THE UNIVERSITY OF BRITISH COLUMBIA

REPORT TO THE BOARD OF GOVERNORS

SUBJECT	**SEISMIC RESILIENCE PLAN – PROGRESS UPDATE**
MEETING DATE	**APRIL 19, 2018**

Forwarded to the Board of Governors on the Recommendation of the President

APPROVED FOR SUBMISSION

Santa J. Ono, President and Vice-Chancellor

	FOR INFORMATION
Report Date	March 19, 2018
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EXECUTIVE SUMMARY

A process to update the seismic mitigation plan for the UBC Vancouver campus was initiated in May 2016. The goal of the update is to incorporate the latest science and best practice and to ensure that that seismic risk is reduced as much as possible and as quickly as possible within the University's logistical and financial capacity.

The need for an update was identified for three reasons, as follows:

- The science of different seismic fault lines has evolved significantly since the buildings were originally assessed in 1994 and re-evaluated in 2012. New fault lines and new earthquake intensities are now recognized that are more severe than were identified previously. As a result, the newest building codes are significantly more stringent than the ones used in the previous assessments so the new evaluation needs to reflect these changes.
- The timeliness of the planned seismic upgrades needed to be re-evaluated with a goal to completing all remaining upgrades within the next 10 years, if feasible.
- Best practice thinking regarding resilience, risk assessment and the ability of a major public institution like UBC to respond to a natural disaster such as an earthquake has evolved. This updated practice shows a more nuanced approach to seismic planning, reflecting a risk assessment approach that allows for a spectrum of needs to be addressed. While life safety is paramount, it looks beyond this one aspect to address the ability of an institution to resume operations after a disaster, and addresses broader technical aspects such as utility vulnerabilities and non-structural seismic hazards.

A significant amount of work on the update has been completed, including an enhanced screening-level analysis of the buildings, utilities and operations on the Vancouver campus. This work reflects the latest thinking in seismic assessment and planning, recognizing that there are different seismic vulnerabilities for different buildings on campus and different levels of criticality for different types of spaces.

The elements that have been completed are as follows:

- A seismic risk hazard assessment identifying the specific seismic risk of the Vancouver campus has been done, and a multi-hazard assessment of all potential natural disasters and re-assessment of all Vancouver campus buildings was completed.
- Measurable resiliency objectives have been set in consultation with key stakeholders.
- A utilities assessment is complete, identifying vulnerabilities and potential failure points,
- A qualitative assessment of vulnerability related to fire following earthquake is complete.
- A screening-level vulnerability assessment of over 340 buildings has been completed utilizing FEMA visual screening methodology augmented with simplified structural analysis to provide a reasonable and conservative identification of high risk buildings. Out of this, all buildings have been ranked on a scale from Tier I to Tier IV based on their likelihood of collapse in a Very Rare earthquake. In addition, based on the populations and contents, an assessment of the vulnerability of each building was completed. This analysis has led to a prioritized list of buildings for which a final, detailed engineering evaluation is under way to assess the suitability of renewal strategies.
- A resilience assessment of campus operations was done and a series of recommendations developed.
- A student housing vulnerability assessment has been completed.

The consultant team (Arup) provided UBC with a set of prioritized recommendations. When the Board of Governors was last updated, these recommendations were very recently received and had not yet been distilled into an action plan. The request was made that the next update from the project team provide an indication of which recommendations would be followed and placed into an action plan and which, if any, would not be enacted. That action plan has been created and addresses items for campus buildings, utilities and operations. Detailed structural modeling is under way on a prioritized list of buildings. A set of guidelines is being developed to address retrofits, new construction projects and non-structural elements within buildings. Most of the operational items are being implemented now or are part of a broader risk plan on campus. The complete action plan and the status of each item is listed in the Action Plan section below.

In addition, a series of principles was requested to inform the Board how decision-making would be undertaken as the project proceeds. That set of principles has been developed to guide the work of the team moving forward as follows:

- *Life Safety*: The safety of students, faculty, staff and visitors is of primary importance.
- *Alignment with Existing Principles and Processes*: The process for prioritizing seismic upgrades and renewals will be completely aligned with, and a regular part of, the University's capital planning process already in place.
- *Bold Vision, Pragmatic Implementation*: The vision presented and supported of a disaster-resilient university that is able to withstand impacts of possible hazard events without harm to people, unacceptable losses to property, or interruptions to our mission is a bold one; however, work done towards this vision must be executed within the financial and logistical constraints of the University.

