Hornby Island Fire Department
3850 Central Road
Hornby Island, BC
V0R 1Z0

COST ANALYSIS AND ESTIMATED PERFORMANCE OF SIESMIC UPGRADING – HORNBY ISLAND FIREHALL BUILDING

Prepared by,
Ron McMurtrie, P.Eng.

May 2, 2001

CONSULTING ENGINEERS

RON McMURTRIE & ASSOCIATES

~~[illegible]~~

5225 JEROW ROAD, HORNBY ISLAND, BC V0R 1Z0
TEL. (250) 335-1192

May 2, 2001

Hornby Island Fire Department
3850 Central Road
Hornby Island BC
V0R1Z0

ATTENTION: MR. GIFFORD LA ROSE, FIRE CHIEF
RE: COST ANALYSIS AND PERFORMANCE OF SEISMIC UPGRADING – HORNBY FIREHALL BUILDING

Dear Sir:

Attached is my report summarizing the findings regarding the estimated costs and performance for upgrading the existing firehall building as per my proposal of November 27, 2000.

I look forward to discussing these findings in further detail with you and the firehall committee to determine a course of action for the future of the Hornby Island Fire Department and its emergency preparedness program.

If you have any questions please do not hesitate to call me at 335-1192.

Yours truly,

PROFESSIONAL
PROVINCE OF BRITISH COLUMBIA
R. J. McMurtrie
ENGINEER

May 2, 2001

Ron McMurtrie, P.Eng.

BATES ENGINEERING 5726 Coral Rd. Courtenay, B.C. V9N 5M9
Tel (250) 334-9227 Fax (250) 334-4164

January 22, 2001

Our File 260-03-1

Ron McMurtrie & Associates
3225 Jerow Road
Hornby Island, B.C.
V0R 1Z0

Attn: Mr. Ron McMurtrie, P.Eng.

Dear Sir:

RE: McMurtrie & Associates Report - Seismic Assessment of Hornby Island Fire Hall

Bates Engineering was retained, by Ron McMurtrie & Associates, to review the above noted report. Our review is limited to a visual inspection of the Fire Hall, cursory review of design calculations and discussions on site.

We inspected the building on January 22, 2001, accompanied by Mr. Ron McMurtrie. The As-built structural sketches generally appear to be representative of the building.

The report generally appears well thought out and appears to have addressed the majority of the seismic concerns of the building. We also would generally concur with the conclusions and recommendations noted in the report.

I trust the foregoing meets your present requirements and if you have any questions or concerns please contact the undersigned.

Yours truly

BATES ENGINEERING

H. Harold Bates, P.Eng.

I. INTRODUCTION

Further to our meetings and discussions following my previous report "Preliminary Seismic Review – Existing Firehall Building" dated November 7, 2000 it was realized that further investigation and analysis would be required to determine to what extent and at what cost the existing firehall building could be upgraded for seismic loading. The recommended course of action was to remove Bays #3 and #4 and rebuild this portion to the latest seismic requirements of the BC Building Code and to look at a program of upgrading Bays #1 and #2 and the office and second floor areas. This report provides the following information: 1. An analysis of the existing structure and its estimated seismic performance versus the requirements of the 1998 BC Building Code; 2. Estimated costs versus Seismic Performance for 3 levels of upgrading of the existing building and; 3. Estimated costs for removing and re-building Bays #3 and #4 to the '98 Code.

II. ANALYSIS OF EXISTING STRUCTURE

A structural analysis of the existing building for seismic loading was performed as per the requirements of Part 4 of the 1998 BC Building Code. The analysis assumes that Bays #3 and #4 are removed and that future re-construction of Bays #3 and #4 will not be structurally connected to Bays #1 and #2 (i.e. a gap would separate the two such that lateral load transfer from one to the other would not occur).

The analysis is based on the building survey of the first report and a subsequent more detailed investigation of some of the structural components and connections. This second investigation involved cutting some holes in the floor and ceiling at wall to floor connections to be able to better evaluate the construction details of the building.

The results of the structural analysis are summarized in Table 1, which is included in the Appendix. Table 1 compares the estimated existing capacity of the various parts of the lateral force resisting system of the building with the loadings calculated as per the requirements of the '98 Code. The 3rd column of the table gives an estimate of the existing capacity expressed as a percent of the Code requirement.

To understand the significance of the figures in Table 1, one must have an understanding of how lateral seismic loads are resisted by the building. The loads at each storey are applied to the roof and floor diaphragms which act as plates or horizontal beams. The loads are then transmitted to the end walls or shearwalls which act as bracing or buttressing. These loads are further passed down through the storeys to the foundation via a system of members and connections. These connections consist of nailing, bolting and other anchorages. This route of load transfer from structure into foundation is called the load path. It is essentially a chain of interconnected elements that connects the building to its foundation. And like any chain it is only as strong as its weakest link or member. Hence any upgrading program must remove the weakest links to be truly effective.

The results of Table 1 are difficult to summarize in a few sentences. In general, some items and/or connections in the building have very low capacity of 0 to 30%

approximately. Others are averaged at about 50% and some components are estimated at 100% or up to the required seismic standard. However even if two elements are both at 100% but the connection between the two is only 25% then only 25% of the load will get transferred from one element to the next.

Essentially the results in Table 1 reflect numerically my comments in the previous report that the building has many weaknesses under conditions of seismic loading. Rather than getting too bogged down in analyzing Table 1 it will be more productive to see what effects upgrading can have on reducing and eliminating the weak links in the structure.

III. UPGRADING OPTIONS

I have looked at upgrading the building in 3 levels namely: Level 1; Level 2 and Level 3. This work could be done in stages or it could all be done all at once. The stages could include part of or all of the work described in each level. Obviously doing the work in stages has advantages. Costs can be spread out over a longer period and disruptions in firehall operation can be controlled or minimized.

The details of the work required for each level and the qualitative results are outlined below. Table 2 in the Appendix provides numerical quantitative results for the 3 levels of upgrading as a percentage of the 1998 Building Code requirements. By moving from 1 column to the next in Table 2 one can see the cumulative improvements made to the building.

In summary: **Level 1** deals mainly with two major weak links in the main floor shearwalls on Grids 4 and 2. **Level 2** completes the main floor shear walls and removal of the hollow masonry block from the building. **Level 3** deals with the second storey and upgrades the roof diaphragm, second floor shearwalls and second floor diaphragm.

1. Level 1 – Scope of Work

1.1 Splice roof diaphragm chords Grids 2 and 4.

1.2 New main floor shearwall and drag strut Grid 4, E to F

- Remove and replace canopies, C to F
- Remove siding, existing main floor retrofit shearwall and concrete curb, block wall, and second floor framing, sheathing, insulation and drywall E to F.
- Temporary support as required.
- Sidewalk removal and replacement as required.
- Drill and set rock anchors for uplift at E and F.
- Concrete piers, footing and anchorage for new shearwall
- New 2x6 plywood shearwall 12'x14' (insulate and drywall).
- Install structural steel collector strut (42' long) C to F. Bolt to 2nd floor diaphragm rim joist and new shearwall.

