Station demand forecasts for Wales

Report to the Welsh Government

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1 Introduction

This report describes work undertaken to develop an enhanced station demand forecasting model for Wales, which builds on trip-end models previously developed in 2015[1]. In these earlier models the station catchment was defined by assigning the population of each census output area, weighted by a distance-decay function, to its nearest station by car travel time. This approach produces discrete non-overlapping catchments which implicitly assume that station choice is a deterministic process (anyone within a specific output area will always use the same station). However, analysis of passenger survey data has shown that station catchments are far more complex entities than this, with substantial overlapping of catchments and competition occurring between stations. This is evident even when zones of far higher spatial resolution are considered, such as unit-level postcodes that typically contain only 15 properties. The enhanced model seeks to address this weakness by incorporating a station choice element, enabling probability-based catchments to be defined. The key features of the enhanced model are as follows:

- It was calibrated for stations in the whole of GB, rather than just England and Wales
- Unit-level postcodes were used to define catchment zones rather than census output areas; providing a much higher spatial resolution to the population data (there are some 1.5 million postcodes covering GB, compared to less than 0.25 million output areas).

[1] Blainey, S. (2015). A new station demand forecasting model for Wales.(Unpublished working paper).

- For comparative purposes, two versions of the model have been calibrated. The first uses a simple catchment definition, where the population of each postcode is assigned to its nearest station. The second defines probability-based catchments by apportioning the population of each postcode to ten alternative stations, based on the estimated probability of each of those stations being chosen.

Although the incorporation of a station choice element should result in a more robust model, the forecasts produced by this type of model remain indicative, and are intended to provide a quick check of the likely viability of a proposed station at a particular site, rather than a detailed prediction of travel patterns following station opening. If the results indicate that a station on a particular site is likely to be viable then more detailed flow-level demand modelling should be carried out before a final decision on construction is taken.

The forecasts from the model do not take into account trip destination, the destinations served by a station, or atypical local factors such as sports stadia or tourist attractions whose demand impacts cannot be adequately represented in the model. The results should therefore be considered alongside expert knowledge of conditions relating to any particular station site.

2 Methodology

2.1 Station choice model

A multinomial logit model was calibrated using revealed preference data obtained from on-train passenger surveys carried out in Wales and Scotland during 2014 and 2015, using a combined dataset of 14,422 observations (choice situations). The unit-level postcode was taken as the trip origin, and the choice set was defined as the ten nearest stations by drive distance to each postcode. In this model the probability of individual n at origin i choosing station k from a choice set of K alternative stations, is given by the following formula:

$$Pr_{nik} = \frac{exp(N_k^{\beta} + \sqrt{D_{ik}}^{\gamma} + U_k^{\delta} + lnF_k^{\zeta} + C_k^{\eta} + P_k^{\iota} + T_k^{\kappa} + B_k^{\lambda} + lnA_k^{\mu})}{\sum_{k=1}^{K} exp(N_k^{\beta} + \sqrt{D_{ik}}^{\gamma} + U_k^{\delta} + lnF_k^{\zeta} + C_k^{\eta} + P_k^{\iota} + T_k^{\kappa} + B_k^{\lambda} + lnA_k^{\mu})}$$

where D is the access distance by road from origin i to station k; F is the daily service frequency at station k; P is the number of car parking spaces at station k; N, U, C, T and B are dummy variables that take the value of 1 if station i is the nearest station, unstaffed, has CCTV, has a ticket machine, or has a bus interchange respectively, and zero otherwise; A is a weighted accessibility term (see below) and $\beta, \gamma, \delta, \zeta, \eta, \iota, \kappa, \lambda$, and μ are parameters to be estimated.

The accessibility term is a measure of the proximity of each station to all the other stations within the same choice set, and takes the following form:

$$A_{ni} = \left(\frac{1}{M-1} \sum_{\substack{k \\ k \neq j}} \frac{W_k}{d_{jk}} \right)^{\theta}$$

where M is the total number of alternatives for individual n at origin i, W is a weighting variable for station k which is the number of trips typically expected at a station of that category (this is based on the Network Rail category thresholds), d is the distance from alternative j to alternative k and θ is a parameter to be estimated. As A increases, a station is closer to more ‘attractive’ alternative stations. The results of the calibration of this model are shown in Table 1. The negative parameter for the accessibility term indicates that there is a competition effect at play, and stations that are more isolated will have a higher probability of being chosen, all else being equal.

2.2 Trip-end models

Two model forms have been used to generate the station forecasts. The first uses simple (deterministic) catchments, where each postcode is assigned to its nearest station, and takes the following form:

Table 1: Station choice model used to define probabilistic station catchments.

	Dependent variable:
Nearest station (y/n)	0.691*** (0.038)
Sqrt(access distance)	−2.265*** (0.040)
Unstaffed (y/n)	−0.638*** (0.044)
ln(daily frequency)	1.214*** (0.035)
CCTV (y/n)	1.076*** (0.125)
Car park spaces (no.)	0.001*** (0.0001)
Ticket machine (y/n)	0.963*** (0.052)
Bus interchange (y/n)	0.731*** (0.056)
ln(accessibility term)	−0.141*** (0.044)
Observations	14,422
Note:	*p<0.1; **p<0.05; ***p<0.01
	Adjusted R-squared = 0.71
	AIC = 19309

$$ln\hat{V}_i = \alpha + \left(ln\sum_{z}^{Z} P_z w_z\right)^{\beta} + lnF_i^{\gamma} + lnT_i^{\delta} + lnJ_i^{\zeta} + lnPk_i^{\eta} + Te_i^{\kappa} + El_i^{\nu} + B_i^{\tau}$$

where V_i is the estimated annual passenger entries and exits for station i; P_z is the resident population of zone z; Z is all zones where the closest station by road distance is station i; w_z is a distance-based decay function; F_i is weekday train frequency at station i; T_i is distance in km from station i to the nearest Category A-D station; J_i is the number of jobs within one-minutes drive of station i, P_k is the number of parking spaces at station i; and Te_i, El_i and B_i are dummy variables that take the value of 1 if station i is a terminus station, served by electric trains or a travelcard boundary station respectively, and zero otherwise; and $\alpha, \beta, \gamma, \delta, \zeta, \eta, \kappa, \nu$, and τ are parameters to be estimated.