The plan currently encompasses University-owned institutional facilities on the Vancouver campus, which represent the highest seismic risk to the University. The Okanagan campus was not included in the scope of work given the substantially lower seismic risk in the Okanagan. The plan also does not include neighbourhood market housing and community buildings or UBC off-site leased spaces, all of which fall outside the direct control of the University. The multi-hazard assessment and planning framework used for the Vancouver campus will be applied in the future to the Okanagan campus and to the neighbourhood facilities. Discussions have been initiated with the UBC Okanagan management team, and UBC Properties Trust to explore options for implementation appropriate to the specific situation and needs of each group. The work that the UBC Okanagan staff has undertaken in this regard can be found in Attachment 3.

If this item was previously presented to the Board, please provide a brief description of any major changes since that time.	Since September 2017, the team has done a complete review of the recommendations and settled on an action plan. Progress has been made on the building, utility-related and operational recommendations. Progress has also been made around the definition of the Chief Resilience Officer position; the effort has been focused on ensuring that the scope and organizational placement of this function is the best fit with UBC's overall resilience and risk management needs. A series of principles has also been developed that will guide the work of the team moving forward. The UBC Okanagan and UBC Properties Trust management teams have been contacted regarding implementation of their own multi-hazard assessment and seismic studies. Concurrent with development of the new seismic resilience plan, work continues on seismic upgrades to UBC buildings. Recently completed and current projects incorporating seismic upgrades include the UBC Life Building (Old SUB Renewal), Undergraduate Life Sciences Teaching Labs and Hebb Tower Renewal.

INSTITUTIONAL STRATEGIC PRIORITIES SUPPORTED

☐ **Learning** ☐ **Research** ☐ **Innovation** ☐ **Engagement (Internal / External)** ☐ **International**

or ✓ **Operational**

DESCRIPTION & RATIONALE

SUMMARY OF RESULTS

Approach

Infrastructure Development and Risk Management Services are updating the seismic mitigation plan with a revised plan that reflects updated thinking with respect to earthquake science and the need to reflect not just life safety but also organizational resilience and ability to recover from major incidents. Arup, an internationally recognized engineering consulting firm, was engaged to work with UBC faculty and staff to undertake the necessary technical assessments and provide recommendations for the development the new seismic resilience plan. Arup has completed similar work for large financial, educational and government institutions around the world.

UBC has had a seismic mitigation plan for the Vancouver campus for over 20 years. This plan has undergone revisions as needed to reflect changes to codes and standards, with the most recent revision coming in 2012. In 2016, work commenced on updating the plan again. The new plan reflects the latest seismic science, which indicates that the forecasted seismic hazard has increased significantly in the Lower Mainland. In addition, UBC asked the project team to consider seismic resilience as part of the plan. The goal is that ultimately, the university will not only make every effort to protect the lives of the campus community but also reduce the impacts of the earthquake and other natural hazards on the continuity of teaching and research, preserve buildings and building contents (including research specimens, collections, and data) and be a resource for the local community in the event of a disaster.

A series of analyses have been undertaken, the results of which are outlined in Attachment 1. Out of this work came a series of recommendations, which were presented in the September 2017 report to the Board. When those results were presented, it was requested that the team return with a set of guiding principles that would define the decision-making process for the on-going seismic efforts and that the team clearly define which of the consultant recommendations would be acted upon and which would not be. This report addresses both of these requests.

Guiding Principles

A series of principles has been developed to guide the work of the team moving forward. These principles are as follows:

- Life Safety: The safety of students, faculty, staff and visitors is of primary importance.
- Alignment with Existing Principles and Processes: The process for prioritizing seismic upgrades and renewals will be completely aligned with, and a regular part of, the University's capital planning process already in place. The planning principles reviewed and supported by the Board of Governors in December 2014 will also be applied to this work.
- Bold Vision, Pragmatic Implementation: The vision presented and supported of a disaster-resilient university that is able to withstand impacts of possible hazard events without harm to people, unacceptable losses to property, or interruptions to our mission is a bold one; however, work done towards this vision must be executed within the financial and logistical constraints of the university.

Action Plan

Based on the work done by the project team, a series of priority recommendations were presented to UBC. These recommendations fall into three categories – Buildings, Utilities and Operations. UBC has evaluated these recommendations and will act or has acted on the majority of them as follows:

Buildings:

1. A subset of buildings at the highest risk of collapse (Tiers III and IV) where the vulnerabilities are highest (such as a large building population, etc.) are currently undergoing a detailed engineering evaluation to confirm the viability of each building's retrofit strategy for moving forward. Approximately 19 buildings will be evaluated using this methodology.

