MONASH University
Accident Research Centre

THE ROLE OF HUMAN FACTORS IN LED OUTDOOR ACTIVITY INCIDENTS: LITERATURE REVIEW AND EXPLORATORY ANALYSIS

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The role of Human Factors in led outdoor activity incidents: Literature review and exploratory analysis

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Abstract:
While the exact rate of incidence is unknown (due to the paucity of exposure data), it is acknowledged that safety compromising accidents and incidents occur in the led outdoor activity domain, and that they represent an important issue. Despite this, compared to other safety critical domains, very little is currently known about the key causal factors involved in such accidents and incidents. This report presents the findings derived from a review of the literature, the aim of which was to identify the Human Factors-related issues involved in accidents and incidents occurring in this area. In addition, to demonstrate the utility of systems-based, theoretically underpinned accident analysis methodologies for identifying the systemic and human contribution to accidents and incidents occurring in the led outdoor activity domain, three case-study accidents were analysed using two such approaches. In conclusion, the review identified a range of causal factors cited in the literature; however, it was noted that the majority of the research undertaken to date lacks theoretical underpinning and focuses mainly on instructor or activity leader causal factors, as opposed to the wider system failures involved. The accident analysis presented highlighted the utility of systems-based, theoretically underpinned accident analysis methodologies for analysing and learning from accidents and incidents in the led outdoor activity sector. In closing, the need for further research in the area is articulated, in particular focussing on the development of standardised and universally accepted accident and incident reporting systems and databases, the development of data driven, theoretically underpinned causal factor taxonomies, and the development and application of systems-based accident analysis methodologies.

Key Words:
Accidents, outdoor led activity, Human Factors, error, causal factors, accident analysis

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Preface

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- David Strickland, (Department of Planning and Community Development, Sports and Recreation Victoria);
- David Petherick (Australian Camps Association);
- Clare Dallat (Outdoor Education Group);
- Brendan Smith (Victorian YMCA);
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- Don MacDowall; and
- Tony Carden (Victorian Outdoor Education Association).

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EXECUTIVE SUMMARY

Background and reasoning behind the work

While the exact rate of incidence is unknown (due to the paucity of exposure data), it is acknowledged that safety compromising accidents and incidents occur in the led outdoor activity domain, and that they represent an important issue. Despite this, compared to other safety critical domains, very little is currently known about the key causal factors involved in such accidents and incidents.

Specific research question being addressed

Initiated by the led outdoor activity sector, the aim of this research was to explore the involvement of Human Factors in led outdoor activity incidents, and to suggest and demonstrate the utility of a framework for studying such incidents. In addressing this aim, the research sought to ascertain what is currently known about the Human Factors-related causal factors involved in led outdoor activity accidents and incidents.

The current research forms the first stage of a proposed three stage research project.

Research tasks undertaken

This research involved the following tasks:

1. *Literature review*. A literature review focussing on led outdoor activity accidents and incidents was undertaken. The aim of the review was to ascertain what is currently known about such accidents and incidents, to distil the Human Factors issues which have already been implicated, to identify gaps in current knowledge, and to suggest a more comprehensive and relevant framework to aid the understanding of incident causation in the led outdoor activity sector.

2. *Exploratory case study analyses*. In order to demonstrate the potential utility of applying theoretically underpinned, systems-based accident analysis methodologies within the led outdoor activity domain, three led outdoor activity accidents were analysed using two systems-based accident analysis methods. The findings from these analyses were then compared to those derived from an analysis, which used a framework developed in the led outdoor activity domain.

3. *Workshop*. A workshop involving project stakeholders, led outdoor activity personnel, and researchers from MUARC was held in order to disseminate the research findings and to determine the most appropriate way forward for the subsequent phases of this research.

What was found?

Compared to other domains in which safety compromising accidents and incidents have been identified as a significant problem, research into accidents and incidents in the led outdoor activity domain has thus far been limited. A number of led outdoor activity accident causation models were identified, however, and the research undertaken to date suggests that there are a range of systemic and instructor/client-related causal factors involved in led outdoor activity accidents and incidents. It is notable, however, that the relationship between these factors remains unknown. Further, a universally accepted model of led outdoor activity accident causation, and a comprehensive taxonomy of causal factors, is yet to emerge. It is also apparent that the majority of causal factors identified are instructor-based, focussing on instructor causal factors and errors as the main causes of accidents and incidents. Previous research in other safety critical domains, however, has highlighted the role of wider systemic failures in accidents and incidents.

The importance of databases in ascertaining causal factors was discussed. The literature review identified a number of National and International databases containing data regarding outdoor activity accidents and incidents. The importance of such databases in the analysis and future prevention of accidents and incidents within the led outdoor activity domain was emphasised. Three such databases were identified within Australia, and it was noted that these are voluntary, and that standardised incident reporting and storage, and analysis procedures are not currently present.

The collection and analysis of near miss incident data was also highlighted as a key commodity in the future prevention of accidents and incidents within the led outdoor activity domain. Widely accepted as a means for learning from, and preventing, accidents and incidents in most other safety critical domains, near miss incident reporting and analysis systems have been identified by many in the area as key to the prevention of future accidents and incidents (e.g. Brackenreg, 1999; Davidson, 2004, Haddock, 1999).

Main conclusions and recommendations

Current knowledge regarding the role of Human Factors in led outdoor activity accidents and incidents is limited. Although previous research has identified a range of causal factors, a lack of linkage between these factors, theoretical underpinning, and consideration of the wider systemic causal factors is apparent. A universally accepted model of led outdoor activity accident causation, and associated causal factors taxonomies, do not yet exist. Further, systems-based accident analysis models and methods, developed and applied with significant safety gains in other safety critical domains (e.g. Rasmussen, 1997; Reason, 1990), have not yet fully transferred into the led outdoor activity domain. Further research into the Human Factors issues involved is therefore required. In particular, theoretically driven, systems-based research into such accidents and incidents is advised. The following key lines of inquiry/activities are recommended:

1. Development of a unified, theoretically underpinned accident and incident reporting system;

2. Development of a National led outdoor activity accident and incident database;

3. Development and application of a theoretically underpinned, systems-based accident analysis method;

4. In-depth analysis of led outdoor activity accident and incidents; and

5. Development of a led outdoor activity accident causation model and associated failure taxonomies.

In closing, it is worth noting that the led outdoor activity industry within Australia recognises the need to further enhance their understanding of accidents and incidents so that preventative measures can be improved. This research represents the first step in that process, and the proposed phases of this overall research program will involve the tasks described above.

Whilst safety compromising accidents and incidents may never be fully eradicated, fully understanding the nature through theoretically driven research allows appropriate measures to be taken so that their likelihood and consequences can be minimised significantly.

1 INTRODUCTION

1.1 BACKGROUND

While the exact rate of incidence is unknown (due to the paucity of exposure data), it is acknowledged that safety compromising accidents and incidents occur in the led outdoor activity domain, and that they represent an important issue. Davidson (2004), for example, notes that, in addition to the injury or loss of life and associated distress for those involved; such incidents generate negative publicity and have the potential to be extremely damaging to the sector.

Despite this, compared to other safety critical domains, very little is currently known about the key causal factors involved in such accidents and incidents. Further, little theoretically driven and systematic research has been undertaken to delineate and to investigate the causal factors involved, or to explore how incident rates in the led outdoor activity sector could be minimised.

1.2 AIM AND OBJECTIVE OF THE CURRENT PROJECT

The aim of this research was to explore the involvement of Human Factors in led outdoor activity incidents, and to suggest and to demonstrate the utility of a framework for studying such incidents. In addressing this aim, the research sought to ascertain what is currently known about the contributing factors involved in led outdoor activity incidents, and what safety-related Human Factors issues, widely researched and understood in other safety critical domains are applicable in the led outdoor activity sector.

1.3 INDUSTRY INVOLVEMENT

It is important to note that this project represents an initiative of the led outdoor activity sector. In early 2009, the Monash University Accident Research Centre (MUARC) was commissioned by a project Steering Committee facilitated by the Department of Planning and Community Development to undertake this research. This Committee comprises representatives from several bodies within the led outdoor activity sector..

As testament to the involvement of industry, a large number of industry bodies have contributed financially to this project. Herein is a list of these stakeholders:

- Australian Camps Association;
- Christian Venues Association;
- United Church Camping;
- Outdoor Council of Australia;
- Sports and Recreation Victoria;
- Outdoor Recreation Industry Council of NSW;
- Victorian Outdoor Education Association;
- Outdoor Recreation Centre, Victoria;
- Queensland Outdoor Recreation Foundation;
- Recreation South Australia;
- Outdoors Western Australia;

- Outdoor Educators' Association of South Australia;
- Victorian YMCA;
- The Bindaree Group;
- Australian Canoeing; and
- Outdoor Education Group.

1.4 SCOPE OF THE CURRENT PROJECT

The scope of this research is limited to that of 'led' outdoor activities. For the purposes of this research, led outdoor activity is defined as those facilitated or instructed activities within outdoor education and recreation that have a learning goal associated with them. The scope was further limited by the types of led outdoor activities which were considered in our review. For this purpose a set of applicable activities was defined in consultation with the project stakeholders (see Appendix A: Activity list). It is acknowledged, nonetheless, that incidents can and do occur during informal recreation time that might be associated with a led outdoor activity.

As stated, this research is focussed on the Human Factors-related issues involved in led outdoor activity accidents and incidents. The discipline of Human Factors represents the study of human performance in socio-technical systems, and has previously been defined as "the scientific study of the relationship between man and his working environment" (Murell, 1965), "the study of how humans accomplish work-related tasks in the context of human-machine systems" (Meister, 1989), and "applied information about human behaviour, abilities, limitations and other characteristics to the design of tools, machines, tasks, jobs and environments" (Sanders & McCormick, 1993). Human Factors is therefore concerned with human capabilities and limitations, human-machine/technology interaction, teamwork, tools, machines and material design, environments, work, organisational design, system performance, efficiency, effectiveness, and safety. It is important to note then, that by identifying the Human Factors issues involved in accidents and incidents in the led outdoor activity domain, we are focussing on both the human (instructors and clients) and the wider outdoor activity 'system', comprising equipment, organisations, rules and regulations/ legislation, local government and government.

1.5 CONTEXT OF THE CURRENT PROJECT

It is important to acknowledge that the research activities comprising the current project form the first stage of a planned three-stage program of work. Building on the outcomes of this first stage, it is proposed that Stage 2 will involve the design and establishment of an industry database, and integration of industry reporting with this database. In turn, Stage 3 will involve a follow up of Stage 1 recommendations through the implementation of measures to reduce injury in led outdoor activities. Further, Stage 3 will extend Stage 2 activities by also involving on-going reporting of incident data contained within the database. It is intended that this final stage will include regular review of data as it emerges from the industry database, and annual reporting of findings, conclusions and recommendations.

1.6 RESEARCH UNDERTAKEN AS PART OF THE CURRENT PROJECT

The research project involved three components: a literature review, case study exploratory accident analyses, and a workshop to discuss the implications of the research findings and also the subsequent phases of the overall research program. Specifically, the research involved the following tasks:

1. *Literature review*. A literature review focussing on led outdoor activity accidents and incidents was undertaken. The aim of the review was to ascertain what is currently known about such accidents and incidents, to distil the Human Factors issues which have already been implicated, to identify gaps in current knowledge, and to suggest a more comprehensive and relevant framework to aid the understanding of incident causation in the led outdoor activity sector.

2. *Exploratory case study analyses*. In order to demonstrate the potential utility of theoretically underpinned, systems-based accident analysis methodologies within the led outdoor activity domain, three led outdoor activity accidents were analysed using two systems-based accident analysis methods. The findings from these analyses were then compared to those derived from an analysis using a framework developed in the led outdoor activity domain.

3. *Workshop on the role of Human Factors in led outdoor activity accidents and incidents*. In order to further disseminate the research findings throughout the Australian led outdoor activity industry and to discuss and identify an appropriate way forward for the overall research program, an industry workshop, organised by the project Steering Committee, was held on 17th September in Melbourne. The workshop was attended by two researchers from MUARC, all members of the project Steering Committee, and selected invitees from the led outdoor activity industry.

1.7 REPORT STRUCTURE

This report presents the findings derived from the research outlined in Section 1.6 above. Chapter 2 presents the findings derived from the literature on led outdoor activity accidents and incidents. Systems-based accident causation models and analysis methods and the exploratory case study are presented in Chapter 3. Lastly, the conclusions to this research, including an overview of the workshop activity and directions for future work in the area, are presented in Chapter 4.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The led outdoor activity industry has expanded significantly over the past three decades, with participation rates now at an all time high. In New Zealand, for example, outdoor adventure pursuits are now a mandated component of the health and physical education school curriculum (Boyes & O'Hare, 2003), and it is estimated that there are in excess of 800 providers involved in the delivery of outdoor education (Davidson, 2004).

Research indicates that serious accidents and incidents are occurring in the led outdoor activity domain (e.g. Davidson, 2004). In addition to the potential injury or loss of life and associated distress for those involved, such incidents can also generate negative publicity and have the potential to be extremely damaging to the sector (Davidson, 2004).

The led outdoor activity industry within Australia currently recognises the need to better understand the nature of accidents and incidents occurring during led outdoor activities, with a view to improving preventative measures and management strategies. As is the case in other safety critical domains, various contributory factors exist. In contrast, however, very little theoretically driven research has been undertaken in the led outdoor activity sector in order to identify these factors and to develop strategies and countermeasures to reduce the incidents that do occur. In this Chapter we present the findings derived from a review of the literature on accidents and incidents in led outdoor activities. The aim of the review was to ascertain what is currently known about such accidents and incidents, to identify the Human Factors issues which have already been implicated, and to identify any gaps in the current approach to investigating and understanding accidents and incidents in the led outdoor activity sector.

2.2 A NOTE ON INCIDENT RATES

It is important to acknowledge that, in the public domain, the exact rate of injuries and deaths resulting from accidents and incidents in the Australian led outdoor activity sector remains largely unknown due to the absence and poor availability of exposure data. In general, exposure data on activity participation levels are needed in order to estimate the rates at which incidents are occurring. Ostensibly, the paucity of exposure data and, in turn, absence of clear information on incident rates, can be attributed to the lack of a standardised, universally accepted accident and incident reporting system and database.

2.3 OUTDOOR ACTIVITY ACCIDENT AND INCIDENT CAUSATION RESEARCH

2.3.1 Accident causation models

Accident and incident causation has received significant attention in most of the safety critical domains in which Human Factors practitioners work, and various models of accident causation now exist (e.g. Hollnagel, 2004; Leveson, 2004; O'Hare, 2000; Perrow, 1999; Rasmussen, 1997; Reason, 1990). The more prominent accident causation models (e.g. Rasmussen, 1997; Reason, 1990) have received significant attention in most safety critical domains; however, the literature indicates that applications of these models in a led outdoor activity context are sparse. Our review did, however, identify a number of accident causation models developed specifically for the outdoor activity sector. An overview of these models is presented in the following section.

2.3.2 Outdoor activity accident causation models

There have been some attempts to develop and apply accident causation models in the outdoor activity sector (e.g. Brackenreg, 1999; Davidson, 2007). Further, a limited number of accident causation models developed in other safety critical domains have been applied in the outdoor activity sector (e.g. Isaac, 1997; Leemon, 2005). Brackenreg (1999) describes the Accident Potential Model (Figure 2-1), which emphasises the interplay between environmental and human dangers and their role in accident causation. The model focuses on the potential for accidents resulting from the interaction between contributory conditions from the environment and from humans. Brackenreg (1999) argues that consideration of these hazards allows accident potential to be estimated, both in terms of likelihood and severity. It is notable; however, that exactly how this estimation is made remains unclear and is not specified.

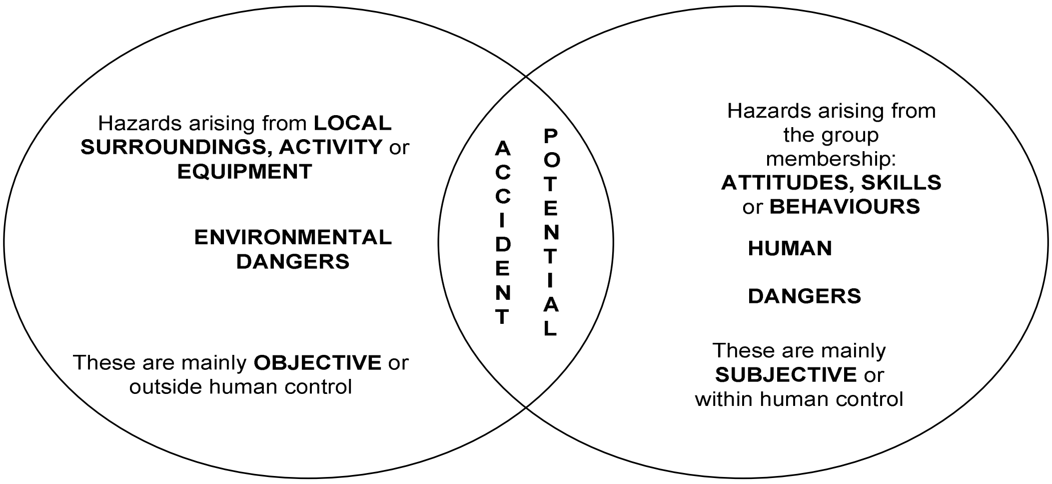

Figure 2-1. The Accident Potential Model (Brackenreg, 1999).

