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Human Performance Laboratories (Australia)

PHYSIOLOGICAL EMPLOYMENT STANDARDS FOR FIREFIGHTERS: *REPORT 1:* THE ESSENTIAL, PHYSICALLY DEMANDING TASKS OF CONTEMPORARY FIRE FIGHTING.

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Human Performance Laboratories (Australia)

Physiological employment standards for firefighters: *Report 1:* The essential, physically demanding tasks of contemporary fire fighting.

EXECUTIVE SUMMARY

Background:

Pre-employment screening tests help to identify individuals well suited to workplace demands and the performance expectations of employers. In physically demanding jobs, screening can ensure that the capability of the workforce is sustained, whilst simultaneously minimising the risk of employee injury. When screening applicants, employers aim to maximise the identification of potentially good employees (true positives or acceptances) and minimise the probability of failing to identify potentially good workers (false negatives or rejections). This attribute reflects the sensitivity of screening procedures. However, screening tests must also correctly identify those for whom the job is too demanding (true negatives or rejections) while minimising the recruitment of inappropriate workers (false positives or rejections). Tests that achieve this outcome are highly specific.

The current research is aimed at providing Fire & Rescue NSW with a series of sensitive and specific screening tools and employment standards (thresholds) that will maximise the identification of true positive and true negative outcomes. However, these tools are also aimed at minimising the number of false positive and negative results.

Three co-existing, yet sometimes incompatible, operational priorities drive recruitment policies for emergency-service organisations. These are workforce operational capability, the minimisation of workplace injury and the avoidance of discrimination. Recruitment must deliver a well-trained and capable workforce. However, the reported injury rate for firefighters within Fire & Rescue NSW is 170.5 injuries per 1,000 full-time firefighters *per annum* (Taylor and Kerry, 2010). This is approximately 50% greater than the injury rate observed for other physically demanding trades within Australia. As part of its health and safety obligation, Fire & Rescue NSW must be able to identify those individuals who are less capable of performing the physically demanding fire-fighting tasks, and who, during the performance of various fire-fighting roles, would be exposed to an unacceptable risk of injury. Pre-employment screening can serve this need. Nevertheless, the employer must also ensure that no individuals, or groups of individuals within society, are discriminated against or treated less favourably.

These three obligations are challenging. However, through the development of *bona fide* physiological and physical employment standards, it is possible to identify capable and robust individuals. This process will satisfy work health and safety requirements with respect to this aspect of the working environment, and it will also address matters of discrimination. The critical legal and scientific steps within this process have been established (Table E-1), and these steps provided the framework for the current research. In this report, the methods and outcomes of the first Phase of this research are described.

Aims:

The first aim of this research Phase was to familiarise the investigators with the operational

requirements of contemporary fire fighting across metropolitan and regional Fire Stations. This involved preliminary briefings, demonstrations and fire-fighting task reviews. The second aim was to meet with subject-matter experts at metropolitan and regional Fire Stations, including permanent and retained firefighters, so that a comprehensive list of the physically demanding tasks could be assembled. The third aim was the validation of this task list across Executive Staff (operational and non-operational) and front-line permanent and retained firefighters.

Table E-1: Procedural summary and framework for developing *bona fide* pre-employment screening tests and physiological employment standards.

Project phase	Step	Description
0	1	Justify need for establishing employment standards
	2	Establish a Project Management Team
1	3	Familiarise research team with the trade
	4	Trade review and preliminary analysis of all tasks
	5	Identify the essential, physically demanding tasks
	6	Validate and approve the fire-fighting task list
	7	Employee survey: importance, difficulty, frequency of tasks
2	8	Characterise critical tasks: observe, measure, quantify
	9	Determine criterion fire-fighting tasks
	10	Validate and approve criterion fire-fighting tasks
3	11	Develop defensible physiological screening tests
	12	Standardise screening tests and administration
	13	Validate and approve screening tests
4	14	Evaluate validity and reliability of screening tests
	15	Acknowledge and approve performance standard development
5	16	Develop performance standards
	17	Validate and approve performance standards
	18	Implement pre-employment screening
		Review the screening process and its outcomes: ongoing

Methods: Comprehensive fire-fighting task list:

The training needs analysis for Fire & Rescue NSW provided much useful preliminary information, and the general classifications formed a framework around which more

detailed task lists were created. However, to generate a comprehensive list of the physically demanding fire-fighting tasks, the researchers interviewed 106 firefighters (~2.5% of the full-time equivalent workforce) at eleven Fire Stations, three of which were retained-only Fire Stations. These Stations were chosen by the Directors for the Metropolitan and Regional Fire Stations such that the broadest range of fire-fighting experience would be made available, although participation was voluntary. Forty-five of those interviewed had served more than 15 years as operational firefighters. Twelve female firefighters (11.3% of the sample) participated, and these Station visits provided a retained sample of 38 firefighters. At each Station, extensive round-table discussions ensued concerning the physically demanding aspects of fire fighting, and this was supported by demonstrations. At four Stations, two platoons from each Station were used, and this process provided an in-Station validation of the tasks identified. In addition, the research team was provided with access to all relevant training manuals and fact sheets. The outcome from this stage was the identification of 50 physically demanding tasks performed by firefighters. In consultation with Executive Staff (operational and non-operational) and several additional subject-matter experts, this list was consolidated and reduced to 31 tasks. In this list, two tasks were included that were identified by the focus groups as relatively simple activities: (1) rolling out uncharged hose lines (38 mm) and (2) 4.6-m ladder use for gaining access, rescue and salvage. These were included as calibration tasks (*e.g.* for importance, difficulty, frequency), since it is recognised that survey tools can be at risk of exaggeration when individuals are asked to rate the frequency, significance and duration of some physical activities. It was anticipated that, if the survey responses resulted in positioning each of these tasks towards the bottom of the rankings for physical demand (effort), then the responses could be viewed as being less prone to exaggeration. This expectation was realised.

Task list (31 items) for evaluation by firefighters: Fire & Rescue NSW

- Rolling out uncharged hose lines: 70 mm
- Rolling out uncharged hose lines: 38 mm
- Finding hydrant, carrying necessary equipment, getting water to appliance
- Coupling and uncoupling hoses
- Dragging 70-mm charged hose across horizontal surfaces
- Dragging 38-mm charged hose across horizontal surfaces
- Dragging 38-mm charged hose up a stairway
- Stair climbing with PPE, BA and charged hose
- Stair climbing: PPE, BA, charged hose, high-rise pack, axe, Halligan Tool
- Prolonged use of charged hose: 38 mm (single person)
- Prolonged use of charged hose: 70 mm (two people)
- Prolonged crawling, kneeling, crouching, squatting: fire attack
- 4.6-m “Jumbo” or “Little Giant” ladder use: gaining access, rescue, salvage
- 10.5-m ladder use: one-person under running
- 10.5-m ladder use: two-person removal and replacement
- Rescue victim via ladder: two people
- Rescue victim via stairs: two people
- Rescue firefighter while wearing PPE and BA: one person
- Rescue victim while wearing PPE and BA: two people

- Moving victims with salvage sheets or Stokes Litter
- Using spreaders and shears
- Prolonged static work (*e.g.* holding victim's head)
- Using sledge hammer to gain entry
- Carrying ventilation fan up stairs: two people
- Carrying Davey pump: two people
- Pulling down ceiling using ceiling hook
- Hazmat: prolonged walking and manual handling when fully encapsulated
- Tunnel search and rescue
- Bush: walking with cordage pack or Stokes Litter
- Bush: dragging charged hose on hilly, sloped, uneven surfaces
- Bush: digging fire break (McLeod Tool).

Methods: Firefighter survey:
To verify and validate the fire-fighting tasks above, firefighters across all ranks and employment classifications were invited to participate in an electronic or paper survey concerning these tasks. This was considered the best way for obtaining a comprehensive and defensible workforce validation, whilst simultaneously obtaining an evaluation of variations in task performance importance, difficulty and frequency for permanent and retained firefighters within both the metropolitan and regional areas served by Fire & Rescue NSW.

Results: Firefighter survey:
Fire & Rescue NSW currently employs 6,781 firefighters. From these, 1,011 individuals returned the survey (including 22 withdrawals), with the vast majority doing this electronically (745 respondents), and 266 completing the paper format. Within each employment category, the following survey returns were realised: 717 permanent (21.4% of this employment category) and 272 retained firefighters (7.9% of this employment category). Responses were received from firefighters within each of five employment classifications: permanent metropolitan = 575, permanent regional = 102, retained metropolitan = 62, retained regional = 210, operational support = 40. The average age of all respondents was 40.6 years (range: 18-74 years), and these individuals had worked with Fire & Rescue NSW for an average duration of 12.8 years (range: 1-49 years).

The subjective task performance ratings (importance, physical effort, frequency and duration) for all fire-fighting tasks were first treated collectively, and then sub-divided into each of the four principal employment classifications: permanent metropolitan, permanent regional, retained metropolitan and retained regional. The purpose of this second analysis was to evaluate the probability that firefighters from different employment classifications may be exposed to different subsets of tasks and to different task frequencies. Since it would be inappropriate to base a pre-employment screening test on physically demanding tasks that a group of workers would not encounter during the course of their employment, then these analyses formed a critical distillation of the survey responses.

Results: Recommended fire-fighting tasks for closer evaluation
The final stage for this Phase was aimed at deriving a list of tasks that would then be studied in fine detail, whilst being performed by operational firefighters from a broad range of

experience and skill levels. The aim is to observe, quantify and evaluate the physical and physiological demands placed upon firefighters during the performance of physically demanding fire-fighting tasks, leading to the characterisation of these tasks.

Since it would be inefficient to study all tasks, the Research Team explored the possible exclusion of tasks if efficiencies could be gained without compromising the integrity of the process. Therefore, in combination with the survey responses (Tables 10-16), a filtration mechanism was devised (Figure E-1) and applied to the four employment classifications.

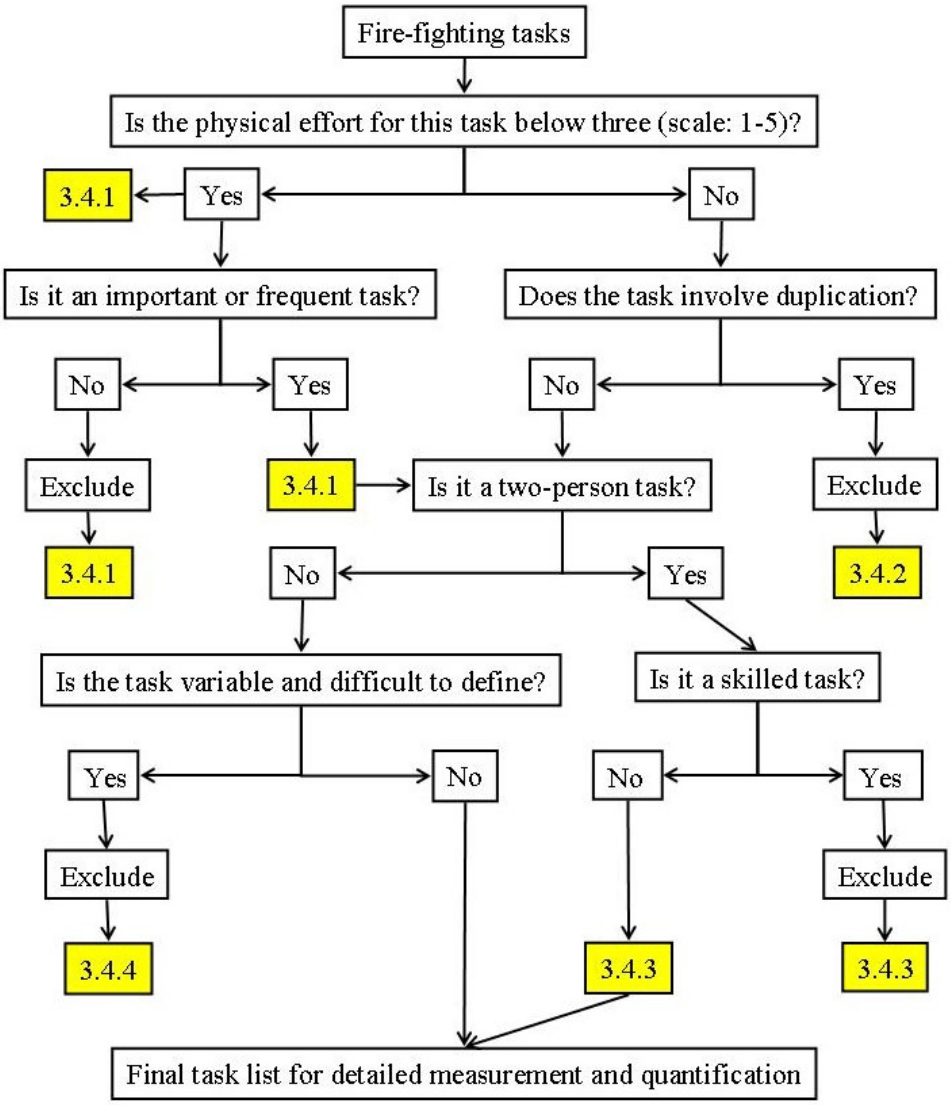

Figure E-1: A flow chart for determining the final list of fire-fighting tasks for detailed evaluation and analysis. The numbered boxes for task exclusion criteria relate to Section numbers from this report (see text for details).

Exclusion criterion one: tasks with sub-threshold physical effort

This criterion resulted in the elimination of tasks for which the required physical effort reported in the survey was less than three (scale: 1-5). This physical effort threshold was

based upon the responses of all firefighters to each of the two calibration tasks (rolling out 38-mm hose (mean response: 2.4) and using a 4.6-m ladder to gain access, rescue or complete salvage work (mean response: 3.0)), with the higher average of the two responses taken as the threshold. That is, this first exclusion criterion was based upon task difficulty being rated less than that of the more difficult of the two calibration tasks. Sub-threshold tasks are unlikely to be useful in the identification of either potentially superior or inferior firefighters, and would probably not be included within a pre-employment screening test, at least as individual test items. Tasks eliminated from each employment category were:

- Rolling out 70-mm hose:
  - retained metropolitan
  - permanent regional
  - retained regional.
- Rolling out 38-mm hose *{This item was included as a calibration task}*:
  - permanent metropolitan
  - retained metropolitan
  - permanent regional
  - retained regional.
- Finding hydrant, carrying necessary equipment, getting water to appliance:
  - retained metropolitan
  - retained regional.
- Coupling hoses:
  - permanent metropolitan
  - retained metropolitan
  - permanent regional
  - retained regional.
- 4.6-m ladder use: gaining access, rescue, salvage *{This item was included as a calibration task}*:
  - permanent metropolitan
  - permanent regional.
- Prolonged static work (*e.g.* holding victim's head):
  - permanent metropolitan
  - permanent regional.

However, if a sub-threshold task was performed very frequently (>30 occasions annually: *i.e.* higher than the more frequent calibration task), or if it was more important than the higher of the two calibration tasks (4.1 on scale 1-5), or if it was identified as an activity that was reported by more than 20% of all firefighters to be limited by their physical capabilities (Table 16), then the task was retained. Tasks retained on these bases were:

- Finding hydrant, carrying necessary equipment, getting water to appliance:
  - permanent metropolitan: importance criterion (4.5)
  - retained metropolitan: importance criterion (4.5)
  - permanent regional: importance criterion (4.4)
  - retained regional: importance criterion (4.4).
- Coupling hoses:
  - task limited by physical capacity criterion: all classifications
  - permanent metropolitan: frequency criterion (39.9 times *per annum*)

- retained metropolitan: frequency criterion (49.8 times *per annum*)
- permanent regional: frequency criterion (36.8 times *per annum*)
- retained regional: frequency criterion (40.8 times *per annum*).

Exclusion criterion two: task duplication

This criterion was aimed at possibly eliminating tasks that duplicated other activities. Since duplication would be inefficient, then, where two or more tasks were deemed to be sufficiently similar in nature, the more difficult of these tasks has generally been retained (*i.e.* tasks requiring greater physical effort). Tasks eliminated at this step include the following, and this occurred simultaneously across each of the four employment classifications in cases where duplication was relevant for tasks still within the list:

- Dragging 38-mm charged hose across horizontal surfaces: More physical effort is required to drag a 70-mm charged hose and to drag a 38-mm charged hose up a flight of stairs (Table 11).
- Dragging 38-mm charged hose up a stairway: Duplicates stairs climbing when wearing the full personal protective ensemble (breathing apparatus) and dragging charged hose; the latter was rated as more difficult (Table 11).
- Moving victims with salvage sheets or Stokes Litter: Across classifications, firefighters rated this task to be less difficult (Table 11) and less important (Table 10) than a one-person rescue of a firefighter wearing the full personal protective ensemble and breathing apparatus.
- Prolonged static work (*e.g.* holding victim's head): In all employment classifications, firefighters rated this task to be less difficult than using spreaders and shears (Table 11):
  - retained metropolitan
  - retained regional.
- 4.6-m ladder use: gaining access, rescue, salvage: In all employment classifications, firefighters rated this task to be less difficult than using a 10.5-m ladder (under running; Table 11) *{This item was included as a calibration task}*:
  - retained metropolitan
  - retained regional.
- Stair climbing: PPE, BA, charged hose, high-rise pack, tools: For three of the four employment classifications, this task was rated as less difficult than stair climbing when wearing the full personal protective ensemble and breathing apparatus, and dragging a charged hose (Table 11).
- Carrying Davey pump: two people: Across all classifications, firefighters rated this task to be less difficult than carrying the ventilation fan (Table 11).
- Bush: walking with cordage pack or Stokes Litter: Less effort than dragging a charged hose (bush) on hilly, sloped and uneven surfaces (Table 11).

Exclusion criterion three: two-person tasks

When two people perform a task, there is always an interaction between those individuals, and the extent of this interaction is influenced by factors such as the level of skill (technique) involved in the task, and the effort that is applied by each individual to the task. This introduces uncontrollable variability (noise) within a task performance, and it reduces

measurement precision. Therefore, the Research Team sought to eliminate this variability by removing, where relevant and practical, tasks that are typically performed by two firefighters and which also have a significant skill component. While such tasks may be difficult, it is often very much harder to evaluate the contributions of each individual to the whole task. Moreover, since the ultimate aim of this Project was to develop screening test recommendations for use on individuals, then tasks that involve two individuals are less than ideal for evaluating individual performance. The following tasks were considered to have a significant skill component, and were eliminated from all classifications:

- Rescue victim while wearing PPE and BA: two people: In all employment classifications, firefighters rated this task to be less difficult (Table 11) and less important (Table 10) than a one-person rescue of a firefighter wearing the full personal protective ensemble and breathing apparatus.
- Rescue victim via ladder: two people: Eliminated due to skill required, effort of second person and difficulty of incorporating this task into a single-person screening test. This task was considered to be potentially more dangerous for use in a screening test.
- Rescue victim via stairs: two people: Eliminated due to skill required, effort of second person and difficulty of incorporating this task into a single-person screening test. This task was also considered to be slightly more dangerous.
- 10.5-m ladder use: two-person removal and replacement: Task was rated less difficult than using a 10.5-m ladder (under running) by all classifications (Table 11).

However, if a two-person task was unskilled and individual contributions could easily be measured, then that task was retained. One task was retained across all classifications:

- Carrying ventilation fan up stairs: two people: This task was universally rated as being more difficult than carrying the Davey pump (Table 11), and it is easy to determine the load distribution for this task between two individuals. Thus, one could imagine that performance on a single-handed carry task could provide an excellent prediction of performance for this task.

One two-person task presented difficulty for the Research Team.

- Prolonged use of charged hose: 70 mm (two people): Even though this task is a two-person activity, it was universally rated as requiring more physical effort that using a 38-mm charged hose (Table 11). It was therefore recommended for inclusion.

Exclusion criterion four: task is variable and difficult to define

Three tasks were difficult to define, due both to the nature of each task and the widely variable duration reported for each within the survey. These characteristics would make it very hard to narrow these tasks down into a discrete and reproducible task (with clear start and end points) that could be simulated, evaluated and subsequently used within a screening test. Whilst this may be so for many activities of fire fighting, it is particularly pertinent to the tasks below. Indeed, this limitation would render the inclusion of such items within screening tests as questionable. That is, one may argue that since the ends points were hard to define, then task performance thresholds would be equally hard to define. On this basis,

the following tasks were eliminated from each employment classification:

- Tunnel search and rescue:
  - permanent metropolitan: duration 28.0 min (SD 37.7)
  - retained metropolitan: duration 12.0 min (SD 10.7)
  - permanent regional: duration 33.2 min (SD 46.4)
  - retained regional: duration 19.7 min (SD 13.9).
  - In addition, this activity involved duplication with several other tasks, and all classifications rated it as being less difficult than (Table 11):
    - prolonged crawling, kneeling, crouching, squatting: fire attack
    - rescue firefighter wearing protective equipment and breathing apparatus (one person)
    - dragging a 70-mm charged hose
    - dragging a charged hose (bush) on hilly, sloped and uneven surfaces.
- Pulling down ceilings using ceiling hook:
  - permanent metropolitan: duration 13.5 min (SD 17.0)
  - retained metropolitan: duration 9.1 min (SD 8.4)
  - permanent regional: duration 18.0 min (SD 30.2)
  - retained regional: duration 12.3 min (SD 8.6).
- Bush: digging fire break (McLeod Tool):
  - permanent metropolitan: duration 62.9 min (SD 67.9)
  - retained metropolitan: duration 26.0 min (SD 22.4)
  - permanent regional: duration 64.8 min (SD 75.5)
  - retained regional: duration 24.3 min (SD 16.3).

Tasks inclusion cross-check procedures

The final stage of this analysis involved cross-checking methods to ensure that tasks had not been eliminated from the final task list without an appropriate justification. This involved two steps.

The first step was focussed upon task importance, difficulty, and task performance frequency, duration and work volume[1]. Within Tables 10-13, these critical tasks were identified (red shaded cells). Thus, this analysis involved cross checking to see that these tasks had not been eliminated from the final task list without an appropriate justification. Only three tasks from those highlighted within Tables 10-13 were not included at the end of this process, and these, along with the reasons for their exclusion, are provided below:

- Rolling out 70-mm hose: Excluded from three classifications (retained metropolitan, permanent regional and retained regional) due to physical effort being less than the threshold of the more difficult calibration task (three).
- Bush: walking with cordage pack or Stokes Litter: Excluded from all classifications due to task duplication and requiring less effort than dragging a charged hose (bush) on hilly, sloped and uneven surfaces.
- Bush: digging fire break (McLeod Tool): Excluded from all classifications due to the task being both widely variable in duration and difficult to define.

[1] Work volume (minutes) is derived from the product of task frequency and task duration.

The second step emphasised tasks that were identified as being limited by the capacity of each respondent. The threshold for this check was that used within Section 3.4.1 (*i.e.* at least 20% of all firefighters found the task to be limited by their physical capabilities: Table 16 (red cells)). Therefore, this stage also involved cross checking to ensure that such tasks had not been eliminated without an appropriate justification. Only one task from those highlighted within Table 16 was not included at the end of this process:

- Stair climbing: PPE, BA, charged hose, high-rise pack, tools: For three of the four employment classifications, this task was rated as less difficult than stair climbing when wearing the full personal protective ensemble and breathing apparatus, and dragging a charged hose (Table 11).

The final step of cross-checking involved a *post hoc* comparison of these tasks by computing the subjective stress imposed on firefighters when performing each task. Stress was derived from the simple product of the subjective task difficulty rating and the task performance frequency. These data permitted a simple ranking of all tasks with respect to imposed stress, and the ranks for the 15 tasks identified from these procedures were compared. This revealed remarkable consistency across employment classifications. Therefore, whilst surveys can result in the artificial inflation of the absolute values for subjective ratings, the uniformity of the current responses indicated that the relative position of each task within this ranking was valid.

The current methods, in combination with the survey sample size, have resulted the valid identification of the essential fire-fighting tasks for the next Research Phase. The tasks identified represent the appropriate fire-fighting tasks for each of the employment classifications of firefighters. Across these four classifications, tasks included at least one of the top three most stressful tasks, and at least five of the ten most stressful tasks. This, the current methods have led to the valid identification of both high- and low-stress tasks, and within each employment classification, the tasks identified represent a broad range of stress.

Recommended tasks for detailed investigation and analysis

Preliminary evaluation of the fire-fighting task list

The list of recommended tasks from these analyses was provided to Fire & Rescue NSW for preliminary evaluation, in the form of a draft version of this report. This evaluation occurred across two teleconferences (November 14th and 18th, 2011) between the Research Team and representatives of Fire & Rescue NSW (Assistant Director Health and Safety, Team Leader for Health and Fitness and Manager of Health Promotion). During these meetings, the Research Team provided additional information concerning the research methods, data analysis and the reported outcomes. These discussions resulted in several text revisions necessary to conform with the language, terms and descriptions used by Fire & Rescue NSW, but also to enhance the clarity of the analysis procedures and the corresponding text for readers across all levels of that organisation.

