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Road and Rail Supply Chain Resilience Review

Resilience analysis of key freight roads and railways

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The analysis and findings contained in this report do not represent government policy

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Acknowledgments 1

1 Introduction 2

Part I Resilience analysis for road 1

2 Method2

3 Road KFR outputs 4

3.1 Overview 4

3.2 Description of outputs 5

4 Modelled road KFR results - overview 9

4.1 KFR route disruption impact trends 10

4.2 KFR route disruption impact by state/territory 7

4.3 Compounding effects of national weather events 23

5 Modelled road KFR results - detail 25

5.1 Albany Highway 25

5.2 Arnhem Highway 32

5.3 Augusta Highway 38

5.4 Barkly Highway 45

5.5 Barrier Highway 51

5.6 Barton Highway 57

5.7 Bass Highway 62

5.8 Brand Highway 68

5.9 Brisbane Valley Highway 74

5.10 Bruce Highway 80

5.11 Buchanan Highway 87

5.12 Bussell Highway 93

5.13 Calder Highway 99

5.14 Capricorn Highway 105

5.15 Carnarvon Highway 111

5.16 Carpentaria Highway 117

5.17 Central Arnhem Road 123

5.18 Coolgardie – Esperance Highway 128

5.19 Cunningham Highway 134

5.20 D'Aguilar Highway 140

5.21 Dukes Highway ... 146
5.22 Eyre Highway ... 152
5.23 Flinders Highway ... 158
5.24 Goldfields Highway ... 164
5.25 Goulburn Valley Highway ... 170
5.26 Great Eastern Highway ... 176
5.27 Great Northern Highway ... 183
5.28 Great Western Highway ... 190
5.29 Gregory Development Road ... 196
5.30 Gregory Highway ... 202
5.31 Henty Highway ... 208
5.32 Hume Highway ... 214
5.33 Landsborough Highway ... 220
5.34 Lasseter Highway ... 226
5.35 Leichhardt Highway ... 232
5.36 Midland Highway ... 238
5.37 Monaro Highway ... 244
5.38 Newell Highway ... 249
5.39 New England Highway ... 256
5.40 North West Coastal Highway ... 262
5.41 Pacific Highway ... 269
5.42 Princes Freeway East ... 275
5.43 Princes Freeway West ... 282
5.44 Princes Highway NSW ... 289
5.45 Princes Highway Vic ... 295
5.46 South Coast Highway ... 301
5.47 South Western Highway ... 307
5.48 Stuart Highway ... 313
5.49 Sturt Highway ... 319
5.50 Victoria Highway ... 325
5.51 Warrego Highway ... 331
5.52 Western Highway ... 337

Part II Resilience analysis for rail 343

6 Rail analysis 344

6.1 Compounding effects of weather events 347

6.2 Queensland Great Northern Line 348

6.3 Queensland North Coast Line 349

6.4 Queensland Western System (West Moreton) 350

6.5 NSW North Coast Line 351

6.6 NSW Main West Line 353

6.7 NSW Main South Line 354

6.8 NSW Broken Hill Line 355

6.9 Victoria North East Line 356

6.10 Tasmania Main Line 357

6.11 Melbourne – Adelaide Main Line 358

6.12 SA Transcontinental Line 359

6.13 The Ghan Line 361

6.14 WA Transcontinental Line 362

6.15 Summary 364

6.16 Shift to alternative rail path 365

Appendices 367

A1 Glossary 368

A2 Essential commodities 369

A3 Methods 374

A4 Overview of TraNSIT 381

Figures

Figure 1 Location of modelled road KFRs 9

Figure 2 Impacts matrix for the ACT 8

Figure 3 Detour costs per tonne for the ACT 8

Figure 4 Impacts matrix for NSW 9

Figure 5 Detour costs per tonne for NSW 10

Figure 6 Impacts matrix for NT 11

Figure 7 Detour costs per tonne for NT 12

Figure 8 Impacts matrix for Queensland 13

Figure 9 Detour costs per tonne for Queensland 14

Figure 10 Impacts matrix for SA 16

Figure 11 Detour costs per tonne for SA 17

Figure 12 Impacts matrix for Tasmania 18

Figure 13 Detour costs per tonnes for Tasmania 18

Figure 14 Impacts matrix for Victoria 19

Figure 15 Detour costs per tonne for Victoria 20

Figure 16 Impacts matrix for WA 21

Figure 17 Detour costs per tonne for WA 22

Figure 18 Road closures (highlighted in blue) from the 2022 high weather season (to July 2022) relative to the modelled road KFRs 24

Figure 19 Albany Highway KFR 25

Figure 20 Arnhem Highway KFR 32

Figure 21 Augusta Highway KFR 38

Figure 22 Barkly Highway KFR 45

Figure 23 Barrier Highway KFR 51

Figure 24 Barton Highway KFR 57

Figure 25 Bass Highway KFR 62

Figure 26 Brand Highway KFR 68

Figure 27 Brisbane Valley Highway KFR 74

Figure 28 Bruce Highway KFR 80

Figure 29 Buchanan Highway KFR 87

Figure 30 Bussell Highway KFR 93

Figure 31 Calder Highway KFR 99
Figure 32 Capricorn Highway KFR 105
Figure 33 Carnarvon Highway KFR 111
Figure 34 Carpentaria Highway KFR 117
Figure 35 Central Arnhem Road KFR 123
Figure 36 Coolgardie – Esperance Highway KFR 128
Figure 37 Cunningham Highway KFR 134
Figure 38 D'Aguilar Highway KFR 140
Figure 39 Dukes Highway KFR 146
Figure 40 Eyre Highway KFR 152
Figure 41 Flinders Highway KFR 158
Figure 42 Goldfields Highway KFR 164
Figure 43 Goulburn Valley Highway KFR 170
Figure 44 Great Eastern Highway KFR 176
Figure 45 Great Northern Highway KFR 183
Figure 46 Great Western Highway KFR 190
Figure 47 Gregory Development Road KFR 196
Figure 48 Gregory Highway KFR 202
Figure 49 Henty Highway KFR 208
Figure 50 Hume Highway KFR 214
Figure 51 Landsborough Highway KFR 220
Figure 52 Lasseter Highway KFR 226
Figure 53 Leichhardt Highway KFR 232
Figure 54 Midland Highway KFR 238
Figure 55 Monaro Highway KFR 244
Figure 56 Newell Highway KFR 249
Figure 57 New England Highway KFR 256
Figure 58 North West Coastal Highway KFR 262
Figure 59 Pacific Highway KFR 269
Figure 60 Princes Freeway East KFR 275
Figure 61 Princes Freeway West KFR 282
Figure 62 Princes Highway NSW KFR 289
Figure 63 Princes Highway Vic KFR 295

Figure 64 South Coast Highway KFR 301

Figure 65 South Western Highway KFR 307

Figure 66 Stuart Highway KFR.. 313

Figure 67 Sturt Highway KFR.. 319

Figure 68 Victoria Highway KFR 325

Figure 69 Warrego Highway KFR.. 331

Figure 70 Western Highway KFR.. 337

Figure 71 Rail lines and breakage points identified for modelling 346

Figure 72 Locations of rail closures from the 2022 high weather season relative to the modelled rail breakage points.. 347

Figure 73 Illustration of the three intersections with the highest freight intensity on a given KFR 376

Figure 74 Illustration of the re-routing of freight from closing one of the intersections on the KFR (in orange) 377

Figure 75 Process diagram of TraNSIT, comprising the stages from set up to running of each model component 382

Figure 76 National baseline road layer used in TraNSIT showing heavy vehicle access 383

Figure 77 Typical PBS road access vehicles... 383

Figure 78 National baseline rail layer used in TraNSIT showing rail gauges............................. 384

Tables

Table 1 Outputs relating to a KFR for the business-as-usual (BAU) category 4

Table 2 Outputs relating to a KFR with the successive closure of the five successive alternative routes 5

Table 3 Trends in response to disruption for the four clusters of road KFR intersection 1

Table 4 KFRs and intersections identified for Cluster 1 1

Table 5 KFRs and intersections identified for Cluster 2 2

Table 6 KFRs and intersections identified for Cluster 3 5

Table 7 KFRs and intersections identified for Cluster 4 5

Table 8 Summary of community reliance metrics for each intersection on the Albany Highway key freight route - most impacted LGA 26

Table 9 Risk metrics for modelled intersections on the Albany Highway KFR 28

Table 10 Freight impact metrics for modelled intersections on the Albany Highway KFR by last successive closure 28

Table 11 Community impact metrics for modelled intersections on the Albany Highway KFR - obstructed supply chains 29

Table 12 Community impact metrics for modelled intersections on the Albany Highway KFR - re-routed supply chains 30

Table 13 Summary of community reliance metrics for each intersection on the Arnhem Highway key freight route - most impacted LGA... 33

Table 14 Risk metrics for modelled intersections on the Arnhem Highway KFR 34

Table 15 Freight impact metrics for modelled intersections on the Arnhem Highway KFR by last successive closure 35

Table 16 Community impact metrics for modelled intersections on the Arnhem Highway KFR - obstructed supply chains 36

Table 17 Community impact metrics for modelled intersections on the Arnhem Highway KFR - re-routed supply chains 37

Table 18 Summary of community reliance metrics for each intersection on the Augusta Highway key freight route - most impacted LGA... 39

Table 19 Risk metrics for modelled intersections on the Augusta Highway KFR – the model..... 40

Table 20 Freight impact metrics for modelled intersections on the Augusta Highway KFR 41

Table 21 Community impact metrics for modelled intersections on the Augusta Highway KFR - obstructed supply chains 42

Table 22 Community impact metrics for modelled intersections on the Augusta Highway KFR - re-routed supply chains 43

Table 23 Summary of community reliance metrics for each intersection on the Barkly Highway key freight route - most impacted LGA... 46

Table 24 Risk metrics for modelled intersections on the Barkly Highway KFR – the model 47

Table 25 Freight impact metrics for modelled intersections on the Barkly Highway KFR 48

Table 26 Community impact metrics for modelled intersections on the Barkly Highway KFR - obstructed supply chains 49

Table 27 Community impact metrics for modelled intersections on the Barkly Highway KFR - re-routed supply chains 50

Table 28 Summary of community reliance metrics for each intersection on the Barrier Highway key freight route - most impacted LGA... 52

Table 29 Risk metrics for modelled intersections on the Barrier Highway KFR – the model....... 53

Table 30 Freight impact metrics for modelled intersections on the Barrier Highway KFR 53

Table 31 Community impact metrics for modelled intersections on the Barrier Highway KFR - obstructed supply chains 55

Table 32 Community impact metrics for modelled intersections on the Barrier Highway KFR - re-routed supply chains 56

Table 33 Summary of community reliance metrics for each intersection on the Barton Highway key freight route - most impacted LGA........ 58

Table 34 Risk metrics for modelled intersections on the Barton Highway KFR – the model....... 59

Table 35 Freight impact metrics for modelled intersections on the Barton Highway KFR 59

Table 36 Community impact metrics for modelled intersections on the Barton Highway KFR - obstructed supply chains 60

Table 37 Community impact metrics for modelled intersections on the Barton Highway KFR - re-routed supply chains........ 61

Table 38 Summary of community reliance metrics for each intersection on the Bass Highway key freight route - most impacted LGA 63

Table 39 Risk metrics for modelled intersections on the Bass Highway KFR – the model........... 64

Table 40 Freight impact metrics for modelled intersections on the Bass Highway KFR 65

Table 41 Community impact metrics for modelled intersections on the Bass Highway KFR - obstructed supply chains 66

Table 42 Community impact metrics for modelled intersections on the Bass Highway KFR - re-routed supply chains........ 67

Table 43 Summary of community reliance metrics for each intersection on the Brand Highway key freight route - most impacted LGA........ 69

Table 44 Risk metrics for modelled intersections on the Brand Highway KFR............................ 70

Table 45 Freight impact metrics for modelled intersections on the Brand Highway KFR by last successive closure 71

Table 46 Community impact metrics for modelled intersections on the Brand Highway KFR - obstructed supply chains 72

Table 47 Community impact metrics for modelled intersections on the Brand Highway KFR - re-routed supply chains........ 73

Table 48 Summary of community reliance metrics for each intersection on the Brisbane Valley Highway key freight route - most impacted LGA........ 75

Table 49 Risk metrics for modelled intersections on the Brisbane Valley Highway KFR – the model 76

Table 50 Freight impact metrics for modelled intersections on the Brisbane Valley Highway KFR 77

Table 51 Community impact metrics for modelled intersections on the Brisbane Valley Highway KFR - obstructed supply chains 78

Table 52 Community impact metrics for modelled intersections on the Brisbane Valley Highway KFR - re-routed supply chains 79

Table 53 Summary of community reliance metrics for each intersection on the Bruce Highway key freight route - most impacted LGA........ 81

Table 54 Risk metrics for modelled intersections on the Bruce Highway KFR – the model......... 83

Table 55 Freight impact metrics for modelled intersections on the Bruce Highway KFR 83

Table 56 Community impact metrics for modelled intersections on the Bruce Highway KFR - obstructed supply chains 84

Table 57 Community impact metrics for modelled intersections on the Bruce Highway KFR - re-routed supply chains 86

Table 58 Summary of community reliance metrics for each intersection on the Buchanan Highway key freight route - most impacted LGA... 88

Table 59 Risk metrics for modelled intersections on the Buchanan Highway KFR 89

Table 60 Freight impact metrics for modelled intersections on the Buchanan Highway KFR by last successive closure 90

Table 61 Community impact metrics for modelled intersections on the Buchanan Highway KFR - obstructed supply chains 91

Table 62 Community impact metrics for modelled intersections on the Buchanan Highway KFR - re-routed supply chains 92

Table 63 Summary of community reliance metrics for each intersection on the Bussell Highway key freight route - most impacted LGA... 94

Table 64 Risk metrics for modelled intersections on the Bussell Highway KFR – the model....... 95

Table 65 Freight impact metrics for modelled intersections on the Bussell Highway KFR 96

Table 66 Community impact metrics for modelled intersections on the Bussell Highway KFR - obstructed supply chains 97

Table 67 Community impact metrics for modelled intersections on the Bussell Highway KFR - re-routed supply chains 98

Table 68 Summary of community reliance metrics for each intersection on the Calder Highway key freight route - most impacted LGA... 100

Table 69 Risk metrics for modelled intersections on the Calder Highway KFR – the model 101

Table 70 Freight impact metrics for modelled intersections on the Calder Highway KFR 102

Table 71 Community impact metrics for modelled intersections on the Calder Highway KFR - obstructed supply chains 103

Table 72 Community impact metrics for modelled intersections on the Calder Highway KFR - re-routed supply chains 104

Table 73 Summary of community reliance metrics for each intersection on the Capricorn Highway key freight route - most impacted LGA... 106

Table 74 Risk metrics for modelled intersections on the Capricorn Highway KFR..................... 107

Table 75 Freight impact metrics for modelled intersections on the Capricorn Highway KFR.... 108

Table 76 Community impact metrics for modelled intersections on the Capricorn Highway KFR - obstructed supply chains 109

Table 77 Community impact metrics for modelled intersections on the Capricorn Highway KFR - re-routed supply chains 110

Table 78 Summary of community reliance metrics for each intersection on the Carnarvon Highway key freight route - most impacted LGA..... 112

Table 79 Risk metrics for modelled intersections on the Carnarvon Highway KFR – the model 113

Table 80 Freight impact metrics for modelled intersections on the Carnarvon Highway KFR... 114

Table 81 Community impact metrics for modelled intersections on the Carnarvon Highway KFR - obstructed supply chains 115

Table 82 Community impact metrics for modelled intersections on the Carnarvon Highway KFR - re-routed supply chains 116

Table 83 Summary of community reliance metrics for each intersection on the Carpentaria Highway key freight route - most impacted LGA..... 118

Table 84 Risk metrics for modelled intersections on the Carpentaria Highway KFR 119

Table 85 Freight impact metrics for modelled intersections on the Carpentaria Highway KFR by last successive closure 120

Table 86 Community impact metrics for modelled intersections on the Carpentaria Highway KFR - obstructed supply chains 121

Table 87 Community impact metrics for modelled intersections on the Carpentaria Highway KFR - re-routed supply chains 122

Table 88 Summary of community reliance metrics for each intersection on the Central Arnhem Highway key freight route - most impacted LGA..... 124

Table 89 Risk metrics for modelled intersections on the Central Arnhem Highway KFR..... 125

Table 90 Freight impact metrics for modelled intersections on the Central Arnhem Highway KFR by last successive closure..... 125

Table 91 Community impact metrics for modelled intersections on the Central Arnhem Highway KFR - obstructed supply chains 126

Table 92 Community impact metrics for modelled intersections on the Central Arnhem Highway KFR - re-routed supply chains 127

Table 93 Summary of community reliance metrics for each intersection on the Coolgardie – Esperance Highway key freight route - most impacted LGA 129

Table 94 Risk metrics for modelled intersections on the Coolgardie – Esperance Highway KFR 130

Table 95 Freight impact metrics for modelled intersections on the Coolgardie – Esperance Highway KFR..... 131

Table 96 Community impact metrics for modelled intersections on the Coolgardie – Esperance Highway KFR - obstructed supply chains 132

Table 97 Community impact metrics for modelled intersections on the Coolgardie – Esperance Highway KFR - re-routed supply chains 133

Table 98 Summary of community reliance metrics for each intersection on the Cunningham Highway key freight route - most impacted LGA..... 135

Table 99 Risk metrics for modelled intersections on the Cunningham Highway KFR..... 136

Table 100 Freight impact metrics for modelled intersections on the Cunningham Highway KFR 137

Table 101 Community impact metrics for modelled intersections on the Cunningham Highway KFR - obstructed supply chains 138

Table 102 Community impact metrics for modelled intersections on the Cunningham Highway KFR - re-routed supply chains 139

Table 103 Summary of community reliance metrics for each intersection on the D'Aguilar Highway key freight route - most impacted LGA..... 141

Table 104 Risk metrics for modelled intersections on the D'Aguilar Highway KFR – the model 142

Table 105 Freight impact metrics for modelled intersections on the D'Aguilar Highway KFR .. 143

Table 106 Community impact metrics for modelled intersections on the D'Aguilar Highway KFR - obstructed supply chains 144

Table 107 Community impact metrics for modelled intersections on the D'Aguilar Highway KFR - re-routed supply chains 145

Table 108 Summary of community reliance metrics for each intersection on the Dukes Highway key freight route - most impacted LGA..... 147

Table 109 Risk metrics for modelled intersections on the Dukes Highway KFR – the model 148

Table 110 Freight impact metrics for modelled intersections on the Dukes Highway KFR 149

Table 111 Community impact metrics for modelled intersections on the Dukes Highway KFR - obstructed supply chains 150

Table 112 Community impact metrics for modelled intersections on the Dukes Highway KFR - re-routed supply chains 151

Table 113 Summary of community reliance metrics for each intersection on the Eyre Highway key freight route - most impacted LGA 153

Table 114 Risk metrics for modelled intersections on the Eyre Highway KFR 154

Table 115 Freight impact metrics for modelled intersections on the Eyre Highway KFR 155

Table 116 Community impact metrics for modelled intersections on the Eyre Highway KFR - obstructed supply chains 156

Table 117 Community impact metrics for modelled intersections on the Eyre Highway KFR - re-routed supply chains 157

Table 118 Summary of community reliance metrics for each intersection on the Flinders Highway key freight route - most impacted LGA..... 159

Table 119 Risk metrics for modelled intersections on the Flinders Highway KFR..................... 160

Table 120 Freight impact metrics for modelled intersections on the Flinders Highway KFR 161

Table 121 Community impact metrics for modelled intersections on the Flinders Highway KFR - obstructed supply chains 162

Table 122 Community impact metrics for modelled intersections on the Flinders Highway KFR - re-routed supply chains 163

Table 123 Summary of community reliance metrics for each intersection on the Goldfields Highway NSW key freight route - most impacted LGA 165

Table 124 Risk metrics for modelled intersections on the Goldfields Highway NSW KFR 166

Table 125 Freight impact metrics for modelled intersections on the Goldfields Highway NSW KFR by last successive closure.. 167

Table 126 Community impact metrics for modelled intersections on the Goldfields Highway NSW KFR - obstructed supply chains 168

Table 127 Community impact metrics for modelled intersections on the Goldfields Highway NSW KFR - re-routed supply chains 169

Table 128 Summary of community reliance metrics for each intersection on the Goulburn Valley Highway NSW key freight route - most impacted LGA 171

Table 129 Risk metrics for modelled intersections on the Goulburn Valley Highway NSW KFR 172

Table 130 Freight impact metrics for modelled intersections on the Goulburn Valley Highway NSW KFR by last successive closure.. 173

Table 131 Community impact metrics for modelled intersections on the Goulburn Valley Highway NSW KFR - obstructed supply chains 174

Table 132 Community impact metrics for modelled intersections on the Goulburn Valley Highway NSW KFR – re-routed supply chains.. 175

Table 133 Summary of community reliance metrics for each intersection on the Great Eastern Highway NSW key freight route - most impacted LGA 177

Table 134 Risk metrics for modelled intersections on the Great Eastern Highway NSW KFR ... 178

Table 135 Freight impact metrics for modelled intersections on the Great Eastern Highway NSW KFR by last successive closure.. 178

Table 136 Community impact metrics for modelled intersections on the Great Eastern Highway NSW KFR - obstructed supply chains 180

Table 137 Community impact metrics for modelled intersections on the Great Eastern Highway NSW KFR – re-routed supply chains.. 182

Table 138 Summary of community reliance metrics for each intersection on the Great Northern Highway key freight route - most impacted LGA... 184

Table 139 Risk metrics for modelled intersections on the Great Northern Highway KFR 185

Table 140 Freight impact metrics for modelled intersections on the Great Northern Highway KFR by last successive closure 186

Table 141 Community impact metrics for modelled intersections on the Great Northern Highway KFR - obstructed supply chains 187

Table 142 Community impact metrics for modelled intersections on the Great Northern Highway KFR – re-routed supply chains 188

Table 143 Summary of community reliance metrics for each intersection on the Great Western Highway key freight route - most impacted LGA 191

Table 144 Risk metrics for modelled intersections on the Great Western Highway KFR – the model 192

Table 145 Freight impact metrics for modelled intersections on the Great Western Highway KFR 193

Table 146 Community impact metrics for modelled intersections on the Great Western Highway KFR - obstructed supply chains 194

Table 147 Community impact metrics for modelled intersections on the Great Western Highway KFR - re-routed supply chains 195

Table 148 Summary of community reliance metrics for each intersection on the Gregory Development Road key freight route - most impacted LGA 197

Table 149 Risk metrics for modelled intersections on the Gregory Development Road KFR – the model 198

Table 150 Freight impact metrics for modelled intersections on the Gregory Development Road KFR 199

Table 151 Community impact metrics for modelled intersections on the Gregory Development Road KFR - obstructed supply chains 200

Table 152 Community impact metrics for modelled intersections on the Gregory Development Road KFR - re-routed supply chains 201

Table 153 Summary of community reliance metrics for each intersection on the Gregory Highway key freight route - most impacted LGA 203

Table 154 Risk metrics for modelled intersections on the Gregory Highway KFR 204

Table 155 Freight impact metrics for modelled intersections on the Gregory Highway KFR by last successive closure 205

Table 156 Community impact metrics for modelled intersections on the Gregory Highway KFR - obstructed supply chains 206

Table 157 Community impact metrics for modelled intersections on the Gregory Highway KFR - re-routed supply chains 207

Table 158 Summary of community reliance metrics for each intersection on the Henty Highway key freight route - most impacted LGA 209

Table 159 Risk metrics for modelled intersections on the Henty Highway KFR – the model 210

Table 160 Freight impact metrics for modelled intersections on the Henty Highway KFR........ 210
Table 161 Community impact metrics for modelled intersections on the Henty Highway KFR - obstructed supply chains 212
Table 162 Community impact metrics for modelled intersections on the Henty Highway KFR - re-routed supply chains.. 213
Table 163 Summary of community reliance metrics for each intersection on the Hume Highway key freight route - most impacted LGA.. 215
Table 164 Risk metrics for modelled intersections on the Hume Highway KFR........................ 216
Table 165 Freight impact metrics for modelled intersections on the Hume Highway KFR by last successive closure 217
Table 166 Community impact metrics for modelled intersections on the Hume Highway KFR - obstructed supply chains 218
Table 167 Community impact metrics for modelled intersections on the Hume Highway KFR - re-routed supply chains.. 219
Table 168 Summary of community reliance metrics for each intersection on the Landsborough Highway key freight route - most impacted LGA... 221
Table 169 Risk metrics for modelled intersections on the Landsborough Highway KFR – the model 222
Table 170 Freight impact metrics for modelled intersections on the Landsborough Highway KFR 223
Table 171 Community impact metrics for modelled intersections on the Landsborough Highway KFR - obstructed supply chains 224
Table 172 Community impact metrics for modelled intersections on the Landsborough Highway KFR - re-routed supply chains 225
Table 173 Summary of community reliance metrics for each intersection on the Lasseter Highway key freight route - most impacted LGA.. 227
Table 174 Risk metrics for modelled intersections on the Lasseter Highway KFR 228
Table 175 Freight impact metrics for modelled intersections on the Lasseter Highway KFR by last successive closure 229
Table 176 Community impact metrics for modelled intersections on the Lasseter Highway KFR - obstructed supply chains 230
Table 177 Community impact metrics for modelled intersections on the Lasseter Highway KFR - re-routed supply chains 231
Table 178 Summary of community reliance metrics for each intersection on the Leichhardt Highway key freight route - most impacted LGA... 233
Table 179 Risk metrics for modelled intersections on the Leichhardt Highway KFR – the model 234

Table 180 Freight impact metrics for modelled intersections on the Leichhardt Highway KFR 235
Table 181 Community impact metrics for modelled intersections on the Leichhardt Highway KFR - obstructed supply chains 236
Table 182 Community impact metrics for modelled intersections on the Leichhardt Highway KFR - re-routed supply chains 237
Table 183 Summary of community reliance metrics for each intersection on the Midland Highway key freight route - most impacted LGA..... 239
Table 184 Risk metrics for modelled intersections on the Midland Highway KFR – the model 240
Table 185 Freight impact metrics for modelled intersections on the Midland Highway KFR.... 241
Table 186 Community impact metrics for modelled intersections on the Midland Highway KFR - obstructed supply chains 242
Table 187 Community impact metrics for modelled intersections on the Midland Highway KFR - re-routed supply chains 243
Table 188 Summary of community reliance metrics for each intersection on the Monaro Highway key freight route - most impacted LGA..... 245
Table 189 Risk metrics for modelled intersections on the Monaro Highway KFR 246
Table 190 Freight impact metrics for modelled intersections on the Monaro Highway KFR by last successive closure 246
Table 191 Community impact metrics for modelled intersections on the Monaro Highway KFR - obstructed supply chains 247
Table 192 Community impact metrics for modelled intersections on the Monaro Highway KFR - re-routed supply chains 248
Table 193 Summary of community reliance metrics for each intersection on the Newell Highway key freight route - most impacted LGA..... 250
Table 194 Risk metrics for modelled intersections on the Newell Highway KFR – the model... 251
Table 195 Freight impact metrics for modelled intersections on the Newell Highway KFR 252
Table 196 Community impact metrics for modelled intersections on the Newell Highway KFR - obstructed supply chains 253
Table 197 Community impact metrics for modelled intersections on the Newell Highway KFR - re-routed supply chains 254
Table 198 Summary of community reliance metrics for each intersection on the New England Highway key freight route - most impacted LGA..... 257
Table 199 Risk metrics for modelled intersections on the New England Highway KFR – the model 258
Table 200 Freight impact metrics for modelled intersections on the New England Highway KFR 259

Table 201 Community impact metrics for modelled intersections on the New England Highway KFR - obstructed supply chains 260

Table 202 Community impact metrics for modelled intersections on the New England Highway KFR - re-routed supply chains 261

Table 203 Summary of community reliance metrics for each intersection on the North West Coastal Highway key freight route - most impacted LGA 263

Table 204 Risk metrics for modelled intersections on the North West Coastal Highway KFR – the model 264

Table 205 Freight impact metrics for modelled intersections on the North West Coastal Highway KFR........ 265

Table 206 Community impact metrics for modelled intersections on the North West Coastal Highway KFR - obstructed supply chains 266

Table 207 Community impact metrics for modelled intersections on the North West Coastal Highway KFR - re-routed supply chains 267

Table 208 Summary of community reliance metrics for each intersection on the Pacific Highway NSW key freight route - most impacted LGA........ 270

Table 209 Risk metrics for modelled intersections on the Pacific Highway NSW KFR 271

Table 210 Freight impact metrics for modelled intersections on the Pacific Highway NSW KFR by last successive closure 272

Table 211 Community impact metrics for modelled intersections on the Pacific Highway NSW KFR - obstructed supply chains 273

Table 212 Community impact metrics for modelled intersections on the Pacific Highway NSW KFR - re-routed supply chains 274

Table 213 Summary of community reliance metrics for each intersection on the Princes Freeway East key freight route - most impacted LGA 276

Table 214 Risk metrics for modelled intersections on the Princes Freeway East KFR 277

Table 215 Freight impact metrics for modelled intersections on the Princes Freeway East KFR by last successive closure 278

Table 216 Community impact metrics for modelled intersections on the Princes Freeway East KFR - obstructed supply chains 279

Table 217 Community impact metrics for modelled intersections on the Princes Freeway East KFR - re-routed supply chains 281

Table 218 Summary of community reliance metrics for each intersection on the Princes Freeway West key freight route - most impacted LGA 283

Table 219 Risk metrics for modelled intersections on the Princes Freeway West KFR – the model 284

Table 220 Freight impact metrics for modelled intersections on the Princes Freeway West KFR 284

Table 221 Community impact metrics for modelled intersections on the Princes Freeway West KFR - obstructed supply chains 286

Table 222 Community impact metrics for modelled intersections on the Princes Freeway West KFR - re-routed supply chains 288

Table 223 Summary of community reliance metrics for each intersection on the Princes Highway NSW key freight route - most impacted LGA 290

Table 224 Risk metrics for modelled intersections on the Princes Highway NSW KFR 291

Table 225 Freight impact metrics for modelled intersections on the Princes Highway NSW KFR by last successive closure 292

Table 226 Community impact metrics for modelled intersections on the Princes Highway NSW KFR - obstructed supply chains 293

Table 227 Community impact metrics for modelled intersections on the Princes Highway NSW KFR - re-routed supply chains 294

Table 228 Summary of community reliance metrics for each intersection on the Princes Highway Vic key freight route - most impacted LGA 296

Table 229 Risk metrics for modelled intersections on the Princes Highway Vic KFR – the model 297

Table 230 Freight impact metrics for modelled intersections on the Princes Highway Vic KFR 298

Table 231 Community impact metrics for modelled intersections on the Princes Highway Vic KFR - obstructed supply chains 299

Table 232 Community impact metrics for modelled intersections on the Princes Highway Vic KFR - re-routed supply chains 300

Table 233 Summary of community reliance metrics for each intersection on the South Coast Highway key freight route - most impacted LGA 302

Table 234 Risk metrics for modelled intersections on the South Coast Highway KFR 303

Table 235 Freight impact metrics for modelled intersections on the South Coast Highway KFR by last successive closure 304

Table 236 Community impact metrics for modelled intersections on the South Coast Highway KFR - obstructed supply chains 305

Table 237 Community impact metrics for modelled intersections on the South Coast Highway KFR - re-routed supply chains 306

Table 238 Summary of community reliance metrics for each intersection on the South Western Highway key freight route - most impacted LGA 308

Table 239 Risk metrics for modelled intersections on South Western Highway KFR – the model 309

Table 240 Freight impact metrics for modelled intersections on South Western Highway KFR 310

Table 241 Community impact metrics for modelled intersections on South Western Highway KFR - obstructed supply chains 311
Table 242 Community impact metrics for modelled intersections on South Western Highway KFR - re-routed supply chains 312
Table 243 Summary of community reliance metrics for each intersection on the Stuart Highway key freight route - most impacted LGA........ 314
Table 244 Risk metrics for modelled intersections on the Stuart Highway KFR 315
Table 245 Freight impact metrics for modelled intersections on the Stuart Highway KFR by last successive closure 316
Table 246 Community impact metrics for modelled intersections on the Stuart Highway KFR - obstructed supply chains 317
Table 247 Community impact metrics for modelled intersections on the Stuart Highway KFR - re-routed supply chains........ 318
Table 248 Summary of community reliance metrics for each intersection on the Sturt Highway key freight route - most impacted LGA........ 320
Table 249 Risk metrics for modelled intersections on the Sturt Highway KFR 321
Table 250 Freight impact metrics for modelled intersections on the Sturt Highway KFR by last successive closure 321
Table 251 Community impact metrics for modelled intersections on the Sturt Highway KFR - obstructed supply chains 323
Table 252 Community impact metrics for modelled intersections on the Sturt Highway KFR - re-routed supply chains........ 324
Table 253 Summary of community reliance metrics for each intersection on the Victoria Highway key freight route - most impacted LGA........ 326
Table 254 Risk metrics for modelled intersections on the Victoria Highway KFR........ 327
Table 255 Freight impact metrics for modelled intersections on the Victoria Highway KFR by last successive closure 328
Table 256 Community impact metrics for modelled intersections on the Victoria Highway KFR - obstructed supply chains 329
Table 257 Community impact metrics for modelled intersections on the Victoria Highway KFR - re-routed supply chains 330
Table 258 Summary of community reliance metrics for each intersection on the Warrego Highway key freight route - most impacted LGA........ 332
Table 259 Risk metrics for modelled intersections on the Warrego Highway KFR 333
Table 260 Freight impact metrics for modelled intersections on the Warrego Highway KFR by last successive closure 333

Table 261 Community impact metrics for modelled intersections on the Warrego Highway KFR - obstructed supply chains 335

Table 262 Community impact metrics for modelled intersections on the Warrego Highway KFR - re-routed supply chains 336

Table 263 Summary of community reliance metrics for each intersection on the Western Highway key freight route - most impacted LGA........ 338

Table 264 Risk metrics for modelled intersections on the Western Highway KFR 339

Table 265 Freight impact metrics for modelled intersections on the Western Highway KFR by last successive closure 339

Table 266 Community impact metrics for modelled intersections on the Western Highway KFR - obstructed supply chains 340

Table 267 Community impact metrics for modelled intersections on the Western Highway KFR - re-routed supply chains 342

Table 268 Annual rail freight summary for Queensland Great Northern Line 348

Table 269 Road comparison summary for rail freight for Queensland Great Northern Line 348

Table 270 Annual rail freight statistics for Queensland North Coast Line........ 349

Table 271 Road comparison summary for Rail freight for Queensland North Coast Line 349

Table 272 Annual rail freight statistics for Queensland Western system 350

Table 273 Road comparison summary for Rail freight for Queensland Western system 350

Table 274 Annual rail freight statistics for NSW North Coast Line 351

Table 275 Road comparison summary for Rail freight for NSW North Coast Line........ 351

Table 276 Annual freight statistics for NSW Main West Line 353

Table 277 Alternative rail route comparison summary for rail freight for NSW Main West Line 353

Table 278 Annual rail freight statistics for NSW Main South Line 354

Table 279 Alternative rail route comparison summary for rail freight for NSW Main South Line 354

Table 280 Annual rail freight statistics for NSW Broken Hill Line 355

Table 281 Alternative rail route comparison summary for Rail freight for NSW Broken Hill Line 355

Table 282 Annual rail freight statistics for Victoria North East Line 356

Table 283 Road comparison summary for Rail freight for Victoria North East Line 356

Table 284 Annual rail freight statistics for Tas Main Line 357

Table 285 Road comparison summary for Rail freight for Tas Main Line 357

Table 286 Annual rail freight statistics for Melbourne – Adelaide Main Line 358

Table 287 Road comparison summary for Rail freight for Melbourne – Adelaide Main Line.... 358
Table 288 Annual rail freight statistics for SA Trans Australia Line 359
Table 289 Road comparison summary for Rail freight for SA Trans Australia Line................... 359
Table 290 Annual rail freight statistics for The Ghan Line... 361
Table 291 Road comparison summary for Rail freight for The Ghan Line................................ 361
Table 292 Annual rail freight statistics for WA Trans Australia Line 362
Table 293 Road comparison summary for Rail freight for WA Trans Australia Line 362
Table 294 Summary of shift to road as a comparison to existing rail 364
Table 295 Summary of freight shifted to alternative rail routes... 365

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1 Introduction

Australians depend on strong and resilient supply chains for all goods and services. Whether for food, fuel, clothing, household products, medical supplies or building materials, resilient supply chains minimise the disruption to critical commodities reaching their final destinations. The impacts of COVID-19 and the major flood events of 2021/2022 demonstrated the vulnerability of Australia's freight routes in transporting critical commodities across the country to urban and regional communities. Freight routes are of critical importance to the national economy, and the lives and livelihoods of Australians. Understanding which supply chains are of national importance for different types of freight, the risks they face and how government and industry can work to mitigate these risks is essential to ensure supply chains remain resilient and fit for purpose now and in the future.

This report provides analysis and input to a larger review conducted by the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (the Department). This larger review, Road and Rail Supply Chain Resilience Review will:

- define and determine key risks to critical supply routes – routes that transport large quantities of freight or are critical to supply of essential commodities or services across Australia;
- identify key risks to critical supply routes in the short, medium and long term — including weather events or natural disasters, limited alternative routes, and limited and difficult to access alternative transport modes;
- assess the potential vulnerabilities in critical supply routes;
- complete a stocktake of recent relevant work by government and industry intended to identify and mitigate Australian domestic road and rail supply chain risks;
- identify data generation, capture and use requirements necessary to assess, inform best practice and improve road and rail supply chain resilience;
- determine the critical routes at highest risk of failure;
- develop and present pragmatic options for governments to mitigate or address risks to critical road and rail supply chains, in alignment with the Government-agreed framework to identify and mitigate critical supply chain risks.

Specifically, this report supports the Department's review by:

- identifying a shortlist of road and rail supply chain routes deemed 'critical';
- identifying the critical road and rail supply chain routes that cannot 'easily shift' their freight onto alternate modes or routes;
- providing details on additional data that could help better inform critical resilience issues in the future.

The scope of this project covers all Australian supply chains modelled in the Transport Network Strategic Investment Tool (TraNSIT) (Higgins *et al* 2018, Transport logistics-TraNSIT - CSIRO) as at May 2022. A brief overview of TraNSIT is contained in Appendix 0. There were 155 commodities in

TraNSIT at the time of this analysis, plus an additional ten categories for freight between distribution centres and markets. The following definitions were used for the purposes of this project:

- **'High-use freight route'**: a freight route carrying a large amount of freight (in terms of volume and/or value, such a national and state highways) or carrying greater than 25% of 'essential commodities' for the destination community/ies (represented as LGA/LGAs);
- **'Critical freight route'**: a freight route that facilitates supply of greater than 25% of essential commodities required for a defined LGA;
- **'Easily shifted commodity':** a commodity that can move to an alternate transport mode or route where the change does not add significant additional amounts of time/cost;
- **'Essential commodity'**: a commodity that is needed for the health and wellbeing of individuals and communities. A list of 'essential commodities' is included in Appendix 0.

This report presents the results and associated outputs from the TraNSIT analysis for a subset of key road and rail freight routes, capturing the impacts due to disruptions to supply chains which use these key freight routes.

The process undertaken included:

- identification of high-use and critical freight routes;
- development of a resilience metric applied across each of the identified routes;
- modelling the supply chain movements across the rail and road networks;
- capturing the resilience metrics for the identified key freight routes.

For this project, the focus of the road component of the analysis was on road corridors identified as key freight routes (KFRs) on the National Key Freight Routes Web App (https://maps.infrastructure.gov.au/KeyFreightRoute/). There are 315 KFRs across Australia. This was reduced to a subset of 52 that met either the 'high-use' or 'critical' freight route definitions, as outlined above. The resilience metric was developed using these 52 KFRs. The rail routes selected for a detailed analysis were chosen based on the diversity of commodities and the higher freight volumes carried, with a preference for routes between major centres. Refer to Chapter 6 for a more detailed description of the rail analysis method.

Part I Resilience analysis for road

2 Method

The National Critical Infrastructure Resilience Strategy 2015 and the NSW Critical Infrastructure Resilience Strategy 2018, identify three types of resilience; (1) infrastructure resilience which is about physical assets, networks and systems, (2) organisational resilience which is about the organisations, personnel and processes supporting infrastructure to supply a service, (3) community resilience, the role the community has in building/maintaining resilience and contributing to.

In a transport context, this report, which relates to (1) and (2) above, defines Resilience according to Jean-Paul Rodrigue's definition: (2022): "For a transportation system, resilience is the capability to recover from a disruption to an operational level similar to prior to the disruption in a timely manner. The longer and deeper the impact of the disruption on operations, the less resilient a transport system is.".

To determine a resilient transport system and the supply chains of freight that use the network, we first identified 52 'high-use' or 'critical' KFRs from the 315 road KFRs Australia-wide (refer Section 1):

- High-use freight route' is a freight route carrying a large amount of freight (in terms of volume and/or value, such a national and state highways) or carrying greater than 25% of 'essential commodities' for the destination community/ies (represented as LGA/LGAs).
- 'Critical freight route' is a freight route that facilitates supply of greater than 25% of essential commodities required for a defined LGA.

Whilst there is no official list, for the purposes of this analysis, an 'essential commodity' is either:

1. principally for household consumption or immediately enters as an input for household consumption (e.g. food (unprocessed and processed) and water (including components for the operations and maintenance of continuity of water supply and sewage services))
2. fuel that is essential to maintain supply chains, or
3. a construction or transport material necessary to respond to broken supply chains.

A list of essential commodities is provided in Appendix 0.

According to these definitions, 44 *high-use* KFRs and eight *critical* KFRs were selected. To ensure that each state and territory were represents, a minimum of the top two KFRs based on the *high-use* criteria were included from each state or territory.

For each KFR, the data derived from TraNSIT was analysed to identify the important feeder roads and a maximum set of three intersections per KFR determined as of strategic importance. These intersections were closed and modelled using TraNSIT to understand the impacts of the road closures. The process involved:

- Closure of the initial intersection and modelling the change in freight flows in terms of re-routing or obstruction
- Identification and closure of the "least cost" alternate route and modelling the change in freight flows. This process is then repeated for five subsequent iterations.

The modelling of the closure of the intersections was reflective of implementing an exclusion zone at each intersection, with the objective being to understand the impacts of each specific intersection's closure. Congestion implications were not considered as part of this modelling.

A measure of the impact of the disruption was then calculated for each intersection of the modelled KFRs and included:

- obstructed freight metrics (volumes and value)
- detour freight metrics (volumes and costs)
- community impact from obstructed and detoured freight (LGA impacted and relative volumes)

A list of all the metrics calculated and their definition is given in Appendix 0.

A clustering analysis was then undertaken to classify KFRs with similar performance trends as defined by these metrics.

Data used for the modelling and analysis presented in this report was based on commodity movements along the road/rail network across Australia from the TraNSIT baseline as at May 2022.

Appendix 0 provides the method used to select the high-use and critical KFRs, and details the metrics definitions. Each of the KFR analysis results provided in Section 5 requires the reader to have a clear understanding of the metric methods and definitions – it is recommended the reader read and understand these, to aid interpretation of results.

Limitations of the analysis include:

- The analysis is based on commodities in TraNSIT as at May 2022. There are some commodity gaps – particularly high-value, low-volume commodities such as pharmaceuticals – which are yet to be added to TraNSIT.
- The five successive alternative route closures for each intersection are insufficient for some KFRs (e.g. Eyre Highway) to achieve the long detours experienced in some flood events. This will be reviewed in the future, along with the method for blocking alternative routes.
- Obstructed freight is defined as freight that cannot reach the destination through any of the available detours. In practice, for many high-priority commodities such as fuel, where freight cannot be sourced from the original provider, supply would be sourced from an alternative supplier or storage (including Distribution Centres). A future version of TraNSIT will map these alternative supply chain paths in the event of an obstruction, accounting for capacity of alternative suppliers/storage, compatibility of buyers to suppliers, and network adaptability.

3 Road KFR outputs

This section describes the simulation model outputs. It is advised that all data and graphs available in the supplementary material is considered in understanding the results. An explanation of how to use the outputs in the supplementary material is given below.

3.1 Overview

Graphs are not produced for all KFRs, as their availability depends on the results of the analysis. For example, when there are no interrupted supply chains, those plots are not produced.

The outputs are classified in two main categories based on the information they relate to:

- business-as-usual (BAU)
  - for the KFR as a whole
  - for each of the three intersections on the KFR
- scenario with the five successive alternative route road closures
  - for each of the three intersections on the KFR

Table 1 and Table 2 below display the types of output that are available for each category and the generic name of these outputs.

Table 1 Outputs relating to a KFR for the business-as-usual (BAU) category

CATEGORY	OUTPUT	FILE NAME
Information for BAU over the whole KFR	KFR map	KFR_name - KFR location map.png
	KFR usage heatmap	KFR_name -proportion_of_trip_LGA-Sector.png
	KFR weekly tonnes heatmap	KFR_name -total_weekly_tonnes_LGA-Sector.png
	KFR percentage of tonnes heatmap	KFR_name -percentage_of_tonnes_LGA-Sector.png
	BAU monthly volumes	KFR_name– monthly volumes.png
	KFR LGA dependence for market access map	KFR_name_export_LGA_Weekly_Tonnes.png
	KFR LGA dependence for access to supplies map	KFR_name_KFR_import_LGA_Weekly_Tonnes.png
Information for BAU at each intersection	BAU monthly volumes by sector for each intersection	KFR_name–intersection-monthly BAU volumes.png

Table 2 Outputs relating to a KFR with the successive closure of the five successive alternative routes

CATEGORY	SUB-CATEGORY	EXPLANATION	FILE NAME
Scenario with successive closure of alternative routes	Freight impact	Re-routing costs plot	KFR_name–intersection-re-routed costs.png
		Obstructed tonnes	KFR_name–intersection-tonnes obstructed.png
		Cumulative impacts plot for re-routed and obstructed freight	KFR_name–intersection-cumulative impacts.png
		Monthly volumes re-routed for each month	KFR_name–intersection - monthly re-routed volumes.png
		Monthly volumes obstructed for each month. Only runs with obstructed supply chains will have this output.	KFR_name–intersection-monthly obstructed volumes.png
		Transport route changes – density difference	KFR_name-intersection _density_difference.png
		Proportion of obstructed tonnes by commodity – pie chart	KFR_name–intersection-tonnes re-routed vs obstructed.pg
	Community impact	Heatmap of the percentage of local consumption for commodities re-routed for the top ten most impacted LGAs	KFR_name–intersection-percent re-routed LGA.png
		Heatmap of the percentage of local consumption for commodities obstructed for the top ten most impacted LGAs	KFR_name–intersection - percent obstructed LGA.png
	Summary of metrics	Modelled impacts data	KFR_name–summaryxlsx
		Matrix of relative impact for three metrics	KFR_name-metrics matrix.png
		Bar plots of the detour costs per tonne	KFR_name-kfr rerouted costs per tonne.png

3.2 Description of outputs

An explanation of the plots and data introduced in Section 3.1 and listed in Table 1 and Table 2 is provided here.

3.2.1 BAU information

- Map of selected KFRs

A map showing the KFR location, freight density (trailers per year) and intersections used for the resilience analysis. These intersections were closed for the analysis to test the outcomes of the disruptions.

- KFR usage heatmap

A plot that displays a heatmap matrix showing LGA (top ten in terms of total import and export tonnages using the KFR) by commodity sector, with each value indicating the proportion of the trips that use the KFR. Where the total trip length was shorter than the KFR, the usage was a proportion of the total trip length; and where the trip length was longer than the KFR, the usage was the proportion of the KFR length. This relative measure uses the trip tonnes as a weight to account for the high tonnage trip distances in the overall averaging.

- KFR weekly tonnes heatmap

A plot that displays the total tonnes using the KFR for each commodity sector by LGA, showing the top ten LGAs by total import and export volumes. Local movements within the LGA have been excluded.

- KFR percentage of tonnes heatmap

A plot that displays the proportion of tonnes using the KFR for each LGA by commodity sector compared with the total tonnes for the LGA by commodity sector (top ten LGAs by total import and export volumes). Local movements withing the LGA have been excluded. This plot provides an overview of the importance of the KFR to support the BAU demand for freight for the LGA by commodity sector.

- BAU monthly volumes

This plot provides information about the monthly tonnes by commodity sector traversing one of the first intersections to be removed. It provides an indication of the variation over the months as well as the importance of the intersection for the different commodity sectors.

- KFR LGA dependence for market access map

An LGA density map that displays the proportion of movements that have an origin in an LGA that uses the KFR compared with the total freight moved out of the LGA by commodity sector. This map provides an understanding of the reach of the KFR across the country and the relative importance it has in supporting access to markets for an LGA.

- KFR LGA dependence for access to supplies map

An LGA density map that displays the proportion of movements that have a destination in an LGA that uses the KFR compared with the total freight destined for the LGA by commodity sector. This map provides an understanding of the reach of the KFR across the country and the relative importance it has in supporting access to supplies for an LGA.

Information relating to the scenario output with n=5 successive closure of the alternative routes

Two categories are considered here: 1) freight impact where freight metrics (transport costs, value, time, etc) are considered across all commodities impacted regardless of their origin or destination; and 2) community impact where freight metrics are calculated for each destination LGA, and percentage of freight consumption impacted within the LGA.

3.2.2 Freight impact

- Re-routing costs plot

This plot provides information about the transport costs encountered by each commodity sector due to the detours. The top plot shows the transport costs for the BAU scenario and those resulting from detours when the last alternative route has been removed *n(=5).* A percentage of the increase in costs is displayed on the graph. The bottom graph shows the total transport costs due to the detours in millions of dollars.

- Obstructed tonnes plot

This plot provides information about the commodity sectors' vulnerability from the successive closure of alternative routes. Each commodity sector that experiences obstruction to its supply chain is plotted. The total volumes of freight unable to reach their destination are displayed (bottom graph), as well as the relative impact of the obstruction (top graph), i.e. the percentage of obstructed commodities compared to BAU.

- Cumulative impacts plot for re-routed and obstructed freight

This plot provides information about the cumulative impact of the successive closure of alternative routes for the freight re-routed as well as the freight unable to move (i.e. obstructed). Two measures are used here: the cumulative impact of re-routed freight is displayed in terms of the average detour cost; and for the obstructed freight, a percentage of the tonnes unable to move compared to the BAU is used.

- Monthly volumes re-routed for each month

This plot provides information about the monthly tonnes by commodity sector that have been re-routed at the closure of the five consecutive alternative routes.

- Monthly volumes not reaching market for each month

This plot provides information about the monthly tonnes by commodity sector that have been obstructed at the closure of the five consecutive alternative routes. This shows those supply chains that cannot find alternative roads, and highlights those months for which a closure might be more critical. For example, commodities such as crops might be impacted at harvest time only, while other commodities would be impacted throughout the year.

- Transport route changes - density difference

This plot shows the changes in preferred routes dependent on the intersection closures. It can highlight the major alternate routes that provide access to destinations for freight impacted by the closures.

- Proportion of obstructed tonnes by commodity – pie chart

This plot shows pie charts for each commodity sector with the proportion of tonnes detoured (in colour) compared to tonnes obstructed (in black). The size of the pie charts varies according to the total tonnes of commodities being disrupted, to enable comparison between the sectors.

3.2.3 Community Impact

- Heatmap of the percentage of local consumption for commodities re-routed for the top ten most impacted LGAs

A plot that displays the percentage of the local consumption within an LGA that has been re-routed following the successive closure of the five alternative routes. Only the supply chains with their destination in the LGA are considered. Only the top ten LGAs impacted are shown here. The plot gives an indication of how much of the local consumption might be delayed or result in cost increase.

- Heatmap of the percentage of local consumption for commodities obstructed for the top ten most impacted LGAs

A plot that displays the percentage of local consumption within an LGA that has been obstructed, following the successive closure of the five alternative routes. Only the supply chains with their destination in the LGA are considered. Only the top ten LGAs impacted are shown here. The plot gives an indication of how much of local consumption might not reach its destination.

- Modelled impacts data

An excel file in the summary material that contains summary impact metrics - total tonnes using the KFR through the modelled intersection by origin and destination LGA.

3.2.4 Matrix of relative impact for three metrics

A matrix of three metrics representing their relative importance for each KFR. The values for each of the selected metrics were normalised across all the KFRs, and the matrix output is thus in relation to all the KFRs studied.

Bar plots of the detour costs per tonne

A bar plot of the detour costs per tonnes for each intersection at the (*n*=5) intersection closure.

4 Modelled road KFR results - overview

The full set of outputs from the modelling and analysis for each road KFR is available as digital files, provided separately in supplementary material to the Department. Detail about each KFR and the output of the simulations is given in Section 5.

An overview of the results across all KFRs is provided in this section, based on trends were identified as part of the clustering analysis (Section 4.1), as well as by state/territory (Section 4.2). Both approaches are presented here as they are complementary and provide different viewpoints.

Figure 1 shows the location of the 52 KFRs selected for analysis in this report. One of the challenges was some KFRs change name at state/territory borders, e.g. the Western Highway changing to the Dukes Highway at the Vic/SA border. These KFRs were modelled either as separate component KFRs, or named according to the state/territory with the largest portion of the KFR (e.g. Hume Highway in NSW).

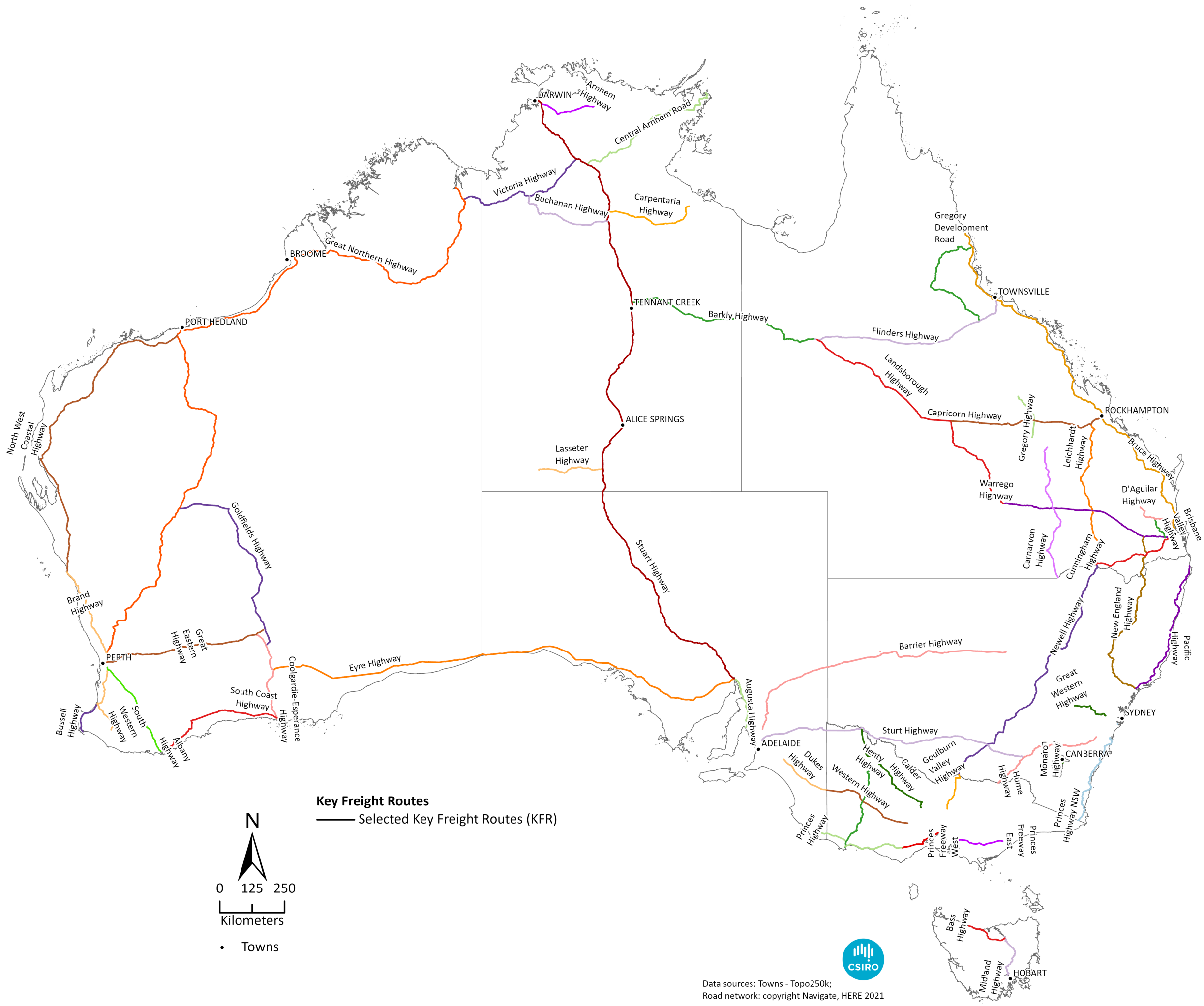

Figure 1 Location of modelled road KFRs

Colours are used to differentiate each KFR.

4.1 KFR route disruption impact trends

4.1.1 Measure of the performance of the system subject to a disruption

The metrics defined in Appendix 0 were determined to provide a sense of impact on both freight and communities. They were calculated for each of the 52 selected road KFRs and for each of the three intersections per KFR. A principal component analysis (PCA) was then undertaken to reduce the number of features (metrics) while preserving the most important structure or relationships between the variables observed in the data. A clustering analysis was then undertaken to classify KFR intersections with similar performance trends as defined by the metrics.

From the clustering analysis, four groupings (‘clusters’) of road KFR intersections were identified. In some cases, all three intersections on a KFR exhibited the same trend. However, in other cases, the three intersections chosen displayed very different trends when closed. This difference in intersection closure output was observed mostly for longer KFRs.

Table 3 presents a reduced set of the metrics defined in Appendix 0 that explains most of the trends over the KFR intersections, and characteristics of each of the identified clusters. Studying the KFR and their clustered intersections enables identification of vulnerability to disruption of some parts of the system, and what the characteristics of this vulnerability are in terms of impact on freight as well as on communities.

In general terms, Cluster 1 can be described as one for which the closure of the successive intersections has little impact on the freight or communities.

Cluster 2 also displays little impact on freight or communities, however the cost increase is higher for the detoured freight.

Cluster 3 is characterised by very low to low risk of commodities being obstructed, however for freight that is obstructed, the impact on the communities is moderate to high.

Cluster 4 is characterised by a high impact on freight, with a large proportion of freight obstructed. It is also characterised by some communities being heavily reliant on the intersection, meaning that the obstructed freight has a greater impact on these communities, which then become vulnerable to the disruption of the KFR.

Table 3 Trends in response to disruption for the four clusters of road KFR intersection

	FREIGHT IMPACT					COMMUNITY IMPACT				
	KFR impacts risk - obstructed volumes for intersection	**KFR impacts risk - detour costs for intersection**	**Relative value obstructed - all commodities**	**Relative detour cost – average increase**	**Relative reliance on intersection for destination LGA**	**Number of LGA impacted**	**Obstructed – All commodities – LGA proportion**	**Detoured – All commodities – LGA proportion**	**Obstructed – All commodities - Relative volumes impacted - All impacted LGAs**	**Community impact – Detoured – All commodities - Relative volumes impacted - All impacted LGAs**
Cluster 1	Negligible	Negligible	Few to none	Very low	Low to moderate	High	Low	High	Low	Low
Cluster 2	Negligible	Negligible	Few to none	Low to moderate	Moderate	Moderate	Low	High	Low	Low to moderate
Cluster 3	Very low to low	Low to moderate	Few	Moderate	Low to moderate	Moderate	Very low	Very high	Low to moderate	Very high
Cluster 4	Moderate to very high	Moderate to very high	High to all	Moderate to high	Moderate to very high	Low	Moderate to high	Low (because most obstructed) to moderate	Moderate to high if only the most reliant LGA is impacted; low to very low otherwise (because all the other LGAs rely very little on this intersection)	Low to moderate

This grouping of clusters can be used to see which KFRs display similar trends and whether the three intersections selected for the analysis also display similar characteristics. Depending on which intersection is disrupted, the outcome can be very different, and therefore can result in each of the three intersections being in a different cluster. An example of this is for the Great Northern Highway, for which the Roe – Reid Highway intersection belongs to Cluster 2, the Tonkin – Brand Highway belongs to Cluster 3, and the Marble Bar Road belongs to Cluster 4. This highlights the relative vulnerability to disruption of the different parts of a KFR, and can be used to rank the KFR intersections in terms of these vulnerabilities.

The information in the tables below can be used to help illustrate impact, as similar characteristics will be found for those KFR intersections belonging to the same cluster.

4.1.2 Cluster 1

In general terms, KFR intersections belonging to Cluster 1 are characterised by large numbers of LGAs receiving freight traversing the intersection, however, with no single community obviously heavily reliant on the intersection. This means that the risks of impact on communities is geographically broad and therefore low for any single community. The risk associated with the successive closure of the alternative intersections is negligible, and so is the risk associated with increased costs of re-routing. Most to all LGAs receiving commodities traversing the intersection will receive them via detours, for which cost increases are small. In addition, the volumes of re-routed freight are small compared to the overall volumes of commodities consumed within the community. This means that the impact of freight costs overall in these communities, if passed to the consumer, or the delays from receiving the commodities, will be low.

Table 4 KFRs and intersections identified for Cluster 1

STATE/TERRITORY	KFR	INTERSECTION
ACT	Barton Highway	Hume Highway
NSW	Barrier Highway	Goyder Highway
		Wilkins Highway
	Hume Highway	Federal Highway
		Olympic Highway
		Sturt Highway
	Newell Highway	Cunningham Highway
		Goldfield Way – Mid Western Highway
		Sturt Highway
	Pacific Highway	Big River Way
		Bruxner Highway
	Sturt Highway	Goyder Highway
	Sturt Highway	Newell Highway
Qld	Bruce Highway	Capricorn Highway
	Cunningham Highway	Leichhardt – Newell Highway
	Leichhardt Highway	Burnett Highway

STATE/TERRITORY	KFR	INTERSECTION
		Cunningham-Newell Road
	Warrego Highway	Leichhardt Highway
SA	Augusta Highway	Copper Coast Highway
		Eyre Highway
	Eyre Highway	Flinders Highway
		Lincoln Highway
		Stuart Highway
	Dukes Highway	Mallee Highway
		Princes Highway
		Riddoch Highway
Vic	Goulburn Valley Highway	Murray Valley Highway
	Princes Freeway East	Monash Freeway
	Princes Freeway West	Geelong Ring Road
		Western Ring Road
	Western Highway	Borung Highway
		Henty Highway
		Sunraysia Highway

4.1.3 Cluster 2

The KFR intersections belonging to Cluster 2 have very similar trends to those of Cluster 1. The characteristic that differentiates the two is that fewer LGAs receive commodities traversing the intersection for Cluster 2. This means that freight disruption impact is less widespread over communities, however the impact is still low to moderate. The increase in costs from detours is also slightly higher for freight going through these intersections compared to those of Cluster 1.

Table 5 KFRs and intersections identified for Cluster 2

STATE/TERRITORY	KFR	INTERSECTION
ACT	Monaro Highway	Morshead Drive
	Barton Highway	Federal Highway
NSW	Barrier Highway	Mitchell Highway
	Carnarvon Highway	Dawson Highway
		Warrego Highway
	Great Western Highway	Castlereagh Highway
		Hawkesbury Road
		Mid Western Highway
	New England Highway	Cunningham Highway
		Pacific Highway
	Pacific Highway	Oxley Highway
	Princes Highway NSW	Jervis Bay Road

STATE/TERRITORY	KFR	INTERSECTION
		Kings Highway
		Snowy Mountain Way
	Sturt Highway	Hume Highway
NT	Lasseter Highway	Luritja Road
		Stuart Highway
Qld	Barkly Highway	Cloncurry-Duchess Road
		Grace Street
		Stuart Highway
	Bruce Highway	D'Aguilar Highway
		Flinders Highway
	Capricorn Highway	Bruce Highway
		Gregory Highway
		Leichhardt Highway
	Gregory Development Road	Flinders Highway
	Cunningham Highway	New England Highway
		Warrego Highway
	Flinders Highway	Bruce Highway
		Gregory Development Road
		Landsborough Highway
	Gregory Highway	Capricorn Highway
		Peak Downs Highway
	Landsborough Highway	Flinders Highway
		Warrego Highway
	Leichhardt Highway	Dawson Highway
	Brisbane Valley Highway	D'Aguilar Hwy
		Gatton — Esk Road
		Warrego Highway
	D'Aguilar Hwy	Bunya Highway
		Burnett Highway
		Kilcoy-Beewah Road
	Warrego Highway	Gore Highway
		Landsborough Highway
SA	Stuart Highway	Eyre Highway
Tas	Bass Highway	Illawarra Road
		Midland Highway
	Midland Highway	Bass Highway
		East and West Tamar Highway
		Lyell – Brooker Highway

STATE/TERRITORY	KFR	INTERSECTION
Vic	Calder Highway	Calder Alternative Highway
		Deakin Avenue
		Sunraysia Highway
	Goulburn Valley Highway	Hume Freeway
		Midland Highway
	Henty Highway	Glenelg Highway
		Princes Highway
		Western Highway
	Princes Freeway East	South Gippsland Highway
		Strzelecki Highway
	Princes Freeway West	Colac – Ballarat Road
	Princes Highway Vic	Dartmoor – Hamilton Road
		Glenelg Highway
		Henty Highway
WA	Albany Highway	Muirs Highway
	Brand Highway	Tonkin Highway
	Bussell Highway	Boundary Road
		Robertson Drive
		Vasse Highway
	Coolgardie – Esperance Highway	Great Eastern Highway
		South Coast Highway
	Goldfields Highway	Coolgardie – Esperance Highway
	Great Eastern Highway	Coolgardie – Esperance Highway
		Roe Highway
		Tonkin Highway
	Great Northern Highway	Roe – Reid Highway
	North West Coastal Highway	Geraldton – Mount Magnet Road
		Great Northern Highway
		Tom Price – Karratha Road
	South Coast Highway	Newdegate – Ravensthorpe Road
	South Western Highway	Albany Highway
		Martin Pelusey Road
		Thomas Road
	Victoria Highway	Buchanan Highway

4.1.4 Cluster 3

Cluster 3 is characterised by a very low to low risk of obstructed commodities. However, for obstructed freight, the impact on the communities is moderate to high. This means that the communities that do rely quite heavily on these intersections to receive some of their consumables do not receive a moderate to high percentage of their commodities. Also, for the freight that is able to be rerouted, this is done often with a moderate cost increase.

Table 6 KFRs and intersections identified for Cluster 3

STATE/TERRITORY	KFR	INTERSECTION
NSW	Carnarvon Highway	Moonie Highway
	New England Highway	Gwydir Highway
NT	Arnhem Highway	Stuart Highway
	Buchanan Highway	Stuart Highway
Qld	Gregory Highway	Capricorn Highway West
	Landsborough Highway	Capricorn Highway
SA	Augusta Highway	Range View Road
	Stuart Highway	Buchanan Highway
WA	Albany Highway	Great Southern Highway
	Brand Highway	Midlands Road
		North West Coastal Highway
	Coolgardie – Esperance Highway	Eyre Highway
	Goldfields Highway	Great Eastern Highway
		Great Northern Highway
	Great Northern Highway	Tonkin – Brand Highway
	Victoria Highway	Gorrie Dry River Road
		Great Northern Highway

4.1.5 Cluster 4

Cluster 4 KFR intersections are generally characterised by moderate to very high risk for obstructed freight, with a high impact on communities and a moderate risk of freight being re-routed.

This group of KFR intersections generally finds alternative routes until the third or fourth alternative route closure, however at high increased costs. By the fifth iteration, most to all alternative routes have been exhausted and the freight is obstructed, representing a high proportion of the commodities consumed within the communities serviced by that intersection.

Table 7 KFRs and intersections identified for Cluster 4

STATE/TERRITORY	KFR	INTERSECTION
NT	Arnhem Highway	Oenpelli Road
		Point Stuart Road
	Buchanan Highway	Buntine Highway
		Victoria Highway
	Carpentaria Highway	Stuart Highway
		Tablelands Highway
	Central Arnhem Road	Stuart Highway
	Lasseter Highway	Mulga Park Road
Qld	Gregory Development Road	Palmerston Highway
		The Lynd Junction
SA	Stuart Highway	Victoria Highway
Tas	Bass Highway	Tarleton Street
WA	South Coast Highway	Harbour Road
	Great Northern Highway	Marble Bar Road

4.2 KFR route disruption impact by state/territory

The clustering described in the previous section grouped KFR intersections according to general trends in response to disruption, allowing classification of the intersections in terms of their relative performance. This section, however, compares the KFR intersections within each state/territory. Two graphs are presented per state/territory.

The first graph shows a matrix for three metrics, described in Appendix 0:

- KFR impacts risk - obstructed volumes for intersection (freight impact - obstructed)
- KFR impacts risk - detour costs for intersection (freight impact - detoured)
- Community impact –obstructed – all commodities - relative volumes impacted - all impacted LGAs (community impact - obstructed)

The choice of showing three metrics only, as opposed to all those presented in Appendix 0 is to improve clarity of interpretation of the graphs. It is however to be noted that most of the metrics described in Appendix 0 were used for the clustering of the KFR-intersections after transformation using a PCA; therefore, no conclusion of the cluster allocation can be derived solely on the three metrics presented in the matrices below. They are presented here for illustration of the relative performance of the KFR-intersections and were chosen because they capture important information relating to the impact on freight (obstructed and re-routed) as well as on the communities expecting to receive the freight. To compare and understand the relative difference between the states/territories, the grading of colours for the metrics is consistent across all graphs.

The second graph shows the average detour costs per tonne for each KFR intersection for the last closure of the *n(=5)* alternative routes. The graphs are displayed for each state/territory with the same y-axis maximum values to allow comparison of the costs per tonne when re-routing freight for all the KFRs within each state/territory. Because of extremely high values for some detours (e.g. for the Northern Territory), the scale changes between the states/territories, to allow readability of graphs. WA has the maximum detour cost per tonne - for the Great Northern Highway – Marble Bar Road intersection - closely followed by NT for two intersections on the Buchanan Highway.

4.2.1 ACT

Two critical KFRs were studied for the ACT (Figure 2) – the Barton Highway and Monaro Highway. The closure of most of the intersections for the selected KFR leads to very low to low impact for freight obstructed and detoured. This means that most to all freight is able to be re-routed, and this could be done at a relatively low increase in freight costs. This relatively low cost in re-routing can be further inspected in Figure 3, where the maximum re-routing cost is observed for the Barton Highway – Hume Highway intersection with a cost of nearly $12 per tonne.

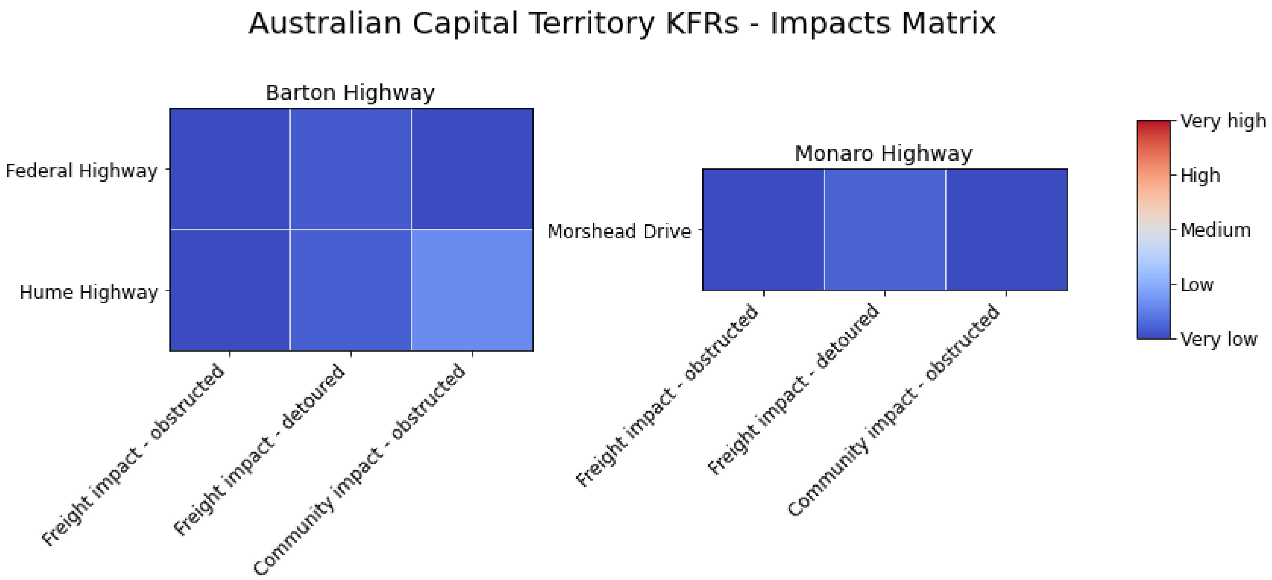

Figure 2 Impacts matrix for the ACT

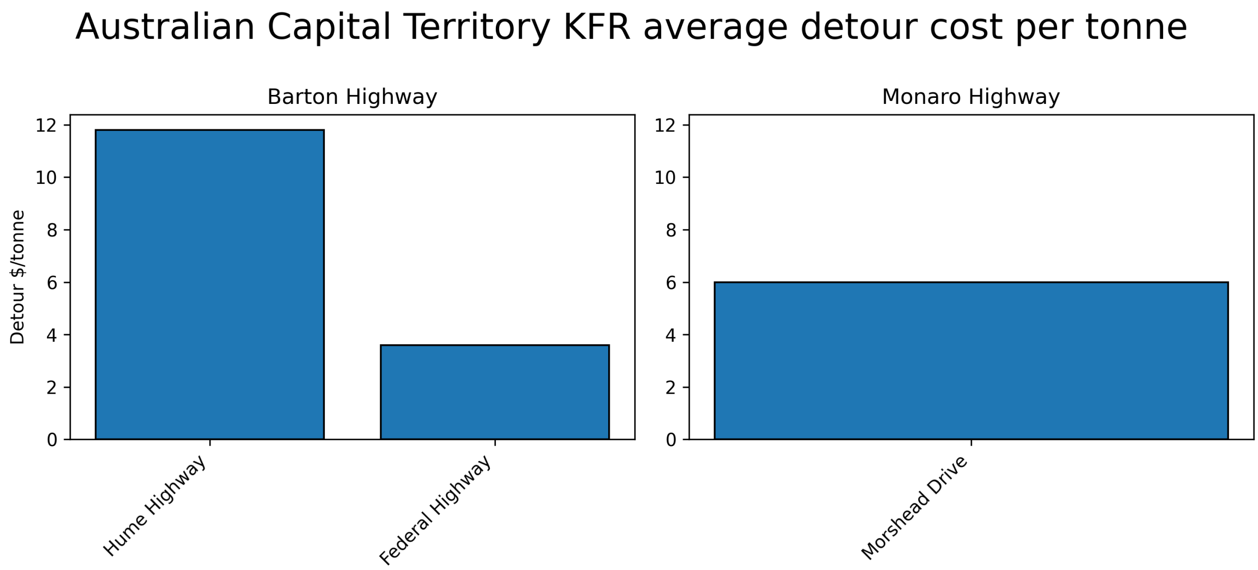

Figure 3 Detour costs per tonne for the ACT

4.2.2 NSW

Ten critical KFRs were studied in NSW (Figure 4) – the Barrier Highway, Carnarvon Highway Great Western Highway, Hume Highway, New England Highway, Newell Highway, Pacific Highway, Princes Highway NSW, Princes Highway Vic and Sturt Highway. The closure of most of the intersections for the selected KFR leads to very low to low impact for freight obstructed and detoured. This means that most to all freight is able to be re-routed, and this could be done at a relatively low increase in freight costs. The relatively low costs to re-routing can be further inspected in Figure 5, where the maximum re-routing cost is observed for the Carnarvon Highway – Dawson Highway intersection with a cost of slightly over $15 per tonne. For the few supply chains obstructed, the impact on the communities is mainly low to moderate except for the New England Highway – Gwydir Highway intersection, for which the impact is medium to high.

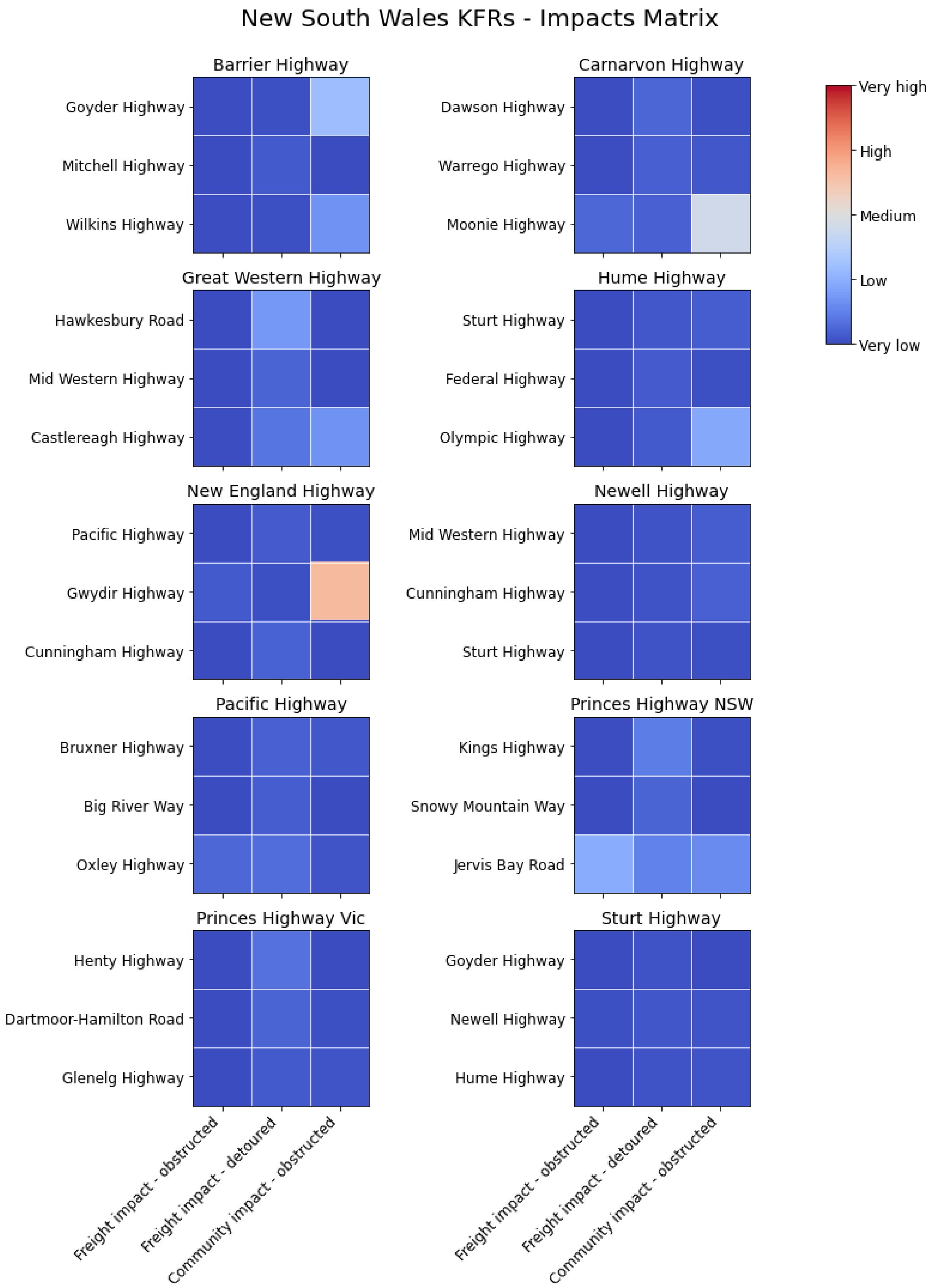

Figure 4 Impacts matrix for NSW

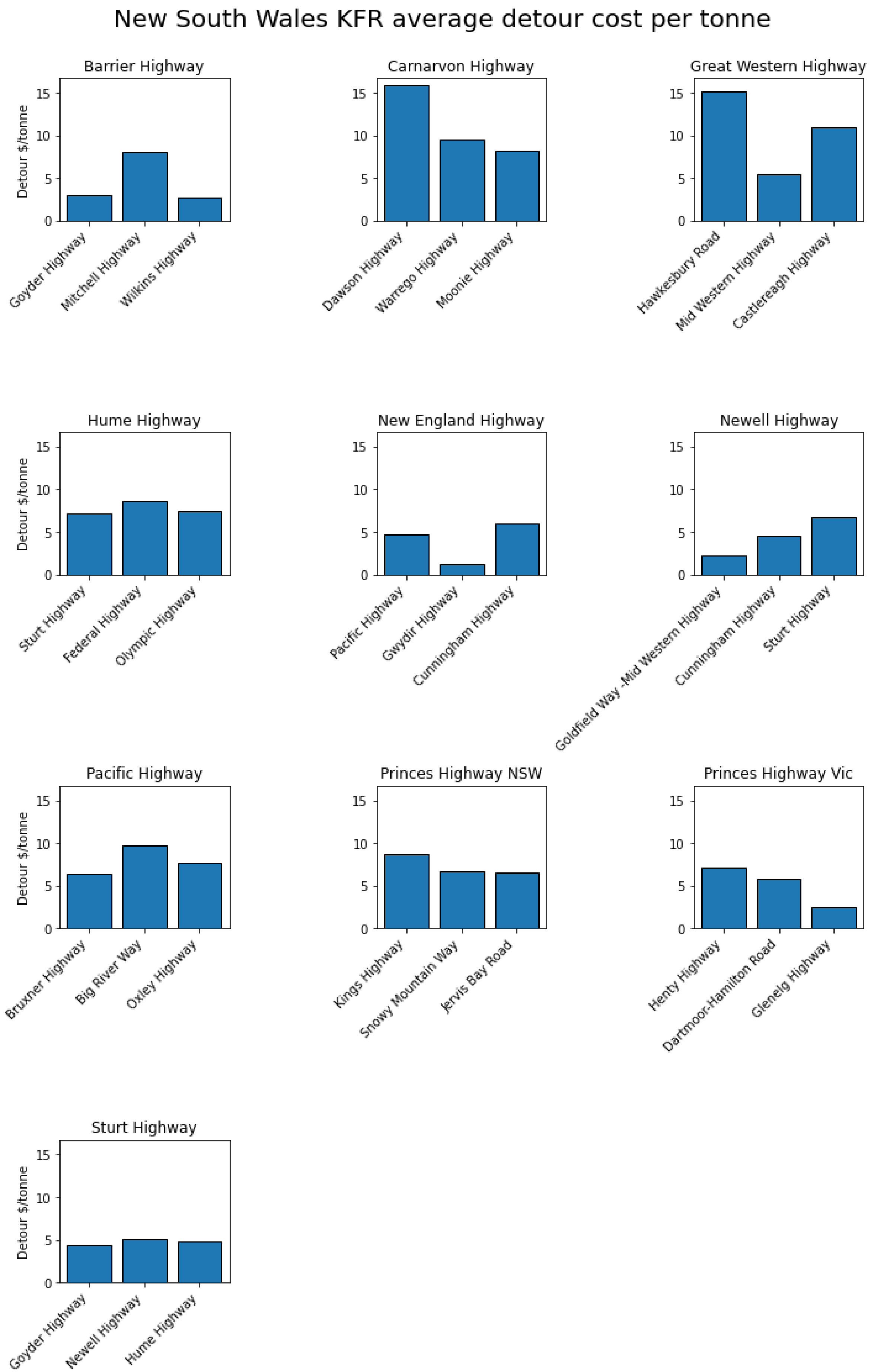

Figure 5 Detour costs per tonne for NSW

4.2.3 NT

Five critical KFRs were studied for the Northern Territory (Figure 6) – the Arnhem Highway, Buchanan Highway, Carpentaria Highway, Central Arnhem Road and Lasseter Highway. The closure of the intersections for the KFR selected in NT leads to very different outcomes depending on their location, however, in all locations one metric shows a high to very high value for at least one of the three metrics. The KFR showing the least impact on freight and community is the Lasseter Highway for the Stuart Highway and the Luritja Road intersections, with very low to low values for the freight-obstructed and community impact-obstructed metrics. This highlights the vulnerability to disruption of many of the roads in the NT, where detouring might only be possible for a limited volume of freight. Even if detouring is possible, costs might be high and some communities might be highly impacted. When re-routing is possible, this is at a high cost per tonne for most freight (Figure 7).

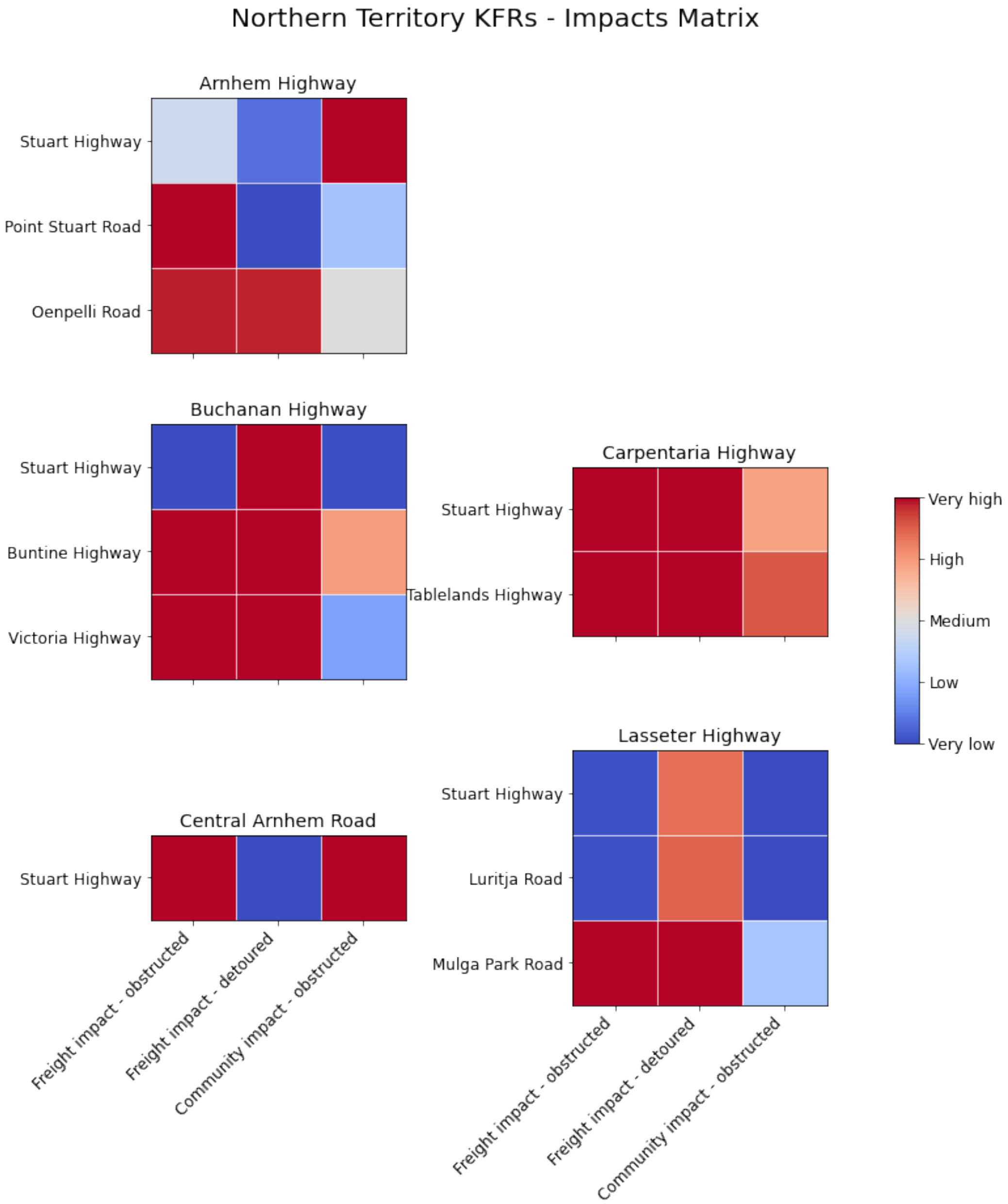

Figure 6 Impacts matrix for NT

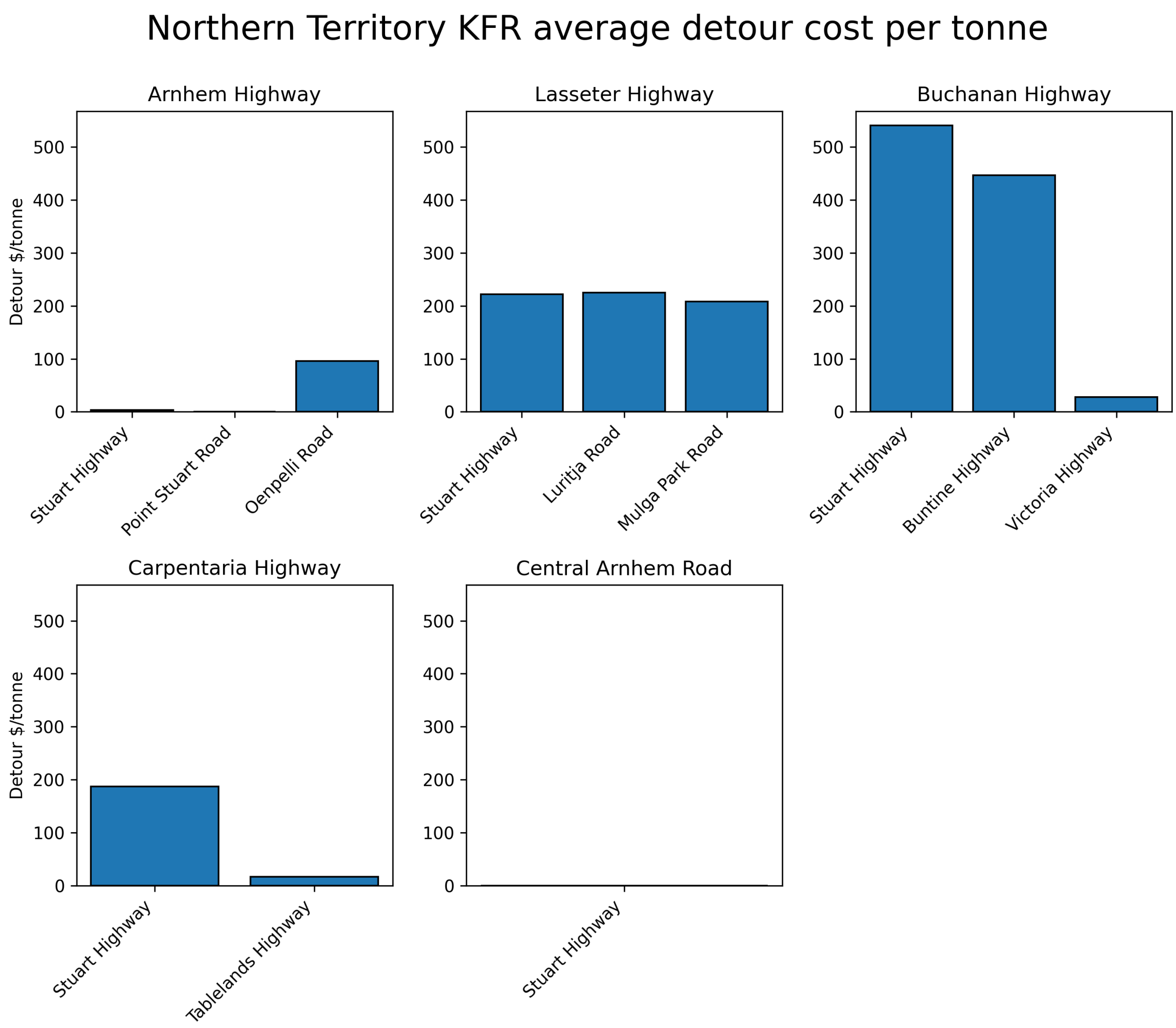

Figure 7 Detour costs per tonne for NT

4.2.4 Queensland

12 KFRs were studied for Queensland (Figure 8) – the Barkly Highway, Brisbane Valley Highway, Bruce Highway, Capricorn Highway, Cunningham Highway, D'Aguilar Highway, Flinders Highway, Gregory Development Road, Gregory Highway, Landsborough Highway, Leichhardt Highway and Warrego Highway. Most show low to very low freight risk for obstructed commodities, with the exception of the Gregory Development Road KFR. The Gregory Development Road KFR exhibits moderate to high values for freight risk impact for obstructed and detoured commodities across two intersections, with very high impact on some communities. The other two KFR intersections with high community impact are the Landsborough Highway – Capricorn Highway and the Gregory Highway – Capricorn Highway intersections; these have medium to high values. For re-routed freight, the detour costs are generally low across all intersections (Figure 9). An exception is the Barkly Highway where detour costs reach up to $125 per tonne – this is up to five times the detour cost elsewhere in the state.

