RANKING PROCEDURES FOR BICYCLE PROJECTS*

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ABSTRACT

This paper describes a project undertaken to develop ranking procedures to prioritise projects designed to improve the ability of the road network to safely carry cyclists. The project was completed for Main Roads Western Australia.

The project involved reviewing current Australian policies and procedures, conducting a state of the art review of literature in the relevant fields and relating all information to Western Australian (WA) conditions. The work was completed with a focus on the WA Government's road safety strategy of providing safer roads for cyclists.

In the development of the procedure for ranking bicycle projects considerable research was undertaken to provide the necessary background and justification for the approach adopted in the procedures that follow. In essence the procedures draw together the quantitative and qualitative aspects associated with cycling projects, whether they be benefits or costs. Within the quantitative assessment valuations are placed on:

- the safety implications of reduced crashes, and a lower risk of crashes.
- the benefits of any change in modal choice and the presence of new users through the

associated health, operational and resource cost savings.

- the benefits of reductions in bicycle theft that a facility may provide, and
- the total cost of the project including planning, design, construction and maintenance of the new facility.

Discounted over the evaluation period this assessment provides a typical benefit cost ratio for the project.

From a qualitative perspective issues related to Level of Service, Coherence and Directness, Attractiveness and Comfort of the Facility, Safety, Environment and Health, Strategic Issues and the effect on other users are all catered for in an event tree analysis.

The final ranking of projects is then completed using a combination of the quantitative and qualitative assessment results to provide a prioritised list of all cycling projects considered.

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INTRODUCTION

Main Roads Western Australia (MRWA) commissioned ARRB Transport Research to provide ranking procedures for projects designed for bicycle transport. The brief required a simple yet comprehensive assessment to be devised that would allow MRWA to determine which cycling investments would provide the highest value for money. To achieve this the procedure that follows includes both a quantitative and qualitative assessment of various factors influenced by a cycling project. Funding arrangements within MRWA do not require those projects identified for cyclists to directly compete against other infrastructure projects. As such the ranking procedure was designed to allow cycling projects to be valued and compared against other cycling projects.

A flow-chart of the overall ranking procedure is provide as **Figure 1**, which covers the identification of potential projects, determination of suitable treatments, the assessment of individual projects and the ranking of all projects.

This paper concentrates on the assessment and ranking stages of the project. In the development of a quantitative measure of the value of a cycling project, the project assessor is required to make a number of estimates covering crash reductions, new use of the facility, impact on bicycle theft and associated project costs. Potential exists to expand on this work to provide the assessor with additional guidance in estimating these factors.

A means of assessing the relative risk of various cycling environments is defined. This risk profile is combined with crash history information to enable an assessment of the safety implications of the project.

Many cycling projects encourage an increase in the use of a particular route. In evaluating benefits from new use, the paper discusses the various operational, resource and health benefits to be gained from an increase in cycling. An estimated value for each new kilometre of travel is then derived to provide an indication of the benefits to be gained from new users on the facility.

With bicycle theft raised as an issue affecting the choice to make a trip by bicycle, the paper considers the theft issue and provides a method of including any benefits (or disbenefits) to be accrued by the provision of parking facilities.

Costs associated in planning, constructing and maintaining the project are then considered. With the tangible benefits and costs estimated, a Benefit-Cost Ratio for the project is determined.

Further to those benefits (and costs) quantified, many qualitative aspects are often relevant in an assessment of a projects importance. A method of evaluating these qualitative aspects is presented, allowing a measure of the qualitative importance of the project.

Combination of the quantitative (Benefit-Cost Ratio) and qualitative (score) assessments is then completed to enable an overall appreciation of the projects importance and provide a means to rank the projects.

This paper provides only a summary of the ranking procedure and the background information completed as part of the project for MRWA. The final output to MRWA consisted of the step by step procedure in one report, with a second report providing the background and source information used in the development of the final procedures. Development of a computer package to further simplify the procedure has since been completed.

RANKING PROCEDURES

In the development of a ranking procedure for bicycle projects an extensive literature review was conducted and a review of Australian practice carried out to provide the background necessary to develop the final procedures. The results of that review are incorporated in the steps of the procedure detailed below.

In quantifying the benefits of a cycling project, safety of the cyclist is often a primary concern. Crash histories can provide an insight into an existing safety problem, although the frequency of cycling crashes is often low, and crash sites scattered, making it difficult to truly assess the relative safety of an existing site compared to the safety of the proposed facility. To assist in quantifying these safety benefits the development of a risk profile was recommended.

Risk Profile

To enable an assessment of risk it is necessary to obtain details on the frequency of events, and the consequence of those events. The cost (or consequence) of crashes is reasonably well defined however the frequency of events is less understood. To enable an understanding of the frequency of a type of crash (or event) a risk profile of the site characteristics is required.

The consideration of crash histories when considering cycling facilities is generally reserved for site specific evaluations. Crash data are typically used for a before study, with benefits calculated from an estimated reduction in those crashes on completion of the new facility or treatment.

Crash statistics for Western Australia (Swadling, Evans, Tziotis, 1997) show that for 1996, ten bicyclists were killed and 138 hospitalised. The five year average for bicyclist fatalities prior to 1996 were 5 per year.

The random scattering of crashes can make judgements on the safety of an individual site difficult without a detailed investigation of the causal factors of the crash and consideration of the relative probabilities of similar crashes occurring. Multi-variate analyses of all intersection vehicle crashes have been undertaken in a number of locations including Adelaide (Affum, Taylor 1996) and various investigations in the UK by the Transport Research Laboratory. It was recommended that a similar approach be adopted in a less detailed fashion to provide an indication of the risk profile of certain riding environments in Western Australia, with this local approach considered necessary in the application of the procedure elsewhere. The relatively small number of total crashes would be unlikely to provide reliable details of crash risk on a site specific basis. However considering crashes on a network wide basis would be likely to provide a reasonable indication of the crash risk for a cyclist in that riding environment.