The causal factors highlighted by Brackenreg's model focus on the humans and the environment involved. The environmental factors include the hazards present in the local surroundings, the activity, and the equipment being used. The human-related hazards include those related to the attitudes, skills and behaviours of the humans involved in the activity (e.g. clients and instructors). Whilst these high level categories are useful, it is notable that specific hazards within each group (e.g. local surroundings, activity, and equipment) are not specified.

Meyer (1979; cited in Davidson, 2007) developed a simplistic Venn diagram-based model of accidents in the led outdoor activity sector. This model is illustrated in Figure 2-2. Meyer's model identifies the following three categories of contributory factors: unsafe conditions (environment), unsafe acts (on behalf of clients) and judgement errors (on the part of the instructor). According to Meyer, accidents occur when any two of these contributory factors overlap.

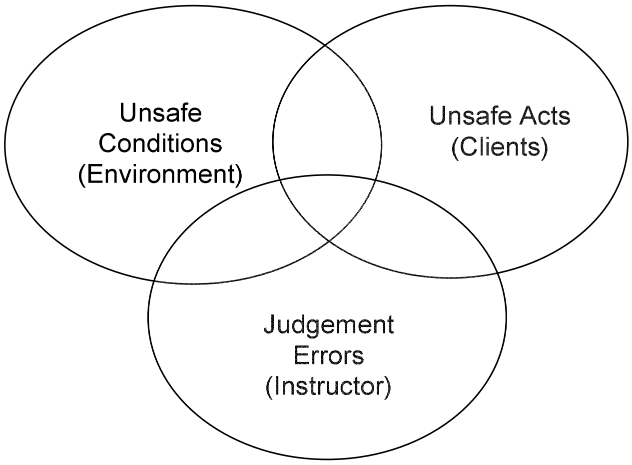

Figure 2-2. Simplification of Meyer's 1979 model, illustrating that an accident occurs when there is an interaction between the contributory factors.

Within the three contributing factor categories, Meyer (1979; cited in Davidson, 2007), and later revised by Williamson (Davidson, 2007), identified a series of specific causal factors. These are presented in Table 2-1.

Table 2-1. Matrix of potential causes of accidents in outdoor pursuits

Potentially unsafe conditions (environment) due to:	**Potentially unsafe acts (clients) due to:**	**Potential errors in judgement (instructor) due to:**
Falling objects (rocks etc)	Inadequate protection	Desire to please others
Inadequate area security (physical, political, cultural)	Inadequate instruction	Trying to adhere to a schedule
Weather	Inadequate supervision	Misperception
Equipment/ clothing	Unsafe speed (fast/ slow)	New or unexpected situation (includes fear and panic)
Swift/ cold water	Inadequate or improper food/ drink/ medications	Fatigue
Animals/ plants	Poor position	Distraction
Physical/ psychological profile of participants and/ or staff	Unauthorised/ improper procedure	Miscommunication
		Disregarding instincts

Meyer's model is therefore useful in that it specifies specific contributory factors within each of the three categories identified. Despite this, the taxonomies presented appear limited. For example, factors such as inexperience, inadequate training and violations are not specified as causal factors in the unsafe acts (clients) and errors in instructor judgement categories. However, these factors play an important role in the errors of clients and instructors in other safety critical domains.

Haddock (1999a) discusses Bird and Germain's (1992; cited in Haddock, 1999a) loss causation model in the context of outdoor activity accidents. Originating from a lack of management control, the model purports that accidents comprise basic causes (e.g. personal or job factors), immediate causes (substandard acts and conditions), the incident itself (contact with energy or substance) and loss (to people, property and process). Similarly, the pathways to change model (Bird & Germain, 1992; cited in Haddock, 1999a) was adapted by Haddock (1999a) for the outdoor activity sector. The model identifies the same five stages of an accident (as the Loss Causation model) but also identifies pathways between each stage where action could be taken to block or mitigate events from culminating in a serious loss (i.e.

modifying systems, changing conditions and blocking events, outcomes and consequences). Thus, Haddock sought to simplify the web-like structure of an accident into a linear model and in so doing, acknowledged that an accident is not purely the result of a single sequence of events but rather, the result of the interaction of multi-linear links between causes. Haddock (1999a) also identifies Albrighton's (1993; cited in Haddock, 1999a) Risk Assessment Model as a tool which has been developed for assessing risk in the outdoors. The model ranks the possibility and seriousness of events in order to produce a risk factor, enabling the significance of an individual event to be estimated.

The literature also reveals a sporadic series of applications within the led outdoor activity domain of prominent accident causation and human error models from other safety critical domains. For example, Leemon (2005) and Isaac (1997) both discuss the utility of Reason's (1990) seminal 'Swiss cheese' model of accident causation and his error classification schemes (e.g. slips, lapses, mistakes and violations) for the analysis of accidents and incidents occurring in the led outdoor activity domain.

In the most recent work in the area, Davidson (2007) developed, based on a program of New Zealand-based research, a root cause model of led outdoor activity accident and incident causation, and an associated error taxonomy for led outdoor activity accidents and incidents. As part of the study, a qualitative analysis of a number of serious incidents, using the Delphi analysis method, was conducted to investigate root causes with a view to developing training strategies for outdoor leaders. The analysis involved the use of a panel of 18 experts (instructors who had been involved in serious incidents) to analyse accident and incident data provided by these instructors. Causal sequences were developed for each of 18 incidents. An average of 13 root causes was found for each incident, and all incidents were found to be caused by a combination of instructor error and management system failures.

The findings were used by Davidson to develop a root cause model of led outdoor activity accident and incident causation. The components of Davidson's model are presented in Figures 2-3 and 2-4 and the associated error taxonomy is presented in Figure 2-5. According to Davidson's model, root causes emerging from poor safety management systems, or poor implementation of safety management systems, can either in themselves lead to instructor errors which cause accidents and incidents, or can lead to the instructors being placed in an unsafe environment, or with unsafe clients, or with unsafe equipment (or combinations of the three), which in turn lead to accidents and incidents. Incidents are classified by Davidson as either error free incidents, where incidents are caused by the inherent risks associated with the activity, or incidents caused by unintentional (i.e. errors) or intentional (i.e. violations) activities.

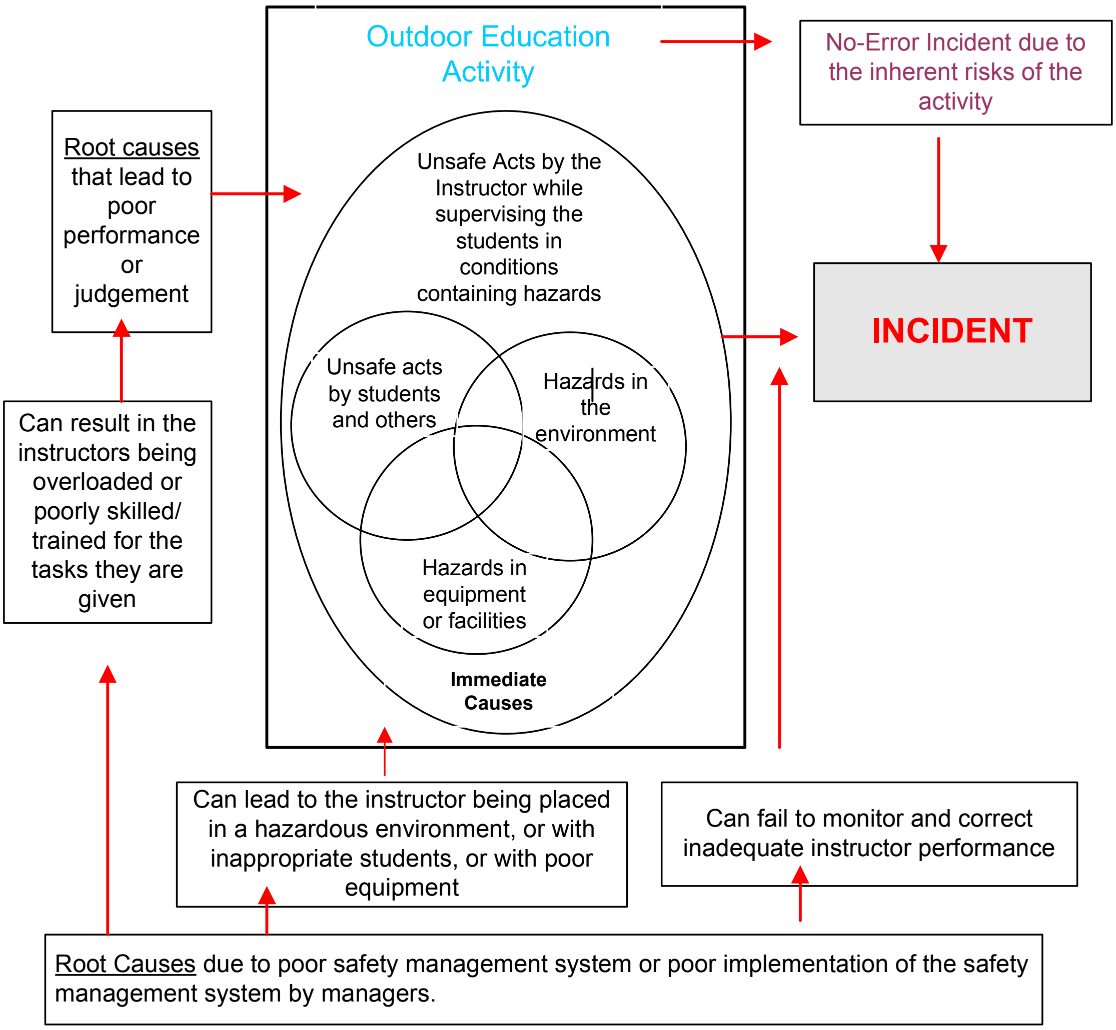

Figure 2-3. Simplified model of incident causation for outdoor education (adapted from Davidson, 2007).

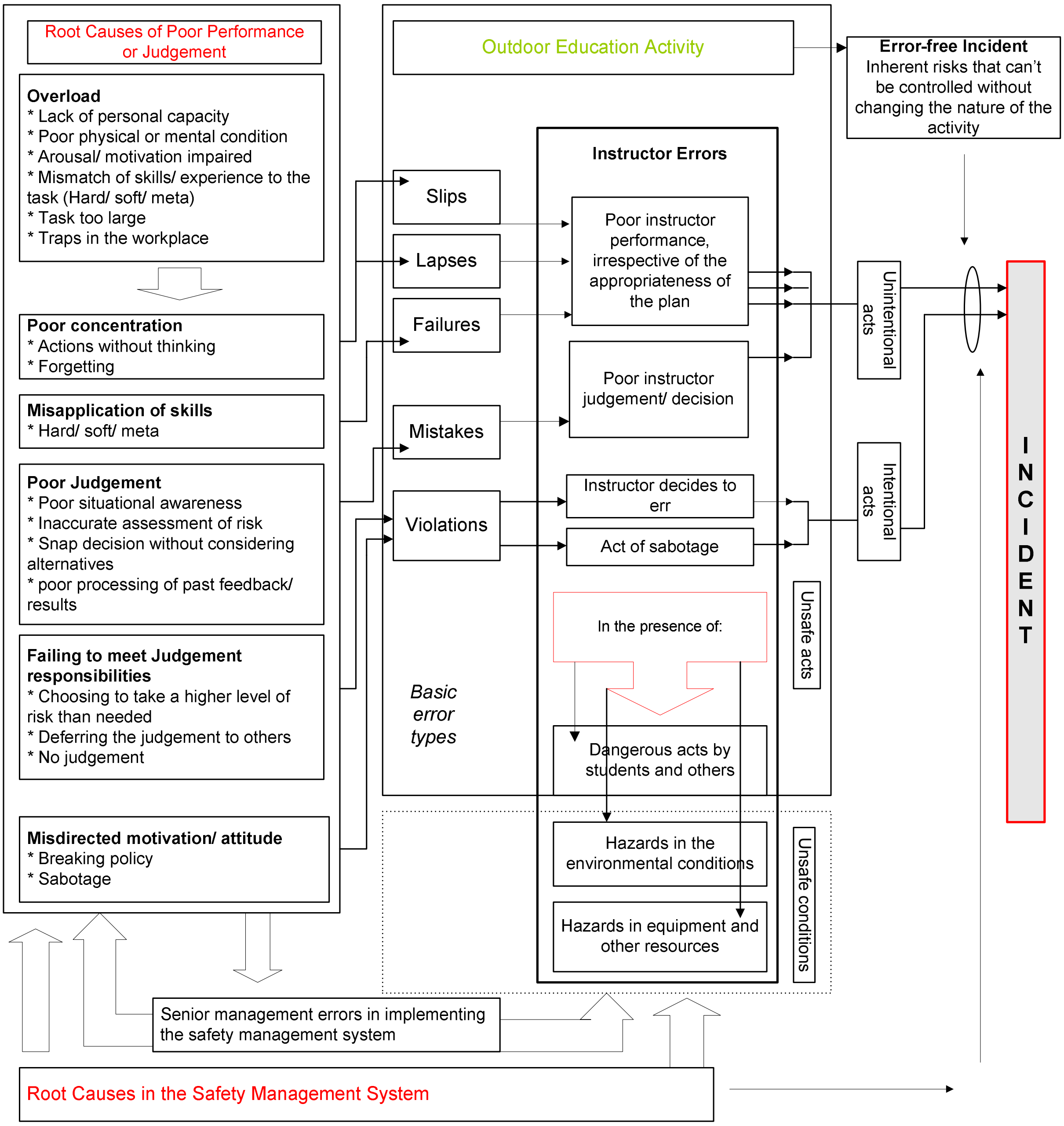

Figure 2-4. Model of outdoor education incident causation (adapted from Davidson, 2007).

Davidson's model goes further than others by presenting a detailed taxonomy of root causes for instructor errors. These include causal factors related to overload, poor concentration, misapplication of skills, poor judgement, failing to meet judgement responsibilities, and misdirected motivation/attitude. The model also draws upon human error models developed in other domains, such as Reason's (1990) basic error types taxonomy to specify the range of error types (e.g. slips, lapses, mistakes and violations) that operators make as a result of the root causes identified.

The model presented by Davidson (2007) represents the most comprehensive attempt to delineate, in detail, the causal Human Factors involved in led outdoor activity incidents. It is useful in that it specifies, in some detail, a range of root causes that can lead to instructors making errors, which in turn can lead to accidents and incidents. In addition to the human-related root causes (overload, poor concentration, poor judgement etc), the model also acknowledges the role of management system failures in operator error and accident and incident causation.

On the other hand, the model has a number of significant limitations. Many in the area of accident causation research have highlighted various problems associated with Root Cause Models (e.g. Hollnagel, 2004; Reason, 2004). It is notable that the model is based on only a limited set of accident and incident data (i.e. reports from only 18 instructors and from within New Zealand only), and that further validation is required through additional accident and incident data analysis that use the model. As a corollary of the limited data set underpinning the model, the current root cause taxonomy appears constrained (although it is far more comprehensive than any others presented for the led outdoor activity domain). The absence of detailed taxonomies of failures at the higher managerial system levels is also problematic, although the acknowledgement of the role of managerial systems in accidents and incidents is an important development. There is also no link between managerial failures and the root causes identified, which means that countermeasures cannot be developed for treating higher management failures. Reason (1997) and Dekker (2002), for example, discuss the problem of proposing human focused countermeasures that ignore the wider systemic failures involved. In addition, although utilising human error theory in some parts, the model appears to lack a sound theoretical underpinning. For example, the term 'situation awareness' is used as a root cause factor, and yet much of the literature on situation awareness-related errors (e.g. Jones & Endsley, 1996), appears to have been ignored

Root causes leading to poor performance or judgement

Over load

1. Lack of Personal Capacity
 a. Physical
 b. Mental
2. Poor Physical of Mental Condition
 a. Injury
 b. Sickness
 c. Physical fatigue
 d. Mental fatigue
3. Arousal/ Motivation Impaired
 a. Drugs/ alcohol
 b. Biorhythmic
 c. Menstrual
 d. Bored
4. Mismatch of Skills/ Experience to Task
 a. Local knowledge
 b. Hard skills
 c. Soft skills
 d. Meta skills
5. Task too Large
 a. Hours per day too great
 b. Days without break too great
6. Traps in Work Environment
 a. Equipment traps
 b. Environment traps
 c. Student traps

Poor Concentration

7. Actions without thinking
8. Forgetting

Misapplication of Skills

9. Misapplication of Skills
 a. Hard skills
 b. Soft skills
 c. Meta skills

Poor Judgement

10. Poor Situational Awareness
 a. Availability
 b. Selective perception
 c. Selective focus
 d. Frequency desensitivity
 e. End of session
 f. Transferred responsibility
 g. Concrete information
11. Inaccurate Assessment of the Risk
 a. Inconsistency
 b. Failure to review
 c. No-risk perception
 d. Perceived as unlikely to happen
 e. Justifying away the risk
 f. Sunny day syndrome
 g. Negative event feedback
 h. Illusion of control
 i. Wishful thinking
 j. Risk homeostasis
12. Snap Decision Without Considering Options
 a. Habits/ rules of thumb
 b. First impressions
13. Poor Processing of Past Experiences
 a. No-accident errors
 b. It must go right next time
 c. Success/ failure attribution
 d. Rebuilding of events
 e. Hindsight bias

Failing to Meet Judgement Responsibilities

14. Choosing to take a Higher Level of Risk than Needed
 a. Physical comfort/ ease
 b. Mental ease
 c. Emotion comfort/ ease
 d. Personal ego needs
 e. Others' needs/ values
 f. Personal goals/ values
 g. Perceived goals of management
 h. Pressured by time/ conditions
 i. Risky shift
 j. Illusions of
 k. Natural risk taker
 l. Gender and other social interactions
15. Deferring Judgement to Others
16. No Judgement Made

Misdirected Motivation/ Attitudes

17. Breaks Organisational Policies
18. Sabotage

Figure 2-5. Taxonomy of error for the outdoor education sector (adapted from Davidson, 2007).

