Visitor Management Model for Port Campbell National Park and Bay of Islands Coastal Reserve

Final Report
August 2001

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In association with:
Digital Land Systems Research
GIS Applications Pty Ltd
Environmental Systems Solutions
Parks Victoria Disclaimer

The views contained in this report concerning future park use are the views of the contractor and do not necessarily correspond with those of Parks Victoria. The future data is derived from predictive modelling techniques and therefore represent situations that may or may not arise. The report was prepared to provide park use data to support the management of the Twelve Apostles visitor site.

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Visitor Management Model for Port Campbell National Park and Bay of Islands Coastal Reserve

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1 Port Campbell National Park and Bay of Islands Coastal Park

Parks Victoria has the responsibility for management of over 3.8 million hectares of parks and reserves in Victoria, or 16% of the total area of Victoria. One of the major natural resource initiatives in Parks Victoria’s 1997-1998 corporate plan is to gain a clear understanding of the natural resources under Parks Victoria management and in the development of systems to guide future resource allocation, including the abilities to support management decision making and reporting.

Underlying the use of Victoria’s parks are two key assumptions: firstly that the visitor use and tourism in parks contributes to individual and collective well being, inspiration, education and economic prosperity, and secondly that visitor use and tourism must be environmentally sustainable in order to maintain or improve the first assumption.

Because the management of visitor services requires a significant proportion of available resources, there is a real need for improvements in understanding relationships between visitor use, customer satisfaction and the condition of the natural environment. These better understandings will allow the improvement in management of resources and in making effective use of limited financial resources, whilst maintaining or improving the condition of the environment.

Port Campbell National Park and the Bay of Islands Coastal Park are located on the Great Ocean Road, approximately 250 Km west of Melbourne. Comprising 65 Km of rugged and spectacular coastal scenery, the two parks are protected in a strip ranging in width from a few metres in the Bay of Islands park to 2 km within the Port Campbell National Park.

The parks have World Conservation Union (IUCN) ratings of Category II (National Parks) and Category III (National Monuments) and are designated for ecosystem conservation and appropriate recreation and protection of outstanding natural features, education, research and recreation respectively.
In addition to the main park attractions of coastal views, walks and water-based recreation, there are a range of other significant regional attractions from the Otways National Park to State Parks and the historic towns of Warrnambool and Port Fairy.

Figure 1. View of 12 Apostles, Port Campbell National Park, Victoria, Australia (photo by Itami)

The Port Campbell National Park and the Bay of Islands Coastal Park attract large and steadily increasing numbers of visitors (2.1 million visits per year in 1996/97 combined between both parks). Annual growth rate of the visitors is estimated at 3.55%, although it may be higher at some key sites.

This increase in visitation suggests that by 2001/2 there will be approximately 2.7 million visits per year to Port Campbell and Bay of Islands combined, causing considerable load on facilities and pressure on the coastal ecosystem. By 2006/7 this is expected to rise to 3.2 million combined visits per year for the parks.

The Visitor Management Model for Port Campbell National Park and Bay of Islands Coastal Park is a unique opportunity in Australia to demonstrate the use of GIS based recreation simulation as a cutting edge tool for evaluating alternative management scenarios. Like high use recreation areas worldwide, this study is typified by the high value the public places on the landscape that leads to the consequential heavy visitor use, and the inevitable crowding and decline of visitor satisfaction and environmental quality. In this study, RBSim 2, a recreation behaviour simulator, is used to examine the impact of changes in park infrastructure and increasing visitor rates over a 10 year period on the Twelve Apostles site in Port Campbell National Park. This site has recently been upgraded with a new parking lot and visitors centre. All parking south of the Great Ocean Road has been removed and visitors must now park in an improved parking lot north of the Great Ocean Road. Some 701,000 people visited the site in 2001/2 and by 2006/7 this is expected to be 864,000. The new visitor centre which
includes new toilet facilities and an interpretive centre provides a gateway to the site via a pedestrian tunnel that leads visitors under the Great Ocean Road along a path to the viewing platforms along the cliff edge of the spectacular views of the 12 Apostles. Traffic counts before and after the construction of the new facilities were taken to provide baseline and calibration data for the RBSim model. This report describes the construction of the simulation model, the results of the before and after simulations and comparisons with actual traffic counts as a means of validating the simulation model. In addition, simulation results are examined to answer a set of five management questions of key interest to the rangers of Port Campbell National Park.

These include:

1. How well will the new facilities at 12 Apostles cope with growing visitor loads?
2. How crowded will the site get in the future?
3. How will visitor satisfaction be affected by the new facilities and growing visitor numbers?
4. How is length of stay affected by the new configuration of the 12 Apostles site?

These management questions are answered via a set of more specific, operational questions using measures generated by the simulator in section 3.1.
2 RBSim Multi-Agent simulation of outdoor recreation.

Outdoor recreation is on the increase worldwide as people have more leisure time, greater mobility, and more disposable income. In addition there is a proliferation of new types of recreation such as mountain bike riding, snow boarding, canyoning and other emerging activities that have different environmental requirements and are often in conflict with more traditional outdoor activities. As visitor numbers increase, there is a simultaneous increase in environmental impacts, crowding, and conflicts between different recreational types and users. These circumstances make recreation management a complex problem. Managers of natural areas must accommodate increasing visitor use while at the same time, maintaining environmental quality and assuring visitors have the high quality experience they anticipate.

Conventional methods used in the design and planning of park management facilities have depended on user surveys and traffic counts to estimate the requirements. However these methods fall far short of the real needs of managers who need to comprehensively evaluate the cascading effects of the flow of visitors through a sequence of sites and estimating the effects of increasing visitor flows through time. In addition, managers need to know if designed capacities for parking, visitor centres, roads, camping areas, and day use facilities can accommodate projected visitor numbers. Crowding, conflicts between different recreation modes, impacts on environments and seasonal effects such as day length and weather are all factors park planners must consider in the design and location of new facilities.

There are many options available to park managers to deal with heavy visitor use. New sites can be opened up, a system of reservations can be implemented; areas can be closed so sites can recover from over use; facilities can be expanded or sites can be hardened to accommodate larger numbers of visitors. Each of these strategies will have different impacts on the overall system. The complex inter-relationships between these decisions are almost impossible for a manager to predict. It is in this context where simulation of recreation behaviour is of real value. This report describes a computer simulation methodology that uses intelligent agents to simulate recreation behaviour, coupled with Geographic Information Systems to represent the environment.

Even though simulations are built on assumptions to represent reality, they provide an excellent and rich source of data to answer management questions relating to facility capacities and visitor flows. Simulations are particularly valuable where “real world” data is difficult or expensive to collect or because of inherent constraints in traditional survey research methods.

RBSim 2 (Recreation Behaviour Simulation) (Gimblett & Itami, 1997; Gimblett, 1998; 1998a; Gimblett et al. 1999; Itami et al., 1999; Itami et al., 2000, Itami and Gimblett, 2000; Itami, in Press) is a computer simulation tool, integrated with a Geographic Information System (GIS) that is designed to be used as a general management evaluation tool for any park. This capability is achieved by providing a simple user interface that will import park information required for the simulation from a geographic information system. Once the geographic data is imported into RBSim 2, the park manager can change a number of variables including the number and kind of vehicles, the number of visitors, and facilities such as the number of parking spaces, road and trail widths and the total capacity of facilities.
RBSim 2 allows park management to explore the consequences of change to one or more variables so that the quality of visitor experience is maintained or improved. The simulation model generates statistical measures of visitor experience to document the performance of any given management scenario. Management scenarios are saved in a database so they can be reviewed and revised. In addition, the results of a simulation are stored in a database for further statistical analysis. The software provides tables from the simulation data so park managers can identify points of over crowding, bottle necks in circulation systems, and conflicts between different user groups.

![Figure 2. Visitors at viewing platform at 12 Apostles. (Photo by Itami)](image)

Specifically RBSim 2 uses concepts from recreation research and artificial intelligence (AI) and combines them in a GIS to produce an integrated system for exploring the complex interactions between humans and the environment (Gimblett et al. 1996a; Gimblett et al. 1996b, Gimblett 1998, Gimblett and Itami, 1997, Itami et al., 1999; Itami et al.,2000; Itami and Gimblett, 2000). RBSim 2 joins two computer technologies:

- Geographic Information Systems to represent the environment
- Autonomous “intelligent” software agents to simulate human behaviour within geographic space.