- Upgrade connection of 2nd floor wall to floor diaphragm and floor diaphragm connection to steel strut, C to F. Includes some removal and restoration of drywall ceiling and flooring along Grid 4.
- Reframe 2nd floor wall and move office window up, re-sheet, insulate and drywall, E to F.
- Replace siding E to F.
- Relocate door to Grid F (or other suitable location).
- Relocate main electrical service and meter.
- Electrical work as required (including temporary measures to keep operational during renovation).

1.3 New main floor shearwall Grid 2, C to E.

- Remove block wall (12'x28') and temporary support 2nd floor wall.
- Drill and set rock anchors for uplift at C and E.
- Concrete piers at C and E.
- Install new 2x6 plywood shearwall, anchor bolts and uplift anchors.
- Side and insulate 2x6 wall.
- Upgrade connection of 2nd floor wall to floor diaphragm and floor diaphragm to new shearwall. Includes some removal and restoration of flooring along Grid 2.

1.4 Splice and anchor at beam Grid D second floor joists.

- Cut and reinstate drywall ceiling along Grid D.
- Install framing anchors to joists and beam.
- Splice joist ends over beam with plates and/or nailing as required.

Results – Level 1:

- ➢ Minor improvement to roof diaphragm integrity.
- ➢ Eliminates major main floor weakness along Grid 4.
- ➢ Eliminates major main floor weakness along Grid 2.
- ➢ Eliminates major out-of-plan weakness on Grid 2 and potential danger from collapse of blocks and 2x4 wall.
- ➢ Prevents potential danger from collapse of 2nd floor at Grid D.
- ➢ Improves part of office wing and eliminates potential danger from collapse of blocks Grid 4, E to F.

(Refer to Table 2 for quantitative results)

2. Level 2 – Scope of Work

The removal of Bays #3 and #4 would be required prior to proceeding with item 2.1 below. The scope of work required for the reconstruction of Bays #3 and #4 is outlined in Section IV below.

2.1 New main floor bearing/shearwall Grid C, 2 to 4.

- Remove block wall 12'x40'

- Install new 2x6 plywood bearing shearwall, anchor bolts and uplift anchors.
- Insulate 2x6 wall (siding not required).
- Upgrade connection of 2nd floor wall to floor diaphragm and floor diaphragm to new shearwall.

2.2 New main floor bearing/shearwall Grid E, 2 to 4.

- Remove block wall 12'x40'.
- Temporarily suport 2nd floor of office.
- Remove 4' of office wall dry and replace (Grid E).
- Install new 2x6 plywood bearing shearwall, anchor bolts and uplift anchors.
- Upgrade connection of 2nd floor wall to floor diaphragm and floor diaphragm to new shearwall.
- Insulate and side 2x6 wall (2 to 3 only).
- Drywall and paint (Grid 3 to 4 only).
- Connect office 2nd floor to 2x6 wall.
- Electrical work as required (including temporary measures to keep operational during renovation).

2.3 Upgrade 2nd floor bearing/shearwall Grid E, 3 to 4.

- Remove drywall Grid 3 in office.
- Add horizontal blocking to existing wall.
- Splice top plate as required.
- Sheet and nail new plywood (from roof to floor).
- Replace drywall and paint.

2.4 Remove main floor office block walls and replace with 2x6 plywood shearwalls Grids 3 and F.

- Remove siding and existing retrofit stud walls (8'x34').
- Remove block walls and temporarily support 2nd floor.
- Remove and reinstate stairs as required.
- Install new 2x6 plywood walls, anchor bolts and uplift anchors.
- Upgrade connection of 2nd floor wall to floor diaphragm and floor diaphragm to new shearwalls.
- Side, insulate, drywall and paint 2x6 walls.
- Electrical work as required (including temporary measures to keep operational during renovation).

Results - Level 2:

- ➢ Completes integrity of main floor system.
- ➢ Reduces weight of structure (blocks all removed) and hence reduces seismic load on building.
- ➢ Improves main floor shearwalls Grid C and E and floor diapghragm connections to shearwalls.
- ➢ Improves main floor shearwalls in office.

- ➢ Eliminates major out-of-plan weakness on Grids C and E and potential danger from collapse of blocks and 2x4 walls.
- ➢ Eliminates potential danger from collapse of block walls Grids 3 and F.
- ➢ Improves 2nd floor shearwall Grid E.

(Refer to Table 2 for quantitative results)

3. Level 3 – Scope of Work

3.1 Upgrade Roof Diaphragm

- Remove metal roof and strapping.
- Remove asphalt shingles.
- Remove and replace perimeter plywood sheets and around hose tower.
- Upgrade connection to shearwalls (blocking and framing anchors and bracing at gable ends).
- Splice chords Grid C,E and F.
- Reinforce opening at hose tower.
- Re-nail plywood diaphragm to '98 Code.
- Install new roofing.

3.2 Upgrade 2nd Floor Shearwalls

- Remove siding and trim.
- Remove plywood.
- Reframe areas as required (possible removal and replacement of interior drywall).
- Anchor struts and headers.
- Install uplift anchorage.
- Install horizontal blocking (at plywood edges).
- Re-route electrical as required.
- Re-insulate as required.
- Re-apply plywood (some new sheets required) and nail to '98 Code.
- Install new siding and trims, flash and seal.

3.3 Upgrade 2nd Floor Diaphragm

- Remove flooring and cabinets etc to expose plywood.
- Remove and replace plywood and sheathing as required to reinforce diaphragm at hose tower. Add blocking and framing and anchorage.
- Nail plywood to '98 Code (nail through 2 layers of existing plywood and 1x8 diagonal sheathing into joists).
- Reinstate cabinets.
- Install new flooring.

Results - Level 3:

- ➢ Completes integrity of roof and 2nd floor wall system.
- ➢ Completes integrity of building as a whole.
- ➢ Improves roof diaphragm.
- ➢ Improves 2nd floor shearwalls and anchorage.

➢ Improves 2nd floor diaphragm.
(Refer to Table 2 for quantitative results)

IV RECONSTRUCTION OF BAYS #3 AND #4

The reconstruction of Bays #3 and #4 involves the taking down of the existing structure and the construction of a new building in its place. It is understood that the new building would be built to a single storey with the potential for addition of a second floor in the future. The design of the new building would have to take this into consideration from both a structural and architectural point of view. In order to make room for the new building (estimated at 35' wide x 48' long with 12' ceiling height) including an approximate 1ft. gap between existing and new structures and to have the slab elevation for Bays #3 and #4 to be the same blasting and removal of rock from the bank and beneath Bay #4 is required.