From these analyses, 15 fire-fighting tasks were identified across each of the employment classifications for further investigation in Phase Two of this Project (Table E-2).

Table E-2: Recommended fire-fighting tasks and observation durations (minutes) for detailed investigation in Phase Two of this project. Times taken from Table 13 and rounded to the nearest whole minute.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out uncharged hose lines: 70 mm	3	1	6	2
Hydrant: locating and connecting	6	5	10	4
Coupling and uncoupling hoses	2	4	6	2
Drag 70-mm charged hose: horizontal	7	4	10	5
Stair climb with PPE, BA, hose	10	7	13	8
Prolonged use of 38-mm hose	32	24	32	24
Prolonged use of charged hose: 70 mm (two people)	38	19	30	17
Fire attack: prolonged crawl, kneel, crouch, squat	18	18	24	16
Ladder use (10.5 m): 1-person, under run	8	5	10	7
Rescue FF with PPE, BA: 1 person	8	10	12	12
Using spreaders and shears	20	14	24	19
Using sledge hammer to gain entry	3	4	7	5
Carry: ventilation fan (up stairs): 2 people	7	6	10	7
Hazmat: walking, manual handling (encapsulated)	30	18	32	20
Bush: drag charged hose (hilly, sloped, uneven)	58	21	50	24

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional.

Conclusion:

On the basis of the methods adopted for this research, and the survey verification involving 717 permanent and 272 retained firefighters employed by Fire & Rescue NSW, it is concluded that this task list represents a valid and representative subset of physically demanding activities associated with fire fighting in regional and metropolitan NSW. This list has been assembled by following a logical flow chart (Figure E-1) to determine task inclusion and exclusion criteria, and through an evaluation of task criticality, the physical effort required to perform each task and task performance frequency.

Approval:

This task list was verified, endorsed and approved by the Project Management Team on February 27th, 2012: Appendix 15 of this report). Progression to the next research Phase for this project was also approved.

AUTHORS

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*Nigel is a human stress physiologist with over 25 years of research experience, and with particular research emphases within exercise physiology, temperature regulation, and work-based physical and physiological assessments and interventions. Nigel's research training was based in Europe and North America, and included extensive involvement with Defence organisations from both continents. He participates in a five-way research collaboration (Environmental Physiology and Ergonomics Research Exchange) involving laboratories in France, Japan, Slovenia and the United Kingdom (www.uow.edu.au/health/epere/index.html). Nigel's research often focuses upon the interface between the worker and the environment, and how human performance may be optimised under physical and environmental extremes (occupational physiology). He has an extensive research background, with more than 300 publications. Nigel is the Vice Chair of the **IUPS Advisory Committee for Thermal Physiology and Pharmacology**. He is the Reviews Editor for the **European Journal of Applied Physiology** and an International Editorial Board member of seven other refereed journals (including Medicine & Science in Sports & Exercise).*

Hugh H.K. Fullagar, *B.Sc.*
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Hugh is a Master of Science student within the School of Health Sciences (University of Wollongong). His undergraduate training was in the discipline of exercise science, majoring in exercise physiology. His current research is centred upon the development of valid and reliable physiological employment standards for Fire & Rescue NSW.

Dr. John A. Sampson, *Ph.D.*
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John has recently completed his Doctoral dissertation within the School of Health Sciences (University of Wollongong), examining musculoskeletal adaptation to resistance exercise. His primary research interest is encompassed within the physiological adaptations that are associated with exercise. The focus of his current and future work is in manipulating exercise training programmes to reduce total work, but without compromising the associated physiological adaptations observed during exercise training.

Dr. Herbert Groeller, *Ph.D.*
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Herb has over 20 years of experience working as an exercise physiologist with occupational, healthy active, sports-injured, aged and cardiac patient groups. He has also worked with various groups as a consultant, advising on the physiological demands and requirements of specific work tasks, the implementation of functional testing regimens, and medical screening procedures and health initiatives. Herb's past research centred upon the impact of

exercise habits on cardiovascular risk factors in middle-aged and older males. His current research focus is upon skeletal muscle strength adaptation within healthy and clinically relevant population samples.

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1. INTRODUCTION

1.1 Predicting job performance

Predictive tools of human functional or pathological states are used across many domains when it is either unfeasible or impossible to take precise measurements. For instance, screening tests and diagnostic tools are used to identify high-risk individuals with respect to cardiovascular disease. However, such tools are only useful when they possess strong predictive capacities. This is illustrated in Figure 1, where a screening tool has a predictive power permitting approximately 75%[2] of those with cardiovascular disease to be correctly diagnosed. For trades that place heavy physical burdens upon workers, some employers use pre-employment screening tests to identify individuals who are well suited to those demands, thereby increasing the capability of their workforce, whilst simultaneously minimising the risk of injury. In the current project, the investigators have been tasked with identifying potential screening tools that may facilitate this predictive process for Fire & Rescue New South Wales (NSW).

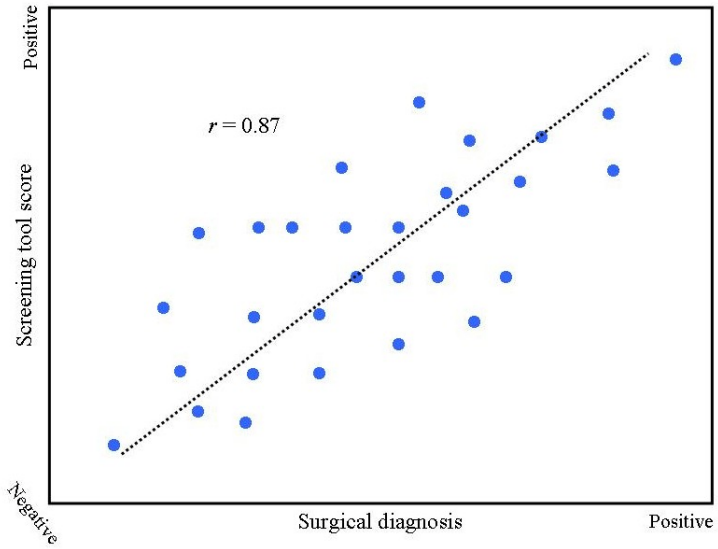

Figure 1: The hypothetical correlational relationship[1] between a diagnostic screening questionnaire (ordinate) and a clinical diagnosis, based upon invasive surgical procedures (abscissa). Both axis scales range between absolute (100%) certainty of a negative (no disease) to a positive diagnosis.

However, whenever such predictive indices are used, the probability exists for both correct and incorrect classifications to eventuate. In the absence of very invasive surgical procedures, some uncertainty concerning disease diagnosis will generally remain. As more

[2] The relationship between two independent sets of data can be evaluated statistically using correlation analyses (cross-correlation). In its most simple form, such a relationship is generally represented by a straight line passing through these data points, with the goodness of fit (*e.g.* least-squares, best fit) for this line being given by the correlation coefficient (r: range -1.00 to +1.00). Strong correlational relationships approach either end of the correlation range, and can be used to predict variations in one set of outcomes on the basis of changes in another (outcome synchronisation). Such predictions can be positive (*e.g.* $r=0.87$), with a strong correlation indicating a high predictive probability (Figure 1). If one squares the correlation coefficient (r^2) and multiplies the product by 100 ($r^2=75.7$), then the result indicates that one can explain about 75% of the variability in one variable (surgical diagnosis) on the basis of changes in the other variable (screening tool score).

knowledge is obtained concerning the relationships between disease and lifestyle choices, pre-clinical signs and the various predisposing clinical states, then the chance of making an incorrect diagnosis from the screening tool is reduced, but it can never be completely removed. Tools with greater sensitivity possess greater diagnostic power, and are generally capable of detecting the presence of cardiovascular disease when it actually exists. This is a true positive classification (Figure 2).

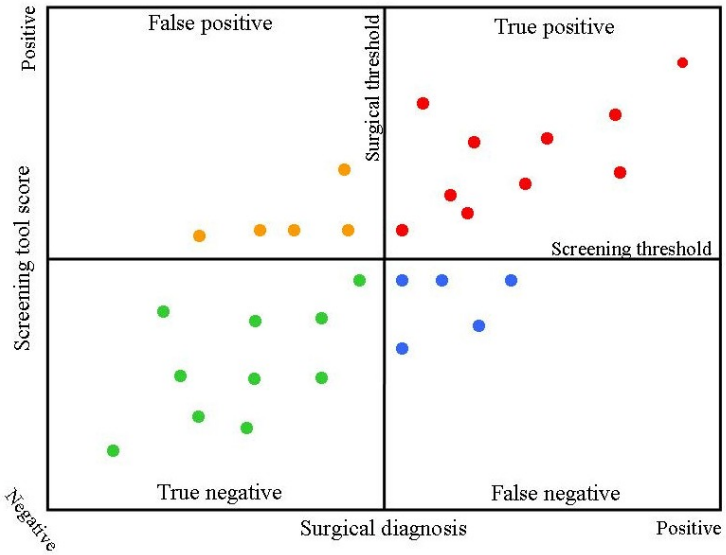

Figure 2: Hypothetical diagnoses of cardiovascular disease using a screening questionnaire (ordinate) and invasive surgical procedures (abscissa). Axis scale ranges: absolute certainty of negative to positive diagnoses.

If one continues this disease analogy, then the assumption that even surgical diagnosis can be imprecise leads to assigning a diagnostic threshold beyond which uncertainty is minimal (Figure 2: surgical threshold). For the screening tool, a similar uncertainty threshold may be employed (screening threshold). These thresholds sub-divide the graph, with the lower left and the upper right corners (quadrants) of Figure 2 defining zones of greatest diagnostic certainty. For both our clinical analogy and Fire & Rescue NSW, the upper right quadrant of Figure 2 is critical. In the latter instance, this quadrant contains applicants with a high probability of possessing superior fire fighting potential and considerable injury resilience. However, as one moves diagonally from the upper left to the lower right, screening delivers false classifications, both of which are problematic.

In complex emergency-service and military trades, pre-employment training is extensive and costly, and the work of such individuals is vital to the safety and protection of others, and of community and private property. Whilst it can be argued that the best measure of one's ability to perform a task is the actual performance of that task, it is most inefficient to first train individuals only to find them to be incapable in the workplace, and prone to injury. Therefore, trade-specific screening tests are used during recruitment for some physically demanding jobs, but particularly for those that serve the community at large.

When screening applicants, employers aim to maximise the identification of true positives (potentially good firefighters: true acceptances), whilst minimising false negative outcomes (failing to identify potentially good firefighters). Thus, researchers aim to produce pre-employment screening tests and physiological employment standards that have an elevated potential for correctly identifying capable employees. This attribute reflects the sensitivity[3] of the screening procedures (see also: precision rate or positive predictive value[4]). However, screening tests and standards must also correctly identify those for whom the job is too demanding (true negatives or true rejections), whilst simultaneously minimising the number of false positive outcomes, by failing to identify, yet still recruiting, potentially inferior firefighters. In this case, researchers aim to provide screening tools that possess a high degree of specificity[5] (see also: negative predictive value[6]). These concepts are illustrated in Figure 3, using green and red shading to reflect the sensitivity and specificity (respectively) of an hypothetical pre-employment screening procedure.

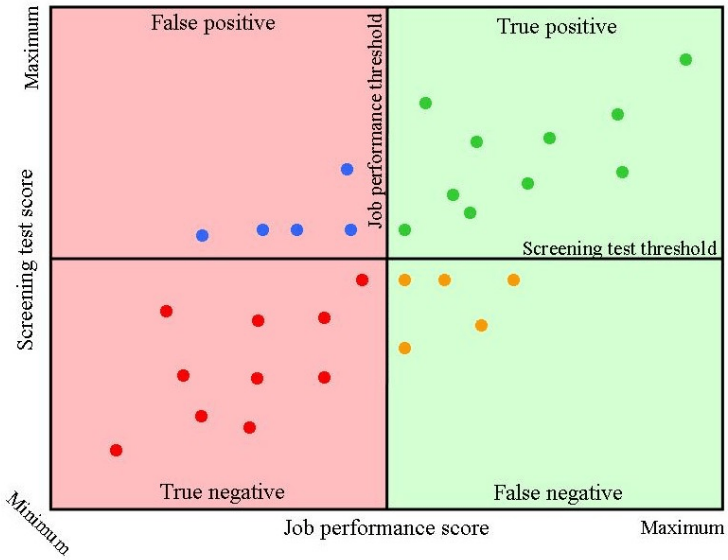

Figure 3: Hypothetical recruit screening from a pre-employment screening tool (ordinate) and from actual job performance ratings (abscissa). Scales range between minimum and maximum scores for each rating. The green shading defines individuals who possess the physical and physiological attributes consistent with the capable performance of fire-fighting duties. The red zone corresponds to those who do not currently possess these attributes.

In this illustration (Figure 3), nominal pass/fail thresholds (performance standards) have been arbitrarily set (for illustrative purposes only) at mid points along both scales.

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[3] Figure 3 (green shading): Test sensitivity = [True positives] / [True positives + False negatives] * 100 (%)

[4] The positive predictive value estimates the percentage of capable workers identified relative to all who pass a screening test: Positive predictive value = [True positives] / [True positives + False positives] * 100 (%)

[5] Figure 3 (red shading): Test specificity = [True negatives] / [True negatives + False positives] * 100 (%)

[6] The negative predictive value estimates the percentage of incapable workers identified relative to all who fail a screening test: Negative predictive value = [True negatives] / [True negatives + False negatives] * 100 (%)

However, since job performance cannot be determined from recruits, then it is imperative that standards (thresholds) are derived using current firefighters, with individuals drawn from a broad range of performance standards, but including an adequate representation of minority groups currently employed with the trade. It is also critical to include those from above and below a pre-determined threshold for acceptable job performance. The current research is aimed at providing Fire & Rescue NSW with a series of screening tools and physiological employment standards (thresholds) that maximise the number of potential firefighters who fall within both of the true quadrants (true acceptances and true rejections) whilst minimising those falling within the two false quadrants (false acceptances and false rejections).

For pragmatic reasons, sometimes related to economic, societal or political motivations, it might be argued that one could move these thresholds to optimise recruiting efficiency and effectiveness. However, changing the job performance threshold would generally not be countenanced, since it implies that the criteria for successful job performance were plastic, and open to arbitrary manipulation. Nevertheless, a significant change in work practices, such as increased automation, would necessitate precisely this type of a threshold change. Indeed, altered fire-fighting practices over the past 20 years demand that the job performance threshold be re-evaluated, and this is a principal justification for the existing research. Generally, however, it is the screening test that is considered when one contemplates a threshold manipulation.

If one was to lower the pass threshold for a screening test, then one could simultaneously, *albeit* artificially, elevate the number of true positives, whilst reducing the number of false negatives. This would appear to make recruit screening more sensitive, and the impact of this is illustrated in Figure 4 (left). Unfortunately, this is associated with a concurrent reduction in the specificity of the screening procedures, and this means that more false positive (inferior) individuals would be recruited, thereby lowering the average capability of the workforce, while also increasing the number of individuals who are at greater risk of suffering work-related injuries. Another strategy might be to elevate the same threshold (Figure 4: right). Now both the number of true acceptances and the test sensitivity would be reduced. However, the employer could have great faith in the capability of these workers, and this would result in a concomitant rise in the specificity of the screening test along with a reduction in the number of inferior (false positive) workers being recruited. Neither of these strategies could be justified scientifically. Indeed, the former may contravene State occupational health and safety obligations (New South Wales Government, 2000), while the latter may be discriminatory (Fair Work Act, 2009).

A more acceptable way to modify the sensitivity and specificity of a screening test is to reduce both the intra-individual and inter-individual variability between the results of a pre-employment screening test and actual job performance. This is illustrated in Figure 5, where the goodness of fit between these outcomes has risen from very poor (upper left: $r=0.45$) to very strong (lower: $r=0.95$). In the first case, either the screening test was unreliable, and failed to provide reproducible outcomes, it was inherently invalid, failing to provide a useful prediction of job performance, or both of these limitations co-existed. In the latter case (lower), a very strong relationship has been created between job performance and the

pre-employment screening procedures by using valid and reproducible procedures, yielding significant reductions in the number of false positive and false negative outcomes.

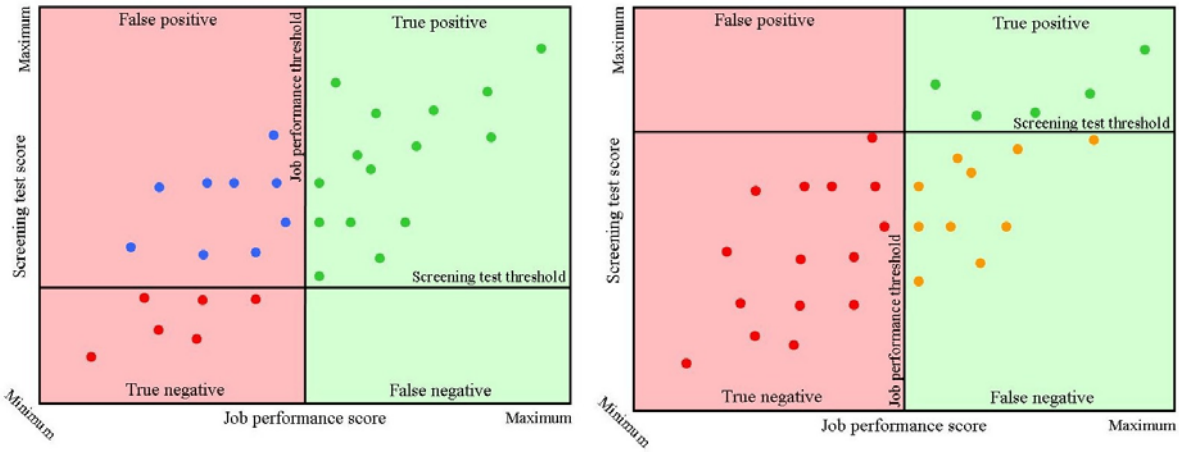

Figure 4: The affects of lowering (left) and elevating (right) the threshold for a pre-employment screening tool on recruitment outcomes.

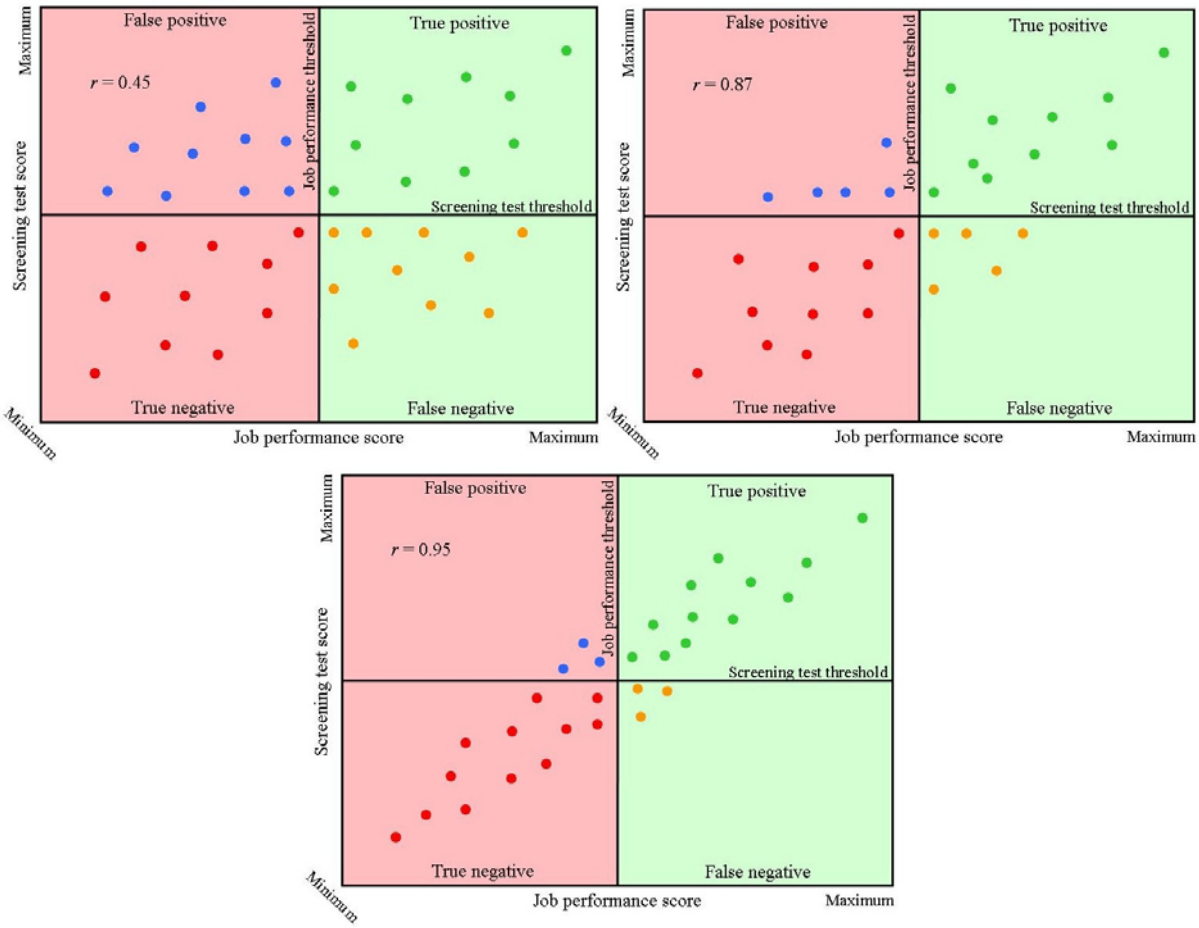

Figure 5: The affects of increasing the validity and reproducibility (reliability) of a pre-employment screening tool on recruitment outcomes.

1.2 Capability, injury prevention and discrimination

The previous theoretical treatment of screening tools provides essential background information concerning the central issues that surround this type of research. However, recruitment policies for emergency-service and defence organisations are driven by needs to provide a workforce with the required operational capability, a workforce in which work-related injuries are minimise, and recruitment practices that do not discriminate against some members of society. These policies are sometimes incompatible.

The first recruitment priority relates to the need to provide a well-trained and capable workforce, and since fire fighting is a most physically demanding profession (Davis *et al.*, 1982; Gledhill and Jamnik, 1992; Bilzon *et al.*, 2001), then it is necessary to understand how to identify individuals who are truly capable of performing these tasks (true positives). Indeed, it can be argued that a failure to secure the services of such suitable employees would render Fire & Rescue NSW incapable of serving its obligations to the community. Moreover, one may argue that, while some reasonable accommodation[7] of incapable individuals may be possible, such accommodation could represent an excessive and unreasonable burden upon some employers (under hardship[8]: Canadian Human Rights Commission, 2007). If the case for such a circumstance can be justifiably established, then it reduces the legal obligation upon the employer to accommodate less capable workers (justifiable exclusion). However, this can only be applied if there has been a reasonable evaluation and exploration of the possibility for accommodation to occur, if the procedures used to identify such individuals are valid and reproducible (reliable), and if these procedures have been applied on the basis of the physical demands associated with job performance and the minimal standards necessary to fulfill those demands (Hatfield, 2005).

Secondly, and perhaps by virtue of the demands of the trade, fire fighting exposes individuals to a high probability of suffering a work-related injury. For example, approximately 695 firefighters from Fire & Rescue NSW (17.1% of the full-time workforce) sustain an injury each year (Taylor and Kerry, 2010), with >98% of these injuries occurring when performing work-related duties. This represents an average of 170.5 injuries per 1,000 full-time firefighters *per annum*, which is approximately 50% greater than the injury rate observed for other physically demanding trades within Australia (Australian Bureau of Statistics, 2008). One possibility that may predispose some individuals to injury is a mismatch between their current physiological capabilities, and the physical demands of contemporary fire fighting. Therefore, it is a health and safety obligation (duty of care) of Fire & Rescue NSW, when insuring the provision of safe working conditions (New South Wales Government, 2000), to know how to identify those

[7] Accommodation refers to the making of provisions within the workplace to permit otherwise less capable individuals to successfully perform a job. Several considerations are necessary, and these pertain to altered hazards and risks within the workplace following accommodation, the extent and likely impact of these changes, and whether or not these are offset by the benefits associated with accommodation (Hatfield, 2005).