RBSim 2 uses autonomous agents to simulate recreator behaviour. An autonomous agent is a computer simulation that is based on concepts from Artificial Life research. Agent simulations are built using object oriented programming technology. The agents are autonomous because once they are programmed they can move about their environment, gathering information and using it to make decisions and alter their behaviour according to specific environmental circumstances generated by the simulation. Each individual agent has its own physical mobility, sensory, and...
cognitive capabilities. This results in actions that echo the behaviour of real animals (in this case, human) in the environment.

The process of building an agent is iterative and combines knowledge derived from empirical data with the intuition of the programmer. By continuing to program knowledge and rules into the agent, watching the behaviour resulting from these rules and comparing it to what is known about actual behaviour, a rich and complex set of behaviours emerge. What is compelling about this type of simulation is that, although it is impossible to predict the behaviour of any single agent in the simulation, it is possible to observe the interactions between agents and draw conclusions that are impossible using any other analytical process or field research.
3 The 12 Apostles RBSim Model

3.1 Introduction

The 12 Apostles site was selected as a case study to test the utility and validity of visitor simulation techniques for applied management. Historic traffic count data available for the study area and the recent changes to site infrastructure including a new parking lot and visitor centre provide an ideal set of circumstances to examine the interactions between visitor numbers, facility capacities, and visitor satisfaction. Park managers were asked early in the process for key management questions relating to the planning of new infrastructure for the site. The simulation model and analysis was then designed to address these management issues directly. These include:

1. How long will the new bus and car parks accommodate the projected increase in visitor use before the capacity of the parking areas are exceeded on peak visitor days? When will the overflow car park be required?
2. How many visual contacts will visitors experience as visitor numbers increase?
3. What are the queuing times for visitors for parking lots?
4. What is the satisfaction of visitors measured by queuing times and success rates of trips.
5. How is length of stay affected by the new configuration of the 12 Apostles site?

Two separate scenarios have been used as the basis for simulation outputs:

- Scenario 1 – previous facilities at the Twelve Apostles locale. This scenario is run to examine the key difference in performance between the old facilities at Twelve Apostles and the new expanded facilities completed in 2001.
- Scenario 2 – existing facilities at the Twelve Apostles locale. The major management questions were examined using the new facilities with visitor growth projections.

In order to examine the effects of increasing visitor pressures, scenario 2 was run for two projected time periods: 5 years (2006) and 10 years (2011). Altogether, five distinct simulation runs were generated. In each case the all simulation parameters remained the same except for the number of visitors:

1. Twelve Apostles in 2001 with the old facilities in use (Scenario 1)
2. Twelve Apostles in 2001 with the new facilities in use (Scenario 2)
3. Twelve Apostles in 2006 with the new facilities in use and car and bus arrivals projected for visitation levels in 2006 (Scenario 2)
4. Twelve Apostles in 2011 with the new facilities in use and car and bus arrivals projected for visitation levels in 2011 (Scenario 2)
5. In addition, the impact of opening overflow parking on facility capacities, and visitor encounters were also examined.

Appendix 1 gives a detailed explanation of each simulation parameter. The following sections show how each component of the scenarios were parameterised.
3.2 Road and Trail Network

Two networks were created to represent the “old” conditions at Port Campbell with the parking lot south of the Great Ocean Road, and the “new” conditions with the parking lot North of the Great Ocean Road. Scenario 1 Network

Figure 3. Scenario 1 network shows the layout of the parking lot south of Great Ocean Road. The roadway is a circular roadway with car parking at Node 317 and bus parking at Node 312. The boardwalk / viewing platform follows the cliff line along nodes 322, 301, 325, 305, 307, 330, 331 and 300.

Figure 3 shows the conditions at the 12 Apostles Locale before the new parking lot and visitor was installed. A single entrance off the Great Ocean Road brings two-way traffic south to a loop road with parking for cars and buses. Pedestrians then walk along the boardwalk with panoramic views to the west and northwest toward the 12 Apostles and toward the spectacular coastal views to the east and southeast.

3.3 Scenario 2 network

Figure 4. Scenario 2 network shows the layout of the parking lot north of Great Ocean Road. There are independent parking bays for buses and cars with overflow parking at node 422. There is a new visitor centre with toilet facilities and a pedestrian tunnel that allows visitors to safely cross the Great Ocean Road. The boardwalk / viewing platform is the same as in Scenario 1.

Figure 4 shows the conditions at the 12 Apostles Locale with the new parking lot and visitor centre. A single entrance off the Great Ocean Road brings two way traffic north with separate parking for 12 buses and 200 cars. In addition there is overflow parking for 40 cars. Pedestrians walk south of the parking lot to the Visitors Centre,
which has facilities for interpretation and toilets. From the Visitor Centre, pedestrians walk south through a tunnel under the Great Ocean Road. They then proceed south along a pedestrian path to the existing boardwalk with panoramic views to the west and northwest toward the 12 Apostles and toward the spectacular coastal views to the east and southeast.

See Appendix 2 (section 10) for details of remaining parameters (ie. facility capacities, agent profiles and behavioural rules, typical trips and arrival rates) for the 12 Apostles simulation runs.
4 Simulation Results

4.1 Introduction

Simulation results are broken into three sections:

- Section 4.2 (Scenario 1) - compares the old and new facilities under 2001 conditions.
- Section 4.3 (Scenario 2) - compares the new facilities under 2001 conditions against projected visitation for 2006 and 2011.
- Section 4.4 (Scenario 2 with overflow car parking) - compares the new facilities under 2006 and 2011 conditions but with the overflow car park open.

Each section uses the following key output criteria:

- Car park and bus park capacity. This is a measure of the locale’s ability to handle average and peak vehicle visitation across the day.
- Trip completion rates. This is a measure of a visitor’s ability to enter the Twelve Apostles locale and visit desired attractions.
- Visitor Encounters. This is a measure of crowding at a particular attraction. For comparison between old and new facilities, only the lookouts can be used as the layout of the locale changed significantly. All attractions were compared for future projections, with emphasis on the boardwalk and lookouts.
- Queuing time. This is a measure of the average and peak waiting time for a visitor to obtain a car park at the Twelve Apostles. Only successful trips are used for output purposes, as vehicles unable to enter the locale do not queue.
- Length of stay. This is a reality check more than a performance measure, as simulated length of stay can be compared to actual length of stay.

4.2 Scenario 1

The simulation results in this section compare the old facilities at the Twelve Apostles (Scenario 1) against the new facilities at the Twelve Apostles (Scenario 2) in the context of equivalent visitation for a 95th percentile day (Easter Saturday). In terms of results therefore, Scenario 1 is most useful for justifying the capital expenditure by Parks Victoria at the Twelve Apostles.

All the results are derived from averages taken from the outputs of 6 simulation runs for Scenario 1 and 6 simulation runs for Scenario 2.

4.2.1 Car Park Capacity

Average available capacity refers to the mean available car spaces over each hour of the day. For example, if the car park is full in the first half-hour and empty in the second half-hour, the mean available capacity is 50%.

The clear disparity in capacity between the old facility and the new facility is apparent in Figure 5. The old car park filled rapidly during the 9th hour and was effectively full from 11am to 5pm. That is, barely one space was available. The new car park has its lowest average available capacity at 14% between 1pm and 2pm.
Minimum available capacity (see Figure 6) refers to the minimum available car spaces at a given point in time during each hour of the day.

The old car park was full for some portion of each hour from 9am through to 7pm. The worst-case scenario at the new facility shows the minimum spaces available to be between 7% and 9% of capacity (approximately 12-14 spaces) between the peak times of 1pm and 5pm.
4.2.2 Bus Park Capacity

The average capacity available for buses (Figure 7) for scenario 1 is very similar to the pattern in scenario 2. This can be put down to the following factors:

- The small sample size of buses on Easter Saturday (44) compared to cars (1589)
- The small increase in the number of bus spaces available
- Buses stay at the site longer because of the increased pedestrian trip time due to the increased size of the site. This offsets the gain in bus parking capacity.

Anecdotal evidence suggests that the parking behaviour of buses has not conformed to the new regulated parking bays which are more distant from the viewing platforms. Buses instead park in informal areas adjacent to the visitor centre which are closer to the viewing platform. This indicates that bus operators are sensitive to the increased length of stay of their passengers.

The overall trend however suggests a slightly higher available capacity at the new facility.

The minimum available bus capacity (Figure 8) offers a clearer indication of the difference between the two facilities. The trend indicates that at a given point during most hours of the day the old facility has a lower available capacity in percent terms. The old bus park was full for periods between 2pm and 4pm. The new bus park, with a minimum available capacity of 3% between 3pm and 4pm, was effectively full at some point within that hour.

