Post Disaster Report

ACUTE CARE CENTRE

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Submitted to BC Children's and Women's Hospital
by HCMA

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1.0 Types of Disaster

The design of post-disaster buildings and the structural attachments of non-structural building components in post-disaster structures are addressed in both the National Building Code of Canada (NBC 2005) and the Vancouver Building Bylaw (VBBL 2007).

In VBBL 2007, the meaning of a ‘post-disaster’ building is clearly defined. Design considerations in post-disaster buildings anticipate eventualities catalyzed by natural disasters such as strong winds, snowstorms, and earthquakes. Importance factors for wind, snow, and earthquake are used in the VBBL 2007 to multiply the required design load for the structure.

The BC Children’s and Women’s hospital (BCCW) Acute Care Centre (ACC) is situated neither in a flood plain nor in a heavily forested area—the occurrence of floods and forest fires thus seems unlikely. Earthquakes seem to be the natural disasters that need to be addressed in the design of the proposed ACC at BCCW.

2.0 Levels of Post Disaster Protection

There are three levels of classification for post-disaster protection.

1. Function protection (FP) designates the highest level of disaster preparedness. Its goal is to protect life and investment, and to ensure that the facility continues to operate post-disaster.

2. Investment protection (IP) signifies an intermediate level of protection, and is intended to protect all or part of the infrastructure and equipment. In the IP model, the facility itself may stop functioning, but is designed to resume operations within a reasonable time and within reasonable cost.

3. Life safety (LS) marks the basic level of protection and aims to ensure that the lives of building occupants are not put at risk.

Post-disaster design strategies for BCCW ACC can be driven by the importance of the clinical departments and the required level of protection. The Emergency Department (ED) must be designed for function protection (FP), whereas other areas could meet a lesser requirement. However, rather than prioritizing the allocation of emergency resources based on critical need, for the purposes of this report, all departments will be assumed to require FP levels of post-disaster preparedness.

3.0 Minimum Design Requirements

VBBL 2007 defines some minimum design requirements for post-disaster buildings. In addition, the function protection of ED and other major departments will require more detailed consideration.

3.1 Structural

A structure designed, detailed and constructed to VBBL 2007 requirements is generally accepted as providing functional protection (FP); minor structural damage may occur, such as cracking of structural and non-structural elements. For a hospital, VBBL 2007 requires an Earthquake Importance Factor of 1.5 for the entire post-disaster structure.

The entire structure of the BCCW Acute Care Centre needs to be designed to meet specifications outlined in VBBL 2007, a set of building standards mandating that the facility meets the function protection requirement.

3.2 Mechanical / Non-structural Components

Non-structural components such as HVAC and plumbing systems must have their connections and equipment designed to accommodate seismic forces.

Building services such as the supply of medical gases, need to be designed to an adequate level of protection for the medical department that they serve. Service connections to the building need t[illegible]e seismic joints. Some building services—potable water and electricity, for instance—will require a reasonable level of redundancy.

3.3 Electrical

Emergency power will be provided to the ACC from new generators within the facility. Service connections will be provided to post-disaster standards through the Basement and Electrical Room, via the new underground service tunnel to the Acute Care Centre.

3.4 Post-Disaster Operations of Departments

While it is not required that building services be functional post-disaster, as a minimum, the Emergency Department should be provided with adequate services to maintain full operation.

For other clinical services, the level of post-disaster protection needs to be evaluated with feasibility and practicality in mind. Refer to Section 4.0 for design options considered in this report.

3.5 Temporary Service Capacity

VBBL 2007 does not outline any specific requirement for temporary services such as water supply or sewage storage. Temporary service can be defined as the on-site storage that will enable the building services to continue functioning until regular service is restored. For example, potable water may not be available if the municipal water line suffers a break off-site during a seismic event. Temporary service for potable water would mean that storage tanks would be depended upon to supply the hospital's regular demands for a given time.