[8] Three facets of undue hardship are directly relevant: an onerous financial burden on the employer, perhaps affecting the viability of the organisation; reduced health and safety for the worker, co-workers and the general public; and capability of the workforce with respect to its community obligations. However, Hatfield (2005) has identified others that may be of relevance to some (but not all) employers: workforce size; adaptability of the workforce and its infrastructure; possible affects upon collective agreements; possible infringements with the rights of other workers; and the morale of employees.

individuals who are less capable of performing physically demanding tasks, and who, during the performance of various fire-fighting roles, would be exposed to an unacceptable risk of injury. Such injuries may have physical, physiological, medical and psychological impacts upon the employee. They may adversely affect work performance, general health and well-being, as well as personal, family and social functions and recreational pursuits. Furthermore, the employer must also consider the health and safety of co-workers and the public (Hatfield, 2005), who may be placed in jeopardy by individuals who are incapable of meeting the physical demands of the job. There is no requirement of the employer to accommodate individuals who may be deemed to be at an elevated risk of injury (justifiable exclusion) if, in doing so, they, or others, would be exposed to a greater than acceptable risk of work-related injury. Indeed, compensation claims for work-related injuries may be filed against employers who fail to identify high-risk individuals, particularly when existing valid physiological employment standards existed, but were not applied, when such standards were inappropriately applied, or when invalid and inferior standards were applied during recruitment or throughout employment tenure. Such claims could be justified on the basis of adverse action[9] against the employee (Fair Work Act, 2009).

Thirdly, when screening tests are used to facilitate recruitment, the employer must ensure that individuals, or groups of individuals within society, are not discriminated against, or treated less favourably. Whilst the Fair Work Act (2009) deals with many different forms of discrimination, those that relate to physically demanding jobs are generally covered within the categories of age, disability, ethnic background and gender (including pregnancy). Discriminatory practices are described as having an adverse action[10] (Fair Work Act, 2009) or an adverse impact[11], either directly or indirectly, upon one or more groups of individuals, and several legal precedents serve to direct decisions in this regard. Perhaps the most widely recognised gender-related discrimination case was that of Meiorin (Supreme Court of Canada, 1999a), and later the same year, the Grismer service discrimination case occurred, based upon a visual disability (Supreme Court of Canada, 1999b). These two cases helped to frame Canadian legislation concerning discrimination, under the Canadian Human Rights Act (Canadian Human Rights Commission, 2007). In the U.S., the Equal Employment Opportunity Commission (1978) established an 80% threshold[12] for determining adverse impact. That is, if one sub-group of the population, following the application of pre-employment screening, fails to obtain an employment representation equal to 80% of the highest population sub-group currently employed within that trade, then the screening procedures would appear to have exerted an adverse action or impact upon that group of individuals (Equal Employment Opportunity Commission, 1978). This is

[9] The employer injures, or fails to prevent the injury of the employee during the course of employment.

[10] A prospective employer discriminates against an existing or prospective employee by refusing employment, or by offering unfair terms or conditions of employment, on the basis of that person's race, colour, gender, sexual preference, age, physical or mental disability, marital status, family or carer's responsibilities, pregnancy, religion, political opinion, national extraction or social origin (Fair Work Act, 2009).

[11] A substantially different rate of employment entry that disadvantages members of any societal group.

[12] "The four-fifths rule" (Equal Employment Opportunity Commission, 1978): The U.S. Equal Employment Opportunity Commission deemed that a recruitment rate for any group (*e.g.* women) that is $<80\%$ of the recruitment rate for the group with the highest representation (*e.g.* men) will generally be regarded as evidence of discrimination against the former group.

illustrated in Figure 6. When an unequal employment representation can be established (those sub-groups below the bar in Figure 6), there may be an obligation upon the employer to accommodate such individuals (Fair Work Act, 2009), unless the possibility of reasonable accommodation has been thoroughly investigated (Hatfield, 2005), a case for undue hardship on the employer has been established (Hatfield, 2005; Canadian Human Rights Commission, 2007), the occupational health and safety of workers, co-workers or the public has been jeopardised (New South Wales Government, 2000)[13], or the existing recruiting programmes result in the pool of applicants from that group being atypical representatives[14] of that group (Equal Employment Opportunity Commission, 1978).

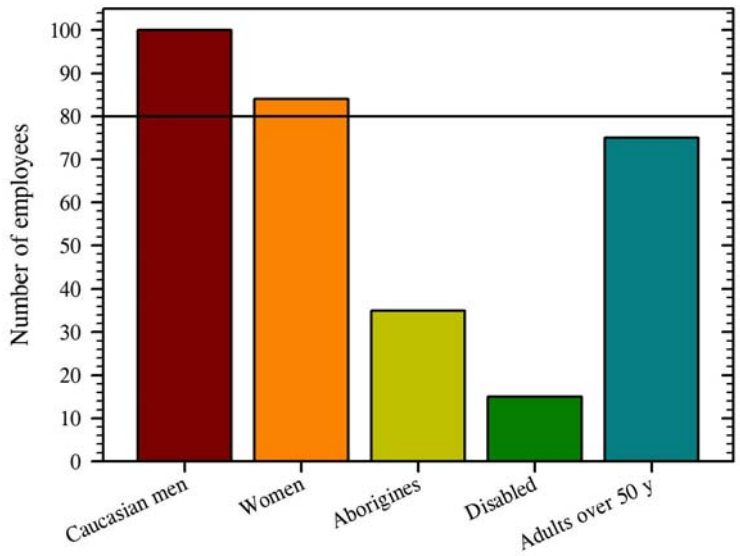

Figure 6: Hypothetical employment representation of five sub-groups within a company of 309 employees. Caucasian men are the largest sub-group. The "four-fifths rule" implies that any sub-group with a representation falling below the horizontal bar (80 employees) may be unfavourably represented (Equal Employment Opportunity Commission, 1978).

These three obligations are challenging. However, through the development of *bona fide* physiological and physical employment standards, it is possible to identify individuals who are capable of fire fighting and who are unlikely to suffer personal injury due to the demands of the job. This process will satisfy work health and safety requirements with respect to this aspect of the working environment (New South Wales Government, 2000), whilst simultaneously addressing matters of discrimination (Fair Work Act, 2009). Furthermore, through the identification and quantification of the most demanding tasks of fire fighting, then through the construction and validation of appropriate screening tests, and

[13] Occupational health and safety legislation within Australia falls under the jurisdiction of each State and Territory. Whilst largely having common requirements, variations do exist across States and Territories.

[14] This may occur when the sub-group sample that applies for a job is, as a result of the nature of the work, comprised of predominately elite representatives from that sub-group. Under these circumstances, such a sample would no longer be deemed to be a fair representation, either in its attributes or in its number, of that societal sub-group.

finally through the careful and thorough determination of physiological employment standards, Fire & Rescue NSW will be placed in a position to identify those individuals who possess the physical and physiological attributes necessary for fire fighting.

Whilst these employment standards may perhaps result in a disproportionate exclusion of the individuals from some sub-groups within society, exclusion criteria must be designed to minimise the risk of injury to such individuals, while at the same time ensuring the provision of a capable workforce for the community that Fire & Rescue NSW serves, and without placing an undue hardship upon that organisation. Moreover, if it can be demonstrated that members from such a sub-group are responsive to physical training, such that training results in satisfactorily lowering the exclusion rate, and this has been shown to occur (Kraemer *et al.*, 2001; Jamnik *et al.*, 2010c), then adverse action or impact does not exist. Instead, when such training reveals that the attributes necessary for the job are able to be manipulated, then it is the health and fitness of the individuals, and not the physiological employment standards *per se*, that have created the adverse action or impact.

The discussion above largely relates to examples of justifiable exclusion of some individuals from certain categories of employment. These are legally defensible positions (Equal Employment Opportunity Commission, 1978; New South Wales Government, 2000; Gledhill and Bonneau, 2001; Canadian Human Rights Commission, 2007; Fair Work Act, 2009; Jamnik *et al.*, 2010). However, there is a prescribed series of steps that must be undertaken by the Research Team to provide this defensible state for Fire & Rescue NSW (Gledhill and Bonneau, 2001; Taylor and Groeller, 2003; Jamnik *et al.*, 2010a; Payne and Harvey, 2010), and this is the focus of the next Section of this report.

1.3 Establishing legally defensible physiological employment standards

The provision of genuine, certifiable (*bona fide*) and legally defensible physiological employment standards will answer two fundamental questions:

- How certain can one be that those who are accepted into this job will be capable of successfully performing the necessary work-related tasks without exposing themselves to an undue risk of injury?
- How certain can one be that those who are deemed to be unacceptable will actually be incapable of successfully performing the necessary work-related tasks, or that during the performance of these tasks, such individuals would expose themselves or others to an undue risk of injury?

Answering the former question is often a critical focus of the employer, since it determines both the short- and long-term operational capability of the workforce. However, a capacity to provide a defensible answer to the latter question is essential to ensure that pre-employment screening is not discriminatory.

Fortunately, the provision of a valid and reproducible answer to the former question will invariably mean that an answer is simultaneously obtained for the latter. Moreover, several groups have previously investigated the critical legal and scientific issues related to answering these questions. These steps are summarised in Table 1, and form the framework for the current project.

Table 1: Procedural summary and framework for the development of *bona fide* pre-employment screening tests and physiological employment standards for physically demanding trades. The current Research Phase is highlighted.

Project phase	Step	Description
0	1	Justify need for establishing employment standards
	2	Establish a Project Management Team
1	3	Familiarise Research Team with the trade
	4	Trade review and preliminary analysis of all tasks
	5	Identify the essential, physically demanding tasks
	6	Validate and approve the fire-fighting task list
	7	Employee survey: importance, difficulty, frequency of tasks
2	8	Characterise critical tasks: observe, measure, quantify
	9	Determine criterion fire-fighting tasks
	10	Validate and approve criterion fire-fighting tasks
3	11	Develop defensible physiological screening tests
	12	Standardise screening tests and administration
	13	Validate and approve screening tests
4	14	Evaluate validity and reliability of screening tests
	15	Acknowledge and approve performance standard development
5	16	Develop performance standards
	17	Validate and approve performance standards
	18	Implement pre-employment screening
		Review the screening process and its outcomes: ongoing

1.4 Research aims

The first aim of this research Phase was to familiarise the investigators with the operational requirements of contemporary fire fighting across metropolitan and regional Fire Stations. This involved preliminary briefings, demonstrations and brief task reviews. The second aim was to meet with a broad range of subject-matter experts at metropolitan and regional Fire Stations, including both permanent and retained[15] firefighters and Fire Stations, so that a comprehensive list of the physically demanding tasks could be assembled for operational

[15] Retained firefighters represent approximately 50% of the workforce for Fire & Rescue NSW. These firefighters are employed in an on-call capacity, as they generally have other full-time employment.

firefighters. Whilst this list may overlap with some of the tasks performed by trained specialists, the current research would not, at this stage, focus on such individuals. The third aim was a validation of this task list across both Executive Staff (operational and non-operational) and front-line permanent and retained firefighters from Fire & Rescue NSW.

2. METHODS

2.1 The Project Management Team

The overall management of this project was undertaken through a Project Management Team made up of Executive Staff (operational and non-operational) from Fire & Rescue NSW (FRNSW), as well as the Research Team from the University of Wollongong (UOW). These individuals, their positions and their roles within the Management Team are summarised in Table 2. The roles of the Management Team included:

- to establish, in consultation, a clear frame of reference for this project
- to identify employment categories to be included in this project
- to identify employment levels (firefighter categories) that may require different physiological employment standards
- to identify the employment levels to which the recommended physiological employment standards may be applied
- to liaise with the researchers and oversee all research activities
- to facilitate easy and appropriate access of the researchers to Firefighters, Officers and facilities
- to review progress of the project, to evaluate reports, to verify and validate fire-fighting task lists and criterion tasks, and to approve progression to subsequent research phases
- to make recommendations to Fire & Rescue NSW concerning the implementation of the recommendations that will arise from this research
- to initiate and facilitate the implementation of those recommendations.

Table 2: The Project Management Team.

Name	Position	Role
Alison Donohoe	Assistant Director Health and Safety (FRNSW)	Project Manager and Steering Committee Member
Fatima Abbas	Director Strategy and Innovation (FRNSW)	Steering Committee Member
Darren Husdell	Director Human Resources (FRNSW)	Project Sponsor and Steering Committee Member
Mark Brown	Director Metropolitan Operations (FRNSW)	Steering Committee Member
Jim Hamilton	Director Regional Operations (FRNSW)	Steering Committee Member
Rick Griffith	Assistant Director Training (FRNSW)	Steering Committee Member

Name	Position	Role
Brendan Mott	Team Leader Health and Fitness (FRNSW)	Research liaison and Steering Committee Member
Megan Smith	Manager Health Promotion (FRNSW)	Research liaison and Steering Committee Member
Nigel Taylor	Associate Professor (UOW)	Scientific expertise
Herb Groeller	Senior Lecturer (UOW)	Scientific expertise
John Sampson	Lecturer (UOW)	Scientific expertise
Hugh Fullagar	Postgraduate student (UOW)	Data collection and analysis

2.2 The existing Training Needs Analysis (TNA)

A training needs analysis for Fire & Rescue NSW has recently been completed (Endeavour Training and Development, 2010), during which the tasks performed by operational firefighters were identified through interviews with subject-matter experts. These tasks included the complete range of firefighter duties, with the aim of enhancing recruit and on-the-job training. These analyses resulted in the provision of much useful preliminary information for the current researchers.

However, the purpose of that analysis was not the teasing out of specific, physically demanding aspects of fire fighting, but to focus upon the identification of broad task categories. As a consequence, more generic task classifications were used, and this, through no fault of those undertaking this work, resulted in the provision of insufficient detail for the current Research Team. However, tasks and sub-tasks relevant to the physical demands of fire fighting were extracted from this source, and these are included within Table 3. These general classifications then formed a framework around which more detailed task lists could be created. Nevertheless, before proceeding, it is perhaps useful to illustrate how the training needs analysis was of limited use to the current research, beyond the provision of this framework.

Table 3: Fire-fighting task classifications thought to be associated with the physically demanding aspects of fire fighting, and extracted from the training needs analysis (Endeavour Training and Development, 2010).

Code	Task	Sub-tasks
28	Gain access to incident (*e.g.* window, door)	Identify safe method of entry
		Use hand tools to enter site as appropriate
		Use power tools to enter site if required
36	Extinguish fire on person	Advise and assist person to ‘stop, drop and roll’
		Use fire blanket or hose as required

Code	Task	Sub-tasks
37	Remove people, victims, deceased from scene	Assist ambulance people as required
		Follow steps for appropriate response to confronting traumatic incidents
49	Assist with primary search	When directed, enter structure
		Lead search using methods appropriate to conditions
		Move safely through structure (smoke)
		Assist to search for victims
		Assist to locate seat of fire
		Lead search to locate seat of fire
50	Contain and extinguish fire	Determine tactics appropriate to fire and threats
		Choose correct extinguishing medium, hose size, branch settings and pressures
		Use correct branch settings and pressures
52	Operate pump and related equipment at incident	Maintain correct pressure
53	Use hoses correctly	Layout hoses correctly
		Connect and disconnect hoses correctly
		Determine branch technique
		Use correct branch technique as directed
		Secure branches if required
55	Assist with tactical ventilation	Use natural ventilation as directed
		Use positive pressure ventilation (PPV) fan
59	Retrieve people, injured, deceased from scene	Use manual handling techniques
		Exit with victim
		Provide emergency medical treatment if required
		Use a ladder for rescue
60	Use Stokes Litter to rescue victim	Lower victim using Stokes Litter
61	Work safely on roofs	Use ladders to access roof

Code	Task	Sub-tasks
65	Use hoses in a fuel fire (foam or water as needed)	Operate pump and related equipment
		Lay out hoses correctly
		Connect and disconnect hoses correctly
		Determine branch appropriate technique
		Use correct branch technique
66	Follow special procedures for CNG buses/LPG tanks	Use hose (spray, mist, fog) as needed
68	Rescue, extricate victims	Use rescue equipment (RIK) to access victim
		Manage vehicle technology hazards (*e.g.* air bags, seat belts, rollover protection)
78	Operate portable pump and related equipment	Maintain correct pressure
79	Operate vehicle mounted pump and related equipment	Maintain correct pressure
110	Assist with vertical extrication	Use cordage techniques
		Use Stokes Litter in rescue
111	Operate rescue equipment	Use hydraulic equipment in rescue incident kit (RIK)
		Use other rescue tools
112	Rescue trapped people, animals	Use basic cutting or bending tools or as required
		Communicate with victims as required
113	Assist to rescue people, animals (confined spaces)	Assist to remove trapped people, animals
		Enter holes, trenches, drains as directed

From the tasks identified in Table 3, we shall briefly consider task codes 37 (remove people, victims, deceased from scene) and 59 (retrieve people, injured, deceased from scene). For the first task code, only three sub-tasks were identified: (a) 37.1: assist ambulance people as required; (b) 37.2: call for assistance with wildlife; and (c) 37.3: follow steps for appropriate response to confronting traumatic incidents. The last two sub-tasks are not associated with any physical demands. However, the first is, and it can be extremely demanding, especially when a heavy victim is encountered, and it will often

occur without the presence of ambulance personnel[16]. For the second task classification, four sub-tasks were identified: (a) 59.1: use manual handling techniques; (b) 59.2: exit with victim; (c) 59.3: provide emergency medical treatment if required; and (d) 59.4: use a ladder for rescue. Under this task code, the first, second and fourth sub-tasks potentially expose firefighters to heavy physical demands. Indeed, before commencing this project, the current investigators undertook a preliminary analysis of three individuals performing a 70-kg casualty (dummy) drag on a level surface (Taylor *et al.*, 2010). This task lasted 1.47 min (range: 0.83-2.00 min), it had an average oxygen cost of 2.12 $L.min^{-1}$ (range: 1.94-2.31 $L.min^{-1}$), and the average peak oxygen demand was 2.67 $L.min^{-1}$ (peak range: 2.17-3.26). To successfully perform this task, a 70-kg individual would need to have a fitness level that could sustain an oxygen consumption of 38.1 $mL.kg^{-1}.min^{-1}$. While the training needs analysis allowed for this task to be identified, it is not useful for the setting of physiological fitness standards. This mismatch between the training needs analysis and the objectives of the current project meant that these task classifications, whilst providing a valuable resource, had to be explored in much greater detail.

In addition, the training analysis was focussed upon duties that were exclusively evaluated by firefighters from metropolitan Fire Stations within the Sydney region. Since the brief for the current project was to address the physiological employment standards for all firefighters, and since one must consider the possibility for variations among the tasks performed by regional and metropolitan firefighters, then it was necessary to ensure that unique subsets of physically demanding tasks were not overlooked.

Finally, the authors of the training needs analysis attempted to define the attributes of an ideal firefighter recruit (Endeavour Training and Development, 2010). Unfortunately, the necessary information with which to make a valid determination of these attributes is not currently available. Moreover, an educational training organisation might not have the necessary expertise to evaluate these tasks. However, one of the outcomes from the current project will be a clear definition of physical and physiological attributes of people who are well suited to the demands of fire fighting, and who can tackle those demands without an undue risk of injury to either themselves or others.

2.3 Interviews with subject-matter experts

Researchers interviewed 106 firefighters (~2.5% of the full-time equivalent workforce) at eleven Fire Stations (Table 4). Three of these were retained-only Fire Stations (Crookwell, Delroy, Helensburgh), and three other Stations included retained firefighters (Dubbo, Goulburn and Regentville)[17]. This provided a total retained sample of 38 firefighters, or 35.8% of those interviewed. At each Station, there was a range of fire-fighting experience, with interviews generally spanning firefighters from two shifts. However, 45 of those interviewed (42.5%) had served more than 15 years as operational firefighters. Twelve female firefighters (11.3% of the sample) participated, representing a participation rate more than three times that of the current full-time equivalent female workforce.

[16] Information provided to Research Team during Fire Station visits.

[17] One retained firefighter was at this Fire Station as a Visiting Retained Firefighter as part of the Station Visits Program, and was assigned to the second platoon that was interviewed.

These Stations were chosen by the Directors for the Metropolitan and Regional Fire Stations (February 2011) such that the broadest range of fire-fighting experience may be made available to the investigators, although participation was voluntary. However, it became clear to the researchers that additional site visits would be required, since high-rise incidents were not adequately represented, and a gender balance, consistent with that found within Fire & Rescue New South Wales, would not be achieved. These decisions resulted in four additional Fire Stations being visited. Firefighters from each Station were invited to participate, and in several instances, Stations were taken off-line to facilitate this process. Prior to undertaking any interviews, the Fire Brigade Employee Union (FBEU) was briefed upon the aims and nature of the entire research project.

Table 4: Summary of firefighters interviewed during this Phase of the research.

Fire Stations	P:FF	P:QFF	P:SFF	P:LFF	P:SO
Alexandria[1-P]		4	3	1	2
Bankstown[2-P]		3	3		2
Botany[2-P]		3	2		2
City of Sydney[3-P]	7	3		2	3
Dubbo[1-P]	1	2	1		1
Goulburn[1-P]	3		3		1
Regentville[2-P]	2	4	5		2
Warrawong[1-P]			3		1
Fire Stations	**R:FF<5**	**R:FF5-10**	**R:FF10-15**	**R:FF>15**	**R:C**
Crookwell[1-R]	2	4			2
Dubbo[1-R]		2	1	2	2
Delroy[1-R]	2	1		2	4
Goulburn[1-R]	2	1	3	2	1
Helensburgh[1-R]	2	2			1

Notes: Superscript numbers denote shifts interviewed. Permanent Stations are indicated with 'P' and retained-only with 'R'. ***Abbreviations:*** P:FF = permanent firefighter (0-3 years experience), P:QFF = permanent qualified firefighter (3-6 years), P:SFF = permanent senior firefighter (>6 years), P:LFF = permanent leading firefighter, P:SO = permanent Station Officer, R:FF<5 = retained firefighter (<years experience), R:FF5-10 = retained firefighter (5-10 years), R:FF10-15 = retained firefighter (10-15 years), R:FF>15 = retained firefighter (>15 years), R:C = retained Deputy Captain or Captain.

2.4 Fire Station visits and interview procedures

To satisfy the first and second aims of this research Phase, a broad range of interviews with subject-matter experts were conducted at metropolitan and regional Fire Stations. All interviews followed the same format, and were comprised of four stages: introduction, overview of research aims, round-table discussion and practical demonstrations. In all instances, interviews were conducted in groups that represented at least one complete shift of firefighters (platoon). Where possible, these were timed so that one platoon was interviewed at the end of its shift, and the second just after commencing the next shift, but after first completing the preliminary equipment inspections and operational readiness duties. This second platoon was used to verify (validate) the list of demanding fire-fighting tasks identified by the first platoon, but they almost invariably added additional items to that list. This in-Station validation was a very important aspect of this research Phase.

2.4.1 Fire Station visit introduction

Each interview commenced with a general introduction from the senior investigator concerning the nature of the research project. The Research Phases to be undertaken across the entire project were described, and it was highlighted that a series of age- and gender-neutral pre-employment screening tests and physiological employment standards would be developed and recommended to the Management of Fire & Rescue NSW.

2.4.2 Aims of the Fire Station visits

An overview of the purpose of the current site visit was then provided: the identification of the physically demanding tasks that firefighters must perform during the course of their employment.

2.4.3 Round-table discussions at each Fire Station

Following these introductions, and brief questions from the firefighters to the investigators, extensive round-table discussions ensued concerning the physically demanding tasks. Many of these discussions were incident-based, using data extracted from the Australasian Incident Reporting System (AIRS), and relevant to each Fire Station. Indeed, for each Fire Station visited, the top ten call-outs were identified prior to each visit so that the Research Team was aware, in advance, of the range of duties that might be discussed at each Fire Station. This information is presented in Appendices 1 to 11.

The following questions were asked at each site visit. However, while some degree of scripting was essential, many exploratory and supplementary questions were used to obtain the necessary information.

INTERVIEW QUESTIONS FOR SUBJECT-MATTER EXPERTS:

- What are the types of incidents that you attend from this Station?
- Which are the most physically demanding of these incidents?
- Which aspects of these incidents cause them to be physically demanding?
- Let us explore the following incident: _____:
  - Walk us through this incident
  - What happens when the call-out occurs?

- What happens in the appliance?
- What happens when you first arrive?
- What happens during the course of the incident?
- What recovery actions are needed?

- Which are the most critical tasks that you perform and why?
- Is this task an individual or a team task?
  - If this is an individual task, is the performance most reliant on fitness or skill?
  - If it is a team task, is the performance of the task heavily influenced by team member level of fitness or team member skill level?
- Do task demands decline significantly as you become more familiar with, and more experienced at performing each task?
  - If yes, how does this occur?
- Are there any tasks that slow down your response time, and if so why?
- Think about any injuries that you have experienced as a firefighter:
  - What were you doing at the time of the injury?
  - Describe the injury
  - What was the cause of the injury?
  - Is this a common injury?
- Tell us about the most physically demanding task that you have experienced as a firefighter.
- How important are the following movement patterns within the role of fire-fighting duties?
  - standing
  - walking
  - running
  - gripping
  - reaching: above shoulder
  - reaching: below shoulder
  - reaching: below knee
  - pushing
  - pulling or dragging
  - lifting
  - carrying
  - climbing
  - jumping.
- Some discussions were aimed specifically at the tasks identified within the training needs analysis report (Endeavour Training and Development, 2010):
  - Tell us about the different ways that a firefighter may be required to gain access to a building (TNA code 28).

