Improving the safety of

WATERSLIDES

with

Recommendations for their design and management in the U.K.

a report by

S a i L

The Safety in Leisure
Research Unit

March 1990

IMPROVING THE SAFETY OF WATERSLIDES

WITH

RECOMMENDATIONS FOR THEIR DESIGN, MANUFACTURE AND MANAGEMENT IN THE U.K..

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ISBN 0 9515935 0 1

March 1990

PREFACE

As demand for leisure and tourism continues to grow, consumers are increasingly searching for new experiences and settings in which to spend their free time. Consequently, visitor attractions, leisure parks and leisure complexes are developing a wide range of thrilling facilities to create new, and keep existing, customers in, what is becoming a very competitive market. The result is a constantly changing leisure environment to meet the demands of the consumer. A feature of this changing environment in Britain is the growing number of waterslides. Waterslides allow a rider to descend on a film of water down a constructed channel at speed, ending in a deacceleration catchment area.

Most people do not associate risk of injury with leisure environments and yet a large proportion of accidents occur during leisure time. There have been deaths associated with waterslides in other countries and the first one in Britain occurred in 1987. This prompted the question - how safe are waterslides in Britain? At that time the data available was paltry and this question could not be properly addressed. The consequence was the formation of the SAIL Research Unit and a detailed investigation into the number, type and cause of accidents in an effort to give a true picture of the risk and hazards faced by users of waterslides in the UK.

This is the most comprehensive survey undertaken of the subject in Britain. The research is also innovative in a European context and appears to be unrivalled elsewhere. The work of SAIL has stimulated considerable interest from around the world - Japan, USA, Canada, New Zealand, Australia and several European Countries - we hope that this report will provide manufacturers, designers, operators and legislators with a solid foundation upon which to help build safer leisure environments for our clients.

Dr T R Stevens
Director of Research

ACKNOWLEDGEMENTS

The SAIL Research Unit is indebted to the many organisations and individuals who have made this investigation possible. In particular our thanks goes to those operators who patiently completed lengthy questionnaires and, who responded to our requests for detailed, often delicate information. The co-operation received was remarkable and is reflective of the industry's corporate concern to improve the safety of leisure settings for our customers.

The Research team also acknowledges the financial support it has received from its Sponsors (see Appendices) and the unstinting commitment of its Steering Committee. Finally our appreciation is recorded to the West Glamorgan Institute of Higher Education which has facilitated the production of this final report. Our particular thanks goes to Mr. D. Davidson, Dean of the Faculty of Business Studies, who has enthusiastically and competently chaired the Steering Committee.

Dr T R Stevens
Ian S Jenkins

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CHAPTER 1

THE INVESTIGATION INTO WATERSLIDES IN THE U.K.

INTRODUCTION

The demand for leisure is ever increasing and with it comes the search for new experiences. As a result the environment of many leisure settings is constantly changing to meet the emerging demands of the consumer. Leisure centres built today are very different to those built ten years ago. One feature of change in this particular environment is the introduction of waterslides. Waterslides are a relatively new concept in Britain. As with all new concepts and technologies, the design, operational procedures and use are constantly changing in response to the learning curve of experience. With all new products the available information for feedback has a tendency to be sketchy. Lack of available information can mask improvements to design, operations and use. Waterslides first appeared in North America in the early 1970's and have become a major component of outdoor water theme parks. In Britain, the appearance of waterslides is essentially a phenomenon of the 1980's and is generally associated with indoor leisure pools or complexes.

The feature of waterslides most commented on over the last few years by journal articles and press reports is **safety**. The reports concentrate on the serious nature of accidents which have occurred on specific waterslides implying that these accidents may well be occurring at all installations in the UK. Aiding this belief is the paucity of available accident statistics relating to waterslides. This has tended to lead to the production of what can only be described as mythology. For example, it is not uncommon for some members of the public to comment that razor blades have been placed strategically in a slide with the intention of producing lacerations. However, further investigation of these occurrences have to date yielded no evidence to substantiate the reports. In one particular case the cause of the accident was a badly aligned joint, resulting in sharp edges which produced lacerations. The effect upon the casualty appears to be very similar to a razor blade cut.

MASSIVE GROWTH

The number of accidents reported has a tendency to heighten the concern, but it must be viewed in the light that the growth of waterslides in Britain have greatly expanded over the last five years. This can be illustrated by comparing the Sports Council's findings with SAIL's present figures. In 1987 a Sports Council study identified 54 operators with slides. To date the unit has established that up to February 1990 there are 236 operators in the United Kingdom with waterslide installations, either running or expected to open in the near future.

From the current research undertaken this growth shows an exponential pattern. The result has been that even small community leisure centres are now being equipped with waterslides. A prime example of this is the leisure centre at Pentwyn, Cardiff, which opened in 1989. It seems likely therefore that more slides will eventually produce more accidents, and with new designs, new types of accidents will emerge. The need for careful consideration of safety issues is particularly important as growth in numbers continues to take place.

PREVENTION AND REDUCTION

The main question raised by the leisure industry is not whether there can be a total eradication of accidents on waterslides (an impossibility), but whether particular types and the overall number of accidents could be prevented, or substantially reduced.

It was evident that this question could not be addressed until a comprehensive, succinct, and clear UK database was established. Armed with this information it is possible to identify particular problem areas and, thus, attempt to form guidelines for the operator, manufacturer, designer and user, in the effort of preventing and reducing accidents.

A COMPLEX EQUATION

A close examination of medical, leisure and architectural research, together with safety guide-lines issued by relevant bodies (World Waterpark Association, Health and Safety Executive and Sports Council) and the facts gathered from each stage of this research have identified the complexity of the problem

that faces the industry. Defining locations on slides where accidents occur is relatively easy; however it is but the tip of an iceberg. Within each area where accidents occur, the variables which change the safety parameters of a slide are many. Current evidence shows that a slide which may be designed to be safe under one set of parameters may become dangerous where the conditions are changed. For example a visit to a very prominent operator with an apparent excellent safety record revealed evidence in support of this argument. Since its opening some 18 months ago there were few identical accidents on any of the flumes. Yet within one week three identical accidents occurred, producing the same injury and occurring at the same location on the slide. The major question raised is, "why has it taken 18 months to emerge?"

There appears to be two possible answers. Firstly, perhaps the experience gained by riders over 18 months have exceeded the design parameter of the slide. A logical answer, especially as many of the other variables have remained constant. Secondly, a less apparent answer could be that some accidents occur, purely by chance, in a clustered pattern. The implication here is that the accidents may not have been related to the experience of the rider, or to the slides design, but are purely a coincidental and statistical occurrence. The solution to these two answers lies only in careful monitoring and evaluation. The inference from these arguments is that for operators, designers, and manufacturers of slides there may not be simple solutions to the reduction of accidents. Complex problems may well produce complex solutions.

Nonetheless, the challenge exists to create safer leisure environments. The complexity of the equation for waterslides is explored fully in the research findings. This report highlights a number of vital conclusions: perhaps more importantly it makes recommendations as to the method and means of making slides safer pieces of equipment to design, install and use. In addition, aspects of 'good practice' are included to assist the implementation of this process.

CHAPTER 2

AIMS AND OBJECTIVES OF THE RESEARCH PROJECT

The monitoring of accidents requiring hospitalisation takes place under the (Department of Trade and Industry's) "Home and Leisure Accident Surveillance System", and the concurrent European system (EHLASS). These exercises clearly illustrate the growing extent of factors that include: inadequacies in design, manufacture, and installation; together with inappropriate management; and ill-prepared users.

At present, our knowledge of the extent, scale and nature of accidents in leisure settings generally is patchy. The Office of Population and Censuses Statistics data, for example, records only fatalities, whilst other sources of information, e.g. medical records, articles, press information and management accident reports, tends to lack national co-ordination. The experience elsewhere indicates that where detailed analysis of data about accidents in leisure settings is available it can have a positive influence reducing the probability of accidents to users (USDHHS, 1986).

Comprehensive data about accidents that occur on, or in, leisure facilities and leisure settings forms the basis for <u>positive</u> measures to prevent their occurrence in the future. There is an <u>urgent need</u> for detailed information to aid the:

DESIGN
MANUFACTURE
INSTALLATION and
MANAGEMENT of leisure equipment to

PREVENT INJURIES ... ACCIDENTS ... and DEATHS

in our leisure facilities. The safety of our customers has got to be the primary consideration of all owners, operators, designers, architects and manufacturers. In the case of waterslides, Lloyce Boyd (1987) has recently stated, "The future of the waterslide industry is dependent upon the subject of safety". This was reiterated by Al Turner (President of World Waterparks Association) (Rhodes, 1987) when he says "this should be the goal of every manufacturer that their design is neither wholly, nor partially, to blame for any injury".

Safety in leisure settings has been identified by the EEC Consumer Division and by several major companies as being one of the dominant consumer issues over the next decade. Walt Disney World Ltd, for example allocates 'Consumer Safety', the central role in its corporate objectives. Safety is critical to the quality of consumer experiences in leisure settings.

This concern for safety is shared by the majority of those involved in leisure provision. It is also of primary concern to RoSPA; to consumer interest groups; to the Health and Safety Executive and to the various grant-aiding and development organisations including the Sports Council , the Sports Council for Wales, the National Tourist Boards and others. In 1988, in response to this concern, the Safety In Leisure Research Unit (SAIL) was established in the Department of Tourism, Leisure and Health Care at the West Glamorgan Institute of Higher Education.

The Research Unit has the following functions:

i) To collect and collate information about injuries and accidents in leisure settings, using existing records and by introducing new monitoring schemes and research methodologies of data capture.

ii) To analyse this data, identify problem areas and to provide regular information of its findings by way of research memoranda, seminars, meetings, articles and fact sheets to manufacturers, suppliers of equipment and managers and operators of the facilities.

iii) To provide resources to assist educational and the advisory work of the RoSPA, the Health and Safety Executive, the professional bodies, the DTI and the EEC Consumer Policy Unit.

iv) To liaise closely with manufacturers, architects, designers and other interested parties to help improve safety consciousness and standards.

v)To assist managers, operators and key personnel working in leisure with the provision of Training and Educational resources and opportunities. This will include: courses, open-learning programmes, printed advice, counselling and support services.

The aims of the Unit are as follows:

a) To reduce the likelihood of accident, injury or death to users and operators.

b) To provide information and a research service to manufacturers, operators and users of these facilities.

c) To improve the design, management and safety standards of leisure facilities and equipment.

d) To increase public awareness of the potential hazards of inappropriate use of leisure facilities and equipment.

e) To promote the cause of safety and the prevention of accidents in our leisure settings.

f) To educate people to become safety conscious in environments which induce a carefree atmosphere.

g) To provide educational resources and opportunities.

In the context of the Research on Waterslides, a Steering Committee was established to set down the aims and objectives of this initial study. They are as follows:

A. **AIMS**

I. To provide a UK database for Waterslides.

2. To use this information in assessing the risk of waterslides to the public.

3. To identify the real nature of the accidents that occur on waterslides.

4. To identify the cause of accidents on waterslides.

5 To put forward recommendations for the reduction and prevention of accidents on waterslides.

B. **OBJECTIVES**

I) To identify the total number of waterslides in the UK.

ii) To gather information concerning the design specification of each waterslide in the UK.

iii) To gather information concerning the operational procedures of each water-slide in the UK.

iv) To detail the types and frequencies of accidents that occur on waterslide in the UK.

v) To isolate and examine variables which may be contingent with accidents on waterslides.

vi) To provide guidelines for the safe operation and design of waterslides.

CHAPTER 3

RESEARCH METHODOLOGY

RESEARCH RATIONALE

The research programme (October 1988 - December 1989) was designed to include both quantitative and qualitative methods of gathering information. This encompassed questionnaire surveys (postal and on-site), monitoring users on slides; and interviews with management, life-guards and other staff. The analysis of this information used appropriate statistical methods to identify significant variables which affect the incidence of accidents on waterslides.

Throughout the period of research a programme of visits to waterslides in Britain, Europe and the United States has been carried out in conjunction with an in-depth assessment of a selection of sites which were considered particularly relevant. An integral part of the research has been the presence of a Steering Committee. This was formed in order to advise and guide the progress of the research. The Committee comprises representative members of the leisure industry who have an interest in waterslide safety. (For list of Committee members see Appendix 1). The Committee has met on three occasions - November 1988, April 1989 and December 1989. The Research Team has been aware of the need to present the findings as quickly as possible. It was felt that information and recommendations should be available within 24 months due to the importance, and topical nature, of this area of concern. The Unit has improved this proposed time scale and effected the research within 14 months.

The programme of research which was undertaken is set out below in chronological order:

<u>STAGE 1: DESK RESEARCH</u> (October 1988)

- Examination of available information concerning all aspects of waterslides - from design to consumer behaviour.

<u>STAGE 2: FOUNDATION DATABASE</u>
(October 1988 - March 1989)

- To establish the number of slides present in the UK.

- To establish the nature of these slides in the UK - concentrating on the design characteristics of these slides.

- To ascertain whether accidents have occurred on these slides; and to analyse and assess relationships between accidents and slide specifications.

<u>STAGE 3: DETAILED DATA BASE</u>
(February 1989 - May 1989)

- To collect details concerning the number of accidents occurring on slides.

- To establish the nature of the accidents and injuries occurring on these waterslides.

- To establish the operating procedures used in the running waterslides.

- To analyse the information and indicate trends that may be occurring related to injuries, causes, operations, and use.

<u>STAGE 4: IN-DEPTH MONITORING</u>
(May 1989 - September 1989)

- To gather in-depth information concerning the use of slides at sample sites in the UK.

- To assess critical variables in a comprehensive manner at each site.

- To compare the trends found in this stage with those already identified in Stages I, 2 and 3.

<u>STAGE 5: ANALYSIS AND EVALUATION OF THE DATA</u>

- To establish any trends that may be forming - identifying variables that appear to be salient in the causation of accidents in the UK.

- To assess the nature of risk and severity of injury that might be occurring on waterslides.

POINTS OF REFERENCE

It should be noted that there is a potential problem in agreeing upon the definition of what constitutes an 'accident' and an 'incident'. There appears to be a wide divergence in what many operators define as an accident. *In order to gain some semblance of uniformity 'accident' in this report is taken to mean "any incident which has resulted in an injury to a user irrespective of the severity of that injury*". However, where specified some effort is made to try and differentiate between the degree of severity of the accident. **We recommend, however, that quality monitoring of use of waterslides differentiates between incidents and accidents**. There is relevance in monitoring and analysing incidents as a pre-emptive attempt to identify potential accidents.

WATERSLIDES

The term waterslide will be used as the generic term to include all types of slides used in leisure locations. The definition used is that stated in the report by the Health & Safety Commission and the Sports Council's - "Safety In Swimming Pools, 1988." A "Slide which begins more than 2m above the surface of the landing pool ..... A slide may be provided singly or as part of a multiple unit; and may be straight or incorporate bends. A flowing water film is usually provided to reduce friction" (1988).

This therefore excludes slides of less than 2 metres. (This definition also concurs with the West German DIN STANDARD 7937).

CHAPTER 4

A DISCUSSION OF THE FINDINGS

RESPONSE

The response rate to Stages 2 and 3 of the research was excellent, especially for a postal questionnaire. In both cases the response has been in the order of 70% which we consider to be exceptional. We attribute this high success rate to careful targeting of operators; the industry's lack of information available related to waterslides linked to the thirst for operators to obtain an overall picture of the UK waterslide industry; and, the genuine interest within the industry for safety.

The response from the users of waterslides during the Stage 4 of the research was also excellent. Of the 1600 people who took part in the survey there was only one refusal. This again indicates the relevances of the research undertaken. Indeed, many respondents commented on the need for this research and that they were pleased to see that a review of safety was taking place.

NUMBER OF SLIDES

Prior to this research, the number of slides in the UK could only be estimated. In order to establish the real nature and rate of accidents it was necessary for the Unit to establish the number and nature of slide provisions and installations. This was not a simple task it entailed the use of a significant proportion of the Unit's resources.