A wood frame building of 2x6 walls and 2x12 joists and plywood sheathing with a central beam of glulam or engineered wood with 2 steel columns is recommended for economy and open space. The building would be supported and securely anchored to a reinforced concrete foundation with a concrete floor slab. The ends of the building (garage doors) can be braced by the use of a structural steel "moment frame" consisting of I-beams and columns welded together and anchored to the foundation and bedrock.

Work associated with this part of the project is detailed below.

1. Removal of Existing Structure – Scope of Work

1.1 Remove weatherproof seal and flashing at Bay#3/#2 interface along Grid C.
1.2 Remove roofing.
1.3 Remove siding.
1.4 Remove garage doors.
1.5 Remove plywood.
1.6 Remove drywall and insulation.
1.7 Disconnect and remove electrical wiring and fixtures, plumbing and heating ducts.
1.8 Take down roof and wall framing lumber.
1.9 Salvage and store materials to be re-used in new construction.
1.10 Re-move from site and/or dispose of materials not to be re-used in new construction.

2. Slab/ Removal and Rock Blasting/Excavation – Scope of Work

2.1 Take down block walls (Grid A and B) and returns with excavator and remove backfill (Grid A).
2.2 Cut (jackhammer) slab along Grid C.
2.3 Remove slabs (Bays #3 and #4) with excavator..

2.4 Drill and blast rock to lower slab elevation of Bay #4 by 14" (make level with Bays #1,#2 and #3).
2.5 Drill and blast rock to cut bank back 4' to 6'. Cut slope to stable angle.
2.6 Stockpile on-site and/or remove materials from site.

3. Construction of New Structure to '98 Code – Scope of Work

3.1 Excavate, fill and compact as required to prepare for slab and foundation of new building.
3.2 Drill and set rock anchors for moment frames at garage door openings.
3.3 Pour foundation and slab.
3.4 Construct 1-storey 35'x48' wood frame building (stud and joist frame/plywood sheathing) with 12' ceiling height. Central beam (i.e. timber or glulam) with steel columns. Design building to accommodate future 2^{nd} story. **Note:** New structure to be separated from existing structure. Connection between the two will be for weatherproofing, cosmetic and access purposes only.
3.5 Supply and erect structural steel moment frames (beams and columns) at garage door ends of building.
3.6 Roofing, insulation, drywall and exterior siding.
3.7 Doors, windows and doorways into Bay #2.
3.8 Electrical wiring and fixtures.
3.9 Plumbing.
3.10 Heating.
3.11 Foundation and site drainage.
3.12 Approach grading.

V ESTIMATED COSTS

Estimated costs for the work outlined in Sections III and IV above are summarized in Table 3 below. These figures should be considered for budgetary purposes only. Actual costs would be realized after construction is completed. There is considerable uncertainty associated with renovation costs. Typically a high to very high labour component is involved compared with new construction. Effort has been made to try and make sure that the budgets are adequate. Table 4 (see Appendix) is a detailed cost estimate for Bays #3 and #4.

Table 3 Cost Estimates

ITEM	ESTIMATED COST
1. Level 1 Upgrading	
1.1 Splice roof diaphragm chords Grids 2 and 4.	(included in 1.2)
1.2 New main floor shearwall and drag strut	$11,500

Grid 4, E to F	
1.3 New main floor shearwall Grid 2, C to E.	$7000
1.4 Splice and anchor at beam Grid D second floor joists.	$1500
Subtotal	$20,000
Contingency	$3000
Total Level 1 Upgrading	**$23,000**
2. Level 2 Upgrading	
2.1 New main floor bearing/shearwall Grid C, 2 to 4.	$5500
2.2 New main floor bearing/shearwall Grid E, 2 to 4.	$10,000
2.3 Upgrade 2nd floor bearing/shearwall Grid E, 3 to 4.	$3000
2.4 Remove main floor office block walls and replace with 2x6 plywood shearwalls Grids 3 and F.	$6000
Subtotal	$24,500
Contingency	$3000
Total Level 2 Upgrading	**$27,500**
3. Level 3 Upgrading	
3.1 Upgrade Roof Diaphragm	$8000
3.2 Upgrade 2nd Floor Shearwalls	$12,500
3.3 Upgrade 2nd Floor Diaphragm	$8000
Subtotal	$28,500
Contingency	$3000
Total Level 3 Upgrading	**$31,500**
Total Level 1,2,3 Upgrading	**$82,000**

Engineering @ 10%	$8000
Grand Total Upgrading Level 1,2 and 3	**$90,000**
4. New Bay#3 and #4 Structure	
4.1 Removal of Existing Structure	$3500
4.2 Slab/ Removal and Rock Blasting/Excavation –	$10,000
4.3 Construction of New Structure to '98 Code	$61,500
Subtotal	$75,000
Contingency @15%	$11,250
Architecture and Engineering @ 10%	$7500
Total Bays #3 and #4	**$94,000**
Grand Total Upgrading and New Construction	**$184,000**

VI SUMMARY AND RECOMMENDATIONS

As shown in Table 2, it is estimated that the upgrading of the existing building can reach levels approaching compliance with the 1998 BC Building Code requirements for seismic loading if all of the work in Levels 1, 2 and 3 is completed. As noted there is some degree of uncertainty regarding this because much of the existing building materials have not been observed by the author. However since much of the upgrading involves removing and exposing existing materials expected performance of the building can be re-evaluated during renovation. It is also noted that the work required to achieve this level of performance is costly and quite onerous. Considerable planning, coordination and management will be required to do the work and keep the firehall and its operations functioning at required levels.

It is recommended that the scope and costs of the work outlined in this report be compared with the cost and work involved in the construction of a new facility for the Fire Department and to compare what the end results will be. A big question to be answered is: Will the upgrading of the existing building and reconstruction of Bays #3 and #4 result in a facility that meets the needs of the Island and its residents well into the future?

From a structural engineering, life safety and emergency preparedness perspective the construction of a new facility to the full Building Code requirement can be done with greater surety than to upgrade the existing building. However the findings of this study show that a fairly high degree of seismic resistance can be achieved through a renovation process. The probability of collapse associated with the existing building is greater than that associated with a new building.

I would be pleased to discuss this further with the firehall committee and to assist in the decision making process. I am also prepared to help develop costs for new construction to compare with the upgrade costs if needed.

I trust this report meets your needs at this time and I look forward to our meeting.

VII APPENDIX

Table 1 Existing Capacity versus 1998 Building Code Requirements for Seismic Loading.