Figure 7. Facility Comparison (Average Available Bus Park Capacity)
4.2.3 Trip Completion Rates

The trip completion rate (Figure 9) reflects the success attempts by visitors to enter the Twelve Apostles locale and visit desired attractions.

The significant contributor to trip completion rates is the car and bus park capacity. At the old facility, the car park remained essentially full between 10am and 6pm. As a
result, many visitors could not access the locale, therefore failing to complete their desired trip. At peak times between 12pm and 5pm, only 1 in 4 visitors were successfully completing their trips.

The development of the new car park with its increased capacity has improved the trip completion rate to effectively 100%. That is, each visitor arriving at the Twelve Apostles locale can park their vehicle and access the attractions at the site.

4.2.4 Visitor Encounters

![Facility Comparison (Visitor Encounters at Lookouts)](image)

Visitor encounters refers to the number of other visitors that can be seen by an agent within their field of view (approximately 500 metres). Inter-visibility and terrain issues apply, so, for example, a visitor is unable to see other visitors around corners’. Other visitors within an agent’s actual party are not included in the count. For example, a car arrives with three people and they visit the boardwalk. Each of those three people sees on average 50 other visitors at 3pm. The two other people within their party are not included in the 50.

Visitor encounters reflect how available parking capacities and the trip completion rates contribute to overall visitation at the key attraction (ie. viewing platforms). At the previous facility, each visitor would see on average 8-10 other visitors during peak times. The old car park with its capacity of 28 spaces placed a theoretical cap on the number of visitors able to access the locale. The new facility, with its capacity of 165 spaces, has lifted this theoretical cap significantly. As the capacity for the locale to handle more vehicles increases, the number of visitors who can access the attractions also increases. This is shown by the significant increase in average visitor encounters to approximately 57 between 3pm and 4pm.

Of note, is that only the lookouts have been chosen for comparison analysis because of the significant change in the layout of the locale with the construction of the new facilities. Only the lookouts remain a consistent measure of comparison between the old and new layouts (see Figure 10).
Encounters should also be viewed in the context that additional crowding at the lookout might limit satisfaction improvements at the site.

### 4.2.5 Queuing Times

Figure 11 shows that the average queuing time at the old and new car parks is very similar. This may appear initially to be counter-intuitive as the first question asked would be “How come people would queue the same time at a car park with five times the spaces?” This can be explained by the following:

- The queuing process reflects the ability and opportunity to queue. The previous car park facility was often so obviously full that visitors often did not even try to queue – they moved on the next locale or tried to obtain a parking space elsewhere (see Appendix 1 for a description of the reasoning system agents use in wayfinding). The spacious new facility currently offers every visitor the chance to find, and queue for, a parking space.

- Carpark topology. The previous car park was simple in design in that it constituted a loop. The current car park has defined sections and is not unlike a supermarket or shopping centre carpark, in that cars drive to nearest spaces first, then negotiate turns to the next layer of bays and so forth. This layout lends itself to increases in queuing.

Figure 11 indicates that for either of the car parks, the average queuing time is essentially the same. Average queuing time remains under one minute, peaking at around 55 seconds between 1pm and 2pm.
Maximum queuing times (Figure 12) represents the extreme queuing time experienced. It only requires queuing by one vehicle to lift the figures.

This graph indicates that the odd visitor at the current car park experiences a higher maximum queuing time than if queuing at the previous car park. In terms of simulator runs, this can be put down to the complexity of the network topology and perhaps an instance of a vehicle queuing, driving around and seeing a vacant space, but then having it taken by another vehicle just before it gets there. This cycle could be repeated, causing the extreme queuing times shown.

4.2.6 Length of Stay

This output is more useful as a reality check than a performance indicator. Simulated length of stay at the previous facility tends to be in the range of 25 to 30 minutes on average. Simulated length of stay at the new facility tends to be in the range of 32 to 36 minutes. The extra walking distance with the new car park is major contributor to this increased time.

Of note in Figure 13 is the orange line, which is an actual length of stay calculated from vehicles at the Twelve Apostles on Easter Saturday 2001. The line has a wide range:

- 43 minutes between 6am and 7am, where visitors come to see the sunrise and wait for at the locale for a period after the rise.
- 36 to 40 minutes during the peak times in the afternoon; represented by the typical trip visitors.
- 28 minutes, falling to 18 minutes around dusk, where visitors come for the sunset but then tend to leave fairly quickly after sunset.
The average over the course of Easter Saturday was 32.5 minutes, which is close to simulator estimates for the current facility.

![Previous Facility v Current Facility Length of Stay (Successful Trips)](image)

**Figure 13. Facility Comparison (Length of Stay)**

### 4.3 Scenario 2

As Scenario 2 reflects the current layout of the Twelve Apostles, it is the ideal tool to run future projections. Benchmarks of 5 years (2006) and 10 years (2011) are used as they reflect strategic best practice and offer scope for capital planning and expenditure.

Bus and car estimates (see section 4.6) are used to increase the arrival curves to reflect estimated visitation for 2006 and 2011. Car visitation was estimated to increase at 3.5% per annum and bus visitation was estimated to increase at 7% per annum.

All the results are derived from averages taken from the outputs of 6 simulation runs for Scenario 2 at 2001, 2006, and 2011.

#### 4.3.1 Car Park Capacity

Although average available capacity is not estimated to reach zero within the next ten years, the critical 5% barrier (nearly full with less than 10 spaces) is projected to be breached between 1pm and 2pm in 2006. In 2011, it is projected that less than 8 spaces will available, on average, between the hours of 1pm and 5pm (see Figure 14).
Minimum available car park capacity, in Figure 15, show that the projections for 2006 indicate the car park will be full at some point in each hour between 1pm and 4pm. For 2011, projections indicate this will be the case for a longer period, ie. from 12pm to 5pm.
4.3.2 Bus Park Capacity

For bus parking capacity (Figure 16), all three curves tend to follow a similar shape. Average available capacity is projected to reach 10% in 2006, and 5% in 2011. In both cases the level is reached between the hours of 3pm and 4pm. Projections indicate average available capacity will not reach zero.

Figure 16. Facility Projection (Average Available Bus Park Capacity)

Figure 17. Facility Projection (Minimum Available Bus Park Capacity)
Projections for 2006 (Figure 17) indicate the bus park will be full at some point in each hour between 2pm and 4pm. For 2011, projections indicate this will be the case for a longer period, from 2pm to 5pm.

4.3.3 Trip Completion Rates

The decline in trip completion rates in Figure 18 is linked with the decrease in available capacity at the car and bus parking bays. Trip completion rates in 2001 are around 100%, primarily because the available capacity (average or minimum) never reaches zero.

In 2006, with average car park capacity projected to fall to 5% and minimum capacity projected to reach zero for at least three hours of the day, trip completions fall to the 91% - 95% range. As visitors arrive at the facility and find no parking spaces, they are forced to leave the locale.

In 2011, with average car park capacity around 3% for three hours of the day, and minimum capacity at zero for approximately 5 hours, trip completions fall to 80% during peak loading.

This is still a much higher figure when compared to the low completion rates attained when the previous facility was open.
4.3.4 Visitor Encounters

Figure 19. Facility Projection (Visitor Encounters at Lookouts)

With the visitation growth rates being applied (3.5% for cars, 7% for buses), the projections show that before 1pm, the corresponding and expected increase in visitor encounters is occurring (see Figure 19).

However, the encounter curves come closer together during peak times and then decline in unison. At peak times, the average visitor encounters at lookouts increase by only 5 visitors over 10 years. This is another example of the ‘theoretical ceiling’ that is placed on visitation at the Twelve Apostles by the parking facilities. Projected minimal capacity in 2006 and more so in 2011, creates a ‘visitation throttle’ at the car parks. That is, even though the locale can handle more visitors, the car parks limit the numbers able to access the site attractions. It is the same theory behind the ceiling created with the previous car park facility, although on a greater scale due to the larger car park spaces available.
Visitor encounters projected for 2006 and 2011 are shown in Figure 20. Visitor encounters in this figure include visitors at the lookouts, along links or paths, parking bays, and the visitor centre.

The shape of the curves is remarkably similar to that of the lookouts. The average encounters at peak times are approximately 75% of the lookouts as visitors are spread further throughout the locale.

4.3.5 Lookout and Boardwalk Capacity

An intermediate review of the outputs conducted in early July 2001 with key planning personnel at Parks Victoria indicated a desire to examine the available capacity at viewing lookouts and the boardwalk.