2.4.4 Equipment discussions and task demonstrations at Fire Stations

Following these interviews, most firefighters were eager to demonstrate to the Research Team, the nature of some tasks that had just been described, and in particular the tools and equipment used by contemporary firefighters. These demonstrations acted as important familiarisation sessions for the Research Team, as each increased the understanding of the Team and also permitted the identification of some tasks that had not arisen within the preceding discussions. Indeed, the change in environment sometimes prompted the identification of different tasks, it enabled the investigators to target some tasks that were less clearly understood by the Research Team, and it permitted a more focussed discussion on specific activities and equipment.

2.5 Training manuals

The Research Team was provided with access to the following training documents and fact sheets to facilitate this research Phase, and to help prepare for subsequent Phases:

- Equipment fact sheets
- Compartment fire behaviour training
- Structural fire fighting
- Structural fire: suppress urban fire
- Large store fire tactics
- High-rise fire-fighting operational procedures
- Stabilisation (motor vehicle)
- Extrication techniques for road accident rescue
- Snatch rescues
- Search and rescue
- Tactical ventilation and positive-pressure ventilation
- Personal protection - hazardous materials.

2.6 Task classification

Once the fire-fighting tasks lists were assembled, the individual tasks were classified into lists that defined the work-related demands placed upon firefighters under each of the three operational stages of fire fighting:

Readiness: Preparation and training.

Response: Actions necessary when responding to an incident, call-out or an alarm:

- response to the initial alarm
- actions involving donning and checking personal protective equipment
- actions on arrival at an incident
- fighting a fire, undertaking a rescue or other critical actions.

Recovery: Actions following the response:

- salvage: unknown victims, fully extinguish fire, checking hazards and structural integrity, and removing debris
- recovery of equipment: recovery and replenishment at Fire Station.

In addition, these tasks were also grouped into the general classifications defined by the training needs analysis presented in Table 3 (Endeavour Training and Development, 2010).

The outcomes from these procedures are reported in Sections 3.1 and 3.2 of this report.

2.7 Executive verification and validation of the fire-fighting task list

The third aim of this research Phase was to obtain the verification and validation of the task list by both Executive Staff (operational and non-operational) and front-line permanent and retained firefighters. The former was finalised at a focus group meeting that contained members of the Project Management Team (Appendix 12). This process was aimed at reducing an extensive, and perhaps exhaustive, list of tasks, into a manageable subset of essential, physically demanding items that could then form the basis of the second research Phase of the whole project.

2.8 Workforce validation and fire-fighting task survey

Given size of the Fire & Rescue NSW workforce, and the breadth and variation in the physically demanding tasks described to the Research Team, it was decided that the best way to obtain a workforce validation, and to simultaneously evaluate task performance frequency and difficulty, was to invite the voluntary participation of all permanent and retained firefighters within a survey. The administration of this survey was approved by the Human Research Ethics Committee (University of Wollongong) and Fire & Rescue NSW.

Since all employees of Fire & Rescue NSW have computer accounts, then each permanent and retained firefighter was contacted and invited to participate in either an online survey or its printed equivalent (Appendix 14), concerning the approved list of physically demanding tasks. The initial contact included an electronic copy of the survey. However, since many retained firefighters may have been infrequent users of the internet and their electronic mail, 3,660 printed copies of the survey (along with reply-paid envelopes), were sent to all retained Fire Stations (244 Stations). Both forms of response were anonymous, with respondents being identified only through the use of subject codes generated by the survey computer programme (Survey Monkey). Firefighters were given 33 days to answer the electronic survey, and 63 days to return the paper version.

Two items on the task list were included as deliberate calibration tasks. That is, since it is well recognised that survey tools can be at risk of exaggeration when individuals are asked to rate the frequency, significance and duration of some physical activities (Aadahl and Jørgensen, 2003; Rzewnicki et al., 2003), or the delivery of socially acceptable responses (Klesges *et al.*, 1990; Moti *et al.*, 2005), then two tasks identified during site visits as not being physically demanding were included. These tasks were quickly unrolling (bowling out) 38-mm hose and using the 4.6-m ladder. It was anticipated that, if the survey responses resulted in positioning each of these tasks towards the bottom of the rankings for physical demand (effort), then the responses could be viewed as being less prone to exaggeration. Moreover, bias may also be revealed in the reporting frequency of these tasks relative to the other activities.

In addition, a question was included relating to firefighters experiencing physical limitations during the performance of these tasks (*e.g.* strength, endurance). This was both a calibration and a cross-check question. Since one could anticipate that if a firefighter found that his/her ability to perform a task was limited by his/her physiological capabilities, then one could anticipate that this task would also be evaluated as a difficult task.

Before the survey was administered, both its electronic and printed versions were trialed. The purpose of this was to evaluate the utility of each instrument with both permanent firefighters (Wollongong City Fire Station: $N=14$), who completed the survey online, and retained firefighters (Belgownie Fire Station: $N=7$), who completed the printed version. This permitted fine tuning of the terminology, clarity and precision of each question.

2.8.1 Participant information package

All firefighters were sent the following information package.

INVITATION TO PARTICIPATE IN SURVEY:
TOPIC: PHYSICALLY DEMANDING DUTIES WITHIN Fire & Rescue NSW

Participant information:

This research project is being undertaken by the Centre for Human and Applied Physiology from the University of Wollongong. Many firefighters will already be aware of this research, the broad aims of which are to develop valid physiological employment standards (tests of work-related physical fitness) for the recruitment of firefighters in NSW. This research will therefore assist in providing direction in the development of Physical Aptitude Tests (PAT) for firefighters. There are several research phases for this project, and these are necessary to ensure that such employment standards are both a fair and reasonable reflection of the physical fitness required to be a firefighter, whilst not being discriminatory in nature. The first phase of this research was conducted through a series of interviews and round-table discussions with 106 firefighters (across all ranks) from eleven metropolitan and regional Fire Stations. Interviews involved 69 permanent and 38 retained firefighters, including 12 female firefighters, and 45 participants with 15 or more years of experience as operational firefighters. These interviews resulted in identifying a comprehensive list of the physically demanding tasks of fire fighting, and that list now forms the basis of this survey.

The aim of the survey is to obtain the opinions of all firefighters across NSW. In so doing, the Research Team will not only be able to validate the current list of physically demanding tasks, but, from the consolidated responses, it will then have considerable confidence in ranking those tasks according to the importance, difficulty and the frequency of their performance, since you and your peers (permanent and retained firefighters), through this survey, will determine this outcome. The researchers will then use aggregate responses obtained from firefighters at both metropolitan and regional Fire Stations.

Other important information:

This survey will take approximately 15 minutes to complete. Before you decide on participating, please take note of the following important points:

- **Voluntary Participation:** Your participation in this project is entirely voluntary. You can withdraw at any stage during the survey.
- **Informed Consent:** In completing this survey, you are confirming that you have read and understood the information contained within this note and that you are voluntarily participating. If you do not wish to participate in the

survey, then please do not answer any of the questions. You can, of course, read the information and questions without participating.

- **Confidentiality:** All information that you provide will be treated with complete confidence and privacy. All data will be stored separately from any information that could identify you, to ensure your confidentiality and privacy. Fire & Rescue NSW will not be permitted access to any data that could be used to identify individual participants.
- **Data use:** Aggregate results from this survey, but not individual responses, will be used by the researchers. Overall responses will be reported to Fire & Rescue NSW in the form of a technical report, and these data may also be subsequently reported within relevant fire fighting and scientific journals.
- **Funding:** This research has been funded by Fire & Rescue NSW.
- **Ethical considerations:** The researchers adhere to the principles governing both the ethical conduct of research and the protection (at all times) of the interests, comfort and safety of participants. All research activities associated with the physiological employment standards project for Fire & Rescue NSW, including this survey, have been approved by the Human Research Ethics Committee (University of Wollongong).

Inquiries:

Questions concerning the procedures for, or rationale of this investigation are welcome at any time. Please ask for clarification of any point that you feel is not explained to your complete satisfaction. Your initial contact person is Assoc. Prof. Nigel Taylor (School of Health Sciences, University of Wollongong: phone 02-4221-3463), the chief investigator for the project. You may direct inquiries to Nigel through (hhkf238@uow.edu.au).

2.8.2 Survey questions and information

Upon entering the survey, firefighters indicated that their awareness that participation was voluntary, that their identity would not be revealed and that they gave permission for their responses to be used by the Research Team. The survey questions are presented below and more fully within Appendix 14. For most questions, respondents either selected one answer from several options that were provided (drop-down menu in the electronic survey), or simply entered numbers or text to answer each question.

When questions were asked concerning task importance or the physical effort of performing tasks (task difficulty), the choice of options was based upon the following five-point scales:

For evaluating **task importance** (criticality), the rating scale was:

1 least important
2
3 moderate importance
4
5 most important

For evaluating the **physical effort required** to perform a task, the rating scale was:

1 least effort

2
3 moderate effort
4
5 most effort.

SURVEY OF PHYSICALLY DEMANDING FIREFIGHTER DUTIES:

Introduction:

Thank you for participating in this voluntary survey, which will take approximately 15 minutes. Please complete all sections of the survey.

In completing this survey you signify that you:

- Have read the survey participant information
- Will not be identified by completing this survey
- Grant permission for your answers to be used to compile aggregate responses which will be reported to FRNSW and in various publications.

(1) Are you a permanent or retained firefighter?

(2) What is your rank?

(3) How many years have you been an employee of FRNSW (Previously NSWFB)? If less than one year then enter 1.

(4) What is your current age in years?

(5) Are you male or female?

(6) Please indicate your current employment status:

Metropolitan (permanent)
Metropolitan (retained)
Regional (permanent)
Regional (retained).

(7) How many years have you worked in each of the following classifications: Round up or down to the nearest whole year. If less than one year enter 1:

Metropolitan (permanent)
Metropolitan (retained)
Regional (permanent)
Regional (retained)
Operational support.

(8) On the next two pages you will be given a number of fire-fighting tasks to review. Please rate them as listed below.

(i) Importance: We recognise that almost every fire-fighting task is very important, but we want you to consider importance only relative to the urgency associated with saving life and property.

(ii) Effort: On average, how much physical effort is required to perform the task?

(iii) Times per year (frequency): What is the average number of times you perform

this task per year?

(iv) Duration: In your experience, what is the average duration for which this task is performed?

(9) Have you ever found that your ability to perform one of the tasks listed below was limited by your physical capacity (*e.g.* strength, endurance fitness)?

(10) If you feel that we have failed to include some tasks that you consider to be as physically demanding, or even more demanding, then please send an electronic mail message to Hugh Fullagar (hhkf238@uowmail.edu.au). In that message, please name and briefly describe each task that you would like to add to this list. Alternatively, if you would like to make any comments concerning the survey or any other aspect of this research, you may write these comments in the box below. Like all other parts of this survey, these comments will be kept confidential.

2.8.3 Data analysis

Data from this experimental Phase were analysed using descriptive statistical procedures, and are reported as means (averages), standard deviations[18] (SD) and response ranges. For survey responses that were chosen using the multiple-point scales, data were treated as ordered-categorical data, with each point being assigned a number and analysed using the entire sample of firefighters responding to the survey. From these data, a rank ordering of the tasks was performed across various criteria. In the first instance, these ranks were determined within categories that reflected task importance, physical demand or task difficulty, and task performance frequency and duration. For the paper surveys, it was noted that some firefighters were entering data incorrectly, perhaps due to failing to understand the question. These data could potential skew the resulting analyses. Therefore, data points that were two standard deviations above the mean were manually deleted.

In consultation with the Management Team, fire-fighting tasks were separated into two classes, with respect to firefighter capability and injury risk minimisation: essential and less critical tasks. Since it would have been inefficient to proceed to the next research Phase[19] without first filtering and trimming the task list, then this step provided a mechanism through which a manageable list of the more critical fire-fighting tasks could be created. For task importance and the physical effort required (difficulty), this separation was designed to identify and isolate tasks of "high importance" as well as those rated as being physically "very hard" (respectively). The combination of these two ratings would help target tasks critical to determining workforce capability and work-related injury minimisation. For task performance frequency, it was considered that tasks that were performed three or more times annually would be more critical, unless a rarely performed task was deemed to be absolutely critical. In addition, inferential statistics (*student t-tests*) were used to compare survey responses across different employment classifications, and for these, the probability threshold was set at the 5% level.

[18] The standard deviation is a measure of variability (distribution) of the observed results around the mean.

[19] Phase Two: Detailed task observations with physical and physiological measurements.

3. RESULTS AND DISCUSSION

3.1 A catalogue of the physically demanding tasks of firefighters

3.1.1 Task classification by operational stage

Three operational stages of fire fighting were explored: ***readiness*** (preparation and training), ***response*** (tasks performed when responding), and ***recovery*** (actions that are performed following the response). The fire-fighting tasks identified for each of these stages are listed in Table 5. The presentation sequence has no significance, and generally matches the order in which tasks were identified for the Research Team.

Table 5: The physically demanding tasks performed by firefighters, classified within the three operational stages of fire fighting.

Operational stages	Fire-fighting tasks
Readiness	Appliance re-stow
	Performing simulation drills
Response	Rescue firefighter/victim while wearing PPE and BA
	Dragging and holding charged hose
	Dragging charged hose through buildings
	Prolonged holding of charged hose: 38 mm and 70 mm
	Rolling out uncharged hose lines
	Stair climbing with PPE, BA and charged hose
	Stair climbing with PPE, BA, charged hose, high rise fire fighting, sledge axe and Halligan Tool
	Lifting and carrying heavy objects (not fire-fighting equipment)
	Using power saw (cutter) to gain access
	Prolonged chain saw use following storms
	Breaking through or jumping over fences and obstacles
	Carrying rapid intervention kit (RIK) for gaining entry
	Sledge hammer carry and use
	Moving slabs of concrete following building collapse
	Removal of vehicle doors and rooves following an accident
	Finding hydrant and carrying the necessary equipment
	Coupling and uncoupling hoses
	Carrying power generator (two-person lift)

Operational stages	Fire-fighting tasks
	Hydraulic hose unwind and rewind
	Tactical ventilation: carrying fan up stairs (two-person lift)
	Moving victims with Stokes Litter (cliff rescue)
	Bush: prolonged walking in bushland carrying cordage pack
	Bush: digging fire break using McLeod Tool (hoe)
	Bush: dragging charged hose (3-4 lengths; 25 mm or 38 mm) for 100 m on hilly, sloped, uneven surfaces
	Bush: prolonged Stokes Litter carry: 1 km over rough terrain
	Lifting and moving heavy loads when wearing Hazmat clothing
	Prolonged walking (up and down inclines) in Hazmat clothing
	Prolonged crawling, kneeling, crouching, squatting: fire attack
	Prolonged crawling, kneeling, crouching, squatting: search
	Prolonged crawling, kneeling, crouching, squatting, dragging: rescue
	Lifting, positioning and stabilising spreaders
	Lifting, positioning and stabilising shears
	Carrying hydraulic pump or Davey pump (two-person lifts)
	"Draughting" with suction hose attachments to remove water from flooded location or to obtain water
	Ladder use: removal, replacement, under running
	Ladder stabilisation: usually 2-3 people, sometimes 1 person
	Rescue via ladder: two-person
	Rescue via ladder with Stokes Litter
	Rescue via stairs
	Dragging charged line of hose onto and throughout a ship
	Prolonged static work (*e.g.* holding victim's head)
	Carrying block sets and tools to stabilise vehicle
	Moving people (often obese) using canvas/salvage sheets
	Using crowbar (2-m bar) to lever open vehicle doors/bonnet

Operational stages	Fire-fighting tasks
	Fire-fighting and Hazmat tasks in tunnels: long walks
Recovery	Salvage and overhaul: internal
	Salvage and overhaul: external
	Rolling lines of uncharged 38-mm and 70-mm hose
	Appliance re-stow
	Shovelling debris or liquids in encapsulating clothing
	Pulling down ceiling using ceiling hook
	Carrying Stokes Litter to return to ambulance or appliance
	Under running wet hoses and hoisting hoses up the whips
	Flaking hose trays and loading onto appliance
	Pushing appliance shelves into position when on a slope

3.1.2 Task classification using the Training Needs Analysis codes

The fire-fighting tasks were then classified into codes and categories that had previously been defined within the Training Needs Analysis (Endeavour Training and Development, 2010), as this provided an ideal template, both for the purposes of this research Phase and for integrating the corresponding research outcomes within the training of new and existing firefighters. These coded lists are presented below. The presentation sequence again has no significance, but generally reflects a grouping of tasks according to the similarity of the incidents through which they were described.

Code 28: Gain access to incident

- Using power saw (cutter) use to gain entry
- Carrying rapid intervention kit (RIK) to gain entry
- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person
- Using sledge hammer to gain entry
- Pulling down ceiling using ceiling hook
- Lifting, positioning and stabilising spreaders
- Lifting, positioning and stabilising shears
- Using crowbar (2-m bar) to lever open vehicle doors/bonnet
- Removal of vehicle doors and rooves following accident
- Breaking through or jumping over fences
- Lifting and carrying heavy objects (not fire-fighting equipment)
- Other tool use (see code 111)

Code 37: Remove people, victims, deceased from scene

- Moving people (often obese) using canvas/salvage sheets

- Rescue firefighter/victim while wearing PPE and BA
- Rescue via ladder
- Rescue via stairs
- Prolonged crawling, kneeling, crouching, squatting, dragging: rescue
- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person
- Prolonged static work (*e.g.* holding victim's head)
- Moving victims with Stokes Litter (cliff rescue)

Code 49: Assist with primary search

- Using power saw (cutter) to gain entry
- Carrying rapid intervention kit (RIK) for gaining entry
- Dragging and holding charged hose
- Stair climbing with PPE, BA and charged hose
- Stair climbing with PPE, BA, charged hose, high rise fire-fighting, sledge axe and Halligan Tool
- Prolonged crawling, kneeling, crouching, squatting: search
- Moving slabs of concrete following building collapse
- Lifting and carrying heavy objects (not fire-fighting equipment)
- Removal of vehicle doors and rooves following accident
- Carrying charged line of hose onto and throughout a ship

Code 50: Contain and extinguish fire

- Rolling out uncharged hose lines
- Finding hydrant and carrying the necessary equipment
- "Draughting" with suction hose attachments to obtain water
- Stair climbing with PPE, BA and charged hose
- Stair climbing with PPE, BA, charged hose, high rise fire fighting, sledge axe and Halligan Tool
- Coupling and uncoupling hoses
- Dragging charged hose through buildings
- Prolonged holding of charged hose: 38 mm (single person)
- Prolonged holding of charged hose: 70 mm (two people)
- Prolonged crawling, kneeling, crouching, squatting: fire search
- Prolonged crawling, kneeling, crouching, squatting: fire attack
- Carrying charged line of hose onto and throughout a ship
- Bush: prolonged walking in bushland carrying cordage pack
- Bush: dragging charged hose (3-4 lengths; 25 mm or 38 mm) for 100 m on hilly, sloped, uneven surfaces
- Bush: digging fire break using McLeod Tool (hoe)

Code 52: Operate pump and related equipment at incident

- Rolling out uncharged hose lines
- Finding hydrant and carrying the necessary equipment
- "Draughting" with suction hose attachments to obtain water
- Coupling and uncoupling hoses

- Carry generator, usually 10-20 m, but can be 100 m, strength based

Code 53: Use hoses correctly

- Rolling out uncharged hose lines
- Finding hydrant and carrying the necessary equipment
- "Draughting" with suction hose attachments to obtain water
- Coupling and uncoupling hoses
- Dragging charged hose through buildings
- Stair climbing with PPE, BA and charged hose
- Stair climbing with PPE, BA, charged hose, high rise fire fighting, sledge axe and Halligan Tool
- Dragging charged line of hose onto and throughout a ship
- Prolonged holding of charged hose: 38 mm (single person)
- Prolonged holding of charged hose: 70 mm (two people)
- Hydraulic hose unwind and rewind
- Bush: dragging charged hose (3-4 lengths; 25 mm or 38 mm) for 100 metres on hilly, sloped, uneven surfaces
- Rolling lines of uncharged 38-mm and 70-mm hose
- Under running wet hoses and hoisting hoses up the whips
- Flaking hose trays and loading onto appliance

Code 55: Assist with tactical ventilation

- Carrying ventilation fan up stairs (two-person lift) often in confined spaces and with awkward postures: climbing stairs, steep slopes, on-board ship
- Tactical ventilation: carrying fan up stairs (two-person lift)

Code 59: Retrieve people, injured, deceased from scene

- Moving people (often obese) using canvas/salvage sheets
- Rescue firefighter/victim while wearing PPE and BA
- Rescue via ladder
- Rescue via stairs
- Prolonged crawling, kneeling, crouching, squatting, dragging: rescue
- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person
- Prolonged static work (*e.g.* holding victim's head)
- Moving victims with Stokes Litter (cliff rescue)

Code 60: Use Stokes Litter to rescue victim

- Moving victims with Stokes Litter (cliff rescue)
- Rescue via ladder with Stokes Litter
- Bush: prolonged Stokes Litter carry: 1 km over rough terrain

Code 61: Work on roof

- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person

- Rescue via ladder: two-person
- Rescue via ladder with Stokes Litter
- Salvage and overhaul: external

Code 65: Use hoses in a fuel fire

- Rolling out uncharged hose lines
- Finding hydrant and carrying the necessary equipment
- "Draughting" with suction hose attachments to obtain water
- Coupling and uncoupling hoses
- Dragging charged hose through buildings
- Stair climbing with PPE, BA and charged hose
- Stair climbing with PPE, BA, charged hose, high rise fire fighting, sledge axe and Halligan Tool
- Dragging charged line of hose onto and throughout a ship
- Prolonged holding of charged hose: 38 mm (single person)
- Prolonged holding of charged hose: 70 mm (two people)
- Hydraulic hose unwind and rewind
- Bush: dragging charged hose (3-4 lengths; 25 mm or 38 mm) for 100 m on hilly, sloped, uneven surfaces
- Rolling lines of uncharged 38-mm and 70-mm hose
- Under running wet hoses and hoisting hoses up the whips
- Flaking hose trays and loading onto appliance

Code 68: Rescue, extricate victims

- Moving victims with Stokes Litter (cliff rescue)
- Lifting, positioning and stabilising spreaders
- Lifting, positioning and stabilising shears
- Using crowbar (2-m bar) to lever open vehicle doors/bonnet
- Removal of vehicle doors and rooves following accident
- Prolonged static work (*e.g.* holding victim's head)

Code 78: Operate portable pump and related equipment

- Carrying Davey pump (two-person lifts)
- Coupling and uncoupling hoses

Code 79: Operate vehicle mounted pump and related equipment

- "Draughting" with suction hose attachments to obtain water or to drain flood area

Code 110: Assist with vertical extrication

- Rescue via ladder
- Rescue via stairs
- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person
- Moving victims with Stokes Litter (cliff rescue)

Code 111: Operate rescue equipment

- Moving victims with Stokes Litter (cliff rescue)
- Rescue via ladder with Stokes Litter
- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person
- Lifting, positioning and stabilising spreaders
- Lifting, positioning and stabilising shears
- Using crowbar (2-m bar) to lever open vehicle doors/bonnet

Code 112: Rescue trapped people, animals

- Moving people (often obese) using canvas/salvage sheets
- Rescue firefighter/victim while wearing PPE and BA
- Rescue via ladder
- Rescue via stairs
- Prolonged crawling, kneeling, crouching, squatting, dragging: rescue
- Prolonged static work (*e.g.* holding victim's head)
- Moving victims with Stokes Litter (cliff rescue)

Code 113: Assist to rescue people, animals (confined spaces)

- Moving people (often obese) using canvas/salvage sheets
- Rescue via ladder
- Rescue via stairs
- Prolonged crawling, kneeling, crouching, squatting, dragging: rescue
- Ladder use: removal, replacement, under running
- Ladder stabilisation: usually 2-3 people, sometimes 1 person
- Prolonged static work (*e.g.* holding victim's head)
- Moving victims with Stokes Litter (cliff rescue).

Whilst the Training Needs Analysis codes appeared extensive, they were not exhaustive, and appeared not to include tasks that were related to hazardous materials operations.