Item	Estimated Existing Capacity	'98 Code Loads	% of '98 Code	Location/ Notes
A. Main Building Bays #1 and #2				
1. Roof Diaphragm				
1.1 Shear	130 plf	380 plf	34 %	Grid 2 governs
1.2 Chords	6000 lb	2600 lb	100 %	Grid C,E govern
1.3 Chord Splice	1000 lb 200 lb	2600 lb 1200 lb	38 % 17 %	Grid C,E Grid 2,4
1.4 Shearwall Connection	50 plf 80 plf	170 plf 260 plf	29 % 31 %	Grid C,E Grid 2,4
1.5 Reinforcing at Tower	-	-	25%	Estimate
2. Floor Diaphragm				
2.1 Shear	110 plf	270 plf	41 %	Grid 2 governs
2.2 Chords	6000 lb	1800 lb	100 %	Grid C,E governs
2.3 Chord Splice	1000 lb 250 lb	1800 lb 500 lb	56 % 50 %	Grid C,E Grid 2,4
2.4 Shearwall Connection	160 plf 160 plf 50 plf	270 plf 630 plf 470 plf	59 % 25 % 11 %	Grid C Grid E Grid 2,4
2.5 Reinforcing at Tower	-	-	25%	Estimate
3. 2nd Floor Shearwalls				
3.1 Shear	90 plf 90 plf 90 plf 90 plf	275 plf 650 plf 275 plf 500 plf	33 % 14 % 33 % 18 %	Grid C Grid E (no plywood 3 to 4) Grid 2 Grid 4 (at windows)
3.2 Anchorage at 2nd Floor	160 plf 160 plf 160 plf 160 plf	290 plf 690 plf 290 plf 290 plf	55 % 23 % 55 % 55 %	Grid C Grid E (2 to 3) Grid 2 Grid 4
3.3 Uplift Anchorage	- 0 lb 0 lb 0 lb	- 3600 lb 2300 lb 2000 lb	100 % 0 % 0 % 0 %	Grid C Grid E (2 to 3) Grid 2 (at ends) Grid 4 (at windows)
3.4 Drag Strut/Anchorage	500 lb 500 lb	2250 lb 900 lb	22 % 56 %	Grid C Grid 4

	500 lb	4300 lb	12 %	Grid E
4. Main Ffloor Shearwalls	.			
4.1 Shear	300 plf 300 plf 300 plf 150 plf	370 plf 535 plf 500 plf 1200 plf	81 % 56 % 60 % 13 %	Grid C Grid E Grid 2 Grid 4 (E to F)
4.2 Anchorage at Slab	250 plf 250 plf 250 plf 250 plf	370 plf 535 plf 500 plf 1200 plf	68 % 47 % 50 % 21%	Grid C Grid E Grid 2 Grid 4 (E to F)
4.3 Uplift Anchorage	0 lb 0 lb 0 lb 0 lb 0 lb 0 lb	2000 lb 3600 lb 5200 lb 8800 lb 8000 lb 15000 lb	0 % 0 % 0 % 0 % 0 % 0 %	Grid C Grid E Grid E Grid E Grid 2 Grid 4 (E & F)
4.4 Drag Strut/Anchorage	>540 lb >540 lb 2000 lb	540 lb 540 lb 13000 lb	100 % 100 % 15 %	Grid C Grid E Grid 4
5. 2nd Floor Out-of-plane Wall Forces and Anchorage				
5.1 Bending	-	-	100 %	Assumed
5.2 Bending and Axial	-	-	100 %	Assumed
5.3 Anchorage	-	-	100 %	Assumed
6. Main Floor Out-of-plane Wall Forces and Anchorage				
6.1 Bending	700 ft-lb	1100 ft-lb	64 %	Grid 2,C,E
6.2 Bending and Axial	-	-	37 %	Grid C,E
6.3 Anchorage to Slab	150 plf	270 plf	56 %	Grid 2,C,E
6.4 Anchorage 2nd floor	200 plf -	270 plf 270 plf	74 % 10 %	Grid C,E Grid 2
7. Slab/Foundation				
7.1Reinforcing/ Integrity	-	-	-	Reinforcing assumed not to '98 Code

7.2 Uplift Resistance	-	-	-	Inadequate at some required anchorage points (2C,2E,4E,4F).
7.3 Bearing Capacity	-	-	-	Inadequate at some point loads from overturning moments(2C,2E,4E, 4F).
7.3 Lateral Resistance	-	-	-	Inadequately anchored at some shearwall locations(4,E to F).
B. Office Wing Addition				
1. Roof Diaphragm				
1.1 Shear	130 plf	140 plf	93 %	
1.2 Chords	6000 lb	680 lb	100 %	
1.3 Chord Splice	300 lb >340 lb	680 lb 340 lb	44 % 100 %	Grid E,F Grid 3,4
1.4 Shearwall Connection	50 plf 80 plf	100 plf 140 plf	50 % 57 %	Grid E,F Grid 3,4
2. Floor Diaphragm				
2.1 Shear	100 plf	130 plf	77 %	Grid E
2.2 Chords	-	360 lb	50%	at stairwell
2.3 Shearwall connection	-	-	30%	Assumed
3. 2nd Floor Shearwalls				
3.1 Shear	90 plf 90 plf 90 plf 30 plf	270 plf 160 plf 200 plf 200 plf	33 % 56 % 46 % 15 %	Grid 4 Grid 3 Grid F Grid E (no plywood)
3.2 Anchorage at 2nd Floor	160 plf 160 plf 160 plf 160 plf	160 plf 160 plf 115 plf 115 plf	100 % 100 % 100 % 100 %	Grid 4 Grid 3 Grid F Grid E
3.3 Uplift anchorage	0 lb 0 lb 0 lb 0 lb	1000 lb 1000 lb 0 lb 0 lb	0 % 0 % 100 % 100 %	Grid 4 Grid 3 Grid F Grid E
3.4 Drag Strut/Anchorage	-	-	50 %	Assumed
4. Main floor Shearwalls				
4.1 Shear	150 plf 90 plf	1200 plf 250 plf	13 % 36 %	Grid 4 Grid 3

	90 plf 0 plf	200 plf 65 plf	45 % 0 %	Grid F Grid E (ledger on block)
4.2 Anchorage to Slab	250 plf 125 plf 125 plf 0 plf	1200 plf 250 plf 200 plf 80 plf	21 % 50 % 63 % 0 %	Grid 4 Grid 3 Grid F Grid E
4.3 Uplift Anchorage	0 lb 0 lb 0 lb 0 lb	15000 lb 2800 lb 500 lb 0 lb	0 % 0 % 0 % 100 %	Grid 4 Grid 3 Grid F Grid E
4.4 Drag Strut/Anchorage	-	-	50 %	assumed
5. 2nd Floor Out-of-plane Wall Forces and Anchorage				
5.1 Bending	-	-	100 %	Assumed
5.2 Bending and Axial	-	-	100 %	Assumed
5.3 Anchorage	-	-	75 %	Assumed
6. Main Floor Out-of-plane Wall Forces and Anchorage				
6.1 Bending	700 ft-lb	500 ft-lb	100 %	Grid 3,F
6.2 Bending and Axial	-	-	75 %	Grid F
6.3 Anchorage to Slab	150 plf	270 plf	56 %	assumed
6.4 Anchorage 2nd floor	150 plf	270 plf	56 %	Grid F