As a result, projections were prepared for the boardwalk and node 300 (the lookout at the extreme south end of the locale). Network topology shows that the boardwalk is actually made up of 4 separate lookouts along the boardwalk link. These nodes were placed along the link at well-known vantage points. Capacity was calculated using the following methodology:

- Initially the boardwalk was measured in its entirety
- On-site photos were taken of the boardwalk during busy periods. These photos confirmed the location of viewing nodes along the boardwalk link
- From each photo, the length of boardwalk shown was estimated.
- The number of people in the photo in that boardwalk segment was counted and applied as capacity for that viewing node.
This method showed that capacity along the boardwalk is approximately 325 people. Capacity at the far lookout is approximately 20 people.

**Figure 21. Facility Projection (Average Available Boardwalk Capacity)**

Projections in Figure 21 show that average available capacity declines uniformly from 2001 to 2011. It also shows that even in 10 years time, average carrying capacity falls just below 40%, indicating the facility, apart from maintenance and upgrades, can adequately handle further increases in visitation.

**Figure 22. Facility Projection (Minimum Available Boardwalk Capacity)**
The minimum capacity available in Figure 22 shows a similar pattern to the average capacity available except the figures are lower, reflecting peak usage throughout each hour. It is projected that in 2011 minimal capacity will dip just below 15%.

Figure 23. Facility Projection (Average Available Lookout Capacity – Node 300)

Average carrying capacity (Figure 23) at the small lookout at the south end of the locale remains between 20% and 25% during peak times for all three runs.

Figure 24. Facility Projection (Minimum Available Lookout Capacity – Node 300)
Figure 24 shows that the small lookout at the end of the boardwalk (known locally as “the bunker”) is, and is projected to be, at zero available capacity during peak usage within each hour from 9am to 7pm.

4.3.6 Queuing Times

![Figure 25. Facility Projection (Average Queuing Time at Car Parks)](image)

Projections in Figure 25 show that average queuing, by 2011, will be double that of 2001. Average peak queuing time is expected to rise to approximately 1.25 minutes by 2006 and to almost 2 minutes by 2011.
Figure 26. Facility Projection (Maximum Queuing Time at Car Parks)

Again, like maximum queuing comparison, the curves in Figure 26 represent the extreme cases. Increases are consistent however with the average queuing times. Visitors will take much longer to find a car park when the car park is near full at 2pm and 4pm.

4.3.7 Length of Stay

Figure 27. Facility Projection (Length of Stay)
Length of stay shown in Figure 27 is projected to remain close to what they are in 2001, with perhaps a slight decline, by at most two minutes during peak times.

Again, the average actual length of stay for the Easter Saturday is shown for reference.

### 4.4 Scenario 2 with overflow car parking

Another management issue raised during the intermediate review of outputs in July 2001 concerned the effect of opening the overflow car park and how it would relate to available car capacity, loading along the boardwalk, and trip completion rates.

With these results, the overflow car park, currently closed, unsealed and unregulated, was estimated to be able to hold another 40 vehicles. This increased the capacity of the current car parking facility to 205 spaces (a 25% increase).

Also, the issue of inter-visibility and the viewing range for visitor encounters was discussed. It was thought that visitors along to boardwalk would be more concerned with visitors within their immediate vicinity, say within 50 metres. However for inter-comparison purposes the resultant outputs are still based on a visible range of 500 metres to be consistent with other simulations. Other runs were accomplished to reduce viewing radius but are not included in this report.

These outputs are based on one simulation run only for the years 2006 and 2011. A simulation run for 2001 was not required as the car park has not reached zero available capacity and trip completion rates are around 100%.

It should be noted that the overflow carpark is not available for buses and will not address tour bus problems.

#### 4.4.1 Car Park Capacity

![Figure 28. Facility Projection (Average available car park capacity with overflow)](image)

Figure 28 shows that opening up the overflow car park has more of an impact in 2006 than it does in 2011. It is projected that in 2006 average available capacity increases by...
around 16% at peak times; in 2011 this increase is limited to the range 4-6% at peak times.

Figure 29. Facility Projection (Minimum Available Car Park Capacity with Overflow)

Again, Figure 29 shows that opening up the overflow car park has more of an impact in 2006 than it does in 2011. In 2006, the minimum available capacity during peak hours increases from zero to 12-15%. In 2011, the minimum available capacity still reaches zero during peak hours and opening the overflow car park has minimal impact as the car park will still be full for periods in each hour even with 25% more capacity.

4.4.2 Trip Completion Rates

Figure 30. Facility Projection (Trip Completion Rates with Overflow)
Opening the overflow car park increases the trip completion rate (Figure 30), as more visitors are able to enter the Twelve Apostles locale. This is an expected result.

### 4.4.3 Visitor Encounters

![Current Facility Projections - 2006 v 2011](image)

**Figure 31. Facility Projection (Visitor Encounters at Lookouts with Overflow)**

The most significant aspect of the above chart is the sizeable increase in visitor encounters in the 2011 case when the overflow car park is opened. Note the minor increase in visitor encounters in the 2006 case. The visitation ceiling created by the current facility car park is lifted as car park capacity is increased. This graph is consistent and complements the graph on Trip Completions, in that there is a substantial increase in successful trips in 2011.

Of note is the trade-off that may occur between trip completions and visitor satisfaction. Trips completions rise with additional car park spaces, but visitor satisfaction may decline as additional encounters can detract from the overall viewing experience, i.e., because of crowding.

### 4.4.4 Boardwalk Capacity

Projections shown in Figure 32 with the overflow car park open show a small decrease in average available capacity for both 2006 and 2011. This is consistent with more people being able to successfully complete trips to the Twelve Apostles because of the additional car parking.
Projections with the overflow car park open (Figure 33) show that in both 2006 and 2011 minimum available capacity would reach zero during peak times on the boardwalk. That is, the whole boardwalk will be crowded at some time during the day in both 2006 and 2011.
5  Management Conclusions and Recommendations

5.1 How well will the new facilities at 12 Apostles cope with growing visitor loads?

Results of the simulation show that bus parking will be inadequate occasionally during the busiest time of the day between 2:00 and 4:00 pm by the year 2006. This shortage is exacerbated by the year 2011 as bus parking is inadequate for the whole period from 3:00 pm to 5:00 pm.

For cars, the problem is worse. By 2006 the car park is full from 1:00 pm to 4:00 pm by 2011 the car park is full from 12:00 pm to 5:00 pm. The overflow car park will be required by 2006 and by 2011 even this facility will not accommodate the traffic volume by 2011 at peak times.

Note that for both cars and buses the situation in 2011 will still be much better than with the old facilities in 2001.

5.2 How crowded will the site get in the future?

As the number of successful visitors increase, there is increasing pressure on viewing platforms and lookouts. Crowding increases because of the increased duration of stay due to the longer walks to the viewing platforms and the increased capacity of car parks.

5.3 How will visitor satisfaction be affected by the new facilities and growing visitor numbers?

It is expected that visitor satisfaction will decrease with an increase in visitors. This is caused by increased queuing times at parking lots, an increase in the length of stay, the number of visual encounters, especially at viewing platforms, and the number of visits that fail because of lack of parking at peak periods. This can partially be resolved by increasing the capacity of viewing platforms, but the long term solution will require redistributing the visitors to other sites, especially at peak periods.

5.4 How is length of stay affected by the new configuration of the 12 Apostles site?

Although there are gains in successful trips from extended car parks, the greater area required will increase the length of stay and queuing times. The impact on the visitor will be that they will be more likely to succeed with their trip, but it will take longer. Bus operators will be particularly sensitive to increase length of stay.

5.5 Recommendations

- Bus parking will need to be managed between 3:00 pm to 5:00 pm within 5 years (eg. use informal spaces near the visitor centre).
- Limit car arrivals after 1:00 pm in 10 years or build an extension to the car park.
- Viewing platforms will have to be increased in capacity in the 5 to 10 year time horizon if the overflow car park is used or if the car park is extended further.
6 Future Research and Enhancements to RBSim

6.1 Research to improve validity and utility of simulation model
Model validation has been based on good traffic data, and typical trips and arrival curves based on intensive traffic counts and number plate matching. Further validation requires:

- A study of pedestrians – does the way RBSim currently simulate behaviour represent reality? This will require GPS tracking of individual visitors and recording movement, behaviour, preferences, and measures of satisfaction.