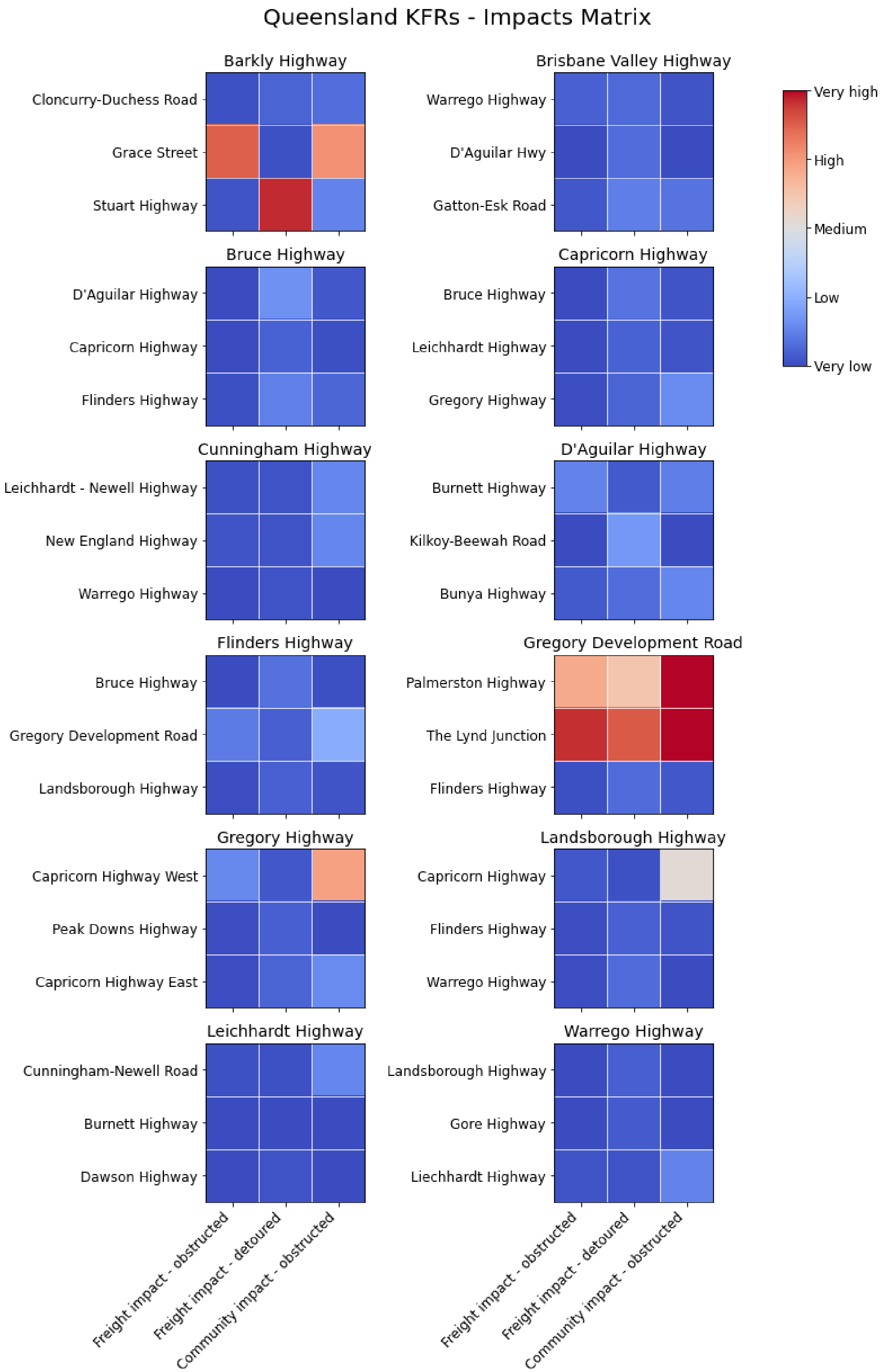

Figure 8 Impacts matrix for Queensland

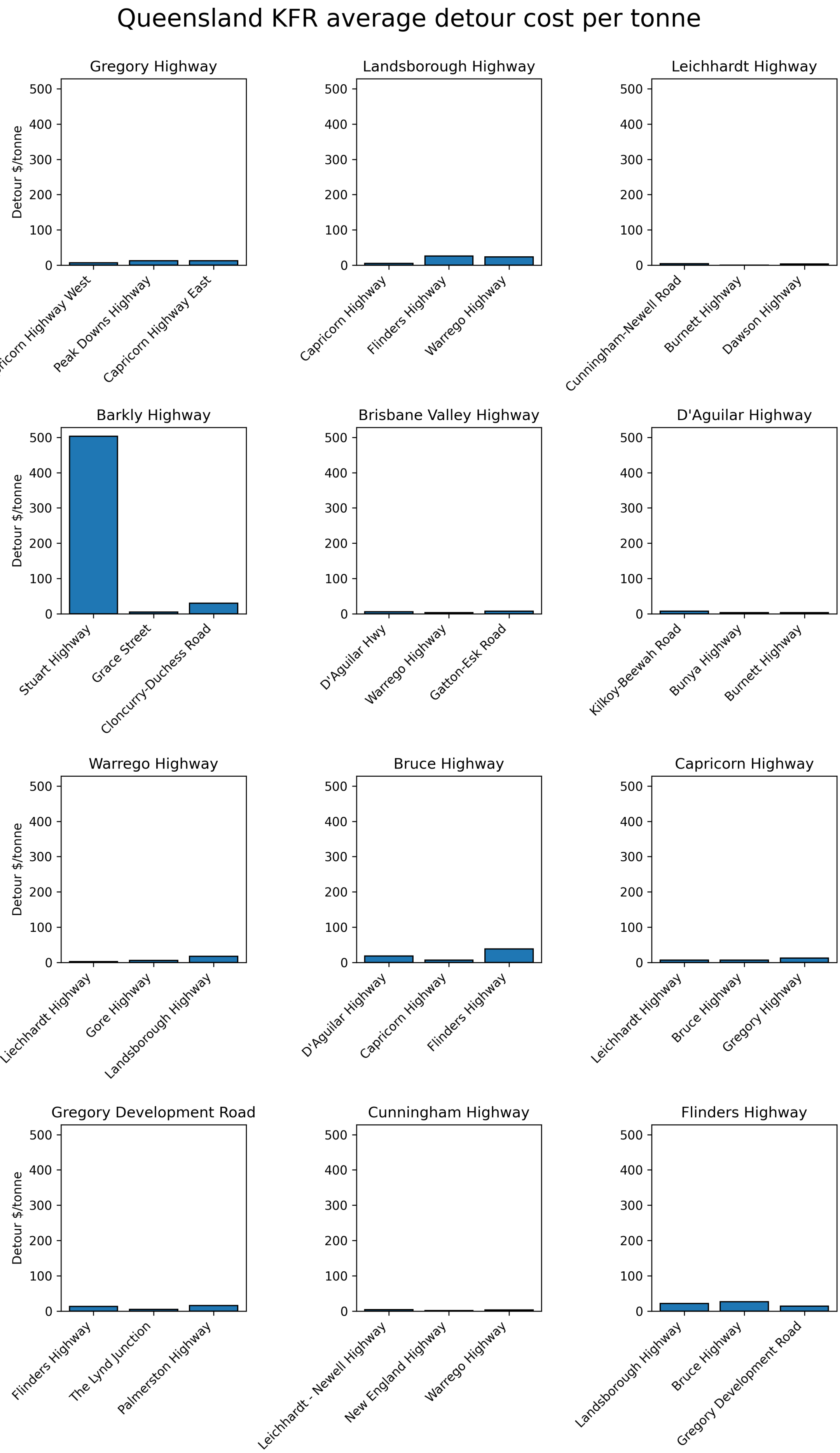

Figure 9 Detour costs per tonne for Queensland

4.2.5 SA

Three KFRs were modelled for SA (Figure 10) – the Augusta Highway, Eyre Highway and Stuart Highway. All three show very different outcomes from the simulations. The Augusta Highway shows the least impact from the disruption on its intersection, except for the Range View Road intersection which showed a high impact on the community. While the Eyre Highway shows very low to low values for all three metrics on all the modelled intersections, the cost of detours is high for the Stuart Highway and the Flinders Highway intersection closure. The Stuart Highway is the most vulnerable to the modelled disruption, with only the Eyre Highway intersection having low impact on all three metrics and the cost per tonnes for the detoured freight. The Buchanan Highway intersection closure on the Stuart Highway shows that the freight expected to detour will do so at a very high cost (Figure 11). The closure of the Victoria Highway intersection results in very high values across all three metrics, and quite high costs per tonne for the detoured freight.

In early 2022, floods in central Australia disrupted freight significantly on the Eyre Highway at the Stuart Highway intersection. This included freight being stranded or taking detours of more than 2000 km via the Plenty Highway. The analysis in this report did not reflect these disruptions. This is because blocking of five alternative routes was insufficient to force the long detours through western Queensland that occurred in early 2022. An extension of the existing analysis would include the blocking of additional routes to achieve the detours observed during the 2022 floods. Through the Australian Climate Service (ACS) project, TraNSIT was applied to the SA road closures of February 2022. The large number of closures forced vehicles to detour greater than 2000 km to reach Darwin or Perth.

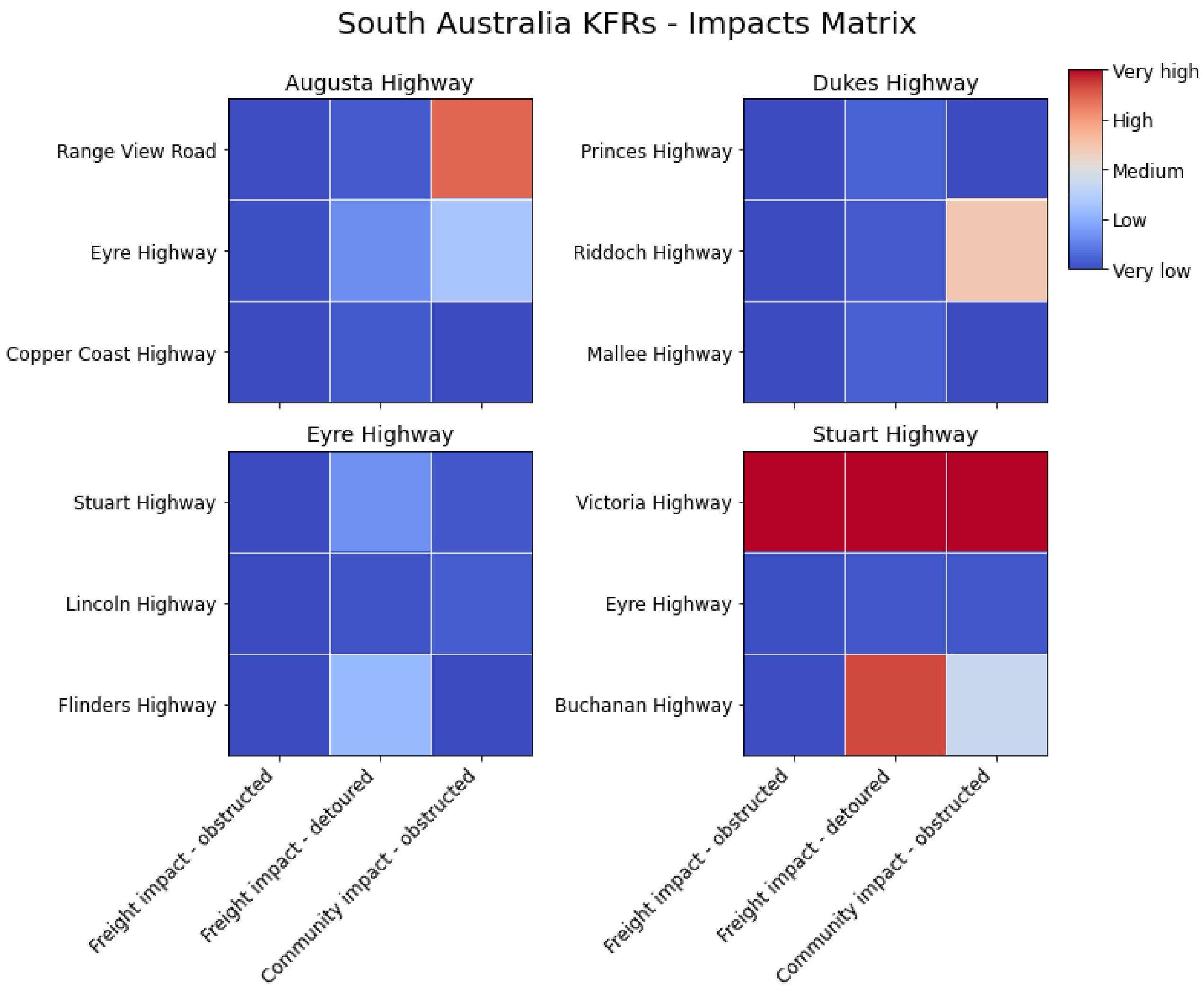

Figure 10 Impacts matrix for SA

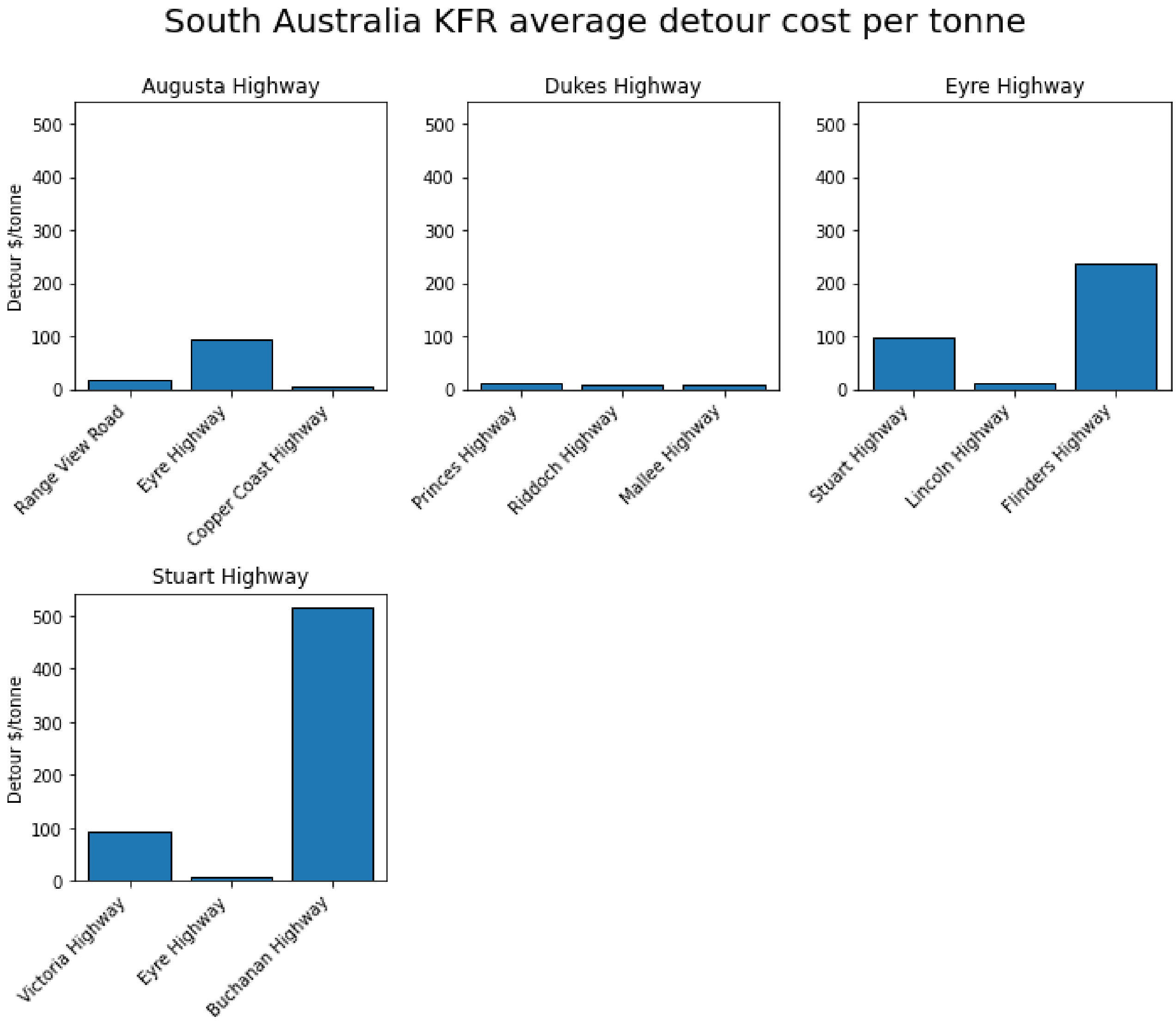

Figure 11 Detour costs per tonne for SA

4.2.6 Tasmania

Two critical KFRs were modelled for Tasmania (Figure 12) – the Bass Highway and Midland Highway. The closure of the intersections results in very low to low values across the three metrics and very low detour costs for freight detoured for all intersections ($2.5-5/tonnes – see Figure 13). An exception is for the Bass Highway – Tarleton Highway intersection. The disruption of freight through this intersection is expected to lead to high impact in terms of obstructed freight, with especially high impact on some communities (Figure 12).

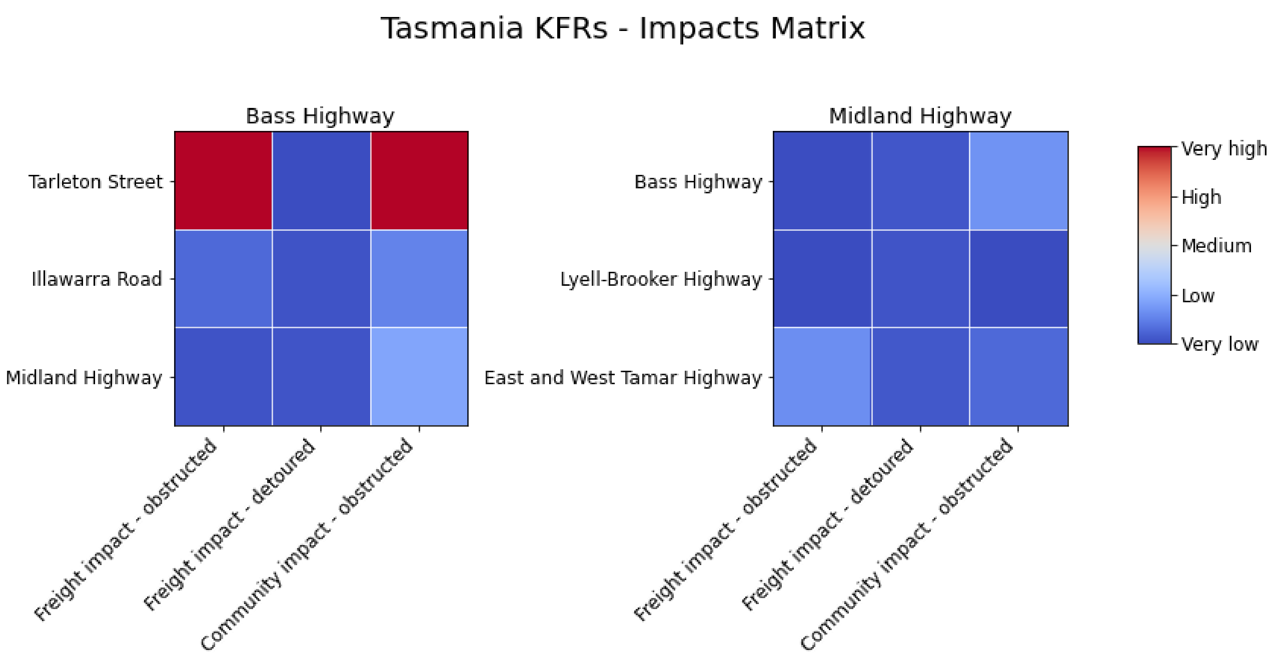

Figure 12 Impacts matrix for Tasmania

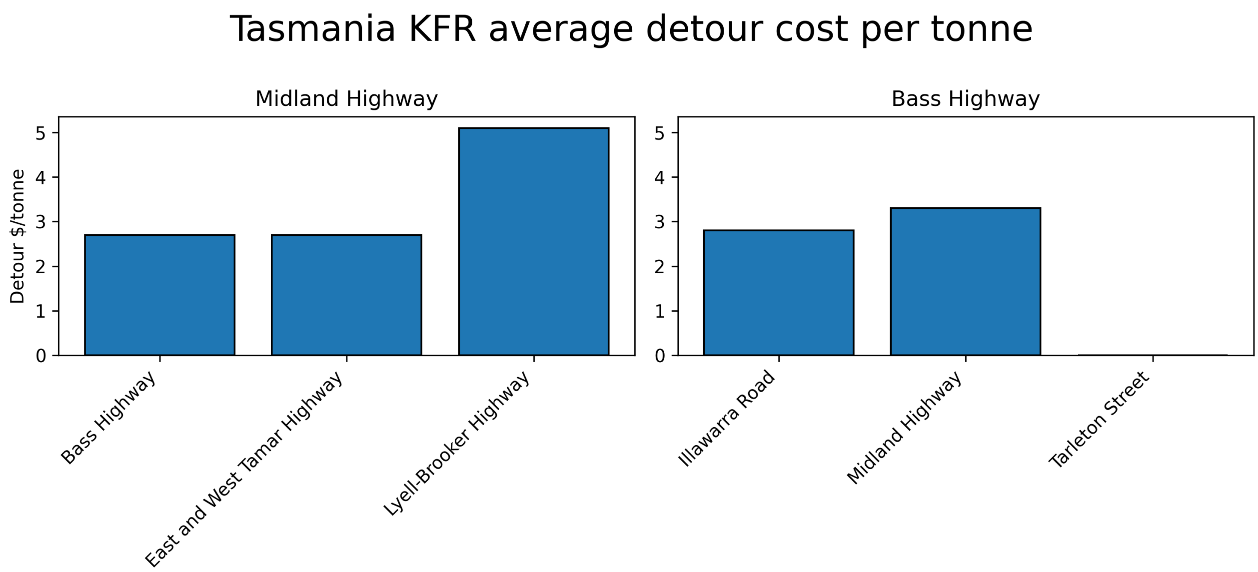

Figure 13 Detour costs per tonnes for Tasmania

4.2.7 Victoria

Seven critical KFRs were studied for the state of Victoria (Figure 14) – the Calder Highway, Dukes Highway, Goulburn Valley Highway, Henty Highway, Princes Freeway East, Princes Freeway West and Western Highway. The KFRs displaying the least impact from the closure of the intersections are the Calder and Henty highways. For these KFRs, the values for the three metrics are very low, meaning that most freight could be re-routed at low cost, with little impact to communities (Figure 15). The most impacted KFRs due to closure of intersections are the Western Highway and the Dukes Highway - these show medium to high values for the impact to communities metrics, due to some obstructed freight. Overall, detour costs on all the KFRs present very low costs of between $2-12 per tonne (Figure 15).

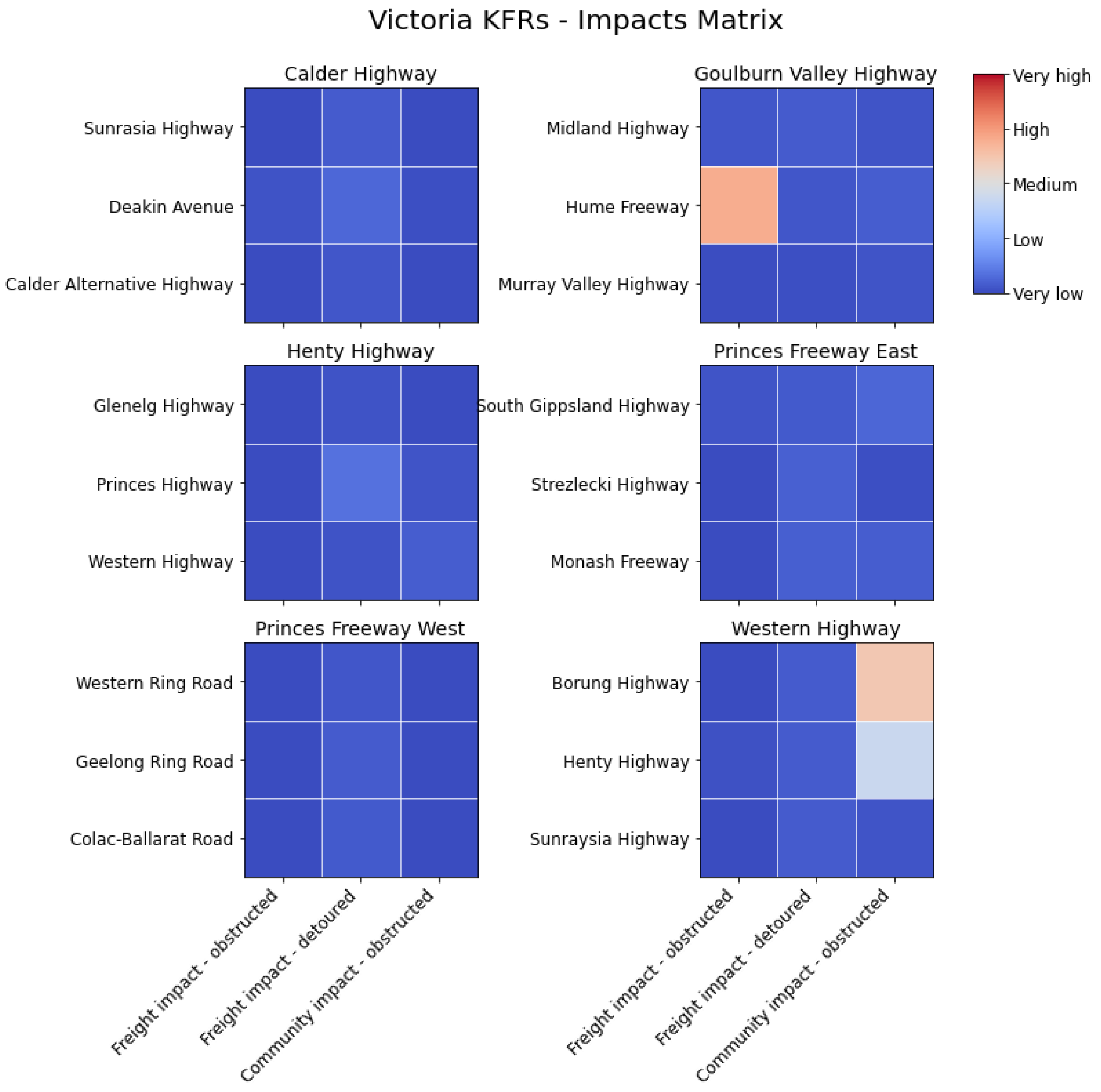

Figure 14 Impacts matrix for Victoria

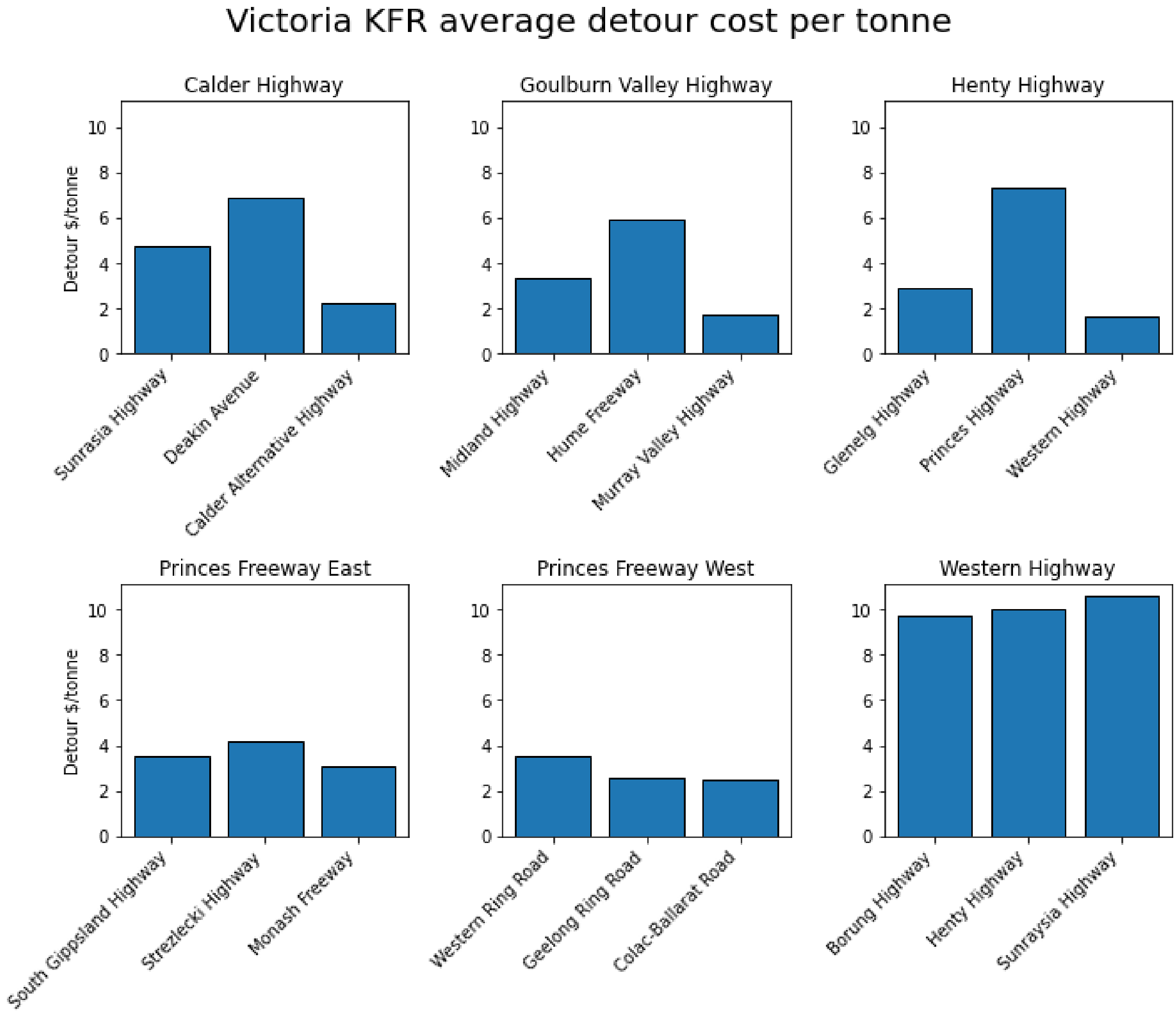

Figure 15 Detour costs per tonne for Victoria

4.2.8 WA

Eleven critical KFRs were studied for the state of WA (Figure 16) – The Albany Highway, Brand Highway, Bussell Highway, Coolgardie – Esperance Highway, Goldfields Highway, Great Eastern Highway, Great Northern Highway, North West Coastal Highway, South Coast Highway, South Western Highway and Victoria Highway. The Bussell Highway, the Great Eastern Highway and the South Western Highway display the least impact from the closure of the intersection. The values for the three metrics are very low, meaning that most freight could be re-routed at a low cost (see Figure 17), with little impact to communities. The most impacted KFRs due to closure of intersections are the Brand, South Coast, Victoria, Great Northern and Goldfields highways - these show medium to high values for the impact to communities metrics due to obstructed freight. Detours were possible for the Great Northern Highway – Marble Bar Road, however at a very high cost per tonne (Figure 17).

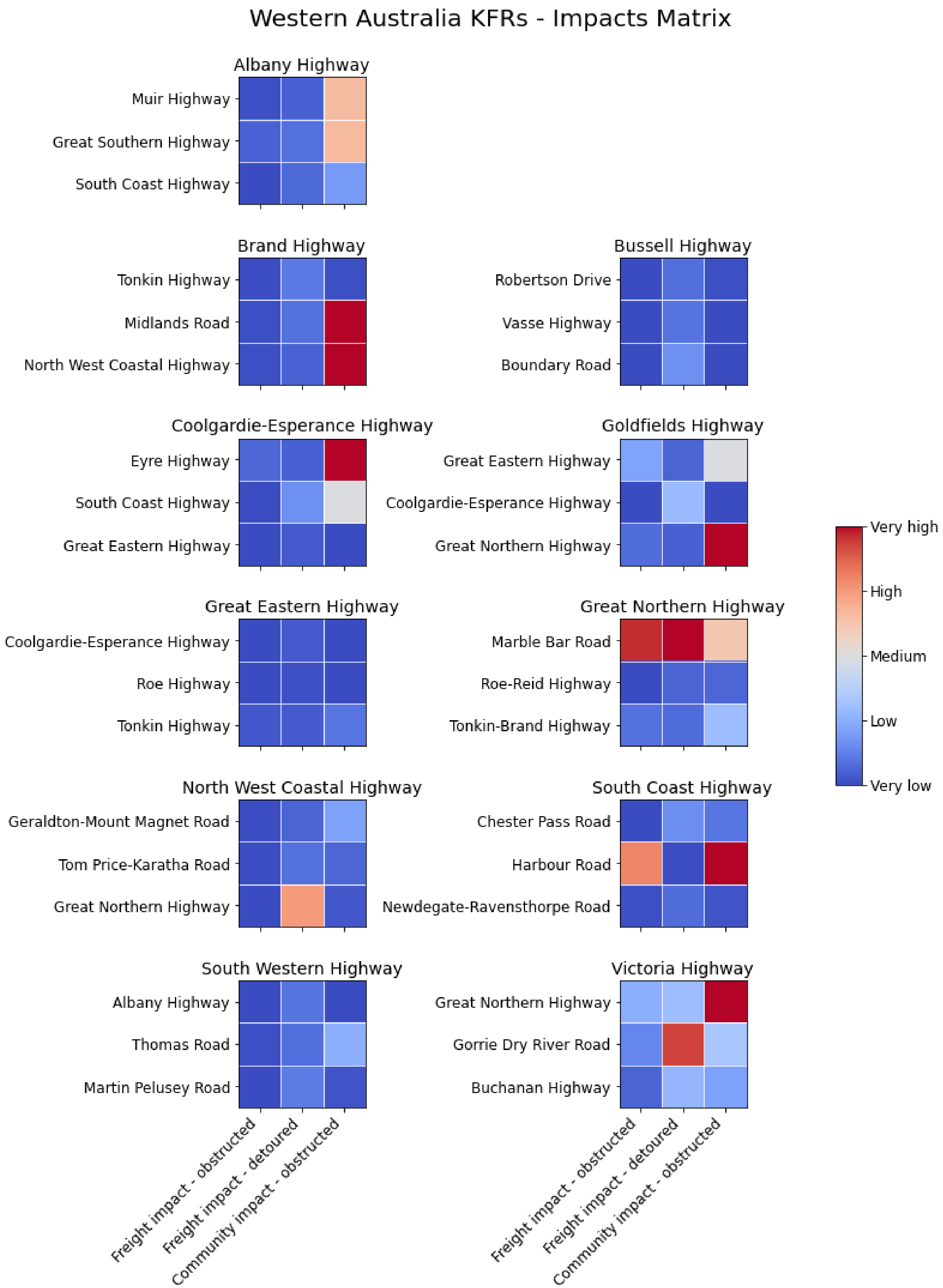

Figure 16 Impacts matrix for WA

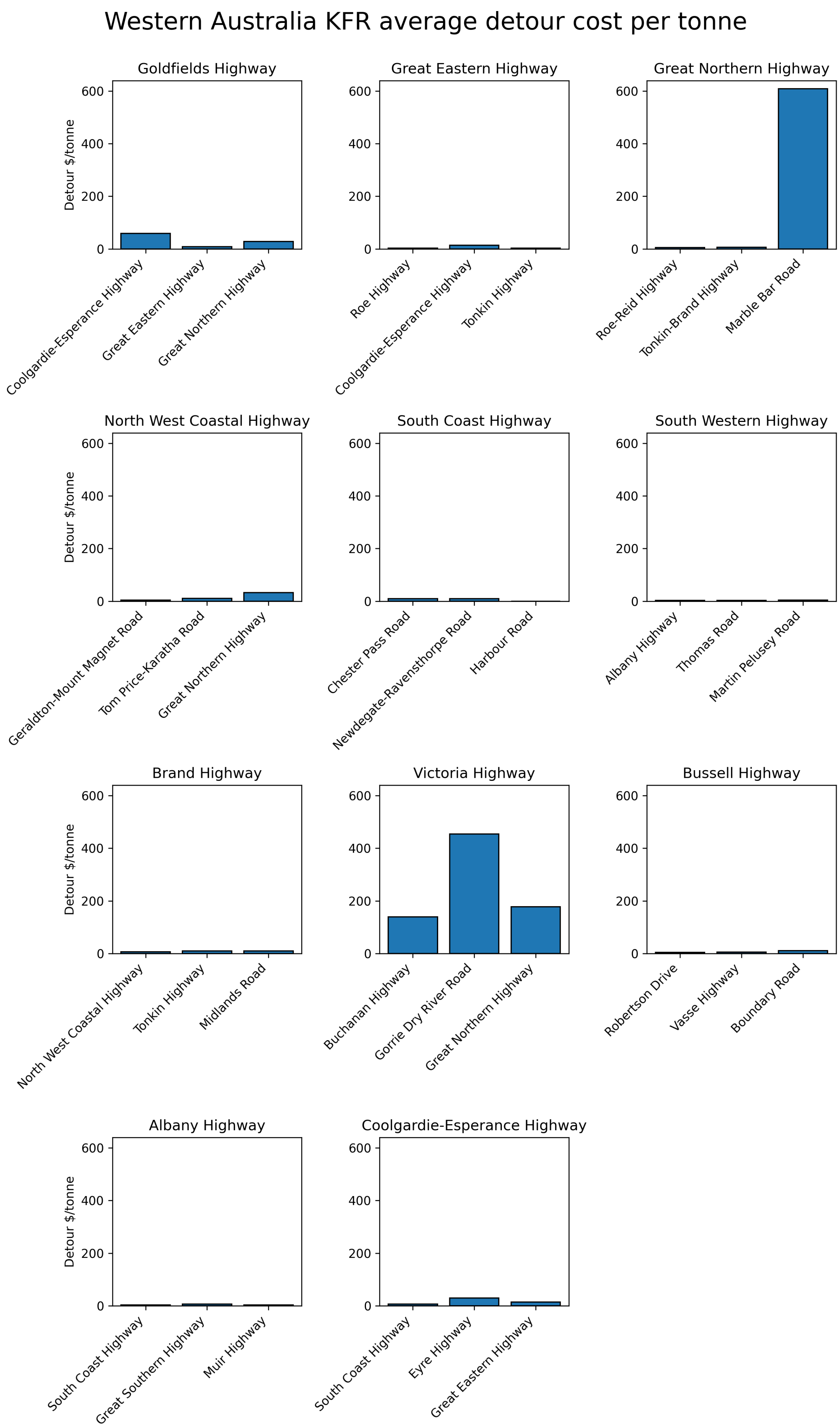

Figure 17 Detour costs per tonne for WA

4.3 Compounding effects of national weather events

Typically, road closures due to an extreme event impact a wider region than a single intersection, especially in e.g. a extreme weather season, but modelled intersections may not be impacted by an extreme event.

Examples of the impacts of significant weather events included in the supplementary material are reports prepared by CSIRO for the National Situation Room of Emergency Management Australia and the National Recovery and Resilience Agency (NRRA) through a partnership with the Australian Climate Services. These examples outline supply chain and community impacts from weather events in 2022, based on TraNSIT analyses. The reports cover the:

- Lismore floods
- Sydney and surrounds floods
- South-east Queensland, central Queensland, and northern Queensland Floods
- Maryborough floods
- SA Floods
- WA Bushfires

Figure 17 shows the roads closed throughout the 2022 extreme weather season (until July 2022) relative to the 52 KFRs selected for analysis in this report. Major roads closed are shown as a wide, dark blue line; minor roads closed are shown as a thin, light blue line. The figure highlights the KFRs that were impacted this season and may be at risk of future closure.

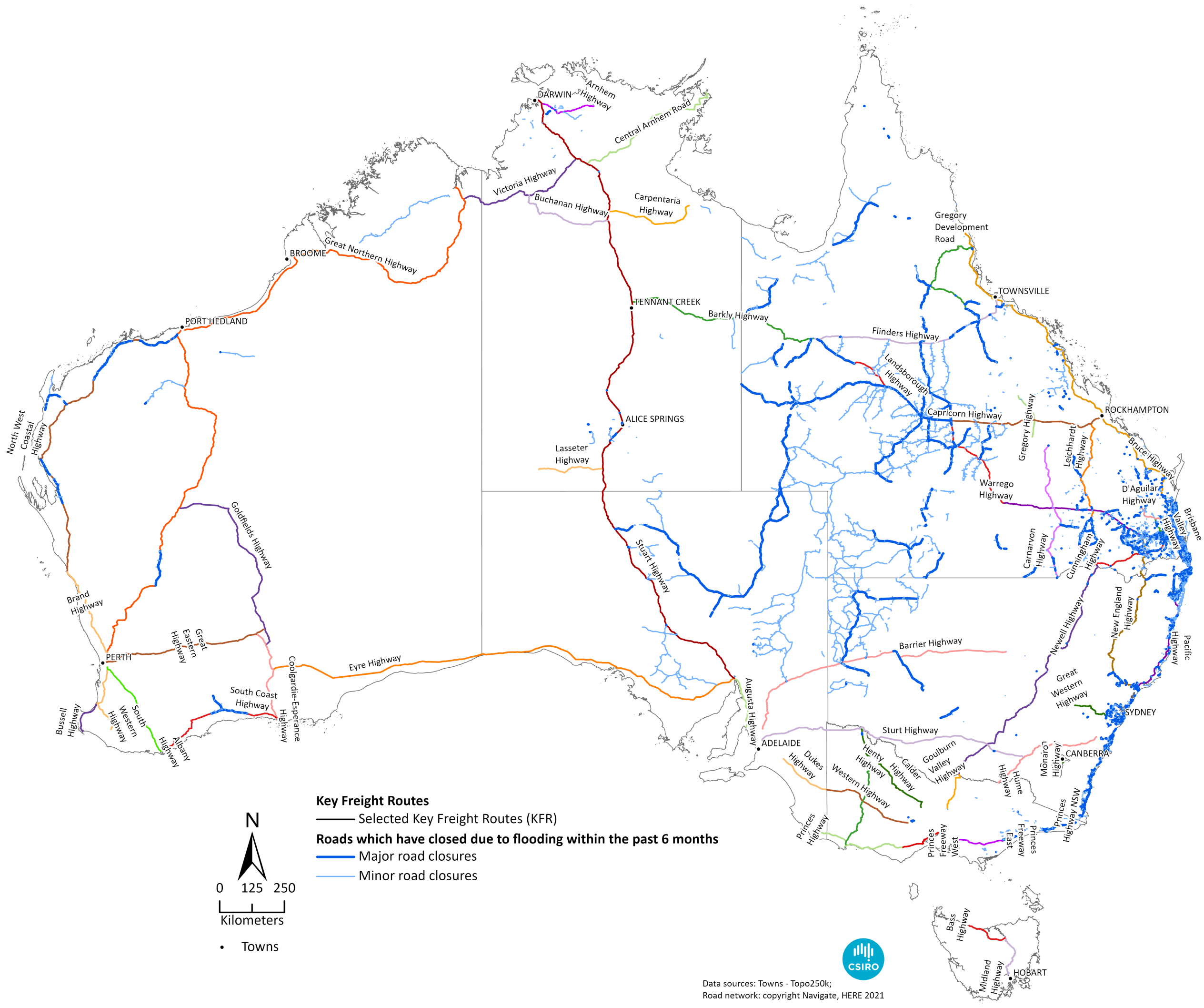

Figure 18 Road closures (highlighted in blue) from the 2022 extreme weather season (to July 2022) relative to the modelled road KFRs

5 Modelled road KFR results - detail

In this section, each modelled KFR is described in detail. Commodities are those that were in TraNSIT as at May 2022.

5.1 Albany Highway

The Albany Highway KFR (Figure 19) is a freight route located in southwest WA. It connects LGAs in Perth to Albany. The corridor is 411 km with at least part of the route used for the transport of $78m of product on 442,573 trailers annually carrying ten million tonnes across 32,487 supply chains spanning 83 commodities (11.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 76,084 trailers annually with the busiest sections carrying 158,987 trailers.

Cropping transport represents approximately 55% of the total freight task, with critical links from properties to silos and on to ports. Wood product contributes a further 20% of the total freight task, with movement to ports comprising a high proportion of these movements. The corridor also supports transport movements for fuel and livestock with a further 15% of the total freight task attributed to these commodity groups. The KFR provides an important role in providing access to markets for primary produce with 40% of all movements originating at a property and a further 35% originating at a silo. Equally important is its role in providing access to ports with 50% of movements having a destination at a port. This route is predominantly classified as PBS2a access

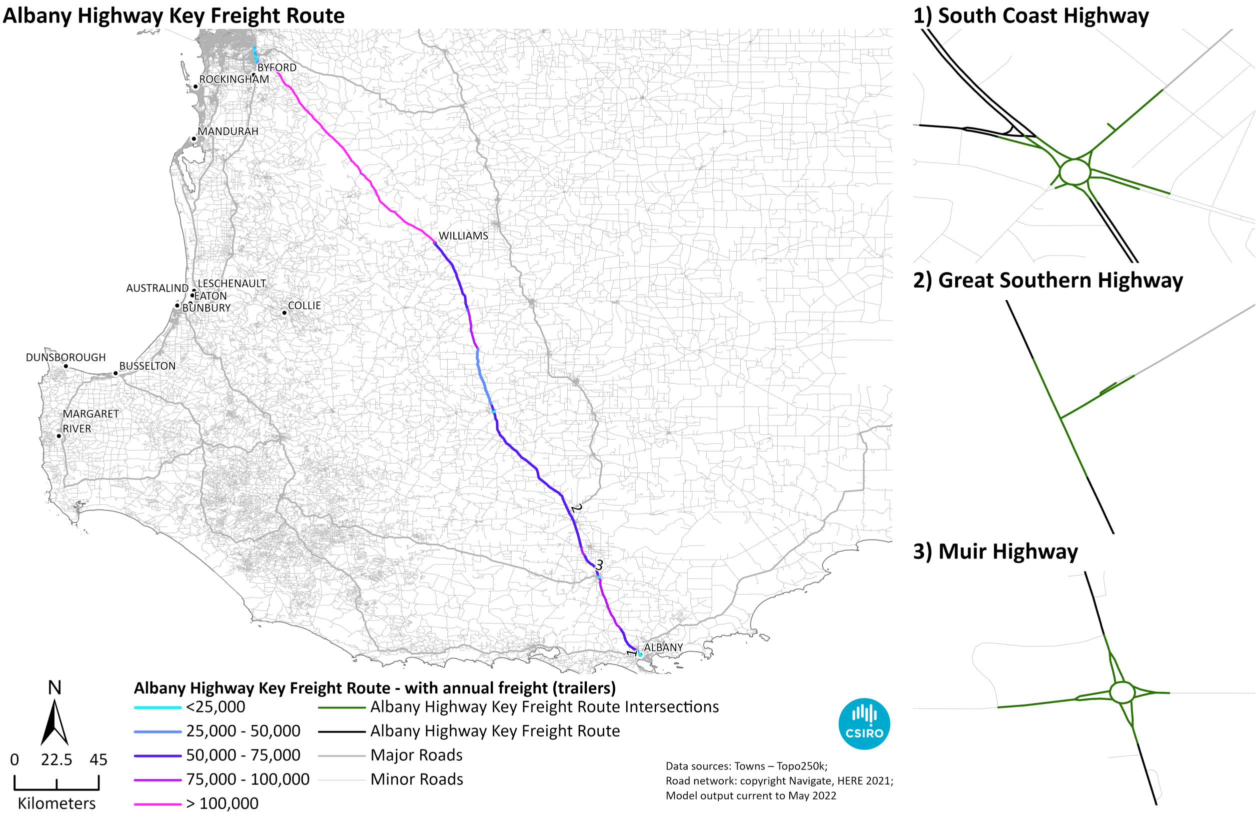

Figure 19 Albany Highway KFR

The Albany Highway KFR passes through 13 LGAs but crucially it supports the supply chain paths for over 199 LGAs along its length and beyond. It provides access to essential commodities for 81 LGAs. Many LGAs including Williams, Narrogin and Albany are reliant on this KFR to provide access to supplies and markets for most commodities but in particular for processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 90% of the supply chain trip length. Horticulture and general freight utilise large sections of the KFR. Figure 19 shows that there is heavier freight flow between Williams and Byford and between the Muirs Highway and Albany.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Great Southern Highway
- Muirs Highway
- South Coast Highway

The reliance described in Table 8 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Albany (C) LGA is heavily reliant on all of the intersections studied. This is especially the case for the South Coast Highway intersection for which 72% of commodities originating from the LGA and 35% of commodities received by the LGA traverse its intersections. The high reliance equates to a high risk factor and highlights the importance – and relative susceptibility – of this key freight route as a pathway for LGAs accessing suppliers and markets.

Table 8 Summary of community reliance metrics for each intersection on the Albany Highway key freight route - most impacted LGA

	SOUTH COAST HIGHWAY	GREAT SOUTHERN HIGHWAY	MUIRS HIGHWAY
Destination LGA most reliant on the intersection	Albany (C)	Albany (C)	Albany (C)
Relative reliance on intersection for destination LGA	0.35	0.19	0.25
Origin LGA most reliant on the intersection	Albany (C)	Albany (C)	Albany (C)
Relative reliance on intersection for origin LGA	0.72	0.48	0.42

5.1.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of each intersection and subsequent high-intensity alternative routes for each of the three modelled intersections along the Albany Highway. The results are based on expected freight for an average week.

- **South Coast Highway intersection**: The closure of the South Coast Highway intersection results in the disruption of 3,393 vehicle trips carrying 72,762 tonnes, 6% being essential commodities. Overall, 72,699 tonnes of freight are re-routed with an average detour length of one km and with an average increase in cost of $2.99 per tonne. A total value of supplies amounting to $1.0 million, none being essential commodities, is unable to reach market.
- **Great Southern Highway intersection**: The closure of the Great Southern Highway intersection results in the disruption of 1,424 vehicle trips carrying 29,002 tonnes, 18% being

essential commodities. Overall, 27,783 tonnes of freight are re-routed with an average detour length of 15 km and with an average increase in cost of $6.19 per tonne. A total value of supplies amounting to $2.1 million, $0.1 million being essential commodities, is unable to reach market.

- **Muirs Highway intersection**: The closure of the Muirs Highway intersection results in the disruption of 1,845 vehicle trips carrying 36,344 tonnes, 14% being essential commodities. Overall, 36,035 tonnes of freight are re-routed with an average detour length of two km and with an average increase in cost of $3.37 per tonne. A total value of supplies amounting to $5.8 million, none being essential commodities, is unable to reach market.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Albany Highway.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Albany Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Albany Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Albany Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Albany Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Albany Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Albany Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Albany Highway-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Albany Highway.

KFR risk profile

Table 9 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity intersection and alternative route closures of five. The metric in Table 9 is unitless and has been rounded to three decimal places. It is a measure of relative risk in terms of volumes of obstructed freight, calculated as the sum of the incremental percentage of volumes obstructed multiplied by the inverse of each increment number. A value of 0.000 indicates that the risk is negligible; meaning little to no volume is impacted. Some freight may still be obstructed, but this does not show due to the rounding of the metric.

The 'Albany Highway-*intersection*-detoured blocked plot.png' plots provide details on the impacts from the successive closures for each intersection. The risk metrics for all intersections are extremely low, indicating that very little volumes of freight are expected to be obstructed from the successive closure of intersections.

Table 9 Risk metrics for modelled intersections on the Albany Highway KFR

	SOUTH COAST HIGHWAY	GREAT SOUTHERN HIGHWAY	MUIRS HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.013	0.002
KFR impacts risk - detour costs for intersection	0.022	0.028	0.015
Last iteration	5	5	5

Freight impact

Table 10 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 10 Freight impact metrics for modelled intersections on the Albany Highway KFR by last successive closure

		SOUTH COAST HIGHWAY [%]	GREAT SOUTHERN HIGHWAY [%]	MUIRS HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	4	1
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	2	3	8
Re-routed supply chains	Relative detour cost – average	13%	15%	9%
	Relative detour cost – maximum	152%	135%	92%

The metrics in Table 10 indicate the supply chains traversing the South Coast Highway intersection that are likely to be re-routed may do so with their average cost increasing by nearly 13% across all commodities, with some supply chain paths incurring an increase of up to 152%. Low volumes of freight that usually traverse the South Coast Highway intersection are expected to be obstructed by the last successive closure. The value of these obstructed commodities represents 2% of the total value usually traversing the intersection.

Similar observations can be made for the Great Southern Highway and the Muirs Highway intersections that result in similar values for their relative detour costs and freight volumes impacted.

Some of the supply chains using the KFR might be more susceptible to obstructed or re-routed movements at various times of the year. ‘Albany Highway-*intersection*-monthly obstructed volumes.png’ and ‘Albany Highway-*intersection*-monthly re-routed volumes.png’ plots show the seasonality of freight using the KFR, and impacted by the successive closure of intersections and alternative routes.

Of note, the Great Southern Highway intersection is susceptible to seasonal movement. As shown in ‘Albany Highway-*intersection*-monthly obstructed volumes.png’, the volumes obstructed (which are relatively small when considered across the whole year) are concentrated over the month of December and for the cropping commodity sector. This highlights the vulnerability of this intersection over a short period of time during the year for cropping, where 30% of the supply chains are expected to be obstructed under the modelling conditions.

Similar observations can be made for the South Coast Highway intersection, for which the construction sector was most vulnerable in March and August.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 11 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The South Coast Highway and the Muirs Highway intersection closures have no impact on the LGA they service for essential commodities, and only one LGA is impacted when considering all commodities. For both intersections, the most impacted LGA is the Albany (C) LGA for the vehicles commodity sector. 37% of the vehicles imported to Albany (C) LGA may be unable to reach market due to the South Coast Highway intersection closure, and 34% due to the Muirs Highway intersection closure.

The Great Southern Highway intersection closure has an impact on one LGA when considering essential commodities, being Plantagenet (S) for which bread may not reach its destination. When considering all commodities, eight out of the 88 LGAs the intersection services may have supply chains not reaching destination. Again, Plantagenet (S) is the most impacted LGA, with four of its general supply chains expected to not reach their destination, representing 27% (of supply chains) of the LGA's total consumption for the general sector.

Table 11 Community impact metrics for modelled intersections on the Albany Highway KFR - obstructed supply chains

			SOUTH COAST HIGHWAY	GREAT SOUTHERN HIGHWAY	MUIRS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/89	1/88	0/131
		Relative volumes impacted	0.0%	16.0%	0.0%
	Most impacted LGA	Name of destination LGA	-	Plantagenet(S)	-
		Highest impacted commodity sector	-	Processed Food	-
		Commodity impacted	-	Bread	-
		Number of supply chains impacted	0	1	0
		Relative volumes impacted	0%	100%	0%
		Weekly tonnes BAU	0.0	0.4	0.0
		Relative number of supply chains impacted	0%	100%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/89	8/88	1/131
		Relative volumes impacted	8.9%	6.0%	18.6%
		Name of destination LGA	Albany(C)	Plantagenet(S)	Albany(C)

			SOUTH COAST HIGHWAY	GREAT SOUTHERN HIGHWAY	MUIRS HIGHWAY
	Most impacted LGA	Highest impacted commodity sector	Vehicles	General	Vehicles
		Number of supply chains impacted	14	4	13
		Relative volumes impacted	19%	66%	65%
		Weekly tonnes BAU	184.3	78.6	184.3
		Relative number of supply chains impacted	37%	27%	34%

Table 12 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The South Coast Highway intersection closure results in 36% of essential commodities (by volume) re-routed for eight of the LGAs it services out of 89. The most impacted LGA is Albany (C) , with three of its bread supply chains expected to be re-routed when considering essential commodities only. When considering all commodities, the wood product commodity sector is the most impacted with nearly all of its supply chains expected to be re-routed.

The Great Southern Highway intersection and the Muirs Highway intersection closures result in 34% and 16% of the volumes expected to be re-routed to 16 LGAs out of 88, and 21 LGAs out of 131 respectively. For both intersection closures, the most impacted LGA is the Albany (C) LGA where 13 supply chains of box chicken are expected to be re-routed when considering essential commodities only. When considering all commodities, Denmark (S) is the most impacted LGA, with 11 of its supply chains for general freight re-routed. These results indicate that these two LGAs have similar freight traversing these two intersections, which may be susceptible to the closure of either of them.

Table 12 Community impact metrics for modelled intersections on the Albany Highway KFR - re-routed supply chains

			SOUTH COAST HIGHWAY	GREAT SOUTHERN HIGHWAY	MUIRS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	8/89	16/88	21/131
		Relative impact on volumes of commodities	36.2%	33.9%	15.7%
	Most impacted LGA	Name	Albany(C)	Albany(C)	Albany(C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Box Chicken	Box Chicken
		Number of supply chains impacted	3	13	13
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	7.2	41.9	41.9
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	88/89	87/88	130/131
		Relative impact on volumes of commodities	17.4%	5.8%	5.8%
		Name	Albany(C)	Denmark(S)	Denmark(S)

		SOUTH COAST HIGHWAY	GREAT SOUTHERN HIGHWAY	MUIRS HIGHWAY
Most impacted LGA	Highest impacted commodity sector	Wood Product	General	General
	Number of supply chains impacted	2257	11	11
	Relative volumes impacted	99%	100%	100%
	Weekly tonnes BAU	25,495.2	84.2	84.2
	Relative number of supply chains impacted	97%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Albany Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Albany Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.2 Arnhem Highway

The Arnhem Highway KFR (Figure 20) is a freight route located in NT. It connects Darwin with LGAs in northwest NT. The corridor is 224 km with at least part of the route used for the transport of $10m of product on 11,259 trailers annually carrying 200,000 tonnes across 1,245 supply chains spanning 41 commodities (15.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 2,294 trailers annually with the busiest sections carrying 6,750 trailers.

Construction transport represents approximately 55% of the total freight task, but importantly the corridor also supports transport movements of processed food and fuel to communities and cropping and livestock to and from enterprises. This route is predominantly classified as PBS4a access.

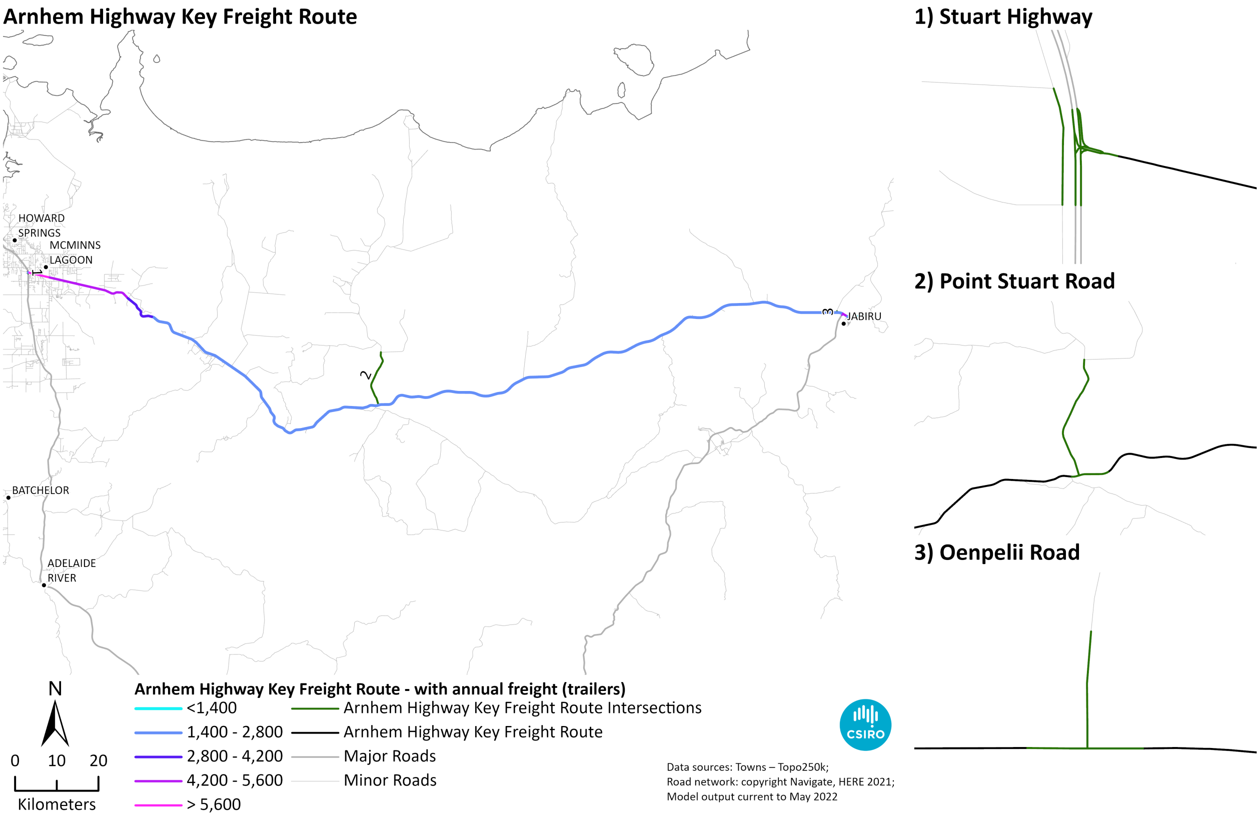

Figure 20 Arnhem Highway KFR

The Arnhem Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 59 LGAs along its length and beyond. It provides access to essential commodities for 18 LGAs. Many LGAs including West Arnhem (R), Roper Gulf (R) and Victoria Daly (R) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with some trips using the KFR for more than half of the supply chain trip length. Figure 20 shows that there is heavier freight at the Stuart Highway end of the KFR.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Stuart Highway
- Point Stuart Road

- Oenpelli Road

The reliance described in Table 13 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Stuart Highway intersection is of relative importance to communities using the KFR, with 61% of all the supply chain paths traversing the intersection destined for Unincorporated NT LGA. In terms of origin LGA, 45% of all the supply chain paths have an origin in West Arnhem (R) LGA. The high supply chain reliance indicates there may be a relatively high risk factor and highlights the importance – and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets.

Table 13 Summary of community reliance metrics for each intersection on the Arnhem Highway key freight route - most impacted LGA

	STUART HIGHWAY	POINT STUART ROAD	OENPELLI ROAD
Destination LGA most reliant on the intersection	Unincorporated NT	Unincorporated NT	Unincorporated NT
Relative reliance on intersection for destination LGA	0.61	0.92	0.94
Origin LGA most reliant on the intersection	West Arnhem (R)	West Arnhem (R)	West Arnhem (R)
Relative reliance on intersection for origin LGA	0.45	0.78	0.82

5.2.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of each intersection and subsequent high-intensity alternative routes for each of the three modelled intersections along the Arnhem Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 129 vehicle trips carrying 2,405 tonnes, with 43% (of the freight volume) being essential commodities. Overall, 1,329 tonnes of freight are re-routed with a negligible detour length and an average increase in cost of $3.50 per tonne. A total value of supplies amounting to $8.6 million, $6.1 million being essential commodities, is unable to reach its destination.
- **Point Stuart Road intersection**: The closure of the Point Stuart Road intersection results in the disruption of 36 vehicle trips carrying 775 tonnes, with 46% being essential commodities. Overall, freight is unable to be re-routed, with all supply chains unable to reach their destination. A total value of supplies amounting to $0.6 million, $0.1 million being essential commodities, is unable to reach its destination.
- **Oenpelli Road intersection**: The closure of the Oenpelli Road intersection results in the disruption of 37 vehicle trips carrying 812 tonnes, with 53% being essential commodities. Overall, 15 tonnes of freight are re-routed with an average detour length of 352 km and an average increase in cost of $95.62 per tonne. A total value of supplies amounting to $0.4 million, $0.2 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix **0** were calculated for each of the supply chains traversing each of the three modelled intersections of the Arnhem Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Arnhem Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Arnhem Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Arnhem Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Arnhem Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Arnhem Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Arnhem Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Arnhem Highway-detoured_obstructed_plot.png' shows the cumulative impacts of successive closures for the Arnhem Highway.

KFR risk profile

Table 14 provides the results of the simulation from closing intersections sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, however all supply chains are obstructed by the fifth iteration for the Point Stuart Road intersection and Oenpelli Road intersection. The 'Arnhem Highway-*intersection*-detoured blocked plot.png' plots provide details on the impacts from the successive closures for each intersection. Oenpelli Road and Point Stuart Road intersections have similar risk factors that are non-negligible.

For the Stuart Highway intersection, all freight is able to re-route until it reaches the third successive closure, albeit at an increased cost. On the fourth successive closure however, many detour options are exhausted and a large proportion of freight is no longer able to reach its destination.

Table 14 Risk metrics for modelled intersections on the Arnhem Highway KFR

	STUART HIGHWAY	POINT STUART ROAD	OENPELLI ROAD
KFR impacts risk - obstructed volumes for intersection	0.112	0.262	0.245
KFR impacts risk - detour costs for intersection	0.028	0.000	0.348
Last iteration	5	5	5

Freight impact

Table 15 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 15 Freight impact metrics for modelled intersections on the Arnhem Highway KFR by last successive closure

		STUART HIGHWAY [%]	POINT STUART ROAD [%]	OENPELLI ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	45	100	98
	Relative freight volume impacted – essential commodities	43	100	100
	Relative value of freight – all commodities	77	100	83
Re-routed supply chains	Relative detour cost – average	13	0	143
	Relative detour cost – maximum	115	0	297

The metrics in Table 15 indicate the supply chains traversing the Stuart Highway intersection that are likely to be re-routed would do so with their average cost increasing by nearly 13% across all commodities, with some supply chain paths incurring an increase of up to 115%. Large volumes of freight (45% of volumes across all commodities and 43% of all essential commodities) that usually traverse the Stuart Highway intersection are expected to be obstructed by the last successive closure. The value of these obstructed commodities represents 77% of the total value usually traversing the intersection.

The Oenpelli Road and Point Stuart Road intersections however see nearly all their freight likely to be obstructed by the last successive closure. There is an average increased cost of 140% for re-routing freight that usually traverses the Oenpelli Road intersection, with some of the freight cost increasing by nearly 300%. None of the freight traversing the Point Stuart Road intersection is likely to be re-routed.

Some of the supply chains using the KFR do not move throughout the whole year. 'Arnhem Highway-*intersection*-monthly re-routed volumes.png' plots show the seasonality of freight using the KFR. For the Oenpelli Road intersection, most livestock and construction supply chains could be re-routed throughout the year. For the Stuart Highway intersection, however, most supply chains for the general and horticulture sectors are obstructed except for a few that are able to move in some months.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 16 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closures result in 15 of the 45 LGAs serviced by the intersection having obstructed supply chains, with 31% of the freight volumes for essential commodities obstructed. The most impacted LGA is Canning (C). Barramundi within the processed food commodity sector is the highest impacted commodity, with 6.7 weekly tonnes not reaching market.

However, overall, only 0.4% (tonnes) of all commodities consumed by all the LGAs impacted may not be available.

The Point Stuart Road and Oenpelli intersections impact two LGAs, with 8% and 10% respectively of the freight volumes for essential commodities obstructed. The most impacted LGA is West Arnhem (R) where fuel supply is significantly impacted.

Table 16 Community impact metrics for modelled intersections on the Arnhem Highway KFR - obstructed supply chains

			STUART HIGHWAY	POINT STUART ROAD	OENPELLI ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	15/45	2/18	2/10
		Relative volumes impacted	31%	8%	10%
	Most impacted LGA	Name of destination LGA	Canning (C)	West Arnhem (R)	West Arnhem (R)
		Highest impacted commodity sector	Processed Food	fuel	fuel
		Commodity impacted	Barramundi	LPG	unleaded fuel
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	100%	100%	57%
		Weekly tonnes BAU	6.7	0.2	86.0
		Relative number of supply chains impacted	100%	100%	50%
All commodities	All impacted LGAs	Number of LGAs impacted	41/45	17/18	5/10
		Relative volumes impacted	0.4%	0.9%	6.8%
	Most impacted LGA	Name of destination LGA	Litchfield(M)	West Arnhem(R)	West Arnhem(R)
		Highest impacted commodity sector	Wood Product	Construction	Fuel
		Number of supply chains impacted	1	20	2
		Relative volumes impacted	100%	32%	50%
		Weekly tonnes BAU	38.3	1,737.9	147.7
		Relative number of supply chains impacted	100%	25%	40%

Re-routed supply chains

Table 17 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 8.4% of the supply chains are expected to be re-routed for four of the LGAs that traverse the Stuart Highway intersection. The most impacted LGA is Darwin (C), suggesting access to supplies and markets for essential commodities may be difficult for LGAs using this intersection of the KFR. In particular, 100% of the barramundi commodity supply chain is re-routed, while 20% of construction sector supply chains heading to West Arnhem (R) are re-routed.

For the Point Stuart Road and Oenpelli Road intersections, there are no essential commodity supply chains paths re-routed - all supply chains are obstructed across all commodities. Only when considering all commodities is it observed that 0.5% of all volumes transported to five LGAs are expected to be re-routed for the Oenpelli Road intersection.

Table 17 Community impact metrics for modelled intersections on the Arnhem Highway KFR - re-routed supply chains

			STUART HIGHWAY	POINT STUART ROAD	OENPELLI ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	4/45	0/18	0/10
		Relative impact on volumes of commodities	8.4%	0.0%	0.0%
	Most impacted LGA	Name	Darwin (C)		
		Highest impacted commodity sector	Processed Food		
		Commodity impacted	Barramundi		
		Number of supply chains impacted	1		
		Relative volumes impacted	100%	0%	0%
		Weekly tonnes BAU	1.1	0.0	0.0
		Relative number of supply chains impacted	100%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	8/45	0/18	5/10
		Relative impact on volumes of commodities	7.3%	0.0%	0.5%
	Most impacted LGA	Name	West Arnhem (R)		West Arnhem (R)
		Highest impacted commodity sector	Construction		Livestock
		Number of supply chains impacted	15		3
		Relative volumes impacted	20%	0%	27%
		Weekly tonnes BAU	1,737.9	0.0	16.9
		Relative number of supply chains impacted	19%	0%	27%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Arnhem Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Arnhem Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.3 Augusta Highway

The Augusta Highway KFR (Figure 21) is a freight route in southern SA. It connects Port Augusta to the Yorke Peninsula along the Spencer Gulf. The corridor is 223 km with at least part of the route used for the transport of $103m of product on 346,180 trailers annually carrying seven million tonnes across 22,757 supply chains spanning 112 commodities (21.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 131,747 trailers annually with the busiest sections carrying 184,223 trailers.

Cropping transport represents approximately 50% of the total freight task, with critical links from properties to silos and on to ports. Fuel movements contribute a further 15% of the total freight task with movements from ports to depots and on to service stations. The corridor also supports transport movements of general freight with a further 10% of the total freight task attributed to movements between DCs and retail. The KFR provides an important role in providing access to markets for primary produce with 35% of all movements originating at a property. Equally important is its role in providing access to ports with 20% of movements having a destination at a port. This route is predominantly classified as PBS3b access.

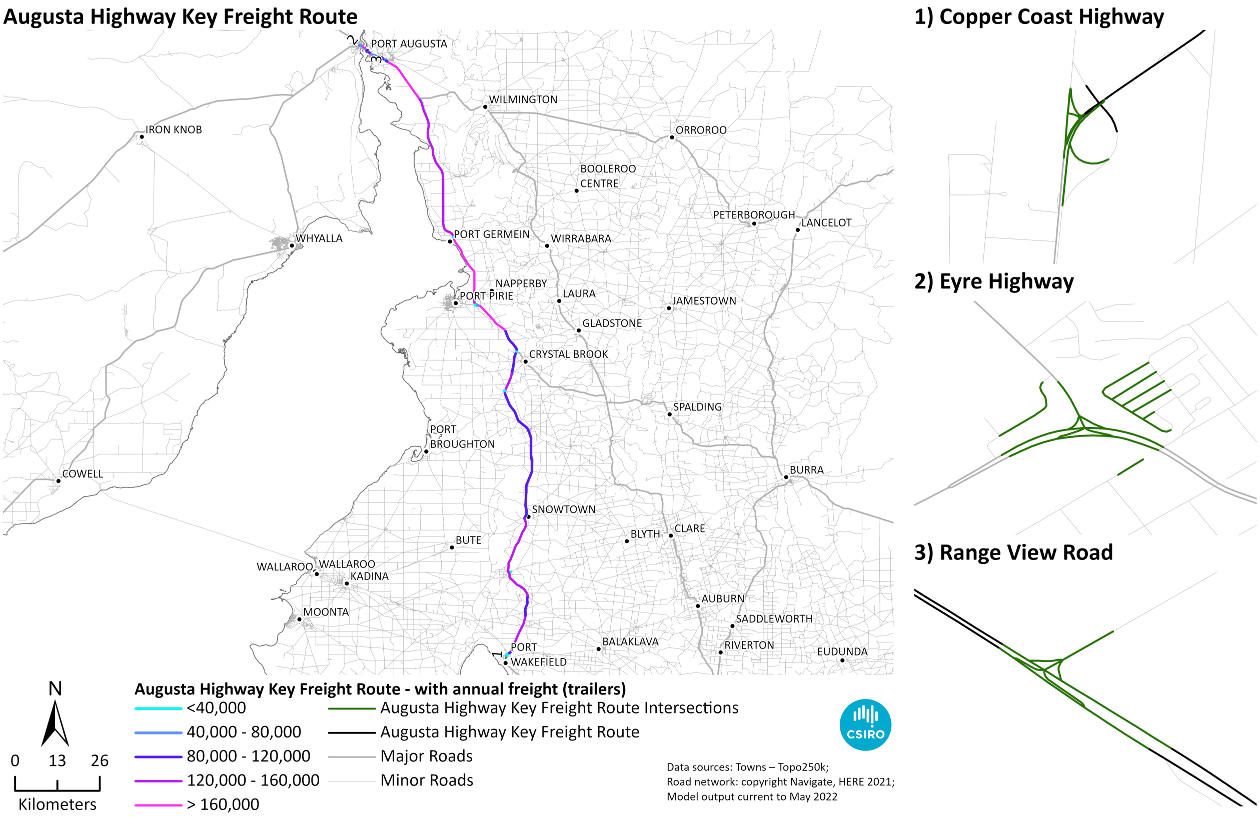

Figure 21 Augusta Highway KFR

The Augusta Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 421 LGAs along its length and beyond. It provides access to essential commodities for 140 LGAs. Many LGAs including Port Augusta (C), Copper Coast (DC) and Yorke Peninsula (DC) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 90% of the supply chain trip length. Horticulture and processed food utilise large sections of the KFR. Figure 21 shows that there is heavier freight between Port Augusta and south of Port Pirie.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Eyre Highway
- Range View Road
- Copper Coast Highway

The reliance described in Table 18 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Port Adelaide Enfield (C) LGA is the most reliant of the LGAs with incoming freight traversing the Copper Coast Highway intersection while the Cockburn (C) LGA is the most reliant on the Eyre Highway and the Range View Road intersections. However, in all three cases the reliance is low. For the LGAs relying on the three studied intersections, their reliance is small as over 85% of their consumed commodities do not rely on these intersections to move. For those LGAs that are sending their commodities, the reliance on any of the three intersections is even lower with a reliance less than 10%.

Table 18 Summary of community reliance metrics for each intersection on the Augusta Highway key freight route - most impacted LGA

	COPPER COAST HIGHWAY	EYRE HIGHWAY	RANGE VIEW ROAD
Destination LGA most reliant on the intersection	Port Adelaide Enfield (C)	Cockburn (C)	Cockburn (C)
Relative reliance on intersection for destination LGA	0.07	0.12	0.12
Origin LGA most reliant on the intersection	Yorke Peninsula (DC)	Port Pirie City and Dists (M)	Port Pirie City and Dists (M)
Relative reliance on intersection for origin LGA	0.05	0.07	0.07

5.3.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of each intersection and subsequent high-intensity alternative routes for each of the three modelled intersections along the Augusta Highway. The results are based on expected freight for an average week.

- **Copper Coast Highway intersection**: The closure of the Copper Coast Highway intersection results in the disruption of 4,135 vehicle trips carrying 91,069 tonnes, 22% being essential commodities. Overall, 91,069 tonnes of freight are re-routed with an average detour length of 20 km and an average increase in cost of $5.65 per tonne. No supply chain is unable to reach its destination.
- **Eyre Highway intersection**: The closure of the Eyre Highway intersection results in the disruption of 3,434 vehicle trips carrying 64,439 tonnes, 24% being essential commodities. Overall, 63,978 tonnes of freight are re-routed with an average detour length of 721 km and an average increase in cost of $93.45 per tonne. A total value of supplies amounting to $0.7 million, $0.7 million being essential commodities, is unable to reach its destination.

- **Range View Road intersection**: The closure of the Range View Road intersection results in the disruption of 3,534 vehicle trips carrying 66,066 tonnes, 25% being essential commodities. Overall, 65,853 tonnes of freight are re-routed with a minimal average detour length and an average increase in cost of $19.94 per tonne. A total value of supplies amounting to $0.2 million, none being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Augusta Highway. These are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Augusta Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Augusta Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Augusta Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Augusta Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Augusta Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Augusta Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Augusta Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Augusta Highway.

KFR risk profile

Table 19 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Augusta Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also extremely low for both the Copper Coast Highway and the Range View Road intersections, indicating that the re-routed freight is done at a very low cost; the value for the Eyre Highway intersection is slightly higher, however still low.

Table 19 Risk metrics for modelled intersections on the Augusta Highway KFR – the model

	COPPER COAST HIGHWAY	EYRE HIGHWAY	RANGE VIEW ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.002	0.001
KFR impacts risk - detour costs for intersection	0.010	0.054	0.012
Last iteration	5	5	5

Freight impact

Table 20 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 20 Freight impact metrics for modelled intersections on the Augusta Highway KFR

		COPPER COAST HIGHWAY [%]	EYRE HIGHWAY [%]	RANGE VIEW ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	1	0
	Relative freight volume impacted – essential commodities	0	3	1
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	8	58	10
	Relative detour cost – maximum	269	839	2717

The metrics in Table 20 indicate the supply chains traversing the Copper Coast Highway and the Range View Road intersections that are likely to be re-routed will do so with their average cost increasing slightly (8% and 10% respectively) over all commodities. However, some supply chain paths are highly impacted with some detour costs increasing up to 2700%. The supply chains traversing the Eyre Highway intersection that are re-routed however, will do so at an increased cost of 58% on average, with a maximum of 800%.

For all three intersections, the obstructed freight is minimal[1].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 21 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Copper Coast Highway intersection closure results in no LGAs serviced by the intersection having obstructed supply chains for – when considering both all and essential commodities.

The Eyre Highway intersection closure results in five LGAs having obstructed supply chains for essential commodities, representing 6.6% of the volumes that are normally received by the 259 LGAs serviced by the intersection. Unincorporated NT is the most impacted LGA with one supply chain for the fuel industry obstructed, representing 38% of the diesel fuel consumption of the LGA. When considering all commodities, MacDonnell (R) is the most impacted also for its fuel received.

[1] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

The Range View Road intersection closure results in two LGAs having obstructed supply chains for essential commodities as well as for all commodities, representing 16.8% and 10.5% respectively of the volumes that are normally received by the 259 LGAs serviced by the intersection. In both cases, Port Augusta (C) is the most impacted LGA for the construction industry.

Table 21 Community impact metrics for modelled intersections on the Augusta Highway KFR - obstructed supply chains

			COPPER COAST HIGHWAY	EYRE HIGHWAY	RANGE VIEW ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/186	5/259	2/259
		Relative volumes impacted	0.0%	6.6%	16.8%
	Most impacted LGA	Name of destination LGA	-	Unincorporated NT	Port Augusta (C)
		Highest impacted commodity sector	-	fuel	construction
		Commodity impacted	-	diesel fuel	cement
		Number of supply chains impacted	-	1	1
		Relative volumes impacted	0%	38%	100%
		Weekly tonnes BAU	0.0	49.2	11.5
		Relative number of supply chains impacted	0%	33%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	0/186	6/259	2/259
		Relative volumes impacted	0.0%	6.4%	10.5%
	Most impacted LGA	Name of destination LGA	-	MacDonnell (R)	Port Augusta (C)
		Highest impacted commodity sector	-	Fuel	Construction
		Number of supply chains impacted	-	2	9
		Relative volumes impacted	0%	33%	86%
		Weekly tonnes BAU	0.0	221.9	111.5
		Relative number of supply chains impacted	0%	22%	90%

Re-routed supply chains

Table 22 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For the Copper Coast Highway intersection, 112 of the 186 LGAs serviced are expected to have freight re-routed, representing 15% of essential commodities consumed within the LGAs. For non-essential commodities, 184 out of the 186 LGAs serviced by the Copper Coast Highway intersection are expected to be impacted by re-routed freight, representing 9.1% of the total volume consumed by all LGAs whose freight traverses the intersection.

For the Eyre Highway intersection, 133 of the 259 LGAs serviced are expected to have freight are re-routed, representing 11.2% of essential commodities consumed within the LGAs. For non-essential commodities, 257 out of the 259 LGAs serviced by the Eyre Highway intersection are expected to be impacted by re-routed freight, which represent 4.6% of the total volume consumed by all LGAs whose freight traverses the intersection.

Similar results are observed for the Range View Road intersection closure. 133 of the 259 LGAs serviced are expected to have freight re-routed, representing 11.8% of essential commodities consumed within the LGAs. For non-essential commodities, 257 out of the 259 LGAs serviced by the Cunningham Highway intersection are expected to be impacted by re-routed freight, representing 4.7% of the total volume consumed by all LGAs whose freight traverses the intersection.

For all three intersection closures, the most impacted LGA when considering all the commodities is Coober Pedy (DC) for the processed food sector where all of its supply chains will be re-routed. When considering essential commodities only, the processed food sector is still the most impacted essential commodity for each of the most impacted LGAs, however the most impacted LGAs are Flinders Ranges (DC) and Alice Springs (T).

Table 22 Community impact metrics for modelled intersections on the Augusta Highway KFR - re-routed supply chains

			COPPER COAST HIGHWAY	EYRE HIGHWAY	RANGE VIEW ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	112/186	133/259	133/259
		Relative impact on volumes of commodities	15.0%	11.2%	11.8%
	Most impacted LGA	Name	Flinders Ranges (DC)	Alice Springs (T)	Alice Springs (T)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Processed Food	Box Chicken	Box Chicken
		Number of supply chains impacted	2	7	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.4	28.7	28.7
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	184/186	257/259	257/259
		Relative impact on volumes of commodities	9.1%	4.6%	4.7%
	Most impacted LGA	Name	Coober Pedy (DC)	Coober Pedy (DC)	Coober Pedy (DC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Number of supply chains impacted	8	8	8
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	3.6	3.6	3.6
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Augusta Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.

- ‘Augusta Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.4 Barkly Highway

The Barkly Highway KFR (Figure 22) extends between Queensland and NT. It connects Cloncurry west to the Stuart Highway. The corridor is 764 km with at least part of the route used for the transport of $34m of product on 74,691 trailers annually carrying 1.5 million tonnes across 5564 supply chains spanning 78 commodities (20.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 37,833 trailers annually, with the busiest sections carrying 55,666 trailers.

Mining transport represents approximately 35% of the total freight task, with links from mines to rail points. Livestock movements contribute a further 22% of the total freight task with movements primarily between properties. The corridor also supports general freight and fuel transport movements for a further 25% of the total freight task. The KFR provides an important role in providing access for movements by primary produce. This route is predominantly classified as PBS4a access

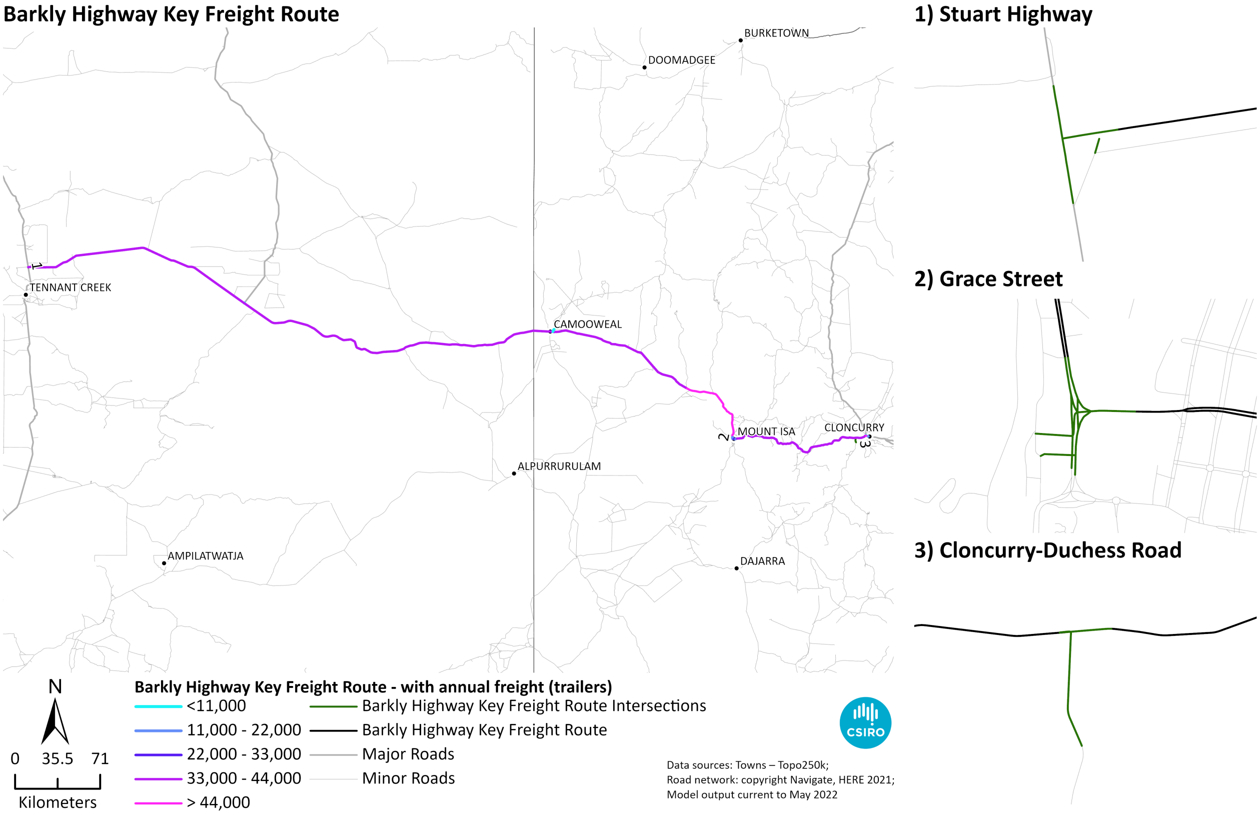

Figure 22 Barkly Highway KFR

The Barkly Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 169 LGAs along its length and beyond. It provides access to essential commodities for 33 LGAs. Many LGAs including Mount Isa (C) and Burke (S) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular cropping, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 90% of the supply chain trip length. Livestock movements utilise large sections of the KFR. Figure 22 shows that there is consistent freight across the KFR with heavier freight around Mount Isa (C).

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Stuart Highway
- Grace Street
- Cloncurry-Duchess Road

The reliance described in Table 23 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Darwin (C) LGA is the most reliant of all the LGAs for all three intersections; however, the reliance is low with over 90% of the commodities imported not relying on these intersections to move. A similar observation can be made for the origin LGA, where the Barkly (R) LGA is the most reliant on all three intersections but only to a small degree, as over 85% of its commodities produced do not rely on these intersections to move.

Table 23 Summary of community reliance metrics for each intersection on the Barkly Highway key freight route - most impacted LGA

	STUART HIGHWAY	GRACE STREET	CLONCURRY-DUCHESS ROAD
Destination LGA most reliant on the intersection	Darwin (C)	Darwin (C)	Darwin (C)
Relative reliance on intersection for destination LGA	0.10	0.08	0.08
Origin LGA most reliant on the intersection	Barkly (R)	Barkly (R)	Barkly (R)
Relative reliance on intersection for origin LGA	0.12	0.12	0.11

5.4.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of each intersection and subsequent high-intensity alternative routes for each of the three modelled intersections along the Barkly Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 625 vehicle trips carrying 11,036 tonnes, 31% being essential commodities. Overall, 10,880 tonnes of freight are re-routed with an average detour length of 3,248 km and with an average increase in cost of $503.06 per tonne. A total value of supplies amounting to $0.9 million, $0.1 million being essential commodities, is unable to reach its destination.
- **Grace Street intersection:** The closure of the Grace Street intersection results in the disruption of 1,071 vehicle trips carrying 22,600 tonnes, 18% being essential commodities. Overall, 12,519 tonnes of freight are re-routed with an average detour length of 15 km and with an average increase in cost of $5.14 per tonne. A total value of supplies amounting to $40.3 million, $0.4 million being essential commodities, is unable to reach it destination.
- **Cloncurry – Duchess Road intersection:** The closure of the Cloncurry – Duchess Road intersection results in the disruption of 794 vehicle trips carrying 14,135 tonnes, 30% being essential commodities. Overall, 14,018 tonnes of freight are re-routed with an average detour length of 191 km and with an average increase in cost of $30.42 per tonne. A total

value of supplies amounting to $0.7 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Barkly Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Barkly Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Barkly Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Barkly Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Barkly Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Barkly Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Barkly Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Barkly Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Barkly Highway.

KFR risk profile

Table 24 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Barkly Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs are low for the Grace Street and the Cloncurry – Duchess Road intersection closures, however of moderate value for the Stuart Highway intersection, indicating that some detours might be quite costly.

Table 24 Risk metrics for modelled intersections on the Barkly Highway KFR – the model

	STUART HIGHWAY	GRACE STREET	CLONCURRY-DUCHESS ROAD
KFR impacts risk - obstructed volumes for intersection	0.005	0.220	0.003
KFR impacts risk - detour costs for intersection	0.344	0.003	0.019
Last iteration	5	5	5

Freight impact

Table 25 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 25 Freight impact metrics for modelled intersections on the Barkly Highway KFR

		STUART HIGHWAY [%]	GRACE STREET [%]	CLONCURRY-DUCHESS ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	45	1
	Relative freight volume impacted – essential commodities	0	6	0
	Relative value of freight – all commodities	1	35	1
Re-routed supply chains	Relative detour cost – average	159	3	15
	Relative detour cost – maximum	1499	81	415

The metrics in Table 25 indicate the supply chains traversing the Stuart Highway intersection that are likely to be re-routed will do so with their average cost increasing by 159% across all commodities, with some supply chain paths incurring an increase of up to 1499%. Little to no freight that usually traverses the Stuart Highway intersection is expected to be obstructed by the last successive closure.

For the Grace Street and the Cloncurry-Duchess Road intersection closures, expected increase in costs due to detours are 3% and 15% on average, respectively. These increases are low, however some of the supply chains incur increasing costs of up to 415% for the Cloncurry – Duchess Road intersection closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 26 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closure results in two out of the 82 LGAs serviced by the intersection having obstructed supply chains, with 13.7% of the freight volumes for essential commodities obstructed. The most impacted LGA is Barkly (R) for the processed food industry for which 36% (tonnes) of meat consumed will not reach its destination. When considering all commodities, the same LGA is the most impacted.

The Grace Street intersection closure results in one out of the 99 LGAs serviced by the intersection having obstructed supply chains, with 20.5% of the freight volumes for essential commodities obstructed. The most impacted LGA is Mount Isa (C) for the fuel industry, for which 38% (tonnes) of unleaded fuel consumed in the LGA will not reach its destination. When considering all commodities, the same LGA is the most impacted, for mining.

The Cloncurry – Duchess Road intersection closure results in no LGAs serviced by the intersection having obstructed supply chains of essential commodities. When considering all commodities, 34 of the 104 LGAs serviced by the intersection are expected to have obstructed freight. The most impacted LGA is Mildura (RC) for the livestock industry, for which 0.2% (tonnes) consumed in the LGA will not reach its destination.

Table 26 Community impact metrics for modelled intersections on the Barkly Highway KFR - obstructed supply chains

			STUART HIGHWAY	GRACE STREET	CLONCURRY-DUCHESS ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/82	1/99	0/104
		Relative volumes impacted	13.7%	20.5%	0.0%
	Most impacted LGA	Name of destination LGA	Barkly (R)	Mount Isa (C)	-
		Highest impacted commodity sector	processed food	fuel	-
		Commodity impacted	meat	unleaded fuel	-
		Number of supply chains impacted	1	2	0
		Relative volumes impacted	36%	38%	0%
		Weekly tonnes BAU	2.7	397.9	0.0
		Relative number of supply chains impacted	25%	40%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	26/82	5/99	34/104
		Relative volumes impacted	0.6%	55.7%	0.2%
	Most impacted LGA	Name of destination LGA	Barkly (R)	Mount Isa (C)	Mildura (RC)
		Highest impacted commodity sector	Horticulture	Mining	Livestock
		Number of supply chains impacted	3	6	1
		Relative volumes impacted	13%	77%	8%
		Weekly tonnes BAU	24.8	12,730.8	19.6
		Relative number of supply chains impacted	17%	86%	9%

Re-routed supply chains

Table 27 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closure results in 29 LGAs having re-routed supply chains for essential commodities, representing 29.5% of the volumes that are normally received by the 82 LGAs serviced by the intersection. Barkly (R) is the most impacted LGA with three supply chains for the construction industry obstructed, representing 100% of the concrete consumption of the LGA. When considering all commodities, Halls Creek (S) is the most impacted for the cropping industry. However, the overall volumes impacted by re-routing represent only 3.6% of the commodities consumed within the 80 impacted LGAs.

Similar observation can be made for the Grace Street and the Cloncurry – Duchess Road intersection closures. The impact on essential commodities is moderate with nearly 33% and 35% of the volumes of essential commodities that are normally received by the 99 and 104 LGAs, respectively, serviced by the intersection expected to be re-routed. When considering all commodities, the impact is less with 3.6% and 4% of the volumes of commodities normally received by the LGAs impacted by re-routing.

Table 27 Community impact metrics for modelled intersections on the Barkly Highway KFR - re-routed supply chains

			STUART HIGHWAY	GRACE STREET	CLONCURRY-DUCHESS ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	29/82	30/99	30/104
		Relative impact on volumes of commodities	29.5%	32.8%	35.0%
	Most impacted LGA	Name	Barkly(R)	Roper Gulf(R)	Mount Isa(C)
		Highest impacted commodity sector	Construction	Processed Food	Horticulture
		Commodity impacted	Concrete	Box Chicken	Fruit
		Number of supply chains impacted	3	4	6
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	16.4	2.3	19.3
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	80/82	97/99	99/104
		Relative impact on volumes of commodities	3.6%	3.6%	4.0%
	Most impacted LGA	Name	Halls Creek(S)	Halls Creek(S)	Mount Isa(C)
		Highest impacted commodity sector	Cropping	Cropping	Cropping
		Number of supply chains impacted	1	1	6
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.3	0.3	5.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Barkly Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Barkly Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.5 Barrier Highway

The Barrier Highway KFR (Figure 23) is a freight route which extends between the Adelaide region and central NSW. The corridor is 1004 km with at least part of the route used for the transport of $82m of product on 180,700 trailers annually carrying three million tonnes across 15,109 supply chains spanning 112 commodities (23.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 51,461 trailers annually with the busiest sections carrying 90,355 trailers.

Cropping transport represents approximately 30% of the total freight task, with critical links from properties to silos. Fuel movements contribute a further 15% of the total freight task with movements from ports to depots and on mines. The corridor also supports transport movements for general freight with a further 18% of the total freight task being movements between DCs and retail. The KFR provides an important role in providing access to markets for primary produce with 40% of all movements originating at a property. Equally important is its role in providing access to DCs with 25% of movements having a destination at a DC. This route is predominantly classified as PBS3a HML access.