If it is decided that parts of the facility are to function after a seismic event, temporary services need to serve the functioning departments for a limited time before regular services are restored. Building services such as medical gases, vacuum service, potable water, sewer, and storm water are to be evaluated to keep the critical clinical services operational.

Storage capacities should be sufficient to last—at a minimum—several days before regular services are available and can be delivered on-site.

Medical gases and vacuum service are provided within the building and as such should remain available. Hot water for building heating is provided from an on-site source, with the service lines and connections provided to meet post-disaster standards. However, a new oxygen generation system will likely be required to meet capacity and to comply with seismic standards. The service lines and connections likewise need to meet post-disaster standards.

Comment [sd1]: PHSA to confirm.

4.0 Design Options

A few post-disaster design options—with varying levels of protection and levels of temporary service capacity—need to be considered. One base option and two additional options are presented so a budget and feasibility analysis can be performed.

Capacity

Option	Temporary Service Capacity	Electrical Capacity	Considerations	Additional Construction Cost Estimate
01	72 hours for entire ACC	72 hours running maximum generator capacity	Lowest cost	SSA to provide
02	120 hours for entire ACC	120 hours running maximum generator capacity	Medium cost	SSA to provide
03	168 hours for entire ACC	168 hours running maximum generator capacity	High cost	SSA to provide

5.0 Temporary Services Matrix

Based on the Clinical Specifications prepared by Resource Planning Group (RPG) for BCCW ACC dated July 15, 2011, estimated capacities for each building service are provided below. All systems designated as post-disaster must meet 100% operational requirements for a period of three, five, or seven days (72, 120, or 168 hours, respectively). The final timeframe to be used in the post-disaster specifications is to be determined based on cost estimates to be provided by SSA (Spiegel Skillen & Associates, Ltd.).

These estimates were calculated for each of the three design options

Services	Option 01	Option 02	Option 03
ELECTRICAL			
Net Additional Fuel Required Emergency + Baseline Normal	**????**	**?????**	**?????**
Generator	**50, 000 litres**	**82, 000 litres**	**115, 000 litres**
Medical Gases Supply	**TBD**	**TBD**	**TBD**
MECHANICAL			
Vacuum Services	Operate on backup power and are note affect in PD Scenario	Operate on backup power and are note affect in PD Scenario	Operate on backup power and are note affect in PD Scenario
Boiler Plant Fuel Required	?????	???????	?????
Potable Water Storage (Domestic Cold Water only)	0.47 million litres	0.78 million litres	1.1 million litres
Sewage Storage	0.52 million litres	0.86 million litres	1.2 million litres
Stormwater	Stormwater drains oversized to accommodate peak storm flow. No storage capacity. Overland overflow, if required, by others.		
Fire Protection Systems	Estimated 14,000 L storage capacity required. Fire sprinklers can be served by potable water storage of fire water service is interrupted.		
Heating Plant	All heating supplied by campus plant. No generation capacity within the building.		
Cooling Plant	Can be served either by building chillers or building geoexchange field.		

Note: A 90,000 Litre (20,000 Gallon) storage is approximately 3.0 x 5.0 x 6.0 m (10 x 15 x 20 Ft); and 0.1 million litres = 26, 500 US gallons = 100 cubic metres = a tank approximately 7m x 7m x 2m tall

Comment [sd2]: Referring to 'Minimum requirement to maintain ED service,' Phase 2 Clinical group need to decide minimum functionality required post disaster. See note on page 7.

Comment [sd3]: AME/PHSA: Storage area required in building. Please advise on quantities of gases required for storage.

Comment [sd4]: AME/AES to confirm

Comment [MH5]: PHSA to provide

6.0 Connection to Existing Facilities

6.1 Electrical

Emergency power will be provided to the ACC from new generators within the facility. Service connections will be provided to Post Disaster Standards through the basement Electrical Room, via the new underground service tunnel to the Acute Care Centre.

