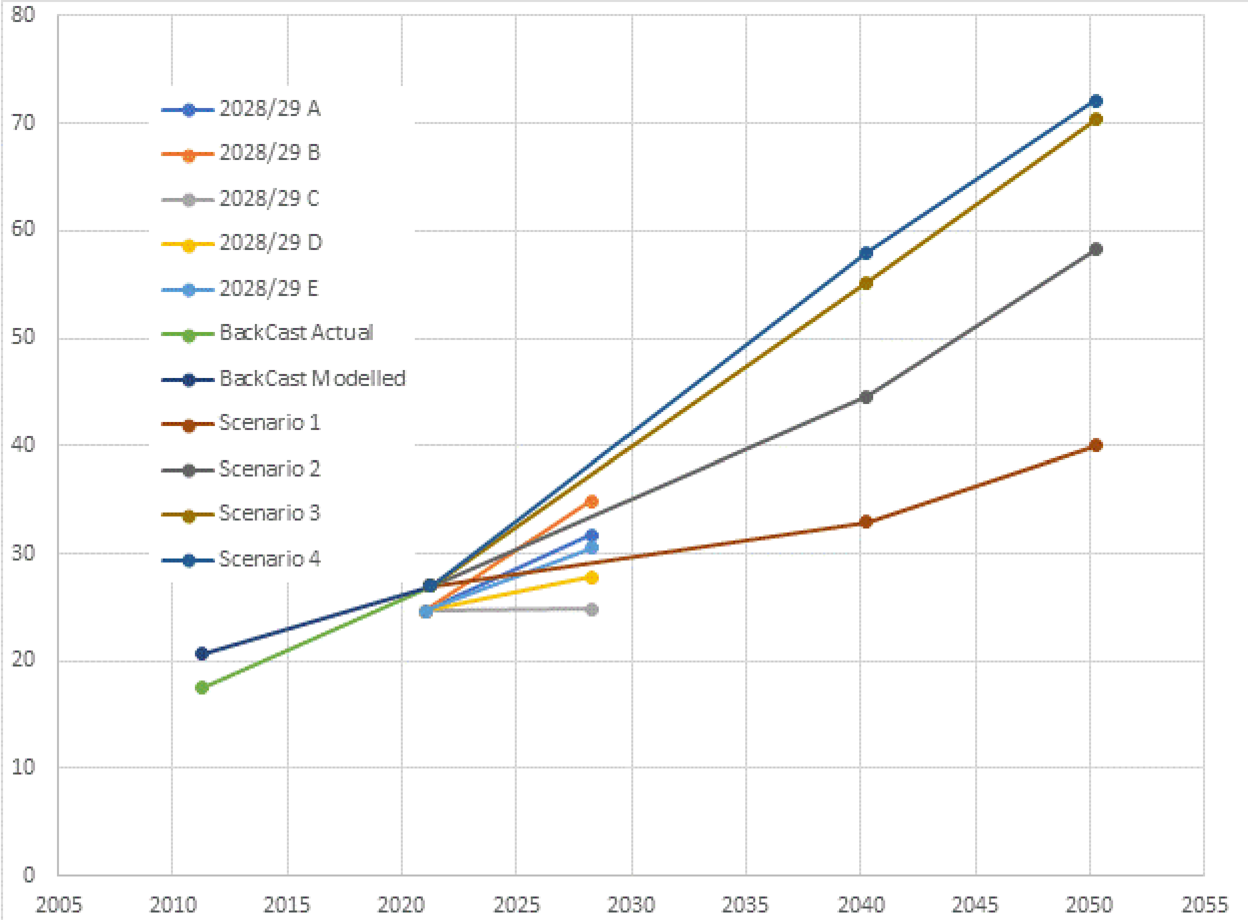
The latest forecasts show similar modest growth for scenarios 1 & 2. However scenarios 3 and 4 show much more significant growth as there is a major shift from ferry and Eurotunnel shuttle to Channel Tunnel through-rail and Piggyback, as the Channel Tunnel captures around 20% of the cross channel non-bulk market.

10.4.5. Construction materials

For 2028/29, construction materials were modelled relatively simply. There was overall market growth, plus some specific extra marine-sourced sand and gravel traffics, plus a mode share component based on changes in cost as reported by GBFM.

For the latest 2040/41 and 2050/51 forecasts, a new approach was developed that incorporated exogenous 2035 forecasts of the market by type (Crushed Rock, Land-won Sand & Gravel, Marine Sand & Gravel, Recycled & Secondaries) produced by the Mineral Products Association, applied to a region to region by type origin-destination matrix. It was then subjected to mode share scale factors based on changes in cost as reported by GBFM.

Figure 24: Comparison of latest forecasts with earlier forecasts for 2028/29 tonnes. Construction materials. Million tonnes per year