Originally, 22 buildings were identified but the three buildings leased to Vancouver Coastal Health were removed from the analysis due to the fact that these facilities are outside direct UBC control. One small building was re-assessed and removed, and the Museum of Anthropology was added in order to effectively evaluate the structural impacts of planned renovations in the building.

The buildings that are being evaluated have been prioritized into three groups based on the timing of the need for information on these buildings as they relate to broader capital planning decisions. The updated list can be found in Attachment 2.

2. The non-structural life safety hazards in all campus buildings will be assessed over the coming year and a mitigation plan will be developed. As noted in the consultant report, work has been done in this area over several years and continues to be done through on-going renovation projects – the recommendation is around expanding and continuing the program in a broader way. Risk Management Services and Infrastructure Development are working to assess the most pragmatic way of executing these upgrades.

3. A series of guidelines is being created. The first is a content protection guideline for the protection of valuable contents to be implemented as a part of the retrofit of existing buildings and as part of the development of new buildings. This guideline is in development.

   The second is a guideline to standardize UBC's approach to the seismic retrofit of existing buildings that will include clear performance indicators beyond the current expectation of a certain building code level as well as a set of criteria for what triggers a seismic retrofit. This guideline is still in procurement as the team is using the development of this guideline as a tool to educate the local design community about the new, beyond-code approaches that UBC is using.

   The final guideline will be for the seismic design of new buildings and will include performance criteria that target higher functionality targets than simply meeting current code. This guideline is under development now.

Utilities:

1. Decommissioning the Power House and relocating the campus water pumps to a new location is a primary recommendation. As part of a larger effort to plan the West Mall precinct, a site has been identified for the water pumps adjacent to the Henry Angus Tower. The water pump replacement project has received Executive 1 approval and is currently undergoing a detailed feasibility analysis. The results of this analysis will form the basis of the future approval requests for this project.
2. Provision of backup water supply for firefighting is recommended. This recommendation is being considered. Work has already been undertaken to look at viable options.

3. Providing the physical and operational infrastructure for storing up to three days of diesel fuel for the campus utility systems is recommended. Energy and Water Services and Infrastructure Development have started a feasibility study to determine the optimal solution for siting this significant piece of campus infrastructure.

4. The final priority recommendation is to develop a strategy and the necessary infrastructure for distributing enough potable water to meet the anticipated needs of the campus population in the event of a protracted disruption to the water supply. This recommendation is being considered. Work has already been undertaken to look at viable options. Since September, testing of the current emergency water distribution systems was undertaken, which allowed Risk Management Services (RMS) to assess both the viability of the current system and where gaps lie in the system. As a result of this testing, RMS has begun more detailed assessment work on the emergency water distribution system.

Operations:

1. The appointment of a Chief Resilience Officer (CRO) similar to that appointed recently by the City of Vancouver is suggested to ensure that there is one person responsible for implementing the seismic strategy. The team has worked to refine the scope of the position to ensure that the scope is best aligned with the current restructuring of the risk functions for the university. The team has undertaken significant investigation of precedent position profiles for this type of role in order to be able to inform the discussion once the new Chief Audit and Risk Officer is in place. It is apparent from that investigation that there is a wide variety of different functions that can be grouped under the purview of a CRO. It is imperative that the selection of functions and the organizational reporting is implemented in a way that aligns with the organization, allowing this important work to be moved forward in a way that supports the mandate of the organization. Issues as diverse as cyber-security and resilience in the face of cyber-attacks through to climate resilience are all potential topics that could be included under a CRO beyond seismic resilience. Once the restructuring of the risk functions is more complete, the research that the team has undertaken can be applied in order to ensure that the functions are optimized for UBC’s context.

2. Life safety risks can be reduced through operational measures. There is a series of suggested actions that are being investigated, validated, prioritized and enacted. One of the significant actions that is under way is the relocation of the campus Emergency Operations Centre (EOC) from the University Services Building. RMS has commenced a project to move the Centre first to a location in Orchard Commons and finally to a dedicated EOC in the new Innovation Hub that is being planned for the current DH Copp site.

3. The need to complete, validate and implement the emergency management plan that is currently in draft form was recommended as a priority. The draft is now complete and awaiting editorial review.