The second model form incorporates probabilistic station catchments, and takes the following form:

$$ln\hat{V}_i = \alpha + \left(ln\sum_{z}^{Z} Pr_z P_z w_z\right)^{\beta} + lnF_i^{\gamma} + lnJ_{it}^{\eta} + lnPk_i^{\eta} + Te_i^{\kappa} + El_i^{\nu} + B_i^{\tau}$$

where Pr_z is the probability of an individual located in zone z choosing station i; Z now consists of all zones which have station i within their choice set; and T_i has been removed. T_i was included in the first model form to try and capture potential competition effects of nearby large stations, something that should now be captured by the station choice component. In both models the zone is defined as the unit-level postcode.

The calibration dataset for both model forms consisted of Category E and F stations in England, Wales and Scotland. Stations with no weekday service, restricted public access, located on the Isle of Wight, or 'grouped' for ticketing purposes were excluded. The final calibration dataset consisted of 1792 stations.

In order to generate the station choice probabilities for the second model form (Pr_z), it was necessary to define a choice set for every unit-level postcode in GB, consisting of the ten nearest stations by road distance, and to then calculate the choice probabilities using the station choice model described in Section 2.1. The unit postcode represents the spatial level at which resident population will be weighted, both by the distance-based decay function and the calculated choice probabilities, before being allocated to each station in the trip-end model. Figure 1 illustrates how this process works for a single example postcode. The calibration results for both model forms are shown in Table 2.

2.3 Generating forecasts

A two-stage process was followed for each proposed station, first generating the station choice probabilities, and then applying the calibrated trip end model. These two stages are described in the sections below.

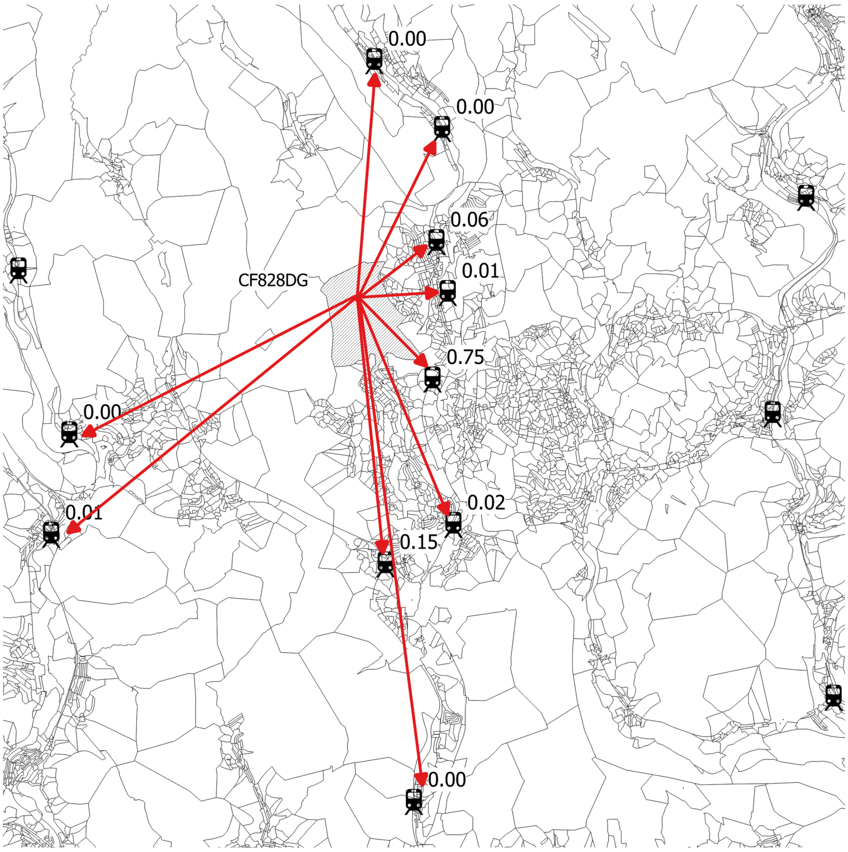

Figure 1: Illustration of the mechanism for defining a probability-based catchment, with the probability of each of 10 alternative stations being chosen assigned to a postcode

Table 2: Trip-end model forms used to generate demand forecast for new stations

	Dependent variable:	
	Deterministic model	Probabilistic model
Intercept	2.368*** (0.175)	3.654*** (0.095)
Distance weighted population	0.336*** (0.019)	
Prob. and dist. weighted population		0.373*** (0.018)
Daily frequency	1.362*** (0.028)	1.133*** (0.027)
Distance to Cat A-D station	0.210*** (0.024)	
Workplace population	0.057*** (0.007)	0.053*** (0.007)
Car park spaces	0.147*** (0.010)	0.128*** (0.009)
Electric services (y/n)	0.216*** (0.042)	0.244*** (0.041)
Travelcard boundary (y/n)	0.304*** (0.093)	0.297*** (0.091)
Terminus station (y/n)	0.857*** (0.085)	0.778*** (0.083)
Observations	1,792	1,792
Adjusted R^2	0.843	0.851
Note:		*p<0.1; **p<0.05; ***p<0.01

2.3.1 Calculating station choice probabilities

The unit postcodes within 60 minutes drive time of the proposed station were first identified using an ArcGIS service area analysis, with a road network based on the OS Open Roads dataset. This represents the set of postcodes from which it is feasible that the proposed station might be chosen, based on prior research that found 60 minutes to be the maximum access journey time in virtually all observed trips. Using the same road network, the nearest 10 stations to each of these unit postcodes by distance were then identified using an OD cost matrix analysis. This represents the limited choice set that it is assumed someone located in a particular unit postcode will choose from. Those unit postcodes where the proposed station was not present as one of the nearest 10 stations were then removed (it is assumed that these will not generate any demand), and the dataset was then written to a PostgreSQL database table (known as the 'probability table'). This table consists of ten rows for each postcode, one for each station in the choice set. The table was then populated with the variables required by the station choice model, and using a window function to group the rows by postcode, the probability of each station being chosen was then calculated using the estimated parameters from the calibrated station choice model.

2.3.2 Applying the trip-end models

The workplace population within one-minute's drive time of the proposed station, and the distance to the nearest Category A-D station, were obtained using ArcGIS. Other variables, for example service frequency and car parking spaces, were either provided by the Welsh Government or assumptions were made based on information contained in the Network Rail 'New Stations Assessment' report.

Using a SQL query, the population of each unit postcode, weighted by the distance-decay function and, for the probabilistic model, weighted by the probability of the proposed station being chosen, was obtained from the probability table and summed. This forms the population variable used in the trip-end model. The demand for the proposed station was then forecast using the estimated parameters from the calibrated trip-end models.