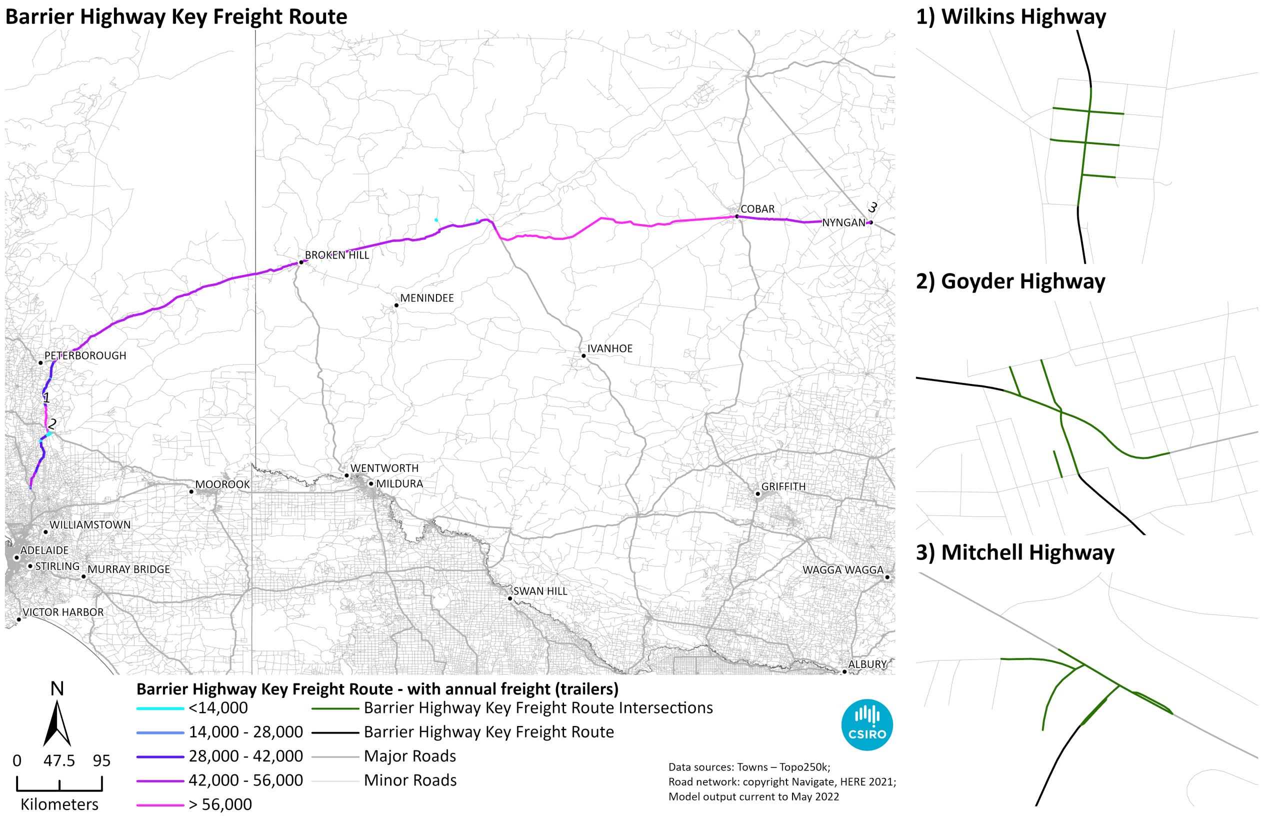

Figure 23 Barrier Highway KFR

The Barrier Highway KFR passes through nine LGAs but crucially it supports the supply chain paths for over 375 LGAs along its length and beyond. It provides access to essential commodities for 82 LGAs. Many LGAs including Clare and Gilbert Valleys (DC), Broken Hill (C) and Central Darling (A) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular for processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains, with trips using the KFR for up to 90% of the supply chain trip length. Horticulture and processed food utilise large sections of the KFR. Figure 23 shows that there is heavier freight between Cobar and Wilcannia along this KFR and a small concentration south of Peterborough in SA.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Goyder Highway
- Wilkins Highway
- Mitchell Highway

The reliance described in Table 28 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Port Adelaide Enfield (C) LGA is the most reliant of the LGAs with incoming freight traversing the Wilkins Highway intersection. The Brisbane (C) LGA is the most reliant on the Mitchell Highway intersection and the Blacktown (C) LGA is most reliant on the Goyder Highway intersection. In all three cases, the reliance is low to moderate. For those LGAs that are sending their commodities and that are traversing the intersections, the reliance on any of the three intersections is lower with a reliance less than 10%.

Table 28 Summary of community reliance metrics for each intersection on the Barrier Highway key freight route - most impacted LGA

	WILKINS HIGHWAY	MITCHELL HIGHWAY	GOYDER HIGHWAY
Destination LGA most reliant on the intersection	Port Adelaide Enfield (C)	Brisbane (C)	Blacktown (C)
Relative reliance on intersection for destination LGA	0.17	0.22	0.23
Origin LGA most reliant on the intersection	Bundaberg (R)	Bundaberg (R)	Loxton Waikerie (DC)
Relative reliance on intersection for origin LGA	0.05	0.08	0.06

5.5.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of each intersection and subsequent high-intensity alternative routes for each of the three modelled intersections along the Barrier Highway. The results are based on expected freight for an average week.

Wilkins Highway intersection: The closure of the Wilkins Highway intersection results in the disruption of 1,540 vehicle trips carrying 27,389 tonnes, 18% being essential commodities. Overall, 27,367 tonnes of freight are re-routed with an average detour length of six km and an average increase in cost of $2.68 per tonne. A total value of supplies amounting to $0.1 million, $0.1 million being essential commodities, is unable to reach its destination.

Mitchell Highway intersection: The closure of the Mitchell Highway intersection results in the disruption of 938 vehicle trips carrying 17,191 tonnes, 31% being essential commodities. Overall, 17,177 tonnes of freight are re-routed with an average detour length of 26 km and an average increase in cost of $7.98 per tonne. A total value of supplies amounting to $0.2 million, $0.0 million being essential commodities, is unable to reach its destination.

Goyder Highway intersection: The closure of the Goyder Highway intersection results in the disruption of 1,050 vehicle trips carrying 16,761 tonnes, 8% being essential commodities. Overall, 16,742 tonnes of freight are re-routed with an average detour length of eight km and an average increase in cost of $3.02 per tonne. A total value of supplies amounting to $0.3 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Barrier Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Barrier Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Barrier Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Barrier Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Barrier Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Barrier Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Barrier Highway-cost bar plot.png' shows the cost impacts of re-routing

'Barrier Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Barrier Highway.

KFR risk profile

Table 29 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Barrier Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs are very low for the Wilkins and the Goyder Highway intersections. For the Mitchell Highway intersection, while low, the metric is not negligible, indicating that there are some detours that might be quite costly.

Table 29 Risk metrics for modelled intersections on the Barrier Highway KFR – the model

	WILKINS HIGHWAY	MITCHELL HIGHWAY	GOYDER HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.000	0.001
KFR impacts risk - detour costs for intersection	0.002	0.010	0.001
Last iteration	5	5	5

Freight impact

Table 30 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 30 Freight impact metrics for modelled intersections on the Barrier Highway KFR

		WILKINS HIGHWAY [%]	MITCHELL HIGHWAY [%]	GOYDER HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	3	9	2
	Relative detour cost – maximum	41	685	95

The metrics in Table 30 indicate that little to no freight that usually traverses any of the three intersections modelled is expected to be obstructed by the last successive closure.

The Wilkins Highway and the Goyder Highway intersection closures result in an expected increase in costs due to detours of 3% and 2% on average respectively, which is very low. The highest cost increases for supply chains are 41% and 95%, which is quite moderate.

The supply chains traversing the Mitchell Highway intersection that are likely to be re-routed will do so with their average cost increasing by 9% across all commodities, with some supply chain paths incurring an increase of up to 685%.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 31 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Mitchell Highway and the Goyder Highway intersection closures result in no LGAs impacted for essential commodities. When considering all commodities, both intersection closures result in few LGAs impacted, however the impact differs between the two intersections. For the Mitchell Highway closure, the impacted volumes are negligible compared to those consumed over the impacted LGAs importing freight traversing the intersection, representing 0.1% of the volumes. However, for the Goyder Highway intersection closure, the impact is greater, with 30% of the commodities consumed within the LGA impacted obstructed. This high percentage is explained by the fact that there is only one LGA impacted, which is the Goyder (DC) LGA for which general commodities are obstructed. While the tonnage is relatively small, it represents a moderate percentage of the total consumption of the LGA for general commodities.

The Wilkins Highway intersection closure results in one out of the 233 LGAs serviced by the intersection having obstructed supply chains, with 17.2% of the freight volumes for essential commodities obstructed. The most impacted LGA is Goyder (DC) for the processed food industry, with the most impacted essential commodity being box pig for which none usually consumed within the LGA will reach destination. When considering all commodities, the same LGA is the only one impacted.

Table 31 Community impact metrics for modelled intersections on the Barrier Highway KFR - obstructed supply chains

			WILKINS HIGHWAY	MITCHELL HIGHWAY	GOYDER HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/233	0/154	0/181
		Relative volumes impacted	17.2%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Goyder (DC)	-	-
		Highest impacted commodity sector	Processed Food	-	-
		Commodity impacted	Box Pigs	-	-
		Number of supply chains impacted	1	0	0
		Relative volumes impacted	100%	0%	0%
		Weekly tonnes BAU	0.2	0.0	0.0
		Relative number of supply chains impacted	100%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/233	2/154	1/181
		Relative volumes impacted	1.0%	0.1%	30.1%
	Most impacted LGA	Name of destination LGA	Goyder (DC)	Western Plains Regional (A)	Goyder (DC)
		Highest impacted commodity sector	Processed Food	Livestock	General
		Number of supply chains impacted	17	5	2
		Relative volumes impacted	17%	0%	30%
		Weekly tonnes BAU	68.1	7,807.5	63.7
		Relative number of supply chains impacted	35%	0%	13%

Re-routed supply chains

Table 32 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Wilkins Highway intersection closure results in 55 LGAs having re-routed supply chains for essential commodities, representing nearly 10% of the volumes that are normally received by the 233 LGAs serviced by the intersection. Broken Hill (C) is the most impacted LGA with four supply chains for the processed food industry obstructed, representing 100% of the box rice consumption of the LGA. When considering all commodities, Alice Spring (T) is the most impacted LGA for the cropping industry, however, the overall volumes impacted by re-routing overall represent only 2% of the commodities consumed within the 231 impacted LGAs.

Similar observations can be made for the Mitchell Highway and the Goyder Highway intersection closures when considering all commodities. However, the impact on essential commodities for the Mitchell Highway intersection closure is moderate as opposed to low, with 20% of the volumes of essential commodities that are normally received by the 28 LGAs serviced by the intersection expected to be re-routed.

Table 32 Community impact metrics for modelled intersections on the Barrier Highway KFR - re-routed supply chains

			WILKINS HIGHWAY	MITCHELL HIGHWAY	GOYDER HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	55/233	28/154	47/181
		Relative impact on volumes of commodities	9.9%	20.6%	4.6%
	Most impacted LGA	Name	Broken Hill (C)	Canning (C)	MacDonnell (R)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Rice	Prawn	Bread
		Number of supply chains impacted	4	2	8
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	7.3	17.2	2.2
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	231/233	152/154	179/181
		Relative impact on volumes of commodities	2.0%	1.6%	2.2%
	Most impacted LGA	Name	Alice Springs (T)	Cobar (A)	Alice Springs (T)
		Highest impacted commodity sector	Cropping	Horticulture	Cropping
		Number of supply chains impacted	7	3	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	16.6	3.3	16.6
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Barrier Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Barrier Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.6 Barton Highway

The Barton Highway KFR (Figure 24) is a freight route located in ACT. It connects Yass and Canberra. The corridor is 80 km with at least part of the route used for the transport of $205m of product on 777,597 trailers annually carrying 13.4 million tonnes across 33,209 supply chains spanning 117 commodities (34% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 32,102 trailers annually with the busiest sections carrying 49,303 trailers.

Fuel and general transport represent approximately 60% of the total freight task. This route is predominantly PBS2a B-Double access.

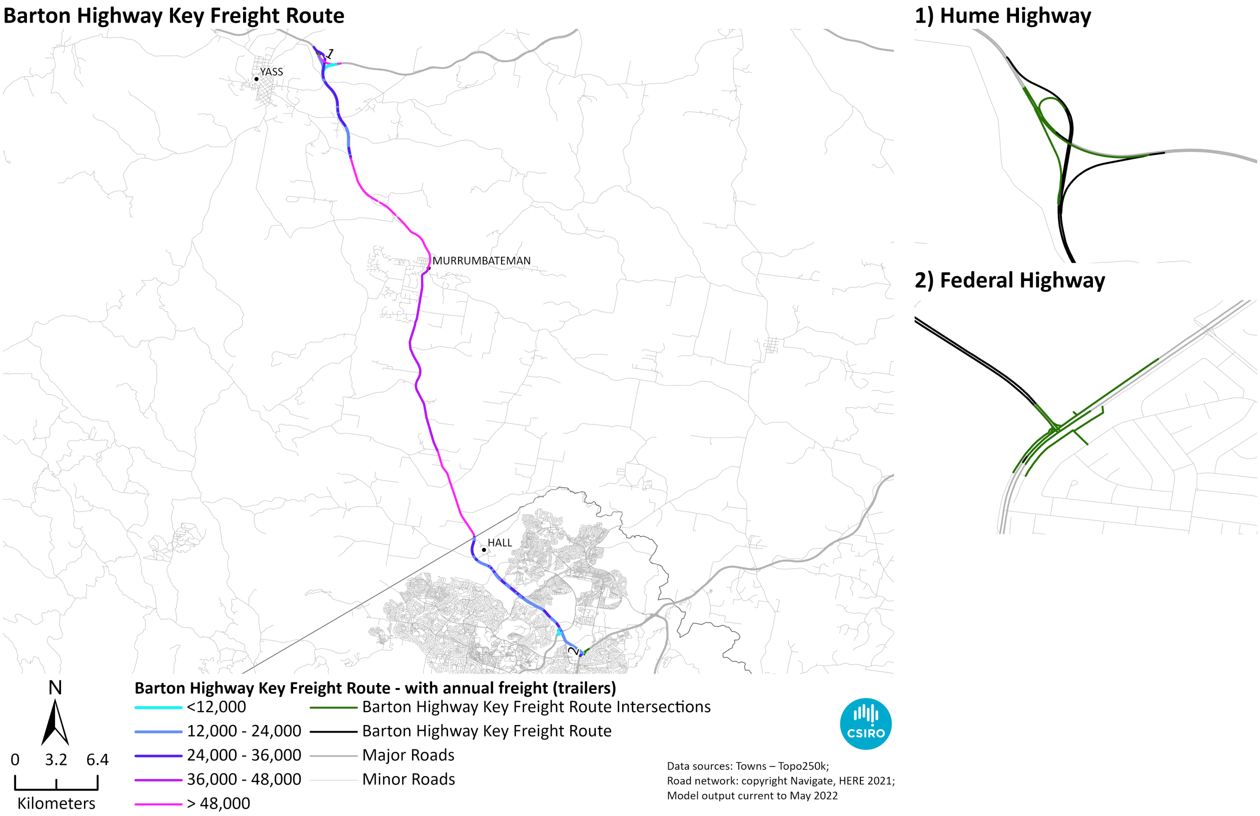

Figure 24 Barton Highway KFR

The Barton Highway KFR passes through two LGAs.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Federal Highway
- Hume Highway

The reliance described in Table 33 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Blacktown (C) LGA is moderately reliant on the Hume Highway intersection and so is the Unincorporated ACT LGA for the Federal Highway intersection. For those LGAs that are sending their commodities, the reliance on any of the two intersections is lower with a reliance less than 20%.

Table 33 Summary of community reliance metrics for each intersection on the Barton Highway key freight route - most impacted LGA

	HUME HIGHWAY	FEDERAL HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Unincorporated ACT
Relative reliance on intersection for destination LGA	0.29	0.42
Origin LGA most reliant on the intersection	Wollongong (C)	Unincorporated ACT
Relative reliance on intersection for origin LGA	0.09	0.18

5.6.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of each intersection and subsequent high-intensity alternative routes for each of the three modelled intersections along the Barton Highway. The results are based on expected freight for an average week.

- **Hume Highway intersection**: The closure of the Hume Highway intersection results in the disruption of 13,741 vehicle trips carrying 235,968 tonnes, 32% being essential commodities. Overall, 235,917 tonnes of freight are re-routed with an average detour length of eight km and with an average increase in cost of $11.83 per tonne. A total value of supplies amounting to $0.3 million, $0.3 million being essential commodities, is unable to reach its destination.
- **Federal Highway intersection**: The closure of the Federal Highway intersection results in the disruption of 1,155 vehicle trips carrying 22,294 tonnes, 59% being essential commodities. Overall, 22,282 tonnes of freight are re-routed with an average detour length of three km and with an average increase in cost of $3.59 per tonne. Little to no freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Barton Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Barton Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Barton Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector
- 'Barton Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Barton Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Barton Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Barton Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Barton Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Barton Highway.

KFR Risk profile

Table 34 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Barton Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also very low, indicating that freight is re-routed at a low cost.

Table 34 Risk metrics for modelled intersections on the Barton Highway KFR – the model

	HUME HIGHWAY	FEDERAL HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000
KFR impacts risk - detour costs for intersection	0.014	0.011
Last iteration	5	5

Freight impact

Table 35 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 35 Freight impact metrics for modelled intersections on the Barton Highway KFR

		HUME HIGHWAY [%]	FEDERAL HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0
	Relative freight volume impacted – essential commodities	0	0
	Relative value of freight – all commodities	0	0
Re-routed supply chains	Relative detour cost – average	7	12
	Relative detour cost – maximum	174	138

The metrics in Table 35 indicate the supply chains traversing any of the two modelled intersections that are likely to be re-routed will do so with their average cost increasing slightly (between 7% and 12%) over all commodities. However, some supply chain paths see their detour costs increasing up to 174%.

For both intersections, the obstructed freight is minimal[2].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

[2] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

Obstructed supply chains

Table 36 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Federal Highway intersection closure results in no LGAs serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Federal Highway intersection results in one LGA having obstructed supply chains, representing 0.2% of the volumes that are normally received by the 108 LGAs serviced by the intersection. Unincorporated ACT is the most impacted LGA with three supply chains for the waste industry obstructed.

The Hume Highway results in one LGA having obstructed supply chains for essential commodities, representing 15% of the volumes that are normally received by this impacted LGA. Yass Valley (A) is the most impacted LGA, with two supply chains for the processed food industry obstructed.

Table 36 Community impact metrics for modelled intersections on the Barton Highway KFR - obstructed supply chains

			HUME HIGHWAY	FEDERAL HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/341	0/108
		Relative volumes impacted	15.4%	0.0%
	Most impacted LGA	Name of destination LGA	Yass Valley(A)	-
		Highest impacted commodity sector	Processed Food	-
		Commodity impacted	Meat	-
		Number of supply chains impacted	2	0
		Relative volumes impacted	27%	0%
		Weekly tonnes BAU	20.9	0.0
		Relative number of supply chains impacted	22%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	3/341	1/108
		Relative volumes impacted	0.7%	0.2%
	Most impacted LGA	Name of destination LGA	Yass Valley (A)	Unincorporated ACT
		Highest impacted commodity sector	Horticulture	Waste
		Number of supply chains impacted	6	3
		Relative volumes impacted	15%	0%
		Weekly tonnes BAU	87.6	5,470.6
		Relative number of supply chains impacted	22%	0%

Re-routed supply chains

Table 37 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 32% of the supply chains are expected to be re-routed for 105 of the 341 LGAs that traverse the Hume Highway intersection. The most impacted LGA is Balranald (A), with two supply chains in the processed food sector representing 3.3 tonnes per week re-routed. For non-essential commodities, 339 out of the 341 LGAs serviced by the Hume Highway intersection are impacted by re-routed freight, representing 9% of the total volumes consumed within these LGAs.

For the Federal Highway intersection, 32 of the 108 LGAs serviced by the intersection have freight re-routed, representing 14.3% of essential commodities consumed within these LGAs. For non-essential commodities, all the LGAs serviced by the Federal Highway intersection are impacted by re-routed freight, representing 3.1% of the total volume consumed by all these LGAs.

Table 37 Community impact metrics for modelled intersections on the Barton Highway KFR - re-routed supply chains

			HUME HIGHWAY	FEDERAL HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	105/341	32/108
		Relative impact on volumes of commodities	32.9%	14.3%
	Most impacted LGA	Name	Balranald (A)	Yass Valley (A)
		Highest impacted commodity sector	Processed Food	Construction
		Commodity impacted	Box Chicken	Cement
		Number of supply chains impacted	2	2
		Relative volumes impacted	100%	100%
		Weekly tonnes BAU	3.3	153.8
		Relative number of supply chains impacted	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	339/341	108/108
		Relative impact on volumes of commodities	9.0%	3.1%
	Most impacted LGA	Name	Hilltops (A)	Queanbeyan-Palerang Regional (A)
		Highest impacted commodity sector	Horticulture	Cropping
		Number of supply chains impacted	15	18
		Relative volumes impacted	100%	81%
		Weekly tonnes BAU	35.3	61.9
		Relative number of supply chains impacted	100%	69%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Barton Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Barton Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.7 Bass Highway

The Bass Highway KFR (Figure 25) is a freight route located in northern Tasmania. It connects Launceston with LGAs in Marrawah. The corridor is 253 km with at least part of the route used for the transport of $74m of product on 358,740 trailers annually carrying seven million tonnes across 15842 supply chains spanning 106 commodities (20% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 87,982 trailers annually with the busiest sections carrying 218,453 trailers.

Wood product transport represents approximately 35% of the total freight task, with critical links from forestry to port. The corridor also supports transport movements of processed food and horticulture for a further 25% of the total freight task. The KFR provides an important role in providing access to markets for primary produce with 10% of all movements originating at a property and on to market. This route is predominantly classified as PBS2a HML access.

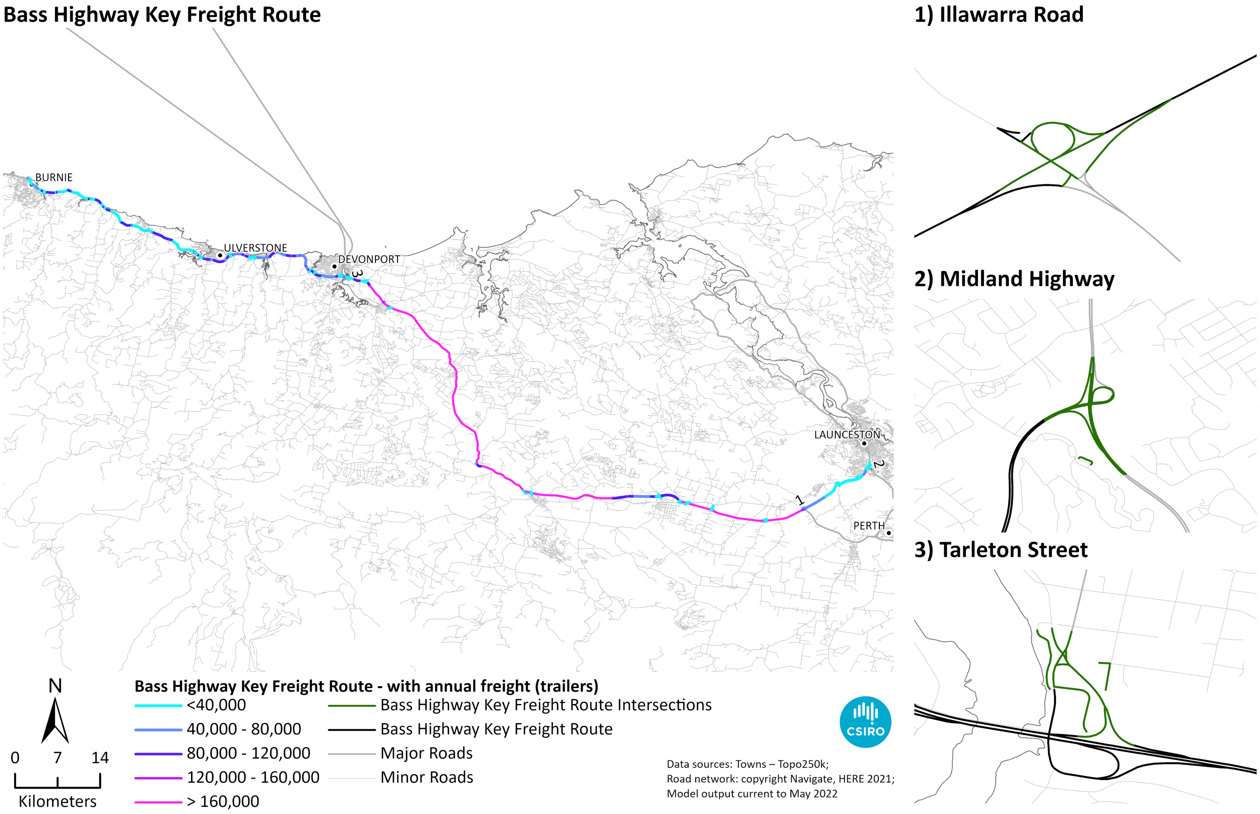

Figure 25 Bass Highway KFR

The Bass Highway KFR passes through seven LGAs but crucially it supports the supply chain paths for over 291 LGAs along its length and beyond. It provides access to essential commodities for 60 LGAs. Most LGAs across Tasmania's north are reliant on this KFR to provide access to supplies and markets for most commodities. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 70% of the supply chain trip length. Figure 25 shows that there are consistent concentrations of freight along the KFR particularly between Devonport and Illawarra Road intersection which connects to the Midland Highway further south

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Midland Highway
- Illawarra Road
- Tarleton Street

The reliance described in Table 38 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Northern Midlands (m) LGA is moderately reliant on the Illawarra Road and Midland Highway intersections, while Devonport (C) LGA has a low reliance on the Tarleton Street intersection. For the LGAs relying on the three studied intersections, their reliance in terms of origin LGA is low as over 80% of their commodities produced do not rely on these intersections to move. Tarleton Street is a key route to the Port of Devonport and East Devonport, with limited alternative routes.

Table 38 Summary of community reliance metrics for each intersection on the Bass Highway key freight route - most impacted LGA

	ILLAWARRA ROAD	MIDLAND HIGHWAY	TARLETON STREET
Destination LGA most reliant on the intersection	Northern Midlands (M)	Northern Midlands (M)	Devonport (C)
Relative reliance on intersection for destination LGA	0.29	0.30	0.14
Origin LGA most reliant on the intersection	Devonport (C)	Dorset (M)	Brimbank (C)
Relative reliance on intersection for origin LGA	0.14	0.22	0.11

5.7.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Bass Highway. The results are based on expected freight for an average week.

- **Illawarra Road intersection**: The closure of the Illawarra Road intersection results in the disruption of 2,514 vehicle trips across 103 supply chain paths carrying 48,529 tonnes, 34% being essential commodities. Overall, 94 supply chains carrying 46,016 tonnes have their freight re-routed with an average detour length of four km and an average increase in cost of $2.78 per tonne. Eight supply chains are unable to reach their destination with a total value of supplies amounting to $10.2 million, $0.3 million being essential commodities.
- **Midland Highway intersection**: The closure of the Midland Highway intersection results in the disruption of 1,494 vehicle trips carrying 29,928 tonnes, 40% being essential commodities. Overall, 29,276 tonnes of freight are re-routed with an average detour length of <1 km and with an average increase in cost of $3.32 per tonne. A total value of supplies amounting to $0.3 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Tarleton Street intersection**: The closure of the Tarleton Street intersection results in the disruption of 2,506 vehicle trips carrying 45,408 tonnes, 17% being essential commodities. Overall, no supply chains are detoured, with all supply chains unable to reach their destination with a total value of supplies amounting to $242.3 million, $51.9 million being essential commodities.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Bass Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Bass Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Bass Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Bass Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Bass Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Bass Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Bass Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Bass Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Bass Highway.

KFR risk profile

Table 39 provides the results of the simulation from closing intersections sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Bass -*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics are low for the Illawarra Road and Midland Highway intersections, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. The risk metric is however large for the Tarleton Street intersection. All freight is able to re-route until it reaches the third successive closure, with a slight increase in cost. On the fourth successive closure however, all detour options are exhausted and all freight is no longer able to reach its destination. This restricts freight to east Devonport and Port of Devonport.

Table 39 Risk metrics for modelled intersections on the Bass Highway KFR – the model

	ILLAWARRA ROAD	MIDLAND HIGHWAY	TARLETON STREET
KFR impacts risk - obstructed volumes for intersection	0.017	0.004	0.251
KFR impacts risk - detour costs for intersection	0.004	0.006	0.000
Last iteration	5	5	5

Freight impact

Table 40 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 40 Freight impact metrics for modelled intersections on the Bass Highway KFR

		ILLAWARRA ROAD [%]	MIDLAND HIGHWAY [%]	TARLETON STREET [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	5	2	100
	Relative freight volume impacted – essential commodities	1	1	100
	Relative value of freight – all commodities	6	0	100
Re-routed supply chains	Relative detour cost – average	7	8	-
	Relative detour cost – maximum	154	114	-

The metrics in Table 40 indicate the supply chains traversing the Illawarra Road and Midland Highway intersections that are likely to be re-routed will do so with their average cost increasing by nearly 7% and 8% respectively across all commodities, with some supply chain paths incurring an increase of up to 150%. Very little freight that usually traverses the Illawarra Road and Midland Highway intersections is expected to be obstructed by the last successive closure.

The results from closing the Tarleton Street intersection show very different output, where all freight may be obstructed.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 41 provides a summary of the obstructed supply chains including the number of impacted LGAs and which commodity and LGA may be most impacted for each intersection modelled on the KFR.

The closure of the Illawarra Road intersection results in over 60% of the LGAs it normally services impacted by obstructed freight, however the impact at the community level is low as these obstructions represent only 0.3% of these LGAs' consumption.

Similarly, the closure of the Midland Highway intersection is of little impact in terms of obstructed freight for non-essential commodities. For essential commodities however, only one out of 93 LGAs is impacted by obstructed freight, but it represents a moderate percentage of essential commodities usually consumed (22%).

The Tarleton Street intersection closure results in nearly all LGAs impacted having non-essential freight obstructed; however these represent a small percentage of their consumed commodities overall (4%). Similar results hold for essential commodities; however, for the most impacted LGA, 100% of its bread supply chains may not be able to reach market.

Table 41 Community impact metrics for modelled intersections on the Bass Highway KFR - obstructed supply chains

			ILLAWARRA ROAD	MIDLAND HIGHWAY	TARLETON STREET
Essential commodities	All impacted LGAs	Number of LGAs impacted	5/104	1/93	56/159
		Relative volumes impacted	0.4%	22.2%	7.1%
	Most impacted LGA	Name of destination LGA	Wyndham(C)	Meander Valley(M)	Clarence(C)
		Highest impacted commodity sector	Processed Food	Fuel	Processed Food
		Commodity impacted	Fish	Diesel fuel	Bread
		Number of supply chains impacted	1	2	9
		Relative volumes impacted	3%	28%	100%
		Weekly tonnes BAU	438.7	130.9	25.9
		Relative number of supply chains impacted	11%	22%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	75/104	5/93	156/159
		Relative volumes impacted	0.3%	0.9%	4.0%
	Most impacted LGA	Name of destination LGA	Ballarat(C)	Meander Valley(M)	Glenorchy(C)
		Highest impacted commodity sector	Horticulture	Fuel	Wood Product
		Number of supply chains impacted	1	6	2
		Relative volumes impacted	13%	22%	100%
		Weekly tonnes BAU	3,757.2	567.8	139.9
		Relative number of supply chains impacted	0%	22%	100%

Re-routed supply chains

Table 42 provides a summary of the re-routed supply chains including the number of impacted LGAs and which commodity and LGA are most impacted for each intersection modelled on the KFR.

For essential commodities, 27% of the supply chains are expected to be re-routed for 23 of the 104 LGAs that traverse the Illawarra Road intersection. The most impacted LGA is Clarence (C), with nine bread supply chains representing 25.9 tonnes per week expected to be re-routed. For non-essential commodities, few LGAs serviced by the Illawarra Road intersection are impacted by re-routed freight, however this freight represents 20.8% of the total volumes consumed within these LGAs overall.

Similar observations can be made for the Midland Highway closure that leads to 18.8% of volumes consumed within 18 of the 93 LGAs impacted having their essential commodities re-routed.

The is no freight re-routed for the Tarleton Street intersection closure, as all freight is obstructed.

Table 42 Community impact metrics for modelled intersections on the Bass Highway KFR - re-routed supply chains

			ILLAWARRA ROAD	MIDLAND HIGHWAY	TARLETON STREET
Essential commodities	All impacted LGAs	Number of LGAs impacted	23/104	18/93	0/159
		Relative impact on volumes of commodities	27.8%	18.8%	
	Most impacted LGA	Name	Clarence(C)	Dorset(M)	
		Highest impacted commodity sector	Processed Food	Construction	
		Commodity impacted	Bread	Cement	
		Number of supply chains impacted	9	1	0%
		Relative volumes impacted	100%	100%	0.0
		Weekly tonnes BAU	25.9	88.5	0%
		Relative number of supply chains impacted	100%	100%	0
All commodities	All impacted LGAs	Number of LGAs impacted	26/104	91/93	0/159
		Relative impact on volumes of commodities	20.8%	2.5%	0%
	Most impacted LGA	Name	Glenorchy(C)	Launceston(C)	
		Highest impacted commodity sector	Wood Product	Vehicles	
		Number of supply chains impacted	2	60	0.0
		Relative volumes impacted	100%	100%	0%
		Weekly tonnes BAU	139.9	213.8	0
		Relative number of supply chains impacted	100%	100%	0.0%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Bass Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Bass Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.8 Brand Highway

The Brand Highway KFR (Figure 26) is a freight route located in western WA (Figure 26). It connects LGAs between Geraldton and Perth. The corridor is 378 km with at least part of the route used for the transport of $32m of product on 105,633 trailers annually carrying 2.3 million tonnes across 9,779 supply chains spanning 76 commodities (20% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 51,706 trailers annually with the busiest sections carrying 76,471 trailers.

Mining transport represents approximately 30% of the total freight task, with critical links from mines to ports. Cropping contributes a further 30% of the total freight task, with movements from silos to ports comprising a high proportion of these movements. Fuel transport movements constitute a further 20% of the total freight task. This route is predominantly classified as PBS2a access.

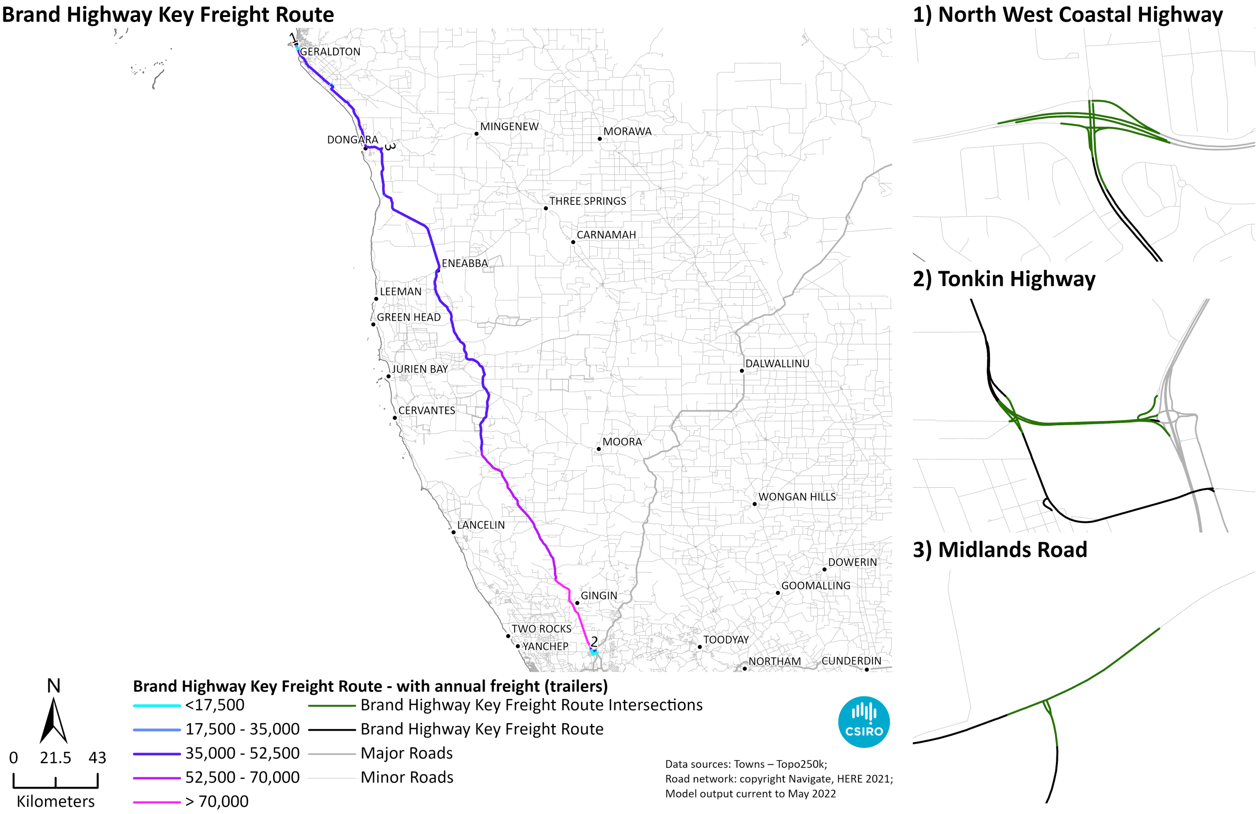

Figure 26 Brand Highway KFR

The Brand Highway KFR passes through eight LGAs but crucially it supports the supply chain paths for over 151 LGAs along its length and beyond. It provides access to essential commodities for 29 LGAs. Many LGAs including Greater Geraldton (C), Dandaragan (S) and Mingenew (S) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for more than 90% of the supply chain trip length. Figure 26 shows that freight volumes increase to the southern end of the KFR.

The intersections identified as of strategic importance and used in the modelling and analysis include:

- Midlands Road
- Tonkin Highway
- North West Coastal Highway

The reliance described in Table 43 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the North West Coastal Highway and the Midlands Road intersections to moderate to low degrees, with 13% and 15% respectively of all the supply chain paths traversing the intersections destined for Greater Geraldton (C) LGA. The Tonkin Highway intersection is also of moderate importance, with 27% of the freight traversing the intersection going to one LGA - Dardanup (S).

Table 43 Summary of community reliance metrics for each intersection on the Brand Highway key freight route - most impacted LGA

	NORTH WEST COASTAL HIGHWAY	TONKIN HIGHWAY	MIDLANDS ROAD
Destination LGA most reliant on the intersection	Greater Geraldton (C)	Dardanup (S)	Greater Geraldton (C)
Relative reliance on intersection for destination LGA	0.13	0.27	0.15
Origin LGA most reliant on the intersection	Carnarvon (S)	Dandaragan (S)	Greater Geraldton (C)
Relative reliance on intersection for origin LGA	0.23	0.35	0.28

5.8.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Brand Highway. The results are based on expected freight for an average week.

- **North West Coastal Highway intersection**: The closure of the North West Coastal Highway intersection results in the disruption of 714 vehicle trips carrying 15,107 tonnes, 51% being essential commodities. Overall 15,015 tonnes of freight are re-routed with an average detour length of nine km and with an average increase in cost of $6.60 per tonne. A total value of supplies amounting to $0.5 million, none being essential commodities, is unable to reach its destination.
- **Tonkin Highway intersection**: The closure of the Tonkin Highway intersection results in the disruption of 1,474 vehicle trips carrying 31,609 tonnes, 28% being essential commodities. Overall, 31,527 tonnes of freight are re-routed with an average detour length of 15 km and an average increase in cost of $9.22 per tonne. A small volume and value of freight is unable to reach its destination.
- **Midlands Road intersection**: The closure of the Midlands Road intersection results in the disruption of 950 vehicle trips across 56 supply chain paths carrying 21,076 tonnes, 41% being essential commodities. Overall, 55 supply chains carrying 20,980 tonnes of freight are re-routed with an average detour length of 31 km and an average increase in cost of $9.39 per tonne. A total value of supplies amounting to $0.9 million, $0.1 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Brand Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Brand Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Brand Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Brand Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Brand Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Brand Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Brand Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Brand Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Brand Highway.

KFR risk profile

Table 44 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with very low impact risk in terms of obstructed volumes, as well as re-routed costs.

Table 44 Risk metrics for modelled intersections on the Brand Highway KFR

	NORTH WEST COASTAL HIGHWAY	TONKIN HIGHWAY	MIDLANDS ROAD
KFR impacts risk - obstructed volumes for intersection	0.002	0.001	0.002
KFR impacts risk - detour costs for intersection	0.017	0.037	0.028
Last iteration	5	5	5

Freight impact

Table 45 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 45 Freight impact metrics for modelled intersections on the Brand Highway KFR by last successive closure

		NORTH WEST COASTAL HIGHWAY [%]	TONKIN HIGHWAY [%]	MIDLANDS ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	1	0	2
Re-routed supply chains	Relative detour cost – average	7	25	14
	Relative detour cost – maximum	145	219	63

The metrics in Table 45 indicate the supply chains traversing the Tonkin Highway intersection that are likely to be re-routed would do so with their average cost increasing by 25% across all commodities, with some supply chain paths incurring an increase of up to 219%. Those traversing the Midlands Road intersection may be re-routed at an average cost increase of 14% across all commodities, while those traversing the North West Coastal Highway intersection may do so at an average cost increase of 7%.

Very little freight is obstructed - 1% of freight volume for all commodities for the North West Coastal Highway intersection.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 46 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The North West Coastal Highway and the Tonkin Highway intersection closures result in no LGAs impacted by obstructed essential commodities. When considering all commodities, seven LGAs may have some commodities not reaching market, representing 5.6% and 0.2% of the LGAs' consumption.

The Midlands Road intersection results in one LGA not receiving essential commodities, where the most impacted LGA is Irwin (S) for box chicken.

When considering all commodities, the number of LGAs having freight obstructed is greater than those for essential commodities. The North West Coastal Highway and Midlands Road intersection closures lead to their most impacted LGA not receiving any livestock or general commodities. While the volumes are low, these still represent a large proportion of their consumed commodities.

Table 46 Community impact metrics for modelled intersections on the Brand Highway KFR - obstructed supply chains

			NORTH WEST COASTAL HIGHWAY	TONKIN HIGHWAY	MIDLANDS ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/79	0/98	1/99
		Relative volumes impacted	0.0%	0.0%	100.0%
	Most impacted LGA	Name of destination LGA			Irwin(S)
		Highest impacted commodity sector			Processed Food
		Commodity impacted			Box Chicken
		Number of supply chains impacted			1
		Relative volumes impacted	0%	0%	100%
		Weekly tonnes BAU	0.0	0.0	0.8
		Relative number of supply chains impacted	0%	0%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	7/79	7/98	12/99
		Relative volumes impacted	5.6%	0.2%	0.3%
	Most impacted LGA	Name of destination LGA	Shark Bay(S)	Chittering(S)	Irwin(S)
		Highest impacted commodity sector	Livestock	Construction	General
		Number of supply chains impacted	1	1	3
		Relative volumes impacted	100%	1%	100%
		Weekly tonnes BAU	1.7	4,099.7	40.0
		Relative number of supply chains impacted	100%	1%	100%

Re-routed supply chains

Table 47 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

With nearly all freight re-routed from the closure of the three intersections, all the LGAs that receive commodities traversing the intersections are impacted for all commodities, and a moderate number are essential commodities. The percentage of goods re-routed compared to the overall consumption is low when considering all commodities, however for essential commodities, these percentages are high. While this could lead to increased prices for a large proportion of essential commodities, if freight costs are passed on to the price of the goods and if the detour costs are low, the impact would be low.

Table 47 Community impact metrics for modelled intersections on the Brand Highway KFR - re-routed supply chains

			NORTH WEST COASTAL HIGHWAY	TONKIN HIGHWAY	MIDLANDS ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	13/79	28/98	17/99
		Relative impact on volumes of commodities	69.2%	57.1%	71.5%
	Most impacted LGA	Name	Carnarvon (S)	Greater Geraldton (C)	Greater Geraldton (C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Dairy Product	Dairy Product	Dairy Product
		Number of supply chains impacted	4	14	14
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	18.8	97.9	97.9
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	79/79	97/98	99/99
		Relative impact on volumes of commodities	3.7%	4.8%	4.4%
	Most impacted LGA	Name	Carnarvon(S)	Carnarvon(S)	Carnarvon(S)
		Highest impacted commodity sector	Horticulture	Horticulture	Horticulture
		Number of supply chains impacted	12	12	12
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	27.7	27.7	27.7
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Brand Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Brand Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.9 Brisbane Valley Highway

The Brisbane Valley Highway KFR (**Error! Reference source not found.**) is a freight route located in Q ueensland. It connects LGAs from Ipswich to the D'Aguilar Highway in the south-east. The corridor is 91 km with at least part of the route used for the transport of $22m of product on 44,372 trailers annually carrying 885 thousand tonnes across 4,524 supply chains spanning 73 commodities (45% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 22,444 trailers annually with the busiest sections carrying 28,765 trailers.

Livestock transport represents approximately 25% of the total freight task, with movements from property to abattoir being a large proportion. Processed food adds 20% to the freight task including product leaving abattoirs and raw milk collection for dairy processing. Construction contributes 15% with fuel and wood products adding a further 10% each. This route is predominantly classified as PBS2a access.

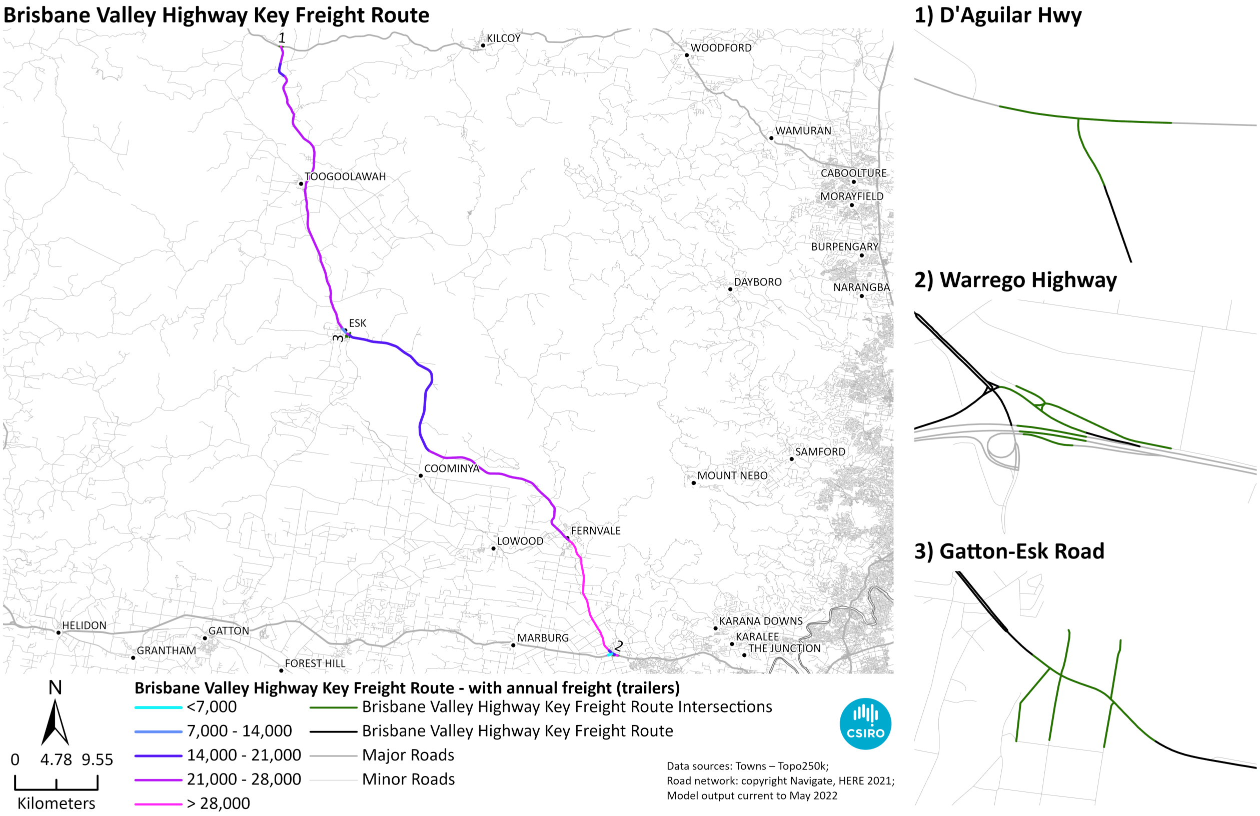

Figure 27 Brisbane Valley Highway KFR

The Brisbane Valley Highway KFR passes through two LGAs but crucially it supports the supply chain paths for over 136 LGAs along its length and beyond. It provides access to essential commodities for 42 LGAs. Somerset (R) and South Burnett (R) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Warrego Highway
- D’Aguilar Highway
- Gatton — Esk Road

The reliance described in **Error! Reference source not found.** equates to risk factor and highlights t he importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections with low to moderate degrees, with 25% (D’Aguilar Hwy), 35% (Warrego Highway) and 29% (Gatton — Esk Road) of all the supply chain paths traversing the intersections destined for the Somerset (R), Brisbane (C) and Somerset (R) LGAs, respectively.

Table 48 Summary of community reliance metrics for each intersection on the Brisbane Valley Highway key freight route - most impacted LGA

	D’AGUILAR HWY	WARREGO HIGHWAY	GATTON — ESK ROAD
Destination LGA most reliant on the intersection	Somerset (R)	Brisbane (C)	Somerset (R)
Relative reliance on intersection for destination LGA	0.25	0.35	0.29
Origin LGA most reliant on the intersection	South Burnett (R)	Somerset (R)	South Burnett (R)
Relative reliance on intersection for origin LGA	0.22	0.46	0.18

5.9.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Brisbane Valley Highway. The results are based on expected freight for an average week.

- **D'Aguilar Hwy intersection**: The closure of the D'Aguilar Hwy intersection results in the disruption of 405 vehicle trips carrying 8,352 tonnes, 46% being essential commodities. Overall, 8,348 tonnes of freight are re-routed with an average detour length of 15 km and with an average increase in cost of $6.04 per tonne. A total value of supplies amounting to $0.0 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Warrego Highway intersection**: The closure of the Warrego Highway intersection results in the disruption of 513 vehicle trips carrying 10,473 tonnes, 63% being essential commodities. Overall, 10,343 tonnes of freight are re-routed with an average detour length of three km and with an average increase in cost of $3.55 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Gatton — Esk Road intersection**: The closure of the Gatton — Esk Road intersection results in the disruption of 476 vehicle trips carrying 9,655 tonnes, 46% being essential commodities. Overall, 9,445 tonnes of freight are re-routed with an average detour length of 22 km and with an average increase in cost of $7.40 per tonne. A total value of supplies amounting to $0.8 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Brisbane Valley Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Brisbane Valley Highway-*intersection*-monthly bau volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Brisbane Valley Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Brisbane Valley Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Brisbane Valley Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Brisbane Valley Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Brisbane Valley Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Brisbane Valley Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Brisbane Valley Highway.

KFR risk profile

Error! Reference source not found. provides the results of the simulation from closing intersections a nd subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Brisbane Valley Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 49 Risk metrics for modelled intersections on the Brisbane Valley Highway KFR – the model

	D'AGUILAR HWY	WARREGO HIGHWAY	GATTON — ESK ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.012	0.007
KFR impacts risk - detour costs for intersection	0.026	0.022	0.041
Last iteration	5	5	5

Freight impact

Error! Reference source not found. provides a summary of the metrics for obstructed and re-routed s upply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 50 Freight impact metrics for modelled intersections on the Brisbane Valley Highway KFR

		D'AGUILAR HWY [%]	WARREGO HIGHWAY [%]	GATTON — ESK ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	1	2
	Relative freight volume impacted – essential commodities	0	2	0
	Relative value of freight – all commodities	0	0	2
Re-routed supply chains	Relative detour cost – average	16	16	17
	Relative detour cost – maximum	376	107	166

The metrics in Table 195 indicate the supply chains traversing the D'Aguilar Hwy intersection that are likely to be re-routed will do so with their average cost increasing slightly (16%), similar to those traversing the Warrego Highway (16%) and the Gatton — Esk Road (17%) over all commodities. The routes most impacted by detours reach a maximum increase cost of 376% (D'Aguilar Hwy intersection).

For all three intersections, the obstructed freight is minimal[3].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Error! Reference source not found. provides a summary of the obstructed supply chains including t he number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The D'Aguilar Hwy closure results in no LGAs having obstructed supply chains, for essential commodities. When considering all commodities, the closure of the D'Aguilar Hwy intersection results in three LGAs having obstructed supply chains, representing 0.1% of the volumes that are normally received by this LGA. Somerset (R) is the most impacted LGA with three supply chains for the cropping industry obstructed.

The Warrego Highway intersection closure results in one LGA serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the closure of the intersection results in the same LGA having obstructed supply chains, representing 2.4% of the volumes that are normally received by this LGA. Ipswich (C) is the most impacted LGA with three supply chains for the fuel industry obstructed.

The Gatton — Esk Road intersection closure results in no LGAs having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Gatton — Esk Road

[3] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

intersection results in three LGAs having obstructed supply chains, representing 2.6% of the volumes that are normally received by this LGA serviced by the intersection.

Table 51 Community impact metrics for modelled intersections on the Brisbane Valley Highway KFR - obstructed supply chains

			D'AGUILAR HWY	WARREGO HIGHWAY	GATTON — ESK ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/55	1/37	0/67
		Relative volumes impacted	0.0%	2.4%	0.0%
	Most impacted LGA	Name of destination LGA	-	Ipswich(C)	-
		Highest impacted commodity sector	-	Fuel	-
		Commodity impacted	-	Unleaded fuel	-
		Number of supply chains impacted	0	1	0
		Relative volumes impacted	0%	4%	0%
		Weekly tonnes BAU	0.0	3,301.3	0.0
		Relative number of supply chains impacted	0%	2%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	3/55	1/37	3/67
		Relative volumes impacted	0.1%	2.4%	2.6%
	Most impacted LGA	Name of destination LGA	Somerset(R)	Ipswich(C)	Toowoomba(R)
		Highest impacted commodity sector	Cropping	Fuel	Wood Product
		Number of supply chains impacted	3	3	1
		Relative volumes impacted	0%	2%	9%
		Weekly tonnes BAU	1,397.9	5,359.5	1,236.8
		Relative number of supply chains impacted	2%	2%	0%

Re-routed supply chains

Error! Reference source not found. provides a summary of the re-routed supply chains including t he number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 3.7% of the supply chains are expected to be re-routed for 27 of the 55 LGAs that traverse the D'Aguilar Hwy intersection. The most impacted LGA is Logan (C), with one supply chain in the processed food sector representing 87 tonnes of box pig per week re-routed. For non-essential commodities, 54 of the 55 LGAs serviced by the D'Aguilar Hwy intersection are impacted by re-routed freight, representing 1.5% of the total volumes consumed within these LGAs.

For the Warrego Highway intersection, 25 of the 37 LGAs serviced are expected to have freight re-routed, with this representing 3.3% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all 37 LGAs serviced by the Warrego Highway intersection are impacted by re-routed freight, representing 1.4% of the total volume consumed within these LGAs.

For the Gatton — Esk Road intersection, 27 of the 67 LGAs serviced are expected to have freight re-routed, representing 2.4% of essential commodities consumed within the LGAs. For non-essential commodities, all 67 LGAs serviced by the Gatton — Esk Road intersection are impacted by re-routed freight, representing 1.1% of the total volume consumed within these LGAs.

Table 52 Community impact metrics for modelled intersections on the Brisbane Valley Highway KFR - re-routed supply chains

			D'AGUILAR HWY	WARREGO HIGHWAY	GATTON — ESK ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	27/55	25/37	27/67
		Relative impact on volumes of commodities	3.7%	3.3%	2.4%
	Most impacted LGA	Name	Logan(C)	Somerset(R)	Logan(C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Pigs	Meat	Box Pigs
		Number of supply chains impacted	1	9	1
		Relative volumes impacted	97%	99%	97%
		Weekly tonnes BAU	87.0	56.8	87.0
		Relative number of supply chains impacted	33%	90%	33%
All commodities	All impacted LGAs	Number of LGAs impacted	54/55	37/37	67/67
		Relative impact on volumes of commodities	1.5%	1.4%	1.1%
	Most impacted LGA	Name	Byron(A)	Byron(A)	Byron(A)
		Highest impacted commodity sector	Wood Product	Wood Product	Wood Product
		Number of supply chains impacted	2	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	51.3	51.3	51.3
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Brisbane Valley Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Brisbane Valley Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.10 Bruce Highway

The Bruce Highway KFR (Figure 28) has two sections: the M1 which is a 223 km corridor north of Brisbane connecting the northern end of the Gateway Motorway to Cooroy, and the A1 which is an 1800 km highway continuing from the M1 to Cairns. The M1 route is a major north – south freight and commuter corridor with connections to the Sunshine Coast and to western freight networks via the D'Aguilar Highway (State Route 85). The A1 has connections to farming and mining regions and regional ports, and major connections to the west via the Capricorn Highway (A4) and Flinders Highway (A6). At least part of the KFR is used to transport $261m worth of product on 1,219,732 trailers annually, carrying 25 million tonnes from 56,739 supply chains spanning 124 commodities. 42% of the total volume of commodities carried on the KFR are classified as essential commodities. The average freight volume across the road segments is 99,566 trailers annually, with the busiest sections carrying 265,325 trailers.

Fuel transport represents approximately 25% of the total freight task on the Bruce Highway, with fuel predominantly transported from ports to depots, fuel stations or mines. Sugarcane and wood products comprise a total of 30% of the freight task. This KFR supports transport movements to/from farms and from ports, with 50% of all freight originating from farms and ports. Ports are also a major destination for movements along this KFR, with 20% of all freight destined for a port. This route is predominantly classified as PBS2a with higher mass limit (HML).

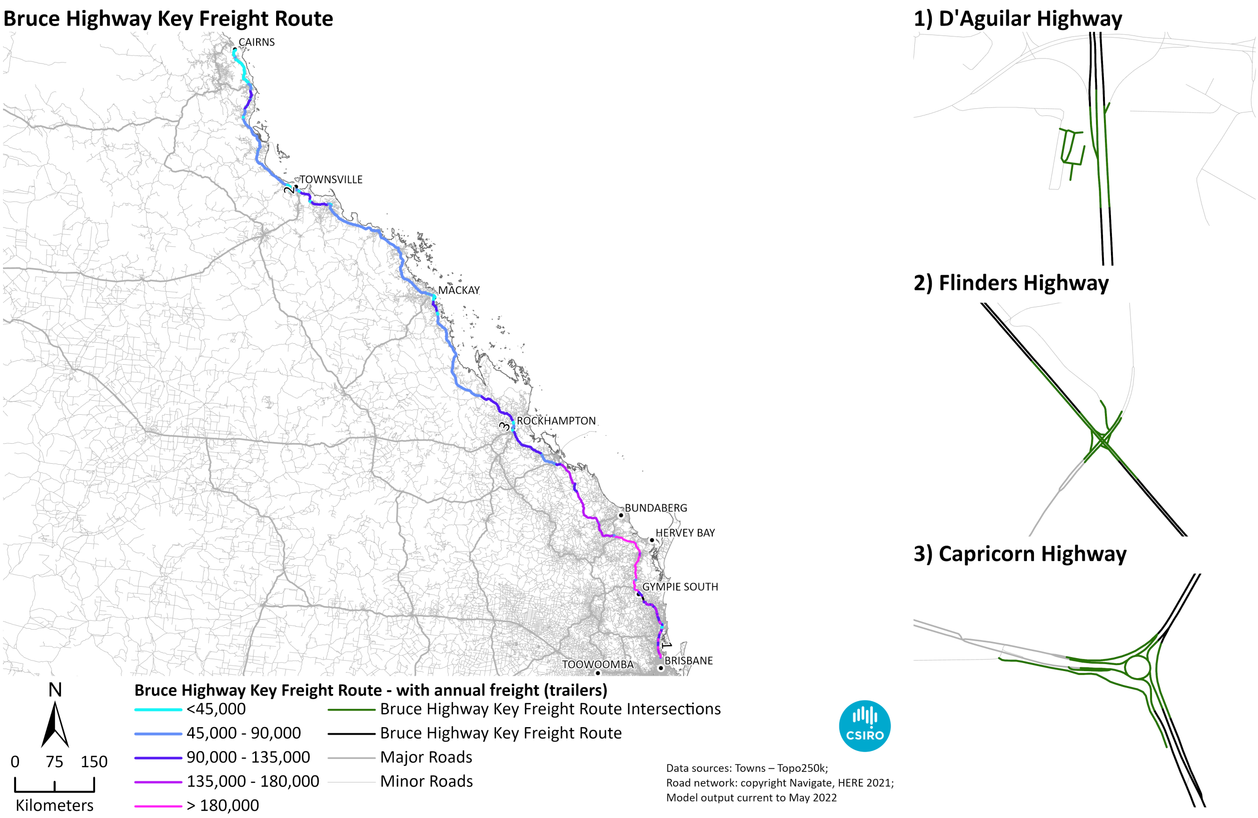

Figure 28 Bruce Highway KFR

The Bruce Highway KFR passes through 18 LGAs but crucially, supply chain paths for over 355 LGAs along its length and beyond are transported along the KFR. It provides access to essential commodities for 108 LGAs. Many LGAs including Fraser Coast, Gladstone, Rockhampton and Mackay rely on this KFR to provide access to supplies and markets for most commodities. Figure 28 shows that the highest concentrations of freight are between Rockhampton and Brisbane with short sections of high freight flows around major centres.

Modelling indicates that the Bruce Highway KFR is used heavily by supply chains with trips using the route for up to 90% of the supply chain trip length. Horticulture and wood products in particular utilise large sections of the KFR. Movements to the Fraser Coast (R) and Mackay (R) LGAs use large proportions of the KFR for their freight.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- D’Aguilar Highway (State Route 85)
- Flinders Highway (A6)
- Capricorn Highway (A4)

The reliance described in Table 53 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Brisbane (C) LGA is moderately reliant on the D’Aguilar Highway intersections and so is Townsville (C) for the Flinders Highway intersection.

Table 53 Summary of community reliance metrics for each intersection on the Bruce Highway key freight route - most impacted LGA

	D'AGUILAR HIGHWAY	CAPRICORN HIGHWAY	FLINDERS HIGHWAY
Destination LGA most reliant on the intersection	Brisbane (C)	Rockhampton (R)	Townsville (C)
Relative reliance on intersection for destination LGA	0.29	0.16	0.39
Origin LGA most reliant on the intersection	Brisbane (C)		Townsville (C)
Relative reliance on intersection for origin LGA	0.24	0.14	0.27

5.10.1 Modelling and analysis outcomes

As discussed in Section 2, the effects from a widespread weather event can result in multiple intersections and bypass routes being closed. These can also be coupled with rail closures which in combination can result in a catastrophic impact on supply chains. Such events occurred January-February 2022.

The following summarises the impacts from closure of the three modelled intersections along the Bruce Highway. The results below are based on an average week.

- **D'Aguilar Highway intersection**: The closure of the D'Aguilar Highway intersection results in the disruption of 7,263 vehicle trips carrying 144,007 tonnes, 48% being essential commodities. Overall, 143,879 tonnes of freight are re-routed with an average detour length of 69 km and an average increase in cost of $18.23 per tonne. A total value of supplies amounting to $0.7 million, $0.6 million being essential commodities, is unable to reach its destination.
- **Capricorn Highway intersection**: The closure of the Capricorn Highway intersection results in the disruption of 3,511 vehicle trips carrying 67,945 tonnes, 46% being essential commodities. Overall, 67,939 tonnes of freight are re-routed with an average detour length

of 11 km and an average increase in cost of $6.59 per tonne. A total value of supplies amounting to $0.0 million, $0.0 million being essential commodities, is unable to reach its destination.

- **Flinders Highway intersection**: The closure of the Flinders Highway intersection results in the disruption of 3,682 vehicle trips carrying 70,049 tonnes, 49% being essential commodities. Overall, 69,789 tonnes of freight are re-routed with an average detour length of 175 km and an average increase in cost of $38.08 per tonne. A total value of supplies amounting to $0.3 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Bruce Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Bruce Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Bruce Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Bruce Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Bruce Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Bruce Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Bruce Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Bruce Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Bruce Highway.

KFR Risk profile

Table 54 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Bruce Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections is extremely low indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections.

Table 54 Risk metrics for modelled intersections on the Bruce Highway KFR – the model

	D'AGUILAR HIGHWAY	CAPRICORN HIGHWAY	FLINDERS HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000[4]	0.000	0.002
KFR impacts risk - detour costs for intersection	0.058	0.017	0.042
Last iteration	5	5	5

Freight impact

Table 55 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 55 Freight impact metrics for modelled intersections on the Bruce Highway KFR

		D'AGUILAR HIGHWAY [%]	CAPRICORN HIGHWAY [%]	FLINDERS HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	39	6	65
	Relative detour cost – maximum	1,060	103	2,710

The metrics in Table 55 indicate the supply chains traversing the D'Aguilar Highway intersection that are likely to be re-routed will do so with their average cost increasing by nearly 39% across all commodities, with modelling indicating some supply chain paths incurring an increase of up to 1000%. Low volumes of freight that usually traverse the D'Aguilar Highway intersection are expected to be obstructed by the last successive closure. The value of these obstructed commodities represents less than 1% of the total value usually traversing the intersection. While some supply chains are obstructed by ongoing impacts throughout the year, others such as cropping or livestock are only expected to be impacted for a few months of the year, as shown in 'Bruce Highway-D'Aguilar Highway -monthly *movement_type* volumes.png'.

The Capricorn Highway intersection closure results in a very small number of supply chains obstructed. For those that are re-routed, their average cost increases by about 6% across all commodities. Only a few supply chains in the livestock sector are obstructed for a few months of the year.

The Flinders Highway intersection closure results in the obstruction of less than 1% of its supply chains traversing it, and a re-routing of the rest of the commodities with average cost increasing by 65% across all commodities. The obstructed supply chains are for the construction, livestock and

[4] This metric is unitless and has been rounded to the nearest third decimal place. It is a measure of relative risk in terms of volumes of obstructed freight, calculated as the sum of the incremental percentage of volumes obstructed multiplied by the inverse of each increment number. A value of 0.000 indicates that the risk is negligible; meaning little to no volumes are impacted. Some freight may still be obstructed but does not show due to the rounding of the metric.

waste sectors. Construction is the most impacted sector with 9% of its volumes expected to be obstructed.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 56 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The D'Aguilar Highway intersection closures result in one of the 91 LGAs serviced by the intersection having obstructed supply chains, with 2.3% of the freight volumes for essential commodities obstructed. The most impacted LGA is Moreton Bay (C). Bread within the processed food commodity sector is the highest impacted, with 184.7 weekly tonnes not reaching market. However, overall, only 0.5% (tonnes) of all commodities traversing the intersection may not reach their destinations for two of the 91 LGAs serviced.

Similar results are observed for the Flinders Highway intersection where the closures result in one of the 188 LGAs serviced by the intersection having obstructed supply chains, with 17% of the freight volumes for essential commodities obstructed. The percentage of tonnes impacted is greater with the construction sector being impacted: two of its supply chains for concrete may not be able to reach market.

No LGAs are impacted for essential commodities by the Capricorn Highway intersection closure, and only two of the 186 LGAs it services across all commodities are obstructed.

Table 56 Community impact metrics for modelled intersections on the Bruce Highway KFR - obstructed supply chains

			D'AGUILAR HIGHWAY	CAPRICORN HIGHWAY	FLINDERS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/91	0/186	1/188
		Relative volumes impacted	2.3%	0.0%	8.1%
	Most impacted LGA	Name of destination LGA	Moreton Bay (R)		Townsville (C)
		Highest impacted commodity sector	Processed Food		Construction
		Commodity impacted	Bread		Concrete
		Number of supply chains impacted[5]	1		2
		Relative volumes impacted	3%	0%	17%
		Weekly tonnes BAU	184.7	0.0	863.3
		Relative number of supply chains impacted	1%	0%	9%

[5] These are annual number of supply chains

			D'AGUILAR HIGHWAY	CAPRICORN HIGHWAY	FLINDERS HIGHWAY
All commodities	All impacted LGAs	Number of LGAs impacted	2/91	2/186	13/188
		Relative volumes impacted	0.5%	0.1%	0.9%
	Most impacted LGA	Name of destination LGA	Moreton Bay (R)	Livingstone (S)	Townsville (C)
		Highest impacted commodity sector	Horticulture	Livestock	Construction
		Number of supply chains impacted	3	1	11
		Relative volumes impacted	3%	1%	6%
		Weekly tonnes BAU	1,373.4	233.8	3,263.3
		Relative number of supply chains impacted	1%	1%	8%

Re-routed supply chains

Table 57 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 17% of the supply chains are expected to be re-routed for 56 of the 91 LGAs that traverse the D'Aguilar Highway intersection. The most impacted LGA is North Burnett (R), with 11 supply chains in the horticulture sectors representing 24.5 tonnes per week re-routed. For non-essential commodities, all LGAs serviced by the D'Aguilar intersection are impacted by re-routed freight, representing 9% of the total volumes consumed within these LGAs overall.

For the Capricorn Highway intersection, 77 of the 186 LGAs serviced by the intersection are re-routed, where these represent 22% of essential commodities consumed within the LGAs. For non-essential commodities, all LGAs serviced by the Capricorn Highway have their freight rerouted, which represents 5% of the total volume consumed by these LGAs.

Table 57 Community impact metrics for modelled intersections on the Bruce Highway KFR - re-routed supply chains

			D'AGUILAR HIGHWAY	CAPRICORN HIGHWAY	FLINDERS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	56/91	77/186	66/188
		Relative impact on volumes of commodities	17.7%	22.2%	32.2%
	Most impacted LGA	Name	North Burnett (R)	Banana(S)	Barcoo(S)
		Highest impacted commodity sector	Horticulture	Construction	Processed Food
		Commodity impacted	Fruit	Cement	Seafood
		Number of supply chains impacted	11	2	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	24.5	11.5	0.5
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	91/91	186/186	185/188
		Relative impact on volumes of commodities	9.1%	5.1%	10.3%
	Most impacted LGA	Name	North Burnett (R)	Woorabinda(S)	McKinlay(S)
		Highest impacted commodity sector	Mining	Cropping	General
		Number of supply chains impacted	10	2	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	4.9	0.9	3.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Bruce Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Bruce Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.11 Buchanan Highway

The Buchanan Highway KFR (Figure 29) is a freight route located in NT. It connects the Stuart Highway to the Victoria Highway. The corridor is 395 km with at least part of the route used for the transport of $2m of product on 3,453 trailers annually carrying 70,000 tonnes across 449 supply chains spanning five commodities. The average freight volume across the road segments is 655 trailers annually with the busiest sections carrying 1,434 trailers. Livestock transport contributes 60% to the total freight task, with construction the only other significant freight along the route. This route is predominantly classified as PBS4a access

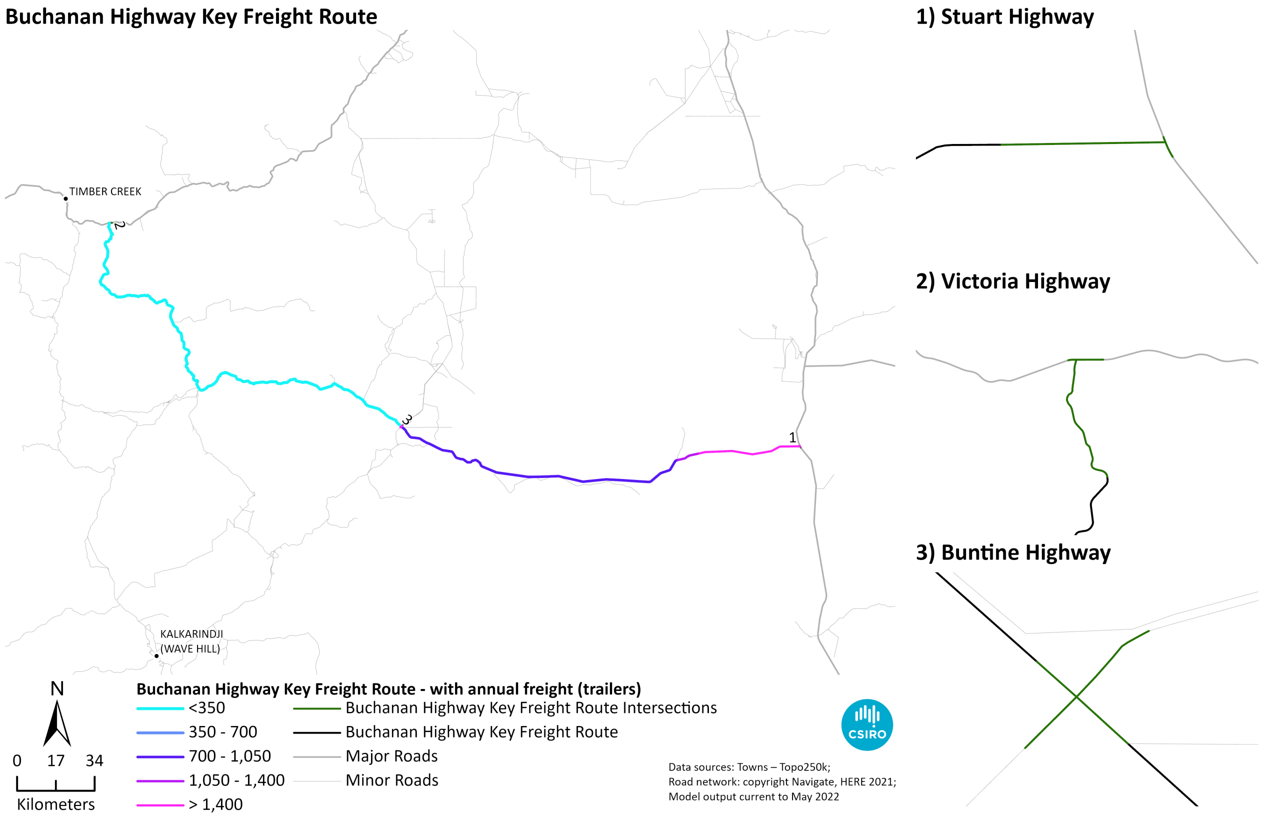

Figure 29 Buchanan Highway KFR

The Buchanan Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 50 LGAs along its length and beyond. It provides access to essential commodities for no LGAs. Victoria Daly (R) LGA is reliant on this KFR to provide access to supplies and markets. Modelling indicates that the route is used by supply chains with trips using 40% of the KFR as part of its trip.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Stuart Highway
- Victoria Highway
- Buntine Highway

The reliance described in Table 58 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Buntine Highway and the Victoria

Highway intersections are of high importance to communities using the KFR, with 46% and 50% of all the supply chain paths traversing the intersections destined to Victoria Daly (R) LGA. In terms of origin LGA, the reliance is even greater. The Stuart Highway intersection is also of importance, however in a more moderate manner (24% of the freight traversing the intersection is destined to one LGA - Victoria Daly (R)). Of note, the Victoria Daly (R) relies on all intersections studied here.

Table 58 Summary of community reliance metrics for each intersection on the Buchanan Highway key freight route - most impacted LGA

	STUART HIGHWAY	BUNTINE HIGHWAY	VICTORIA HIGHWAY
Destination LGA most reliant on the intersection	Victoria Daly (R)	Victoria Daly (R)	Victoria Daly (R)
Relative reliance on intersection for destination LGA	0.24	0.46	0.50
Origin LGA most reliant on the intersection	Victoria Daly (R)	Victoria Daly (R)	Victoria Daly (R)
Relative reliance on intersection for origin LGA	0.43	0.60	0.58

5.11.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Buchanan Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 27 vehicle trips carrying 535 tonnes, 11% being essential commodities. Overall, 532 tonnes of freight are re-routed with an average detour length of 5,057 km and with an average increase in cost of $540.54 per tonne. No supply chains are obstructed.
- **Buntine Highway intersection**: The closure of the Buntine Highway intersection results in the disruption of 51 vehicle trips carrying 1,014 tonnes, 22% being essential commodities. Overall, 201 tonnes of freight are re-routed with an average detour length of 4,402 km and with an average increase in cost of $446.55 per tonne. A total value of supplies amounting to $1.8 million, $0.1 million being essential commodities, is unable to reach its destination.
- **Victoria Highway intersection**: The closure of the Victoria Highway intersection results in the disruption of 13 vehicle trips carrying 281 tonnes, less than 1% being essential commodities. Overall, three tonnes of freight is re-routed with a reduced length but with an average increase in cost of $27.47 per tonne. A total value of supplies amounting to $0.8 million, none being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Buchanan Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Buchanan Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Buchanan Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed

- ‘Buchanan Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Buchanan Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘Buchanan Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Buchanan Highway-cost_bar_plot.png’ shows the cost impacts of re-routing
- ‘Buchanan Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Buchanan Highway.

KFR risk profile

Table 59 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model is able to reach the maximum number of successive high-intensity alternative route closures of five, however their risk profile is very different depending on the intersection.

The ‘Buchanan Highway-*intersection*-detoured blocked plot.png’ plots provide details on the impacts from the successive closures for each intersection.

For the Stuart Highway intersection, very little freight is obstructed at the fifth iteration; however, re-routing happens at a very high cost.

For the Buntine Highway intersection, all freight can be re-routed until it reaches the second successive closure, with little increased cost. On the third successive closure however, many detour options are exhausted and a large proportion of freight (80%) is no longer able to reach its destination. For those that are able to re-route, the cost increases greatly.

The Victoria Highway intersection sees nearly all its freight obstructed by the fifth iteration. Of note, a very high percentage of freight is already obstructed by the third iteration, with those able to re-route doing so at a high cost.

Table 59 Risk metrics for modelled intersections on the Buchanan Highway KFR

	STUART HIGHWAY	BUNTINE HIGHWAY	VICTORIA HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.267	0.413
KFR impacts risk - detour costs for intersection	0.696	0.716	1.520
Last iteration	5	5	5

Freight impact

Table 60 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 60 Freight impact metrics for modelled intersections on the Buchanan Highway KFR by last successive closure

		STUART HIGHWAY [%]	BUNTINE HIGHWAY [%]	VICTORIA HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	80	99
	Relative freight volume impacted – essential commodities	0	100	0
	Relative value of freight – all commodities	1	59	98
Re-routed supply chains	Relative detour cost – average	574	498	35
	Relative detour cost – maximum	3852	2865	56

The metrics in Table 60 indicate the supply chains traversing the Stuart Highway intersection that are likely to be re-routed will do so with their average cost increasing by nearly 600% across all commodities, with some supply chain paths incurring an increase of up to 3800%.

The Buntine Highway intersection has very high volumes of freight obstructed (80% over all commodities) with 100% of its essential commodities obstructed. The value of these obstructed commodities represents nearly 60% of the total value usually traversing the intersection. For the little freight that is able to be re-routed, this is done at very high-cost increase (nearly 500%).

The Victoria Highway has nearly all of its freight obstructed with none being essential commodities. The value of these obstructed commodities represents 98% of the total value usually traversing the intersection.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 61 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and LGA most impacted for each intersection modelled on the KFR.

The Stuart Highway intersection closures result in no LGA impacted by obstructed essential commodities, and one out of 42 LGAs impacted when considering all commodities. The livestock sector is the most impacted for the Roper Gulf (R) LGA for which two supply chains with 550 weekly tonnes are unable to reach market. Only 0.6% of all commodities consumed by all the LGAs impacted will not reach destination.

The Buntine Highway intersection closure results in one LGA out of 35 with obstructed essential commodities, representing nearly 60% of all essential commodities consumed in that LGA. For non-essential commodities, 28 out of the 35 LGAs serviced by the intersection will have some of their freight obstructed, however only representing 3.3% of these LGAs' overall consumption.

The Victoria Highway intersection closure leads to all LGAs serviced by the intersection having some of their received freight obstructed, representing only 4.1% of the total volumes consumed.

For both the Stuart Highway and the Buntine Highway intersection closures, the Victoria Daly (R) LGA is the most impacted - for the construction sector.

Table 61 Community impact metrics for modelled intersections on the Buchanan Highway KFR - obstructed supply chains

			STUART HIGHWAY	BUNTINE HIGHWAY	VICTORIA HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/42	1/35	0/10
		Relative volumes impacted	0.0%	57.9%	0.0%
	Most impacted LGA	Name of destination LGA	-	Victoria Daly (R)	-
		Highest impacted commodity sector	-	Construction	-
		Commodity impacted	-	Concrete	-
		Number of supply chains impacted	0	5	0
		Relative volumes impacted	0%	58%	0%
		Weekly tonnes BAU	0.0	388.7	0.0
		Relative number of supply chains impacted	0%	38%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/42	28/35	10/10
		Relative volumes impacted	0.6%	3.3%	4.1%
	Most impacted LGA	Name of destination LGA	Roper Gulf (R)	Victoria Daly (R)	Victoria Daly (R)
		Highest impacted commodity sector	Livestock	Construction	Construction
		Number of supply chains impacted	2	30	14
		Relative volumes impacted	1%	74%	21%
		Weekly tonnes BAU	550.8	734.9	734.9
		Relative number of supply chains impacted	1%	70%	33%

Re-routed supply chains

Table 62 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and LGA most impacted for each intersection modelled on the KFR.

Because most freight is obstructed for the Buntine Highway and the Victoria Highway intersections, very little freight is re-routed. In both cases, no essential commodities are re-routed. When considering all commodities, Victoria Daly (R) and Wyndham-East Kimberley (S) are the LGAs the most impacted for the livestock sector.

For the Stuart Highway intersection closure, only one LGA is impacted by re-routed freight for essential commodities, while all LGAs relying on the intersection have detours for their non-essential commodities; however the detoured freight represents only 0.8% of all goods consumed within these LGAs.

Table 62 Community impact metrics for modelled intersections on the Buchanan Highway KFR - re-routed supply chains

			STUART HIGHWAY	BUNTINE HIGHWAY	VICTORIA HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/42	0/35	0/10
		Relative impact on volumes of commodities	14.7%	0.0%	0.0%
	Most impacted LGA	Name	Victoria Daly (R)	-	-
		Highest impacted commodity sector	Construction	-	-
		Commodity impacted	Concrete	-	-
		Number of supply chains impacted	2	0	0
		Relative volumes impacted	15%	0%	0%
		Weekly tonnes BAU	388.7	0.0	0.0
		Relative number of supply chains impacted	15%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	42/42	28/35	2/10
		Relative impact on volumes of commodities	0.8%	0.6%	0.2%
	Most impacted LGA	Name	Darwin (C)	Victoria Daly (R)	Wyndham-East Kimberley (S)
		Highest impacted commodity sector	Livestock	Livestock	Livestock
		Number of supply chains impacted	2	40	1
		Relative volumes impacted	17%	6%	0%
		Weekly tonnes BAU	101.5	970.8	370.2
		Relative number of supply chains impacted	5%	7%	1%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Buchanan Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Buchanan Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.12 Bussell Highway

The Bussell Highway KFR (Figure 30) is a freight route located in southwest WA. It connects Bunbury and Augusta. The corridor is 178 km with at least part of the route used for the transport of $13m of product on 48,706 trailers annually carrying one million tonnes across 3233 supply chains spanning 73 commodities (35.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 11,956 trailers annually with the busiest sections carrying 36,730 trailers.

Wood product transport represents approximately 25% of the total freight task, with critical links from properties to ports. Fuel contributes a further 15% of the total freight task, with movement from depot to service stations comprising a high proportion of these movements. The corridor also supports transport movements of processed food and cropping with a further 25% of the total freight task attributed to these commodity groups. The KFR provides an important role in providing access to markets for primary produce with 45% of all movements originating at a property. Equally important is its role in providing access to ports with 20% of movements having a destination at a port. This route is predominantly classified as PBS2a access.

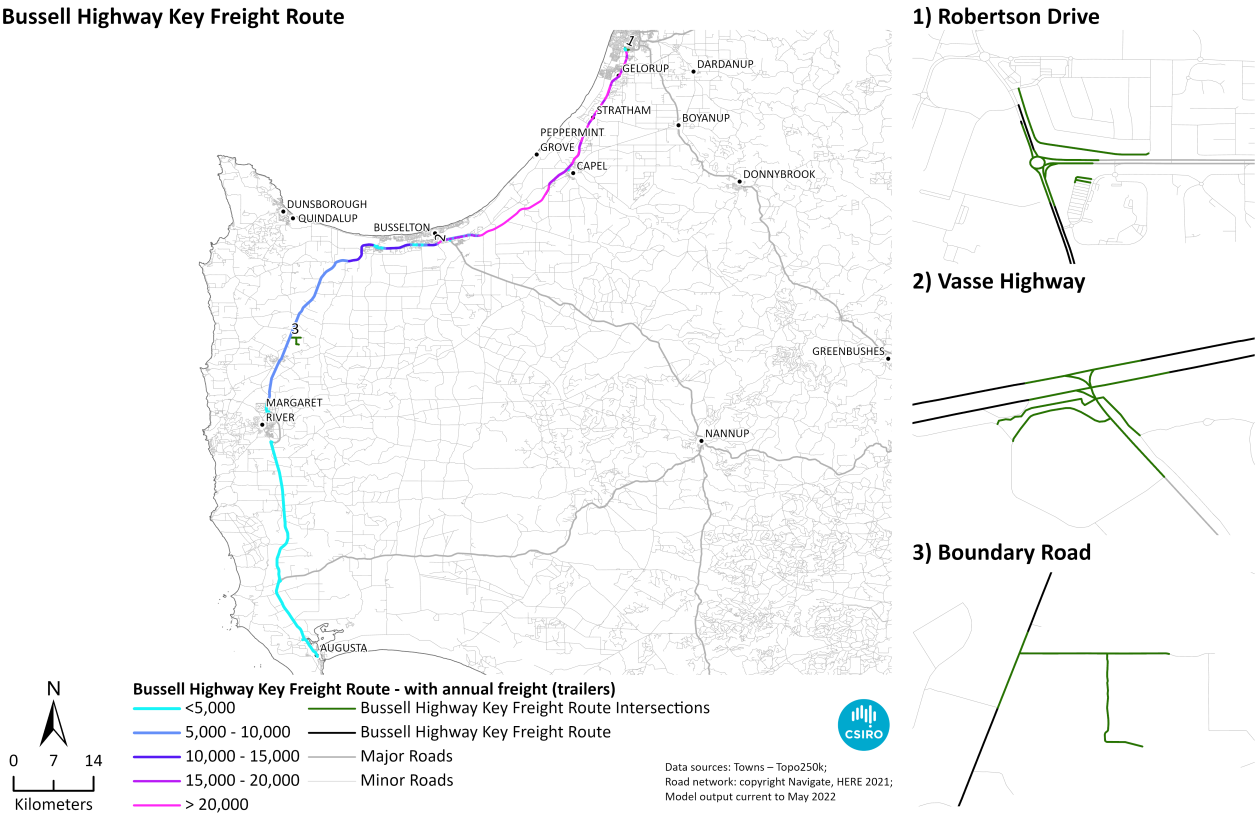

Figure 30 Bussell Highway KFR

The Bussell Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 130 LGAs along its length and beyond. It provides access to essential commodities for 17 LGAs. Many LGAs including Augusta -- Margaret River (S), Capel (S) and Busselton (C) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and fuel. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Vasse Highway
- Boundary Road
- Robertson Drive

The reliance described in Table 63 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Busselton (C) LGA is the most reliant of all the LGAs whose freight traverses the Robertson Drive and the Vasse Highway intersections, and that this reliance is moderate with up to 25% of the commodities imported relying on these intersections to move. A similar observation can be made for the origin LGAs where the Busselton (C) LGA is the most reliant for the same two intersection, with a slightly higher value. For the Boundary Road intersection, Augusta –-Margaret River (S) is the most reliant LGA for both origin and destination freight with a moderate to high value.

Table 63 Summary of community reliance metrics for each intersection on the Bussell Highway key freight route - most impacted LGA

	ROBERTSON DRIVE	VASSE HIGHWAY	BOUNDARY ROAD
Destination LGA most reliant on the intersection	Busselton (C)	Busselton (C)	Augusta-Margaret River (S)
Relative reliance on intersection for destination LGA	0.19	0.24	0.56
Origin LGA most reliant on the intersection	Busselton (C)	Busselton (C)	Augusta-Margaret River (S)
Relative reliance on intersection for origin LGA	0.27	0.39	0.42

5.12.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Bussell Highway. The results are based on expected freight for an average week.

- **Robertson Drive intersection**: The closure of the Robertson Drive intersection results in the disruption of 762 vehicle trips carrying 15,036 tonnes, 34% being essential commodities. Overall, 15,032 tonnes of freight are re-routed with an average detour length of five km and with an average increase in cost of $4.05 per tonne. No supply chain is unable to reach its destination.
- **Vasse Highway intersection**: The closure of the Vasse Highway intersection results in the disruption of 526 vehicle trips carrying 10,276 tonnes, 43% being essential commodities. Overall, 10,274 tonnes of freight are re-routed with an average detour length of 13 km and with an average increase in cost of $5.48 per tonne. No supply chain is unable to reach its destination.
- **Boundary Road intersection**: The closure of the Boundary Road intersection results in the disruption of 159 vehicle trips carrying 3,239 tonnes, 47% being essential commodities. Overall, 3,237 tonnes of freight are re-routed with an average detour length of 54 km and

with an average increase in cost of $11.20 per tonne. No supply chain is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Bussell Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Bussell Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Bussell Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Bussell Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Bussell Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Bussell Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Bussell Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Bussell Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Bussell Highway.

KFR risk profile

Table 64 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Bussell Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be quite costly.

Table 64 Risk metrics for modelled intersections on the Bussell Highway KFR – the model

	ROBERTSON DRIVE	VASSE HIGHWAY	BOUNDARY ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.027	0.031	0.057
Last iteration	5	5	5

Freight impact

Table 65 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 65 Freight impact metrics for modelled intersections on the Bussell Highway KFR

		ROBERTSON DRIVE [%]	VASSE HIGHWAY [%]	BOUNDARY ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	14	15	37
	Relative detour cost – maximum	77	106	107

The metrics in Table 65 indicate the supply chains traversing the Robertson Drive intersection that are likely to be re-routed will do so with their average cost increasing by 14% across all commodities, with some supply chain paths incurring an increase of up to 77%.

Similar results are observed for the Vasse Street and the Boundary Road intersection closures, with expected increase in costs due to detours being 15% and 37% on average, respectively. These increases are low to moderate, with the highest increase in cost being 106% for some of the supply chains.

Little to no freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 66 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of the three intersections results in no LGAs impacted for essential commodities.

The Vasse Highway and the Boundary Road intersection closures result in one out of the 67 and three out of 34 LGAs, respectively, serviced by the intersections having obstructed supply chains, with less than 1% of the freight volumes for all commodities obstructed. The most impacted LGA in both cases is Augusta – Margaret River (S) for the livestock industry which represents less than 1% (tonnes) of commodities consumed in the LGA.

Table 66 Community impact metrics for modelled intersections on the Bussell Highway KFR - obstructed supply chains

			ROBERTSON DRIVE	VASSE HIGHWAY	BOUNDARY ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/65	0/67	0/34
		Relative volumes impacted	0.0%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	-	-	-
		Highest impacted commodity sector	-	-	-
		Commodity impacted	-	-	-
		Number of supply chains impacted	0	0	0
		Relative volumes impacted	0%	0%	0%
		Weekly tonnes BAU	0.0	0.0	0.0
		Relative number of supply chains impacted	0%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/65	1/67	3/34
		Relative volumes impacted	0.8%	0.3%	0.0%
	Most impacted LGA	Name of destination LGA	Bunbury (C)	Augusta-Margaret River (S)	Augusta-Margaret River (S)
		Highest impacted commodity sector	Waste	Livestock	Livestock
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	1%	0%	0%
		Weekly tonnes BAU	515.1	792.2	792.2
		Relative number of supply chains impacted	1%	1%	1%

Re-routed supply chains

Table 67 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA most impacted for each intersection modelled on the KFR.

The Robertson Drive intersection closure results in 14 LGAs out of 65 having re-routed supply chains for essential commodities, representing 17.9% of the volumes that are normally received by these LGAs. Augusta – Margaret River (S) is the most impacted LGA with 13 supply chains for the processed food industry obstructed, representing 100% of the box chicken consumption of the LGA. When considering all commodities, Busselton (C) is the most impacted for general freight, however, the overall volumes impacted by re-routing overall represent only 2.8% of the commodities consumed within the 65 impacted LGAs.

Similar observation can be made for the Vasse Highway and the Boundary Road intersection closures. The impact on essential commodities is moderate with nearly 25% and 15% of the volumes of essential commodities that are normally received by the 14 and nine respectively, impacted LGAs serviced by the intersection expected to be re-routed. When considering all commodities, the impact is less with 1.9% and 1.5% of the volumes of commodities normally received by the LGAs impacted by re-routing.

Table 67 Community impact metrics for modelled intersections on the Bussell Highway KFR - re-routed supply chains

			ROBERTSON DRIVE	VASSE HIGHWAY	BOUNDARY ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	14/65	14/67	9/34
		Relative impact on volumes of commodities	17.9%	24.3%	15.5%
	Most impacted LGA	Name	Augusta-Margaret River (S)	Augusta-Margaret River (S)	Augusta-Margaret River (S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Chicken	Box Lamb	Box Lamb
		Number of supply chains impacted	13	3	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	21.5	1.4	1.4
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	65/65	67/67	34/34
		Relative impact on volumes of commodities	2.8%	1.9%	1.5%
	Most impacted LGA	Name	Busselton (C)	Busselton (C)	Augusta-Margaret River (S)
		Highest impacted commodity sector	General	Vehicles	General
		Number of supply chains impacted	60	20	36
		Relative volumes impacted	100%	100%	83%
		Weekly tonnes BAU	1,483.6	108.8	296.2
		Relative number of supply chains impacted	100%	100%	86%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Bussell Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Bussell Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.13 Calder Highway

The Calder Highway KFR (Figure 31) is a freight route located in Victoria. It connects LGAs in northwest Victoria between Mildura and Bendigo. The corridor is 449 km with at least part of the route used for the transport of $115m of product on 417,518 trailers annually carrying nine million tonnes across 28,936 supply chains spanning 103 commodities (36.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 56,453 trailers annually with the busiest sections carrying 113,538 trailers.

Fuel transport represents approximately 30% of the total freight task, with critical links from port to depots and on to service stations. Cropping also contributes 30% of the total freight task, with movement from property to silos and on to stock feed manufactures comprising a high proportion of these movements. The corridor also supports transport movements of general freight and horticulture with a further 25% of the total freight task attributed to these commodity groups. This route is predominantly classified as PBS3a access with the southern section PBS2a classified.