In addition to research focussing on entire accident causation sequences, a significant proportion of research in the area has focussed on specific problematic issues in isolation. Risk management, for example, has been identified as having a key role to play in safety management (Ajango, 2005; Boyes & O'Hare, 2003; Cline, 2007; Hunter, 2007; Powell, 2007). Similarly, risk perception on behalf of activity instructors has also been identified as a key factor (e.g. Powell, 2007). Situation awareness (e.g. Endsley, 1995; Salmon et al, 2008), the concept that focuses on how humans and systems develop and maintain sufficient levels of awareness of 'what is going on' in order to perform optimally has also been discussed (e.g. Boyes & O'Hare, 2003; Davidson, 2007). Supervision, the "co-ordination by someone taking responsibility for the work of others including planning, scheduling, allocating, instructing and monitoring actions" (Mintzberg, 1979), has also received attention (e.g. Davidson, 2004). Similarly, leadership, which is defined as "the ability to direct and co-ordinate the activities of other members, assess team performance, assign tasks, motivate team members, plan and organise actions, and establish a positive atmosphere" (Cannon-Bowers et al, 1995, p. 345), has also been discussed (Boyes & O'Hare, 2003). Related to the concept of leadership is that of instructor qualification, which has received a substantial amount of attention, with the issue of certification standardisation (or lack thereof) within led outdoor education being a controversial one (Crosby & Benseman, 2003). Naturalistic decision making (Klein, 2008), the term given to the way in which experienced people in dynamic, uncertain and fast-paced environments assess situations, make decisions, and take actions (Zsambok, 1997), has also been studied as a key factor. Finally, complacency and fatigue have also been identified as key issues in the led outdoor activity context (e.g. Haddock, 1999a; Hunter, 2007).

As evidenced by the literature review findings, research in the area to date has identified a number of key Human Factors issues purported to be involved in outdoor led activity accidents and incidents. A number of these are concepts that have been researched in the past extensively in their own right as well as having been applied to many other safety critical domains. They have been applied using appropriate theoretical frameworks which have enabled them to be explored as contributory factors; how they contribute, to what extent and how they interact with others and in what ways. Because the outdoor sector has yet to embrace an appropriate theoretical model, these Human Factors have surfaced from the literature as 'terms' that may potentially be involved in some way. Without an appropriate model, there is no way of knowing how these factors are involved or to what extent and in what circumstances. The extent to which the factors are mutually exclusive is also unknown, as is the nature of the relationships between them. The issues discussed above are therefore neither exhaustive nor do they represent a cohesive portfolio of the Human Factors involved in led outdoor activity accidents; the issues discussed above are merely a listing of those that have been raised in the literature.

2.4 INCIDENT REPORTING SCHEMES AND ACCIDENT AND INCIDENT DATABASES

2.4.1 On the need for effective incident reporting accident and incident databases

Incident reporting schemes and accident and incident databases are widely accepted approaches used in most safety critical domains to enhance our understanding of the nature of, and causal factors involved in, safety compromising accidents and incidents.

2.4.1.1 Near miss incident reporting systems

Incident reporting systems are used to collect data regarding near miss incidents, errors, safety compromising incidents, and safety concerns within safety critical systems. They are now common in most safety critical domains, including aviation (e.g. Aviation Safety Reporting System), healthcare (e.g. MedWatch) and nuclear power (e.g. MARS). These systems work on the premise that near miss incidents are indicators of accidents waiting to happen, and so preventative measures can be taken before large-scale or costly accidents occur. Near misses represent those hazardous situations, events or unsafe acts that occur where the sequence of events could have caused an accident if it had not been interrupted (Jones, Kirchsteiger & Bjerke, 1999). The importance of reporting near miss data has been articulated by many (e.g. Reason, 1997; Jones et al, 1999; Koorneef, 2000; cited in Ternov et al, 2004; Van Der Schaaf, 1995) and it is a well established method of improving safety in complex socio-technical systems (Koorneef, 2000; cited in Ternov et al, 2004). So long as they are analysed correctly, and the appropriate conclusions are drawn and acted upon, near misses mobilise a system's defences against more serious future occurrences (Reason, 1997). They also provide a powerful reminder of the hazards present within a particular system. The utility of reporting near miss incidents lies in their capacity to generate large amounts of data that would otherwise go unreported. Further, the data obtained is useful as it can be used to identify error causing conditions, errors and their consequences, and potential recovery strategies for errors made in the future. On the other hand, workers may be reluctant to report error-related incidents for a number of reasons including fear of reprisals and/or scepticism. Finally, the validity of incident descriptions is often problematic, and there is typically a high cost associated with database operation.

The importance of reporting and analysing near miss incidents has also been discussed in the context of the outdoor activity sector. Brackenreg (1999), for example, discusses the accident ratio triangle theory, illustrated in Figure 2-6, which proposes that for every major injury there are a large number of minor injuries and a correspondingly larger number of near miss incidents. He argues that the proportionally larger number of near misses means that significant lessons can be learned without anyone having suffered any injury. Haddock (1999) also uses the pyramid analogy to describe the degree of severity and frequency of occurrence of normal operation through to a disaster in the outdoor activity sector. Davidson (2004) discussed a study of industrial accidents undertaken in the United States (US) by Bird and Germaine (1969; cited in Davidson, 2004) that revealed a ratio to represent the severity of reported incidences: for every 1 serious or major injury, there are 10 minor injuries, 30 property damage accidents and 600 incidents with no visible injury or damage. Although often misinterpreted, the ratio was intended to indicate that accidents are the culmination of a number of factors coming together to produce an accident potential.

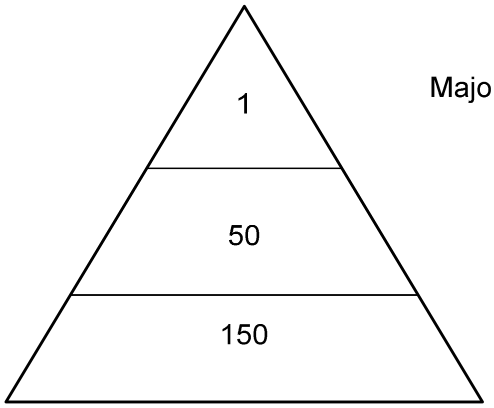

Figure 2-6. The Accident ratio triangle (Brackenreg, 1999).

The need for near miss reporting systems within the led outdoor activity domain is well recognised (e.g. Brackenreg, 1999; Davidson, 2004); however, to date there is no evidence of such schemes being implemented within the Australian led outdoor activity sector.

2.4.1.2 Accident and incident databases

Like databases of near miss reporting, the utility of accident and incident databases is also well accepted across the safety critical domains. A database containing the information surrounding accidents and incidents that have occurred within a particular system, along with their associated causal factors and consequences, can be an extremely powerful resource and can be used for a number of purposes including in-depth studies, the identification of different error trends, the development of domain-specific taxonomies of error, quantitative error analysis, and to inform the development of error countermeasures. Most safety-critical systems have an accident or error database of some form. For example, the Computerised Operator Reliability and Error Database (CORE-DATA; Basra & Kirwan, 1998) is a database of human or operator errors that have occurred within the nuclear, chemical and offshore oil domains. CORE-DATA contains over four hundred records describing errors and their associated causes, error mechanisms and probability of occurrence.

The need for appropriate accident and incident databases for analysing, learning from, and ultimately preventing accidents and incidents is well recognised within the led outdoor activity sector (e.g. Davidson, 2004; Ajango, 2005). Curtis (2009) who initiated the International Database Design Project (discussed in more detail in Section 2.4.2.1), explains that risk managers understand the need to track close calls and accidents in their programs, and that only by identifying what is actually occurring in the field can managers respond to situations and improve protocols. He goes on to point out that the current state of the outdoor education industry is fragmented in the lack of consistency across data collection means (www.incidentdatabase.org/design/Rationale.aspx). Curtis (2009) argues that building a common database will provide programs with a powerful tool for recording and analysing their own in-house data. At the same time, it would mean that measurements generated by one program could be compared against another in a meaningful way using an international standard. Additionally, it creates the possibility for more extensive research into the causes and responses to incidents, which would benefit the entire outdoor education industry (www.incidentdatabase.org).

Davidson (2004) argues that a database should be designed and used in such a way that they collect the same information from all sources. This implies that a national template for incident reporting should be created. He suggested that the Wilderness Risk Management Committee Incident Reporting Project (described below) could provide the basis for such a system. He argues that each incident should also be reported for potential severity by the organisation, and that the annual trends from the database should be distributed throughout the outdoor education community to provide learning points to improve risk management practices. Davidson (2004) also suggests that incident rate data could also be used in a positive media campaign for the outdoor education sector, highlighting the positive aspects of the experience and dispelling ideas that participation is unduly dangerous.

Haddock (1999b) discusses the need to develop an honest and open incident reporting culture within the outdoor activity domain, to encourage and support a successful and thorough reporting process. Davidson (2004) also argues that there is currently no ‘culture’ within the outdoor education sector in New Zealand of sharing information about mistakes. Davidson suggests that when accidents occur, there is a tendency to “close ranks, keep heads down, investigate the accident internally, and do what can be done within the organisation to prevent similar incidents occurring in the future” (p.15). Organisations try to contain knowledge of any accident to avoid publicity, investigation by outside authorities and possible legal action. Not only are there legislative and punitive issues to avoid in keeping a low profile when an accident occurs, there are the more subtle negative marketing issues. Competition for clients among organisations is widespread, and within that competitive environment, no organisation wants to concede an edge to other organisations by disclosing unsafe practices (Davidson, 2004).

Brookes (2007) raises the issue that fatal incidents are rare and argues that the study of fatal incidents can help those who work in the field to learn to recognise the kinds of circumstances that contribute to those rare fatal accidents that do occur. He also raises the issue that very few fatal incidents in the outdoors involve recklessness or ill-intent. He stresses that it can be too easy to see ‘if only’ factors that would have apparently prevented the incident, and to be tempted to distribute blame. Rather, he argues that those involved should focus attention on lessons learned for the future. Brookes (2003) goes on to argue that compiling incidents and the contexts in which they occur provides a ‘set’ of fatalities to learn lessons from and that ‘freak’ events may be seen to fit patterns only evident from this wider perspective. Experience and common sense alone will not prevent all fatalities. Cline (2004) discusses the concept of “error management” (Reason, 1997) that is based not on the premise that people making decisions *might* make errors (mistakes) but that they *will* make errors. This then raises the importance of highlighting, rather than hiding, the errors made.

The difficulties facing the outdoor industry in setting up a standardised accident and incident database are apparent. In the study undertaken by Davidson (2004), each of the 12 participating organisations were described as having their own unique approach for collecting and recording incident data. Additionally, incident forms were completed by the instructor who was in charge of the group at the time of the incident, with seemingly little quality control over the standard of completion by a person in management. This manifested itself as incomplete information on the forms, scant detail in narratives, and the near illegibility of some forms. The variety of incident forms and incomplete nature of many of the completed forms led to a limited amount of data that could be recorded in common across all incidents.

2.4.2 Existing accident and incident databases

There are a number of accident and incident databases currently used both Nationally and Internationally, each with the overall goal of creating a systematic and consistent way of reporting incidents and using the resultant information to learn from accidents and incidents and improve safety/reduce the number of incidents in the sector. An overview of the accident and incident databases identified by our literature review is presented below.

2.4.2.1 International Incident Database Project

The International Incident Database Project is a project headed by the International Incident Database Working Group, an international consortium of program and risk managers in the outdoor education field. It was initiated in 2002 after discussion with program managers from many countries at the 2002 Wilderness Risk Management Conference in the US and the Risk 2002 Conference in New Zealand, the goal being to define an international standard for collecting incident data for outdoor and adventure based programs. Having a common standard, it is argued, would allow the industry to communicate across programs about incident types in ways that would enhance the programs. The Project seeks to:

- define the key data elements that are essential to capture for incidents;
- create a database structure that is both flexible and comprehensive to handle a wide range of program types and countries; and
- build a model database that will allow programs to store their own incident data and to make this available in a collated, summarised format.

The database covers 38 outdoor activity types (with no 'other' category), including 'transportation' related incidents or near misses.

In order to facilitate discussion and collaboration, the project website was built as an application model for the outdoor education community to demonstrate a number of key technology pieces related to collecting and analysing incident data, including database design, web-based submission, browsing aggregate data and data analysis (www.incidentdatabase.org).

2.4.2.2 The National Incident Database Project

The National Incident Database Project was initiated by the New Zealand Mountain Safety Council (MSC) after discussions arising from the Risk 2002 Conference. The Project is a joint effort between New Zealand Mountain Safety Council, Outdoors New Zealand, Education Outdoors New Zealand and the Ministry of Education. The online database is designed for use by those involved in outdoor activities. The project aims to:

- provide a single incident reporting platform for the outdoor sector, using a standard method for the collection and comparison of data from a variety of sources;
- provide timely and accurate incident data to varying government agencies to assist in developing emerging practices and ensure safety advice is current and reflects actual participant behaviour in New Zealand conditions; and
- work towards developing an international standard to integrate program data from around the world.

Like the International Incident Database, the incident form for the National Incident Database covers 38 outdoor activity types (with an 'other' option), including transportation related incidents and near misses. A number of these 38 activities are unique to the respective databases: for example the NZ database includes abseiling, bungy jumping and cooking that the International database excludes. The International database includes running, rappelling and sportyak, which the NZ database does not.

Since the database was launched in May 2004, over 15,745 incidents have been reported. Individuals and organisations voluntarily and anonymously report incidents, near misses, injuries and fatalities. Incident data can then be analysed to identify trends and increase understanding about the common risks and causal factors. A driving principle behind the project is to encourage a culture of safety in New Zealand, where participants are willing to share information, learn from experiences and manage risks. The scope of the database was made deliberately wide to cater to all forms of participation. The type of data collected includes what occurred, when it occurred, the type of injury, communications used, weather conditions and the number of persons involved and the nature of their injury. Users are also asked to rate the severity of the incident on a scale of 1 to 10 (www.incidentreport.org.nz).

2.4.2.3 The Wilderness Risk Managers Committee Incident Reporting Project

Established in 1992, The Wilderness Risk Managers Committee and Association for Experiential Education Incident Reporting Project is a consortium of outdoor schools and organisations in the United States that work towards a better understanding and management of risks in the outdoors. Among other activities, the Committee collects incident data from members, who voluntarily submit data. Incidents are reported using a standardised form, and there are specific criteria to determine what a reportable incident is. The Project is sponsored by NOLS (National Outdoor Leadership School) and AEE (Association for Experiential Education). A total of 65 organisations have submitted incident data amounting to 1195 incident records. This database covers 32 activity types (with an 'other' option), including transportation related incidents and near misses.

Recently (early 2009) the Project was terminated due to the need for a system upgrade and modernisation as well as a lack of technical expertise and resource availability. The Wilderness Risk Manager's Committee has also disbanded, leaving the project with no management. AEE are currently considering how a similar project can be initiated and are waiting on the roll out of the International Incident Database Project.

2.4.2.4 The Outdoor Medical Incident Database

Based in Australia, the Outdoor Medical Incident Database (OMID) is another computer-based incident management system designed to help organisations manage risk. It can identify areas of potential risk and point to causes of incidents, as well as keep a record of incidents for future reference. It has been successfully used by Outward Bound Australia (OBA) for the past 3 years to actively reduce the number of medical incidents within the organisation. This reduction was accomplished through careful analysis of incident patterns and the implementation of changes in policies and practices. Haddad (2006) explains that "Ten years ago OBA staff were reluctant to report accidents and incidents, fearing that it would reflect on their abilities. By implementing OMID and using its information to target ways of reducing incidents staff gain the opportunity to learn from a variety of incidents. This active learning culture is an important part of an effective risk management strategy". Haddad goes on to say that using OMID certainly requires expending additional time and effort to enter and analyse data, but if incidents can be reduced, then that time is spent well. Not only are participants safer, but there are fewer incidents to manage and less time lost from programs (www.outward-bound.org/docs/safety/OMID.htm).

2.4.2.5 The National Accident Incidence Report Form Database

The National Accident Incidence Report Form Database (NAIRFD) is a voluntary reporting Australian database that assists organisations in the review of their operations. The initial evaluation of the database showed 603 individual incidents that occurred in outdoor education programs throughout Australia from June 1995 to August 1999 (Dickson, Chapman & Hurrell, 2000).

2.4.2.6 The Australian Accident Register

The Australian Accident Register (AAR) contains a list of accidents (including near misses) that have occurred in the outdoor and adventure environment throughout Australia. It was established (as a non-profit organisation) as a readily accessible learning tool for adventurers. Until April 2006 the site only covered the Blue Mountains region of NSW, but has since expanded in scope to cover the whole country (www.accidentregister.info). In terms of activity type, the incident form specifies abseiling (dry/non canyon), canyoning (wet or dry/with or without abseils) and rock climbing, followed by an 'other' category.