Fig I shows the distribution and number of existing and proposed slides in the UK as at February 1990. Table I below shows the number of operators and slides in the UK as at the same date.

TABLE 1: SUMMARY OF SITES AND NUMBER OF FLUMES

Table 1a: Number of UK Operators

I.	Slide operators responding to survey	= 136
2.	Known operators who failed to respond	= 50
3.	Additional sites/future sites actually planned	= 48
4.	Possible sites/under consideration, no firm action	= 6
	TOTAL	240

Table 1b: Number of UK Slides

I.	Slides identified in survey	= 165
2.	Operators yet not replying but slides known	= 50
3.	Extra slides = 5 (8% of operators have more than 1 slide)	
4.	Future and possible slides identified	= 83
5.	Dubious sites	= 5
	TOTAL	308

Compared with the Sports Council figure of 1987 of 54 operators, and considering that waterslides were rare before 1985, the above tables show an exponential growth since 1985. Fig 1 illustrates the locations of waterslides and shows that they correspond to the main centres of resident or holiday populations. This further underlines the fact that most people within the UK have now or will have shortly, access to a waterslide. Increasingly, a waterslide is considered, by many, to be a standard facility requirement in any new leisure centre development.

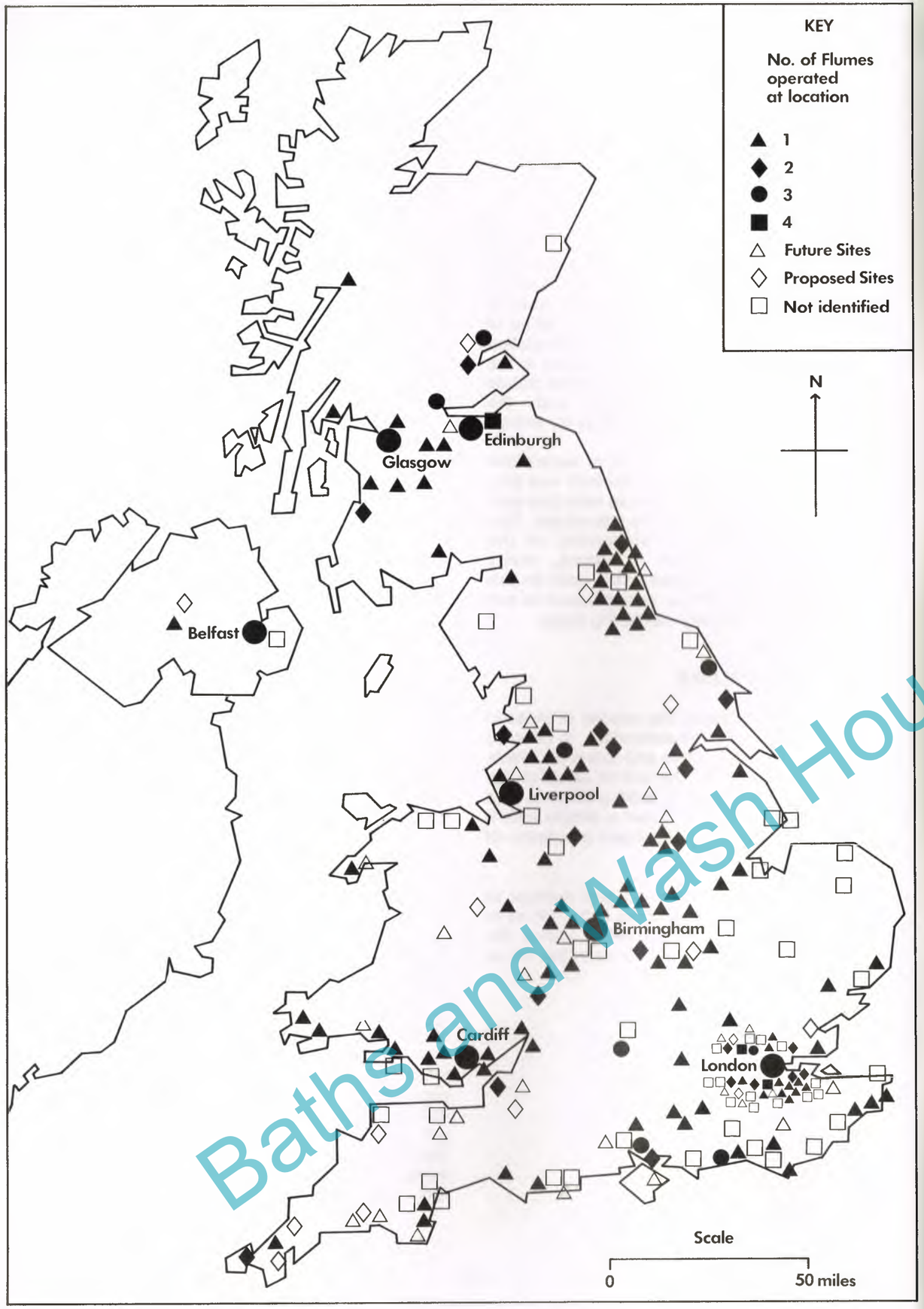


Fig. 1 **Waterslide locations in the UK**

Table 2 identifies the reasons for management incorporating a waterslide into a centre. It is clear that management sees a waterslide as a means of increasing the number of visits made to a facility - a salient point in these times of competitive tendering and increasing competition for the public's disposable time and income. However, as the report will indicate later, not every slide will necessarily result in increased revenue, nor to increased visitor attendance. Indeed, the impact of a slide installation upon a centre's existing and potential value should be carefully reviewed.

Careful consideration must be given to staffing levels and how the slide/s will affect the environment of the centre, especially if there is concern over the safety of a slide. It is asserted that safety is contingent with profit. This is argued on the premise that serious accidents resulting in litigation may increase premiums to insurance companies, and adverse publicity concerning safety may reduce visits to the centre which affects total revenue generated.

TABLE 2: ATTRACTION STATUS

	FREQUENCY	%
MAIN ATTRACTION	29	17.6
ADDED ATTRACTION	132	80.0
MISSING	4	2.4
	165	100.0

Table 3 illustrates that the majority of slides in the UK are at present, under the management of Local Authorities. With the advent of Compulsory Competitive Tendering (CCT) and the pressure to become more efficient, the use of waterslides to increase revenue may be seen as an easy way to achieve this. However, even though management views a waterslide as an added attraction from an operational point of view it must not be seen as just an add-on operational procedure. Careful consideration should be given to a range of factors, such as the number of additional staff required and how the slide will affect the supervision and environment of the centre as a whole. As the report will show, we believe that supervision is a critical variable in maintaining the safety of a slide, and that the number of slides directly influences the number of staff required to supervise them from a safety point of view.

The onset of CCT will inevitably lead to an increasingly higher proportion of installations being managed by private sector operators. There are obvious concerns for the future status of safety in this scenario where operational costs will be subject to particular scrutiny. We urge those responsible for the CCT process in local authorities to be mindful of the need to address these real safety concerns in their contracting mechanisms.

TABLE 3: PROPORTION OF PRIVATE\LOCAL AUTHORITY MANAGED SLIDES

	FREQUENCY	%
PRIVATE	18	10.9
LOCAL AUTHORITY	145	87.7
STATUS UNKNOWN	2	1.2
TOTAL	165	100.0

INJURIES

Of central concern to the investigation has been the nature and amount of injuries occurring on, or associated with the use of, waterslides. All too often the press reports have focused upon individual centres and featured specific injuries. In most cases there has not been any related risk analysis. Isolated injuries on their own are not grounds for concern- the frequency and the severity of the injury must be assessed before judgement is passed. One objective of the current research therefore, is to establish some form of risk analysis so that individual operators are able to assess whether their

accident ratio is acceptable or not, in relation to other waterslides and hazards that the public face.

A problem encountered by the research has been the diversity of accident recording systems used by operators. Table 4 illustrates this point. Although 50% of operators record all incidents, the other 50% of operators record only those incidents that constitute an 'accident'. As a result there must be a divergence in the data being collected which must, therefore, be treated with some degree of caution. This divergence in recording systems was confirmed on the many site visits that SAIL carried out. This situation would also appear to be common to organisations who collate accident data (for example the Home Accident Surveillance Survey HASS and European Leisure Accident Surveillance Survey ELASS reports). In order to standardise the data for the purpose of this report we have taken incidents as the base line for compiling accident statistics. Using this method no data has been excluded. By definition an 'incident' also includes an 'accident'. This means that all harm, however minor, sustained by users of waterslides has been included whenever this data has been available.

TABLE 4: ACCIDENTS RECORDED

	FREQUENCY	%
ALL INCIDENTS	42	50.6
ALL ACCIDENTS (minor & major)	28	33.7
ONLY MAJOR ACCIDENTS	2	2.4
MISSING	11	13.2
TOTAL	83	100.0

SAIL believes that a contributory factor complicating the existence of an appropriate data base is the lack of any standardised reporting technique and system. The detailing of an incident\accident in many cases appears to be dealt with by the duty life-guard or pool attendant. Most are anxious to return to their duties as soon as possible, with the result that there is a tendency for the reporting and the information detailing the incident to be very sparse, to the extent that in some instances an attempt to ascertain how the incident occurs cannot be effected. Even simple details like name and address of injured party have sometimes been omitted. Hence it is not surprising that when information is requested about the nature of an injury little is available. A typical example of accident reporting which SAIL encountered was "cut, boy, cause - misbehaviour". No indication was given of where the incident\accident occurred on the body or the severity of the injury and there was no information regarding the specific area in the building where the incident occurred. Examples of good practice were identified at a number of centres. These aspects of good practice are detailed later.

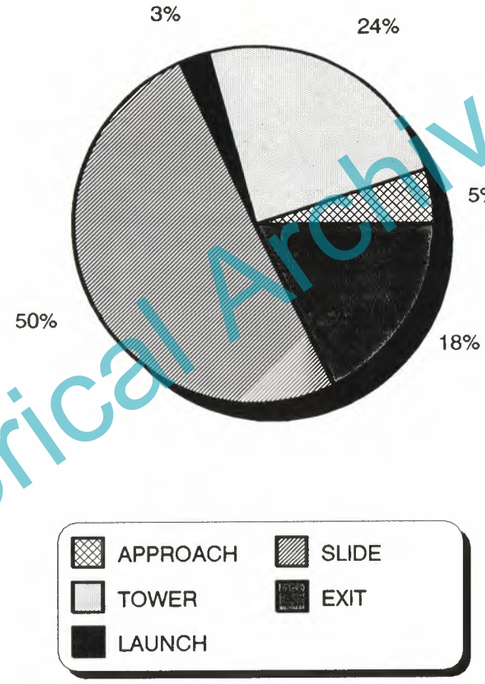
It is recommended that a reappraisal of the accident and incident reporting systems in centres and complexes should be actioned immediately. A system should be devised which allows the employee completing it, to write as little as possible thereby standardising the response and speeding up report procedures. A short questionnaire/ proforma would be an ideal method of gathering incident/accident information. This should clearly stipulate questions which must be answered by the reporting officer. Where appropriate, a computer based reporting system should be designed.

ACCIDENTS ON UK SLIDES

As can be seen from the Table 5, nearly 70% of the waterslides operated in Britain which took part in our survey admit to have suffered from some form of accident. The Unit believes that this figure is much higher but is being masked for two reasons:

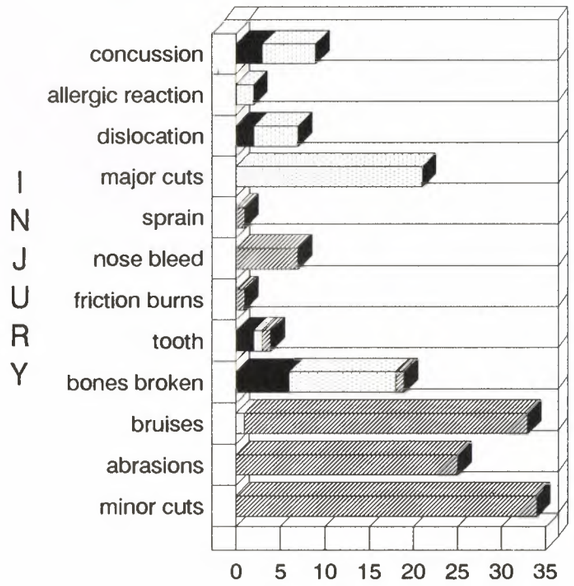
ACCIDENTS

FIGURE 2 - SLIDE LOCATION



INJURIES

FIGURE 3



a) Accidents have occurred but operators failed to reply 'yes' believing that there should be no accidents at their facility. The Unit has confirmed at least one case where this has occurred.

b) Due to the different definitions of what constitutes an 'accident' and an 'incident' as interpreted by staff completing the questionnaire.

TABLE 5: RECORDED ACCIDENTS ASSOCIATED WITH WATER SLIDES IN THE UK

	FREQUENCIES	%
YES	115	69.7
NO	41	24.8
MISSING	9	5.5
	165	100.0

This information provides basic insights on the state of UK waterslide operations. However, it is the intention of the research to ascertain the number and type of accidents which have occurred. In order to realise this objective the next set of questions which were addressed included how many accidents have occurred and where on the slide have these injuries taken place?

These questions were asked of all operators in our survey. The results are illustrated below. This data shows the number of recorded accidents in Britain. These accidents relate to the operational period 1984 - 1989 (October) (Fig 2 and Table 6).

TABLE 6: ACCIDENTS AND LOCATION ON SLIDE

	FREQUENCY	%
TOWER (APPROACH)	233	4.7
TOWER	1123	22.77
LAUNCH	120	2.4
SLIDE PATH	2347	47.59
EXIT AREA	827	16.77
TOTAL	4932	100.0

Although some operators failed to respond to this question, of those that did over 73% noted accidents. This concurs with our initial findings. The figure above shows the distribution of these accidents in the waterslide system. Three areas prove to be particularly significant. Most accidents are concentrated on the slide path; however, the exit area and the tower also have a high proportion of injuries and must be a cause of concern.

What is not shown here is the nature of the injuries - which in essence relate to the hazards faced on the waterslide. The allocation of the injuries to different slide locations indicates that; purely in numerical terms, the splash pool may not be presenting the industry with the problems so often reported in articles and emphasised by the World Waterpark Association. One suggestion for the apparent reduced importance of the splash pool in Britain, compared with the U.S. and other countries experience, is that in Britain the majority of pools fall within the DIN minimum standard (see Chapter 6, fig. 17).

Attention is drawn to the fact that the tower has had more accidents than the exit area. A large proportion of articles cite the slide path and exit areas as primary subjects of concern. Yet in this analysis the tower is more important than the exit area. 1123 accidents occurred here, which is equivalent to 22% of all accidents occurring on waterslides. The evidence therefore suggests that the tower may be as, if not more, important as the exit area in relation to injuries.

The information presented on total injuries provides data on where the accidents are occurring on waterslides. The objective of this investigation was to examine whether slides, in general, presented the public with an unnecessary risk. In order to achieve this objective the Unit examined the frequency of accidents, in relation to the number of rides on the slide. At present however, recording systems adopted by most operators fails to detail, accurately, the number of riders using a slide at any point in time. At best, establishments may keep the number of people using the entire centre. This information can be used to indicate the number of people using the slide but not the number of rides on the slide. The Unit has undertaken a risk analysis of injury by assuming a ratio of one ride per person. This of course will produce the worst scenario in relation to potential risk for waterslides in the UK.

The table below shows the potential for risk for each year of operation of an average establishment. (It should be noted that only those operators having accidents have been included in the analysis thereby producing the 'worst' possible risk ratio for UK waterslides.

TABLE 7: RISK OF ACCIDENTS ON SLIDES UK

1st yr I:27,580 Descents

2nd yr I:17,685 Descents

3rd yr I:24,258 Descents

The figures show a distinct decrease in accidents during the second year of operation. A possible explanation for this is that the management/operational mistakes in the first year have been rectified. The third year, however, shows a considerable increase in the accident rate. A possible reason for this increase may well be the occurrence of complacency by user, staff and management. It should be remembered that these figures are an average for all slides recording accidents in the UK and few slides will fall exactly within the figures given above. The standard deviation of these figures is in the order 40-50,000 which indicates that some establishments have accidents I:100,000 descents. Others, however, will have accidents as high as I:205 descents. This indicates either the inaccuracy of the figures (estimates of descents) or that some slide operators have serious problems. It is important to recognise even at this stage that a slide system is by no means standard, and that each slide operates within different safety parameters.