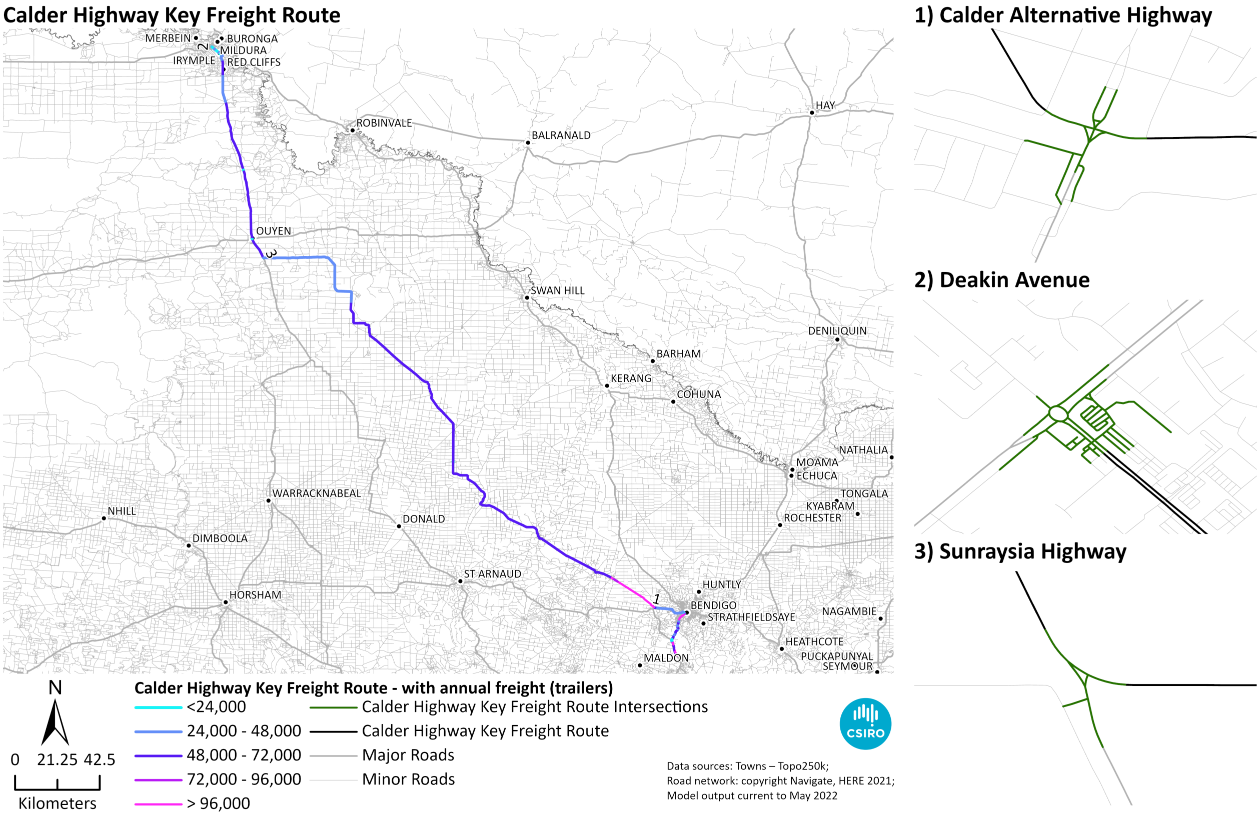

Figure 31 Calder Highway KFR

The Calder Highway KFR passes through five LGAs but crucially it supports the supply chain paths for over 323 LGAs along its length and beyond. It provides access to essential commodities for 159 LGAs. Many LGAs including Greater Bendigo (C), Loddon (S) and Buloke (S) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Sunraysia Highway
- Calder Alternative Highway
- Deakin Avenue

The reliance described in Table 68 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Melbourne (C) LGA is the most reliant of all the LGAs whose freight traverse the Calder Alternative Highway and the Sunraysia Highway intersections, and that this reliance is moderate with up to 30% of the commodities imported relying on these intersections to move. For the Deakin Avenue intersection, Mildura (RC) is the most reliant LGA for both origin and destination freight with a moderate value of 34% and 27% respectively of freight consumed and produced in the LGA traversing the intersection.

Table 68 Summary of community reliance metrics for each intersection on the Calder Highway key freight route - most impacted LGA

	CALDER ALTERNATIVE HIGHWAY	SUNRAYSIA HIGHWAY	DEAKIN AVENUE
Destination LGA most reliant on the intersection	Melbourne (C)	Melbourne (C)	Mildura (RC)
Relative reliance on intersection for destination LGA	0.25	0.30	0.34
Origin LGA most reliant on the intersection	Swan Hill (RC)	Mildura (RC)	Mildura (RC)
Relative reliance on intersection for origin LGA	0.14	0.25	0.27

5.13.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Calder Highway. The results are based on expected freight for an average week.

- **Calder Alternative Highway intersection**: The closure of the Calder Alternative Highway intersection results in the disruption of 2,602 vehicle trips carrying 54,300 tonnes, 35% being essential commodities. Overall, 54,300 tonnes of freight are re-routed with negligible detour length and with an average increase in cost of $2.17 per tonne. No supply chain is unable to reach its destination.
- **Sunraysia Highway intersection**: The closure of the Sunraysia Highway intersection results in the disruption of 1,260 vehicle trips carrying 27,577 tonnes, 32% being essential commodities. Overall, 27,562 tonnes of freight are re-routed with an average detour length of four km and with an average increase in cost of $4.70 per tonne. No supply chain is unable to reach its destination.
- **Deakin Avenue intersection**: The closure of the Deakin Avenue intersection results in the disruption of 726 vehicle trips carrying 12,755 tonnes, 22% being essential commodities. Overall, 12,703 tonnes of freight are re-routed with an average detour length of seven km and with an average increase in cost of $6.93 per tonne. A total value of supplies amounting to $0.7 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Calder Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Calder Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Calder Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Calder Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Calder Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Calder Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Calder Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Calder Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Calder Highway.

KFR risk profile

Table 69 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Calder Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive intersection closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be costly.

Table 69 Risk metrics for modelled intersections on the Calder Highway KFR – the model

	CALDER ALTERNATIVE HIGHWAY	SUNRAYSIA HIGHWAY	DEAKIN AVENUE
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.004
KFR impacts risk - detour costs for intersection	0.007	0.012	0.021
Last iteration	5	5	5

Freight impact

Table 70 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 70 Freight impact metrics for modelled intersections on the Calder Highway KFR

		CALDER ALTERNATIVE HIGHWAY [%]	SUNRAYSIA HIGHWAY [%]	DEAKIN AVENUE [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	1
Re-routed supply chains	Relative detour cost – average	3	5	10
	Relative detour cost – maximum	65	118	106

The metrics in Table 70 indicate the supply chains traversing the Calder Alternative Highway intersection that are likely to be re-routed will do so with their average cost increasing by 3% across all commodities, with some supply chain paths incurring an increase of up to 65%.

Similar results are observed for the Sunraysia Highway and the Deakin Avenue intersection closures, with expected increase in costs due to detours being 5% and 10%, respectively, on average. These increases are low, with the highest increase in cost being 118% for some of the supply chains.

Little to no freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 71 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of the three intersections results in no LGAs impacted for essential commodities. In addition, the Calder Alternative Highway intersection also has no freight obstructed when considering all commodities.

The Sunraysia Highway and the Deakin Avenue intersection closures result in one out of the 129 and 87 LGAs, respectively, serviced by the intersections having obstructed supply chains, with less than 1% of the freight volumes for all commodities obstructed. The most impacted LGA in both cases is Mildura (RC), where one supply chain for cropping is obstructed from the Sunraysia Highway intersection closure, and three general freight supply chains are obstructed for the Deakin Avenue intersection closure.

Table 71 Community impact metrics for modelled intersections on the Calder Highway KFR - obstructed supply chains

			CALDER ALTERNATIVE HIGHWAY	SUNRAYSIA HIGHWAY	DEAKIN AVENUE
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/131	0/129	0/87
		Relative volumes impacted	0.0%	0.0%	0.0%
	most impacted LGA	Name of destination LGA	-	-	-
		Highest impacted commodity sector	-	-	-
		Commodity impacted	-	-	-
		Number of supply chains impacted	0	0	0
		Relative volumes impacted	0%	0%	0%
		Weekly tonnes BAU	0.0	0.0	0.0
		Relative number of supply chains impacted	0%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	0/131	1/129	1/87
		Relative volumes impacted	0.0%	0.2%	1.0%
	Most impacted LGA	Name of destination LGA	-	Mildura (RC)	Mildura (RC)
		Highest impacted commodity sector	-	Cropping	General
		Number of supply chains impacted	-	1	3
		Relative volumes impacted	0%	0%	1%
		Weekly tonnes BAU	0.0	9,030.5	4,756.4
		Relative number of supply chains impacted	0%	0%	5%

Re-routed supply chains

Table 72 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Calder Alternative Highway intersection closure results in 70 LGAs out of 131 having re-routed supply chains for essential commodities, representing 15% of the volumes that are normally received by these LGAs. Balranald (A) is the most impacted LGA with two supply chains for the processed food industry obstructed, representing 100% of the box rice consumption of the LGA. When considering all commodities, Balranald (A) is also the most impacted LGA but for the horticulture industry. However, the overall volumes impacted by re-routing overall represent only 5% of the commodities consumed within the 130 impacted LGAs.

Similar observations can be made for the Sunraysia Highway and the Deakin Avenue intersection closures. The impact on essential commodities is moderate with nearly 21% and 11% of the volumes of essential commodities that are normally received by the 28 and 18, respectively, impacted LGAs serviced by the intersection expected to be re-routed. When considering all commodities, the impact is less, with 3.7% and 2.5% of the volumes of commodities normally received by the LGAs impacted by re-routing.

Table 72 Community impact metrics for modelled intersections on the Calder Highway KFR - re-routed supply chains

			CALDER ALTERNATIVE HIGHWAY	SUNRAYSIA HIGHWAY	DEAKIN AVENUE
Essential commodities	All impacted LGAs	Number of LGAs impacted	70/131	28/129	18/87
		Relative impact on volumes of commodities	15.0%	20.9%	10.6%
	Most impacted LGA	Name	Balranald (A)	Peterborough (DC)	Peterborough (DC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Rice	Bread	Bread
		Number of supply chains impacted	2	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	1.6	1.6	1.6
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	130/131	128/129	86/87
		Relative impact on volumes of commodities	5.0%	3.7%	2.5%
	Most impacted LGA	Name	Balranald (A)	Horsham (RC)	Peterborough (DC)
		Highest impacted commodity sector	Horticulture	Construction	Cropping
		Number of supply chains impacted	6	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	13.3	96.2	1.1
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Calder Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Calder Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.14 Capricorn Highway

The Capricorn Highway KFR (Figure 32) is a freight route located in central Queensland. It connects LGAs from Barcaldine to Rockhampton. The corridor is 585 km with at least part of the route used for the transport of $72m of product on 182,670 trailers annually carrying 3.6 million tonnes across 12,786 supply chains spanning 106 commodities (37.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 28,157 trailers annually with the busiest sections carrying 78,697 trailers.

Fuel transport represents approximately 35% of the total freight task, with critical links from port to mine. Livestock contributes a further 20% of the total freight task, with transport between properties and from property to abattoir comprising a high proportion of these movements. Cropping and general freight transport movements constitute a total of 30% of the total freight task attributed to these commodity groups. This route is predominantly classified as PBS3a access.

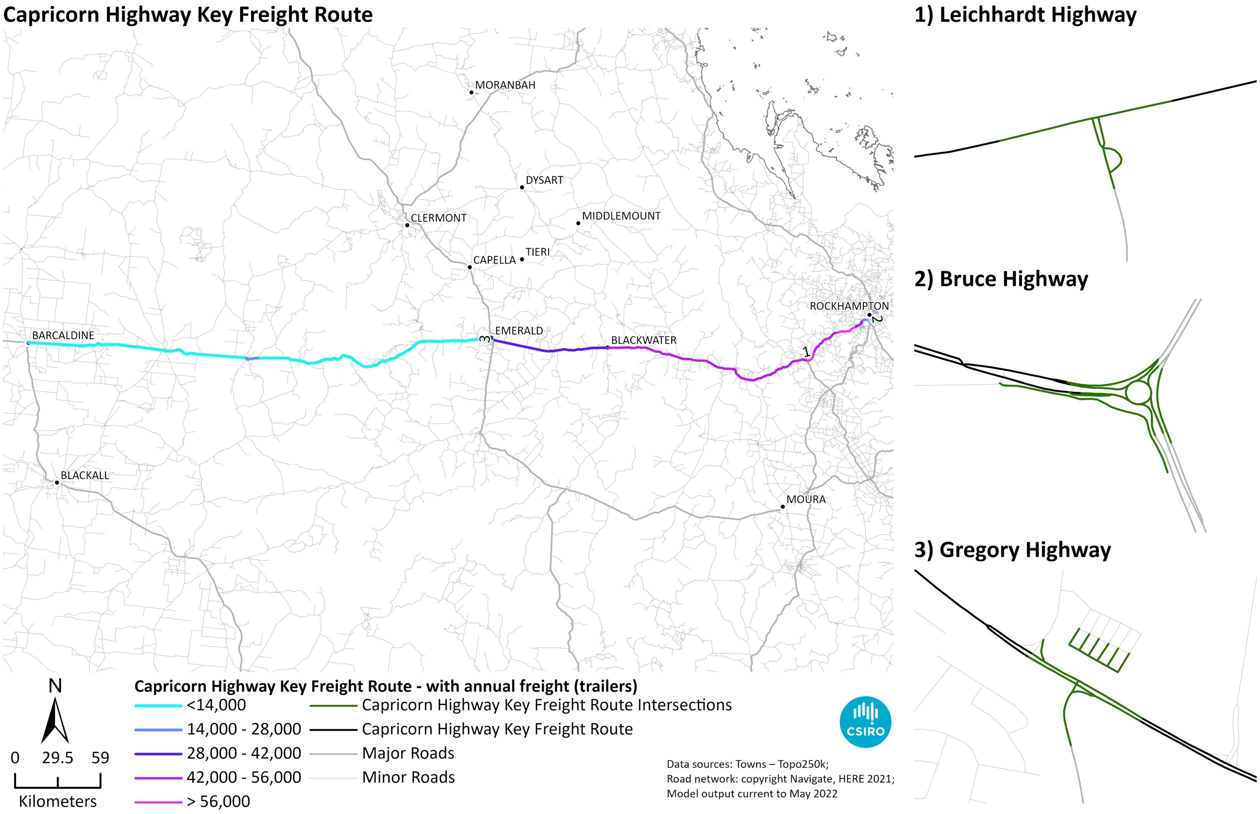

Figure 32 Capricorn Highway KFR

The Capricorn Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 303 LGAs along its length and beyond. It provides access to essential commodities for 61 LGAs. Many LGAs including Central Highlands (R) (Qld) and Isaac (R) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, livestock and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 60% of the supply chain trip length. Horticulture and general freight utilise large sections of the KFR.

The intersections identified as of strategic importance and used in the modelling and analysis include:

- Bruce Highway
- Gregory Highway
- Leichhardt Highway

The reliance described in Table 73 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Rockhampton (R) LGA is the most reliant of all the LGAs whose freight traverse the Leichhardt Highway and the Bruce Highway intersections. This reliance is moderate to high with 37% (Leichhardt Highway) and 55% (Bruce Highway) of the supply chain paths imported relying on these intersections to move. In terms of origin LGA, the Rockhampton (R) LGA is also the most reliant for the same two intersections, with a lower value. For the Gregory Highway intersection, Central Highlands (R) (Qld) is the most reliant LGA for both origin and destination freight, with a moderate value.

Table 73 Summary of community reliance metrics for each intersection on the Capricorn Highway key freight route - most impacted LGA

	LEICHHARDT HIGHWAY	BRUCE HIGHWAY	GREGORY HIGHWAY
Destination LGA most reliant on the intersection	Rockhampton (R)	Rockhampton (R)	Central Highlands (R) (Qld)
Relative reliance on intersection for destination LGA	0.37	0.55	0.24
Origin LGA most reliant on the intersection	Rockhampton (R)	Rockhampton (R)	Central Highlands (R) (Qld)
Relative reliance on intersection for origin LGA	0.17	0.18	0.25

5.14.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Capricorn Highway. The results are based on expected freight for an average week.

- **Leichhardt Highway intersection**: The closure of the Leichhardt Highway intersection results in the disruption of 1,308 vehicle trips carrying 29,009 tonnes, 57% being essential commodities. Overall, 29,004 tonnes of freight are re-routed with an average detour length of five km and with an average increase in cost of $6.32 per tonne. No supply chain is unable to reach its destination.
- **Bruce Highway intersection**: The closure of the Bruce Highway intersection results in the disruption of 1,081 vehicle trips carrying 24,422 tonnes, 66% being essential commodities. Overall, 24,408 tonnes of freight are re-routed with an average detour length of seven km and with an average increase in cost of $6.36 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Gregory Highway intersection**: The closure of the Gregory Highway intersection results in the disruption of 1,586 vehicle trips carrying 30,260 tonnes, 35% being essential commodities. Overall, 30,115 tonnes of freight are re-routed with an average detour length of 45 km and an average increase in cost of $12.55 per tonne. A total value of supplies

amounting to $1.5 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Capricorn Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Capricorn Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Capricorn Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Capricorn Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Capricorn Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Capricorn Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Capricorn Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Capricorn Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Capricorn Highway.

KFR risk profile

Table 74 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Capricorn Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low are not negligible, indicating that there are some detours that might be quite costly.

Table 74 Risk metrics for modelled intersections on the Capricorn Highway KFR

	LEICHHARDT HIGHWAY	BRUCE HIGHWAY	GREGORY HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.001
KFR impacts risk - detour costs for intersection	0.017	0.031	0.018
Last iteration	5	5	5

Freight impact

Table 75 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 75 Freight impact metrics for modelled intersections on the Capricorn Highway KFR

		LEICHHARDT HIGHWAY [%]	BRUCE HIGHWAY [%]	GREGORY HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	1
Re-routed supply chains	Relative detour cost – average	10	10	23
	Relative detour cost – maximum	111	257	1326

The metrics in Table 75 indicate the supply chains traversing the Leichhardt Highway and the Bruce Highway intersections that are likely to be re-routed will do so with their average cost increasing by 10%. These increases are low, with the highest increase in cost being 111% and 257% respectively for some of the supply chains.

Similar results are observed for the Gregory Highway intersection closure, with expected increase in costs due to detours being 23% on average. This increase is higher than for the other intersections, however still moderate. The highest increase in cost however reaches 1300% for some of the supply chains.

Little to no freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 76 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of the three intersections results in one LGA impacted for essential commodities, with the closure of the Leichhardt Highway and the Bruce Highway intersections showing the exact same results.

The Leichhardt Highway and the Bruce Highway intersection closures result in one out of the 110 and 91 LGAs, respectively, serviced by the intersections having obstructed supply chains for essential commodities, with nearly 6% of the freight volumes for essential commodities obstructed. The most impacted LGA in both cases is the Central Highlands (R) (Qld) LGA for the construction industry. When considering all commodities, the impact on the one (Leichhardt Highway intersection) and four (Bruce Highway intersection) LGAs not receiving freight is lower with 0.2% and 0.1% respectively of commodities consumed within the LGA not reaching their destination.

The closure of the Gregory Highway intersection results in one out of 135 LGAs serviced by the intersections having obstructed essential commodities, which represents 12% of the consumption of this impacted LGA. The most impacted LGA is the Central Highlands (R) (Qld) LGA which will not receive bread, however this represents only 14% of its bread usually consumed. When considering all commodities, the impact is even lower, with three out of the 135 LGAs not receiving commodities, representing less than 1% of their goods consumed.

Table 76 Community impact metrics for modelled intersections on the Capricorn Highway KFR - obstructed supply chains

			LEICHHARDT HIGHWAY	BRUCE HIGHWAY	GREGORY HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/110	1/91	1/135
		Relative volumes impacted	5.9%	5.9%	12.3%
	Most impacted LGA	Name of destination LGA	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)
		Highest impacted commodity sector	Construction	Construction	Processed Food
		Commodity impacted	Gravel	Gravel	Bread
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	6%	6%	14%
		Weekly tonnes BAU	65.4	65.4	19.7
		Relative number of supply chains impacted	8%	8%	4%
All commodities	All impacted LGAs	Number of LGAs impacted	1/110	4/91	3/135
		Relative volumes impacted	0.2%	0.1%	0.5%
	Most impacted LGA	Name of destination LGA	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)
		Highest impacted commodity sector	Construction	Construction	General
		Number of supply chains impacted	1	1	3
		Relative volumes impacted	2%	2%	15%
		Weekly tonnes BAU	207.7	207.7	619.3
		Relative number of supply chains impacted	4%	4%	4%

Re-routed supply chains

Table 77 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Leichhardt Highway intersection closure results in 51 LGAs out of 110 having re-routed supply chains for essential commodities, representing 19% of the volumes that are normally received by these LGAs. Barcaldine (R) is the most impacted LGA with one supply chain for the processed food industry obstructed, representing 100% of the box beef consumption of the LGA. When considering all commodities, Barcaldine (R) is again the most impacted, for wood products. However, the overall volumes impacted by re-routing represent only 3.4% of the commodities consumed within the 110 impacted LGAs.

Similar observations can be made for the Bruce Highway and the Gregory Highway intersection closures. The impact on essential commodities is moderate with nearly 21% (Bruce Highway intersection) and 15% (Gregory Highway intersection) of the volumes of essential commodities that are normally received by the 49 and 43 impacted LGAs serviced by each intersection respectively, expected to be re-routed. When considering all commodities, the impact is less with 3.2% (Bruce Highway intersection) and 4.3% (Gregory Highway intersection) of the volumes of commodities normally received by the LGAs impacted by re-routing.

Table 77 Community impact metrics for modelled intersections on the Capricorn Highway KFR - re-routed supply chains

			LEICHHARDT HIGHWAY	BRUCE HIGHWAY	GREGORY HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	51/110	49/91	43/135
		Relative impact on volumes of commodities	19.0%	20.6%	15.1%
	Most impacted LGA	Name	Barcaldine(R)	Barcaldine(R)	Douglas(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Beef	Box Beef	Bread
		Number of supply chains impacted	1	1	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.5	0.5	4.9
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	110/110	91/91	134/135
		Relative impact on volumes of commodities	3.4%	3.2%	4.3%
	Most impacted LGA	Name	Barcaldine(R)	Woorabinda(S)	Etheridge(S)
		Highest impacted commodity sector	Wood Product	Cropping	Cropping
		Number of supply chains impacted	1	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	38.3	0.9	0.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Capricorn Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Capricorn Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.15 Carnarvon Highway

The Carnarvon Highway KFR (Figure 33) is a freight and commuter route connecting the NSW border in southern Queensland near Mungindi to the Dawson Highway near Rolleston in central Queensland. The corridor is 574 km with at least part of the route used for the transport of $41m of product on 151,089 trailers annually carrying three million tonnes across 8904 supply chains spanning 76 commodities (15.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 38,878 trailers annually with the busiest sections carrying 69,694 trailers.

Cropping transport represents approximately 45% of the total freight task, with critical links from properties to silos. Livestock contributes a further 20% and fuel a further 15% of the total freight task. The KFR provides an important role in providing access to markets for primary produce with 55% of all movements originating at a property. Equally important is its role in providing access to silos with 30% of movements having a destination at a port. This route is predominantly classified as PBS3a access.

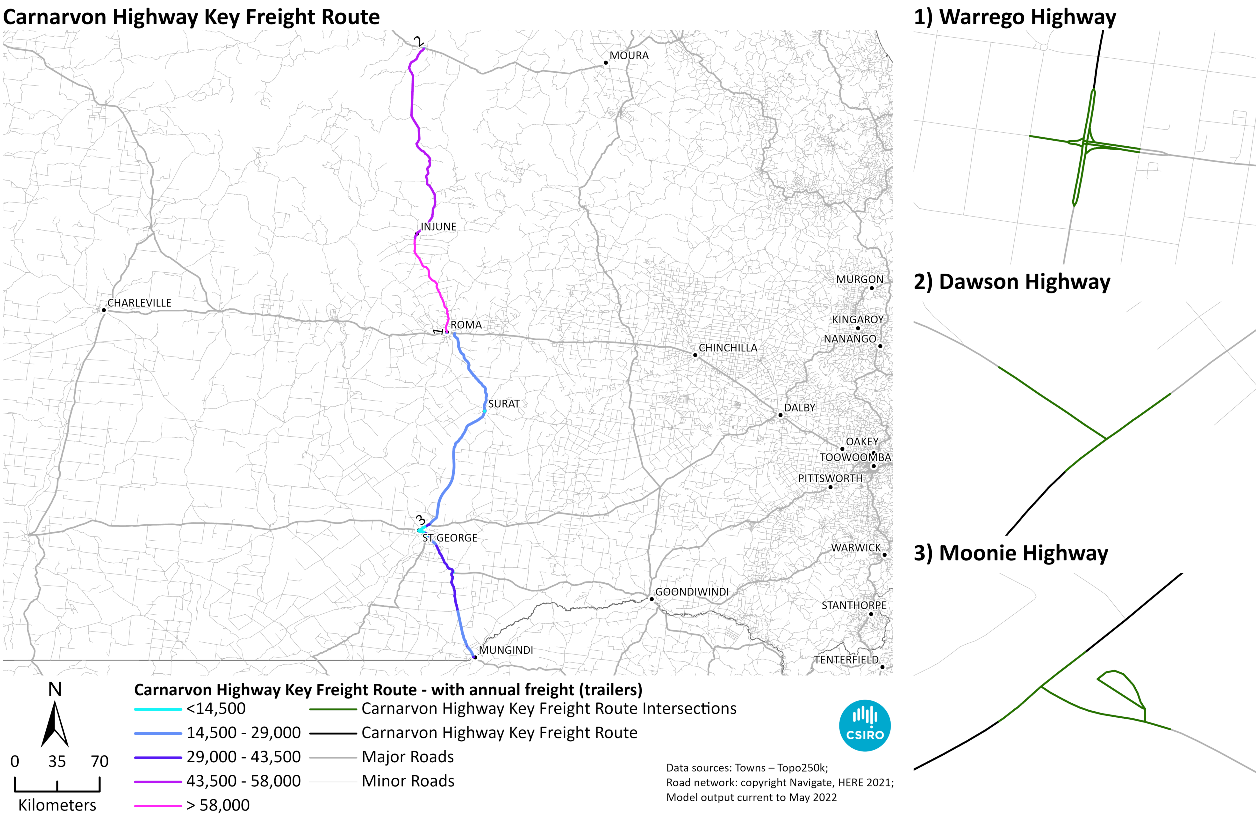

Figure 33 Carnarvon Highway KFR

The Carnarvon Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 213 LGAs along its length and beyond. It provides access to essential commodities for 43 LGAs. Many LGAs including Balonne (S) and Maranoa (R) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Warrego Highway
- Dawson Highway
- Moonie Highway

The reliance described in Table 78 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Maranoa (R) LGA is the most reliant of all the LGAs whose freight traverse the Warrego Highway intersection, and that this reliance is low to moderate with 19% of the commodities imported relying on this intersection to move. In terms of origin LGA, the Ro Central Highlands (R) (Qld) LGA is the most reliant for that intersection. For the Dawson Highway intersection, Central Highlands (R) (Qld) is the most reliant LGA for both origin and destination freight with a moderate value. For the Moonie Highway intersection, Balonne (S) is the most reliant LGA for destination freight while Brisbane (C) is the one most relying on the intersection for its origin freight with low to moderate values.

Table 78 Summary of community reliance metrics for each intersection on the Carnarvon Highway key freight route - most impacted LGA

	WARREGO HIGHWAY	DAWSON HIGHWAY	MOONIE HIGHWAY
Destination LGA most reliant on the intersection	Maranoa (R)	Central Highlands (R) (Qld)	Balonne (S)
Relative reliance on intersection for destination LGA	0.19	0.17	0.23
Origin LGA most reliant on the intersection	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)	Brisbane (C)
Relative reliance on intersection for origin LGA	0.23	0.35	0.15

5.15.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Carnarvon Highway. The results are based on expected freight for an average week.

- **Warrego Highway intersection**: The closure of the Warrego Highway intersection results in the disruption of 1,395 vehicle trips carrying 27,037 tonnes, 17% being essential commodities. Overall, 26,889 tonnes of freight are re-routed with an average detour length of 34 km and with an average increase in cost of $9.46 per tonne. A total value of supplies amounting to $0.3 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Dawson Highway intersection**: The closure of the Dawson Highway intersection results in the disruption of 1,184 vehicle trips carrying 22,205 tonnes, 26% being essential commodities. Overall, 22,072 tonnes of freight are re-routed with an average detour length of 92 km and with an average increase in cost of $15.88 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Moonie Highway intersection**: The closure of the Moonie Highway intersection results in the disruption of 592 vehicle trips carrying 11,512 tonnes, 10% being essential commodities.

Overall, 10,782 tonnes of freight are re-routed with an average detour length of 39 km and with an average increase in cost of $8.16 per tonne. A total value of supplies amounting to $2.5 million, $1.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Carnarvon Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Carnarvon Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Carnarvon Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Carnarvon Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Carnarvon Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Carnarvon Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Carnarvon Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Carnarvon Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Carnarvon Highway.

KFR risk profile

Table 79 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Carnarvon Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for the Warrego and Dawson Highway intersection are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The values for the Moonie Highway intersection are slightly higher, however still low. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be quite costly.

Table 79 Risk metrics for modelled intersections on the Carnarvon Highway KFR – the model

	WARREGO HIGHWAY	DAWSON HIGHWAY	MOONIE HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.001	0.016
KFR impacts risk - detour costs for intersection	0.014	0.020	0.015
Last iteration	5	5	5

Freight impact

Table 80 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 80 Freight impact metrics for modelled intersections on the Carnarvon Highway KFR

		WARREGO HIGHWAY [%]	DAWSON HIGHWAY [%]	MOONIE HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	1	6
	Relative freight volume impacted – essential commodities	3	2	52
	Relative value of freight – all commodities	0	0	6
Re-routed supply chains	Relative detour cost – average	10	15	12
	Relative detour cost – maximum	124	640	441

The metrics in Table 80 indicate the supply chains traversing the Warrego Highway, the Dawson Highway and the Moonie Highway intersections that are likely to be re-routed will do so with their average cost increasing by 10%, 15% and 12% respectively, on average. These increases are low, with the highest increase in cost being 124%, 640% and 441% for some of the supply chains.

Little freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 81 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of any of the three intersections results in one LGA impacted for essential commodities. The impact on the communities, however, differs greatly depending on the intersection closed. As such, the Warrego Highway and the Dawson Highway intersection closure means that the two most impacted LGAs have 1.6% and 0.9% of their usual essential commodities not reaching destination, respectively, with fuel being the most important commodity. The Moonie Highway intersection closure however results in having 78% of its essential commodities that would normally be consumed within the impacted LGA not reach it; being diesel fuel for the Balonne (S) LGA, highlighting the higher impact on that community when the intersection is closed.

When considering all commodities, the results are in line with those of essential commodities. The proportion of obstructed commodities for the Moonie Highway intersection is however smaller over all the impacted LGA compared to when only considering essential commodities. Balonne (S) remains the most impacted for the fuel sector, with 45% of its fuel (diesel and LPG) not reaching its destination.

Table 81 Community impact metrics for modelled intersections on the Carnarvon Highway KFR - obstructed supply chains

			WARREGO HIGHWAY	DAWSON HIGHWAY	MOONIE HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/129	1/119	1/110
		Relative volumes impacted	1.6%	0.9%	77.6%
	Most impacted LGA	Name of destination LGA	Western Downs (R)	Central Highlands (R) (Qld)	Balonne (S)
		Highest impacted commodity sector	Fuel	Fuel	Fuel
		Commodity impacted	Unleaded fuel	Unleaded fuel	Diesel fuel
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	3%	2%	78%
		Weekly tonnes BAU	3,785.2	3,901.9	815.8
		Relative number of supply chains impacted	4%	6%	20%
All commodities	All impacted LGAs	Number of LGAs impacted	4/129	1/119	2/110
		Relative volumes impacted	0.8%	0.8%	5.9%
	Most impacted LGA	Name of destination LGA	Maranoa (R)	Central Highlands (R) (Qld)	Balonne (S)
		Highest impacted commodity sector	Waste	Fuel	Fuel
		Number of supply chains impacted	1	2	1
		Relative volumes impacted	3%	1%	45%
		Weekly tonnes BAU	157.8	14,816.0	1,410.4
		Relative number of supply chains impacted	3%	4%	7%

Re-routed supply chains

Table 82 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA most impacted for each intersection modelled on the KFR.

The Warrego Highway intersection closure results in 23 LGAs out of 129 having re-routed supply chains for essential commodities, representing 12.4% of the volumes that are normally received by these LGAs. Etheridge (S) is the most impacted LGA with two supply chains for the processed food industry obstructed, representing 100% of the bread consumption of the LGA. When considering all commodities, Etheridge (S) is again the most impacted but for the cropping industry, however, the overall volumes impacted by re-routing represent only 4% of the commodities consumed within the 129 impacted LGAs.

Similar observations can be made for the Dawson Highway intersection closure. The impact on essential commodities is however higher, with a moderate value of nearly 29% of the volumes of essential commodities that are normally received by the 19 out of 119 impacted LGAs serviced by the intersection expected to be re-routed. Etheridge (S) is also the most impacted LGA for the processed food industry when considering essential commodities, and the cropping industry when considering all commodities.

The Moonie Highway intersection closure results in 17 LGAs out of 110 having re-routed supply chains for essential commodities, representing nearly 7% of the volumes that are normally received by these LGAs. Paroo (S) is the most impacted LGA with four supply chains for the processed food industry obstructed, representing 100% of the box rice consumption of the LGA. When considering all commodities, Paroo (S) is again the most impacted but for general commodities, however, the overall volumes impacted by re-routing overall represent only 2% of the commodities consumed within the 110 impacted LGAs.

Table 82 Community impact metrics for modelled intersections on the Carnarvon Highway KFR - re-routed supply chains

			WARREGO HIGHWAY	DAWSON HIGHWAY	MOONIE HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	23/129	19/119	17/110
		Relative impact on volumes of commodities	12.4%	28.7%	6.9%
	Most impacted LGA	Name	Etheridge(S)	Etheridge(S)	Paroo(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Bread	Box Rice
		Number of supply chains impacted	2	2	4
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.3	0.3	1.5
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	129/129	119/119	110/110
		Relative impact on volumes of commodities	4.0%	3.7%	2.1%
	Most impacted LGA	Name	Etheridge(S)	Etheridge(S)	Paroo(S)
		Highest impacted commodity sector	Cropping	Cropping	General
		Number of supply chains impacted	2	2	8
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.2	0.2	27.1
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Carnarvon Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Carnarvon Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.16 Carpentaria Highway

The Carpentaria Highway KFR (Figure 34) is a freight route located in NT. It connects LGAs between the Gulf of Carpentaria to the Stuart Highway. The corridor is 367 km with at least part of the route used for the transport of $2m of product on 13,312 trailers annually carrying 300 thousand tonnes across 378 supply chains spanning 22 commodities (77.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 9,205 trailers annually with the busiest sections carrying 10,496 trailers.

Fuel transport represents approximately 75% of the total freight task, with critical links from ports to depots and mines. Livestock and mining contribute a further 20% of the total freight task. This route is predominantly classified as PBS4a access.

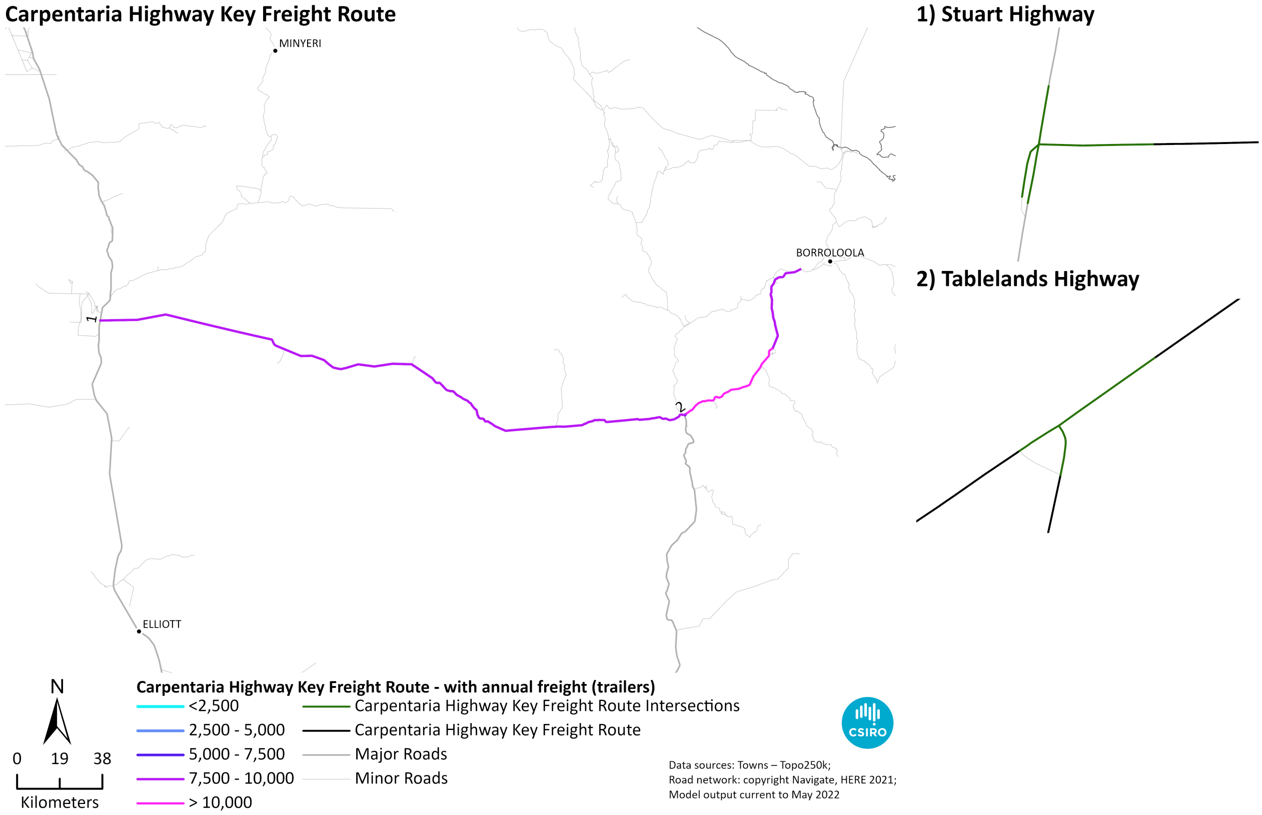

Figure 34 Carpentaria Highway KFR

The Carpentaria Highway KFR passes through two LGAs but crucially it supports the supply chain paths for over 48 LGAs along its length and beyond. It provides access to essential commodities for 43 LGAs. Roper Gulf R) (LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Stuart Highway
- Tablelands Highway

The reliance described in Table 83 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the Stuart Highway and the Tablelands Highway intersections to moderate to high degrees, with 39% and 40%, respectively, of all the supply chain paths traversing the intersections destined for the Roper Gulf (R) LGA. In terms of origin LGA, the reliance is slightly greater for both intersections, and for the same LGA.

Table 83 Summary of community reliance metrics for each intersection on the Carpentaria Highway key freight route - most impacted LGA

	STUART HIGHWAY	TABLELANDS HIGHWAY
Destination LGA most reliant on the intersection	Roper Gulf (R)	Roper Gulf (R)
Relative reliance on intersection for destination LGA	0.39	0.40
Origin LGA most reliant on the intersection	Roper Gulf (R)	Roper Gulf (R)
Relative reliance on intersection for origin LGA	0.43	0.45

5.16.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Carpentaria Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 178 vehicle trips carrying 4,385 tonnes, 72% being essential commodities. Overall, 962 tonnes of freight are re-routed with an average detour length of 1,853 km and with an average increase in cost of $186.90 per tonne. A total value of supplies amounting to $6.6 million, $5.1 million being essential commodities, is unable to reach its destination.
- **Tablelands Highway intersection**: The closure of the Tablelands Highway intersection results in the disruption of 247 vehicle trips carrying 6,104 tonnes, 79% being essential commodities. Overall, 1,112 tonnes of freight are re-routed with an average detour length of 144 km and an average increase in cost of $16.67 per tonne. A total value of supplies amounting to $8.9 million, $7.8 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Carpentaria Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Carpentaria Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection.
- ‘Carpentaria Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed.

- ‘Carpentaria Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Carpentaria Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed.
- ‘Carpentaria Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Carpentaria Highway-cost_bar_plot.png’ shows the cost impacts of re-routing.
- ‘Carpentaria Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Carpentaria Highway.

KFR risk profile

Table 84 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for the two KFR intersections, the model is able to reach the maximum number of successive high-intensity alternative route closures of five, however their risk profile is different depending on the intersection.

The ‘Carpentaria Highway-*intersection*-detoured blocked plot.png’ plots provide details on the impacts from the successive closures for each intersection.

For the Stuart Highway intersection, nearly all freight can be re-routed until it reaches the second successive closure. On the third successive closure however, many detour options are exhausted and a large proportion of freight (80%) is no longer able to reach its destination, with that percentage remaining constant until the fifth iteration. The remainder of the freight that can be re-routed is however re-routed at an increased cost for each successive iteration.

The Tablelands Highway intersection successive closures result in nearly all its freight (80%) obstructed by the fifth iteration. Until the fourth iteration, however, the majority of freight can still be re-routed, albeit at a very high cost. At the fourth iteration when most freight is obstructed, the re-routing cost of the remaining freight is much reduced. This high cost of re-routing at the third iteration is reflected in Table 84 for the metric *KFR impacts risk - detour costs for intersection*.

Table 84 Risk metrics for modelled intersections on the Carpentaria Highway KFR

	STUART HIGHWAY	TABLELANDS HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.263	0.252
KFR impacts risk - detour costs for intersection	0.366	0.470
Last iteration	5	5

Freight impact

Table 85 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 85 Freight impact metrics for modelled intersections on the Carpentaria Highway KFR by last successive closure

		STUART HIGHWAY [%]	TABLELANDS HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	78	82
	Relative freight volume impacted – essential commodities	100	100
	Relative value of freight – all commodities	44	49
Re-routed supply chains	Relative detour cost – average	203	25
	Relative detour cost – maximum	522	448

The metrics in Table 85 indicate that the Stuart Highway intersection has very high volumes of freight obstructed (78% over all commodities) with 100% of its essential commodities obstructed. The value of these obstructed commodities represents 44% of the total value usually traversing the intersection. For the little freight that is able to be re-routed, this is done at very high-cost increase (200%), with some supply chains seeing up to 500% cost increase.

The Tablelands Highway intersection closure results in similar output - 82% of its freight is obstructed when considering all commodities, with 100% of essential commodities obstructed. By the fifth iteration, the cost increase is however much lower than for the freight detoured for the Stuart Highway intersection closure, with an average cost increase of 25%. However, freight costs increase up to 450% for some of the supply chains.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 86 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closure results in no LGAs impacted by obstructed essential commodities, and one out of 42 LGAs impacted when considering all commodities. The fuel sector is the most impacted for the Roper Gulf (R) LGA for which two supply chains with 550 weekly tonnes are unable to reach market. Only 0.6% of all commodities consumed by all the LGAs impacted will not reach their destination.

The Tablelands Highway intersection closure has four out of 39 LGAs with obstructed essential commodities, representing nearly 65% of all essential commodities consumed in the impacted LGAs. For non-essential commodities, 29 out of the 39 LGAs serviced by the intersection will have some of their freight obstructed, representing 10.5% of their overall consumption.

For both the Stuart Highway and the Tablelands Highway intersection closures, the Roper Gulf (R) LGA is the most impacted for the fuel sector, which represents a high percentage of the volumes consumed within the LGA. This means that the communities are very vulnerable to the closure of these intersections.

Table 86 Community impact metrics for modelled intersections on the Carpentaria Highway KFR - obstructed supply chains

			STUART HIGHWAY	TABLELANDS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/14	4/39
		Relative volumes impacted	65.7%	64.6%
	Most impacted LGA	Name of destination LGA	Roper Gulf (R)	Roper Gulf (R)
		Highest impacted commodity sector	Fuel	Fuel
		Commodity impacted	Diesel fuel	Diesel fuel
		Number of supply chains impacted	4	5
		Relative volumes impacted	79%	97%
		Weekly tonnes BAU	3,851.8	3,851.8
		Relative number of supply chains impacted	36%	45%
All commodities	All impacted LGAs	Number of LGAs impacted	12/14	29/39
		Relative volumes impacted	25.7%	10.5%
	Most impacted LGA	Name of destination LGA	Roper Gulf (R)	Roper Gulf (R)
		Highest impacted commodity sector	Fuel	Fuel
		Number of supply chains impacted	6	7
		Relative volumes impacted	73%	89%
		Weekly tonnes BAU	4,208.6	4,208.6
		Relative number of supply chains impacted	30%	35%

Re-routed supply chains

Table 87 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

Because most freight is obstructed for the Stuart Highway and the Tablelands Highway intersections, very little freight is re-routed. For the Stuart Highway intersection closure, no essential commodities are re-routed. When considering all commodities, Unincorporated NT LGA is the most impacted for the mining sector.

For the Tablelands Highway intersection closure, only one LGA is impacted by re-routed freight for essential commodities, while 28 out of 39 LGAs relying on the intersection have detours for their non-essential commodities; however, the detoured freight represents only 1.9% of all the goods consumed within these LGAs.

Table 87 Community impact metrics for modelled intersections on the Carpentaria Highway KFR - re-routed supply chains

			STUART HIGHWAY	TABLELANDS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/14	1/39
		Relative impact on volumes of commodities	0.0%	3.1%
	Most impacted LGA	Name	-	Roper Gulf(R)
		Highest impacted commodity sector	-	Construction
		Commodity impacted	-	Concrete
		Number of supply chains impacted	0	2
		Relative volumes impacted	0%	3%
		Weekly tonnes BAU	0.0	527.8
		Relative number of supply chains impacted	0%	13%
All commodities	All impacted LGAs	Number of LGAs impacted	10/14	28/39
		Relative impact on volumes of commodities	7.7%	1.9%
	Most impacted LGA	Name	Unincorporated NT	Unincorporated NT
		Highest impacted commodity sector	Mining	Mining
		Number of supply chains impacted	1	1
		Relative volumes impacted	15%	15%
		Weekly tonnes BAU	5,634.6	5,634.6
		Relative number of supply chains impacted	50%	50%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Carpentaria Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Carpentaria Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.17 Central Arnhem Road

Central Arnhem Road KFR (Figure 35) is a freight route located in NT. It connects LGAs between the Stuart Highway and Nhulunbuy in the north-east. The corridor is 675 km with at least part of the route used for the transport of $3.3m of product on 4,843 trailers annually carrying 85 thousand tonnes across 1431 supply chains spanning 29 commodities (43.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 2,353 trailers annually with the busiest sections carrying 4,346 trailers.

Construction transport represents approximately 50% of the total freight task with livestock contributing a further 12% and processed food and fuel a further 10%. This route is predominantly classified as PBS4a access.

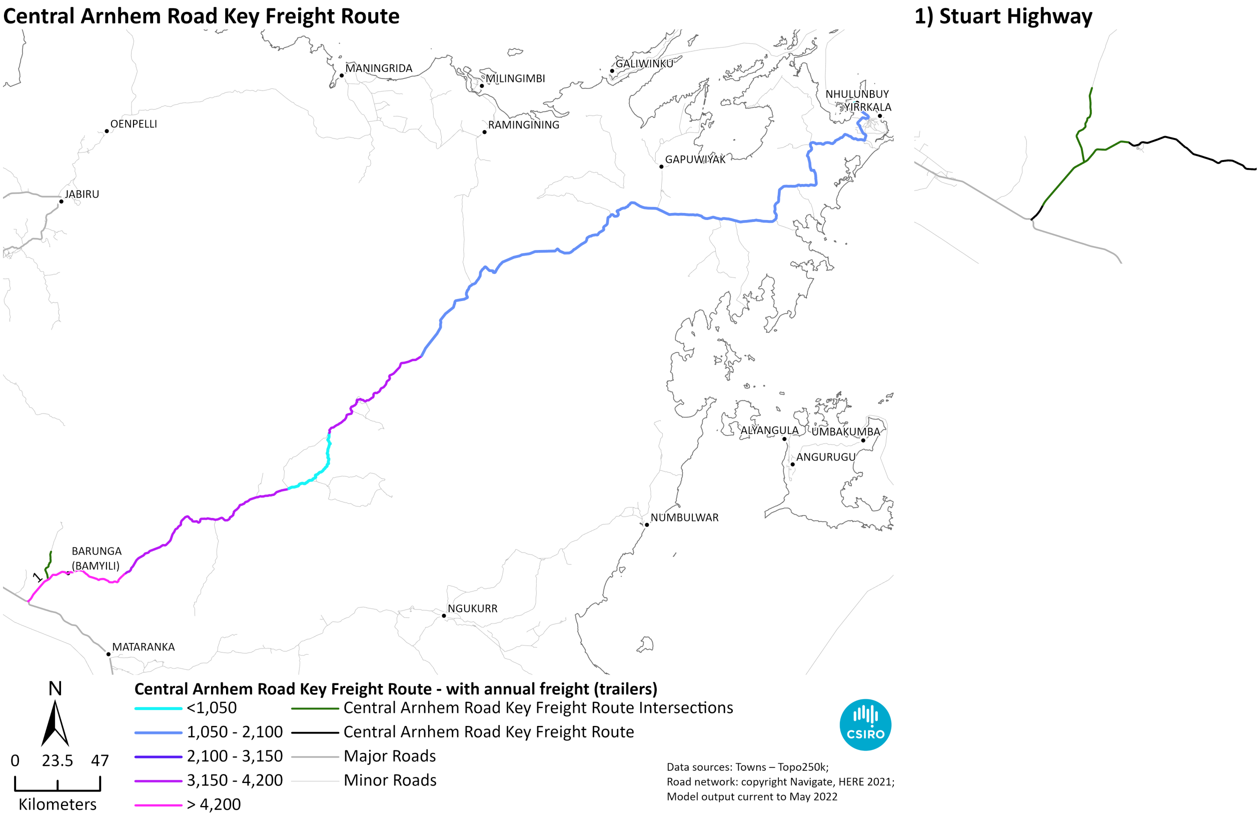

Figure 35 Central Arnhem Road KFR

Central Arnhem Road KFR passes through five LGAs but crucially it supports the supply chain paths for over 34 LGAs along its length and beyond. It provides access to essential commodities for three LGAs. Remote communities are reliant on this KFR to provide access to supplies and markets for most commodities. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersection identified as of strategic importance and used in the modelling and analysis was:

- Stuart Highway

The reliance described in Table 88 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Stuart Highway intersection is of very high importance to communities using the KFR, with 93% of all the supply chain paths traversing the intersection destined to the Unincorporated NT LGA. In terms of origin LGA, the reliance is less however still moderate for the Roper Gulf (R) LGA.

Table 88 Summary of community reliance metrics for each intersection on the Central Arnhem Highway key freight route - most impacted LGA

	STUART HIGHWAY
Destination LGA most reliant on the intersection	Unincorporated NT
Relative reliance on intersection for destination LGA	0.93
Origin LGA most reliant on the intersection	Roper Gulf (R)
Relative reliance on intersection for origin LGA	0.52

5.17.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Central Arnhem Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 83 vehicle trips carrying 1,511 tonnes, 46% being essential commodities. Overall, no supply chain have their freight re-routed. All supply chains are unable to reach their destination with a total value of supplies amounting to $4.3 million, $1.3 million being essential commodities.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Central Arnhem Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Central Arnhem Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Central Arnhem Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Central Arnhem Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Central Arnhem Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Central Arnhem Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Central Arnhem Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Central Arnhem Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Central Arnhem Highway.

KFR risk profile

Table 89 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for the KFR intersection, the model is not able to reach the maximum number of successive high-intensity alternative route closures of five, and stops at two. As such, all freight is obstructed by the second iteration, and no freight is detoured.

Table 89 Risk metrics for modelled intersections on the Central Arnhem Highway KFR

	STUART HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.503
KFR impacts risk - detour costs for intersection	0.000
Last iteration	2

Freight impact

Table 90 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 90 Freight impact metrics for modelled intersections on the Central Arnhem Highway KFR by last successive closure

		STUART HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	100
	Relative freight volume impacted – essential commodities	100
	Relative value of freight – all commodities	100
Re-routed supply chains	Relative detour cost – average	-
	Relative detour cost – maximum	-

The metrics in Table 90 indicate that the Stuart Highway intersection has all volumes of freight obstructed.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 91 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closure results in three LGAs out of 16 impacted by obstructed essential commodities, and all LGAs are impacted when considering all commodities. All sectors are impacted.

Table 91 Community impact metrics for modelled intersections on the Central Arnhem Highway KFR - obstructed supply chains

			STUART HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	3/16
		Relative volumes impacted	75.9%
	Most impacted LGA	Name of destination LGA	East Arnhem (R)
		Highest impacted commodity sector	Processed Food
		Commodity impacted	Box Rice
		Number of supply chains impacted	1
		Relative volumes impacted	100%
		Weekly tonnes BAU	0.3
		Relative number of supply chains impacted	100%
All commodities	All impacted LGAs	Number of LGAs impacted	16/16
		Relative volumes impacted	7.8%
	Most impacted LGA	Name of destination LGA	East Arnhem (R)
		Highest impacted commodity sector	General
		Number of supply chains impacted	2
		Relative volumes impacted	100%
		Weekly tonnes BAU	1.6
		Relative number of supply chains impacted	100%

Re-routed supply chains

Table 92 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

Because all freight is obstructed for the Stuart Highway, no freight is re-routed.

Table 92 Community impact metrics for modelled intersections on the Central Arnhem Highway KFR - re-routed supply chains

			STUART HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/16
		Relative impact on volumes of commodities	0.0%
	Most impacted LGA	Name	-
		Highest impacted commodity sector	-
		Commodity impacted	-
		Number of supply chains impacted	0
		Relative volumes impacted	0%
		Weekly tonnes BAU	0.0
		Relative number of supply chains impacted	0%
All commodities	All impacted LGAs	Number of LGAs impacted	0/16
		Relative impact on volumes of commodities	0.0%
	Most impacted LGA	Name	-
		Highest impacted commodity sector	-
		Number of supply chains impacted	-
		Relative volumes impacted	0
		Weekly tonnes BAU	0%
		Relative number of supply chains impacted	0.0

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Central Arnhem Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Central Arnhem Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.18 Coolgardie – Esperance Highway

The Coolgardie – Esperance Highway KFR (Figure 36) is a freight route located in WA. It connects LGAs from Coolgardie to Esperance. The corridor is 370 km with at least part of the route used for the transport of $73m of product on 324,227 trailers annually carrying 7.3 million tonnes across 17,859 supply chains spanning 106 commodities (8.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 91,509 trailers annually with the busiest sections carrying 155,683 trailers.

Cropping transport represents approximately 55% of the total freight task, with critical links from properties to silos and on to port. Mining contributes a further 15% and fuel a further 10% of the total freight task. The KFR provides an important role in providing access to markets for primary produce with 40% of all movements originating at a property. Equally important is its role in providing access to silos with 35% of movements having a destination at a port. This route is predominantly classified as PBS3a access

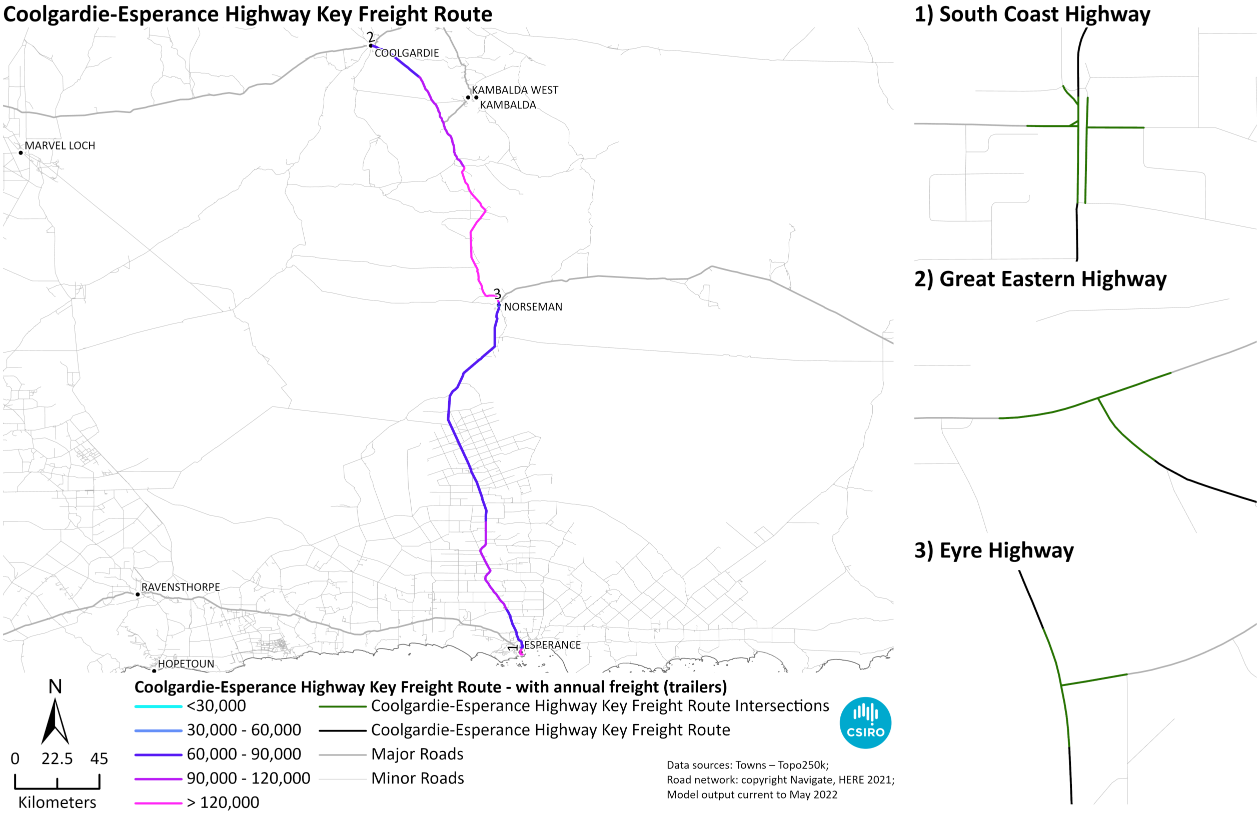

Figure 36 Coolgardie – Esperance Highway KFR

The Coolgardie – Esperance Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 353 LGAs along its length and beyond. It provides access to essential commodities for 52 LGAs. Many LGAs including Coolgardie (S) and Esperance (S) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Eyre Highway
- Great Eastern Highway
- South Coast Highway

The reliance described in Table 93 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Cockburn (C) LGA is the most reliant of all the LGAs whose freight traverse the Eyre Highway and the Great Eastern Highway intersections. This reliance is low to moderate with 17% (Eyre Highway) and 23% (Great Eastern Highway) of the supply chain paths imported relying on these intersections to move. For the South Coast Highway intersection, Esperance (S) is the most reliant LGA for both origin and destination freight, with a high to very high value.

Table 93 Summary of community reliance metrics for each intersection on the Coolgardie – Esperance Highway key freight route - most impacted LGA

	SOUTH COAST HIGHWAY	EYRE HIGHWAY	GREAT EASTERN HIGHWAY
Destination LGA most reliant on the intersection	Esperance (S)	Cockburn (C)	Cockburn (C)
Relative reliance on intersection for destination LGA	0.60	0.17	0.23
Origin LGA most reliant on the intersection	Esperance (S)	Esperance (S)	Gingin (S)
Relative reliance on intersection for origin LGA	0.93	0.07	0.10

5.18.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Coolgardie – Esperance Highway. The results are based on expected freight for an average week.

- **South Coast Highway intersection:** The closure of the South Coast Highway intersection results in the disruption of 3,019 vehicle trips carrying 76,239 tonnes, 2% being essential commodities. Overall, 76,045 tonnes of freight are re-routed with an average detour length of 25 km and with an average increase in cost of $6.00 per tonne. A total value of supplies amounting to $1.6 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Eyre Highway intersection:** The closure of the Eyre Highway intersection results in the disruption of 2,692 vehicle trips carrying 49,956 tonnes, 21% being essential commodities. Overall, 46,575 tonnes of freight are re-routed with an average detour length of 37 km and with an average increase in cost of $29.79 per tonne. A total value of supplies amounting to $4.3 million, $0.7 million being essential commodities, is unable to reach its destination.
- **Great Eastern Highway intersection:** The closure of the Great Eastern Highway intersection results in the disruption of 1,372 vehicle trips carrying 21,435 tonnes, 13% being essential commodities. Overall, 21,433 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $13.81 per tonne. A negligible value of supplies is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Coolgardie – Esperance Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Coolgardie – Esperance Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Coolgardie – Esperance Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Coolgardie – Esperance Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Coolgardie – Esperance Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Coolgardie – Esperance Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Coolgardie – Esperance Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Coolgardie – Esperance Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Coolgardie – Esperance Highway.

KFR risk profile

Table 94 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Coolgardie – Esperance Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be quite costly.

Table 94 Risk metrics for modelled intersections on the Coolgardie – Esperance Highway KFR

	SOUTH COAST HIGHWAY	EYRE HIGHWAY	GREAT EASTERN HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.016	0.000
KFR impacts risk - detour costs for intersection	0.057	0.015	0.011
Last iteration	5	5	5

Freight impact

Table 95 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 95 Freight impact metrics for modelled intersections on the Coolgardie – Esperance Highway KFR

		SOUTH COAST HIGHWAY [%]	EYRE HIGHWAY [%]	GREAT EASTERN HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	7	0
	Relative freight volume impacted – essential commodities	11	4	0
	Relative value of freight – all commodities	1	1	0
Re-routed supply chains	Relative detour cost – average	44	2	1
	Relative detour cost – maximum	265	319	147

The metrics in Table 95Table 75 indicate the supply chains traversing the Eyre Highway and the Great Eastern Highway intersections that are likely to be re-routed will do so with their average cost increasing by 2% and 1% respectively, on average. These increases are very low, with the highest increase in cost being 319% and 147% for some of the supply chains.

The increase in costs for re-routing from the South Coast Highway intersection closure are higher than for the other intersections, being 44% on average, with the highest increase in cost reaching 265% for some of the supply chains.

Little to no freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 96 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of the three intersections results in one LGA impacted for essential commodities, with the impacted sector being fuel. However, the impacted LGA is different in the three cases.

The South Coast Highway intersection closure results in nearly 17% of the freight volumes for essential commodities obstructed. When considering all commodities, the impact on the two LGAs not receiving freight is 13% for commodities consumed within the LGA not reaching their destination, with the vehicles sector the most impacted.

The closure of the Eyre Highway intersection results in one out of 179 LGAs serviced by the intersections having obstructed essential commodities, which represents 37% of the consumption of this impacted LGA. The most impacted LGA is the Dundas (S) LGA. When considering all commodities, the impact is lower, however not negligible, with six out of the 179 LGAs not receiving commodities, representing less than 14.5% of their goods consumed.

The closure of the Great Eastern Highway intersection results in one out of 124 LGAs serviced by the intersections having obstructed essential commodities, which represents 33% of the consumption of this impacted LGA. The most impacted LGA is the Coolgardie (S) LGA. When considering all commodities, the impact is much lower, with one out of the 124 LGAs not receiving commodities, representing less than 1% of their goods consumed.

Table 96 Community impact metrics for modelled intersections on the Coolgardie – Esperance Highway KFR - obstructed supply chains

			SOUTH COAST HIGHWAY	EYRE HIGHWAY	GREAT EASTERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/38	1/179	1/124
		Relative volumes impacted	16.7%	37.0%	33.3%
	Most impacted LGA	Name of destination LGA	Esperance(S)	Dundas(S)	Coolgardie(S)
		Highest impacted commodity sector	Fuel	Fuel	Fuel
		Commodity impacted	Diesel fuel	Diesel fuel	LPG
		Number of supply chains impacted	1	3	1
		Relative volumes impacted	22%	48%	33%
		Weekly tonnes BAU	273.8	294.1	4.3
		Relative number of supply chains impacted	17%	43%	33%
All commodities	All impacted LGAs	Number of LGAs impacted	2/38	6/179	1/124
		Relative volumes impacted	13.1%	14.5%	0.1%
	Most impacted LGA	Name of destination LGA	Esperance(S)	Dundas(S)	Coolgardie(S)
		Highest impacted commodity sector	Vehicles	Livestock	Fuel
		Number of supply chains impacted	4	1	1
		Relative volumes impacted	49%	100%	0%
		Weekly tonnes BAU	85.2	1.5	2,181.9
		Relative number of supply chains impacted	16%	100%	6%

Re-routed supply chains

Table 97 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The South Coast Highway intersection closure results in three LGAs out of 38 having re-routed supply chains for essential commodities, representing 71% of the volumes that are normally received by these LGAs. Esperance (S) is the most impacted LGA with one supply chain for the processed food industry obstructed, representing 100% of the bread consumption of the LGA. When considering all commodities, Esperance (S) is again the most impacted, for wood products. The overall volumes impacted by re-routing represent nearly 27% of the commodities consumed within the 37 impacted LGAs.

For the Eyre Highway and the Great Eastern Highway intersection closures, many more LGAs are impacted by re-routing freight, however the relative impact of these closures on these LGAs is much lower. For essential commodities, 8.4% (Eyre Highway intersection) and 7% (Great Eastern Highway intersection) of the volumes of essential commodities that are normally consumed by the 46 and 24 impacted LGAs serviced by each intersection respectively, are expected to be re-routed. When considering all commodities, the impact is even lower with 3.7% (Eyre Highway intersection) and 2.5% (Great Eastern Highway intersection) of the volumes of commodities normally received by the LGAs impacted by re-routing.

Table 97 Community impact metrics for modelled intersections on the Coolgardie – Esperance Highway KFR - re-routed supply chains

			SOUTH COAST HIGHWAY	EYRE HIGHWAY	GREAT EASTERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	3/38	46/179	24/124
		Relative impact on volumes of commodities	71.0%	8.4%	7.0%
	Most impacted LGA	Name	Esperance(S)	Canning(C)	Canning(C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Fish	Fish
		Number of supply chains impacted	1	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.7	40.7	40.7
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	37/38	177/179	124/124
		Relative impact on volumes of commodities	26.7%	3.7%	2.5%
	Most impacted LGA	Name	Esperance(S)	Menzies(S)	Coolgardie(S)
		Highest impacted commodity sector	Wood Product	Fuel	General
		Number of supply chains impacted	2	1	4
		Relative volumes impacted	100%	89%	95%
		Weekly tonnes BAU	139.9	1,157.0	41.4
		Relative number of supply chains impacted	100%	25%	67%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Coolgardie – Esperance Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Coolgardie – Esperance Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.19 Cunningham Highway

The Cunningham Highway KFR (Figure 37) is a freight route located in south-eastern Queensland. It connects LGAs from Goondiwindi through Warwick to Brisbane. The corridor is 339 km with at least part of the route used for the transport of $162m of product on 437,163 trailers annually carrying eight million tonnes across 30,297 supply chains spanning 123 commodities (30% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 44,726 trailers annually with the busiest sections carrying 228,168 trailers.

Cropping transport represents approximately 20% of the total freight task, with fuel and general freight each adding a further 15% and livestock, construction and horticulture adding 10% each to the total freight task. The KFR provides an important role in providing access to markets for primary produce with 30% of all movements originating at a property. Equally important is its role in providing access to DCs with 25% of movements having a destination at a DC. This route is predominantly classified as PBS2a through to PBS3a access.

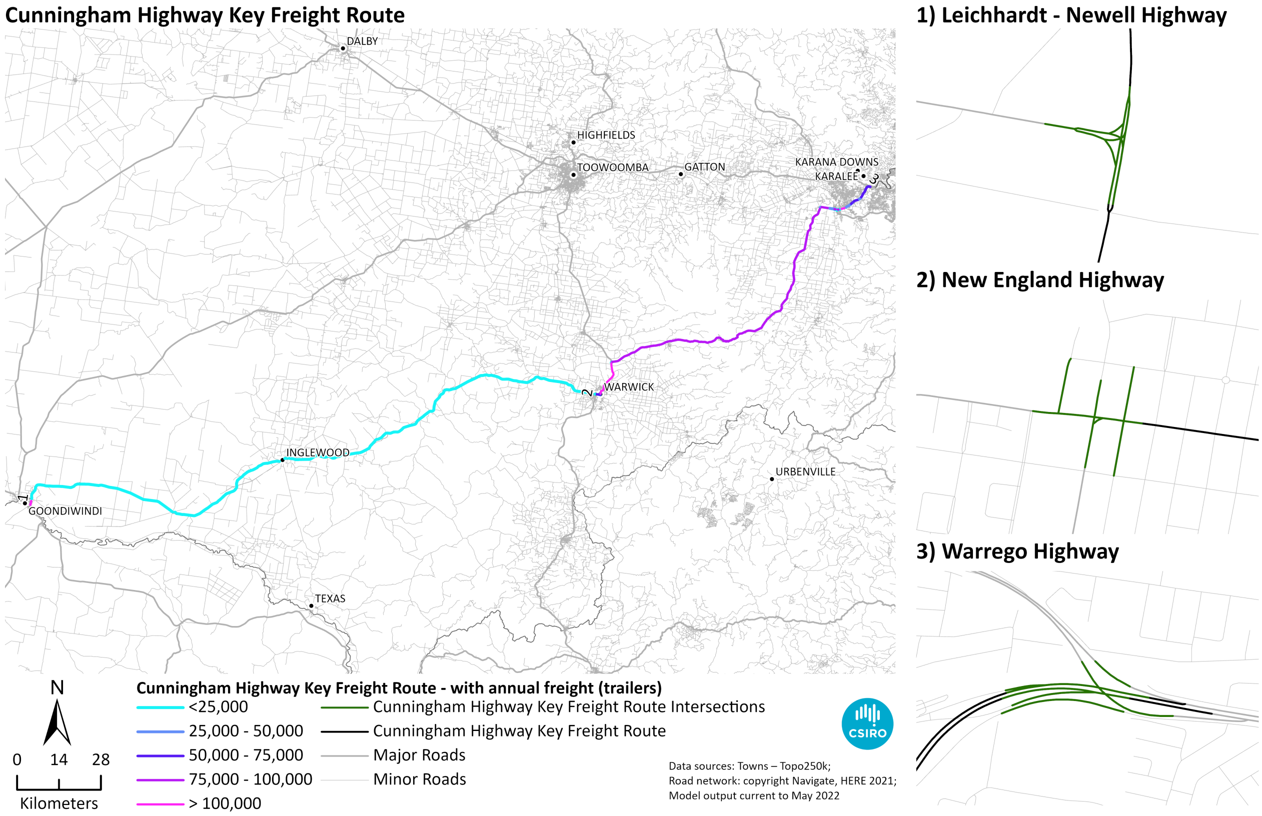

Figure 37 Cunningham Highway KFR

The Cunningham Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 385 LGAs along its length and beyond. It provides access to essential commodities for 115 LGAs. Many LGAs including Southern Downs (R) and Inverell (A) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Warrego Highway
- New England Highway
- Leichhardt – Newell Highway

The reliance described in Table 98 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Brisbane (C) LGA is the most reliant of all the LGAs whose freight traverse the Leichhardt – Newell Highway and the Warrego Highway intersections. This reliance is moderate to high with 29% (Leichhardt – Newell Highway) and 58% (Warrego Highway) of the supply chain paths imported relying on these intersections to move. For the New England Highway intersection, Southern Downs (R) is the most reliant LGA for both origin and destination freight, with a low to moderate value.

Table 98 Summary of community reliance metrics for each intersection on the Cunningham Highway key freight route - most impacted LGA

	LEICHHARDT – NEWELL HIGHWAY	NEW ENGLAND HIGHWAY	WARREGO HIGHWAY
Destination LGA most reliant on the intersection	Brisbane (C)	Southern Downs (R)	Brisbane (C)
Relative reliance on intersection for destination LGA	0.29	0.17	0.58
Origin LGA most reliant on the intersection	Mareeba (S)	Southern Downs (R)	Brisbane (C)
Relative reliance on intersection for origin LGA	0.06	0.27	0.19

5.19.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Cunningham Highway. The results are based on expected freight for an average week.

- **Leichhardt – Newell Highway intersection**: The closure of the Leichhardt – Newell Highway intersection results in the disruption of 4,638 vehicle trips carrying 84,841 tonnes, 19% being essential commodities. Overall, 84,316 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $3.96 per tonne. A total value of supplies amounting to $0.9 million, $0.8 million being essential commodities, is unable to reach its destination.
- **New England Highway intersection**: The closure of the New England Highway intersection results in the disruption of 1,488 vehicle trips carrying 28,463 tonnes, 50% being essential commodities. Overall, 27,811 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $1.28 per tonne. A total value of supplies amounting to $0.6 million, $0.4 million being essential commodities, is unable to reach its destination.
- Warrego Highway intersection: The closure of the Warrego Highway intersection results in the disruption of 4,235 vehicle trips carrying 75,220 tonnes, 35% being essential commodities. Overall, 75,216 tonnes of freight are re-routed with an average detour length of two km and with an average increase in cost of $3.37 per tonne. A total value of supplies

amounting to $0.0 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Cunningham Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Cunningham Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Cunningham Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Cunningham Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Cunningham Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Cunningham Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Cunningham Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Cunningham Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Cunningham Highway.

KFR risk profile

Table 99 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Cunningham Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be quite costly.

Table 99 Risk metrics for modelled intersections on the Cunningham Highway KFR

	LEICHHARDT – NEWELL HIGHWAY	NEW ENGLAND HIGHWAY	WARREGO HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.003	0.005	0.000
KFR impacts risk - detour costs for intersection	0.004	0.004	0.005
Last iteration	5	5	5

Freight impact

Table 100 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 100 Freight impact metrics for modelled intersections on the Cunningham Highway KFR

		LEICHHARDT – NEWELL HIGHWAY [%]	NEW ENGLAND HIGHWAY [%]	WARREGO HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	2	0
	Relative freight volume impacted – essential commodities	3	2	0
	Relative value of freight – all commodities	2	1	0
Re-routed supply chains	Relative detour cost – average	5	4	4
	Relative detour cost – maximum	814	104	62

The metrics in Table 100 indicate the supply chains traversing the three intersections that are likely to be re-routed will do so with a low average cost increase of 5% (Leichhardt – Newell Highway), 4% (New England Highway) and 1% (Warrego Highway). These increases are very low, with the highest increase in cost being 814%, 104% and 62% respectively for some of the supply chains.

Little to no freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 101 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Leichhardt – Newell Highway intersection closure results in two out of 309 LGAs serviced by the intersection having obstructed essential commodities, which represents 8% of the freight volumes for essential commodities obstructed. When considering all commodities, the impact on the three LGAs not receiving freight is 4% of the commodities consumed within the LGA not reaching their destination, with the fuel sector the most impacted for the most impacted LGA.

The closure of the New England Highway intersection results in one out of 112 LGAs serviced by the intersection having obstructed essential commodities, which represents 14% of the consumption of this impacted LGA. The most impacted LGA is the Southern Downs (R) LGA. When considering all commodities, the impact is low, with six out of the 112 LGAs not receiving commodities, representing 1.3% of their goods consumed.

The closure of the Warrego Highway intersection results in no LGAs serviced by the intersections having obstructed essential commodities. When considering all commodities, the impact is very lower, with one out of the 190 LGAs not receiving commodities, representing less than 1% of their goods consumed.

Table 101 Community impact metrics for modelled intersections on the Cunningham Highway KFR - obstructed supply chains

			LEICHHARDT – NEWELL HIGHWAY	NEW ENGLAND HIGHWAY	WARREGO HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/309	1/112	0/190
		Relative volumes impacted	8.2%	14.3%	0.0%
	Most impacted LGA	Name of destination LGA	Goondiwindi(R)	Southern Downs(R)	-
		Highest impacted commodity sector	Fuel	Fuel	-
		Commodity impacted	Unleaded fuel	Diesel fuel	-
		Number of supply chains impacted	2	2	0
		Relative volumes impacted	18%	15%	0%
		Weekly tonnes BAU	892.5	699.0	0.0
		Relative number of supply chains impacted	17%	14%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	3/309	6/112	1/190
		Relative volumes impacted	4.0%	1.3%	0.1%
	Most impacted LGA	Name of destination LGA	Southern Downs(R)	Southern Downs(R)	Ipswich(C)
		Highest impacted commodity sector	Fuel	Fuel	Waste
		Number of supply chains impacted	4	6	1
		Relative volumes impacted	14%	14%	0%
		Weekly tonnes BAU	1,816.8	1,816.8	3,169.4
		Relative number of supply chains impacted	10%	15%	0%

Re-routed supply chains

Table 102 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Leichhardt – Newell Highway intersection closure results in 95 LGAs out of 309 having re-routed supply chains for essential commodities, representing 7.2% of the volumes that are normally received by these LGAs. Canning (C) is the most impacted LGA with two supply chains for the processed food industry re-routed, representing 100% of the prawn consumption of the LGA. When considering all commodities, Horsham (RC) is the most impacted, for the construction industry. When considering all commodities, the impact is even lower with 4.1% of the volumes of commodities normally received by the LGAs impacted by re-routing.

For the New England Highway and the Warrego Highway intersection closures, 45 out of 112 LGAs, and 49 out of 190 LGAs, respectively, are impacted by re-routing freight. The impact on essential commodities is low to moderate with 17% (New England Highway intersection) and 9.5% (Warrego Highway intersection) of the volumes of essential commodities that are normally received by the 46 and 24 impacted LGAs serviced by each intersection respectively, expected to be re-routed. When considering all commodities, the impact is even lower with 3.3% (New England Highway intersection) and 4.8% (Warrego Highway intersection) of the volume of commodities normally consumed by the LGAs impacted by re-routing. In both cases, the most impacted LGA for essential commodities is Inverell (A) LGA where seven supply chains for the horticulture industry are re-routed, representing 100% of the fruit consumption of the LGA. When considering all commodities, the Glen Innes Severn (A) LGA is the most impacted where 24 supply chains for general freight are expected to be rerouted.

Table 102 Community impact metrics for modelled intersections on the Cunningham Highway KFR - re-routed supply chains

			LEICHHARDT – NEWELL HIGHWAY	NEW ENGLAND HIGHWAY	WARREGO HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	95/309	45/112	49/190
		Relative impact on volumes of commodities	7.2%	17.0%	9.5%
	Most impacted LGA	Name	Canning(C)	Inverell(A)	Inverell(A)
		Highest impacted commodity sector	Processed Food	Horticulture	Horticulture
		Commodity impacted	Prawn	Fruit	Fruit
		Number of supply chains impacted	2	7	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	17.2	41.0	41.0
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	306/309	112/112	188/190
		Relative impact on volumes of commodities	4.1%	3.3%	4.8%
	Most impacted LGA	Name	Horsham (RC)	Glen Innes Severn(A)	Glen Innes Severn(A)
		Highest impacted commodity sector	Construction	General	General
		Number of supply chains impacted	1	24	24
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	96.2	249.5	249.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Cunningham Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Cunningham Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.20 D'Aguilar Highway

The D'Aguilar Highway KFR (**Error! Reference source not found.**) is a freight route located in Q ueensland. It connects LGAs from the Bruce Highway at Caboolture to Kingaroy and the Bunya Highway in the south-east. The corridor is 168 km with at least part of the route used for the transport of $34m of product on 118 thousand trailers annually carrying 2.4 million tonnes across 7181 supply chains spanning 80 commodities (45% classified as essential commodities).

Fuel and wood product transport each represent approximately 25% of the total freight task. Livestock movements add 20% with movements from property to abattoir being a large proportion. Processed food adds 12% to the freight task including product leaving abattoirs and raw milk collection for dairy processing. This route is predominantly classified as PBS2a access.

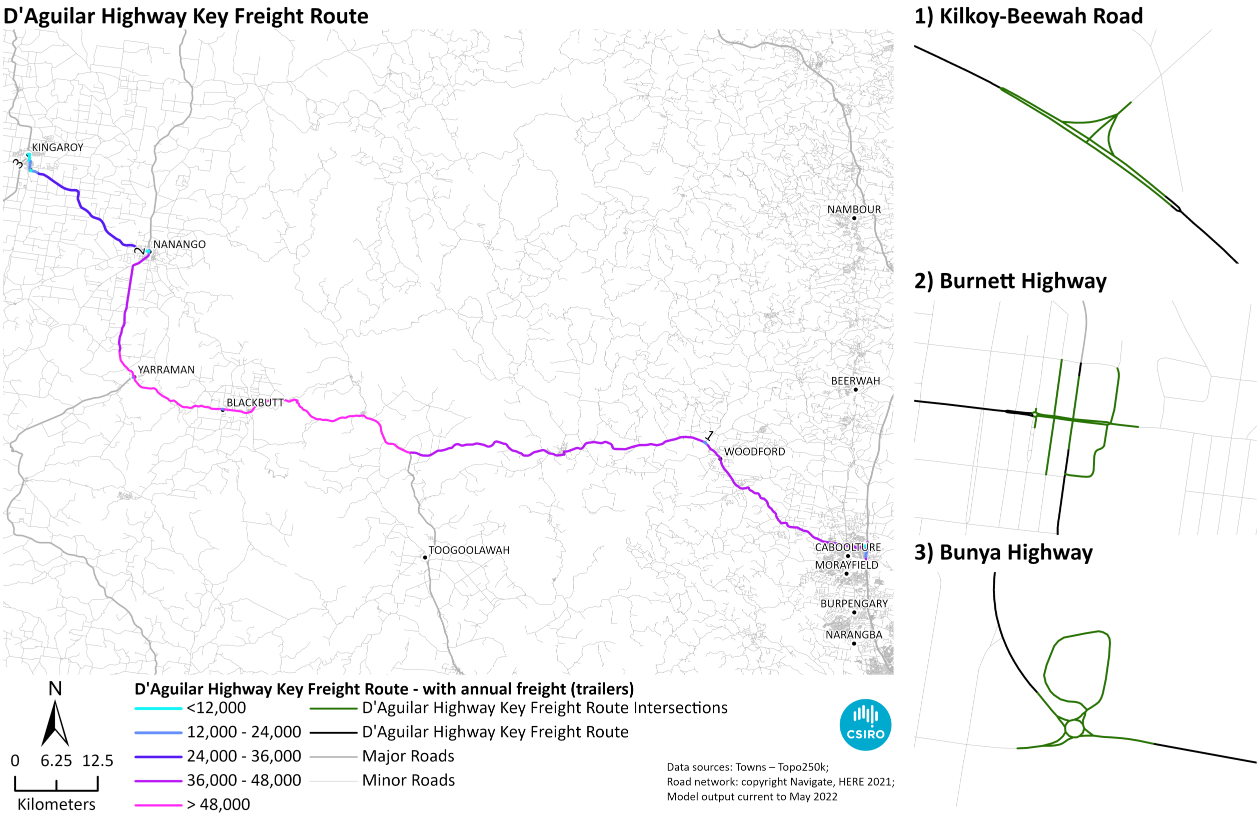

Figure 38 D'Aguilar Highway KFR

The D'Aguilar Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 152 LGAs along its length and beyond. It provides access to essential commodities for 51 LGAs. Somerset (R) and South Burnett (R) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Burnett Highway
- Bunya Highway
- Kilcoy – Beerwah Road

The reliance described in **Error! Reference source not found.** equates to risk factor and highlights t he importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the South Burnett (R) LGA is moderately reliant on the Bunya Highway intersection, while the Somerset (R) LGA and the Gympie (R) LGA are little to moderately reliant on the Kilcoy – Beerwah Road and Burnett Highway intersections, respectively, as a destination LGA.

Table 103 Summary of community reliance metrics for each intersection on the D'Aguilar Highway key freight route - most impacted LGA

	KILCOY – BEERWAH ROAD	BUNYA HIGHWAY	BURNETT HIGHWAY
Destination LGA most reliant on the intersection	Somerset (R)	South Burnett (R)	Gympie (R)
Relative reliance on intersection for destination LGA	0.24	0.40	0.25
Origin LGA most reliant on the intersection	Somerset (R)	South Burnett (R)	Toowoomba (R)
Relative reliance on intersection for origin LGA	0.21	0.63	0.19

5.20.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the D'Aguilar Highway. The results are based on expected freight for an average week.

- **Kilcoy – Beerwah Road intersection**: The closure of the Kilcoy – Beerwah Road intersection results in the disruption of 845 vehicle trips carrying 18,501 tonnes, 64% being essential commodities. Overall, 18,494 tonnes of freight are re-routed with an average detour length of 28 km and with an average increase in cost of $7.68 per tonne. Little freight is unable to reach its destination.
- **Bunya Highway intersection**: The closure of the Bunya Highway intersection results in the disruption of 461 vehicle trips carrying 10,619 tonnes, 82% being essential commodities. Overall, 10,536 tonnes of freight are re-routed with an average detour length of one km and with an average increase in cost of $3.71 per tonne. Little freight is unable to reach its destination.
- **Burnett Highway intersection**: The closure of the Burnett Highway intersection results in the disruption of 323 vehicle trips carrying 6,541 tonnes, 18% being essential commodities. Overall, 6,269 tonnes of freight are re-routed with an average detour length of eight km and with an average increase in cost of $3.61 per tonne. A total value of supplies amounting to $1.8 million, $0.3 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the D'Aguilar Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'D'Aguilar Highway-*intersection*-monthly bau volumes.png' shows the BAU freight (monthly volumes) using the specific intersection

- ‘D’Aguilar Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘D’Aguilar Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘D’Aguilar Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘D’Aguilar Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘D’Aguilar Highway-cost bar plot.png’ shows the cost impacts of re-routing
- ‘D’Aguilar Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the D’Aguilar Highway.

KFR risk profile

Error! Reference source not found. provides the results of the simulation from closing intersections a nd subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The ‘D’Aguilar Highway-*intersection*-cumulative impact.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 104 Risk metrics for modelled intersections on the D’Aguilar Highway KFR – the model

	KILCOY – BEERWAH ROAD	BUNYA HIGHWAY	BURNETT HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.008	0.033
KFR impacts risk - detour costs for intersection	0.065	0.025	0.010
Last iteration	5	5	5

Freight impact

Error! Reference source not found. provides a summary of the metrics for obstructed and re-routed s upply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 105 Freight impact metrics for modelled intersections on the D'Aguilar Highway KFR

		KILCOY – BEERWAH ROAD [%]	BUNYA HIGHWAY [%]	BURNETT HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	1	4
	Relative freight volume impacted – essential commodities	0	0	12
	Relative value of freight – all commodities	0	4	7
Re-routed supply chains	Relative detour cost – average	30	11	7
	Relative detour cost – maximum	861	65	43

The metrics in **Error! Reference source not found.** indicate the supply chains traversing the Kilcoy – B eerwah Road intersection that are likely to be re-routed will do so with their average cost increasing moderately (30%) while those traversing the Bunya Highway and the Burnett Highway will do so with a slight increase (11% and 7% respectively) over all commodities. The routes most impacted by detours reach a maximum increase cost of 861% (Kilcoy – Beerwah Road intersection).

For all three intersections, the obstructed freight is minimal[6].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Error! Reference source not found. provides a summary of the obstructed supply chains including t he number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Kilcoy – Beerwah Road closure results in no LGAs having obstructed supply chains, for essential commodities. When considering all commodities, the closure of the Kilcoy – Beerwah Road intersection results in three LGAs having obstructed supply chains, representing 0.1% of the volumes that are normally received by these LGAs. Moreton Bay (R) is the most impacted LGA with one supply chain for the livestock industry obstructed.

The Bunya Highway intersection closure results in no LGAs having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Bunya Highway intersection results in one LGA having obstructed supply chains, representing 4.8% of the volumes that are normally received by this LGA serviced by the intersection.

The Burnett Highway intersection closure results in one LGA serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Burnett Highway intersection results in the same LGA having obstructed supply chains,

[6] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

representing 1.9% of the volumes that are normally received by this LGA. South Burnett (R) is the most impacted LGA with five supply chains obstructed for general freight.

Table 106 Community impact metrics for modelled intersections on the D'Aguilar Highway KFR - obstructed supply chains

			KILCOY – BEERWAH ROAD	BUNYA HIGHWAY	BURNETT HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/53	0/34	1/43
		Relative volumes impacted	0.0%	0.0%	1.8%
	Most impacted LGA	Name of destination LGA	-	-	South Burnett(R)
		Highest impacted commodity sector	-	-	Fuel
		Commodity impacted	-	-	LPG
		Number of supply chains impacted	0	0	1
		Relative volumes impacted	0%	0%	7%
		Weekly tonnes BAU	0.0	0.0	11.8
		Relative number of supply chains impacted	0%	0%	7%
All commodities	All impacted LGAs	Number of LGAs impacted	3/53	1/34	1/43
		Relative volumes impacted	0.1%	4.8%	1.9%
	Most impacted LGA	Name of destination LGA	Moreton Bay (R)	South Burnett(R)	South Burnett(R)
		Highest impacted commodity sector	Livestock	Vehicles	General
		Number of supply chains impacted	1	7	5
		Relative volumes impacted	0%	14%	12%
		Weekly tonnes BAU	1,881.4	137.8	739.8
		Relative number of supply chains impacted	0%	25%	8%

Re-routed supply chains

Error! Reference source not found. provides a summary of the re-routed supply chains including t he number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 6.5% of the supply chains are expected to be re-routed for 20 of the 53 LGAs that traverse the Kilcoy – Beerwah Road intersection. The most impacted LGA is South Burnett (R), with five supply chains in the fuel sector representing 6,443 tonnes of diesel fuel per week re-routed. For non-essential commodities, all of the 53 LGAs serviced by the Kilcoy – Beerwah Road intersection are impacted by re-routed freight, representing 2% of the total volumes consumed within these LGAs.

For the Bunya Highway intersection, 11 of the 34 LGAs serviced are expected to have freight re-routed, with this representing 8.1% of essential commodities consumed within the impacted LGAs.

For non-essential commodities, all of the 34 LGAs serviced by the Bunya Highway intersection are impacted by re-routed freight, representing 2.9% of the total volume consumed within these LGAs.

For the Burnett Highway intersection, 12 of the 43 LGAs serviced are expected to have freight re-routed, representing 3.9% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 43 LGAs serviced by the Burnett Highway intersection are impacted by re-routed freight, representing less than 2% of the total volume consumed within these LGAs.

Table 107 Community impact metrics for modelled intersections on the D'Aguilar Highway KFR - re-routed supply chains

			KILCOY – BEERWAH ROAD	BUNYA HIGHWAY	BURNETT HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	20/53	11/34	12/43
		Relative impact on volumes of commodities	6.5%	8.1%	3.9%
	Most impacted LGA	Name	South Burnett(R)	South Burnett(R)	Gympie(R)
		Highest impacted commodity sector	Fuel	Fuel	Construction
		Commodity impacted	Diesel fuel	Diesel fuel	Cement
		Number of supply chains impacted	5	5	1
		Relative volumes impacted	91%	79%	47%
		Weekly tonnes BAU	6,443.5	6,443.5	65.4
		Relative number of supply chains impacted	29%	29%	50%
All commodities	All impacted LGAs	Number of LGAs impacted	53/53	34/34	43/43
		Relative impact on volumes of commodities	2.0%	2.9%	1.7%
	Most impacted LGA	Name	South Burnett(R)	South Burnett(R)	South Burnett(R)
		Highest impacted commodity sector	Fuel	Fuel	Wood Product
		Number of supply chains impacted	19	15	39
		Relative volumes impacted	80%	70%	36%
		Weekly tonnes BAU	7,605.9	7,605.9	852.3
		Relative number of supply chains impacted	41%	33%	17%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'D'Aguilar Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'D'Aguilar Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.21 Dukes Highway

The Dukes Highway KFR (Figure 39) is a freight route located in SA. It connects LGAs between the Victoria border to Talem Bend in SA. The corridor is 195 km with at least part of the route used for the transport of $103m of product on 408,604 trailers annually carrying 7.8 million tonnes across 21,355 supply chains spanning 114 commodities (25% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 246,927 trailers annually with the busiest sections carrying 330,519 trailers.

Cropping transport represents approximately 25% of the total freight task, with fuel and general freight each adding a further 20% and livestock adding 10% to the total freight task. The KFR provides an important role in providing access to markets for primary produce with 33% of all movements originating at a property. Equally important is its role in providing access to DCs with 20% of movements having a destination at a DC. This route is predominantly classified as PBS3a access.

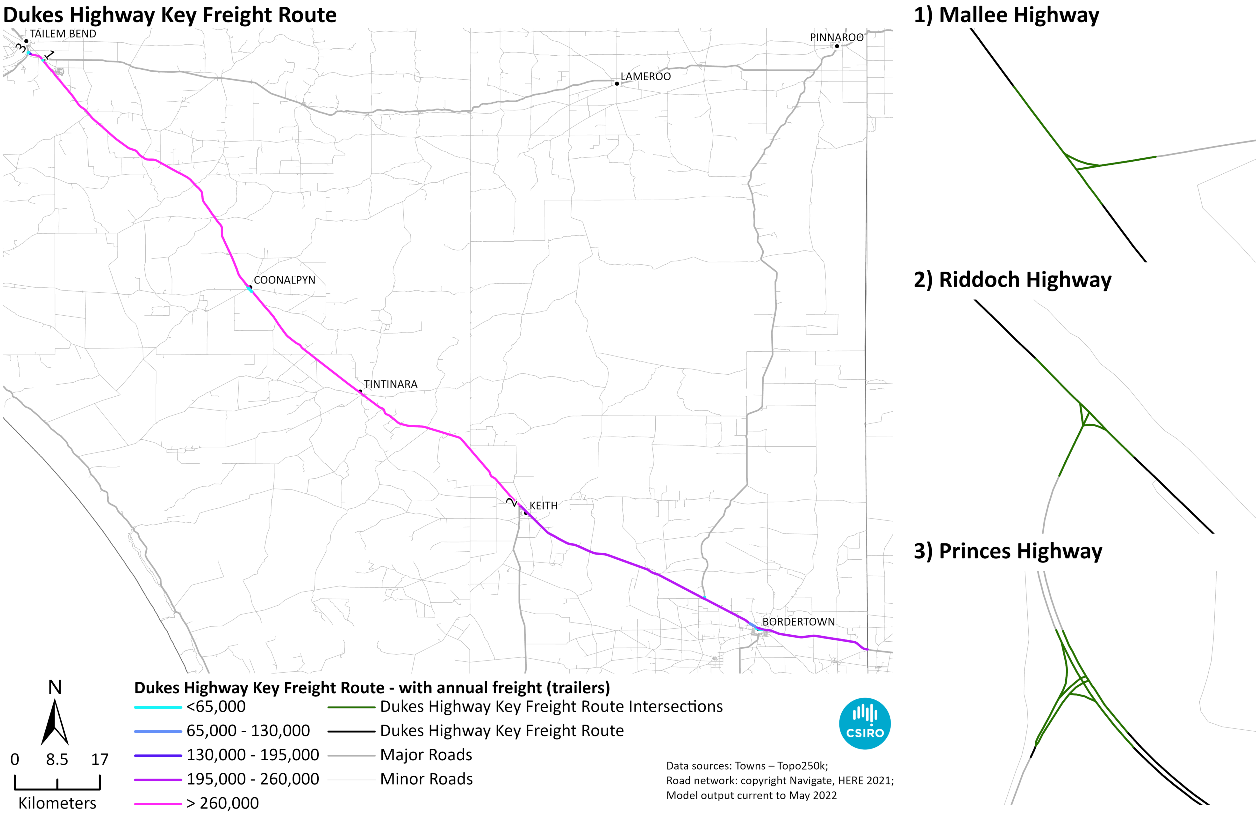

Figure 39 Dukes Highway KFR

The Dukes Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 394 LGAs along its length and beyond. It provides access to essential commodities for 143 LGAs. Many LGAs including Southern Mallee (DC) and Tatiara (DC) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Princes Highway
- Mallee Highway
- Riddoch Highway

The reliance described in Table 108 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. For the LGAs relying on the three studied intersections, their reliance is low to very low as over 90 % of the commodities sent or received within the LGAs do not rely on these intersections to move.