4. Similarly, the need to prepare, complete and validate business continuity and contingency plans for hastening post-earthquake recovery was recommended as a priority as well. Again, this project has been started by Risk Management Services, who will continue to work on it.
5. The recommendation was made to develop an interactive digital risk management platform to capture current building risks and to chart the progress of mitigation. This recommendation will be considered in the context of other information management and IT priorities.

Finally, discussions have been initiated with the UBC Okanagan management team and UBC Properties Trust to investigate how the methodology used for the multi-hazard assessment and planning framework used in this work can be applied in those portfolios. In Attachment 3, the work that has been undertaken to date by the UBC Okanagan staff to understand their seismic risk has been included. Discussions are on-going with them to undertake further analysis.

BENEFITS
Learning, Research, Financial, Sustainability & Reputational

The most direct benefits of the updated plan will be the ability of the campus community to better understand and quantify the risks and vulnerabilities associated with the updated seismic events that are likely to strike the Vancouver campus. A clearer and more nuanced assessment of these risks and vulnerabilities will enable UBC to move to a point where the seismic plan is a more comprehensive, best practice plan that will result in a safer campus. It will also be benchmarked against other leading institutions.

As part of the proposed plan, clear, measurable goals will be set which will be reported on to the Executive and the Board of Governors. These goals will allow for a transparent dialogue with the campus community so that all stakeholders will understand the priority that UBC places on safety and resilience.

In addition, by engaging in a broader assessment of vulnerabilities associated with seismic resilience, some of the vulnerabilities associated with climate change or other natural hazards will be addressed. Utility vulnerabilities are a clear example where increasing storm intensities and seismic issues can all be addressed at the same time.

RISKS
Financial, Operational & Reputational

The most significant risk to this project is the risk of not updating the plan. Ignoring best practice would result in an increased risk of loss of life or serious injury to members of the campus community.

Remaining at a code-based assessment methodology means that a broad assessment of business risk and business continuity associated with seismic events is not possible. While it will be necessary from a financial and logistical perspective to complete all seismic upgrades and retrofits over a number of years, this type of nuanced assessment will allow for a more thorough evaluation of how to optimally allocate resources.

Finally, because the approach being used is beyond the code-based performance criteria that the local structural engineering community is familiar with, there is a risk that the execution of the guidelines is not undertaken to the level anticipated. The team is working diligently to mitigate this risk by including a panel of local peer reviewers with the detailed evaluation analysis. In addition, the retrofit guidelines will be drafted by a local firm under the guidance of Arup in order to provide a capacity-building function.

COSTS
Capital & Lifecycle Operating

The estimated cost to deliver the building-related priority recommendations, including the detailed engineering analysis of the 19 priority buildings, the guidelines, and the non-detailed evaluation of approximately 30 buildings where insufficient information was available to do a complete assessment is $2.5 - 2.8 million. This expense will be funded through seismic insurance savings or other appropriate means.

FINANCIAL
Funding Sources, Impact on Liquidity

Until the costs have been developed for the complete building and utilities retrofit strategy, it is not possible to determine the optimal avenues for funding and financing. A complete proposal will be brought forward when the retrofit plan has been fully developed.

SCHEDULE
Implementation Timeline

The schedule for the implementation of the next steps has been updated as follows.

Priority Recommendation	Estimated Completion Date
Detailed evaluation of priority buildings	September 2018
Costed plan of building retrofits	December 2018
Non-Structural Hazard Assessment	December 2018
Guidelines for Contents, Retrofits & New Bldgs	September 2018
Relocation of Water Pump Station and Decommissioning of old Power House	May 2020
Water Supply Option Study (Fire & Potable)	September 2018
Diesel Infrastructure Study	July 2018
Operations Priorities	Phased

CONSULTATION
Relevant Units, Internal & External Constituencies

The work for this investigation is being led by the Seismic Steering Committee. This committee includes representatives from Infrastructure Development, Building Operations, Finance, Energy & Water Services, and Risk Management Services. In addition, the Seismic Steering Committee is working closely with Professor Carlos Ventura and his team in the UBC Earthquake Engineering Research Facility. Project management is being provided by Project Services (Infrastructure Development).

Previous Report Date	September 21, 2017
Decision	Information
Action / Follow Up	A series of principles has been developed, the set of recommendations has been evaluated and the execution of the action plan has commenced.