It was recommended that an analysis of crash data from a 10 year period be carried out to provide an indication of the risk profile for cycling in Western Australia. Each crash can then be allocated to a certain environment type, similar to the approach used for Crash Type codes (for example rear end, side swipe, head-on etc.) in crash analysis. Suggested groupings are provided below:

1. Off Road - Cycle Only
2. Off Road - Dual Use
3. Off Road - Road Crossing
4. On Road - Exclusive Bike Lane Provided
5. On Road - Bike Lane, with Parking of motorised vehicles permitted
6. On Road - No Bike Lane provided, no parking permitted.
7. On Road - No Bike Lane provided, parking permitted.
8. On Road - Traffic Calming Present.

For each facility type the following 'environmental' categories should also be assigned.

Table 1: Categories of Cycling Environments

Code	"Environmental Condition"	Categories
A	Speed Environment (km/hr)	0: NA, 1: <60, 2: 60 - <80, 3: 80 - <100, 4: >100
B	Road Class	0: NA, 1: CBD, 2: Arterial, 3: Collector, 4: Local
C	Location:	1: Intersection or 2: Midblock
D	Surrounding Environment	1: Local / Residential, 2: Shopping, 3: Commercial, 4: Open Area.
E	Traffic Flows - Cyclists	1: Low, 2: Medium, 3: High
F	Traffic Flows - Vehicles AADT:	0: NA, 1: 0-5000, 2: 5000-10000, 3: 10000-20000, 4: >20000.
G	Locality in LGA area	Codes as assigned for various local government areas
H	Injury Code *	As taken from crash type codes

NA - Not Applicable: For example on off-road facilities.

In this way a route used by bicycles (or where a cycling crash has occurred) can be assigned a distinct code. For example:

A midblock section of road in Applecross (Western Australian LGA area) with an AADT of

8,500 which has a bike lane where at certain times vehicles can park, in a 60km/hr zone, on a collector road, with primarily residential properties adjoining the road, and carries a reasonable number of cyclists would have the following code:

5 A2 B3 C2 D1 E2 F2 G119.

In this way all crashes can be grouped into "typical environment" types and trends or a risk profile can be generated.

An appreciation of the length of networks is required and the number of point locations such as intersections. From this analysis the risk profile of cycling can be considered, with the aim of providing details such as:

The fatal and hospitalisation crashes per year per km of cyclists on dual use paths in open areas. (Code 2 D4 H01 and 2 D4 H04 - A B* C* E* F* G*)*

The fatal and hospitalisation crashes per year per km of cyclists on roads with exclusive bike lanes on mid-block sections of arterial roads in shopping precincts where vehicle traffic volumes are between 5,000 and 10,000 AADT in 60-<80 km/hr zones. (Code 4 A2 B2 C2 D2 E F2 G* H01 and H04).*

The extent of groupings can be altered to suit the level of detail required although it is recommended that the first analysis be completed with sufficient detail to allow accurate representation of the relative risks of differing riding environments. The outputs of this exercise can then be incorporated into evaluations of new projects, and assist in identifying possible areas where improvements can be made. For example where the average casualties per km / per year is exceeded (evaluated over a 5-10 year history) for a certain location, indicating that there may be another factor at the site (possibly simple to counteract) that contributes to crashes which can be identified and remedied.

The preparation of this risk profile will require an investment of resources by the road authority. With current trends towards digitised road maps linked to crash databases the task required to develop a risk profile may well be simplified.

Quantitative Assessment

Provision of cycling facilities can affect crash numbers, encourage new use, reduce the incidence of bicycle theft and also provide many 'intangible' benefits. Where possible the quantification of benefits (and any disbenefits) can assist in providing a valuation of the project relative to costs. The selection of the project life should be determined and all analyses of benefits and costs carried out over that period (usually 5-10 years depending on treatment type).

The areas recommended for the MRWA ranking procedures were:

- Crash Analysis considering both crash history and crash risk.
- Operational and Resource cost savings from mode change.
- Benefits in terms of improvement in general health of all users.
- Impact on bicycle theft, and
- Total cost of the project.

Crash Analysis

Evaluations of road safety projects primarily consider crash histories and anticipated crash reduction values after a certain type of treatment. When crashes are scattered and few in number, the crash trends at a site level can be difficult to determine, and consequently benefits of a treatment difficult to quantify. The knowledge of a risk profile becomes invaluable at this stage of the evaluation and combined with crash histories for the particular site can provide an insight into the likely needs and therefore benefits of a treatment.

The approach taken for the ranking procedure has been to consider an assessment of both history and risk to obtain an overall benefit to be achieved through crash (and crash risk) reductions. Crash costs are obtained from standard figures in use by the road authority at the time of assessment.

Crash History and Reductions

The determination of the typical crash reductions from the installation of a particular treatment requires analysis of the actual before data (or history) and assessment of the likely crashes that could be anticipated after the treatment.

From determining the anticipated change in crash numbers as a result of the treatment the benefits can be calculated.

$$\text{Crash Reductions} = \text{CRASH Numbers}_{\text{Base Case}} - \text{CRASH Numbers}_{\text{Project Case}}$$

$$\$\text{BENEFITS}_{\text{Crash History}} = \text{Crash Reductions} * \text{Crash Cost}$$

Costs for specific cycling crashes by type or nature are not generally available, however in the absence of this data typical average costs may be assigned to the total crash reductions from either fatality or hospitalisation data.

The crash reduction from a particular treatment needs to be carefully addressed. For example the installation of a cycle-path may not necessarily reduce crashes to cyclists. Poor design of paths for example poor sightlines and tight turns, can have a negative influence of safety for the cyclist. Likewise, a false sense of security may be developed by the cyclist from not having to share the roads with motorists. This may lead to carelessness on the part of the cyclist resulting in an increase in the number of crashes (Sharples 1995). The design of any proposed facility is therefore critical in achieving estimated crash reductions in practice.

