Millbay Paramics Model Validation and Option Testing Report

Plymouth City Council

Validation and Option Testing Report

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MILLBAY PARAMICS MODEL

Description:

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MILLBAY PARAMICS MODEL

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1 INTRODUCTION

1.1 Purpose of Report

1.1.1 SIAS Ltd was requested by Alan Baxter and Associates (ABA) to build a Paramics model of the Millbay area to the west of Plymouth City Centre.

1.1.2 The objective of the Paramics model is to assess the impact of the planned developments in the Millbay area on the surrounding road system. The model should be capable of assessing the vehicular demands from the developments identified in the Millbay Action Plan so that a robust highway network can be formulated to meet the forecast demands.

1.1.3 SIAS was provided with the following information in order to construct the Millbay Paramics model:

- existing TTWA Paramics model of Plymouth
- traffic counts for eight junctions in the study area from Plymouth City Council (PCC)
- DXF digitised drawings of proposed improvements in the study area from ABA
- Paramics Modelling Information Package April 2005 – from ABA

1.1.4 The modelling study was undertaken in the following stages:

- cordoning of the Millbay Paramics model from the Plymouth TTWA Paramics model
- validation of cordoned Millbay Paramics model using observed traffic counts in order to establish a Base Millbay Paramics Model
- establishment of a Do-Minimum Millbay Paramics Model to take account of Drakes Circus development
- testing of various improvement schemes in the Millbay and Royal William Yard area using drawings provided by ABA and inclusion of proposed development traffic
- summarising outputs from the option tests

1.1.5 This report contains the following. Chapter Two details the Base Model Development; Chapter Three summarises the Model Validation and development of the Do-Minimum Model whilst Chapter Four describes the development of the Do-Something models. Chapter Five summarises the results from the Option Tests whilst Chapter Six provides an overall Summary and Conclusions.

2 BASE MODEL DEVELOPMENT

2.1 Study Area Network

2.1.1 The Millbay area Paramics model is based on the existing Plymouth TTWA traffic model.

2.1.2 The network that has been modelled covers the Millbay area as well as Plymouth City Centre due to the proximity of the City Centre to the study area. A plan of the Paramics network is shown in Figure 2.1.

2.2 Paramics Matrix Estimation

2.2.1 It was agreed that the matrix would be derived from a cordoned version of the Plymouth area wide Paramics model. The purpose of this was to assess the impacts of the Millbay developments on the immediate study area and City Centre. A cordon was drawn around the study area and an AM, PM and Inter peak matrix of traffic movements was extracted from this based on the standard Paramics assignment for the TTWA model. The existing zoning system was used within the cordoned area but a number of external zones were added at the cordon edges. Matrix estimation was then used to create a new matrix for the Millbay Paramics model area. The matrix extracted was used as the prior matrix in the matrix estimation process along with a series of observed traffic counts.

2.2.2 The existing zoning system for the Plymouth area wide model within the study area was retained.

2.2.3 A cordoned matrix was produced for both the AM and PM peak period. The cordoned matrix was used in conjunction with the available traffic data in order to produce an estimated matrix for the study area.

2.2.4 Trip matrices were developed for the following vehicle types:

- Cars & light goods
- Heavy goods vehicles – OGV1 & OGV2

2.2.5 Public service vehicles were coded as fixed route vehicle types, using the bus route and timetable information from the existing Plymouth TTWA model.

2.2.6 The following time-periods were modelled:

- AM Peak 0700-1000
- PM Peak 1500-1900

2.2.7 The traffic profiles from the existing TTWA model were used. The estimated matrices were assigned to the network and the modelled flows compared with the observed flows. The results of this are described in Chapter Three.

Figure 2.1 : Paramics Model Study Area

3 MODEL VALIDATION

3.1 Validation Data

3.1.1 In the absence of any other data the model was validated against the turning counts provided. The observed data is described below.

3.1.2 Peak hour turning count data was provided for the following junctions:

- Millbay Road/Martin Street/ Ferry roundabout
- Exeter Street/Bretonside junction

3.1.3 Peak hour link count data was provided on the following links:

- Union Street
- Hampton Street to Charles Cross
- North Hill to Drakes Circus
- Western Approach
- Saltash Road
- Stonehouse Bridge.

3.1.4 The locations of the counts are shown in Figure 3.1 over the page.

3.1.5 The model was validated using the GEH statistic. The Design Manual for Roads and Bridges has outlined the GEH statistic as one of the analytic methods which can be applied to validation comparisons. The GEH statistic is a form of the Chi-squared statistic that incorporates both relative and absolute errors. The GEH values have been calculated for individual links. DMRB guidelines indicate that when applying the GEH statistic for individual flows then GEH must be less than 5 in 85% or more of the cases.

3.2 AM Peak Validation

3.2.1 A comparison has been made between the observed AM peak traffic counts and the modelled traffic counts. Two separate comparisons have been undertaken. The first comparison is a comparison between observed and modelled flows over the entire study area. The second comparison has been undertaken for the cordon only. The results of the area wide comparison have been summarised in Table 3.1 below and are shown in their entirety in Appendix A:

Table 3.1: AM Peak Comparison between Area Wide Modelled and Observed Flows

Summary	GEH < 5
AM Peak	92%

3.2.2 The results indicate that the model is replicating existing conditions well in the AM peak and conforms to DMRB guidelines.