Table 2 Seismic Performance vs Level of Upgrading[1]

Item	Exist	Level 1	Level 2	Level 3	Location/Notes
A. Main Building Bays #1 and #2					
1. Roof Diaphragm					
1.1 Shear	34 %	34 %	37 %[2]	**100 %**	Grid 2 governs
1.2 Chords	100 %	100 %	100 %	100 %	Grid C,E govern
1.3 Chord Splice	38 % 17 %	38 % **100 %**	38 % **100 %**	**100 %** **100 %**	Grid C,E Grid 2,4
1.4 Shearwall Connection	29 % 31 %	29 % 31 %	29 % 31 %	**100 %** **100 %**	Grid C,E Grid 2,4
1.5 Reinforcing at Tower	25%	25%	25%	**100 %**	
2. Floor Diaphragm					
2.1 Shear	41 %	41 %	**80 %**[2]	**90 %**	Grid 2 governs
2.2 Chords	100 %	100 %	100 %	100 %	Grid C,E governs
2.3 Chord Splice	56 % 50 %	56 % **100 %**	**100 %** **100 %**	**100 %** **100 %**	Grid C,E Grid 2,4
2.4 Shearwall Connection	59 % 25 % 11 %	59 % 25 % **100 %**	**100 %** **100 %** **100 %**	**100 %** **100 %** **100 %**	Grid C Grid E Grid 2,4
2.5 Reinforcing at Tower	25%	25%	25%	**100 %**	Estimate
3. 2nd Floor Shearwalls					
3.1 Shear	33 % 14 % 33 % 18 %	33 % 14 % 33 % **33 %**	33 % **60 %** 33 % **33 %**	**100 %** **100 %** **100 %** **100 %**	Grid C Grid E Grid 2 Grid 4 (at windows)
3.2 Anchorage at 2nd Floor	55 % 23 % 55 % 55 %	55 % 23 % **100 %** **100 %**	**100 %** **100 %** **100 %** **100 %**	100 % 100 % 100 % **100 %**	Grid C Grid E Grid 2 Grid 4
3.3 Uplift Anchorage	100 % 0 % 0 % 0 %	100 % 0 % 0 % 0 %	100 % **100 %** 0 % 0 %	100 % **100 %** **100 %** **80 %**	Grid C Grid E Grid 2 (at ends) Grid 4 (at windows)
3.4 Drag	22 %	22 %	22 %	**100 %**	Grid C

Strut/Anchorage	56 % 12 %	56 % 12 %	56 % 12 %	**100 %** **100 %**	Grid 4 Grid E
4. Main Ffloor Shearwalls					
4.1 Shear	81 % 56 % 60 % 13 %	81 % 56 % **100 %** **100 %**	**100 %** **100 %** **100 %** **100 %**	**100 %** **100 %** **100 %** **100 %**	Grid C Grid E Grid 2 Grid 4 (E to F)
4.2 Anchorage at Slab	68 % 47 % 50 % 21%	68 % 47 % **100 %** **100 %**	**100 %** **100 %** **100 %** **100 %**	**100 %** **100 %** **100 %** **100 %**	Grid C Grid E Grid 2 Grid 4 (E to F)
4.3 Uplift Anchorage	0 % 0 % 0 % 0 %	0 % 0 % **80 %** **80 %**	**100 %** **100 %** **80 %** **80 %**	**100 %** **100 %** **80 %** **80 %**	Grid C Grid E Grid 2 Grid 4 (E & F)
4.4 Drag Strut/Anchorage	100 % 100 % 15 %	100 % 100 % **80 %**	100 % 100 % **80 %**	100 % 100 % **80 %**	Grid C Grid E Grid 4
5. 2nd Floor Out-of-plane Wall Forces and Anchorage					
5.1 Bending	100 %	100 %	100 %	100 %	Assumed
5.2 Bending and Axial	100 %	100 %	100 %	100 %	Assumed
5.3 Anchorage	100 %	100 %	100 %	100 %	Assumed
6. Main Floor Out-of-plane Wall Forces and Anchorage					
6.1 Bending	64 % 64 %	**100 %** 64 %	**100 %** **100 %**	**100 %** **100 %**	Grid 2, Grid C,E
6.2 Bending and Axial	37 %	37 %	**100 %**	**100 %**	Grid C,E
6.3 Anchorage to Slab	56 % 56 %	**100 %** 56 %	**100 %** **100 %**	**100 %** **100 %**	Grid 2, Grid C,E
6.4 Anchorage 2nd floor	74 % 10 %	74 % **75 %**	**100 %** **75 %**	**100 %** **75 %**	Grid C,E Grid 2
7. Slab/Foundation					
7.1Reinforcing/ Integrity	-	-	-	-	Reinforcing assumed not to '98 Code

7.2 Uplift Resistance	-	**80 %**	**80 %**	**80 %**	2C,2E,4E,4F
7.3 Bearing Capacity	-	**80 %**	**80 %**	**80 %**	2C,2E,4E,4F
7.3 Lateral Resistance	-	**80 %**	**80 %**	**80 %**	Grid 4 (E to F).
B. Office Wing Addition					
1. Roof Diaphragm					
1.1 Shear	93 %	93 %	93 %	**100 %**	
1.2 Chords	100 %	100 %	100 %	100 %	
1.3 Chord Splice	44 % 44 % 100 %	44 % 44 % 100 %	**100 %** 44 % 100 %	**100 %** **100 %** 100 %	Grid E Grid F Grid 3,4
1.4 Shearwall Connection	50 % 57 % 57 %	50 % 57 % **100 %**	50 % 57 % **100 %**	**100 %** **100 %** **100 %**	Grid E,F Grid 3 Grid 4
2. Floor Diaphragm					
2.1 Shear	77 %	77 %	**100 %**[2]	**100 %**	Grid E
2.2 Chords	50%	50%	50%	**75%**	at stairwell
2.3 Shearwall connection	30%	30%	**80 %**	**80 %**	
3. 2nd Floor Shearwalls					
3.1 Shear	33 % 56 % 46 % 15 %	**100 %** 56 % 46 % 15 %	**100 %** 56 % 46 % **100 %**	**100 %** **100 %** **100 %** **100 %**	Grid 4 Grid 3 Grid F Grid E
3.2 Anchorage at 2nd Floor	100 % 100 % 100 % 100 %	100 % 100 % 100 % 100 %	100 % 100 % 100 % 100 %	100 % 100 % 100 % 100 %	Grid 4 Grid 3 Grid F Grid E
3.3 Uplift anchorage	0 % 0 % 100 % 100 %	**100 %** 0 % 100 % 100 %	**100 %** 0 % 100 % 100 %	**100 %** **100 %** 100 % 100 %	Grid 4 Grid 3 Grid F Grid E
3.4 Drag Strut/Anchorage	50 % 50 %	**100 %** 50 %	**100 %** 50 %	**100 %** **100 %**	Grid 4 Grid F
4. Main floor Shearwalls					
4.1 Shear	13 % 36 % 45 % 0 %	**100 %** 36 % 45 % 0 %	**100 %** **100 %** **100 %** **100 %**	**100 %** **100 %** **100 %** **100 %**	Grid 4 Grid 3 Grid F Grid E
4.2 Anchorage to Slab	21 % 50 % 63 % 0 %	**100 %** 50 % 63 % 0 %	**100 %** **100 %** **100 %** 100 %	**100 %** **100 %** **100 %** **100 %**	Grid 4 Grid 3 Grid F Grid E