Table 108 Summary of community reliance metrics for each intersection on the Dukes Highway key freight route - most impacted LGA

	MALLEE HIGHWAY	PRINCES HIGHWAY	RIDDOCH HIGHWAY
Destination LGA most reliant on the intersection	Port Adelaide Enfield (C)	Murray Bridge (RC)	Wyndham (C)
Relative reliance on intersection for destination LGA	0.08	0.08	0.08
Origin LGA most reliant on the intersection	Southern Mallee (DC)	The Coorong (DC)	Tatiara (DC)
Relative reliance on intersection for origin LGA	0.06	0.07	0.05

5.21.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Dukes Highway. The results are based on expected freight for an average week.

- **Mallee Highway intersection**: The closure of the Mallee Highway intersection results in the disruption of 6,320 vehicle trips carrying 119,203 tonnes, 29% being essential commodities. Overall, 119,200 tonnes of freight are re-routed with an average detour length of 33 km and with an average increase in cost of $10.09 per tonne. No supply chain is unable to reach its destination.
- **Princes Highway intersection**: The closure of the Princes Highway intersection results in the disruption of 6,662 vehicle trips carrying 126,008 tonnes, 28% being essential commodities. Overall, 126,000 tonnes of freight are re-routed with an average detour length of 39 km and with an average increase in cost of $11.62 per tonne. No supply chain is unable to reach its destination.
- **Riddoch Highway intersection**: The closure of the Riddoch Highway intersection results in the disruption of 5,219 vehicle trips carrying 95,739 tonnes, 28% being essential commodities. Overall, 95,709 tonnes of freight are re-routed with an average detour length of 26 km and with an average increase in cost of $8.30 per tonne. No supply chain is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Dukes Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Dukes Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Dukes Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Dukes Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Dukes Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Dukes Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Dukes Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Dukes Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Dukes Highway.

KFR risk profile

Table 109 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Dukes Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. The impacts risk for the detour costs is very low, indicating that the freight is re-routed at a low cost.

Table 109 Risk metrics for modelled intersections on the Dukes Highway KFR – the model

	MALLEE HIGHWAY	PRINCES HIGHWAY	RIDDOCH HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.015	0.017	0.011
Last iteration	5	5	5

Freight impact

Table 110 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 110 Freight impact metrics for modelled intersections on the Dukes Highway KFR

		MALLEE HIGHWAY [%]	PRINCES HIGHWAY [%]	RIDDOCH HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	13	18	8
	Relative detour cost – maximum	363	691	136

The metrics in Table 110 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing little to moderately (between 8% and 18%) over all commodities. However, some supply chain paths in all the three intersections are highly impacted with some detour costs increasing up to 691%.

For all three intersections, the obstructed freight is minimal[7].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 111 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Mallee Highway and the Princes Highway intersection closures result in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. Only the Riddoch Highway intersection closure results in one of the 220 LGAs it services having supply chains for essential commodities obstructed; the Coorong (DC) being the most impacted for its box chicken supply chains; representing 22% (volume) of essential commodities received for that LGA.

When considering all commodities, the closure of the Mallee Highway intersection results in one LGA having obstructed supply chains, representing less than 0.1% of the volumes that are normally received by the 264 LGAs serviced by the intersection. The Coorong (DC) is the LGA impacted with one supply chain for the cropping industry obstructed.

Similar results were observed for the Princes Highway and the Riddoch Highway intersection closures. The Princes Highway results in three LGAs having obstructed supply chains, representing less than 0.1% of the volumes that are normally received by the 263 LGAs serviced by the intersection. The Coorong (DC) is the most impacted LGA with one supply chain for the livestock industry obstructed.

[7] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

The Riddoch Highway results in two LGAs having obstructed supply chains, representing 0.2% of the volumes that are normally received by the 220 LGAs serviced by the intersection. The Coorong (DC) is the most impacted LGA with one supply chain for the wood product industry obstructed.

Table 111 Community impact metrics for modelled intersections on the Dukes Highway KFR - obstructed supply chains

			MALLEE HIGHWAY	PRINCES HIGHWAY	RIDDOCH HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/264	0/263	1/220
		Relative volumes impacted	0.0%	0.0%	22.1%
	Most impacted LGA	Name of destination LGA	-	-	The Coorong (DC)
		Highest impacted commodity sector	-	-	Processed Food
		Commodity impacted	-	-	Box Chicken
		Number of supply chains impacted	-	-	1
		Relative volumes impacted	0%	0%	27%
		Weekly tonnes BAU	0.0	0.0	5.2
		Relative number of supply chains impacted	0%	0%	11%
All commodities	All impacted LGAs	Number of LGAs impacted	1/264	3/263	2/220
		Relative volumes impacted	0.0%	0.0%	0.2%
	Most impacted LGA	Name of destination LGA	The Coorong (DC)	The Coorong (DC)	The Coorong (DC)
		Highest impacted commodity sector	Cropping	Livestock	Wood Product
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	0%	0%	61%
		Weekly tonnes BAU	12,698.8	412.2	41.7
		Relative number of supply chains impacted	0%	0%	50%

Re-routed supply chains

Table 112 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

From the Mallee Highway intersection closure, 134 out of the 264 LGAs serviced by the intersection are expected to have essential commodities re-routed, representing 14% of essential commodities consumed within these LGAs. The most impacted LGA is the Grant (DC) LGA with three supply chains in the processed food sector representing 0.5 tonnes per week re-routed. For non-essential commodities, 261 out of the 264 LGAs serviced by the Mallee Highway intersection are impacted by re-routed freight, representing 6.2% of the total volumes consumed within these LGAs overall.

For the Princes Highway intersection, 136 of the 263 LGAs serviced are expected to have their freight re-routed for essential commodities, where these represent 14.5% of essential commodities consumed within these LGAs. For non-essential commodities, 260 out of the 263 LGAs serviced by the Princes Highway intersection are impacted by re-routed freight, which represent 6.5% of the total volume consumed by these LGAs.

Similar results are observed for the Riddoch Highway intersection closure. 122 of the 220 LGAs serviced are expected to have their freight re-routed, where these represent 14.2% of essential commodities consumed within these LGAs. For non-essential commodities, 217 out of the 220 LGAs serviced by the Riddoch Highway intersection are expected to be impacted by re-routed freight, which represent 6% of the total volume consumed by these LGAs.

In all three cases, the most impacted LGA for essential commodities is Grant (DC) for the processed food sector; while when considering all commodities, the wood product sector is the most impacted for Burnside (C) and Light (RegC) LGAs.

Table 112 Community impact metrics for modelled intersections on the Dukes Highway KFR - re-routed supply chains

			MALLEE HIGHWAY	PRINCES HIGHWAY	RIDDOCH HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	134/264	136/263	122/220
		Relative impact on volumes of commodities	14.2%	14.5%	14.2%
	Most impacted LGA	Name	Grant (DC)	Grant (DC)	Grant (DC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Seafood	Seafood	Seafood
		Number of supply chains impacted	3	3	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.5	0.5	0.5
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	261/264	260/263	217/220
		Relative impact on volumes of commodities	6.2%	6.5%	6.0%
	Most impacted LGA	Name	Burnside (C)	Light (RegC)	Burnside(C)
		Highest impacted commodity sector	Wood Product	Wood Product	Wood Product
		Number of supply chains impacted	1	10	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	25.6	100.5	25.6
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Dukes Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Dukes Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.22 Eyre Highway

The Eyre Highway KFR (Figure 40) is a freight route which extends between WA and SA. It connects LGAs from Norseman in southern WA to Port Augusta in SA. The corridor is 1667 km with at least part of the route used for the transport of $85m of product on 231,259 trailers annually carrying 4.6 million tonnes across 17,683 supply chains spanning 108 commodities (20% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 99,926 trailers annually with the busiest sections carrying 145,104 trailers.

Cropping transport represents approximately 40% of the total freight task, with fuel and general freight each adding a further 15% to the total freight task. The KFR provides an important role in providing access to markets for primary produce with 38% of all movements originating at a property. Equally important is its role in providing access to silos with 30% of movements having a destination at a silo. This route is predominantly classified as PBS3a or PBS3b access.

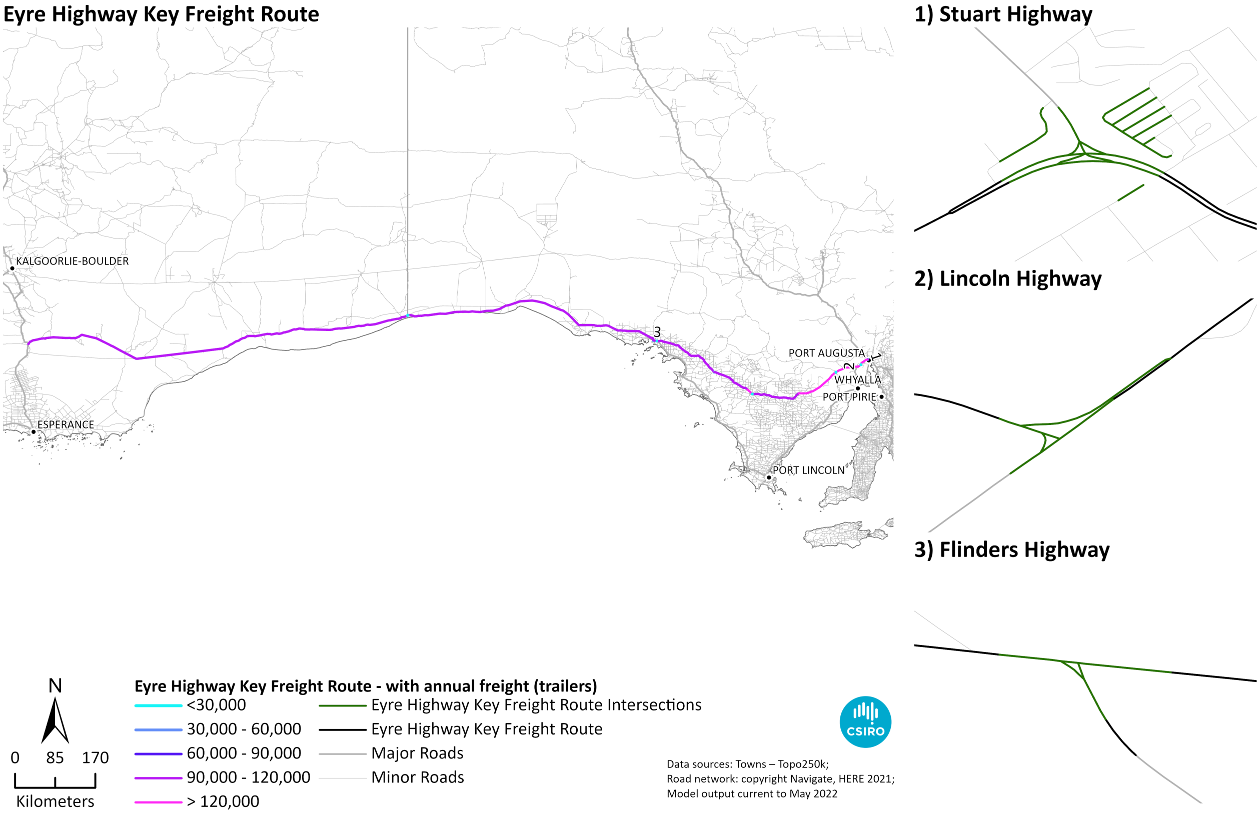

Figure 40 Eyre Highway KFR

The Eyre Highway KFR passes through seven LGAs but crucially it supports the supply chain paths for over 417 LGAs along its length and beyond. It provides access to essential commodities for 135 LGAs. Many LGAs including Kimba (DC), Streaky Bay (DC), Wudinna (DC) and Ceduna (DC) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Flinders Highway (SA)

- Lincoln Highway
- Stuart Highway

The reliance described in Table 113 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Cockburn (C) LGA is not very reliant on all of the intersections studied here in terms of freight received. While Port Pirie City and Dists (M) and Gingin (S) LGAs are the LGAs the most reliant on the Stuart Highway, the Lincoln Highway and the Eyre Highway intersections, their reliance is low. For all of them, less than 10% of their freight originating from the LGA go through these intersections.

Table 113 Summary of community reliance metrics for each intersection on the Eyre Highway key freight route - most impacted LGA

	STUART HIGHWAY	LINCOLN HIGHWAY	FLINDERS HIGHWAY
Destination LGA most reliant on the intersection	Cockburn (C)	Cockburn (C)	Cockburn (C)
Relative reliance on intersection for destination LGA	0.12	0.14	0.16
Origin LGA most reliant on the intersection	Port Pirie City and Dists (M)	Port Pirie City and Dists (M)	Gingin (S)
Relative reliance on intersection for origin LGA	0.07	0.07	0.07

5.22.1 Modelling and analysis outcomes

As discussed in Section 2, the effects from a widespread weather event can result in multiple intersections and bypass routes being closed. These can also be coupled with rail closures which in combination can result is a catastrophic impact on supply chains. Such an event occurred January-February 2022. A summary of the supply chain impacts is provided in the supplementary material labelled SA Floods.

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Eyre Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 3,476 vehicle trips carrying 65,400 tonnes, 25% being essential commodities. Overall, 65,293 tonnes of freight are re-routed with an average detour length of 727 km and with an average increase in cost of $98.92 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Lincoln Highway intersection**: The closure of the Lincoln Highway intersection results in the disruption of 2,773 vehicle trips carrying 50,450 tonnes, 18% being essential commodities. Overall, 50,438 tonnes of freight are re-routed with an average detour length of 36 km and with an average increase in cost of $10.66 per tonne. Very little freight is unable to reach its destination, none being essential commodities.
- **Flinders Highway intersection**: The closure of the Flinders Highway intersection results in the disruption of 2,252 vehicle trips carrying 39,378 tonnes, 12% being essential commodities. Overall, 39,363 tonnes of freight are re-routed with an average detour length

of 1,263 km and with an average increase in cost of $238.18 per tonne. Very little freight is unable to reach its destination, none being essential commodities.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Eyre Highway and are presented in the tables below. Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Eyre Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Eyre Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Eyre Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Eyre Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Eyre Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Eyre Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Eyre Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Eyre Highway.

KFR risk profile

Table 114 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Eyre Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be costly, more so from the Flinders Highway intersection closure.

Table 114 Risk metrics for modelled intersections on the Eyre Highway KFR

	STUART HIGHWAY	LINCOLN HIGHWAY	FLINDERS HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.058	0.005	0.102
Last iteration	5	5	5

Freight impact

Table 115 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 115 Freight impact metrics for modelled intersections on the Eyre Highway KFR

		STUART HIGHWAY [%]	LINCOLN HIGHWAY [%]	FLINDERS HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	1	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	64	6	193
	Relative detour cost – maximum	5,164	99	20,079

The metrics in Table 115 indicate the supply chains traversing the Stuart Highway intersection that are likely to be re-routed will do so with a moderate average cost increase of 64%, however with some supply chains the cost increase is expected to reach up to 5000%. The average increased cost for freight traversing the Flinders Highway intersection that are expected to be re-routed will be even greater (193%), with some supply chains reaching up to a 20,000% increase. The Lincoln Highway intersection closure is expected to result in an increase cost of 6% on average, with some of the supply chains reaching up to a nearly 100% cost increase.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 116 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closure has an impact on one LGA out of 259 when considering essential commodities, with Port Augusta (C) being the most impacted with unleaded fuel unable to reach its destination. When considering all commodities, two out of the 259 LGAs the intersection services will have supply chains obstructed. Port Augusta (C) is again the most impacted LGA, with three of its fuel supply chains obstructed, representing 3% (volume) of the LGA’s total consumption for the fuel sector.

The Lincoln Highway and the Flinders Highway intersection closures have no impact on the LGA they service for essential commodities, and little impact when considering all commodity types.

Table 116 Community impact metrics for modelled intersections on the Eyre Highway KFR - obstructed supply chains

			STUART HIGHWAY	LINCOLN HIGHWAY	FLINDERS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/259	0/226	0/183
		Relative volumes impacted	2.9%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Port Augusta (C)	-	-
		Highest impacted commodity sector	Fuel	-	-
		Commodity impacted	Unleaded fuel	-	-
		Number of supply chains impacted	1	0	0
		Relative volumes impacted	6%	0%	0%
		Weekly tonnes BAU	1,329.9	0.0	0.0
		Relative number of supply chains impacted	8%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	2/259	1/226	4/183
		Relative volumes impacted	2.9%	3.9%	0.1%
	Most impacted LGA	Name of destination LGA	Port Augusta (C)	Whyalla (C)	Ceduna (DC)
		Highest impacted commodity sector	Fuel	Waste	Mining
		Number of supply chains impacted	3	3	4
		Relative volumes impacted	3%	4%	0%
		Weekly tonnes BAU	3,343.9	315.7	185.4
		Relative number of supply chains impacted	8%	4%	1%

Re-routed supply chains

Table 117 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway intersection closure results in 134 LGAs out of 259 having re-routed supply chains for essential commodities, representing 12% of the volumes that are normally received by these LGAs. MacDonnell (R) is the most impacted LGA with three supply chains for the processed food industry re-routed, representing 100% of the box pig consumption of the LGA. When considering all commodities, the impact is much lower with 4.7% of the volumes of commodities normally received by the LGAs impacted by re-routing. Coober Pedy (DC) is the most impacted LGA, for the processed food industry.

For the Lincoln Highway and the Flinders Highway intersection closures, 224 out of 226 LGAs, and 182 out of 183 LGAs, respectively, are impacted by re-routing freight. The impact on essential commodities is low with nearly 8% (Lincoln Highway intersection) and 5% (Flinders Highway intersection) of the volumes of essential commodities that are normally received by the LGAs serviced by each intersection expected to be re-routed. When considering all commodities, the impact is lower with 3.8% (Lincoln Highway intersection) and 3.6% (Flinders Highway intersection) of the volumes of commodities normally received by the LGAs impacted by re-routing. In both cases, the most impacted LGA for essential commodities is Ceduna (DC) LGA where six supply chains for general freight are re-routed, representing 100% of the LGA's consumption of general commodities.

Table 117 Community impact metrics for modelled intersections on the Eyre Highway KFR - re-routed supply chains

			STUART HIGHWAY	LINCOLN HIGHWAY	FLINDERS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	134/259	126/226	52/183
		Relative impact on volumes of commodities	12.1%	7.8%	4.7%
	Most impacted LGA	Name	MacDonnell(R)	Streaky Bay(DC)	Canning(C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Pigs	Bread	Fish
		Number of supply chains impacted	3	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.3	1.8	40.7
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	257/259	224/226	182/183
		Relative impact on volumes of commodities	4.7%	3.8%	3.6%
	Most impacted LGA	Name	Coober Pedy (DC)	Ceduna (DC)	Ceduna (DC)
		Highest impacted commodity sector	Processed Food	General	General
		Number of supply chains impacted	8	6	6
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	3.6	63.9	63.9
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Eyre Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Eyre Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.23 Flinders Highway

The Flinders Highway KFR (Figure 41) is a freight route connecting LGAs between Cloncurry and Townsville in North Queensland. The corridor is 783 km with at least part of the route used for the transport of $82m of product on 186,037 trailers annually carrying 3.6 million tonnes across 13603 supply chains spanning 100 commodities (34% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 38,413 trailers annually with the busiest sections carrying 99,907 trailers.

Fuel and livestock transport combined represent approximately 45% of the total freight task, with general freight and mining each adding a further 15% to the total freight task. The KFR provides an important role in providing access to markets for primary produce with 24% of all movements originating at a property and an important role accessing supplies with 15% originating at a port. This route is predominantly classified as PBS4a access.

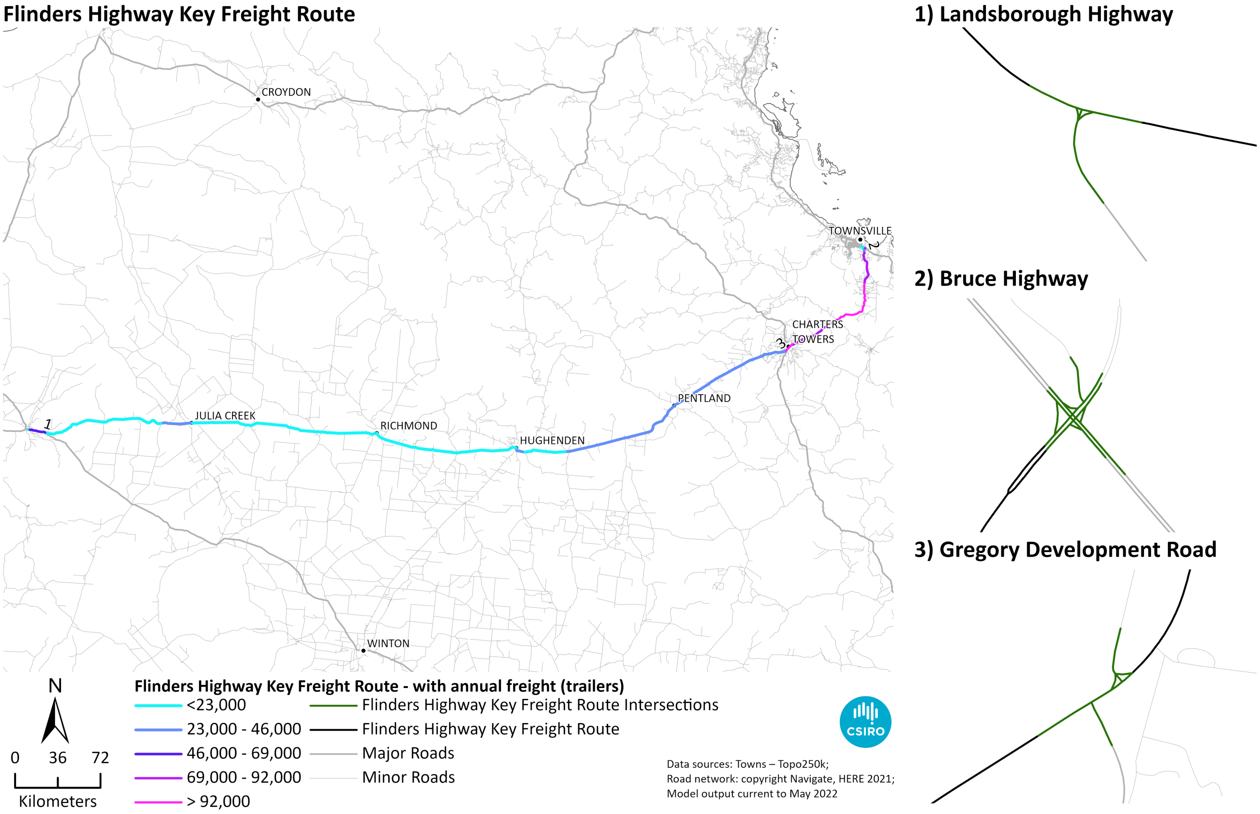

Figure 41 Flinders Highway KFR

The Flinders Highway KFR passes through six LGAs but crucially it supports the supply chain paths for over 292 LGAs along its length and beyond. It provides access to essential commodities for 72 LGAs. Many LGAs including Charters Towers (R) and Mount Isa (C) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Bruce Highway

- Landsborough Highway
- Gregory Development Road

The reliance described in Table 118 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Townsville (C) LGA is the most reliant of all the LGAs whose freight traverse the Bruce Highway and the Gregory Development Road intersections. This reliance is moderate to high with 51% (Bruce Highway) and 30% (Gregory Development Road) of the supply chain paths imported relying on these intersections to move. For the Landsborough Highway intersection, Darwin (C) is the most reliant LGA for destination freight, with a low value. For all three intersections, the Townsville (C) LGA is the most reliant for origin freight.

Table 118 Summary of community reliance metrics for each intersection on the Flinders Highway key freight route - most impacted LGA

	LANDSBOROUGH HIGHWAY	BRUCE HIGHWAY	GREGORY DEVELOPMENT ROAD
Destination LGA most reliant on the intersection	Darwin (C)	Townsville (C)	Townsville (C)
Relative reliance on intersection for destination LGA	0.07	0.51	0.30
Origin LGA most reliant on the intersection	Townsville (C)	Townsville (C)	Townsville (C)
Relative reliance on intersection for origin LGA	0.08	0.31	0.17

5.23.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Flinders Highway. The results are based on expected freight for an average week.

- **Landsborough Highway intersection**: The closure of the Landsborough Highway intersection results in the disruption of 877 vehicle trips carrying 15,932 tonnes, 38% being essential commodities. Overall, 15,898 tonnes of freight are re-routed with an average detour length of 145 km and with an average increase in cost of $21.86 per tonne. A total value of supplies amounting to $0.2 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Bruce Highway intersection**: The closure of the Bruce Highway intersection results in the disruption of 1,750 vehicle trips carrying 33,852 tonnes, 52% being essential commodities. Overall, 33,815 tonnes of freight are re-routed with an average detour length of 143 km and with an average increase in cost of $26.95 per tonne. A total value of supplies amounting to $0.2 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Gregory Development Road intersection**: The closure of the Gregory Development Road intersection results in the disruption of 1,928 vehicle trips carrying 37,132 tonnes, 43% being essential commodities. Overall, 36,073 tonnes of freight are re-routed with an average detour length of 102 km and with an average increase in cost of $14.22 per tonne. A total value of supplies amounting to $6.5 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Flinders Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Flinders Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Flinders Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Flinders Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Flinders Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Flinders Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Flinders Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Flinders Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Flinders Highway.

KFR risk profile

Table 119 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Flinders Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be quite costly.

Table 119 Risk metrics for modelled intersections on the Flinders Highway KFR

	LANDSBOROUGH HIGHWAY	BRUCE HIGHWAY	GREGORY DEVELOPMENT ROAD
KFR impacts risk - obstructed volumes for intersection	0.001	0.000	0.028
KFR impacts risk - detour costs for intersection	0.015	0.029	0.014
Last iteration	5	5	5

Freight impact

Table 120 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 120 Freight impact metrics for modelled intersections on the Flinders Highway KFR

		LANDSBOROUGH HIGHWAY [%]	BRUCE HIGHWAY [%]	GREGORY DEVELOPMENT ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	3
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	3
Re-routed supply chains	Relative detour cost – average	12	37	14
	Relative detour cost – maximum	349	2146	1444

The metrics in Table 120 indicate the supply chains traversing the three intersections that are likely to be re-routed will do so with a low to moderate average cost increase of 12% (Landsborough Highway), 37% (Bruce Highway) and 14% (Gregory Development Road). While low to moderate, the highest increase in costs is rather large with 349%, 2146% and 1444% respectively for some of the supply chains.

Little to no freight that usually traverses the three intersections is expected to be obstructed by the last successive closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 121 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of the three intersections results in no LGAs impacted for essential commodities obstructed.

The Landsborough Highway intersection closure results in nine out of 116 LGAs serviced by the intersection having obstructed commodities, which represents less than 1% of the freight volumes of commodities obstructed, with the livestock sector the most impacted for the most impacted LGA.

The closure of the Bruce Highway intersection results in ten out of 88 LGAs serviced by the intersection having obstructed commodities, which represents 0.2% of the consumption of these impacted LGAs. The most impacted LGA is the Murrumbidgee (A) LGA for the livestock industry.

The closure of the Gregory Development Road intersection results in 42 out of 148 LGAs serviced by the intersections having obstructed commodities, representing 1.7% of their goods consumed. The most impacted LGA is the Charters Towers (R) LGA for the livestock industry.

Table 121 Community impact metrics for modelled intersections on the Flinders Highway KFR - obstructed supply chains

			LANDSBOROUGH HIGHWAY	BRUCE HIGHWAY	GREGORY DEVELOPMENT ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/116	0/88	0/148
		Relative volumes impacted	0.0%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	-	-	-
		Highest impacted commodity sector	-	-	-
		Commodity impacted	-	-	-
		Number of supply chains impacted	0	0	0
		Relative volumes impacted	0%	0%	0%
		Weekly tonnes BAU	0.0	0.0	0.0
		Relative number of supply chains impacted	0%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	9/116	10/88	42/148
		Relative volumes impacted	0.5%	0.2%	1.7%
	Most impacted LGA	Name of destination LGA	Cloncurry (S)	Murrumbidgee (A)	Charters Towers (R)
		Highest impacted commodity sector	Livestock	Livestock	Livestock
		Number of supply chains impacted	13	1	296
		Relative volumes impacted	2%	1%	24%
		Weekly tonnes BAU	890.8	147.2	2,393.7
		Relative number of supply chains impacted	3%	1%	21%

Re-routed supply chains

Table 122 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Landsborough Highway intersection closure results in 32 LGAs out of 116 having re-routed supply chains for essential commodities, representing 44% of the volumes that are normally received by these LGAs. Mount Isa (C) is the most impacted LGA with six supply chains for the processed food industry re-routed, representing 100% of the LGA’s meat consumption. When considering all commodities, the impact is much lower with 4.2% of the volumes of commodities normally received by the LGAs impacted by re-routing. Burke (S) is the most impacted LGA, for the cropping industry.

For the Bruce Highway and the Gregory Development Road intersection closures, 47 out of 88 LGAs, and 61 out of 148 LGAs, respectively, are impacted by re-routing freight. The impact on essential commodities is moderate with 28% (Bruce Highway intersection) and 21% (Gregory Development Road intersection) of the volumes of essential commodities that are normally received by the 88 and 148 impacted LGAs serviced by each intersection respectively, expected to be re-routed. When considering all commodities, the impact is lower with 9.6% (Bruce Highway intersection) and 6.4% (Gregory Development Road intersection) of the volumes of commodities normally received by the LGAs impacted by re-routing. In both cases, the most impacted LGA for essential commodities is Barcoo (S) LGA where three supply chains for the processed food industry are re-routed, representing 100% of the seafood consumption of the LGA.

Table 122 Community impact metrics for modelled intersections on the Flinders Highway KFR - re-routed supply chains

			LANDSBOROUGH HIGHWAY	BRUCE HIGHWAY	GREGORY DEVELOPMENT ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	32/116	47/88	61/148
		Relative impact on volumes of commodities	44.1%	28.1%	21.2%
	Most impacted LGA	Name	Mount Isa(C)	Barcoo(S)	Barcoo(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Meat	Seafood	Seafood
		Number of supply chains impacted	6	3	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	18.5	0.5	0.5
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	115/116	85/88	146/18
		Relative impact on volumes of commodities	4.2%	9.6%	6.4%
	Most impacted LGA	Name	Burke(S)	McKinlay(S)	Etheridge(S)
		Highest impacted commodity sector	Cropping	General	Cropping
		Number of supply chains impacted	1	3	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.8	3.5	0.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Flinders Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Flinders Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.24 Goldfields Highway

The Goldfields Highway KFR (Figure 42) is a freight route located in central WA. It connects LGAs from Kalgoorlie and Wiluna to the Coolgardie – Esperance Highway. The corridor is 790 km with at least part of the route used for the transport of $3m of product on 48,725 trailers annually carrying one million tonnes across 466 supply chains spanning 40 commodities (49.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 7,916 trailers annually with the busiest sections carrying 22,641 trailers.

Fuel and mining transport represents approximately 90% of the total freight task, with most movements between port and mines of fuel and mining output. The route is also used for transport of processed food and general freight to communities but these are small quantities relative to mining freight. This route is predominantly classified as PBS4a access.

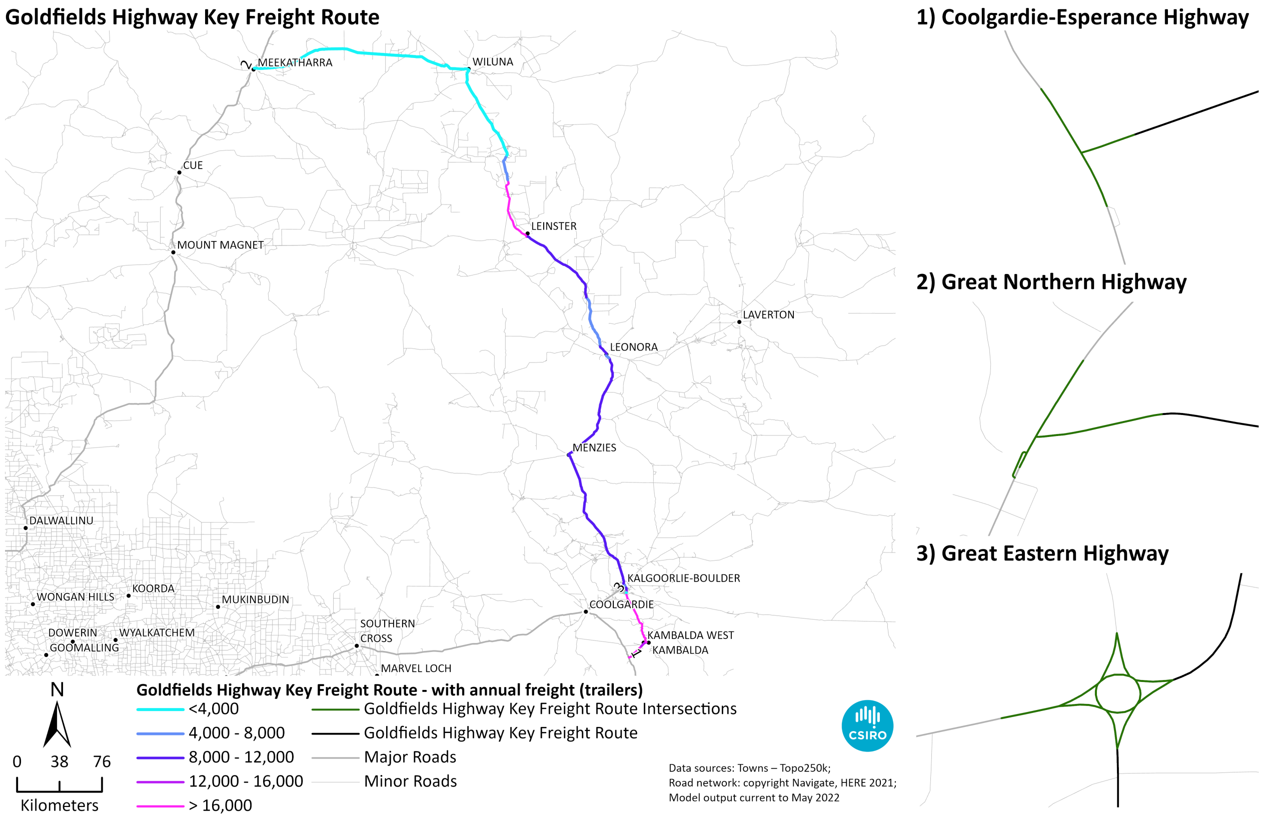

Figure 42 Goldfields Highway KFR

The Goldfields Highway KFR passes through six LGAs but crucially it supports the supply chain paths for over 75 LGAs along its length and beyond. It provides access to essential commodities for 13 LGAs. Many LGAs including Wiluna (S), Laverton (S) and Leonora (S) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 50% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Great Eastern Highway
- Great Northern Highway

- Coolgardie – Esperance Highway

The reliance described in Table 123 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low to moderate degrees, with 28% (Coolgardie – Esperance Highway), 42% (Great Eastern Highway) and 20% (Great Northern Highway) of all the supply chain paths traversing the intersections destined for the Kalgoorlie/Boulder (C) and the Wiluna (S) LGAs, respectively.

Table 123 Summary of community reliance metrics for each intersection on the Goldfields Highway NSW key freight route - most impacted LGA

	COOLGARDIE – ESPERANCE HIGHWAY	GREAT EASTERN HIGHWAY	GREAT NORTHERN HIGHWAY
Destination LGA most reliant on the intersection	Kalgoorlie/Boulder (C)	Kalgoorlie/Boulder (C)	Wiluna (S)
Relative reliance on intersection for destination LGA	0.28	0.42	0.20
Origin LGA most reliant on the intersection	Esperance (S)	Kalgoorlie/Boulder (C)	Cockburn (C)
Relative reliance on intersection for origin LGA	0.19	0.18	0.19

5.24.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Goldfields Highway NSW. The results are based on expected freight for an average week.

- **Coolgardie – Esperance Highway intersection**: The closure of the Coolgardie – Esperance Highway intersection results in the disruption of 339 vehicle trips carrying 7,582 tonnes, 80% being essential commodities. Overall, 7,580 tonnes of freight are re-routed with an average detour length of 450 km and with an average increase in cost of $59.37 per tonne. A total value of supplies amounting to $0.0 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Great Eastern Highway intersection**: The closure of the Great Eastern Highway intersection results in the disruption of 335 vehicle trips carrying 7,330 tonnes, 78% being essential commodities. Overall, 5,911 tonnes of freight are re-routed with an average detour length of five km and with an average increase in cost of $8.82 per tonne. A total value of supplies amounting to $2.8 million, $2.1 million being essential commodities, is unable to reach its destination.
- **Great Northern Highway intersection**: The closure of the Great Northern Highway intersection results in the disruption of 19 vehicle trips carrying 354 tonnes, 83% being essential commodities. Overall, 334 tonnes of freight are re-routed with an average detour length of 305 km and with an average increase in cost of $27.81 per tonne. A total value of supplies amounting to $0.2 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Goldfields Highway NSW and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Goldfields Highway NSW-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Goldfields Highway NSW-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Goldfields Highway NSW-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Goldfields Highway NSW-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Goldfields Highway NSW-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Goldfields Highway NSW-cost bar plot.png' shows the cost impacts of re-routing.
- 'Goldfields Highway NSW-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Goldfields Highway NSW.

KFR risk profile

Table 124 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight is expected to be re-routed at low costs. The exception is for the Coolgardie – Esperance Highway for which re-routed costs might be higher than for the other two intersections.

Table 124 Risk metrics for modelled intersections on the Goldfields Highway NSW KFR

	COOLGARDIE – ESPERANCE HIGHWAY	GREAT EASTERN HIGHWAY	GREAT NORTHERN HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.055	0.019
KFR impacts risk - detour costs for intersection	0.101	0.019	0.015
Last iteration	5	5	5

Freight impact

Table 125 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 125 Freight impact metrics for modelled intersections on the Goldfields Highway NSW KFR by last successive closure

		COOLGARDIE – ESPERANCE HIGHWAY [%]	GREAT EASTERN HIGHWAY [%]	GREAT NORTHERN HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	19	6
	Relative freight volume impacted – essential commodities	0	23	2
	Relative value of freight – all commodities	0	8	18
Re-routed supply chains	Relative detour cost – average	48	8	17
	Relative detour cost – maximum	483	96	57

The metrics in Table 125 indicate the supply chains traversing the Coolgardie – Esperance Highway intersection that are likely to be re-routed would do so with their average cost increasing by 48% across all commodities, with some supply chain paths reaching an increase of up to 483%. Those traversing the Great Eastern Highway intersection are expected to be re-routed at an average cost increasing by 8% across all commodities, while those traversing the Great Northern Highway intersection may do so at an average cost increasing by 17%.

No freight is obstructed for the Coolgardie – Esperance Highway intersection closure, and little freight is obstructed for the Great Northern Highway intersection closure. However, 19% of all commodities and 23% of essential commodities is expected to be obstructed by the fifth iteration for the Great Eastern Highway closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 126 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Coolgardie – Esperance Highway intersection results in one LGA not receiving essential commodities, being Coolgardie (S), which represent 33.3% of the LGA's consumption for LPG. When considering all commodities, the same LGA serviced by the intersection has freight obstructed, representing 0.1% of the LGA's overall consumption.

The Great Eastern Highway intersection results in four LGAs not receiving essential commodities, representing 16% of the LGAs' consumption where the most impacted LGA is Dundas (S) for unleaded fuel. When considering all commodities, four LGAs serviced by the intersection have freight obstructed, representing 15.9% of the LGAs' overall consumption.

The Great Northern Highway intersection results in one LGA not receiving essential commodities, representing 100% of the LGA's consumption where the most impacted LGA is Wiluna (S) for box chicken. When considering all commodities, five LGAs serviced by the intersection have freight obstructed, representing 0.7% of the LGAs' overall consumption.

Table 126 Community impact metrics for modelled intersections on the Goldfields Highway NSW KFR - obstructed supply chains

			COOLGARDIE – ESPERANCE HIGHWAY	GREAT EASTERN HIGHWAY	GREAT NORTHERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/32	4/37	1/20
		Relative volumes impacted	33.3%	16.0%	100.0%
	most impacted LGA	Name of destination LGA	Coolgardie(S)	Dundas(S)	Wiluna(S)
		Highest impacted commodity sector	Fuel	Fuel	Processed Food
		Commodity impacted	LPG	Unleaded fuel	Box Chicken
		Number of supply chains impacted	1	4	1
		Relative volumes impacted	33%	54%	100%
		Weekly tonnes BAU	4.3	679.4	0.6
		Relative number of supply chains impacted	33%	50%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	1/32	4/37	5/20
		Relative volumes impacted	0.1%	15.9%	0.7%
	Most impacted LGA	Name of destination LGA	Coolgardie(S)	Dundas(S)	Wiluna(S)
		Highest impacted commodity sector	Fuel	Fuel	Horticulture
		Number of supply chains impacted	1	7	3
		Relative volumes impacted	0%	49%	100%
		Weekly tonnes BAU	2,181.9	984.9	2.2
		Relative number of supply chains impacted	6%	30%	100%

Re-routed supply chains

Table 127 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 31.9% of the supply chains are expected to be re-routed for 13 of the 32 LGAs that traverse the Coolgardie – Esperance Highway intersection. The most impacted LGA is Menzies (S), with one supply chain in the fuel sector representing 1,084 tonnes of diesel fuel per week re-routed. For non-essential commodities, 31 out of 32 LGAs serviced by the Coolgardie – Esperance Highway intersection are impacted by re-routed freight, representing 3.3% of the total volumes consumed within these LGAs.

For the Great Eastern Highway intersection, eight of the 37 LGAs serviced are expected to have freight re-routed, with this representing 36.8% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 34 out of 37 LGAs serviced by the Great Eastern

Highway intersection are impacted by re-routed freight, representing 1.6% of the total volume consumed within these LGAs.

For the Great Northern Highway intersection, eight of the 20 LGAs serviced are expected to have freight re-routed, representing 12.5% of essential commodities consumed within the LGAs. For non-essential commodities, 16 out of 20 LGAs serviced by the Great Northern Highway intersection are impacted by re-routed freight, representing 1% of the total volume consumed within these LGAs.

Table 127 Community impact metrics for modelled intersections on the Goldfields Highway NSW KFR - re-routed supply chains

			COOLGARDIE – ESPERANCE HIGHWAY	GREAT EASTERN HIGHWAY	GREAT NORTHERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	13/32	8/37	8/20
		Relative impact on volumes of commodities	31.9%	36.8%	12.5%
	Most impacted LGA	Name	Menzies(S)	Menzies(S)	Laverton(S)
		Highest impacted commodity sector	Fuel	Fuel	Fuel
		Commodity impacted	Diesel fuel	Diesel fuel	LPG
		Number of supply chains impacted	1	1	2
		Relative volumes impacted	95%	95%	100%
		Weekly tonnes BAU	1,084.6	1,084.6	2.8
		Relative number of supply chains impacted	50%	50%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	31/32	34/37	16/20
		Relative impact on volumes of commodities	3.3%	1.6%	1.0%
	Most impacted LGA	Name	Dundas(S)	Dundas(S)	Dundas(S)
		Highest impacted commodity sector	Livestock	Livestock	Livestock
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	1.5	1.5	1.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Goldfields Highway NSW-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Goldfields Highway NSW-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.25 Goulburn Valley Highway

The Goulburn Valley Highway KFR (Figure 43) is a freight route located in central Victoria. It connects LGAs between Eildon and the Newell Highway on the NSW border. The corridor is 225 km with at least part of the route used for the transport of $127m of product on 372,216 trailers annually carrying 7.6 million tonnes across 28,206 supply chains spanning 112 commodities (34% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 118,990 trailers annually with the busiest sections carrying 136,176 trailers.

Cropping transport represents approximately 30% of the total freight task, with most movements from properties. The route is also used for processed food and fuel, contributing 15% each and horticulture and general freight adding a further 10% each to the freight task. 18% of movements along this route are destined to a DC. This route is predominantly classified as PBS2a HML access.

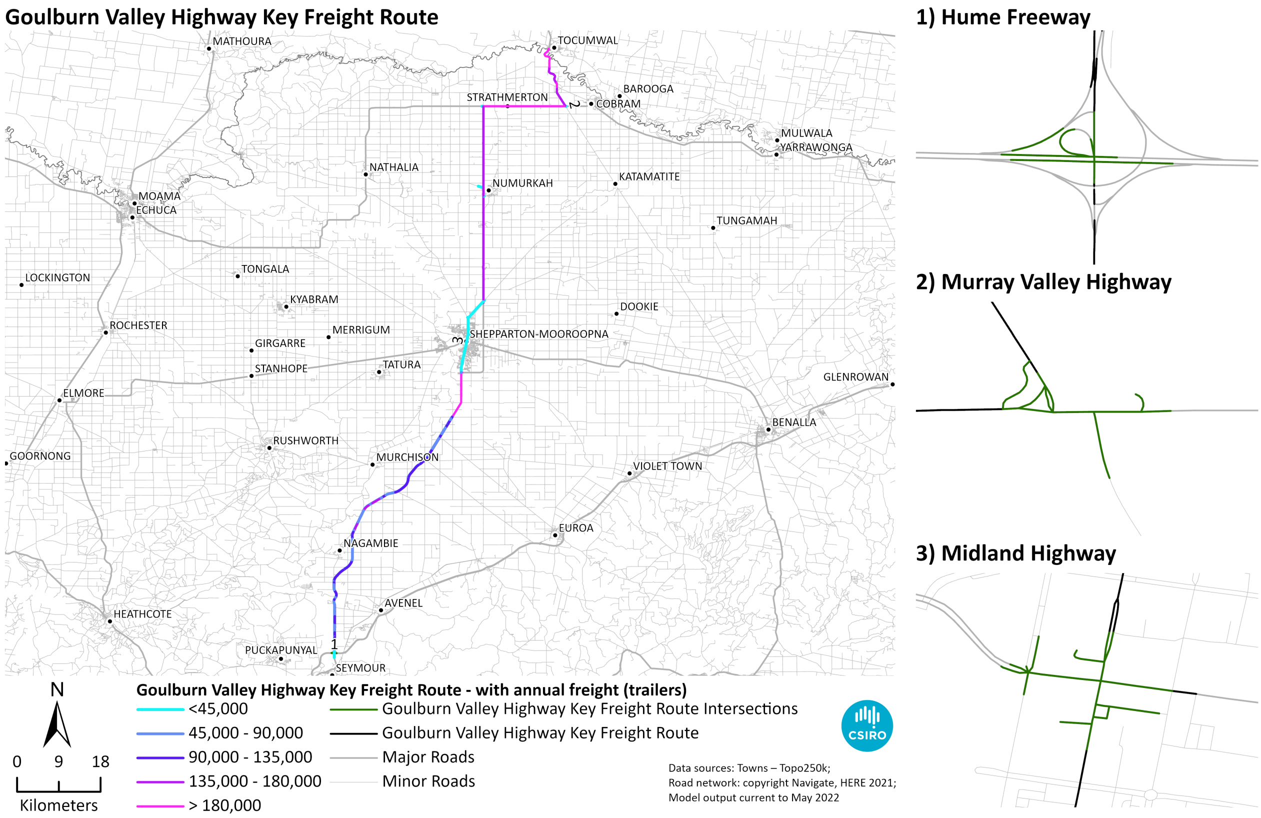

Figure 43 Goulburn Valley Highway KFR

The Goulburn Valley Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 297 LGAs along its length and beyond. It provides access to essential commodities for 123 LGAs. Many LGAs including Greater Shepparton (C), Moira (S) and Berrigan (A) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Hume Freeway
- Midland Highway

- Murray Valley Highway

The reliance described in Table 128 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 11% (Hume Freeway), 16% (Murray Valley Highway) and 14% (Midland Highway) of all the supply chain paths traversing the intersections destined for the Carrathool (A), Melbourne (C) and the Greater Shepparton (C) LGAs, respectively.

Table 128 Summary of community reliance metrics for each intersection on the Goulburn Valley Highway NSW key freight route - most impacted LGA

	HUME FREEWAY	MURRAY VALLEY HIGHWAY	MIDLAND HIGHWAY
Destination LGA most reliant on the intersection	Carrathool (A)	Melbourne (C)	Greater Shepparton (C)
Relative reliance on intersection for destination LGA	0.11	0.16	0.14
Origin LGA most reliant on the intersection	Bayside (C)	Griffith (C)	Greater Shepparton (C)
Relative reliance on intersection for origin LGA	0.32	0.15	0.41

5.25.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Goulburn Valley Highway NSW. The results are based on expected freight for an average week.

- **Hume Freeway intersection**: The closure of the Hume Freeway intersection results in the disruption of 1,697 vehicle trips carrying 29,378 tonnes, 40% being essential commodities. Overall, 24,244 tonnes of freight are re-routed with an average detour length of 15 km and with an average increase in cost of $5.90 per tonne. A total value of supplies amounting to $0.5 million, $0.4 million being essential commodities, is unable to reach its destination.
- **Murray Valley Highway intersection**: The closure of the Murray Valley Highway intersection results in the disruption of 3,873 vehicle trips carrying 76,002 tonnes, 21% being essential commodities. Overall, 75,801 tonnes of freight are re-routed with an average detour length of -3 km and with an average increase in cost of $1.70 per tonne. A total value of supplies amounting to $0.4 million, $0.3 million being essential commodities, is unable to reach its destination.
- **Midland Highway intersection**: The closure of the Midland Highway intersection results in the disruption of 1,416 vehicle trips carrying 31,243 tonnes, 45% being essential commodities. Overall, 30,723 tonnes of freight are re-routed with an average detour length of three km and with an average increase in cost of $3.26 per tonne. A total value of supplies amounting to $0.9 million, $0.4 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Goulburn Valley Highway NSW and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Goulburn Valley Highway NSW-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Goulburn Valley Highway NSW-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Goulburn Valley Highway NSW-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Goulburn Valley Highway NSW-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Goulburn Valley Highway NSW-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Goulburn Valley Highway NSW-cost bar plot.png' shows the cost impacts of re-routing.
- 'Goulburn Valley Highway NSW-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Goulburn Valley Highway NSW.

KFR risk profile

Table 129 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight is expected to be re-routed at low costs. The exception is for the Hume Freeway for which re-routed costs might be higher than for the other two intersections.

Table 129 Risk metrics for modelled intersections on the Goulburn Valley Highway NSW KFR

	HUME FREEWAY	MURRAY VALLEY HIGHWAY	MIDLAND HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.175	0.001	0.006
KFR impacts risk - detour costs for intersection	0.007	0.002	0.011
Last iteration	5	5	5

Freight impact

Table 130 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 130 Freight impact metrics for modelled intersections on the Goulburn Valley Highway NSW KFR by last successive closure

		HUME FREEWAY [%]	MURRAY VALLEY HIGHWAY [%]	MIDLAND HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	17	0	2
	Relative freight volume impacted – essential commodities	32	1	1
	Relative value of freight – all commodities	0	0	1
Re-routed supply chains	Relative detour cost – average	10	4	15
	Relative detour cost – maximum	93	88	263

The metrics in Table 130 indicate the supply chains traversing the Hume Freeway intersection that are likely to be re-routed would do so with their average cost increasing by 10% across all commodities, with some supply chain paths reaching an increase of up to 93%. Those traversing the Murray Valley Highway intersection are expected to be re-routed at an average cost increasing by 4% across all commodities, while those traversing the Midland Highway intersection may do so at an average cost increasing by 15%.

Little freight is obstructed for the Murray Valley Highway intersection closure and the Midland Highway intersection closure. However, 17% of all commodities and 32% of essential commodities are expected to be obstructed by the fifth iteration for the Hume Freeway closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 131 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Hume Freeway intersection results in six LGAs not receiving essential commodities, representing 4.9% of the LGAs' consumption where the most impacted LGA is Yarra (C) for gravel. When considering all commodities, ten LGAs serviced by the intersection have freight obstructed, representing 1.9% of the LGAs' overall consumption.

The Murray Valley Highway intersection results in one LGA not receiving essential commodities, representing 1.3% of the LGA's consumption where the most impacted LGA is Moira (S) for LPG. When considering all commodities, eight LGAs serviced by the intersection have freight obstructed, representing 0.3% of the LGAs' overall consumption.

The Midland Highway intersection results in one LGA not receiving essential commodities, representing 1.5% of the LGA's consumption where the most impacted LGA is Greater Shepparton

(C) for box beef. When considering all commodities, four LGAs serviced by the intersection have freight obstructed, representing 0.8% of the LGAs' overall consumption.

Table 131 Community impact metrics for modelled intersections on the Goulburn Valley Highway NSW KFR - obstructed supply chains

			HUME FREEWAY	MURRAY VALLEY HIGHWAY	MIDLAND HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	6/123	1/227	1/106
		Relative volumes impacted	4.9%	1.3%	1.5%
	Most impacted LGA	Name of destination LGA	Yarra(C)	Moira(S)	Greater Shepparton(C)
		Highest impacted commodity sector	Construction	Fuel	Processed Food
		Commodity impacted	Gravel	LPG	Box Beef
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	6%	7%	51%
		Weekly tonnes BAU	11,726.9	66.8	11.4
		Relative number of supply chains impacted	5%	7%	25%
All commodities	All impacted LGAs	Number of LGAs impacted	10/123	8/227	4/106
		Relative volumes impacted	1.9%	0.3%	0.8%
	Most impacted LGA	Name of destination LGA	Port Phillip(C)	Moira(S)	Greater Shepparton(C)
		Highest impacted commodity sector	Construction	Fuel	Construction
		Number of supply chains impacted	1	3	3
		Relative volumes impacted	4%	2%	2%
		Weekly tonnes BAU	646.2	6,148.0	14,104.5
		Relative number of supply chains impacted	4%	8%	2%

Re-routed supply chains

Table 132 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 14.4% of the supply chains are expected to be re-routed for 23 of the 123 LGAs that traverse the Hume Freeway intersection. The most impacted LGA is Murrumbidgee (A), with five supply chains in the processed food sector representing 1.2 tonnes of seafood per week re-routed. For non-essential commodities, 114 out of 123 LGAs serviced by the Hume Freeway intersection are impacted by re-routed freight, representing 2.5% of the total volumes consumed within these LGAs.

For the Murray Valley Highway intersection, 105 of the 227 LGAs serviced expect to have freight re-routed for essential commodities, representing 6.5% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 224 out of 227 LGAs serviced by the Murray Valley

Highway intersection are impacted by re-routed freight, representing 3.6% of the total volume consumed within these LGAs.

For the Midland Highway intersection, 39 of the 106 LGAs serviced are expected to have freight re-routed, representing 9% of essential commodities consumed within these LGAs. For non-essential commodities, all 106 LGAs serviced by the Midland Highway intersection are impacted by re-routed freight, representing 3.3% of the total volume consumed within these LGAs.

Table 132 Community impact metrics for modelled intersections on the Goulburn Valley Highway NSW KFR – re-routed supply chains

			HUME FREEWAY	MURRAY VALLEY HIGHWAY	MIDLAND HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	23/123	105/227	39/106
		Relative impact on volumes of commodities	14.4%	6.5%	9.0%
	Most impacted LGA	Name	Murrumbidgee (A)	Murrumbidgee (A)	Benalla (RC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Seafood	Seafood	Box Beef
		Number of supply chains impacted	5	5	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	1.2	1.2	9.0
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	114/123	224/227	106/106
		Relative impact on volumes of commodities	2.5%	3.6%	3.3%
	Most impacted LGA	Name	Berrigan (A)	Berrigan (A)	Benalla (RC)
		Highest impacted commodity sector	General	General	Fuel
		Number of supply chains impacted	10	10	3
		Relative volumes impacted	100%	100%	81%
		Weekly tonnes BAU	10.6	10.6	3,917.3
		Relative number of supply chains impacted	100%	100%	16%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Goulburn Valley Highway NSW-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Goulburn Valley Highway NSW-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.26 Great Eastern Highway

The Great Eastern Highway KFR (Figure 44) is a freight route located in WA. It connects LGAs from Kalgoorlie to Perth. The corridor is 636 km with at least part of the route used for the transport of $69m of product on 690,716 trailers annually carrying 16.5 million tonnes across 19,609 supply chains spanning 110 commodities (8% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 171,022 trailers annually with the busiest sections carrying 427,436 trailers.

Mining transport represents approximately 55% of the total freight task, mainly due to movements from mine to a rail loading point. Cropping contributes 25% to the freight task with movements from property to silo. This route is predominantly classified as PBS3a access.

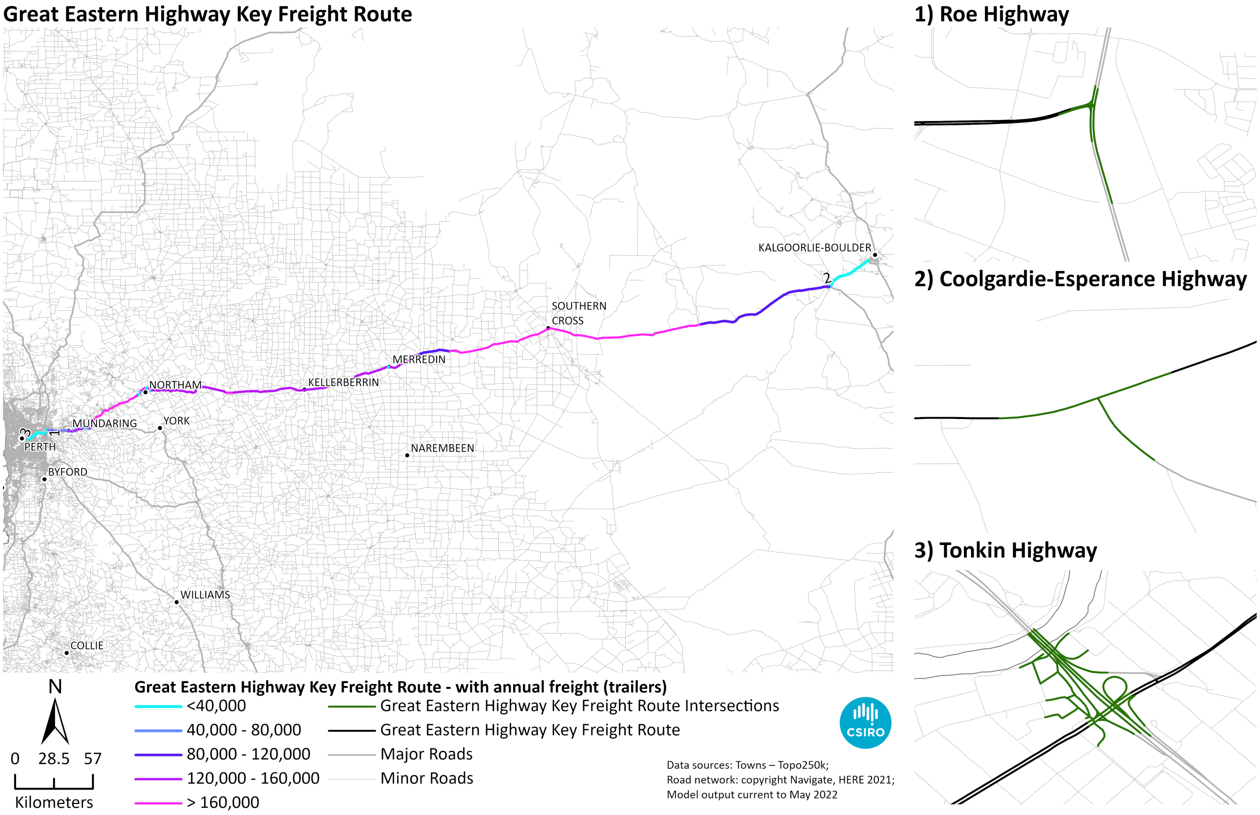

Figure 44 Great Eastern Highway KFR

The Great Eastern Highway KFR passes through 13 LGAs but crucially it supports the supply chain paths for over 359 LGAs along its length and beyond. It provides access to essential commodities for 76 LGAs. Many LGAs including Yilgarn (S), Merredin (S), Quairading (S) and Northam (S) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Roe Highway
- Tonkin Highway
- Coolgardie – Esperance Highway

The reliance described in Table 133 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 18% (Roe Highway), 22% (Coolgardie – Esperance Highway) and 23% (Tonkin Highway) of all the supply chain paths traversing the intersections destined for the Cockburn (C) and the Belmont (C) LGAs, respectively.

Table 133 Summary of community reliance metrics for each intersection on the Great Eastern Highway NSW key freight route - most impacted LGA

	ROE HIGHWAY	COOLGARDIE – ESPERANCE HIGHWAY	TONKIN HIGHWAY
Destination LGA most reliant on the intersection	Cockburn (C)	Cockburn (C)	Belmont (C)
Relative reliance on intersection for destination LGA	0.18	0.22	0.23
Origin LGA most reliant on the intersection	Kwinana (C)	Gingin (S)	Swan (C)
Relative reliance on intersection for origin LGA	0.22	0.09	0.21

5.26.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Great Eastern Highway NSW. The results are based on expected freight for an average week.

- **Roe Highway intersection**: The closure of the Roe Highway intersection results in the disruption of 4,152 vehicle trips carrying 83,236 tonnes, 21% being essential commodities. Overall, 83,231 tonnes of freight are re-routed with an average detour length of two km and with an average increase in cost of $2.77 per tonne. Little freight is unable to reach its destination.
- **Coolgardie – Esperance Highway intersection**: The closure of the Coolgardie – Esperance Highway intersection results in the disruption of 1,786 vehicle trips carrying 29,686 tonnes, 30% being essential commodities. Overall, 29,683 tonnes of freight are re-routed with an average detour length of -19 km and with an average increase in cost of $13.95 per tonne. Little freight is unable to reach its destination.
- **Tonkin Highway intersection**: The closure of the Tonkin Highway intersection results in the disruption of 455 vehicle trips carrying 7,160 tonnes, 28% being essential commodities. Overall, 6,950 tonnes of freight are re-routed with an average detour length of two km and with an average increase in cost of $3.46 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Great Eastern Highway NSW and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Great Eastern Highway NSW-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection.

- 'Great Eastern Highway NSW-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Great Eastern Highway NSW-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Great Eastern Highway NSW-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Great Eastern Highway NSW-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Great Eastern Highway NSW-cost bar plot.png' shows the cost impacts of re-routing.
- 'Great Eastern Highway NSW-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Great Eastern Highway NSW.

KFR risk profile

Table 134 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight is expected to be re-routed at low costs.

Table 134 Risk metrics for modelled intersections on the Great Eastern Highway NSW KFR

	ROE HIGHWAY	COOLGARDIE – ESPERANCE HIGHWAY	TONKIN HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.007
KFR impacts risk - detour costs for intersection	0.003	0.012	0.012
Last iteration	5	5	5

Freight impact

Table 135 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 135 Freight impact metrics for modelled intersections on the Great Eastern Highway NSW KFR by last successive closure

		ROE HIGHWAY [%]	COOLGARDIE – ESPERANCE HIGHWAY [%]	TONKIN HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	3
	Relative freight volume impacted – essential commodities	0	0	6
	Relative value of freight – all commodities	0	0	1
Re-routed supply chains	Relative detour cost – average	6	1	24
	Relative detour cost – maximum	105	334	130

The metrics in Table 135 indicate the supply chains traversing the Roe Highway intersection that are likely to be re-routed would do so with their average cost increasing by 6% across all commodities, with some supply chain paths reaching an increase of up to 105%. Those traversing the Coolgardie – Esperance Highway intersection are expected to be re-routed at an average cost increasing by 1% across all commodities, while those traversing the Tonkin Highway intersection may do so at an average cost increasing by 24%.

Little freight is obstructed for the Coolgardie – Esperance Highway intersection closure and the Tonkin Highway intersection closure. However, 17% of all commodities and 32% of essential commodities are expected to be obstructed by the fifth iteration for the Roe Highway closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 136 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Roe Highway intersection results in no LGA not receiving essential commodities. When considering all commodities, one LGA serviced by the intersection has freight obstructed, representing 0.1 % of the LGA's overall consumption.

The Coolgardie – Esperance Highway intersection results in one LGA not receiving essential commodities, representing 33% of the LGA's consumption where the most impacted LGA is Coolgardie (S) for LPG. When considering all commodities, the same LGA has freight obstructed, representing 0.1% of the LGA's overall consumption.

The Tonkin Highway intersection results in one LGA not receiving essential commodities, representing 10% of the LGA's consumption where the most impacted LGA is Greater Belmont (S) for unleaded fuel. When considering all commodities, two LGAs serviced by the intersection have freight obstructed, representing 2.5% of the LGAs' overall consumption.

Table 136 Community impact metrics for modelled intersections on the Great Eastern Highway NSW KFR - obstructed supply chains

			ROE HIGHWAY	COOLGARDIE – ESPERANCE HIGHWAY	TONKIN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/134	1/147	1/27
		Relative volumes impacted	0.0%	33.3%	10.0%
	Most impacted LGA	Name of destination LGA	-	Coolgardie(S)	Belmont(C)
		Highest impacted commodity sector	-	Fuel	Fuel
		Commodity impacted	-	LPG	Unleaded fuel
		Number of supply chains impacted	0	1	1
		Relative volumes impacted	0%	33%	12%
		Weekly tonnes BAU	0.0	4.3	791.0
		Relative number of supply chains impacted	0%	33%	10%
All commodities	All impacted LGAs	Number of LGAs impacted	1/134	1/147	2/27
		Relative volumes impacted	0.1%	0.1%	2.5%
	Most impacted LGA	Name of destination LGA	Canning(C)	Coolgardie(S)	Belmont(C)
		Highest impacted commodity sector	Waste	Fuel	Fuel
		Number of supply chains impacted	1	1	3
		Relative volumes impacted	0%	0%	10%
		Weekly tonnes BAU	7,198.6	2,181.9	1,231.2
		Relative number of supply chains impacted	0%	6%	10%

Re-routed supply chains

Table 137 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 14.6% of the supply chains are expected to be re-routed for 54 of the 134 LGAs that traverse the Roe Highway intersection. The most impacted LGA is Coolgardie (S), with two supply chains in the horticulture sector representing four tonnes of fruit per week re-routed. For non-essential commodities, 133 out of 134 LGAs serviced by the Roe Highway intersection are impacted by re-routed freight, representing 6.7% of the total volumes consumed within these LGAs.

For the Coolgardie – Esperance Highway intersection, 34 of the 147 LGAs serviced are expected to have freight re-routed, with this representing 6% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 146 out of 147 LGAs serviced by the Coolgardie – Esperance Highway intersection are impacted by re-routed freight, representing 2.5% of the total volume consumed within these LGAs.

For the Tonkin Highway intersection, nine of the 27 LGAs serviced are expected to have freight re-routed, representing 13.8% of essential commodities consumed within the LGAs. For non-essential commodities, 26 of the 27 LGAs serviced by the Tonkin Highway intersection are impacted by re-routed freight, representing 5.1% of the total volume consumed within these LGAs.

Table 137 Community impact metrics for modelled intersections on the Great Eastern Highway NSW KFR – re-routed supply chains

			ROE HIGHWAY	COOLGARDIE – ESPERANCE HIGHWAY	TONKIN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	54/134	34/147	9/27
		Relative impact on volumes of commodities	14.6%	6.0%	13.8%
	Most impacted LGA	Name	Coolgardie(S)	Canning(C)	Bayswater(C)
		Highest impacted commodity sector	Horticulture	Processed Food	Processed Food
		Commodity impacted	Fruit	Fish	Box Lamb
		Number of supply chains impacted	2	2	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	4.0	40.7	3.1
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	133/134	146/147	26/27
		Relative impact on volumes of commodities	6.7%	2.5%	5.1%
	Most impacted LGA	Name	Laverton(S)	Laverton(S)	Nedlands(C)
		Highest impacted commodity sector	General	General	Fuel
		Number of supply chains impacted	2	2	4
		Relative volumes impacted	100%	100%	99%
		Weekly tonnes BAU	1.9	1.9	246.2
		Relative number of supply chains impacted	100%	100%	67%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Great Eastern Highway NSW-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Great Eastern Highway NSW-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.27 Great Northern Highway

The Great Northern Highway KFR (Figure 45) is a freight route located in WA. It connects Perth to Wyndham in northern WA. The corridor is 3254 km with at least part of the route used for the transport of $74m of product on 514,306 trailers annually carrying 12.4 million tonnes across 22,920 supply chains spanning 96 commodities (28% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 26,736 trailers annually with the busiest sections carrying 134,801 trailers.

Mining transport represents approximately 35% of the total freight task, with movements from mine to port being the majority. Cropping contributes 25% to the freight task with movements from property to silo. This route is predominantly classified as PBS4a access north of Geraldton.

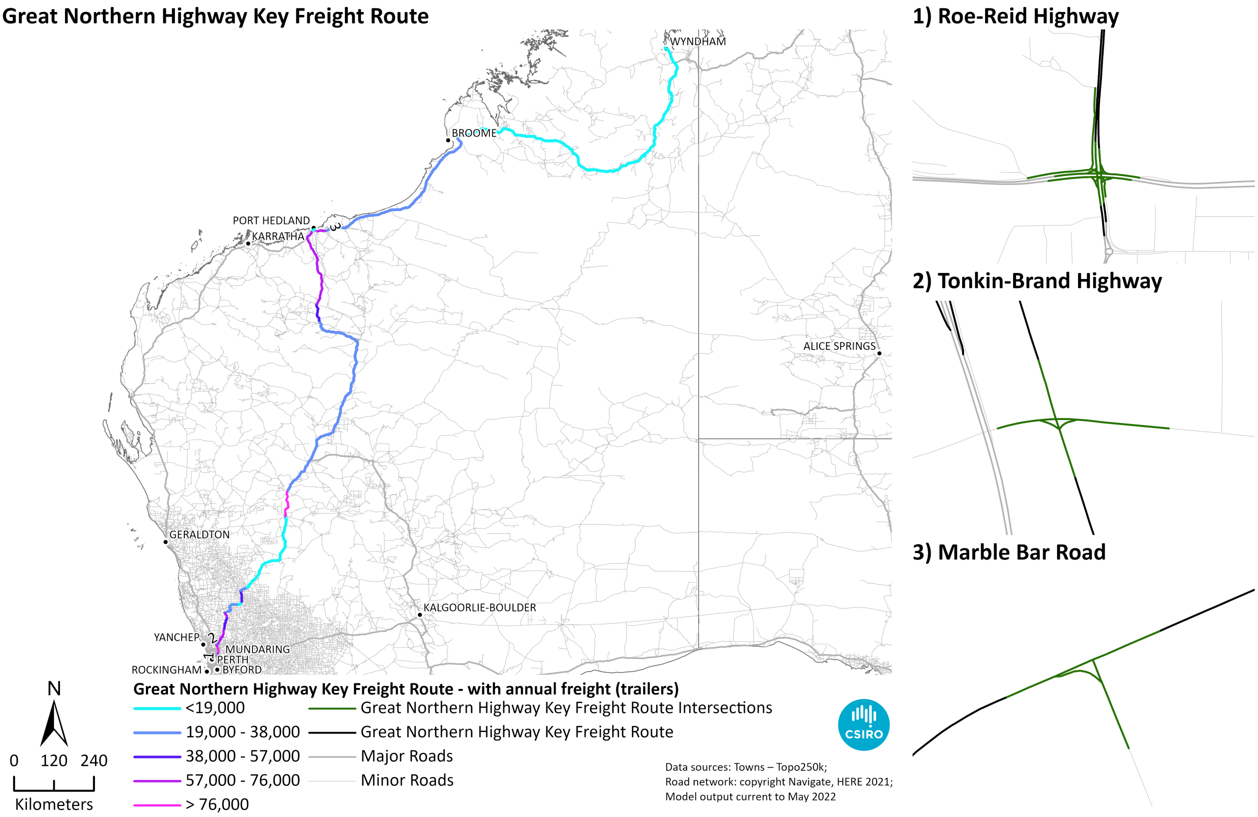

Figure 45 Great Northern Highway KFR

The Great Northern Highway KFR passes through 17 LGAs but crucially it supports the supply chain paths for over 234 LGAs along its length and beyond. It provides access to essential commodities for 95 LGAs. Many LGAs in northwest WA are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Roe – Reid Highway
- Tonkin – Brand Highway
- Marble Bar Road

The reliance described in Table 138 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Dardanup (S) LGA is moderately reliant on the Roe – Reid Highway and Tonkin – Brand Highway intersections and so is Broome for the Marble Bar Road intersection. For the LGAs relying on the three studied intersections, their reliance is low to moderate as 70-90% of commodities they either produce or consume do not rely on these intersections to move.

Table 138 Summary of community reliance metrics for each intersection on the Great Northern Highway key freight route - most impacted LGA

	ROE – REID HIGHWAY	TONKIN – BRAND HIGHWAY	MARBLE BAR ROAD
Destination LGA most reliant on the intersection	**Dardanup (S)**	**Dardanup (S)**	**Broome (S)**
Relative reliance on intersection for destination LGA	**0.26**	**0.29**	**0.20**
Origin LGA most reliant on the intersection	**Dandaragan (S)**	**Dandaragan (S)**	**East Pilbara (S)**
Relative reliance on intersection for origin LGA	**0.20**	**0.22**	**0.10**

5.27.1 Modelling and analysis outcomes

The following summarises the impacts from closure of the three modelled intersections along the Great Northern Highway. The results below are based on an average week.

- **Roe – Reid Highway intersection**: The closure of the Roe – Reid Highway intersection results in the disruption of 2,725 vehicle trips carrying 60,130 tonnes, 32% being essential commodities. Overall, 60,003 tonnes of freight are re-routed with an average detour length of three km and with an average increase in cost of $5.01 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Tonkin – Brand Highway intersection**: The closure of the Tonkin – Brand Highway intersection results in the disruption of 2,558 vehicle trips carrying 56,970 tonnes, 31% being essential commodities. Overall, 55,711 tonnes of freight are re-routed with an average detour length of four km and with an average increase in cost of $6.11 per tonne. A total value of supplies amounting to $0.3 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Marble Bar Road intersection**: The closure of the Marble Bar Road intersection results in the disruption of 1,247 vehicle trips carrying 30,886 tonnes, 27% being essential commodities. Overall, 8,569 tonnes of freight are re-routed with an average detour length of 4,492 km and with an average increase in cost of $608.77 per tonne. A total value of supplies amounting to $68.3 million, $3.7 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Great Northern Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Great Northern Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection
- ‘Great Northern Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘Great Northern Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Great Northern Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘Great Northern Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Great Northern Highway-cost_bar_plot.png’ shows the cost impacts of re-routing
- ‘Great Northern Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Great Northern Highway.

KFR risk profile

Table 139 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model is able to reach the maximum number of successive high-intensity alternative route closures of five. The ‘Greater Northern Highway-*intersection*-detoured blocked plot.png’ plots provide details on the impacts from the successive closures for each intersection. The risk metrics for all intersections is extremely low indicating that very little volumes of freight are expected to be obstructed from successive closures.

Table 139 Risk metrics for modelled intersections on the Great Northern Highway KFR

	ROE – REID HIGHWAY	TONKIN – BRAND HIGHWAY	MARBLE BAR ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.022	0.241
KFR impacts risk - detour costs for intersection	0.019	0.024	0.558
Last iteration	5	5	5

Freight impact

Table 140 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 140 Freight impact metrics for modelled intersections on the Great Northern Highway KFR by last successive closure

		ROE – REID HIGHWAY [%]	TONKIN – BRAND HIGHWAY [%]	MARBLE BAR ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	2	72
	Relative freight volume impacted – essential commodities	1	6	28
	Relative value of freight – all commodities	0	0	67
Re-routed supply chains	Relative detour cost – average	14	18	347
	Relative detour cost – maximum	139	165	15,757

The metrics in Table 140 indicate the supply chains traversing the Roe – Reid Highway intersection that are likely to be re-routed will do so with their average cost increasing by nearly 14% across all commodities, with some supply chain paths incurring an increase of up to 139%. Very little volumes of freight that usually traverse the Roe – Reid Highway intersection are expected to be obstructed by the last successive closure. The volumes of these obstructed essential commodities represent 1% of the total volumes usually traversing the intersection.

Similar observations can be made for the Tonkin – Brand Highway intersection for which similar values for their relative detour cost increases (18%) and freight volumes obstructed (6%) can be observed.

The Marble Bar Road intersection closure leads to very different outcomes. High percentages of freight by volumes are obstructed by the last iteration (72%), however with a lesser proportion of these being essential commodities (28%). For the remaining freight paths, the re-routing costs increase dramatically with an average increase over the year amounting to 347%, with one of the freight paths increasing by 150 times.

Some of the supply chains using the KFR might be more susceptible to obstructed or re-routed movements at various times of the year. 'Great Northern Highway-*intersection*-monthly obstructed volumes.png' and 'Great Northern Highway-*intersection*-monthly re-routed volumes.png' plots show the seasonality of freight using the KFR, and impact by the successive closures.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 141 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Roe – Reid Highway intersection closure has little impact on the LGAs it services with 6% of its essential commodities obstructed, and 0.4% of its commodities overall. The most impacted LGA is the Swan (C) LGA for the fuel commodity sector where 7% of its unleaded fuel will not be received, and when considering all commodities 6% of its fuel volumes will be obstructed (this also includes diesel fuel).

Similarly, the Tonkin – Brand Highway intersection closure has little impact in terms of LGA affected by obstructed freight with two out of its 113 LGAs impacted. However, 31% of its volumes are obstructed, due to the fact that the construction sector - which has large volumes of freight - is the one the most impacted by the closure of the intersection. Chittering (S) is the LGA most impacted with 54% of its supply chains in the construction sector impacted by obstructed freight.

The Marble Bar Road intersection closure has an impact on one LGA when considering essential commodities, being East Pilbara (S) for which diesel fuel will not reach its destination. When considering all commodities, three out of the 51 LGA the intersection services will have supply chains not reaching destination. Port Headland (T) is the most impacted LGA, with two of its mining supply chains not reaching their destination, representing 61% of the LGA's total import in terms of volumes, and 33% of its supply chains for the mining sector.

Table 141 Community impact metrics for modelled intersections on the Great Northern Highway KFR - obstructed supply chains

			ROE – REID HIGHWAY	TONKIN – BRAND HIGHWAY	MARBLE BAR ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/146	2/113	1/51
		Relative volumes impacted	5.9%	31.6%	9.6%
	Most impacted LGA	Name of destination LGA	Swan (C)	Chittering (S)	East Pilbara (S)
		Highest impacted commodity sector	Fuel	Construction	Fuel
		Commodity impacted	Unleaded fuel	Cement	Diesel fuel
		Number of supply chains impacted	1	1	4
		Relative volumes impacted	7%	100%	10%
		Weekly tonnes BAU	1,348.8	53.8	24,031.4
		Relative number of supply chains impacted	6%	100%	17%
All commodities	All impacted LGAs	Number of LGAs impacted	9/146	5/113	3/51
		Relative volumes impacted	0.4%	7.5%	37.8%
	Most impacted LGA	Name of destination LGA	Swan (C)	Chittering (S)	Port Hedland (T)
		Highest impacted commodity sector	Fuel	Construction	Mining
		Number of supply chains impacted	3	40	2
		Relative volumes impacted	6%	30%	61%
		Weekly tonnes BAU	2,093.0	4,099.7	33,019.2
		Relative number of supply chains impacted	6%	54%	33%

Re-routed supply chains

Table 142 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Roe – Reid Highway and the Tonkin – Brand Highway intersection closures result in 31% and 36% of their freight re-routed for 67 out of 146 and 43 out of 113 LGAs they service, respectively. The most impacted LGA for these two intersections is Karratha (C) when considering essential commodities, with all its bread requiring re-routing. When considering all commodities, Dandaragan (S) LGA is expected to have its six supply chains for general freight re-routed. These similar results indicate that these two LGAs have the same freight traversing these two intersections, and are susceptible to the closure of either of them.

The Marble Bar Road intersection closure results in 12% of the volumes that traverse it re-routed to 18 LGA out of 51 LGAs it services. The most impacted LGA is the Broome (S) LGA where all its supply chains of meat are re-routed when considering essential commodities; when considering all commodities, all of its supply chains for wood product are re-routed.

Table 142 Community impact metrics for modelled intersections on the Great Northern Highway KFR – re-routed supply chains

			ROE – REID HIGHWAY	TONKIN – BRAND HIGHWAY	MARBLE BAR ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	67/146	43/113	18/51
		Relative impact on volumes of commodities	31.1%	36.3%	12.3%
	Most impacted LGA	Name	Karratha (C)	Karratha (C)	Broome (S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Bread	Meat
		Number of supply chains impacted	2	2	5
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	4.1	4.1	38.1
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	144/146	112/113	50/51
		Relative impact on volumes of commodities	6.1%	7.1%	6.4%
	Most impacted LGA	Name	Dandaragan (S)	Dandaragan (S)	Broome (S)
		Highest impacted commodity sector	General	General	Wood Product
		Number of supply chains impacted	6	6	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	27.8	27.8	139.9
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Greater Northern Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Greater Northern Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.28 Great Western Highway

The Great Western Highway KFR (Figure 46) is a freight route located in NSW. It connects LGAs from Bathurst to Penrith. The corridor is 213 km with at least part of the route used for the transport of $42m of product on 289,476 trailers annually carrying six million tonnes across 12,929 supply chains spanning 101 commodities (44% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 127,918 trailers annually with the busiest sections carrying 229,311 trailers.

Fuel transport represents approximately 27% of the total freight task, with movements from port to depot being the majority. Wood product contributes 23% to the freight task with general freight, processed foods and construction adding 10% each to the freight task. This route is predominantly classified as PBS2a HLM access west of Castlereagh Highway with the eastern section PBS1 HML access.

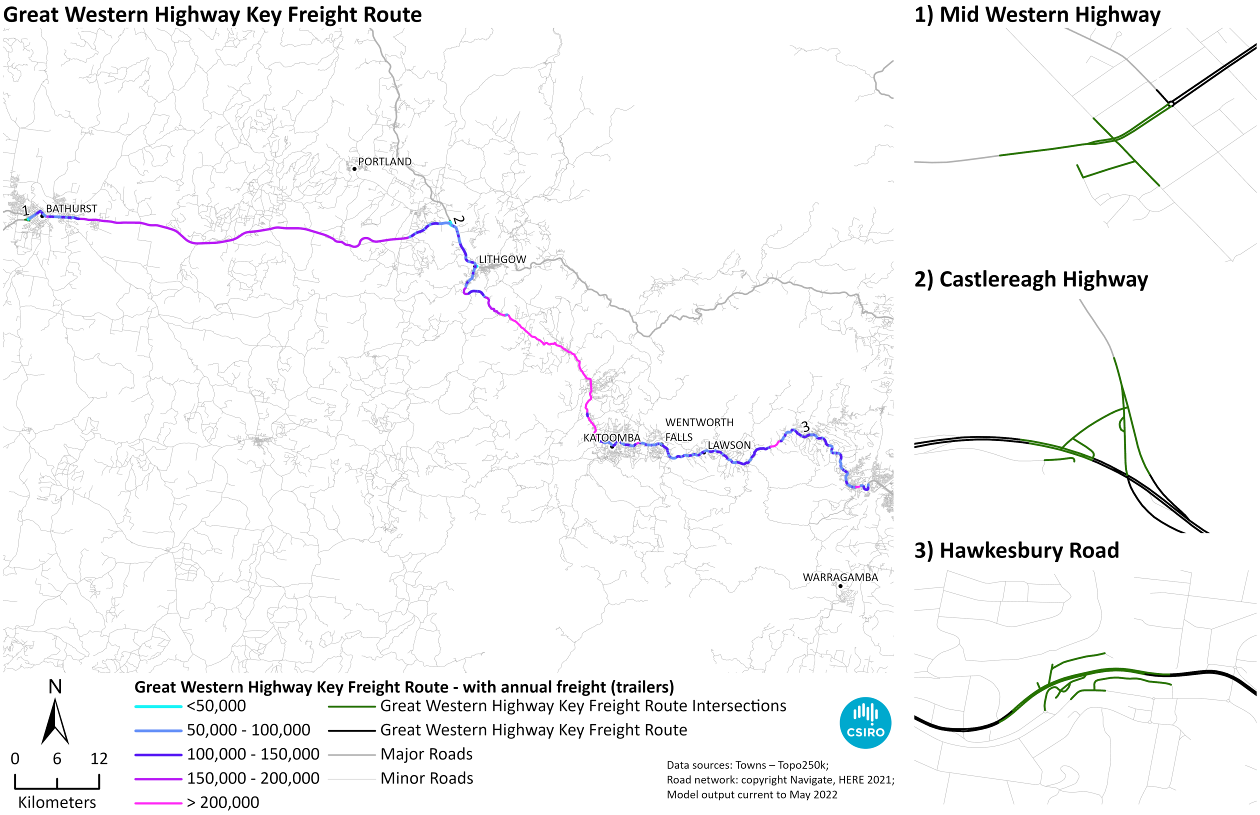

Figure 46 Great Western Highway KFR

The Great Western Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 209 LGAs along its length and beyond. It provides access to essential commodities for 91 LGAs. Many LGAs including Lithgow (C), Oberon (A) and Blue Mountains (C) rely on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Castlereagh Highway

- Mid Western Highway
- Hawkesbury Road

The reliance described in Table 143 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Bathurst Regional (A) LGA is moderately reliant on the Mid Western Highway intersection, while Blacktown (C) LGA has a low reliance on the Castlereagh Highway and the Hawkesbury Road intersections. For the LGAs relying on the three studied intersections, their reliance in terms of origin LGA is low as over 85% of their commodities produced do not rely on these intersections to move.

Table 143 Summary of community reliance metrics for each intersection on the Great Western Highway key freight route - most impacted LGA

	MID WESTERN HIGHWAY	CASTLEREAGH HIGHWAY	HAWKESBURY ROAD
Destination LGA most reliant on the intersection	Bathurst Regional (A)	Blacktown (C)	Blacktown (C)
Relative reliance on intersection for destination LGA	0.43	0.15	0.13
Origin LGA most reliant on the intersection	Snowy Valleys (A)	Blacktown (C)	Oberon (A)
Relative reliance on intersection for origin LGA	0.16	0.13	0.13

5.28.1 Modelling and analysis outcomes

The following summarises the impacts from closure of the three modelled intersections along the Great Western Highway. The results below are based on an average week.

- **Mid Western Highway intersection**: The closure of the Mid Western Highway intersection results in the disruption of 1,089 vehicle trips carrying 23,253 tonnes, 45% being essential commodities. Overall, 23,253 tonnes of freight are re-routed with an average detour length of three km and with an average increase in cost of $5.52 per tonne. No supply chain is obstructed.
- **Castlereagh Highway intersection**: The closure of the Castlereagh Highway intersection results in the disruption of 3,434 vehicle trips carrying 67,426 tonnes, 54% being essential commodities. Overall, 67,120 tonnes of freight are re-routed with an average detour length of 39 km and with an average increase in cost of $10.98 per tonne. A total value of supplies amounting to $3.4 million, none being essential commodities, is unable to reach its destination.
- **Hawkesbury Road intersection**: The closure of the Hawkesbury Road intersection results in the disruption of 4,219 vehicle trips carrying 84,298 tonnes, 51% being essential commodities. Overall, 84,289 tonnes of freight are re-routed with an average detour length of 64 km and with an average increase in cost of $15.15 per tonne. No supply chain is obstructed.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Great Western Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Great Western Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Great Western Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Great Western Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Great Western Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Great Western Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Great Western Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Great Western Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Great Western Highway.

KFR risk profile

Table 144 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Great Western Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures.

Table 144 Risk metrics for modelled intersections on the Great Western Highway KFR – the model

	MID WESTERN HIGHWAY	CASTLEREAGH HIGHWAY	HAWKESBURY ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.001	0.000
KFR impacts risk - detour costs for intersection	0.019	0.033	0.065
Last iteration	5	5	5

Freight impact

Table 145 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 145 Freight impact metrics for modelled intersections on the Great Western Highway KFR

		MID WESTERN HIGHWAY [%]	CASTLEREAGH HIGHWAY [%]	HAWKESBURY ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	1	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	9	17	31
	Relative detour cost – maximum	56	363	348

The metrics in Table 145 indicate the supply chains traversing the Mid Western Highway intersection that are likely to be re-routed will do so with their average cost increasing by nearly 9% across all commodities, with some supply chain paths incurring an increase of up to 56%. No freight that usually traverses the Mid Western Highway intersection is expected to be obstructed by the last successive closure.

Similar results are observed for the Castlereagh Highway and the Hawkesbury Road intersection closures, albeit with slightly higher increase in costs due to detours, 17% and 31% on average, respectively. These increases are moderate, however some of the supply chains see their costs increasing up to 350%.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 146 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and LGA most impacted for each intersection modelled on the KFR.

The Mid Western Highway intersection closure results in no LGAs impacted for either essential commodities or all commodities.

The Castlereagh Highway intersection closure results in one out of the 135 LGAs serviced by the intersection having obstructed supply chains, with 7.7% of the freight volumes for essential commodities obstructed. The most impacted LGA is Bathurst Regional (A). Overall, 3.2% (tonnes) of all commodities consumed in the LGAs impacted will not reach their destinations.

The Hawkesbury Road intersection closure results in no LGAs impacted for essential commodities and one out of the 108 LGAs serviced by the intersection having obstructed supply chains, with 0.3% of the freight volumes obstructed.

Table 146 Community impact metrics for modelled intersections on the Great Western Highway KFR - obstructed supply chains

			MID WESTERN HIGHWAY	CASTLEREAGH HIGHWAY	HAWKESBURY ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/88	1/135	0/108
		Relative volumes impacted	0.0%	7.7%	0.0%
	Most impacted LGA	Name of destination LGA		Bathurst Regional (A)	
		Highest impacted commodity sector		Fuel	
		Commodity impacted		LPG	
		Number of supply chains impacted		1	
		Relative volumes impacted	0%	8%	0%
		Weekly tonnes BAU	0.0	17.2	0.0
		Relative number of supply chains impacted	0%	8%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	0/88	1/135	1/108
		Relative volumes impacted	0.0%	3.2%	0.3%
	Most impacted LGA	Name of destination LGA		Bathurst Regional (A)	Penrith (C)
		Highest impacted commodity sector		General	Waste
		Number of supply chains impacted		1	2
		Relative volumes impacted	0%	17%	0%
		Weekly tonnes BAU	0.0	1,126.4	2,724.9
		Relative number of supply chains impacted	0%	2%	0%

Re-routed supply chains

Table 147 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and LGA most impacted for each intersection modelled on the KFR.

For essential commodities, 25% of the supply chains are expected to be re-routed for 22 of the 88 LGAs that traverse the Mid Western Highway intersection. The most impacted LGA is Blayney (A), with one supply chain in the processed food sector representing 0.6 tonnes per week re-routed. For non-essential commodities, all LGAs serviced by the Mid Western Highway intersection are however impacted by re-routed freight, representing 4.2% of the total volumes consumed within these LGAs overall.

Similar observations can be made for the Castlereagh Highway and Hawksbury Rad intersection closures, leading to 31.8% and 26.7% of their volumes re-routed for essential commodities, respectively, with Gilgandra (A) being the most impacted LGA for the horticulture sector.

Table 147 Community impact metrics for modelled intersections on the Great Western Highway KFR - re-routed supply chains

			MID WESTERN HIGHWAY	CASTLEREAGH HIGHWAY	HAWKESBURY ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	22/88	72/135	73/108
		Relative impact on volumes of commodities	25.2%	31.8%	26.7%
	Most impacted LGA	Name	Blayney (A)	Gilgandra (A)	Gilgandra (A)
		Highest impacted commodity sector	Processed Food	Horticulture	Horticulture
		Commodity impacted	Box Rice	Vegetables	Vegetables
		Number of supply chains impacted	1	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.6	2.0	2.0
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	88/88	134/135	108/108
		Relative impact on volumes of commodities	4.2%	7.8%	11.1%
	Most impacted LGA	Name	Blayney(A)	Bogan(A)	Bogan(A)
		Highest impacted commodity sector	General	Horticulture	Horticulture
		Number of supply chains impacted	3	18	18
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	59.6	19.5	19.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Great Western Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Great Western Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.29 Gregory Development Road

The Gregory Development Road KFR (Figure 47) is a freight route located in central Queensland. It connects LGAs from Charters Towers to Cairns via an inland route providing access to the Atherton Tablelands. The corridor is 549 km with at least part of the route used for the transport of $31m of product on 50,603 trailers annually carrying one million tonnes across 6361 supply chains spanning 69 commodities (25.0% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 12,453 trailers annually with the busiest sections carrying 29,147 trailers.

Cropping, fuel, horticulture and livestock each contribute 15% to the total freight task. Wood Product adds a further 10%. The KFR provides an important role in providing access to markets for primary produce with 40% of all movements originating at a property. This route is predominantly classified as PBS4a access.

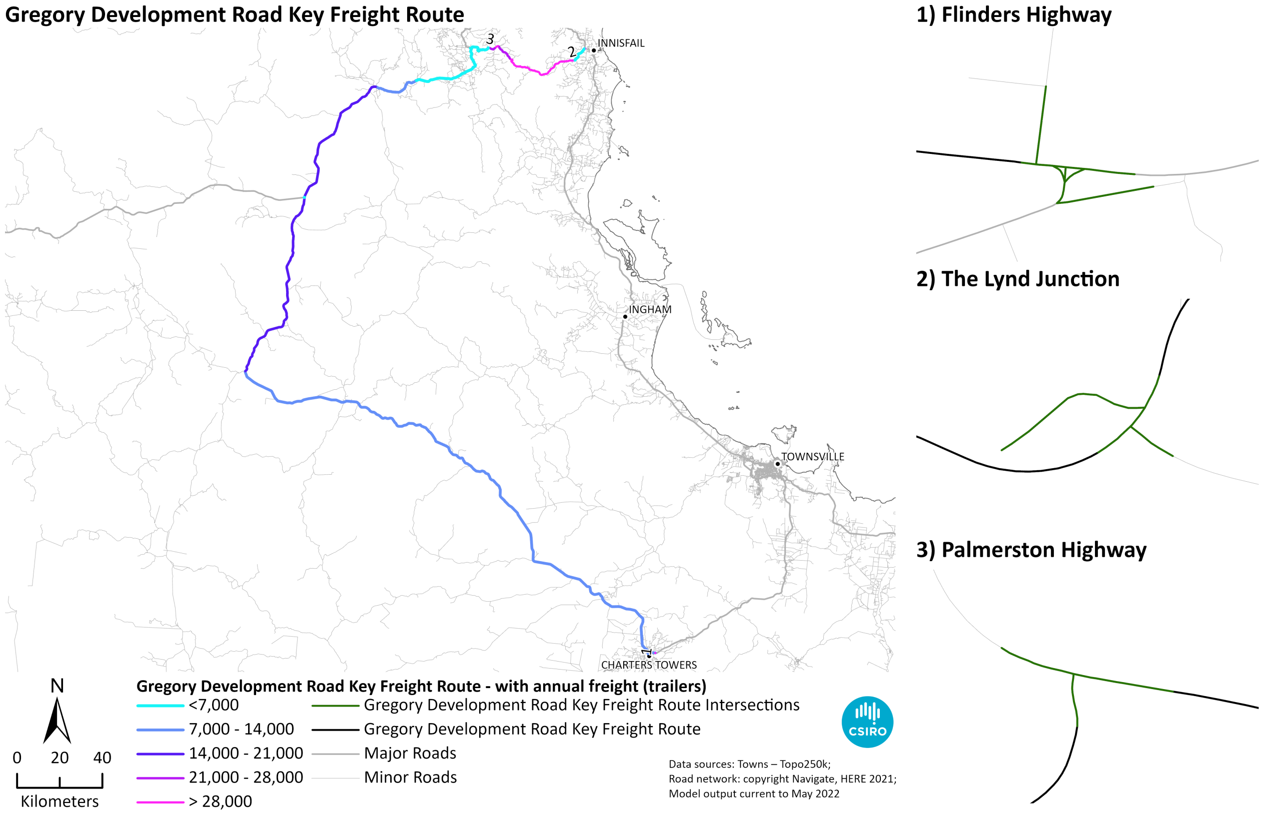

Figure 47 Gregory Development Road KFR

The Gregory Development Road KFR passes through five LGAs but crucially it supports the supply chain paths for over 143 LGAs along its length and beyond. It provides access to essential commodities for 49 LGAs. Many LGAs including Cook (S), Mareeba (S) and Tablelands (R) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Palmerston Highway

- Flinders Highway
- The Lynd Junction

The reliance described in Table 148 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Blacktown (C) LGA is the most reliant of all the LGAs whose freight traverse the Lynd Junction intersection and the Palmerston Highway intersection, and that this reliance is low to moderate with 15% and 16% respectively of the commodities imported relying on the intersections to move. For the Flinders Highway intersection, Charters Towers (R) is the most reliant LGA for destination freight. In terms of origin LGA, Mareeba (S) LGA is the most reliant of all intersections, with a moderate value for the Flinders Highway intersection, and high value for the Lynd Junction and the Palmerston Highway intersections.