As the source of the postcode population data is the 2011 census (obtained from NOMIS and Scotland's Census), the number of station entries/exits in 2011/12 (obtained from the Office of Rail and Road) is used as the dependent variable in the trip end models. It is therefore necessary to apply an uplift to the demand forecasts, to reflect growth in rail travel over recent years. The percentage change in the total number of entries/exits for Welsh stations in the calibration dataset between 2011/12 and 2015/16 (the latest available data), calculated as 10.48%, was used for the uplift. The demand forecasts before and after applying the uplift are reported.

2.4 Estimating abstraction effects

The Network Rail 'New Stations Assessment' report identified the potential for stations at Cockett, Ely Mill, Deeside Industrial Park, and South Wrexham to abstract passengers from existing stations. The following methodology was therefore developed to assess the potential extent of this abstraction:

- Identify the unit postcodes within 60 minutes drive-time of the station(s) at risk of abstraction
- Generate a 'before' choice set for each postcode - selecting from current stations only
- Generate an 'after' choice set for each postcode - selecting from current stations *and* the proposed new station
- Create separate probability tables for the before and after situation
- Calculate the weighted population (applying the probability and distance weightings) for the at risk station, in both the before and after situation
- Calculate the percentage change in the weighted population after the proposed station is added
- Assume an elasticity of one between weighted population and number of entries/exits, and apply the percentage change to the reported entries/exists in 2015/16, thus giving an estimate of the abstraction effect.

The result of the abstraction analysis is reported alongside the demand forecast for each of the four stations.

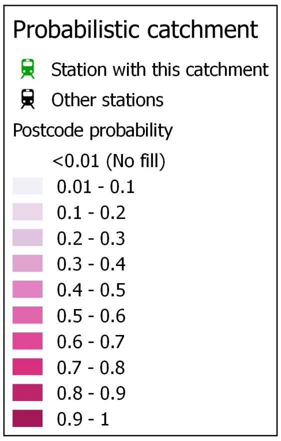

Figure 2: Legend for all catchment maps.

2.5 Catchment maps

Probability-based catchment maps have been produced for each proposed station, and for the existing Ruabon station to illustrate the potential impact of abstraction by South Wrexham. These maps use a choropleth to indicate the probability that the proposed station will be chosen for each postcode within a station's catchment. It should be noted that this only indicates the probability of a station being chosen by someone located in a specific postcode *if they were to choose to travel by rail*; it does not indicate the likelihood of someone choosing to travel by rail over other modes. To avoid cluttering the maps, a separate legend that is applicable to all the maps is provided in Figure 2. In addition, to aid clarity, a transparent fill is applied to those postcodes where the probability of the station being chosen is $<$ 1%. It should be noted that only those postcodes included in the 2011 census population releases have been used in this work. This may result in gaps in the catchment maps, as data is not available for all postcodes that appear in the OS postcode polygon dataset. It should also be noted that the scale of the catchment maps varies by station.

3 Demand forecasts

A set of demand forecasts has been produced for 12 stations, based on information provided in the Network Rail 'New Stations Assessment' report. Forecasts have been produced using both deterministic (simple) and probabilistic catchment definitions. The assumptions made when producing the forecasts for each station are described in detail in the sections that follow. It should be noted that the assumptions may differ from earlier forecasting work. For example, it has been necessary to ensure that proposed service frequencies reflect current service patterns at existing stations, otherwise the station choice model might unduly favour the new station, when in reality any future increase in service frequency is likely to apply to existing stations too. The station details provided are also likely to differ from earlier work. Possible reasons include the use of a more detailed road network with different underlying assumptions affecting travel time or distance measures (OS Open Roads rather than OS Meridian 2); and in the case of weighted population figures, due to using a zonal unit of much higher spatial resolution (postcode rather than census output zone) and a different distance decay function which was estimated by analysing access trips from the passenger survey dataset.

3.1 Summary results

A summary of the demand forecasts is provided in Table 3, and the bar chart in Figure 3. For some stations additional forecasts were generated using an increased number of car parking spaces; these are not included in the summaries.

Table 3: Summary station demand forecasts using models with deterministic and probabilistic catchments for model base year (2011/12) and with growth uplift applied (2015/16).

	Predicted annual entries/exits			
	Deterministic catchment		Probablistic catchment	
Proposed Station	2011/12	2015/16	2011/12	2015/16
Cockett	106,093	117,212	130,932	144,654
Ely Mill/Victoria park	116,133	128,304	92,137	101,793
Llanwern	334,951	370,054	346,411	382,715
Newport Road/Rover Way	319,390	352,862	212,338	234,591
Landore	26,407	29,174	31,348	34,633
St. Clears	98,306	108,608	90,362	99,832
Deeside Industrial Park	37,361	41,276	50,685	55,997
North Wrexham	56,959	62,928	64,043	70,755
South Wrexham	88,882	98,197	102,859	113,639
Llangefni	241,760	267,096	225,896	249,570
St. Mellons/Cardiff Parkway	193,303	213,561	141,467	156,293
Carno	35,273	38,970	26,845	29,658

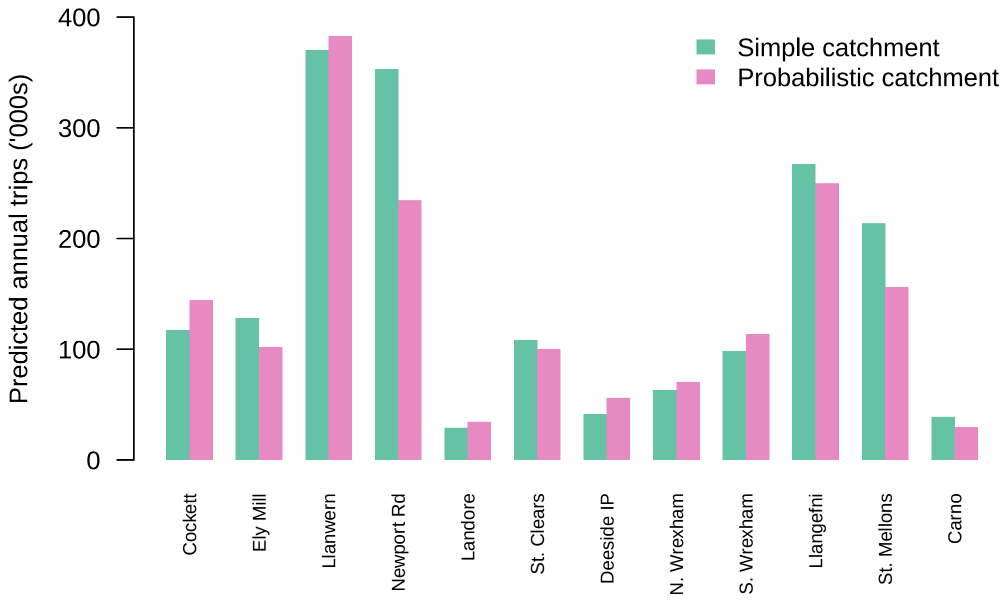

Figure 3: Predicted annual entries/exits using simple and probabilistic catchment definitions with growth uplift applied.