4.3 Uplift Anchorage	0 % 0 % 0 % 100 %	**100 %** 0 % 0 % 100 %	**100 %** **100 %** **100 %** 100 %	**100 %** **100 %** **100 %** 100 %	Grid 4 Grid 3 Grid F Grid E
4.4 Drag Strut/Anchorage	50 %	50 %	**100 %**	**100 %**	
5. 2nd Floor Out-of-plane Wall Forces and Anchorage					
5.1 Bending	100 %	100 %	100 %	100 %	Assumed
5.2 Bending and Axial	100 %	100 %	100 %	100 %	Assumed
5.3 Anchorage	75 %	75 %	75 %	**100 %**	
6. Main Floor Out-of-plane Wall Forces and Anchorage					
6.1 Bending	100 %	100 %	100 %	100 %	Grid 3,F
6.2 Bending and Axial	75 %	75 %	**100 %**	**100 %**	Grid F
6.3 Anchorage to Slab	56 %	56 %	**100 %**	**100 %**	
6.4 Anchorage 2nd floor	56 %	56 %	**100 %**	**100 %**	Grid F

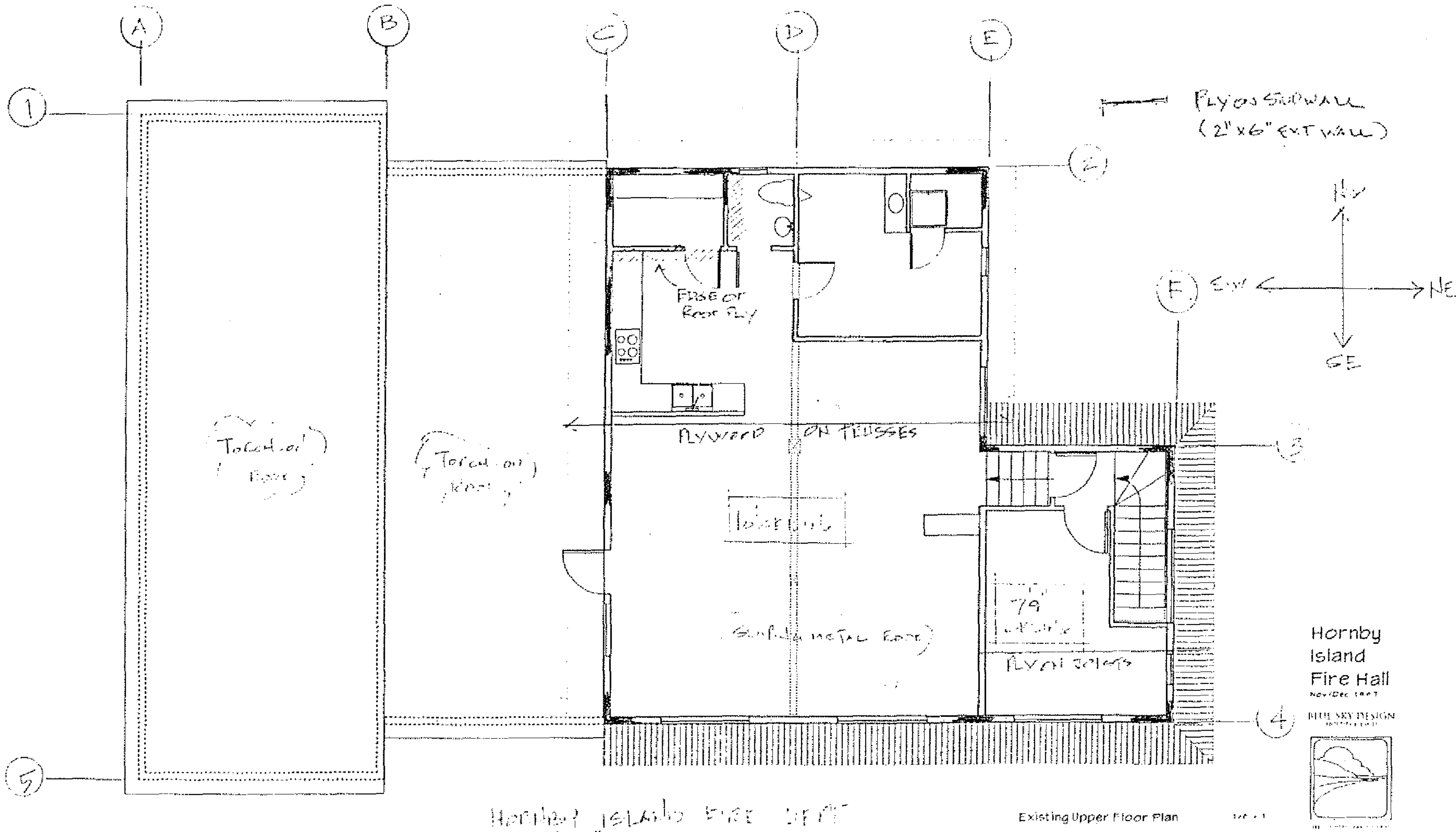
Notes to Table 2

1. **Values of percentage of Code requirements are estimates only and will require verification during construction of renovations. Hence these values are subject to change once actual conditions are uncovered.**

2. **Elimination of masonry block walls reduces load to floor diaphragm by 52 % and to roof diaphragm by 8 %.**