6.2 Mechanical

The new ACC will obtain hot water for building heating from the campus central plant. The balance of the services will be self-contained and dedicated to the ACC. However, there are no existing facilities to accommodate the needs for domestic cold water and sanitary effluent storage: new on-site infrastructure will be required.

7.0 Assumptions & Discussions

7.1 Electrical

Post Disaster operation of the facility is to meet the requirements of CSA Z232.

Post-disaster operation of the facility requires additional fuel storage capacity for the emergency generators. This additional fuel storage must be provided adjacent to or within the ACC. There are three options for sizing this capacity.

1. Operation of the full capacity ACC load (3.2MVA) for 72 hours requires an additional 48,500 litres of fuel.
2. 120 hours requires an additional 82,000 litres of fuel storage
3. 168 hours requires an additional 115, 000 litres of fuel

7.1.1 Power

Normal power to the new facility will be via dual parallel service from the existing substation in the Acute Care Building (ACB). Calculated required power for the building is 3.2 MVA, based on the total area and preliminary mechanical plant load of 2 MW.

Emergency generators—two units of 1 MVA each to ensure full redundancy—will be provided to support critical loads in the new facility. Service connections will be provided to post-disaster standards. Refer to mechanical design requirements for the fuel tank sizing and capacity.

A centralized 150 kW UPS in N+1 configuration will be provided to cover for the transition from the normal power supply to generator power for all critical loads. A UPS battery will be sized to support the load for a duration of 30 minutes, and will have a manual bypass switch. An additional external connection on the envelope of the building could be provided for re-fueling. All servers, data switches, security equipment, nurse call system, and FA system will be on UPS power.

The main electrical room will be in the basement, built to a two-hour fire-separation rating, and connected with dual underground feeders from two separate sources. Generator rooms will be in the basement with two-hour separations and separate rooms for full redundancy. All automatic transfer switches will have double bypass manual switches.

A complete grounding system will be provided in accordance to current codes and regulations.

7.1.2 Communications

Dual fiber underground connections to a new dual core in the main communication room will be provided. Both fiber connections will be pulled in independent conduit system and pathways for full redundancy.

The main communication room will be in the basement and will be fire-rated for two hours.

Communication rooms on all floors will have a direct fiber homerun to the main communication room. Fiber connections between the communication rooms on the same floors are proposed for additional redundancy.

The entirety of the new facility is to have wireless coverage for redundant connectivity

The communication grounding system will be designed in accordance to the ANSI/EIA/TIA-607-A and IEEE 1100.

7.1.3 Fire Alarm (FA) system

A two-stage FA system will be provided in the new facility.

All FA wiring will be in separate pathways.

A VESDA system—a very early warning aspirating smoke detection apparatus—is proposed for the main communication room, UPS room, CT room, and any other similarly valuable equipment rooms.

Dry sprinkler systems are to be installed in the main electrical and generator rooms.

Fire separations of the main electrical and communication rooms are to be two hours.

7.1.4 Emergency Operation Center (EOC)

Comment [sd6]: PHSA: Please provide direction on EOC. Currently 132 m2 of the area proposed is included in the RPG funcational program See Appendix A for full area proposed.

The entire EOC will be on emergency/UPS power.

A higher density of power outlets will be provided along the walls of the EOC.

A dedicated redundant fiber connection will be provided for the EOC.

A higher density of data outlets will be provided along the walls of the EOC.

A dedicated AP for wireless connectivity will be provided in the EOC.

7.2 Mechanical

Domestic cold water and sanitary effluent drainage are considered in this analysis only.

The central campus plant will meet normal operation standards and will supply the ACC through post-disaster rated structures. All other services are either electrically powered or require only additional storage space. The Existing steam plant consists of three 17,500 lbs./hr boilers. The new ACC load has been estimated at 7.6 MWt, requiring two boilers operating at full load and one trimmed.