3.2 Cockett

The service pattern at Cockett was assumed to be the same as Gowerton. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 4, with the demand forecasts given in Table 5. The probabilistic catchment for Cockett is shown in Figure 4.

Table 4: Cockett station details.

Easting	263167
Northing	195095
Car park spaces (no.)	0
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	53
Distance to nearest Category A-D station (km)	3.54
Jobs (within 1 minute drive)	1085
Distance-weighted population	11319
Distance- and probability-weighted population	6336

Table 5: Cockett demand forecasts.

Model	2011/12	2015/16
Simple catchment	106,093	117,212
Probabilistic catchment	130,932	144,654

3.2.1 Abstraction analysis - Gowerton

The Network Rail 'New Stations Assessment' report suggests that a new station at Cockett may abstract passengers from Gowerton station. An abstraction analysis was carried out to assess this possibility, and the results are shown in Table 6.

Table 6: Cockett: results of abstraction analysis.

Station	Weighted pop. (before new station)	Weighted pop. (after new station)	% change	Trips 2015/16	Adjusted trips	Change (trips)
Gowerton	4569	4111	-10	142836	128552	-14284

3.3 Ely Mill/Victoria Park

The service pattern at Ely Mill was assumed to be the same as Waun-Gron Park. The planned Ely Mill development is reported to consist of 800 dwellings[2]. For the purposes of these forecasts it was assumed that there would be 2.32 residents per dwelling[3]. This additional population was assigned to CF5 1BG, which is located 0.31km from the proposed station. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 7, with the demand forecasts given in Table 8. The probabilistic catchment for Ely Mill/Victoria Park is shown in Figure 5.

[2]Obtained from http://trionhomes.co.uk/developments/ely-mill.
[3]Figure based on data from StatsWales for Cardiff: https://statswales.gov.wales/Catalogue/Housing/Households/Estimates/averagehouseholdsize-by-localauthority-year

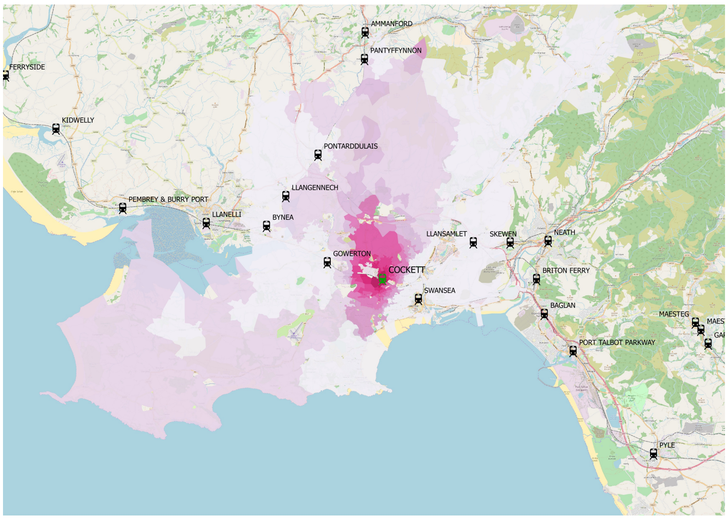

Figure 4: Cockett probabilistic catchment.

Table 7: Ely Mill/Victoria Park station details.

Easting	314994
Northing	176870
Car park spaces (no.)	0
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	56
Distance to nearest Category A-D station (km)	3.50
Jobs (within 1 minute drive)	2753
Distance-weighted population	10195
Distance- and probability-weighted population	1831

Table 8: Ely/Victoria Park demand forecasts.

Model	2011/12	2015/16
Simple catchment	116,133	128,304
Probabilistic catchment	92,137	101,793

3.3.1 Abstraction analysis - Waun-Gron Park and Ninian Park

The Network Rail ‘New Stations Assessment’ report suggests that a new station at Ely Mill may abstract passengers from Waun-Gron Park and Ninian Park stations. An abstraction analysis was carried out to assess this possibility, and the results are shown in Table 9.

Table 9: Ely Mill: results of abstraction analysis.

Station	Weighted pop. (before new station)	Weighted pop. (after new station)	% change	Trips 2015/16	Adjusted trips	Change (trips)
Waun-Gron Park	1015	888	-13	78000	67860	-10140
Ninian Park	705	690	-2	105784	103668	-2116

Figure 5: Ely Mill/Victoria Road probabilistic catchment.

3.4 Llanwern

The road network does not currently exist at the proposed station location. To avoid the station being snapped to a road north of the rail line in old Llanwern village (which would substantially increase access distances from the Glan Lyn development), for modelling purposes the station was located next to the new housing development, accessed via a roundabout on the A480. The Glan Lyn development will eventually consist of 4000 dwellings. It was assumed that there will be 2.33 residents per dwelling[4] and these were assigned to existing postcode NP18 3YG, which is located 0.87km from the station location used for modelling purposes. The Glan Lyn development website[5] suggests that the development will eventually support 6000 jobs, and states that 2000 of those will be located on the new Celtic Business Park. The source and location of the other 4000 jobs is not clear. For these demand forecasts, an additional workplace population of 2000 was assumed to be located within 1 minute of the new station (this is based on the likely location of the new station, adjacent to the Celtic Business Park). As the Network Rail assessment document notes that this station is likely to be best served by Cardiff to Bristol services, the service pattern at Llanwern was assumed to be the same as current direct services from Cardiff to Bristol Temple Meads (2 tph in each direction 5am to midnight). The details of the station, used in the models to produce the demand forecasts, are summarised in Table 10, with the demand forecasts for 100, 500 and 1000 car parking spaces given in Table 11. The probabilistic catchment for Llanwern is shown in Figure 6.

[4]Figure based on data from StatsWales for Newport: https://statswales.gov.wales/Catalogue/Housing/Households/Estimates/averagehouseholdsize-by-localauthority-year

[5]http://www.glanlyn-newport.co.uk

Table 10: Llanwern station details.