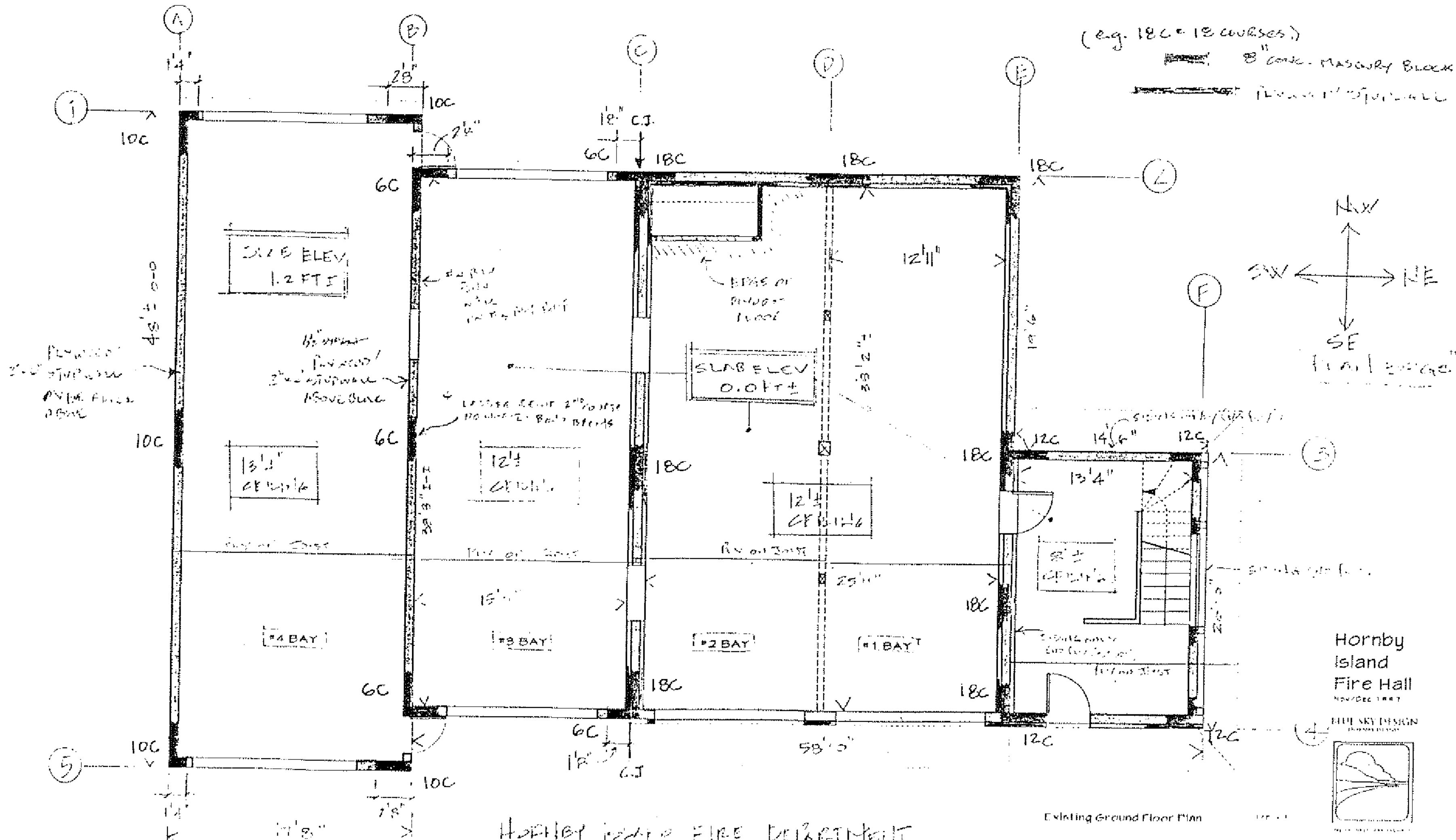
Table 4 Detailed Cost Estimate for Removal and Reconstruction of Bays #3 and #4.

Item	Unit	Quantity	Unit Cost	Estimated cost
Remove existing #3/#4	LS			3500
Blasting/slab removal	LS			10,000
Fill and compact	LS			1000
Rock anchors	LS			2500
Footings	cu.yd	8	250	2000
Slab	cu.yd.	25	250	6250
Column footings	cu.yd	5	275	1375
Foundation drains	LS			1000
Misc. site grading	LS			1000
Studwalls and plywood	sq.ft.	1500	3	4500
Roof beam and columns	LS			1000
Roof joists and plywood	sq.ft.	1850	4	7400
Structural steel frames	each	2	3000	6000
Roofing	sq.ft.	1850	1.5	2775
Siding	sq.ft.	1000	3	3000
Insulation walls	sq.ft.	1500	0.75	1125
Insulation roof	sq.ft.	1600	0.9	1440
Gyproc ceiling 2 @ 5/8"	sq.ft.	1600	3	4800
Gyproc walls @ 1/2"	sq.ft.	1500	1.5	2250
Garage doors	each	4	1000	4000
Doors and windows	LS			2000
Electrical	LS			2500
Plumbing	LS			1000
Heating	LS			1500
Painting	sq.ft.	3100	0.4	1240
Subtotal				**75155**
Contingency @ 15%				**11273.25**
Arch and Eng @10%				**7515.5**
Total Estimated Cost				**93943.75**