- A library of agents. Intelligent agents use logic, some of which is based on assumptions. What is required is a cognitive model based on data that will produce a library of transferable agents using some cognitive rational system. This will be important in using the simulator at other parks and adapting agents.

- Impacts on the park. Apply studies 1 and 2 to model aberrant behaviour and study the impacts of littering, trampling etc on the park environment and where this is most likely to occur. Impacts will effect sustainability of improvements.

- Study the effectiveness of management controls on visitor behaviour. This type of research will assist park managers to determine the appropriate and most cost effective methods for controlling visitor behaviour. Controls can range from closing off areas, to public education programs for long-term modification of attitudes and behaviour, particularly mitigating aberrant behaviour.

- Study of management decision-making processes to understand the most effective means of integrating modelling and simulation into Park Victoria’s visitor management business processes, particularly for large scale “visitor management” infrastructure projects.

6.2 Work to extend the application of RBSim to other Parks Victoria Properties
- Extending the scope of this simulation into visitation at Loch Ard Gorge
- Extending the scope to other park infrastructure provision locations eg.The Great Ocean Walk

6.3 Enhancements to RBSim functionality
- Implement probabilistic rules. Currently rules are conditional upon triggers defined by the user, however if an agent is assigned a rule it must always execute that rule if conditions of the triggers are met. In some cases, it would be desirable to execute a rule probabilistically. An example of a probabilistic rule might be “There is a 0.7 probability that an agent will go to the visitor centre” or 0.07 probability a visitor will walk off track if specific conditions are met.

- Implement options for agent behaviour relating to queuing for facilities. Currently if agents have an imperative rule (such as parking) and there is no
available capacity for that facility, the agent simply abandons the locale. It would be desirable in such cases to allow the option of having the agent enter the locale and queue even in cases where all parking spots are taken, to develop a more realistic measure of queuing times. If this rule were also probabilistic, field research could be used to validate and parameterise this rule.

- Implement concessionary transport modes, such as shuttle buses, tours, and other facilities that transport agents on a schedule.
- Enhance output reporting to generate standard summaries and interpretations of key measures such as queuing times, visual encounters, and facility capacities.
- Implement multi-day simulation schedules.
- Implement user fees, so RBSim can track potential income generated from the use of facilities.
- Link facility cost databases with RBSim facility attributing to apply infrastructure costing to simulations.
- Automate the generation of graphs from queries in the simulation outputs.
7 Acknowledgements

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8 References and Bibliography


9 Appendix 1 - Visitor simulation using RBSim 2

RBSim 2 uses object oriented software technology to model components of the overall simulation system. These software objects include:

9.1 Environment Model

The model of the environment is comprised of a travel network, a 3D terrain model and global events.

9.1.1 The Travel Network

The travel network contains network topology for roads, trails and other linear features with associated attributes and methods for calculating travel time and distances across the network. The travel network is defined by a set of links and nodes.

Nodes represent intersections between two links, or locations with one or more facilities. Nodes are connected to other nodes by one or more links. Node attributes include type of facility (car park, toilet block, visitor centre, etc) (if any), capacity of the facility, duration of stay, qualitative ratings of the node including scenic quality, historic value, or environmental value. Nodes may be grouped into “locales”. Locales are a group of nodes in proximity to each other that are accessed by one or more common entries and often represent a travel destination.

Links are linear features connecting two nodes. Links can support one way or two-way travel. Attributes associated with links include maximum travel speed, road or trail classification, one or two-way schedule of opening and closures and elevations at the start and end of the link. A link can be opened or closed on a schedule defined by the user.

9.1.2 Digital elevation model (DEM)

The DEM represents the elevation of the land surface and is stored as a grid matrix of elevations. Agents use it to define the elevation at endpoints of each link and in line of sight calculations.

9.1.3 Global Events

Global events are schedule events defined by the user that affect all agents simultaneously. These can be things like rainstorms, nightfall, temperature changes or any other event the user wishes to define. Agents respond to events via rules.

9.2 Agent Model

Agents are software tourists. Agents have inherent capabilities, such as vision, and a reasoning system in the form of a trip planner that allows them to navigate within a locale. Agents are assigned a “Typical Trip” when the simulation engine creates them. Each of these characteristics is described in more detail below.
9.2.1 Agent Vision

Agent’s can perform line of site calculations between themselves and any other object in the simulation environment. The line of site calculations take into account the screening effects of intervening terrain as represented by the DEM.

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Figure 34. Figure 6. Intervisibility is calculated in geographic information systems by calculating the angle of view starting from the observer position. As the angle of view increases moving away from the viewer’s position, the target is visible. If the angle of view decreases from the last maximum angle of view, the target is not visible.

9.2.2 Typical Trips

The typical trip represents a pattern of visitation within a park. The typical trip is defined by an entry and exit node to the travel network, one or more destinations, a travel mode, (car, bus etc.), a personality, a set of rules, a trip duration and an arrival curve.

9.2.2.1 Entry and Exit nodes

are the points in the travel network where the agent enters and leaves the park

9.2.2.2 Destination nodes

are a sequence of one or more nodes, normally defined as locale entry nodes, which define the order in which the agent visits major sites in the park. Each destination is defined by a node ID and a minimum and maximum duration of stay.
9.2.2.3 **Travel mode**

is the means by which the agent travels on arrival to the park. Travel modes are defined by a name (eg. “Car”) the maximum speed of travel, and whether or not the travel is “human powered” (eg. foot, cycling, backpacking). For travel modes such as cars or buses where there may be more than one passenger, the simulation engine assigns the numbers of passengers.

9.2.2.4 **Personality**

is defined by a set of preferences for site qualities. Preferences are ranked using the Analytical Hierarchy Process which allows ranks preferences using a method of pair wise comparisons. Each preference must correspond to a site quality attribute in the network.

9.2.2.5 **Agent rules**

are a set of user defined agent actions that are triggered by changes in the agent’s location, travel mode, or other characteristics of the network or agent. An interface for designing rules exposes the set of simulation properties that can act as triggers. Behaviours are always in the form of “find a facility”. A facility can be a parking lot, visitor centre, viewing platform, or any other facility defined by the user for the simulation. Each facility has three attributes of importance to the agent. The “Change Travel Mode” attribute, determines if the agent will change from its current travel mode to a new travel mode. The “Revisit” attribute determines if the agent will revisit the same or similar facility (eg. viewing platforms). The “Queuing” attribute determines if the agent will queue at the facility to wait for space to become available if the available capacity of the facility drops to zero. Agent rules are active within the context of a locale.

9.2.2.6 **Trip duration**

defines the probable duration of the trip in terms of the minimum, maximum and average time in minutes.

9.2.2.7 **The arrival curve**

represents the number of agents taking this trip during each hour of the day.

9.2.3 **Agent reasoning**

Agents are *goal oriented*. **Goals** are defined as destination or attraction nodes that the agent wishes to visit. Goals achieved by a *Travel plan*. A **Travel Plan** is a list of primary destinations within a “locale” in a network. A **locale** is a collection of one or more **nodes** with associated facilities that have a shared identity defined by proximity to each other and / or common access

When an agent arrives at a locale, the agent uses its internal reasoning system to decide which nodes to visit and in what order. The mode of travel, the personality profile, agent rules, time constraints and proximity of different attraction nodes to the point of arrival determine these decisions.
9.2.3.1 Motivations defined by agent rules

Motivations are defined by a set of rules that define triggers or “stimulus” that elicit a “response” or goal seeking behaviour to find a facility such as a parking lot, visitor centre, or viewing platform. Motivations are given priority based on the order in which the corresponding rules are assigned to the agent. Higher order rules are always executed before lower order rules. Some rules are imperative, in that they must execute before all lower order rules. An example of an imperative rule is that an agent arriving in a car must find a car park before executing any other rules.

9.2.3.2 Preferences for Site qualities

Agent preferences for scenery, history, environment or other user defined preferences must correspond to site qualities which are assigned to nodes. Site quality ratings are multiplied by agent preferences to calculate the “attractiveness” of a site to an agent. For example if an agent has scenic preference of 0.5, a preference for environment at 0.3 and a preference for history at 0.2. If a node has site quality rating of 7 for scenery, 10 for environment and 3 for history, the attractiveness rating is calculated as:

\[
\text{Site Attractiveness} = (0.5 \times 7) + (0.3 \times 10) + (0.2 \times 3)
\]

\[
\text{Site Attractiveness} = 7.2
\]

Site Attractiveness ratings are calculated for each node in the locale.