2.4.2.7 Other database examples

Further examples of incident databases used by led outdoor programs include that of Australian Canoeing, which maintains an incident database for all incidents and accidents that resulted in injury or had the potential to result in injury (Australian Canoeing, 2008). Similarly, Outward Bound schools record all safety incidents including injuries, illnesses, near misses, client drop outs and incident associated activities (Paton, 1992). The YMCA Adventure Camp Widjiwagan in Minnesota has employed paper based documentation of incidents in the past. A project was conducted, the goal of which was to create a database for the camp and to use it to identify those clients most at risk. The findings highlighted the usefulness of a data collection and electronic storage system and accident analysis methods in understanding the risks posed to the campers and staff (www.wemjournal.org).

A summary of the incident databases discussed is presented in Table 2-2.

Table 2-2 Current incident databases

Database	Country of origin	Summary	Good	Bad
International Incident Database Project	USA	▪ Headed by a working group- an international consortium of program and risk managers in the outdoor education field, initiated by Rick Curtis (of OutdoorEd.com and OutdoorSafety.org). ▪ Aims to define an international standard for collecting incident data for outdoor and adventure based programs ▪ Define key elements essential to incidents ▪ Create a common, accessible database to integrate data from around the world ▪ Project website built as an application model for the outdoor education community-to demonstrate aspects of the collection and analysis process ▪ 38 activity types	▪ Web based ▪ Voluntary ▪ Anonymous ▪ Includes close calls ▪ Can browse and analyse aggregate data and compare records with others ▪ Attempt to create an international standard ▪ Includes a narrative and recommendation section	▪ Selection of provided contributory factors ▪ Lack of wider/system related information ▪ Same form/process for incidents and close calls ▪ Specifies the collection of 'outdoor adventure/ activity programs'-so may be specific to led but eliminates other data of potential value ▪ Minimal information about the leader
National Incident Database	New Zealand	▪ NZ Mountain Safety Council, Outdoors NZ, Education Outdoors NZ and the Ministry of Ed ▪ Online incident data collection and analysis tool using a standard method ▪ Launched in 2004, now contains over 15 745 incidents ▪ Works towards creating an international standard to integrate data from around the world ▪ Identify trends, increase understanding about risks and causal factors ▪ Voluntary and anonymous with growing support ▪ 38 activity types	▪ Web based ▪ Voluntary ▪ Anonymous ▪ Includes near misses ▪ Wide scope to gather more data- all outdoor activity/adventure incidents/near misses ▪Comparison/summary and presentation of data/ findings ▪ Attempt to create a national/potentially international standard ▪ Includes a narrative and recommendation section	▪ Selection of *provided* 'causal' factors ▪ Lack of wider/system related information ▪ Same form/process for incidents and close calls ▪ Minimal information about the leader

Table 2-2 (cont'd) Current incident databases

Database	Country of origin	Summary	Good	Bad
Wilderness Risk Mangers Committee/ Association for Experiential Education Incident Reporting Project	USA	▪ Consortium of outdoor schools and organisations ▪ Collection and management of incident data with the aim of better understanding risk ▪ Sponsored by NOLS- recently concluded (2009) because the systems needs upgrading and the expertise and resources needed are now unavailable available ▪ Over 65 organisations submitted incident data amounting to 1195 incident records ▪ 32 activity types	▪ Web based- unknown ▪ Voluntary ▪ Anonymous ▪ Includes near miss ▪ Accompanying instruction sheet ▪ Data published in periodic reports ▪ Includes a narrative and recommendation section	▪ Ranking of provided contributory factors ▪ Large emphasis on type/ location of illness or injury and lack of wider/system related information ▪ Nothing about the activity leader ▪ Same form/process for incidents and close calls
Australian Accident Register (AAR)	Australia	▪ List of accidents including near misses that have occurred in the outdoor and adventure environment ▪ Now covers all of Australia, voluntary ▪ Established as a readily accessible learning tool ▪ Includes Abseiling, canyoning, rock climbing and 'other'	▪ Web-based ▪ Voluntary ▪ Anonymous ▪ Includes near miss ▪ Downloadable reports/lists ▪ No fixed contributory factor categories ▪ Includes a narrative and recommendation section	▪ Comparatively brief reporting form ▪ Lack of wider/system related information ▪ Nothing about the leader ▪ Same form/process for incidents and close calls
National Accident Incidence Report Form Database (NAIRF)	Australia	▪ Voluntary reporting database to assist organisations in the review of their operations		
Outdoor Medical Incident Database (OMID)	Australia	▪ Incident recording and management system designed to help organisations manage risk ▪ Has been used successfully by Outward Bound Australia for the past 3 years		

While it is acknowledged that the list presented in Table 2-2 is not an exhaustive one, it outlines several databases that are currently in use, including several within Australia. Although these databases do exist, they have a number of limitations, which, when compared to those that are well established in other domains (e.g. the National Transportation Safety Board and Aviation Safety Reporting System databases) make those in the outdoor activity domain appear far less comprehensive and detailed. Furthermore, they tend to highlight the persons-based focus that currently predominates in the sector, and may perpetuate the failure to consider the critical wider context in the led outdoor activity domain.

2.5 DISCUSSION

2.5.1 What is currently known?

The aim of this research was to identify the Human Factors-related causal factors involved in led outdoor activity accidents and incidents. The review of the literature has identified several recurring causal factors referenced by research in the area. A summary of the causal factors identified from the review, along with their associated source references, is presented in Table 2.3. As evidenced by Table 2.3, the research undertaken in the area suggests that there are a range of wider systemic and instructor/client-related causal factors involved. It is notable, however, that the relationship between these factors remains unknown and that a universally accepted model of outdoor activity accident causation or taxonomy of causal factors is yet to emerge. For example, the extent to which poor situation awareness, risk perception, and judgement are mutually exclusive is doubtful; however, no empirical research has been conducted to explore the relationships between factors. Further, the linkage between the issues identified, in terms of cause-effect relationships, has been minimal. It is also apparent that the majority of causal factors identified are instructor-based, focussing on instructor causal factors and errors as the main cause of accidents and incidents. The role of wider systems failures (which are now accepted as key causal factors in accidents and incidents) has, to a large extent, been ignored.

Table 2-3 Key human factors issues identified in the literature.

Wider systems factors	Instructor/client factors	Source
Hazards in the local surroundings		Brackenreg (1999)
Hazards associated with the activity		Brackenreg (1999)
Hazards associated with the equipment being used		Brackenreg (1999)
	Hazards arising from instructor and client attitudes, skills and behaviours	Brackenreg (1999)
Environmental conditions (e.g. falling rocks, weather, inadequate security, equipment, clothing)		Meyer (1979; cited in Davidson, 2004)
	Client unsafe acts (e.g. inadequate protection, instruction and supervision, unauthorised procedure)	Meyer (1979; cited in Davidson, 2004)
	Judgement errors on behalf of the instructor	Meyer (1979; cited in Davidson, 2004)
Poor safety management system		Davidson (2004)
Poor implementation of safety management system		Davidson (2004)
	Poorly skilled/trained instructors	Davidson (2004)
	Overload (due to lack of capacity, poor physical/mental condition, impaired arousal/motivation, mismatch of skills/experience to task, tasks too large, traps in the work environment etc.	Davidson (2004)
	Poor concentration	Davidson (2007)
	Misapplication of skills	Davidson (2007)
	Poor judgement	Davidson (2007)
	Failing to meet judgement responsibilities	Davidson (2007)
	Risk management	Boyes & O'Hare (2003), Hogan (2002), American Camp Association, Capps (2007), Wilks & Davis (2000), Brown (1995), Davidson (2007), Brookes (2003), Powell (2007), Cline (2007), Hunter (2007), Harper & Robinson, 2005).
	Failure to record near misses	Brackenreg (1999), Capps (2007), Brookes (2003), Watters (1996), Davidson (2007), Haddock (1999).
	Risk perception	Dallat (2007), Dickson, et al (2000), Powell (2007), Brown (1995), Cline (2007).
	Leadership	Boyes & O'Hare (2003), Galloway (2002), Harper & Robinson (2005), Brookes (2003), Wilks & Davis (2000), Brown (1995), Davidson (2004).
	Instructor qualification	Crosby & Bensemen (2003), Wilks & Davis (2000), Brookes (2003).
	Level of participant supervision	Davidson (2004; 2004), Brookes (2003).
	Decision making	Ewert et al (2006), Boyes & O'Hare (2003), Watters (1996), Galloway (2002), Wickens & Hollands (2000).
	Situation awareness	Boyes & O'Hare (2003), Galloway (2002).
	Complacency and Fatigue	Hunter (2007), Haddock (1999), Davidson (2007), American Camp Association.

The literature review indicates that, compared to other domains in which accidents have been identified as a significant problem, the research into accidents and incidents in the field of outdoor activity and education is still in its infancy. The review did identify a number of accident and incident causation models either developed specifically for the led outdoor activity domain, or developed in other domains and applied in a led outdoor activity context; however, it is apparent that these models are limited in scope and application and lack sound theoretical underpinning. For example, the most evident flaws relate to the lack of a systemic viewpoint of failure and accident and incident causation. Although some of the models presented do highlight the role of systemic failures other than human instructor failures, such as environmental conditions, equipment, and managerial failures, it is notable that most, including the most detailed model (i.e. Davidson, 2007) do not provide taxonomies of the wider systemic contributory factors. Also notable is the fact that applications of the most prominent accident causation models and methods from other domains (e.g. Rasmussen, 1997; Reason, 1990) have to date been sparse in the outdoor activity context.

The failure of the models presented to adequately describe the wider systemic causal factors involved in accidents and incidents is one that has been traditionally common in most safety critical systems, but that has now been rectified in most areas. Reason (2000), for example, describes the two distinct schools of thought concerning error and accident causation, namely the person and system perspective approaches (Reason, 2000), or as Dekker (2002) asserts, the old and new views.

The person approach focuses upon the errors that operators make at the ‘sharp-end’ of system operation (Reason, 2000). Errors are seen to emerge from psychological factors in individuals such as aberrant mental processes, including forgetfulness, inattention, poor motivation, carelessness, negligence, and recklessness (Reason, 2000). Early human error models were person-based including Norman’s schema activation error model (Norman, 1981), Reasons Generic Error Modelling System (GEMS; Reason, 1990) and Rasmussen’s model of human malfunction (Rasmussen, 1982). Person approach-based research typically attempts to identify the nature and frequency of the errors made by operators within complex systems, the ultimate aim being to propose individual operator-focussed strategies, remedial measures and countermeasures designed to reduce variability in human behaviour. Whilst it is worthwhile for these reasons, it is often criticised for its contribution to individualistic blame cultures within organisations (Reason, 1997, 2000) and the fact that, person approach-based error countermeasures (e.g. poster campaigns, procedures, disciplinary measures, threat of litigation, retraining and naming, blaming and shaming, Reason, 2000), are ultimately focussed upon reducing the variability in human behaviour rather than the inadequate conditions present in the system itself. Despite its failings, the person approach still remains dominant in a number of domains, including road transport (Salmon, Regan & Johnston, 2007).

Systems perspective approaches, on the other hand, treat error as a systems failure, rather than solely an individual operator’s failure, and consider the presence of latent or error-causing conditions and their role in the errors made at the sharp-end by operators. Unlike the person approach, human error is no longer seen as the primary cause of accidents, rather it is treated as a consequence of the latent failures residing within the system. First entertained by Chapanis in the 1940s (1949; cited in Stanton & Baber, 2002), who, in conclusion to an analysis of incidents in which pilots failed to lower the landing gear, found that pilots were instead erroneously adjusting the flaps. Chapanis concluded that ‘pilot error’ was actually ‘designer error’, since the landing gear and flap controls were identical and were located adjacent to one another. The systems approach began to gain further credence during the

1980s as a result of a series of catastrophes in which managerial failures were identified as causal factors, such as the Challenger, Piper Alpha, Hillsborough and Narita catastrophes (Johnson, 1999). The systems approach is now the dominant approach to error and error management in most safety critical domains.

Our review of the literature, indicates then, that the approach to understanding accident and incident causation within the led outdoor activity domain, has, to a large extent, been person-based, focussing on the instructor or activity leader as the main causal factor in accidents and incidents. A number of the models presented do consider wider systemic causal factors (e.g. Davidson, 2004), however, a lack of specific details is apparent. The development of systems-based accident and incident reporting, storage and data analysis procedures is critical for a detailed understanding of the causal factors in led outdoor activity accidents and incidents.

2.5.2 What data exists?

The literature review also identified a number of National and International databases containing data regarding outdoor activity accidents and incidents. The importance of such databases in the analysis and future prevention of accidents and incidents within the led outdoor activity domain was emphasised, and it is widely recognised by those working in the area that National accident databases are required (e.g. Brackenreg, 1999; Davidson, 2004; Haddock, 1999a). Three such databases were identified within Australia, and it was noted that these are voluntary, and that standardised incident reporting, storage and analysis procedures are not currently present.

The collection and analysis of near miss incident data was also highlighted as a key commodity in the future prevention of accidents and incidents within the led outdoor activity domain. Widely accepted as a means for learning from, and preventing, accidents and incidents in most safety critical domains, near miss incident reporting and analysis systems have also been identified by many in the area as key to the prevention of future accidents and incidents (e.g. Brackenreg, 1999; Davidson, 2004; Haddock, 1999).

2.5.3 What is the way forward?

Davidson’s (2007) work is the most recent and comprehensive attempt to explore the causes of accidents and incidents in the led outdoor activity sector. While it acknowledges the complexity of the problem, it remains inadequate in coping with the entirety of factors involved. Although the root cause model acknowledges the failures of safety management systems, it is still very much persons-based, with the emphasis placed on the role of individual instructors in accident and incident causation. It is also unclear as to how his model can be applied in the analysis of incidents, therefore lacking practicality.

It is clear that the led outdoor activity domain’s current understanding of accident and incident causation is limited. This is mainly down to four key issues. Firstly, theoretically driven accident and incident causation models, widely applied in other safety critical domains, have not yet fully transferred into the led outdoor activity domain. Secondly, compared to other safety critical domains in which accidents are a significant problem, there has been only limited investigation into accident causation in the led outdoor activity domain. Thirdly, the data on which to base such investigations simply do not exist. Currently there is no universally accepted led outdoor activity accident and incident reporting system or database. Fourthly and finally, the methods and systems required for collecting, coding, storing and analysing data regarding led outdoor activity accidents and incidents do not exist. The lack of a universal database has already been touched on, and there is also a lack of theoretically underpinned data collection systems and also accident analysis methods that have been developed specifically for the led outdoor activity domain.

In sum, the led outdoor activity domain is currently in its infancy regarding accident data collection and analysis and the understanding and prevention of future accidents and incidents. To properly manage and minimise risk, it must learn more about accidents and incidents (including near misses). To successfully identify causal factors, more appropriate system-based models and methods are required. The use of standardised, theoretically underpinned recording and reporting systems and procedures is a critical step that must be taken and from there, the utilisation of a common database to monitor incidents can occur. Once established and working efficiently, such a system will greatly improve the current gaps in our knowledge of why accidents and incidents occur during led outdoor activities.

Further research into the Human Factors issues involved in accident and incident causation in the outdoor activity sector is therefore required, in particular, theoretically driven, systems-based research into such accidents and incidents. The following key lines of inquiry are recommended:

1. Development of a unified, theoretically underpinned accident and incident reporting system.

2. Development of a unified led outdoor activity accident and incident database.

3. Development and application of a theoretically underpinned, systems-based accident analysis method.

4. In-depth analysis of led outdoor activity accident and incidents.

3 SYSTEMS-BASED ACCIDENT CAUSATION MODELS AND ANALYSIS METHODS FROM OTHER SAFETY CRITICAL DOMAINS: AN EXPLORATORY CASE STUDY

3.1 INTRODUCTION

It is now widely accepted that the accidents which occur in complex socio-technical systems are caused by a range of interacting human and systemic factors (e.g. Reason, 1990, Hollnagel, 2009). This so called systems approach to human error began to gain credence during the 1980s as a result of a series of catastrophes in which managerial failures were identified as key causal factors, such as the Challenger, Piper Alpha, Hillsborough and Narita catastrophes (Johnson, 1999). Following seminal theoretical work (e.g. Reason, 1990), the systems approach is now the dominant approach to error and error management in most safety critical domains. Accordingly, there exists a range of systems theory-based accident analysis and investigation methodologies designed to allow investigators to identify the human and system contribution to accidents and incidents occurring in the complex socio-technical domains. Based on a targeted review of the accident causation theory and methods literature, this chapter presents an introduction to systems-based accident causation and human error models and the range of methodologies available for analysing accidents and incidents. To demonstrate the utility of such approaches in the outdoor led activity sector, the most appropriate accident analysis methodologies are then used to analyse a series of example case study accidents.