Easting	335149
Northing	186537
Car park spaces (no.)	100
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	76
Distance to nearest Category A-D station (km)	5.55
Jobs (within 1 minute drive)	3115
Distance-weighted population	6723
Distance- and probability-weighted population	5061

Table 11: Llanwern demand forecasts.

Model	2011/12	2015/16
100 car park spaces		
Simple catchment	334,951	370,054
Probabilistic catchment	346,411	382,715
500 car park spaces		
Simple catchment	423,968	468,400
Probabilistic catchment	442,723	489,120
1000 car park spaces		
Simple Catchment	469,427	518,623
Probabilistic catchment	504,997	557,921

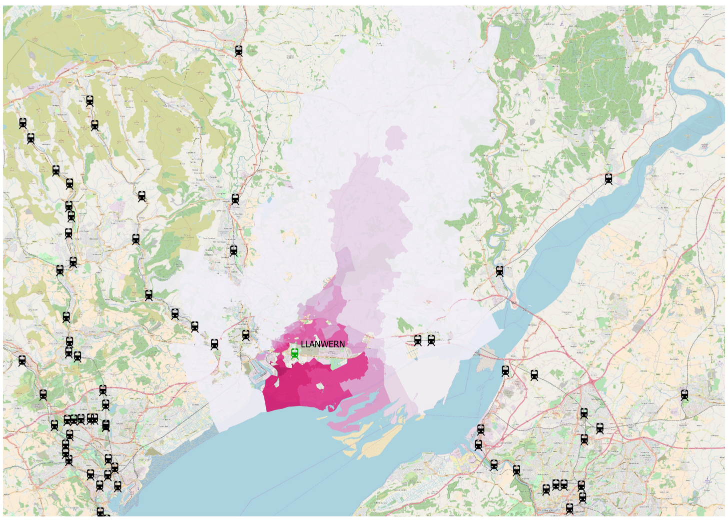

Figure 6: Llanwern probabilistic catchment.

3.5 Newport Road/Rover Way

As the Network Rail assessment document notes that this station is likely to be best served by Cardiff to Bristol services, the service pattern at Newport Road/Rover Way was assumed to be the same as current direct services from Cardiff to Bristol Temple Meads (2 tph in each direct 5am to midnight). The details of the station, used in the models to produce the demand forecasts, are summarised in Table 12, with the demand forecasts given in Table 13. The probabilistic catchment for Newport Road/Rover Way is shown in Figure 7.

Table 12: Newport Road/Rover Way station details.

Easting	320794
Northing	177838
Car park spaces (no.)	50
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	76
Distance to nearest Category A-D station (km)	2.62
Jobs (within 1 minute drive)	3674
Distance-weighted population	12249
Distance- and probability-weighted population	1683

Table 13: Newport Road/Rover Way demand forecasts.

Model	2011/12	2015/16
Simple catchment	319,390	352,862
Probabilistic catchment	212,338	234,591

Figure 7: Newport Road/Rover Way probabilistic catchment.

3.6 Landore

The access point to Landore station was assumed to be the current entrance to Landore Depot. The service pattern at Landore was assumed to be the same as Llansamlet station. The Network Rail assessment report notes that the main market for this station would be events and conferences at the nearby Liberty Stadium. It should be noted that the models used are unable to take account of trips generated by visits to/from the stadium. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 14, with the demand forecasts given in Table 15. The probabilistic catchment for Landore is shown in Figure 8.

Table 14: Landore station details.

Easting	265970
Northing	195133
Car park spaces (no.)	0
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	22
Distance to nearest Category A-D station (km)	1.65
Jobs (within 1 minute drive)	1947
Distance-weighted population	9299
Distance- and probability-weighted population	1825

Table 15: Landore demand forecasts.

Model	2011/12	2015/16
Simple catchment	26,407	29,174
Probabilistic catchment	31,348	34,633

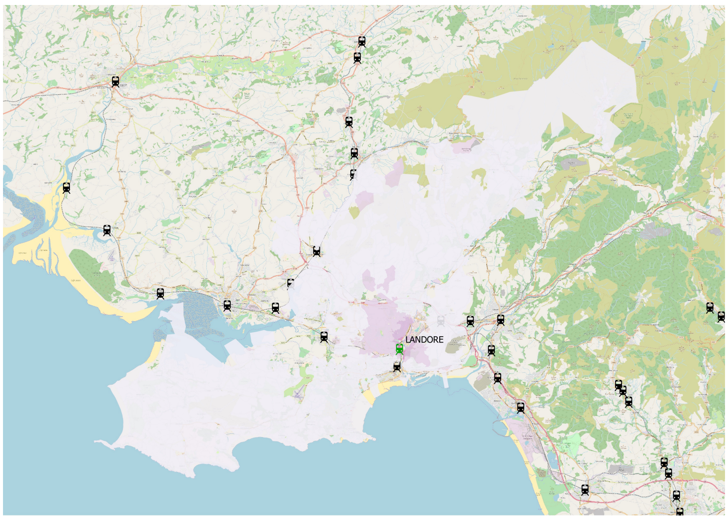

Figure 8: Landore probabilistic catchment.

3.7 St. Clears

The service pattern at St. Clears was assumed to be the same as Whitland station. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 16, with the demand forecasts given in Table 17. The probabilistic catchment for St. Clears is shown in Figure 9.

Table 16: St. Clears station details.

Easting	228287
Northing	217331
Car park spaces (no.)	20
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	49
Distance to nearest Category A-D station (km)	15.17
Jobs (within 1 minute drive)	720
Distance-weighted population	1406
Distance- and probability-weighted population	1103

Table 17: St. Clears demand forecasts.

Model	2011/12	2015/16
Simple catchment	98,306	108,608
Probabilistic catchment	90,362	99,832

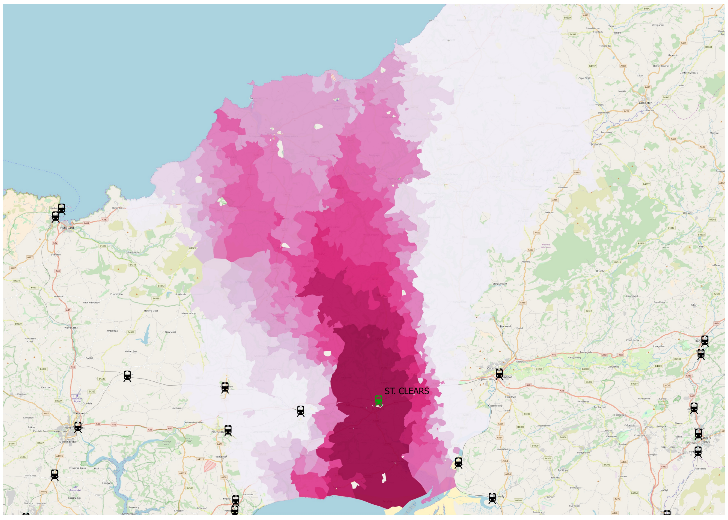

Figure 9: St Clears probabilistic catchment.