3.2 Consolidation of tasks

The next stage of this process involved the consolidation of these tasks into one list, but with items grouped according to the type of activity with which each task is generally associated, and with task duplication eliminated. This became the master list for the fire-fighting tasks from which a suitable subset of tasks could be extracted, in consultation with the Management Team, for use within the survey.

Preliminary task list:

1. Rolling out uncharged hose lines
2. Finding hydrant and carrying the necessary equipment
3. "Draughting" with suction hose attachments to obtain water
4. Coupling and uncoupling hoses
5. Dragging charged hose through buildings
6. Stair climbing with PPE, BA and charged hose
7. Stair climbing: PPE, BA, charged hose, high-rise pack, axe, Halligan Tool

8. Prolonged holding of charged hose: 38 mm (one person)
9. Prolonged holding of charged hose: 70 mm (two people)
10. Using power saw (cutter) use to gain entry
11. Carrying rapid intervention kit (RIK) to gain entry
12. Using sledge hammer to gain entry
13. Prolonged crawling, kneeling, crouching, squatting: fire attack
14. Carrying charged line of hose onto and throughout a ship
15. Carrying ventilation fan up stairs (two-person lift) often in confined spaces and with awkward postures: stairs, slopes, on-board ship
16. Under running wet hoses and hoisting hoses up the whips
17. Flaking hose trays and loading onto appliance
18. Ladder use: removal, replacement, under running
19. Ladder stabilisation: usually 2-3 people, sometimes 1 person
20. Rescue via ladder: two people
21. Rescue via ladder with Stokes Litter
22. Rescue via stairs
23. Moving people (often obese) using canvas/salvage sheets
24. Rescue firefighter/victim while wearing PPE and BA
25. Moving victims with Stokes Litter (cliff rescue)
26. Prolonged crawling, kneeling, crouching, squatting, dragging: rescue
27. Lifting, positioning and stabilising spreaders
28. Lifting, positioning and stabilising shears
29. Carrying hydraulic pump (two-person lifts)
30. Hydraulic hose unwind and rewind
31. Carrying block sets and tools to stabilise vehicle
32. Using crowbar (2-m bar) to lever open vehicle doors/bonnet
33. Removal of vehicle doors and rooves following accident
34. Prolonged static work (*e.g.* holding victim's head)
35. Moving slabs of concrete following building collapse
36. Lifting and carrying heavy objects (not fire-fighting equipment)
37. Pulling down ceiling using ceiling hook
38. Salvage and overhaul: external
39. Hazmat: prolonged walking, possibly on slopes
40. Hazmat: prolonged carrying of heavy objects
41. Hazmat: prolonged shovelling
42. Hazmat: shipboard or tunnel operations
43. Breaking through or jumping over fences
44. Bush: prolonged walking in bushland carrying cordage pack
45. Bush: dragging charged hose (3-4 lengths; 25 mm or 38 mm) for 100 m on hilly, sloped, uneven surfaces
46. Bush: digging fire break using McLeod Tool (hoe)
47. Bush: prolonged Stokes Litter carry: 1 km over rough terrain
48. Carry generator, 10-20 m but can be up to 100 m, strength based
49. Carrying Davey pump (two-person lifts)
50. Carrying power generator (two-person lift).

3.2.1 The consolidated list of fire-fighting tasks

The final stage of this filtration process resulted in the culling of items from the consolidated (master) tasks list, so that a manageable task list could be created for use in a survey of firefighters. This process involved members of the Project Management Team and additional subject-matter experts (Appendix 12). In some cases, the task descriptors were refined to impart greater meaning to the broadest possible range of firefighters. In other instances, tasks were sub-divided to tease out other variations of the same task. In still other cases, two or more tasks were combined to more closely reflect real scenarios. This process produced a list containing the 31 items shown below, of which there were two calibration tasks. One open-ended item was added, providing an opportunity for firefighters to add and rate additional items that were not included within this consolidated task list.

Task list: Fire & Rescue NSW

- Rolling out uncharged hose lines: 70 mm
- Rolling out uncharged hose lines: 38 mm *{calibration task}*
- Finding hydrant, carrying necessary equipment, getting water to appliance
- Coupling and uncoupling hoses
- Dragging 70-mm charged hose across horizontal surfaces
- Dragging 38-mm charged hose across horizontal surfaces
- Dragging 38-mm charged hose up a stairway
- Stair climbing with PPE, BA and charged hose
- Stair climbing: PPE, BA, charged hose, high-rise pack, axe, Halligan Tool
- Prolonged use of charged hose: 38 mm (single person)
- Prolonged use of charged hose: 70 mm (two people)
- Prolonged crawling, kneeling, crouching, squatting: fire attack
- 4.6-m ladder use: gaining access, rescue, salvage *{calibration task}*
- 10.5-m ladder use: one-person under running
- 10.5-m ladder use: two-person removal and replacement
- Rescue victim via ladder: two people
- Rescue victim via stairs: two people
- Rescue firefighter while wearing PPE and BA: one person
- Rescue victim while wearing PPE and BA: two people
- Moving victims with salvage sheets or Stokes Litter
- Using spreaders and shears
- Prolonged static work (*e.g.* holding victim's head)
- Using sledge hammer to gain entry
- Carrying ventilation fan up stairs: two people
- Carrying Davey pump: two people
- Pulling down ceiling using ceiling hook
- Hazmat: prolonged walking and manual handling when fully encapsulated
- Tunnel search and rescue
- Bush: walking with cordage pack or Stokes Litter
- Bush: dragging charged hose on hilly, sloped, uneven surfaces
- Bush: digging fire break (McLeod Tool)
- Other: please add any other task that you feel should be included.

3.3 Survey responses

The workforce within Fire & Rescue NSW to whom invitations were issued to participate in this survey was 6,781, and this was made up from 3,252 permanent and 3,429 retained firefighters (New South Wales Fire Brigades, 2010). From these firefighters, 1,011 individuals participated in this survey (14.9% of all firefighters) to some level[20], with 989 completing and 22 withdrawing from the survey during the process. The vast majority of firefighters chose to complete the electronic questionnaire (723 respondents), with 266 completing and returning surveys in paper format[21]. Within each employment category, the following survey returns were realised: 717 permanent (21.4% of this employment category) and 272 retained firefighters (7.9% of this employment category). Data below pertain only to firefighters who completed the full survey.

3.3.1 Characteristics of the respondents

The average age of respondents was 40.6 years (range: 18-74 years), and these individuals had worked with Fire & Rescue NSW (or the NSW Fire Brigades) for an average of 12.8 years (range: 1-49 years). These data are summarised within Table 6, with breakdowns provided according to both gender and employment classification (Permanent versus Retained). Women responded in excess of their employment representation, providing 5.2% of all responses, with retained firefighters making up 27.5% of respondents.

Table 6: The age (years) and experience as a firefighter (years) of all respondents, with gender and employment classification breakdowns.

	Age (mean)	Standard deviation	Experience (mean)	Standard deviation
Overall	40.6	9.7	12.8	9.5
Males	40.7	9.8	13.0	9.6
Females	38.3	7.5	8.8	6.1
Permanent	40.1	8.7	13.3	9.1
Retained	41.9	11.9	11.4	10.4

Within both the permanent and retained employment classifications, firefighters can be grouped into each of two sub-divisions (Metropolitan and Regional), or under the role of Operational Support. Responses were received from firefighters within each of these five groups, and the proportional representation of each group is summarised in Figure 7 (actual survey returns: permanent metropolitan = 575, permanent regional = 102, retained metropolitan = 62, retained regional = 210 and operational support = 40). Table 7 provides a detailed age and experience breakdown of these firefighters. Figure 8 shows the age distributions within each of these five employment groups, providing an indication of

[20] Twenty-two commenced the online survey, but decided to withdraw without answering any questions.

[21] The closing date for the paper version of the survey was October 31st (2011). However, this was extended to November 30th (2011) for the convenience of retained firefighters.

variations in this demographic trait.

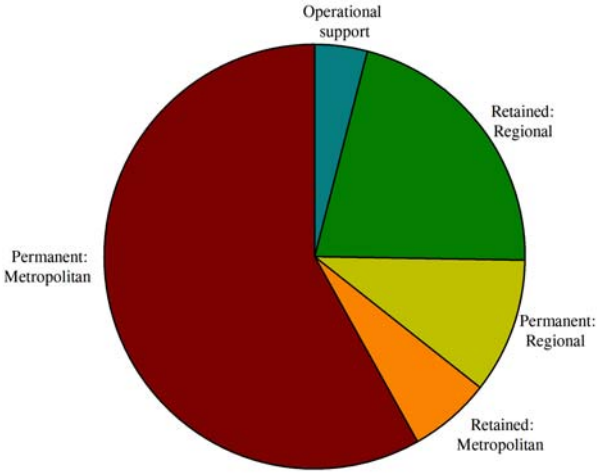

Figure 7: Distribution of respondents on the basis of employment classification.

Table 7: The age (years) and experience as a firefighter (years) within the five major employment breakdowns. ***Note:*** These data are influenced by transfers, with some firefighters working across all classifications.

	Age (mean)	Standard deviation	Experience (mean)	Standard deviation
Permanent: Metropolitan	39.0	8.7	11.1	12.1
Retained: Metropolitan	39.1	11.6	5.9	7.0
Permanent: Regional	44.6	7.7	5.8	6.2
Retained: Regional	42.7	11.9	8.8	10.0
Operational support	44.8	7.4	3.3	2.9

From the 15 ranks of firefighters across the two employment classifications, responses were received from all but two: permanent ranks of Chief Superintendent and Executive Staff (operational and non-operational)[22]. The breakdown of these response classifications is shown in Table 8, with the gender distributions across ranks. Table 9 summarises the overall gender distribution of the respondents. The breakdown of ages within each gender is also shown in Table 9, and it is noted that 197 respondents were 50 years of age or older. This information is of importance for a subsequent Section where responses were evaluated on the basis of age and gender.

[22] These individuals, if attending an incident, do not operate as front-line firefighters, but serve roles as incident controllers and perform various liaison and organisational tasks.

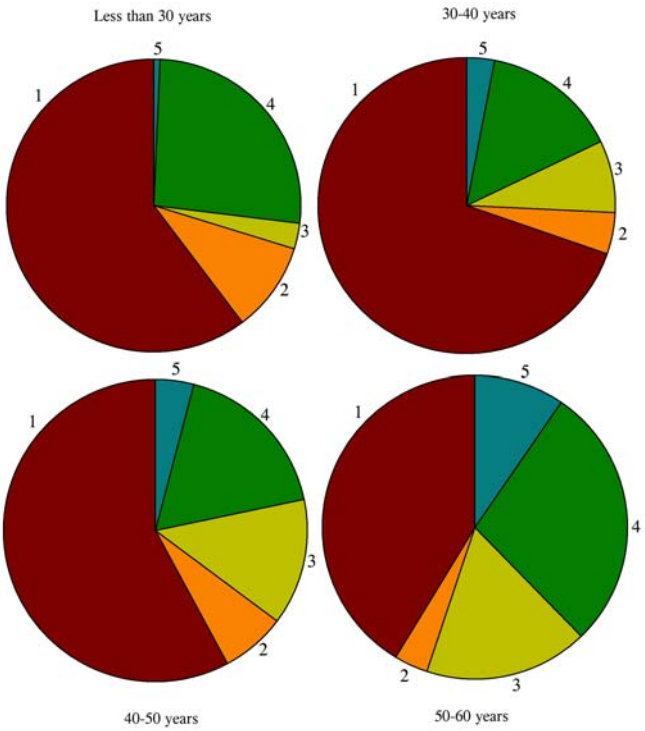

Figure 8: Age distribution of respondents across employment classifications. 1 = Permanent: Metropolitan, 2 = Retained: Metropolitan, 3 = Permanent: Regional, 4 = Retained: Regional, 5 = Operational support.

Table 8: Summary of respondents according to employment classification (permanent versus retained), ranks within each classification and gender. Data are normalised to the total number of respondents (percent total), to the number of respondents from each classification (percent class) and to the total number of male and female respondents.

Rank	Count	Percent total	Percent class	Male count	Percent male	Female count	Percent female
P: FF	61	6.2%	8.5%	56	6.0%	5	9.8%
P: QFF	169	17.1%	23.6%	156	16.6%	13	25.5%
P: SFF	252	25.5%	35.1%	233	24.8%	19	37.3%
P: LFF	6	0.6%	0.8%	6	0.6%	0	0.0%
P: SO	184	18.6%	25.7%	177	18.9%	7	13.7%
P: I	26	2.6%	3.6%	26	2.8%	0	0.0%
P: Super	8	0.8%	1.1%	8	0.9%	0	0.0%
P: C Super	0	0.0%	0.0%	0	0.0%	0	0.0%
P: Exec	0	0.0%	0.0%	0	0.0%	0	0.0%
R: FF<5	95	9.6%	34.9%	93	9.9%	2	3.9%

Rank	Count	Percent total	Percent class	Male count	Percent male	Female count	Percent female
R: FF 5-10	49	5.0%	18.0%	46	4.9%	3	5.9%
R: FF 10-15	25	2.5%	9.2%	24	2.6%	1	2.0%
R: FF >15	32	3.2%	11.8%	32	3.4%	0	0.0%
R: Dep Capt	34	3.4%	12.5%	33	3.5%	1	2.0%
R: Capt	34	3.4%	12.5%	34	3.6%	0	0.0%

Notes: P:FF = permanent firefighter (0-3 years experience), P:QFF = permanent qualified firefighter (3-6 years), P:SFF = permanent senior firefighter (>6 years), P:LFF = permanent leading firefighter, P:SO = permanent Station Officer, R:FF<5 = retained firefighter (<years experience), R:FF5-10 = retained firefighter (5-10 years), R:FF10-15 = retained firefighter (10-15 years), R:FF>15 = retained firefighter (>15 years), R:C = retained Deputy Captain or Captain.

Table 9: Distribution of respondents by age and across genders (completed surveys). ***Note:*** Some individuals did not declare either their age or gender.

	All	Male	Female
Total count	989	938	51
Percent all responders	100.0%	94.8%	5.2%
<30 years old	141	134	7
Percent	14.3%	14.3%	13.7%
30-40 years old	330	311	19
Percent	33.4%	33.2%	37.3%
40-50 years old	318	294	24
Percent	32.2%	31.3%	47.1%
50-60 years old	167	166	1
Percent	16.9%	17.7%	2.0%
>60 years old	30	30	0
Percent	3.0%	3.2%	0.0%

3.3.2 Task performance questions

Analysis of the subjective ratings (importance, physical effort, frequency and duration) for all tasks was first treated collectively, and then sub-divided into each of the four principal employment classifications: permanent metropolitan, permanent regional, retained

metropolitan, retained regional. The purpose of this second analysis was to evaluate the probability that firefighters from different employment classification may be exposed to different subsets of tasks and to different task performance frequencies. Since it would be inappropriate to base a pre-employment screening test on physically demanding tasks that a group of workers would not encounter during the course of their employment, then these analyses formed a critical distillation of the survey responses. Moreover, this breakdown permitted the use of inferential statistical procedures, and a more rigid justification of the fire-fighting tasks selected for more detailed investigation. Whilst such an extraction of data reduces the sample size upon which interpretation may be based, the survey returns for each employment classification was sufficiently large (range: 62-575) for these sub-divisions to remain robust.

In addition to answering questions related to the 31 tasks that were identified, all respondents were invited to comment upon these tasks, and also to add other physically demanding tasks that had not been included. Two-hundred and sixty additional comments were received[23], many of which reinforced the appropriateness of the task list. However, from these, some additional tasks were nominated for consideration, and these, along with several pertinent supplementary comments, have been summarised below:

- driving an appliance, particularly when fatigued
- working in confined spaces
- connecting auxiliary lines to breathing apparatus
- carrying generator and lights up stairs
- digging fire trails
- climbing a fence wearing turnout gear and breathing apparatus
- carrying heavy drums
- vehicle stabilisation
- carrying the patient protection kit
- encapsulating suits come in one size; this is a problem for shorter people
- equipment mass is very demanding for less strong people
- the impact of equipment on people of varying size and dimensions
- the impact that weather has upon some task performances
- the impact that the time of day has upon some task performances
- the impact of sleep deprivation and fatigue on some task performances
- more detail is required for some trade specialisations
- tasks included within a screening test must reflect real situations (*e.g.* under running a ladder should be performed without fixed anchorage).

The fact that very few new tasks were identified through the survey, and then only by a small number of firefighters, provides a strong verification of the utility of the Fire Station visits, and the capacity of these visits to generate an appropriate list of the most physically demanding tasks of fire fighting. That is, the outcomes from the initial sample of 106

[23] The vast majority of these comments reflected concerns regarding the need to maintain fitness standards of firefighters throughout their active careers, with many being worried that recruitment fitness standards may be reduced. Comments of this nature came from both genders, and from firefighters spanning a wide range of ages and work experience. A significant number felt that this survey was aimed at producing such an outcome. However, this seemed to be balanced by others who felt it may work in the opposite direction.

firefighters has now been validated by 989 firefighters across operational ranks within Fire & Rescue NSW.

3.3.2.1 Task importance, physical effort, frequency and duration of performance
Data relating to the importance of each task, the physical effort required to successfully complete each task, and the performance frequency and duration are reported in Tables 10-13. Cells are colour coded into response bands to facilitate comparisons across the four employment classifications: permanent metropolitan, permanent regional, retained metropolitan and retained regional. Statistical comparisons between the reported task performance frequencies of the permanent and retained firefighters are indicated in Table 12. A superscript "R" has been positioned in the column for the permanent firefighters to show that data in the corresponding cell of the adjacent column (retained firefighters) differs significantly ($P < 0.05$). These data will be useful for subsequent Phases of this project.

Table 14 contains a work volume assessment (minutes). It is the simple product of task frequency (Table 12) and task duration (Table 13), and provides a useful survey summary.

Question 9 was included as both a calibration and a cross-check question. Firefighters were asked to identify tasks in which they felt their performance was limited due to their physical capacity (*e.g.* strength, endurance). Table 15 (all respondents) summarises these answers, where just to top ten (descending order) fire-fighting tasks for which affirmative responses were reported. Also presented are the corresponding data for the ratings of physical effort required to perform each of these tasks (top ten in descending order). Answers to both questions share seven common fire-fighting tasks in the top ten. This correspondence is taken as a broad validation of the ratings of physical effort.

3.3.2.2 Gender comparison
It is always difficult to make gender comparisons when one gender dominates employee numbers. However, with 5.2% of the total respondents being women, this represented a greater proportional representation than currently exists within the workforce.

Table 16 summarises data from Question 9 (tasks performance limited by physical capacity). Cells are shaded red (in rows) to correspond with those tasks in which >20% of the male firefighters found their physical capacity had limited their performance. Nine tasks were identified in this manner. Whilst there is good agreement across three of these tasks, six differences stand out due to fewer women reporting a physical capacity limitation:

- Drag 38-mm charged hose: stairs
- Stairs: PPE, BA, hose
- Using 70 mm
- Fire attack
- Rescue FF: 1 person
- Bush: drag charged hose.

Table 10: Ratings of task importance (scale 1-5) under employment classification.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out 70 mm	4.0	3.8	3.8	3.6
Rolling out 38 mm	4.2	4.2	3.9	3.9
Hydrant: locating and connecting	4.5	4.5	4.4	4.4
Coupling hoses	3.9	3.9	3.5	3.9
Drag 70-mm charged hose: flat	3.8	3.6	3.5	3.5
Drag 38-mm charged hose: flat	4.3	4.0	4.0	3.8
Drag 38-mm charged hose: stairs	4.3	4.0	4.0	3.6
Stairs: PPE, BA, hose	4.5	4.3	4.3	4.0
Stairs: PPE, BA, hose, tools	4.3	4.1	4.1	3.6
Using 38 mm	4.2	4.1	3.9	4.0
Using 70 mm	4.0	3.9	3.8	3.8
Fire attack	4.3	4.0	4.1	3.8
Ladder use: 4.6 m	3.7	4.0	3.4	3.6
Ladder use: 10.5 m: 1 person	4.2	3.9	4.0	3.6
Ladder use: 10.5 m: 2 people	4.0	3.8	3.7	3.5
Rescue victim: ladder - 2 people	4.5	4.3	4.3	4.0
Rescue victim: stairs - 2 people	4.6	4.5	4.3	4.2
Rescue FF: 1 person	4.9	4.9	4.9	4.7
Rescue victim: 2 people	4.9	4.8	4.8	4.6
Moving victim	4.0	4.3	4.1	4.0
Using spreaders and shears	4.2	4.4	4.2	4.2
Prolonged static work	3.9	4.3	3.8	4.2
Using sledge hammer	3.8	3.5	3.6	3.3
Carry: ventilation fan (stairs): 2 people	3.4	3.8	3.3	3.2
Carry: Davey pump: two people	3.2	3.6	3.1	3.2
Pulling down ceiling	3.3	3.5	3.2	3.2
Hazmat: walking, manual handling	3.8	4.0	3.9	4.0
Tunnel search and rescue	3.7	3.8	3.6	3.7
Bush: walking, manual handling	3.3	3.4	3.2	3.3
Bush: drag charged hose	3.9	3.7	3.8	3.6
Bush: digging fire break	3.8	3.8	3.8	3.7

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: >4.5, orange: 3.5-4.5, white: <3.5.

Table 11: Ratings of physical effort (scale 1-5) grouped by employment classification.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out 70 mm	3.1	3.0	2.9	2.7
Rolling out 38 mm	2.6	2.5	2.4	2.3
Hydrant: locating and connecting	3.4	3.0	3.3	2.7
Coupling hoses	2.8	2.2	2.8	2.2
Drag 70-mm charged hose: flat	4.4	4.5	4.2	4.0
Drag 38-mm charged hose: flat	3.5	3.7	3.4	3.5
Drag 38-mm charged hose: stairs	4.3	4.3	4.1	4.0
Stairs: PPE, BA, hose	4.6	4.6	4.5	4.1
Stairs: PPE, BA, hose, tools	4.4	4.5	4.3	4.2
Using 38 mm	3.6	3.7	3.4	3.6
Using 70 mm	4.3	4.2	4.2	4.1
Fire attack	3.9	3.9	4.0	3.8
Ladder use: 4.6 m	3.0	3.2	3.0	3.1
Ladder use: 10.5 m: 1 person	4.0	3.9	3.8	3.6
Ladder use: 10.5 m: 2 people	3.7	3.7	3.3	3.4
Rescue victim: ladder - 2 people	4.4	4.3	4.0	3.9
Rescue victim: stairs - 2 people	4.3	4.3	4.1	4.1
Rescue FF: 1 person	4.9	4.7	4.8	4.5
Rescue victim: 2 people	4.7	4.6	4.6	4.3
Moving victim	3.7	4.2	3.8	3.7
Using spreaders and shears	3.8	3.8	3.8	3.6
Prolonged static work	2.7	3.2	3.0	3.1
Using sledge hammer	3.6	3.5	3.6	3.3
Carry: ventilation fan (stairs): 2 people	3.6	3.7	3.5	3.3
Carry: Davey pump: two people	3.4	3.6	3.3	3.2
Pulling down ceiling	3.2	3.0	3.3	3.1
Hazmat: walking, manual handling	4.1	4.3	4.2	4.2
Tunnel search and rescue	3.7	4.1	4.0	3.8
Bush: walking, manual handling	3.4	3.6	3.4	3.5
Bush: drag charged hose	4.2	4.2	4.2	4.1
Bush: digging fire break	3.8	3.8	3.8	3.7

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: >4.5, orange: 3.5-4.5, white: 3.1-3.5, green: <3.1.