For many treatments the increase in use of the facility may well result in an increase in the number of crashes as exposure levels rise. The effect of exposure levels dropping on nearby (less safe) routes as cyclists move to the safer facility also requires consideration. The effect of route change and new users as a result of a proposed facility should be considered when estimating crash numbers for the project (or after) case. As shown by these statements a number of assumptions need to be made when assessing crash reductions, which should be recognised when considering final BCR values obtained.

Crash Risk Analysis

The effectiveness of types of cycling facilities was discussed in a number of the reports reviewed but quantification has been limited. Some of these details are discussed in the qualitative section on safety. The development of the risk profile as discussed earlier can enable an insight into the inherent safety problems of different riding environments. This can assist in removing some of the discrepancies that can be caused by the random scattering of crash locations as the behaviour of the rider (and / or the driver or rider of another vehicle) can influence the occurrence of a crash.

In developing the risk profile an appreciation of the 'average' crash risk for a certain location can be obtained. Incorporating this factor into the evaluation of a new project can be completed by considering the before and after environment. With an average crash rate for the before case and after case calculated, the anticipated benefits of a treatment can be determined.

$$\text{Crash Risk Reduction} = \text{Crash Rate}_{\text{Base Case}} - \text{Crash Rate}_{\text{Project Case}}$$

$$\$\text{BENEFITS}_{\text{Crash Risk}} = \text{Crash Risk Reduction} * \text{Crash Cost}$$

The role of crash reductions and risk analysis

The approach used to combine the crash history and crash risk analysis into the final assessment required an approach to ensure that the safety benefits are not double-counted. Balancing the risk factor with the crash history of the site will allow historical site information, and inherent risks to be included in a project evaluation. No major research has been carried out in this area with limited data available on crashes and crash risk. It was recommended that in the consideration of the project a 50% weighting is applied to the crash history valuation and a 50% weighting applied to the crash risk component such that:

$$\$\text{BENEFITS}_{\text{Crash Reductions}} = 0.5 * \$\text{BENEFITS}_{\text{Crash History}} + 0.5 * \$\text{BENEFITS}_{\text{Crash Risk}}$$

(At this stage the risk profile in Western Australia is yet to be developed, with benefits from crash reductions calculated solely on crash history analyses until such time as the risk profile has been completed).

Further research may be appropriate within this area to provide a more reliable evaluation of the suitable components of crash history and crash risk to incorporate in the evaluation. When considering crash history the analysis of actual crash data is important to determine causal factors that may be related to the site under consideration. The impact of the 'proposed' treatment on these causal factors can then be determined.

Effect on Modal Choice and New Trips

Benefits of cycling can be expressed in terms of the number of 'new users' that are encouraged to travel by bicycle. Generally the benefits accrue when that trip is in place of a vehicular trip that would otherwise have been taken. A component of health benefits can also be attributed to 'recreational' cycling as well as commuter cycling.

Estimation of the number and length of new trips

A theme common to many previous reports on bicycle use is the negative effect a lack of parking facilities can have on bicycle use (Sharples 1995). Without secure parking facilities many trips are avoided, whereas with the provision of secure parking, cyclists are much more likely to use the facility. This factor should be incorporated into planning activities and considered when evaluating the number of 'new users' likely to use a facility. Cycle parking areas encourage cyclists to park in one place rather than at random locations. This may also help to clear the area of clutter which is safer for pedestrians and the visually handicapped. Many other factors that are addressed in the qualitative assessment are impacting factors on the degree of modal change and increase in recreational usage that may occur following a treatment. Education campaigns are also a factor that may lead to an increase in cycling. All these factors should be considered when evaluating the number of new trips.

Calculating the benefits of new trips

In evaluating the benefits of a project the number of new users will need to be estimated and an indication of the type of users whether commuter or recreational obtained. An understanding of the local 'cyclist population' is required at this stage. The quantifiable elements of this increased use can be considered to be a function of user operational cost savings, resource savings, and health benefits.

User operational cost savings

Bicycles require replacement of worn parts and regular maintenance. The (UK) Cyclist's Touring Club suggests an operating cost of 14.9p/mile (20.7 cents/km) (Sharples, 1993). This cost takes into consideration: equipment, depreciation, insurance, spares and replacements, lighting, clothing and maintenance. The London Borough of Sutton suggests an operating cost of 44p/mile (61.1 cents/ km) for motor vehicles.

Henson and Walker (1995) include details of vehicle operating costs at 55¢ per km for medium cars and 69¢ per km for upper medium cars. Bicycle operating costs are estimated at 16¢ per km, assuming annual depreciation of $100 per year and $150 in other costs, with an average distance travelled of 1500 km per year. Therefore, 39¢ per km saving can be experienced from riding a bicycle. For 1500 km this represents a saving of $585 per year. This compares to the equivalent benefit of 40¢ per km utilising the UK data. It is therefore recommended that for use in this ranking procedure a value of 39¢ per km is adopted for the difference in user operational costs.

Resource cost savings

Henson and Walker (1995) investigated the resource costs of running a vehicle (consumption of human and natural resources):

Car 19¢ per km

Bicycle 4¢ per km

Savings: 15¢ per km ($225 per year assuming 1500 km per year)

Health Benefit

Medical cost savings gained from a cycle-way can come from two means. Firstly to the cyclist who changes from another less healthy mode of transport. Secondly to the entire local population and those passing through the locality who experience a reduction in pollution. The financial value assigned to this increase in health can be expressed in terms of the savings in health insurance premium, similar to those obtained by non-smokers (Sharples, 1995).

Although difficult to place an economic valuation on health benefits, figures are usually related to health insurance premiums. Henson and Walker (1995) valued benefits based on a reduction of 5% in health insurance premiums. For 21 million additional bicycle kilometres a benefit of $900,000 was accrued, or 4.3¢

per km. Not all figures used in the evaluation of this figure were available. The 1986 Perth study by Campbell (1989) indicated a health cost saving of $372,750 for a total of 104 million km of bicycle travel replacing car travel per year. This equates to 0.36¢ per km.