Previous Report Date	April 13, 2017
Decision	Information
Action / Follow Up	Substantial hazard assessment and building evaluation work has been undertaken to inform the seismic mitigation plan update.

Previous Report Date	June 14, 2016
Decision	Information
Action / Follow Up	Project team has undertaken work to update the seismic mitigation plan.

ATTACHMENT 1 – SUMMARY OF WORK DONE TO DATE

SUMMARY OF RESULTS

Approach

Arup, an internationally recognized engineering consulting firm, was engaged to work with UBC faculty and staff to undertake the necessary technical assessments and provide recommendations for the development the new seismic resilience plan. State-of-the art thinking and techniques were employed by the project team to virtually simulate earthquake damage and consequences both to utilities and buildings. Holistic resilience approaches, business continuity planning and a cost-benefit approach were also used. The holistic nature of the analysis means that it included not only the buildings as had been the focus in earlier plans but also included utilities, operations and financial impacts and strategies.

The project team worked with UBC faculty to refine the seismic hazard that was used in the analysis. The team used four different intensities of earthquake to understand not only how the campus will respond to the worst cases but also to the more frequent situations. The return periods of these intensities are as follows:

Intensity Level of Earthquake	Return Period (years)
Frequent	43
Probable	200
Rare	475
Very Rare	2,475

Based on this set of scenarios, the project team quantified the current situation, identified key risks and reviewed a series of three mitigation strategies for consideration.

Current Situation and Key Risks

While the study results note that the current situation is actually better than the 2012 assessment indicated, there are still approximately 25% of the buildings on campus that have a greater than 20% risk of structural collapse in a Very Rare earthquake. These buildings are denoted as Tier III or IV on a scale that goes from Tier I to Tier IV. In comparison, modern codes define a benchmark of 10% risk of collapse in a Very Rare event. The distribution of buildings and the definition of the tiers are as follows:

Structural Vulnerability Tiers (Collapse Risk)	Probability of Collapse in Very Rare Earthquake	Number of Buildings
I	0% - 10%	165
II	11% - 19%	79
III	20% - 49%	55
IV	50% - 100%	29
	Total	**328**

The life safety risks associated with the collapse potential as well as with other building damage are shown in the table below. There is significant variability in the results obtained in this analysis as there is significant uncertainty associated with predictions such as these. Regardless, it underlines that action is necessary to reduce the potential for fatalities and injuries.

Earthquake Intensity Level	Anticipated Injuries	Anticipated Fatalities
Frequent	58	0
Probable	60	0
Rare	192	33
Very Rare	678	153

While life safety and injury risk are obviously paramount, downtime and lack of business continuity are also significant risks after an earthquake. The table below shows the proportion of campus spaces that are anticipated to be functional after different earthquake scenarios as well as the length of time to restore those areas that are disrupted. It is important to note that some of the facilities that are expected to be down include hospitals and other facilities that are needed for disaster response.

Intensity Level of Earthquake	% of Total Floor Space Functional Immediately Following Earthquake	Time to Restore 50% of the Total Floor Space to Functionality	Time to Restore 75% of the Total Floor Space to Functionality	Time to Restore 90% of the Total Floor Space to Functionality
Frequent	91%	0 days	0 days	0 days
Probable	35%	3.5 months	5 months	6.5 months
Rare	2%	6.5 months	7.5 months	<2 years
Very Rare	<1%	10.5 months	<2 years	>4 years

The targets that have been set for the campus as reported in the April 2017 Update to the Board are as follows:

Resilience-Based Objectives – UBC Vancouver Campus					
Earthquake Intensity	**Life Safety?**	**Continuity of Teaching**	**Continuity of Research**	**Housing Re-Occupancy**	**Preserve Assets?**
Frequent	Yes	< 24 hours	< 24 hours	Immediate	All
Rare	Yes	< 30 days	< 30 days	Immediate	All
Very Rare	Yes	< 1 semester	< 1 semester	< 1 semester	Only critical /invaluable

Clearly, while some of the projections meet the objectives, investment will be needed to align all of the projected performance with the targets set. The planned next steps are in line with this goal.

The costs associated with both the repair and replacement of contents that are projected to be lost were estimated as a part of this project. It is difficult to quantify the actual value of cultural artifacts, research specimens and collections of the type housed at UBC, but as a starting point, the project team used insurance values provided by Risk Management Services. In additional analysis of the cost of downtime, economic losses caused by the interruption of the “business” of the university – lost tuition revenue and lost research grants – were used to assist in the prioritization of retrofit strategies. For context, the estimated total replacement value of the buildings on campus is approximately $6.5B and the estimated value of contents from the insurance valuation is $4.7B.