9.2.3.3 Travel mode and Travel Time

The travel mode of the agent will determine access to different sections of the travel network for a locale and the speed of travel. Travel time from a point of origin to each facility node or attraction node is calculated.

9.2.3.4 Time constraints

Each locale an agent visits has a duration of visit which is generated by the simulation engine between the minimum and maximum duration defined for that locale. As the agent executes its trip plan it constantly keeps track of the time left. The remaining time is compared to the estimated time to exit from the locale. If the difference in time approaches zero, the agent then abandons its trip plan and initiates behaviour to leave the locale (which may include stopping to return to a car).

9.2.4 Way finding during the execution of a plan

The above factors are all used in the agent’s trip planning reasoning system. The main aim of the agent’s trip planning logic is to maximise satisfaction by visiting as many attraction nodes as possible with the minimum amount of travel time within the constraints of the agent’s duration of visit for that locale. The agent must first satisfy any rules that apply to the given situation the agent is in, and secondarily seek attraction nodes that have the values reflected in the agent’s preference profile. For imperative rules (such as “find a car park”) the agent checks the locale to see if the specified facility is available (that is, there is available capacity). If there is nothing, then the agent cancels the trip and the trip to that locale is counted as a “failed trip”.

40
The trip planner is incremental in that the agent seeks to satisfy as many rules as possible, but will always seek the path that leads to the highest priority nodes as defined by the ordering of rules (the first rule is always higher priority than the last rule), and to nodes that have the highest preference values. The simulator uses a simple gravity model to weight nodes that are closest in travel time to the agent than those that are further away. This produces a satisfying behaviour where the agent does not generate an entire “perfect trip”, but incrementally moves from one attraction node to the next, each time, re-evaluating the trip as the agent arrives at an attraction node. The agent keeps track of nodes that have already been visited and sets the site attraction values and the facility values to zero, so as each incremental segment of the trip is selected, sites that have already been visited will always have lower value than sites that have not been visited. This ensures the agent is always moving toward “new” opportunities and does not do a lot of backtracking to visit new locations.

At execution time the agent’s reasoning system works in the following logic:

At then entry node for a locale, the agent generates a duration for the locale.

If the duration is zero, the agent does not enter the locale and continues on its global trip.

If the duration is greater than zero, but greater than the duration for the remainder of the global trip, the agent does not enter the locale and continues on its global trip.

The agent then checks its list of rules. If there are any imperative rules (eg. find a parking space) for a facility the agent checks the locale for nodes that match this facility that have available capacity. If there are no nodes that meet this criterion, the agent records the trip as a failure and continues on its global trip. If there is one or more nodes with facilities with capacity, the agent then evaluates all trips and selects the trip that ranks the highest according to the method described earlier.

Once a trip is generated, the agent traverses the path selected. Travel speed is determined by travel mode, maximum speed of the link, fitness of the agent, and whether travel is downhill or uphill.

When an agent reaches a node with a facility, the agent checks it’s rule list to see if it is a facility that it needs to visit. If the facility matches a rule, the agent generates a duration for the facility and waits at the node until the duration is complete. If the facility has the “Change travel mode” attribute, then the agent changes travel mode from the current mode to the alternate mode and then stores the NodeID in a special list to keep track of where the agent left the vehicle. If the facility does not have the “repeated visit” attribute, then the Facility ID for the rule is set to zero so the rule does not fire again for this locale. The agent continues checking each facility (if there is more than one) at the node checking each against its rule list until all facilities and all rules have been processed for that node. After each facility is processed, the NodeID is recorded in the agent’s “Nodes Visited” list. If a facility has the “Queuing” attribute set and there is no capacity at this facility, then the agent changes it’s state to “queuing” and is added to the bottom of a queuing list. In the next iteration of the simulation the simulation engine processes all agents in queues in the order that they entered the queue before other agents. This ensures that there is no “queue jumping” by agents. The agent then generates a new trip in the manner described above.

Time constraints on the agent’s trip are checked as the agent enters each node. The agent compares the time remaining for the duration to the locale and estimates the time it takes to exit the locale. If the sum of the time it takes to exit the locale and the
duration at the node exceeds the remaining duration at the locale, the agent then 
abandons the current trip. I doing this, it checks it’s rule list to see if any facility that 
was visited had a “change travel mode” attribute. If it did, then the agent plans a trip 
to return to the node where the vehicle was left. Once the agent returns to that node, 
the agent changes travel modes and then plans a trip to the exit node for the locale. 
Once the exit node is reached, the agent continues on its “global trip”.

9.3 Scenario
A scenario is a specific combination of:

- Network
- Typical trips
- Agent rules
- Global Events
- Link closure schedules

The user uses the scenario builder interface to select these. In addition, the user may 
also select the simulation outputs for the scenario, including graphics display, 
statistical outputs, sampling rate, and simulation time step.

9.4 Simulation Engine
The simulation engine controls the scheduling of agents, controls simulation events 
such as weather, road opening and closure, seasonal events and other user defined 
events. It works by reading in all the data files specified in the scenario. It then 
subsets locales and pre-calculates travel times for each locale network. It then 
generates an arrival schedule for each agent from the arrival curves for each typical 
trip. Finally it starts the simulation time clock and performs the following functions 
during runtime:

- Generates agents from the arrival schedule assigning them a personality, a 
  travel mode, a fitness level, a global trip, trip duration, and a set of rules.
- Generates any global events scheduled at the times defined for each event.
- Opens and closes gates according the gates defined for the scenario.
- Determines the execution order by processing agents waiting in queues first 
  and then randomising the order of remaining agents.
- Generates outputs if specified in the simulation set up.
- Displays graphical output at run time if the user requests graphic outputs.
10 Appendix 2 – Simulation parameters for 12 Apostles

10.1 Facilities and Site Attractions

The 12 apostles site has a number of facilities and site attractions that are attributed to nodes in the two scenario networks these are summarised below:

10.1.1 Scenario 1

The original layout at 12 apostles has the facilities shown in table 1. These figures are based on a physical survey of the site.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewing Platform</td>
<td>345 People</td>
</tr>
<tr>
<td>Disabled Car Park</td>
<td>2 Cars</td>
</tr>
<tr>
<td>Bus Park</td>
<td>6 Buses</td>
</tr>
<tr>
<td>Car Park</td>
<td>28 Cars</td>
</tr>
<tr>
<td>Informal Lookout</td>
<td>5 People</td>
</tr>
</tbody>
</table>

*Table 1. Facilities and capacities for Scenario 1*

Viewing platforms and lookout points were attributed with site quality ratings for scenery, education, and environmental values.

10.1.2 Scenario 2

There are major differences between the new site layout for 12 Apostles in Scenario 2 and the old layout in Scenario 1. The main difference is in the number of parking spaces. Table 2 shows that the increase in car and bus parking places. The viewing platform is identical in the two scenarios. Scenario 2 also has a visitor centre with toilet facilities. These figures were estimated from master plan drawings and site photographs.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewing Platform</td>
<td>345 People</td>
</tr>
<tr>
<td>Informal Lookout</td>
<td>30 People</td>
</tr>
<tr>
<td>Bus Park</td>
<td>12 Buses</td>
</tr>
<tr>
<td>Car Park</td>
<td>245 Cars</td>
</tr>
<tr>
<td>Visitor Centre</td>
<td>100 People</td>
</tr>
<tr>
<td>Toilet</td>
<td>29 People</td>
</tr>
<tr>
<td>Trailer Park</td>
<td>12 Cars</td>
</tr>
</tbody>
</table>

*Table 2. Facilities and capacities for Scenario 2*

The site quality ratings in scenario 2 were identical to scenario 1 except that additional educational values were assigned to the visitor centre.
10.2 Agent Profiles

10.2.1 Personality Profiles

Personality Profiles for both scenarios were identical. Two personality profiles were developed to demonstrate how different personality profiles are generated. The “Average Family” profile has equal preferences for Scenery, Environment and History, whereas the “Nature Lover” has higher preferences for Environment and Scenery and a lower preference for History as indicated in Table 4. Typical trips for each scenario had an equal probability of having Average Family or Nature Lover assigned to each agent. Table 3 shows this distribution.

<table>
<thead>
<tr>
<th>Trip</th>
<th>PersonalityName</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car Trips</td>
<td>Average Family</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Nature Lover</td>
<td>0.5</td>
</tr>
<tr>
<td>Bus Trips</td>
<td>Average Family</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Nature Lover</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 3. Probability distribution of agent personalities to typical trips

Table 4 shows the importance ratings for each personality for site attributes. These weights were identical for agents in each scenario.