3.2.3 The comparison undertaken between AM peak observed and modelled flows at the cordon points of the study area provides the following results:

Table 3.2: AM Peak Comparison between Cordon Modelled and Observed Flows

Summary	GEH < 5
AM Peak	90%

3.2.4 The above results again indicate that the model is replicating the observed counts satisfactorily.

3.3 PM Peak Validation

3.3.1 A comparison has also been undertaken for the PM peak. The results of this comparison for the whole study area have been summarised in Table 3.3 below and are shown in their entirety in Appendix A.

Table 3.3: PM Peak Comparison between Area Wide Modelled and Observed Flows

Summary	GEH < 5
PM Peak	88%

3.3.2 The results indicate that the PM peak model is replicating existing conditions well and also conforms to DMRB guidelines.

3.3.3 As with the AM Peak, a comparison has been undertaken between observed and modelled counts at the cordon points surrounding the study area. The results are shown below.

Table 3.4: PM Peak Comparison between Cordon Modelled and Observed Flows

Summary	GEH < 5
PM Peak	100%

3.3.4 It is reasonable to conclude from the above results that a Base Millbay Paramics Model has been established and validated against observed traffic flows and that the DMRB criteria have been satisfied.

3.4 Do minimum Paramics model

3.4.1 It was felt that it would be more appropriate to test any design options for Millbay against the most up to date highway network within the study area. The Drakes Circus development scheme has been undertaken since the original Plymouth TTWA model was built. The scheme comprises the following:

- redesign of Drakes Circus junction from roundabout to signalised junction
- reassignment and increase in car parking around Drakes Circus

3.4.2 SIAS was supplied with drawings for the scheme from PCC as well as proposed traffic movements from the development. The Base Paramics network was therefore modified to take account of the Drakes Circus development. The update of the network was based on Drawing No: 30327/SL-01.

3.4.3 The estimated peak hour demands from the Drakes Circus development are shown in Appendix B. They have been incorporated into the model by amending the demands from Zone 459, the zone that represents the Drakes Circus development.

3.4.4 The demands provided to SIAS were for the peak hour only. The demand to and from Zone 459 has been factored by 1.67, which SIAS understands represents the increase in car parking spaces at Drakes Circus. The trips to Drakes Circus for the entire model period have then been determined by using the existing profile of background traffic (shown in Appendix C) and adding these to Zone 459.

3.4.5 The net additional trips to the Drakes Circus development (and therefore Zone 459) is as follows:

- AM Model Period (0700-1000) - 816 trips
- PM Model Period (1500-1900) - 1267 trips

3.4.6 The do-minimum model has therefore been used as the reference case against which the do-something models have been tested.

3.5 Royal William Yard

3.5.1 SIAS understands that the Royal William Yard development is taking place at present. It was decided that the development should be included within the Do-minimum situation. SIAS was provided with forecast 12-hour generated trips for the development by Plymouth City Council.

3.5.2 The volume of trips generated by the development are shown below.

- AM Model Period (0700-1000) - 726 trips
- PM Model Period (1500-1900) - 1917 trips

3.5.3 The generated trips have been incorporated into the model in a separate matrix and have all been assigned to Zone 175. The distribution of trips to and from the development has been based on the assumption that most of the trips will originate outside of the existing study area. This is considered a reasonable assumption given the nature of the development.

Figure 3.1 : Locations of Traffic Counts

4 DO SOMETHING MODEL DEVELOPMENT

4.1 Do Something Models

4.1.1 A series of do-something models has been created so as to test the proposed development scenarios. The development of the do-something models involves the following tasks:

- amendment of the matrices to represent additional development trips
- amendment of the network to represent associated highway improvements and changes

4.1.2 The developments included within the do-something matrix comprise the trips associated with the Millbay developments. The highway network changes are extensive and involve the replacement of roundabouts with signalised junctions and an additional highway network in the Millbay area. The changes to both the matrix and the network are summarised below. Diagrams of the network changes have been included in a separate ABA report.

4.2 Scheme Options

4.2.1 SIAS has been provided with the following information from ABA with regard to schemes to be tested:

- DXF digitised scheme drawings from ABA for Options 1 and 2.
- DXF digitised scheme drawings from ABA for Options 3a and 3b
- Development trips associated with Millbay developments from ABA

4.2.2 It is understood that Option 3a represents the MacKay Plan option whilst Option 3b represents a variation on the MacKay Plan option.

4.3 Matrix

4.3.1 SIAS was provided with a document entitled Paramics Modelling Information Package dated April 2005 by ABA. The information contained in this document has enabled the building of the do-something matrices. The document included information on the volume of trips that would be supplanted in the Millbay area by new land uses as well as the volume of trips that would be generated by these new land uses. The developments were disaggregated by ABA into blocks. SIAS was able to identify the physical location of each development block from plans provided by ABA.

4.3.2 SIAS then identified the location of each supplanted development relative to the existing Paramics zones. The supplanted trips as a proportion of the total numbers of trips in the validated matrix varies from zone to zone. For example, in Zone 416 the supplanted trips represented all of the existing trips within the matrix whilst in Zone 307 they only represented around 10% of the existing trips. The proportions also vary depending on whether they are origin or destination trips. The proportion of supplanted trips against existing trips is summarised in Table 4.1 below.

