IT'S OUR FAULT – PROGRAMME SUMMARY
June 2008

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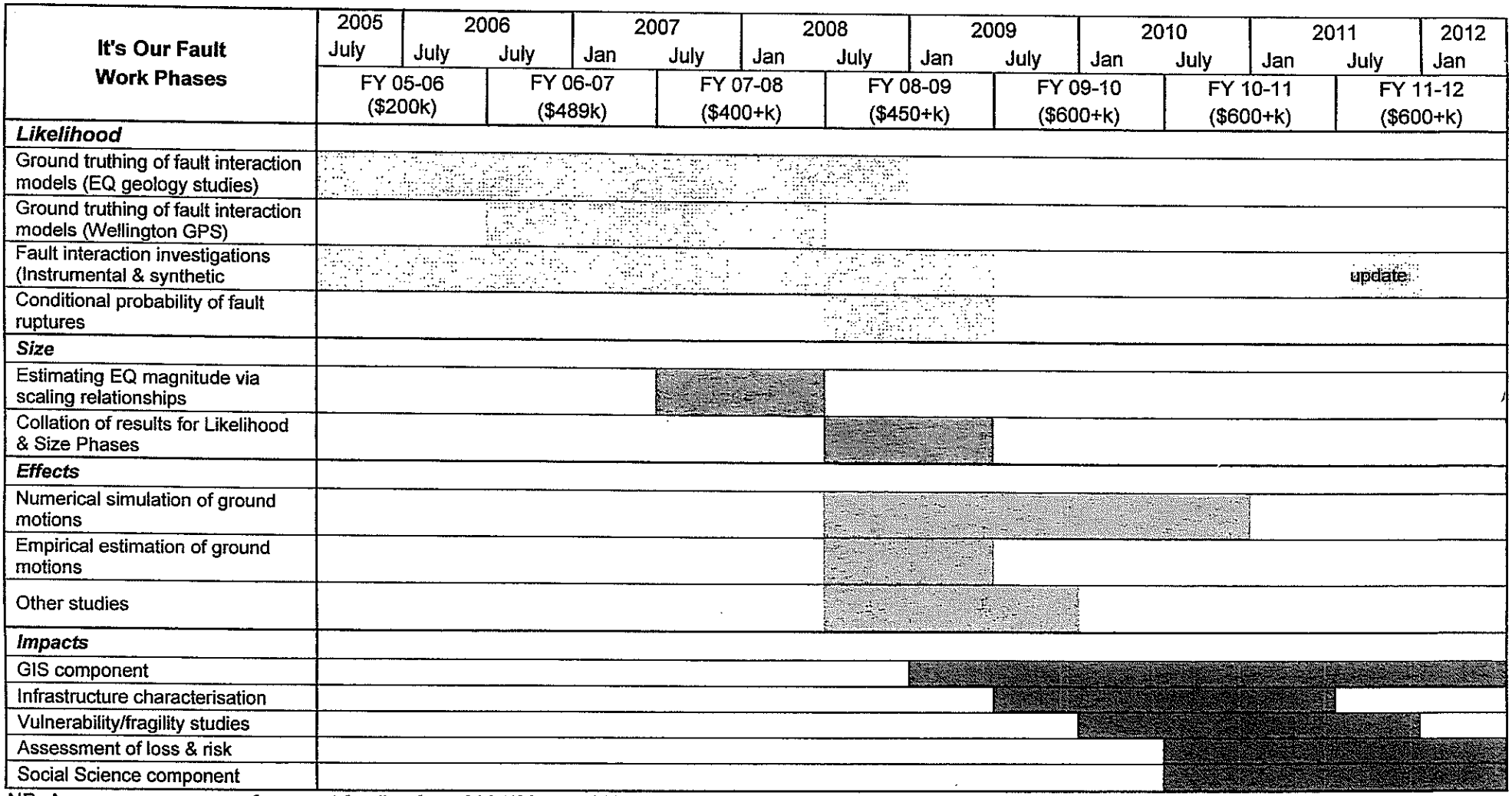
OBJECTIVE

The objective of "It's Our Fault" is to see Wellington positioned to become a more resilient city through a comprehensive study of the likelihood of large Wellington earthquakes, the size of these earthquakes, their effects and their impacts on the built environment.

TIMEFRAME

The entire "It's Our Fault" programme will be implemented over a period of 7 years (see Figure 1) and comprises four main components: Likelihood, Size, Effects and Impacts. Major advances in the understanding and quantification of earthquake hazard and risk in the Wellington region are anticipated at the completion of each main component of work.



NB: Assumes carry-over of unspent funding from 2005/06 to 2006/07

Figure 1: Timeline for the entire "It's Our Fault" programme with indicative annual budgets.