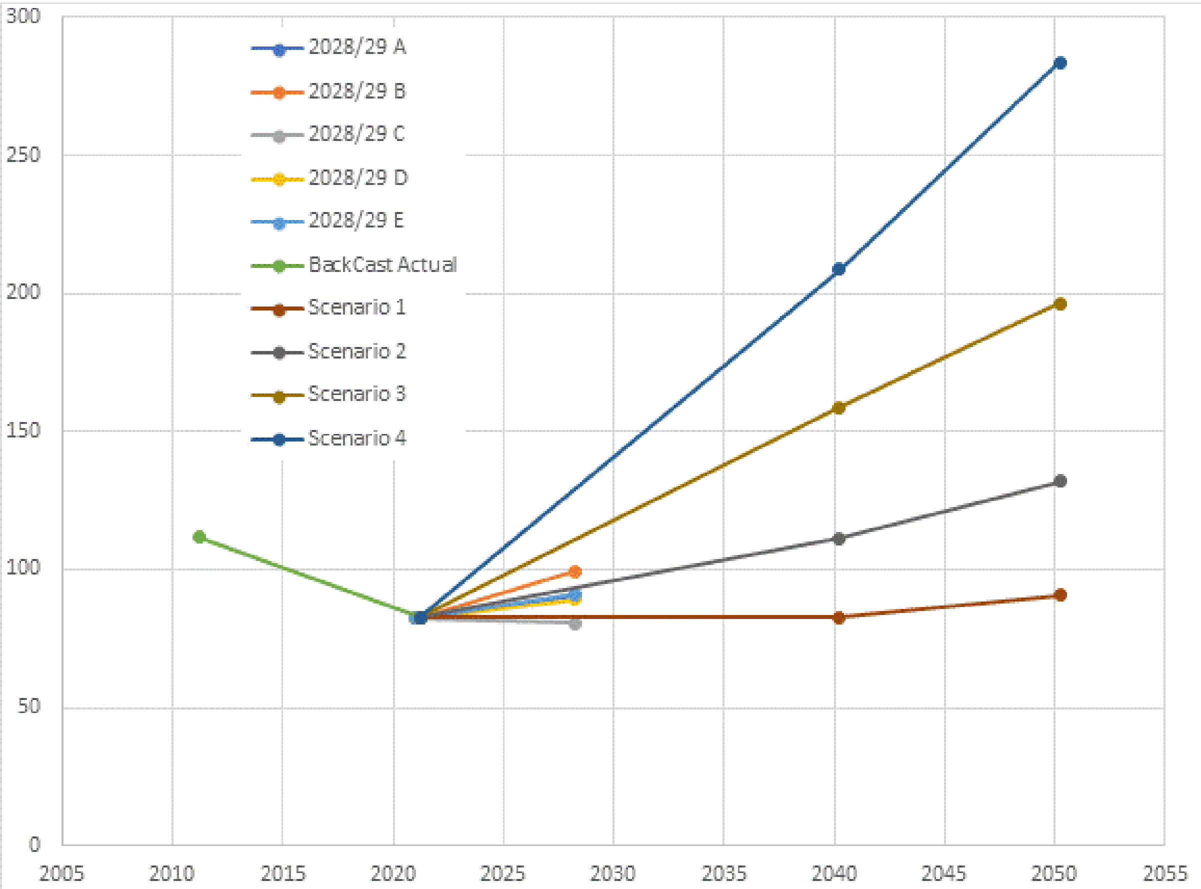
There appears to be a notable difference between the 2021 base year for the 2028/29 forecasts and the 2021/22 base year for the latest 2040/41 and 2050/51 forecasts. This is due to a change in categorisation; which commodities are grouped into “Construction”. For the latest forecasts, Spoil (waste), Timber and Sugarstone are now included in Construction. The actual change in Construction materials tonnages from 2021 to 2021/22 is very small.

The 2028/29 forecasts showed a variety of growth rates. The latest forecasts show a similar spectrum of growth rates.

10.4.6. Comparison of results for total traffic

For 2028/2029, several of the non-core commodities did have mode share changes applied to them. However in the latest forecasts, commodities other than intermodal containers and construction, had simple assumptions applied affecting all traffic in that commodity, or were assumed to remain constant.

Figure 25: Comparison of latest forecasts with earlier forecasts for 2028/29 tonnes. All commodities. Million tonnes per year



The most significant change in the last 10 years has been the loss of 40 million tonnes of coal travelling by rail. That has partly been mitigated with a switch to biomass, along with growth in the construction sector.

The overall growth rates for the various 2028/29 scenarios are broadly in line with the latest Scenarios 1 & 2. Scenarios 3 and 4 show higher growth than the 2028/29 scenarios.

11. CONCLUSION

This report describes the forecasting process and results for unconstrained long-term rail freight forecasts using the GB Freight Model (GBFM).

Four scenarios were agreed for 2021/22-based 2040/41 and 2050/51 forecasts, with each having a theme:

- Scenario 1: A road-reliant scenario where policy and investment choices favour road over rail
- Scenario 2: A TAG-compliant scenario which broadly reflects Business-As-Usual
- Scenario 3: A scenario where the rail infrastructure manager autonomously takes decisions to support rail freight
- Scenario 4: A Pro-rail scenario where policy and investment choices favour rail over road

11.1. Summary results

Table 24 summarises the forecasts for each scenario.

Table 24: Unconstrained rail freight demand forecasts by scenario. Tonnes, tonne kms and trains per weekday

	Thousand Tonnes	Million Tonne kms	Trains per weekday
Base year 2021/22	82,830	18,181	465
2040/41 Sc1	82,709	20,394	574
2040/41 Sc2	111,253	26,520	644
2040/41 Sc3	158,844	39,888	887
2040/41 Sc4	208,698	58,567	1,206
2050/51 Sc1	90,705	22,579	630
2050/51 Sc2	131,810	32,314	766
2050/51 Sc3	196,462	51,242	1,108
2050/51 Sc4	283,789	80,179	1,676

These forecasts show a wide range of possible overall outcomes for the rail freight market – from broadly constant to a significant growth. In the higher-growth scenarios, the key findings are large increases in intermodal traffic (domestic, to-and-from the ports, and Channel Tunnel) and construction materials. These are counterbalanced by the end of the movement of carbon fuels by rail (coal and petroleum).

The key drivers of intermodal growth, particularly in scenarios 3 and 4 are:

- General market growth, particularly trade growth
- Building large warehousing developments with on-site rail terminals, and other intermodal terminals
- Cost changes affecting road vs rail competition, particularly:
    - Drivers' wages increasing

    - Fuel price increases
    - Road pricing introduced (scenario 4)
    - More efficient rail industry
- The reduction in the Channel Tunnel toll.

For construction materials, the main drivers of growth are:

- The switch from locally sourced aggregates by road, to sourcing from rail-served super-quarries and marine-dredged sand and gravel to rail-served ports.
- General growth in the market
- Cost changes affecting road vs rail competition as per intermodal

11.2. Limitations

These forecasts are focussed on the core markets of intermodal and construction materials because they are the largest markets with likely significant future growth. Generic assumptions on decline are made for the movement of carbon-based fuels. However there are other smaller (non-core) rail freight sectors that we have not modelled for which our assumption of stability may not be appropriate.

The models implicitly assume that the market has fully adapted to the prices it experiences. However it can take time for market conditions to fully feed through to behaviour, particularly for long term decisions if there is uncertainty over future conditions. For example, developers of rail-served warehousing may not wish to invest if there is uncertainty over available capacity for the trains they would wish to run.