Figures gained on a more accurate framework - analysis of sample sites (Stage 4 of research) - indicate that these average risk factors may not be as inaccurate as suggested. The in-depth analysis carried out under stringent controlled conditions indicates that risk ratios range from :

DESCENTS I:10,000 to 1:20,000

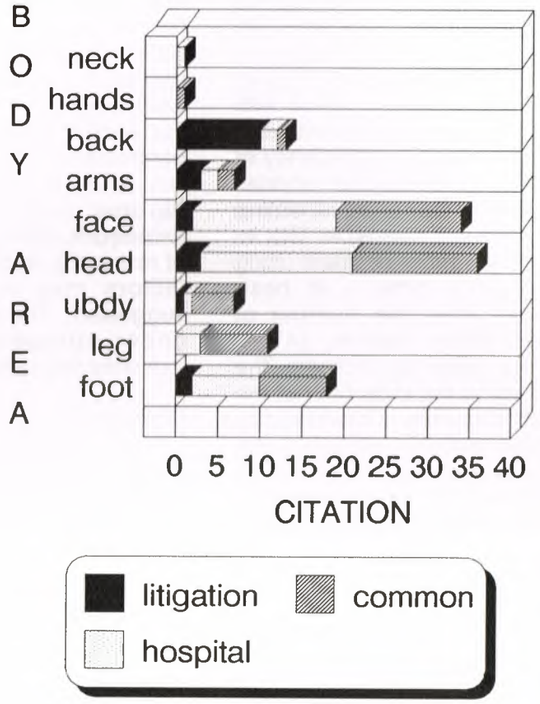
These figures are not so far removed from those proposed in the total UK survey where we investigated both the number of rides and the number of riders. The important element here is that if a slide is producing injuries higher than I:10,000 descents then it may be salient for the management to consider improving the slide conditions (design, management and user). Sadly, most operators are unable to provide accurate statistics of the number of riders; rides; or, descents per year for their slide(s). Consequently, **it is recommended that an accurate system of measuring the number of rides on a slide should be incorporated immediately**.

A method which could be used, involving minimal human resources would be the placement, at the entrance, to the slide of either a turnstile with counters; a pressure panel and counters; or an electronic sensor.

Although this will incur an initial capital cost it can be argued that this may be recouped by early warning signs detecting an increase in the risk ratio. This information will also provide management with an analysis of the use of the slide over periods of time. This is important for as we have seen most centres employ a slide as an added attraction to increase overall revenue. Like all products, slides do have a limited product cycle - tastes change and the first thrills gained on a slide by a rider eventually turn to apathy and complacency in relation to safety considerations. There is a higher proportion of males who sustain injury compared to female users (60% male : 40% female).

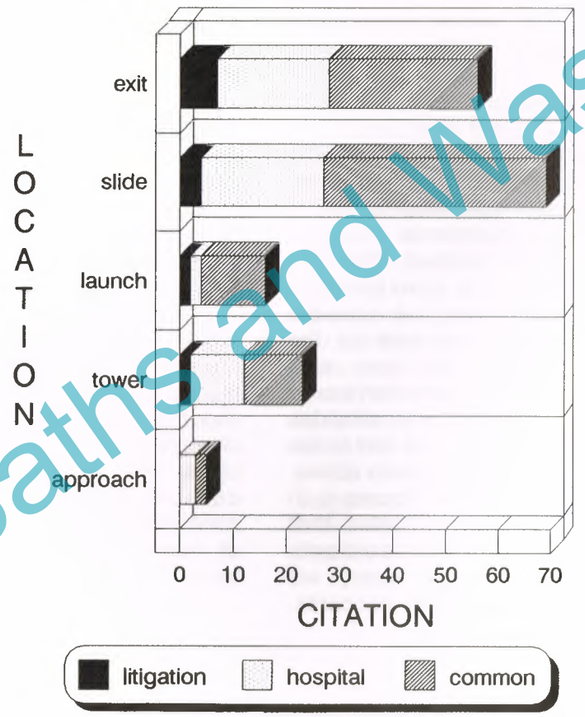
INJURIES

FIGURE 4. BODY AREA



INJURIES

FIGURE 5 - LOCATION ON SLIDE



Males are the dominant user group exceeding females by 10%. Males are, therefore, injured more frequently in proportion to use than are females. It should be noted with concern, however, that the level of female injuries is still higher than you would expect in terms of normal injury patterns. It would appear, therefore, that both male and female users are at risk - males have a higher frequency of injury in proportion to use than females but female riders also have a higher than normal propensity to suffer injury according to our medical advisor.

INJURIES: MALE AND FEMALE

TABLE 8: MALE AND FEMALE INJURIES

	FREQUENCY	%
MALES	2530	60
FEMALE	1649	40
TOTAL	4179	100

TABLE 9: USE OF SLIDE BY GENDER
(Stage 4 Sample Sites)

	FREQUENCY	%
MALES	689	54.5
FEMALES	572	45.25
MISSING	3	0.25
TOTAL	1264	100.0

Clearly then, the argument that more males are injured than females because of greater usage does not hold true(referring to Tables 9 and 10). Evidence to suggest that males have a higher propensity to injury is also supported in Stage 4 of the research. This information shows clearly the spread and distribution of injuries on slides.

TABLE 10: INJURY BY GENDER
(Stage 4 Sample Sites)

	FREQUENCY	%
MALES	70	76.9
FEMALES	17	18.7
MISSING	4	4.4
TOTAL	91	100.0

The sample survey, (Stage 4), supports the assumption that males are more prone to accidents than females. The next question to be asked is why? This is not easy to explain. However, one answer may lie in the relationship with speed travelled on a waterslide. As the report will show, at a later stage, there is a significant relationship between speed and gender. This may be important as other studies into injuries on waterslides also show a higher proportion of males being injured than females. A possible reason for this may be that males have a propensity to travel faster than females on waterslides, and that fast speeds on waterslides are linked to injury. Caution is expressed here, however, as increased injuries to males for these reasons are likely to be slide specific.

NATURE OF INJURIES

Risk ratios only explain half of the equation relating to safety on waterslides. Hazard is a means of assessing the severity of accidents which occur on waterslides. In order to achieve this objective the research was designed to gather information on accidents relating to:

a) common injuries

b) those resulting in hospitalisation (a visit to a casualty unit rather than a stay in hospital over a 24 hour period;

c) those resulting in litigation;

d) those injuries resulting from joints;

e) injuries resulting from collisions;

f) worst injuries to occur;

This information is summarised into four headings:

1. Type of injury

2. Location of injury on body

3. Location of injury on slide

4. Cause

These frequencies are illustrated in Figures 3 to 6 - (Tables 4.1 to 4.11 in Appendix 4) Common injuries.

COMMON INJURIES

Figure 3 shows that the most common (frequently occurring) accidents to occur are those resulting in minor cuts, bruises and abrasions which constitute up to nearly 90% of accidents occurring on waterslides. Even though these injuries appear minor a worrying statistic is found when the area of the body (Fig 4) most at risk from injury is identified. Injuries to the face and head constitute up to 54% of all the injuries cited. This is disturbingly high when compared with injuries to other areas of the body. Of those operators who cited common accidents, 44% (Fig 5) noted that the slide was the most frequent area in which those accidents occurred closely followed by the exit area or splash pool (29%). This would seem to concur with the profile of accidents found on the different areas of the slide. However, the tower section is noticeably reduced in its importance with regard to accidents causing common injuries. The most frequent cause (Fig 6) of these injuries appears to be collisions with the slide walls : up to 25% of operators cited this as occurring. Closer examination shows that slipping is also a fairly common cause 24% of accidents.

In summary the majority of common injuries are caused by three areas in the slide system (constituting 65%): Collision with walls, collision with exit area and slipping.

INJURIES RESULTING IN HOSPITALISATION

Most injuries resulting in hospitalisation are a consequence of major cuts (Fig 3) (43% cited these). Next, in frequency, are broken bones, cited by 25%. SAIL is particularly concerned that 68% (Fig 4) of operators cite injuries to the head and neck area as a cause of hospitalisation. Concurring with the trend of common accidents, the slide path and the exit area constitute the locations where most of these injuries occur (74%) (Fig 5). Significantly, hospitalisation occurs on a ratio of l:23 injuries.

It can be argued by examining the statistics that the pattern of common injuries mirrors those injuries which result in hospitalisation, (Fig 4) especially if the area of the body affected and the slide location are taken as guides. It can be argued that minor accidents may well be a guide, therefore, to predicting the characteristics of injuries that result in hospitalisation. The data suggests, however, that there is no correlation between the number of accidents and hospitalisation. However, there does appear to be a very strong positive correlation between the number of people who use the slide and the number of hospitalisations occurring.

LITIGATION

Our preliminary survey of waterslide operations showed that at least 20% of the operators in the UK incurred some form of litigation. This proportion must be considered in relation to the total number of accidents which are occurring on waterslides in the UK For example, Stage 3 of the research has found that there have been 28 cases of litigation out of 4932 recorded incidents. Litigation then arises out of 0.57% of all incidents, or l:176 incidents.

What type of injury produces litigation proceedings? In the light of the above information (Common accidents and hospitalisation) it would seem salient to presume that litigation would be reflected in the trend of common injuries and hospitalisation cases. This is suggested on the premise that litigation arises out of the supposed negligence of the operator/ manufacturer resulting in an injury which is

CAUSE OF ACCIDENTS

FIG. 6 COMMON AND LITIGATION

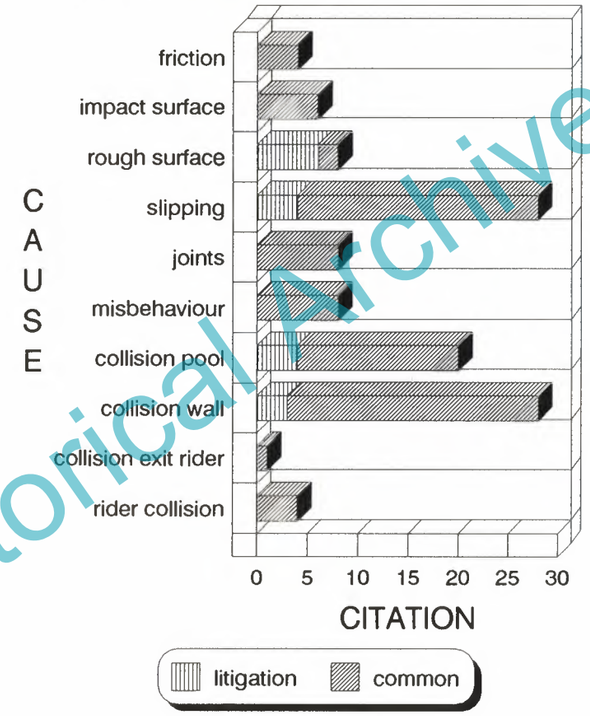
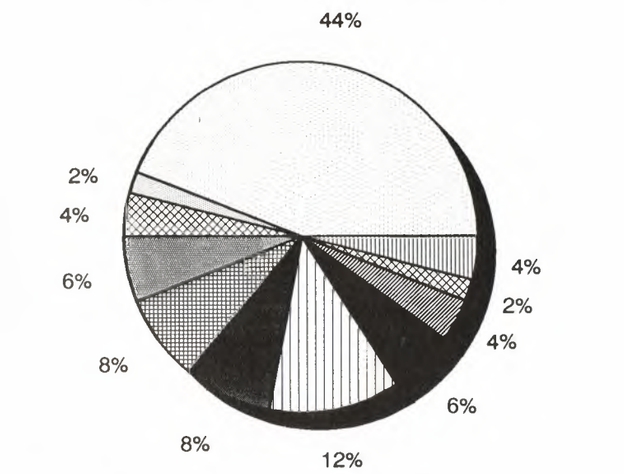
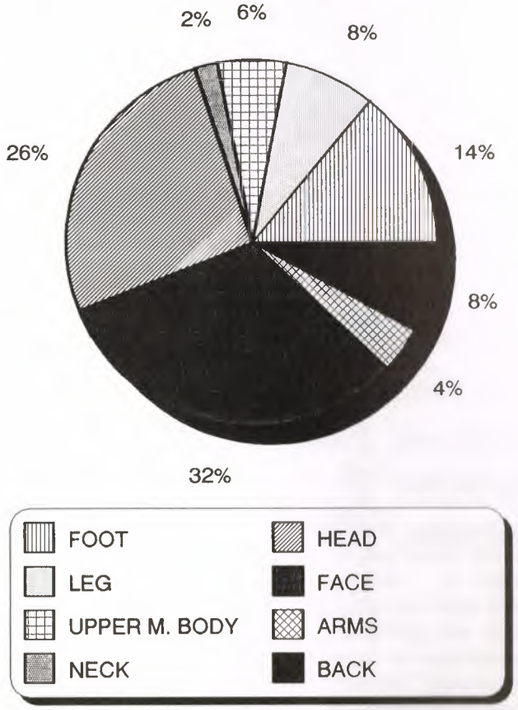


FIGURE 7. WORST INJURIES



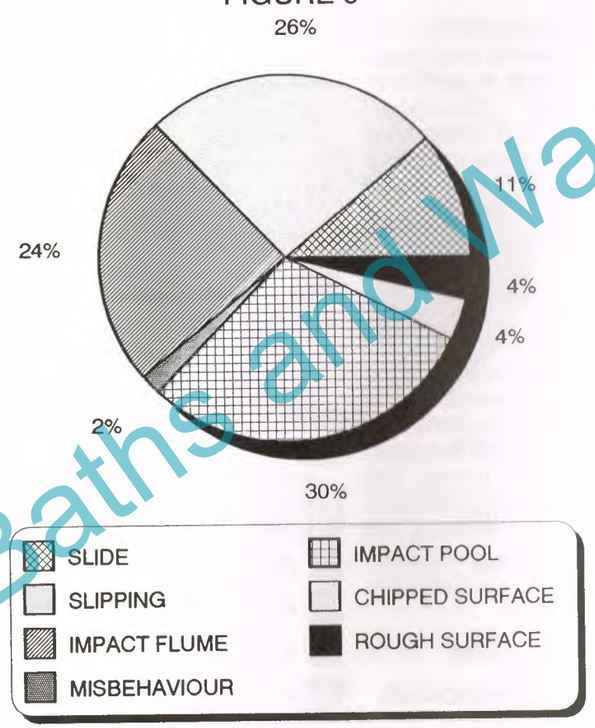
WORST INJURIES

FIGURE 8 - BODY AREA AFFECTED



WORST INJURIES

FIGURE 9

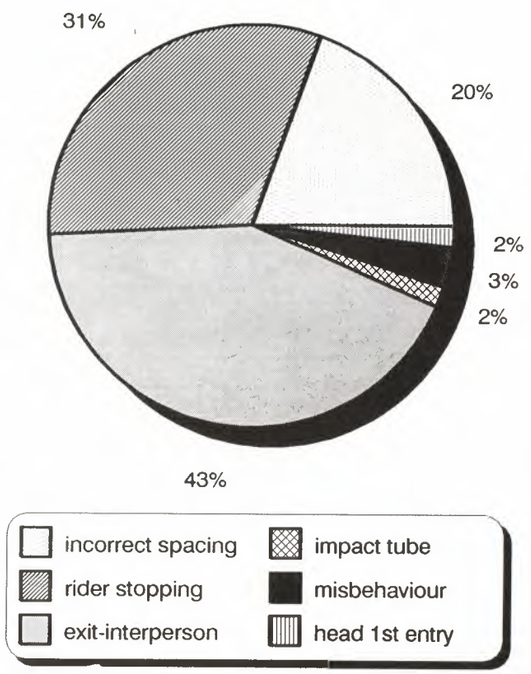


COLLISIONS - LOCATION

FIGURE 10

COLLISION - CAUSES

FIGURE 11



considered to be severe. But an examination of the data shows a different picture to this argument (Fig 3, 4, 5). The most prolific injuries found in hospitalisation are those occurring to the head. The type of injury most frequently cited is that of major cuts (defined as a deep wound which may require sutures or stitches). Yet the area of the body resulting in most litigation proceedings is the back (Fig 4). Nearly 40% of those who have entered litigation cite this area of the body. Injuries to the head still feature, however their role in provoking litigation is significantly less than would be expected (23%). The most significant injury (Fig 3) appears to be broken bones - representing 36% of the injuries cited by the operators. On waterslides the exit area and the slide path were cited by operators as the most (Fig 5) important location giving rise to litigation injury, representing up to 73% of the total. An interesting point here is now the change of status of the exit area. The table showing the total number of accidents identifies the slide path as being the most important area for total accidents. In litigations, it is the exit area which clearly results in more litigations than the slide path. A major cause of these litigations appears to be the result of (Fig 6) collisions with surfaces of the slide and in the splash pool (36%). Slipping also represents a considerable proportion of litigation cases.