2005/2006 FINANCIAL YEAR:
The 2005/06 financial year saw progress made in the following Size and Likelihood Phase tasks:

Ground Truthing of Fault Interaction Models (Earthquake Geology Studies)
Wairarapa Fault Slip Rate Investigations
Objective: Geological investigations of the Wairarapa Fault will determine the degree of slip transfer between the Wairarapa Fault and the Carterton, Masterton and Mokonui Faults by constraining their slip rates and slip vectors. This data will provide validation for synthetic seismicity modelling components of the project, as well as primary input data for the model.
Progress to Date: Initial site selection was completed in the 2005/06 year, and detailed field investigations and task completion were in 2006/07.

Wairarapa Fault Past Surface Rupture Timing
Objective: Geological investigations of the Wairarapa Fault will provide baseline information on the frequency and size of past Wairarapa Fault ruptures as well as the fault's late Quaternary slip-rate. This data will provide validation for synthetic seismicity modelling components of the project, as well as primary input data for the model.
Progress to Date: Field work along the southern section of the Wairarapa Fault was completed in 2005/06. Four paleoearthquake investigation trenches were excavated, sampled, logged and interpreted. From these investigations, over 20 radiocarbon samples were submitted for dating, and it is anticipated that these will provide constraints on the timing of the past 5–6 ruptures on the fault. 2006/07 saw the excavation and investigation of one additional trench, and completion of this task will be in 2007/08.

Ohariu Fault Paleoearthquake Trenching Investigations
Objective: Geological investigations of the Ohariu Fault will be used to calculate conditional probabilities of rupture for the Wellington faults, and will provide critical input and validation for the synthetic seismicity modelling of the region.
Progress to Date: 2005/06 saw the scheduling of two trenches for excavation, and this task was completed in 2006/07.

Fault Interaction Investigations (Instrumental and Synthetic Seismicity)
Synthetic Seismicity Modelling
Objective: The synthetic seismicity modelling work involves developing a realistic computer model of earthquake occurrence and fault interaction in the Wellington region, and using it to statistically assess the rupture triggering/un-triggering relationships of the Wellington/ Wairarapa Faults pair. The result will be validated through comparisons with actual fault data, collected during the geological investigation and geodetic phases of the project.

- *Rewrite Synthetic Seismicity Program*

This work was necessary to take advantage of the global shared memory now available to GNS Science, which will allow the construction of bigger and more complex but more realistic synthetic seismicity models.
Progress to Date: This work was completed in the 2005/06 financial year.

- *Stresses in Visco-elastic Medium*

The current synthetic seismicity model is an over-simplification of the 'real world', in that it only considers elastic effects. To make the model more realistic, it was critical to introduce visco-elastic effects.
Progress to Date: Work commenced in this task during 2005/06, and was also a focus of work in 2006/07.

- *Ground Shaking Finite Difference Code*

Progress to Date: The work scheduled for 2005/06 has been completed, and is ready to be used when this task is progressed further in 2008/09.

2006/2007 FINANCIAL YEAR:
Advancement of the It's Our Fault programme in 2006/07 continued to be focussed on the Likelihood and Size phases, as was also the case in 2007/08.

The milestones established for 2006/07, and the associated costs, are as follows:

Wairarapa Fault Slip Rate Investigations (Total: $47,505)

1. Finalise selection of study sites and land owner access. ($10,000)
2. Completion of field investigations. ($20,000)
3. Finalisation of completion report documenting field data, results and uncertainties; focusing specifically on findings most relevant to further quantifying fault slip rate, timing of past earthquakes, earthquake recurrence interval and/or single-event displacement size. ($17,505)

Wairarapa Fault Past Surface Rupture Timing (Total: $31,325)

1. Finalise selection of study sites, and land owner access. ($3,100)
2. Completion of field investigations. ($19,000)
3. Finalisation of completion report documenting field data, results and uncertainties; focusing specifically on findings most relevant to further quantifying fault slip rate, timing of past earthquakes, earthquake recurrence interval and/or single-event displacement size. ($9225)

Wellington Fault Paleoearthquake Trenching Investigations (Total: $57,500)

1. Finalise selection of first year's trench sites (nominally 2-4) and land owner access. ($5,750)
2. Completion of field investigations. ($34,500)
3. Finalisation of progress report presenting trench logs, dating results and highlighting results to date that are most relevant to further quantifying fault slip rate, timing of past earthquakes, earthquake recurrence interval and/or single-event displacement size. ($17,250)

Cook Straight Offshore Faults (Total: $30,000)

1. Compile existing seismic reflection, bathymetric and sample data from central Cook Strait, and process Boomer seismic reflection sections from Cloudy Bay. ($15,000)
2. Interpret active faults in seismic sections and bathymetric data, and construct a revised fault map for central Cook Strait. ($15,000)

Past Subduction Zone Ruptures (Total: $50,000)