Every model is limited in its scope. There are many things that can change in the real world that are either not incorporated into the assumptions or are not modellable given the functionality of the models used. Covid is one such example.

APPENDIX 1. GENERAL ASSUMPTIONS; CHANGES FROM BASE YEAR (2021/22) TO 2040/41 AND 2050/51

The table below describes the general assumptions for the 4 scenarios referred to in section 3. The variables that are changed are separated out into those affecting road, those affecting rail and those affecting the market.

Table A1.1: General assumptions; Changes from base year (2021/22) to 2040/41 and 2050/51

		Yr	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Backcast 2011/12 from 2021/22
	Theme		**Road-reliant**	**TAG-compliant; Central**	**GBRTT invests**	**Pro-rail**	
Road	**HGV and rail drivers' wages**	40	+20.4%	+30.4%	+40.4%	+40.4%	-10.5%
		50	+39.1%	+49.1%	+59.1%	+59.1%	
			TAG -10%	TAG	TAG + 10%	TAG + 10%	
			Cheaper in 1st scenario. Potential causes: Greater availability of HGV drivers from overseas, Autonomous vehicles, or Reduced drivers regulations				
			More expensive in 3rd and 4th scenarios. Potential causes: Shortage of HGV drivers, or Increased drivers regulations				
			Source: DfT TAG Data book. January 2023 v1.20.2. Table A.1.3.2.				
	HGV tractor lease costs compared to existing diesel	40	Unchanged	15% higher	15% higher	15% higher	Unchanged
		50	Unchanged	Double the price	Double the price	Double the price	
			All new heavy goods vehicles in the UK will be zero-emission by 2040 (Source: UK Govt). In 2040, the vast majority on the roads could still be diesel, but by 2050, the vast majority will be zero-emission				
			Our long term (2050) assumption for the different scenarios is for battery electric (or other zero-emission) HGV tractors to cost either the same or double, so 2040 is one step in that direction. Currently they cost around 3X as much as diesels				
	Road congestion	40	Road journey times 2.1% longer	Road journey times 2.1% longer	Road journey times 4.3% longer	Road journey times 4.3% longer	Unchanged
		50	Road journey times 3.1% longer	Road journey times 3.1% longer	Road journey times 7.4% longer	Road journey times 7.4% longer	
			Source: National-road-transport-projections 2022. Core scenario for Sc1 & Sc2. High economy for Sc3 & Sc4				
	Road pricing		None	None	None	Covers non-user costs (e.g. road congestion)	None
			Source from Mode Shift Benefits (MSBs), but exclude Greenhouse gases and Air quality				
			January 2022: https://www.gov.uk/government/publications/freight-mode-shift-benefit-values-technical-report-an-update/mode-shift-benefit-values-update)				
	Fuel duty for road	40	+4.0%	Same as Sc1	Same as Sc1	Same as Sc1	+24.4%
		50	+1.0%	Same as Sc1	Same as Sc1	Same as Sc1	

			Source: DfT TAG Data book. January 2023 v1.20.2. Table A.1.3.7				
	Diesel resource cost	40	+27.1%	Same as Sc1	Same as Sc1	Same as Sc1	+13.6%
		50	+27.1%	Same as Sc1	Same as Sc1	Same as Sc1	
			Source: DfT TAG Data book. January 2023 v1.20.2. Table A.1.3.7				
	Electricity costs for road & rail		Equivalent to diesel per km				
Rail	**Fuel duty for rail**	40	-4.5%	-4.5%	-14.5%	-4.5%	+24.4%
		50	-7.3%	-7.3%	-17.3%	-7.3%	
			TAG	TAG	TAG -10%	TAG	
			Source: DfT TAG Data book. January 2023 v1.20.2. Table A.1.3.7				
	Variable Usage Charge		As per 2028/29 Central forecasts: Changes as planned by ORR up to 2028/29 to cover long run marginal costs of damage caused to the track, and then no change in subsequent years. All scenarios				Intermodal -1.5%. NON-Intermodal -22.7%
	Freight Specific Charge		Apply ESI Coal FSC (2023/24) to all bulks	As per 2028/29 Central forecasts: Changes as planned by ORR up to 2023/24 and then no change			Zero
	Tonnes per train		10% decrease	No change	5% increase	5% increase	No change
			Apply as a proxy for train length.				
	Operational hours per week		5% decrease	No change	5% increase	5% increase	No change
	End-to-end journey times		10% worse	No change	10% improvement	10% improvement	No change
	Wagon lease costs		No change	No change	20% reduction	No change	No change
	Loading Gauge		Assume loading gauge is W8 or better to allow 9ft 6inch (standard ISO) containers to run on lowliner wagons to all intermodal terminals				
			If loading gauge to an intermodal terminal is below W8 such that more expensive well-wagons are required, the FOC would be compensated by GBRTT for the extra cost				
	Electrification		No impact on relative cost to FOC operation (road vs rail), so no need to choose where it happens. Alternative (not overhead electric) zero-carbon locos assumed to cost the same as current diesels overall				
Market growth	**Real GDP**	40	+37.5%	+37.5%	+64.9%	+64.9%	-13.5%
		50	+57.0%	+57.0%	+108.4%	+108.4%	
			Source: Sc1 & Sc2: DfT TAG Data book. January 2023 v1.20.2. Table "Annual Parameters". Sc3 & Sc4: DfT's Common Analytical Scenarios: "High Economy"				
	Population	40	+2.5%	+2.5%	+11.4%	+11.4%	-6.1%
		50	+2.3%	+2.3%	+17.6%	+17.6%	
			Source: Sc1 & Sc2: DfT TAG Data book. January 2023 v1.20.2. Table "Annual Parameters". Sc3 & Sc4: DfT's Common Analytical Scenarios: "High Economy"				
	Deep-sea unitised trade growth – for maritime containers	40	+49.2%	Same as Sc1	Same as Sc1	Same as Sc1	-9.4%
		50	+73.8%	Same as Sc1	Same as Sc1	Same as Sc1	
			Source: MDST World Cargo Database. See section A1.2				
	Container port capacity growth for deep sea containers		Liverpool to be fully utilised. London Gateway to be fully built out (6 berths) and utilised. Any remaining growth to be applied to all deep sea ports with a blanket growth rate				