Table 4.1: Proportion of Supplanted Trips v Existing Validated Trips (%)

Zone	AM Peak		PM Peak	
	In	Out	In	Out
416	90	100*	100*	100*
29	15	20	3	9
309	90	100*	100*	100*
307	15	4	4	8
305	66	15	71	19

4.3.3 It should be noted that where the proportion of supplanted trips against existing trips from the validated model is 100 it might be that the supplanted trips actually exceeded the existing trips. These cells are marked with an asterisk. All this indicates is that the majority of the existing trip generators and attractors in that zone are to be removed and replaced with new developments. It does not impact upon the net trips added to the matrix.

4.3.4 A similar exercise was undertaken for the proposed uses with each proposed development block assigned to an existing Paramics zone. This allowed the net change in trips to be calculated. The process of calculating the net change in trips is shown in Appendix D. The results are summarised below with the net additional peak hour trips as follows:

- AM Peak – 2028 trips
- PM Peak – 1631 trips

4.3.5 The model period for the AM period is 0700-1000 and 1500-1900 for the PM period. The above figures represent the peak hour only.

4.3.6 In order to determine the trips for the entire model period the TRICS database was interrogated. The database indicated the following profile of trips for the dominant land uses relative to the AM peak hour:

- 0700-0800 – 0.6
- 0800-0900 – 1.0 (benchmark)
- 0900-1000 – 0.6

4.3.7 The following profile was calculated for the PM model period:

- 1500-1600 – 0.6
- 1600-1700 – 1.0
- 1700-1800 – 1.0 (benchmark)
- 1800-1900 – 0.6

4.3.8 The peak hour trips were factored to reflect the calculated profiles with the result that the Millbay development matrix contained the following vehicle trips:

- AM Model Period (0700-1000) - 4462 trips
- PM Model Period (1500-1900) - 5218 trips

4.3.9 The distribution of trips from the Millbay developments was based (in the absence of any additional information) on the existing distribution of trips from the zones in the Millbay area.

4.3.10 The volume of trips added to the network is therefore a calculation based on the estimated supplanted trips and the estimated newly generated trips. The results contained in Table 4.1 indicate that in Zones 309 and 416 the majority of the existing uses have been removed and supplanted by new development. Zone 309 represents the geographical area bounded by Martin Street, Union Street, Millbay Road and the Crescent whilst Zone 416 represents the geographical area bounded by Union Street, Martin Street, Millbay Road and Durnford Street.

4.4 Network

4.4.1 The network changes to the do-something models varied depending on the Scenario. The main changes can be summarised as follows:

- replacement of Octagon Roundabout with a four-arm signalised junction – 2-stage 60 second cycle
- replacement of the Western Approach/Union Street junction with a simplified four-arm signalised junction – 2-stage 60 second cycle
- replacement of the Edgcumbe Street/Stonehouse Bridge roundabout with a four-arm signalised junction – 2-stage 60 second cycle
- replacement of Bath Street with a boulevard linking Union Street and Millbay docks
- revised street layout in the Millbay area with various hierarchies of road

4.4.2 SIAS was provided with a street hierarchy by ABA for the new road layout within the Millbay area. The hierarchy was replicated in Paramics through the use of different speed limits, link costs and road widths.

4.5 Ferry

4.5.1 SIAS was also requested to undertake a sensitivity test in order to assess the impact of ferries arriving and departing in the peak hours. ABA provided SIAS with an AM and PM peak hour scenario as follows:

- arrival of the Bretagne (580 trips) at 1700 from Roscoff. The trips to appear on the port end of Martin Street evenly between the times of 1700-1720.
- departure of the Bretagne (580 trips) at 0930 to St Malo. Trips to appear on the network evenly over the period between 0800-0900.

4.5.2 The above ferry arrival and departure profiles have been incorporated into the model with the exception of the PM peak arrival where the trips have been spread over a 40 minute period rather than 20 minutes. It was assumed that for a departing ferry, vehicle trips would be distributed over a longer period hence the 60-minute profile for departing ferry trips. For the arriving ferry, vehicles disembark the ferry over a shorter period. The 20 minute disembarking profile led to what appeared to be unrealistic queuing and delay on the highway network so this was revised to 40 minutes. The time period for disembarkation is an arbitrary figure and is not based on any observed data.

4.6 Paramics Results

4.6.1 The following options have therefore been tested.

- Base Scenario
- Do-minimum Scenario
- Option 1 AM and PM peak with and without ferry
- Option 2 AM and PM peak with and without ferry
- Option 3a AM and PM peak with and without ferry

- Option 3b AM and PM peak with and without ferry

4.6.2 The scenarios have all been run in Paramics and a series of outputs collected including journey times, flows and speeds. The results are summarised in Chapter Five.

5 OPTION TEST RESULTS

5.1 Results

5.1.1 The following outputs have been collected from the Paramics model:

- average network speeds
- average network journey times
- disaggregated journey times
- link flows

5.1.2 The outputs have been collected so that a comparison can take place between the Do-minimum scenario (reference case) and the Do-something scenarios. The results should allow us to assess what the likely impact of the proposed Millbay and Royal William Yard developments will have on the wider highway network. The results for the without ferry situation are presented first so that the impacts of the developments can be isolated.