In summary, broken bones and injuries to the back are the main reasons for litigation. Trends in common injuries and trends in injuries resulting in hospitalisation cannot be used directly to postulate what injuries will result in litigation. The major cause of litigation is impact with the surface of a flume or an exit area. The exit area appears more important where litigations are concerned. Head injuries are represented but not in the same proportion as seen in common and hospitalisation cases. These are important issues in the context of risk management and limitation.

WORST INJURIES

Figures 7-9 provide a picture of the worst types of injuries that occur on specific waterslides. Major cuts represent 44% of injuries, broken bones 20%. Figure 8 illustrates that injuries to the head, face and neck areas are cited by 60% of operators. SAIL believes that this is a matter of grave concern, especially as Stage 4 of the research revealed that 46% of the recorded injuries occurred to children between the ages of 8-15 yrs, (a fact reiterated by an Accident and Emergency consultant at a hospital which was receiving what he considered to be a high proportion of injuries from a waterslide in that area of the UK). It must be remembered that this age group represents 63% of the users on the slide so it may be argued that it is not surprising that this age group sustains the largest number of accidents. However, SAIL considers that any injury to the head is of great concern and as the evidence shows such large number of injuries to the heads of children, requires particular attention.

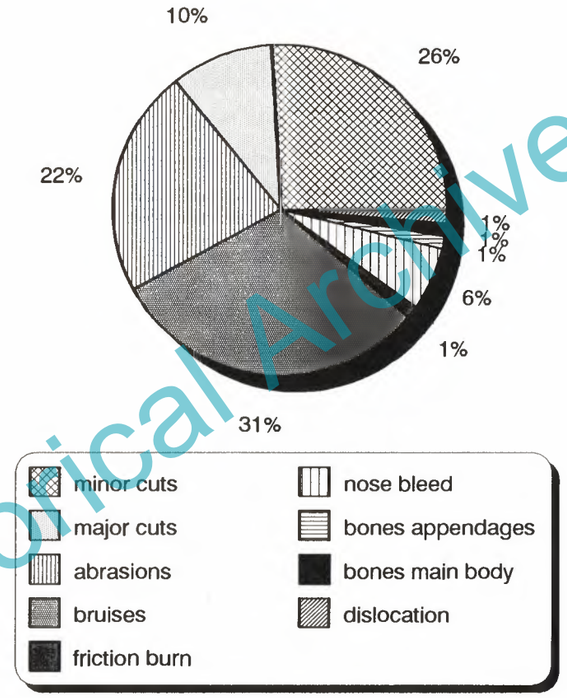
COLLISIONS

Figures 10-11 illustrate the situation with regards collisions. At the outset it should be stated that the Unit feels that most operators saw this question as representing person to person collision rather than person to surface collision. Consequently, most of the information relates to the former method of contact. The most important area of the slide system with regard to collisions is the splash pool. Two causes are given for collision. The first being riders stopping in the tube, the second incorrect spacing in descent. This has obvious implications for the management and design of the slide.

It can be argued from the evidence here that spacing reliant solely upon time is insufficient to anticipate the riders descent rate and the consequence of the rider stopping for whatever reason. The Unit argues that, on the evidence available, the only safe method to avoid this type of incident is not to allow the next rider down until the present rider has entered the splash pool. This is a similar system used by speed-slides and hydro-whips. However to incorporate this on a slide which has a heavy through-put would not be viable. As a safe compromise **it is recommended that some critical point is calculated on the slide which the rider must pass before the next rider is allowed to descend.** This critical point should be calculated so that the chance of collision is

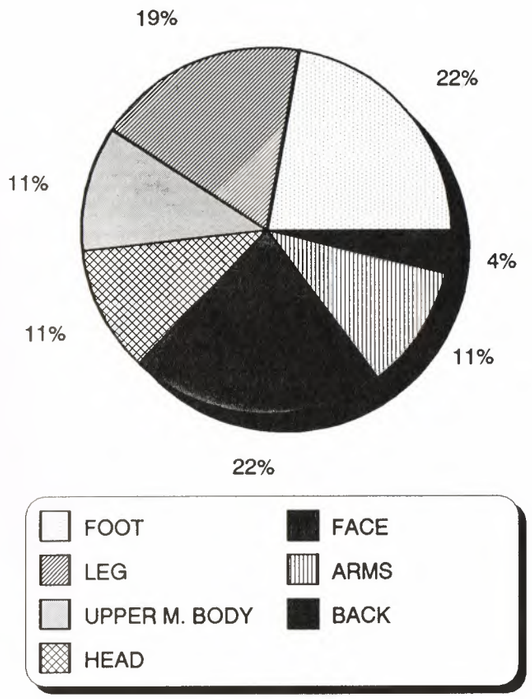
JOINTS - INJURIES

FIGURE 12



JOINTS - BODY AREA

FIGURE 13



minimal even if the rider were to stop in the flume or take an unreasonable length of time to clear the splash pool or exit area.

INJURIES RESULTING FROM JOINTS

As mentioned earlier, the lack of available evidence on many aspects of slides has resulted in the proliferation of spurious mythology. As a result attention has been paid to the problem of joints. Looking at the current evidence the number of injuries caused by jointing represents 12% of those occurring on the slide path. Of those operators to report accidents, 2347 accidents occurred on the slide, with 290 of these being accidents related to joints. The majority of these injuries appear relatively minor (Fig 12-13). Approximately 79% cited the injuries as being minor cuts, abrasions and bruises. However joints have also been cited as causing broken bones and major cuts, all of which have resulted in litigation procedures. It can therefore be argued that the effect of poor jointing can result in major injuries but the occurrence of this is infrequent. Poor jointing is more likely to result in minor rather than major injuries. 55% of accidents caused by poor jointing occur on the limbs, 33% occur on the head and neck.

CHAPTER 5

DISCUSSION - FACTORS WHICH AFFECT SAFETY

The scale, nature and character of injuries occurring on waterslides have now been established. A further aim of the research was to try and ascertain the reasons why accidents occur on waterslides. The disparate nature and variety of injuries, examined in the last chapter, suggests that the causes of these accidents may well form a complex equation. Through the process of examining the variables against each other it is possible to show relationships between accidents and factors that may affect them. The research programme was designed to investigate not only those variables that previous researchers considered salient to accidents (for example: nature of slide path) but also variables that have never been considered (for example: number of staff). The following discussion explains the importance of each variable within the overall context of safety associated with waterslides and their operational environment.

HEIGHT OF SLIDE

Statistical tests have shown that there is a clear relationship between the height of a slide and accidents. Both the first and second stages of the research indicated that accidents are associated with the height of the slide. In essence, the higher the slide the greater the propensity of accidents. The first survey identified a strong relationship between height and whether an establishment had accidents or not. The second survey established that there was a relationship between sites incurring a low rate of accidents (less than 39) and those incurring accidents greater than this figure. This second survey suggests that slides with heights of greater than six metres produce more accidents than those with heights of less than six metres. The statistical test proved this to be highly significant. However, a statistical test does not explain why this relationship occurs no matter what level of test is used and causation therefore has to be inferred. SAIL suggest that there are three reasons for this relationship:

a. potential speed generated
b. accidents on the tower. (As mentioned earlier, the tower represents 22% of all injuries).
c. gradients (DIN standards recommend 10%)

SPEED

Earlier studies have shown that fast speeds can be an important factor in the proliferation of accidents on the different slides. Faster slides producing higher frequencies of injury. This concurs with evidence found during Stage 4 of this research. For example, one slide which produced higher speeds than two others which were monitored resulted in 100% more accidents than the slower ones.

SAIL has established that slides with speeds reaching up to a maximum of 6.9 metres/second yielded twice as many accidents as those slides which reached maximum speeds of only 5.5 metres/second or 5.8 metres/second.

Speeds on slides are solely reliant upon the force of gravity to produce the main energy for descent (there are however other factors which act upon the overall speed - these will be discussed later). Therefore, height may well be related to the speed travelled upon the slide and this may well have a bearing upon the speed of entry to the splash pool.

Speed on its own may not necessarily result in injury. What may also be important is the nature of the slide profile, in particular the positioning of bends. The importance of this factor is indicated by two axioms. The first relates to evidence from the 2nd stage of the research which shows a significant relationship between accidents and bends. The results from this test gave support to the argument that there is an association between accidents and the presence of bends, indicating that slides which deviate from the straight line are more prone to produce accidents than those which do not. There was no relationship, however, with the number of bends present in the slide system. The second axiom points to the nature of the bend rather than the bend itself: this was subsequently confirmed. There is no relationship to be found between the number of accidents and the number of bends. Hence, it can be argued that it is the nature of these bends which is important.

Other studies have also found that slides with higher speeds and sharp changes of direction occurring nearly simultaneously, resulted in higher accident ratios. (It is important to note here that speed slides have no changes of direction and hydro-whips, which are a cross between speed slides and normal waterslides, have deviations which have shallow changes in direction from a straight line). SAIL suggests that two factors may be contingent, in particular instances, to the rider losing control on the slide path. These are (i) a combination of sharp changes of direction in conjunction with (ii) considerable speed.

Visits to a number of locations have found connections between the strategic placement of drops, or accelerator points, close to sudden changes of direction. The result has been to produce consecutive injuries amongst users. In one particular case these injuries were to the eyebrow and occurred on the same point in the slide. (It is pertinent here to note that the riding position of every rider on this particular slide was head first).

There is evidence to suggest that speeds in excess of 6.5m per second is a significant factor in causing injuries if other inputs such as design (location of bends and drops) and rider positions are incorrect. Careful consideration then should be given to the location and also the radius of bends, the positioning of sharp changes in slope, and the maximum speeds the riders may reach at these points. **It is recommended that further research is required on the critical radius for safe bends**.

FACTORS AFFECTING SPEED

At this stage it was decided specifically to look at factors which may affect the speed of users on slides. A number of significant factors emerge.

GENDER

Of the slides studied in Stage 4 evidence emerged to suggest that gender was significant in the production of speed. Where appropriate statistical tests could be applied, two thirds of the slides showed a significant relationship between speed and gender. In all those cases that proved significant, males were found to reach much higher speeds than females. If this is linked with accident ratios where males tend to have a much higher level of injury it would not seem inappropriate to suggest that speed may well be a factor in producing this larger ratio of injury. This is not to suggest that all injuries are contingent on gender and speed. One establishment, for example, did not show a relationship between these two variables. A reason for this may well be that certain slides provide and create an environment where the male bravado is contained. In others, this form of behaviour may be encouraged. The full impact of slides upon the market using the centre must, therefore, be carefully reviewed.

AGE

This variable also proved to be significant when the appropriate statistical test could be carried out, with significant levels ranging from 99.5% to 99.9%. The test clearly suggests that there is a strong relationship between age and speed obtained on the slide. An analysis of the structure infers that age groups between 16 to 40 travel faster than the lower ages. One factor here may be that weight is a contributory variable. *However, correlation tests were run between speed and weight and surprisingly there was no significant correlation to be found (only 20% of the sample was explained by weight).* This is not to say that weight doesn't affect speed but that it may do so only if other variables are also present. For example, certain ride position and gender.

At first there would appear then to be an anomaly between the mean and median ages of injury. The most prolific age group for injury is between the ages of 8-15, which is noted above does not coincide with ages groups producing the fastest speeds.

However, closer examination shows that although in percentage terms this age group produces lower speeds, in real terms - actual number of individuals - it produced between 55-66% of those riders reaching the top speeds. This shows the relationship with the frequency of injuries sustained to particular age groups.

RIDING POSITION

Our detailed sample survey (Stage 4) examined the relationship between speed and riding position. Appropriate statistical tests were applied and very significant results were found. SAIL would argue that on the evidence available the variable of riding position of the user is probably the most significant of all those affecting speed. The significant levels were the highest of all those variables tested. The fastest riding positions were assigned to riders who descended lying flat on their backs and those lying flat on their stomachs. Between 84% and 92% respectively, of those people who reached the highest speeds on a slide were in either of these positions. Sitting upright proved to be the slowest position of descent, resulting in between 39% to 66% of those people who obtained the slowest speeds on the slides. The importance of correct ride positions as a safety consideration is well documented in relation to speed slides. To descend sitting or kneeling on a speed slide is tantamount to having a death wish. It should not seem so surprising then that ordinary waterslides should also be designed to allow only certain prescribed riding positions.

Close examination of the figures identifies that head-first entry, lying down, is a fairly common ride position in the majority of the slides examined. It is true that the most common area of the body to sustain injury is the head. It can, therefore, be argued that head-first entry in a lying down position may well be linked to the proliferation of head injuries found in the in-depth survey. If one also considers that collisions, whether inter-person or inter-flume/pool are very common and that the first area of the body to impact on a surface is the area travelling in front, then it does not take too much imagination to ponder the consequences of impacting a head into a surface at between 5 to 7 metres per second. Only recently, a BBC Watch-Dog programme (October 1989) urged young cyclists to wear crash helmets. It is suggested that young cyclists rarely travel faster than 25 kilometres per hour (6.9 m per second). As a corollary to this reasoning it is not so far removed to suggest in certain circumstances that protective helmets should be worn on waterslides. This is not such a far fetched suggestion as one particular ride at Wet and Wild Waterpark in Florida USA actually insists on helmets being used. The overall point being made here is that incorrect riding position/ incorrect use of the slide is leading to injuries. **SAIL recommends that head first entry be prevented unless the slide has been specifically designed for this riding position.**

It is further recommended that it should be the responsibility of the manufacturer to guide the operator on these aspects of slide operation. In turn, it should be the suppliers responsibility to provide appropriate and sufficient notices for public display to communicate this information and it should be the responsibility of the manager to effect adequate methods of communication with its customers.

An interesting point also to emerge from this stage of the research is that the use of mats has little effect upon the type of riding position. The sitting position on a mat still resulted in a slow ride where as lying down on a mat still produced higher speeds. The only defined difference could be seen in a more even distribution of speeds.

WATER FLOW

Water flow has only been considered on a UK basis and statistical analysis could find no correlation between the number of accidents and the volume of water on a slide. In essence a large proportion of operators were unaware of water flow and the possible importance of speeds obtained by riders, with the consequence that they failed to answer the question. During Stage 4 of the survey it was not possible to examine the effect of water flow on speed due to time constraints. **It is recommended that further study is needed on the effects of water flow in relation to speed**. Sadly it is outside the confines of this report to comment on the effects of this variable on speed.

COSTUME MATERIAL

Observational and qualitative evidence suggests that there may well be a relationship between speed and the type of material on slides. There is also evidence to suggest that swimming costume material may also contribute to friction burns on certain slides.

OTHER FACTORS RELATING TO SAFETY

EXTRA STAFF

There appears to be a relationship between accidents occurring on slides and the number of staff taken on to supervise the waterslide. The statistical test suggests that there is a significant relationship here. The reasons for this relationship can only be inferred, indeed there is also evidence to suggest that operators that took on more than two members of staff were sustaining more accidents than those who took on one or none.