	European unitised trade growth (for short sea (European) trade including Channel Tunnel containers)	40	+35.3%	Same as Sc1	Same as Sc1	Same as Sc1	-13.2%
		50	+52.5%	Same as Sc1	Same as Sc1	Same as Sc1	
			Source: MDST World Cargo Database. See section A1.2				
	Domestic non-bulk traffic market growth	40	+20.0%	+20.0%	+38.2%	+38.2%	-9.8%
		50	+29.6%	+29.6%	+63.0%	+63.0%	
			Average of GDP and Population growth.				
Commodity specific	**Power station (ESI) coal**		Zero	Same as Sc1	Same as Sc1	Same as Sc1	Not included
	Biomass		Zero	Remain constant	Remain constant	Remain constant	Not included
	Construction materials market growth		See below for detailed construction materials assumptions				
			It is unknown where the major projects will be in 2040/41 and 2050/51				
	Petroleum	40	Down 60%	Same as Sc1	Same as Sc1	Same as Sc1	Not included
		50	Zero	Same as Sc1	Same as Sc1	Same as Sc1	
	Other Coal		Zero Other Coal in 2050/51. Leave unchanged in 2040/41				Not included
	Chemicals, Industrial Minerals, Metals, Automotive		Non-core. Assume same rail traffic as base year for all scenarios				Not included
	Waste, Ore, Other and Network Rail Engineering		Non-core. Assume same rail traffic as base year for all scenarios				Not included
	Channel Tunnel		No change	No change	Channel Tunnel toll halved	Channel Tunnel toll halved	No change
					Introduce Piggyback to Barking	Introduce Piggyback to Barking	No piggyback
			Trade growth and changes in road vs rail costs will also impact on Channel Tunnel traffics				
	Light logistics / express freight and Royal Mail		DIRFT extra	DIRFT extra	DIRFT + Doncaster extra	DIRFT + Doncaster extra	Not included
			DIRFT: as per 2028/29 forecasts				

Notes:

- Year: “40” = 2040/41. “50” = 2050/51.

“TAG” = Transport Analysis Guidance, from the DfT

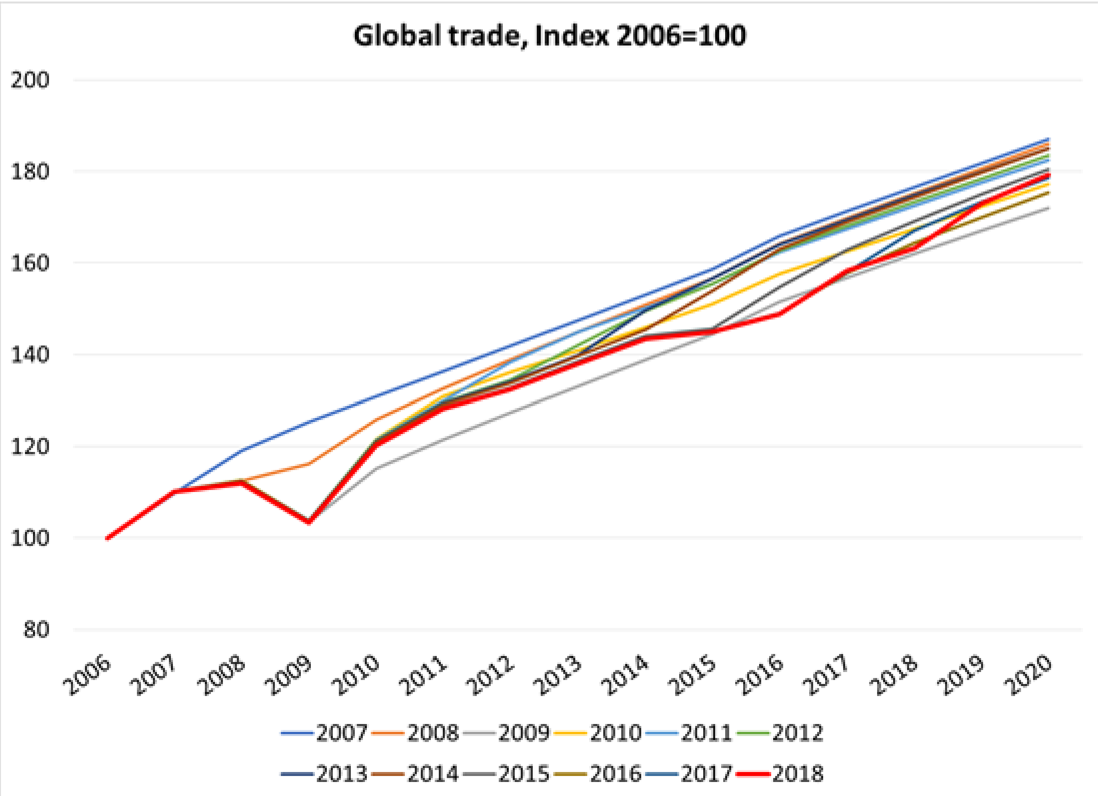
A1.2. World Cargo Database (WCD)

The main purpose of our World Cargo Database (WCD) is to be able to provide forecasts of world trade on a country to country by commodity basis for each future quarter-year. These are based on observing past trends in trade by origin country, destination country and commodity. The trends are forecast to continue into the future, with near-future forecasts much more focussed on recent trends, and long term forecasts based on long term trends. This is achieved by weighting historical data based on how recent it is, with the extent of the weighting determined by the forecast quarter-year required. To calculate the trend for a very-near-future forecast, recent historical data will be weighted very highly, with older data having a low weighting. For a very distant future year, all historic data would be weighted equally, with a standard least-squares trend used. As we move from calculating near future forecasts to longer term forecasts, the weighting of very recent history gradually reduces and the influence of the long term trend is increased.

Overall world trade for each commodity in total is forecast in a similar way and constrains the whole world market forecast for that commodity.