5.1.3 The Options tested are as follows:

- Option 1 – Alan Baxter Associates Option 1
- Option 2 – Alan Baxter Associates Option 2
- Option 3a – MacKay Plan Option
- Option 3b – MacKay Plan Option (ABA variant)

5.1.4 For a description of the various options this report should be read in conjunction with the ABA Final Report.

5.2 AM Peak

5.2.1 The average network speed output from Paramics is a useful indicator as to the overall performance of the network. The figures represent the average speed of each vehicle in the network over the entire model period. The results for the AM peak are summarised in Table 5.1 below:

Table 5.1: AM Peak Average Network Speeds – km/h

Period	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
AM Peak	29.6	28.0	25.0	25.7	25.2	24.6

5.2.2 The network speeds indicate that speeds will decrease by between 8% and 12% depending on the Option chosen.

5.2.3 The network speeds, although a useful indicator of the overall performance, are relatively coarse in identifying where additional delays are taking place. The journey time output in Paramics allows the user to express the differences between Options in a more readily understandable format.

Table 5.2: AM Peak Overall Journey Times

Period	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
AM Peak	2m 30s	2m 41s	2m 51s	2m 51s	2m 54s	3m 00s

5.2.4 The results indicate that in the AM peak each trip on the network is experiencing around an additional 10s to 30s of delay. In percentage terms this is similar to the changes in average network speed that could be expected as a result of the Millbay developments.

5.2.5 A series of link count comparisons have also been undertaken for Millbay for the peak hour only. The results are summarised in Appendix E. A number of the key changes are shown below for Option 2. The changes in flow represent the average change in flow over all scenarios for the peak hour only. The results are also based on the two-way flow on the link (for Option 2 only).

- Saltash Road +5%
- Western Approach + 35%
- Union Street East – 10%
- Martin Street + 40%
- Millbay Road West + 10%
- Millbay Road East – 40%
- Stonehouse Bridge + 25%
- Durnford Street – 85%

5.2.6 The results are unsurprising for the links in and around Millbay such as Millbay Road West and Martin Street. It appears that the decrease in flows on Union Street East and Millbay Road East are caused by a significant decrease in westbound flows. This may be partly explained by new connections off Union Street and The Crescent into Millbay which have drawn traffic away from Union Street East and Millbay Road East.

5.2.7 In addition, there is a significant decrease in flows along Durnford Street particularly in the southbound direction in the AM peak but also northbound as well. This is believed to be the result of alternative routes opening in and around Millbay. This is perhaps a direct result of the increased permeability of the network.

5.2.8 In terms of the impact on junctions, a comparison of delay between each Option has been undertaken for the major junctions around Millbay. The results of this comparison are shown in Table 5.3 below.

Table 5.3: AM Peak Junction Vehicle Delay Comparison (Seconds)

Junction	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
Durnford/ Union St	128	122	168	192	157	140
Octagon	159	141	191	153	160	176
Union St/ Western Approach	163	171	196	179	181	199

5.2.9 The results indicate that in general there are significant increases in delay at all of the major junctions in the Millbay area although the pattern is not repeated from one option to the next. The results also indicate that the overall increases in delay from one option to the next when compared to the Base is reasonably consistent for these three junctions. However, they also show that the delay can be distributed unevenly across these three particular junctions and that the Octagon junction appears to be operating satisfactorily in most of the options.

5.3 PM Peak

5.3.1 The results for the PM peak network speed are summarised in Table 5.4 below:

Table 5.4: PM Peak Average Network Speeds – km/h

Period	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
PM Peak	28.6	24.5	24.2	24.3	24.3	23.5

5.3.2 The average network speeds comparison indicates that speeds will decrease by between 2% and 4% on the network.

5.3.3 The journey times for the through trips in the PM peak are shown in Table 5.5 below. The through trips represent all those trips that originate from an external zone and have a destination in an external zone.

Table 5.5: PM Peak Overall Journey Times

Period	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
PM Peak	2m 33s	3m 01s	2m 56s	2m 55s	2m 55s	3m 01s

5.3.4 The journey time comparison indicates that for the PM peak the impact of the Millbay developments will be negligible on the existing network.

5.3.5 A series of link count comparisons have also been undertaken for Millbay for the PM peak hour as with the AM peak. The results are summarised in Appendix E. A number of the key changes are shown below for Option 2. The changes in flow represent the average change in flow over all scenarios for the peak hour only (for Option 2 only).

- Saltash Road + 10%
- Union Street East – 15%
- Martin Street + 65%
- Millbay Road East – 45%
- Union Street West + 35%
- Stonehouse Bridge + 10%
- Durnford Street – 95%

5.3.6 The results for the PM peak appear to mirror those of the AM peak with significant increases on some of the links in and around Millbay but with some notable decreases on Millbay Road East and Union Street East.

5.3.7 A similar exercise has been undertaken for the PM peak with respect to junction delay at some of the junctions around the study area.

Table 5.6: PM Peak Junction Vehicle Delay Comparison (Seconds)

Junction	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
Durnford/ Union St	138	126	229	199	197	185
Octagon	183	183	172	184	180	191
Union St/ Western Approach	194	195	195	211	250	231

5.3.8 The results indicate that the Octagon junction is operating satisfactorily in each option whilst the Durnford/Union Street junction is experiencing significant additional delay. The Union Street/Western Approach junction is also experiencing additional delay although not as significant.

5.4 Flow Differences between Options

5.4.1 The differences between the Options are marginal. There are no significant differences between Options 1 and 2 for example. In the Mackay Plan options it is noticeable that flows on Durnford Street, for example northbound in the AM peak, appear to fall as a result of the Port Link Road. The effect is not as apparent in the PM peak.