3.2 MODELS OF ACCIDENT CAUSATION

Various models of accident causation exist (e.g. Heinrich, 1931; Leveson, 2004; Perrow, 1999; Rasmussen, 1997; Reason, 1990). Undoubtedly the most popular and widely applied is Reason's (1990) systems perspective model of human error and accident causation. The 'Swiss cheese' model, as it is more commonly known, focuses on the interaction between system wide inadequate (referred to as latent) conditions and errors and their contribution to organisational accidents. The model presents a hierarchical description of organisational systems and suggests that each layer (e.g. decision makers, line management, productive activities and defences) has defences, such as protective equipment, rules and regulations, training, checklists and engineered safety features, which are designed to prevent the occurrence of occupational accidents. Weaknesses in these defences, created by the latent conditions and unsafe acts create 'windows of opportunity' for accident trajectories to breach the defences and cause an accident. Organisational accidents occur when the holes in the systems defences line up in a way that allows the accident trajectory to breach each of the different layers. Reason's systems perspective model is presented in Figure 3-1.

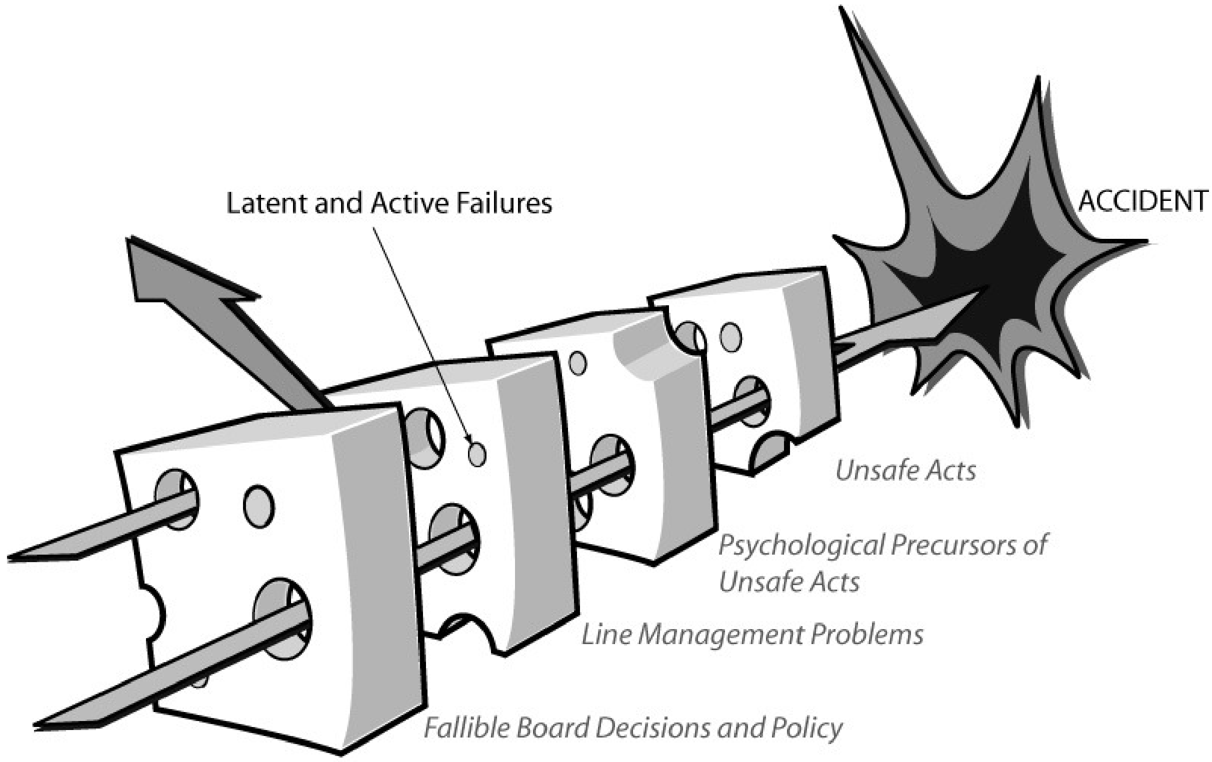

Figure 3-1. Reason's Swiss cheese systems perspective on error and accident causation (adapted from Reason, 2000).

Within Reason's model, latent conditions and unsafe acts combine to produce organisational accidents and incidents. Latent conditions include poor designs, inadequate supervision, manufacturing defects, maintenance failures, inadequate training, clumsy automation, inappropriate or ill-defined procedures, inadequate equipment and procedural short cuts, to name only a few. Unsafe acts, on the other hand, represent those errors that are made by human operators that have an immediate impact upon system safety. At the fallible board decisions and policy level, fallible decisions made by higher-level management create latent conditions. Examples of failures at this level include the selection of inappropriate (i.e. badly designed) equipment, vetoing system enhancement measures and the introduction of inappropriate policies and procedures. At the next level, line management problems arise from incompetent management and also the fallible board decisions and policy from the preceding level in the model. Examples of line management problems include inadequate management or supervision, hiring inappropriately qualified staff, and the use of inadequate or inappropriate training and procedures. The psychological precursors of unsafe acts failure level refers to latent states that create the potential for unsafe acts. According to Reason (1990), the precise nature of unsafe acts is defined through the complex combination of a number of factors, including the task being performed, the environmental conditions and the presence of hazards. Each precursor can contribute to a great number of unsafe acts, depending upon the associated conditions. Examples of these precursors include fatigue, poor motivation, negative attitudes, and a failure to perceive hazards.

3.3 SYSTEMS-BASED ACCIDENT ANALYSIS METHODS

The widespread acceptance of systems-based accident causation models, particularly Reason's, has led to the development of various systems-based accident analysis and investigation methods. Such methodologies are used to reconstruct accidents so that both the human and wider system contributions to accidents or incidents can be identified. The findings are then used to inform the development of measures to ensure similar accidents do not occur again. There are various systems-based accident analysis methods available; however, the most applicable to this domain seem to be the Human Factors Analysis and Classification System (HFACS; Wiegmann & Shappell, 2003) and the Accimaps approach (Svedung & Rasmussen, 2002).

3.3.1 The Human Factors Analysis and Classification System

One of the most popular systems-based approaches for accident and investigation is the Human Factors Analysis and Classification System (HFACS; Wiegmann & Shappell, 2003). HFACS is a comprehensive analysis tool that considers both the errors at the 'sharp end' of system operation and also the latent conditions involved in a particular incident or accident. Although originally developed for the aviation domain, the flexibility and utility of the approach is such that it has since been applied for accident analysis and investigation purposes in a wide range of safety critical domains, including civil and general aviation (e.g. (Lenné, Ashby, & Fitzharris, 2008; Li & Harris, 2006), coal mining (Lenné, Liu, Salmon & Trotter, 2009), rail transport (Baysari, McIntosh, & Wilson, 2008), construction (Walker, 2007), and healthcare (El Bardissi et al., 2007).

The HFACS method is based on Reason's (1990) systems perspective on human error and analyses the human errors and systemic causal factors involved in accidents and incidents. The method builds on Reason's model by specifying a range of different failure modes at each of the different levels specified by Reason. HFACS therefore comprises a series of error and latent failure modes spread across the following four organisational levels: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organisational influences. The structure of the HFACS method is presented in Figure 3-2, which also includes a representation of how the HFACS methodology maps onto Reason's systems perspective model of human error. Working backward from the immediate causal factors, analysts classify the errors and associated causal factors involved using the taxonomies presented at each level.

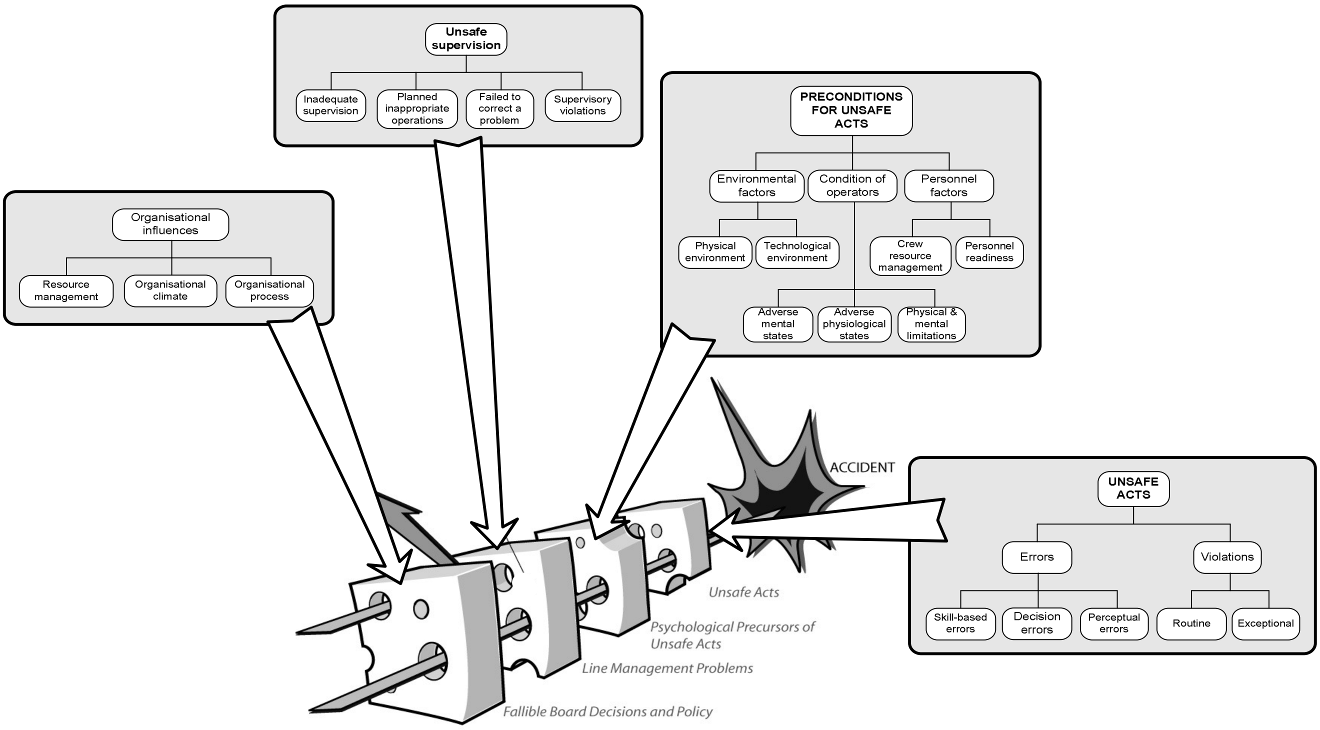

Figure 3-2. HFACS mapped onto Reason's Swiss Cheese model.

Each of the failure categories presented in Figure 3-2 has an associated external error mode taxonomy. For example, the external error mode taxonomies for the errors and violations failure categories are presented in Table 3-1.

Table 3-1. Unsafe acts level external error mode taxonomies.

Errors	Violations
Skill-based Errors	***Routine***
- Breakdown in visual scan	- Inadequate briefing for flight
- Inadvertent use of flight controls	- Failed to use ATC radar advisories
- Poor technique/airmanship	- Flew an unauthorised approach
- Over-controlled the aircraft	- Violated training rules
- Omitted checklist item	- Filed VFR in marginal weather conditions
- Omitted step in procedure	- Failed to comply with departmental manuals
- Over reliance on automation	- Violation of orders, regulations, SOPs
- Failed to prioritise attention	- Failed to inspect aircraft after in-flight caution light
- Task overload	***Exceptional***
- Negative habit	- Performed unauthorised acrobatic manoeuvre
- Failure to see and avoid	- Improper takeoff technique
- Distraction	- Failed to obtain valid weather brief
Decision Errors	- Exceeded limits of aircraft
- Inappropriate manoeuvre/procedure	- Failed to complete performance computations
- Inadequate knowledge of systems & procedures	- Accepted unnecessary hazard
- Exceeded ability	- Not current/qualified for flight
- Wrong response to emergency	- Unauthorised low altitude canyon running
Perceptual Errors	
- Due to visual illusion	
- Due to spatial disorientation/vertigo	
- Due to misjudged distance, altitude, airspeed, clearance	

The HFACS approach is attractive for a number of reasons, including its treatment of both the errors and latent conditions involved in a particular accident, and also that it provides analysts with taxonomies of errors and latent conditions for each of the levels of failure. The approach is intuitive and easy to learn and apply, and has had considerable success across a range of safety critical domains. On the downside, however, taxonomic approaches such as HFACS are limited by the data on which they are based; often the data being analysed does not contain sufficient detail to permit a reliable and valid analysis. Further, the taxonomy may not always be exhaustive, depending on the domain of application. Analysts using techniques such as HFACS often find themselves 'fitting' the data to the technique, so the validity of such approaches is sometimes questionable. HFACS also suffers from problems that are typically associated with all accident analysis techniques, such as hindsight bias and counterfactual reasoning (Dekker, 2002).

3.3.2 The Accimaps approach

The Accimaps approach is based on Rasmussen's risk management framework (Rasmussen, 1997). Also underpinned by systems-thinking, Rasmussen's risk management framework (Rasmussen, 1997) suggests that accidents are shaped by the activities of people who can either trigger accidental flows or divert normal work flows. Like Reason's model, Rasmussen's framework considers the various organisational levels involved in production and controlling safety and, in addition to errors and violations, focuses on the mechanisms generating behaviour within a dynamic work context. The model views complex socio-technical systems as comprising a hierarchy of actors, individuals, and organisations (Cassano-Piche et al, 2009). Although the number of levels is not rigid and varies according to domain, the model typically uses the following levels: government, regulators, company, company management, staff, and work. Safety is viewed as an emergent property arising from the interactions between actors at each of the levels.

In a similar manner to Reason, Rasmussen purports that various levels contribute to safety management via the control of hazardous processes through laws, rules, and instructions (see Figure 3-3). According to the framework, for systems to function safely, the decisions made at high levels should promulgate down and be reflected in the decisions and actions occurring at lower levels of the system, and information regarding the system's status needs to transfer up the hierarchy to inform the decisions and actions occurring at the higher levels (Cassano-Piche et al, 2009). Without this so called 'vertical integration', systems can lose control of the processes that they control (Cassano-Piche et al, 2009).

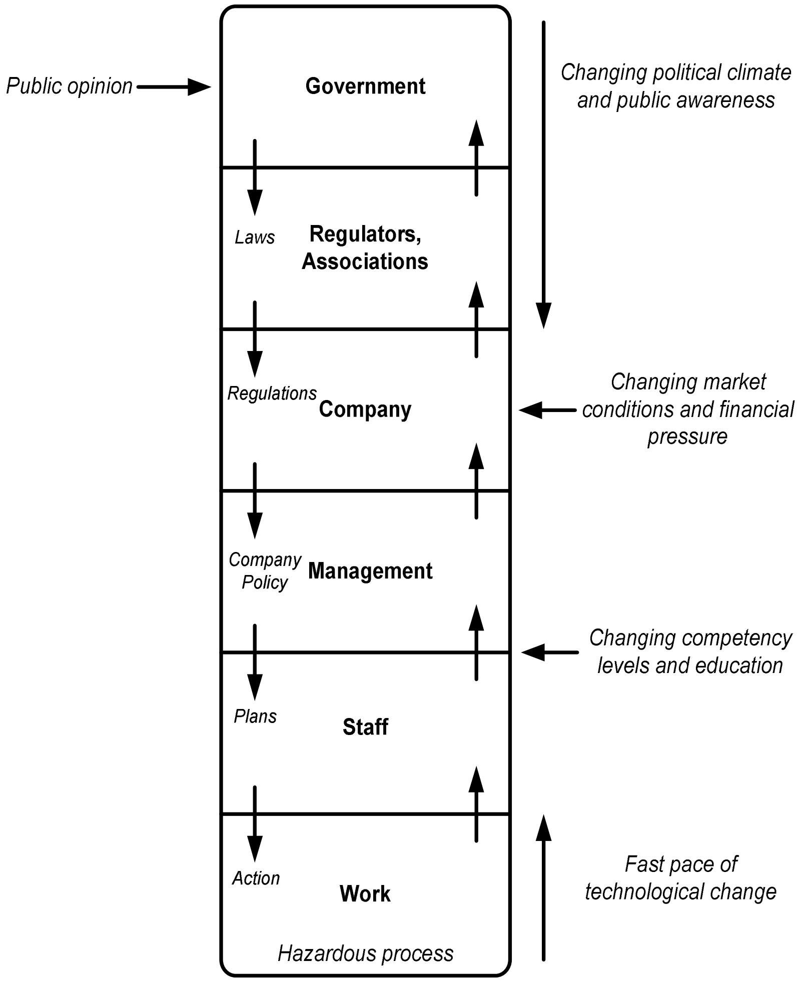

Figure 3-3. The levels of complex sociotechnical systems involved in risk management (adapted from Rasmussen, 1997).

According to Rasmussen (1997), accidents are typically 'waiting for release', the stage being set by the routine work practices of various actors. Normal variation in behaviour then serves to release accidents. Thus, Rasmussen suggests that explaining accidents in terms of events, acts and errors has no utility for system redesign; rather, new approaches focussing on the mechanisms generating behaviour in the dynamic work context are required.

