Impacts of Climate Change on Urban Infrastructure & the Built Environment

A Toolbox

Tool 3.5: Subjective Quantified Risk Assessment (sQRA) Tool

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Contents

1. Introduction

This document is one of a number of reference and guidance documents designed to assist Councils, and others, in taking account of long-term climate change effects in their on-going management of the urban environment.

The tool described here gives details of a subjective quantified approach to risk assessment which can be used to assist decision-makers with the aim of making the built environment more resilient to climate change effects.

This and other risk-related documents within the Toolbox are specifically concerned with the risks that will arise from climate change effects and uncertainties, and not the risks and uncertainties associated with the drivers of climate change.

The reader is referred to [Tool 1.3] for an introduction to risk assessment and to [Tool 3.1] for risk assessment good practice in the context of climate change.

1.1 Background

While semi-quantitative risk assessment methods (i.e. using scoring systems) are useful for determining priorities, they are of limited use in determining the effectiveness of risk controls since they do not provide absolute measures of risk [refer to Tool 1.3 for background information on risk assessment].

It is therefore necessary to use quantitative methods to provide a sufficiently accurate absolute measure of risk, so as to undertake an economic analysis of risk reduction options. Quantitative methods make it possible to determine not only the reduction in risk achieved by a particular course of action, but also the residual risk that remains despite action being taken[1].

Unfortunately, quantified risk assessment (QRA) methods normally require considerably more resources, data and time to undertake than semi-quantified methods. The Subjective Quantified Risk Assessment (sQRA) Tool described here provides a compromise solution in that it provides an order of magnitude quantified measure of risk but uses the same subjective elicitation techniques typically used in semi-quantified methods (O'Hagan et al, 2006) for assessing the levels of damage caused.

[1] Unless a risk can be entirely eliminated, risk reduction measures are not perfect and some residual risk remains.

While subjective elicitation techniques offer significant savings in time, they result in a loss in accuracy. Accordingly, it is emphasised that this Tool provides results that are order-of-magnitude only. The Tool is designed to be used in the early stages of assessing the viability of high-level strategic alternative options, such as whether it is better to protect against a hazard or move vulnerable assets out of harm's way.

The structure and operation of the Subjective QRA Tool is described here principally through its application in assessing fluvial flood risk. A similar methodology can be applied to any form of risk that is amenable to subjective elicitation.

1.2 Purpose of Tool

The Subjective QRA Tool provides order-of-magnitude estimates of the consequences and risks of defined events which may be used in preliminary evaluations of high-level strategic options for adapting to climate change, amongst other things.

1.3 Obtaining this Tool

Contact the author of this report for information about obtaining and using this Tool.

2. Overview of the Subjective QRA Tool

The Subjective QRA Tool is a development of the Risk Matrix method described in [Tool 1.3] and also in MfE Guidance (MfE, 2008a and 2008b), but uses risk ratings defined in a way that can be translated into annual average risk-adjusted dollar costs. To achieve this, two specific enhancements of the standard Risk Matrix method are required:

a) The consequence rating scales need to be defined so that ratings for each consequence type (e.g. social, environmental, cultural, and economic) are equivalent in terms of the dollar cost of the damages they represent. Thus a consequence score of 3 for environmental damage represents the same order-of-magnitude damage cost as a consequence score of 3 for social, cultural or economic impacts.

b) The Subjective QRA Tool incorporates a consistent method of relating consequence scores to damage costs. The Tool described here uses a logarithmic translation from risk ratings to cost. Using this translation a consequence rating of 3 represents a damage cost of $1,000, a rating of 4 represents a damage cost of $10,000, etc.

A schematic showing the main inputs and elements for the Subjective QRA Tool as applied to a flood/inundation scenario is given in Figure 2.1. The risk workshop is central to the subjective aspect of the quantification process, through which experts assign absolute levels of risk and damage, informed by mapped information and local knowledge. The main elements of the tool are shown in the box on the left hand side of Figure 2.1 and are described later in the document.