Figure A1.1 shows some validation of WCD results by considering several forecasts of worldwide maritime container TEU. For each year from 2007 to 2018, a WCD forecast up to 2020 was made with the data available in that year. The thick red line (forecasts made in 2018) shows the actual trade up to 2018 (with 2 years of forecast beyond that up to 2020). The forecast lines made in each year do diverge from the actual traffic but it can be seen visually that most of the forecasts made have matched actual traffics reasonably well, and that the linear growth of trade appears to be broadly realistic.

Figure A1.1: Global WCD forecasts made in each year from 2007 to 2018 (maritime container TEU)



MDS Transmodal

In reality there are many variables that affect trade that are not represented in WCD such that actual traffics do not necessarily follow trend. If projections of such events can be made and their likely impact translated into changes in trade patterns, these could potentially be manually incorporated into the WCD inputs.

The WCD outputs used were generated on 23rd March 2023 and include trade data up to the end of 2022. There was a downturn in freight in the first lockdown (Spring 2020). However there was subsequently a good recovery in mid-to-late 2020. Again this is incorporated into the historical data from which WCD forecasts are made.

Forecasts are “straight-line” rather than exponential. For example if the growth trend was for +100 tonnes per year and the 2022 tonnage was 10,000 tonnes, WCD would continue to add 100 tonnes each future year rather than 1% compound each year. Back engineering of forecasts using WCD suggests such a straight line approach reflects actual outcomes.

WCD-based trade scale factors from 2021/22 to each future year are applied to the 2021/22 trade data in the model for deep-sea unitised trade and European unitised trade.

WCD was also used for the 2028/29 Central forecasts produced in 2022.

APPENDIX 2. NEW AND EXPANDED RAIL-SERVED WAREHOUSING AND INTERMODAL TERMINALS

The table below describes the assumptions for each scenario in terms of the square meters of warehousing at each rail-served site.

Table A2.1: Assumed warehousing at each rail-served site. Thousand square metres

	Base year	2040/41				2050/51			
Site	**2021/22**	**Sc1**	**Sc2**	**Sc3**	**Sc4**	**Sc1**	**Sc2**	**Sc3**	**Sc4**
London Gateway Logistics Park	116	756	756	756	1,216	756	756	1,061	1,764
Radlett	-	-	331	331	532	-	331	465	772
DIRFT	522	1,222	1,222	1,222	1,965	1,222	1,222	1,715	2,852
Northampton Gateway	-	468	468	468	753	468	468	657	1,092
East Midlands Gateway	433	555	555	555	893	555	555	779	1,295
East Midlands Distrib Centre	143	143	223	223	359	143	223	313	520
East Midlands Intermodal Park	-	-	485	485	780	-	485	681	1,132
Hinckley SRFI	-	-	650	650	1,045	-	650	912	1,517
West Midlands Interchange	-	743	743	743	1,195	743	743	1,043	1,734
Birch Coppice	406	445	445	445	716	445	445	625	1,039
Oxfordshire SRFI	-	-	600	600	965	-	600	842	1,400
Doncaster iPort	230	373	373	568	914	373	373	798	1,327
3MG (Ditton)	74	119	119	181	292	119	119	255	423
Port Salford or Parkside	25	25	470	716	1,152	25	470	1,005	1,672
Port Warrington	-	-	205	312	502	-	205	438	729
Teesport	121	121	571	870	1,399	121	571	1,221	2,031
Mossend IRFP	-	-	200	305	490	-	200	428	711
Port of Grangemouth	86	86	286	436	701	86	286	612	1,017
Wakefield	330	330	330	503	809	330	330	706	1,174
Hams Hall	374	374	374	374	601	374	374	525	873
Llanwern	-	-	-	200	322	-	-	281	467
Avonmouth	-	-	-	300	482	-	-	421	700
Spalding	-	-	-	500	804	-	-	702	1,167
Huncoat	-	-	-	200	322	-	-	281	467
Total	**2,860**	**5,760**	**9,406**	**11,944**	**19,208**	**5,760**	**9,406**	**16,763**	**27,875**

Narrative:

- Scenario 2: Assume the sites assumed in the 2028/29 rail freight forecasts get fully built out, but no further development. Existing sites are renewed if they life-expire. This equates to 23% of new-build warehousing being rail-served in 2040/41, and just 17% in 2050/51 because no further growth is assumed after 2040/41
- Scenario 1: As scenario 2, but those sites that are at an earlier stage of the development process are assumed to not be built.
- Scenario 3: Scenario 2 has 23% of new-build warehousing being rail-served in 2040/41. Scenario 3 boosts this to 30%. Compared to all existing large warehousing, Scenario 2 has a higher proportion in the Midlands and South East (including London Gateway). Likely new sites in other regions are added to redress the balance - at Llanwern, Avonmouth, Spalding (representing East of England even though it is over the border in Lincolnshire) and Huncoat (North Lancashire). Scenario 2 sites outside of the Midlands and South East are then scaled up (X 1.52) to achieve the overall 30% target. 2050/51 maintains the 30% target; All sites grow from 2040/41 to 2050/51 by X 1.40 to achieve this target
- Scenario 4: Instead of the 30% target for Scenario 3, the Scenario 4 target is 50%. All sites are scaled up from their Scenario 3 2040/41 warehousing areas to achieve this target in 2040/41 (Scenario 3 2040/41 X 1.61) and 2050/51 (Scenario 4 2040/41 X 1.45)
- For the high rail-served warehousing scenarios (e.g. Scenario 4 2050/51), the capacities of the named sites are exceeded, so the warehousing are assumed to be built at nearby equivalent sites, or the named sites would have to be expanded

11.2.1. New intermodal terminals

As well as new intermodal terminals associated with on-site warehousing, there are plans to build other intermodal terminals without on-site warehousing.

In scenarios 1 and 2, we do not include such terminals. However in scenarios 3 and 4, we assume the following terminals are built and attract intermodal container services:

Table A2.2: Additional intermodal container terminals without on-site warehousing in scenarios 3 & 4

Intermodal Container terminal name
Ripple Lane
Hull Docks
Immingham Docks
Telford
Salfords (North of Gatwick Airport)
Port Talbot
St Austell
Exeter Riverside
Sunderland Port
Tyne Dock
Theale
Elton (Ellesmere Port)
Buxton
Holyhead Port

There were several inputs to the decision of which new intermodal terminals should be built, with or without on-site warehousing. A long-list (informed by MDST market intelligence, RFGT Call for Evidence responses, and GBRTT's Market Development) was condensed to a credible list of potential future sites.