3.8 Deeside Industrial Park

A number of assumptions were made with respect to the proposed new station at Deeside Industrial Park, as detailed below:

- Access to the station would be provided directly from the A548.
- The Northern Gateway development would provide 1400 new dwellings, with an average occupancy of 2.35 per dwelling[6]. This population was assigned to postcode CH5 2JE which is located 5.93km from the proposed station access point.
- There are no workplace population centroids accessible within a 1-minute drive of the proposed station. However, given the expectation of new jobs on the industrial park and improved access to/from the station location, it was assumed that 5000 jobs would be accessible within a 1-minute drive.
- Hawarden Bridge station would be closed.
- Service frequency on the Bidston to Wrexham line would increase to two trains per hour in both directions (28 services were added to the service frequency of all stations on the line).

The details of the station, used in the models to produce the demand forecasts, are summarised in Table 18, with the demand forecasts for 100, 500 and 1000 car parking spaces given in Table 19. In addition, a forecast based on 10,000 jobs being accessible within a 1-minute drive of the station is provided. It should be noted that the weighted catchment population for this station is very low when compared to the other stations considered in this report (69). The demand forecasts generated should be treated with additional caution, as the model performs less well on stations with very small catchment populations, with larger under- or over-predictions more likely to occur. The probabilistic catchment for Deeside Industrial Park is shown in Figure 10.

Table 18: Deeside IP station details.

Easting	330745
Northing	372073
Car park spaces (no.)	100
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	56
Distance to nearest Category A-D station (km)	13.31
Jobs (within 1 minute drive)	5000
Distance-weighted population	17
Distance- and probability-weighted population	69

[6]Figure based on data from StatsWales for Flintshire https://statswales.gov.wales/Catalogue/Housing/Households/Estimates/averagehouseholdsize-by-localauthority-year

Table 19: Deeside IP demand forecasts.

Model	2011/12	2015/16
100 car park spaces		
Simple catchment	37,361	41,276
Probabilistic catchment	50,685	55,997
500 car park spaces		
Simple catchment	47,290	52,246
Probabilistic catchment	73,831	81,568
1000 car park spaces		
Simple Catchment	52,360	57,847
Probabilistic catchment	98,874	109,236
Jobs 10,000 (100 car park spaces)		
Simple Catchment	38,863	42,936
Probabilistic catchment	52,563	58,072

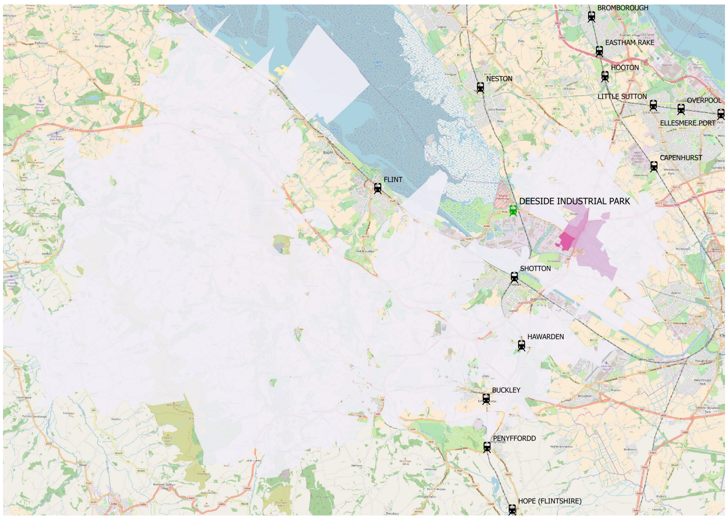

Figure 10: Deeside Industrial Park probabilistic catchment.

3.9 North Wrexham

The proposed location of North Wrexham station has changed since previous modelling work was carried out. It is now in the village of Rossett, and is assumed to be located at the site of the former station, with access via Station Road and the B5445/B5102. The service frequency at this station was assumed to be hourly in both directions between 6am and 11pm. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 20, with the demand forecasts given in Table 21. The probabilistic catchment for north Wrexham is shown in Figure 11.

Table 20: North Wrexham station details.

Easting	336210
Northing	357172
Car park spaces (no.)	268
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	34
Distance to nearest Category A-D station (km)	8.74
Jobs (within 1 minute drive)	0
Distance-weighted population	1716
Distance- and probability-weighted population	1396

Table 21: North Wrexham demand forecasts.

Model	2011/12	2015/16
Simple catchment	56,959	62,928
Probabilistic catchment	64,043	70,755

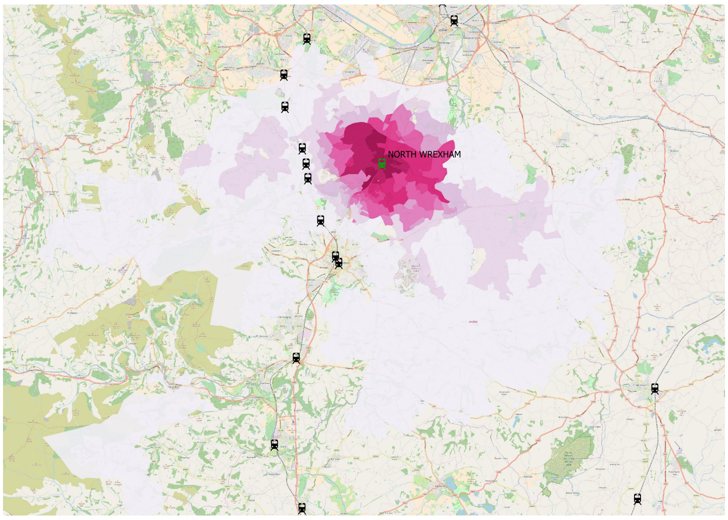

Figure 11: North Wrexham probabilistic catchment.

3.10 South Wrexham

The access to South Wrexham was assumed to be from the High Street railway bridge in Rhosymedre. The service frequency at this station was assumed to be the same as Chirk station. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 22, with the demand forecasts given in Table 23. The probabilistic catchment for South Wrexham is shown in Figure 12.