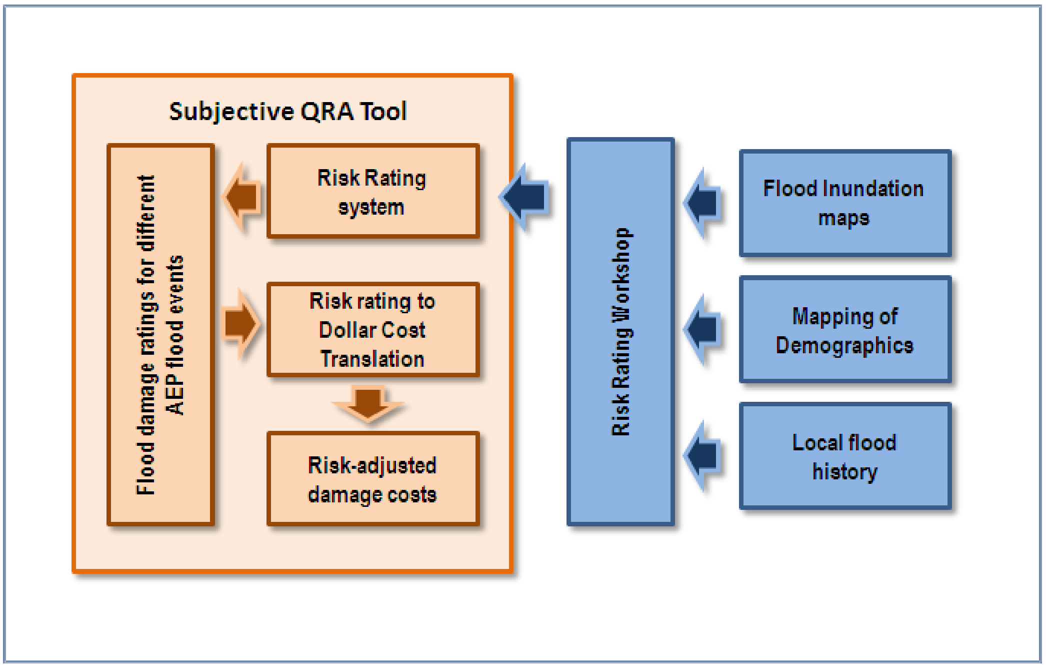

Figure 2.1: Main Elements of Subjective QRA Tool

The Tool itself is embodied within a spreadsheet which has been developed to capture the required information, and to perform the calculation and summation of the components of risk.

The Subjective QRA Tool has been developed, and is described here with examples, for the evaluation of flood risk. The Tool is intended to be complementary to data intensive risk-mapping tools that use empirical functions to evaluate spatial estimates of flood risk, associated impacts, and building damage, e.g. RiskScape (NIWA / GNS, 2009), see [Tools 3.2 and 3.3].

2.1 Basis of Subjective QRA Process

Subjective quantification uses a structured and facilitated group workshop approach to determine the levels of impact, from a flood for example, using technical experts and others with relevant local knowledge. Ideally, representatives of the organisation, groups or bodies charged with making or guiding the decisions should also be invited to aid in their understanding and acceptance of the process. The experts need to come to the workshop prepared to brief the group on local matters within their sphere of expertise. The whole group may then contribute to the discussion and rating of the levels of impact (e.g. for a defined flood event), guided by mapped information and local knowledge.

The consequence ratings are converted within the Tool to order-of-magnitude costs and then, in this example, multiplied by the Annual Exceedance Probability (AEP) of the flood event causing the damage to generate an average annual risk-adjusted cost, or 'cost-risk' for short.

The following sections illustrate how the Subjective Quantitative Risk Assessment Tool is applied in the context of flood modelling of a river catchment.

2.2 Flood Modelling

In order to apply the Subjective QRA methodology it is important that flood extent maps are generated, and overlain with the major roads, property locations and boundaries. It is helpful to have flood inundation maps for a range of severity events (see example in Figure 2.2). If the impacts of flood management schemes are to be assessed, the effects of these schemes on flood extent will also need to be considered and mapped.

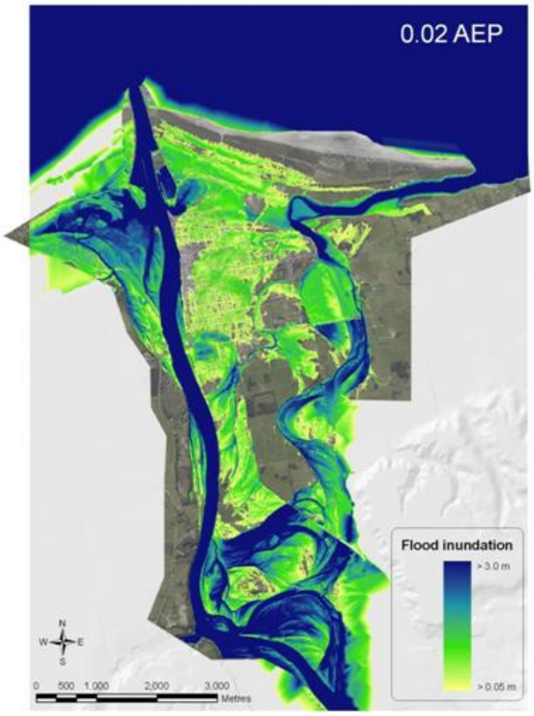

Figure 2.2: Example Flood Extent Map

Under normal circumstances, flood modelling can be very resource intensive and time-consuming to achieve a high degree of accuracy. Since the Subjective QRA Tool seeks to provide order of magnitude costs, based on subjective interpretations, it is not necessary to use highly detailed flood models if they are not available. Simplified flood models can be used to explore a wide range of possible flood management scenarios. However, the accuracy of simplified models can be improved through a process of calibration against a few selective scenarios generated from a more complex model and against records of past events.

2.3 Rating Flood Impacts

The impacts from flooding are best assessed by sub-dividing the river and its adjacent catchment of interest into a manageable number of reaches (referred to in the Tool as river segments), as illustrated diagrammatically in Figure 2.3.

Impact or consequence ratings may then be determined more easily for the area associated with each reach according to its land use and assets vulnerable to flooding. A pre-defined consequence rating scale and records of past floods (if they exist) are used to guide this rating process.

An illustrative example of a consequence rating guidance table is given in Table 2.1. An example of a record of a past flood event, prepared to inform the subjective risk rating process, is given in Annex A.