The standard top hospital cover with standard essentials costs approximately $1,000 for singles cover (HBF, October 1997). Australian regulations do not allow individual reductions in premiums although for this project the 5% reduction in premium is assumed and adopting the 1500 km per year average travel distance from Henson and Walker (1995), this equates to a benefit of 3.3¢ per km. Given the relative unknowns in these estimates a valuation of 3¢ per km was adopted for this ranking procedures. The potential exists to complete a more in-depth study on the health effects of cycling to provide a more definitive evaluation of the monetary benefits to be achieved by an increase in cycling.

'New trip' benefits

Operational and resource benefits result from new trips that replace trips that would otherwise have been completed with the use of a motor vehicle. Health benefits will accrue whether the trip is for recreational purposes or commuting. With 50% of growth assumed to be for trips replacing car trips (Bikewest 1988 cited in Henson and Walker 1995) the calculation of benefits for new use and modal shift is:

$\$BENEFIT_{\text{mode shift and new users}}$

=New trips (km) * (0.5*(Operat'nl Cost Savings + Resource Cost Savings) + Health Savings)

=New trips (km) * (0.5*($0.39 + $0.15) + $0.03)

=New trips (km) * ($0.30)

That is for each new kilometre of bicycle travel generated by a project $0.30 or 30¢ of operational, resource and health benefits are generated. It is noted that a number of assumptions have been made in this evaluation to meet the needs of the client in keeping the evaluation process simple. Should the estimated proportion of commuter versus recreational trips vary greatly from the 50% assumed this value should be adjusted accordingly.

Reduced bicycle theft

In assessing the benefits of reduced bicycle theft Henson and Walker (1995) assumed a cost per theft of $300. For the ranking procedures, the anticipated reduction in thefts can be estimated depending on the type of facility provided. For example if the project is considering secure parking at a train station then the estimated reductions in theft for that location are likely to be high if considering police data for thefts from that station. Provision of facilities at a location that is not specifically an origin or destination, the area wide reduction in theft is likely to be considerably less. To simplify the evaluation the reduction in bicycle thefts should be limited to either 0, 20, 40, 60, 80 or 100%, with a valuation of $300 per theft. (For use in Western Australia the WA Police Crime Operations Section hold data on bicycle theft from July 1991 onwards). It should be noted that Police records will not necessarily reflect all bicycle thefts.

The recommended process involves the following steps:

1. Select the area that the facility will serve.
2. Obtain theft details from the Police, Crime Operations Section.
3. Select the theft reduction anticipated: either 0, 20, 40, 60, 80 or 100%
4. Calculate the number of theft reductions over the evaluation period.

$$\$BENEFIT_{\text{reduced theft}} = \text{Theft reductions} * \$300$$

Calculation of Costs

The calculation of costs for the treatment should include all costs to be incurred in the completion and ongoing maintenance of the project being considered. Costs to be included are:

- Planning and overhead costs.
- Design costs.
- Pre-construction costs.
- Construction costs.
- Any costs resulting from construction disruption.

- Maintenance and running costs.
- Terminal or salvage value (expressed as a negative cost).

The costs of maintaining the current as is facility should be deducted from these costs if appropriate.

$$\$COST_{Project} = \sum \text{All Costs}$$

Benefit Cost Ratio

The use of Benefit Cost Ratio (or a similar derivative such as Net Present Worth) is generally accepted as a ranking tool for projects.

$$\$BENEFIT_{Project} = \$BENEFITS_{Crash\ Reductns} + \$BENEFIT_{mode\ shift\ /\ new\ users} + \$BENEFIT_{reduced\ theft}$$

$$BenefitCostRatio(BCR) = \frac{\$BENEFIT_{Project}}{\$COST_{Project}} \quad \text{(Discounted over evaluation period)}$$

Each project is assessed in the same way to provide a BCR for each project and provide a method for ranking individual projects.

Qualitative Assessment

A qualitative assessment allows a value to be placed on those factors that are difficult to express in terms of monetary value of benefits or costs accrued. Many factors associated with a cycling development relate to user perceptions and other needs. They may also be part of a larger strategic initiative such as the Perth Bicycle Network Plan (Perth is the capital city of Western Australia). As part of the overall approach to evaluate cycling projects an allowance for these factors needs to be included in a project ranking procedure to highlight the projects importance.

In considering levels of service for bicycles the Dutch Bicycle Master Plan considered five main areas of interest (Centre for Research and Contract Standardisation in Civil and Traffic Engineering - The Netherlands, 1983).

"Coherence	The cycling-infrastructure forms a coherent unit and links with all departure points and destinations of cyclists.
Directness	The cycling-infrastructure continually offers the cyclist as direct a route as possible (so detours are kept to a minimum).
Attractiveness	The cycling-infrastructure is designed and fitted in the surroundings in such a way that cycling is attractive.
Safety	The cycling-infrastructure guarantees the road safety of cyclists and other road-users.
Comfort	The cycling-infrastructure enables a quick and comfortable flow of bicycle traffic."

The areas recommended for the MRWA ranking procedures were:

- Level of Service
- Coherence and Directness
- Attractiveness and Comfort
- Safety
- Environment and Health
- Strategic
- Other Users

A: Level of Service

As part of their commitment to cycling in Western Australia, MRWA have developed a tool to assess the Level of Service (LoS) of a particular route for cyclists.

The tool considers such factors as traffic, design, intersection and pavement conditions in calculating an overall score for the route. The higher the score the higher the LoS for that route. Various cut-off levels in the scores are then used to discern between a Level of Service A (high quality) through to a Level of Service E (low quality).

A: In summary variables to be considered within level of service are

A1. What is the **current level of service** compared to Level of Service ‘B’?

Based on MRWA assessment procedures for level of service, the project will be located within a section with a current Level of Service category, either A,B,C,D or E. LoS ‘A’ indicates a high level of service while those locations with a LoS ‘E’ generally provide poor facilities for cyclists. Scoring is based on the LoS relative to the desired network level of service of ‘B’. Assigning numerical values to LoS as A=1, B=2, C=3, D=4 and E=5 a rating can be determined for the project being considered. For example a project located at a site with LoS ‘E’ will rate E(5)-B(2)=+3. Likewise an existing LoS ‘A’ will rate A(1)-B(2)=-1

A2. What **effect on LoS** will the project have?