HORNBY ISLAND FIRE DEPT
SKETCH #3
BY: RH OCT 19, 2020

PROJECT NO. 2020-03



HORNBY ISLAND FIRE DEPARTMENT
SKETCH #1
BY: RH OCT. 19, 2000

PROJECT NO. 2000-05

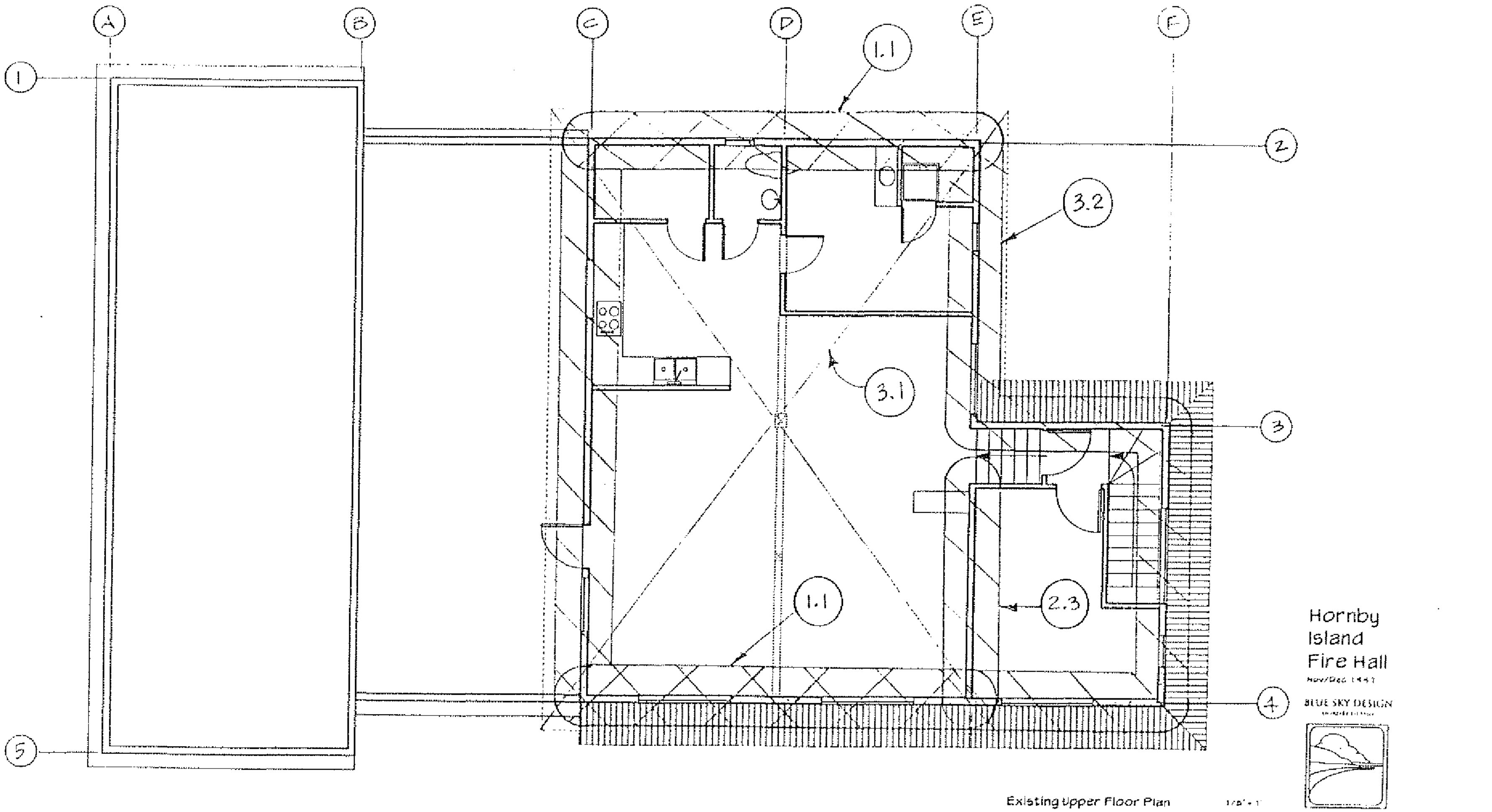


FIG. 2 UPGRADE PLAN

RON McMURTRIE & ASSOCIATES
CONSULTING ENGINEERS

BY: RM. MAY 2, 2001

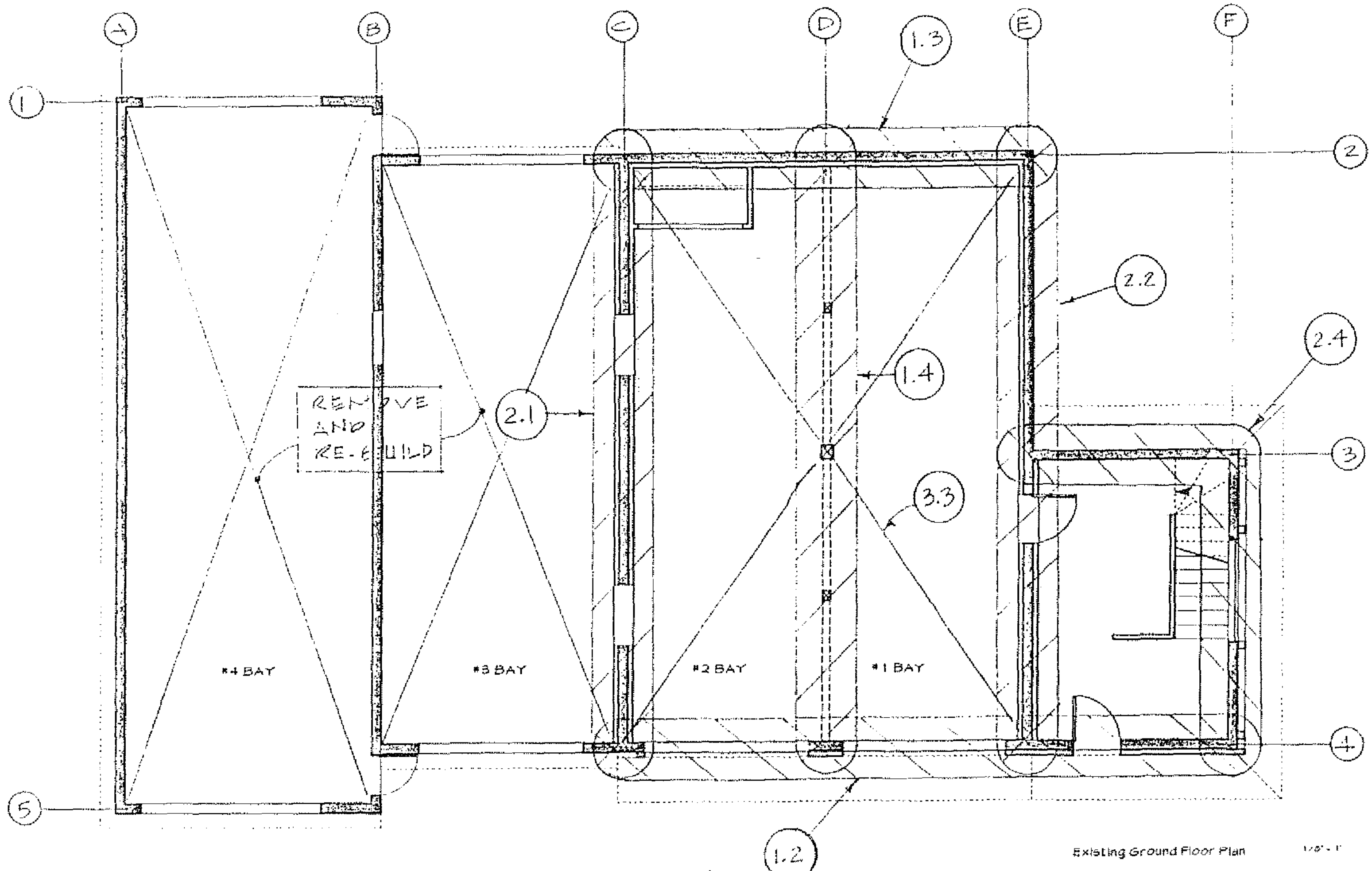


FIG 1. UPGRADE PLAN

Hornby
Island
Fire Hall

BLUE SKY DESIGN

RON McMURTRIE & ASSOCIATES
CONSULTING ENGINEERS

BY: RM MAY 2, 2001