5.4.2 In general terms the effects of the Millbay developments appear to dissipate relatively quickly, the further one gets from the Millbay area. Increases in flow on the main City Centre routes are relatively small and generally less than 10%

5.5 Impact of Ferry

5.5.1 A similar exercise has been undertaken in terms of outputs for the ferry arrival and departure scenario.

5.5.2 A comparison of the average speeds for both the AM and PM peak is shown below in Table 5.7.

Table 5.7: Peak Hour Average Network Speeds with Ferry Sensitivity Test – km/h

Period	Base	Do-Min	Option 1	Option 2	Option 3A	Option 3B
AM Peak	28.3	25.8	22.2	17.9	23.2	21.0
PM Peak	28.6	19.4	21.4	18.9	23.8	24.5

5.5.3 The results indicate that the arrival or departure of a ferry has a significant impact on City Centre speeds and therefore journey times. The effect appears to be more significant with the arrival of a ferry in the PM peak. This is not surprising given the concentrated nature of the trips generated by a ferry arrival. The departure of the ferry is not as significant as the trips are spread over a longer period.

5.5.4 The results also appear to indicate that the presence of the Port Link Road in Options 3A and 3B has a positive impact on the effects of the ferry arrival in the PM peak. The effects of the Port Link Road are not as significant in the AM peak with the departure of a ferry.

5.5.5 It should be noted that in Options 1 and 2 measures have been taken to mitigate against the effects of a ferry arrival. For example, it may be that some relatively simple VMS signs or traffic management measures may mitigate against some of the delays apparent in the above results.

6 SUMMARY AND CONCLUSIONS

6.1.1 A Base Paramics model for the Millbay study area has been produced which replicates existing conditions in both Millbay and the City Centre.

6.1.2 A Do Minimum Paramics model has been created to take into account the Drakes Circus development.

6.1.3 A number of option tests have been undertaken based on scheme drawings and development trips provided by ABA.

6.1.4 SIAS has been provided with the following information so that the proposed Millbay developments can be modelled:

- DXF digitised scheme drawings from ABA for Options 1, 2, 3a and 3b
- Development trips associated with Millbay developments from ABA
- Development trips associated with Royal William Yard developments from PCC

6.1.5 The above mentioned development trips have been incorporated into the Paramics model as a separate matrix for each of the Millbay and Royal William Yard developments for both the AM and PM peaks.

6.1.6 The initial Paramics modelling indicates that the additional trips can be accommodated on the highway network satisfactorily along with the network changes proposed by ABA.

6.1.7 The overall impact of the proposed development trips (from all of the developments considered) is to increase peak hour traffic volumes in the Millbay Paramics Model study area by 19% in the AM peak and 16% in the PM peak. The effect of the Millbay generated trips on their own is to increase trips on the network by 17% and 12% respectively. A summary of the development trips associated with the Millbay scheme and their impact on existing flows is provided as Appendix C.

6.1.8 A series of outputs has been collected from the model including network speeds, average journey times and link flows. There are a number of key conclusions that can be made from the results.

6.1.9 The impact of the Millbay development trips in the AM peak is to increase journey times by around 10s-30s per trip or in percentage terms increase journey times by between 8%-20%.

6.1.10 In the PM peak, the differences are less significant with increases in journey times of between 2% and 4%.

6.1.11 It is reasonable to conclude that the effects of the Millbay developments on their own will not have a significantly detrimental effect on traffic movements within Plymouth City Centre.

6.1.12 A comparison of flows between the Do-minimum and the Do-something options has also been undertaken. The results indicate that there will be significant increases in flow in and around the Millbay area but that the increases in flow dissipate relatively quickly the further one gets from the development.

6.1.13 An analysis of delay at the major junctions within the Millbay area indicates that the Durnford/Union Street junction is suffering significant additional delay in both the AM and PM peak period whilst the Octagon junction is operating satisfactorily. The Union Street/Western Approach junction also experiences additional delay in both the AM and PM peak.

6.1.14 The impact of a ferry arrival in the PM peak has a significant negative effect on delay although the Port Link Road appears to offer a benefit in terms of mitigating against additional delays.

6.1.15 A visual examination of the Do Something Paramics models has also been undertaken. The examination confirms the conclusions made above that the Millbay developments can be satisfactorily accommodated on the existing highway network subject to detailed design of the revised junctions. An analysis of junction delay indicates particular attention should be paid to the Durnford/Union Street and Union Street/Western Approach junctions.