Comment [sd7]: PHSA: Please confirm boiler numbers.

The existing steam plant will likely be replaced by a possible future Biomass plant to meet the estimated ACC load (7.6 MWt). All three existing boilers will be replaced with new 35,000 lbs./hr capacity boilers, so that two boilers will be able to meet the new total load. (One boiler will remain as backup).

Existing boilers are dual fuel (Natural gas, interruptible and #2 fuel oil). New boilers will also be dual fuel. Existing #2 fuel oil capacity is 2x50kL (Kilolitres) for a total of 100kL. Existing fuel capacity allows boilers to operate at current load for 48 hours. Additional fuel storage capacity will be required to operate the new upgraded steam plant to meet the new demands of ACC.

A new bulk oxygen service is to be provided by a new Biomass plant. A new system will be provided by the vendor. A two inch (2") dedicated line will be provided to meet the new ACC requirements.

Medical air and vacuum service for the new ACC will be provided by stand-alone systems that will be connected to emergency power. To comply with post-disaster mandates, nitrogen, nitrous oxide, and other bottled gases—as well as respective backup quantities—will be located within the ACC. Adequate space allowance for such supplies has not yet been factored into the indicative design. New ACC Architectural indicative design information (without furniture layout) was used to estimate both domestic cold water and sanitary effluent loads. Stand-alone systems will provide storage capability to meet post-disaster considerations. All calculations concerned with plumbing fixtures assume a frequency of use of nine (9) times a day.

Comment [sd8]: PHSA: Please confirm capacity of new boilers and whether one will remain as backup.

Comment [sd9]: PHSA: Please provide info for existing.

Comment [sd10]: PHSA / AME: Please supply space allowance data for gas supplies.

7.2.1 Sanitary Drainage

A sewage holding tank will be installed to accommodate all building sanitary drainage flows for the post-disaster timeframe, including possible decontamination shower flows.

The sewage holding tank will have a pumpout connection accessible by truck. Each sewer drain servicing the building will also have a pumpout connection accessible by truck.

Quantity estimate for holding tank based on domestic water usage + 10%.

7.2.2 Stormwater Drainage

The building storm drains will be capable of handling the flow from a 100-year storm event. The services will be increased in size from standard engineering design to handle the additional capacity required.

7.2.3 Domestic Water

The building will be served by two independent water supply mains from the municipal service.

The building will have two independent water supply connections at the exterior, accessible by truck.

A potable water storage tank complete with primary and secondary filtration system will be installed to accommodate all building potable water needs for the post-disaster timeframe.

The potable water storage tank will also connect to the fire protection system as a backup water supply, complete with appropriate backflow prevention.

Quantity estimate for storage tank based on 500 L/bed/per day usage.

7.2.4 Medical Gases

Comment [sd11]: AME / PHSA: Please confirm quantities required.

The building will be served by a dedicated medical gas plant complete with storage supply of all necessary medical gases for the post-disaster timeframe.

7.2.5 Fire Protection Systems

The fire pump and all fire protection equipment will be connected to emergency power.

Duplex fire pumps will be installed for 100% redundancy of fire sprinkler operation.

Fire pumps will draw primarily from the fire water service, with the capability to automatically switch to the potable water reservoir tank if the main service supply fails.

7.2.6 Building Ventilation

Air handling units will be capable of 100% recirculation where possible. Where exhaust air cannot be recirculated, the minimum fresh air supply level needed for make-up air will be rerouted through high-efficiency filters

Class I spaces will remain 100% operational. Class II and III spaces will be designed to maintain reduced ventilation levels. Class I spaces include all procedure suites and ICU areas.

Comment [sd12]: PHSA: Please confirm. Direction was for "all services to remain operational."

7.2.7 Building Piping Systems

All building piping systems (water, hydronics, medical gases) will be piped with multiple risers and branch piping to each functional program unit. This arrangement will provide redundancy such that at least part of the functional unit can remain operational if any single riser main becomes damaged and the flow must be valved shut.