Utilising the weighted Level of Service assessment method developed by MRWA, the LoS Before is compared to the LoS after (following completion of the proposed project). Based on the difference (LoS after - LoS before) a rating between -3 and +3 can be derived. (These ranges are yet to be determined for WA).

B: Coherence and Directness

Campbell (1989) stated that cycling facilities must be installed as part of a continuous network, not stopping or starting according to other traffic or land-use constraints. Cyclists viewed route continuity, speed and safety as favourable elements of a cycling facility. Herrstedt (1996) also recognised that the individual parts of the network must be interconnected. The lack of such connection will result in detours and limit the use of the network. Path planning should therefore be based on a registration of existing paths and on an assessment of the possibilities of establishing the total functional integration often lacking between otherwise good but uncoordinated path systems

Dorrestyn’s (1996) review of the Adelaide bicycle network highlighted arterial roads as playing a role in the transport mode of cycling. They are generally the most direct route, have the highest standard of road surface quality and maintenance, flattest gradients and highest level of speed maintenance. These roads are the first choice of cyclists who travel long distances and are experienced in these traffic conditions. Herrstedt (1996) found that cyclists are very sensitive to detours. Paths will only be used as intended if they take the shortest route between starting point and destination. The requirement for direct routes applies both vertically and horizontally. Stairs, long steep ramps and other kinds of barriers are discouraging and should be avoided if possible.

“It is important that a coherent network of routes exist through local areas, which offer similar advantages to arterial roads but without the same level of traffic in order to adequately serve cyclists who choose not to use arterial roads” (Dorrestyn 1996). Paths should lead directly to and be given close contact with the most important destinations for light road users: schools, other institutions for children, shopping centres, traffic terminals, bus stops, sports facilities and recreation areas (Herrstedt, 1996).

Time and distance are important factors in a cyclist’s route choice (Sharples, 1995). Factors affecting the time a journey takes include the distance of the journey, terrain, interaction with other users, the number of stops and starts (dependant upon number of intersections), kerbs which are not dropped sufficiently and any detours.

B: In summary variables to be considered within coherence and directness are

B1. To what level does the project contribute to **interconnection of the bicycle network**?

B2. To what level does the project contribute to a **consistent quality of service** for the cyclist?

B3. To what level does the project contribute to enabling the user to have **a clear understanding of the network** (such as signing, logical layouts)?

B4. To what level does the project contribute to **reducing the time taken**, or the **distance travelled** by a cyclist completing a designated trip?

C: Attractiveness and Comfort

The attractiveness of the facility to the cyclists is an important feature which influences the amount of use, and the comfort of the users. Herrstedt (1996) considered three areas of importance:

1. Maintenance and quality of surface: The path must be passable and with acceptable quality of surface in the full width of cross section. Otherwise the capacity will be reduced and cyclists will not use the path network as intended.
2. Parking facilities: Parking facilities should be included in planning the network. In general cyclists park as close to the destination as possible. If parking facilities are not available the bicycles are left leaning against the nearest tree, wall or lamppost and scattered at the adjacent areas giving problems for other road users. Theft was highlighted by Replogle (1992) and Sharples (1995) who stated that cycle parking facilities are an important consideration in the decision whether or not to cycle. The implementation of cycle facilities may prevent injuries to other user groups and may also prevent cycle theft.
3. Public transport connections: Combining bicycle travel with public transport has high potential benefits. The combination is attractive if good parking facilities are available at terminals and even more when it is possible to bring the bicycle on the train or bus.

For recreational users the aesthetic quality of the facility is a factor to be considered in the decision to make a journey.

C: In summary variables to be considered within attractiveness and comfort are:

C1 To what level does the project contribute to **improving the amenity** of the cycling environment?

C2 To what level does the project contribute to **improving the perception** by the public of the safety and security of the facility?

C3 To what level does the project contribute to **improving bicycle security** and reducing the likelihood of bicycles being stolen or damaged?

C4 To what level does the project contribute to **increasing the capacity** of the facility to a level that encourages use?

C5 To what level does the project contribute to **simplifying the riding task** required of the cyclist?

D: Safety

Safety can have a qualitative as well as quantitative aspect from the cyclists viewpoint. Intimidation, the threat of crashes and possible conflicts can influence the choice of cycling as a mode of transport. Personal security when using the facilities can also impact cycle use.

In a report by Snelson and Lawson (cited in Sharples, 1995) it was suggested that one of the most common reasons given for cyclists not cycling more often is due to the dislike of having to travel with fast and/or heavy traffic. The cycle facility can serve to reduce cyclist intimidation by positioning the cyclepath away from the proximity of the traffic, or by inserting a barrier between the cyclist and other traffic. A cyclepath with safe surroundings can provide the inspiration for some people to gain the confidence to use the roads.

Security is an important factor for cycle facilities (Sharples, 1995). Cyclists are exposed to other road user groups and the road environment itself in a different way to motorists. Travelling at night, for example, through a dangerous area and in the presence of drivers with poor driving skills, the cyclist may have more exposure to danger. A cycling scheme can provide safety to the cyclist in terms of the provision of lighting and merely by the presence of an increased number of users.

D: In summary variables to be considered within safety are:

D1 To what level does the project contribute to improving the actual and perceived level of **personal security** for the cyclist?

D2 To what level does the project contribute to **reducing the feeling of intimidation** that a cyclist might perceive, or in reducing the threat of a crash?

D3 To what level does the project contribute to **reducing possible conflict points** on the cycling network?

E: Environment and Health

Benefits to the environment can be obtained when users who would otherwise have used a motor vehicle choose to change modes and travel by bicycle. Henson and Walker (1995) listed environmental benefits as:

- Reduction in pollutants such as carbon dioxide, carbon monoxide, nitrogen oxide, hydrocarbons and lead.
- Reduced background noise.
- Improved environment, particularly in residential areas.