For this purpose, Rasmussen (1997) proposes the Accimaps methodology (Rasmussen, 1997; Svedung & Rasmussen, 2002), which is an accident analysis method that is used to graphically represent the systemic causal factors involved in accidents and incidents. The Accimaps method differs from typical accident analysis approaches in that it is used to identify and represent the causal flow of events upstream from the accident and looks specifically at the planning, management and regulatory bodies that may have contributed to the accident (Svedung & Rasmussen, 2002). The method is underpinned by the notion that safety is an emergent property of complex socio-technical systems and is impacted by the decisions of all actors – politicians, chief executives, managers, safety officers and work planners – not just front line operators alone (Cassano-Piche et al, 2009). Accimaps therefore use the following six main levels: government policy and budgeting; regulatory bodies and associations; local area government planning & budgeting (including company management, technical and operational management; physical processes and actor activities; and equipment and surroundings). Failures at each of the levels are identified and linked between and across levels based on cause-effect relations. Starting from the bottom of the graph, the equipment and surroundings level provides a description of the accident scene in terms of the configuration and physical characteristics of the landscape, buildings, equipment, tools, and vehicles involved. The physical processes and actor activities level provides a description of the failures involved at the 'sharp end'. The remaining levels above the physical processes level represent all of the failures by decision makers that, in the course of the decision making involved in their normal work context, did or could have influenced the accident flow during the first two levels. Due to its generic nature, Accimaps is applicable in any domain and has subsequently been applied to a range of accidents and incidents, including gas plant explosions (Hopkins, 2000), police firearm mishaps (Jenkins, Salmon, Stanton & Walker, 2009), loss of space vehicles (Johnson & de Almeida, 2008), aviation accidents (Royal Australian Aviation Force, 2001), public health incidents, including the Walkerton E-coli incident (Vicente & Christoffersen; 2006) and the UK BSE outbreak (Cassano-Piche et al, 2009), and road and rail accidents (Svendung & Rasmussen, 2002; Hopkins, 2005). An example Accimaps output, taken from Jenkins et al (In Press) analysis of the Stockwell Charles Demenez shooting incident is presented in Figure 3-4.

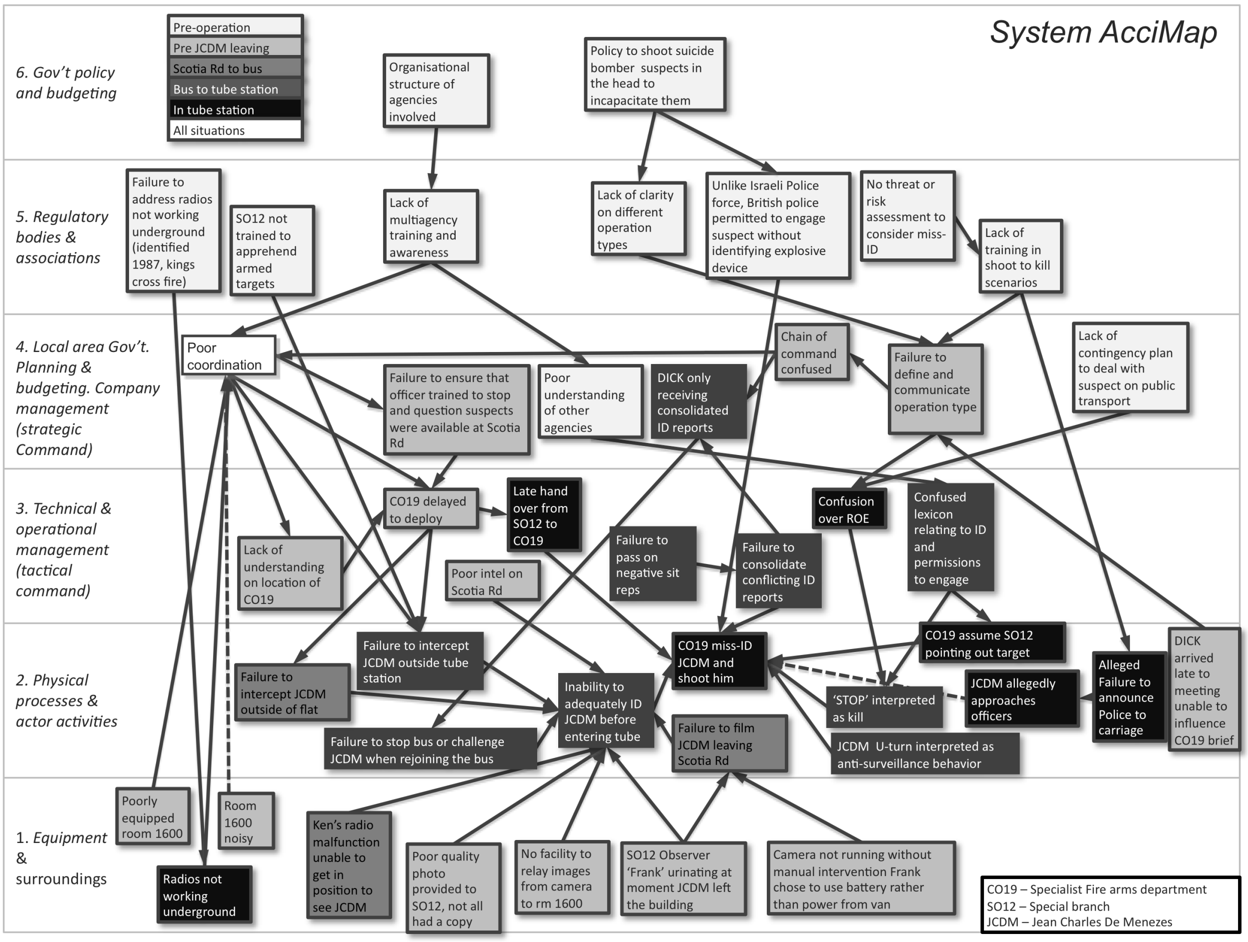

Figure 3-4. Stockwell incident Accimap (Source: Jenkins et al, In Press).

3.4 SYSTEMS-BASED ACCIDENT ANALYSIS METHODS AND LED OUTDOOR ACTIVITY INCIDENTS

Both of the accident analyses methods described show potential for being applied in the context of outdoor led activity. To investigate this, and to demonstrate the potential contribution of such analyses, we applied both methods to three outdoor led activity accidents. A brief overview of the three incidents analysed is given below.

Lyme bay canoeing incident

The Lyme Bay sea canoeing incident involved the death of four individuals whilst on an outdoor education activity trip on March 22nd 1993. The activity involved a group of eight students, a school teacher, a junior instructor and a senior instructor engaging in an introductory open sea canoeing activity in Lyme Bay, Dorset, in the United Kingdom. After a series of initial capsizes, the junior instructor and eight students became separated from the senior instructor and their school teacher and were blown out to sea. Due to high wind and wave conditions, each canoe in the junior instructor/student group was subsequently swamped and capsized, and the junior instructor and students were left in the water with all canoes abandoned. Four students drowned as a result. The ensuing inquiry identified a number of failures on behalf of the company providing the activity and also the instructors overseeing the activity, including that the activity was not suitable for novices, that the instructors were not adequately qualified to oversee the activity, and that various pieces of key equipment were not provided, including spray decks, flares, towlines, and a survival bag.

New Zealand 'Entrapment and near drowning' kayaking incident

The entrapment and near drowning incident involved a student becoming trapped underwater in a rock formation following his raft overturning on the 'long drop' rapid on the Rangitikei River, New Zealand. After initial unsuccessful attempts to free the student, the trip leader managed to free the student by pushing his foot forcibly down on the students back. The unconscious student was subsequently pulled from the water and resuscitated, and was discharged from hospital the following day.

Rip swing incident

The rip swing incident analysed involved a 17 year old boy falling head first to the ground when preparing to ride upside down on a giant swing activity known as the 'Rip Swing' at an adventure activities park in Victoria, Australia. The boy eventually died from his injuries, and the subsequent coroner inquiry identified a range of causal factors, including the unsafe design of the rip swing device, the use of the device upside down, the failure of the company management to consider the inherent risks of using the device upside down, and also the failure to provide a failsafe back up for the rip swing device.

Each of the incidents described was analysed using the Accimaps and HFACS approaches. Both methods were applied by one Human Factors researcher with significant experience in the area of human error and accident analysis and investigation. The data used for each analysis was derived from various sources; however, it is notable that the Lyme Bay incident analysis was informed by a comprehensive data set, including the official inquiry report. The outputs from each analysis are presented below. As a result of the more comprehensive data set available for the Lyme Bay analysis, this analysis is described in greater detail than the other analyses.

3.4.1 Lyme Bay case study analysis

The Lyme Bay Accimap is presented in Figure 3-5.

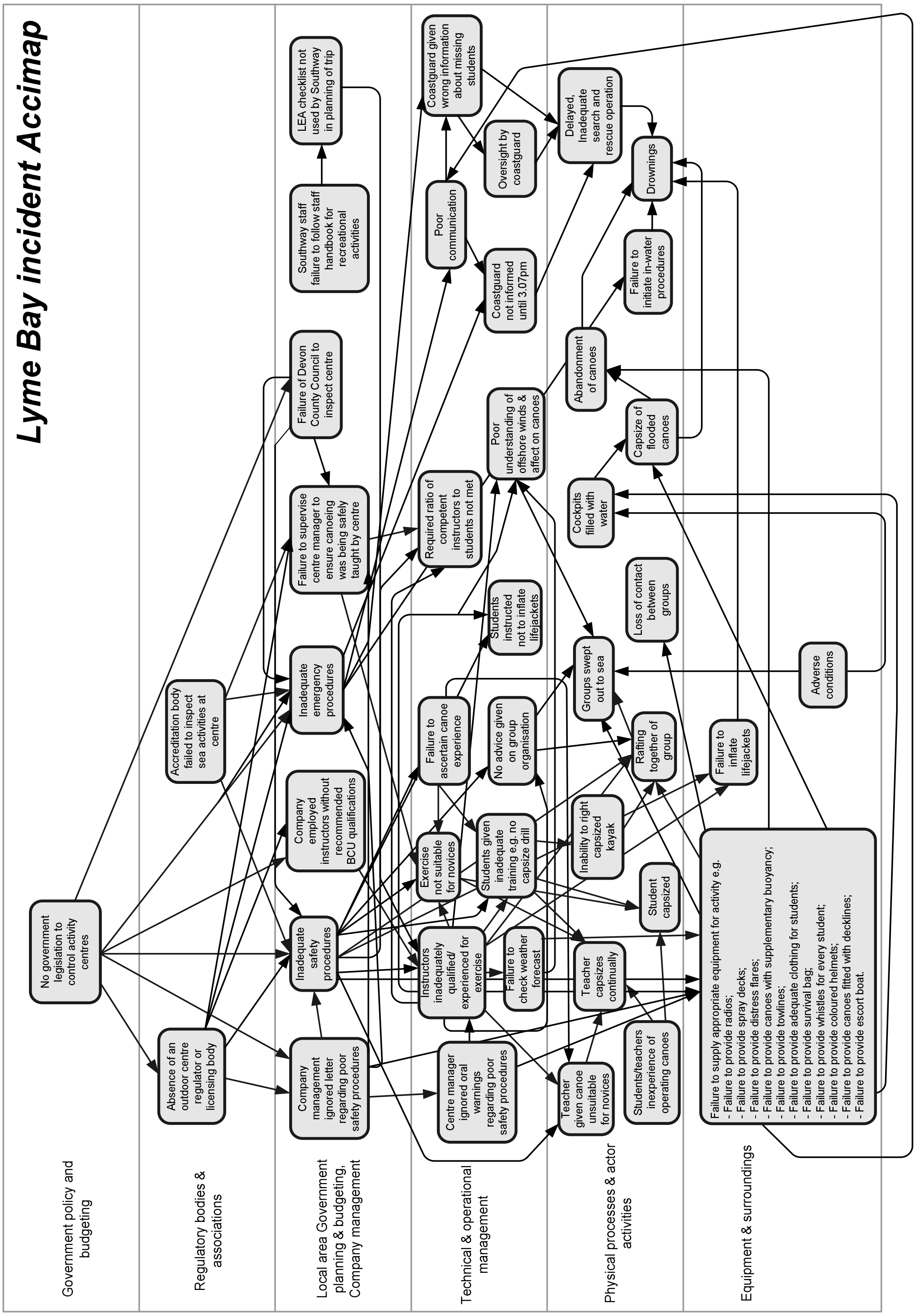

Figure 3-5. Lyme Bay Accimap output.

Equipment & surroundings

It is the absence of appropriate equipment that is most evident at the equipment and surroundings level. Spray decks, the device which creates a water tight seal at the point where the user sits in the kayak, were not used, despite the students all being inexperienced in the operation of canoes and also in sea canoeing in general. This was a key causal factor in the ease in which the canoes were swamped and capsized. The student's canoes also did not have supplementary buoyancy (recommended for sea canoeing) and did not have deck lines fitted. All students were inadequately clothed for sea canoeing, and the lifejackets worn by the students were not inflated, on instruction from the instructors, and had no whistles attached to them. Other equipment that would normally be taken on sea canoeing trips, but that was not taken in this case, included radios, distress flares, towlines and a survival bag. The absence of towlines meant that the group was not connected and allowed the students to drift out to sea. Without radios and distress flares the alarm could not quickly be raised by the instructors or students. Along with the instructors, the school teacher on the trip, also inexperienced, was given a Lazer three fifty canoe (Devon County Council, 1993), which was shorter and lighter than the others and deemed inappropriate for use by a novice at sea. Finally, at this level the conditions also played a role; whilst the wind speed level was not overly high, the offshore winds and high seas were the key factors in sweeping the students out to sea.

Physical processes & actor activities

At the physical processes and actor activities level, most of the contributing factors relate to the instructors and students inability to respond to the unfolding situation. It is worth remembering here that all students and teachers were inexperienced in the operation of canoes. First of all, the initial, continued capsizing of the teacher and the inability of the senior instructor and the teacher to successfully right the capsized canoe were the trigger events. Whilst the senior instructor attempted to right the capsized canoe, the junior instructor proceeded to raft together the students, although prior to this no advice was given on organisation. Influenced by the offshore winds, the rafted group was quickly swept out to sea, and, due to the absence of distress flares and radios, the two groups (instructor and teacher group and rafted group, including eight students and one junior instructor) lost contact with each other. Due to the absence of tow or deck lines, the rafted group could not be tied together. As the students were swept further out to sea, the increasingly adverse conditions (e.g. higher waves), coupled with the lack of spray decks, led to further capsizes and the canoes becoming swamped with water until eventually all of the students were submerged in the water with only one upturned canoe to hold onto. Eventually, after a failed attempt to paddle ashore using the upturned canoe, the final canoe was abandoned. Whilst in the water, standard in-water procedures, designed to keep submerged entities warm and prevent hyperthermia, were not initiated.

The activities undertaken in organising a response are also important. The alarm was not raised on-shore until the group were over 3 hours late, and initially the site manager did not immediately notify the coastguard; rather, he spent some time searching the shoreline for the missing group. In addition, the coastguard was wrongly informed that the instructors were well qualified, 18 years of age, and were well equipped for the activity, all of which was not the case. Once the rescue was underway, the coastguards themselves also made a number of errors, although this is not the focus of the analysis presented.

Technical & operational management

At the technical and operational management level, there are a number of failures and decisions that contributed to the incident. Prior to the incident, the centre's manager (and also the company management) failed to heed the content of a letter sent by two previous employees to management regarding poor safety procedures and inadequate equipment at the centre. The centre manager also failed to heed verbal warnings from the same two employees regarding the fact that canoeing was not being safely taught at the centre (Devon County Council, 1993). The instructors employed by the centre were also not sufficiently qualified for sea canoeing, which represents a failure on behalf of the manager to employ adequately qualified staff. The exercise itself was not suitable for novices; further, the inquiry report suggests that no attempt was made by staff to ascertain the experience levels of the students or teacher. As a result, the training given to the teacher and students prior to the trip in the centre's swimming pool was inadequate, involving no capsize drills whereby the procedure to 'right' and re-board the canoe are taught.

On the day of the activity, neither of the two instructors checked the weather forecast, and no attempt was made to ascertain the conditions out at sea. Students were also told not to inflate their lifejackets (inflation of lifejackets is a standard approach for avoiding drowning). Due to their lack of qualifications and the type of activity being undertaken, the required ratio of competent instructors to students was not met.

Local area Government planning & budgeting, Company management

At the company management level, management also failed to heed the content of the letter sent by two previous employees regarding the safety of canoeing activities at the centre in question. The inquiry also reported that the managing director was charged with failing to devise and enforce safe procedures for executing sea canoeing activities, and the emergency procedures in place were also inadequate. The employment of inadequately qualified instructors is also represented at this level, with the company management failing to procure employment of staff suitably qualified to provide safe canoeing activities. There was also a failure on behalf of company management to supervise and ensure that safe activities were being provided by the centre in question. Finally, the inquiry report also concluded that the school involved had not planned the trip adequately; the school in question failed to adequately follow their own staff handbook for organising such trips, and a local education authority checklist for planning such activities was not used.

Regulatory bodies and associations

At the time of the incident, there was no regulatory body or licensing body for outdoor activity centres. Following the incident, the inquiry report recommended that a National independent system of registration and regulation of outdoor centres be developed as a matter of urgency, and also that no school or youth group should be permitted to use such centres until they had been approved for registration by an appropriate body. The absence of a regulator and legislation undoubtedly allowed the company management to continue with unsafe and inappropriate procedures, and to employ inadequately qualified staff. The report concluded that, if a regulatory body had been in place at the time, the concerns reported by previous employees would undoubtedly have been reported to the body, and appropriate action would have ensued.

In addition, although the centre in question was accredited by the British Activity Holidays Association, it is notable that no examination of sea canoeing activities was undertaken, rather, only land and pool based activities were examined.