All building piping systems will incorporate flexible connections at building seismic joints.

7.2.8 Heating Plant

The building heating will be served via hot water from the campus heating plant. There will not be a stand-alone heating place to serve this building's space and ventilation heating requirements.

7.2.9 Cooling Plant

The building cooling will be served by a dedicated chiller plant. The equipment will be located within the building.

7.2.10 Geoexchange Field

At this time, the Indicative Design includes a geoexchange field to maximize building energy efficiency. The field will be sized to accommodate the entire 24/7 cooling load of the building at a minimum. Therefore, the 24/7 cooling capacity will not be affected even if the chiller plant is offline.

7.2.11 Generator Fuel

Multiple fuel storage tanks will be installed to ensure operation of the emergency generator(s) for the post-disaster timeframe. The tanks will be manifolded together for redundancy and for rotation of usage for weekly generator tests.

7.2.12 Emergency Operations Centre

This area will require HVAC and plumbing systems designed for 60 people, and be capable of operating in a post-disaster situation.

8.0 References

Protecting New Health Facilities from Disasters: Guidelines for the Promotion of Disaster Mitigation, Washington D.C., PAHO/WHO 2003.

2008-2009 World Disaster Reduction Campaign: Hospitals Safe from Disasters, International Strategy for Disaster Reduction.

Guidelines for Vulnerability Reduction in the Design of New Health Facilities, Washington D.C., PAHO/World Bank 2004.

Appendix A: BCCW EMERGENCY OPERATIONS CENTRE RPG Schedule of Accommodation

3A.-- BCCW EMERGENCY OPERATIONS CENTRE

Attachment B: Schedule of Accommodation

Space Requirements

Ref	Space	Proposed Area units	nsm/unit	nsm	Remarks
01	Security Control Area	1		6.0	Reception desk, card access control to EOC
02	Operations Centre	1		836.0	60 person, tables, 40 computer stations, 3600 mm to 4200 mm , ceiling height, raised floor, 2 stentofon stations, tepehone (2), fax
03	Storage, Emergency Suupply Cabinets	3	1.0	3.0	
04	Storage, EOC Bins	1		8.0	3 bins
05	Communications Room	1		8.0	Incl. 2 stentofon stations, 2 ham radio antennae links, 3 channel commercial band/repeater link, conduit to roof top antennaes
	Lounge, Staff			0.0	Use of staff lounge
	Respite Rooms			0.0	Use of on-call rooms
	Washroom, Showers, Lockers			0.0	Use of staff locker/washrooms
	Breakout Rooms			0.0	Use of conference/meeting/classrooms
	Refuge Area			0.0	Use of soiled holding rooms for garbage/ recycling materials
	Total			**861.0**	**Estimated gross area @ 1.25 ratio = 1 076 CGSM**

DEFINITIONS

Net Square Metres (NSM) – the actual occupiable area of each room or space as measured to the interior finished surfaces of all walls, partitions, or mechanical enclosures.
Component Gross Square Metres (CGSM) – that portion of a building assigned to a specific component (a cohesive grouping of activities or spaces related by service or physical arrangement), including net areas, internal circulation, partitions, building structure and small mechanical shafts/areas as measured from the inside fact of exterior walls and to the centre line of partitions adjoining other components or general circulation space.

Appendix B: Calculation of Estimate Construction Cost

To be completed by SSA.

Appendix C: Structural Post-Disaster Design Considerations

The design of Post Disaster Buildings and the structural attachment of non-structural building components in Post Disaster Structures is addressed in both the National Building Code of Canada (NBC 2005) and the British Columbia Building Code (VBBL 2007).

The basic methodology in both codes is to assign Importance Factors to the climatic conditions of Wind, Snow and Earthquake loads; unlike previous code editions these current codes now assign specific Importance Factors for Post Disaster Structures related to Wind and Snow loading conditions whereas past codes only assigned Importance Factors to Earthquake Loads.