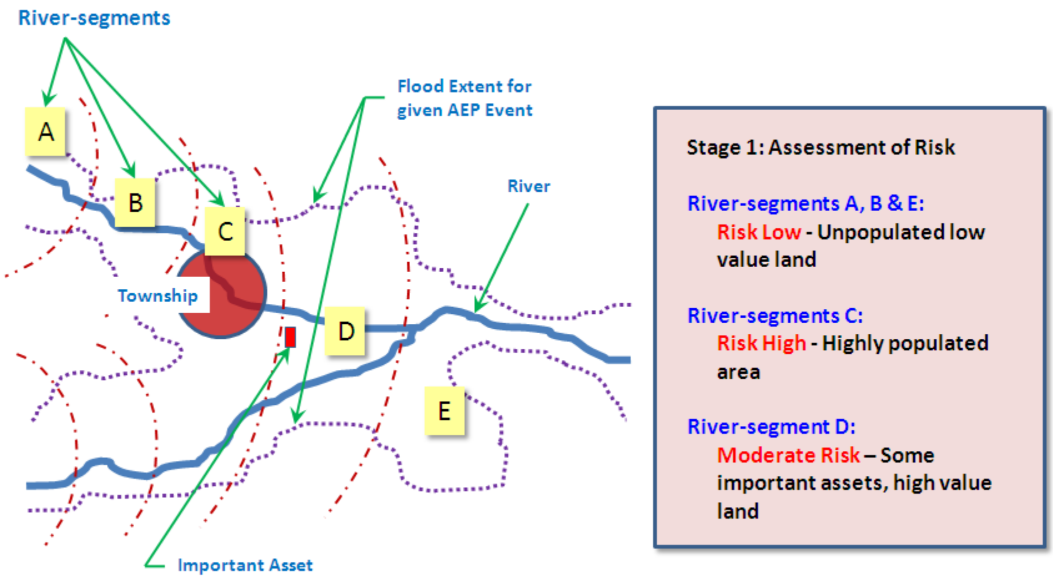

Figure 2.3: Illustration of River Catchment Sub-divided into River Segments Based on Reach Prior to Subjective QRA

Table 2.1: Example Consequence Rating Table Used in the Subjective QRA Tool

	Economic	Population At Risk[#1 & #2]	Social	Environment	Cultural	Critical Asset
1	Negligible cost, Typically $10 direct costs per event	No residents at risk	Little or no social disruption	Negligible damage to habitat and/or rapid regeneration of habitat	Negligible damage to cultural heritage or taonga	No critical assets affected
2	Very low cost, typically $100 direct costs per event	No more than 3 people at risk	No more than minor, short-term social disruption and recovery	Minor damage to habitat, vegetation or crop	Minor repairable/rectifiable damage to cultural heritage or taonga	Access to critical asset impaired
3	Low cost, typically $1000 direct costs per event	Between 4 and 30 people at risk	Some social disruption and stress for a significant period	Moderate repairable/rectifiable damage to valued habitat, temporary loss of vegetation or lost crop for season	Moderate repairable/rectifiable damage to cultural heritage or taonga	Critical asset damaged and temporarily disabled
4	Moderate cost, typically $10,000 direct costs per event	Between 31 and 90 people at risk	Significant social disruption, moderate chance of injuries, significant stress over a moderate period of time	Major repairable/rectifiable damage to valued habitat, prolonged damage to vegetation or lost crop, some remediation required	Major repairable/rectifiable damage to cultural heritage or taonga of some importance	Major damage to critical asset
5	High cost, typically $100,000 direct costs per event	Between 91 and 300 and people at risk	Significant social disruption, moderate chance of major injuries and/or several minor injuries	Localised degradation or damage to valued habitat, significant remediation of vegetation or land required	Degraded or major damage to cultural heritage or taonga of local significance	Major damage to critical asset resulting in wider impacts, e.g. loss of essential services
6	Very high cost typically $1,000,000 direct costs per event	Between 301 and 1000 people at risk	Prolonged social disruption, high chance of several major injuries and/or one fatality	Permanent loss of valued habitat or degraded land over a small area	Permanent loss of cultural heritage or taonga of regional significance	Critical asset destroyed and wider impacts, e.g. loss of essential services
7	Extremely high cost typically $10,000,000 direct costs per event	More than 1000 people at risk	Prolonged social disruption and high chance of major injuries and multiple fatalities	Permanent loss of valued habitat or degraded land over a wide area	Loss of nationally significant heritage and/or taonga	Several critical assets destroyed and wider impacts, e.g. loss of essential services

Note #1: Injuries and health effects factored in using the Disability Adjusted Life Year (DALY) approach promulgated by the WHO, Pruss-Ustun A, Mathers C, Corvalan C and Woodward A, 2003 Assessing the Environmental Burden of Disease at National and Local Levels – Introduction and Methods, World Health Organisation, Environmental Burden of Disease Series, No. 1

Note #2: Itinerants factored in according to temporal and spatial exposure

The consequence rating table provides a generic description of the effects to be expected based on the four well-beings (social, cultural, environmental and economic) across an integer rating scale from 1 to 7. These ratings are converted to a cost in the spreadsheet tool using the following logarithmic relationship:

$$\text{Cost (\$)} = 10^{\text{(Consequence Rating)}}$$

This logarithmic translation between the subjective consequence rating scale and the dollar cost scale is further illustrated in Figure 2.4.