The forecast traffic demand outputs from the modelling are unconstrained by capacity, so the traffic allocated to each of these sites may in many cases exceed the planned capacity. This applies to both existing and proposed sites.

Figure A2.1: Existing and planned intermodal terminals, shown separately for those with on-site warehousing and those without.

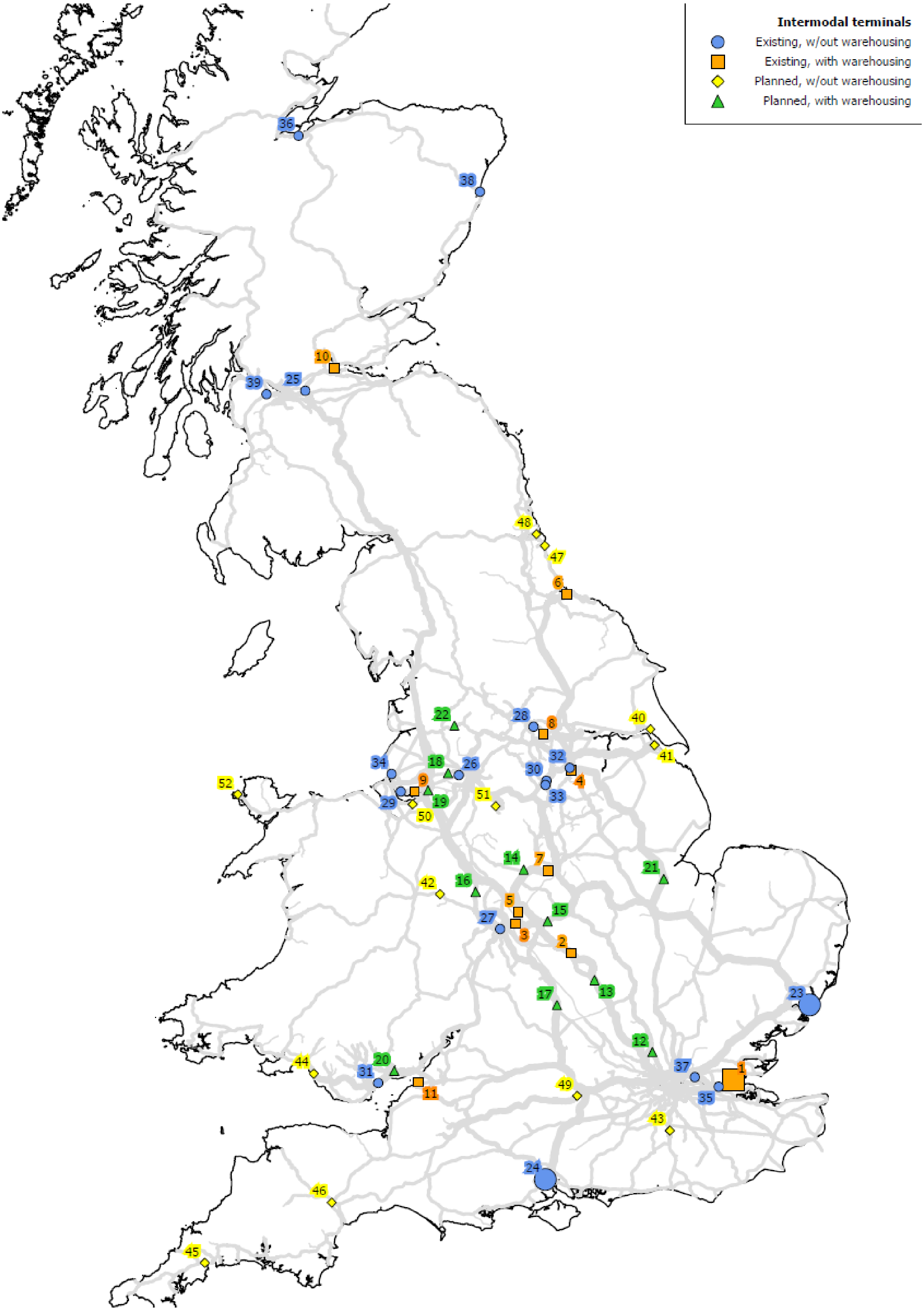


Table A2.3: Intermodal terminals

Number	Name	Type
1	London Gateway	Existing, with warehousing
2	Daventry	Existing, with warehousing
3	Hams Hall	Existing, with warehousing
4	Doncaster iPort	Existing, with warehousing
5	Birch Coppice	Existing, with warehousing
6	Teesport	Existing, with warehousing
7	East Mids Gateway	Existing, with warehousing
8	Wakefield	Existing, with warehousing
9	Ditton (3MG)	Existing, with warehousing
10	Grangemouth	Existing, with warehousing
11	Avonmouth / Bristol	Existing, with warehousing
12	Radlett	Planned, with warehousing
13	Northampton Gateway	Planned, with warehousing
14	East Midlands Intermodal Park	Planned, with warehousing
15	Hinckley SRFI	Planned, with warehousing
16	West Midlands Interchange	Planned, with warehousing
17	Oxfordshire SRFI	Planned, with warehousing
18	Port Salford or Parkside	Planned, with warehousing
19	Port Warrington	Planned, with warehousing
20	Llanwern	Planned, with warehousing
21	Spalding	Planned, with warehousing
22	Huncoat	Planned, with warehousing
23	Felixstowe	Existing, without warehousing
24	Southampton	Existing, without warehousing
25	Coatbridge / Mossend	Existing, without warehousing
26	Trafford Park	Existing, without warehousing
27	Lawley St	Existing, without warehousing
28	Leeds	Existing, without warehousing
29	Garston	Existing, without warehousing
30	Masborough	Existing, without warehousing
31	Wentloog	Existing, without warehousing
32	Doncaster	Existing, without warehousing
33	Tinsley	Existing, without warehousing
34	Seaforth	Existing, without warehousing
35	Tilbury	Existing, without warehousing
36	Inverness	Existing, without warehousing
37	Ripple Lane	Existing, without warehousing
38	Aberdeen	Existing, without warehousing
39	Elderslie	Existing, without warehousing
40	Hull Docks	Planned, without warehousing
41	Immingham Docks	Planned, without warehousing
42	Telford	Planned, without warehousing
43	Salfords	Planned, without warehousing
44	Port Talbot	Planned, without warehousing
45	St Austell	Planned, without warehousing
46	Exeter Riverside	Planned, without warehousing
47	Sunderland Port	Planned, without warehousing
48	Tyne Dock	Planned, without warehousing
49	Theale	Planned, without warehousing
50	Elton	Planned, without warehousing
51	Buxton	Planned, without warehousing
52	Holyhead Port	Planned, without warehousing