The introduction of cycling facilities causes a shift away from motorised traffic and thereby can reduce levels of pollution (Sharples, 1995). Pollution in turn affects all road-users, animal and plant life and structure surfaces. It should be noted however, that people who may have taken up cycling because of a new facility may be people who were previously car or public transport passengers. These particular vehicles will continue to operate. Therefore an increase in the number of cyclists may not necessarily lead to a proportionate decrease in pollution levels as the number of vehicles is not reduced in a proportionate manner.

Benefits to health have been estimated within the quantitative assessment, with some subjective assessment of the impacts on health also required. Reduced pollution can assist users and non-users. Increased levels of fitness from cycling can prompt activities other than cycling. Community well-being can also be viewed with positive health effects.

E: In summary variables to be considered within environment and health are:

E1 To what level does the project contribute to a change in modal choice, and reduce the number of motorised vehicles on the network, thereby **reducing air, noise and other forms of pollution**?

E2 To what level does the project contribute to an **increase in fitness and health** of users and non-users?

E3 To what level does the project contribute to an **improvement in the amenity of the area** through promoting community gathering for example?

F: Strategic

The Western Australian Government and MRWA have taken a strategic approach to cycling with the development of the Perth Bicycle Network Plan. Cycling treatments can therefore form part of the overall aim's of the organisation and government from a whole of transport perspective. These desires may have importance at a network, local, political, community or social equity level. Asset preservation is also important from a strategic perspective.

Cycling can allow a degree of independence, particularly for those who can not drive. If by introducing a cycle-way facility a person is allowed to make a trip for which they previously relied on someone else, then it has increased their mobility (Sharples, 1995).

Botma (1995) investigated demographic and economic characteristics of cyclists and concluded that "bicycle planners should give greater attention to neighbourhoods of lower than average affluence, particularly where extreme poverty exists and transit availability is inferior. This would be especially true in areas of relatively low population density because of lowered transit availability and unwalkable distances between homes, jobs and retail locations."

F: In summary variables to be considered within the strategic area are:

F1 To what level does the project contribute to **network level strategies**? If the project has a very high positive contribution to network strategic issues (that is a rating of +3) then the project is flagged for further attention.

F2 To what level does the project contribute to **local level strategies**?

F3 To what level does the project contribute to **educating** new and potential users, and **encouraging** the use of cycling facilities?

F4 To what level does the project contribute to providing **equitable access to services** and assist users who would otherwise have no other form of transport available?

F5 To what level does the project contribute to meeting the **needs expressed through community channels or political input**? If community desires indicate a very high requirement for the project (that is a rating of +3) then the project is flagged for further attention.

F6 To what level does the project contribute to ensuring that the facilities already provided are **maintained in a cost-effective manner**?

G: Other Users

The provision of a cycling facility may have negative or positive impacts on groups such as other road users, nearby businesses and pedestrians and may impact on vehicle parking facilities and residential areas.

The introduction of a bike-path may reduce the space available to other road-users due to a removal of area from the existing facility to incorporate the path (Sharples, 1995). This has the potential to increase congestion. It is straightforward to calculate the area which has been removed from the existing facility, however it is difficult to measure the loss to other groups from sharing the facility. A subjective analysis of this variable is required. Carriageway capacity will be decreased by on-road cycle facilities. This decrease will be felt more at various times throughout the day. The capacity in other areas may increase as new cyclists using the cycle-way are no longer driving. Parking capacity could also be affected.

The introduction of a cycle facility may affect the travel times and journey lengths of pedestrians. However it will often change for the better as the cycleway often provides for the pedestrian, where previously there was no facility for pedestrians (Sharples, 1995).

Sharples (1995) also considered the effects on the occupiers of adjacent properties. An alteration to their environment due to disruption by construction, earthworks and visual intrusion from the construction of the cycle-way is possible. Parking or access for customers can also be affected by construction or earthworks and can reduce the income of businesses in the vicinity. Positive benefits to business on completion of the project should also be considered.

Construction disruption caused by the construction of a cycle-way can be ranked. For example, does the construction cause a complete blockage or will it only cause a diversion for isolated numbers and types of users (Sharples, 1995).

G: In summary variables to be considered for other users are:

G1 Does the project contribute to any **positive or negative impacts on motorists**, through change in road space, capacity or parking, or influence the number of vehicles on the road?

G2 Does the project contribute to any **positive or negative impacts on pedestrians or disadvantaged groups**?

G3 Does the project contribute to any **positive or negative impacts on the residential area**?

G4 Does the project contribute to any **positive or negative impacts on businesses** in the area?

Event tree analysis

An event tree analysis is recommended for placing a valuation on these factors. The event tree allows subjective judgements to be made while recognising the relative importance of the individual factor. In essence the importance of each factor is considered relative to sub-sets of the other similar factors and an overall weighting calculated. When assessing a particular project these factors are rated between +3 (a high positive effect) and -3 (a high negative effect).

Variable Weightings

The weighting of each factor was completed initially through consultation with MRWA personnel involved at the strategic, policy and operational levels. For the majority of the factors the relative weightings were similar between respondents, and the weighting's provided on the qualitative score sheet attached **refer Figure 2** were agreed upon. Details of the qualitative assessment have also been presented to the Bicycle Transport Working Group in WA, which includes representatives from local cycling community groups and other Government stake-holders.

Variable Ratings

With the variable weightings set, the individual variables can then be rated in relation to the effect the project has on that particular variable. Completed by the project manager, project officer or in many cases by the Bicycle Transport Working Group ratings for the individual variables can be assessed. A positive rating indicates that the project will return positive benefits for that variable. A negative rating indicates that the project will have some adverse effects (or disbenefits) for that variable. A zero rating indicates that the project either does not have any effect on that variable (for example a grab rail does not contribute to the interconnection of networks), or the impact is neutral (for example resurfacing a track may not effect time and distance savings)

+3 The project has a high positive (or highly favourable) impact for that particular variable.

+2 The project has a moderately positive (or favourable) impact for that particular variable.