Table 22: S. Wrexham station details.

Easting	328361
Northing	342545
Car park spaces (no.)	25
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	39
Distance to nearest Category A-D station (km)	10.68
Jobs (within 1 minute drive)	606
Distance-weighted population	3072
Distance- and probability-weighted population	2975

Table 23: S. Wrexham demand forecasts.

Model	2011/12	2015/16
Simple catchment	88,882	98,197
Probabilistic catchment	102,859	113,639

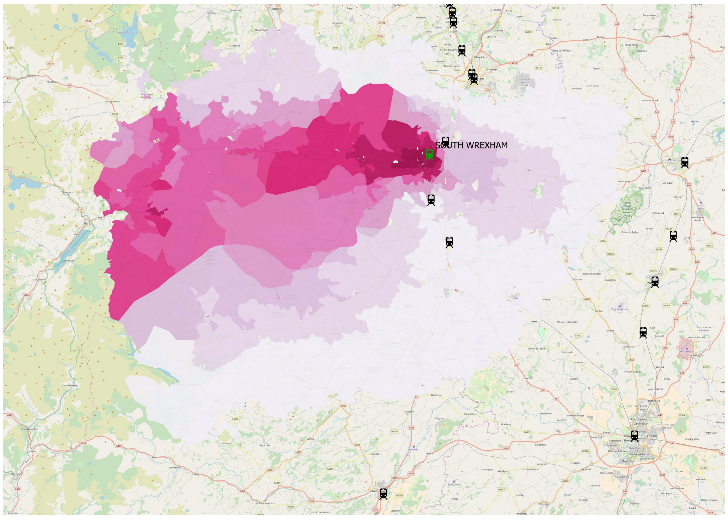

Figure 12: South Wrexham probabilistic catchment.

3.10.1 Abstraction analysis - Ruabon and Chirk

The Network Rail 'New Stations Assessment' report suggests that a new station at South Wrexham may abstract passengers from Ruabon and Chirk stations. An abstraction analysis was carried out to assess this possibility, and the results are shown in Table 24. The results show a substantial abstraction from Ruabon and, to a lesser extent, from Chirk. Taking both stations into account, the analysis suggests that some 45% of the forecast demand at South Wrexham would be abstracted from Ruabon and Chirk. To examine this effect further, catchment maps have been produced for Ruabon station before and after South Wrexham, and these are shown in Figures 13 and 14.

Table 24: South Wrexham: results of abstraction analysis.

Station	Weighted pop. (before new station)	Weighted pop. (after new station)	% change	Trips 2015/16	Adjusted trips	Change (trips)
Ruabon	3344	1894	-43	92986	53002	-39984
Chirk	1493	1259	-16	68444	57493	-10951

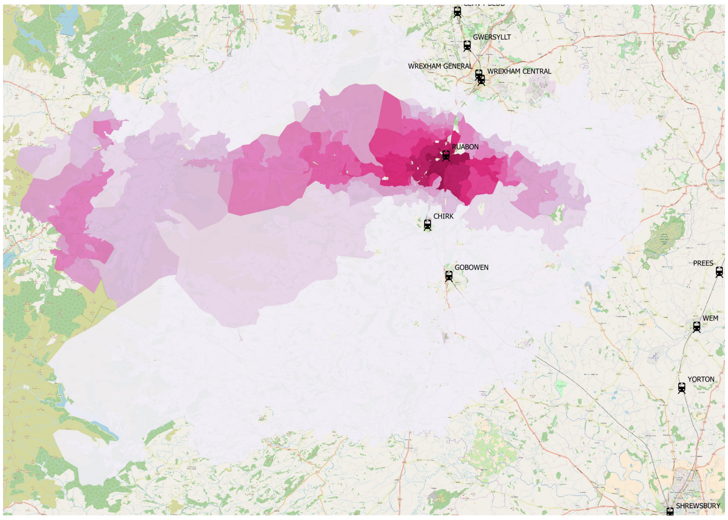

Figure 13: Ruabon probabilistic catchment without South Wrexham.

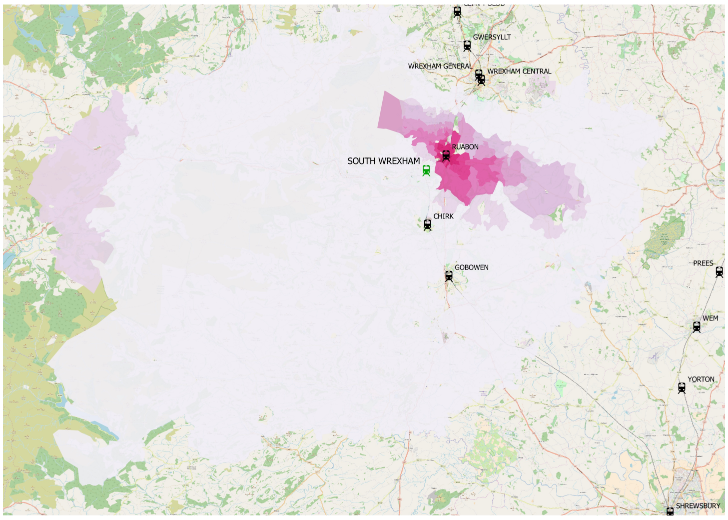

Figure 14: Ruabon probabilistic catchment showing the effect of South Wrexham.

3.11 Llangefni

The station at Llangefni was assumed to be located at the site of the former station. It was assumed that one train per hour would both arrive and depart from this terminus station between 6am and 11pm. The details of the station, used in the models to produce the demand forecasts, are summarised in Table 25, with the demand forecasts given in Table 26. The probabilistic catchment for Llangefni is shown in Figure 15.

Table 25: Llangefni station details.

Easting	245700
Northing	375771
Car park spaces (no.)	100
Bus services (0/1)	1
Terminus (0/1)	1
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	34
Distance to nearest Category A-D station (km)	14.52
Jobs (within 1 minute drive)	2543
Distance-weighted population	2933
Distance- and probability-weighted population	2367

Table 26: Llangefni demand forecasts.