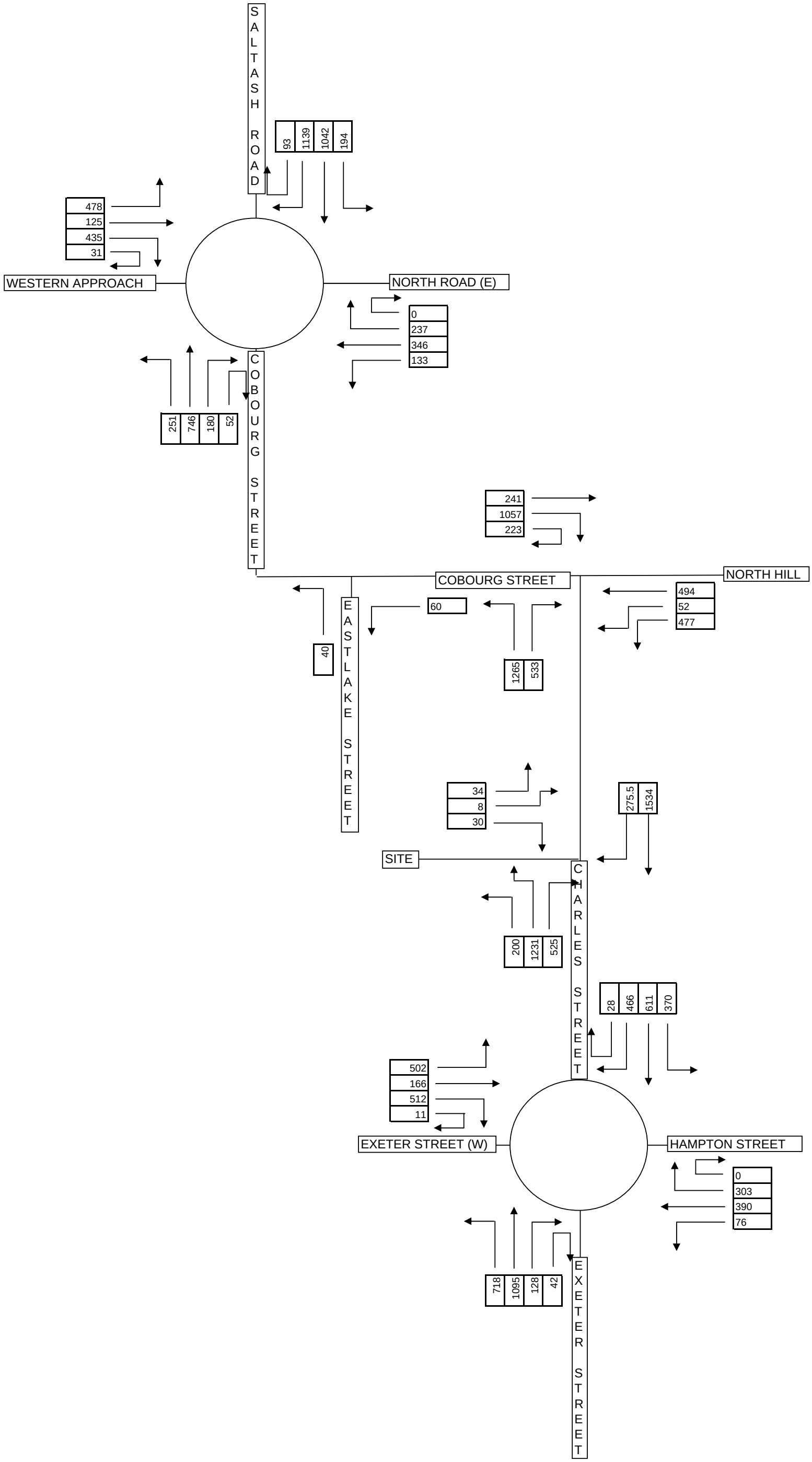
A COMPARISON BETWEEN OBSERVED AND MODELLED FLOWS

Appendix A - Comparison between observed and modelled traffic counts

AM Peak 0800-0900		Observed	Modelled	GEH
Union Street	Eastbound	440	465	1.2
Union Street	Westbound	688	623	2.5
Martin Street	Entry	264	282	1.1
	Exit	108	157	4.3
Citadel Road	Entry	333	409	3.9
	Exit	296	299	0.2
Ferry	Entry	6	17	3.2
	Exit	61	79	2.2
Millbay Road	Entry	170	156	1.1
	Exit	308	331	1.3
Ebrington Street	Entry	385	445	2.9
	Exit	760	745	0.5
North Hill	Entry	553	539	0.6
	Exit	412	384	1.4
Cattledown	Bretonside	1057	914	4.6
Castledown	Charles Cross	1488	1742	6.3
Bretonside	Exeter Street	403	403	0.0
Charles Cross	Exeter Street Eastbound	1091	967	3.9
Saltash Road	Southbound	1144	1448	8.4
	Northbound	890	914	0.8
Western Approach	Southbound	1048	1105	1.7
	Northbound	689	677	0.5
Devonport Hill	Westbound	473	483	0.5
	Eastbound	551	617	2.7

PM Peak 1700-1800		Observed	Modelled	GEH
Union Street	Eastbound	654	536	4.8
Union Street	Westbound	675	571	4.2
Martin Street	Entry	83	82	0.1
	Exit	198	202	0.3
Citadel Road	Entry	369	479	5.3
	Exit	182	270	5.9
Ferry	Entry	76	121	4.5
	Exit	33	32	0.2
Millbay Road	Entry	203	201	0.1
	Exit	318	379	3.3
Ebrington Street	Entry	312	419	5.6
	Exit	757	668	3.3
North Hill	Entry	431	456	1.2
	Exit	714	598	4.5
Cattledown	Bretonside	563	545	0.8
Castledown	Charles Cross	1198	1186	0.3
Bretonside	Exeter Street	903	828	2.5
Charles Cross	Exeter Street Eastbound	1344	1283	1.7
Saltash Road	Southbound	1328	1168	4.5
	Northbound	1913	1871	1.0
Western Approach	Southbound	744	728	0.6
	Northbound	1560	1461	2.5
Devonport Hill	Westbound	832	824	0.3
	Eastbound	550	443	4.8