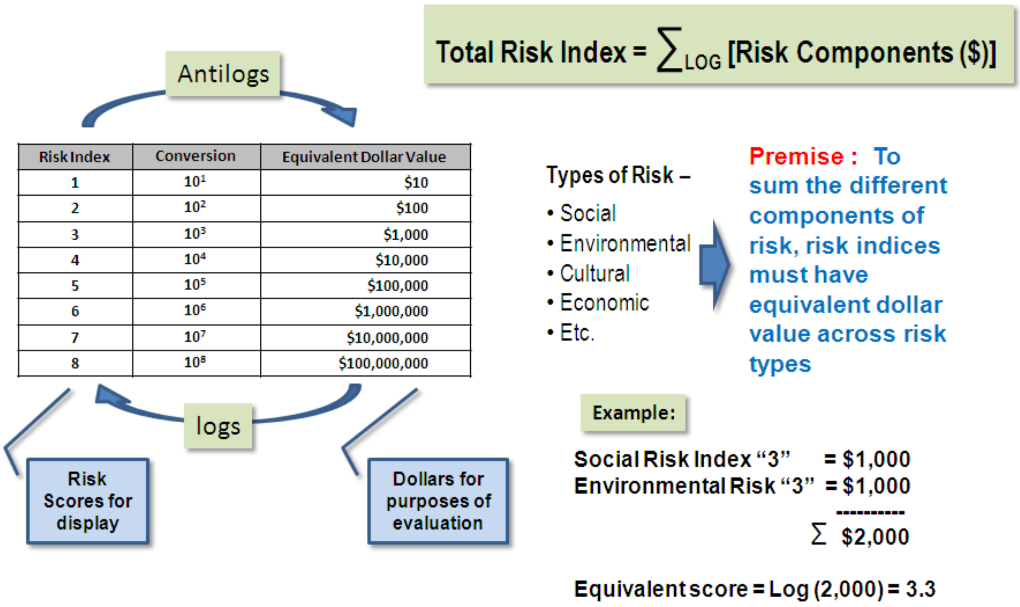

Figure 2.4: Relationship between Consequence Rating Scale and Cost

2.4 Evaluation of Risk

Having rated each consequence type for each river reach (using Table 2.1) and converted ratings to dollars using the method shown in Figure 2.4, the various cost components can be summed for each river reach. Note that this summation is only valid if the equivalence of ratings across the different consequence types is adhered to, and a consistent translation between ratings and cost is used.

The summed costs are then multiplied by the annual exceedance probability (AEP) of the flood event. The result is an average annual risk-adjusted damage cost for each river reach; for example, an event with an AEP of 0.01 that causes $100 million dollars worth of damage has a risk-adjusted cost of $1 million dollars (0.01 x $100,000,000).

Risk-adjusted costs can be converted back into a risk ratings (or indices) using the reverse log relationship. Mapping risk indices for an event can be advantageous to emphasise the-order-of-magnitude expected accuracy in damages and to avoid misinterpretation of risk-adjusted costs as actual damage costs.

In the example described, the consequence rating for each river reach is likely to change depending on the severity of the flood event. If the differences are significant (e.g. the number of properties that are inundated changes), then the reaches should be re-rated and new risk-adjusted costs determined for a range of different AEP events.

2.5 Treatment of Climate Change

It is important when making decisions about investments in potentially costly infrastructure that must perform for many decades to factor in the long-term effects of climate change. In the case of flood model predictions, this can be achieved by suitable adjustment to the event AEPs or by including more extreme flood events to represent future conditions, for example. The typical range in AEP flood events that may be considered is shown in Table 2.2.

Table 2.2 Typical Range of AEP Flood Events for Use in the Subjective QRA Tool

Chance of flood event occurring in any year	Annual exceedance probability AEP	Average recurrence interval ARI (years)	Comments
1 in 2	0.5	2	Nuisance event
1 in 10	0.1	10	Relatively frequent flood
1 in 50	0.02	50	Building design criteria, Building Act 2004
1 in 100	0.01	100	Typical design criteria for engineered flood alleviation schemes
1 in 200	0.005	200	Typical design criteria to allow for climate change effects

2.6 Determination of Scheme Benefits and Residual Risk

The benefit of a particular flood management scheme is determined from the damage that the scheme prevents. In the Subjective QRA Tool, this is determined by subjectively assessing the flood damage, both with and without the scheme in place.

The damage cost without the scheme, minus the damage cost with the scheme in place, represents the benefit derived from the scheme. The damage costs that remain after the scheme has been implemented represent the 'residual risk', arising from the potential for floods that are more severe than the maximum design event(s) for the stopbank.

Evaluating the damage costs for different flood mitigation schemes, as described above, allows different schemes to be compared using, for example, a cost-benefit approach [see Tool 4.3 which describes the Rapid Cost-Benefit Evaluation methodology].

Because damage costs are derived subjectively, it is possible to consider variants in the different flood management schemes under consideration without necessarily re-running flood models, provided the differences can be subjectively determined. If amenable to subjective assignment, there are significant savings to be made in the amount of effort required over integrated risk-models such as RiskScape to evaluate the merits of different options at an early stage in the optioneering process. Subjective methods also provide greater flexibility in assessing a wide range of different flood management scenarios.

A further advantage in using a subjective approach is that damage costs held in the spreadsheet tool can more readily be updated as new information becomes available. Such updates may be applied directly to consequence rating tables or discussed in further workshops.

3. Brief Guidance on Use

Figure 3.1 outlines the key elements of the Subjective Quantified Risk Assessment process, using a river flood scenario.