1. Finalise selection of first year's study site(s) and land owner access. ($5000)
2. Completion of field investigations. ($30,000)
3. Finalisation of progress report documenting field data and highlighting results to date that are most relevant to further quantifying and timing of past earthquakes, earthquake recurrence interval and/or single-event displacement size. ($15,000)

Study Integration & Site Selection Workshops (Total: $16,000)

1. Host an interdisciplinary scientific study workshop to facilitate coordination of project. ($16,000)

Instrumental & Synthetic Seismicity Studies (Total: $105,050)

1. Complete theoretical formulation towards the incorporation of visco-elastic effects into the synthetic seismicity model. ($21,000)
2. Finish implementation of visco-elastic effects into the synthetic seismicity model. ($52,550)
3. Test the synthetic seismicity model, incorporating visco-elastic effects. (31,500)

Wellington Geodetic & GPS Studies Task (Total: $132,000)
Objective: The Wellington GPS studies will involve re-observation of an expanded GPS network to help constrain the earthquake generating potential of the subduction thrust under Wellington, as well as possibly further constraining slip rate uncertainties for the major upper plate faults in the region.

1. Reconnaissance and selection/installation of 20 new campaign GPS sites to improve the network around Wellington and the south coast. ($23,000)
2. Observation of the complete Wellington network, approximately 100 stations total. ($90,000)
3. Field Report on the observation campaign. ($19,000)

Project Management of the Likelihood Phase (Total: $20,000)

1. Project management of the Likelihood Phase of the programme. ($20,000)

2007/2008 FINANCIAL YEAR:
The Services and Deliverables provided during the 2007-08 Financial Year have continued to be focussed on the Likelihood phase. This is the second of three years in which the Likelihood phase is the main focus of work for the "It's Our Fault" project, with the three components being geological investigations; geodetic and GPS studies; and instrumental and synthetic seismicity studies.

The 2007-08 geological investigations of the Wellington Fault, subduction zone and Cook Strait will provide validation for synthetic seismicity modelling components of the project, as well as some primary input data for the model. The completion of the geodetic and GPS studies will provide an up-dated location of the currently locked portion of the subduction thrust beneath the Wellington region, and may also assist with constraining slip rate and locking uncertainties for the major upper plate faults in the region. The synthetic seismicity modelling work will continue to develop a realistic computer model of earthquake occurrence and fault interaction in the Wellington region, and use it to statistically assess the rupture triggering/un-triggering relationships of the Wellington/Wairarapa Fault pair. The synthetic seismicity model is the primary means by which key issues will be assessed within the Likelihood phase. In addition, the earthquake slip histories generated by the synthetic seismicity model are primary inputs to the modelling of earthquake ground motions, which is the principle goal of the Effects phase.

Progress made during the 2006-07 Financial Year toward each of these components has reconfirmed the scope for this year's work and will allow for the final year of the Likelihood Phase to commence in the 2008-09 Financial Year, when the Size, Effects and Impacts Phases are also scheduled to commence.

The milestones established for each task to be completed in 2007-08, with their associated costs are as follows:

Wairarapa Fault Slip Rate Investigations (Total: $12,250)
Objective: Geological investigations in the Wairarapa area to determine the degree of slip transfer between the Wairarapa Fault and the Carterton, Masterton and Mokonui faults by constraining their slip rates and slip vectors. This data will provide validation for synthetic seismicity modelling components of the project, as well as primary input data for the model.

1. Finalisation of completion report documenting field data, interpretations and results (and uncertainties); focusing specifically on findings most relevant to further quantifying fault slip rate and single-event displacement size and, if applicable, earthquake recurrence interval and timing of past earthquakes. ($12,253).

Wellington Fault Paleoearthquake Trenching Investigations (Total: $122,175)
Objective: Geological investigations of the Wellington-Hutt Valley segment of the Wellington Fault will provide baseline information on the frequency and size of past fault ruptures, and possibly also

the fault's late Quaternary slip-rate. This data will provide validation for synthetic seismicity modelling components of the project, as well as primary input data for the model.

1. Milestone 1: Finalise selection of second year's trench sites (nominally 2-5) and land owner access. ($8,000)
2. Completion of all field investigations and submission of dating samples. ($84,175)
3. Finalisation of progress report on second year's work presenting trench logs, dating results and highlighting results to date most relevant to further quantifying timing of past surface rupture earthquakes, and earthquake recurrence interval and, if applicable, single-event displacement size, and fault slip rate. ($30,000)

Cook Straight Offshore Faults (Total: $30,000)

Objective: The investigations will lead to an updated active fault map of Cook Straight region, including fault dip and slip rate data, providing validation for synthetic seismicity modelling components of the project, as well as primary input data for the model.