B DRAKES CIRCUS REDEVELOPMENT REVISED DEMANDS



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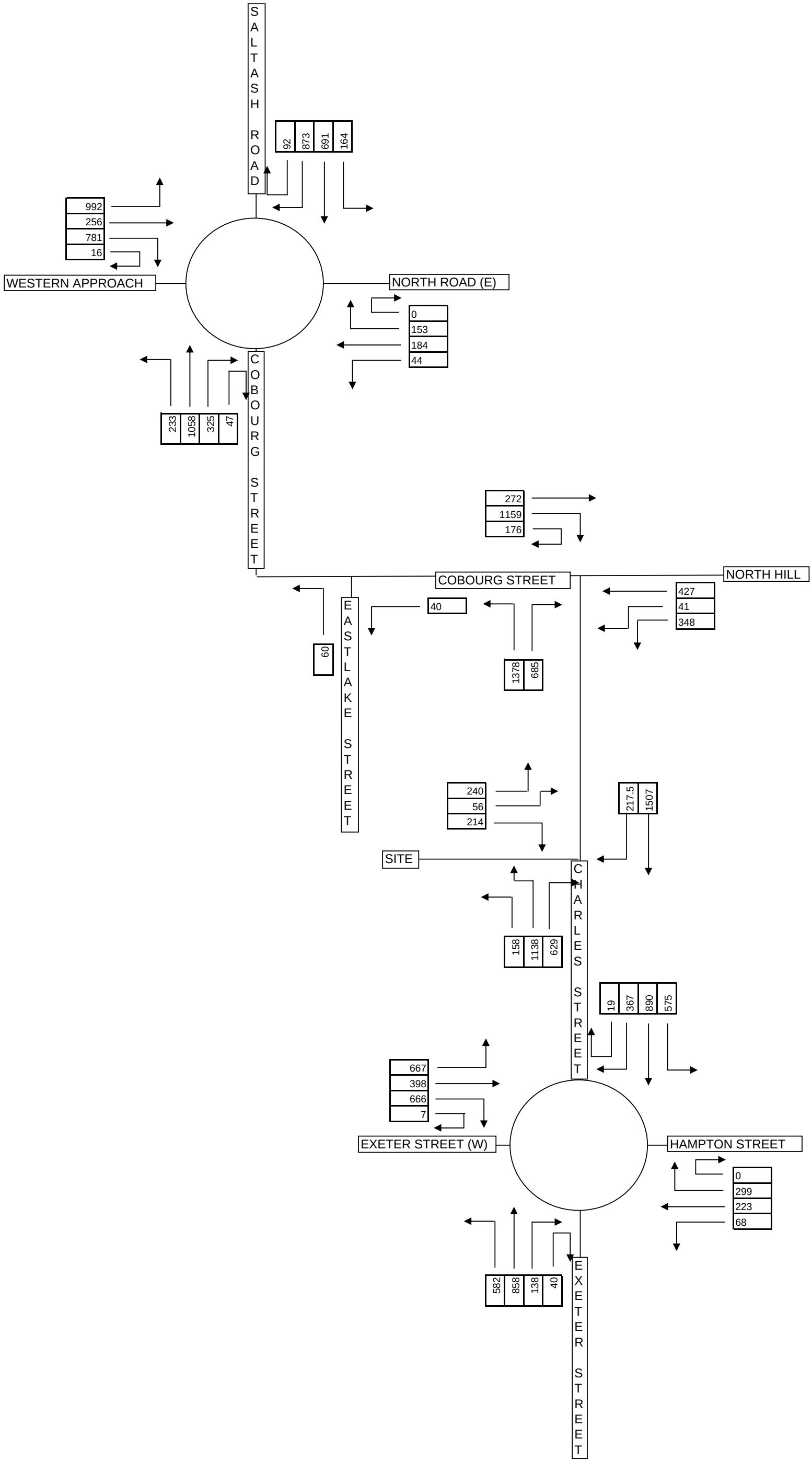
WSP

TITLE

DRAKE CIRCUS
2006 BASE (PROPOSED SCHEME) WITH DEVELOPMENT FLOW - WEEKDAY AM PEAK

FIGURE No:

16b



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WSP

TITLE

DRAKE CIRCUS
2006 BASE (CASE B) WITH DEVELOPMENT FLOW - WEEKDAY PM PEAK

FIGURE No:

16b

C HOURLY VEHICLE PROFILES FOR AM AND PM MODELLED PERIODS

Appendix C - Vehicular profiles for Paramics Millbay model

	Background traffic	Drakes Circus	Royal William Yard	Millbay	Total	Total Development	% additional trips	% Millbay additional
0700-0800	6895	218	129	1217	8459	1564	18%	18%
0800-0900	9644	304	357	2028	12333	2689	22%	21%
0900-1000	9347	294	240	1217	11098	1751	16%	13%
	25886	816	726	4462	31890	6004	19%	17%
1500-1600	10823	320	391	978	12512	1689	13%	9%
1600-1700	11182	332	409	1631	13554	2372	18%	15%
1700-1800	10703	317	538	1631	13189	2486	19%	15%
1800-1900	10079	298	579	978	11934	1855	16%	10%
	42787	1267	1917	5218	51189	8402	16%	12%