Table 12: Task performance frequencies (*per annum*) under employment classification.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out 70 mm	25.5^{R}	18.3	22.4^{R}	13.9
Rolling out 38 mm	32.3	34.0	28.5^{R}	23.8
Hydrant: locating and connecting	23.8	22.9	24.9^{R}	19.5
Coupling hoses	39.9^{R}	49.8	36.8	40.9
Drag 70-mm charged hose: flat	16.8	13.7	12.2^{R}	8.5
Drag 38-mm charged hose: flat	27.2	29.5	26.1^{R}	18.8
Drag 38-mm charged hose: stairs	13.6^{R}	6.1	10.4^{R}	3.6
Stairs: PPE, BA, hose	13.7^{R}	6.7	9.9^{R}	4.1
Stairs: PPE, BA, hose, tools	26.3^{R}	2.8	12.0^{R}	3.0
Using 38 mm	18.5	16.0	15.4^{R}	10.9
Using 70 mm	10.5	7.6	5.8^{R}	6.4
Fire attack	15.6	11.5	12.4^{R}	9.3
Ladder use: 4.6 m	22.0^{R}	10.4	20.3^{R}	6.8
Ladder use: 10.5 m: 1 person	15.5^{R}	5.5	11.3^{R}	3.7
Ladder use: 10.5 m: 2 people	16.2^{R}	6.6	11.5^{R}	4.9
Rescue victim: ladder - 2 people	5.1	1.8	4.8^{R}	2.4
Rescue victim: stairs - 2 people	5.7^{R}	1.8	4.0^{R}	2.1
Rescue FF: 1 person	4.0	3.6	3.5	3.2
Rescue victim: 2 people	4.1	2.3	3.4	2.9
Moving victim	8.2^{R}	3.3	5.5^{R}	2.7
Using spreaders and shears	17.3^{R}	4.2	15.3^{R}	5.1
Prolonged static work	11.3^{R}	3.5	7.3^{R}	3.0
Using sledge hammer	12.4^{R}	2.7	6.7^{R}	2.5
Carry: ventilation fan (stairs): 2 people	15.4^{R}	5.2	10.5^{R}	3.4
Carry: Davey pump: two people	8.7	6.0	8.3^{R}	4.0
Pulling down ceiling	11.1^{R}	5.2	8.3^{R}	3.7
Hazmat: walking, manual handling	6.1^{R}	2.3	5.1^{R}	2.7
Tunnel search and rescue	3.8	2.0	2.0	2.3
Bush: walking, manual handling	5.1	3.0	4.0^{R}	2.5
Bush: drag charged hose	10.8	14.2	12.7^{R}	5.6
Bush: digging fire break	5.9	7.1	6.9	5.0

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: >24, orange: 12-24, white = 6-12, green: = <6. Superscripts denote statistical differences (see text).

Table 13: Task performance durations (minutes) grouped by employment classification.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out 70 mm	2.7	1.4	6.1	1.7
Rolling out 38 mm	2.9	1.5	8.3	1.7
Hydrant: locating and connecting	5.7	4.8	10.2	4.3
Coupling hoses	1.9	2.0	6.2	2.3
Drag 70-mm charged hose: flat	7.1	3.8	10.3	4.7
Drag 38-mm charged hose: flat	8.9	5.6	14.2	6.9
Drag 38-mm charged hose: stairs	8.2	4.9	11.4	5.8
Stairs: PPE, BA, hose	9.9	6.7	12.8	7.8
Stairs: PPE, BA, hose, tools	9.6	6.3	15.6	7.6
Using 38 mm	32.3	23.9	31.7	23.7
Using 70 mm	38.1	18.6	29.9	17.4
Fire attack	18.2	17.7	24.4	16.1
Ladder use: 4.6 m	10.5	6.9	13.8	9.7
Ladder use: 10.5 m: 1 person	7.5	5.0	10.3	6.5
Ladder use: 10.5 m: 2 people	7.1	5.1	9.4	6.4
Rescue victim: ladder - 2 people	8.6	9.6	13.2	10.5
Rescue victim: stairs - 2 people	9.3	12.2	12.4	10.1
Rescue FF: 1 person	8.4	10.1	12.2	12.4
Rescue victim: 2 people	8.6	9.7	11.9	12.3
Moving victim	10.7	13.8	16.0	10.0
Using spreaders and shears	19.5	13.6	24.0	19.2
Prolonged static work	23.3	17.9	26.0	20.1
Using sledge hammer	3.2	3.7	6.9	5.1
Carry: ventilation fan (stairs): 2 people	6.6	6.1	10.3	6.8
Carry: Davey pump: two people	7.4	8.0	11.3	8.3
Pulling down ceiling	13.5	9.1	18.0	12.3
Hazmat: walking, manual handling	29.9	18.1	31.6	20.2
Tunnel search and rescue	28.0	12.0	33.2	19.7
Bush: walking, manual handling	34.5	19.4	38.3	22.5
Bush: drag charged hose	57.7	20.7	50.3	24.3
Bush: digging fire break	62.9	26.0	64.8	24.3

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: >30, orange: 15-30, white = 5-15, green: = <5.

Table 14: Task performance volume (minutes) grouped by employment classification.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out 70 mm	69.5	25.7	135.6	23.5
Rolling out 38 mm	92.8	49.9	235.4	41.4
Hydrant: locating and connecting	135.4	110.3	253.8	84.6
Coupling hoses	76.3	101.3	228.8	93.1
Drag 70-mm charged hose: flat	119.0	52.6	125.2	39.8
Drag 38-mm charged hose: flat	242.1	165.6	370.5	128.8
Drag 38-mm charged hose: stairs	111.3	30.1	118.1	20.5
Stairs: PPE, BA, hose	135.6	44.8	126.5	31.9
Stairs: PPE, BA, hose, tools	252.5	17.6	188.3	23.1
Using 38 mm	596.7	382.0	487.5	258.1
Using 70 mm	399.4	142.5	172.9	111.8
Fire attack	284.3	203.9	301.2	149.7
Ladder use: 4.6 m	230.7	72.0	279.9	66.2
Ladder use: 10.5 m: 1 person	116.3	27.1	116.6	24.0
Ladder use: 10.5 m: 2 people	116.0	33.9	107.9	31.5
Rescue victim: ladder - 2 people	43.6	17.0	63.2	25.6
Rescue victim: stairs - 2 people	53.0	21.4	50.2	21.1
Rescue FF: 1 person	33.6	36.3	43.1	39.2
Rescue victim: 2 people	35.3	22.8	40.6	35.4
Moving victim	87.8	45.2	87.3	26.4
Using spreaders and shears	336.6	57.5	366.3	97.5
Prolonged static work	262.7	62.8	188.4	59.4
Using sledge hammer	39.4	9.8	46.0	13.0
Carry: ventilation fan (stairs): 2 people	102.2	31.9	108.3	23.4
Carry: Davey pump: two people	64.6	48.3	93.9	33.3
Pulling down ceiling	150.5	47.4	148.8	45.0
Hazmat: walking, manual handling	182.8	41.1	161.2	54.2
Tunnel search and rescue	106.0	23.9	67.2	44.3
Bush: walking, manual handling	176.9	58.1	152.3	55.1
Bush: drag charged hose	626.2	291.5	637.4	136.2
Bush: digging fire break	370.8	185.2	446.3	121.5

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: >500, orange: 250-500, white = 50-250, green: = <50.

Table 15: Tasks limited by physical capacity (left two columns) and the physical effort required to perform these tasks. Data are absolute counts (limitations) and effort ratings (scale: 1-5).

Task	Count	Task	Rating
Drag 70-mm charged hose: flat	257	Rescue FF: 1 person	4.8
Stairs: PPE, BA, hose, tools	248	Rescue victim: 2 people	4.6
Using 70 mm	248	Stairs: PPE, BA, hose	4.5
Stairs: PPE, BA, hose	244	Stairs: PPE, BA, hose, tools	4.3
Bush: drag charged hose	217	Drag 70-mm charged hose: flat	4.3
Coupling hoses	206	Using 70 mm	4.3
Fire attack	204	Rescue victim: stairs - 2 people	4.2
Drag 38-mm charged: stairs	201	Rescue victim: ladder - 2 people	4.2
Rescue FF: 1 person	198	Drag 38-mm charged: stairs	4.2
Hazmat: walking, manual handling	168	Bush: drag charged hose	4.2

3.3.2.3 Age comparison

From Table 9, it is seen that 197 respondents were aged 50 years or older. Table 16 also summarises answers to Question 9 (tasks performance limited by physical capacity) by separating the responses of those firefighters who are >50 years of age. Cells are shaded red (in rows) to correspond with those tasks in which >20% of the male firefighters found their physical capacity had limited their performance. Nine tasks were identified in this manner, and there is good agreement across seven of these, with just two instances in which older firefighters felt limited by their physical capacity:

- Coupling hoses
- Drag 38-mm charged hose: stairs.

Table 16: Task performances limited by firefighter's physical capacity (% affirmative).

Task	Male	Female	>50 years
Rolling out 70 mm	8.7%	11.8%	6.1%
Rolling out 38 mm	4.3%	2.0%	2.0%
Hydrant: locating and connecting	8.0%	5.9%	3.6%
Coupling hoses	20.6%	19.6%	14.2%
Drag 70-mm charged hose: flat	25.7%	25.5%	21.8%
Drag 38-mm charged hose: flat	8.7%	2.0%	6.6%
Drag 38-mm charged hose: stairs	20.4%	13.7%	13.2%
Stairs: PPE, BA, hose	24.7%	17.6%	19.8%
Stairs: PPE, BA, hose, tools	24.5%	29.4%	24.4%
Using 38 mm	11.3%	7.8%	8.1%
Using 70 mm	25.4%	13.7%	24.4%
Fire attack	21.1%	9.8%	21.3%
Ladder use: 4.6 m	5.8%	2.0%	3.0%
Ladder use: 10.5 m: 1 person	14.9%	17.6%	12.7%
Ladder use: 10.5 m: 2 people	11.8%	5.9%	8.1%
Rescue victim: ladder - 2 people	14.6%	3.9%	12.2%
Rescue victim: stairs - 2 people	15.4%	7.8%	9.6%
Rescue FF: 1 person	20.0%	13.7%	16.8%
Rescue victim: 2 people	16.0%	13.7%	10.2%
Moving victim	12.4%	2.0%	11.2%
Using spreaders and shears	13.5%	13.7%	8.6%
Prolonged static work	8.7%	2.0%	6.6%
Using sledge hammer	10.0%	7.8%	5.6%
Carry: ventilation fan (stairs): 2 people	11.4%	5.9%	9.1%
Carry: Davey pump: two people	9.9%	3.9%	10.2%
Pulling down ceiling	9.2%	9.8%	4.6%
Hazmat: walking, manual handling	17.1%	7.8%	20.8%
Tunnel search and rescue	9.2%	2.0%	8.6%
Bush: walking, manual handling	11.1%	2.0%	8.6%
Bush: drag charged hose	22.0%	15.7%	23.4%
Bush: digging fire break	11.8%	2.0%	9.1%

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: 20% or more firefighters found their physical capacity to be a limit when performing this task.

3.4 Fire-fighting tasks recommended for detailed evaluation (Project Phase Two)

The final stage for this Phase was aimed at deriving a list of tasks that would then be observed, quantified and evaluated, whilst being performed by operational firefighters from a broad range of experience and skill levels. This would improve our understanding of the physical and physiological demands placed upon firefighters.

Since it would be inefficient to study all 30 tasks, a decision-analysis approach was adopted (Howard, 1966). An algorithm was developed through which possible task exclusions were evaluated (Figure 9), if efficiencies could be gained without compromising the integrity of the process. Therefore, in combination with the survey responses (Tables 10-16), this filtration mechanism was applied to each of the four employment classifications.

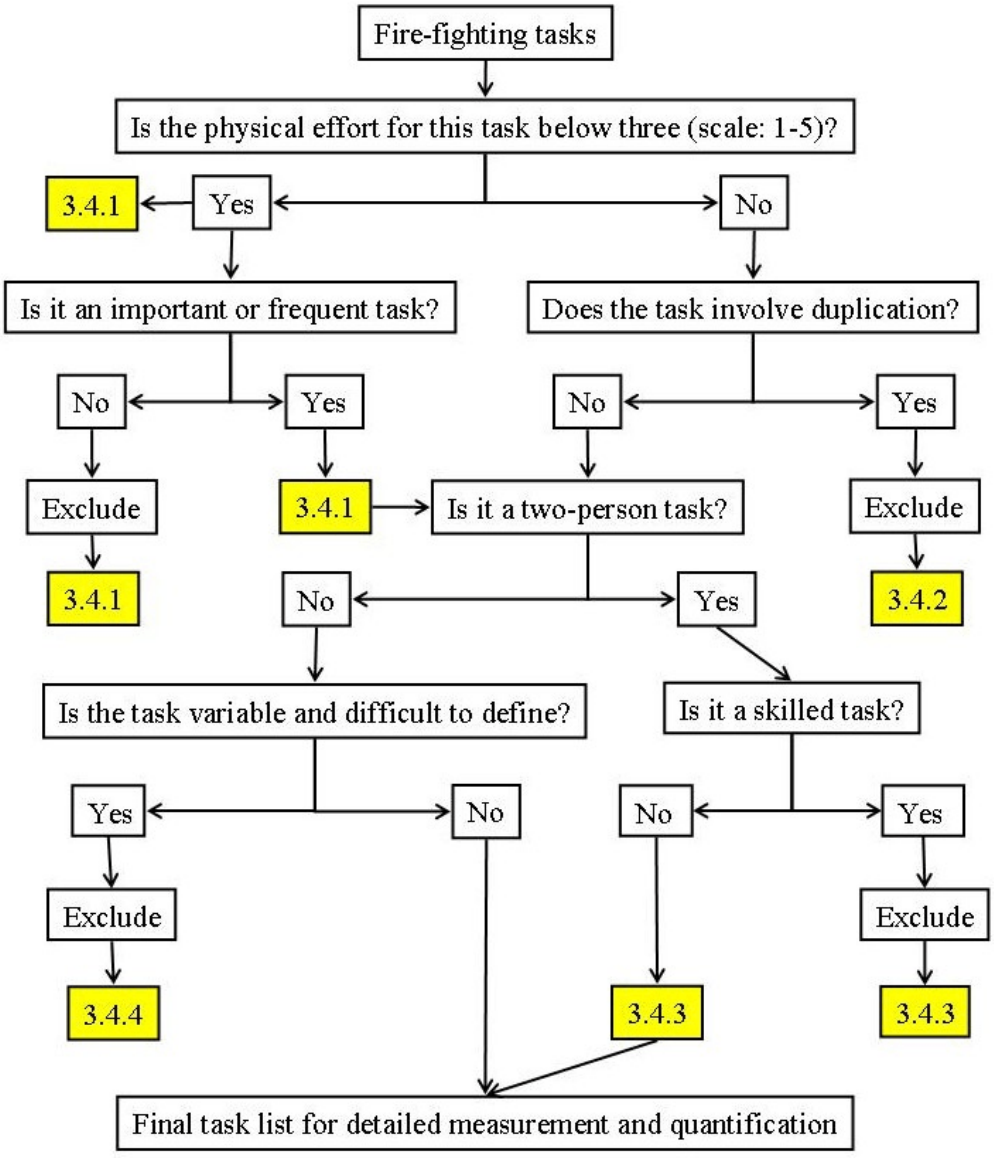

Figure 9: A flow chart for determining the final list of fire-fighting tasks for detailed evaluation and analysis. The numbered boxes for task exclusion criteria relate to Section numbers from this report (see text for details).

3.4.1 Exclusion criterion one: tasks with sub-threshold physical effort

This criterion resulted in the elimination of tasks for which the required physical effort reported in the survey was less than three (scale: 1-5). This physical effort threshold was based upon the responses of all firefighters to each of the two calibration tasks (rolling out 38-mm hose (mean response: 2.4) and using a 4.6-m ladder to gain access, rescue or complete salvage work (mean response: 3.0)), with the higher average of the two responses taken as the threshold. That is, this first exclusion criterion was based upon task difficulty being rated less than that of the more difficult of the two calibration tasks. Sub-threshold tasks are unlikely to be useful in the identification of either potentially superior or inferior firefighters, and would probably not be included within a pre-employment screening test, at least as individual test items. Tasks eliminated from each employment category were:

- Rolling out 70-mm hose:
  - retained metropolitan
  - permanent regional
  - retained regional.
- Rolling out 38-mm hose *{Calibration task}*:
  - permanent metropolitan
  - retained metropolitan
  - permanent regional
  - retained regional.
- Finding hydrant, carrying necessary equipment, getting water to appliance:
  - retained metropolitan
  - retained regional.
- Coupling hoses:
  - permanent metropolitan
  - retained metropolitan
  - permanent regional
  - retained regional.
- 4.6-m ladder use: gaining access, rescue, salvage *{Calibration task}*:
  - permanent metropolitan
  - permanent regional.
- Prolonged static work (*e.g.* holding victim's head):
  - permanent metropolitan
  - permanent regional.

However, if a sub-threshold task was performed very frequently (>30 occasions annually: *i.e.* higher than the more frequent calibration task)[24], or if it was more important than the higher of the two calibration tasks (4.1 on scale 1-5), or if it was identified as an activity that was reported by more than 20% of all firefighters to be limited by their physical capabilities (Table 16), then the task was retained. Tasks retained on these bases were:

- Finding hydrant, carrying necessary equipment, getting water to appliance:
  - permanent metropolitan: importance criterion (4.5)
  - retained metropolitan: importance criterion (4.5)

[24] Reported task frequency (all respondents): rolling out 38-mm hose: mean response = 29.1 *per annum*; and using a 4.6-m ladder to gain access, rescue or complete salvage work: mean response = 16.4 *per annum*.

- permanent regional: importance criterion (4.4)
- retained regional: importance criterion (4.4).

- Coupling hoses:
  - task limited by physical capacity criterion: all classifications
  - permanent metropolitan: frequency criterion (39.9 times *per annum*)
  - retained metropolitan: frequency criterion (49.8 times *per annum*)
  - permanent regional: frequency criterion (36.8 times *per annum*)
  - retained regional: frequency criterion (40.8 times *per annum*).

3.4.2 Exclusion criterion two: task duplication

This criterion was aimed at possibly eliminating tasks that duplicated other activities. Since duplication would be inefficient, then, where two or more tasks were deemed to be sufficiently similar in nature, the more difficult of these tasks has generally been retained (*i.e.* tasks requiring greater physical effort). Tasks eliminated at this step include the following, and this occurred simultaneously across each of the four employment classifications in cases where duplication was relevant for tasks still within the list:

- Dragging 38-mm charged hose across horizontal surfaces: More physical effort is required to drag a 70-mm charged hose and to drag a 38-mm charged hose up a flight of stairs (Table 11).
- Dragging 38-mm charged hose up a stairway: Duplicates stairs climbing when wearing the full personal protective ensemble (breathing apparatus) and dragging charged hose; the latter was rated as more difficult (Table 11).
- Moving victims with salvage sheets or Stokes Litter: Across classifications, firefighters rated this task to be less difficult (Table 11) and less important (Table 10) than a one-person rescue of a firefighter wearing the full personal protective ensemble and breathing apparatus.
- Prolonged static work (*e.g.* holding victim's head): In all employment classifications, firefighters rated this task to be less difficult than using spreaders and shears (Table 11):
  - retained metropolitan
  - retained regional.
- 4.6-m ladder use: gaining access, rescue, salvage: In all employment classifications, firefighters rated this task to be less difficult than using a 10.5-m ladder (under running; Table 11) *{Calibration task}*:
  - retained metropolitan
  - retained regional.
- Stair climbing: PPE, BA, charged hose, high-rise pack, tools: For three of the four employment classifications, this task was rated as less difficult than stair climbing when wearing the full personal protective ensemble and breathing apparatus, and dragging a charged hose (Table 11).
- Carrying Davey pump: two people: Across all classifications, firefighters rated this task to be less difficult than carrying the ventilation fan (Table 11).
- Bush: walking with cordage pack or Stokes Litter: Less effort than dragging a charged hose (bush) on hilly, sloped and uneven surfaces (Table 11).

3.4.3 Exclusion criterion three: two-person tasks

When two people perform a task, there is always an interaction between those individuals, and the extent of this interaction is influenced by factors such as the level of skill (technique) involved in the task, and the effort that is applied by each individual to the task. This introduces uncontrollable variability (noise) within a task performance, and it reduces measurement precision. Therefore, the Research Team sought to eliminate this variability by removing, where relevant and practical, tasks that are typically performed by two firefighters and which also have a significant skill component. While such tasks may be difficult, it is often very much harder to evaluate the contributions of each individual to the whole task. Moreover, since the ultimate aim of this Project was to develop screening test recommendations for use on individuals, then tasks that involve two individuals are less than ideal for evaluating individual performance. The following tasks were considered to have a significant skill component, and were eliminated from all classifications:

- Rescue victim while wearing PPE and BA: two people: In all employment classifications, firefighters rated this task to be less difficult (Table 11) and less important (Table 10) than a one-person rescue of a firefighter wearing the full personal protective ensemble and breathing apparatus.
- Rescue victim via ladder: two people: Eliminated due to skill required, effort of second person and difficulty of incorporating this task into a single-person screening test. This task was considered to be potentially more dangerous for use in a screening test.
- Rescue victim via stairs: two people: Eliminated due to skill required, effort of second person and difficulty of incorporating this task into a single-person screening test. This task was also considered to be slightly more dangerous.
- 10.5-m ladder use: two-person removal and replacement: Task was rated less difficult than using a 10.5-m ladder (under running) by all classifications (Table 11).

However, if a two-person task was unskilled and individual contributions could easily be measured, then that task was retained. One task was retained across all classifications:

- Carrying ventilation fan up stairs: two people: This task was universally rated as being more difficult than carrying the Davey pump (Table 11), and it is easy to determine the load distribution for this task between two individuals. Thus, one could imagine that performance on a single-handed carry task could provide an excellent prediction of performance for this task.

One two-person task presented difficulty for the Research Team.

- Prolonged use of charged hose: 70 mm (two people): Even though this task is a two-person activity, it was universally rated as requiring more physical effort that using a 38-mm charged hose (Table 11). It was therefore recommended for inclusion.

3.4.4 Exclusion criterion four: task is variable and difficult to define

Three tasks were difficult to define, due both to the nature of each task and the widely variable duration reported for each within the survey. These characteristics would make it very hard to narrow these tasks down into a discrete and reproducible task (with clear start

and end points) that could be simulated, evaluated and subsequently used within a screening test. Whilst this may also be true for many activities of fire fighting, it is particularly pertinent to the tasks below. Indeed, this limitation would render the inclusion of such items within screening tests as questionable. That is, one may argue that since the ends points were hard to define, then task performance thresholds would be equally hard to define. On this basis, the following tasks were eliminated from each employment classification:

- Tunnel search and rescue:
  - permanent metropolitan: duration 28.0 min (SD 37.7)
  - retained metropolitan: duration 12.0 min (SD 10.7)
  - permanent regional: duration 33.2 min (SD 46.4)
  - retained regional: duration 19.7 min (SD 13.9).
  - In addition, this activity involved duplication with several other tasks, and all classifications rated it as being less difficult than (Table 11):
    - prolonged crawling, kneeling, crouching, squatting: fire attack
    - rescue firefighter wearing protective equipment and breathing apparatus (one person)
    - dragging a 70-mm charged hose
    - dragging a charged hose (bush) on hilly, sloped and uneven surfaces.
- Pulling down ceilings using ceiling hook:
  - permanent metropolitan: duration 13.5 min (SD 17.0)
  - retained metropolitan: duration 9.1 min (SD 8.4)
  - permanent regional: duration 18.0 min (SD 30.2)
  - retained regional: duration 12.3 min (SD 8.6).
- Bush: digging fire break (McLeod Tool):
  - permanent metropolitan: duration 62.9 min (SD 67.9)
  - retained metropolitan: duration 26.0 min (SD 22.4)
  - permanent regional: duration 64.8 min (SD 75.5)
  - retained regional: duration 24.3 min (SD 16.3).

3.4.5 Tasks inclusion cross-check procedures

The final stage of this analysis involved cross-checking methods to ensure that tasks had not been eliminated from the final task list without an appropriate justification. This involved three steps.

The first step was focussed upon task importance, difficulty, and task performance frequency, duration and work volume[25]. Within Tables 10-13, these critical tasks were identified (red shaded cells). Thus, this analysis involved cross checking to see that these tasks had not been eliminated from the final task list without an appropriate justification. Only three tasks from those highlighted within Tables 10-13 were not included at the end of this process, and these, along with the reasons for their exclusion, are provided below:

- Rolling out 70-mm hose: Excluded from three classifications (retained metropolitan, permanent regional and retained regional) due to physical effort being less than the threshold of the more difficult calibration task (three).

[25] Work volume (minutes) is derived from the product of task frequency and task duration.

- Bush: walking with cordage pack or Stokes Litter: Excluded from all classifications due to task duplication and requiring less effort than dragging a charged hose (bush) on hilly, sloped and uneven surfaces.
- Bush: digging fire break (McLeod Tool): Excluded from all classifications due to the task being both widely variable in duration and difficult to define.

The second step emphasised fire-fighting tasks that were identified as being limited by the capacity of each respondent. The threshold for this check was that used within Section 3.4.1 (*i.e.* at least 20% of all firefighters found the task to be limited by their physical capabilities: Table 16 (red cells)). Therefore, this stage also involved cross checking to ensure that such tasks had not been eliminated without an appropriate justification. Only one task from those highlighted within Table 16 was not included at the end of this process:

- Stair climbing: PPE, BA, charged hose, high-rise pack, tools: For three of the four employment classifications, this task was rated as less difficult than stair climbing when wearing the full personal protective ensemble and breathing apparatus, and dragging a charged hose (Table 11).

Since this two-level, cross-checking procedure failed to identify any tasks that had been inappropriately eliminated, then it was concluded that this filtration mechanism was valid.