This is surprising and appears contradictory. Staffing and operational regimes clearly have to be considered at an early stage of slide design. One particular explanation for the confusion about staffing ratios caused by these findings could be that management substitutes high levels of staffing for well trained and well briefed staff. SAIL stresses the fact that adequate training and briefing of operatives is essential. Even the safest slide design can become a unsafe piece of equipment if it is inappropriately supervised. Operational considerations are of paramount importance. Extra staff may be seen by the management as sufficient. However the research has found that, unless the life-guards are vigilant and well trained in operational procedures; unless they are aware of the risks that riders misusing the slides may face, then there may in effect be a rise in the number of accidents rather than a reduction - irrespective of how many staff are on duty.

Most slides are introduced to increase revenue and therefore minimum inputs especially in labour are required if the increased revenue objective is to be achieved. Staffing ratios, rotas and regimes are clearly, therefore, a vital consideration at an early stage of slide planning. Examples have been found where extra staff have been employed after accidents have started to occur on slides. This suggests that managers believe that extra staff may well solve the accident problem. It should be emphasised here that whilst staff should be regarded as the lynch pin between the design of the slide and the control of users, adequate training is essential. **The Unit recommends that the inclusion of one slide in a centre necessitates the positioning of a minimum of one trained operative at the launch area and one at the exit area**. The number of staff should be increased as appropriate to the nature, character and design of the slide systems.

MATS

Within the third and fourth stages of the research the use/non-use of mats on waterslides was examined. Statistical tests show that there is a relationship between the use of mats and accidents occurring on a waterslide. The significance level is 95%. Further examination shows that of those centres incurring more than 200 accidents, slides which use mats accounted for 46% of accidents, whereas those without mats were equivalent to only 15%. Taken in proportion (more slides operate without mats 85%) then mats do seem to be linked to higher accident levels. Why? As with all statistical tests the reasons can only be inferred. Mats are generally used on the premise that speeds are evened out amongst users. Examining the standard deviation, minimum and maximum speeds of those slides in the detailed sample survey the results were as follows:

TABLE 12: SPEEDS ON SLIDES

	MEAN	MAX	MIN
SLIDE A: NO MAT	16.22	25.27	6.22
SLIDE C: MATS	16.46	20.00	11.61
SLIDE D: MATS	18.15	24.00	11.61

	STANDARD DEVIATION
SLIDE A:NO MAT	4.44
SLIDE C:MATS	
SLIDE D:MATS	2.10

From this information there is evidence to suggest that mats do standardise the speeds of a riders. The Unit would argue, therefore, that other variables are more important in controlling the speed of the rider. Clearly the standard deviation of the riders in slides C and D is smaller than in Slide A. Added to this the minimum speeds do seem to be maintained whereas in A the lowest speed is some 2.8 seconds below the mean.

One explanation for accidents occurring on slides that use mats may lie in the fact that minimum speeds are maintained. Should the rider lose contact with the mat it is possible that the rider may stop. If the spacing is on a timed system then the possibility of collision with the next rider is increased.

It should be noted here that the DIN standard is not designed for mat usage, consequently slide systems in Britain designed to the DIN standards may well be compromised if mats are used. The primary reason for introducing mats in U K slides tends to be to assist management in monitoring and controlling use. Additionally, some operators use mats to ensure a smoother ride **It is recommended that mats should only be used on slide systems which have been specifically designed for this purpose.** There are inherent dangers in the simple application of the use of mats, or indeed circular tubes, to inappropriate slide design.

CHAPTER 6

UK WATERSLIDES VITAL STATISTICS - A SUMMARY
(see appendix 5.)

The initial survey identified salient variables related to the safe design of slides. To date there is no legal requirement specifying the parameters that must be met in the design of waterslides in the UK. With the exclusion of inflatable slides, (which have a tendency to be between 0-3 metres), most manufacturers take note of and tend to adhere to the only known available standard: DIN 7937. This specifies what are considered to be safe parameters for waterslide design in West Germany.

The DIN Standard 7937 (see appendices) provides a useful bench mark upon which to base slide design considerations. SAIL is concerned, however, that DIN has many inadequacies and is already out-of-date in the context of the rapid advance of new technology and the range of new designs currently available. In particular SAIL notes that the DIN standard was not designed for tube rides and that it does not embrace operational standards. **SAIL recommends that, although DIN provides many valuable and useful guidelines, it is inadequate and should not be regarded as a surrogate for a British Standard.** Nonetheless, it is clear from the research that where DIN parameters have been used on British slides the incidence of accidents has been minimised (for details see Tables in Appendix 3).

HEIGHT (Fig 14)

Height is seen as being a critical variable, as the speed gained on a slide is produced by gravity and hence the higher the slide the faster the fall. Depending upon the gradient of the slope it will necessarily follow that a slide with the same proportions but having a greater height will produce faster speeds than one which is lower 'all things being equal'. To date it has also been shown that on an individual basis slides with higher speeds yield higher ratios of accidents. However, due to the complexity of the variables inputted on a slide on most occasions 'all things being equal' is rarely obtained. To date it has also been shown that on an individual basis slides with higher speeds yield higher ratios of accidents.

Fig 14 shows that over 70% of the slides have a height in excess of 3 metres - with nearly 40% of those slides having heights in excess of 6 metres; in addition 1/5th of all slides reach heights in excess of 8 metres. It can be argued then that a fair proportion of the slides may well provide the factor of increasing speed with height.

LENGTH (Fig 15)

60% of the slides in the UK are less than 50 metres long. Length is important in relation to height particularly in respect of gradients . A slide with a height of 8 metres and a length of 50 metres will produce higher speeds than a slide with a length of 100 metres. Essentially it is the gradient or slope of the slide which produces the speed. Under DIN 7937 the slope of a waterslide should not exceed 11%. The reasoning behind this is the critical factor of speed. Implicitly this regulation applies to waterslides with deviations from the straight line and does not relate to speed slides, sometimes known as Kamikaze Rides.

BENDS (Fig 16)

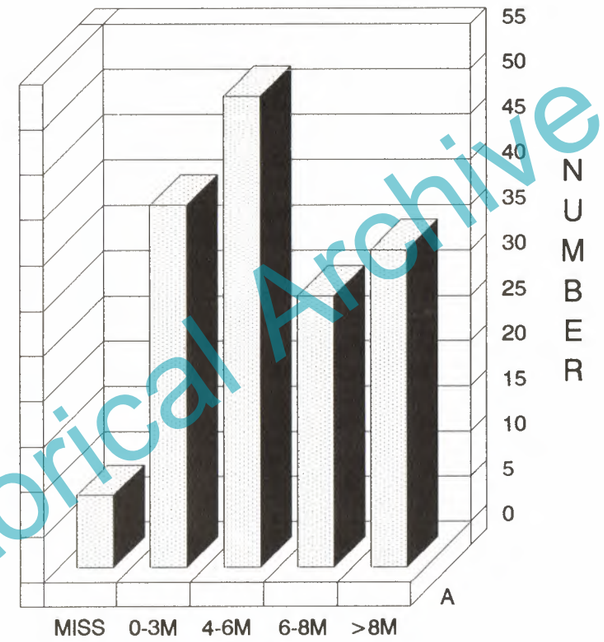
75% of the slides in the UK have some form of bends; 42% having between 1 and 3 bends - a relationship has been found between bends and accident occurrence. It is important to note that the number of bends on a slide are irrelevant to safety. The Unit believes it is the sequential effect of these bends together with their radius that affects safety on a waterslide. **It is recommended that further work needs to be undertaken to ascertain the parameters of the radius of 'safe' bends.**

DEPTH OF POOL (Fig 17)

Examination of the current literature dealing with safety on waterslides highlights the problem of splash pools. DIN is also well aware of the importance of the design of the splash pool area, and recommends that the splash pool should be at least 1 metre in depth. This is an arbitrary figure which should be increased pro-rate depending on the height of the end of the slide above the water. An examination of the UK figures shows that only 33% of the slides fall below

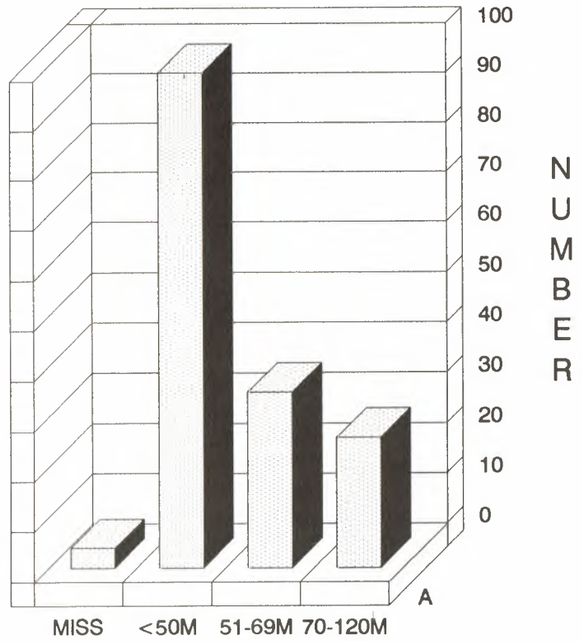
HEIGHT ABOVE GROUND

FIGURE 14



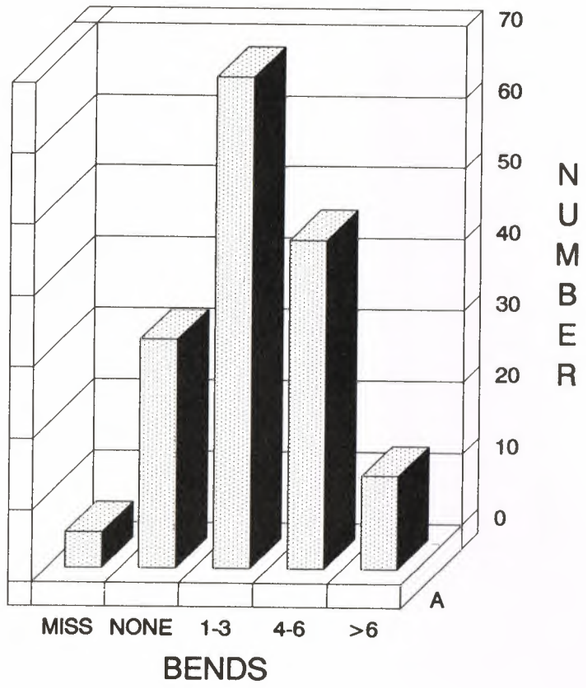
LENGTH OF SLIDE

FIGURE 15



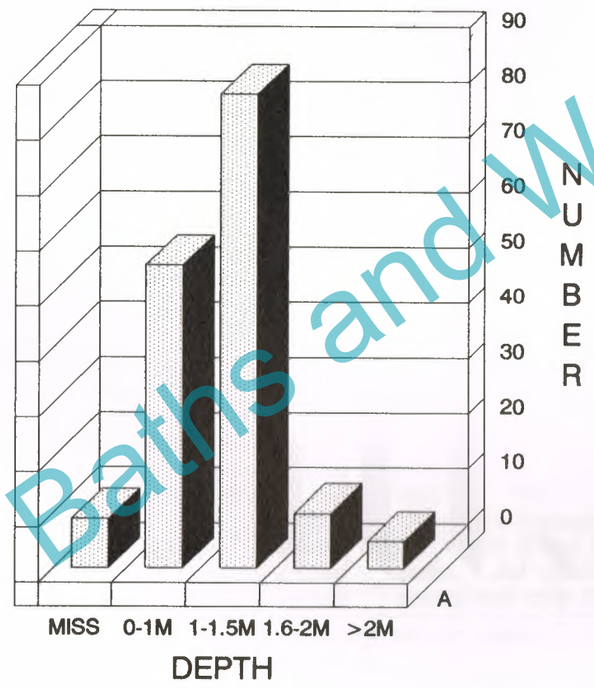
BENDS ON SLIDE

FIGURE 16



SPLASH POOL DEPTH

FIGURE 17



the DIN recommendations. Incorporated in this figure are those slides which also have aqua-catches and run-outs. Therefore 66% of the slides in the UK meet with this standard which on the face of it seems acceptable.

CHAPTER 7

SAFETY RECOMMENDATIONS AND CONCLUSIONS

Examination of the evidence available has led to the conclusion that injuries on waterslides are caused by a large number of factors. SAIL has identified the major variables which seem to be closely related to the cause of accidents on waterslides. It is argued that there are three types of accidents:

i) those accidents that occur while approaching or waiting to ride the slide

ii) those that occur during the descent on the slide

iii) those that occur whilst exiting from the slide system

Most previous reports connected with the slides concentrate upon (ii) and in most cases, quite rightly so, as the area of the slide from the launch to the splash pool/exit area results in nearly 70% of all accidents connected with the slide system. It is demonstrated in this report however, that the slide is in essence a whole system with the approach, the tower and the exit being just as important as the actual descent and splash area. In order to emphasise this point it should be noted that major injuries and litigations occur as a direct result of accidents in the approach and tower areas.

It is clear from the evidence presented that the control and minimisation of accidents on waterslides is reliant upon three major components of the 'safety' equation.

1. DESIGN
2. MANAGEMENT/OPERATION
3. USER BEHAVIOUR

There must be a balance achieved within this equation in order to minimise accidents on waterslides. Clear and effective communications between all parties involved is essential if acceptable safety is to be ensured. An imbalance in any one of these areas effectively exaggerates the input of the other variables. It is on the basis of these three axioms that the recommendations will be presented.

DESIGN

As discussed in the previous chapter, a large proportion of slides now follow the DIN standard 7937. The Unit believes that this provides a sound basis for the safe design of waterslides. Statistical tests on many of the critical variables have proved negative. One reason suggested for this is that the waterslide industry in Britain has learnt from the mistakes of other countries and has subsequently incorporated improvements into its own slides. The majority of the slides in Britain conform to this DIN standard and this is possibly one reason for the high number of negative results using appropriate statistical tests. As with any bench mark, however, there is always room for improvement and the following section is seen as an addendum to the DIN Standard 7937. It provides, therefore, a useful base for considering a British safety standard.

APPROACH TO TOWER

The siting of the waterslide is an important consideration within the building. The approach to the slide should also be seen as critical in the first step to informing, communicating with and controlling the potential rider. Injuries occurring here tend to be dominated by slips, which indicates a slippery floor surface and/or the excitement engendered by individuals trying to get to the slide. Observational surveys of this area revealed individuals, under certain circumstances, jockeying for positions and in some instances running. **It is recommended that particular attention is paid to the surface gradients, the floor surfaces in approach areas to the tower. Similar attention to detail is required in the exit paths.**

This should be seen in the context of non-slip flooring and the efficient drainage of surface water from this area. **It is also recommended that some form of physical or visual barrier is erected to separate those queuing to use the slide from other users of the facility**. In this way impact upon other users can be minimised. **It is recommended that all approach paths must conform to current British Standards Building Regulations relating to path width and surfacing.**

TOWER

Up to a 1/3rd of accidents occur on this section of the waterslide. As mentioned earlier, height has been found to be a variable which affects accidents. It also follows that the higher a tower the increased possibility of accidents occurring. The tower section is again prone to users slipping. A number of reasons are put forward. Firstly, slipping may well be connected with two factors (i) the abundance of ill-drained water together with (ii) excited individuals. It is also related to the design of the access stairs which often are only suitable for single person ascent.

It is recommended that towers are designed to channel water away efficiently or are able to maintain non-slip flooring. It is not sufficient to let water disperse of its own means. All too often this water collects below the tower on the direct approach route to the tower - adding to the problems of the approach.

Secondly, most slides have age limits on those children using a slide. Frequently an attendant is faced with the dilemma of sending a child back down a crowded tower which is only just barely wide enough for one person, or sending the child down a slide not designed to be used by this individual. It would also appear that little thought has been given in design to bringing down an injured individual from the launch area.

It is recommended that towers are designed with straight run staircases with landings and that the tower allows easy passage for two people with hand rails on both sides. All staircases should be designed to meet current BS Building Regulations. Spiral staircases are considered to be inherently dangerous in the context of waterslides.