<table>
<thead>
<tr>
<th>Personality</th>
<th>Caption</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Family</td>
<td>Scenery</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>History</td>
<td>0.33</td>
</tr>
<tr>
<td>Nature Lover</td>
<td>Environment</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Scenery</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>History</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 4. Site quality preferences for the two agents in the simulation. The weights for each agent sum to 1 and correspond to the site qualities assigned to the travel network.

10.2.2 Agent Rules

Table 5 shows the agent rules used in the scenarios. Scenario 1 used rules 1,2 and 5 and Scenario 2 used all 5 rules. These rules direct the behaviour of the agents once they enter the 12 Apostles locale. Note that special rules (3 and 4) are needed in Scenario 2 for the new visitor centre and toilet facilities.

<table>
<thead>
<tr>
<th>Rule ID</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>If Arriving at a Locale in a Car then find a Car Park</td>
</tr>
<tr>
<td>2</td>
<td>If arriving at locale entry in a bus then find bus parking</td>
</tr>
<tr>
<td>3</td>
<td>When at 12 Apostles Find Visitor Centre</td>
</tr>
<tr>
<td>4</td>
<td>At 12 Apostles Find Toilet</td>
</tr>
<tr>
<td>5</td>
<td>At any Locale find Viewing Platform (repeatedly)</td>
</tr>
</tbody>
</table>

Table 5. Rules used by agents during the simulation runs. Scenario 1 uses only rules 1, 2 and 5, Scenario 2 uses all 5 rules.
10.3 Typical Trips

Two typical trips were assigned to each scenario: one for buses, the second for cars.

<table>
<thead>
<tr>
<th>Description</th>
<th>Min Duration</th>
<th>Max Duration</th>
<th>Travel Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buses Easter Saturday 2001</td>
<td>60</td>
<td>80</td>
<td>Bus</td>
</tr>
<tr>
<td>Cars  Easter Saturday</td>
<td>30</td>
<td>40</td>
<td>Car</td>
</tr>
</tbody>
</table>

Table 6. Typical trips for scenarios 1 and 2. The trip durations for the 12 Apostles are generated randomly by the simulator between the minimum and maximum duration (in minutes) for cars and buses.

10.3.1 Arrival Curves for Cars at 12 Apostles for 2001, 2006 and 2011

The arrival curves for cars were the same for both scenarios. Arrival curves were taken from traffic counts commissioned by Parks Victoria. Counts used in the simulation were summarised from counts taken on Easter Saturday 14 April 2001. This was the busiest visitor day over a survey period from 13 April to 13 May 2001. Figure 35 shows the arrival curves for 2001, 2006 and 2011. The projections for 2006 and 2011 were based on an estimated annual growth rate of 3.55% (See Appendix 4 for the method used to estimate this growth rate). The total number of vehicles per day is 3590 cars for 2001, 3893 cars for 2006, and 4253 cars for 2011.

Figure 35. Car arrival curves used in the simulations for 12 Apostles. The chart shows the 2001 Easter Saturday traffic count data as well as the projections for 2006 and 2011 based on a 3.5% annual increase.
10.3.2 Arrival Curves for Buses at 12 Apostles for 2001, 2006 and 2011

The arrival curve for buses was the same for both scenarios. Arrival curves were taken from traffic counts commissioned by Parks Victoria on the same date as for cars (Easter Saturday 14 April 2001). Figure 36 shows the arrival curves for 2001, 2006 and 2011. The projections for 2006 and 2011 were based on an estimated annual growth rate of 7% (See Appendix 4 for the method used to estimate this growth rate). The total number of vehicles per day is 44 buses for 2001, 61 buses for 2006, and 88 buses for 2011.

![Arrival Curves for Buses at 12 Apostles for 3 simulation periods](image)

Figure 36. Bus arrival curves used in the simulations for 12 Apostles. The chart shows the 2001 Easter Saturday traffic count data as well as the projections for 2006 and 2011 based on a 7% annual increase.

10.4 Simulation Runs

RBSim randomises many parameters during each run. It is therefore necessary to run each scenario more than once in order to ensure conclusions are not drawn from artefacts that result from a specific random event from a single run. To buffer these effects, each scenario was run 6 times with the same simulation parameters and then the results averaged before interpreting the results.

Each simulation was run from 6:00 am to 11:00 pm
Appendix 3 – Methods for Calculating Summary Statistics

The summary statistics can be calculated because each agent in a simulation is able to ‘dump’ statistical data about their trips into various output tables for analysis.

11.1 Available Capacity

1. An initial query linking the ‘Facility Loads’ table with the ‘Locale’ and ‘Facility’ tables to put ‘names’ to table identifiers is used. The time field for each record is converted to an hour frame variable. For example, if the time in the record is 09:59:00, the hour frame is 10 (representing the 10th hour).

2. Outputs are generally split into daily loads and hourly loads. Intermediate calculated queries are used, grouping output by Locale, Node and Facility ID. For daily loads, the average is applied for each group over the course of the day. For hourly loads, the average and minimum capacity is calculated for each group over each hour of the day.

3. Final queries based on the intermediate queries filter output by given nodes (eg. car park, bus park or lookout).

4. The exceptions to this are the new facility carpark and the boardwalk. Both are made up of multiple nodes and the output process varies slightly…
   - The initial query is still used, but other intermediate queries are required
   - The first query filters the relevant nodes for the facility and sums the load over all the nodes
   - The second query then converts that load to available capacity. This is done by subtracting the summed load from the new summed capacity
   - Intermediate calculated queries are used to generate averages and minimums as per other capacities

11.2 Visitor Encounters

1. Visitor encounters are derived from two tables – ‘Links’ and ‘Nodes’. Each record in those tables contains the time and the number of encounters. Initially, a macro is run that extracts this information from both tables and combines it in a new table ‘tbl_TotalEncounters’.

2. Encounters are calculated by agent. Therefore an intermediate query is used that for each agent, converts the time of contact from each agent’s record to an hour frame variable, and calculates the total encounters and the average encounters for that agent.

3. The final query uses the intermediate query and links it with the ‘Locale’ table to put a ‘name’ to the link identifier

4. Queries used to determine encounters at lookouts use the same methodology but apply a filter to separate the lookout nodes from other nodes
11.3 Trip Completions

1. Trip Completions use data extracted from the ‘TripResults’ table. The major intermediate query takes the trips planned and trips successful and calculates the number of trips that were altered or failed. It also converts the departure time into an hour frame variable.

2. Separate queries are used for buses, cars, and overall trips. These use a filter on the Arrival Travel Mode.

3. The second intermediate query calculates totals and averages for total trips planned for each agent, successful trips and failed trips. These are grouped by hour frame for hourly figures and ungrouped for daily figures.

4. The final query formats the data and calculates completion and failure rate percentages.

11.4 Length of Stay

Length of stay can be calculated for an entire trip throughout the park or for time spent in individual locales. For the entire trip, one query is used that calculates the average planned trip stay, average actual stay, average number of sites visited, and the average length of stay at those sites.

For individual locales, the process is more complicated...

1. An initial query linking the ‘Nodes’ table with the ‘Locale’ and ‘Facility’ tables to put ‘names’ to table identifiers is used.

2. The first intermediate query sorts each agent output in the node table in node output id order.

3. The second intermediate query uses the sorting query to isolate the first and last records for each agent during their stay in the locale. Two queries are then used to transfer the first and last contact time based on the records isolated in the previous query.

4. A Minimum-Maximum query takes the first and last contact times and calculates the time difference in between ie. length of stay. The hour frame variable is calculated on the entry time.

5. The final query which calculates the average length of stay for each locale over each hour of the day.

11.5 Queuing Times

Like length of stay, queuing can be for a trip throughout the park or individual queuing at a particular node (generally car parks). For the entire trip, one query is used that takes the total queuing time from the ‘TripResults’ table and calculates the average passenger queuing time and maximum passenger queuing time.

For individual nodes:

1. An initial query linking the ‘Nodes’ table with the ‘Locale’ and ‘Facility’ tables to put ‘names’ to table identifiers is used.

2. As the ‘Nodes’ table records cumulative queuing, an intermediate query is used to extract the final record in the sequence for each agent at each node and facility.
3. The next intermediate query eliminates the agent and groups the records by hour frame. This can be done at either the node level or at the locale level.

4. Different queries are used to calculate total queuing, average queuing, and maximum queuing. The queries are duplicated so output can be arranged by locale, node or facility.