Government policy and budgeting

At the Government policy and budgeting level, the absence of legislation to control activity centres is the key failure involved. This meant that there was no regulating or licensing body overseeing outdoor activity providers, which enabled the centre to continue engaging in unsafe practices, despite these being identified and documented by previous employees of the centre.

The HFACS analysis for the Lyme Bay incident is presented in Figure 3-6.

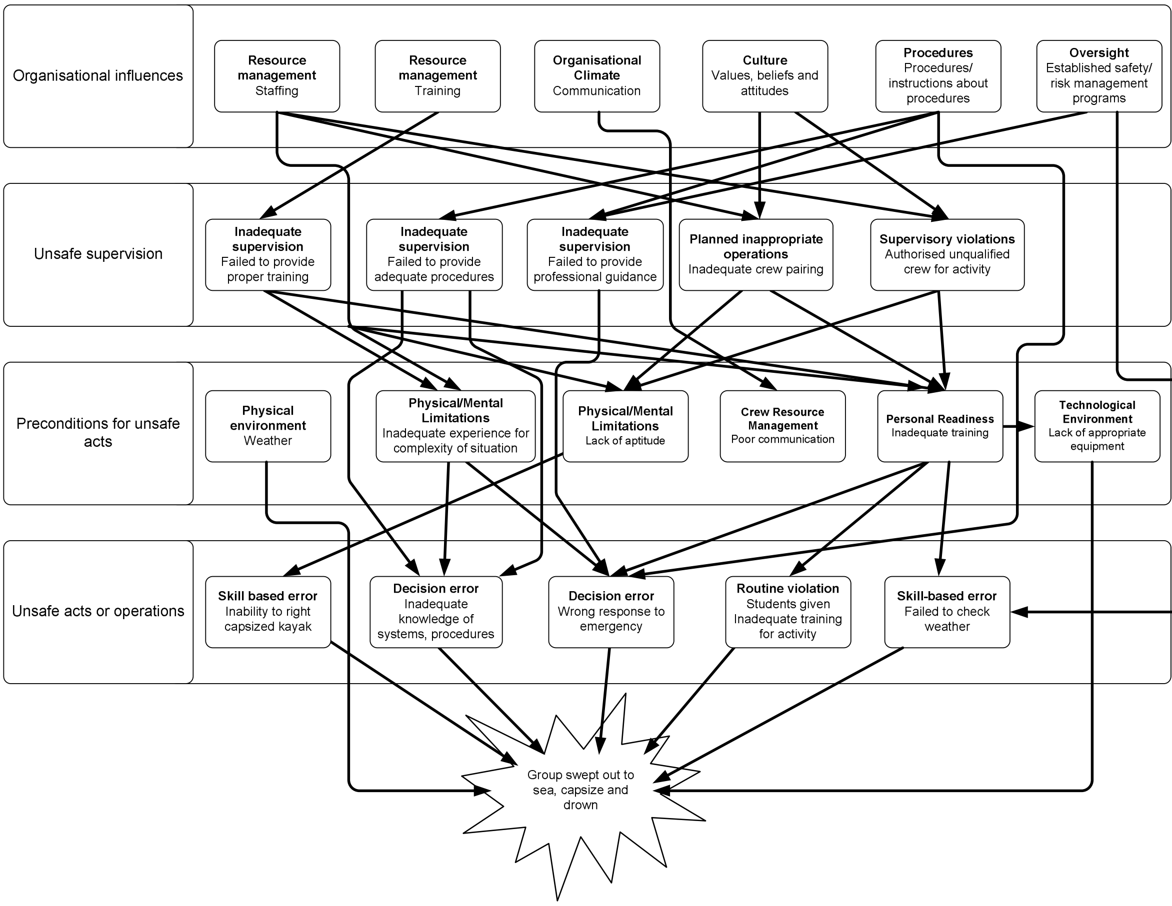

Figure 3-6. Lyme Bay HFACS output.

The HFACS analysis identifies the majority of the failures involved in the accident; however, it is notable that it does not look further up the chain than the failures within the company itself. As a corollary, failures in government policy and legislation are not considered.

3.4.2 Rip swing incident analysis

The rip-swing incident Accimap is presented in Figure 3-7.

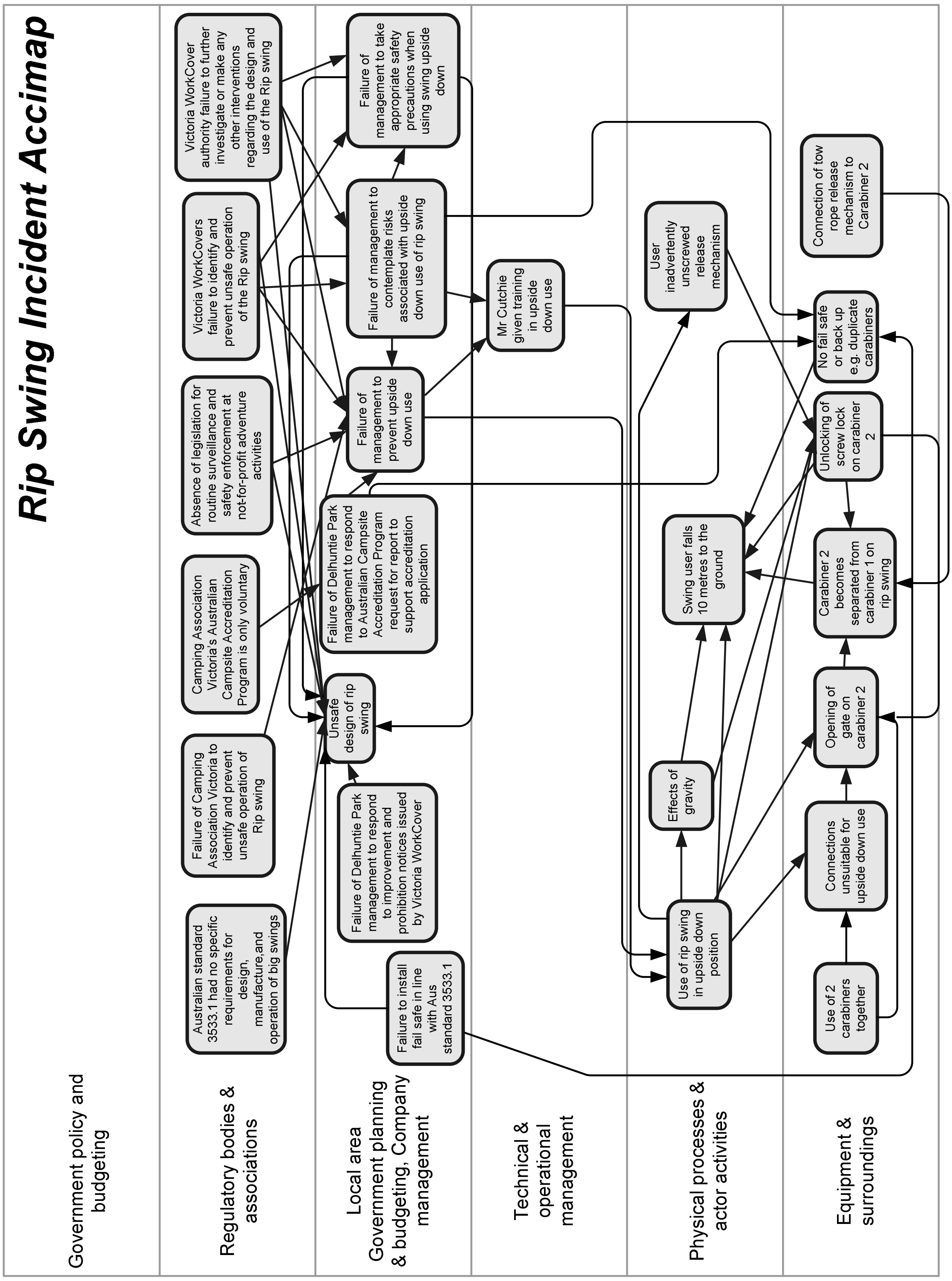

Figure 3-7. Rip swing incident Accimap output.

The HFACS analysis of the rip-swing incident is presented in Figure 3-8.

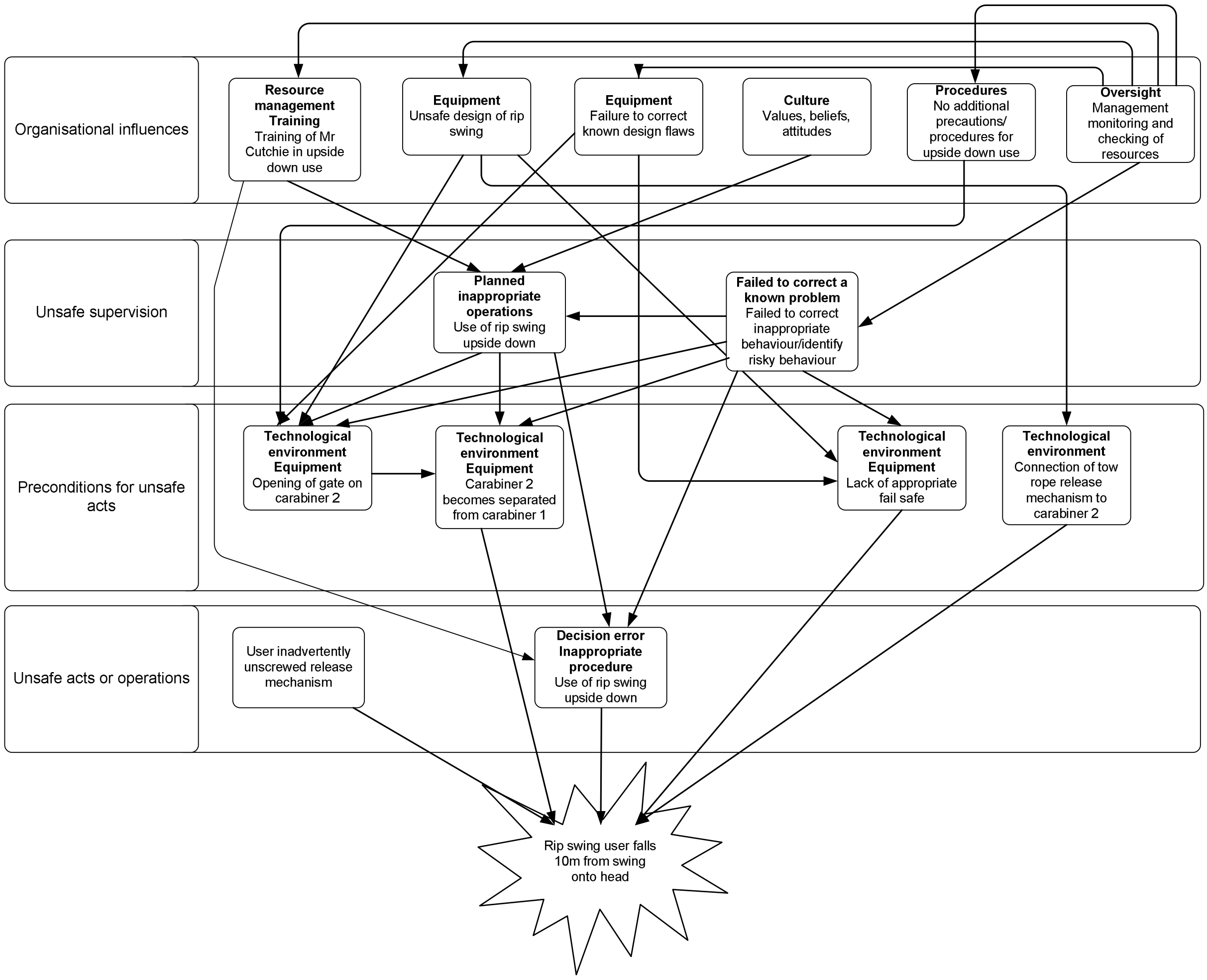

Figure 3-8. Rip swing incident HFACS output.

Both analyses demonstrate that the rip swing failure was caused by the unsafe upside down use of the ride, the conditions for which were set by a series of regulatory, management, and design failures regarding the rip swing device. In the context of upside down use, the design itself was unsafe, and the activity centre management failed to appreciate the risks associated with the upside down use of the device, even providing training for the instructor involved in upside down use. Further up the chain, standards and local regulatory bodies had failed to identify and prevent the unsafe upside down use of the rip swing device. Again, a comparison between the two analyses presented highlights how the Accimaps approach goes further up the accident chain than the HFACS approach, which in this case cannot cater for the regulatory body and standards-related failures.

3.4.3 Entrapment and near drowning incident analysis

The Accimaps analysis for the entrapment and near drowning incident is presented in Figure 3-9.

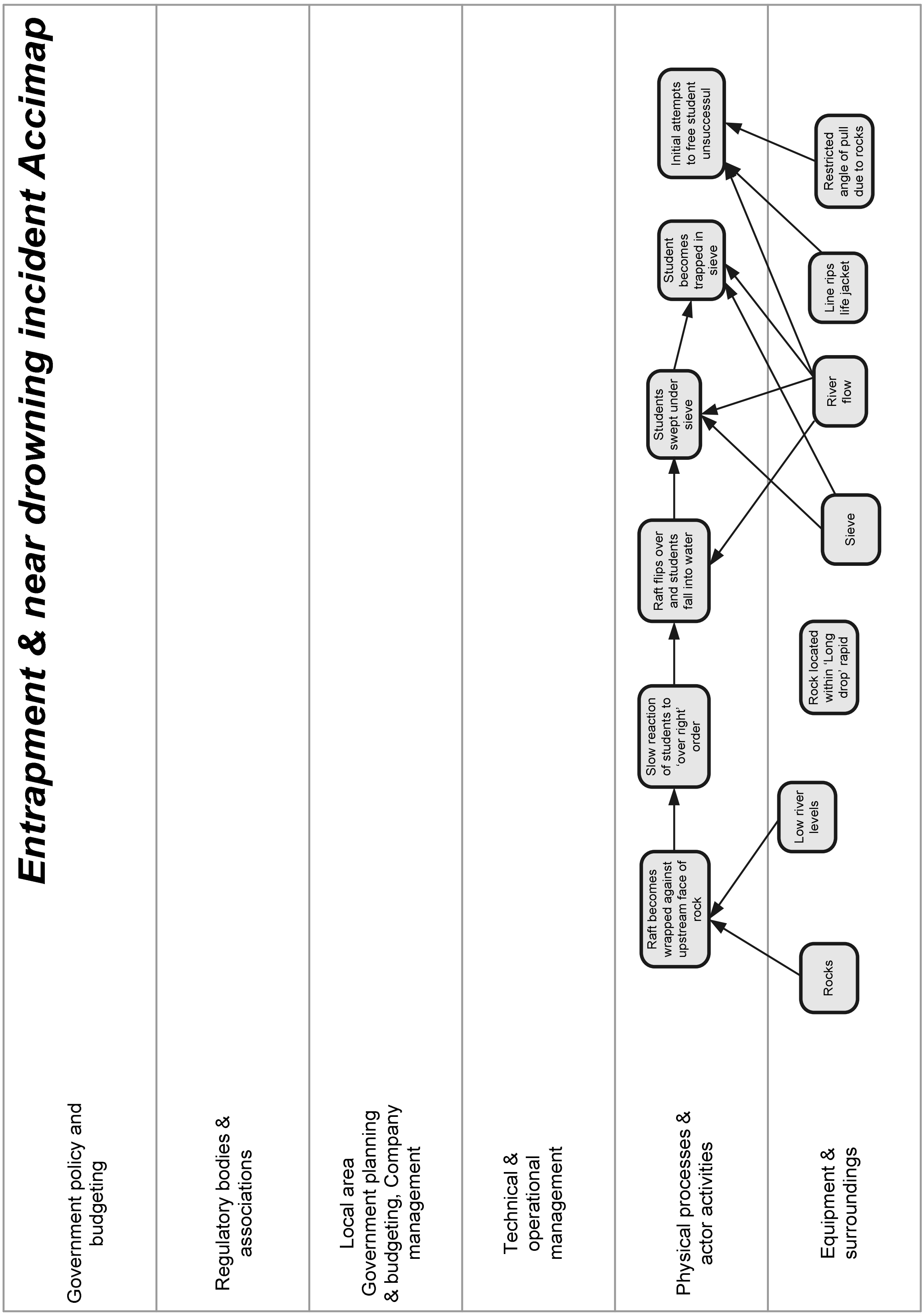

Figure 3-9. Entrapment and near drowning incident Accimap output.

The HFACS analysis of the entrapment and near drowning incident is presented in Figure 3-10.