Earthquake Intensity Level	Estimated Costs to Repair Building Damage	Contents Losses
Frequent	$70M	$9M
Probable	$325M	$200M
Rare	$794M	$621M
Very Rare	$2.58B	$1.91B

Mitigation Options & Strategies

In order to understand how to address the challenge raised by the current state analysis, the project team looked at different strategies for prioritizing which buildings should be renewed first based on vulnerability.

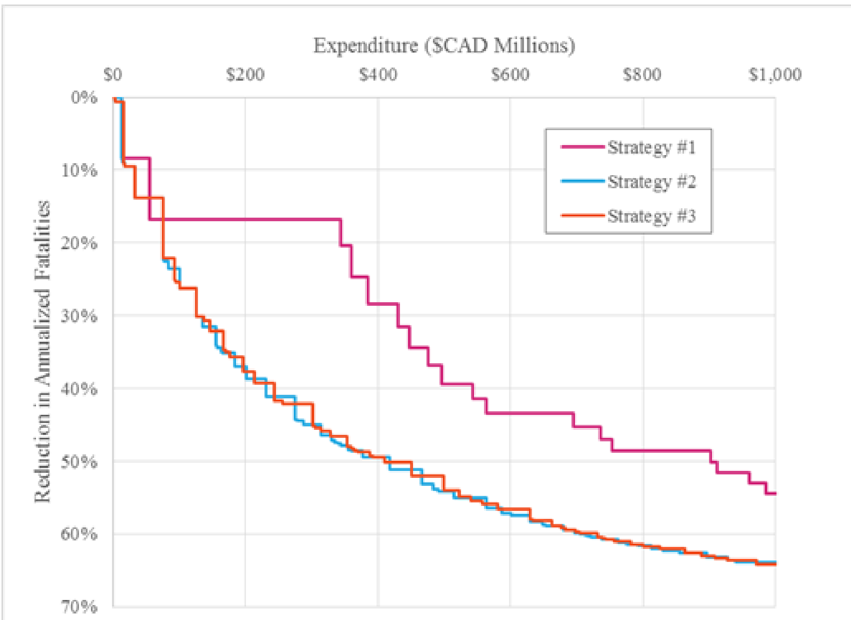
With improving life safety as the most important outcome of any building retrofits, three strategies were presented to UBC for consideration. All three strategies are based on the concept of a reduction in the projected annualized fatalities from all four earthquake scenarios. In other words, based on the projected fatalities presented in this report and statistically spreading them based on the earthquake return period, there is a quantified fatality risk for the campus around which progress can be measured.

Strategy 1 prioritizes the building retrofits based on the highest exposed population within a given building, ranking buildings in order of highest anticipated casualties.

While targeting the highest number of casualties may be appropriate, Strategy 2 looked at the cost-benefit equation of how many lives could be saved for a given capital expenditure. In other words, while at first it may sound odd to approach prioritization in this way, the graph below shows that the impact of using a least cost to save lives approach results in a greater reduction in the fatality risk for the campus than Strategy 1.

Strategy 3 is similar to Strategy 2 in terms of using most cost-effective reduction in fatality risk but also incorporates avoided repair costs and business interruption losses due to lost tuition or research grants in order to provide the most holistic look at the impacts of the possible retrofits. The results between Strategies 2 and 3 are comparable in terms of reduction in fatality risk.

The graph below compares the impacts of these three strategies in terms of reduction in fatality risk.



As a next step, UBC has prioritized all those buildings that are a high or very high priority under Strategy 1 as candidates for renewal. Starting with those buildings that have a high or very high rating in Strategy 2 or 3, the project team will complete a detailed engineering evaluation, examining the viability for retrofit strategies for these approximately 19 buildings. The list of buildings can be seen in Attachment 2.

Utilities

The consultant team noted that there was a high level of understanding by UBC staff of the vulnerabilities to the utility network and that actions have been taken to begin to address them. The most significant vulnerability is to the water supply thanks to the location of the main water distribution pumps within the Power House. Because the Power House is at significant risk of collapse, the amount of time needed to restore water service in all but the Frequent earthquake is lengthy. Because of the vulnerability of the water supply, priority action items also include assessing and implementing additional strategies for both firefighting water supply and potable water supply for after an earthquake.