5. Daily totals are also calculated by eliminating the hour frame variable.


## 12.1 Survey Period Summary for Traffic Count Data April/May 2001

<table>
<thead>
<tr>
<th>Date</th>
<th>2&amp;3 Axle Truck/Bus</th>
<th>4 Axle Truck / Articulated</th>
<th>Car Towing</th>
<th>Motorcycle</th>
<th>Unknown</th>
<th>Total Vehicles</th>
<th>Total Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-Apr-2001</td>
<td>59</td>
<td>3</td>
<td>1291</td>
<td>4</td>
<td>15</td>
<td>0</td>
<td>1372</td>
</tr>
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<td>14-Apr-2001</td>
<td>44</td>
<td>4</td>
<td>1587</td>
<td>2</td>
<td>11</td>
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<td>1648</td>
</tr>
<tr>
<td>15-Apr-2001</td>
<td>56</td>
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<td>1451</td>
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<td>26</td>
<td>1</td>
<td>1536</td>
</tr>
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<td>16-Apr-2001</td>
<td>43</td>
<td>2</td>
<td>1282</td>
<td>9</td>
<td>20</td>
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</tr>
<tr>
<td>17-Apr-2001</td>
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<td>982</td>
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<td>27</td>
<td>0</td>
<td>1049</td>
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<td>3</td>
<td>23</td>
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<td>989</td>
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<td>21-Apr-2001</td>
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<td>0</td>
<td>661</td>
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<td>447</td>
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<td>644</td>
<td>9</td>
<td>24</td>
<td>1</td>
<td>722</td>
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<tr>
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<td>537</td>
<td>4</td>
<td>8</td>
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<td>7</td>
<td>0</td>
<td>567</td>
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<td>0</td>
<td>522</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>568</td>
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<tr>
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<td>5</td>
<td>0</td>
<td>426</td>
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<td>2</td>
<td>486</td>
<td>6</td>
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<td>02-May-2001</td>
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<td>467</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>516</td>
</tr>
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<td>432</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>482</td>
</tr>
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<td>04-May-2001</td>
<td>37</td>
<td>1</td>
<td>456</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>505</td>
</tr>
<tr>
<td>05-May-2001</td>
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<td>534</td>
<td>5</td>
<td>8</td>
<td>0</td>
<td>581</td>
</tr>
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<td>06-May-2001</td>
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<td>6</td>
<td>520</td>
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<td>11</td>
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<tr>
<td>07-May-2001</td>
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</tr>
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<td>08-May-2001</td>
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<td>2</td>
<td>459</td>
<td>4</td>
<td>3</td>
<td>1</td>
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</tr>
<tr>
<td>09-May-2001</td>
<td>55</td>
<td>2</td>
<td>427</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>493</td>
</tr>
<tr>
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<td>40</td>
<td>2</td>
<td>391</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>446</td>
</tr>
<tr>
<td>11-May-2001</td>
<td>39</td>
<td>3</td>
<td>434</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>480</td>
</tr>
<tr>
<td>12-May-2001</td>
<td>30</td>
<td>2</td>
<td>519</td>
<td>5</td>
<td>14</td>
<td>0</td>
<td>570</td>
</tr>
<tr>
<td>13-May-2001</td>
<td>40</td>
<td>3</td>
<td>547</td>
<td>4</td>
<td>15</td>
<td>0</td>
<td>609</td>
</tr>
</tbody>
</table>

**Totals**: 1170, 66, 20276, 140, 308, 4, 21964, 68440

Of note:
- The four peak days occurred over Easter – Good Friday to Easter Monday.
• Easter Saturday recorded the highest visitation of any day over the survey period. Throughout the rest of this report, this day is referred to as the ‘peak day’.

• The number of visitors is calculated on previous modelling at Port Campbell National Park that showed that the number of occupants per vehicle is approximately 3.116. This is higher than the state-wide average of 2.7 occupants per vehicle.


IMIS data below is available on a day-to-day basis. Only the summary totals are shown below:

<table>
<thead>
<tr>
<th>IMIS data vehicles</th>
<th>209,200</th>
<th>(visitation of 651,867)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMIS data vehicles</td>
<td>216,113</td>
<td>(visitation of 673,408)</td>
</tr>
</tbody>
</table>

Regression analysis between actual survey and historical data:

<table>
<thead>
<tr>
<th>Estimated vehicles</th>
<th>225,000</th>
<th>(visitation of 701,100)</th>
</tr>
</thead>
</table>

Growth rate from 1998/1999 to 1999/2000 3%
Growth rate from 1999/2000 to 2000/2001 4%
Growth rate from 1998/1999 to 2000/2001 7%
13 Appendix 5 - Methods for forecasting visitor numbers

13.1 Planning for the 95th percentile

The 95th percentile was chosen as the benchmark for simulations at the Twelve Apostles. Two different cases can be argued as to its appropriateness:

13.1.1 Case 1 – Comparison with other percentiles

- The 100th percentile represents the most extreme case, and is generally too unreliable. Planning for the 100th percentile is very difficult and involves trying to identify this day within the year. For example, the 100th percentile may be only the Sundays two days after Christmas day or Australia Day when it falls on a Saturday. It is not a consistent measure and is prone to estimating error.

- The 95th percentile offers stability as it represents the top 18 days per year (5% of 365 days) where visitation meets or exceeds the peak load. In terms of visitation at Twelve Apostles, this includes the week between Christmas and New Year, the Easter holiday period, and the school holiday period in January incorporating the Australia Day holiday. Hence, it provides a predictable measure of peak visitation from year to year.

- The 90th percentile represents the top 36 days per year (10% of 365 days) where visitation meets or exceeds the peak load. The additional 18 days when compared to the 95th percentile extend the planning towards ‘floating’ days throughout the year, and are therefore more difficult to determine. Contributing factors that lift visitation into the 90th percentile include proximity to holiday days and periods and favourable weather patterns.

13.1.2 Case 2 – Parks Victoria as a service provider

- Parks Victoria is an organisation where the services provided (parks and open space and the facilities within them) are generally over-supplied. That is, the services are aimed at higher visitation levels such as weekend and holiday use rather than the lower visitation that occurs on weekdays. In essence, management revolves around maximising the availability of recreation time, and this relies on managing the peak loads. At a venue like the Twelve Apostles, planning for the highest 18 days of visitation per year (95th percentile) assists in creating an environment where visitors can make the most of their available recreation time throughout the year.

13.2 Method for estimating visitor numbers

The following method was used to estimate visitor numbers at the Twelve Apostles:

1. Collect traffic and visitor data in three major surveys.
   - The first of these occurred in late 1997 and early 1998 and involved intensive traffic analysis, including number plate matching that determined arrival curves and typical trips for Port Campbell National Park.
• The second involved IMIS data collection at the old Twelve Apostles site in 1999 and 2000.
• The third involved placing a vehicle counter at the entrance to the new facility from 13th April 2001 to 13th May 2001.

2. Use time series (regression) analysis between the data from survey 2 and survey 3 to estimate annual visitation for the financial year 2000/2001.

3. Use historical and estimated data to calculate visitation growth rates from year to year

4. Estimate growth rates from visitor segment contribution data from the Australian Bureau of Statistics (ABS), Bureau of Tourism Research (BTR) and worldwide tourism trends.

The following summary highlights the results from applying the above method:
• Total visitation for Twelve Apostles is estimated at 701,100 (+/- 5.8%) for the year 2000/2001.
• Average visitation growth from traffic data estimated at 3.5%
• Average visitation growth from visitor segment contribution at 3.55%

See Appendix 4 for traffic count data from survey 3 and for detailed growth rate and visitation calculations.

13.2.1 Estimates for Buses
It is important to recognise that the majority of the coaches that visit the Twelve Apostles contain overseas visitors. With this in mind, bus projections are factored for 7% growth (annual growth of international tourism) rather than the average Twelve Apostles growth of 3.5%.

On the 95th percentile day (Easter Saturday), 44 buses visited the Twelve Apostles. In 2006, at 7% growth per year, this is estimated to rise to 62 buses (40.3% growth from 2001). In 2011, visitation is estimated at 87 buses (96.7% growth from 2001).

13.2.2 Estimates for cars
Car projections are factored for the average growth of Twelve Apostles visitation (3.5%).

On the 95th percentile day (Easter Saturday), 1589 cars visited the Twelve Apostles. In 2006, at 3.5% growth per year, this is estimated to rise to 1887 cars (18.8% growth from 2001). In 2011, visitation is estimated at 2241 cars (41.1% growth from 2001).