Table 148 Summary of community reliance metrics for each intersection on the Gregory Development Road key freight route - most impacted LGA

	FLINDERS HIGHWAY	THE LYND JUNCTION	PALMERSTON HIGHWAY
Destination LGA most reliant on the intersection	Charters Towers (R)	Blacktown (C)	Blacktown (C)
Relative reliance on intersection for destination LGA	0.21	0.15	0.16
Origin LGA most reliant on the intersection	Mareeba (S)	Mareeba (S)	Mareeba (S)
Relative reliance on intersection for origin LGA	0.26	0.54	0.59

5.29.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Gregory Development Road. The results are based on expected freight for an average week.

- **Flinders Highway intersection**: The closure of the Flinders Highway intersection results in the disruption of 250 vehicle trips carrying 4,489 tonnes, 6% being essential commodities. Overall, 4,469 tonnes of freight are re-routed with an average detour length of 28 km and with an average increase in cost of $13.23 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.
- **The Lynd Junction intersection**: The closure of the Lynd Junction intersection results in the disruption of 562 vehicle trips carrying 11,167 tonnes, 25% being essential commodities. Overall, 317 tonnes of freight are re-routed with an average detour length of 27 km and with an average increase in cost of $4.54 per tonne. A total value of supplies amounting to $31.6 million, $8.5 million being essential commodities, is unable to reach its destination.
- **Palmerston Highway intersection**: The closure of the Palmerston Highway intersection results in the disruption of 520 vehicle trips carrying 10,381 tonnes, 29% being essential commodities. Overall, 1,196 tonnes of freight are re-routed with an average detour length of 147 km and with an average increase in cost of $16.11 per tonne. A total value of supplies amounting to $28.4 million, $7.6 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Gregory Development Road and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Gregory Development Road-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Gregory Development Road-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Gregory Development Road-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Gregory Development Road-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Gregory Development Road-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Gregory Development Road cost bar plot.png' shows the cost impacts of re-routing
- 'Gregory Development Road-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Gregory Development Road.

KFR Risk profile

Table 149 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Gregory Development Road-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for the Flinders Highway intersection are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The values for the Lynd Junction and the Palmerston Highway intersections are however moderate indicating that a large proportion of freight is obstructed by the last iteration. The risk metrics for the detour costs are low for the Flinders Highway intersection. For the Lynd Junction and the Palmerston Highway, this value is moderate to high, indicating that while the last iteration costs are not too high, those at the third or fourth iteration are quite costly.

Table 149 Risk metrics for modelled intersections on the Gregory Development Road KFR – the model

	FLINDERS HIGHWAY	THE LYND JUNCTION	PALMERSTON HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.002	0.240	0.177
KFR impacts risk - detour costs for intersection	0.024	0.317	0.221
Last iteration	5	5	5

Freight impact

Table 150 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 150 Freight impact metrics for modelled intersections on the Gregory Development Road KFR

		FLINDERS HIGHWAY [%]	THE LYND JUNCTION [%]	PALMERSTON HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	97	88
	Relative freight volume impacted – essential commodities	0	91	63
	Relative value of freight – all commodities	0	95	82
Re-routed supply chains	Relative detour cost – average	11	30	36
	Relative detour cost – maximum	135	74	133

The metrics in Table 150 indicate the supply chains traversing the Flinders Highway, the Lynd Junction and the Palmerston Highway intersections that are likely to be re-routed will do so with their average cost increasing by 11%, 30% and 36% respectively, on average. These increases are low to moderate, with the highest increase in cost being 135%, 74% and 133%, respectively, for some of the supply chains.

Little to no freight that usually traverses the Flinders Highway intersection is expected to be obstructed by the last successive closure. However, nearly all freight (87% and 88% respectively) traversing the Lynd Junction and the Palmerston Highway intersections is obstructed by the last iteration.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 151 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Flingers Highway intersection closure results in one out of the 88 LGAs serviced by the intersection having obstructed supply chains, with 1.8% of the freight volumes for essential commodities obstructed. The most impacted LGA is the Tablelands (R) LGA for the processed food industry. When considering all commodity types, six out of 88 LGAs are impacted by obstructed freight, representing 0.2% of the consumed goods in these LGAs.

The impact of the Lynd Junction and the Palmerston Highway intersection closures is greater on the communities.

The Lynd Junction intersection closure results in 24 out of the 55 LGAs serviced by the intersection having obstructed supply chains, with 19% of the freight volumes for essential commodities obstructed. The most impacted LGA is the Tablelands (R) LGA for the horticulture industry where all fruit commodity is unable to reach its destination. When considering all commodity types, 49 out of 55 LGAs are impacted by obstructed freight, representing 3.2% of the consumed goods in these LGAs.

The Palmerston Highway intersection closure results in 23 out of the 63 LGAs serviced by the intersection having obstructed supply chains, with 14.2% of the freight volumes for essential commodities obstructed. The most impacted LGA is the Tablelands (R) LGA for the horticulture industry where all of the fruit commodity is unable to reach its destination. When considering all commodity types, 54 out of 63 LGAs are impacted by obstructed freight, representing 2.7% of the consumed goods in these LGAs.

Table 151 Community impact metrics for modelled intersections on the Gregory Development Road KFR - obstructed supply chains

			FLINDERS HIGHWAY	THE LYND JUNCTION	PALMERSTON HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/88	24/55	23/63
		Relative volumes impacted	1.8%	19.1%	14.2%
	Most impacted LGA	Name of destination LGA	Tablelands(R)	Tablelands(R)	Tablelands(R)
		Highest impacted commodity sector	Processed Food	Horticulture	Horticulture
		Commodity impacted	Bread	Fruit	Fruit
		Number of supply chains impacted	1	10	10
		Relative volumes impacted	2%	100%	100%
		Weekly tonnes BAU	8.8	39.9	39.9
		Relative number of supply chains impacted	17%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	6/88	49/55	54/63
		Relative volumes impacted	0.2%	3.2%	2.7%
	Most impacted LGA	Name of destination LGA	Fraser Coast (R)	Tablelands(R)	Tablelands(R)
		Highest impacted commodity sector	Livestock	Horticulture	Horticulture
		Number of supply chains impacted	1	30	30
		Relative volumes impacted	3%	100%	100%
		Weekly tonnes BAU	55.4	87.7	87.7
		Relative number of supply chains impacted	3%	100%	100%

Re-routed supply chains

Table 152 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA most impacted for each intersection modelled on the KFR.

The Flinders Highway intersection closure results in 14 LGAs out of 88 having re-routed supply chains for essential commodities, representing nearly 7% of the volumes that are normally received by these LGAs. Douglas (S) is the most impacted LGA with seven supply chains for the processed food industry obstructed, representing 100% of the bread consumption of the LGA. When considering all commodities, Etheridge (S) is the most impacted for the cropping industry, however, the overall volumes impacted by re-routing over all the LGAs represent only 1.9% of the commodities consumed within the 88 impacted LGAs.

The Lynd Junction and the Palmerston Highway intersection closures result in four and eight LGAs out of 55 and 63 respectively, having re-routed supply chains for essential commodities, representing nearly 32% and 28%, respectively, of the volumes that are normally received by these LGAs. The most impacted LGAs by re-routing of freight are the Croydon (S) and the Cook (S) LGAs for the fuel industry where 83% and 100%, respectively, of the consumed fuel in these LGAs will be re-routed.

Table 152 Community impact metrics for modelled intersections on the Gregory Development Road KFR - re-routed supply chains

			FLINDERS HIGHWAY	THE LYND JUNCTION	PALMERSTON HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	14/88	4/55	8/63
		Relative impact on volumes of commodities	6.7%	32.6%	28.2%
	Most impacted LGA	Name	Douglas(S)	Croydon(S)	Cook(S)
		Highest impacted commodity sector	Processed Food	Fuel	Fuel
		Commodity impacted	Bread	Diesel fuel	LPG
		Number of supply chains impacted	7	1	5
		Relative volumes impacted	100%	83%	100%
		Weekly tonnes BAU	4.9	64.5	3.9
		Relative number of supply chains impacted	100%	50%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	88/88	14/55	24/63
		Relative impact on volumes of commodities	1.9%	0.7%	4.9%
	Most impacted LGA	Name	Etheridge (S)	Croydon (S)	Torres Strait Island (R)
		Highest impacted commodity sector	Cropping	Fuel	General
		Number of supply chains impacted	2	2	1
		Relative volumes impacted	100%	50%	100%
		Weekly tonnes BAU	0.2	259.7	0.5
		Relative number of supply chains impacted	100%	33%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Gregory Development Road-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Gregory Development Road-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.30 Gregory Highway

The Gregory Highway KFR (Figure 48) is a freight route located in central Queensland. It connects LGAs from Springsure to the Peak Downs Highway. The corridor is 188 km with at least part of the route used for the transport of $33.5m of product on 103,549 trailers annually carrying two million tonnes across 6,229 supply chains spanning 72 commodities (36% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 57,051 trailers annually with the busiest sections carrying 70,853 trailers.

Fuel transport represents approximately 32% of the total freight task, with movements from port to depot being the majority. Cropping contributes 20% to the freight task with general freight and livestock adding 15% each to the freight task. This route is predominantly classified as PBS3a access with the northern section from Emerald PBS3b access.

Figure 48 Gregory Highway KFR

The Gregory Highway KFR passes through two LGAs but crucially it supports the supply chain paths for over 198 LGAs along its length and beyond. It provides access to essential commodities for 42 LGAs. Central Highlands (R) (Qld) LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Capricorn Highway East
- Peak Downs Highway

- Capricorn Highway West

The reliance described in Table 153 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections in moderate degrees with 26% (Capricorn Highway), 19% (Peak Downs Highway) and 24% (Capricorn Highway) of all the supply chain paths traversing the intersections destined for the Central Highlands (R) (Qld) LGA. In terms of origin LGA, the reliance is similar for all intersections.

Table 153 Summary of community reliance metrics for each intersection on the Gregory Highway key freight route - most impacted LGA

	CAPRICORN HIGHWAY WEST	PEAK DOWNS HIGHWAY	CAPRICORN HIGHWAY EAST
Destination LGA most reliant on the intersection	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)	Central Highlands (R) (Qld)
Relative reliance on intersection for destination LGA	0.26	0.19	0.24
Origin LGA most reliant on the intersection	Central Highlands (R) (Qld)	Isaac (R)	Central Highlands (R) (Qld)
Relative reliance on intersection for origin LGA	0.26	0.14	0.26

5.30.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Gregory Highway. The results are based on expected freight for an average week.

- **Capricorn Highway intersection West**: The closure of the Capricorn Highway intersection results in the disruption of 1,451 vehicle trips carrying 27,930 tonnes, 37% being essential commodities. Overall, 23,777 tonnes of freight are re-routed with an average detour length of 16 km and with an average increase in cost of $6.88 per tonne. A total value of supplies amounting to $10.8 million, $6.2 million being essential commodities, is unable to reach its destination.
- **Peak Downs Highway intersection**: The closure of the Peak Downs Highway intersection results in the disruption of 1,351 vehicle trips carrying 25,808 tonnes, 36% being essential commodities. Overall, 25,724 tonnes of freight are re-routed with an average detour length of 45 km and with an average increase in cost of $12.38 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Capricorn Highway intersection East**: The closure of the Capricorn Highway intersection results in the disruption of 1,439 vehicle trips carrying 27,251 tonnes, 35% being essential commodities. Overall, 27,117 tonnes of freight are re-routed with an average detour length of 44 km and with an average increase in cost of $12.75 per tonne. A total value of supplies amounting to $1.5 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Gregory Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Gregory Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Gregory Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Gregory Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Gregory Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Gregory Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Gregory Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Gregory Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Gregory Highway.

KFR risk profile

Table 154 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five.

The risk metrics for obstructed volumes for the Peak Downs Highway and Capricorn Highway East intersections are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be costly.

Table 154 Risk metrics for modelled intersections on the Gregory Highway KFR

	CAPRICORN HIGHWAY WEST	PEAK DOWNS HIGHWAY	CAPRICORN HIGHWAY EAST
KFR impacts risk - obstructed volumes for intersection	0.036	0.001	0.001
KFR impacts risk - detour costs for intersection	0.009	0.014	0.018
Last iteration	5	5	5

Freight impact

Table 155 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 155 Freight impact metrics for modelled intersections on the Gregory Highway KFR by last successive closure

		CAPRICORN HIGHWAY WEST [%]	PEAK DOWNS HIGHWAY [%]	CAPRICORN HIGHWAY EAST [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	15	0	0
	Relative freight volume impacted – essential commodities	37	0	0
	Relative value of freight – all commodities	35	0	0
Re-routed supply chains	Relative detour cost – average	11	15	24
	Relative detour cost – maximum	298	613	1326

The metrics in Table 155 indicate the supply chains traversing the Capricorn Highway West intersection that are likely to be re-routed would do so with their average cost increasing by 11% across all commodities, with some supply chain paths reaching an increase of up to 298%. Those traversing the Peak Downs Highway intersection may be re-routed at an average cost increasing by 15% across all commodities, while those traversing the Capricorn Highway East intersection may do so at an average cost increasing by 24%, however the maximum increase for some supply chains reaches 1300%.

Very little freight is obstructed for the Peak Downs Highway and the Capricorn Highway East intersections. However, when closing the Capricorn Highway West intersection, 37% of essential commodities and 15% of all commodities are expected to be obstructed.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 156 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Capricorn Highway West intersection results in nine LGAs out of 129 not receiving essential commodities, where the most impacted LGA is the Central Highlands (R) (Qld) LGA for fuel, representing 71% of that LGA’s consumption. When considering all commodities, nine LGAs have their freight obstructed with Central Highlands (R) (Qld) the most impacted LGA, for which ten supply chains for the vehicles sector will not reach their destination.

The Peak Downs Highway intersection closure results in no LGAs impacted by obstructed essential commodities. When considering all commodities, seven out of 140 LGAs may have some commodities not reaching market, representing 0.2% of the LGAs’ consumption.

The Capricorn Highway East intersection results in one LGA out of 119 not receiving essential commodities, where the most impacted LGA is the Central Highlands (R) (Qld) LGA for box chicken. When considering all commodities, three LGAs have their freight obstructed - for general freight.

Table 156 Community impact metrics for modelled intersections on the Gregory Highway KFR - obstructed supply chains

			CAPRICORN HIGHWAY WEST	PEAK DOWNS HIGHWAY	CAPRICORN HIGHWAY EAST
Essential commodities	All impacted LGAs	Number of LGAs impacted	9/129	0/140	1/119
		Relative volumes impacted	5.7%	0.0%	11.1%
	Most impacted LGA	Name of destination LGA	Central Highlands(R)(Qld)	-	Central Highlands(R)(Qld)
		Highest impacted commodity sector	Fuel	-	Processed Food
		Commodity impacted	Unleaded fuel	-	Box Chicken
		Number of supply chains impacted	3	0	1
		Relative volumes impacted	71%	0%	11%
		Weekly tonnes BAU	3,901.9	0.0	34.6
		Relative number of supply chains impacted	18%	0%	4%
All commodities	All impacted LGAs	Number of LGAs impacted	9/129	7/140	3/119
		Relative volumes impacted	5.7%	0.2%	0.5%
	Most impacted LGA	Name of destination LGA	Central Highlands(R)(Qld)	Walcha(A)	Central Highlands(R)(Qld)
		Highest impacted commodity sector	Vehicles	Livestock	General
		Number of supply chains impacted	10	1	3
		Relative volumes impacted	73%	0%	15%
		Weekly tonnes BAU	89.8	384.8	619.3
		Relative number of supply chains impacted	53%	0%	4%

Re-routed supply chains

Table 157 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 10% of the supply chains are expected to be re-routed for 30 of the 129 LGAs that traverse the Capricorn Highway West intersection. The most impacted LGA is Douglas (S) with seven supply chains in the processed food sector representing 4.9 tonnes per week re-routed. For non-essential commodities, all 129 LGAs serviced by the Capricorn Highway West intersection are impacted by re-routed freight, representing 3.4% of the total volumes consumed within these LGAs.

Similar results are observed for the Peak Downs Highway and the Capricorn Highway East intersection closures, with the same most impacted LGA for both essential and non-essential commodities, and for the same industry sector.

Table 157 Community impact metrics for modelled intersections on the Gregory Highway KFR - re-routed supply chains

			CAPRICORN HIGHWAY WEST	PEAK DOWNS HIGHWAY	CAPRICORN HIGHWAY EAST
Essential commodities	All impacted LGAs	Number of LGAs impacted	30/129	42/140	30/119
		Relative impact on volumes of commodities	10.0%	7.0%	14.0%
	Most impacted LGA	Name	Douglas(S)	Douglas(S)	Douglas(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Bread	Bread
		Number of supply chains impacted	7	7	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	4.9	4.9	4.9
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	129/129	140/140	119/119
		Relative impact on volumes of commodities	3.4%	3.3%	4.0%
	Most impacted LGA	Name	Etheridge(S)	Etheridge(S)	Etheridge(S)
		Highest impacted commodity sector	Cropping	Cropping	Cropping
		Number of supply chains impacted	2	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.2	0.2	0.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Gregory Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Gregory Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.31 Henty Highway

The Henty Highway KFR (Figure 49) is a freight route located in western Victoria. It connects LGAs from the Sunraysia Highway to Portland. The corridor is 358 km with at least part of the route used for the transport of $43m of product on 463,628 trailers annually carrying 9.3 million tonnes across 23,311 supply chains spanning 78 commodities (13% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 31,914 trailers annually with the busiest sections carrying 233,952 trailers.

Wood product transport represents approximately 56% of the total freight task, with movements from property to port being the majority. Cropping contributes 20% to the freight task with fuel adding 10% to the freight. This route is predominantly classified as PBS3a access to the north of Horsham and PBS2a to the south.

Figure 49 Henty Highway KFR

The Henty Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 305 LGAs along its length and beyond. It provides access to essential commodities for 65 LGAs. Glenelg (S) LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used sparingly by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Princes Highway
- Western Highway

- Glenelg Highway

The reliance described in Table 158 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Glenelg (S) LGA is moderately reliant on the Princes Highway intersection as a destination LGA, and quite heavily as an origin LGA. For the Western Highway and the Glenelg Highway intersections, the reliance of the destination LGAs is little to moderate. However, Glenelg (S) LGA relies very heavily on the Western Highway intersection to send their commodities.

Table 158 Summary of community reliance metrics for each intersection on the Henty Highway key freight route - most impacted LGA

	WESTERN HIGHWAY	PRINCES HIGHWAY	GLENELG HIGHWAY
Destination LGA most reliant on the intersection	Yarriambiack (S)	Glenelg (S)	Mount Gambier (C)
Relative reliance on intersection for destination LGA	0.21	0.42	0.14
Origin LGA most reliant on the intersection	Glenelg (S)	Glenelg (S)	Glenelg (S)
Relative reliance on intersection for origin LGA	0.75	0.64	0.15

5.31.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Henty Highway. The results are based on expected freight for an average week.

- **Western Highway intersection**: The closure of the Western Highway intersection results in the disruption of 673 vehicle trips carrying 14,769 tonnes, 13% being essential commodities. Overall, 14,756 tonnes of freight are re-routed with a negligible detour length and with an average increase in cost of $1.64 per tonne. Little to no freight is unable to reach its destination.
- **Princes Highway intersection**: The closure of the Princes Highway intersection results in the disruption of 4,818 vehicle trips carrying 90,734 tonnes, 2% being essential commodities. Overall, 90,716 tonnes of freight are re-routed with an average detour length of 30 km and with an average increase in cost of $7.32 per tonne. Little to no freight is unable to reach its destination.
- **Glenelg Highway intersection**: The closure of the Glenelg Highway intersection results in the disruption of 1,500 vehicle trips carrying 26,274 tonnes, 7% being essential commodities. Overall, 26,271 tonnes of freight are re-routed with an average detour length of one km and with an average increase in cost of $2.89 per tonne. Little to no freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Henty Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Henty Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection

- ‘Henty Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘Henty Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Henty Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘Henty Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Henty Highway-cost bar plot.png’ shows the cost impacts of re-routing
- ‘Henty Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Henty Highway.

KFR risk profile

Table 159 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The ‘Henty Highway-*intersection*-cumulative impact.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also extremely low, indicating that freight is re-routed at a low cost.

Table 159 Risk metrics for modelled intersections on the Henty Highway KFR – the model

	WESTERN HIGHWAY	PRINCES HIGHWAY	GLENELG HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.005	0.029	0.005
Last iteration	5	5	5

Freight impact

Table 160 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 160 Freight impact metrics for modelled intersections on the Henty Highway KFR

		WESTERN HIGHWAY [%]	PRINCES HIGHWAY [%]	GLENELG HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	6	20	5
	Relative detour cost – maximum	85	156	45

The metrics in Table 160 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing slightly (between three and 20%) over all commodities, and the routes most impacted by detours reach a maximum increase cost of 156% (for the Princes Highway intersection).

For all three intersections, the obstructed freight is minimal[8].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 161 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Western Highway and the Glenelg Highway intersection closures result in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. Only the Princes Highway intersection closure results in one of the 51 LGAs it services having supply chains for essential commodities obstructed; Glenelg (S) being the most impacted for one of its LPG supply chains.

When considering all commodities, the closure of the Western Highway intersection results in two LGAs having obstructed supply chains, representing 0.3% of the volumes that are normally received by the 120 LGAs serviced by the intersection. Horsham (RC) is the most impacted LGA with two supply chains for the waste industry obstructed.

Similar results are observed for the Princes Highway and the Glenelg Highway intersection closures. The Princes Highway results in two LGAs having obstructed supply chains, representing 0.1% of the volumes that are normally received by the 51 LGAs serviced by the intersection. Glenelg (S) is the most impacted LGA, with one supply chain for the waste industry obstructed.

The Glenelg Highway results in one LGA having obstructed supply chains, representing 0.1% of the volumes that are normally received by the 134 LGAs serviced by the intersection. Southern Grampians (S) is the most impacted LGA, with one supply chain for the cropping industry obstructed.

[8] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

Table 161 Community impact metrics for modelled intersections on the Henty Highway KFR - obstructed supply chains

			WESTERN HIGHWAY	PRINCES HIGHWAY	GLENELG HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/120	1/51	0/134
		Relative volumes impacted	0.0%	12.5%	0.0%
	Most impacted LGA	Name of destination LGA	-	Glenelg(S)	-
		Highest impacted commodity sector	-	Fuel	-
		Commodity impacted	-	LPG	-
		Number of supply chains impacted		1	
		Relative volumes impacted	0%	12%	0%
		Weekly tonnes BAU	0.0	38.2	0.0
		Relative number of supply chains impacted	0%	12%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	2/120	2/51	1/134
		Relative volumes impacted	0.3%	0.1%	0.1%
	Most impacted LGA	Name of destination LGA	Horsham (RC)	Glenelg(S)	Southern Grampians(S)
		Highest impacted commodity sector	Waste	Waste	Cropping
		Number of supply chains impacted	2	1	1
		Relative volumes impacted	4%	2%	0%
		Weekly tonnes BAU	216.0	224.3	2,044.8
		Relative number of supply chains impacted	4%	2%	0%

Re-routed supply chains

Table 162 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 8.5% of the supply chains are expected to be re-routed for 12 of the 120 LGAs that traverse the Western Highway intersection. The most impacted LGA is Yarriambiack (S), with one supply chain in the processed food sector representing 0.6 tonnes per week re-routed. For non-essential commodities, all of the 120 LGAs serviced by the Western Highway intersection are impacted by re-routed freight, representing 2.4% of the total volumes consumed within these LGAs.

For the Princes Highway intersection, seven of the 51 LGAs serviced are expected to have freight re-routed, with this representing 6.5% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 51 LGAs serviced by the Princes Highway intersection are impacted by re-routed freight, representing 24.9% of the total volume consumed by all LGAs whose freight traverses the intersection.

Similar results are observed for the Glenelg Highway intersection closure. 24 of the 134 LGAs serviced are expected to have freight are re-routed, representing 3.2% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 134 LGAs serviced by the

Glenelg Highway intersection are impacted by re-routed freight, representing 2.8% of the total volume consumed by all LGAs whose freight traverses the intersection.

Table 162 Community impact metrics for modelled intersections on the Henty Highway KFR - re-routed supply chains

			WESTERN HIGHWAY	PRINCES HIGHWAY	GLENELG HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	12/120	7/51	24/134
		Relative impact on volumes of commodities	8.5%	6.5%	3.2%
	Most impacted LGA	Name	Yarriambiack (S)	Glenelg(S)	Robe(DC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Beef	Box Lamb	Box Chicken
		Number of supply chains impacted	1	2	1
		Relative volumes impacted	100%	76%	100%
		Weekly tonnes BAU	0.6	4.4	2.7
		Relative number of supply chains impacted	100%	33%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	120/120	51/51	134/134
		Relative impact on volumes of commodities	2.4%	24.9%	2.8%
	Most impacted LGA	Name	Horsham (RC)	Glenelg(S)	Corangamite (S)
		Highest impacted commodity sector	Construction	Vehicles	Wood Product
		Number of supply chains impacted	1	8	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	96.2	17.0	38.3
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Henty Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Henty Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.32 Hume Highway

The Hume Highway KFR is a north-east – south-west corridor through NSW connecting the Hume Freeway to the Hume Motorway. It has connections to the Sturt Highway heading west and the Barton and Federal highways into the ACT as well as the Olympic Highway. It is an 870 km corridor where at least part of the route is used in the movement of $280m worth of product on 1,133,658 trailers annually carrying 20.5 million tonnes capturing 50,580 supply chains spanning 122 commodities with 32% of the total volume on the KFR is classified as essential commodities. The average freight volume across the road segments is 332,761 trailers annually with the busiest sections carrying 463,679 trailers.

General freight and fuel moving from port to depots/DCs and on to markets each contribute 20% to the freight task for the corridor while wood product movements contribute approximately 17% of the total freight task, moving from forestry to port or mills and then on to DCs and market. Construction and processed food both contribute 10% each to the total freight task. This route is predominantly PBS2a access classified with HML approved.

Figure 50 Hume Highway KFR

The Hume Highway KFR passes through ten LGAs but crucially it supports the supply chain paths for over 420 LGAs along its length and beyond. It provides access to essential commodities for 181 LGAs. Many LGAs including Snowy Valleys (A) and Goulburn Mulwaree (A) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 50% of their supply chain trip length. General freight and vehicles utilise large sections of the KFR. Figure 50 shows that the highest concentration of freight is between Sturt Highway near Wagga Wagga and Sydney, with a slight reduction south to Albury Wodonga.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Sturt Highway
- Federal Highway
- Olympic Highway

The reliance described in Table 163 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Blacktown (C) LGA is moderately reliant on all of the intersections studied here in terms of freight received. While Greater Shepparton (C), Wollongong (C) and Snowy Valleys (A) are the LGAs most reliant on the Sturt Highway, the Federal Highway and the Olympic Highway intersections respectively, the reliance is low. For all of them, less than 10% of freight originating from the LGA traverses these intersections.

Table 163 Summary of community reliance metrics for each intersection on the Hume Highway key freight route - most impacted LGA

	STURT HIGHWAY	FEDERAL HIGHWAY	OLYMPIC HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Blacktown (C)	Blacktown (C)
Relative reliance on intersection for destination LGA	0.28	0.28	0.12
Origin LGA most reliant on the intersection	Greater Shepparton (C)	Wollongong (C)	Snowy Valleys (A)
Relative reliance on intersection for origin LGA	0.05	0.09	0.07

5.32.1 Modelling and analysis outcomes

The following summarises the impacts from closure of the three modelled intersections along the Hume Highway. The results below are based on an average week.

- **Sturt Highway intersection:** The closure of the Sturt Highway intersection results in the disruption of 13,767 vehicle trips carrying 235,333 tonnes, 31% being essential commodities. Overall, 235,131 tonnes of freight are re-routed with an average detour length of -4 km and with an average increase in cost of $7.25 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.

Federal Highway intersection: The closure of the Federal Highway intersection results in the disruption of 15,554 vehicle trips carrying 269,464 tonnes, 36% being essential commodities. Overall, 269,443 tonnes of freight are re-routed with an average detour length of 12 km and with an average increase in cost of $8.60 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.

Olympic Highway intersection: The closure of the Olympic Highway intersection results in the disruption of 12,380 vehicle trips carrying 217,117 tonnes, 32% being essential commodities. Overall, 216,975 tonnes of freight are re-routed with an average detour length of one km and with an average increase in cost of $7.35 per tonne. A total value of supplies amounting to $0.5 million, $0.2 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Hume Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Hume Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Hume Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Hume Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Hume Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Hume Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Hume Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Hume Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Hume Highway.

KFR risk profile

Table 164 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five. The 'Hume Highway-*intersection*-detoured blocked plot.png' plots provide details on the impacts from the successive closures for each intersection. The risk metrics for all intersections are extremely low, indicating that low volumes of freight were expected to be obstructed from the successive closure of intersection and alternative routes.

Table 164 Risk metrics for modelled intersections on the Hume Highway KFR

	STURT HIGHWAY	FEDERAL HIGHWAY	OLYMPIC HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.008	0.011	0.010
Last iteration	5	5	5

Freight impact

Table 165 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 165 Freight impact metrics for modelled intersections on the Hume Highway KFR by last successive closure

		STURT HIGHWAY [%]	FEDERAL HIGHWAY [%]	OLYMPIC HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	4	7	6
	Relative detour cost – maximum	78	510	333

The metrics in Table 165 indicate the supply chains traversing the Sturt Highway intersection that were likely to be re-routed will do so with their average cost increasing by 4% across all commodities, with modelling indicating some supply chain paths incurring an increase of up to 78%. Low volumes of freight that usually traverse the Sturt Highway intersection are expected to be obstructed by the last successive closure.

Similar observations can be made for the Federal Highway and the Olympic Highway intersections, which see similar values for their relative detour costs.

Some of the supply chains using the KFR may be more susceptible to obstructed or re-routed movements at various times of the year. 'Hume Highway-*intersection*-monthly obstructed volumes.png' and 'Hume Highway-*intersection*-monthly re-routed volumes.png' plots show the seasonality of freight using the KFR, and impacts by the successive closure of intersections and alternative routes.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 166 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR. While some commodities are not able to reach their destination, the successive closures have little impact overall on the LGAs.

The Sturt Highway intersection closure impacts three LGAs out of 323 when considering essential commodities, the most impacted being Greater Hume Shire (A) for which gravel may not reach its destination. When considering all commodities, seven out of the 323 LGAs the intersection services have supply chains that may not reach their destination. Yass Valley (A) is the most impacted LGA, with four of its construction supply chains expected to not reach their destination, representing 7% (supply chains) of the LGA's total consumption for the construction sector.

The Federal Highway intersection closure has no impact on the LGAs they service for essential commodities, and seven LGAs out of 326 receiving freight are impacted when considering all commodities. The most impacted LGA is the Shoalhaven (C) LGA for the livestock commodity sector.

The Olympic Highway intersection closure impacts one LGA out of 240 when considering essential commodities, with the most impacted being Greater Hume Shire (A) for which unleaded fuel may not reach its destination. When considering all commodities, four out of the 240 LGAs the intersection services may have supply chains not reaching destination. Again, Greater Hume Shire (A) is the most impacted LGA, with one of its vehicle supply chains expected to not reach its destination, representing 10% (supply chains) of the LGA's total consumption for the vehicles sector.

Table 166 Community impact metrics for modelled intersections on the Hume Highway KFR - obstructed supply chains

			STURT HIGHWAY	FEDERAL HIGHWAY	OLYMPIC HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	3/323	0/326	1/240
		Relative volumes impacted	7.5%	0.0%	19.3%
	Most impacted LGA	Name of destination LGA	Greater Hume Shire(A)	-	Greater Hume Shire(A)
		Highest impacted commodity sector	Construction	-	Fuel
		Commodity impacted	Gravel	-	Unleaded fuel
		Number of supply chains impacted	1	0	1
		Relative volumes impacted	8%	0%	22%
		Weekly tonnes BAU	46.2	0	389.6
		Relative number of supply chains impacted	12%	0%	20%
All commodities	All impacted LGAs	Number of LGAs impacted	7/323	7/326	4/240
		Relative volumes impacted	1.3%	0.2%	1.6%
	Most impacted LGA	Name of destination LGA	Yass Valley(A)	Shoalhaven(C)	Greater Hume Shire(A)
		Highest impacted commodity sector	Construction	Livestock	Vehicles
		Number of supply chains impacted	4	1	1
		Relative volumes impacted	4%	1%	23%
		Weekly tonnes BAU	4,161.9	300.0	27.3
		Relative number of supply chains impacted	7%	1%	10%

Re-routed supply chains

Table 167 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR. Many of the LGAs that receive freight traversing the three intersections may see their freight being detoured because of the successive closures, however the impact is not likely to exceed 30% of the total volumes they normally receive.

Table 167 Community impact metrics for modelled intersections on the Hume Highway KFR - re-routed supply chains

			STURT HIGHWAY	FEDERAL HIGHWAY	OLYMPIC HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	88/323	109/326	118/240
		Relative impact on volumes of commodities	30.6%	30.5%	31.7%
	Most impacted LGA	Name	Balranald(A)	Unincorporated ACT	Alpine(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Chicken	Box Rice	Box Beef
		Number of supply chains impacted	2	73	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	3.3	148.1	0.4
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	321/323	324/326	239/240
		Relative impact on volumes of commodities	8.8%	9.8%	8.1%
	Most impacted LGA	Name	Federation(A)	Hilltops(A)	Federation(A)
		Highest impacted commodity sector	Vehicles	Horticulture	Vehicles
		Number of supply chains impacted	1	15	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	7.5	35.3	7.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘Hume Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Hume Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.33 Landsborough Highway

The Landsborough Highway KFR (Figure 51) is a freight route located in Queensland. It connects LGAs from the Flinders Highway in the north-west to the Warrego Highway in the south-west via Barcaldine. The corridor is 1034 km with at least part of the route used for the transport of $64m of product on 108,172 trailers annually carrying two million tonnes across 10,660 supply chains spanning 98 commodities (20% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 39,909 trailers annually with the busiest sections carrying 62,880 trailers.

Livestock transport represents approximately 30% of the total freight task, with movements between properties being the majority. Mining contributes 20% to the freight task, with fuel adding a further 15% to the freight task. Horticulture heading south-east and general freight heading north-west each contribute 10% of the freight task. This route is predominantly classified as PBS4a access.

Figure 51 Landsborough Highway KFR

The Landsborough Highway KFR passes through eight LGAs but crucially it supports the supply chain paths for over 316 LGAs along its length and beyond. It provides access to essential commodities for 56 LGAs. Longreach (R) LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, horticulture and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Flinders Highway

- Capricorn Highway
- Warrego Highway

The reliance described in Table 168 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the LGAs are little to moderately reliant on any of the three intersections to both send and receive their commodities.

Table 168 Summary of community reliance metrics for each intersection on the Landsborough Highway key freight route - most impacted LGA

	CAPRICORN HIGHWAY	FLINDERS HIGHWAY	WARREGO HIGHWAY
Destination LGA most reliant on the intersection	Townsville (C)	Brisbane (C)	Brisbane (C)
Relative reliance on intersection for destination LGA	0.20	0.11	0.12
Origin LGA most reliant on the intersection	Mareeba (S)	Litchfield (M)	Blackall-Tambo (R)
Relative reliance on intersection for origin LGA	0.05	0.11	0.08

5.33.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Landsborough Highway. The results are based on expected freight for an average week.

- **Capricorn Highway intersection**: The closure of the Capricorn Highway intersection results in the disruption of 1,156 vehicle trips carrying 20,665 tonnes, 20% being essential commodities. Overall, 20,515 tonnes of freight are re-routed with an average detour length of seven km and with an average increase in cost of $5.25 per tonne. A total value of supplies amounting to $0.3 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Flinders Highway intersection**: The closure of the Flinders Highway intersection results in the disruption of 500 vehicle trips carrying 8,640 tonnes, 28% being essential commodities. Overall, 8,615 tonnes of freight are re-routed with an average detour length of 142 km and with an average increase in cost of $26.25 per tonne. A total value of supplies amounting to $0.2 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Warrego Highway intersection**: The closure of the Warrego Highway intersection results in the disruption of 480 vehicle trips carrying 8,134 tonnes, 11% being essential commodities. Overall, 8,120 tonnes of freight are re-routed with an average detour length of 102 km and with an average increase in cost of $23.37 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Landsborough Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Landsborough Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection
- ‘Landsborough Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘Landsborough Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Landsborough Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘Landsborough Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Landsborough Highway-cost bar plot.png’ shows the cost impacts of re-routing
- ‘Landsborough Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Landsborough Highway.

KFR risk profile

Table 169 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The ‘Landsborough Highway-*intersection*-cumulative impact.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are low, indicating that very little freight is expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 169 Risk metrics for modelled intersections on the Landsborough Highway KFR – the model

	CAPRICORN HIGHWAY	FLINDERS HIGHWAY	WARREGO HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.007	0.001	0.001
KFR impacts risk - detour costs for intersection	0.003	0.016	0.024
Last iteration	5	5	5

Freight impact

Table 170 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 170 Freight impact metrics for modelled intersections on the Landsborough Highway KFR

		CAPRICORN HIGHWAY [%]	FLINDERS HIGHWAY [%]	WARREGO HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	0	0
	Relative freight volume impacted – essential commodities	3	0	0
	Relative value of freight – all commodities	2	0	0
Re-routed supply chains	Relative detour cost – average	3	9	15
	Relative detour cost – maximum	191	58	95

The metrics in Table 170 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing slightly (between 3% and 15%) over all commodities, and the routes most impacted by detours reach a maximum increase cost of 191% (for the Capricorn Highway intersection).

For all three intersections, the obstructed freight is minimal[9].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 171 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Flinders Highway and the Warrego Highway intersection closures result in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. Only the Capricorn Highway intersection closure results in two of the 188 LGAs it services having supply chains for essential commodities obstructed; Barcaldine (R) being the most impacted for one of its box beef supply chains.

When considering all commodities, the closure of the Capricorn Highway intersection results in five LGAs having obstructed supply chains, representing 0.8% of the volumes that are normally received by the 188 LGAs serviced by the intersection. Longreach (R) is the most impacted LGA with one supply chain for the cropping industry obstructed.

Similar results are observed for the Flinders Highway and the Warrego Highway intersection closures. The Flinders Highway results in seven LGAs having obstructed supply chains, representing 0.4% of the volumes that are normally received by the 103 LGAs serviced by the intersection. Winton (S) is the most impacted LGA, with eight supply chains for the livestock industry obstructed.

[9] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

The Warrego Highway results in five LGAs having obstructed supply chains, representing 0.1% of the volumes that are normally received by the 94 LGAs serviced by the intersection. Murweh (S) is the most impacted LGA, with five supply chains for the livestock industry obstructed.

Table 171 Community impact metrics for modelled intersections on the Landsborough Highway KFR - obstructed supply chains

			CAPRICORN HIGHWAY	FLINDERS HIGHWAY	WARREGO HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/188	0/103	0/94
		Relative volumes impacted	10.0%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Barcaldine(R)	-	-
		Highest impacted commodity sector	Processed Food	-	-
		Commodity impacted	Box Beef	-	-
		Number of supply chains impacted	1	0	0
		Relative volumes impacted	100%	0%	0%
		Weekly tonnes BAU	0.5	0.0	0.0
		Relative number of supply chains impacted	100%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	5/188	7/103	5/94
		Relative volumes impacted	0.8%	0.4%	0.1%
	Most impacted LGA	Name of destination LGA	Longreach (R)	Winton (S)	Murweh (S)
		Highest impacted commodity sector	Cropping	Livestock	Livestock
		Number of supply chains impacted	1	8	5
		Relative volumes impacted	52%	2%	0%
		Weekly tonnes BAU	1.1	680.3	1,870.9
		Relative number of supply chains impacted	33%	2%	1%

Re-routed supply chains

Table 172 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 21% of the supply chains are expected to be re-routed for 42 of the 188 LGAs that traverse the Capricorn Highway intersection. The most impacted LGA is Burke (S), with one supply chain in the processed food sector representing 0.4 tonnes per week re-routed. For non-essential commodities, nearly all of the 187 LGAs serviced by the Capricorn Highway intersection are impacted by re-routed freight, representing 3.6% of the total volumes consumed within these LGAs.

For the Flinders Highway intersection, 23 of the 103 LGAs serviced are expected to have freight re-routed, with this representing 34.3% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 103 LGAs serviced by the Flinders Highway intersection are impacted by re-routed freight, representing 2.6% of the total volume consumed by all LGAs whose freight traverses the intersection.

Similar results are observed for the Warrego Highway intersection closure. 27 of the 94 LGAs serviced are expected to have freight re-routed, representing nearly 16% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 94 LGAs serviced by the Warrego Highway intersection are impacted by re-routed freight, representing 2.3% of the total volume consumed by all LGAs whose freight traverses the intersection.

Table 172 Community impact metrics for modelled intersections on the Landsborough Highway KFR - re-routed supply chains

			CAPRICORN HIGHWAY	FLINDERS HIGHWAY	WARREGO HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	42/188	23/103	27/94
		Relative impact on volumes of commodities	21.0%	34.3%	15.9%
	Most impacted LGA	Name	Burke(S)	Burke(S)	Blackall-Tambo(R)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Bread	Box Chicken
		Number of supply chains impacted	1	1	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.4	0.4	2.0
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	187/188	103/103	94/94
		Relative impact on volumes of commodities	3.6%	2.6%	2.3%
	Most impacted LGA	Name	Winton(S)	Burke(S)	Boulia(S)
		Highest impacted commodity sector	Cropping	Cropping	Cropping
		Number of supply chains impacted	4	1	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	2.4	0.8	0.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Landsborough Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Landsborough Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.34 Lasseter Highway

The Lasseter Highway KFR (Figure 52) is a freight route located in the NT. It connects LGAs from the Stuart Highway west to Yulara. The corridor is 245 km with at least part of the route used for the transport of $620,000 of product on 747 trailers annually carrying 15,030 tonnes across 104 supply chains spanning 21 commodities (60% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 425 trailers annually with the busiest sections carrying 631 trailers.

Fuel transport represents approximately 50% of the total freight task, with movements from depot to stations being the majority. Livestock contributes 30% to the freight task and importantly movements to supermarkets add 10% to the freight task and include processed food and general freight. This route is predominantly classified as PBS4a access.

Figure 52 Lasseter Highway KFR

The Lasseter Highway KFR passes through two LGAs but crucially it supports the supply chain paths for over 38 LGAs along its length and beyond. It provides access to essential commodities for two LGAs. MacDonnell (R) LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Stuart Highway
- Luritja Road
- Mulga Park Road

The reliance described in Table 173 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections studied to high degrees, with 66% (Stuart Highway intersection), 68% (Luritja Road intersection) and 54% (Mulga Park Road intersection) of all the supply chain paths traversing the intersections destined for the MacDonnell (R) LGA. In terms of origin LGA, the reliance is slightly lower for all intersections.

Table 173 Summary of community reliance metrics for each intersection on the Lasseter Highway key freight route - most impacted LGA

	STUART HIGHWAY	LURITJA ROAD	MULGA PARK ROAD
Destination LGA most reliant on the intersection	MacDonnell (R)	MacDonnell (R)	MacDonnell (R)
Relative reliance on intersection for destination LGA	0.66	0.68	0.54
Origin LGA most reliant on the intersection	West Torrens (C)	West Torrens (C)	MacDonnell (R)
Relative reliance on intersection for origin LGA	0.34	0.36	0.29

5.34.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Lasseter Highway. The results are based on expected freight for an average week.

- **Stuart Highway intersection**: The closure of the Stuart Highway intersection results in the disruption of 12 vehicle trips carrying 265 tonnes, 66% being essential commodities. Overall, 262 tonnes of freight are re-routed with an average detour length of 1,574 km and with an average increase in cost of $221.95 per tonne. Little to no freight is unable to reach its destination.
- **Luritja Road intersection**: The closure of the Luritja Road intersection results in the disruption of 12 vehicle trips carrying 256 tonnes, 68% being essential commodities. Overall, 253 tonnes of freight are re-routed with an average detour length of 1,587 km and with an average increase in cost of $225.13 per tonne. Little to no freight is unable to reach its destination.
- **Mulga Park Road intersection**: The closure of the Mulga Park Road intersection results in the disruption of seven vehicle trips carrying 155 tonnes, 54% being essential commodities. Overall, three tonnes of freight are re-routed with an average detour length of 2,231 km and with an average increase in cost of $208.28 per tonne. A total value of supplies amounting to $0.6 million, $0.2 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Lasseter Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Lasseter Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.

- 'Lasseter Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Lasseter Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Lasseter Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Lasseter Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Lasseter Highway-cost_bar_plot.png' shows the cost impacts of re-routing.
- 'Lasseter Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Lasseter Highway.

KFR risk profile

Table 174 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for the three KFR intersections, the model is able to reach the maximum number of successive high-intensity alternative route closures of five, however their risk profile is different depending on the intersection.

The 'Lasseter Highway-*intersection*-detoured blocked plot.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for the Stuart Highway and the Luritja Road intersections are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The Mulga Park Road intersection successive closures result in nearly all its freight obstructed by the fifth iteration. Until the second iteration, the majority of freight can still be re-routed, however for each successive closure, the volume of obstructed freight increases.

The risk metrics for the detour costs while low, are not negligible, indicating that there are some detours that might be costly.

Table 174 Risk metrics for modelled intersections on the Lasseter Highway KFR

	STUART HIGHWAY	LURITJA ROAD	MULGA PARK ROAD
KFR impacts risk - obstructed volumes for intersection	0.003	0.003	0.290
KFR impacts risk - detour costs for intersection	0.302	0.309	0.501
Last iteration	5	5	5

Freight impact

Table 175 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 175 Freight impact metrics for modelled intersections on the Lasseter Highway KFR by last successive closure

		STUART HIGHWAY [%]	LURITJA ROAD [%]	MULGA PARK ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	1	98
	Relative freight volume impacted – essential commodities	0	0	100
	Relative value of freight – all commodities	0	0	100
Re-routed supply chains	Relative detour cost – average	108	108	84
	Relative detour cost – maximum	252	254	88

The metrics in Table 175 indicate that the Mulga Park Road intersection has very high volumes of freight obstructed (98% over all commodities) with 100% of its essential commodities obstructed. The value of these obstructed commodities represents 100% of the total value usually traversing the intersection. For the little freight that is able to be re-routed, this is done at high-cost increase (84%).

The supply chains traversing the Stuart Highway and the Luritja Road intersections that are likely to be re-routed will do so with a high average cost increase of 108%, however some supply chains are expected to reach up to 254% increase. Little freight that usually traverses the Stuart Highway and the Luritja Road intersections is expected to be obstructed by the last successive closure

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 176 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Stuart Highway and the Luritja Road intersection closures result in no LGA impacted by obstructed essential commodities, and one out of 23 and 19 LGAs, respectively, impacted when considering all commodities. The livestock sector is the most impacted for the Unincorporated SA LGA for which two supply chains with 725 weekly tonnes are unable to reach market. Only 0.4% of all commodities consumed by all the LGAs impacted will not reach their destination.

The Mulga Park Road intersection closure has two out of seven LGAs with obstructed essential commodities, representing nearly 32% of all essential commodities consumed in the impacted LGAs. For non-essential commodities, all LGAs serviced by the intersection will have some of their freight obstructed, representing 0.8% of their overall consumption.

Table 176 Community impact metrics for modelled intersections on the Lasseter Highway KFR - obstructed supply chains

			STUART HIGHWAY	LURITJA ROAD	MULGA PARK ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/23	0/19	2/17
		Relative volumes impacted	0.0%	0.0%	31.9%
	Most impacted LGA	Name of destination LGA	-	-	MacDonnell(R)
		Highest impacted commodity sector	-	-	Processed Food
		Commodity impacted	-	-	Box Beef
		Number of supply chains impacted	0	0	1
		Relative volumes impacted	0%	0%	47%
		Weekly tonnes BAU	0.0	0.0	2.3
		Relative number of supply chains impacted	0%	0%	25%
All commodities	All impacted LGAs	Number of LGAs impacted	1/23	1/19	17/17
		Relative volumes impacted	0.4%	0.4%	0.8%
	Most impacted LGA	Name of destination LGA	Unincorporated SA	Unincorporated SA	Unincorporated NT
		Highest impacted commodity sector	Livestock	Livestock	Fuel
		Number of supply chains impacted	2	2	3
		Relative volumes impacted	0%	0%	33%
		Weekly tonnes BAU	725.8	725.8	221.9
		Relative number of supply chains impacted	1%	1%	33%

Re-routed supply chains

Table 177 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

Because most freight is obstructed for the Mulga Park Road intersection, very little freight is re-routed, with none for essential commodities. When considering all commodities, MacDonnell (R) LGA is the most impacted for the livestock sector.

For the Stuart Highway intersection closure, two LGAs are impacted by re-routed freight of essential commodities, while all LGAs relying on the intersection have detours for their non-essential commodities; however, the detoured freight represents only 0.9% of all the goods consumed within these LGAs. Similar results are observed for the Luritja Road intersection closure.

Table 177 Community impact metrics for modelled intersections on the Lasseter Highway KFR - re-routed supply chains

			STUART HIGHWAY	LURITJA ROAD	MULGA PARK ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/23	2/19	0/17
		Relative impact on volumes of commodities	35.8%	35.8%	0.0%
	Most impacted LGA	Name	MacDonnell (R)	MacDonnell (R)	-
		Highest impacted commodity sector	Processed Food	Processed Food	-
		Commodity impacted	Meat	Meat	-
		Number of supply chains impacted	3	3	0
		Relative volumes impacted	77%	77%	0%
		Weekly tonnes BAU	4.8	4.8	0.0
		Relative number of supply chains impacted	60%	60%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	23/23	19/19	2/17
		Relative impact on volumes of commodities	0.9%	0.9%	0.3%
	Most impacted LGA	Name	MacDonnell (R)	MacDonnell (R)	MacDonnell (R)
		Highest impacted commodity sector	Horticulture	Horticulture	Livestock
		Number of supply chains impacted	9	9	1
		Relative volumes impacted	62%	62%	1%
		Weekly tonnes BAU	14.3	14.3	283.1
		Relative number of supply chains impacted	43%	43%	1%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Lasseter Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Lasseter Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.35 Leichhardt Highway

The Leichhardt Highway KFR (Figure 53) is a freight route located in Queensland. It connects LGAs from the Capricorn Highway west of Rockhampton to the NSW border near Goondiwindi. The corridor is 610 km with at least part of the route used for the transport of $149m of product on 360,218 trailers annually carrying seven million tonnes across 28,491 supply chains spanning 119 commodities (27% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 83,469 trailers annually with the busiest sections carrying 132,940 trailers.

Cropping transport represents approximately 30% of the total freight task, with movements from property to silo being the majority. Fuel contributes 15% to the freight task, while livestock, horticulture moving south and general freight moving north add 10% each to the freight task. This route is predominantly classified as PBS3a access.

Figure 53 Leichhardt Highway KFR

The Leichhardt Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 389 LGAs along its length and beyond. It provides access to essential commodities for 101 LGAs. Banana (S) LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 50% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Dawson Highway
- Cunningham – Newell highways

- Burnett Highway

The reliance described in Table 178 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Brisbane (C) LGA is moderately reliant on the Cunningham – Newell Road intersection to send its commodities, while Blacktown (C) LGA is little to moderately reliant on the Burnett Highway and Dawson Highway intersections. Mareeba (S) is the LGA the most reliant on all three intersections as an origin LGA, however the reliance is little to moderate with a value lower than 20%.

Table 178 Summary of community reliance metrics for each intersection on the Leichhardt Highway key freight route - most impacted LGA

	CUNNINGHAM-NEWELL ROAD	BURNETT HIGHWAY	DAWSON HIGHWAY
Destination LGA most reliant on the intersection	Brisbane (C)	Blacktown (C)	Blacktown (C)
Relative reliance on intersection for destination LGA	0.30	0.17	0.16
Origin LGA most reliant on the intersection	Mareeba (S)	Mareeba (S)	Mareeba (S)
Relative reliance on intersection for origin LGA	0.06	0.19	0.18

5.35.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Leichhardt Highway. The results are based on expected freight for an average week.

Cunningham – Newell Road intersection: The closure of the Cunningham – Newell Road intersection results in the disruption of 4,383 vehicle trips carrying 80,356 tonnes, 20% being essential commodities. Overall, 79,827 tonnes of freight are re-routed with an average detour length of four km and with an average increase in cost of $3.88 per tonne. A total value of supplies amounting to $0.9 million, $0.8 million being essential commodities, is unable to reach its destination.

Burnett Highway intersection: The closure of the Burnett Highway intersection results in the disruption of 1,230 vehicle trips carrying 21,416 tonnes, 17% being essential commodities. Overall, 21,416 tonnes of freight are re-routed with a negligible average detour length and with a negligible average increase in cost per tonne. No freight is unable to reach its destination.

Dawson Highway intersection: The closure of the Dawson Highway intersection results in the disruption of 1,761 vehicle trips carrying 34,615 tonnes, 43% being essential commodities. Overall, 34,600 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $3.80 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Leichhardt Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Leichhardt Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Leichhardt Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Leichhardt Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Leichhardt Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Leichhardt Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Leichhardt Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Leichhardt Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Leichhardt Highway.

KFR risk profile

Table 179 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Leichhardt Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are low, indicating that very little freight is expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 179 Risk metrics for modelled intersections on the Leichhardt Highway KFR – the model

	CUNNINGHAM-NEWELL ROAD	BURNETT HIGHWAY	DAWSON HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.003	0.000	0.000
KFR impacts risk - detour costs for intersection	0.003	0.002	0.004
Last iteration	5	5	5

Freight impact

Table 180 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 180 Freight impact metrics for modelled intersections on the Leichhardt Highway KFR

		CUNNINGHAM-NEWELL ROAD [%]	BURNETT HIGHWAY [%]	DAWSON HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	0	0
	Relative freight volume impacted – essential commodities	3	0	0
	Relative value of freight – all commodities	2	0	0
Re-routed supply chains	Relative detour cost – average	5	1	6
	Relative detour cost – maximum	867	45	545

The metrics in Table 180 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing slightly (between 1% and 6%) over all commodities, and the routes most impacted by detours reach a maximum increase cost of 867% (for the Cunningham – Newell Road intersection).

For all three intersections, the obstructed freight is minimal[10].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 181 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Burnett Highway and the Dawson Highway intersection closures result in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. Only the Cunningham – Newell Road intersection closure results in two of the 303 LGAs it services having supply chains for essential commodities obstructed; Goondiwindi (R) being the most impacted for two of its unleaded fuel supply chains.

When considering all commodities, the closure of the Cunningham – Newell Road intersection results in four LGAs having obstructed supply chains, representing 2.5% of the volumes that are normally received by the 303 LGAs serviced by the intersection. Southern Downs (R) is the most impacted LGA with four supply chains for the fuel industry obstructed.

The Burnett Highway has no LGAs with obstructed supply chains when considering all commodities.

The Dawson Highway results in three LGAs having obstructed supply chains, representing 0.1% of the volumes that are normally received by the 168 LGAs serviced by the intersection. Banana (S) is the most impacted LGA, with one supply chain for the cropping industry obstructed.

[10] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

Table 181 Community impact metrics for modelled intersections on the Leichhardt Highway KFR - obstructed supply chains

			CUNNINGHAM-NEWELL ROAD	BURNETT HIGHWAY	DAWSON HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/303	0/173	0/168
		Relative volumes impacted	8.2%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Goondiwindi(R)	-	-
		Highest impacted commodity sector	Fuel	-	-
		Commodity impacted	Unleaded fuel	-	-
		Number of supply chains impacted	2	0	0
		Relative volumes impacted	18%	0%	0%
		Weekly tonnes BAU	892.5	0.0	0.0
		Relative number of supply chains impacted	17%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	4/303	0/173	3/168
		Relative volumes impacted	2.5%	0.0%	0.1%
	Most impacted LGA	Name of destination LGA	Southern Downs(R)	-	Banana(S)
		Highest impacted commodity sector	Fuel	-	Cropping
		Number of supply chains impacted	4	0	1
		Relative volumes impacted	14%	0%	0%
		Weekly tonnes BAU	1,816.8	0.0	1,849.5
		Relative number of supply chains impacted	10%	0%	1%

Re-routed supply chains

Table 182 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 7.1% of the supply chains are expected to be re-routed for 89 of the 303 LGAs that traverse the Cunningham – Newell Road intersection. The most impacted LGA is Canning (C), with two supply chains in the processed food sector representing 17.2 tonnes of prawns per week re-routed. For non-essential commodities, nearly all of the 303 LGAs serviced by the Capricorn Highway intersection are impacted by re-routed freight, representing 4% of the total volumes consumed within these LGAs.

For the Burnett Highway intersection, 37 of the 173 LGAs serviced are expected to have freight re-routed, with this representing 4.3% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 173 LGAs serviced by the Burnett Highway intersection are impacted by re-routed freight, representing 2.3% of the total volume consumed by all LGAs whose freight traverses the intersection.

For the Dawson Highway intersection closure, 36 of the 168 LGAs serviced are expected to have freight re-routed, representing 19% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 168 LGAs serviced by the Dawson Highway intersection are impacted by re-routed freight, representing 3.8% of the total volume consumed by all LGAs whose freight traverses the intersection.

Table 182 Community impact metrics for modelled intersections on the Leichhardt Highway KFR - re-routed supply chains

			CUNNINGHAM-NEWELL ROAD	BURNETT HIGHWAY	DAWSON HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	89/303	37/173	36/168
		Relative impact on volumes of commodities	7.1%	4.3%	19.0%
	Most impacted LGA	Name	Canning(C)	Goondiwindi (R)	Banana(S)
		Highest impacted commodity sector	Processed Food	Construction	Mining
		Commodity impacted	Prawn	Cement	Coal
		Number of supply chains impacted	2	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	17.2	7.7	9,730.8
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	300/303	173/173	168/168
		Relative impact on volumes of commodities	4.0%	2.3%	3.8%
	Most impacted LGA	Name	Horsham (RC)	Livingstone(S)	Woorabinda(S)
		Highest impacted commodity sector	Construction	Vehicles	General
		Number of supply chains impacted	1	2	4
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	96.2	23.8	3.8
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Leichhardt Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Leichhardt Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.36 Midland Highway

The Midland Highway KFR (Figure 54) is a freight route located in Tasmania. It connects LGAs from Launceston to Hobart. The corridor is 225 km with at least part of the route used for the transport of $46m of product on 306,186 trailers annually carrying six million tonnes across 10,945 supply chains spanning 106 commodities (42% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 83,469 trailers annually with the busiest sections carrying 132,940 trailers.

Wood product transport represents approximately 35% of the total freight task, with movements from property to port being the majority. Construction contributes 29% to the freight task. Processed food and general freight add 10% each to the freight task. This route is predominantly classified as PBS2a access.

Figure 54 Midland Highway KFR

The Midland Highway KFR passes through five LGAs but crucially it supports the supply chain paths for over 241 LGAs along its length and beyond. It provides access to essential commodities for 55 LGAs. Most LGAs along the route are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Bass Highway
- East and West Tamar highways

- Lyell – Brooker Highway

The reliance described in Table 183 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the George Town (M) LGA is moderately to highly reliant on the Bass Highway and the East and West Tamar Highway intersection as a destination LGA. The Huon Valley (M) LGA however is little reliant on the Lyell – Brooker Highway.

Table 183 Summary of community reliance metrics for each intersection on the Midland Highway key freight route - most impacted LGA

	BASS HIGHWAY	EAST AND WEST TAMAR HIGHWAY	LYELL – BROOKER HIGHWAY
Destination LGA most reliant on the intersection	George Town (M)	George Town (M)	Huon Valley (M)
Relative reliance on intersection for destination LGA	0.31	0.54	0.17
Origin LGA most reliant on the intersection	Dorset (M)	Northern Midlands (M)	Huon Valley (M)
Relative reliance on intersection for origin LGA	0.15	0.22	0.26

5.36.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Midland Highway. The results are based on expected freight for an average week.

- **Bass Highway intersection**: The closure of the Bass Highway intersection results in the disruption of 2,428 vehicle trips carrying 48,544 tonnes, 39% being essential commodities. Overall, 48,424 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $2.73 per tonne. A total value of supplies amounting to $1.3 million, $0.4 million being essential commodities, is unable to reach its destination.
- **East and West Tamar Highway intersection**: The closure of the East and West Tamar Highway intersection results in the disruption of 1,797 vehicle trips carrying 35,445 tonnes, 47% being essential commodities. Overall, 34,009 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $2.65 per tonne. A total value of supplies amounting to $0.4 million, $0.4 million being essential commodities, is unable to reach its destination.
- **Lyell – Brooker Highway intersection**: The closure of the Lyell – Brooker Highway intersection results in the disruption of 1,499 vehicle trips carrying 27,276 tonnes, 38% being essential commodities. Overall, 27,276 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $5.13 per tonne. No freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Midland Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Midland Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection
- ‘Midland Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘Midland Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Midland Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘Midland Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Midland Highway-cost bar plot.png’ shows the cost impacts of re-routing
- ‘Midland Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Midland Highway.

KFR risk profile

Table 184 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The ‘Midland Highway-*intersection*-cumulative impact.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also very low, indicating that freight is re-routed at a low cost.

Table 184 Risk metrics for modelled intersections on the Midland Highway KFR – the model

	BASS HIGHWAY	EAST AND WEST TAMAR HIGHWAY	LYELL – BROOKER HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.040	0.000
KFR impacts risk - detour costs for intersection	0.007	0.009	0.006
Last iteration	5	5	5

Freight impact

Table 185 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 185 Freight impact metrics for modelled intersections on the Midland Highway KFR

		BASS HIGHWAY [%]	EAST AND WEST TAMAR HIGHWAY [%]	LYELL – BROOKER HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	4	0
	Relative freight volume impacted – essential commodities	0	8	0
	Relative value of freight – all commodities	1	2	0
Re-routed supply chains	Relative detour cost – average	10	13	14
	Relative detour cost – maximum	93	103	337

The metrics in Table 185 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing between 10% and 14% over all commodities, and the routes most impacted by detours reach a maximum increase cost of 337% (for the Lyell – Brooker Highway intersection).

For all three intersections, the obstructed freight is minimal[11].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 186 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Lyell – Brooker Highway intersection closure result in no LGAs serviced by the intersection having obstructed supply chains for essential commodities, nor non-essential commodities.

The Bass Highway and the East and West Tamar Highway intersection closures result in one of the 103, and one of the 65 LGAs, respectively, they service having supply chains for essential commodities obstructed; Launceston (C) being the most impacted in both cases but for different sectors.

When considering all commodities, the closure of the Bass Highway intersection results in one LGA having obstructed supply chains, representing 1.4% of the volumes that are normally received by the 103 LGAs serviced by the intersection. Launceston (C) is the most impacted LGA with six supply chains for the vehicles industry obstructed.

Similar results are observed for the East and West Tamar Highway intersection closure. The East and West Tamar Highway intersection closure results in one LGA having obstructed supply chains, representing 6.9% of the volumes that are normally received by the 65 LGAs serviced by the

[11] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

intersection. Launceston (C) is the most impacted LGA, with 22 supply chains for the construction industry obstructed.

Table 186 Community impact metrics for modelled intersections on the Midland Highway KFR - obstructed supply chains

			BASS HIGHWAY	EAST AND WEST TAMAR HIGHWAY	LYELL – BROOKER HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/103	1/65	0/69
		Relative volumes impacted	10.7%	15.6%	0.0%
	Most impacted LGA	Name of destination LGA	Launceston(C)	Launceston(C)	-
		Highest impacted commodity sector	Processed Food	Construction	-
		Commodity impacted	Box Chicken	Concrete	-
		Number of supply chains impacted	2	9	0
		Relative volumes impacted	20%	16%	0%
		Weekly tonnes BAU	48.9	8,772.5	0.0
		Relative number of supply chains impacted	10%	26%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/103	1/65	0/69
		Relative volumes impacted	1.4%	6.9%	0.0%
	Most impacted LGA	Name of destination LGA	Launceston(C)	Launceston(C)	
		Highest impacted commodity sector	Vehicles	Construction	
		Number of supply chains impacted	6	22	
		Relative volumes impacted	17%	7%	0%
		Weekly tonnes BAU	213.8	19,830.2	0.0
		Relative number of supply chains impacted	10%	12%	0%

Re-routed supply chains

Table 187 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 24.1% of the supply chains are expected to be re-routed for 27 of the 103 LGAs that traverse the Bass Highway intersection. The most impacted LGA is Dorset (M), with two supply chains in the processed food sector representing 1.7 tonnes per week re-routed. For non-essential commodities, 100 of the 103 LGAs serviced by the Bass Highway intersection are impacted by re-routed freight, representing 4.4% of the total volumes consumed within these LGAs.

For the East and West Tamar Highway intersection, 21 of the 65 LGAs serviced are expected to have freight re-routed, with this representing 27.3% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 62 of the 65 LGAs serviced by the East and West Tamar Highway intersection are impacted by re-routed freight, representing 4% of the total volume consumed by these LGAs.

Similar results are observed for the Lyell – Brooker Highway intersection closure. 35 of the 69 LGAs serviced are expected to have freight re-routed, representing 19.4% of essential commodities consumed within the LGAs. For non-essential commodities, 67 of the 69 LGAs serviced by the Lyell – Brooker Highway intersection are impacted by re-routed freight, representing 3.1% of the total volume consumed by these LGAs.

Table 187 Community impact metrics for modelled intersections on the Midland Highway KFR - re-routed supply chains

			BASS HIGHWAY	EAST AND WEST TAMAR HIGHWAY	LYELL – BROOKER HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	27/103	21/65	35/69
		Relative impact on volumes of commodities	24.1%	27.3%	19.4%
	Most impacted LGA	Name	Dorset(M)	Dorset(M)	Glenorchy(C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Beef	Box Beef	Meat
		Number of supply chains impacted	2	2	6
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	1.7	1.7	69.4
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	100/103	62/65	67/69
		Relative impact on volumes of commodities	4.4%	4.0%	3.1%
	Most impacted LGA	Name	Launceston(C)	West Tamar(M)	Glenorchy(C)
		Highest impacted commodity sector	Mining	General	Wood Product
		Number of supply chains impacted	3	10	2
		Relative volumes impacted	100%	91%	100%
		Weekly tonnes BAU	0.4	108.6	139.9
		Relative number of supply chains impacted	100%	50%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Midland Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Midland Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.37 Monaro Highway

The Monaro Highway KFR (Figure 55) in a freight route located in ACT. It runs north – south through Canberra. The corridor is 32 km with at least part of the route used for the transport of $15m of product on 139,070 trailers annually carrying 2.9 million tonnes across 3,151 supply chains spanning 71 commodities (69% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 25,332 trailers annually with the busiest sections carrying 70,428 trailers.

Fuel transport represents approximately 42% of the total freight task with construction adding a further 28% to the freight task. This route is predominantly PBS2a B-Double access.

Figure 55 Monaro Highway KFR

The Monaro Highway KFR passes through one LGA.

The intersection identified as of strategic importance and used in the modelling and analysis was:

- Morshead Drive

The reliance described in Table 188 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Morshead Drive intersection is of moderate importance to communities using the KFR, with 24% of all the supply chain paths traversing the intersection destined to the Unincorporated ACT LGA. In terms of origin LGA, the reliance is the same for the Snowy Monaro Regional (A) LGA.

Table 188 Summary of community reliance metrics for each intersection on the Monaro Highway key freight route - most impacted LGA

	MORSHEAD DRIVE
Destination LGA most reliant on the intersection	Unincorporated ACT
Relative reliance on intersection for destination LGA	0.24
Origin LGA most reliant on the intersection	Snowy Monaro Regional (A)
Relative reliance on intersection for origin LGA	0.24

5.37.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Monaro Highway. The results are based on expected freight for an average week.

- **Morshead Drive intersection**: The closure of the Morshead Drive intersection results in the disruption of 2,123 vehicle trips carrying 43,299 tonnes, 69% being essential commodities. Overall, 43,290 tonnes of freight are re-routed with an average detour length of 18 km and with an average increase in cost of $6.03 per tonne. Little to no freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Monaro Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Monaro Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Monaro Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Monaro Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Monaro Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Monaro Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Monaro Highway-cost_bar_plot.png' shows the cost impacts of re-routing
- 'Monaro Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Monaro Highway.

KFR risk profile

Table 189 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for the KFR intersection, the model was able to reach the maximum number of successive closures of five. The 'Monaro Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metric for the obstructed volumes is extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The risk metrics for the detour costs are very low.

Table 189 Risk metrics for modelled intersections on the Monaro Highway KFR

	MORSHEAD DRIVE
KFR impacts risk - obstructed volumes for intersection	0.000
KFR impacts risk - detour costs for intersection	0.019
Last iteration	2

Freight impact

Table 190 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 190 Freight impact metrics for modelled intersections on the Monaro Highway KFR by last successive closure

		MORSHEAD DRIVE [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0
	Relative freight volume impacted – essential commodities	0
	Relative value of freight – all commodities	0
Re-routed supply chains	Relative detour cost – average	11
	Relative detour cost – maximum	137

The metrics in Table 190 indicate the supply chains traversing the Morshead Drive intersection that are likely to be re-routed will do so with a low average cost increase of 11%, however some supply chains are expected to increase by upto 137%.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 191 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Morshead Drive intersection closure results in no LGAs serviced by the intersection having obstructed supply chains for essential commodities. Only one of the 100 LGAs it services is expected to have supply chains obstructed when considering all commodities; Unincorporated ACT being the only impacted LGA for two of its waste supply chains.

Table 191 Community impact metrics for modelled intersections on the Monaro Highway KFR - obstructed supply chains

			MORSHEAD DRIVE
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/100
		Relative volumes impacted	0.0%
	Most impacted LGA	Name of destination LGA	
		Highest impacted commodity sector	
		Commodity impacted	
		Number of supply chains impacted	
		Relative volumes impacted	0%
		Weekly tonnes BAU	0.0
		Relative number of supply chains impacted	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/100
		Relative volumes impacted	0.2%
	Most impacted LGA	Name of destination LGA	Unincorporated ACT
		Highest impacted commodity sector	Waste
		Number of supply chains impacted	2
		Relative volumes impacted	0%
		Weekly tonnes BAU	5,470.6
		Relative number of supply chains impacted	0%

Re-routed supply chains

Table 192 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 19.5% of the supply chains are expected to be re-routed for 29 of the 100 LGAs that traverse the Morshead Drive intersection. The most impacted LGA is East Gippsland (S), with one supply chain in the construction sector representing 3.8 tonnes per week re-routed. For non-essential commodities, all the LGAs serviced by the Morshead Drive intersection are impacted by re-routed freight, representing 7.4% of the total volumes consumed within these LGAs.

Table 192 Community impact metrics for modelled intersections on the Monaro Highway KFR - re-routed supply chains

			MORSHEAD DRIVE
Essential commodities	All impacted LGAs	Number of LGAs impacted	29/100
		Relative impact on volumes of commodities	19.5%
	Most impacted LGA	Name	East Gippsland(S)
		Highest impacted commodity sector	Construction
		Commodity impacted	Cement
		Number of supply chains impacted	1
		Relative volumes impacted	100%
		Weekly tonnes BAU	3.8
		Relative number of supply chains impacted	100%
All commodities	All impacted LGAs	Number of LGAs impacted	100/100
		Relative impact on volumes of commodities	7.4%
	Most impacted LGA	Name	Snowy Monaro Regional(A)
		Highest impacted commodity sector	Horticulture
		Number of supply chains impacted	39
		Relative volumes impacted	73%
		Weekly tonnes BAU	81.2
		Relative number of supply chains impacted	93%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- 'Monaro Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Monaro Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.38 Newell Highway

The Newell Highway KFR (Figure 56) is a freight route extending between the NSW/Queensland border at Goondiwindi in the north to the NSW/Victoria border at Tocumwal in the south. The corridor is 1065 km with at least part of the route used for the transport of $367m of product on 1,102,973 trailers annually carrying 22 million tonnes across 87,013 supply chains spanning 127 commodities (18% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 160,398 trailers annually with the busiest sections carrying 262,822 trailers.

Cropping transport represents approximately 50% of the total freight task, with movements from property to silo being the majority. Fuel, livestock and general freight add 10% each to the freight task with processed food and horticulture adding 7% each. This route is a mixture of PBS2a and PBS3a access.

Figure 56 Newell Highway KFR

The Newell Highway KFR passes through 17 LGAs but crucially it supports the supply chain paths for over 455 LGAs along its length and beyond. It provides access to essential commodities for 310 LGAs. Narrabri (A), Moree Plains (A) and Griffith (C) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 30% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Sturt Highway

- Cunningham Highway
- Goldfield Way – Mid Western Highway

The reliance described in Table 193 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Brisbane (C) LGA is moderately reliant on the Goldfield Way – Mid Western Highway and the Cunningham Highway intersections and so is Blacktown (C) LGA for the Sturt Highway intersection. For the LGAs relying on the three studied intersections, their reliance is moderate as over 60% of their consumed commodities do not rely on these intersections to move. For those LGAs that are sending their commodities, the reliance on any of the three intersections is even lower with a reliance less than 10%.

Table 193 Summary of community reliance metrics for each intersection on the Newell Highway key freight route - most impacted LGA

	STURT HIGHWAY	GOLDFIELD WAY – MID WESTERN HIGHWAY	CUNNINGHAM HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Brisbane (C)	Brisbane (C)
Relative reliance on intersection for destination LGA	0.23	0.30	0.29
Origin LGA most reliant on the intersection	Leeton (A)	Griffith (C)	Mareeba (S)
Relative reliance on intersection for origin LGA	0.07	0.08	0.06

5.38.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Newell Highway. The results are based on expected freight for an average week.

- **Sturt Highway intersection**: The closure of the Sturt Highway intersection results in the disruption of 5,327 vehicle trips carrying 92,226 tonnes, 20% being essential commodities. Overall, 92,205 tonnes of freight are re-routed with an average detour length of five km and with an average increase in cost of $6.68 per tonne. A total value of supplies amounting to $0.1 million, none being essential commodities, is unable to reach its destination.

Goldfield Way – Mid Western Highway intersection: The closure of the Goldfield Way – Mid Western Highway intersection results in the disruption of 3,313 vehicle trips carrying 59,781 tonnes, 22% being essential commodities. Overall, 59,776 tonnes of freight are re-routed with an average detour length of two km and with an average increase in cost of $2.32 per tonne. Few supply chains are unable to reach their destination.

- **Cunningham Highway intersection**: The closure of the Cunningham Highway intersection results in the disruption of 4,240 vehicle trips carrying 75,906 tonnes, 20% being essential commodities. Overall, 75,829 tonnes of freight are re-routed with an average detour length of one km and with an average increase in cost of $4.50 per tonne. Few supply chains are unable to reach their destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Newell Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Newell Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Newell Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Newell Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Newell Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Newell Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Newell Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'Newell Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Newell Highway.

KFR risk profile

Table 194 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Newell Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also extremely low, indicating that freight is re-routed at a low cost.

Table 194 Risk metrics for modelled intersections on the Newell Highway KFR – the model

	STURT HIGHWAY	GOLDFIELD WAY – MID WESTERN HIGHWAY	CUNNINGHAM HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.001
KFR impacts risk - detour costs for intersection	0.005	0.004	0.004
Last iteration	5	5	5

Freight impact

Table 195 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 195 Freight impact metrics for modelled intersections on the Newell Highway KFR

		STURT HIGHWAY [%]	GOLDFIELD WAY – MID WESTERN HIGHWAY [%]	CUNNINGHAM HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	6	4	3
	Relative detour cost – maximum	728	383	609

The metrics in Table 195 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing slightly (between 3% and 6%) over all commodities. However, some supply chain paths in all three intersections are highly impacted with some detour costs increasing up to 700%.

For all three intersections, the obstructed freight is minimal[12].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 196 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Sturt Highway and the Goldfield Way – Mid Western Highway intersection closures result in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. Only the Cunningham Highway intersection closure results in two of the 307 LGAs it services having supply chains for essential commodities obstructed; Western Downs (R) being the most impacted for two of its gravel supply chains.

When considering all commodities, the closure of the Sturt Highway intersection results in five LGAs having obstructed supply chains, representing 0.1% of the volumes that are normally received by the 376 LGAs serviced by the intersection. Narrandera (A) is the most impacted LGA with one supply chain for the livestock industry obstructed.

Similar results are observed for the Goldfield Way – Mid Western Highway and the Cunningham Highway intersection closures. The Goldfield Way – Mid Western Highway results in one LGA having obstructed supply chains, representing 4% of the volumes that are normally received by the 242

[12] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

LGAs serviced by the intersection. Bland (A) is the most impacted LGA, with one supply chain for the waste industry obstructed.

The Cunningham Highway results in two LGAs having obstructed supply chains, representing 0.7% of the volumes that are normally received by the 307 LGAs serviced by the intersection. Western Downs (R) is the most impacted LGA, with two supply chains for the construction industry obstructed.

Table 196 Community impact metrics for modelled intersections on the Newell Highway KFR - obstructed supply chains

			STURT HIGHWAY	GOLDFIELD WAY – MID WESTERN HIGHWAY	CUNNINGHAM HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/376	0/242	2/307
		Relative volumes impacted	0.0%	0.0%	1.2%
	Most impacted LGA	Name of destination LGA	-	-	Western Downs (R)
		Highest impacted commodity sector	-	-	Construction
		Commodity impacted	-	-	Gravel
		Number of supply chains impacted	-	-	2
		Relative volumes impacted	0%	0%	7%
		Weekly tonnes BAU	0.0	0.0	103.8
		Relative number of supply chains impacted	0%	0%	10%
All commodities	All impacted LGAs	Number of LGAs impacted	5/376	1/242	2/307
		Relative volumes impacted	0.1%	4.0%	0.7%
	Most impacted LGA	Name of destination LGA	Narrandera (A)	Bland (A)	Western Downs (R)
		Highest impacted commodity sector	Livestock	Waste	Construction
		Number of supply chains impacted	1	1	2
		Relative volumes impacted	1%	4%	5%
		Weekly tonnes BAU	107.1	103.8	169.2
		Relative number of supply chains impacted	2%	4%	6%

Re-routed supply chains

Table 197 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 8.3% of the supply chains are expected to be re-routed for 201 of the 376 LGAs that traverse the Sturt Highway intersection. The most impacted LGA is MacDonnell (R), with eight supply chains in the processed food sector representing 2.2 tonnes per week re-routed. For non-essential commodities, 372 out of the 376 LGAs serviced by the Sturt Highway intersection are impacted by re-routed freight, representing 3.2% of the total volumes consumed within these LGAs.

For the Goldfield Way – Mid Western Highway intersection, 56 of the 242 LGAs serviced may have freight re-routed, representing 7.6% of essential commodities consumed within the LGAs. For non-essential commodities, 240 out of the 242 LGAs serviced by the Goldfield Way – Mid Western Highway intersection are impacted by re-routed freight, representing 3.1% of the total volume consumed by these LGAs.

Similar results are observed for the Cunningham Highway intersection closure. 91 of the 307 LGAs serviced may have freight re-routed, representing 7.2% of essential commodities consumed within the LGAs. For non-essential commodities, 304 out of the 307 LGAs serviced by the Cunningham Highway intersection are impacted by re-routed freight, representing 3.7% of the total volume consumed by these LGAs.

Table 197 Community impact metrics for modelled intersections on the Newell Highway KFR - re-routed supply chains

			STURT HIGHWAY	GOLDFIELD WAY – MID WESTERN HIGHWAY	CUNNINGHAM HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	201/376	56/242	91/307
		Relative impact on volumes of commodities	8.3%	7.6%	7.2%
	Most impacted LGA	Name	MacDonnell (R)	Bland (A)	Canning (C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Bread	Box Lamb	Prawn
		Number of supply chains impacted	8	1	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	2.2	0.4	17.2
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	372/376	240/242	304/307
		Relative impact on volumes of commodities	3.2%	3.1%	3.7%
	Most impacted LGA	Name	Flinders(M) (Tas)	Horsham (RC)	Horsham (RC)
		Highest impacted commodity sector	Cropping	Construction	Construction
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.3	96.2	96.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Newell Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Newell Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.39 New England Highway

The New England Highway KFR (Figure 57) is a freight route extending between Toowoomba (Queensland) to Newcastle (NSW). The corridor is 813 km with at least part of the route used for the transport of $246m of product 786,248 trailers annually carrying 14 million tonnes across 49,829 supply chains spanning 127 commodities (40% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 89,212 trailers annually with the busiest sections carrying 260,237 trailers.

Fuel transport represents approximately 25% of the total freight task, with movements from port to depot and on the stations being the majority. Livestock, processed food, wood product and general freight add 10% each to the freight task. This route is predominantly classified as PBS2a access.

Figure 57 New England Highway KFR

The New England Highway KFR passes through 15 LGAs but crucially it supports the supply chain paths for over 343 LGAs along its length and beyond. It provides access to essential commodities for 147 LGAs. Southern Downs (R) and Tamworth (A) regional LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Pacific Highway
- Cunningham Highway

- Gwydir Highway

The reliance described in Table 198 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Blacktown (C) LGA is moderately reliant on the Pacific Highway intersection as a destination LGA, and little reliant on the Gwydir Highway, however still the most reliant of all the LGAs serviced by the Gwydir Highway intersection. The Brisbane (C) LGA is moderately reliant on the Cunningham Highway intersection.

Table 198 Summary of community reliance metrics for each intersection on the New England Highway key freight route - most impacted LGA

	PACIFIC HIGHWAY	GWYDIR HIGHWAY	CUNNINGHAM HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Blacktown (C)	Brisbane (C)
Relative reliance on intersection for destination LGA	0.34	0.12	0.31
Origin LGA most reliant on the intersection	Lockyer Valley (R)	Southern Downs (R)	Southern Downs (R)
Relative reliance on intersection for origin LGA	0.12	0.24	0.33

5.39.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the New England Highway. The results are based on expected freight for an average week.

- Pacific Highway intersection: The closure of the Pacific Highway intersection results in the disruption of 3,458 vehicle trips carrying 71,166 tonnes, 34% being essential commodities. Overall, 71,159 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $4.72 per tonne. A total value of supplies amounting to $0.1 million, $0.1 million being essential commodities, is unable to reach its destination.
- Gwydir Highway intersection: The closure of the Gwydir Highway intersection results in the disruption of 1,795 vehicle trips carrying 30,896 tonnes, 45% being essential commodities. Overall, 30,452 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $1.33 per tonne. A total value of supplies amounting to $2.2 million, $1.0 million being essential commodities, is unable to reach its destination.
- Cunningham Highway intersection: The closure of the Cunningham Highway intersection results in the disruption of 740 vehicle trips carrying 13,525 tonnes, 44% being essential commodities. Overall, 13,523 tonnes of freight are re-routed with an average detour length of three km and with an average increase in cost of $6.05 per tonne. A total value of supplies amounting to $0.0 million, none being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the New England Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘New England Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection
- ‘New England Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘New England Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘New England Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘New England Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘New England Highway-cost bar plot.png’ shows the cost impacts of re-routing
- ‘New England Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the New England Highway.

KFR risk profile

Table 199 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The ‘New England Highway-*intersection*-cumulative impact.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 199 Risk metrics for modelled intersections on the New England Highway KFR – the model

	PACIFIC HIGHWAY	GWYDIR HIGHWAY	CUNNINGHAM HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.008	0.000
KFR impacts risk - detour costs for intersection	0.011	0.002	0.017
Last iteration	5	5	5

Freight impact

Table 200 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 200 Freight impact metrics for modelled intersections on the New England Highway KFR

		PACIFIC HIGHWAY [%]	GWYDIR HIGHWAY [%]	CUNNINGHAM HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	1	0
	Relative freight volume impacted – essential commodities	0	2	0
	Relative value of freight – all commodities	0	2	0
Re-routed supply chains	Relative detour cost – average	5	3	12
	Relative detour cost – maximum	164	80	81

The metrics in Table 200 indicate the supply chains traversing any of the three modelled intersections that are likely to be re-routed will do so with their average cost increasing slightly (between 3% and 12%) over all commodities, and the routes most impacted by detours reach a maximum increase cost of 164% (for the Pacific Highway intersection).

For all three intersections, the obstructed freight is minimal[13].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 201 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Pacific Highway results in one LGA out of 157 LGAs serviced by the intersection, having obstructed supply chains, representing 5.5% of the volumes that are normally consumed within these LGAs. Newcastle (C) is the most impacted LGA, with one supply chain for the processed food industry obstructed.

The Gwydir Highway results in one LGA having obstructed supply chains for essential commodities, representing 44.2% of the volumes that are normally received by that LGA. Glen Innes Severn (A) is the most impacted LGA, with two supply chains for diesel fuel obstructed, which represent 67% of its usual consumption. When considering all commodities, the closure of the Gwydir Highway intersection results in four LGAs having obstructed supply chains, representing 0.8% of the volumes that are normally received by these LGAs serviced by the intersection.

The Cunningham Highway intersection closure results in no LGAs serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Cunningham Highway intersection results in one LGA having obstructed supply chains, representing 0.1% of the volumes that are normally received by the 43 LGAs serviced by the

[13] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

intersection. Southern Downs (R) is the most impacted LGA with one supply chain for the livestock industry obstructed.

Table 201 Community impact metrics for modelled intersections on the New England Highway KFR - obstructed supply chains

			PACIFIC HIGHWAY	GWYDIR HIGHWAY	CUNNINGHAM HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/157	1/152	0/43
		Relative volumes impacted	5.5%	44.2%	0.0%
	most impacted LGA	Name of destination LGA	Newcastle(C)	Glen Innes Severn(A)	-
		Highest impacted commodity sector	Processed Food	Fuel	-
		Commodity impacted	Box Chicken	Diesel fuel	-
		Number of supply chains impacted	1	2	0
		Relative volumes impacted	6%	67%	0%
		Weekly tonnes BAU	130.2	116.9	0.0
		Relative number of supply chains impacted	3%	67%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/157	4/152	1/43
		Relative volumes impacted	0.7%	0.8%	0.1%
	Most impacted LGA	Name of destination LGA	Newcastle(C)	Glen Innes Severn(A)	Southern Downs(R)
		Highest impacted commodity sector	Processed Food	Fuel	Livestock
		Number of supply chains impacted	1	5	1
		Relative volumes impacted	1%	66%	0%
		Weekly tonnes BAU	1,067.9	354.6	3,023.0
		Relative number of supply chains impacted	0%	56%	0%

Re-routed supply chains

Table 202 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 12.6% of the supply chains are expected to be re-routed for 54 of the 157 LGAs that traverse the Pacific Highway intersection. The most impacted LGA is Wodonga (C), with one supply chain in the processed food sector representing 32.6 tonnes per week re-routed. For non-essential commodities, all of the 157 LGAs serviced by the Pacific Highway intersection are impacted by re-routed freight, representing 6.2% of the total volumes consumed within these LGAs.

For the Gwydir Highway intersection, 45 of the 152 LGAs serviced are expected to have freight re-routed, with this representing 18.2 % of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 152 LGAs serviced by the Gwydir Highway intersection are impacted by re-routed freight, representing 2.8% of the total volume consumed by all LGAs whose freight traverses the intersection.

For the Cunningham Highway intersection, 24 of the 43 LGAs serviced are expected to have freight re-routed, representing 14% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 43 LGAs serviced by the Cunningham Highway intersection are impacted by re-routed freight, representing 2.7% of the total volume consumed by all LGAs whose freight traverses the intersection.

Table 202 Community impact metrics for modelled intersections on the New England Highway KFR - re-routed supply chains

			PACIFIC HIGHWAY	GWYDIR HIGHWAY	CUNNINGHAM HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	54/157	45/152	24/43
		Relative impact on volumes of commodities	12.6%	18.2%	14.0%
	Most impacted LGA	Name	Wodonga(C)	Tenterfield(A)	Glen Innes Severn(A)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Fish	Bread	Box Rice
		Number of supply chains impacted	1	3	10
		Relative volumes impacted	88%	94%	100%
		Weekly tonnes BAU	32.6	3.1	16.2
		Relative number of supply chains impacted	33%	75%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	157/157	152/152	43/43
		Relative impact on volumes of commodities	6.2%	2.8%	2.7%
	Most impacted LGA	Name	Cabonne(A)	Glen Innes Severn(A)	Glen Innes Severn(A)
		Highest impacted commodity sector	Wood Product	Wood Product	General
		Number of supply chains impacted	1	1	24
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	38.3	25.6	249.5
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'New England Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'New England Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.40 North West Coastal Highway

The North West Coastal Highway KFR (Figure 58) is a freight route located in WA. It connects LGAs from Geraldton to the Great Northern Highway near Port Hedland. The corridor is 1300 km with at least part of the route used for the transport of $10m of product on 282,632 trailers annually carrying seven million tonnes across 2,830 supply chains spanning 58 commodities (30% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 14,584 trailers annually with the busiest sections carrying 161,944 trailers.

Mining transport represents approximately 40% of the total freight task, with movements from mine to port being the majority. Fuel and cropping add 25% each to the freight task. This route is predominantly classified as PBS4a access.

Figure 58 North West Coastal Highway KFR

The North West Coastal Highway KFR passes through nine LGAs but crucially it supports the supply chain paths for over 123 LGAs along its length and beyond. It provides access to essential commodities for 32 LGAs. Northampton (S), Karratha (C) and Greater Geraldton (C) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 50% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Great Northern Highway
- Tom Price – Karratha Road
- Geraldton – Mount Magnet Road

The reliance described in Table 203 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Karratha (C) LGA is moderately reliant on the Great Northern Highway intersection, and moderately to highly reliant on the Tom Price – Karratha Road intersection as a destination LGA. The Northampton (S) LGA is little to moderately reliant on the Geraldton – Mount Magnet Road intersection.

Table 203 Summary of community reliance metrics for each intersection on the North West Coastal Highway key freight route - most impacted LGA

	GERALDTON – MOUNT MAGNET ROAD	TOM PRICE – KARRATHA ROAD	GREAT NORTHERN HIGHWAY
Destination LGA most reliant on the intersection	Northampton (S)	Karratha (C)	Karratha (C)
Relative reliance on intersection for destination LGA	0.24	0.46	0.34
Origin LGA most reliant on the intersection	Greater Geraldton (C)	Karratha (C)	Port Hedland (T)
Relative reliance on intersection for origin LGA	0.22	0.26	0.33

5.40.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the North West Coastal Highway. The results are based on expected freight for an average week.

- **Geraldton – Mount Magnet Road intersection**: The closure of the Geraldton – Mount Magnet Road intersection results in the disruption of 4,055 vehicle trips carrying 102,059 tonnes, 14% being essential commodities. Overall, 101,789 tonnes of freight are re-routed with an average detour length of 10 km and with an average increase in cost of $4.08 per tonne. A total value of supplies amounting to $3.0 million, $0.6 million being essential commodities, is unable to reach its destination.
- **Tom Price – Karratha Road intersection**: The closure of the Tom Price – Karratha Road intersection results in the disruption of 300 vehicle trips carrying 6,323 tonnes, 75% being essential commodities. Overall, 6,298 tonnes of freight are re-routed with an average detour length of 62 km and with an average increase in cost of $10.66 per tonne. A total value of supplies amounting to $0.1 million, $0.1 million being essential commodities, is unable to reach its destination.
- **Great Northern Highway intersection**: The closure of the Great Northern Highway intersection results in the disruption of 709 vehicle trips carrying 16,883 tonnes, 94% being essential commodities. Overall, 16,870 tonnes of freight are re-routed with an average detour length of 262 km and with an average increase in cost of $32.63 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the North West Coastal Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'North West Coastal Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'North West Coastal Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'North West Coastal Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'North West Coastal Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'North West Coastal Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'North West Coastal Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'North West Coastal Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the North West Coastal Highway.

KFR risk profile

Table 204 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'North West Coastal Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost, except for the Great Northern Highway intersection for which the value is moderate.

Table 204 Risk metrics for modelled intersections on the North West Coastal Highway KFR – the model

	GERALDTON – MOUNT MAGNET ROAD	TOM PRICE – KARRATHA ROAD	GREAT NORTHERN HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.001	0.000
KFR impacts risk - detour costs for intersection	0.019	0.028	0.266
Last iteration	5	5	5

Freight impact

Table 205 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 205 Freight impact metrics for modelled intersections on the North West Coastal Highway KFR

		GERALDTON – MOUNT MAGNET ROAD [%]	TOM PRICE – KARRATHA ROAD [%]	GREAT NORTHERN HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	1	0	0
	Relative value of freight – all commodities	2	2	0
Re-routed supply chains	Relative detour cost – average	12	22	98
	Relative detour cost – maximum	150	370	684

The metrics in Table 205 indicate the supply chains traversing the Geraldton – Mount Magnet Road and the Tom Price – Karratha Road intersections that are likely to be re-routed will do so with their average cost increasing slightly, by 12% and 22% respectively, over all commodities. The increase in the average cost for the Great Northern Highway intersection is however higher, reaching 98%. The routes most impacted by detours reach a maximum increase cost of 684%.

For all three intersections, the obstructed freight is minimal[14].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 206 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Geraldton – Mount Magnet Road closure results in one out of the 95 LGAs serviced by the intersection having obstructed supply chains, representing 21.3% of the volumes that are normally consumed within this LGA. Greater Geraldton (C) is the most impacted LGA, with one supply chain for the processed food industry obstructed.