The process starts on the left side (yellow box) with the documentation of past flood events for the catchment being analysed (see example in Annex A). These records can be invaluable for calibrating flood models and in providing benchmarks against which assessments of the severity of future flood events may be judged.

Typically, a range of severity flood events from say 0.02 to 0.005 AEP may be modelled and mapped. Further maps showing property boundaries and key infrastructure that are potentially at risk from inundation are also required. Together, these maps provide the essential input to the risk assessment workshop.

The flood event AEP provides the 'likelihood' part of the risk equation. The workshop participants are responsible for assigning 'consequence ratings' to each river segment (reach) and for each flood being considered. Records of past events, local knowledge, and a consequence rating table should be provided to assist in this rating process.

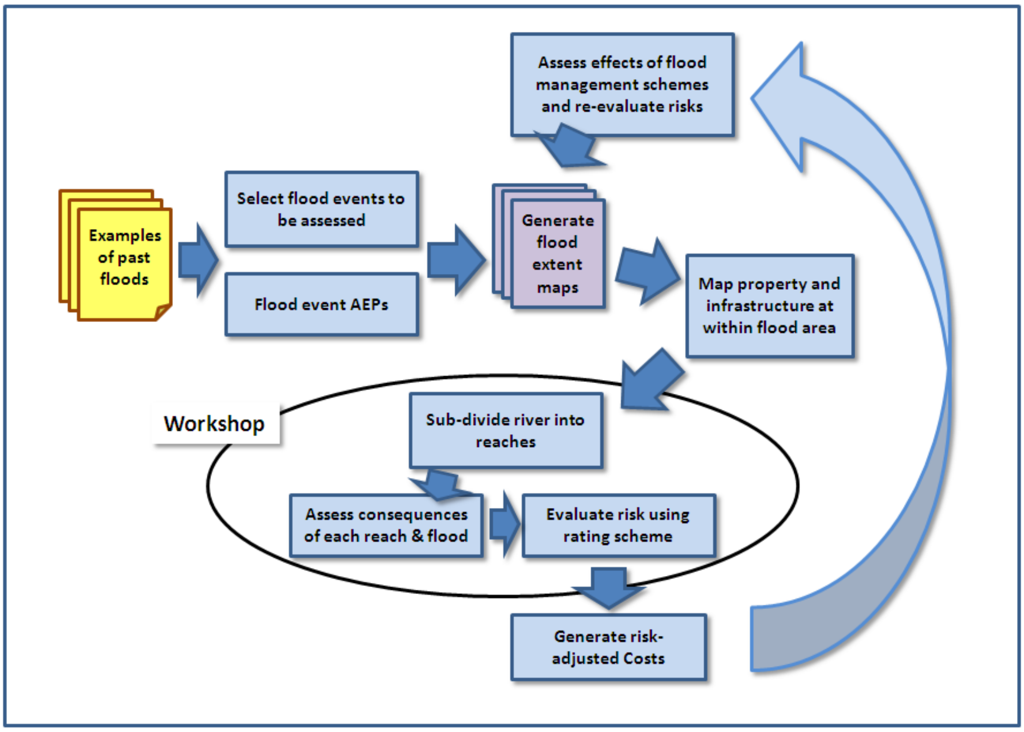

Figure 3.1: Schematic of the Subjective Quantified Risk Assessment Process

At or following the workshop the different consequence ratings are translated to costs, summed and multiplied by the flood AEP to obtain estimates of the annual average risk-adjusted cost.

The risk rating process described above may be repeated for a number of different severity flood events. The analyses may also be repeated taking into account different flood management options. In some cases this may require additional flood modelling in order that workshop participants may adequately assess the effect of flood management on flood extent.

3.1 Data Needs

The essential data needs of the Subjective QRA Tool, as described above for a river flooding scenario, are summarised here:

- Details of historical floods and local knowledge of the river being assessed, including the potential long-term effects of climate change and urban development;
- Flood extent maps for different severity floods to explore the effects of the flood management schemes of interest;
- Maps of the flood-prone areas showing the land types, buildings and infrastructure at risk from flooding. Particular attention should be given to any high value vulnerable and critical assets, such as hospitals and essential utilities;
- Outline plans of flood management schemes with sufficient detail to allow judgements to be made on their effect in reducing flood risk;
- Available experts and knowledgeable locals willing to participate in the risk assessment workshop.

Similar types of information would be required for assessing other hazards.

3.2 Outputs Generated to Aid Decision-Making

The main outputs from the Subjective Quantified Risk Assessment Tool are likely to be tabular (see Figure 3.2 for the river flooding example).

Summary of Catchment-Level Consequences and Cost-Risks

Catchment	Total Consequence Event 1 ($)	Overall Cost Risk ($)
Waiarohia-Raumanga River Catchment (1)	20,116,504	201,165
Ruakaka (2)	2,014,523	20,145
Otaika (3)	26,620	266
Waitangi (4)	117,648	1,176
Hatea (5)	2,285,675	22,857
Wairau Maungaturoto (8)	112,634	1,126
Pupuke (9)	30,310	303
Rotokakaahi & Pawarenga (10)	14,990	150
Panguru (12)	1,489,500	14,895
Awapokonui (13)	21,847	218
Whangarei Heads (14)	150,849	1,508
Taupo Bay (15)	140,595	1,406
Helena Bay (16)	113,766	1,138
Ngunguru (17)	121,570	1,216
Whirinaki (18)	113,583	1,136
Tauranga (19)	112,564	1,126
Matangirau (20)	121,413	1,214

Figure 3.2: Example Tabular Summary Output

The tabular output shown in Figure 3.2 gives a summary of the flood damage costs and cost-risks for various different river catchments. These results were obtained by summing the damage costs across all reaches that make up each of the river catchments. The variation in consequences and risks between catchments reflects the amount of urbanisation close to the river in each of the catchments.