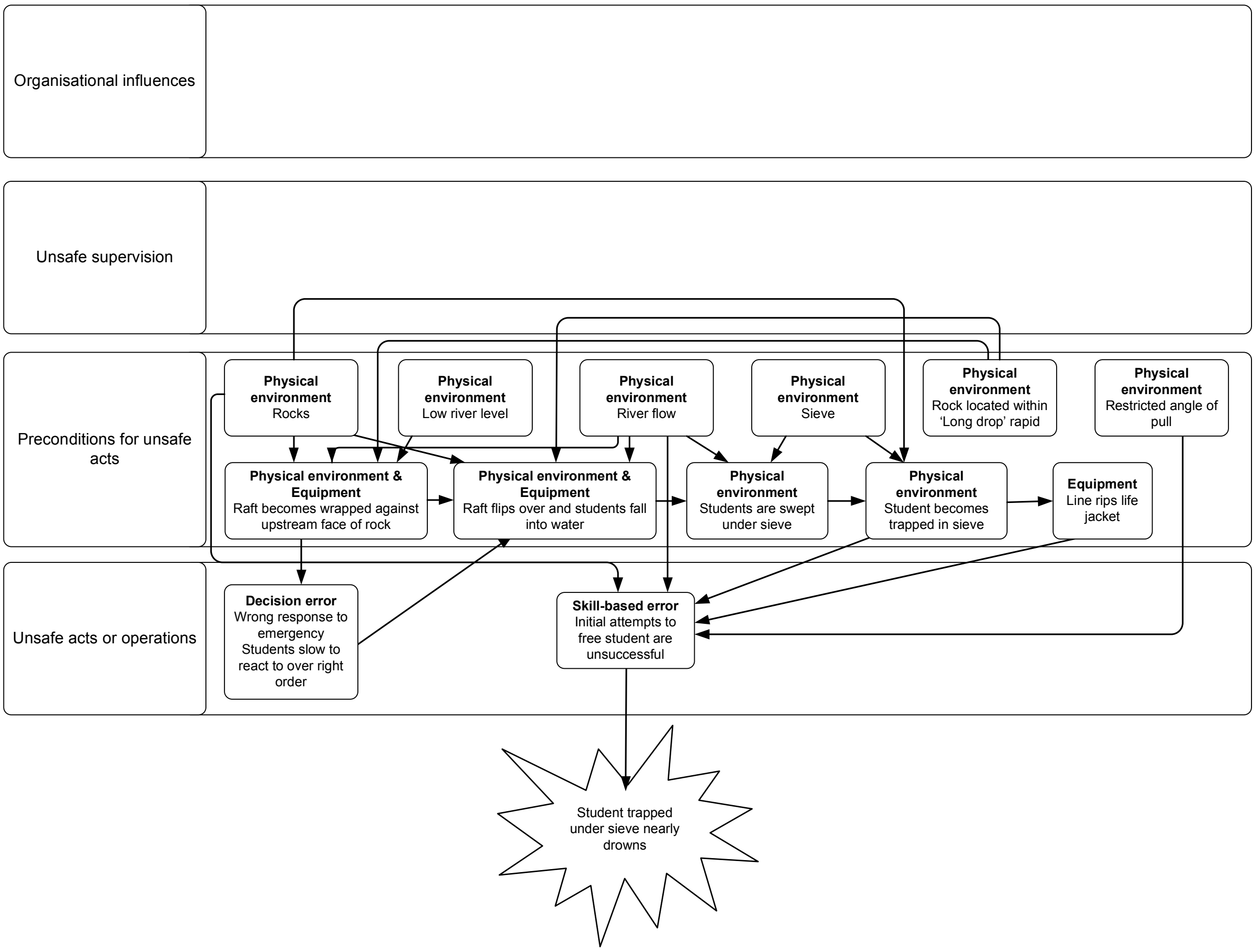

Figure 3-10. Entrapment and near drowning incident HFACS output.

The entrapment and near drowning incident is interesting in this case in that it represented a near-miss incident in the sense that the tragedy was avoided. It was difficult with both methods to therefore identify higher system failures, since the data available did not focus on such matters (presumably because a death had not occurred). Rather, the analyses demonstrate that the incident was caused by mainly environmental factors, such as the rock formations (e.g. the sieve), river flow, and low river levels present on the day, although the lifejacket ripping during initial attempts to free the student was also a factor.

3.5 SUMMARY

Two systems-based accident analysis approaches that show potential for analysing accidents and incidents occurring in the led outdoor activity were applied to three led outdoor activity accidents. The analyses presented highlight that failures at all levels of the 'led outdoor activity system' can have a significant role in the accidents and incidents that occur. The Lyme Bay analysis, for example, demonstrates how failures across the entire system were involved.

3.5.1 Data challenges

In any complex socio-technical system, our understanding of accidents is heavily constrained by the quality of the data gathered, the methods used to interrogate it, and the analysts applying the methods involved (Grabowski et al, 2009). In terms of the methods applied, the three analyses presented demonstrate that both approaches seem suitable for the analysis of led outdoor activity accidents and incidents; however, whilst a taxonomic approach such as HFACS is encouraged, the analyses demonstrate that the Accimaps approach is the more comprehensive of the two approaches since it considers higher governmental and legislative issues, whereas HFACS stops at the level of company management and organisational processes.

The case study analyses were also useful in that they raised a number of concerns that are likely to represent barriers to systems-based led outdoor activity accident and incident data analysis. The data available is likely to be a significant barrier. For example, for the three accidents (more so the latter two) there was only limited data available. In addition, the data available focussed on a limited set of parameters, mostly surrounding the instructors involved. In addition, the data available is likely to be presented differently on a case by case basis. The lack of a standardised procedure and methodology for collecting accident data will ensure this. There are also concerns about the data collection procedures currently in use. Anecdotal evidence suggests that these are currently not based on existing theoretical frameworks, such as Reason (1990) or Rasmussen (1997). This limits the ensuing data, and prevents a more in-depth understanding of the causal factors underlying accidents, and their complex interactions. The personnel involved in collecting accident data is also an issue. Often they may not have received appropriate training in Human Factors and the systems approach to accident causation, and so their understanding of the role of systemic failures in accidents may be limited.

Where the data collected should be stored, in what format, and by who is also of concern. The culmination of accident and error-related data collection in most safety critical systems is typically a database of some sort, containing descriptions of the different accidents that have occurred within a particular system, along with their associated causal factors and consequences. The utility of such approaches was discussed in Chapter 2. It is apparent that appropriate systems-based databases do not yet exist within the led outdoor activity domain.

The resources required to collect the data that is required to support systems-based accident analysis is also problematic. Comprehensive data collection in this sense requires significant resources in terms of time invested at the accident scene and also in terms of the actual coding and analysis of the data. It is questionable whether such time could be made available in the current system, and the responsibility for undertaking data collection and analysis activities remains unclear. The feasibility of employing exhaustive, systems-based accident data collection systems requires further examination in a led outdoor activity context.

3.5.2 Methodological comparison

The Accimaps analyses presented demonstrate the utility of the Accimaps approach for analysing, and learning from, accidents and incidents in the led outdoor activity domain, and suggest that the Accimaps approach is suited to analysing such accidents and incidents in a way that lessons can be learned and safety can be improved. The approach is generic and can be applied in any domain (the outdoor activity sector being an example of a domain in which the application of systems-based accident analysis methods has previously not been explored), is simple to apply, and the output is easily interpretable. The identification of factors across the range of systemic levels allows the development of appropriate systems-focussed countermeasures and remedial strategies, as opposed to individual oriented measures that ignore the wider systemic causal factors often produced from individual operator at the sharp end accident analyses (Dekker, 2002; Reason, 1997). That said, the approach also caters for the unsafe acts made by operators at the sharp end.

On the downside, a by product of its comprehensiveness, the approach is time consuming in application and requires significant resources for data collection and analysis activities. Further, as with all accident analysis approaches, the quality and validity of the analysis produced is ultimately dependent upon the quality of the data available and of the analyst(s) undertaking the analysis. For example, for this approach to become an industry standard in the outdoor activity sector, development of appropriate analyst training programs and standardised data collection and storage systems would be required. In addition, significant resources would be required for accident and incident analyses, and it is notable that the method provides no guidance in the development of remedial measures and countermeasures. Also, as with most accident analysis approaches, Accimaps suffers from various problems associated with hindsight; Dekker (2002), for example, suggests that hindsight can potentially lead to oversimplified causality and counterfactual reasoning.

Finally, there were problems surrounding the methodologies used. As a result of its aviation origins, the HFACS approach has a number of error modes that are simply not applicable in other contexts. Conversely, the Accimaps approach does not provide taxonomies of failures at the different organisational levels, which raises questions about its reliability. Unlike other safety critical domains in which accidents and incidents are a significant problem, the development, application, and validation of systems-based accident analysis methods in the led outdoor activity domain has largely been ignored. Without such approaches, the utility of accident analysis in another domain is limited significantly.

Similarly, the HFACS analyses presented also demonstrates that the approach could potentially be modified for the led outdoor activity sector. On the downside, the HFACS approach does not consider the higher government and local authority levels that the Accimaps approach does, and the use of aviation specific taxonomies of failures at each of the levels means that a portion are inappropriate, and also that some of the failures identified cannot be classified. It is therefore concluded from the analysis that the Accimaps approach is the more suited of the two for analysing accidents and incidents in the led outdoor activity domain.

4 CONCLUSIONS

4.1 SUMMARY OF FINDINGS

The aim of this research was to explore the involvement of Human Factors in led outdoor activity incidents, and to suggest and demonstrate the utility of a framework for studying such incidents.

4.1.1 Literature review findings

Compared to other domains in which accidents have been identified as a significant problem, it was found that only limited research focussing on the causal factors involved in led outdoor activity accidents and incidents has been undertaken. A number of accident causation models were identified (e.g. Brackenreg, 1999; Davidson, 2004; Meyer, 1979; cited in Davidson, 2007), however, these models were found to be limited in terms of scope, theoretical underpinning, and practical application. Of particular concern is the notion that the models previously applied do not fully consider the wider systems failures involved in accidents and incidents, and also that there has been a lack of cross over of theoretically underpinned accident causation models developed and widely applied in other safety critical domains (e.g. Rasmussen, 1997; Reason, 1990).

In addition to accident causation models, it was found that a significant proportion of the literature focuses on causal factors in isolation. This has led to a series of different concepts being discussed, including risk management (e.g. Boyes & O'Hare, 2003), risk perception (Powell, 2007), situation awareness (e.g. Boyes & O'Hare, 2003; Davidson, 2007), supervision and leadership (e.g. Boyes & O'Hare, 2003; Davidson, 2004), instructor qualification (e.g. Crosby & Benseman, 2003), decision making, and complacency and fatigue (e.g. Haddock, 1999a; Hunter, 2007). The disparate nature of the manner in which these issues have been investigated was highlighted, and it is concluded that establishing the relationships between these issues in terms of accident causation is a pertinent line of future inquiry. It was also noted that many of these concepts have been widely investigated in other safety critical domains; however, it is apparent that much of this research has not be consulted.

A summary of the causal factors identified indicates that, according to the literature there are a range of systemic and instructor/client related causal factors involved in the accidents and incidents that occur. It is notable; however, that the relationship between these factors remains unknown, and a universally accepted model of led outdoor activity accident causation, along with an associated comprehensive taxonomy of causal factors, is yet to emerge. It is also apparent that the majority of causal factors identified are instructor-based, focussing on instructor causal factors and errors as the main cause of accidents and incidents in the led outdoor activity sector. Previous research in other safety critical domains, however, has highlighted the role of wider systemic failures (e.g. at Governmental, local authority, and company management levels) in accidents and incidents (e.g. Reason, 1990; Rasmussen, 1997.

The literature review also identified a number of National and International databases containing data regarding led outdoor activity accident and incidents. The importance of such databases in the analysis and future prevention of accidents and incidents within the led outdoor activity domain was emphasised. Three such databases were identified within Australia, and it was noted that these are voluntary, and that standardised incident reporting, and data storage and analysis procedures are not currently present. The collection and analysis of near miss incident data was also highlighted as a key commodity in the future prevention of accidents and incidents within the led outdoor activity domain. Widely accepted as a means for learning from, and preventing, accidents and incidents in most safety critical domains, near miss incident reporting and analysis systems have been identified by many in the area as key to the prevention of future accidents and incidents (e.g. Brackenreg, 1999; Davidson, 2004).

4.1.2 Exploratory case study analysis

Two accident analysis methods were applied to three case study led outdoor activity accidents. The purpose of the analysis was to demonstrate the utility of such approaches and also to determine which of the two approaches was the most suited to analysing led outdoor activity accidents and incidents with a view to identifying the system-wide causal factors involved.

The analyses undertaken demonstrated that failures at all levels across the led outdoor activity system are likely to play a role in led outdoor activity accidents. Further, the analysis demonstrated that the Accimaps approach was the more comprehensive of the two methods applied. In particular, it was noted that the Accimaps approach permits the identification of causal factors both at the 'sharp-end' of system operation (i.e. instructor/client errors, environmental hazards, and equipment failures) and also the wider systemic causal factors at the managerial, local authority, and Governmental levels. The results of this case study therefore provide support for the Accimaps approach as a valid and appropriate accident analysis methodology for use in the led outdoor activity domain. This evidence adds to the considerable evidence presented in the literature regarding the utility of the Accimaps approach for analysing, and learning from, accidents and incidents in complex socio-technical systems. One pertinent line of future inquiry would appear to be the development of failure taxonomies for each of the levels specified by the Accimaps approach.

The exploratory analysis was also useful in highlighting the issues likely to be faced when attempting to implement systems-based accident data collection, storage and analysis systems in the led outdoor activity domain. In particular, likely issues include the quality and depth of the data available, the lack of experience in systems-based theory and Human Factors on behalf of those collecting the data, the lack of universally accepted, standardised data collection, coding and storage systems, the lack of a led outdoor activity specific accident analysis methodology, and the significant resources required to implement such systems.

4.2 MAIN CONCLUSIONS AND RECOMMENDATIONS

In terms of understanding the nature of, and responding to accidents, the led outdoor activity domain is currently in its infancy. Current knowledge regarding the role of Human Factors in led outdoor activity accidents and incidents is limited. Although previous research has identified a range of causal factors, a lack of linkage between these factors, theoretical underpinning, and consideration of the wider systemic causal factors is apparent. Critically, a universally accepted model of led outdoor activity accident causation, and associated causal factors taxonomies, do not yet exist. Further, systems-based accident analysis models and methods, developed and applied with significant safety gains in other safety critical domains (e.g. Rasmussen, 1997; Reason, 1990), have not yet fully transferred into the led outdoor activity sector. Further research into the Human Factors issues involved is therefore required.

In particular, theoretically driven, systems-based research into such accidents and incidents is indicated. The following key lines of inquiry/activities are recommended:

1. Development of a unified, theoretically underpinned accident and incident reporting system;

2. Development of a unified led outdoor activity accident and incident database;

3. Development and application of a theoretically underpinned, systems-based accident analysis method;

4. In-depth analysis of led outdoor activity accident and incidents; and

5. Development of a led outdoor activity accident causation model and associated failure taxonomies.

It is recommended that the activities described above be explored via a feasibility study designed to investigate the application of theoretically underpinned systems-based methods for accident and incident reporting, data storage and analysis.

4.3 INDUSTRY WORKSHOP

In order to further disseminate the research findings throughout the Australian led outdoor activity industry and to discuss and identify an appropriate way forward for the overall research program, an Industry Workshop, organised by the project Steering Committee, was held on 17th September in Melbourne. The workshop was attended by two researchers from MUARC, and all members of the project Steering Committee. The following individuals from key organisations and bodies were invited to the workshop, with those who were able to attend given in italics:

- Phil Anderson, Sport & Recreation, New South Wales;

- *David Clarke, Dept of Economic Development, Tourism & the Arts, Tasmania;*

- Ian Dewey, Australian Canoeing;

- Ralph Gurr, Outdoors Western Australia;

- *Matt Harrington, Parks Victoria;*

- *Kathy Kingsford, Dept of Communities (Sport & Recreation), Queensland;*

- *Jarrad Laird, The Bindaree Group, Victoria;*

- *Donna Little, Queensland Outdoor Recreation Federation (QORF), Queensland;*

- *Alistair McArthur, Odyssey Consultants, Victoria;*

- Andrew McGuckian, Uniting Church Camps;

- Mike Meredith, Outdoor Education Association of South Australia;

- *Kirsten Piralta, ORIC, New South Wales;*
- *Ken Pullen, Christian Venues Association, New South Wales;*
- Rosemary Sage, Recreation Western Australia; and
- Tim Swart, Sport & Recreation, Western Australia.

The findings which derived from the research that had been conducted to date were presented, following which a discussion was held focussing on Stage 2 of the overall research program. It was proposed that Stage 2 should involve the conduct of a feasibility study designed to investigate the potential for completing the five steps recommended above in Section 4.2.

4.4 CONCLUDING REMARKS

Within the led outdoor activity domain, safety compromising accidents and incidents currently represent an important issue. Encouragingly, within Australia the led outdoor activity industry collectively recognises the need to enhance their current understanding of such events so that preventative measures can be developed and implemented. This research represents the first step in that process, and has highlighted the need for further, theoretically driven research in the area in order to develop an in-depth understanding of led outdoor activity accidents and incidents. The next stages of this research will involve the development and implementation of the methods required, and the conduct of the research needed, to enhance the industry's understanding of led outdoor activity accidents and incidents in a way that appropriate preventative measures and management strategies can be developed and implemented.

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6 APPENDICES

6.1 APPENDIX A: ACTIVITY LIST

Camping, including:

- Base camp soft top (i.e. tent type accommodation)
- Base camp hard top (i.e. indoor accommodation)

Bushwalking

Horse back riding

Inland aquatic activities including:

- Canoeing
- Kayaking
- Rafting

Harness sports including:

- Rock climbing
- Initiatives
- Caving
- Abseiling
- Climbing artificial surfaces
- Challenge ropes courses
- Flying fox/ zip line

Marine aquatic sports including:

- Sailing
- Windsurfing
- Sea kayaking
- Surfing
- Swimming
- Snorkelling
- Scuba

Marine wildlife swim

Wheel sports including:

Cycling

Mountain biking

Skating- inline and skateboarding