The Tom Price – Karratha Road closure results in one LGA having obstructed supply chains for essential commodities, representing 6.4% of the volumes that are normally received by that LGA. Karratha (C) is the most impacted LGA, with three supply chains for meat obstructed, which represent 7% of its usual consumption. When considering all commodities, the closure of the Tom Price – Karratha Road intersection results in one LGA having obstructed supply chains, representing 3.5% of the volumes that are normally received by this LGA serviced by the intersection.

The Great Northern Highway intersection closure results in no LGAs serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the

[14] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

closure of the Great Northern Highway intersection results in six LGAs having obstructed supply chains, representing 0.3% of the volumes that are normally received by these LGAs. Port Hedland (T) is the most impacted LGA with one supply chain for the livestock industry obstructed.

Table 206 Community impact metrics for modelled intersections on the North West Coastal Highway KFR - obstructed supply chains

			GERALDTON – MOUNT MAGNET ROAD	TOM PRICE – KARRATHA ROAD	GREAT NORTHERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/95	1/31	0/22
		Relative volumes impacted	21.3%	6.4%	0.0%
	most impacted LGA	Name of destination LGA	Greater Geraldton(C)	Karratha(C)	-
		Highest impacted commodity sector	Processed Food	Processed Food	-
		Commodity impacted	Box Chicken	Meat	-
		Number of supply chains impacted	1	3	0
		Relative volumes impacted	21%	7%	0%
		Weekly tonnes BAU	36.0	45.9	0.0
		Relative number of supply chains impacted	8%	33%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/95	1/31	6/22
		Relative volumes impacted	17.8%	3.5%	0.3%
	Most impacted LGA	Name of destination LGA	Greater Geraldton(C)	Karratha(C)	Port Hedland(T)
		Highest impacted commodity sector	Processed Food	Horticulture	Livestock
		Number of supply chains impacted	7	9	1
		Relative volumes impacted	21%	6%	3%
		Weekly tonnes BAU	313.1	108.3	52.3
		Relative number of supply chains impacted	7%	33%	3%

Re-routed supply chains

Table 207 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 26.2% of the supply chains are expected to be re-routed for 23 of the 95 LGAs that traverse the Geraldton – Mount Magnet Road intersection. The most impacted LGA is Carnarvon (S), with four supply chains in the processed food sector representing 18.8 tonnes per week re-routed. For non-essential commodities, all of the 95 LGAs serviced by the Geraldton – Mount Magnet Road intersection are impacted by re-routed freight, representing 19.5% of the total volumes consumed within these LGAs.

For the Tom Price – Karratha Road intersection, 15 of the 31 LGAs serviced are expected to have freight re-routed, with this representing 31.1 % of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 31 LGAs serviced by the Tom Price – Karratha Road intersection are impacted by re-routed freight, representing 10.4% of the total volume consumed within these LGAs.

For the Great Northern Highway intersection, 17 of the 22 LGAs serviced are expected to have freight re-routed, representing 34.3% of essential commodities consumed within the LGAs. For non-essential commodities, 20 of the 22 LGAs serviced by the Great Northern Highway intersection are impacted by re-routed freight, representing 13.4% of the total volume consumed within these LGAs.

Table 207 Community impact metrics for modelled intersections on the North West Coastal Highway KFR - re-routed supply chains

			GERALDTON – MOUNT MAGNET ROAD	TOM PRICE – KARRATHA ROAD	GREAT NORTHERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	23/95	15/31	17/22
		Relative impact on volumes of commodities	26.2%	31.1%	34.3%
	Most impacted LGA	Name	Carnarvon(S)	Karratha(C)	Carnarvon(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Dairy Product	Bread	Box Beef
		Number of supply chains impacted	4	2	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	18.8	4.1	0.2
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	95/95	31/31	20/22
		Relative impact on volumes of commodities	19.5%	10.4%	13.4%
	Most impacted LGA	Name	Carnarvon(S)	Karratha(C)	East Pilbara(S)
		Highest impacted commodity sector	Horticulture	Wood Product	Cropping
		Number of supply chains impacted	12	1	5
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	27.7	25.6	14.8
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘North West Coastal Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘North West Coastal Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.41 Pacific Highway

The Pacific Highway KFR (Figure 59) is a major north – south freight and commuter corridor connecting south of Byron Bay (NSW) to Newcastle (NSW), with connections to LGAs in central west NSW. The corridor is 612 km with at least part of the route used for the transport of $165m of product on 539, 774 trailers annually carrying 10.3 million tonnes across 26975 supply chains spanning 119 commodities (36% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 125,653 trailers annually with the busiest sections carrying 244,037 trailers.

Fuel transport represents approximately 25% of the total freight task, with critical links from ports to depots and on to service stations. General freight and processed food comprise a further 23% of the total freight task, with movement from ports to Distribution Centres (DCs) and DCs and on to markets. The corridor also supports transport movements primarily of wood products from forestry plantations to sawmills and on to markets and cropping (sugar), with a further 25% of the total freight task attributed to these commodity groups. This route is predominantly classified as PBS2a access.

Figure 59 Pacific Highway KFR

The Pacific Highway KFR passes through 12 LGAs but crucially it supports the supply chain paths for over 280 LGAs along its length and beyond. It provides access to essential commodities for 91 LGAs. Many LGAs including Ballina (A), Mid Coast and Port Macquarie-Hastings (A) are reliant on this KFR to provide access to supplies and markets for most commodities. Figure 59 shows that consistent concentrations of freight along the full KFR.

Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 90% of the supply chain trip length. Fuel, processed food and wood products in particular utilise large sections of the KFR. Large proportions of the KFR are used for movement of freight to Brisbane (C) and Parramatta (C) LGAs.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Big River Way
- Bruxner Highway
- Oxley Highway

The reliance described in Table 208 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections with low to very high degrees, with 20% (Big River Way), 21% (Bruxner Highway) and 91% (Oxley Highway) of all the supply chain paths traversing the intersections destined for the Blacktown (C), Brisbane (C) and the Port Macquarie-Hastings (A) LGAs, respectively.

Table 208 Summary of community reliance metrics for each intersection on the Pacific Highway NSW key freight route - most impacted LGA

	BIG RIVER WAY	BRUXNER HIGHWAY	OXLEY HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Brisbane (C)	Port Macquarie-Hastings (A)
Relative reliance on intersection for destination LGA	0.20	0.21	0.91
Origin LGA most reliant on the intersection	Lockyer Valley (R)	Brisbane (C)	Port Macquarie-Hastings (A)
Relative reliance on intersection for origin LGA	0.08	0.13	0.32

5.41.1 Modelling and analysis outcomes

As discussed in Section 2, the effects from a widespread weather event can result in multiple intersections and bypass routes being closed. These can also be coupled with rail closures which in combination can result is a catastrophic impact on supply chains. Such events occurred February and March 2022. A summary of the supply chain impacts is provided in the supplementary material labelled Lismore floods.

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Pacific Highway NSW. The results are based on expected freight for an average week.

- **Big River Way intersection**: The closure of the Big River Way intersection results in the disruption of 4,776 vehicle trips carrying 84,319 tonnes, 39% being essential commodities. Overall, 84,316 tonnes of freight are re-routed with an average detour length of -12 km and with an average increase in cost of $9.76 per tonne. Little freight is unable to reach its destination.
- **Bruxner Highway intersection**: The closure of the Bruxner Highway intersection results in the disruption of 4,902 vehicle trips carrying 85,434 tonnes, 35% being essential commodities. Overall, 85,348 tonnes of freight are re-routed with a negligible average

detour length and with an average increase in cost of $6.44 per tonne. Little freight is unable to reach its destination.

- **Oxley Highway intersection**: The closure of the Oxley Highway intersection results in the disruption of 446 vehicle trips carrying 7,711 tonnes, 61% being essential commodities. Overall, 7,584 tonnes of freight are re-routed with an average detour length of 21 km and with an average increase in cost of $7.69 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Pacific Highway NSW and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Pacific Highway NSW-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Pacific Highway NSW-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Pacific Highway NSW-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Pacific Highway NSW-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Pacific Highway NSW-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Pacific Highway NSW-cost bar plot.png' shows the cost impacts of re-routing.
- 'Pacific Highway NSW-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Pacific Highway NSW.

KFR risk profile

Table 209 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number (five) of successive high-intensity alternative route closures, with low impact risk in terms of obstructed volumes, and also low values for the re-routed costs indicating that freight is expected to be re-routed at low costs.

Table 209 Risk metrics for modelled intersections on the Pacific Highway NSW KFR

	BIG RIVER WAY	BRUXNER HIGHWAY	OXLEY HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.001	0.016
KFR impacts risk - detour costs for intersection	0.013	0.016	0.026
Last iteration	5	5	5

Freight impact

Table 210 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 210 Freight impact metrics for modelled intersections on the Pacific Highway NSW KFR by last successive closure

		BIG RIVER WAY [%]	BRUXNER HIGHWAY [%]	OXLEY HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	2
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	2
Re-routed supply chains	Relative detour cost – average	6	4	39
	Relative detour cost – maximum	283	199	190

The metrics in Table 210 indicate the supply chains traversing the Big River Way intersection that are likely to be re-routed would do so with their average cost increasing by 6% across all commodities, with some supply chain paths reaching an increase of up to 283%. Those traversing the Bruxner Highway intersection are expected to be re-routed at an average cost increase of 4% across all commodities, while those traversing the Oxley Highway intersection may do so at an average cost increasing by 39%.

Little to no freight is obstructed for the three intersection closures intersection closure.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 211 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of any of the Big River Way and the Bruxner Highway intersection results in no LGA not receiving essential commodities.

When considering all commodities, the Big River Way intersection results in three LGAs not receiving commodities, representing less than 1% of the LGAs' consumption where the most impacted LGA is Logan (C) for livestock.

When considering all commodities, the Bruxner Highway intersection results in seven LGAs not receiving commodities, representing less than 1% of the LGAs' consumption where the most impacted LGA is Ballina (A) for mining.

When considering all commodities, the Oxley Highway intersection results in one LGA not receiving commodities, representing 2.2% of the LGA's consumption where the most impacted LGA is Port Macquarie-Hastings (A) for fuel freight.

Table 211 Community impact metrics for modelled intersections on the Pacific Highway NSW KFR - obstructed supply chains

			BIG RIVER WAY	BRUXNER HIGHWAY	OXLEY HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/166	0/173	1/13
		Relative volumes impacted	0.0%	0.0%	2.4%
	Most impacted LGA	Name of destination LGA	-	-	Port Macquarie-Hastings(A)
		Highest impacted commodity sector	-	-	fuel
		Commodity impacted	-	-	Diesel fuel
		Number of supply chains impacted	0	0	1
		Relative volumes impacted	0%	0%	3%
		Weekly tonnes BAU	0.0	0.0	584.4
		Relative number of supply chains impacted	0%	0%	5%
All commodities	All impacted LGAs	Number of LGAs impacted	3/166	7/173	1/13
		Relative volumes impacted	0.0%	0.2%	2.2%
	Most impacted LGA	Name of destination LGA	Logan(C)	Ballina(A)	Port Macquarie-Hastings(A)
		Highest impacted commodity sector	Livestock	Mining	Fuel
		Number of supply chains impacted	1	3	3
		Relative volumes impacted	0%	3%	2%
		Weekly tonnes BAU	3,697.7	30.8	4,837.3
		Relative number of supply chains impacted	0%	3%	5%

Re-routed supply chains

Table 212 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 21.1% of the supply chains are expected to be re-routed for 59 of the 166 LGAs that traverse the Big River Way intersection. The most impacted LGA is Bellingen (A), with five supply chains in the processed food sector representing 2.8 tonnes of box rice per week re-routed. For non-essential commodities, all 166 LGAs serviced by the Big River Way intersection are impacted by re-routed freight, representing 5.2% of the total volumes consumed within these LGAs.

For the Bruxner Highway intersection, 60 of the 173 LGAs serviced are expected to have freight re-routed, with this representing 19.2% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 172 out of 173 LGAs serviced by the Bruxner Highway intersection are impacted by re-routed freight, representing 5.3% of the total volume consumed within these LGAs.

For the Oxley Highway intersection, eight of the 13 LGAs serviced are expected to have freight re-routed, representing 21.1% of essential commodities consumed within the LGAs. For non-essential commodities, all 13 LGAs serviced by the Oxley Highway intersection are impacted by re-routed freight, representing 7.7% of the total volume consumed within these LGAs.

Table 212 Community impact metrics for modelled intersections on the Pacific Highway NSW KFR - re-routed supply chains

			BIG RIVER WAY	BRUXNER HIGHWAY	OXLEY HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	59/166	60/173	8/13
		Relative impact on volumes of commodities	21.1%	19.2%	21.1%
	Most impacted LGA	Name	Bellingen(A)	Clarence Valley(A)	Port Macquarie-Hastings(A)
		Highest impacted commodity sector	Processed Food	Processed Food	Fuel
		Commodity impacted	Box Rice	Meat	LPG
		Number of supply chains impacted	5	16	8
		Relative volumes impacted	100%	100%	96%
		Weekly tonnes BAU	2.8	76.3	513.0
		Relative number of supply chains impacted	100%	100%	36%
All commodities	All impacted LGAs	Number of LGAs impacted	166/166	172/173	13/13
		Relative impact on volumes of commodities	5.2%	5.3%	7.7%
	Most impacted LGA	Name	Bellingen(A)	Bellingen(A)	Port Macquarie-Hastings(A)
		Highest impacted commodity sector	General	General	Horticulture
		Number of supply chains impacted	10	10	33
		Relative volumes impacted	100%	100%	74%
		Weekly tonnes BAU	14.2	14.2	268.2
		Relative number of supply chains impacted	100%	100%	52%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Pacific Highway NSW-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Pacific Highway NSW-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.42 Princes Freeway East

The Princes Freeway East KFR (Figure 60) in a freight route located in Victoria. It connects LGAs from Sale in the east to Melbourne. The corridor is 338 km with at least part of the route used for the transport of $46m of product on 357,052 trailers annually carrying 7.4 million tonnes across 13,609 supply chains spanning 80 commodities (39% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 83,127 trailers annually with the busiest sections carrying 129,949 trailers.

Wood product transport represents approximately 32% of the total freight task with processed food and fuel adding a further 20% each to the freight task. This route is predominantly PBS2a B-Double HML access.

Figure 60 Princes Freeway East KFR

The Princes Freeway East KFR passes through five LGAs but crucially it supports the supply chain paths for over 263 LGAs along its length and beyond. It provides access to essential commodities for 59 LGAs. Latrobe (C) (Vic), Wellington (S), Baw Baw (S) and Cardinia (S) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, general freight and cropping. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- South Gippsland Highway
- Strezlecki Highway
- Monash Freeway

The reliance described in Table 213 equates to a risk factor and highlights the importance - and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 21% (South Gippsland Highway), 17% (Strzelecki Highway) and 12% (Monash Freeway) of all the supply chain paths traversing the intersections destined for the East Gippsland (S), Wellington (S) and the Glenelg (S) LGAs, respectively.

Table 213 Summary of community reliance metrics for each intersection on the Princes Freeway East key freight route - most impacted LGA

	SOUTH GIPPSLAND HIGHWAY	STRZELECKI HIGHWAY	MONASH FREEWAY
Destination LGA most reliant on the intersection	East Gippsland (S)	Wellington (S)	Glenelg (S)
Relative reliance on intersection for destination LGA	0.21	0.17	0.12
Origin LGA most reliant on the intersection	Wellington (S)	Wellington (S)	Wellington (S)
Relative reliance on intersection for origin LGA	0.28	0.32	0.20

5.42.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Princes Freeway East. The results are based on expected freight for an average week.

- **South Gippsland Highway intersection**: The closure of the South Gippsland Highway intersection results in the disruption of 1,624 vehicle trips carrying 31,473 tonnes, 25% being essential commodities. Overall, 31,318 tonnes of freight are re-routed with a negligible average detour and with an average increase in cost of $3.47 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Strzelecki Highway intersection**: The closure of the Strzelecki Highway intersection results in the disruption of 3,237 vehicle trips carrying 66,091 tonnes, 36% being essential commodities. Overall, 66,087 tonnes of freight are re-routed with an average detour length of five km and with an average increase in cost of $4.24 per tonne. A total value of supplies amounting to $0.0 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Monash Freeway intersection**: The closure of the Monash Freeway intersection results in the disruption of 4,666 vehicle trips carrying 93,973 tonnes, 34% being essential commodities. Overall, 93,953 tonnes of freight are re-routed with an average detour length of -5 km and with an average increase in cost of $3.08 per tonne. A total value of supplies amounting to $0.3 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Princes Freeway East and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Princes Freeway East-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Princes Freeway East-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Princes Freeway East-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Princes Freeway East-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Princes Freeway East-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Princes Freeway East-cost bar plot.png' shows the cost impacts of re-routing.
- 'Princes Freeway East-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Princes Freeway East.

KFR risk profile

Table 214 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight might be re-routed at low cost.

Table 214 Risk metrics for modelled intersections on the Princes Freeway East KFR

	SOUTH GIPPSLAND HIGHWAY	STRZELECKI HIGHWAY	MONASH FREEWAY
KFR impacts risk - obstructed volumes for intersection	0.005	0.000	0.000
KFR impacts risk - detour costs for intersection	0.010	0.016	0.014
Last iteration	5	5	5

Freight impact

Table 215 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 215 Freight impact metrics for modelled intersections on the Princes Freeway East KFR by last successive closure

		SOUTH GIPPSLAND HIGHWAY [%]	STRZELECKI HIGHWAY [%]	MONASH FREEWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	2	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	7	10	8
	Relative detour cost – maximum	57	116	73

The metrics in Table 215 indicate the supply chains traversing the South Gippsland Highway intersection that are likely to be re-routed would do so with their average cost increasing by 7% across all commodities, with some supply chain paths incurring an increase of up to 57%. Those traversing the Strzelecki Highway intersection are expected to be re-routed at an average cost increasing by 10% across all commodities, while those traversing the Monash Freeway intersection may do so at an average cost increasing by 8%.

Very little freight is obstructed for all three intersections for all commodities.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 216 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The South Gippsland Highway intersection results in one LGA (Wellington (S)) not receiving essential commodities, representing 5.9% of the LGA's essential commodities consumption. When considering all commodities, the same LGA serviced by the intersection has freight obstructed, representing 5.2% of the LGA's overall consumption.

The Strzelecki Highway intersection and the Monash Freeway intersection closures result in no LGAs impacted by obstructed essential commodities.

When considering all commodities, one LGA (Latrobe (C) (Vic)) out of the 162 LGAs serviced by the Strzelecki Highway intersection has freight obstructed, representing 0.7% of the LGA's overall consumption. And two out of the 192 LGAs serviced by the Monash Freeway intersection have freight obstructed, representing 0.6% of the LGAs' overall consumption.

Table 216 Community impact metrics for modelled intersections on the Princes Freeway East KFR - obstructed supply chains

			SOUTH GIPPSLAND HIGHWAY	STRZELECKI HIGHWAY	MONASH FREEWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/132	0/162	0/192
		Relative volumes impacted	5.9%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Wellington(S)	-	-
		Highest impacted commodity sector	Fuel	-	-
		Commodity impacted	Unleaded fuel	-	-
		Number of supply chains impacted	1	0	0
		Relative volumes impacted	6%	0%	0%
		Weekly tonnes BAU	1,778.7	0.0	0.0
		Relative number of supply chains impacted	6%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	1/132	1/162	2/192
		Relative volumes impacted	5.2%	0.7%	0.6%
	Most impacted LGA	Name of destination LGA	Wellington(S)	Latrobe(C) (Vic)	Casey(C)
		Highest impacted commodity sector	Fuel	Waste	Vehicles
		Number of supply chains impacted	3	1	2
		Relative volumes impacted	6%	1%	4%
		Weekly tonnes BAU	2,566.4	581.5	277.8
		Relative number of supply chains impacted	6%	1%	5%

Re-routed supply chains

Table 217 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 8.4% of the supply chains are expected to be re-routed for 20 of the 132 LGAs that traverse the South Gippsland Highway intersection. The most impacted LGA is East Gippsland (S), with 27 supply chains in the horticulture sector representing 75.8 tonnes of fruit per week re-routed. For non-essential commodities, all 132 LGAs serviced by the South Gippsland Highway intersection are impacted by re-routed freight, representing 3.2% of the total volumes consumed within these LGAs.

For the Strzelecki Highway intersection, 38 of the 162 LGAs serviced are expected to have freight re-routed, with this representing 11.7% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 160 of the 162 LGAs serviced by the Strzelecki Highway intersection are impacted by re-routed freight, representing 6% of the total volume consumed within these LGAs.

For the Monash Freeway intersection, 53 of the 192 LGAs serviced are expected to have freight re-routed, representing 11.1% of essential commodities consumed within the LGAs. For non-essential commodities, 188 of the 192 LGAs serviced by the Monash Freeway intersection are impacted by re-routed freight, representing 7.4% of the total volume consumed within these LGAs.

Table 217 Community impact metrics for modelled intersections on the Princes Freeway East KFR - re-routed supply chains

			SOUTH GIPPSLAND HIGHWAY	STRZELECKI HIGHWAY	MONASH FREEWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	20/132	38/162	53/192
		Relative impact on volumes of commodities	8.4%	11.7%	11.1%
	Most impacted LGA	Name	East Gippsland(S)	East Gippsland(S)	Cardinia(S)
		Highest impacted commodity sector	Horticulture	Horticulture	Construction
		Commodity impacted	Fruit	Fruit	Cement
		Number of supply chains impacted	27	27	1
		Relative volumes impacted	97%	97%	100%
		Weekly tonnes BAU	75.8	75.8	3.8
		Relative number of supply chains impacted	93%	93%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	132/132	160/162	188/192
		Relative impact on volumes of commodities	3.2%	6.0%	7.4%
	Most impacted LGA	Name	Manningham (C)	Ceduna (DC)	Baw Baw(S)
		Highest impacted commodity sector	Wood Product	Wood Product	Mining
		Number of supply chains impacted	1	1	4
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	25.6	25.6	0.8
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Princes Freeway East-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Princes Freeway East-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.43 Princes Freeway West

The Princes Freeway West KFR (Figure 61) is a freight route located in Victoria. The route heads west from Melbourne to Colac - this section is part of a longer KFR but has been separated into two sections due to geographical and freight task differences. This section of the corridor is 292 km with at least part of the route used for the transport of $137m of product on 1,357,019 trailers annually carrying 24 million tonnes across 34,017 supply chains spanning 116 commodities (35%of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 148,293 trailers annually with the busiest sections carrying 501,899 trailers.

General freight transport represents approximately 40% of the total freight task, with movements from port being a large proportion. Fuel and wood product add 20% each to the freight task. This route is predominantly classified as PBS2a access.

Figure 61 Princes Freeway West KFR

The Princes Freeway West KFR passes through five LGAs but crucially it supports the supply chain paths for over 356 LGAs along its length and beyond. It provides access to essential commodities for 161 LGAs. Colac-Otway (S), Greater Geelong (C) and Hobsons Bay (C) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Western Ring Road
- Geelong Ring Road

- Colac – Ballarat Road

The reliance described in Table 218 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Glenelg (S) LGA is moderately reliant on the Geelong Ring Road and the Colac – Ballarat Road intersections, while the Greater Geelong (C) LGA is little reliant on the Western Ring Road intersection as a destination LGA.

Table 218 Summary of community reliance metrics for each intersection on the Princes Freeway West key freight route - most impacted LGA

	WESTERN RING ROAD	GEELONG RING ROAD	COLAC – BALLARAT ROAD
Destination LGA most reliant on the intersection	Greater Geelong (C)	Glenelg (S)	Glenelg (S)
Relative reliance on intersection for destination LGA	0.11	0.22	0.30
Origin LGA most reliant on the intersection	Wyndham (C)	Greater Geelong (C)	Colac-Otway (S)
Relative reliance on intersection for origin LGA	0.17	0.14	0.13

5.43.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Princes Freeway West. The results are based on expected freight for an average week.

- **Western Ring Road intersection**: The closure of the Western Ring Road intersection results in the disruption of 8,717 vehicle trips carrying 154,311 tonnes, 31% being essential commodities. Overall, 154,311 tonnes of freight are re-routed with an average detour length of four km and with an average increase in cost of $3.54 per tonne. No freight is unable to reach its destination.
- **Geelong Ring Road intersection**: The closure of the Geelong Ring Road intersection results in the disruption of 5,070 vehicle trips carrying 102,271 tonnes, 37% being essential commodities. Overall, 102,267 tonnes of freight are re-routed with an average detour length of -4 km and with an average increase in cost of $2.64 per tonne. Little freight is unable to reach its destination.
- **Colac – Ballarat Road intersection**: The closure of the Colac – Ballarat Road intersection results in the disruption of 4,612 vehicle trips carrying 91,615 tonnes, 32% being essential commodities. Overall, 91,608 tonnes of freight are re-routed with an average detour length of -5 km and with an average increase in cost of $2.46 per tonne. Little freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Princes Freeway West and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Princes Freeway West-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection

- ‘Princes Freeway West-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed
- ‘Princes Freeway West-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Princes Freeway West-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed
- ‘Princes Freeway West-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Princes Freeway West-cost bar plot.png’ shows the cost impacts of re-routing
- ‘Princes Freeway West-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Princes Freeway West.

KFR risk profile

Table 219 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The ‘Princes Freeway West-*intersection*-cumulative impact.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 219 Risk metrics for modelled intersections on the Princes Freeway West KFR – the model

	WESTERN RING ROAD	GEELONG RING ROAD	COLAC – BALLARAT ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.007	0.011	0.010
Last iteration	5	5	5

Freight impact

Table 220 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 220 Freight impact metrics for modelled intersections on the Princes Freeway West KFR

		WESTERN RING ROAD [%]	GEELONG RING ROAD [%]	COLAC – BALLARAT ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
	Relative detour cost – average	11	8	6

		WESTERN RING ROAD [%]	GEELONG RING ROAD [%]	COLAC – BALLARAT ROAD [%]
Re-routed supply chains	Relative detour cost – maximum	101	85	143

The metrics in Table 220 indicate the supply chains traversing all three intersections that are likely to be re-routed will do so with their average cost increasing slightly, between 6% and 11% over all commodities. The routes most impacted by detours reach a maximum increase cost of 143% (Colac – Ballarat Road intersection).

For all three intersections, the obstructed freight is minimal[15].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 221 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Western Ring Road closure results in no LGAs having obstructed supply chains, for essential as well as non-essential commodities.

The Geelong Ring Road closure results in no LGAs having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Geelong Ring Road intersection results in one LGA having obstructed supply chains, representing 0.2% of the volumes that are normally received by this LGA serviced by the intersection.

The Colac – Ballarat Road intersection closure results in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Colac – Ballarat Road intersection results in one LGA having obstructed supply chains, representing 0.5% of the volumes that are normally received by this LGA. Colac-Otway(S) is the most impacted LGA with two supply chains for the cropping industry obstructed.

[15] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

Table 221 Community impact metrics for modelled intersections on the Princes Freeway West KFR - obstructed supply chains

			WESTERN RING ROAD	GEELONG RING ROAD	COLAC – BALLARAT ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/176	0/175	0/153
		Relative volumes impacted	0.0%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	-	-	-
		Highest impacted commodity sector	-	-	-
		Commodity impacted	-	-	-
		Number of supply chains impacted	0	0	0
		Relative volumes impacted	0%	0%	0%
		Weekly tonnes BAU	0.0	0.0	0.0
		Relative number of supply chains impacted	0%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	0/176	1/175	1/153
		Relative volumes impacted	0.0%	0.2%	0.5%
	Most impacted LGA	Name of destination LGA	-	Greater Geelong(C)	Colac-Otway(S)
		Highest impacted commodity sector	-	Waste	Cropping
		Number of supply chains impacted	-	1	2
		Relative volumes impacted	0%	0%	0%
		Weekly tonnes BAU	0.0	2,305.4	1,595.0
		Relative number of supply chains impacted	0%	0%	1%

Re-routed supply chains

Table 222 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 14.8% of the supply chains are expected to be re-routed for 95 of the 176 LGAs that traverse the Western Ring Road intersection. The most impacted LGA is Moyne (S), with 14 supply chains in the processed food sector representing 3.6 tonnes of box rice per week re-routed. For non-essential commodities, 172 of the 176 LGAs serviced by the Western Ring Road intersection are impacted by re-routed freight, representing 9.8% of the total volumes consumed within these LGAs.

For the Geelong Ring Road intersection, 77 of the 175 LGAs serviced are expected to have freight re-routed, with this representing 12.8% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 175 LGAs serviced by the Geelong Ring Road intersection are impacted by re-routed freight, representing 6.4% of the total volume consumed within these LGAs.

For the Colac – Ballarat Road intersection, 53 of the 153 LGAs serviced are expected to have freight re-routed, representing 11.1% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 153 LGAs serviced by the Colac – Ballarat Road intersection are impacted by re-routed freight, representing 8% of the total volume consumed within these LGAs.

Table 222 Community impact metrics for modelled intersections on the Princes Freeway West KFR - re-routed supply chains

			WESTERN RING ROAD	GEELONG RING ROAD	COLAC – BALLARAT ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	95/176	77/175	53/153
		Relative impact on volumes of commodities	14.8%	12.8%	11.1%
	Most impacted LGA	Name	Moyne(S)	Warrnambool (C)	Warrnambool (C)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Rice	Seafood	Seafood
		Number of supply chains impacted	14	10	10
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	3.6	12.7	12.7
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	172/176	175/175	153/153
		Relative impact on volumes of commodities	9.8%	6.4%	8.0%
	Most impacted LGA	Name	Ceduna (DC)	Warrnambool (C)	Warrnambool (C)
		Highest impacted commodity sector	Wood Product	General	General
		Number of supply chains impacted	1	73	73
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	25.6	2,534.7	2,534.7
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Princes Freeway West-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Princes Freeway West-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.44 Princes Highway NSW

The Princes Highway NSW KFR (Figure 62) is a freight route located in NSW. It connects LGAs from Shellharbour to the NSW – Victoria border. The corridor is 504 km with at least part of the route used for the transport of $45m of product on 233,634 trailers annually carrying 4.3 million tonnes across 7,295 supply chains spanning 68 commodities (60% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 23,829 trailers annually with the busiest sections carrying 105,043 trailers.

Fuel transport represents approximately 40% of the total freight task with movements between port to depot and on to fuel stations. Construction adds 15% and processed food a further 10% to the freight task, mostly raw milk to dairy processors. This route has a mix of classifications, from PBS2a access through PBS1 HML to PBS1.

Figure 62 Princes Highway NSW KFR

The Princes Highway NSW KFR passes through eight LGAs but crucially it supports the supply chain paths for over 271 LGAs along its length and beyond. It provides access to essential commodities for 77 LGAs. Eurobodalla (A), Bega Valley (A), Shellharbour (C) and Shoalhaven (C) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, general freight and cropping. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 40% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Kings Highway
- Snowy Mountain Way

- Jervis Bay Road

The reliance described in Table 223 equates to a risk factor and highlights the importance - and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 21% (Jervis Bay Road), 17% (Snowy Mountain Way) and 12% (Kings Highway) of all the supply chain paths traversing the intersections destined for the East Gippsland (S), Wellington (S) and the Glenelg (S) LGAs, respectively.

Table 223 Summary of community reliance metrics for each intersection on the Princes Highway NSW key freight route - most impacted LGA

	JERVIS BAY ROAD	SNOWY MOUNTAIN WAY	KINGS HIGHWAY
Destination LGA most reliant on the intersection	East Gippsland (S)	Wellington (S)	Glenelg (S)
Relative reliance on intersection for destination LGA	0.21	0.17	0.12
Origin LGA most reliant on the intersection	Wellington (S)	Wellington (S)	Wellington (S)
Relative reliance on intersection for origin LGA	0.28	0.32	0.20

5.44.1 Modelling and analysis outcomes

As discussed in Section 2, the effects from a widespread weather event can result in multiple intersections and bypass routes being closed. These can also be coupled with rail closures which in combination can result is a catastrophic impact on supply chains. Such an event occurred March 2022. A summary of the supply chain impacts is provided in the supplementary material labelled Sydney and surrounds floods.

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Princes Highway NSW. The results are based on expected freight for an average week.

- **Jervis Bay Road intersection**: The closure of the Jervis Bay Road intersection results in the disruption of 812 vehicle trips carrying 15,818 tonnes, 75% being essential commodities. Overall, 14,869 tonnes of freight are re-routed with an average detour length of 26 km and with an average increase in cost of $6.63 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Snowy Mountain Way intersection**: The closure of the Snowy Mountain Way intersection results in the disruption of 422 vehicle trips carrying 8,603 tonnes, 76% being essential commodities. Overall, 8,603 tonnes of freight are re-routed with an average detour length of 24 km and with an average increase in cost of $6.66 per tonne. No freight is unable to reach its destination.
- **Kings Highway intersection**: The closure of the Kings Highway intersection results in the disruption of 729 vehicle trips carrying 14,167 tonnes, 72% being essential commodities. Overall, 14,132 tonnes of freight are re-routed with an average detour length of 25 km and with an average increase in cost of $8.67 per tonne. Little freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Princes Highway NSW and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Princes Highway NSW-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Princes Highway NSW-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Princes Highway NSW-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Princes Highway NSW-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Princes Highway NSW-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Princes Highway NSW-cost bar plot.png' shows the cost impacts of re-routing.
- 'Princes Highway NSW-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Princes Highway NSW.

KFR risk profile

Table 224 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight might be re-routed at low cost.

Table 224 Risk metrics for modelled intersections on the Princes Highway NSW KFR

	JERVIS BAY ROAD	SNOWY MOUNTAIN WAY	KINGS HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.060	0.000	0.001
KFR impacts risk - detour costs for intersection	0.043	0.019	0.039
Last iteration	5	5	5

Freight impact

Table 225 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 225 Freight impact metrics for modelled intersections on the Princes Highway NSW KFR by last successive closure

		JERVIS BAY ROAD [%]	SNOWY MOUNTAIN WAY [%]	KINGS HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	6	0	0
	Relative freight volume impacted – essential commodities	7	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	16	8	16
	Relative detour cost – maximum	163	38	133

The metrics in Table 225 indicate the supply chains traversing the Jervis Bay Road intersection that are likely to be re-routed would do so with their average cost increasing by 16% across all commodities, with some supply chain paths incurring an increase of up to 163%. Those traversing the Snowy Mountain Way intersection are expected to be re-routed at an average cost increasing by 8% across all commodities, while those traversing the Kings Highway intersection may do so at an average cost increasing by 16%.

Very little freight is obstructed for all three intersections for all commodities.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 226 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Jervis Bay Road intersection results in two LGAs not receiving essential commodities, representing 12% of the LGAs' consumption where the most impacted LGA is Shoalhaven (C) for cement. When considering all commodities, the same two LGAs serviced by the intersection have freight obstructed, representing 7.6% of the LGAs' overall consumption.

The Snowy Mountain Way intersection closure results in no LGAs impacted by obstructed essential and non-essential commodities.

The Kings Highway intersection results in one LGA (Eurobodalla (A)) not receiving essential commodities, representing 2.4% of the LGA's essential commodities consumption. When considering all commodities, the same LGA serviced by the intersection has freight obstructed, representing 1.2% of the LGA's overall consumption.

Table 226 Community impact metrics for modelled intersections on the Princes Highway NSW KFR - obstructed supply chains

			JERVIS BAY ROAD	SNOWY MOUNTAIN WAY	KINGS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/42	0/71	1/46
		Relative volumes impacted	12.0%	0.0%	2.4%
	Most impacted LGA	Name of destination LGA	Shoalhaven(C)	-	Eurobodalla(A)
		Highest impacted commodity sector	Construction	-	Construction
		Commodity impacted	Cement	-	Gravel
		Number of supply chains impacted	2	0	2
		Relative volumes impacted	19%	0%	2%
		Weekly tonnes BAU	219.2	0.0	957.7
		Relative number of supply chains impacted	25%	0%	4%
All commodities	All impacted LGAs	Number of LGAs impacted	2/42	0/71	1/46
		Relative volumes impacted	7.6%	0.0%	1.2%
	Most impacted LGA	Name of destination LGA	Shoalhaven(C)	-	Eurobodalla(A)
		Highest impacted commodity sector	Construction	-	Construction
		Number of supply chains impacted	41	0	3
		Relative volumes impacted	15%	0%	1%
		Weekly tonnes BAU	5,983.6	0.0	2,583.7
		Relative number of supply chains impacted	25%	0%	3%

Re-routed supply chains

Table 227 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 17.9% of the supply chains are expected to be re-routed for 16 of the 42 LGAs that traverse the Jervis Bay Road intersection. The most impacted LGA is Bega Valley (A), with 18 supply chains in the fuel sector representing 23.9 tonnes of LPG per week re-routed. For non-essential commodities, all 42 LGAs serviced by the Jervis Bay Road intersection are impacted by re-routed freight, representing 4.8% of the total volumes consumed within these LGAs.

For the Snowy Mountain Way intersection, nine of the 71 LGAs serviced are expected to have freight re-routed, with this representing 21.4% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all 71 LGAs serviced by the Snowy Mountain Way intersection are impacted by re-routed freight, representing 2% of the total volume consumed within these LGAs.

For the Kings Highway intersection, 16 of the 46 LGAs serviced are expected to have freight re-routed, representing 13.6% of essential commodities consumed within the LGAs. For non-essential commodities, all 46 LGAs serviced by the Kings Highway intersection are impacted by re-routed freight, representing 3.8% of the total volume consumed within these LGAs.

Table 227 Community impact metrics for modelled intersections on the Princes Highway NSW KFR - re-routed supply chains

			JERVIS BAY ROAD	SNOWY MOUNTAIN WAY	KINGS HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	16/42	9/71	16/46
		Relative impact on volumes of commodities	17.9%	21.4%	13.6%
	Most impacted LGA	Name	Bega Valley (A)	Bega Valley (A)	Bega Valley (A)
		Highest impacted commodity sector	Fuel	Fuel	Fuel
		Commodity impacted	LPG	LPG	LPG
		Number of supply chains impacted	18	15	18
		Relative volumes impacted	100%	83%	100%
		Weekly tonnes BAU	23.9	23.9	23.9
		Relative number of supply chains impacted	100%	83%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	42/42	71/71	46/46
		Relative impact on volumes of commodities	4.8%	2.0%	3.8%
	Most impacted LGA	Name	Eurobodalla(A)	Bega Valley (A)	Eurobodalla(A)
		Highest impacted commodity sector	Horticulture	Vehicles	Horticulture
		Number of supply chains impacted	51	30	51
		Relative volumes impacted	100%	70%	100%
		Weekly tonnes BAU	134.7	215.8	134.7
		Relative number of supply chains impacted	100%	60%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Princes Highway NSW-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Princes Highway NSW-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.45 Princes Highway Vic

The Princes Highway Vic KFR (Figure 63) is a freight route located in Victoria. It continues from the Princes Freeway West at Colac to Mount Gambier in south-east SA via Portland. The corridor is 313 km with at least part of the route used for the transport of $45m of product on 531,783 trailers annually carrying 10.5 million tonnes across 17,455 supply chains spanning 69 commodities (24%of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 124,794 trailers annually with the busiest sections carrying 233,952 trailers.

Wood product transport represents approximately 55% of the total freight task, with movements from property to port being a large proportion. Processed food adds 15% to the freight task, mostly collection of raw milk for dairy processing. Cropping contributes 10% to the freight task, with movements from silos to stock feed manufactures and on to properties. This route is predominantly classified as PBS2a access.

Figure 63 Princes Highway Vic KFR

The Princes Highway Vic KFR passes through seven LGAs but crucially supports the supply chain paths for over 315 LGAs along its length and beyond. It provides access to essential commodities for 63 LGAs. Warrnambool (S), Glenelg (C) and Moyne (S) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and general freight. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Henty Highway
- Glenelg Highway
- Dartmoor – Hamilton Road

The reliance described in Table 228 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Glenelg (S) LGA is moderately reliant on the Glenelg Highway intersection, moderately to highly reliant on the Dartmoor – Hamilton Road intersection and very highly reliant on the Henty Highway intersection as a destination LGA. The reliance of the LGAs as an origin LGA is moderate on any of the three intersections.

Table 228 Summary of community reliance metrics for each intersection on the Princes Highway Vic key freight route - most impacted LGA

	HENTY HIGHWAY	DARTMOOR – HAMILTON ROAD	GLENELG HIGHWAY
Destination LGA most reliant on the intersection	Glenelg (S)	Glenelg (S)	Glenelg (S)
Relative reliance on intersection for destination LGA	0.84	0.42	0.28
Origin LGA most reliant on the intersection	Glenelg (S)	Glenelg (S)	Wattle Range (DC)
Relative reliance on intersection for origin LGA	0.26	0.23	0.21

5.45.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Princes Highway Vic. The results are based on expected freight for an average week.

- **Henty Highway intersection**: The closure of the Henty Highway intersection results in the disruption of 4,631 vehicle trips carrying 87,069 tonnes, 2% being essential commodities. Overall, 87,055 tonnes of freight are re-routed with an average detour length of 26 km and with an average increase in cost of $7.24 per tonne. Little freight is unable to reach its destination.
- **Dartmoor – Hamilton Road intersection**: The closure of the Dartmoor – Hamilton Road intersection results in the disruption of 3,011 vehicle trips carrying 55,841 tonnes, 18% being essential commodities. Overall, 55,771 tonnes of freight are re-routed with an average detour length of 16 km and with an average increase in cost of $5.79 per tonne. Little freight is unable to reach its destination.
- **Glenelg Highway intersection**: The closure of the Glenelg Highway intersection results in the disruption of 2,660 vehicle trips carrying 49,308 tonnes, 17% being essential commodities. Overall, 49,275 tonnes of freight are re-routed with a negligible average detour length and with an average increase in cost of $2.55 per tonne. A total value of supplies amounting to $0.1 million, none being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Princes Highway Vic and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Princes Highway Vic-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'Princes Highway Vic-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'Princes Highway Vic-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Princes Highway Vic-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'Princes Highway Vic-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Princes Highway Vic-cost bar plot.png' shows the cost impacts of re-routing
- 'Princes Highway Vic-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Princes Highway Vic.

KFR risk profile

Table 229 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'Princes Highway Vic-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are extremely low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. The impacts risk for the detour costs is low, indicating that freight is re-routed at a low cost.

Table 229 Risk metrics for modelled intersections on the Princes Highway Vic KFR – the model

	HENTY HIGHWAY	DARTMOOR – HAMILTON ROAD	GLENELG HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.000	0.000
KFR impacts risk - detour costs for intersection	0.029	0.018	0.010
Last iteration	5	5	5

Freight impact

Table 230 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 230 Freight impact metrics for modelled intersections on the Princes Highway Vic KFR

		HENTY HIGHWAY [%]	DARTMOOR – HAMILTON ROAD [%]	GLENELG HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	20	18	11
	Relative detour cost – maximum	156	162	132

The metrics in Table 230 indicate the supply chains traversing all three intersections that are likely to be re-routed will do so with their average cost increasing slightly, between 11% and 20% over all commodities. The routes most impacted by detours reach a maximum increase cost of 162% (Dartmoor – Hamilton Road intersection).

For all three intersections, the obstructed freight is minimal[16].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 231 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Henty Highway closure results in one LGA having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Henty Highway intersection results in one LGA having obstructed supply chains, representing 0.1% of the volumes that are normally received by this LGA serviced by the intersection.

The Dartmoor – Hamilton Road intersection closure results in no LGAs serviced by the intersections having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Dartmoor – Hamilton Road intersection results in 11 LGAs having obstructed supply chains, representing less than 1% of the volumes that are normally received by these LGAs. Gannawarra (S) is the most impacted LGA with one supply chain for the livestock industry obstructed.

The Glenelg Highway intersection closure results in no LGAs serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Glenelg Highway intersection results in five out of 107 LGAs impacted having obstructed

[16] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

supply chains, representing less than 1% of the volumes that are normally received by these LGAs. Grant (DC) is the most impacted LGA with five supply chains for the cropping industry obstructed.

Table 231 Community impact metrics for modelled intersections on the Princes Highway Vic KFR - obstructed supply chains

			HENTY HIGHWAY	DARTMOOR – HAMILTON ROAD	GLENELG HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/30	0/112	0/107
		Relative volumes impacted	12.5%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Glenelg(S)	-	-
		Highest impacted commodity sector	Fuel	-	-
		Commodity impacted	LPG	-	-
		Number of supply chains impacted	1	0	0
		Relative volumes impacted	12%	0%	0%
		Weekly tonnes BAU	38.2	0.0	0.0
		Relative number of supply chains impacted	12%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	2/30	11/112	5/107
		Relative volumes impacted	0.1%	0.0%	0.2%
	Most impacted LGA	Name of destination LGA	Glenelg(S)	Gannawarra(S)	Grant (DC)
		Highest impacted commodity sector	Fuel	Livestock	Cropping
		Number of supply chains impacted	1	1	3
		Relative volumes impacted	0%	1%	2%
		Weekly tonnes BAU	2,084.9	246.0	801.5
		Relative number of supply chains impacted	4%	1%	2%

Re-routed supply chains

Table 232 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 6.4% of the supply chains are expected to be re-routed for five of the 30 LGAs that traverse the Henty Highway intersection. The most impacted LGA is Glenelg (S), with two supply chains in the processed food sector representing 4.4 tonnes of box lamb per week re-routed. For non-essential commodities, all 30 LGAs serviced by the Henty Highway intersection are impacted by re-routed freight, representing 28.7% of the total volumes consumed within these LGAs.

For the Dartmoor – Hamilton Road intersection, 28 of the 112 LGAs serviced are expected to have freight re-routed, with this representing 19% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 110 of the 112 LGAs serviced by the Dartmoor – Hamilton Road intersection are impacted by re-routed freight, representing 8.1% of the total volume consumed within these LGAs.

For the Glenelg Highway intersection, all 107 LGAs serviced by the intersection are expected to have freight re-routed, representing 16.5% of essential commodities consumed within the LGAs. For non-essential commodities, all of the 107 LGAs serviced by the Glenelg Highway intersection are impacted by re-routed freight, representing 8% of the total volume consumed within these LGAs.

Table 232 Community impact metrics for modelled intersections on the Princes Highway Vic KFR - re-routed supply chains

			HENTY HIGHWAY	DARTMOOR – HAMILTON ROAD	GLENELG HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	5/30	28/112	22/107
		Relative impact on volumes of commodities	6.4%	19.0%	16.5%
	Most impacted LGA	Name	Glenelg(S)	Robe(DC)	Robe(DC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Lamb	Box Beef	Box Beef
		Number of supply chains impacted	2	1	1
		Relative volumes impacted	76%	100%	100%
		Weekly tonnes BAU	4.4	3.3	3.3
		Relative number of supply chains impacted	33%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	30/30	110/112	107/107
		Relative impact on volumes of commodities	28.7%	7.5%	8.1%
	Most impacted LGA	Name	Glenelg(S)	Mount Gambier(C)	Mount Gambier(C)
		Highest impacted commodity sector	Vehicles	Construction	Construction
		Number of supply chains impacted	8	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	17.0	96.2	96.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Princes Highway Vic-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Princes Highway Vic-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.46 South Coast Highway

The South Coast Highway KFR (Figure 64) is a freight route located in WA. It connects LGAs from Albany to Esperance. The corridor is 467 km with at least part of the route used for the transport of $29m of product on 298,000 trailers annually carrying seven million tonnes across 13,996 supply chains spanning 75 commodities (3% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 77,232 trailers annually with the busiest sections carrying 155,683 trailers.

Cropping transport represents approximately 80% of the total freight task with movements from property to silo and on to ports. Wood product movements add 10% with movements to port comprising a large proportion. This route is predominantly classified as PBS3a access.

Figure 64 South Coast Highway KFR

The South Coast Highway KFR passes through four LGAs but crucially it supports the supply chain paths for over 181 LGAs along its length and beyond. It provides access to essential commodities for 30 LGAs. Esperance (S) and Ravensthorpe (S) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Newdegate – Ravensthorpe Road
- Chester Pass Road
- Harbour Road

The reliance described in Table 233 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that for the three intersections, the reliance on the intersections is moderate for the destination LGAs, with the highest percentage of freight traversing the intersection (32%) destined for Esperance (S). In terms of origin LGA, however, Albany (C) is heavily reliant on the Chester Pass Road intersection and Esperance (S) on the Harbour Road intersection, having 82% and 86% respectively of the freight traversing the intersection with these LGAs as origin.

Table 233 Summary of community reliance metrics for each intersection on the South Coast Highway key freight route - most impacted LGA

	CHESTER PASS ROAD	NEWDEGATE – RAVENSTHORPE ROAD	HARBOUR ROAD
Destination LGA most reliant on the intersection	Albany (C)	Dardanup (S)	Esperance (S)
Relative reliance on intersection for destination LGA	0.24	0.17	0.32
Origin LGA most reliant on the intersection	Albany (C)	Esperance (S)	Esperance (S)
Relative reliance on intersection for origin LGA	0.82	0.52	0.86

5.46.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the South Coast Highway. The results are based on expected freight for an average week.

- Chester Pass Road intersection: The closure of the Chester Pass Road intersection results in the disruption of 2,115 vehicle trips carrying 48,455 tonnes, 2% being essential commodities. Overall, 48,395 tonnes of freight are re-routed with an average detour length of 49 km and with an average increase in cost of $9.91 per tonne. A total value of supplies amounting to $0.1 million, none being essential commodities, is unable to reach its destination.
- Newdegate – Ravensthorpe Road intersection: The closure of the Newdegate – Ravensthorpe Road intersection results in the disruption of 2,268 vehicle trips, 55,281 tonnes, 2% being essential commodities. Overall, 55,062 tonnes of freight are re-routed with an average detour length of 26 km and with an average increase in cost of $9.86 per tonne. A total value of supplies amounting to $0.1 million, none being essential commodities, is unable to reach its destination.
- Harbour Road intersection: The closure of the Harbour Road intersection results in the disruption of 1,498 vehicle trips carrying 37,186 tonnes, 3% being essential commodities. Overall, no supply chain is re-routed. All supply chains are unable to reach their destination with a total value of supplies amounting to $47.7 million, $2.1 million being essential commodities.

Metrics relating to the network performance as described in this section were calculated for each of the supply chains traversing each of the three modelled intersections of the South Coast Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'South Coast Highway-intersection-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'South Coast Highway-intersection-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'South Coast Highway-intersection-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'South Coast Highway-intersection-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'South Coast Highway-intersection-tonnes bar plot.png' shows the relative tonnes detoured and 'South Coast Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'South Coast Highway-intersection-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the South Coast Highway.

KFR risk profile

Table 234 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model is able to reach the maximum number of successive high-intensity intersection and alternative route closures of five. The 'South Coast Highway-*intersection*-detoured blocked plot.png' plots provide details on the impacts from the successive closures for each intersection. The risk metrics for all intersections are extremely low for Chester Pass Road and Newdegate – Ravensthorpe Road, indicating that very little volumes of freight are expected to be obstructed from the successive closure of intersections.

Table 234 Risk metrics for modelled intersections on the South Coast Highway KFR

	CHESTER PASS ROAD	NEWDEGATE – RAVENSTHORPE ROAD	HARBOUR ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.002	0.200
KFR impacts risk - detour costs for intersection	0.055	0.026	0.000
Last iteration	5	5	5

Freight impact

Table 235 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 235 Freight impact metrics for modelled intersections on the South Coast Highway KFR by last successive closure

		CHESTER PASS ROAD [%]	NEWDEGATE – RAVENSTHORPE ROAD [%]	HARBOUR ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	100
	Relative freight volume impacted – essential commodities	2	0	100
	Relative value of freight – all commodities	0	0	100
Re-routed supply chains	Relative detour cost – average	47	15	-
	Relative detour cost – maximum	428	1592	-

The metrics in Table 235 indicate the supply chains traversing the Chester Pass Road intersection that are likely to be re-routed will do so with their average cost increasing by 47% across all commodities, with some supply chain paths incurring an increase of up to 428%. Very little volumes of freight that usually traverse the Chester Pass Road intersection are expected to be obstructed by the last successive closure. The volume of these obstructed essential commodities represents 2% of the total volumes usually traversing the intersection.

Similar observations can be made for Newdegate – Ravensthorpe Road intersection, however with cost increases due to detours lower overall but extremely high for some freight.

The Harbour Road intersection however exhibits very different results with all of its freight obstructed by the last iteration.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 236 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Chester Pass Road intersection closure results in one LGA impacted by obstructed essential commodities, being Moyne (S) for which one supply chain for milk will not reach its destination.

For the Newdegate – Ravensthorpe Road intersection, the closure results in no essential commodities impacted, and seven of the 143 LGAs impacted by obstructed commodities representing 0.3% of their local consumption.

For the Harbour Road intersection closure, only three of the 39 LGAs have essential commodities obstructed, however it represents 52% of essential commodities usually consumed within the three LGAs. The most impacted LGA is Esperance (S) where the supply chain for bread will not reach its destination. When considering all commodities, all LGAs are impacted, with 12% of their usual consumption not reaching destination.

Table 236 Community impact metrics for modelled intersections on the South Coast Highway KFR - obstructed supply chains

			CHESTER PASS ROAD	NEWDEGATE – RAVENSTHORPE ROAD	HARBOUR ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/93	0/143	3/39
		Relative volumes impacted	0.3%	0.0%	52.9%
	Most impacted LGA	Name of destination LGA	Moyne(S)	-	Esperance(S)
		Highest impacted commodity sector	Processed Food	-	Processed Food
		Commodity impacted	Milk Raw	-	Bread
		Number of supply chains impacted	1	0	1
		Relative volumes impacted	0%	0%	100%
		Weekly tonnes BAU	6,770.8	0.0	0.7
		Relative number of supply chains impacted	0%	0%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	4/93	7/143	39/39
		Relative volumes impacted	0.1%	0.3%	12.7%
	Most impacted LGA	Name of destination LGA	Plantagenet(S)	Ravensthorpe(S)	Esperance(S)
		Highest impacted commodity sector	Waste	Mining	Wood Product
		Number of supply chains impacted	3	12	2
		Relative volumes impacted	10%	2%	100%
		Weekly tonnes BAU	120.5	830.2	139.9
		Relative number of supply chains impacted	10%	2%	100%

Table 237 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Chester Pass Road intersection closure results in 6.2% of essential commodities (by volume) being re-routed for 13 of the LGAs it services out of 93. The most impacted LGA is Dundas (S), with one of its box lamb supply chains re-routed when considering essential commodities only. When considering all commodities, the cropping commodity sector is the most impacted with nearly all (88%) of its 172 supply chains needed re-routing. Overall, for LGAs that receive freight traversing the Chester Pass Road intersection, the re-routed freight represents 12% of the LGAs' overall consumption.

The Newdegate – Ravensthorpe Road intersection closure results in 2% (essential commodities) and 6% (all commodities) of the volumes being re-routed to 16 out of 143 LGAs. The most impacted LGA is the Esperance (S) LGA where five supply chains of box rice are re-routed when considering essential commodities only; when considering all commodities, 15 of its horticulture supply chains are re-routed.

Table 237 Community impact metrics for modelled intersections on the South Coast Highway KFR - re-routed supply chains

			CHESTER PASS ROAD	NEWDEGATE – RAVENSTHORPE ROAD	HARBOUR ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	13/93	16/143	0/39
		Relative impact on volumes of commodities	6.2%	2.0%	0.0%
	Most impacted LGA	Name	Dundas(S)	Esperance(S)	
		Highest impacted commodity sector	Processed Food	Processed Food	
		Commodity impacted	Box Lamb	Box Rice	
		Number of supply chains impacted	1	5	
		Relative volumes impacted	100%	100%	0%
		Weekly tonnes BAU	1.1	3.0	0.0
		Relative number of supply chains impacted	100%	100%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	91/93	142/143	0/39
		Relative impact on volumes of commodities	12.2%	6.1%	0.0%
	Most impacted LGA	Name	Albany(C)	Esperance(S)	
		Highest impacted commodity sector	Cropping	Horticulture	
		Number of supply chains impacted	172	15	
		Relative volumes impacted	86%	100%	0%
		Weekly tonnes BAU	41,678.3	24.8	0.0
		Relative number of supply chains impacted	29%	100%	0%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material.

- ‘South Coast Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘South Coast Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.47 South Western Highway

The South Western Highway KFR (Figure 65) is a freight route located in WA. It connects LGAs from Perth to Manjimup in the southwest. The corridor is 300 km with at least part of the route used for the transport of $98m of product on 423,280 trailers annually carrying 8.8 million tonnes across 41,205 supply chains spanning 82 commodities (18% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 31,801 trailers annually with the busiest sections carrying 98,602 trailers.

Wood product transport represents approximately 30% of the total freight task with movements from property to ports. Cropping movements add 20% with movements from silo to port comprising a large proportion. Mining and fuel add a further 10% each to the freight task. This route is predominantly classified as PBS2a (27.5m B-Double) access.

Figure 65 South Western Highway KFR

The South Western Highway KFR passes through 11 LGAs but crucially it supports the supply chain paths for over 194 LGAs along its length and beyond. It provides access to essential commodities for 74 LGAs. Busselton (C), Dardanup (S), Bunbury (C) and Bridgetown-Greenbushes (S) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 50% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Albany Highway
- Thomas Road

- Martin Pelusey Road

The reliance described in Table 238 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the Dardanup (S) LGA is moderately reliant on the Martin Pelusey Road intersection, while the Serpentine-Jarrahdale (S) LGA is little to moderately reliant on the Albany Highway and Thomas Road intersections as a destination LGA.

Table 238 Summary of community reliance metrics for each intersection on the South Western Highway key freight route - most impacted LGA

	ALBANY HIGHWAY	THOMAS ROAD	MARTIN PELUSEY ROAD
Destination LGA most reliant on the intersection	Serpentine-Jarrahdale (S)	Serpentine-Jarrahdale (S)	Dardanup (S)
Relative reliance on intersection for destination LGA	0.20	0.13	0.29
Origin LGA most reliant on the intersection	Kwinana (C)	Kwinana (C)	Bunbury (C)
Relative reliance on intersection for origin LGA	0.41	0.59	0.29

5.47.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the South Western Highway. The results are based on expected freight for an average week.

- **Albany Highway intersection**: The closure of the Albany Highway intersection results in the disruption of 722 vehicle trips carrying 17,008 tonnes, 5% being essential commodities. Overall, 17,008 tonnes of freight are re-routed with an average detour length of four km and with an average increase in cost of $2.69 per tonne. No freight is unable to reach its destination.
- **Thomas Road intersection**: The closure of the Thomas Road intersection results in the disruption of 1,678 vehicle trips carrying 39,464 tonnes, 12% being essential commodities. Overall, 39,103 tonnes of freight are re-routed with an average detour length of five km and with an average increase in cost of $3.16 per tonne. A total value of supplies amounting to $0.3 million, $0.3 million being essential commodities, is unable to reach its destination.
- **Martin Pelusey Road intersection**: The closure of the Martin Pelusey Road intersection results in the disruption of 1,896 vehicle trips carrying 40,219 tonnes, 15% being essential commodities. Overall, 40,192 tonnes of freight are re-routed with an average detour length of six km and with an average increase in cost of $4.25 per tonne. No freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of South Western Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'South Western Highway-*intersection*-monthly bau volumes.png' shows the BAU freight (monthly volumes) using the specific intersection
- 'South Western Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed
- 'South Western Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'South Western Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed
- 'South Western Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'South Western Highway-cost bar plot.png' shows the cost impacts of re-routing
- 'South Western Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for South Western Highway.

KFR risk profile

Table 239 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three intersections, the model was able to reach the maximum number of successive closures of five. The 'South Western Highway-*intersection*-cumulative impact.png' plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for all intersections for the obstructed volumes are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closure of intersections. Similarly, the impacts risk for the detour costs is also low, indicating that freight is re-routed at a low cost.

Table 239 Risk metrics for modelled intersections on South Western Highway KFR – the model

	ALBANY HIGHWAY	THOMAS ROAD	MARTIN PELUSEY ROAD
KFR impacts risk - obstructed volumes for intersection	0.000	0.002	0.000
KFR impacts risk - detour costs for intersection	0.033	0.027	0.038
Last iteration	5	5	5

Freight impact

Table 240 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 240 Freight impact metrics for modelled intersections on South Western Highway KFR

		ALBANY HIGHWAY [%]	THOMAS ROAD [%]	MARTIN PELUSEY ROAD [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	1	0
	Relative freight volume impacted – essential commodities	0	7	0
	Relative value of freight – all commodities	0	1	0
Re-routed supply chains	Relative detour cost – average	17	15	17
	Relative detour cost – maximum	129	80	176

The metrics in Table 240 indicate the supply chains traversing the three intersections that are likely to be re-routed will do so with their average cost increasing little. The average annual cost increase is 17% for the Albany Highway and Martin Pelusey Road intersections, and 15% for the Thomas Road intersection over all commodities. The routes most impacted by detours reach a maximum increase cost of 176% (Martin Pelusey Road intersection).

For all three intersections, the obstructed freight is minimal[17].

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 241 provides a summary of the obstructed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Albany Highway closure results in no LGAs having obstructed supply chains, for both essential commodities and non-essential commodities.

The Thomas Road intersection closure results in two LGAs having obstructed supply chains for essential commodities, representing 8.2% of the volumes that are normally received by these LGAs serviced by the intersection. When considering all commodities, the closure of the Thomas Road intersection results in five LGAs having obstructed supply chains, representing 2.2% of the volumes that are normally received by these LGAs serviced by the intersection.

The Martin Pelusey Road intersection closure results in one LGA serviced by the intersection having obstructed supply chains for essential commodities. When considering all commodities, the closure of the Martin Pelusey Road intersection results in two LGAs having obstructed supply chains, representing 1.9% of the volumes that are normally received by this LGA. Manjimup (S) is the most impacted LGA with one supply chain for the processed food industry obstructed.

[17] Percentages given in the table are rounded to the closest integer. While showing values of 0%, some of the freight may still be obstructed.

Table 241 Community impact metrics for modelled intersections on South Western Highway KFR - obstructed supply chains

			ALBANY HIGHWAY	THOMAS ROAD	MARTIN PELUSEY ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/79	2/108	1/89
		Relative volumes impacted	0.0%	8.2%	2.7%
	Most impacted LGA	Name of destination LGA	-	Jerramungup(S)	Manjimup(S)
		Highest impacted commodity sector	-	Fuel	Processed Food
		Commodity impacted	-	Diesel fuel	Milk Raw
		Number of supply chains impacted	0	1	1
		Relative volumes impacted	0%	28%	3%
		Weekly tonnes BAU	0.0	182.5	768.5
		Relative number of supply chains impacted	0%	25%	3%
All commodities	All impacted LGAs	Number of LGAs impacted	0/79	5/108	2/89
		Relative volumes impacted	0.0%	2.2%	1.9%
	Most impacted LGA	Name of destination LGA	-	Jerramungup(S)	Manjimup(S)
		Highest impacted commodity sector	-	Fuel	Processed Food
		Number of supply chains impacted	0	2	1
		Relative volumes impacted	0%	25%	2%
		Weekly tonnes BAU	0.0	492.5	870.0
		Relative number of supply chains impacted	0%	17%	1%

Re-routed supply chains

Table 242 provides a summary of the re-routed supply chains including the number of impacted LGAs, along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 5.9% of the supply chains are expected to be re-routed for 23 of the 79 LGAs that traverse the Albany Highway intersection. The most impacted LGA is Ashburton (S), with one supply chain in the processed food sector representing 2.9 tonnes of bread per week re-routed. For non-essential commodities, all of the 79 LGAs serviced by the Albany Highway intersection are impacted by re-routed freight, representing 5% of the total volumes consumed within these LGAs.

For the Thomas Road intersection, 54 of the 108 LGAs serviced are expected to have freight re-routed, with this representing 19% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all of the 108 LGAs serviced by the Thomas Road intersection are impacted by re-routed freight, representing 8.3% of the total volume consumed within these LGAs.

For the Martin Pelusey Road intersection, 26 of the 89 LGAs serviced are expected to have freight re-routed, representing nearly 16% of essential commodities consumed within the LGAs. For non-essential commodities, 88 of the 89 LGAs serviced by the Martin Pelusey Road intersection are impacted by re-routed freight, representing nearly 10% of the total volume consumed within these LGAs.

Table 242 Community impact metrics for modelled intersections on South Western Highway KFR - re-routed supply chains

			ALBANY HIGHWAY	THOMAS ROAD	MARTIN PELUSEY ROAD
Essential commodities	All impacted LGAs	Number of LGAs impacted	23/79	54/108	26/89
		Relative impact on volumes of commodities	5.9%	19.0%	15.8%
	Most impacted LGA	Name	Ashburton(S)	Albany(C)	Donnybrook-Balingup(S)
		Highest impacted commodity sector	Processed Food	Fuel	Processed Food
		Commodity impacted	Bread	LPG	Processed Food
		Number of supply chains impacted	1	11	4
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	2.9	15.7	1.1
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	79/79	108/108	88/89
		Relative impact on volumes of commodities	5.0%	8.3%	9.9%
	Most impacted LGA	Name	Port Hedland (T)	Port Hedland (T)	Bassendean(T)
		Highest impacted commodity sector	Cropping	Cropping	Wood Product
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	3.8	3.8	38.3
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘South Western Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘South Western Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.48 Stuart Highway

The Stuart Highway KFR (Figure 66) is a freight route that extends between Port Augusta in SA and Darwin in NT via Alice Springs. The corridor is 2781 km with at least part of the route used for the transport of $58m of product on 166,326 trailers annually carrying 3.4 million tonnes across 11,485 supply chains spanning 96 commodities (42% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 29,808 trailers annually with the busiest sections carrying 71,366 trailers.

Fuel transport represents approximately 32% of the total freight task. Mining and livestock add a further 20% each. The route provides a critical north – south route with 40% of movements originating at a property or port, and 20% destined to a port. This route is predominantly classified as PBS4a access.

Figure 66 Stuart Highway KFR

The Stuart Highway KFR passes through 16 LGAs but crucially it supports the supply chain paths for over 283 LGAs along its length and beyond. It provides access to essential commodities for 67 LGAs. Barkly (R), Litchfield (M), Darwin (C) and Katherine (T) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 60% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Eyre Highway
- Buchanan Highway

- Victoria Highway

The reliance described in Table 243 equates to risk factor and highlights the importance - and relative susceptibility - of each of these three intersections for this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections studied to low to moderate degrees, with 16% (Buchanan Highway intersection), 33% (Victoria Highway intersection) and 15% (Eyre Highway intersection) of all the supply chain paths traversing the intersections.

Table 243 Summary of community reliance metrics for each intersection on the Stuart Highway key freight route - most impacted LGA

	BUCHANAN HIGHWAY	VICTORIA HIGHWAY	EYRE HIGHWAY
Destination LGA most reliant on the intersection	Darwin (C)	Unincorporated NT	Darwin (C)
Relative reliance on intersection for destination LGA	0.16	0.33	0.15
Origin LGA most reliant on the intersection	Litchfield (M)	Roper Gulf (R)	Unincorporated SA
Relative reliance on intersection for origin LGA	0.14	0.22	0.12

5.48.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Stuart Highway. The results are based on expected freight for an average week.

- **Buchanan Highway intersection**: The closure of the Buchanan Highway intersection results in the disruption of 929 vehicle trips carrying 17,526 tonnes, 22% being essential commodities. Overall, 17,493 tonnes of freight are re-routed with an average detour length of 4,026 km and with an average increase in cost of $515.76 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Victoria Highway intersection**: The closure of the Victoria Highway intersection results in the disruption of 1,134 vehicle trips carrying 23,103 tonnes, 38% being essential commodities. Overall, 22 tonnes of freight are re-routed with an average detour length of 239 km and with an average increase in cost of $93.80 per tonne. A total value of supplies amounting to $107.5 million, $25.9 million being essential commodities, is unable to reach its destination.
- **Eyre Highway intersection**: The closure of the Eyre Highway intersection results in the disruption of 737 vehicle trips carrying 15,656 tonnes, 52% being essential commodities. Overall, 15,560 tonnes of freight are re-routed with an average detour length of 26 km and with an average increase in cost of $7.17 per tonne. A total value of supplies amounting to $0.2 million, $0.2 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Stuart Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Stuart Highway-intersection-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection.
- ‘Stuart Highway-intersection-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed.
- ‘Stuart Highway-intersection-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Stuart Highway-intersection-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed.
- ‘Stuart Highway-intersection-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Stuart Highway-cost_bar_plot.png’ shows the cost impacts of re-routing.
- ‘Stuart Highway-intersection-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Stuart Highway.

KFR risk profile

Table 244 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for the three KFR intersections, the model is able to reach the maximum number of successive high-intensity alternative route closures of five, however their risk profile is different depending on the intersection.

The ‘Stuart Highway-*intersection*-detoured blocked plot.png’ plots provide details on the impacts from the successive closures for each intersection.

The risk metrics for the obstructed volumes for the Buchanan Highway and the Eyre Highway intersections are very low, indicating that very little to no volumes of freight are expected to be obstructed from the successive closures. The Victoria Highway intersection successive closures result in nearly all its freight obstructed by the fourth iteration. Until the third iteration, the majority of freight can still be re-routed, though at a high re-routing cost.

The risk metrics for the detour costs for the Eyre Highway intersections while low, are not negligible, indicating that there are some detours that might be costly. The risk metrics for the detour costs for the Buchanan Highway and the Victoria Highway intersections are quite high.

Table 244 Risk metrics for modelled intersections on the Stuart Highway KFR

	BUCHANAN HIGHWAY	VICTORIA HIGHWAY	EYRE HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.001	0.255	0.002
KFR impacts risk - detour costs for intersection	0.328	0.369	0.009
Last iteration	5	5	5

Freight impact

Table 245 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 245 Freight impact metrics for modelled intersections on the Stuart Highway KFR by last successive closure

		BUCHANAN HIGHWAY [%]	VICTORIA HIGHWAY [%]	EYRE HIGHWAY
Obstructed supply chains	Relative freight volume impacted – all commodities	0	100	1
	Relative freight volume impacted – essential commodities	0	100	1
	Relative value of freight – all commodities	0	100	0
Re-routed supply chains	Relative detour cost – average	229	812	5
	Relative detour cost – maximum	4,997	2,558	372

The metrics in Table 245 indicate that the Victoria Highway intersection has nearly all of its freight obstructed for both essential and all commodities. For the little freight that is able to be re-routed, this is done at very high-cost increase (812%) on average, and extremely high for some of the supply chains.

The supply chains traversing the Buchanan Highway intersection that are likely to be re-routed will do so with a high average cost increase of 229%, however some supply chains are expected to reach up to a 5000% increase. Little freight that usually traverses the Buchanan Highway intersection is expected to be obstructed by the last successive closure.

The supply chains traversing the Eyre Highway intersection that are likely to be re-routed will do so with a low average cost increase of 5%, however cost increase for some supply chains is expected to increase up to 372%. Little freight that usually traverses the Buchanan Highway intersection is expected to be obstructed by the last successive closure

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 246 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Buchanan Highway intersection closure results in one out of 85 LGAs with obstructed essential commodities, representing nearly 43% of all essential commodities consumed in the impacted LGAs. For non-essential commodities, four out of the 85 LGAs serviced by the intersection have some of their freight obstructed, representing 1.1% of their overall consumption.

The Eyre Highway intersection closure results in one out of 118 LGAs with obstructed essential commodities, representing 3% of all essential commodities consumed in the impacted LGAs. For non-essential commodities, one out of the 118 LGAs serviced by the intersection has some of its freight obstructed, representing 2.9% of the LGAs' overall consumption.

The Victoria Highway intersection closure results in 36 out of 91 LGAs with obstructed essential commodities, representing nearly 37% of all essential commodities consumed in the impacted LGAs.

For non-essential commodities, 90 out of 91 LGAs serviced by the intersection are expected to have some of their freight obstructed, representing 5.8% of their overall consumption.

Table 246 Community impact metrics for modelled intersections on the Stuart Highway KFR - obstructed supply chains

			BUCHANAN HIGHWAY	VICTORIA HIGHWAY	EYRE HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/85	36/91	1/118
		Relative volumes impacted	42.9%	36.8%	3.0%
	Most impacted LGA	Name of destination LGA	Central Desert(R)	Barkly(R)	Port Augusta(C)
		Highest impacted commodity sector	Construction	Processed Food	Fuel
		Commodity impacted	Concrete	Seafood	Unleaded fuel
		Number of supply chains impacted	1	6	1
		Relative volumes impacted	43%	100%	6%
		Weekly tonnes BAU	28.6	2.1	1,329.9
		Relative number of supply chains impacted	20%	100%	8%
All commodities	All impacted LGAs	Number of LGAs impacted	4/85	90/91	1/118
		Relative volumes impacted	1.1%	5.8%	2.9%
	Most impacted LGA	Name of destination LGA	Central Desert (R)	Barkly (R)	Port Augusta (C)
		Highest impacted commodity sector	Construction	Horticulture	Fuel
		Number of supply chains impacted	4	18	2
		Relative volumes impacted	43%	100%	3%
		Weekly tonnes BAU	55.6	24.8	3,343.9
		Relative number of supply chains impacted	33%	100%	5%

Re-routed supply chains

Table 247 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

Because most freight is obstructed for the Victoria Highway intersection, very little freight is re-routed, none being essential commodities.

For the Buchanan Highway intersection closure, 33 LGAs are expected to be impacted by re-routed freight of essential commodities, while 84 out of 85 LGAs relying on the intersection have detours for their non-essential commodities; however, the detoured freight represents only 5% of all the goods consumed within these LGAs. Similar results are observed for the Eyre Highway intersection closure.

Table 247 Community impact metrics for modelled intersections on the Stuart Highway KFR - re-routed supply chains

			BUCHANAN HIGHWAY	VICTORIA HIGHWAY	EYRE HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	33/85	0/91	36/118
		Relative impact on volumes of commodities	24.6%	0.0%	28.4%
	Most impacted LGA	Name	Barkly (R)	-	MacDonnell (R)
		Highest impacted commodity sector	Processed Food	-	Processed Food
		Commodity impacted	Seafood	-	Box Pigs
		Number of supply chains impacted	6	0	3
		Relative volumes impacted	100%	0%	100%
		Weekly tonnes BAU	2.1	0.0	0.3
		Relative number of supply chains impacted	100%	0%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	84/85	4/91	117/118
		Relative impact on volumes of commodities	4.6%	0.7%	6.0%
	Most impacted LGA	Name	Barkly (R)	Katherine (T)	Coober Pedy (DC)
		Highest impacted commodity sector	Horticulture	Waste	Processed Food
		Number of supply chains impacted	18	3	8
		Relative volumes impacted	100%	9%	100%
		Weekly tonnes BAU	24.8	132.9	3.6
		Relative number of supply chains impacted	100%	9%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Stuart Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Stuart Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.49 Sturt Highway

The Sturt Highway KFR (Figure 66) is a freight route located in southwest NSW extending into SA. It connects Hume Highway in NSW to Gawler in SA. It is a 1000 km corridor where at least part of the route is used in the movement of $287m worth of product on 898,640 trailers annually carrying 17 million tonnes capturing 61,423 supply chains spanning 123 commodities with 17% of the total volume on the KFR is classified as essential commodities. The average freight volume across the road segments is 154,064 trailers annually with the busiest sections carrying 312,764 trailers.

General Freight moving between ports, DCs and retail contributes 33% to the freight task for the corridor with fuel from port to depots adding a further 25% and wood product contributing 15%. This route is classified PBS2a/HML access with parts HML A-Double access in NSW and PBS3a/HML access in SA.

Figure 67 Sturt Highway KFR

The Sturt Highway KFR passes through 17 LGAs but crucially it supports the supply chain paths for over 445 LGAs along its length and beyond. It provides access to essential commodities for 224 LGAs. Many LGAs including Light (RegC), Loxton Waikerie (DC) and Wagga Wagga (C) are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel and general freight. Modelling indicates that the route is used heavily by supply chains with trips using the KFR for up to 80% of the supply chain trip length. General freight and vehicles utilise large sections of the KFR. Figure 66 shows that there is a relatively consistent freight flow along the length of the Sturt Highway.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Goyder Highway
- Newell Highway
- Hume Highway

The reliance described in Table 248 equates to a risk factor and highlights the importance - and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to moderate to high degrees, with 43% (Hume Highway), 39% (Newell Highway) and 30% (Goyder Highway) of all the supply chain paths traversing the intersections destined for the Blacktown (C) and the Port Adelaide Enfield (C) LGAs.

Table 248 Summary of community reliance metrics for each intersection on the Sturt Highway key freight route - most impacted LGA

	HUME HIGHWAY	NEWELL HIGHWAY	GOYDER HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Blacktown (C)	Port Adelaide Enfield (C)
Relative reliance on intersection for destination LGA	0.43	0.39	0.30
Origin LGA most reliant on the intersection	Swan Hill (RC)	Swan Hill (RC)	Loxton Waikerie (DC)
Relative reliance on intersection for origin LGA	0.08	0.08	0.11

5.49.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Sturt Highway. The results are based on expected freight for an average week.

- **Hume Highway intersection**: The closure of the Hume Highway intersection results in the disruption of 3,044 vehicle trips carrying 51,241 tonnes, 22% being essential commodities. Overall, 51,213 tonnes of freight are re-routed with an average detour length of six km and with an average increase in cost of $4.77 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Newell Highway intersection**: The closure of the Newell Highway intersection results in the disruption of 2,988 vehicle trips carrying 51,673 tonnes, 21% being essential commodities. Overall, 51,320 tonnes of freight are re-routed with an average detour length of 11 km and with an average increase in cost of $5.13 per tonne. A total value of supplies amounting to $0.2 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Goyder Highway intersection**: The closure of the Goyder Highway intersection results in the disruption of 3,355 vehicle trips carrying 53,698 tonnes, 16% being essential commodities. Overall, 53,698 tonnes of freight are re-routed with an average detour length of six km and with an average increase in cost of $4.43 per tonne. A total value of supplies amounting to $0.0 million, $0.0 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Sturt Highway NSW and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- ‘Sturt Highway-*intersection*-monthly BAU volumes.png’ shows the BAU freight (monthly volumes) using the specific intersection.
- ‘Sturt Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed.
- ‘Sturt Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Sturt Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed.
- ‘Sturt Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Sturt Highway-cost bar plot.png’ shows the cost impacts of re-routing.
- ‘Sturt Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Sturt Highway.

KFR risk profile

Table 249 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, and also low values for the re-routed costs indicating that freight is expected to be re-routed at low costs.

Table 249 Risk metrics for modelled intersections on the Sturt Highway KFR

	HUME HIGHWAY	NEWELL HIGHWAY	GOYDER HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.000	0.002	0.000
KFR impacts risk - detour costs for intersection	0.004	0.007	0.005
Last iteration	5	5	5

Freight impact

Table 250 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 250 Freight impact metrics for modelled intersections on the Sturt Highway KFR by last successive closure

		HUME HIGHWAY [%]	NEWELL HIGHWAY [%]	GOYDER HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	1	0
	Relative freight volume impacted – essential commodities	0	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	4	6	3
	Relative detour cost – maximum	67	727	94

The metrics in Table 250 indicate the supply chains traversing the Hume Highway intersection that are likely to be re-routed would do so with their average cost increasing by 4% across all commodities, with cost for some supply chain paths increasing up to 67%. Those traversing the Newell Highway intersection are expected to be re-routed at an average cost increasing of 6% across all commodities, however some supply chain paths reach an increase of up to 727%. Those traversing the Goyder Highway intersection may do so at an average cost increasing by 3%.

Little to no freight is obstructed for the three intersection closures.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 251 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The closure of any of the three intersections results in no LGA not receiving essential commodities.

When considering all commodities, the Hume Highway intersection results in seven LGAs not receiving commodities, representing less than 1% of these LGAs’ consumption where the most impacted LGA is Shoalhaven (C) for cropping.

When considering all commodities, the Newell Highway intersection results in six out of 262 LGAs not receiving commodities, representing less than 1% of these LGAs’ consumption where the most impacted LGA is Coolamon (A) for cropping.

When considering all commodities, the Goyder Highway intersection results in no LGA not receiving commodities.

Table 251 Community impact metrics for modelled intersections on the Sturt Highway KFR - obstructed supply chains

			HUME HIGHWAY	NEWELL HIGHWAY	GOYDER HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/195	0/262	0/240
		Relative volumes impacted	0.0%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	-	-	-
		Highest impacted commodity sector	-	-	-
		Commodity impacted	-	-	-
		Number of supply chains impacted	0	0	0
		Relative volumes impacted	0%	0%	0%
		Weekly tonnes BAU	0.0	0.0	0.0
		Relative number of supply chains impacted	0%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	7/195	6/262	0/242
		Relative volumes impacted	0.2%	0.7%	0.0%
	Most impacted LGA	Name of destination LGA	Shoalhaven(C)	Coolamon(A)	-
		Highest impacted commodity sector	Cropping	Cropping	-
		Number of supply chains impacted	1	29	0
		Relative volumes impacted	2%	2%	0%
		Weekly tonnes BAU	594.7	14,327.8	0.0
		Relative number of supply chains impacted	1%	3%	0%

Re-routed supply chains

Table 252 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 11% of the supply chains are expected to be re-routed for 47 of the 195 LGAs that traverse the Hume Highway intersection. The most impacted LGA is Balranald (A), with two supply chains in the processed food sector representing 3.3 tonnes of box chicken per week re-routed. For non-essential commodities, 192 of the 195 LGAs serviced by the Hume Highway intersection are impacted by re-routed freight, representing 5.3% of the total volumes consumed within these LGAs.

For the Newell Highway intersection, 115 of the 263 LGAs serviced are expected to have freight re-routed, with this representing 13.7% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 260 out of 262 LGAs serviced by the Newell Highway intersection are impacted by re-routed freight, representing 3.2% of the total volume consumed within these LGAs.

For the Goyder Highway intersection, 73 of the 240 LGAs serviced are expected to have freight re-routed, representing 13.1% of essential commodities consumed within the LGAs. For non-essential commodities, 238 of the 240 LGAs serviced by the Goyder Highway intersection are impacted by re-routed freight, representing 3.9% of the total volume consumed within these LGAs.

Table 252 Community impact metrics for modelled intersections on the Sturt Highway KFR - re-routed supply chains

			HUME HIGHWAY	NEWELL HIGHWAY	GOYDER HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	47/195	115/262	73/240
		Relative impact on volumes of commodities	11.0%	13.7%	13.1%
	Most impacted LGA	Name	Balranald(A)	MacDonnell(R)	Alice Springs(T)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Chicken	Bread	Bread
		Number of supply chains impacted	2	8	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	3.3	2.2	15.0
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	192/195	260/262	238/240
		Relative impact on volumes of commodities	5.3%	3.2%	3.9%
	Most impacted LGA	Name	Gawler(T)	Gawler(T)	Alice Springs(T)
		Highest impacted commodity sector	Vehicles	Vehicles	Cropping
		Number of supply chains impacted	1	1	7
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	7.5	7.5	16.6
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Sturt Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Sturt Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.50 Victoria Highway

The Victoria Highway KFR (Figure 68) is a freight route located in the NT. It connects LGAs from the Great Northern Highway west of Kununurra in WA to the Stuart Highway at Katherine in the NT. The corridor is 555 km with at least part of the route used for the transport of $12m of product on 23,198 trailers annually carrying 437,528 tonnes across 2,223 supply chains spanning 58 commodities (31% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 16,736 trailers annually with the busiest sections carrying 42,864 trailers.

Livestock transport represents approximately 25% of the total freight task with the majority being movements from property to property or to export depot. Construction adds a further 20% and fuel and general freight add 15% each to the total freight task. This route is predominantly classified as PBS4a access.

Figure 68 Victoria Highway KFR

The Victoria Highway KFR passes through three LGAs but crucially it supports the supply chain paths for over 113 LGAs along its length and beyond. It provides access to essential commodities for 20 LGAs. The Wyndham-East Kimberly (S) LGA is reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, general freight and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 90% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Great Northern Highway

- Buchanan Highway
- Gorrie Dry River Road

The reliance described in Table 253 equates to a risk factor and highlights the importance - and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 9% (Buchanan Highway), 12% (Gorrie Dry River Road) and 14% (Great Northern Highway) of all the supply chain paths traversing the intersections destined for the Victoria Daly (R) and the Cockburn (C) LGAs.

Table 253 Summary of community reliance metrics for each intersection on the Victoria Highway key freight route - most impacted LGA

	BUCHANAN HIGHWAY	GORRIE DRY RIVER ROAD	GREAT NORTHERN HIGHWAY
Destination LGA most reliant on the intersection	Victoria Daly (R)	Victoria Daly (R)	Cockburn (C)
Relative reliance on intersection for destination LGA	0.09	0.12	0.14
Origin LGA most reliant on the intersection	Wyndham-East Kimberley (S)	Wyndham-East Kimberley (S)	Darwin (C)
Relative reliance on intersection for origin LGA	0.39	0.32	0.15

5.50.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Victoria Highway. The results are based on expected freight for an average week.

- **Buchanan Highway intersection**: The closure of the Buchanan Highway intersection results in the disruption of 294 vehicle trips carrying 5,778 tonnes, 34% being essential commodities. Overall, 5,621 tonnes of freight are re-routed with an average detour length of 927 km and with an average increase in cost of $139.08 per tonne. Little freight is unable to reach its destination.
- **Gorrie Dry River Road intersection**: The closure of the Gorrie Dry River Road intersection results in the disruption of 332 vehicle trips carrying 6,538 tonnes, 34% being essential commodities. Overall, 5,943 tonnes of freight are re-routed with an average detour length of 3,746 km and with an average increase in cost of $454.37 per tonne. A total value of supplies amounting to $3.2 million, $0.1 million being essential commodities, is unable to reach its destination.
- **Great Northern Highway intersection**: The closure of the Great Northern Highway intersection results in the disruption of 174 vehicle trips carrying 3,143 tonnes, 37% being essential commodities. Overall, 2,652 tonnes of freight are re-routed with an average detour length of 1,809 km and with an average increase in cost of $177.77 per tonne. A total value of supplies amounting to $2.2 million, $0.4 million being essential commodities, is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Victoria Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Victoria Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Victoria Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Victoria Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Victoria Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Victoria Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Victoria Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Victoria Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Victoria Highway.

KFR risk profile

Table 254 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight might be re-routed at non-negligible costs.

Table 254 Risk metrics for modelled intersections on the Victoria Highway KFR

	BUCHANAN HIGHWAY	GORRIE DRY RIVER ROAD	GREAT NORTHERN HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.014	0.035	0.063
KFR impacts risk - detour costs for intersection	0.096	0.330	0.105
Last iteration	5	5	5

Freight impact

Table 255 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 255 Freight impact metrics for modelled intersections on the Victoria Highway KFR by last successive closure

		BUCHANAN HIGHWAY [%]	GORRIE DRY RIVER ROAD [%]	GREAT NORTHERN HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	3	9	16
	Relative freight volume impacted – essential commodities	0	3	21
	Relative value of freight – all commodities	0	13	13
Re-routed supply chains	Relative detour cost – average	124	366	107
	Relative detour cost – maximum	1,343	2,324	1,147

The metrics in Table 255 indicate the supply chains traversing the Buchanan Highway intersection that are likely to be re-routed would do so with their average cost increasing by 124% across all commodities, with some supply chain paths incurring an increase of up to 1,343%. Those traversing the Gorrie Dry River Road intersection may be re-routed at an average cost increasing by 366% across all commodities, while those traversing the Great Northern Highway intersection may do so at an average cost increasing by 1077%.

Very little freight is obstructed - 1% of freight volumes for all commodities for the Buchanan Highway intersection; however a greater percentage of freight is obstructed from the closure of the other two intersections.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 256 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Buchanan Highway intersection closure results in no LGAs impacted by obstructed essential commodities. When considering all commodities, one LGA is expected to not receive supplies, representing 9.2% of the LGA's consumption.

The Gorrie Dry River Road intersection results in one LGA (Victoria Daly (R)) not receiving essential commodities, which represents 33% of the LGA's essential commodities consumption. When considering all commodities, 24 out of the 82 LGAs serviced by the intersection have freight obstructed, representing 3.1% of the LGAs' overall consumption.

The Great Northern Highway results in two LGAs not receiving essential commodities, representing 43% of the LGAs' consumption where the most impacted LGA is Halls Creek (S) for box beef. When considering all commodities, 19 out of the 48 LGAs serviced by the intersection have freight obstructed, representing 1.5% of the LGAs' overall consumption.

Table 256 Community impact metrics for modelled intersections on the Victoria Highway KFR - obstructed supply chains

			BUCHANAN HIGHWAY	GORRIE DRY RIVER ROAD	GREAT NORTHERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	0/81	1/82	2/48
		Relative volumes impacted	0.0%	33.3%	43.1%
	Most impacted LGA	Name of destination LGA	-	Victoria Daly (R)	Halls Creek(S)
		Highest impacted commodity sector	-	Fuel	Processed Food
		Commodity impacted	-	Unleaded fuel	Box Beef
		Number of supply chains impacted	0	1	1
		Relative volumes impacted	0%	40%	100%
		Weekly tonnes BAU	0.0	122.9	0.6
		Relative number of supply chains impacted	0%	33%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	1/81	24/82	19/48
		Relative volumes impacted	9.2%	3.1%	1.5%
	Most impacted LGA	Name of destination LGA	Victoria Daly (R)	Victoria Daly (R)	Halls Creek(S)
		Highest impacted commodity sector	Construction	Fuel	Cropping
		Number of supply chains impacted	14	2	1
		Relative volumes impacted	21%	33%	100%
		Weekly tonnes BAU	734.9	221.6	0.3
		Relative number of supply chains impacted	33%	25%	100%

Re-routed supply chains

Table 257 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 20% of the supply chains are expected to be re-routed for 17 of the 81 LGAs that traverse the Buchanan Highway intersection. The most impacted LGA is Ashburton (S), with three supply chains in the processed food sector representing 2.6 tonnes of box beef per week re-routed. For non-essential commodities, 80 of the 81 LGAs serviced by the Buchanan Highway intersection are impacted by re-routed freight, representing 2.6% of the total volumes consumed within these LGAs.

For the Gorrie Dry River Road intersection, 17 of the 82 LGAs serviced are expected to have freight re-routed, with this representing 21% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 80 of the 82 LGAs serviced by the Gorrie Dry River Road intersection are impacted by re-routed freight, representing 2.7% of the total volume consumed within these LGAs.

For the Great Northern Highway intersection, 14 of the 48 LGAs serviced are expected to have freight re-routed, representing 12.3% of essential commodities consumed within the LGAs. For non-essential commodities, 43 of the 48 LGAs serviced by the Great Northern Highway intersection are impacted by re-routed freight, representing less 2.7% of the total volume consumed within these LGAs.

Table 257 Community impact metrics for modelled intersections on the Victoria Highway KFR - re-routed supply chains

			BUCHANAN HIGHWAY	GORRIE DRY RIVER ROAD	GREAT NORTHERN HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	17/81	17/82	14/48
		Relative impact on volumes of commodities	20.1%	21.0%	12.3%
	Most impacted LGA	Name	Ashburton(S)	Ashburton(S)	Ashburton(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Beef	Box Beef	Box Beef
		Number of supply chains impacted	3	3	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	2.6	2.6	2.6
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	80/81	80/82	43/48
		Relative impact on volumes of commodities	2.6%	2.7%	2.7%
	Most impacted LGA	Name	Halls Creek(S)	Halls Creek(S)	Exmouth(S)
		Highest impacted commodity sector	Cropping	Cropping	General
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	100%	100%	88%
		Weekly tonnes BAU	0.3	0.3	21.7
		Relative number of supply chains impacted	100%	100%	20%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- ‘Victoria Highway-*intersection*-percent obstructed lga.png’ shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- ‘Victoria Highway-*intersection*-percent re-routed lga.png’ shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.51 Warrego Highway

The Warrego Highway KFR (Figure 69) is a freight route that is located in southern Queensland. It connects LGAs from the Landsborough Highway at Morven in the southwest to Ipswich in the south-east. The corridor is 754 km with at least part of the route used for the transport of $269m of product on 768,258 trailers annually carrying 15 million tonnes across 55,916 supply chains spanning 126 commodities (35% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 93,938 trailers annually with the busiest sections carrying 259,188 trailers.

Cropping transport represents approximately 20% of the total freight task with fuel and livestock adding 15% each. Construction, processed food, horticulture and general freight add 10% each to the total freight task. This route is classified as PBS4a access in the western sections from Morven to Roma, with PBS3a access across the eastern sections.

Figure 69 Warrego Highway KFR

The Warrego Highway KFR passes through seven LGAs but crucially it supports the supply chain paths for over 405 LGAs along its length and beyond. It provides access to essential commodities for 137 LGAs. Toowoomba (R), Maranoa (R) and the Lockyer Valley (R) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, general freight and livestock. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 50% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Landsborough Highway

- Leichhardt Highway
- Gore Highway

The reliance described in Table 258 equates to a risk factor and highlights the importance - and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 10% (Leichhardt Highway), 18% (Gore Highway) and 10% (Landsborough Highway) of all the supply chain paths traversing the intersections destined for the Blacktown (C), Western Downs (R) and the Brisbane (C) LGAs, respectively.

Table 258 Summary of community reliance metrics for each intersection on the Warrego Highway key freight route - most impacted LGA

	LEICHHARDT HIGHWAY	GORE HIGHWAY	LANDSBOROUGH HIGHWAY
Destination LGA most reliant on the intersection	Blacktown (C)	Western Downs (R)	Brisbane (C)
Relative reliance on intersection for destination LGA	0.10	0.18	0.10
Origin LGA most reliant on the intersection	Mareeba (S)	Brisbane (C)	Maranoa (R)
Relative reliance on intersection for origin LGA	0.11	0.37	0.10

5.51.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Warrego Highway. The results are based on expected freight for an average week.

- **Leichhardt Highway intersection**: The closure of the Leichhardt Highway intersection results in the disruption of 3,077 vehicle trips carrying 56,192 tonnes, 18% being essential commodities. Overall, 55,838 tonnes of freight are re-routed with an average detour length of -15 km and with an average increase in cost of $2.07 per tonne. A total value of supplies amounting to $1.2 million, $0.5 million being essential commodities, is unable to reach its destination.
- **Gore Highway intersection**: The closure of the Gore Highway intersection results in the disruption of 2,774 vehicle trips carrying 54,679 tonnes, 29% being essential commodities. Overall, 54,679 tonnes of freight are re-routed with an average detour length of 12 km and with an average increase in cost of $5.71 per tonne. No freight is unable to reach its destination.
- **Landsborough Highway intersection**: The closure of the Landsborough Highway intersection results in the disruption of 614 vehicle trips carrying 10,755 tonnes, 14% being essential commodities. Overall, 10,750 tonnes of freight are re-routed with an average detour length of 83 km and with an average increase in cost of $17.72 per tonne. Little freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Warrego Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Warrego Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.
- 'Warrego Highway-*intersection*-tonnes pie chart.png' shows the proportion of each commodity sector obstructed.
- 'Warrego Highway-*intersection*-monthly obstructed volumes.png' shows the monthly tonnage impacts for commodities obstructed and 'Warrego Highway-*intersection*-monthly re-routed volumes.png' shows the monthly tonnage impacts for commodities re-routed.
- 'Warrego Highway-*intersection*-tonnes bar plot.png' shows the relative tonnes detoured and 'Warrego Highway-cost bar plot.png' shows the cost impacts of re-routing.
- 'Warrego Highway-*intersection*-detoured obstructed plot.png' shows the cumulative impacts of successive closures for the Warrego Highway.