Other outputs may be generated to aid comparison of options or to show the distribution of expected damages in the study area e.g. see Figure 3.3 for a plot of the risk profile along the river.

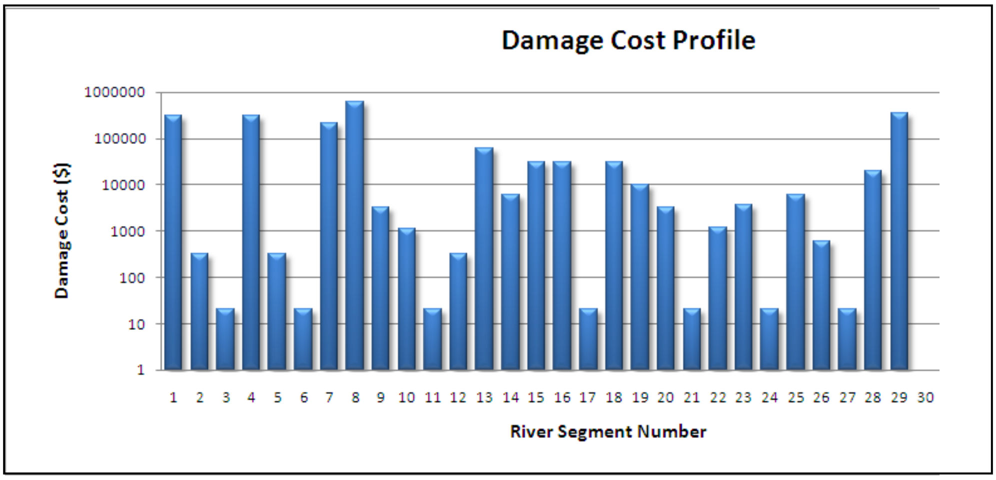

Figure 3.3: Example Graphical Output of Damage Cost Against River Segment (Reach)

Figure 3.3 is an example showing the subjectively-derived damage costs in each of the separate river reaches that make up a river. The level of cost varies dramatically from reach to reach because the costs are strongly dependent on topography and how many properties are flooded (which is related to the degree of urbanisation of the area).

3.3 Assumptions and Limitations

The overriding assumption in applying the Subjective Quantified Risk Assessment (sQRA) Tool is that it is reasonable to establish estimates of the potential damage caused by future floods by subjective elicitation using local knowledge and an appropriate group of experts. It also assumes that order-of-magnitude cost-based judgements can be applied to intangible aspects of social, cultural and environmental effects.

It is considered that these assumptions are valid if the sQRA approach is only used where its outputs are interpreted as order-of-magnitude estimates and used for broad strategic decision-making and not for design purposes, e.g. setting priorities for attention.

The accuracy of the assessments made depends on the quality of local knowledge and information available; the ability of the workshop facilitator; the accuracy of flood models; the level of detail with which the river environment is sub-divided, and the different consequences evaluated.

Given the reliance on the workshop to determine risks, it is advisable to use a risk expert proficient in facilitation techniques. In any event, exploring variability and uncertainty in the subjectively-derived cost estimates is very important to ensure that estimates are robust [see Tool 3.1].

4. How to Apply the Decision Tool

A spreadsheet has been developed for the sQRA Tool for interactive use at a river flooding workshop. It is used to capture pertinent information to inform the rating of flood damage, and to record the flood AEP and consequence scores for each of the river reaches.

Figure 4.1 shows a screen image of the main worksheet used to capture the subjective risk assessment information. It comprises a two-dimensional matrix, where each row contains the flood event likelihood (AEP) and the consequence scores for each river reach or sub-catchment.

On the far left of the spreadsheet is a yellow text box which gives brief instructions on how the worksheet is intended to be used. Next to this, the left most columns of the matrix are used to give each river segment (reach) a unique reference code and to record the key assets at risk from inundation in each river segment. To the right of these are three sets of columns provided to record the flood event likelihood and the consequence scores for up to three different flood events as indicated by the differently coloured headings and columns.