These analyses resulted in the identification of 15 tasks across the four employment classifications. The final step of cross-checking involved a *post hoc* comparison of these tasks by computing the subjective stress imposed on firefighters when performing each task. Stress was derived from the simple product of the subjective task difficulty rating and the task performance frequency. These data permitted a simple ranking of all tasks with respect to imposed stress, and the ranks for the 15 tasks identified from these procedures are presented in Table 17. Several conclusions may be drawn from these data:

- Subjective stress ranks were remarkably consistent across employment classifications:
  - ***Conclusion 1:*** Whilst it is widely recognised that surveys can result in the artificial inflation of the absolute values for subjective ratings, the uniformity of the current responses indicates that the relative position of each task within this ranking is valid.
  - ***Conclusion 2:*** The current methods, in combination with the survey sample size, have resulted a valid identification of the essential tasks for the next Research Phase.
  - ***Conclusion 3:*** The tasks identified represent the appropriate fire-fighting tasks for each of the employment classifications of firefighters.
- Across the four employment classifications, the tasks identified included at least one of the top three most stressful tasks, and at least five of the ten most stressful tasks:
  - ***Conclusion 4:*** The current methods have led to the valid identification of both high- and low-stress tasks.
  - ***Conclusion 5:*** Within each employment classification, the tasks identified represent a broad range of subjective stress.

Table 17: Subjective stress ranking within employment classifications for the 15 tasks identified. Ranks are from 1-30 (1=most stressful). Top ten shaded.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out uncharged hose lines: 70 mm	28	29	30	29
Hydrant: locating and connecting	26	26	25	27
Coupling and uncoupling hoses	30	28	29	28
Drag 70-mm charged hose: horizontal	20	25	21	25
Stair climb with PPE, BA, hose	11	16	15	17
Prolonged use of 38-mm hose	6	2	7	3
Prolonged use of charged hose: 70 mm (two people)	3	4	6	7
Fire attack: prolonged crawl, kneel, crouch, squat	9	7	8	10
Ladder use (10.5 m): 1-person, under run	22	23	22	21
Rescue FF with PPE, BA: 1 person	14	13	13	11
Using spreaders and shears	8	11	9	8
Using sledge hammer to gain entry	27	27	27	26
Carry: ventilation fan (up stairs): 2 people	25	19	24	23
Hazmat: walking, manual handling (encapsulated)	4	5	3	4
Bush: drag charged hose (hilly, sloped, uneven)	1	3	2	1

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional. Shading: red: task ranked in the top ten for subjective stress.

3.4.6 Recommended tasks for detailed investigation and analysis

3.4.6.1 Preliminary evaluation of the task list

The preliminary list of recommended fire-fighting tasks from these analyses was provided to Fire & Rescue NSW for preliminary evaluation, in the form of a draft version of this report. This evaluation occurred across two teleconferences (November 14th and 18th, 2011) between the Research Team and representatives of Fire & Rescue NSW (Assistant Director Health and Safety, Team Leader for Health and Fitness and Manager of Health Promotion). During these meetings, the Research Team provided additional information concerning the research methods, data analysis and the reported outcomes. These discussions resulted in several text revisions necessary to conform with the language, terms and descriptions used by Fire & Rescue NSW. In addition, a number of text revisions were instituted to enhance the clarity of the analytical procedures and the corresponding communication of this information to readers across all levels of that organisation.

From the procedures and analyses described above, 15 tasks were identified across each of the four employment classifications. These tasks are recommended for further investigation within Phase Two of this Project (Table 18).

Table 18: Recommended tasks ('yes') for each of the four employment classifications.

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out uncharged hose lines: 70 mm	Yes			
Hydrant: locating and connecting	Yes	Yes	Yes	
Coupling and uncoupling hoses	Yes	Yes	Yes	Yes
Drag 70-mm charged hose: horizontal	Yes	Yes	Yes	Yes
Stair climb with PPE, BA, hose	Yes	Yes	Yes	Yes
Prolonged use of 38-mm hose	Yes	Yes	Yes	Yes
Prolonged use of charged hose: 70 mm (two people)	Yes			
Fire attack: prolonged crawl, kneel, crouch, squat	Yes	Yes	Yes	Yes
Ladder use (10.5 m): 1-person, under run	Yes	Yes	Yes	Yes
Rescue FF with PPE, BA: 1 person	Yes	Yes	Yes	Yes
Using spreaders and shears	Yes	Yes	Yes	Yes
Using sledge hammer to gain entry	Yes	Yes	Yes	Yes
Carry: ventilation fan (up stairs): 2 people	Yes	Yes	Yes	Yes
Hazmat: walking, manual handling (encapsulated)	Yes	Yes	Yes	Yes
Bush: drag charged hose (hilly, sloped, uneven)	Yes	Yes	Yes	Yes

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional.

3.4.6.2 Evaluation of the task list by the Project Management Team

The fire-fighting task list was submitted to the Project Management Team for consideration, with the Research Team seeking endorsement and validation of this task list, and approval to progress to the next research Phase. These outcomes were each achieved at the Project Management Team meeting held on February 27th (2012).

4. CONCLUSION

On the basis of the methods adopted for this research, and the survey verification involving 717 permanent and 272 retained firefighters employed by Fire & Rescue NSW, it is concluded that this task list represents a valid and representative subset of physically demanding activities associated with fire fighting in regional and metropolitan NSW. This list has been assembled by following a logical flow chart (Figure 9) to determine task inclusion and exclusion criteria, and through an evaluation of task criticality, the physical effort required to perform each task and task performance frequency. Therefore, Table 19 contains the approved fire-fighting tasks for further investigation, along with the recommended observation durations necessary to evaluate each task in accordance with its expected duration in the field for each employment classification (Table 13).

Table 19: Recommended tasks and observation durations (minutes) for detailed investigation in Phase Two of this project. Data are derived from surveys administered to each of four firefighter classifications (Table 13).

Task	P-Metro	R-Metro	P-Region	R-Region
Rolling out uncharged hose lines: 70 mm	3	1	6	2
Hydrant: locating and connecting	6	5	10	4
Coupling and uncoupling hoses	2	4	6	2
Drag 70-mm charged hose: horizontal	7	4	10	5
Stair climb with PPE, BA, hose	10	7	13	8
Prolonged use of 38-mm hose	32	24	32	24
Prolonged use of charged hose: 70 mm (two people)	38	19	30	17
Fire attack: prolonged crawl, kneel, crouch, squat	18	18	24	16
Ladder use (10.5 m): 1-person, under run	8	5	10	7
Rescue FF with PPE, BA: 1 person	8	10	12	12
Using spreaders and shears	20	14	24	19
Using sledge hammer to gain entry	3	4	7	5
Carry: ventilation fan (up stairs): 2 people	7	6	10	7
Hazmat: walking, manual handling (encapsulated)	30	18	32	20
Bush: drag charged hose (hilly, sloped, uneven)	58	21	50	24

Notes: P-Metro = permanent metropolitan; R-Metro = retained metropolitan; P-Region = permanent regional; R-Region = retained regional.

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6. APPENDICES

The following appendices summarise the Project Management Team meetings prior to commencing, and after completing, the Fire Station visits. Also summarised are data pertinent to each of the eleven Fire Stations that were visited during this Phase of the Project (April 1st to May 18th, 2011). These site visits involved meetings with, or evaluations of the duties performed by male and female permanent and retained firefighters of Fire & Rescue NSW. The paper version of the Survey is in Appendix 14.

APPENDIX ONE: INTRODUCTORY MEETING: Project Management Team:
Date: 22/2/11
Location: Board Room Head Office (FRNSW).
Present: Alison Donohoe (FRNSW), Fatima Abbas (FRNSW), Darren Husdell (FRNSW), Mark Brown (FRNSW), Jim Hamilton (FRNSW), Richard Griffiths (FRNSW), Brendan Mott (FRNSW), Nigel Taylor (UOW), Herb Groeller (UOW), John Sampson (UOW), Hugh Fullagar (UOW).
Summary:
(1) **Introductions:** The FRNSW Management Team and the UOW Research Team conducted introductions.

(2) **Background to the Physical Employment Standards (PES) Project:** Nigel Taylor (NT) presented background overview of the project. Fatima Abbas (FA) questioned using the Training Needs Analysis (TNA) and the potential replication of this work. NT explained deficiencies within the TNA in relation to the detailed information that were required for this project. After clarification, it was agreed this tool would be used in conjunction with the Research Team's planned approach to this project, along with the Resource Allocation Model (RAM).

(3) **Research Frame of Reference:** It was agreed that all Permanent FF should fall under one employment standard and not be separated in terms of specialised areas (*e.g.* Hazmat or Rescue) as the roles are not performed exclusively within those areas. A tiered approach for regional firefighters is likely, depending upon the risks associated with work performed in local areas. The potential for different PES within stations (both permanent and retained) was also discussed, but this application would not change the early Phases of this research, and this will be explored later in the process depending on organisational position. NT explained that PES need to be based solely on work performed, and not based on age or gender. All members agreed with this approach. There was agreement that this will provide flexibility in the way FRNSW will then use these research data. MB and JH to discuss stations to be visited and provide details to NT.

(4) **Communication Between Management Team and Research Team:** All agreed that regular communication will be essential throughout this project. This may be via email.

APPENDIX TWO: Fire Station visit: Alexandria Fire Station

Date of site visit: 13/4/11
Fire Station Zone: Metropolitan East 1
Research Team members: Herb Groeller, Hugh Fullagar
Accompanying persons: Alison Donohoe
Ranks of firefighters interviewed:

- Firefighter level one: nil
- Firefighter level two: nil
- Qualified firefighter: four
- Senior firefighter (<15 y): three
- Senior firefighter (>15 y): nil
- Leading firefighter: one
- Station Officer: two

Female firefighters interviewed: four

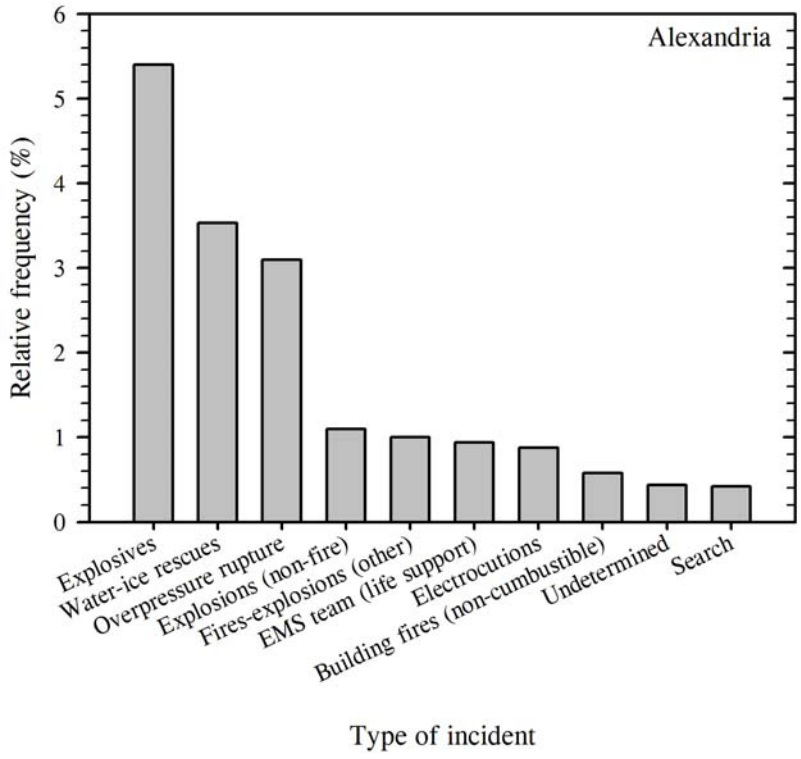

Figure A1: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX THREE: Fire Station visit: Bankstown Fire Station

Date of site visit: 1/4/11
Fire Station Zone: Metropolitan East 3
Research Team members: Nigel Taylor, Herb Groeller, John Sampson, Hugh Fullagar
Accompanying persons: Brendan Mott
Ranks of firefighters interviewed:

- Firefighter level one: nil
- Firefighter level two: nil
- Qualified firefighter: three
- Senior firefighter (< 15 y): one
- Senior firefighter (> 15 y): two
- Leading firefighter: nil
- Station Officer: two

Female firefighters interviewed: nil

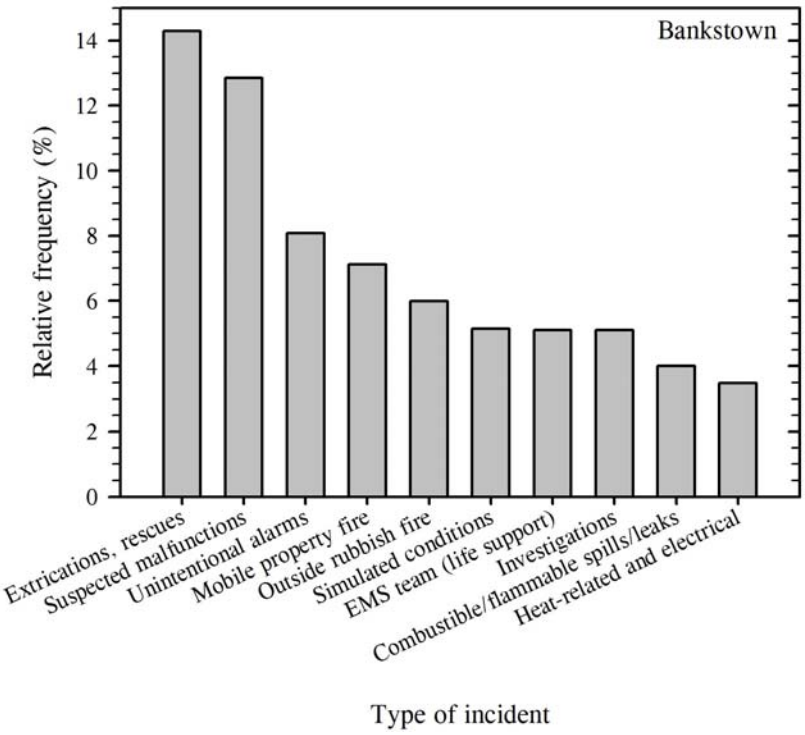

Figure A2: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX FOUR: Fire Station visit: Botany Fire Station

Date of site visit: 4/4/11
Fire Station Zone: Metropolitan South 2
Research Team members: Nigel Taylor, John Sampson, Hugh Fullagar
Accompanying persons: Brendan Mott, Megan Smith, Brain Johnson (Zone Commander MS2)
Ranks of firefighters interviewed:

- Firefighter level one: nil
- Firefighter level two: nil
- Qualified firefighter: three
- Senior firefighter (< 15 y): one
- Senior firefighter (> 15 y): one
- Leading firefighter: nil
- Station Officer: two

Female firefighters interviewed: nil

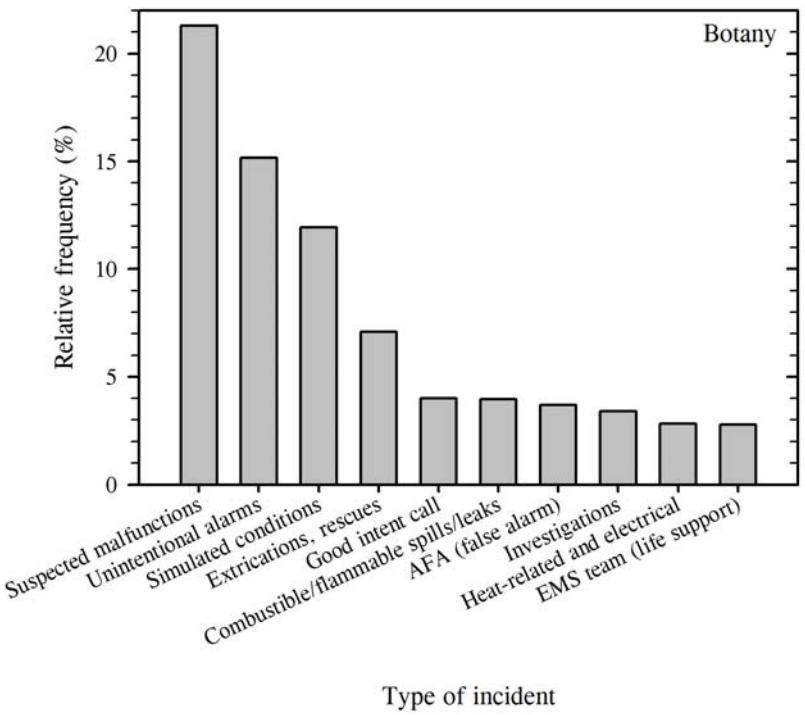

Figure A3: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX FIVE: Fire Station visit: City of Sydney Fire Station

Date of site visit: 13/4/11
Fire Station Zone: Metropolitan East 1
Research Team members: Nigel Taylor, Herb Groeller, Hugh Fullagar
Accompanying persons: Alison Donohoe, Brendan Mott, Megan Smith
Ranks of firefighters interviewed:

- Firefighter level one: four
- Firefighter level two: three
- Qualified firefighter: three
- Senior firefighter (<15 y): nil
- Senior firefighter (>15 y): nil
- Leading firefighter: two
- Station Officer: three

Female firefighters interviewed: one

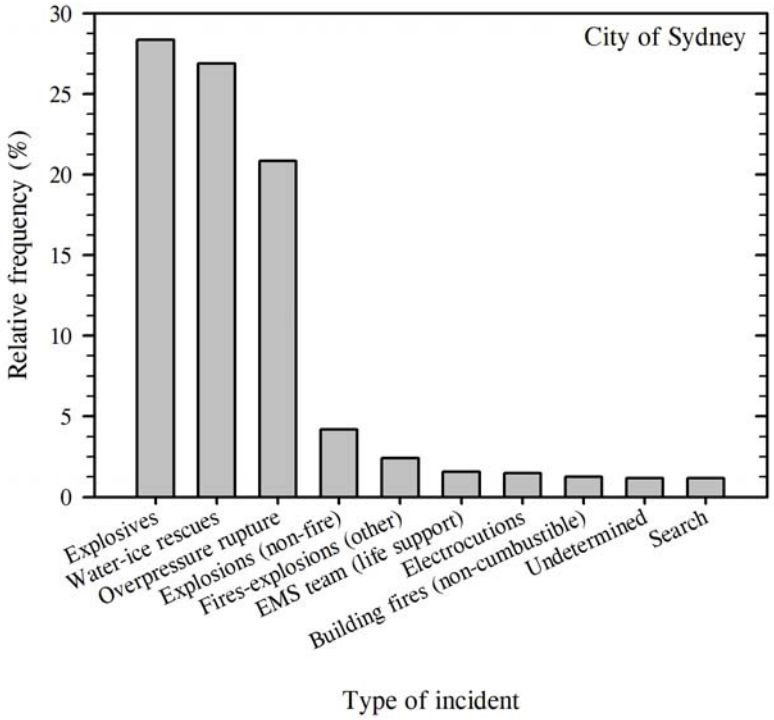

Figure A4: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX SIX: Fire Station visit: Crookwell Fire Station

Date of site visit: 12/4/11
Fire Station Zone: Regional South 2
Research Team members: John Sampson, Hugh Fullagar
Accompanying persons: Brendan Mott, David Lewis (Zone Commander RS2)
Ranks of firefighters interviewed:

- Firefighter level one: one
- Firefighter level two: one
- Qualified firefighter: four
- Senior firefighter (<15 y): nil
- Senior firefighter (>15 y): nil
- Leading firefighter: nil
- Station Officer: two

Female firefighters interviewed: nil

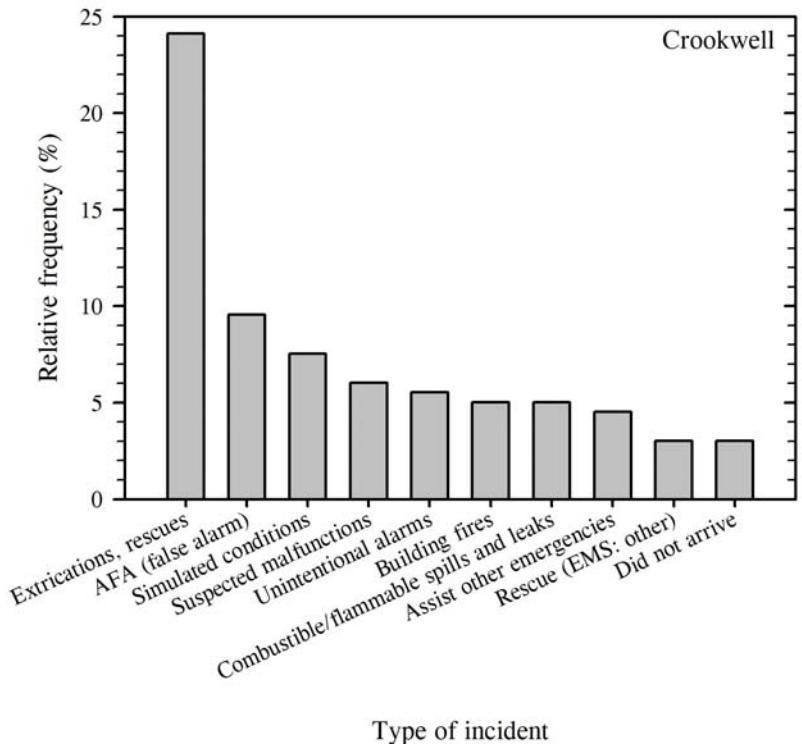

Figure A5: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX SEVEN: Fire Station visit: Delroy Fire Station

Date of site visit: 3/5/11
Fire Station Zone: Regional West 1
Research Team members: Herb Groeller, Hugh Fullagar
Accompanying persons: Brendan Mott
Ranks of firefighters interviewed:

- Firefighter level one: one
- Firefighter level two: one
- Qualified firefighter: one
- Senior firefighter (<15 y): one
- Senior firefighter (>15 y): nil
- Leading firefighter: two
- Station Officer: four

Female firefighters interviewed: two

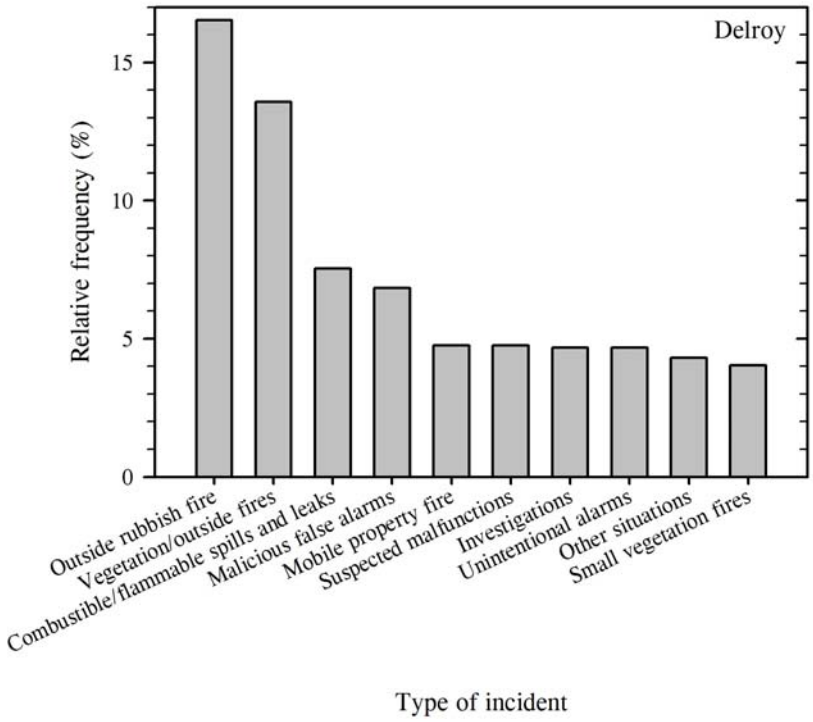

Figure A6: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX EIGHT: Fire Station visit: Dubbo Fire Station

Date of site visit: 2/5/11 (retained) and 3/5/11 (permanent)
Fire Station Zone: Regional West 1
Research Team members: Herb Groeller, Hugh Fullagar
Accompanying persons: Brendan Mott
Ranks of firefighters interviewed:

- Firefighter level one: nil
- Firefighter level two: one
- Qualified firefighter: four
- Senior firefighter (<15 y): nil
- Senior firefighter (>15 y): two
- Leading firefighter: two
- Station Officer: five