Model	2011/12	2015/16
Simple catchment	241,760	267,096
Probabilistic catchment	225,896	249,570

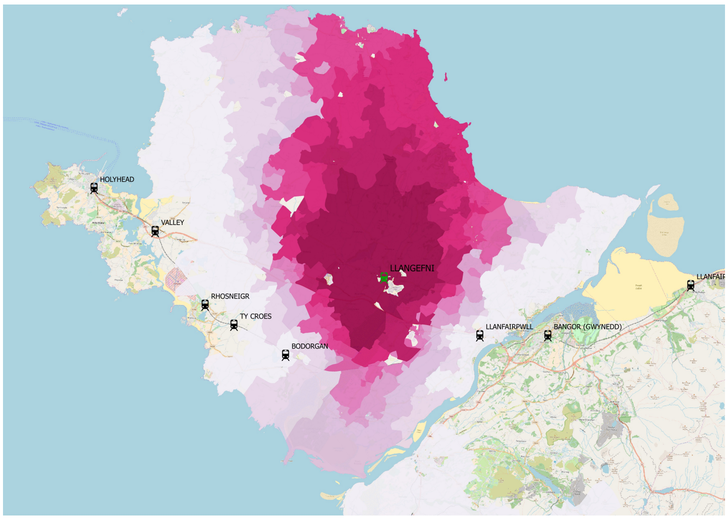

Figure 15: Llangefni probabilistic catchment.

3.12 St. Mellons/Cardiff Parkway

The service pattern at St. Mellons/Cardiff Parkway was assumed to be the same as current direct services from Cardiff to Bristol Temple Meads (2 tph in each direct 5am to midnight). The details of the station, used in the models to produce the demand forecasts, are summarised in Table 27, with the demand forecasts for 100, 500 and 1000 car parking spaces given in Table 28. In addition, a forecast based on service frequency increasing to 4 trains per hour in both directions (152 daily services) is provided (an additional 76 services were also assumed for Newport and Cardiff Central stations). The probabilistic catchment for St. Mellons is shown in Figure 16.

Table 27: St. Mellons station details.

Easting	325358
Northing	180820
Car park spaces (no.)	100
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	76
Distance to nearest Category A-D station (km)	10.01
Jobs (within 1 minute drive)	0
Distance-weighted population	3530
Distance- and probability-weighted population	1422

Table 28: St. Mellons demand forecasts.

Model	2011/12	2015/16
100 car park spaces		
Simple catchment	193,303	213,561
Probabilistic catchment	141,467	156,293
500 car park spaces		
Simple catchment	244,675	270,317
Probabilistic catchment	187,800	207,481
1000 car park spaces		
Simple Catchment	270,910	299,301
Probabilistic catchment	223,377	246,787
Service frequency 152 (100 car park spaces)		
Simple Catchment	496,862	548,933
Probabilistic catchment	350,309	387,021

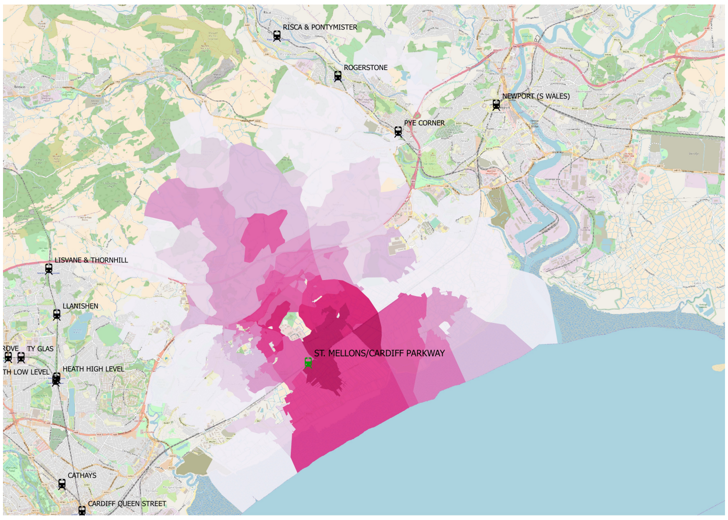

Figure 16: St Mellons probabilistic catchment.

3.13 Carno

The service pattern at Carno was assumed to be the same as Caersws. The Local Development Plan identifies the following potential new housing developments in Carno:

- 13 new houses on land off Ffordd Dol-Llin. It was assumed that there would be 2.2 residents per dwelling[7] and the population was attached to SY17 5LD, located 0.22km from the proposed station.
- 25 new houses on land north of Gerddi Cledan. 2.2 residents per dwelling were assumed, as above, and the population was attached to SY17 5JT, located 1.81km from the proposed station.

The details of the station, used in the models to produce the demand forecasts, are summarised in Table 29, with the demand forecasts given in Table 30. The probabilistic catchment for Carno is shown in Figure 17.

Table 29: Carno station details.

Easting	296544
Northing	296503
Car park spaces (no.)	33
Bus services (0/1)	1
Terminus (0/1)	0
Travelcard boundary (0/1)	0
Category	F
Ticket machine (0/1)	1
CCTV (0/1)	1
Electric trains (0/1)	0
Service frequency	24
Distance to nearest Category A-D station (km)	55.07
Jobs (within 1 minute drive)	291
Distance-weighted population	505
Distance- and probability-weighted population	358

Table 30: Carno demand forecasts.

Model	2011/12	2015/16
Simple catchment	35,273	38,970
Probabilistic catchment	26,845	29,658

[7] Figure based on data from StatsWales for Powys https://statswales.gov.wales/Catalogue/Housing/Households/Estimates/averagehouseholdsize-by-localauthority-year

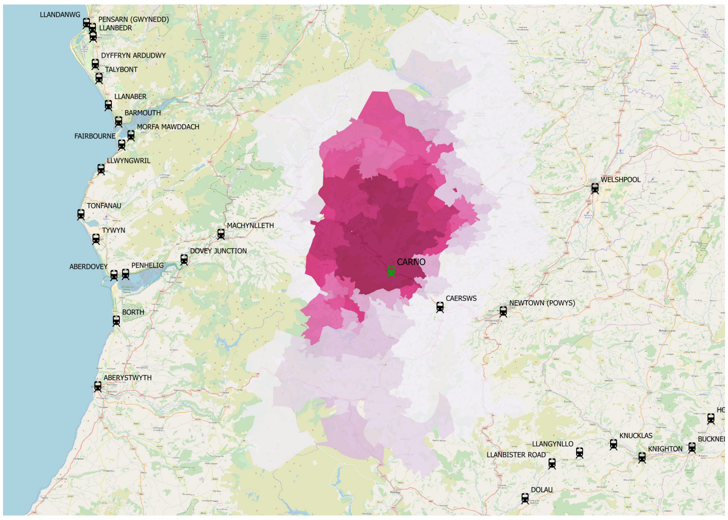

Figure 17: Carno probabilistic catchment.

4 Acknowledgements

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