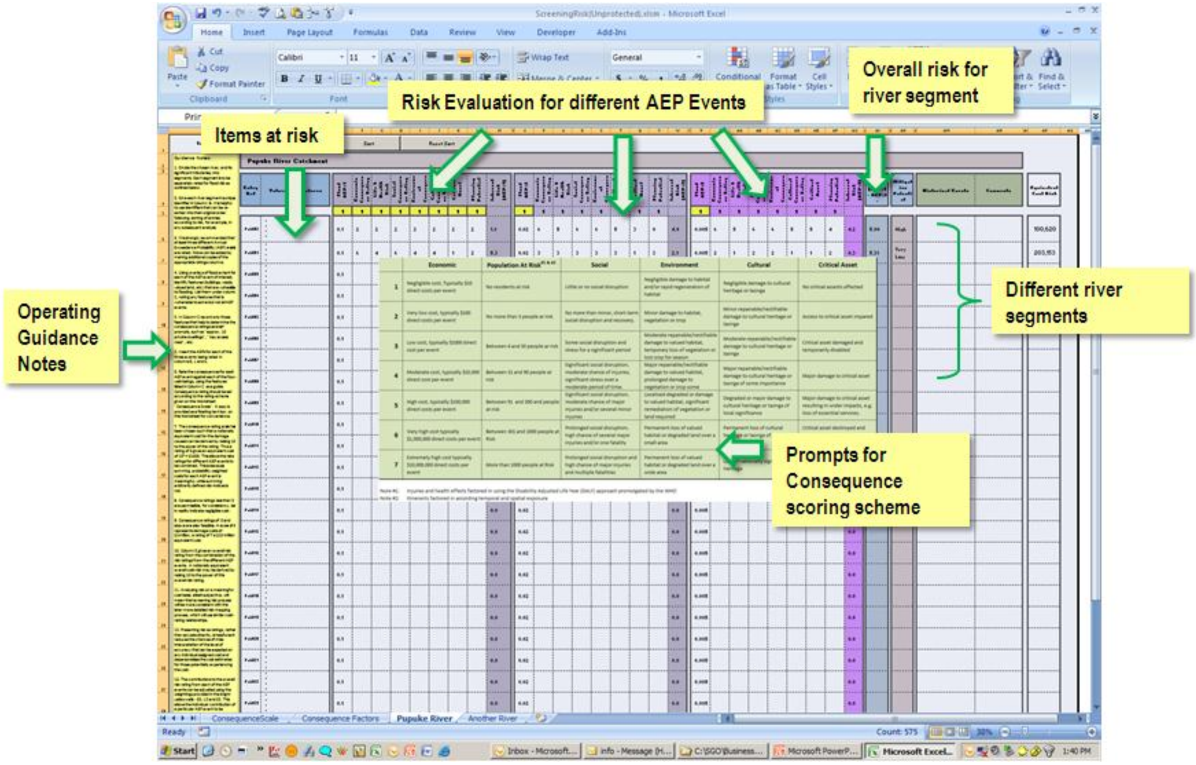

Figure 4.1: Screen Image of a Spreadsheet from the Subjective QRA Tool

4.1 Tool Structure and Content

The green text box that is overlain on top of the risk matrix in Figure 4.1 gives guidance on how the different consequences arising from the flood should be rated (the text is reproduced in readable form in Table 2.1 of this document). In this case, it is used to guide the user on the subjective assignment of consequence scores for the six different aspects of Economics, Population at Risk (Life Risk), Social, Environmental, Cultural and Critical Asset impacts.

Figure 4.2 is an enlargement of the Risk Register from Figure 4.1 showing one set of the spreadsheet columns for a single flood event. This includes columns to identify: the river reach, a bullet point record of the vulnerable features identified, flood likelihood and six further columns for the different consequence scores. The two columns on the far right give, respectively, the Sum of Consequences score across consequence types and the equivalent Inherent Risk index.

Entry Ref	Vulnerable Features	Flood AEP:1	Economic Consequence Rating	Life & Health Risk	Social Consequence Rating	Environment Consequence Rating	Cultural Consequence Rating	Critical Asset	Sum of Consequences	Inherent Risk [AEP:1]
		1	1	1	1	1	1	1		
Rua001	• Higher ground, unlikely to flood • Stream bank erosion could threaten access to Dune Lake Road	0.01	0	0	0	0	5	0	5.0	3.0
Rua002	• Includes outfall for sub-catchment 2 • Basin formed by old lake • Flooding of McCarthie Road access, but there are alternative routes	0.01	0	0	0	0	2	0	2.0	0.0
Rua003	• Comprises of old stable sand dunes • High voltage tower in flood plain	0.01	0	0	0	0	0	0	0.8	-1.2
Rua004	• Artificially low lying industrial land, formed from old peat-bed • Area being developed • Market garden at risk • Localised ponding rather than inundation	0.01	5	0	3	0	0	0	5.0	3.0
Rua005	• Access road of water treatment plant at risk (border of SC5 & SC6) • Assume WTP in this sub-catchment • Building thought to be a shed(?) At risk	0.01	0	0	0	0	0	2	2.0	0.0

Note: The negative risk shown in Figure 4.2 is a consequence of the logarithmic translation with a very low event probability

Figure 4.2: Enlargement of Risk Register in sQRA Tool

4.2 Tool Structure and Content

Table 4.1 gives a short description of the worksheets provided within the Subjective Quantified Risk Assessment Tool.

Table 4.1: Description of Worksheets within the sQRA Tool

Worksheet(s)	Description
Application Sheet	Records basic contextual information on the location and hazard being assessed and a record of the people that were involved in workshops at which the risks were assessed and rated.
Consequences Prompt Sheet	Provides a copy of prompt lists used to assist experts in assigning consistent risk ratings across quadruple bottom line aspects when assessing the impacts of a natural hazard. See Section 2.3 and Table 2.1 for more information and an example prompt list designed for flood risk assessment.
Risk Rating Sheet	The main worksheet used for capturing event likelihood and consequence damage ratings for each river reach (in the case of flood risk assessment). Screen shots of this worksheet are given in Figures 4.1 and 4.2 (Section 4.1). Multiple copies of this worksheet might be used if a number of different rivers or catchments are to be assessed.
Damage Cost Summary Sheet	A tabular summary of the overall flood damage for each of the flood events considered and the total average annual risk-adjusted cost. These results are generated for each river or catchment that is held within the spreadsheet, i.e. for each copy of the “Risk Rating Sheet”. Figure 3.2 provides an illustration of this summary output, where the results for 22 different rivers are listed but only 1 flood event considered in this case.
Consequence Table	A table of the flood damage costs for each river and reach. Plots showing a profile of the flood damage cost across the river reaches for a particular river may also be generated on this worksheet. An example cost profile plot is given in Figure 3.3 of Section 3.2 above.
Cost-Risk Table	A table of the flood average annual cost-risks for each river and reach similar to the Consequence Table sheet. Profile plots of cost-risk along a river can also be generated from this worksheet.
Catchment Maximums	Used to identify the river-reach for which damages were rated most highly for each river considered.