APPENDIX 3. 2021 ESTIMATED ORIGIN TO DESTINATION MATRIX OF AGGREGATES BY SOURCE TYPE

The table below shows the 2021 Origin to Destination matrix of aggregates by source type, not including recycled and secondaries; 2019 AMS scaled to 2021 MPA national totals referred to in section 5.2.

Table A3.1: 2021 Origin to Destination matrix of aggregates by source type, not including recycled and secondaries. 2019 AMS scaled to 2021 MPA national totals. Thousand tonnes

	E Mids	E of E	Lond	NE	N Wal	N West	Scot	SE	S Wal	S West	W Mids	Y&H	Total
Crushed Rock	**17,759**	**8,816**	**3,411**	**6,136**	**2,969**	**12,962**	**21,135**	**6,417**	**7,587**	**19,240**	**8,583**	**10,984**	**126,000**
E Mids	16,454	4,133	901	8	11	3,604	6	1,112	3	161	2,996	2,072	31,462
E of E	2	91	8	-	-	-	-	12	-	-	-	-	112
London	-	-	-	-	-	-	-	-	-	-	-	-	-
NE	25	15	-	5,516	-	91	2	3	-	-	1	199	5,852
N Wal	-	41	2	-	2,895	1,232	-	35	616	-	11	-	4,831
N West	67	-	-	88	-	6,675	37	-	-	-	-	108	6,975
Scot	-	432	539	108	-	108	21,079	432	-	-	-	-	22,697
SE	104	19	27	-	-	-	-	1,949	-	11	76	-	2,186
S Wal	35	102	113	4	54	166	-	84	6,790	451	1,135	28	8,963
S West	9	3,821	1,762	-	-	-	-	2,701	167	18,584	273	-	27,317
W Mids	628	56	59	1	10	334	1	60	11	33	4,091	23	5,308
Y&H	436	106	-	411	-	752	10	28	-	-	1	8,554	10,297
Land-won Sand & Gravel	**5,863**	**9,747**	**971**	**1,060**	**523**	**2,393**	**4,853**	**6,088**	**179**	**2,713**	**5,931**	**2,680**	**43,000**
E Mids	4,962	584	3	-	1	2	-	140	-	1	403	499	6,596
E of E	328	9,002	302	-	-	-	-	378	-	12	34	1	10,057
London	-	-	443	-	-	-	-	-	-	-	-	-	443
NE	35	-	-	787	-	8	1	-	-	-	-	277	1,108
N Wal	-	-	-	-	491	400	-	-	-	-	43	-	934
N West	8	-	-	75	23	1,925	4	-	-	-	32	22	2,089
Scot	-	-	-	-	-	-	4,828	-	-	-	-	-	4,828
SE	4	154	222	-	-	10	-	5,313	1	183	5	-	5,892
S Wal	-	-	-	-	-	-	-	-	169	-	-	-	169
S West	-	-	-	-	-	-	-	216	6	2,430	27	-	2,678
W Mids	503	1	-	-	7	41	-	41	4	87	5,362	1	6,048
Y&H	23	6	-	198	-	7	21	-	-	-	25	1,879	2,158
Marine Sand & Gravel	**-**	**2,228**	**2,819**	**728**	**37**	**109**	**-**	**6,662**	**699**	**665**	**4**	**49**	**14,000**
E Mids	-	-	-	-	-	-	-	-	-	-	-	-	-
E of E	-	413	17	-	-	-	-	1	-	-	-	-	431
London	-	1,788	2,587	-	-	-	-	828	-	-	-	-	5,202
NE	-	-	-	728	-	-	-	-	-	-	-	49	777
N Wal	-	-	-	-	27	-	-	-	-	-	-	-	27
N West	-	-	-	-	10	109	-	-	-	-	-	-	119
Scot	-	-	-	-	-	-	-	-	-	-	-	-	-
SE	-	28	215	-	-	-	-	5,757	-	7	-	-	6,007
S Wal	-	-	-	-	-	-	-	50	695	1	-	-	746
S West	-	-	-	-	-	-	-	26	4	657	4	-	690
W Mids	-	-	-	-	-	-	-	-	-	-	-	-	-
Y&H	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**23,621**	**20,792**	**7,201**	**7,924**	**3,529**	**15,464**	**25,988**	**19,166**	**8,465**	**22,618**	**14,518**	**13,713**	**183,000**

APPENDIX 4. LIGHT LOGISTICS / EXPRESS FREIGHT

This market is in its infancy, will be subject to change and is uncertain. We have done the best we can to appropriately represent and quantify an expansion of operations similar to today, but nothing should preclude changes for future forecasts as the sector develops.

There has been considerable interest in the development of express freight services by rail in recent years. However, no clear model has yet to develop as to how these opportunities will be realised. From a modelling perspective this raises different issues as compared with the remainder of this study in that the only existing such traffic is that carried by Royal Mail between just four dedicated depots as part of an entirely 'in-house' door to door business so that modelling through incremental cost changes is not really possible.

We have therefore taken a more fundamental approach and considered the cost effectiveness that such services could offer, still using more or less the same cost models as to analyse other freight markets, using the cost structures used for other cargo within this modelling for the sake of good order and consistency.