KFR risk profile

Table 259 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight might be re-routed at non-negligible costs.

Table 259 Risk metrics for modelled intersections on the Warrego Highway KFR

	LEICHHARDT HIGHWAY	GORE HIGHWAY	LANDSBOROUGH HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.004	0.000	0.000
KFR impacts risk - detour costs for intersection	0.004	0.011	0.014
Last iteration	5	5	5

Freight impact

Table 260 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 260 Freight impact metrics for modelled intersections on the Warrego Highway KFR by last successive closure

		LEICHHARDT HIGHWAY [%]	GORE HIGHWAY [%]	LANDSBOROUG H HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	1	0	0
	Relative freight volume impacted – essential commodities	3	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	4	11	14
	Relative detour cost – maximum	388	384	114

The metrics in Table 260 indicate the supply chains traversing the Leichhardt Highway intersection that are likely to be re-routed would do so with their average cost increasing by 4% across all commodities, with some supply chain paths incurring an increase of up to 388%. Those traversing the Gore Highway intersection are expected to be re-routed at an average cost increasing by 11% across all commodities, while those traversing the Landsborough Highway intersection may do so at an average cost increasing by 14%.

Very little freight is obstructed for all three intersections for all commodities.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 261 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Leichhardt Highway intersection results in one LGA (Western Downs (R)) not receiving essential commodities, representing 3.2% of the LGA's essential commodities consumption. When considering all commodities, four out of the 222 LGAs serviced by the intersection have freight obstructed, representing 0.5% of the LGAs' overall consumption.

The Gore Highway intersection closure results in no LGAs impacted by obstructed essential and non-essential commodities.

The Landsborough Highway results in no LGA not receiving essential commodities. When considering all commodities, one out of the 140 LGAs serviced by the intersection has freight obstructed, representing 0.1% of the LGA's overall consumption.

Table 261 Community impact metrics for modelled intersections on the Warrego Highway KFR - obstructed supply chains

			LEICHHARDT HIGHWAY	GORE HIGHWAY	LANDSBOROUGH HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	1/222	0/109	0/140
		Relative volumes impacted	3.2%	0.0%	0.0%
	Most impacted LGA	Name of destination LGA	Western Downs(R)	-	-
		Highest impacted commodity sector	Fuel	-	-
		Commodity impacted	LPG	-	-
		Number of supply chains impacted	2	0	0
		Relative volumes impacted	9%	0%	0%
		Weekly tonnes BAU	17.3	0.0	0.0
		Relative number of supply chains impacted	9%	0%	0%
All commodities	All impacted LGAs	Number of LGAs impacted	4/222	0/109	1/140
		Relative volumes impacted	0.5%	0.0%	0.1%
	Most impacted LGA	Name of destination LGA	Western Downs(R)	-	Maranoa(R)
		Highest impacted commodity sector	Wood Product	-	Livestock
		Number of supply chains impacted	1	0	3
		Relative volumes impacted	13%	0%	0%
		Weekly tonnes BAU	191.7	0.0	3,862.9
		Relative number of supply chains impacted	17%	0%	0%

Re-routed supply chains

Table 262 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 11% of the supply chains are expected to be re-routed for 71 of the 222 LGAs that traverse the Leichhardt Highway intersection. The most impacted LGA is Murweh (S), with eight supply chains in the processed food sector representing 0.9 tonnes of seafood per week re-routed. For non-essential commodities, all 222 LGAs serviced by the Leichhardt Highway intersection are impacted by re-routed freight, representing 3.9% of the total volumes consumed within these LGAs.

For the Gore Highway intersection, 61 of the 109 LGAs serviced are expected to have freight re-routed, with this representing 12.8% of essential commodities consumed within the impacted LGAs. For non-essential commodities, all 109 LGAs serviced by the Gore Highway intersection are impacted by re-routed freight, representing 4.7% of the total volume consumed within these LGAs.

For the Landsborough Highway intersection, 35 of the 140 LGAs serviced are expected to have freight re-routed, representing 12.6% of essential commodities consumed within the LGAs. For non-essential commodities, all 140 LGAs serviced by the Landsborough Highway intersection are impacted by re-routed freight, representing 2.1% of the total volume consumed within these LGAs.

Table 262 Community impact metrics for modelled intersections on the Warrego Highway KFR - re-routed supply chains

			LEICHHARDT HIGHWAY	GORE HIGHWAY	LANDSBOROUGH HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	71/222	61/109	35/140
		Relative impact on volumes of commodities	11.0%	12.8%	12.6%
	Most impacted LGA	Name	Murweh (S)	Murweh (S)	Barcoo(S)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Seafood	Seafood	Box Chicken
		Number of supply chains impacted	8	8	3
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.9	0.9	1.3
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	222/222	109/109	140/140
		Relative impact on volumes of commodities	3.9%	4.7%	2.1%
	Most impacted LGA	Name	Etheridge(S)	Etheridge(S)	Boulia(S)
		Highest impacted commodity sector	Cropping	Cropping	Cropping
		Number of supply chains impacted	2	2	2
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	0.2	0.2	0.2
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Warrego Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Warrego Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

5.52 Western Highway

The Western Highway KFR (Figure 70) is a freight route located in Victoria. It connects LGAs from Ballarat to the SA border east of Bordertown. The corridor is 368 km with at least part of the route used for the transport of $81m of product on 360,002 trailers annually carrying seven million tonnes across 21,955 supply chains spanning 106 commodities (27% of the total volume on the KFR is classified as essential commodities). The average freight volume across the road segments is 179,816 trailers annually with the busiest sections carrying 230,374 trailers.

Cropping transport represents approximately 35% of the total freight task with fuel and general freight adding 20% each. This route is classified as PBS2b access with some PBS3a access in SA.

Figure 70 Western Highway KFR

The Western Highway KFR passes through seven LGAs but crucially it supports the supply chain paths for over 350 LGAs along its length and beyond. It provides access to essential commodities for 134 LGAs. Hindmarsh (S), Horsham (RC) and Yarriambiack (S) LGAs are reliant on this KFR to provide access to supplies and markets for most commodities but in particular processed foods, fuel, general freight and cropping. Modelling indicates that the route is used by supply chains with trips using the KFR for up to 80% of the supply chain trip length.

The intersections identified as of strategic importance and used in the modelling and analysis comprise:

- Henty Highway
- Sunraysia Highway
- Borung Highway

The reliance described in Table 263 equates to a risk factor and highlights the importance - and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. The analysis indicates that the communities using the KFR rely on the three intersections to low degrees, with 9% (Henty Highway), 12% (Borung Highway) and 16% (Sunraysia Highway) of all the supply chain paths traversing the intersections destined for the Yarriambiack (S) and the Wyndham (C) LGAs, respectively.

Table 263 Summary of community reliance metrics for each intersection on the Western Highway key freight route - most impacted LGA

	HENTY HIGHWAY	BORUNG HIGHWAY	SUNRAYSIA HIGHWAY
Destination LGA most reliant on the intersection	Yarriambiack (S)	Wyndham (C)	Wyndham (C)
Relative reliance on intersection for destination LGA	0.09	0.12	0.16
Origin LGA most reliant on the intersection	Glenelg (S)	Hindmarsh (S)	Brimbank (C)
Relative reliance on intersection for origin LGA	0.35	0.05	0.07

5.52.1 Modelling and analysis outcomes

The following summarises the impacts from the closure of the intersection and subsequent *n* high-intensity alternative routes for each of the three modelled intersections along the Western Highway. The results are based on expected freight for an average week.

- **Henty Highway intersection**: The closure of the Henty Highway intersection results in the disruption of 4,395 vehicle trips carrying 77,226 tonnes, 30% being essential commodities. Overall, 77,015 tonnes of freight are re-routed with an average detour length of 24 km and with an average increase in cost of $10.02 per tonne. A total value of supplies amounting to $1.6 million, $0.2 million being essential commodities, is unable to reach its destination.
- **Borung Highway intersection**: The closure of the Borung Highway intersection results in the disruption of 4,151 vehicle trips carrying 73,954 tonnes, 27% being essential commodities. Overall, 73,925 tonnes of freight are re-routed with an average detour length of 31 km and with an average increase in cost of $9.67 per tonne. A total value of supplies amounting to $0.1 million, $0.0 million being essential commodities, is unable to reach its destination.
- **Sunraysia Highway intersection**: The closure of the Sunraysia Highway intersection results in the disruption of 4,082 vehicle trips carrying 69,569 tonnes, 30% being essential commodities. Overall, 69,569 tonnes of freight are re-routed with an average detour length of 38 km and with an average increase in cost of $10.56 per tonne. Little freight is unable to reach its destination.

Metrics relating to the network performance as described in Appendix 0 were calculated for each of the supply chains traversing each of the three modelled intersections of the Western Highway and are presented in the tables below.

Detailed plots showing specific impacts on supply chains and commodities are available in the supplementary material. These are:

- 'Western Highway-*intersection*-monthly BAU volumes.png' shows the BAU freight (monthly volumes) using the specific intersection.

- ‘Western Highway-*intersection*-tonnes pie chart.png’ shows the proportion of each commodity sector obstructed.
- ‘Western Highway-*intersection*-monthly obstructed volumes.png’ shows the monthly tonnage impacts for commodities obstructed and ‘Western Highway-*intersection*-monthly re-routed volumes.png’ shows the monthly tonnage impacts for commodities re-routed.
- ‘Western Highway-*intersection*-tonnes bar plot.png’ shows the relative tonnes detoured and ‘Western Highway-cost bar plot.png’ shows the cost impacts of re-routing.
- ‘Western Highway-*intersection*-detoured obstructed plot.png’ shows the cumulative impacts of successive closures for the Western Highway.

KFR risk profile

Table 264 provides the results of the simulation from closing intersections and subsequent alternative routes sequentially. It shows that for all three KFR intersections, the model was able to reach the maximum number of successive high-intensity alternative route closures of five, with low impact risk in terms of obstructed volumes, however with slightly higher values for the re-routed costs indicating that freight might be re-routed at low costs.

Table 264 Risk metrics for modelled intersections on the Western Highway KFR

	HENTY HIGHWAY	BORUNG HIGHWAY	SUNRAYSIA HIGHWAY
KFR impacts risk - obstructed volumes for intersection	0.003	0.000	0.000
KFR impacts risk - detour costs for intersection	0.012	0.011	0.012
Last iteration	5	5	5

Freight impact

Table 265 provides a summary of the metrics for obstructed and re-routed supply chains including the proportion of supply chains impacted for each intersection modelled on the KFR.

Table 265 Freight impact metrics for modelled intersections on the Western Highway KFR by last successive closure

		HENTY HIGHWAY [%]	BORUNG HIGHWAY [%]	SUNRAYSIA HIGHWAY [%]
Obstructed supply chains	Relative freight volume impacted – all commodities	0	0	0
	Relative freight volume impacted – essential commodities	1	0	0
	Relative value of freight – all commodities	0	0	0
Re-routed supply chains	Relative detour cost – average	6	6	6
	Relative detour cost – maximum	80	169	69

The metrics in Table 265 indicate the supply chains traversing the Henty Highway intersection that are likely to be re-routed would do so with their average cost increasing by 6% across all commodities, with some supply chain paths incurring an increase of up to 80%. Those traversing the Borung Highway intersection are expected to be re-routed at an average cost increase of 6% across all commodities, while those traversing the Sunraysia Highway intersection may do so at an average cost increase of 6%.

Very little freight is obstructed for all three intersections for all commodities.

Community impact

The section below provides a summary of the impacts on communities from the modelled intersection closures. The output includes detail on the obstructed and re-routed supply chains and which LGAs are expected to be impacted.

Obstructed supply chains

Table 266 provides a summary of the obstructed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

The Henty Highway intersection results in two LGAs not receiving essential commodities, representing 2.3% of the LGAs' consumption where the most impacted LGA is The Coorong (DC) for Box Chicken. When considering all commodities, two out of the 250 LGAs serviced by the intersection have freight obstructed, representing 3% of the LGAs' overall consumption.

The Borung Highway intersection and the Sunraysia Highway intersection closures results in the same LGA (The Coorong (DC)) impacted by obstructed essential commodities.

Table 266 Community impact metrics for modelled intersections on the Western Highway KFR - obstructed supply chains

			HENTY HIGHWAY	BORUNG HIGHWAY	SUNRAYSIA HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	2/250	1/210	1/196
		Relative volumes impacted	2.3%	22.1%	3.0%
	Most impacted LGA	Name of destination LGA	The Coorong (DC)	The Coorong (DC)	The Coorong (DC)
		Highest impacted commodity sector	Processed Food	Processed Food	Processed Food
		Commodity impacted	Box Chicken	Box Chicken	Box Chicken
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	3%	27%	3%
		Weekly tonnes BAU	5.2	5.2	5.2
		Relative number of supply chains impacted	11%	11%	11%
All commodities	All impacted LGAs	Number of LGAs impacted	2/250	1/210	2/196
		Relative volumes impacted	3.0%	0.2%	0.7%
	Most impacted LGA	Name of destination LGA	Horsham (RC)	The Coorong (DC)	Ballarat(C)
		Highest impacted commodity sector	Vehicles	Wood Product	Mining
		Number of supply chains impacted	13	1	1
		Relative volumes impacted	43%	61%	2%

		HENTY HIGHWAY	BORUNG HIGHWAY	SUNRAYSIA HIGHWAY
	Weekly tonnes BAU	128.1	41.7	8.6
	Relative number of supply chains impacted	46%	50%	3%

Re-routed supply chains

Table 267 provides a summary of the re-routed supply chains including the number of impacted LGAs along with the commodity and most impacted LGA for each intersection modelled on the KFR.

For essential commodities, 14.5% of the supply chains are expected to be re-routed for 114 of the 250 LGAs that traverse the Henty Highway intersection. The most impacted LGA is Hindmarsh (S), with six supply chains in the horticulture sector representing 4.6 tonnes of fruit per week re-routed. For non-essential commodities, 248 of the 250 LGAs serviced by the Henty Highway intersection are impacted by re-routed freight, representing 4.7% of the total volumes consumed within these LGAs.

For the Borung Highway intersection, 115 of the 210 LGAs serviced are expected to have freight re-routed, with this representing 14.2% of essential commodities consumed within the impacted LGAs. For non-essential commodities, 208 of the 210 LGAs serviced by the Borung Highway intersection are impacted by re-routed freight, representing 4.7% of the total volume consumed within these LGAs.

For the Sunraysia Highway intersection, 108 of the 196 LGAs serviced are expected to have freight re-routed, representing 15.8% of essential commodities consumed within the LGAs. For non-essential commodities, 194 of the 196 LGAs serviced by the Sunraysia Highway intersection are impacted by re-routed freight, representing 4.7% of the total volume consumed within these LGAs.

Table 267 Community impact metrics for modelled intersections on the Western Highway KFR - re-routed supply chains

			HENTY HIGHWAY	BORUNG HIGHWAY	SUNRAYSIA HIGHWAY
Essential commodities	All impacted LGAs	Number of LGAs impacted	114/250	115/210	108/196
		Relative impact on volumes of commodities	14.5%	14.2%	15.8%
	Most impacted LGA	Name	Hindmarsh(S)	Coober Pedy(DC)	Hindmarsh(S)
		Highest impacted commodity sector	Horticulture	Processed Food	Horticulture
		Commodity impacted	Fruit	Bread	Fruit
		Number of supply chains impacted	6	1	6
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	4.6	0.3	4.6
		Relative number of supply chains impacted	100%	100%	100%
All commodities	All impacted LGAs	Number of LGAs impacted	248/250	208/210	194/196
		Relative impact on volumes of commodities	4.7%	4.7%	4.7%
	Most impacted LGA	Name	Ceduna(DC)	Ceduna(DC)	Ceduna(DC)
		Highest impacted commodity sector	Wood product	Wood Product	Wood Product
		Number of supply chains impacted	1	1	1
		Relative volumes impacted	100%	100%	100%
		Weekly tonnes BAU	25.6	25.6	25.6
		Relative number of supply chains impacted	100%	100%	100%

Detailed plots showing specific impacts on LGAs for supply of essential commodities can be seen in the supplementary material:

- 'Western Highway-*intersection*-percent obstructed lga.png' shows the proportion of commodities obstructed that cannot reach the LGA due to closures on the KFR.
- 'Western Highway-*intersection*-percent re-routed lga.png' shows the proportion of commodities re-routed that is likely to result in an increased transport cost to reach the LGA due to closures on the KFR.

Part II Resilience analysis for rail

6 Rail analysis

A goal of the rail resilience analysis is to understand the impacts of disruptions at key points of the rail network. The key points of interest on the rail network are shown as red and green dots in Figure 71 and Figure 72. The focus in this analysis was on freight routes handling multiple commodities rather than freight routes that are predominately bulk freight.

Breakage points to simulate disruptions were selected either near major cities/towns, or at locations with high potential for flood blockage. The red dots (Figure 71) represent locations where there are no alternative rail routes and the freight would need to transfer to road, in the event of a disruption. Green dots represent where the freight could take an alternative rail route.

The approach used in this analysis for where a rail alternative was not available, was to transfer freight to road between the current rail load/unload points. Where there was an alternative rail option available, a cost comparison was determined between BAU and the cost of taking the alternative route. When the rail line was disrupted, it was assumed the entire trip between origin and destination was shifted to road. In practice, some trips would shift back on to rail at an intermodal after the disrupted point.

Disruption to the below rail lines were modelled as scenarios in this study:

1. Qld Great Northern Line
2. Qld North Coast Line
3. Qld Western system (West Moreton)
4. NSW North Coast Line
5. NSW Main West Line
6. NSW Main South Line
7. NSW Broken Hill Line
8. Vic North East Line
9. Tas Main Line
10. Melbourne – Adelaide Main line
11. SA Transcontinental line
12. The Ghan
13. WA Transcontinental line

Each scenario was run using the following methods:

1. Use TraNSIT to capture the rail movements impacted at the point of the disruption, as shown by the dot;
2. For lines where no alternate rail route is possible, shift freight to road transport (modal shift) and use TraNSIT to model the movements along the road network;

3. For the lines where an alternate rail route is possible, close the existing line and use TraNSIT to model using the rail network;
4. Use TraNSIT to estimate backlogging for each scenario.

Outputs from each scenario include summary tables for the BAU freight; a table showing the additional costs from the detour, assuming annual movements; and a seasonality plot.

Rail routes for coal and iron ore usually exceed 50 million tonnes per year. A disruption to these rail links provides limited to no options for alternative rail paths. Where alternative rail paths are available (e.g. coal freight in the Bowen basin travelling via Emerald), the large detour would not be able to accommodate the frequent number of large coal and iron ore trains. A switch to road transport would be difficult as it would require a large number of suitable vehicles for coal and iron ore, which would not be readily available. For both the Hunter and Bowen Basin regions, transferring coal from rail to road could lead to more than a 1000% increase in heavy freight along regional freight routes, depending on the amount of and type of road fleet available at the time and would lead to significant congestion at intersections within townships and ports. These alternative regional freight routes include the New England Highway, Dawson Highway, Peak Downs Highway, and Bowen Development Road.

Several branch lines in the country rail networks of NSW, SA, Victoria and WA predominantly carry grains to port or milling facilities. Rail transport is used from grain silos where a suitable rail siding is present. Trips from gain silos to domestic markets is usually via road due to the lack of rail infrastructure at destinations. Unlike coal and iron ore, the use of rail for grain transport is more concentrated in the harvest season.

Outputs from TraNSIT show that in an average year, 24.4 million tonnes of grain are transported from grain silos, largely to ports (22.25 million tonnes), with the remainder transported to flour mills, stock feed manufacturers and malt houses. This compares to 81.8 million tonnes transported by road across the various supply chain legs. The impact of a disruption on a grain rail line depends on the location, volume of grain being transported, available road links and time of year. Combined, these will determine the capacity of road vehicles to shift the grain. Country rail branch lines commence up country, with a path to one of the ports. Rail freight volumes accumulate enroute. A disruption to an up-country point of the rail will impact fewer grain tonnes compared to near the port.

Most sugarcane in Queensland is transported to mills using a 2ft narrow gauge railway, with an annual cartage of over 30 million tonnes. Specialised locomotives and sugarcane rolling stock are used, with an average travel distance to the mills of around 20 km. Sugarcane railways only operate during the harvest season of June to November. A major rain event that disrupts the cane harvest for several days will in turn remove the need to operate the cane railways. Therefore, cane trains are rarely directly disrupted by weather events, but rather by a knock-on effect of the disrupted harvest.

Figure 71 Rail lines and breakage points identified for modelling

6.1 Compounding effects of weather events

Figure 72 shows the rail closures from the 2022 high weather season as blue squares in relation to the modelled rail breakage points, providing an indication of risk of closure.

Figure 72 Locations of rail closures from the 2022 high weather season relative to the modelled rail breakage points

Details of the impacts of the closures are provided in the supplementary materials prepared by CSIRO for the National Situation Room of Emergency Management Australia and the National Recovery and Resilience Agency in (January to July 2022) through a partnership with the Australian Climate Services that provided supply chain and community impacts from weather events in 2022.

6.2 Queensland Great Northern Line

This modelled rail breakage point is situated west of Townsville on the Mount Isa to Townsville route which is a 950 km rail line linking numerous connectors and terminals. The line carries 2.3 million tonnes of freight annually with an average cost of $41.45 per tonne, which is nearly all minerals freight. It also provides a cattle service.

Table 268 provides the current commodities, annual tonnes and costs for rail freight using the Queensland Great Northern Line. Table 269 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 268 Annual rail freight summary for Queensland Great Northern Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Livestock	7,680	$ 1,554,334	$ 53,760,000	$202.39
Minerals	2,301,000	$ 94,130,991	$ 6,612,000,000	$40.91
Total	**2,308,680**	**$ 95,685,325**	**$ 6,665,760,000**	**$41.45**

Table 269 Road comparison summary for rail freight for Queensland Great Northern Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Livestock	7,680	$1,345,415	384	$175.18	-16
Minerals	2,301,000	$139,086,275	85,222	$60.45	32
Total	**2,308,680**	**$140,431,691**	**85,606**	**$60.83**	**32**

Transferring from rail to road would result in an extra 85,606 annual trailers on the road network (largely travelling east) and importantly the costs would increase significantly for the mining sector. The nearby point on the Flinders Highway currently carries 93,511 annual trailers (both directions), based on existing freight in TraNSIT). Disruption to the rail network would increase the road traffic by 92%.

6.3 Queensland North Coast Line

This modelled breakage point is situated north of Brisbane near Yandina on the Queensland North Coast line, which is 1840 km long route connecting to numerous connectors and terminals. The line carries 143,744 tonnes of freight annually, with a wide range of agriculture and general freight and an average cost of $88.24 per tonne.

Table 270 provides the current commodities, annual tonnes and costs for the rail freight using the Queensland North Coast Line. Table 271 provides the comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 270 Annual rail freight statistics for Queensland North Coast Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	2,083	$126,512	$14,583,338	$60.73
Cropping	940	$57,822	$475,525	$61.51
General	45,399	$3,989,855	$622,359,012	$87.88
Horticulture	34,640	$2,225,789	$95,013,518	$64.25
Livestock	23,824	$3,305,999	$147,770,858	$138.77
Processed Food	29,713	$1,764,176	$180,116,839	$59.37
Vehicles	5,708	$1,129,369	$142,689,950	$197.87
Wood Product	1,438	$84,746	$6,772,570	$58.95
Total	**143,744**	**$12,684,269**	**$1,209,781,610**	**$88.24**

Table 271 Road comparison summary for Rail freight for Queensland North Coast Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	2,083	$176,998	83	$84.96	40
Cropping	940	$94,216	43	$100.22	63
General	45,399	$7,038,026	3,235	$155.02	76
Horticulture	34,640	$3,964,399	1,772	$114.45	78
Livestock	23,824	$3,426,330	1,184	$143.82	4
Processed Food	29,713	$3,041,374	1,489	$102.36	72
Vehicles	5,708	$1,948,929	951	$341.47	73
Wood Product	1,438	$145,008	72	$100.87	71
Total	**143,744**	**$19,835,281**	**8,830**	**$137.99**	**56**

Transferring from rail to road would result in an extra 8,830 annual trailers on the road network and importantly the costs would increase significantly for all sectors. The nearby Bruce Highway carries 165,000 northbound and 107,000 south bound freight trailers per year, based on existing freight in TraNSIT. A disruption to the rail link would increase road freight only by 3.1%.

6.4 Queensland Western System (West Moreton)

This modelled rail breakage point is situated west of Brisbane in the Lockyer Valley on the Queensland Western System (West Moreton) which is a 300 km section that connects the Western line and other lines servicing the southwest of Queensland to Brisbane. It carries a large amount of coal, grains and cattle, totalling 5.1 million tonnes annually with an average cost of $20.55 per tonne.

Table 272 provides the current commodities, annual tonnes and costs for rail freight using the Queensland Western System (West Moreton). Table 273 provides the comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 272 Annual rail freight statistics for Queensland Western system

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Coal	4,420,000	$ 88,423,820	$ 707,200,000	$ 20.01
Grains	631,979	$ 15,386,999	$ 239,094,869	$ 24.35
Total	5,051,979	$ 103,810,819	$ 946,294,869	$ 20.55

Table 273 Road comparison summary for Rail freight for Queensland Western system

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Coal	4,420,000	$111,097,184	163,704	$25.14	20
Grains	631,979	$31,986,795	26,068	$50.61	52
Total	5,051,979	$143,083,979	189,772	$28.32	27

Shifting from rail to road would result in an extra 189,772 trailers annually (largely eastbound) on the road network and an increase in costs for all sectors. The nearby Warrego Highway carries 177,500 trailers annually in an eastbound direction, based on existing freight in TraNSIT. A disruption to the rail link would increase freight by 107% on the Warrego Highway.

6.5 NSW North Coast Line

This modelled rail breakage point is situated north of Sydney, near Gosford on the NSW North Coast Line which is a 1000 km long section of rail connecting Sydney and south/west NSW to Queensland via Brisbane. It carries 2.5 million tonnes of freight annual from a wide range of commodities (mainly general freight and construction (steel)) with an average cost of $87.95 per tonne.

Table 274 provides the current commodities, annual tonnes and costs for rail freight using the NSW North Coast Line. Table 275 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 274 Annual rail freight statistics for NSW North Coast Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	1,166,417	$64,418,640	$ 8,150,637,889	$55.23
Cropping	78,308	$3,273,101	$ 29,938,435	$41.80
General	906,859	$112,565,600	$ 9,369,944,600	$124.13
Horticulture	66,886	$8,489,539	$ 285,909,603	$126.93
Livestock	500	$30,071	$ 7,000,000	$60.14
Mining	94,000	$2,548,072	$ 846,000,000	$27.11
Processed Food	91,523	$8,371,313	$ 613,868,135	$91.47
Vehicles	32,736	$8,858,520	$ 818,388,125	$270.61
Wood Product	89,203	$13,638,781	$ 142,525,493	$152.90
Total	**2,526,432**	**$222,193,637**	**$ 20,264,212,279**	**$87.95**

Table 275 Road comparison summary for Rail freight for NSW North Coast Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	1,166,417	$129,092,965	46,728	$110.67	100
Cropping	78,308	$9,503,327	3,473	$121.36	190
General	906,859	$203,081,699	59,958	$223.94	80
Horticulture	66,886	$15,906,847	3,340	$237.82	87
Livestock	500	$64,122	25	$128.24	113
Mining	94,000	$4,870,434	3,481	$51.81	91
Processed Food	91,523	$15,090,054	4,747	$164.88	80
Vehicles	32,736	$15,795,768	5,456	$482.52	78
Wood Product	89,203	$25,924,587	3,579	$290.62	90
Total	**2,526,432**	**$419,329,803**	**130,788**	**$165.98**	**89**

Shifting from rail to road would result in an extra 130,788 trailers per year on the road network and importantly the costs would increase significantly for all sectors to an average of $215.10 per tonne.

The nearby Pacific Motorway carries 322,000 trainers northbound and 263,000 southbound per year, based on current freight in TraNSIT. A rail disruption would increase freight along the Pacific Motorway by 22%.

6.6 NSW Main West Line

This modelled rail breakage point is situated west of Sydney, near Orange on the Main West line which is a 500 km operational section and carries 8.2 million tonnes of annual freight including a large range of mining and general freight with an average cost of $40.77 per tonne. This freight would take an alternative rail route rather than be moved onto road.

Table 276 provides the current commodities, annua tonnes and costs for rail freight using the NSW Main West Line. Table 277 provides the comparisons based on the rail line being disrupted and the freight being routed on to an alternate rail line. Given some mining trips can not reach the port using a suitable rail path with a disruption to the NSW Main West Line, the increase in transport costs per tonne (3.3%) was calculated without the mining trips. The long-distance containerised freight commodities (general, horticulture, construction) are minimally impacted since freight to/from Sydney could take the southern line via Cootamundra.

Table 276 Annual freight statistics for NSW Main West Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	350,484	$43,227,013	$2,441,350,785	$123.34
Cropping	309,478	$9,882,263	$148,704,637	$31.93
General	403,381	$99,584,891	$6,236,767,714	$246.88
Horticulture	46,469	$7,998,786	$199,813,594	$172.13
Mining	6,899,000	$145,962,606	$3,747,000,000	$21.16
Processed Food	26,807	$2,575,721	$180,876,393	$96.08
Vehicles	7,711	$3,062,549	$192,767,800	$397.18
Wood Product	141,687	$21,395,881	$226,698,464	$151.01
Total	**8,185,016**	**$333,689,710**	**$13,373,979,385**	**$40.77**

Table 277 Alternative rail route comparison summary for rail freight for NSW Main West Line

SECTOR	TOTAL TONNES	TOTAL COST	COST PER TONNE	% CHANGE FROM BASE
Construction	350,484	$43,726,146	$124.76	1%
Cropping	309,478	$12,067,467	$38.99	22%
General	403,381	$102,436,534	$253.94	3%
Horticulture	46,469	$8,096,174	$174.23	1%
Mining#	299,000	$9,123,449	$30.51	44%
Processed Food	26,807	$2,838,992	$105.91	10%
Vehicles	7,711	$3,170,525	$411.18	4%
Wood Product	141,687	$21,645,365	$152.77	1%
Total	**1,585,016**	**$203,104,653**	**$128.14**	**3.3% (excl mining)**

6.6 million tonnes of mining is obstructed and unable to reach the ports

6.7 NSW Main South Line

This modelled rail breakage point is situated southwest of Sydney near Goulburn on the NSW Main South line between Sydney and Albury. It has connections to many branch lines and terminals along its length. It carries 14.9 million tonnes of annual freight, largely coal and minerals but also a large amount of general freight with an average cost of $32.21 per tonne. This freight would take an alternative rail route rather than be moved onto road.

Table 278 provides the current commodities, annual tonnes and costs for rail freight using the NSW Main South Line. Table 279 provides comparisons based on the rail line being disrupted and the freight being routed on to an alternate rail line. The impact on increased freight costs is highly variable since it depends on the detour required for each commodity. Waste has high additional costs since the original short trip is from Sydney to Goulburn. A detour via the Blue Mountains is much longer. For cropping, the average additional distance from the grain silos via Newcastle or Blue Mountains is short, thus leading to minimal increase in transport costs.

Table 278 Annual rail freight statistics for NSW Main South Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	1,302,051	$61,661,186	$ 5,361,254,953	$47.36
Cropping	5,378,104	$145,679,883	$ 2,939,621,385	$27.09
General	764,321	$75,114,080	$ 8,107,988,871	$98.28
Horticulture	35,492	$3,017,240	$ 144,841,952	$85.01
Mining	6,600,000	$138,323,048	$ 1,056,000,000	$20.96
Processed Food	75,104	$6,242,793	$ 486,921,450	$83.12
Vehicles	25,401	$6,965,613	$ 635,023,675	$274.23
Waste	736,128	$43,448,274	$ 73,612,800	$59.02
Wood Product	6,500	$254,983	$ 9,750,000	$39.23
Total	**14,923,100**	**$480,707,102**	**$ 18,815,015,085**	**$32.21**

Table 279 Alternative rail route comparison summary for rail freight for NSW Main South Line

SECTOR	TOTAL TONNES	TOTAL COST	COST PER TONNE	% CHANGE FROM BASE
Construction	1,302,051	$90,842,707	$69.77	52%
Cropping	5,378,104	$150,753,349	$28.03	4%
General	764,321	$79,889,497	$104.52	10%
Horticulture	35,492	$3,304,020	$93.09	9%
Mining#				
Processed Food	75,104	$6,824,027	$90.86	10%
Vehicles	25,401	$6,784,906	$267.11	9%
Waste	736,128	$88,586,974	$120.34	126%
Wood Product	6,500	$301,759	$46.42	17%
Total	**8,323,100**	**$427,287,239**	**$51.34**	**63%**

6.6 million tonnes of mining is obstructed and unable to reach the ports.

6.8 NSW Broken Hill Line

This modelled rail breakage point is situated in western NSW near Ivanhoe on the Broken Hill line, which is part of the Transcontinental line. It carries 1.9 million tonnes of freight annually, largely general freight with an average cost of $140.36 per tonne. This freight would take an alternative rail route via Melbourne rather than be moved onto road.

Table 280 provides the current commodities, annual tonnes and costs for rail freight using the line. Table 281 provides comparisons based on the rail line being disrupted and the freight being routed on to an alternate rail line.

Table 280 Annual rail freight statistics for NSW Broken Hill Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	350,484	$43,227,013	$2,441,350,785	$123.34
Cropping	22,831	$3,170,662	$13,339,735	$138.88
General	576,528	$133,864,994	$8,159,120,564	$232.19
Horticulture	50,741	$8,599,989	$215,204,708	$169.49
Mining	625,852	$34,870,967	$673,851,852	$55.72
Processed Food	67,099	$10,729,835	$258,365,650	$159.91
Vehicles	13,292	$4,894,198	$332,308,750	$368.20
Wood Product	155,164	$21,996,711	$248,261,680	$141.76
Total	**1,861,990**	**$261,354,370**	**$12,341,803,724**	**$140.36**

Table 281 Alternative rail route comparison summary for Rail freight for NSW Broken Hill Line

SECTOR	TOTAL TONNES	TOTAL COST	COST PER TONNE	% CHANGE FROM BASE
Construction	350,484	$47,811,139	$136.41	11%
Cropping	22,831	$3,445,043	$150.90	9%
General	576,528	$147,475,041	$255.80	10%
Horticulture	50,741	$9,318,727	$183.65	8%
Mining	625,852	$59,964,761	$95.81	72%
Processed Food	67,099	$12,207,520	$181.93	14%
Vehicles	13,292	$5,397,798	$406.08	10%
Wood Product	155,164	$23,838,877	$153.64	8%
Total	**1,861,990**	**$309,458,907**	**$166.20**	**18%**

6.9 Victoria North East Line

This modelled rail breakage point is situated north of Melbourne near Seymour on the Victoria North East line, which runs between Melbourne and Albury and carries 3.4 million tonnes of annual freight including general freight and steel with an average cost of $59.13 per tonne.

Table 282 provides the current commodities, annual tonnes and costs for rail freight using the Victoria North East Line. Table 283 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 282 Annual rail freight statistics for Victoria North East Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	944,751	$55,295,679	$ 5,228,534,953	$58.53
Cropping	622,441	$21,075,138	$ 883,105,529	$33.86
General	972,909	$83,726,132	$ 10,634,945,578	$86.06
Horticulture	35,492	$3,017,242	$ 144,843,017	$85.01
Livestock	417	$8,878	$ 1,653,774	$21.28
Processed Food	188,879	$9,566,946	$ 1,025,900,354	$50.65
Vehicles	26,269	$7,029,473	$ 656,716,375	$267.60
Wood Product	624,500	$22,252,805	$ 3,099,750,000	$35.63
Total	**3,415,657**	**$201,972,293**	**$ 21,675,449,580**	**$59.13**

Table 283 Road comparison summary for Rail freight for Victoria North East Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	944,751	$70,736,658	39,004	$74.87	28
Cropping	622,441	$30,550,327	26,560	$49.08	45
General	972,909	$142,402,935	60,346	$146.37	70
Horticulture	35,492	$5,322,982	1,762	$149.98	76
Livestock	417	$18,726	20	$44.88	111
Processed Food	188,879	$15,134,179	9,662	$80.12	58
Vehicles	26,269	$12,325,017	4,378	$469.19	75
Wood Product	624,500	$26,845,908	28,386	$42.99	21
Total	**3,415,657**	**$303,336,733**	**170,119**	**$88.81**	**50**

Shifting from rail to road would result in an extra 170,119 trailers on the road network and importantly the costs would increase significantly for all sectors to an average of $88.81 per tonne. The nearby Hume Highway carries 252,000 and 361,000 trailers per annum, based on existing freight in TraNSIT. A disruption to the rail network would increase freight along the Hume Highway by 25%.

6.10 Tasmania Main Line

This modelled rail breakage point was situated halfway between Hobart and Launceston on the Tasmania Main Line. It carries 70,000 tonnes of annual freight at an average cost of $19.20 per tonne.

Table 284 provides the current commodities, annual tonnes and costs for rail freight using the Tasmania Main Line. Table 285 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 284 Annual rail freight statistics for Tas Main Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	12,034	$230,329	$ 2,410,213	$19.14
Wood Product	57,805	$1,110,597	$ 73,778,539	$19.21
Grand Total	**69,839**	**$1,340,926**	**$ 76,188,751**	**$19.20**

Table 285 Road comparison summary for Rail freight for Tas Main Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	12,034	$287,308	620	$23.88	25
Wood Product	57,805	$1,387,604	2,990	$24.01	25
Grand Total	**69,839**	**$1,674,912**	**3,610**	**$23.98**	**25**

Shifting from rail to road would result in an extra 3,610 trailers on the road network per year and importantly the costs would increase significantly for all sectors to an average of $23.98 per tonne. The nearby Midland Highway carries 101,000 freight trailers per annum (both directions), based on existing freight in TraNSIT. A disruption to the rail line would increase freight along the Midland Highway by 3.6%.

6.11 Melbourne – Adelaide Main Line

This modelled rail breakage point is situated between Melbourne and Adelaide near the SA – Victoria border (Bordertown) and carries 1.9 million tonnes annually, including a large amount of general freight and steel. The average cost per tonne is $112.16

Table 286 provides the current commodities, annual tonnes and costs for rail freight using the Melbourne – Adelaide Line. Table 287 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 286 Annual rail freight statistics for Melbourne – Adelaide Main Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	727,578	$48,713,770	$4,929,460,708	$66.95
Cropping	259,700	$5,644,190	$133,575,717	$21.73
General	712,523	$122,144,491	$9,513,064,380	$171.43
Horticulture	68,757	$10,072,409	$232,776,716	$146.49
Livestock	6,900	$266,680	$96,600,000	$38.65
Processed Food	115,586	$19,094,414	$439,625,287	$165.20
Vehicles	20,864	$8,498,676	$521,600,125	$407.34
Total	**1,911,908**	**$214,434,630**	**$15,866,702,933**	**$112.16**

Table 287 Road comparison summary for Rail freight for Melbourne – Adelaide Main Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	727,578	$109,705,730	29,893	$150.78	125
Cropping	259,700	$16,166,064	10,512	$62.25	186
General	712,523	$245,149,718	52,315	$344.06	101
Horticulture	68,757	$20,052,717	3,560	$291.65	99
Livestock	6,900	$732,501	345	$106.16	175
Processed Food	115,586	$38,631,582	7,006	$334.22	102
Vehicles	20,864	$16,686,183	3,477	$799.76	96
Total	**1,911,908**	**$447,124,495**	**107,108**	**$233.86**	**109**

Shifting from rail to road would result in an extra 107,108 trailers on the road network per year and importantly the costs would increase significantly for all sectors to an average of $233.86 per tonne. There are two nearby alternative routes - the Riddoch/Princess Highway (131,000 trailers per year) and the Western/Dukes Highway (207,000 trailers per year). A disruption to the rail link would increase freight along these two highways by 32%.

6.12 SA Transcontinental Line

This modelled rail breakage point is situated northwest of Port Augusta, near Pimba on the Transcontinental line and carries 2.2 million tonnes of freight annually, mainly general freight of which 85,000 tonnes travel to Darwin. The average cost per tonne is $194.21.

Table 288 provides the current commodities, annual tonnes and costs for rail freight using the SA Transcontinental Line. Table 289 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 288 Annual rail freight statistics for SA Trans Australia Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	373,496	$52,433,610	$2,296,928,081	$140.39
Cropping	37,658	$5,378,211	$25,052,423	$142.82
General	1,164,382	$264,672,493	$16,863,303,328	$227.31
Horticulture	153,157	$22,681,145	$563,325,857	$148.09
Livestock	13,700	$1,555,513	$191,800,000	$113.54
Mining	25,000	$1,124,648	$225,000,000	$44.99
Processed Food	182,281	$30,703,972	$786,550,895	$168.44
Vehicles	35,321	$16,160,363	$883,036,250	$457.52
Wood Product	175,826	$24,935,904	$315,660,700	$141.82
Total	**2,160,821**	**$419,645,858**	**$22,150,657,534**	**$194.21**

Table 289 Road comparison summary for Rail freight for SA Trans Australia Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	373,496	$130,679,221	16,455	$349.88	149
Cropping	37,658	$15,632,041	1,827	$415.11	191
General	1,164,382	$530,366,058	88,746	$455.49	100
Horticulture	153,157	$43,792,302	7,785	$285.93	93
Livestock	13,700	$2,910,708	685	$212.46	87
Mining	25,000	$1,671,131	926	$66.85	49
Processed Food	182,281	$61,154,995	11,076	$335.50	99
Vehicles	35,321	$31,880,037	5,887	$902.57	97
Wood Product	175,826	$46,734,969	7,619	$265.81	87
Total	**2,160,821**	**$864,821,463**	**141,005**	**$400.23**	**106**

Shifting from rail to road would result in an extra 141,005 trailers on the road network per year and importantly the costs would increase significantly for all sectors to an average of $400.23 per tonne. The nearby Eyre Highway carries 106,000 freight trailers annually (both directions), based on existing freight in TraNSIT. A disruption to the rail link would increase freight along the Eyre Highway by 133%.

6.13 The Ghan Line

This modelled rail breakage point is situated north of Alice Springs on the Ghan Line and carries 178,000 annual tonnes of general freight at an average cost of $106.54 per tonne.

Table 290 provides current commodities, tonnes and costs for the rail freight using the Ghan Line. Table 291 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 290 Annual rail freight statistics for The Ghan Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	4,933	$666,482	$23,813,331	$135.10
Cropping	23	$3,461	$18,746	$147.71
General	11,523	$2,236,849	$164,952,885	$194.12
Horticulture	10,917	$1,570,612	$20,671,191	$143.87
Mining	139,000	$11,881,363	$1,251,000,000	$85.48
Processed Food	2,121	$282,399	$9,344,920	$133.14
Vehicles	3,201	$1,575,823	$80,015,075	$492.35
Wood Product	5,939	$711,018	$29,696,465	$119.71
Total	**177,658**	**$18,928,007**	**$1,579,512,614**	**$106.54**

Table 291 Road comparison summary for Rail freight for The Ghan Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	4,933	$1,024,212	206	$207.61	54
Cropping	23	$6,474	one	$276.28	87
General	11,523	$3,880,754	867	$336.79	73
Horticulture	10,917	$2,902,355	545	$265.86	85
Mining	139,000	$21,575,635	5,148	$155.22	82
Processed Food	2,121	$493,582	108	$232.70	75
Vehicles	3,201	$2,947,483	533	$920.92	87
Wood Product	5,939	$1,173,857	297	$197.64	65
Total	**177,658**	**$34,004,352**	**7,705**	**$191.40**	**80**

Shifting from rail to road would result in an extra 7,705 trailers on the road network per year and importantly the costs would increase significantly for all sectors to an average of $191.40 per tonne. The nearby Stuart Highway carries 14,500 freight trailers per year, based on existing freight in TraNSIT. A disruption to the rail link would increase freight along the Stuart Highway by 53%.

6.14 WA Transcontinental Line

This modelled rail breakage point is situated west of Perth, near Toodyay on the Transcontinental Line and carries 12.7 million tonnes of annual freight, largely iron ore and grains, plus important general freight. The average cost per tonne is $47.79.

Table 292 provides the current commodities, annual tonnes and costs for rail freight using the WA Transcontinental Line. Table 293 provides comparisons based on the rail line being disrupted and the freight shifted to road freight. The same backloading percentage for the route was applied to both road and rail. The costs and tonnes are annual figures, and can be adjusted to represent the duration the rail line was disrupted.

Table 292 Annual rail freight statistics for WA Trans Australia Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL VALUE	COST PER TONNE
Construction	368,563	$51,767,129	$2,273,114,750	$140.46
Cropping	5,197,896	$72,497,547	$2,605,164,599	$13.95
General	1,152,859	$262,435,643	$16,698,350,443	$227.64
Horticulture	142,239	$21,110,533	$542,654,666	$148.42
Livestock	13,700	$1,555,513	$191,800,000	$113.54
Mining	5,400,000	$126,290,269	$702,000,000	$23.39
Processed Food	180,159	$30,421,573	$777,205,975	$168.86
Vehicles	32,121	$14,584,540	$803,021,175	$454.05
Wood Product	169,887	$24,224,886	$285,964,235	$142.59
Total	**12,657,425**	**$604,887,633**	**$24,879,275,843**	**$47.79**

Table 293 Road comparison summary for Rail freight for WA Trans Australia Line

SECTOR	TOTAL TONNES	TOTAL COST	TOTAL EXTRA TRAILERS	COST PER TONNE	% CHANGE FROM BASE
Construction	368,563	$119,453,596	16,249	$324.11	131
Cropping	5,197,896	$158,908,200	208,236	$30.57	119
General	1,152,859	$559,404,577	87,879	$485.23	113
Horticulture	142,239	$43,608,090	7,240	$306.58	107
Livestock	13,700	$4,482,491	685	$327.19	188
Mining	5,400,000	$125,765,859	200,000	$23.29	0
Processed Food	180,159	$64,457,241	10,968	$357.78	112
Vehicles	32,121	$30,911,314	5,353	$962.34	112
Wood Product	169,887	$48,461,903	7,322	$285.26	100
Total	**12,657,425**	**$1,155,453,271**	**543,933**	**$91.29**	**91**

Shifting from rail to road would see an extra 543,933 trailers on the road network and importantly the costs would increase significantly for all sectors to an average of $91.29 per tonne. The nearby Great Eastern Highway carries 201,000 freight trailers per annum (both directions), based on freight in TraNSIT. A disruption to the rail link would increase freight along the Great Eastern Highway by 271%. This is largely due to large volumes of mining freight having to switch to road, which is unlikely to occur in practice due to the large vehicle fleet requirements.

6.15 Summary

6.15.1 Rail links with shift to road

The impact from shifting from rail to road from a disruption varies significantly across the major lines (Table 294). Significant factors are travel distance, commodities transported and access to road alternatives. The highest risk line is the SA Transcontinental line between Adelaide and Perth. It carries a large amount of general freight between the east coast and WA and is efficient. A disruption to the line leads to expensive road freight and a large amount of likely backloading due to requiring an extra 133% of additional vehicle capacity. The disruption points selected on the Queensland Great Northern Line, West Moreton Line and WA Transcontinental Line for the analysis have a large amount of mining freight, thus accounting for the large increases in road freight if they are disrupted. It is less likely the mining freight would immediately move to road due to the large requirement in additional vehicles. The Queensland North Coast Line and the Tasmania Main Line incur the lowest impact from a disruption, due to lowest-cost increase and lowest additional road freight.

Table 294 Summary of shift to road as a comparison to existing rail

RAIL LINK	ADDITIONAL COST (%)	ADDITIONAL COST ($/T)	ADDITIONAL ANNUAL TOTAL COST ($)	EXTRA TRAILERS REQUIRED	EXTRA FREIGHT ON NEARBY HIGHWAY (%)
Queensland Great Northern Line	32	$60.83	$44,746,366	85,606	92
Queensland North Coast Line	56	$137.99	$7,151,012	8,830	3.1
Qld Western System (West Moreton)	27	$28.32	$39,273,160	189,772	107
NSW North Coast Line	89	$165.98	$191,136,166	130,788	22
Victoria North East Line	50	$88.81	$101,364,440	170,119	25
Tasmania Main Line	25	$23.98	$333,986	3,610	3.6
Melbourne – Adelaide Main Line	109	$233.86	$232,689,865	107,108	32
SA Transcontinental Line	106	$400.23	$445,175,605	141,005	133
The Ghan Line	80	$191.40	$15,076,345	7,705	53
WA Transcontinental Line	91	$91.29	$550,565,638	543,933	271

6.16 Shift to alternative rail path

Table 295 summarises the change in costs of freight having to take alternative rail routes, when the rail line is disrupted. Overall, the cost increases are significantly less compared to the disrupted rail links that force freight onto roads (Table 294). It shows that an alternative rail route is preferred to a modal shift if the option is available.

Table 295 Summary of freight shifted to alternative rail routes

RAIL LINK	ADDITIONAL COST (%)	ADDITIONAL COST ($/T)	ADDITIONAL TOTAL COST ($)
NSW Main West Line*	3.3	$4.86	$6,254,099
NSW Main South Line	63	$19.13	$53,419,863
NSW Broken Hill Line	18	$25.84	$48,104,537

* excludes mining which was mostly obstructed

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Appendices

A1 Glossary

ACRONYM	
KFR	Key Freight Route
ROSI	Roads of Strategic Importance
TraNSIT	Transport Network Strategic Investment Tool
PCA	Principal component analysis
DC	Distribution centre
HML	Higher mass limit
LGA	Local Government Area
PBS	Performance Based Standard. Generally PBS1 = Semitrailer, PBS2a = B-Double limit, PBS2B = A-Double; PBS3a = Type one road train; PBS4a= Type two road train.

A2 Essential commodities

	COMMODITY	SECTOR	ESSENTIAL GOOD
1	Apples	Fruit	
2	Bananas	Fruit	
3	Cattle_Small	Livestock	
4	Cattle_Large	Livestock	
5	Box_Beef	Processed_Food	Yes
6	Box_Chicken	Processed_Food	Yes
7	Box_Lamb	Processed_Food	Yes
8	Box_Pigs	Processed_Food	Yes
9	Box_Rice	Processed_Food	Yes
10	Broccoli	Vegetables	
11	Buffalo	Livestock	
12	Capsicums	Vegetables	
13	Carrots	Vegetables	
14	Cheese	Dairy_Product	
15	Chicken	Livestock	
16	Coal	Coal	Yes
17	Cotton	Fibre	
18	Cottonseed	Fibre	
19	Milk_Raw	Dairy_Product	Yes
20	Fertilizer	Chemicals	
21	Flour	Grains	
22	Diesel_Fuel	Fuel	Yes
23	Unleaded_Fuel	Fuel	Yes
24	Cottonfibre	Fibre	
25	Grain_Barley	Grains	
26	Grain_Beans	Grains	
27	Grain_Canola	Grains	
28	Grain_Chickpeas	Grains	
29	Grain_Durum	Grains	
30	Grain_FabaBeans	Grains	
31	Grain_Lentils	Grains	
32	Grain_Maize	Grains	
33	Grain_Oats	Grains	
34	Grain_Peas	Grains	

	COMMODITY	SECTOR	ESSENTIAL GOOD
35	Grain_Sorghum	Grains	
36	Grain_Wheat	Grains	
37	Grains	Grains	
38	Harvested_Hardwood	Forestry	
39	Iron_Ore	Iron_Ore	
40	Lettuces	Vegetables	
41	Mandarins	Fruit	
42	Mangoes	Fruit	
43	Melons	Fruit	
44	Milk	Dairy_Product	Yes
45	Bauxite	Minerals	
46	Copper	Minerals	
47	Lead	Minerals	
48	Manganese	Minerals	
49	Nickel	Minerals	
50	Stone	Minerals	
51	Zinc	Minerals	
52	Mixed_Food	Mixed	Yes
53	Onions	Vegetables	
54	Oranges	Fruit	
55	Pears	Fruit	
56	Pigs	Livestock	
57	Pineapples	Fruit	
58	Potatoes	Vegetables	
59	Pumpkins	Vegetables	
60	Rice	Rice	
61	Sheep_Goat	Livestock	
62	Harvested_Softwood	Forestry	
63	Sugar	Sugar	
64	Sugarcane	Sugar	
65	Timber	Wood_Product	
66	Tomatoes	Vegetables	
67	Wood_Chips	Wood_Product	
68	Almonds	Nuts	
69	Avocados	Fruit	
70	Blueberries	Fruit	
71	Cauliflowers	Vegetables	
72	Cherries	Fruit	

	COMMODITY	SECTOR	ESSENTIAL GOOD
73	Grapefruits	Fruit	
74	Grapes	Fruit	
75	Lemons	Fruit	
76	Limes	Fruit	
77	Macadamias	Nuts	
78	Mushrooms	Vegetables	
79	Nectarines	Fruit	
80	Olives	Fruit	
81	Peaches	Fruit	
82	Plums	Fruit	
83	Strawberries	Fruit	
84	Apricots	Fruit	
85	Wool	Fibre	
86	Cream_Butter	Dairy_Product	
87	Yoghurt	Dairy_Product	
88	Milk_Powder	Dairy_Product	
89	Tissue_Pulp	Wood_Product	
90	Tissues	Wood_Product	
91	Cars	Vehicles	
92	Liquor	Beverage	
93	Sheep	Livestock	
94	Goats	Livestock	
95	Building_Material	Household_General	
96	Clothes	Household_General	
97	Furniture	Household_General	
98	Home_Appliance	Household_General	
99	Plasticware	Household_General	
100	Paper_Product	Household_General	
101	Wine_Bottle	Beverage	
102	Food_Oil	Processed_Food	
103	Grapes_Wine	Viticulture	
104	Wine_Bulk	Beverage	
105	Bottles	Beverage	
106	Paper	Wood_Product	
107	Pet_Food	Processed_Food	
108	Beer	Beverage	
109	Malt	Grains	
110	Eggs	Processed_Food	

	COMMODITY	SECTOR	ESSENTIAL GOOD
111	Softdrink	Beverage	
112	Steel	Steel	
113	Woodpanel	Wood_Product	
114	Plywood	Wood_Product	
115	Post_Poles	Wood_Product	
116	Pulp	Wood_Product	
117	Firewood	Wood_Product	
118	Export_Logs	Wood_Product	
119	Bread	Processed_Food	Yes
120	Fish	Seafood	Yes
121	Prawn	Seafood	Yes
122	Salmon	Seafood	Yes
123	Barramundi	Seafood	Yes
124	Phosphate	Minerals	
125	Acid	Minerals	
126	Fishfeed	Grains	
127	Cyanide	Chemicals	
128	Lime	Chemicals	
129	Grinding_Media	Minerals	
130	Ammonium_Nitrate	Minerals	
131	Aluminium	Minerals	
132	Magnesia	Minerals	
133	Spirits	Beverage	
134	Gravel	Construction	Yes
135	Wood_Pellets	Wood_Product	
136	Sawdust	Wood_Product	
137	Compost	Wood_Product	
138	LPG	Fuel	Yes
139	Oil	Fuel	Yes
140	Household_Waste	Waste	
141	Plasterboard	Construction	
142	Aviation_Fuel	Fuel	
143	Cement	Construction	Yes
144	Lithium_Concentrate	Minerals	
145	Lithium_Hydroxide	Minerals	
146	Mixed_General	General	
147	Sand	Construction	
148	Rock	Construction	

	COMMODITY	SECTOR	ESSENTIAL GOOD
149	Asphalt	Construction	
150	Bitumen	Construction	
151	Concrete	Construction	Yes
152	Limestone	Construction	
153	Molasses	Sugar	
154	Hides_Skins	Livestock	
155	Hay	Grains	
156	Clinker	Construction	
157	Titanium_Dioxide	Minerals	
158	Mineral_Sands	Minerals	
159	Magnetite	Minerals	
160	Footwear	Household_General	
161	Tungsten_concentrate	Minerals	
162	Meat	Processed_Food	Yes
163	Fruit	Fruit	Yes
164	Vegetables	Vegetables	Yes
165	Nuts	Nuts	
166	Grain_Product	Processed_Food	
167	Box_Rice	Processed_Food	
168	Alcohol_Beverage	Beverage	
169	Dairy_Product	Dairy_Product	Yes
170	Beverage	Beverage	
171	Seafood	Seafood	Yes
172	Household_General	Household_General	
173	Processed_Food	Processed_Food	Yes
174	Tissue_Product	Wood Product	Yes

A3 Methods

The method used to identify roads for modelling and analysis followed a two-step process.

Firstly, criticality of key freight routes (KFRs) was defined. A 'high-use' KFR was defined as one that moves a large number of freight vehicles, such as those to/from major centres, or carrying large volumes of a small number of commodities. A 'critical' freight route was defined by the reliance of a community (or communities) on receiving essential commodities using the KFR, according to commodity movements along the road/rail network across Australia from the TraNSIT baseline as of May 2022. The list of essential commodities is shown in Appendix A2. In this report, a community or regional centre is defined by the LGA that it resides in. LGA boundaries are sufficiently geographically granular to represent the destination towns/communities that rely on the KFRs. As such, if a community (i.e. an LGA) relies heavily on the commodities being transported on a given KFR (e.g. if 60% of an LGA's fuel was transported along that road) with limited alternatives, if the road were inaccessible, there would be a big impact on the community. There is no predefined percentage threshold to define criticality across the routes, as defining criticality of a KFR depends upon accessibility of alternative routes to supply freight to the community.

The method leading to the selection of the high-use and critical KFRs is explained in Appendix 0.

Secondly, resilience of KFRs was defined. There are many definitions of resilience, however one that was chosen to inform this analysis was *"For a transportation system, resilience is the capability to recover from a disruption to an operational level similar to prior to the disruption in a timely manner. The longer and deeper the impact of the disruption on operations, the less resilient a transport system is."* (Jean-Paul Rodrigue, 2022). According to this definition, each KFR was subjected to a disruption, defined as a set of road closures at high-use intersections along the route. The method defining where these closures were is provided in Appendix 0.

TraNSIT has the capacity to find the most likely freight route between any two points within the Australian road network based on logistics requirements and road access constraints. TraNSIT was therefore used to understand how freight could be re-routed in the event of closure of a given intersection on a modelled KFR. In some cases, however, re-routing was not possible, leading to some commodities not reaching their intended destination. A measure of the capacity of the system to recover and adapt from the disruption was therefore calculated for each of the disruptions for the modelled KFRs. The method describing this calculation is provided in Section 2.

A3.1 High-use and critical KFRs

Data from the National Key Freight Routes Web App was used to determine the KFRs to use in the analysis. An initial 315 KFRs were reduced to 52 high-use or critical KFRs for modelling and analysis, according to the below method.

Using TraNSIT road data, the KFRs were conflated with road segments in TraNSIT, and data relating to the supply chains on the initial 315 KFRs were derived. For each of these 315 KFRs, the following information was extracted using TraNSIT:

- the total volume of freight travelling on a KFR by commodity sector for each LGA that receives or sends freight
- the proportion of freight travelling on a KFR relative to all that move in and out of the LGA otherwise. This provides a measure of importance of the KFR, i.e. reliance of any LGA on a given KFR used to determine *critical* KFRs
- annual tonnage and value of all commodities being transported, number of trailers, number of supply chains and total unique commodity types on each KFR
- annual tonnage of essential good commodities transported, number of trailers, number of supply chains and total unique essential good commodity types on each KFR
- states or territories where the greatest proportion of each KFR passes through.

The final set selected for modelling included 42 *high-use* KFRs where there were: large annual volumes of freight and a diverse range of commodities, and high overall values and high proportions of essential commodities travelling on the KFR. To ensure that each state and territory were represented, a minimum of the top two KFRs based on the *high-use* criteria were included from each state or territory. The remaining ten KFRs captured the *critical* KFRs where LGAs are dependent on an accessible freight route for supply and/or pathway to markets. These KFRs were added since they were not captured as high freight use routes in the national picture. This resulted in the selection of a total of 52 KFRs for modelling and analysis.

A3.2 Disruption over the modelled KFRs

Using the data derived from TraNSIT on supply chains, each modelled KFR was analysed to identify the important feeder roads and their intersection with the modelled KFR, based on usual transport movements. The process involved ranking all intersections along the KFR based on total volume of freight moving through them and selecting the top three. These intersections were reviewed to determine their suitability for the modelling. If there was an expectation the intersection was not likely to provide insights to the vulnerability of the KFR overall, due to short detour opportunities, the next busiest intersection was used. The final set of intersections was identified as of strategic importance and subsequently used for the modelling to understand the potential impact of a disruption on each KFR – see Figure 73.

For each of these top three intersections, a road network was altered by closing (cutting transport across) the identified intersection, and then the TraNSIT model was re-run to understand the impacts on freight flows and determine if freight normally passing through that intersection could be re-routed. Figure 74 (a) illustrates this step for one of the three intersections on the KFR, where freight could find alternative paths (in orange). Here, three detours are illustrated - Detour 1 and Detour 2 (in orange), and Detour 3 (blue).

In some cases, re-routing was not possible and supply chains were deemed obstructed. Where re-routing was possible, the alternative route of the intersection with the highest increase in freight volume was closed in turn. This process was re-iterated until five alternative routes with the highest freight volume re-routed were closed sequentially. These subsequent alternative routes are referred to as alternative routes at increment *n,* where the maximum value for *n* was set to five in our model. Figure 74 (b) illustrates this step, where freight needed to be re-routed again from the closure of the intersection on the KFR, and the alternative route from increment 1. The freight movements previously re-routed in Detour 1 remain the same, however, those from Detour 2, cannot move through the closed intersection, which results in Detour 3. This leads to the identification of the next alternative route that would need to be closed for increment 2.

Algorithm 1 describes the steps implemented in the modelling for the alternative route selection.

```
For Intersection one to three of each KFR:
        Close main intersection and produce re-routed solution
 For each alternative route increment n= one to five:
                Find alternative freight path (route) n with highest increase in freight volume
                Close alternative route n, produce re-routed solution, and extract summary information
        Until n=5 or no alternative freight paths
```

Algorithm 1 Pseudo-code used in the modelling of the alternative route selections

This approach of successively removing alternative freight paths from a network is commonly used to test network performance. In the context of this project, successively closing alternative routes (i.e. removing edges in the overall road network) gave information about alternative paths for freight to reach its destination and how 'costly' these were. The notion of 'cost' here is broader than freight cost and includes a variety of metrics as defined in Appendix 0. By removing the edges one after the other, it was possible to get an indication of the performance of the network as it was pushed to its limit, and to inform when the maximum decline in performance was observed. The higher the number of recursive closed alternative routes, the greater the information about network performance. Due to the short timeline of this project and the high computing requirements to run the simulations, the maximum number of alternative route closures was set to 5.

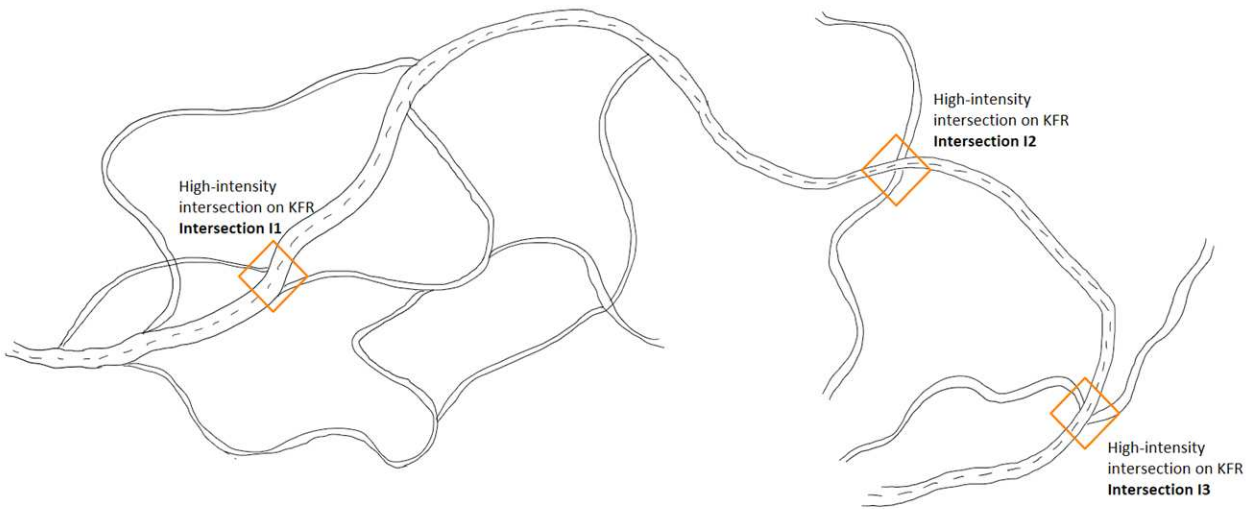

Figure 73 Illustration of the three intersections with the highest freight intensity on a given KFR

A model run is completed for each of these intersections, where it and its five alternative routes are closed in turn

(a) Re-routing from closure of high-intensity intersection on KFR (Intersection I1 and Intersection I2 orange box); and identification of next alternative route (n = 1), followed by (n=2)	(b) Re-routing from closure of high-intensity intersection on KFR (Intersection I1 - orange box) and high-intensity alternative route (n = 1,2) (Intersection $I1_{Inc1}$ - blue); and identification of next alternative route (n = 3)

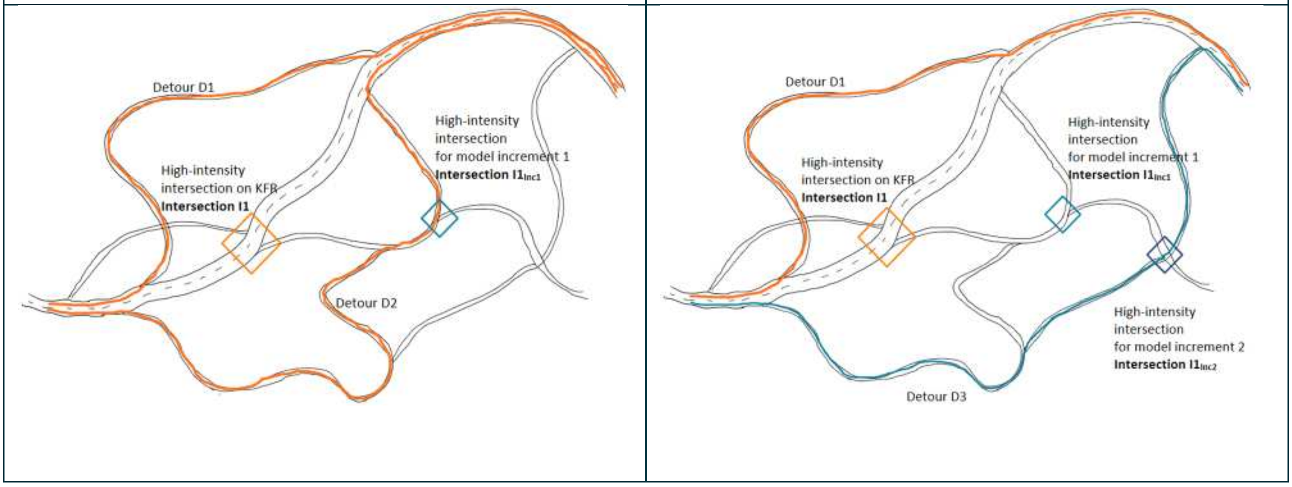

Figure 74 Illustration of the re-routing of freight from closing one of the intersections on the KFR (in orange)

The consequent re-routing of the freight is shown as well as the next alternative route to be closed in the following incremental model run (in blue). This is illustrated for increment one (a) and increment two (b).

Outputs of the modelling included:

1. Details of disrupted supply chain routes for each intersection closure and each iterative subsequent alternative route closure; and
2. Details of re-routed supply chain routes for each intersection closure and each iterative subsequent alternative route closure.

As such, for each KFR (52), there were three initial intersection closures, with five subsequent closures from the re-routed increments. This led to the TraNSIT model running 52*3*5 = 765 scenarios.

A3.3 Definition of metrics from the modelled KFRs

Using the results from the 765 scenarios, metrics were calculated for two main categories, relating to 1) the impact of the disruption on freight, and 2) the impact of the disruption on the communities receiving or sending the freight. For each of these broad categories, the following metrics were calculated:

Metrics relating to freight impact

KFR impacts risk - obstructed volumes for intersection: The relative risk of having high volumes of freight obstructed. This is calculated as the incremental proportion of freight volumes obstructed compared to business-as-usual (BAU) for each of the *n* high-intensity alternative routes removed, multiplied by the inverse of the increment number. It is calculated as:

$$\sum_{increment=1}^{n} (volume_{increment} - volume_{increment-1}) \Big/ volume_{BAU} * \, 1 \Big/ increment$$

The smaller the increment number, the higher the likelihood of a closure; the larger the volumes unable to move, the higher the consequences. This therefore results in a measure of risk, where the measure is between 0 and 1. Indeed, if most of the freight is obstructed at increment 1, this modelled KFR is at higher risk than the likelihood of closure at increment 5, even if the volumes obstructed are larger. Each route on the KFR had this value calculated, and the following metric was derived to describe each of the KFR intersections of interest:

- The relative risk over all the routes (KFR impacts risk - obstructed volumes for intersection)

KFR impacts risk - detour costs for intersection: The relative risk of having high costs of freight associated with their re-routing. This is calculated as the proportional increase of costs for the re-routed freight compared to BAU for the maximum value over all the increments. This relative maximum increase is then multiplied by the inverse of the increment for which the maximum increase was is found, so that it takes into account the likelihood of the occurrence of it. It is calculated as:

$$\left(\max(cost_{all\ increments}) - cost_{BAU}\right) / cost_{BAU} * 1 / increment_{max}$$

The smaller the increment number, the higher the likelihood of a closure; the larger the cost increase for freight re-routed, the higher the consequences. This therefore results in a measure of risk, where the measure is between 0 and 1. Indeed, if the freight costs increase the most at increment 1, this modelled KFR is at higher risk than the likelihood of closure at increment 5, even if the costs are increment five are larger. Each route on the KFR had this value calculated, and the following metric was derived to describe each of the KFR intersections of interest:

- The relative risk over all the routes (KFR impacts risk - detour costs for intersection)

<u>Note</u>: The two metrics defined above (*KFR impacts risk - obstructed volumes for intersection and KFR impacts risk - detour costs for intersection*) are unitless. In the analysis output, these measures are rounded to three decimal points for clarity purpose. In the case of very small values, the rounding can lead to a 0.000 value. While in some cases, this means that no freight has been obstructed or re-routed, in other cases, there might still be some obstructions or re-routing of freight, however these are very small.

Relative detour cost: The relative difference (in percent) between the tonnage-costs of the BAU situation and the situation with the *n* (here *n* = 5) high-intensity alternative routes removed. It is calculated for each of the routes as:

$$\left(cost^{k}_{increment\_n} - cost^{k}_{BAU}\right) / cost_{BAU}$$

where k is a freight path traversing an intersection on a given KFR.

This measure gives an indication as to how costly the closure of a series of alternative routes on the given KFR is.

Three metrics were derived to describe a KFR in terms of relative detour cost:

- The average relative detour cost over all the routes (***Relative detour cost – average***);
- The maximum relative detour cost over all the routes (***Relative detour cost – maximum***); and

- The average relative detour cost over each of the 12 months for all the routes (***Relative seasonal detour cost – average***).

The average relative detour cost value gives an overall value over all the supply chains, whereas the maximum annual relative detour cost value gives an understanding of the variability across supply chains using the KFR. The monthly information is used to highlight period of the years when the impact of the closure might be greater than at other times.

Relative value of freight unable to reach destination: The relative difference (in percent) between the value of freight of the BAU situation and the situation with the *n* alternative route is closed. It is calculated for each of the routes on a given KFR as:

$$\left(value^{k}_{increment\_n} - value^{k}_{BAU}\right) \Big/ value_{BAU}$$

This was done for two sets of supply chain routes: 1) all the commodities in TraNSIT, 2) essential commodities as defined in (Appendix A.2).

This measure gives an indication of the economic impact from a series of closures on the given KFR.

Two metrics were derived to describe a KFR in terms of relative value of freight:

- The total annual relative value for all commodities over all the routes (***Relative value obstructed - all commodities***); and
- The total annual relative value for all essential commodities over all the routes (***Relative value obstructed - essential commodities***)

<u>Metrics relating to community impact</u>

LGAs were used as the measure of population centre, or communities. As such, the metrics relating to the impact of the road disruption on the community were calculated using measures grouped at the LGA level. The following metrics were defined:

Relative reliance of a community on commodities traversing the intersection: The relative importance of the intersection to communities that are sending or receiving commodities traversing the intersection. This is calculated by getting the LGA with the highest volumes traversing the LGA, and calculating the percentage of this volumes to all volumes traversing the intersection, using the BAU data. It can be expressed as:

$$(volume_{BAU})_{LGA\,max} \Big/ (volume_{BAU})_{Traversing\ intersection}$$

The reliance described here equates to a risk factor and highlights the importance – and relative susceptibility - of this key freight route as a pathway for LGAs accessing suppliers and markets. This metric is calculated for the freight having its origin or destination in the LGA; where the value for the destination is more critical if the community has little alternative to receiving their commodities from other freight routes. Each of the three intersections on the KFR had this value calculated, and the following metrics were derived:

- The relative reliance for commodities having their destination in the LGA (***Relative reliance on intersection for destination LGA***)

- The relative reliance for commodities having their origin in the LGA (***Relative reliance on intersection for origin LGA***)
- The name of the most reliant LGA is also provided for both the origin and destination.

Relative impact on the overall population: The impact in terms of the percentage of LGA that are normally serviced by freight traversing the intersection that sees their freight disrupted, either with obstructed or re-routed freight. This gives an indication of how wide the disruption will be over many communities. It is calculated as the proportion of LGAs having any of its freight obstructed (or re-routed) over the total number of LGA serviced by the intersection. The following metrics were calculated and are available in the tables relating to community impact:

- The proportion of LGAs with obstructed freight – ***Number of LGAs impacted***
- The proportion of LGAs with detoured freight – ***Number of LGAs impacted***

Relative impact on communities' consumption: The relative impact of freight unable to reach its destination compared to the population's needs. The volumes considered are for all commodity types as well as those classified as essential in Appendix A2. It is calculated for each LGA as the percentage of tonnes not reaching its destination with the n (here n = 5) alternative routes closed compared to the BAU LGA consumption (i.e. imported plus local volumes of freight) over all commodity groups. Four metrics were derived for each KFR:

- The percentage of **obstructed** commodities over all impacted LGAs for all the routes on the KFR compared to these LGAs overall consumption
    1. Essential Commodities - All impacted LGA - Relative volumes impacted
    2. All Commodities - All impacted LGAs - Relative volumes impacted
- For the most impacted LGA, the percentage of **obstructed** commodities compared to its BAU consumption volumes
    1. Essential Commodities - most impacted LGA - Relative volumes impacted
    2. All Commodities - most impacted LGA - Relative volumes impacted
- The percentage of **detoured** commodities over all impacted LGAs for all the routes on the KFR compared to these LGAs overall consumption
    1. Essential Commodities - All impacted LGA - Relative volumes impacted
    2. All Commodities - All impacted LGAs - Relative volumes impacted
- For the most impacted LGA, the percentage of **detoured** commodities compared to its BAU consumption volumes
    1. Essential Commodities - most impacted LGA - Relative volumes impacted
    2. All Commodities - most impacted LGA - Relative volumes impacted

Note: the four metrics have the same names here for the obstructed and re-routed freight. This is so that the reader can refer more easily to the tables for obstructed and re-routing freight in each of the KFR analysis sections; and also because they are very similar in the way they are calculated.

A4 Overview of TraNSIT

TraNSIT is a modularised tool (Figure 75) where data for each commodity is an input to the core engine, along with the operating characteristics of the infrastructure and regulatory environment associated with the movement and handling of the commodity. The infrastructure and regulatory attributes can be adjusted for the purposes of testing scenarios of interest.

The core engine of TraNSIT simulates the number of vehicle trips per month moved between origin and destination enterprises. The goal of the TraNSIT model is to optimise transport route and vehicle selection along the transport network for each trip (from origin to destination), and then calculate the cumulative impacts at the enterprise or regional scale. Cumulative impacts can also be calculated at any other scale such as commodity, sector or network.

To determine the optimal road route, the analysis considers parameters such as costs, vehicle access and vehicle type according to the regulatory road class. TraNSIT will select/default to the lowest-cost vehicle combination based on heavy vehicle access restrictions throughout the journey from origin to destination. The optimal route selected may not necessarily be the actual route taken by the driver but rather the route that would be taken should the driver be seeking a least-travel-cost option.

To map rail movements the analysis also takes into account track standards (e.g. tonne axle load, siding lengths, gradients), train configurations, number and type of locomotives and rolling stock and the location and type of handling facilities (e.g. intermodal terminals).

The first stage processed inputs, constructs a set of vehicle and train movements between enterprises across the supply chains (Figure 75). Once the set of movements has been constructed, TraNSIT determines the optimal route (based on transport cost) and selection of vehicle types for each Origin-Destination (O-D) pair. Once the optimal network sections travelled for each O-D pair are saved within the model, Python scripts calculate the cost of transport and number of vehicles for a given flow between each O-D pair. These are then aggregated over all O-D pairs to provide a total cost of transport for the scenario being modelled. These outputs are synthesised to produce summary economics tables and freight usage maps.

Two user-friendly web portals have been developed to analyse outputs from TraNSIT (Figure 75). TraNSIT Web allows various freight analyses along the transport network and is currently available to Australian and state/territory government agencies responsible for freight and logistics. The Supply Chain Benchmarking Dashboard, released 15 October 2021, provides the capacity to analyse and compare freight trends between commodities and across each leg of the supply chain. The Dashboard can be accessed at www.freightaustralia.gov.au/dashboard.

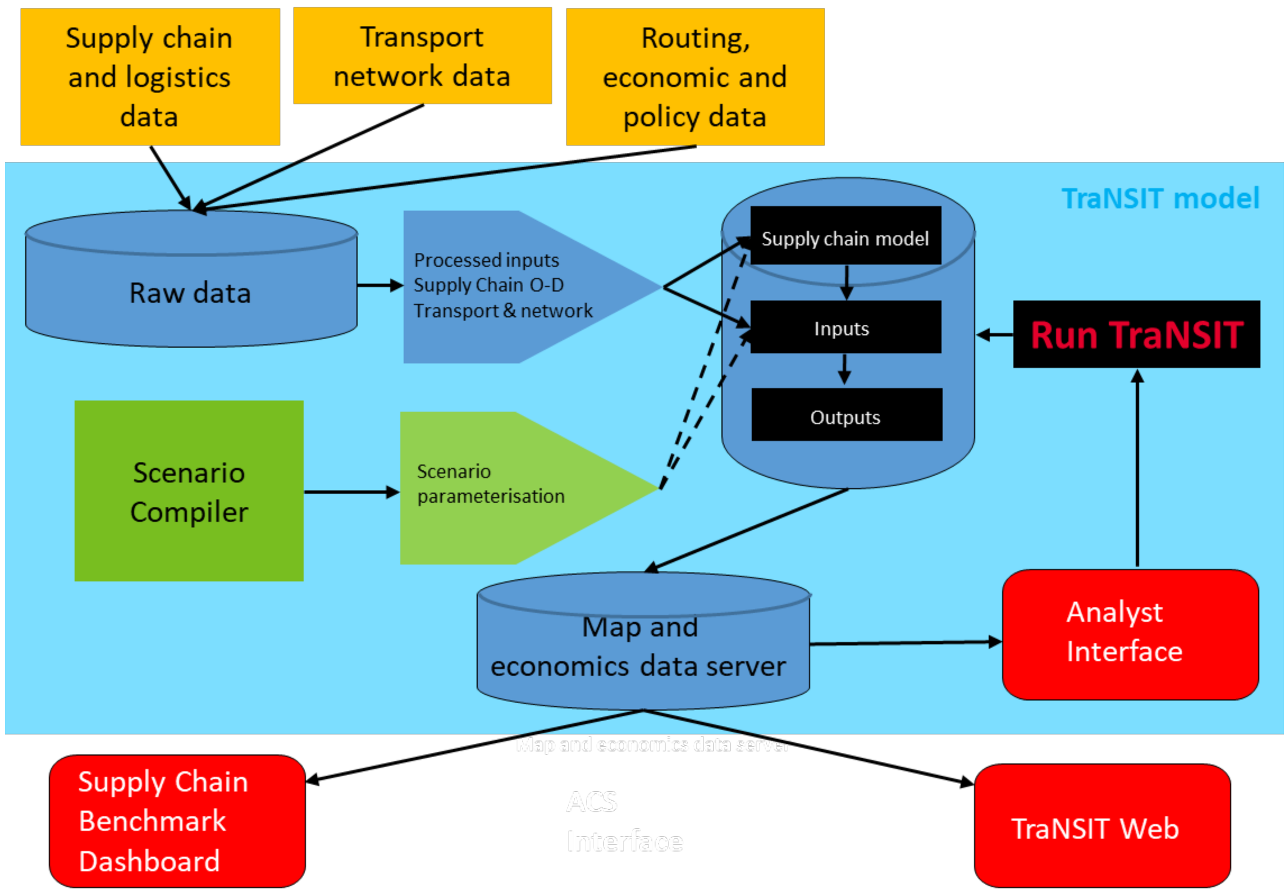

Figure 75 Process diagram of TraNSIT, comprising the stages from set up to running of each model component

An industrial enterprise relates to a site where a commodity (or commodities) is produced or consumed. Consumption in the context of an industrial enterprise relates to a commodity being used as an input transformed into a new commodity (e.g. wheat into flour), or as an input to a service enterprise (e.g. processed food into supermarkets).

As a route optimisation model, defining the transport network within TraNSIT is critical. TraNSIT contains data relating to the Australian road and rail networks, and this has been used for this project.

Road network data included in TraNSIT are ranked as primary, secondary and minor (including unsealed) roads. The road layer, represents in Figure 76, was constructed using the HERE network www.HERE.com, with additional road features incorporated from numerous other spatial files. These features include access restrictions and information on breakdown pads, biosecurity restrictions and rest stops. Spatial layers with different projections or coordinate systems were conflated to this road network using Artificial Neural Networks.

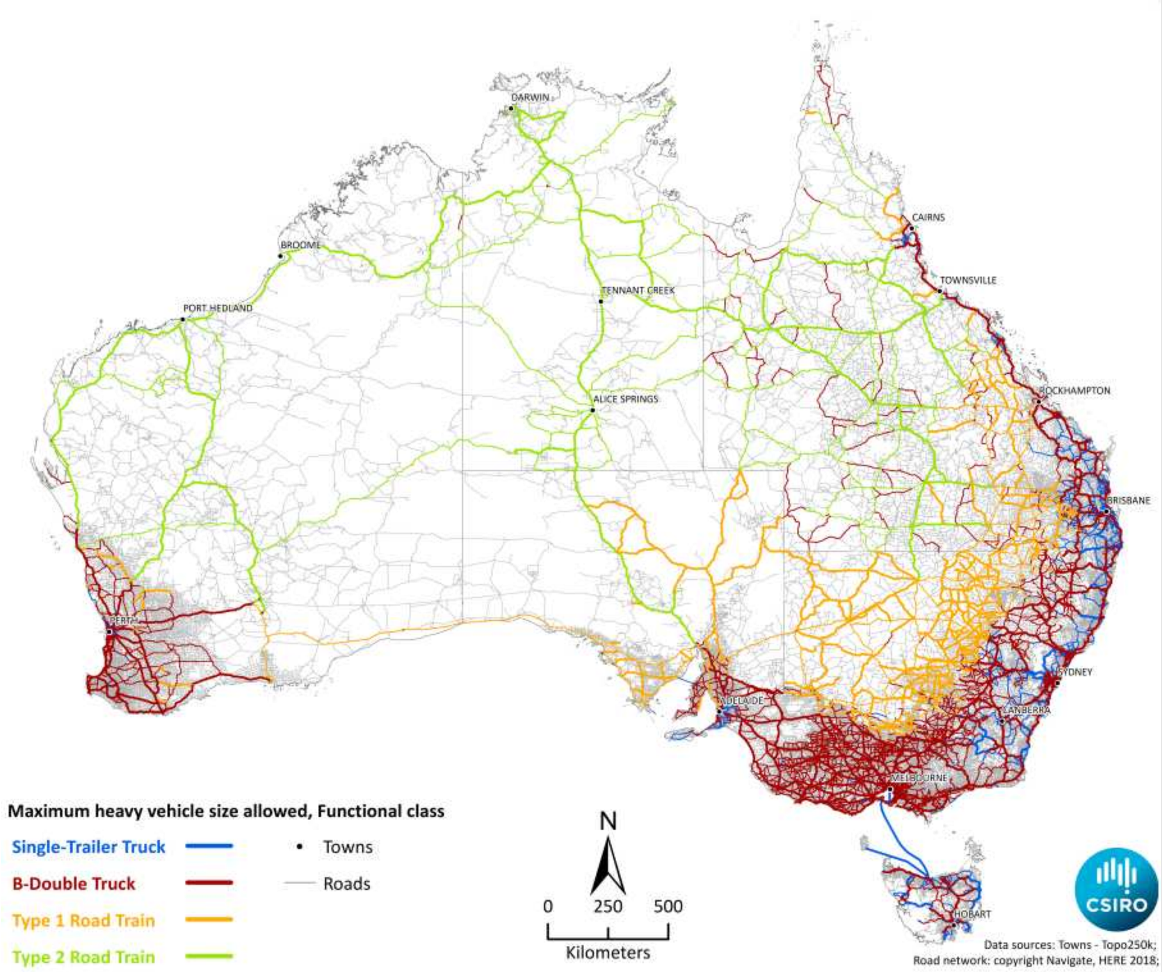

Figure 76 National baseline road layer used in TraNSIT showing heavy vehicle access

The National Heavy Vehicle Regulator (NHVR) www.nhvr.gov.au provides information on Performance Based Standard (PBS) access limitations for different types of heavy vehicles across the road network. The PBS system is used for most of Australia (WA uses a Restricted Access Vehicle system) to categorise permitted vehicle access for general mass limit combinations and for HML combinations. Figure 77 shows four basic PBS categories that accord with conventional truck and trailer configurations.

Figure 77 Typical PBS road access vehicles

Roads are also classified in terms of their relative importance, where a ranking of one represents major roads such as highways, a ranking of two represents significant local roads and a ranking of three represents roads mainly used for local travel.

Roads were further separated into segments with attributes describing surface type, width, speed limit and any special limits (e.g. one-way bridges). All of these attributes affect average speed and transport cost per kilometre.

The road layer required spatial enhancements (e.g. creating connections, correcting locations of some roads) to provide a fully routable road layer. The road network was further updated (particularly for southern Australia) to accommodate minor roads linking farms to storage facilities and processors, as well as to incorporate local government restrictions.

Figure 78 shows the rail layer used in TraNSIT for this project, highlighting different rail track gauges across the network. While not shown in Figure 78, the TraNSIT rail network layer also describes additional features including average speeds and axle load limits.

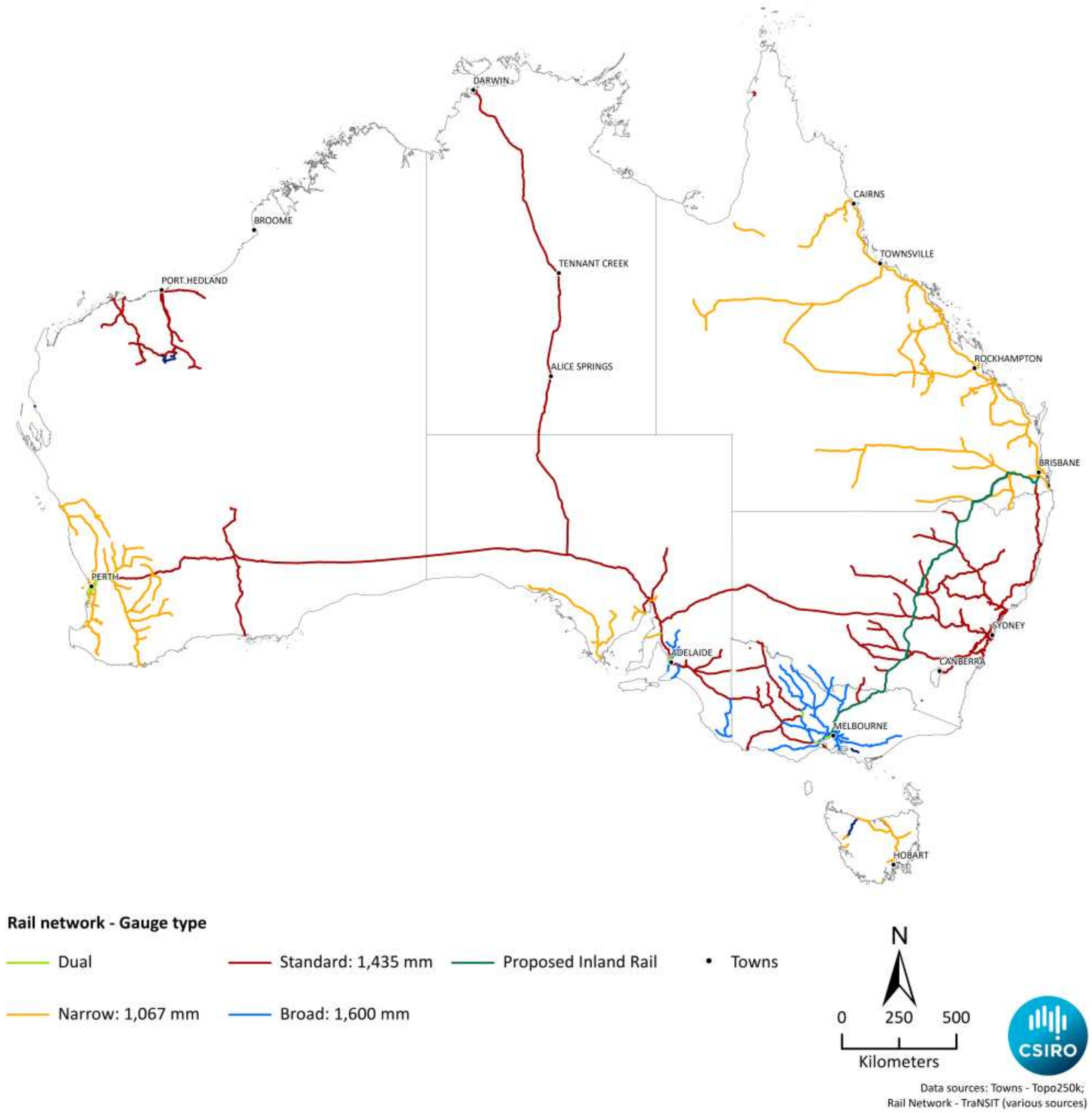

Figure 78 National baseline rail layer used in TraNSIT showing rail gauges

TraNSIT uses operating cost models for road and rail that estimate the cost of operating the heavy vehicle or train from origin to destination, including backloading. The costs include track access charges (rail) as well as registration and fuel excise costs (road) that cover income for rail and road network managers. They do not account for costs of road or rail construction. Costs of transport can be translated to dollars per payload tonne or total costs for individual supply chains.

Transport costs through the report are based on these cost models and do not represent freight rates (prices) charged for the transport service. Freight rates often differ from modelled costs depending on backloading, competition on different routes and market structures.

The operating cost models have been validated with freight operators across Australia over the past six years, who provided valuable knowledge to calibrate many of the input cost parameters.

Common cost parameters for road and rail are driver costs, capital depreciation, maintenance, fuel and fixed costs (e.g. administration, registration). The operating cost model is used to calculate the cost of the vehicle trip from origin to destination, accommodating changes in road conditions (surface, speed, gradient, etc.) for every segment. The total cost of the trip can be disaggregated into $/tonne or $/km or $/hr.

The road cost model is based on published equations for vehicle operating costs (Tan *et al* 2012; QDTMR 2011). Additional vehicle types were incorporated to accommodate vehicles used for different types of agriculture and post-processing supply chains. Variables described in the model include:

- Vehicle type - four typical vehicle configurations based on PBS road access regulations (see Figure 77), disaggregated further into more than 30 other vehicle types. These include AB triples (PBS3a) and BAB Quads (PBS4a)
- Fuel price
- Payload
- Fuel consumption - a function of incline, international roughness index, speed, tare, gross mass and vehicle type
- Travel distance and time, disaggregated for each segment along the route
- Driver costs
- Maintenance and tyre costs
- Fixed, capital and depreciation costs.

Throughout this and previous projects, the cost model has been enhanced for different types of unsealed roads, accommodating additional maintenance costs for vehicles.

Loading and unloading parameters of time and costs are uniquely determined by specific enterprises and are included in the freight travel time and cost, rather than vehicle transport costs.

Vehicle decoupling time and costs are included when required. For example, a Type one road train passing through Bourke to Dubbo would need to decouple into B-Doubles or Semi-trailers at Narromine. In this case, there is a cost in the decoupling at Narromine plus the cost of running two vehicle trips from Narromine to Dubbo instead of a single road train. This example applies to many road train trips from western NSW to Inland Rail loading points that only have B-Double access.

Driver fatigue management time and costs are also incorporated in the road operating model, implementing the Basic Fatigue Management solo driver work/rest schedule as described on the NHVR fatigue management website www.nhvr.gov.au.[18] Two-up basic, solo and two-up advanced schedules are options that can be implemented for scenario modelling. The two-up advanced fatigue management concept allows flexibility for drivers to manage their work hours providing for more efficient/effective route completion.

Greenhouse gas emissions (carbon dioxide equivalent (CO2e)) are also calculated using information on heavy vehicle fuel usage published by the Australian Trucking Association (ATA 2016) and emissions factors for combustion of different fuels as published in the National Greenhouse Accounts Factors (DEE 2016).

The rail operating cost model calculates the cost of every train along each rail segment. Variables included in the rail model include:

- 82+ train configurations, including number and types of locomotives and rolling stock, wagon capacity and train length
- Distance and track conditions – travel speed, tonne axle load limit (TAL)
- Track access charges
- Load efficiency and backloading
- Maintenance
- Fuel and crew costs
- Fixed, capital and depreciation costs.

A separate set of train configurations was set up for each commodity along each rail freight path, ensuring the configurations are representative of actual train movements and costs. As with the road operating cost modelling, loading and unloading parameters (time and costs) are enterprise and commodity-specific and are included in the freight travel time and cost, rather than rail operating costs.

[18] https://www.nhvr.gov.au/safety-accreditation-compliance/fatigue-management/work-and-rest-requirements/basic-fatigue-management-bfm

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