4.3 Illustrative Examples

The sQRA Tool described here has been developed by the author of this report and has been used on a number of client projects, mostly in the context of flood risk assessment. Some of the illustrations used in this document are taken from work undertaken by MWH (in collaboration with URS) for Northland Regional Council (Oldfield, 2010). In this work, an early version of the tool was applied across 22 different river catchments in order to provide risk-based information on which to set priorities for addressing flood hazards in the Northland Region.

4.4 The Next Steps

As well as providing a means of rapidly identifying sections of each river catchment at greatest flood risk, the Subjective Quantified Risk Assessment Tool provides a means of capturing information, not generally available in GIS data records, from River Managers who have many years' of local knowledge. This data provides insight into where floods have occurred previously and can therefore assist in the calibration of flood models provision of subsequent more detailed analysis.

Having subjectively assessed broad levels of risk and consequential damages on a risk-adjusted cost basis, these estimates can then be used in an economic evaluation of alternative flood management schemes, e.g. using the rapid Cost Benefit Evaluation (rCBE) Tool [refer to Tool 4.3].

5. References

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Annex: An Example Flood Record

Northland Storm Event: 19th & 20th March, 1981

Description of Weather Event

Northland experienced heavy rainfall on the 19th and 20th of March 1981 resulting from an extremely large cumulonimbus (thunderstorm) cloud which developed over the region and grew to a large cluster over about 10 hours. The storm was centred around the Kapiro area in the Waipapa catchment. The maximum recorded rainfall was in excess of 448 mm over a period of approximately 9 hours. The rainfall was so intense that rain gauges had to be emptied several times (NRC, 2009).

Relatively light winds meant that the storm tracked quite slowly over Kerikeri, producing a localised rainfall of 328mm, 30% in excess of the previously recorded 7-hour period. Overflows from the Kerikeri catchment contributed to flood flows in the Waipapa catchment. Waitangi was just on the fringe of the area directly affected by the storm.

Rainfall occurred in two peaks as can be seen from level recorder records at Whangai Weir, for example:

Peak 1: 2.078m at 23:00 hours on 19/03/81

(Dropped to: 1.376m at 01:00 hours on 20/03/81)

Peak 2: 1.795m at 02:30 hours on 20/03/81

Fortuitously, peak flood flows did not coincide with high tide. Had they done so, it is estimated that flood heights would have been approximately 2m greater than those experienced.

Estimated Return Period

In part because of its intense localised effect, the storm was considered be an extremely rare event, exceeding any other recorded event of this type (NRC, 2009). Although rare for any given catchment, the east coast of Northland is quite often subject to intense thunderstorms.

Analysis of rainfall records using Tideda™ (NIWA, 2000) suggests that the high rainfall event in Waitangi River Catchment produced river flows of 605.2 m^3/s, equivalent to a 1 in 32 year ARI event, measured at the Wakelins rain gauge.

Recorded Damage

Creation and subsequent collapse of debris dams was suggested as a reason that led to the formation of waves that added to the level of destruction. While this might be true, the combination of storm intensity and duration occurring in the largest catchment was a major contributor to the rapid rise in river levels, akin to a flood wave. Overland flow and catchment overflows from one to another were also contributing factors. In particular, the Puketotara River overflowed into the Kerikeri River on the flood plain near SH10. The Kerikeri River overflowed into the Waipapa Stream across Waipapa Road. These overflows were up to 1m deep and spread over an area of approximately 10 km^2.

The position of the bridge at the Kerikeri Basin caused a restriction to flood waters. A massive amount of debris was lodged under the deck of the bridge and amongst the upstream railings. It is estimated that this blockage effect added approximately 1m to the flood depth upstream of the bridge. A similar influence from tides and debris build-up was experienced for Waipapa Landing.

The calculated mean velocity for each individual flood varied from 0.7m/s to 4.3m/s, with an overall average of 2.2m/s. (NRC, 2009). The maximum flood height at Kemp House was 7.4m above low tide (window sill height).

This flash flood event washed away a bridge and several yachts. It damaged the historic Stone Store, built in 1819, and Kemp House (the Kerikeri Mission House), constructed in 1822 (NRC, 2009). In addition, the gardens of Kemp House and some irreplaceable items were destroyed.

The Northland 1981 flood caused considerable damage to property and horticultural blocks, and one person died (NRC, 2002).

Damage Costs

Insurance Council records show that the 1981 Northland floods resulted in claims of $2 million at that time, which adjusted for inflation is approximately $7.34 million at 2007 prices. The Ministry for the Environment records quote damages of $6.62 million.

References

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NRC, 2002, State of the Environment Report, Northland Regional Council, 2002.
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