LAUNCH AREA

A minimal amount of injuries were sustained at this location. It is argued, however, that improvements are still required here. Both during the detailed surveys and on the evidence submitted by operators a particular cause of accidents in the launch area relates to slipping. Consideration should be given to improving the surface so that the chance of slipping while preparing to start is minimised. **The Unit recommends that the non-slip, well drained floor surfaces at the launch area are essential. In addition, there should be sufficient space at the launch area for adequate control and management of users.**

Another area of concern is found in the lack of provision to differentiate between children who are allowed down the slide and those who are not. In many cases children under the age of 7 are not allowed to ride the slides. There appears to be no universal reason for adopting an age at which a child may or may not use the slide. The reasons given for age restrictions will vary from defining the appropriate age that a child has the maturity to use the slide correctly to preventing non-swimmers (children) from using a slide exiting into a splash pool.

Signs informing of age restrictions do appear on the approach to the tower but in many cases the attendant at the top has to resort to questioning under age riders - most by this age have learnt to inflate their age. When asked "How old are you?" the reply is "Six, oh I'm just seven". In many cases this was seen to be supported by the parent.

One method of control can be through segregation by differentiating riders by height. *(It should be noted that there is no evidence to suggest that the height of an individual, has any bearing upon the safe use of the slide)*. However, by using height as a means of segregating individuals no arguments can be raised: you are or you are not the correct height. A visual or measuring scale then can be placed on the approach, at the bottom and top of the tower. *In situations where this method is being used it has proved more successful than using age and is regarded as an example of good practice.*

The Unit suggests that on slides where age restrictions are enforced a method of measuring height related to age may be more effective than verbal questioning. **If this system is adopted, it is recommended that this measuring scale be placed on the approach to the slide, at the bottom of the tower and at the launch area.**

The swimming ability of users is clearly a critical factor, arguably more so than age or

height. **Consequently, it is recommended that non-swimmers should not be allowed to use slides unless they are designed with a run-out or an aqua-catch and that this message has to be effectively communicated.**

SLIDE PATH

The evidence to date suggests that the German DIN Standard presents the designer and manufacturer with a confident bench mark for the safe design of slides. The critical design parameters which are suggested to relate to injury on slides have been examined. It must be stressed, however, that DIN does not apply to certain slide systems and should not, therefore, be applied to all slide designs.

The Unit suggests that until such time as a new **accepted** standard related to slide design, is published, that DIN 7937 be used as a confident guide to the overall design of safe waterslides. However, SAIL believes that there are specific areas of the slide which still cause concern in particular. The Unit argues that caution must be given to the degree of curvature of bends especially when they occur in quick succession. To illustrate this point, a slide at Wet and Wild Waterslide Park, Florida, is cited as a good example of fast speeds of descent coupled with a multiple series of sharp changes in direction. This ride has produced a large number of head injuries and the wearing of protective helmets is now compulsory.

It is recommended that sharp changes of direction that occur in quick succession, especially in combination with accelerator points, be avoided on waterslides. It is recommended that further detailed research be undertaken on this particular aspect of design. To ascertain critical parameters for radii and gradient slopes.

END SECTION

Although the number of accidents recorded on waterslides are highest on the slide run, we continue to express concern, supported by operators, with regard to the splash pool or exit area. The exit area appears to have a higher propensity of major accidents (hospitalisation) than other areas. *The Unit believes that correct entry into a splash pool is critical*. In conjunction with the DIN standard and World Waterpark Association recommendations 1988, entry into the pool must be controlled by the slide path. The end section of the slide should be contingent with reducing speed, correcting the position of the rider for a straight line entry at an angle parallel to the surface of the water, or with entry just under the surface of the water.

It is recommended, therefore, that a reasonable length of the end section of the slide path be specifically designed to reduce speed, and eject the rider in a manner which is controlled and the angle of entry is parallel to the surface of the water.

JOINTS

The problem of joints is not as significant as was first thought. Major injuries do occur and these are in a minority; most injuries tend to be minor. There are, to date, four different types of joints all of which give varying degrees of problems. Work is needed still on the development of a standardised jointing system with a low degree of maintenance. There are many examples of joint seals constantly having to be repaired, resulting in increased maintenance costs. Joints can be a source of serious injury but the Unit believes that they are not a major problem due primarily, to the vigilance of operators in constantly checking them.

It is recommended that in order to maintain safety standards, joints should be checked every day prior to public use for misalignment and changes in the surface surrounding the joint.

At this stage we draw attention to the requirements of the Health and Safety at Work Act 1974 and the need to ensure safe practice for staff involved in undertaking safety checks on slide apparatus.

EXIT AREAS

This area is still the source of problems relating to major injuries occurring on waterslides. All problems stem from one aspect - collisions. Two types are identified: inter-person and inter-surface. The inter-person collision is primarily the subject of inadequate management control and will be discussed under the management section. Inter-surface collision is not so clear. Wrong sliding positions can be attributed to collisions of this nature, however, consideration must also be given to design in trying to minimise misuse of the riding position.

There is now a tendency to physically separate splash pool areas, but this is not always possible. The Unit argues that safety presides in favour of exit areas which provide run-outs or aqua-catches. All these tendencies, the Unit would argue, have emerged in response to the industry's learning curve of experience. Why do speed slides have run-outs and hydro-whips have aqua-catches? - In order to decelerate and stop the rider in the safest possible manner.

The Unit argues that entry into a splash pool head first is analogous to diving, and as most operators are aware, diving used to be a major source of injury at swimming pools, especially paraplegics. Therefore, a method of stopping a rider which avoids this analogy would seem preferable to splash pool entry. This is not advocating that all splash pools should be removed, but that where possible hydrostatic breaking and aqua-catches should used.

It is recommended that where possible methods involving hydrostatic breaking and aqua-catches should be used in preference to splash pools.

A problem identified with splash pools appears to be the angle of entry of the rider, which in turn is related to the design of the end section of the waterslide. The DIN Standard does specify appropriate heights of the end slide above the water level of the pool in relation to the depth of the plunge pool. However, there is evidence to suggest that this may not be adequate even though the slide specifications do meet these standards. SAIL believes that adults are particularly at risk, even when riding in the correct position on the slide. There is a tendency for adults when being ejected from a slide into a 1 metre deep pool to impact onto the bottom of a pool. The slide profile should be designed to reduce the chance of an individual colliding with the bottom of a splash pool. (The World Waterpark Association advocates that people are ejected directly into the water and that the end slide height is no higher than the level of the water). On one of the slides examined in detail, a rider who came down head first on his stomach, hit the bottom of the pool with the result that a vertebra was broken in his neck. This, SAIL submits, is a classic example of the slide exit being effectively used as a diving board with all the typical consequences associated with diving into shallow water. This further strengthens the evidence in support of feet first entry unless the slide system has been designed otherwise.

It is recommended that if discrete splash pools are not in use then a separated area from the main pool should be used where possible. This eliminates the possibility of swimmers in the main pool being inadvertently struck by a rider on the slide. On a number of visits and in observations made, all too often a splash pool which is part of the main pool area presents the life-guard with a multitude of problems. These problems are increased if there is no physical barrier erected between the two areas. In an unsegregated splash pool the life-guard is presented with four aspects of supervision and control:

1. Ensuring that spent riders move quickly away from the splash area;
2. Swimmers are prevented from entering the exit path of slide riders;
3. Preventing parents or friends from remaining within collision distance of the slide exit;
4. Scanning the area for weak swimmers who may have got into difficulty.

It is recommended that where splash pools are part of the main pool, some form of physical barrier should be placed so that swimmers do not interfere with or impede the path of waterslide riders. (This barrier should not, in its own right, present a hazard to the rider)

In addition, it is recommended that all splash areas should have clearly indicated exit points and have notices which help orientate riders. These design points are required to facilitate a quick and easy exit

from the splash pool. The splash pool itself should confirm to the minimum requirements set down in the HSE Safety in Swimming Pools Document, 1988.

MANAGEMENT

It is argued that management and operations procedures are the most important factor in the control of and minimisation of accidents once a slide is in place. The management sets the scene for the control and enjoyment of the individuals who are to use the flume. A well thought out and comprehensive plan for the waterslide is as important as the design itself.

It should be noted here that on the current available evidence SAIL believes that a waterslide, although seen in the majority of cases as being an added attraction to an establishment, does change the overall environment and nature of the leisure centre/ complex. *It is critical to first assess what type of slide the management would like, the market appeal, existing users of the complex and likely implications on user characteristics in introducing a new slide.*

Certain slides are self-selective in their users. For example, speed slides are not for pregnant women, individuals with heart problems or the more senior members of society. Other waterslides vary in their market appeal depending upon their configurations, speeds obtained, etc. Consideration should be given to these factors in the light of the evidence which has been presented. For example, the evidence suggests that males between the ages of 8-15 are likely to have a higher propensity to injury that any other social group. Those slides which overtly encourage this age group may well have a higher injury ratio than other slides.

It is recommended that careful market planning and assessment is required before a waterslide is incorporated into a centre.

TRAINING OF PERSONNEL

The key personnel are those who deal with the users of the slide. They should be given detailed and proper training concerning the essential elements in maintaining the slide safety parameters. This is especially important in the control of individuals who are using the slide. As seen in the report, the tower is a source of 30% of accidents and proper control here may well have a positive effect upon accidents occurring elsewhere on the slide. SAIL believes that vigilance is required by the life-guards/operatives at all times to ensure that the correct riding position is maintained when entering the slide. If transgressions do occur, then immediate action should be taken to prevent the individual from using this incorrect riding position again.

A structured programme of training should be incorporated for life-guards and other personnel associated with waterslide operations concerning waterslide safety risks and control. It should be the responsibility of the manufacturer to advise on the issues and the responsibility of the manager to provide the training and monitoring.

The staff involved with the waterslide must maintain a positive attitude towards safety and that this is never compromised by familiarity. It also follows that to ensure positive attitudes careful consideration should be given to the methods used in recruiting personnel. The principles of good personnel recruitment should never be compromised.

ACCIDENT REPORTING AND RECORDING SYSTEMS

Visits and detailed viewing of accident records have revealed that there is a desperate need for more comprehensive, accurate and consistent accident recording procedures both generally and at individual centres.

It is recommended that appropriate and influential bodies should encourage a standard definition of what constitutes an incident and an accident and how they should ideally be recorded.

A systematic method of recording accidents should also be insisted upon by the appropriate governing leisure bodies. An accident report needs to be designed which will allow for standardising the data and which also provides the quickest method of recording it, thereby allowing the life-guard or other personnel to return to their main duties. Consideration should be given to computer-aided reporting systems. SAIL suggests that a standardised accident recording form be produced which is based upon the lines of a simple questionnaire.(see appendix 2) This should include the collection of the following minimum amount of information:

* NAME OF EMPLOYEE
* NAME OF CASUALTY
* ADDRESS
* AGE
* DATE
* TIME
* GENDER
* OCCUPATION
* TYPE OF INJURY
* LOCATION OF INJURY ON BODY
* THE SPECIFIC LOCATION OF ACCIDENT IN THE BUILDING
* SPECIFIC DETAILS OF HOW IT OCCURRED
* WHAT IS SUGGESTED TO BE THE CAUSE
* ACTION TAKEN TO ASSIST PATIENT
* WHETHER REFERRED TO HOSPITAL

It may also prove salient in the case of serious injury to collect more information. This may be along the lines of interviewing other employees and witnesses to the incident which took place. This is a system adopted by some American operators and can prove useful in cases where litigation may be the likely outcome, although disclosure in litigation should be considered in format design.

The research Unit recommends that a standardised reporting format for recording all accidents is developed which should include at a minimum all those items listed above.

Supporting this argument is the current scarcity of information concerning leisure accidents - with the exception of serious injury that result in death. It was the death of a teenager in 1987 which sparked the concern into waterslides and because of the scarcity of information, the industry was unable to respond to the adverse press reports. The (HASS) Home Accident Surveillance System, European Leisure Accident Surveillance System (ELASS) and the Dutch pilot called (PORS) were established to try and provide data. All these existing reporting systems support SAIL's argument concerning the scarcity of immediate access to accident data especially in leisure settings. The 1986 PORS report notes "there is, moreover, an increasing awareness that, in the western countries, accidents are one of the major causes of mortality and morbidity" (p2, 1986). A standardised definition and format for recording this information would transform the gathering of this type of data. It would also assist management in identifying problems before they possibly develop into serious accidents. As shown in the report, minor injuries can mirror major injuries.

MANAGEMENT OF STAFF

NUMBER OF STAFF

The installation of a waterslide involves either increased labour or at the very least appropriate redeployment and training if safety standards are to be at their best. The Unit believes that in order to provide a safe service to the public there are minimum levels of staffing to be maintained.

It is recommended that at any waterslide installation there should be a minimum of two trained and briefed personnel: one located at the launch area and the other located at the exit area.

Where sites have more than one waterslide then wherever possible the staff level should be *increased as appropriate to the nature, character and design of the slide systems. This may be seen as an element of good practice.*

CHANGEOVER OF STAFF

SAIL has observed that an attendant or life-guards' concentration is an important factor in controlling the safe use of the slide. Many collisions occur due to lack of concentration by a life-guard in spacing

riders in accordance with the critical point on the slide. The salient point here is the time that life-guards spend at each location. Some may remain in position for up to an hour. The Unit believes that this is far too long to maintain vigilance and concentration. Management should also consider the fact that certain positions on the slide are more tedious and others more demanding to supervise than others. For example, the launch area presents the life-guard in most instances with an environment that is humid and hot which added to the tedium of spacing riders may well affect levels of concentration. We suggest that staff supervising the launch area may need to be replaced sooner than those in other positions on the waterslide.

It is recommended that attendants should not spend long periods at any particular control location on the waterslide. It is also recommended that further research is required to ascertain specific time spans of concentrations amongst slide staff.

SPACING OF RIDERS

Most operators do not allow chain rides on waterslides, this has effectively reduced the number of injuries that occur on waterslides.

It is recommended, therefore, that chain rides on slides are never allowed on waterslides. Parents riding/holding infants or small children should only be allowed at the management's discretion. *We are concerned, however, about the dangers of this practice.* **The Unit is also concerned with the irresponsible nature of many promotional photographs which show chain rides and other dangerous riding positions occurring on slides.** SAIL believes that these photographs encourage riders to mimic the positions seen with the possible consequences of injury.

In order to reduce the number of collisions that occur on slides, SAIL advocates that the safest method is not to release the top rider until the descending rider has reached the exit area. However, in slides where this is operated the result has been to produce a slide which is unexciting: too long is spent queuing and as a result excitement is removed from the slide ride. It is also an uneconomic way of running a slide when a slide is used as a main attraction and volume of traffic/throughput cannot be achieved. The Unit advocates a compromise: a critical point on the slide path should be used. When this point is reached by a descending rider, the next rider should be sent down. The Unit believes that it is not sufficient to allow a time difference between riders as this does not cater for exceptional circumstances. For example, an experienced rider travelling in a fast riding position descending after a child riding in a slow riding position has the potential to cause injury. Under these circumstances, time lapse spacing is unsafe. It is the duty of the manufacturer and the operator to calculate a critical point on the slide where the chances of collision are regarded as minimal. This then would avoid the consequences of the situation given above.

The Unit recommends that spacing of riders are effected on the basis of a critical point in preference to time. *However, it is accepted that timed spacing (controlled generally by traffic light systems) does constitute good practice.* **It is recommended, however, that whatever system is adopted, there is a need to adequately communicate the reasons for control to users.**

RIDE POSITION

As shown earlier, the ride position is regarded as possibly the most important factor in governing speed on a slide. There is also evidence to suggest that certain ride positions may increase the propensity for injury. The management should discuss with the manufacturer, the ride position that the slide is designed for or should be designed for. A sitting position on a fast slide can be as dangerous as any other type of position. The sitting position, although being the slowest is possibly the most unstable position. Hence, entering bends at high speed in this position results in the loss of control and in some cases impact with the slide wall. The Unit would advocate that head first entry also increases the propensity of injury on a slide. Therefore, where possible, feet first entry should be effected. Ensuring that the correct ride position is maintained is the responsibility of the life-guard.