+1 The project has a low positive (or slightly favourable) impact for that particular variable.

0 The project does not contribute at all to that particular variable.

-1 The project has a low negative (or slightly unfavourable) impact for that particular variable.

-2 The project has a moderately negative (or unfavourable) impact for that particular variable.

-3 The project has a high negative (or highly unfavourable) impact for that particular variable.

With the ratings assessed for an individual project's qualitative effect, and the relative factor weightings provided, the rating and weighting are multiplied together to obtain a score for each factor. The sum of all the scores results in a Qualitative Score for use in the ranking of the projects.

Ranking of Projects

To enable a ranking of one value only for a project an indication of the monetary value of the qualitative score would need to be made. To do so would require considerable assumptions and the credibility of the valuation would be doubtful. It was therefore recommended that the projects be ranked considering both the quantitative and qualitative factors in isolation. That is both the values are available to the fund managers. To provide the whole picture a listing of the $BENEFIT, the $COST, BCR, and the Qualitative Valuation is recommended. A project assessment summary sheet is provided as **Figure 3**.

Throughout both the quantitative and qualitative assessments a number of assumptions have been made by the assessor. For example changes in crash rates, the number and length of new trips, recreational versus commuter trips and the impact of the project on qualitative factors. Further refinement to provide guidance on the these assumptions is recommended. The BCR and Qualitative score must therefore be viewed as indicators and not definitive measures of a projects worth. In considering this it is recommended that the ranking of the projects is carried out as follows:

1. Rank the projects based on BCR (or Net Present Worth if desired).
2. Group the BCR's into like scales, for example 0 to <0.5, 0.5 to <1.0, 1.0 to <1.5, 1.5 to <2, 2 to <3, 3 to <5, 5 to <10, >10. (depending on the typical benefit cost ratios actually noted in practice, a review of these ranges may be required).
3. For each group rank within the group by the qualitative factor from highest positive value to the lowest negative and provide a rank number eg 1,2,3,4…..x.
4. The resultant list provides the final ranking of the projects from 1 to x.

For Example:

PROJECT	BCR	Qualitative Score	Ranked Order	
Hoighty Path	5.7	22	1	BCR Group 1 (BCR 5 to<10)
Pedal Pass	7.1	11	2	BCR Group 1
Chain Link Rd	4.1	18	3	BCR Group 2 (BCR 3 to<5)
Farthing Track	3.9	8	4	BCR Group 2
Puncture Path	4.4	-13	5	BCR Group 2……etc

A further refinement could be completed where a secondary ranking is completed considering a different grouping of BCR ranges. The other steps are completed as above, providing a second ranked order. The rank number from each assessment is summed for each project and the list sorted again in ascending order to determine the final ranking of the projects.

It is noted that some factors will at times override the ranking provided from this assessment, such as commitments to elements of the Perth Bicycle Network Plan. These factors can be highlighted in the process and allow flagging of projects that would otherwise finish further down the prioritised list. That is critical levels or factors are pre-designated such that if their importance rates a +3 then a flag is created indicating that for individual projects there is extenuating circumstances to consider in the ranking of the project. Committed projects may fall into this category where for example community pressure rates a +3, and the project is flagged for further consideration even though the benefit cost ratio and qualitative valuation may be relatively low. If the total qualitative score is high, this may also prompt a need for reconsideration of the projects ranked position, with the possibility of moving the project higher up the prioritised list. The final decision for these types of projects should be made at the strategic level.

THE RANKING PROCEDURE IN PRACTICE

Following completion of the report a series of consultations have been made with MRWA staff involved in the ranking of cycling projects to finalise the details and ensure an understanding of the needs and processes involved. To further simplify the ranking process a computer package has been developed to carry out the project assessment and ranking process. Following this it is anticipated that on completion of gathering relevant information bicycle projects will be able to be evaluated in a very short time, requiring only a small investment of time by the project assessor.

RIDING ON FROM HERE

Testing of the ranking procedure is still in its infancy, with scope for future improvements likely to arise from "in-field" use of the package. Areas where other developments are possible include:

- quantifying some of those factors listed in the qualitative analysis so they may be included in the BCR analysis.
- more definitive work in helping practitioners assess crash reductions, risks of typical riding environments, estimation of the number and length of new trips generated by a facility and the purpose of trips.

Many of these improvements will need to be conducted at a local level, given existing bicycle use and the particular circumstances of the local area. With these additions the ranking procedure should help authorities determine the right projects to complete at the right time, and keep cycling on track!

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Rob joined the Western Australian office of ARRB Transport Research in March 1997. He obtained first class honours in the Bachelor of Engineering in Civil Engineering at the University of South Australia (1992).

Since joining ARRB Transport Research Rob has been involved in projects to rank pedestrian, cycling, and intersection treatments; the ranking of road safety audit recommendations; investigation of relationships between skid resistance and crashes; review of ITS and traffic management state of the art practice; frangible sign pole design; and disaster planning to name a few.

Rob's previous position was with the Department of Transport (SA), working in both rural and urban regions. His work has included planning, design and construction of a number of road projects. He has also been involved in the formulation of tactical and field management systems for both outback and sealed networks and on the implementation and running of road maintenance contracts. In 1996 Rob successfully completed a Road Safety Auditors Course and is now an accredited auditor.