The following table illustrates the anticipated disruption times for the various utilities on campus under the four studied scenarios.

Intensity Level of Earthquake	Electric Power	Water	Natural Gas	Thermal Energy	Sanitary Sewer
Frequent	6 hours	1 day	12 hours	0 days	0 days
Probable	1 day	61-65 days	2-6 days	0 days	4 days
Rare	2-3 days	65-70 days	7-13 days	0 days	6 days
Very Rare	7-13 days	68-76 days	14-40 days	0 days	8 days

Operations

There were several findings related to operations but they are quite fine-grained. The most critical recommendations are outlined above in the Action Plan section. The highest priority recommendation is that UBC consider hiring a Chief Resilience Officer so that oversight of the implementation of the seismic risk mitigation strategy is centralized under one person.

In addition, the consultant team evaluated UBC against a Campus Resilience Index. UBC scored a 2.9 out of 5 showing that there is some opportunity for improvement but that there are some areas where UBC has done significant work.

The complete report from Arup, including recommendations, can be found at:

http://www.infrastructuredevelopment.ubc.ca/infrastructure/projects/seismic

ATTACHMENT 2 – LIST OF BUILDINGS UNDERGOING DETAILED EVALUATION

	DETAILED BUILDING ANALYSIS PHASE	PRIORITY 1	PRIORITY 2	PRIORITY 3
1	MUSEUM OF ANTHROPOLOGY			
2	LOWER MALL RESEARCH STATION			
3	ANTHROPOLOGY AND SOCIOLOGY BUILDING			
4	BOOKSTORE			
5	J. B. MACDONALD BUILDING			
6	CIVIL AND MECHANICAL ENGINEERING BUILDING			
7	MACLEOD BUILDING			
8	H. R. MACMILLAN BUILDING			
9	ROBERT F. OSBORNE CENTRE - UNIT 1			
10	ROBERT F. OSBORNE CENTRE - UNIT 2			
11	CHEMISTRY A BLOCK, CHEMISTRY PHYSICS BUILDING			
12	MEDICAL SCIENCES BLOCK C			
13	WOODWARD BIOMEDICAL LIBRARY			
14	FRANK FORWARD BUILDING			
15	MUSIC BUILDING			
16	DOUGLAS KENNY BUILDING (PSYCHOLOGY)			
17	JACK BELL BUILDING			
18	CHEMISTRY B BLOCK, SOUTH WING			
19	THE LEONARD S. KLINCK BUILDING			
	TOTALS	5	5	9

ATTACHMENT 3 – UBC OKANAGAN CAMPUS SEISMIC RISK ASSESSMENT

Okanagan Campus Seismic Risk

The risk of Okanagan region seismic events, the possible impacts and our level of preparedness

Seismic hazard comparison between the Vancouver and Okanagan campuses using the 2015 National Building Code calculation with Geological Survey of Canada data.

Key points of comparison are as follows:

Peak Ground Acceleration (PGA)	Peak Ground Velocity (PGV)
UBC Vancouver 0.382 g UBC Okanagan 0.064 g **(16.8% of UBCV)**	UBC Vancouver 0.576 m/s UBC Okanagan 0.113 m/s **(19.6% of UBCV)**

This shows the significantly lower seismic hazard at UBC Okanagan. As per 1990 BC Building Code Part 4, the Okanagan is in the lowest seismic zone (1) versus Vancouver which is in the highest risk zone (6).

Further, the City of Kelowna has indicated that they manage potential earthquake risk by ensuring compliance with the BC Building Code and no additional measures are seen as necessary.

Life safety hazards from nonstructural components and contents

According to current code, 2010 National Building of Canada (NBCC) and 2012 British Columbia Building Code (BCBC), in order to determine if seismic restraints are required or not on secondary components in a particular building, we need to have the site specific seismic parameters I_E, F_a, and $S_a(0.2)$ for that building. If the product of these parameters is less than 0.35, and the building is not classified as post-disaster, then seismic restraints are not required by code on secondary components.

A review of soil site classifications for all buildings post-2005 was conducted in 2016 to determine requirements for seismic restraint and address issues of non-compliance. Okanagan soil classifications ranged “C” very dense soil and soft rock (ASC) to “D” stiff (EME, Fipke, Hangar, Purcell, RHS, TLC) to “E” soft soil (UNC). In terms of Importance Factor, none of the campus buildings are considered “post disaster”. While data was not available for all UBCO buildings, five of the eight buildings were calculated at 0.28 and therefore not requiring seismic restraint. Further assessment would be required to confirm remaining buildings.