The Unit recommends that the correct riding positions on a slide should be strictly adhered to and it is the responsibility of the manufacturer to advise on this aspect, and management to implement.

It is recommended that head first entry should not be allowed unless the entire slide system is specifically designed for this ride position.

COMMUNICATION

Communication with the user of the slide is vital if the prevention of possible accidents are to be effected. This means that there should be an effective system of informing the user what action is required to ensure a safe experience on the slide system. Lifeguards/attendants must be aware of how to communicate efficiently with the user, in order to impart important information. An essential aid in assisting the dissemination of information, lies with the correct use of signs *(see appendix 3)*. All too often signs appear to be used as reactive rather than a proactive measure for imparting information. As a result, signs appear to be located in areas where they are not seen and in some cases signs constitute a ragged piece of paper which can barely be read.

SAIL recommends that an appropriately designed pertinent system of signs is present at every waterslide to assist the life-guard with the dissemination of pertinent safety information. This should be complemented by literature, PA systems, and close circuit TV, where appropriate. It is recommended that an agreed series of symbols for use on signs should be established and that signs should be supplied by manufacturers as part of the purchase package on the slide.

USE OF SLIDE

A problem the research has encountered has been the lack of information concerning the number of rides or descents on a slide. This is important from the aspect of safety as it provides management with a tool to assess accident ratios. A preponderance of accidents may not be due purely to poor safety but to the volume of people using the slide. For example a slide which has 25 accidents a year and 100,000 rides will have a higher accident ratio and therefore risk than a slide that has 50 accidents and 500,000 rides. The number of accidents must always be seen in the context of the number of rides. However, the management is unable to assess this without basic information. Therefore, as an aid to management, an accurate method of calculating the number of rides on a slide is needed. An electronic or mechanical device placed on entry to the slide would serve this need. Good accurate recording is an essential tool for effective management.

It is recommended that an accurate method of calculating the number of rides on a slide is required by operators.

MAINTENANCE

SAIL believes that of essential importance to maintaining the safety on a slide is a continuous programme of maintenance which involves daily checks and close attention to detail.

It is recommended that the waterslide is checked every day prior to public use by appropriate staff. This checking should be undertaken in a safe and appropriate manner.

The staff should have a check-list and the slide should, where possible, be visually and physically checked (joints actually being examined and physically touched).

It is recommended that the maintenance examination should involve the use of a check-list so that no area of the slide is overlooked.

A comment made by a large proportion of operators concerned the aspect of maintenance after the slide has been installed. Waterslides as with other types of equipment need to be maintained. There is no such thing as a perfect joint, water pumps do break down and slides can also be affected by osmosis resulting in the surface flaking. Too often operators are left to deal with these problems on their own, often calling in contractors who have no experience of waterslide construction. SAIL believes that when slides are installed there

should also be a contract with the supplier to provide maintenance and further advice and technical back-up.

It is recommended that the manufacturer, supplier or installer of a slide system provides an after sales service which involves regular maintenance and ongoing advice on matters of safety. This then helps to alleviate the burden placed at present on the operator.

CHAPTER 8
SUMMARY OF RECOMMENDATIONS

DESIGN

APPROACH

It is recommended that particular attention is paid to the surface gradients, the floor surfaces in approach areas to the tower. Similar attention to detail is required in the exit paths.

It is also recommended that some form of physical or visual barrier is erected to separate those queuing to use the slide from other users of the facility.

It is recommended that all approach paths must conform to current British Standards Building Regulations relating to path width and surfacing.

TOWER

It is recommended that towers are designed to channel water away efficiently or are able to maintain non-slip flooring. It is not sufficient to let water disperse of its own means.

It is recommended that towers are designed with straight run staircases with landings and that the tower allows easy passage for two people with hand rails on both sides. All staircases should be designed to meet current BS Building Regulations. Spiral staircases are considered to be inherently dangerous in the context of waterslides.

LAUNCH AREA

The Unit recommends that non-slip, well drained floor surfaces at the launch area are essential. In addition, there should be sufficient space at the launch area for adequate control and management of users.

It is recommended that, where height is used as a means of separating riders, that a measuring scale be placed on the approach to the slide, at the bottom of the tower and at the launch area.

SLIDE PATH

It is recommended that mats should only be used on slide systems which have been specifically designed for this purpose. There are inherent dangers in the simple application of the use of mats, or indeed circular tubes, to inappropriate slide design.

SAIL recommends that, although DIN provides many valuable and useful guidelines, it is inadequate and should not be regarded as a surrogate for a British Standard.

It is recommended that sharp changes of direction that occur in quick succession, especially in combination with accelerator points, be avoided on waterslides.

It is recommended that further detailed research be undertaken on this particular aspect of design. To ascertain critical parameters for radii and gradient slopes.

It is recommended that further study is needed on the effects of water flow in relation to speed.

It is recommended that a reasonable length of the end section of the slide path be specifically designed to reduce speed, and eject the rider in a manner which is controlled and the angle of entry is parallel to the surface of the water.

SPLASH POOL

It is recommended that where possible methods involving hydrostatic breaking and aqua-catches should be used in preference to splash pools.

It is recommended that if discrete splash pools are not in use then a separated area from the main pool should be used where possible.

It is recommended that where splash pools are part of the main pool, some form of physical barrier should be placed so that swimmers do not interfere with or impede the path of waterslide riders. (This barrier should not, in its own right, present a hazard to the

rider)

In addition, it is recommended that all splash areas should have clearly indicated exit points and have notices which help orientate riders.

MANAGEMENT

It is recommended that careful market planning and assessment is required before a waterslide is incorporated into a centre.

ACCIDENT REPORTING AND RECORDING SYSTEMS

We recommend, that quality monitoring of the use of waterslides differentiates between incidents and accidents.

It is recommended that an accurate system of measuring the number of rides on a slide should be incorporated immediately.

It is recommended that appropriate and influential bodies should encourage a standard definition of what constitutes an incident and an accident and how they should ideally be recorded.

A systematic method of recording accidents should also be insisted upon by the appropriate governing leisure bodies.

The research Unit recommends that a standardised reporting format for recording all accidents is developed which should include at a minimum all those items listed in the appropriate section.

It is recommended that non-swimmers should not be allowed to use slides unless they are designed with a run-out or an aqua-catch and that this message has to be effectively communicated.

TRAINING OF PERSONNEL

MANAGEMENT OF STAFF

NUMBER OF STAFF

The Unit recommends that the inclusion of one slide in a centre necessitates the positioning of a minimum of one trained operative at the launch area and one at the exit area.

It is recommended that at any waterslide installation there should be a minimum of two trained and briefed personnel: one located at the launch area and the other located at the exit area.

CHANGEOVER OF STAFF

It is recommended that attendants should not spend long periods at any particular control location on the waterslide.

It is also recommended that further research is required to ascertain specific time spans of concentration amongst slide staff.

SPACING OF RIDERS

It is recommended, that chain rides on waterslides are never allowed. Parents riding/holding infants or small children should only be allowed at the management's discretion. We are concerned, however, about the dangers of this practice.

The Unit is also concerned with the irresponsible nature of many promotional photographs which show chain rides and other dangerous riding positions occurring on slides.

The Unit recommends that spacing of riders are effected on the basis of a critical point in preference to time.

It is recommended, that whatever spacing system is adopted, that there is a need to adequately communicate the reasons for control to users.

RIDE POSITION

The Unit recommends that the correct riding positions on a slide should be strictly adhered to and it is the responsibility of the manufacturer to advise on this aspect, and management to implement.

It is recommended that head first entry should not be allowed unless the entire slide system is specifically designed for this ride position.

It is further recommended that it should be the responsibility of the manufacturer to guide the operator on these aspects of slide operation.

COMMUNICATION

SAIL recommends that an appropriately designed pertinent system of signs is present at every waterslide to assist the life-guard with the dissemination of pertinent safety information. This should be complemented by literature, PA systems, and close circuit TV.

It is recommended that an agreed series of symbols for use on signs should be established and that signs should be supplied by manufacturers as part of the purchase package on the slide.

MAINTENANCE

It is recommended that in order to maintain safety standards, joints should be checked every day prior to public use for misalignment and changes in the surface surrounding the joint.

It is recommended that the waterslide is checked every day prior to public use by appropriate staff. This checking should be undertaken in a safe and appropriate manner.

It is recommended that the maintenance examination should involve the use of a check-list so that no area of the slide is overlooked.

It is recommended that the manufacturer, supplier or installer of a slide system provides an after sales service which involves regular maintenance and ongoing advice on matters of safety. This then helps to alleviate the burden placed at present on the operator.

APPENDIX 1

LIST OF MEMBERS ON THE S.A.I.L. STEERING COMMITTEE

WALES TOURIST BOARD
BRUNEL HOUSE
2 FITZALAN ROAD
CARDIFF
CF21U9 O222 499909
JOHN WALSH-HERON HEAD OF TRADE & CONSUMER AFFAIRS

.....

LEISURE MANAGEMENT
40 BANCROFT
HITCHIN HERTS.
0462 431385
LIZ TERRY EDITOR

.....

INST. BATHS & RECREATION MANAGEMENT
MANAGER OASIS LEISURE CENTRE
SWINDON
0793 533404
PETER MILLS. MANAGER

.....

I.L.A.M.
I.L.A.M. HOUSE
LOWER BASILDON
READING
RG89NE
0491 30940
MR IAN FLEMMING ASSISTANT DIRECTOR

.....

SPLASH DOWN WATER SLIDES LTD
DERBY POOL
NORTH PROMANADE
BLACKPOOL
FY1 ZJ2 0253 28578

LLOYCE BOYD MANAGING DIRECTOR

.....

THE SPORTS COUNCIL
16 UPPER WOBURN PLACE
LONDON
WC1 HOQT 01 3881277
DAVID BUTLER ARCHITECT

.....

EAST GLAM HOSPITAL
CHURCH VILLAGE
NR PONTYPRIDD
CF3 81AB 0443 204242

MR D.T. MOODY JONES CONSULTANT IN CHARGE

.....

HEALTH AND SAFETY EXECUTIVE
3RD FLOOR
VICTORIA HOUSE
ORMSKIRK RD
PRESTON
PR1 1HH 0772 59321

JOHN GOWLING SENIOR PRINCIPAL

.....

ROSPA
CAMMON HOUSE
THE PRIORY
QUEENSWAY
BIRM.
B46 B5 021 2002461

TOM SANDERS WATER SAFETY ADVISOR

.....

ASSOC. DISTRICT COUNCILS
9, BUCKINGHAM GATE
LONDON
SWI E6LE 10-828 7931

PHIL READER

DAVID LUNN BORO. SEC. WINDSOR & MAIDENHEAD

.....

SPORTS COUNCIL FOR WALES
THE NATIONAL STADIUM
SOPHIA GDNS.
CARDIFF 0222 397571

DR. HUW JONES HEAD OF POLICY & PLANNING

.....

VAN EGDOM
VAN EGDOM HOUSE
LODGE RD
STOURPORT-ON SEVERN
WORC
DY13 9HE 02993 78444

JOHN HALL GENERAL MANAGER

.....

FAULKNER BROWNS
DOBSON HOUSE
NORTHUMBRIAN WAY
KILLINGWORTH
NEWCASTLE UPON TYNE
NE120QW 091 268 3007

BILL STONOR

.....

SARGENT & POTIRIADIS
S & P SAFETY
S & P HOUSE
3-5 CHARING CROSS ROAD
LONDON
WC2H OHA 01-925 02225

KEITH SACH MANAGING DIRECTOR
.....
MUNICIPAL MUTUAL INSURANCE LTD
25/27 OLD QUEEN STREET
WESTMINSTER
LONDON
SW1 9HN 01- 222 7933

BILL DELAMARE HEALTH AND SAFETY MANAGER
.....

APPENDIX 2

ACCIDENT/INCIDENT REPORTING

1. The primary purpose of a comprehensive accident/incident reporting system is to provide management with relevant information, not to compile statistics for their own sake. The information on a completed form should help to:

   a) Assess whether any accident/incident could have been prevented by practice or safer design.

   b) Assess whether better staff have inadvertently contributed to an accident/incident.

   c) Give an indication as to the effectiveness of operational policy and practice.

   d) Assess whether adequate first aid was given by qualified staff.

   e) Assess whether correct follow-up procedure was actioned.

   f) Provide an accurate picture of the accident/incident and the action taken, for use in any subsequent litigation.

   g) Identify long-term trends and/or future serious accident potential.

2. Good practice suggests that recording of waterslide related accidents/ incidents should be done on a separate specialised document. Therefore a Leisure Pool with waterslides may have up to four types of primary document ie:

   a) Waterslide Accident/Incident Form

   b) General First Aid Form

   c) General Incident Form

   d) Pool Rescue Report

   S.A.I.L concerns itself in this report with the waterslide Accident/ Incident Form.

3. Obviously comprehensive logging of accidents/incidents will enable meaningful statistics to be drafted, thus aiding the management over-view for acident prevention.

4. A balance will always need to be struck between administrative and operational requirements, ie the administration of an accident/incident should not keep staff away from operational duties for longer than necessary.

SAMPLE DRAFT

ANY TOWN LEISURE POOL No_____

NOTE No

WATERSLIDE ACCIDENT/INCIDENT FORM
(To be completed by qualified First Aider if First Aid administered). PLEASE COMPLETE IN BLOCK LETTERS AND TICK CORRECT BOXES WHERE APPLICABLE.

1. FOR OFFICE USE ONLY

	MGR	ASST MAN	ASST MAN	ASST MAN	ADMIN OFF
	_____	_____	_____	_____	_____
{sign)					

FILE

a) DATE OF ACCIDENT/INCIDENT .....TIME.....

2. b) CASUALTY PERSONAL DETAILS

SURNAME..... AGE.....

FORNAME.....

BUILD (ADULTS ONLY) SMALL ☐ MEDIUM ☐ LARGE ☐

MR/MRS/MISS/MS.....

ADDRESS.....

.....POST CODE..... TEL NO.....

No of previous visits: ☐ FIRST VISIT ☐ 1-10 VISITS ☐

3. c) CIRCUMSTANCES IN WHICH ACCIDENT OCCURRED.....

.....

.....

AREA OF ACCIDENT TUBE 1 ☐ TUBE 2 ☐ TUBE 3 ☐

SPLASH TANK ☐ TOWER ☐ OTHER ☐ (STATE WHICH).....

SIGNATURE OF CASUALTY.....

4. WITNESS (1) NAME..... (2) NAME.....

ADDRESS..... ADDRESS.....

TEL NO..... TEL NO.....

WITNESSES ACCOUNT OF INCIDENT (IF APPLICABLE).....

.....

.....

SIGNATURE OF WITNESS (1) ..... (2).....

5. d) FIRST AID TREATMENT

TREATMENT GIVEN.....

CONDITION OF PATIENT AFTER TREATMENT.....

AMBULANCE CALLED YES ☐ No ☐

6. SIGNED..... SIGNED.....
(FIRST AIDER) {DUTY SUPERVISOR)

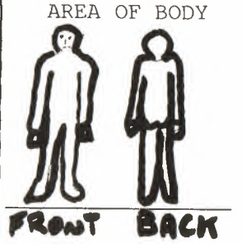
e) FOLLOW UP PROCEDURE (FOR HOSPITAL CASES)

Detained more than 24 hours YES ☐ NO ☐

Details.....

.....

AREA OF BODY



7. f) MANAGERS FOLLOW UP (ACTION TAKEN) .....

.....

.....Signed:.....(Manager)

Date:.....

8. g) FURTHER ACTION (AS NECESSARY)

1) Injury/Dangrous Occurrence Form (F2508)

YES/NO DATE SENT TO HSE.....

2) His an Indication that a claim for compensation may be received? Yes/No
(Yes copy to Group/Admin Officer/Insurance Co Date.....)