Female firefighters interviewed: nil

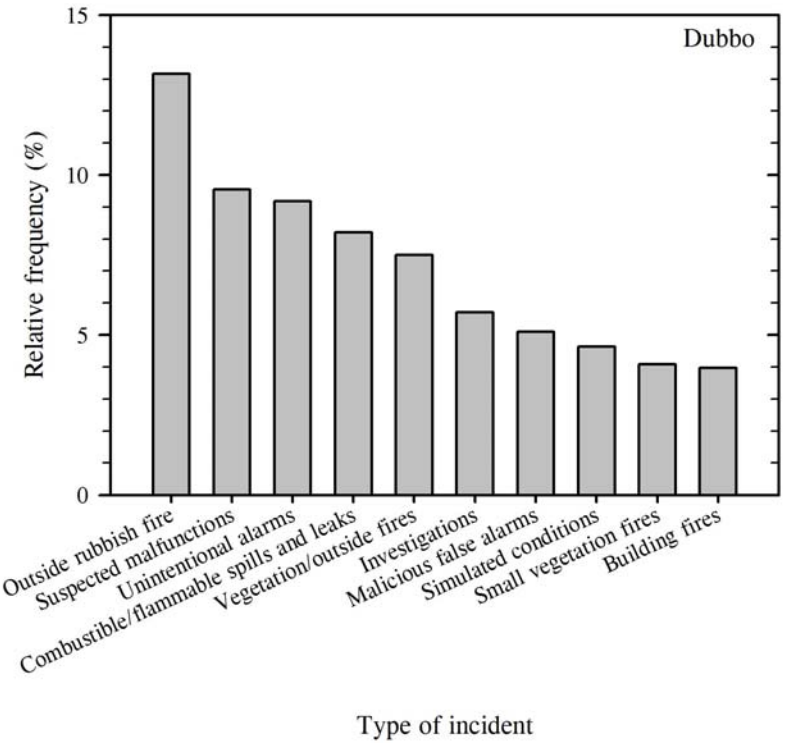

Figure A7: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX NINE: Fire Station visit: Goulburn Fire Station

Date of site visit: 11/4/11 (retained) and 12/4/11 (permanent)
Fire Station Zone: Regional South 2
Research Team members: John Sampson, Hugh Fullagar
Accompanying persons: Brendan Mott
Ranks of firefighters interviewed:

- Firefighter level one: four
- Firefighter level two: one
- Qualified firefighter: one
- Senior firefighter (<15 y): five
- Senior firefighter (>15 y): two
- Leading firefighter: one
- Station Officer: one

Female firefighters interviewed: two

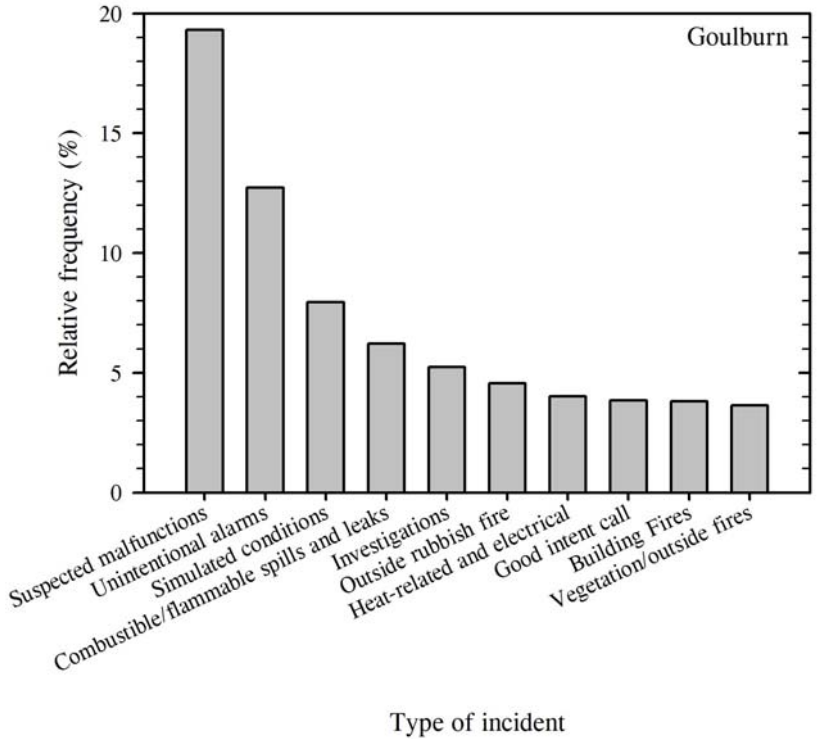

Figure A8: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX TEN: Fire Station visit: Helensburgh Fire Station

Date of site visit: 18/5/11
Fire Station Zone: Metropolitan South 1
Research Team members: Nigel Taylor, Hugh Fullagar
Accompanying persons: Brendan Mott
Ranks of firefighters interviewed:

- Firefighter level one: one
- Firefighter level two: one
- Qualified firefighter: two
- Senior firefighter (<15 y): nil
- Senior firefighter (>15 y): nil
- Leading firefighter: nil
- Station Officer: one

Female firefighters interviewed: two

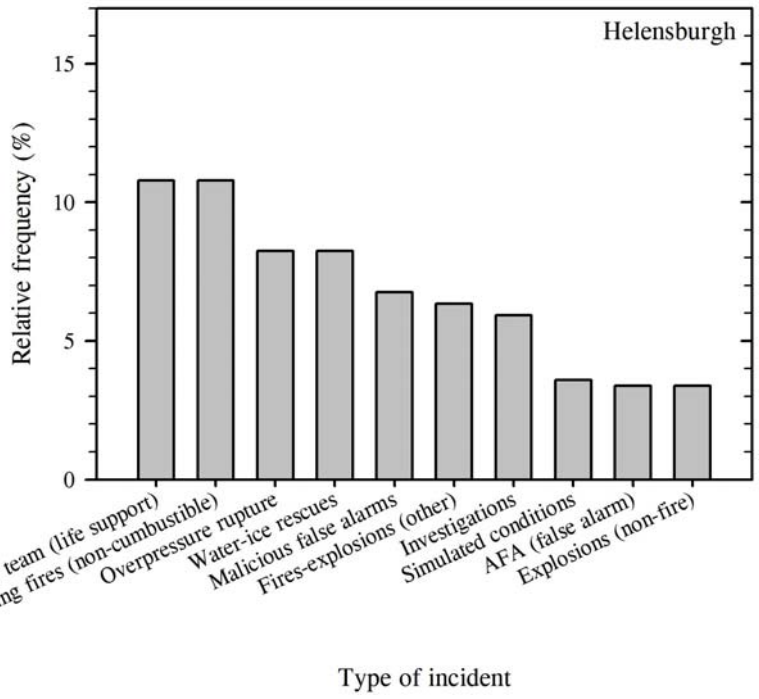

Figure A9: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX ELEVEN: Fire Station visit: Regentville Fire Station

Date of site visit: 7/4/11
Fire Station Zone: Metropolitan West 1
Research Team members: Nigel Taylor, John Sampson, Hugh Fullagar
Accompanying persons: Brendan Mott, Megan Smith
Ranks of firefighters interviewed:

- Firefighter level one: two
- Firefighter level two: nil
- Qualified firefighter: four
- Senior firefighter (< 15 y): two
- Senior firefighter (> 15 y): three
- Leading firefighter: nil
- Station Officer: two

One retained firefighter was at this Fire Station as a Visiting Retained Firefighter as part of the Station Visits Program.

Female firefighters interviewed: nil

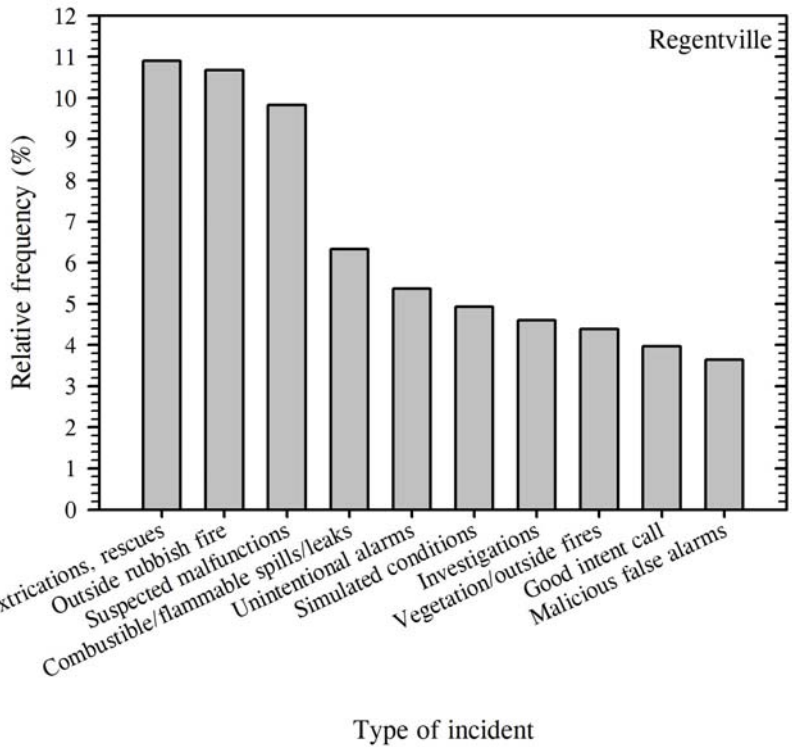

Figure A10: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX TWELVE: Fire Station visit: Warrawong Fire Station

Date of site visit: 6/5/11
Fire Station Zone: Metropolitan South 1
Research Team members: Herb Groeller, John Sampson, Hugh Fullagar
Accompanying persons: Brendan Mott, Megan Smith
Ranks of firefighters interviewed:

- Firefighter level one: nil
- Firefighter level two: nil
- Qualified firefighter: nil
- Senior firefighter (<15 y): nil
- Senior firefighter (>15 y): three
- Leading firefighter: nil
- Station Officer: one

Female firefighters interviewed: one

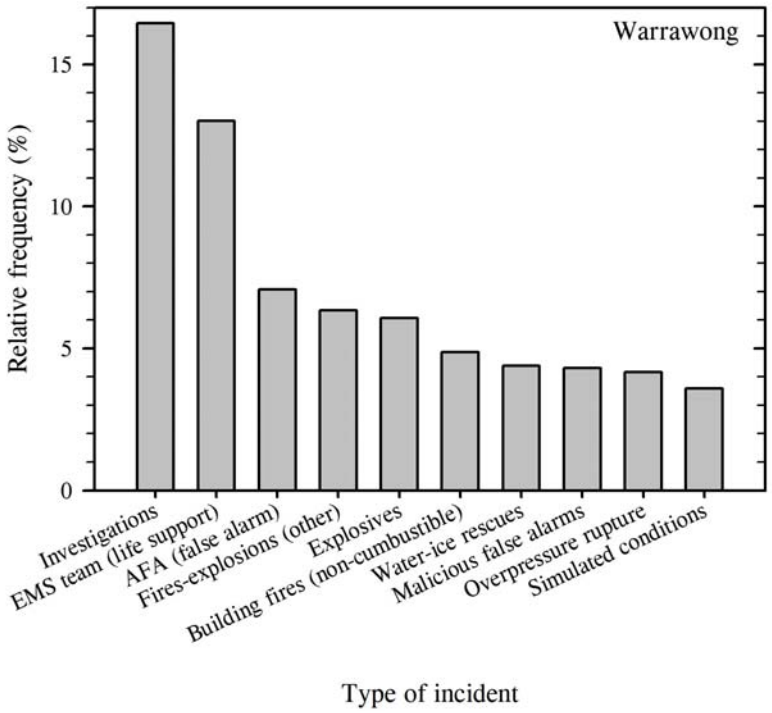

Figure A11: Fire-fighting incident representation provided through this site visit (top ten incidents). Data obtained from the Australian Incident Reporting System (AIRS).

APPENDIX THIRTEEN: Task list review, verification and Executive validation for use in the firefighter task Survey

SECOND MEETING: Project Management Team and other subject-matter experts:
Date: 15/6/11
Location: City Of Sydney Fire Station (FRNSW).
Present: Brendan Mott (FRNSW), Robert Caldwell (Station Officer), Ross Bramich (Station Officer), Scott Donohoe (Station Officer), Jason Kaul (Station Officer), David Scott (Station Officer), Andrew Dadley (Station Officer). Via electronic mail correspondence: Jim Hamilton (Director Of Regional Operations - Assistant Commissioner), Terrence Farley (Assistant Director Of Education and Training - Chief Superintendent) and Wayne Phillips (Operational Safety Coordinator -Station Officer).
Summary:
(1) A face-to-face focus group meeting was held at City Of Sydney Fire Station with six Station Officers, all with greater than 10 years operational firefighting experience. The Director of Regional Operations, the Assistant Director of Education and the Operational Safety Coordinator were also consulted, and each provided feedback via electronic mail.

(2) To assist with fire-fighting task verification and executive validation, the focus group was asked to provide an opinion on the following parameters with respect to the 50 preliminary tasks (Section 3.2):

(a) Inclusion/exclusion of the task based on the physical demands of the task.
(b) Inclusion/exclusion of the task based on shared physical demands existing between two or more tasks (resulting in unnecessary duplication).

(3) Twenty tasks received inclusion votes from greater than or equal to 75% of the nine participants for both parameters (a) and (b).

(4) This information was recorded in a spreadsheet and provided to the Research Team for consideration with respect to developing an organisation wide survey of the essential and physically demanding tasks of fire fighting.

APPENDIX FOURTEEN: Meeting to finalise and approve the firefighter task Survey prior to its online release, printing and distribution

THIRD MEETING: Survey approval
Date: 6/9/11
Location: Head Office (FRNSW).
Present: Darren Husdell (FRNSW), Brendan Mott (FRNSW), Megan Smith (FRNSW), Nigel Taylor (UOW), Herb Groeller (UOW).

Summary:
(1) Review of overview presentation of the entire project.

(2) Discussion of the possible benefits of running a larger survey.

(3) Fine tuning of the questions, rating scales, format and language.

(4) Revisions to be returned for final approval from DH.

(5) This requirement was satisfied and the online survey was released on September 28th, 2011. Paper versions (Appendix Fourteen) were posted as soon as possible thereafter, along with reply-paid envelopes.

APPENDIX FIFTEEN: Paper version of the Survey

A SURVEY OF PHYSICALLY DEMANDING DUTIES: FIREFIGHTERS OF FIRE AND RESCUE NSW

University of Wollongong

Thank you for participating in this voluntary survey, which will take approximately 15 minutes. Please complete all sections of the survey.

In completing this survey you signify that you:

- Have read the survey participant information
- Will not be identified by completing this survey
- Grant permission for your answers to be used to compile aggregate responses which will be reported to FRNSW and in various publications.

QUESTION 1: Are you a permanent or retained fire fighter?

☐ Permanent ☐ Retained ☐ Other

Question 2: What is your rank?

Permanent

- ☐ Firefighter
- ☐ Qualified Firefighter
- ☐ Senior Firefighter
- ☐ Leading Firefighter
- ☐ Station Officer
- ☐ Inspector
- ☐ Superintendent
- ☐ Chief Superintendent
- ☐ Other Senior/Executive officer

Retained

- ☐ Retained Firefighter <5 years
- ☐ Retained Firefighter 5-10 years
- ☐ Retained Firefighter 10-15 years
- ☐ Retained Firefighter >15 years
- ☐ Deputy Captain
- ☐ Captain

Question 3: How many years have you been an employee of FRNSW (Previously NSWFB)? If less than one year then enter 1.

☐ Number of years (whole numbers only please)

Question 4: What is your current age in years?

☐ Age in years (whole numbers only please)

Question 5: Are you male or female ?

☐ Male ☐ Female

Question 6: Please indicate your current employment status.

☐ Metropolitan (permanent)
☐ Regional (permanent)
☐ Operational support
☐ Metropolitan (retained)
☐ Regional (retained)

Question 7: How many years have you worked in each of the following classifications:
Round up or down to the nearest whole year. If less than one year enter 1.

☐ Metropolitan (permanent)
☐ Regional (permanent)
☐ Operational support
☐ Metropolitan (retained)
☐ Regional (retained)

Question 8: On the next two pages you will be given a number of fire fighting tasks to review. Please rate them as listed below.

i) **Importance:** We recognise that almost every fire fighting task is very important, but we want you to consider importance only relative to the urgency associated with saving life and property.
ii) **Physical effort:** On average, how much physical effort is required to perform the task?
iii) **Times per year** (frequency)**:** What is the average number of times you perform this task **per year**?
iv) **Duration:** In your experience what is the average duration for which the task is performed?

Fire fighting tasks	Importance 1 least 2 3 moderate 4 5 most	Physical effort 1 least 2 3 moderate 4 5 most	Times per year	Duration (min)
Bowling out 70 mm hose				
Bowling out 38 mm hose				
Locating hydrant carrying equipment and getting water to appliance				
Coupling/uncoupling hoses				
Dragging 70 mm charged hose across a horizontal surface				
Dragging 38 mm charged hose across a horizontal surface				
Dragging charged 38 mm hose up a stairway				
Stair climbing in PPE, with BA and charged hose				
Stair climbing in PPE, with BA, high rise pack, axe and halligan tool				
Prolonged use of charged hose: 38 mm (1 person)				
Prolonged use of charged hose: 70 mm (2 people)				
Prolonged crawling, kneeling, crouching, squatting: fire attack				
4.6 m "Jumbo/Little Giant" ladder use: gaining access and/or rescue/salvage work				
10.5 m ladder use: under running, stabilisation				
10.5 m ladder use: 2 person removal and replacement				

Question 8 (continued): Review the following fire fighting tasks. Please rate them as listed below.

i) **Importance:** We recognise that almost every fire fighting task is very important, but we want you to consider importance only relative to the urgency associated with saving life and property.
ii) **Physical effort:** On average, how much physical effort is required to perform the task?
iii) **Times per year** (frequency)**:** What is the average number of times you perform this task **per year**?
iv) **Duration:** In your experience what is the average duration for which the task is performed?

Fire fighting tasks	Importance 1 least 2 3 moderate 4 5 most	Physical effort 1 least 2 3 moderate 4 5 most	Times per year	Duration (min)
Rescue via ladder (2 person)				
Rescue victim via stairs (2 person)				
Rescue firefighter while wearing PPE and BA (1 person)				
Rescue victim while wearing PPE and BA (2 person)				
Moving victims with salvage sheets or Stokes litter				
Using spreaders and shears				
Prolonged static work (e.g. holding victim's head)				
Using sledge hammer to gain entry				
Carrying ventilation fan up stairs (2 person)				
Carrying Davey pump (2 person)				
Pulling down ceiling using ceiling hook				
Hazmat: Prolonged walking and manual handling in fully encapsulated suit				
Tunnel search and rescue				
Bush: Walking with cordage pack or Stokes Litter				
Bush: Dragging charged hose on hilly, sloped, uneven surfaces				
Bush: Digging fire break (McLeod Tool)				
Any other task (please list and rate)				

Question 9: Have you ever found that your ability to perform one of the tasks listed below was limited by your physical capacity (e.g strength, endurance or cardiovascular fitness)? Please enter Yes (Y) or No (N) for each task.

Fire fighting tasks	YES	NO
Bowling out 70 mm hose		
Bowling out 38 mm hose		
Locating hydrant carrying equipment and getting water to appliance		
Coupling/uncoupling hoses		
Dragging 70 mm charged hose across a horizontal surface		
Dragging 38 mm charged hose across a horizontal surface		
Dragging charged 38 mm hose up a stairway		
Stair climbing in PPE, with BA and charged hose		
Stair climbing in PPE, with BA, high rise pack, axe and halligan tool		
Prolonged use of charged hose: 38 mm (1 person)		
Prolonged use of charged hose: 70 mm (2 people)		
Prolonged crawling, kneeling, crouching, squatting: fire attack		
4.6 m "Jumbo/Little Giant" ladder use: gaining access and or rescue/salvage work		
10.5 m ladder use: under running, stabilisation		
10.5 m ladder use: 2 person removal and replacement		
Rescue via ladder (2 person)		
Rescue victim via stairs (2 person)		
Rescue firefighter while wearing PPE and BA (1 person)		
Rescue victim while wearing PPE and BA (2 person)		
Moving victims with salvage sheets or Stokes litter		
Using spreaders and shears		
Prolonged static work (e.g. holding victim's head)		
Using sledge hammer to gain entry		
Carrying ventilation fan up stairs (2 person)		
Carrying Davey pump (2 person)		
Pulling down ceiling using ceiling hook		
Hazmat: Prolonged walking and manual handling in fully encapsulated suit		
Tunnel search and rescue		
Bush: Walking with cordage pack or Stokes Litter		
Bush: Dragging charged hose on hilly, sloped, uneven surfaces		
Bush: Digging fire break (McLeod Tool)		
Any other task (please list and rate)		

FINAL COMMENTS

If you feel that we have failed to include some tasks that you consider to be as physically demanding, or even more demanding, then please send an electronic mail message to Hugh Fullagar (hhkf238@uowmail.edu.au). In that message, please name and briefly describe each task that you would like to add to this list. Alternatively, if you would like to make any comments concerning the survey or any other aspect of this research, you may write these comments in the box below. Like all other parts of this survey, these comments will be kept confidential.

Additional comments

END OF SURVEY

Thank you for taking the time to complete this survey

APPENDIX SIXTEEN: Meeting to validate and approve the final fire-fighting task list recommended for Phase Two of the research project

FOURTH MEETING: Project Management Team:
Date: 27/2/12
Location: Board Room Head Office (FRNSW).
Present: Chair: Alison Donohoe (FRNSW), Darren Husdell (FRNSW), Jim Hamilton (FRNSW), Ken Murphy (FRNSW), Geoffrey Parkes (FRNSW), Brendan Mott (FRNSW), Megan Smith (FRNSW), Nigel Taylor (UOW).
Summary:
(1) Introductions and welcome (AD).
(2) NT gave a very brief overview of the PAT review to date:
During focus groups performed at 11 stations across NSW, 50 physically demanding tasks were identified. 106 FF participated in the focus groups, from 11 stations that were nominated by JH (DRO) & MB (DGMO) to give a good cross section of the organisation's population, considering gender, age, experience etc. The project management team and subject matter experts then looked at the 50 tasks to determine overlap and duplication etc. and the task list was subsequently reduced to 30 tasks for inclusion in the survey. The survey went out to the organisation and we received approximately 250 paper based responses and 750 electronic responses. The survey amongst other things asked staff to rank tasks according to frequency, critical importance, and difficulty involved. The results of the survey were then analysed using a filtration process which was detailed by NT utilising the Executive Summary for this phase of the research. The results of the filtration process identified 15 tasks for detailed task analysis. The 15 trade tasks were tabled as appendix A for approval by all members of the Project Management team.

A minor amendment to the wording requested by JH, “Ladder use (10.5m) 1-person, under run and stabilise” to “Ladder use (10.5m) 1-person, under run”. JH expressed that this is required as the person footing the ladder is also assisting with the stabilisation.

The agreed task list is as follows:

1. Rolling out uncharged hose lines: 70 mm
2. Hydrant: Locating and connecting
3. Coupling and uncoupling hoses
4. Drag 70-mm charged hose: horizontal
5. Stair climb with PPE, BA and Hose
6. Prolonged use of 38-mm hose
7. Prolonged use of charged hose: 70-mm (two people)
8. Fire attack: prolonged crawl, kneel, crouch and squat
9. Ladder use (10.5 m) 1-person, under run
10. Rescue FF with PPE and BA: 1 person
11. Using spreaders and shears
12. Using sledge hammer to gain entry
13. Carry: ventilation fan (up stairs): 2 people
14. Hazmat: walking, manual handling (encapsulated)
15. Bush: drag charged hose (hilly, sloped and uneven)

This list was endorsed by the committee as the 15 tasks that should be used as the basis for the development of the physical employment standard.

NT provided overview of analysis performed on the tasks to date including explanations of the photos taken on the field testing, and that will appear in the report for phase 2 of the project. NT outlined that his team were able to borrow from the Department of Defence physiological monitoring devices which allowed the field studies to collect essential data. The limited access to this equipment was the reason for commencing task analysis prior to final task list endorsement. The expectation that not all 15 identified tasks will be in the final standard was discussed.

It was acknowledged that a tiered approach to retained firefighter PATs would be considered based on job demands at a various locations. The FRNSW Resource Allocation Model may be able to be utilised in this regard. It was discussed that DRO Jim Smith had expressed out of session that he would discuss this with the Senior Planner ORU LLC, plus a risk assessment would be conducted on each station to facilitate this process.

ACTION: NT to provide report detailing final endorsed task list developed during phase 1 of the project.

(3) It was unanimously agreed to have the wording “Trade” removed from in front of “task” throughout the report. The title on the report is also to be amended to “The essential, physically demanding tasks of contemporary firefighting”.

ACTION: NT to make necessary amendment to report.

(4) NT: In the next phase UOW will utilise the data obtained during the task analysis to develop screening tests. Once these tests are developed FF will be involved in completing the screening test to receive feedback on appropriateness.