Figure 1: FLOWCHART - RANKING PROCEDURE FOR BICYCLE FACILITIES

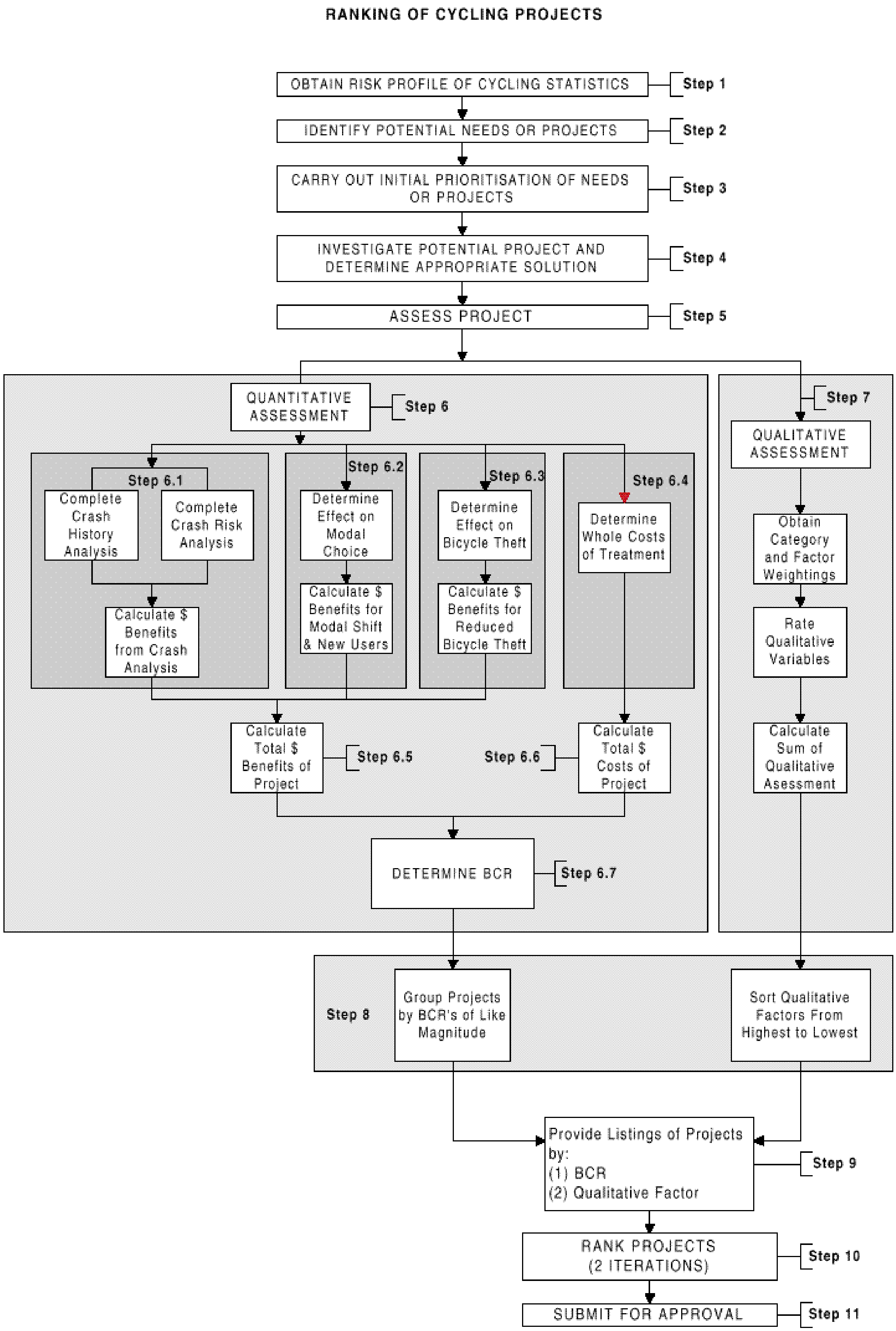

Figure 2: Qualitative Assessment Form

Category	Cat. weight	Factors	Factor weight	Final weight (A)	Rating +3 to -3 (B)	Score (A*B)
A Level of Service	20%	1. What is the current Level of Service compared to Level of Service 'B' E=+3, D=+2, C=+1, B= 0, A=-1	50%	0.1		
		2. What effect will this project have on LoS of the section = Weighted score project case - Current weighted score. (ranges to score to be determined)	50%	0.1		
		TOTAL	100%			
B Coherence and directness	20%	1. Interconnection of networks	35%	0.07		
		2. Consistency of quality	25%	0.05		
		3. Clearness of layout	10%	0.02		
		4. Time and distance savings	30%	0.06		
		TOTAL	100%			
C Attractiveness and comfort	15%	1. Scenic value of physical environment	30%	0.045		
		2. Perception of facility	15%	0.0225		
		3. Bike security	15%	0.0225		
		4. Capacity of facility	20%	0.03		
		5. Complexity of riding task	20%	0.03		
		TOTAL	100%			
D Safety	15%	1. Personal security	30%	0.045		
		2. Reducing intimidation or crash threat concern	25%	0.0375		
		3. Reduction in areas of possible conflict	45%	0.0675		
		TOTAL	100%			
E Environment and Health	10%	1. Reduction in pollution	35%	0.035		
		2. Health effects of facility	35%	0.035		
		3. Community benefits	30%	0.03		
		TOTAL	100%			
F Strategic	10%	1. **Network strategic importance** *	25%	0.025		
		2. Local strategic importance	20%	0.02		
		3. Education and encouragement	15%	0.015		
		4. Social equity and mobility	20%	0.02		
		5. **Community pressure** *	10%	0.01		
		6. Asset preservation value	10%	0.01		
		TOTAL	100%			
G Other Users	10%	1. Motorists	15%	0.015		
		2. Pedestrians and disadvantaged groups	45%	0.045		
		3. Residential environment	25%	0.025		
		4. Business environment	15%	0.015		
		TOTAL	100%			
TOTAL	100%				SCORE	

Ratings: +3 high positive impact; **+2** moderate positive impact; **+1** low positive impact;

0 no impact; **-1** low negative impact; **-2** moderate negative impact; **-3** high negative impact

If Qualitative Score is > 20 then Project is flagged also (max score 30) *

Figure 3: PROJECT SUMMARY SHEET

Project Name: ____________________

Project Description: ____________________

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PROJECT ANALYSIS

Evaluation Period		
Project Cost		
Project Benefits		
- Crash Reductions		
- Mode Shift		
- Reduced Theft		
Project Benefits Σ =		
Benefit Cost Ratio =		Discounted over Evaluation Period
Qualitative Value =		

Other Details - flags ____________________

____

____

Assessed by: ____________________

Date: ____________________