SAMPLE FORM - EXPLANATORY NOTES

NOTE NO	
1.	Have carboned and numbered copies. Retain master on file, circulate to relevant staff the copy and return to file.
2.	Casualty personal details - a judgement to be made on the build of adults. This information may be useful when looking for accident correlations. Definition of small, medium and large build tobe posted in staff areas.
3.	Circumstances - Provide full details and get the casualty (or parent for under 8 years) to sign that the report is accurate. This assumes of course that the casualty is in a fit state to sign the document and therefore discretion must be used. The signature should be requested after treatment has been given.
4.	Witnesses - If a witness claims to have seen the full incident, then getting a signed account will be invaluable.
5.	CONDITION OF PATIENT - eg. Conscious, shock, hysterical, O.K. good.
6.	The Shift Supervisor or Duty Manager should counter-sign forms by the end of each shift ensuring correct completion, alerting the Manager of any immediate problems and then forwarding the copy for circulation.
7.	Managers follow-up will contain details of action taken and/ or relevant notes.
8.	To be completed by relevant officer and forwarded as necessary.

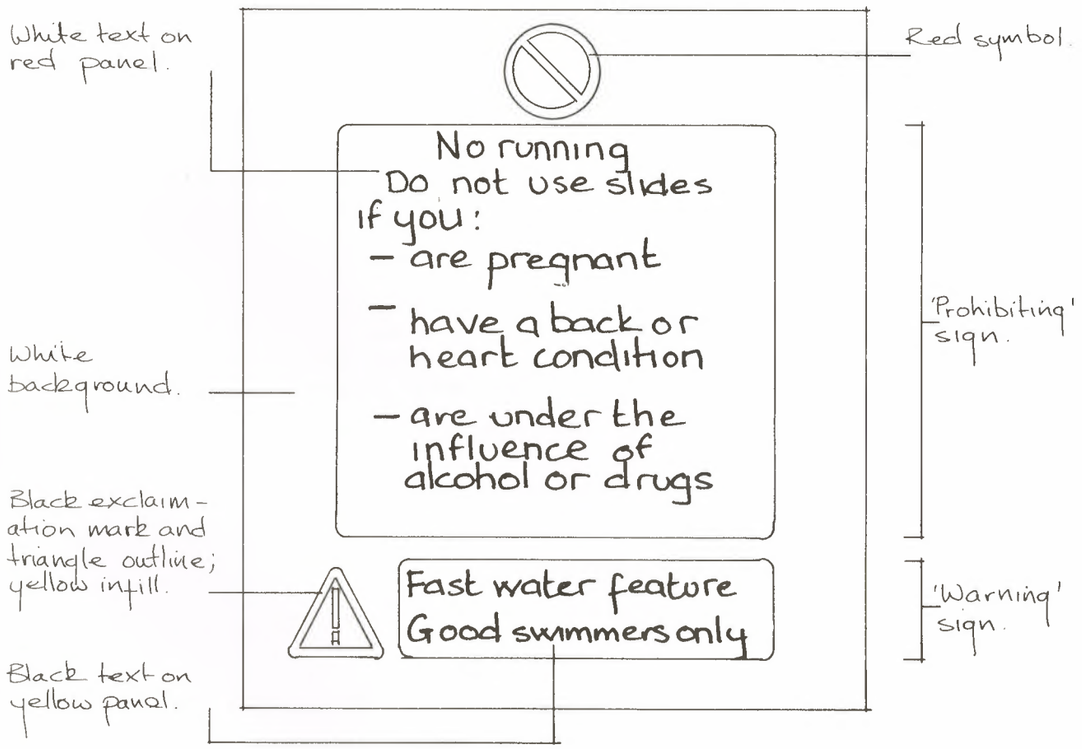
APPENDIX 3 : SAFETY SIGNS

Safety signs should comply with The Safety Signs Regulations, 1980 and BS 5378, Part I. The Regulations are based upon a Directive of the European Community, designed to encourage the standardisation of safety signs throughout the EC.

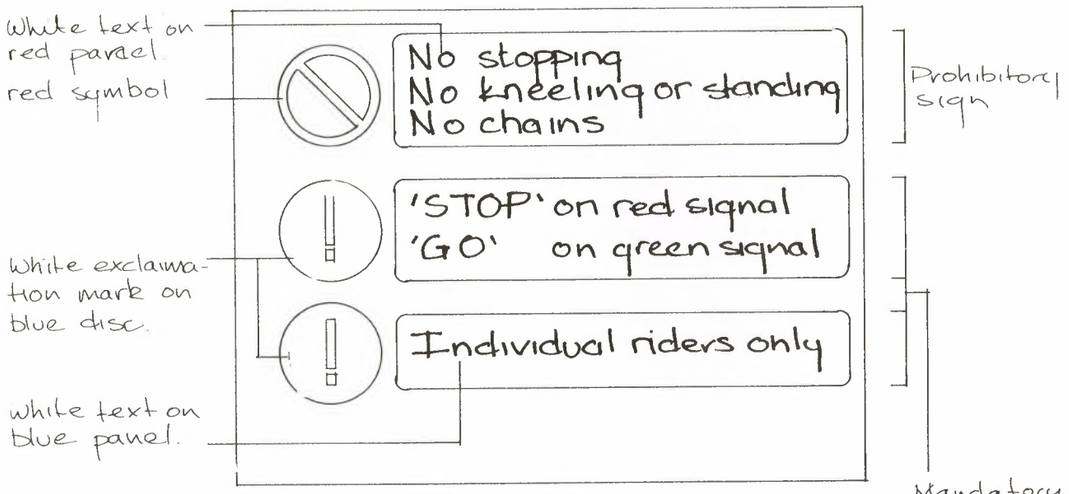
The following are examples of safety signage associated with waterslides, intended to illustrate:

- which information is appropriate at various points on the waterslide approach;
- how the standard shapes, colours and symbols for safety signs can be used to convey this information.

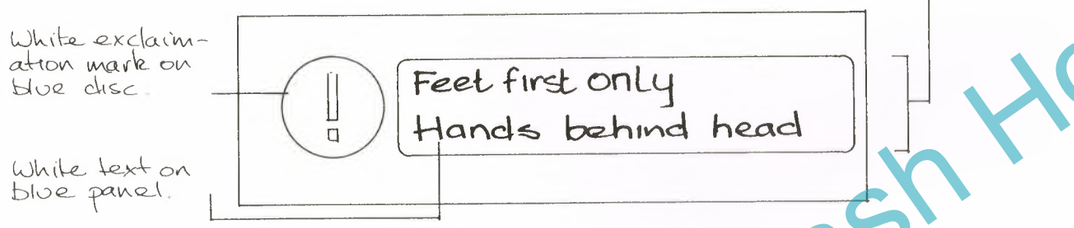
[A] At the foot of the waterslide approach tower or steps -



[B] At the top of the tower or steps -



[C] By the opening of each waterslide -



For more information on The Safety Signs Regulations, 1980, etc, and on how signs may be obtained, telephone RoSPA (021-200-2461) and ask for a free copy of their "Safety Signs" catalogue to be sent to you.

This Appendix has been supplied by:

S&P Safety Limited, Leisure Safety Consultants (01-925-0225) -

as part of their support for SAIL's Waterslide research.

APPENDIX 4

COMMON ACCIDENTS

TABLE 4.1 COMMON ACCIDENTS INJURIES

TABLE 4.1 COMMON ACCIDENTS INJURIES

	FREQUENCY	%
MINOR CUTs	34	33.33
ABRASIONS	25	24.50
BRUISES	32	31.37
BONES MAIN BODY	1	.98
TOOTH	1	.98
BURNS FRICTION	1	.98
NOSE BLEED	7	6.86
SPRAIN	1	.98
TOTAL	102	100.0

TABLE 4.2 COMMON ACCIDENTS - BODY LOCATION

	FREQUENCY	%
FOOT	8	14.55
LEG	8	14.55
UPPER MAIN BODY	5	9.09
HEAD	15	27.27
FACE	15	27.27
ARMS	2	3.64
BACK	1	1.82
HANDS	1	1.82
TOTAL	55	100.0

TABLE 4.3 COMMON ACCIDENTS - SLIDE LOCATION

	FREQUENCY	%
APPROACH TOWER	2	2.11
TOWER	11	11.58
LAUNCH	12	12.63
SLIDE PATH	42	44.21
EXIT AREA	28	29.47
TOTAL	95	100.0

TABLE 4.4 COMMON ACCIDENTS- CAUSE

	FREQUENCY	%
COLLISION RIDER	4	4.08
COLLISION EXIT PEOPLE	1	1.02
COLLISION WALLS	25	25.51
COLLISION POOL	16	16.32
MISBEHAVIOUR	8	8.16
JOINTS	8	8.16
SLIPPING	24	24.49
ROUGH SURFACE	2	2.04
IMPACT SURFACE	6	6.10
FRICTION	4	4.08
TOTAL	98	100.0

INJURIES RESULTING ATTENDANCE AT HOSPITAL

TABLE 4.5 HOSPITAL - INJURIES

	FREQUENCY	%
MAJOR CUTS	21	43.75
BRUISES	1	2.08
BONES LIMBS	2	4.17
BONES APPENDAGES	5	10.42
BONES MAIN BODY	5	10.42
CONCUSSION	6	12.50
TOOTH	1	2.08
DISLOCATION	5	10.42
ALLERGIC REACTION	2	4.17
TOTAL	48	100.0

TABLE 4.6 HOSPITAL - BODY LOCATION

	FREQUENCY	%
FOOT	8	15.38
LEG	3	5.77
UPPER MAIN BODY	1	1.92
NECK	1	1.92
HEAD	18	34.61
FACE	17	32.69
ARMS	2	3.85
BACK	2	3.85
TOTAL	57	100.0

TABLE 4.7 HOSPITAL - SLIDE LOCATION

	FREQUENCY	%
APPROACH TOWER	3	5.09
TOWER	10	16.95
LAUNCH	2	3.39
SLIDE PATH	23	38.98
EXIT AREA	21	35.59
TOTAL	59	100.0

LITIGATION

TABLE 4.8 LITIGATION - INJURIES

	FREQUENCY	%
MAJOR CUTS	3	18.75
BONES APPENDAGES	3	18.75
BONES MAIN BODY	3	18.75
TOOTH	2	12.50
CONCUSSION	3	18.75
DISLOCATION	2	12.50
TOTAL	16	100.0

TABLE 4.9 LITIGATION - BODY LOCATION

	FREQUENCY	%
FOOT	2	9.52
UPPER MAIN BODY	1	4.76
HEAD	3	14.29
FACE	2	9.52
ARMS	3	14.29
BACK	10	47.62
TOTAL	21	100.0

TABLE 4.10 LITIGATION - SLIDE LOCATION

	FREQUENCY	%
TOWER	2	13.33
LAUNCH	2	13.33
SLIDE PATH	4	26.66
EXIT AREA	7	46.66
TOTAL	15	100.0

TABLE 4.11 LITIGATION - CAUSE

	FREQUENCY	%
SLIDE PATH	2	10.53
SLIPPING	4	21.05
COLLISION FLUME	3	15.79
COLLISION POOL	4	21.05
CHIPPED SURFACE	4	21.05
ROUGH SURFACE	2	10.53
TOTAL	19	100.00

WORST INJURIES

TABLE 4.12 WORST INJURIES - INJURIES

	FREQUENCY	%
MAJOR CUTS	22	44.00
ABRASIONS	1	2.0
BRUISES	2	4.0
BONES LIMBS	3	6.0
BONES APPENDAGES	4	8.0
BONES MAIN BODY	4	8.0
TOOTH	6	12.0
CONCUSSION	3	6.0
NOSE BLEEDS	2	4.0
SPRAIN	1	2.0
DISLOCATION	2	4.0
TOTAL	50	100.0

TABLE 4.13 WORST INJURIES - BODY LOCATION

	FREQUENCY	%
FOOT	7	14.0
LEG	4	8.0
UPPER MAIN BODY	3	6.0
NECK	1	2.0
HEAD	13	26.0
FACE	16	16.0
ARMS	2	4.0
BACK	4	4.0
TOTAL	50	100.0

TABLE 4.14 WORST INJURIES CAUSES

	FREQUENCY	%
SLIDE PATH	6	11.11
SLIPPING	14	25.93
COLLIDING FLUME	13	24.07
MISBEHAVIOUR	1	1.85
COLLISION POOL	16	29.63
CHIPPED SURFACE	2	3.70
ROUGH SURFACE	2	3.70
TOTAL	54	100.0

COLLISION INJURIES

TABLE 4.15 COLLISION - SLIDE LOCATION

	FREQUENCY	%
SLIDE PATH	19	28.00
EXIT AREA	48	71.64
TOTAL	67	100.0

TABLE 4.16 COLLISION - CAUSES

	FREQUENCY	%
INCORRECT SPACING	12	19.67
RIDER STOPPING	19	31.15
INTER PERSON/ EXIT AREA	26	42.62
COLLISION WITH TUBE	1	1.64
MISBEHAVIOUR	2	3.38
HEAD 1ST ENTRY	1	1.64
TOTAL	61	100.0

JOINTS CAUSING INJURY

TABLE 4.17 JOINTS - INJURIES

	FREQUENCY	%
MINOR CUTS	21	25.93
MAJOR CUTS	8	9.88
ABRASIONS	18	22.22
BRUISES	25	30.86
BURNS FRICTION	1	1.23
NOSE BLEED	5	6.17
BONES APPENDAGES	1	1.23
BONES MAIN BODY	1	1.23
DISLOCATION	1	1.23
TOTAL	81	100.0

TABLE 4.18 JOINTS - BODY LOCATION

	FREQUENCY	%
FOOT	6	22.20
LEG	5	18.52
UPPER MAIN BODY	3	11.11
HEAD	3	11.11
FACE	6	22.22
ARMS	3	11.11
BACK	1	3.70
TOTAL	27	100.0

APPENDIX 5

TABLE 5.1. HEIGHT ABOVE GROUND

	FREQUENCY	%
MISSING	8	4.8
0-3M	40	24.2
4-6M	52	31.5
6-8M	30	18.2
>8M	35	21.2
TOTAL	165	100.0

TABLE 5.2 LENGTH OF SLIDE

	FREQUENCY	%
MISSING	4	2.4
<50M	99	60.0
51-69M	35	21.2
70-120	26	15.8
NOT SPECIFIED	1	.6
TOTAL	165	100.0

TABLE 5.3 BENDS ON SLIDE

	FREQUENCY	%
MISSING	5	3.0
NONE	32	19.4
1-3	69	41.8
4-6	46	27.9
>6	13	7.9
TOTAL	165	100.0

TABLE 5.4 DEPTH OF SPLASH POOL

	FREQUENCY	%
MISSING	9	5.5
0-1M	55	33.3
1-1.5M	86	52.1
1.6-2M	10	6.1
>2M	5	3.0
TOTAL	165	100.0

TABLE 5.5 HEIGHT OF END SLIDE

	FREQUENCY	%
MISSING	16	9.7
0-.25M	94	57.0
.26M-.5M	46	27.9
.6M-.75M	5	3.0
.76-1.00M	2	1.2
>2M	2	1.2
TOTAL	165	100.0

TABLE 5.6 MATERIAL

	FREQUENCY	%
MISSING	6	3.6
GRP	128	77.6
PLASTIC	29	17.6
PLASTIC/CAN	1	0.6
OTHER	1	0.6
TOTAL	165	100.0

APPENDIX 6

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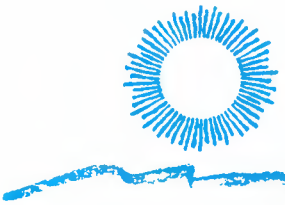
APPENDIX 7

FINANCIAL SUPPORT:

THE HEALTH AND SAFETY EXECUTIVE
THE SPORTS COUNCIL FOR WALES
THE WALES TOURIST BOARD
MUNICIPAL MUTUAL INSURANCE
FAULKNER BROWNS ARCHITECTS
SARGENT AND POTIRIADIS
FITCH BENOY
SPLASHDOWN WATERSLIDES

SUPPORT IN KIND:
OUR THANKS ALSO GO TO THE REST OF THE STEERING COMMITTEE WHO HELPED TO ASSIST SAIL WITH THE PROVISION OF VARIOUS FACILITIES, WHEN THE NEED AROSE DURING THE RESEARCH.



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ISBN. 0 9515935 0 1