We have not considered the 'courier' service market whereby urgent parcels are carried on and off passenger trains, such as are offered by 'Inter City Rail Freight', as these do not generate additional trains on the network.

The Continuing Survey of Road Goods Transport identified a mean of 4.82m HGV movements p.a. carrying mail and parcels corresponding to 39.23m tonnes of goods between the years 2015 and 2018, which equates to 8.14 tonnes per vehicle movement.

If the relationship is used as the cost comparator to assess rail viability for long distance transport then we can conclude that if there is no incremental handling or collection and delivery costs then (for the truck haul) rail can be cheaper than road and for specific flows faster (but probably not more frequent). However, any additional handling costs render rail more expensive at more or less any distance.

Several modes of operation appear to be under consideration.

One is to operate converted EMUs that are very similar to the train sets already operated by Royal Mail. 'Dry runs' have been operated into passenger railway stations (i.e. Euston) with a view to operating from large rail linked distribution parks. This implies an immediate transfer of goods to small vans (presumably electric to minimise emissions) or even cycles although it is important to recognise that the volume arriving in a single train would equate to large numbers of light road vans (100-150), which could itself create logistical challenges given the absence of storage capacity at such locations. Such activity may only be practical overnight when, in any event, roads are uncongested and few receiving premises could receive goods. A more practical variation could be using EMUs at the 'country end' of trains arriving into London termini from the Golden Triangle and joining shorter off-peak trains to share paths from, say, Milton Keynes or Bedford etc.. This provides a competitive daytime frequency for office deliveries, servicing restaurants and sandwich bars and convenience stores.

This does not address the challenge of platforms heights being lower than rail vehicle floor decks which would render the use of roll cages difficult. It would also require trains to discharge and reload very rapidly if passenger train asset and station platform utilisation is to be acceptable. While using passenger stations might just be viable where goods can be loaded directly to 'conventional' trains, by comparison with using road haulage (HGVs) from distribution centres that do not include internal tracks, rail does not currently appear to be viable. This is because double handling of goods at the parcel level would be required between existing parcel company sheds and rail served sheds, even where both sheds are on the same rail linked distribution park.

In all these circumstances the investment by Royal Mail in an 80,000m2 shed at DIRFT, if open to third parties, may represent a model that could be viable, particularly if tracks were under cover so that forklift trucks could serve trains directly. Given the storage, racking and the way the building is equipped, we shall assume this corresponds to a building with the ability to store 80,000m3 of goods, which would equate to the capacity of 800 high capacity HGV trailers.

Royal Mail has indicated that its terminal will be available to independent operators currently planning to enter the light logistics and parcels market. The shed is also expected to permit the transfer of air freight between southern Britain and Scotland from air (via East Midlands Airport) to rail, adding a further estimated 30,000 tonnes p.a..

That is, established parcels companies will enjoy a choice of train service suppliers (and presumably depot space within other Royal Mail sheds) and are therefore much more likely to find rail freight commercially acceptable. Goods that are for delivery to regions for which a rail service is viable and available could be held at the large shed and loaded to rail for cross docking when required.

In this context it is important to note that a trial service operated between Royal Mail's existing rail connected depots at Shieldmuir (Glasgow) and Willesden, offering a 7.5 hour transit including a 30 minute stop at Royal Mail's depot at Warrington. These facilities will allow parcel companies to consolidate traffic adjacent to railway platforms and therefore eliminate double handling, effectively shifting the origin and destinations of goods to rail linked sites. In this respect, the Royal Mail sites will play the same role as intermodal terminals on rail linked sites in attracting warehouses to sites that render rail freight much more competitive than hitherto.

Rail freight growth in the parcels sector can therefore be anticipated as a result of the Royal Mail investment. The three sites along the West Coast Main Line at Shieldmuir, Warrington and Willesden offer a total of around 55,000m2 and could presumably operate as cross-docking facilities, allowing the facility at DIRFT to act as distribution centre by cargo owners where goods can be 'called off' as required by receivers. A fourth terminal is available at Low Fell (Gateshead) while a fifth site at Bristol Parkway could also be brought back into action. However, growth beyond the existing Royal Mail traffic will depend heavily on the extra space available at distribution parks such as at DIRFT, their capacity to hold goods and the range of rail services each will offer. As currently understood, no other new equivalent sites beyond that at DIRFT will be open in the near future.

Not all the goods held at such a site can be expected to use rail. The existing Royal Mail sheds, acting as cross-docking facilities, serve Greater London, the North West, Scotland and the North East. Taken together, these regions account for around 50% of non-intraregional mail and parcels traffic destinations in Great Britain.

The volume of rail freight that a building of finite size and capacity can support will depend upon the turnover of goods passing through it. Overall, large distribution centres may hold goods for an average of around one month (12 p.a.), but a facility of this type can expect a much faster turnover rate. Based upon a 350 day year, we shall assume a mean turnover rate of 75 p.a. for goods held on the site (4.67 days for each turn), which would imply a shed 'throughput' of 17,143 m3 goods per day (i.e. 80,000 m3/4.67 day turnover = 17,143m3). If 50% left by rail that would be 8,571m3 per day or 3.0m m3 of goods p.a. or 300,000 tonnes p.a., occupying 71 rail carriages per day departing.

Inbound traffic is less likely to be rail borne because much of it would be derived from Distribution Centres in the Midlands that are relatively local to a Golden Triangle site, and we shall assume only a 50% load factor for inbound trains (therefore 150,000 tonne p.a. inbound), making a total of approximately 0.45m tonnes of extra potential rail freight as a consequence of the new facility. Diverted air freight would add a further 0.03m tonnes raising total extra parcels traffic by rail to 0.48m tonnes. Added to our current estimate of 260,000 tonnes of current parcel traffic p.a. by rail this will produce a forecast volume of 0.74 tonnes of parcels traffic.

We adopt this figure for DIRFT for Scenarios 1 and 2.

Our conclusion is that further growth would depend upon more such 'rail sheds' as being developed at DIRFT being built.

For scenarios 3 and 4, we assume an equivalent site on the East Coast Main Line at Doncaster is developed, resulting in the same amount of extra traffic as DIRFT generates.