1. Establish relevant seismic stratigraphy and age estimates for key stratigraphic and geomorphic markers in central Cook Strait. Determine slip rates on major faults where possible from displaced markers, and interpret potential scenarios for earthquake rupture segmentation. Tabulate earthquake source parameters. ($15,000)
2. Submit a report to GNS Science documenting a summary map of active faults in central Cook Strait, potential fault rupture scenarios, and earthquake source parameters. Provide to GNS Science a final interpreted map of active faults in ArcGIS format, with accompanying spreadsheet of earthquake source parameters for inclusion in the synthetic seismicity model ($15,000)

Past Subduction Zone Ruptures (Total: $50,000)

Overall task objective: Undertake geological investigation at sites (nominally 2-3) in the greater Wellington region that are undergoing vertical deformation in order to potentially constrain the timing and possibly size of past subduction interface ruptures. These data will provide critical input and validation for the synthetic seismicity modelling of the region.

1. Complete detailed paleoenvironmental reconstruction of existing Big Lagoon cores. ($20,000)
2. Complete field investigations at additional Wairau Valley sites (or possibly Wairarapa Valley). ($20,000)
3. Complete progress report covering results obtained in milestones 1 and 2 above. ($10,000)

Wellington Geodetic & GPS Studies Task (Total: $28,000)

Overall task objective: The Wellington GPS studies will involve re-observation of an expanded GPS network to help constrain the earthquake generating potential of the subduction thrust under Wellington, as well as possibly further constraining slip rate and locking uncertainties for the major upper plate faults in the region.

1. Reduction and analysis of 06-07 campaign data, modelling of 06-07 data and past observations to provide an up-dated assessment of location (shape and extent) of currently locked portion of the subduction thrust beneath Wellington region, and completion of final report that documents the above and present findings, if applicable, relevant to constraining slip rate and locking uncertainties for the major upper plate faults in the region. ($28,000)

Instrumental & Synthetic Seismicity Studies (Total: $173,150)

Objective: The synthetic seismicity modelling work involves developing a realistic computer model of earthquake occurrence and fault interaction in the Wellington region, and using it to statistically assess the rupture triggering/un-triggering relationships of the Wellington/Wairarapa Fault pair. Variables and modelling procedures that need consideration include, but are not limited to, loading mechanism, number of faults, fault slip vector and rate, and fault geometry. The result will be validated through comparisons with actual field data, collected during the geological investigation and geodetic phases of the project. Statistically robust recurrence time distributions for the major faults in the region will also be an output for this task for application in assessing conditional probability of rupture.

1. Complete geometric description of fault model (including offshore faults and subduction zone) of largest faults in the model. ($25,000)
2. Complete kinematic parameterisation (e.g. dip, slip rate, single event displacement, recurrence interval) of largest faults in the model. ($25,000)
3. Characterize and implement driving mechanism for model. ($71,210)
4. Run simplified model with viscoelastic effects to assess importance, or otherwise, of this effect; and embark on sensitivity analysis of key uncertainties pertaining to fault geometry and kinematic parameterisation. ($51,940)

Study Integration & Site Selection Workshops (Total: $8,100)

1. Host a project workshop to facilitate coordination of the Likelihood phase of the project. ($4,000)
2. Host a project workshop to facilitate coordination of the Likelihood phase of the project. ($4,100)

Project Management of the Likelihood Phase (Total: $26,325)

1. Project management of the Likelihood Phase for the first quarter of the year's programme. ($6,500)
2. Project management of the Likelihood Phase for the second quarter of the year's programme. ($6,500)
3. Project management of the Likelihood Phase for the third quarter of the year's programme. ($6,500)
4. Project management of the Likelihood Phase for the fourth quarter of the year's programme. ($6,830)

RESEARCH COLLABORATION

The goal of It's Our Fault is ambitious, and to meet it will require expertise and collaboration across a number of interrelated disciplines including earth science, engineering, planning and social science, and across a number of public and private sector institutions. With this challenge in mind, we have also identified the potential for significant cost efficiencies by, for example, collaboration with University researchers and the use of student research studies to complete sub-tasks within the larger programme.

There has been significant collaboration with Victoria University (VUW) in the Likelihood component of It's Our Fault, primarily because of expertise in relevant capabilities, but also to acknowledge and build on areas of current VUW field research, and to take advantage of logistical efficiencies. For example, VUW staff and students are currently involved in earthquake geology investigations along the Wellington and Wairarapa faults and several of the proposed It's Our Fault tasks along these faults build on this current work. It has been vital to involve VUW staff and students in these investigations. Geological investigation of the offshore faults has involved expertise from NIWA, in order to develop a revised fault map for central Cook Strait.

Subsequent components of It's Our Fault, particularly the Effects and Impacts phases will need to draw on engineering, planning and social science expertise. As such, we will foster collaborations with Auckland, Massey and Canterbury Universities, as well as selected private sector institutions nationally and internationally.