D CALCULATION OF NET CHANGE IN TRIPS ASSOCIATED WITH MILLBAY DEVELOPMENTS

Appendix D Calculation of Net Change in Trips associated with Millbay Developments

Existing Trips			**AM**			**PM**	
		Zone	**In**	**Out**		**In**	**Out**
Peak hour trips to be removed by zone		**416**	324	137		348	537
		29	13	4		1	11
		309	78	47		118	106
		307	61	8		7	36
		305	143	61		137	175
			619	257		611	865
Existing matrix totals		**416**	800	200		928	973
		29	199	45		123	463
		309	192	102		150	277
		307	935	426		706	1600
		305	487	891		726	3375
Calculated existing peak hour by zone		**416**	357	89		249	261
		29	89	20		33	124
		309	86	46		40	74
		307	417	190		189	428
		305	217	397		194	904
Proposed trips to be added			**In**	**Out**		**In**	**Out**
		416	767	453		651	780
		29	123	169		298	282
		309	651	463		376	483
		307	27	40		31	22
		305	498	257		386	480
			2066	1382		1742	2047
Net trips to be added			**In**	**Out**		**In**	**Out**
		416	443	316		303	243
		29	110	165		297	271
		309	573	416		258	377
		307	-34	32		24	-14
		305	355	196		249	305
			1447	1125		1131	1182
Adjustment (Provided by ABA)	0.842	**416**	646	381	0.820	534	640
		29	104	142		244	231
		309	548	390		308	396
		307	23	34		25	18
		305	419	216		317	394
			1740	1164		1428	1679
Net trips to be added		**416**	322	244		186	103
		29	91	138		243	220
		309	470	343		190	290
		307	-38	26		18	-18
		305	276	155		180	219
			1121	907		817	814

E PEAK HOUR LINK FLOW COMPARISONS

Appendix E - Peak Hour Link Flow Comparisons

AM Peak Hourly Flow

		Do-nothing	Do-minimum	Option 1	Option 2	Option 3a	Option 3b
Saltash Road	SB	1448	1492	1604	1602	1605	1601
	NB	914	923	998	1008	1006	966
Cobourg Street	SB	1227	1232	1268	1260	1259	1288
	NB	1036	931	1019	1043	988	1027
Charles Street	SB	1369	1382	1396	1410	1411	1413
	NB	1195	1055	1133	1171	1116	1127
Exeter Street	WB	2672	2799	3009	3028	2996	2969
	EB	1337	1414	1561	1583	1570	1572
Vauxhall Street	WB	378	369	431	436	449	538
	EB	283	304	378	350	344	319
Western Approach	SB	875	855	1105	1134	1108	1109
	NB	462	435	590	592	588	589
Union Street East	WB	993	1145	1046	1026	990	463
	EB	610	743	897	875	893	550
Martin Street	SB	253	415	635	578	534	602
	NB	207	236	531	513	457	454
Millbay Road East	WB	505	506	420	300	388	333
	EB	210	172	192	192	175	203
Union Street West	WB	557	710	642	672	825	839
	EB	521	637	941	983	947	928
Millbay Road West	WB	332	278	272	300	228	238
	EB	156	144	329	239	251	265
Durnford Street	SB	367	417	69	53	71	95
	NB	197	282	280	265	128	132
Stonehouse Bridge	WB	693	734	902	907	913	913
	NB	793	817	986	998	992	995
Boulevard North	NB	N/A	N/A	152	165	217	314
	SB	N/A	N/A	345	350	460	442
Boulevard South	NB	N/A	N/A	215	242	222	261
	SB	N/A	N/A	73	46	98	310

PM Peak Hourly Flow

		Do-nothing	Do-minimum	Option 1	Option 2	Option 3a	Option 3b
Saltash Road	SB	1176	1237	1338	1339	1342	1338
	NB	1874	1948	2101	2086	2099	2102
Cobourg Street	SB	1171	1354	1185	1202	1200	1210
	NB	1287	1278	1389	1358	1358	1045
Charles Street	SB	1136	1418	1261	1249	1240	1252
	NB	1256	1164	1319	1290	1290	1321
Exeter Street	WB	1733	1785	2080	2031	2010	2140
	EB	2053	2219	2194	2186	2192	2189
Vauxhall Street	WB	253	248	212	251	245	253
	EB	629	742	475	613	688	600
Western Approach	SB	580	999	782	771	764	777
	NB	1083	1352	1312	1322	1337	1322
Union Street East	WB	962	1126	892	972	854	437
	EB	767	810	952	918	902	688
Martin Street	SB	128	170	343	283	255	284
	NB	294	293	696	641	610	586
Millbay Road East	WB	371	327	217	175	197	209
	EB	518	573	348	387	415	333
Union Street West	WB	549	723	951	984	928	986
	EB	609	668	768	813	792	790
Millbay Road West	WB	378	336	378	312	297	265
	EB	217	293	360	370	262	361
Durnford Street	SB	157	359	32	26	33	41
	NB	544	702	288	273	322	297
Stonehouse Bridge	WB	1093	1151	1317	1294	1296	1301
	NB	666	720	781	797	800	797
Boulevard North	NB	N/A	N/A	72	150	187	352
	SB	N/A	N/A	250	333	365	477
Boulevard South	NB	N/A	N/A	297	335	280	390
	SB	N/A	N/A	176	102	114	301