Preparedness

Preparedness is focused on education (Shakeout, understanding the risk at http://emergency.ok.ubc.ca/shakeout.html), the ability to sustain ourselves for up to 72 hours (more work is needed on this), as well as what we can support within the region (group lodging, medical professionals/volunteers/counselling/first aid/hazmat expertise) in responding and recovering from emergencies – most of these preparedness measures apply to any hazard, not just earthquakes. See page 3 for “Why do Earthquakes happen and could one happen here?”

2. Risk of impacts from a Vancouver event: What would be the impact on our campus of a major event in Vancouver? Which of our critical systems, teaching, research, IT, administrative, finance, etc. would be affected?

All shared systems such as financial, IT, and human resources could be affected, especially if housed in one of the higher risk buildings listed in the Vancouver assessment report. An assessment of the vulnerabilities of these systems and how they would impact the Okanagan campus is recommended.

However, the greater reality is that if UBCV was affected by a significant earthquake, so would the rest of the Lower Mainland, and it would most likely become a provincial/federal led response. What this means to us is that provincial EOC (PREOC)/policy decisions would most likely move from Victoria to the interior backup location in Kamloops and we could see more federal involvement (i.e. there would be significant supply chain issues), both of which could direct the activities and resources within the province including the City of Kelowna/UBCO. This makes it difficult from a continuity planning perspective as it is unclear what this direction if provided would look like.

Additional considerations:

Short-term:

- Work with the Vancouver campus to better understand our vulnerabilities associated with shared system functions.
- Craft a communication plan that allows for each campus to support the other in the event of a significant emergency (i.e. ability for Okanagan executive to speak for Vancouver if unable).
- Obtain archival data from the City of Kelowna for building site classifications pre-2005 to confirm secondary component requirements.
- Ensure best practice for chemical and other hazardous material storage.

Medium term:

- Conduct all hazards review (not just earthquake) to determine where resources should be focused. This should include a review of utility risks (water, electrical, natural gas, sanitary, geothermal) and recommendations for resiliency, as well as secondary risks. The assessment could resemble the Arup study completed for the Vancouver campus.

Why do Earthquakes happen and could one happen here?

http://emergency.ok.ubc.ca/shakeout.html

The Vancouver campus is located near where the Juan de Fuca Plate is moving westwards and is subducting (sinking) under the North American Plate. This happens just west of Vancouver Island and the two plates here are coming together and create a zone of compression near surface.

The movement between the plates is accommodated by a mix of sliding that we do not feel, and earthquakes that we do.

Earthquakes happen when friction between the two plates prevents sliding for a while, which allows tension to build up until the fault zone "pops" and moves all at once. Imagine pushing down on a book placed on the surface of a table, then trying to slide it.

The pushing together increases the friction between the book and the table, and so you can build up more tension before the system slides. Vancouver experiences lots of small earthquakes all the time, but could one day experience a very damaging earthquake in the range of magnitude 6 to 8 on the Richter Scale.

In the Okanagan, we are further from the edge of the North American plate, but we do live very close to a fault that runs up the middle of Okanagan Lake. Here, the North American plate is slowly stretching out as the area gradually readjusts from the formation of the Rockies, which was from 55-80 million years ago. There are two things that make our region different.

First, there is less plate movement to accommodate than near Vancouver.

Second, the two sides of the Okanagan fault are trying to move away from each other. To return to the book on the table analogy, imagine instead that you are lifting the book and supporting some of its weight before you try to slide it sideways. In this case, you would build up far less sideways tension before the book slides.

These two factors mean we tend to get smaller earthquakes, the majority of which are never even felt. The largest in this region was a magnitude 4.5 in 2002 located about 50 km west of Kelowna, and all the rest are in the 3's and below.

The logarithmic nature of the earthquake amplitude and energy scales means an increase of 1 in the Richter Scale is an energy difference of about 30. This means a magnitude 4 is a thousand times less powerful than a 6, about 30,000 times less powerful than a 7 and nearly a million times less powerful than a magnitude 8.

While the Earth sometimes surprises us, the Okanagan is not expected to encounter the same earthquakes as the Lower Mainland.

- Dr. Craig Nichol, Assistant Professor, Earth & Environmental Sciences and Physical Geography