The Importance Factor for Wind and Snow Loads apply to both Ultimate Limit States (ULS) and serviceability Limit States (SLS) whereas the Importance Factor for Earthquake Loads applies only to ULS design.

The Importance Factors for Post Disaster Structures are as follows.

	ULS	SLS
WIND	IW = 1.25	IW = 0.75
SNOW	IS = 1.25	IS = 0.90
EARTHQUAKE	IE = 1.50	N/A

Overall Building Structure (Seismic)

The Seismic performance objectives are based on the 2% in 50 year level of earthquake ground motion, termed as the maximum earthquake ground motion, to be considered or more simply the design ground motion (DGM) this level is equivalent to a 1 in 2475 year return period.

The Performance objectives for Post Disaster Buildings subject to DGM level shaking are best described as "immediate occupancy" there should be very little damage to the structural system so as not to impede the continued use and occupancy of the building and minor damage to non-structural systems; the structure is expected to retain most of its pre-earthquake strength and stiffness; mechanical, electrical, plumbing and other systems necessary for normal operation are expected to remain functional. This more stringent performance objective is achieved in two ways:

1. Through the application of an importance factor of 1.5 for postdisaster buildings used to increase the design lateral load, and

2. Through the establishment of a much lower interstorey drift limit.

Other factors such as a building configuration, type of structural framing, materials and as-built details have a significant effect on the ability of the building to achieve this performance objective. VBBL 2007 incorporates some of these considerations by prohibiting most structural irregularities in locations having moderate to high levels of DGM.

These Seismic Design provisions for Post Disaster Buildings in the Code impose certain very specific restrictions on the type of Lateral Force Resisting System (LFRS) and its performance under earthquake conditions.
These specific conditions are as follows.

DEFLECTIONS AND LATERAL DRIFT

The code limits lateral deflections to 0.01 hs (hs = inter storey height) in Post Disaster Structures.

STRUCTURAL SEPARATIONS

The code requires structural separation between adjacent structures which do not share a common LFRS. These are to be separated by the square root of the sum of the squares of their individual deflections as calculated by the prescribed methods.

SYSTEM RESTRICTIONS

The code prohibits the use of certain Building Irregularities, except in cases where the value IeFaSa (0.2) are below prescribe thresholds.

These prohibited irregularities include those listed in table 4.1.8.6 of the code, namely,

Type 1 Vertical Stiffness Irregularly – occurs when the vertical stiffness of the system in a storey is less than 70% of an adjacent storey or less than 80% of the average stiffness of the 3 stories above and below

Type 3 Vertical Geometry Irregularly – occurs where the horizontal dimensions of a system in any storey is more than 130% of an adjacent storey

Type 4 In Plane Discontinuity in Vertical SFRS – occurs if there is an in plane offset of a system or a reduction in lateral stiffness of the element below

Type 5 Out of Plane Offsets – occurs if there are discontinuities in a lateral force path such as offsets in the vertical plane

Type 6 Discontinuity in Capacity (Weak Storey)

Type 7 Torsional Sensitivity (for fl exible diaphragm situations)

The code also requires the Lateral Force Resisting System for post-disaster structures to have an Rd value of 2.0 or greater (Rd = ductility related force modification Factor reflecting the capability of a structure to dissipate energy through inelastic behaviour). This requirement is to ensure a higher level of ductile behaviour in the structure under earthquake condition.

Elements of Structure (Seismic) Non-structural Components & Equipment

These elements of the building and their connection to the buildings need to be designed to accommodate the building deflections calculated under the Post Disaster provisions for the overall structure and for Lateral Forces applied though the centre of mass of the element or component.

The code applies variable Force calculation values dependent on the nature of the component and the type of connection used to support and/or restrain the individual component. The later restraint of equipment is provided by each trade having responsibility to design and install appropriate systems to attain this goal.