STRUCTURAL ASSESSMENT

OF

THE HOLLOW TREE
STANLEY PARK

CLIENT
VANCOUVER PARKS & RECREATION

7 March 2008

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7 March 2008 **DNA 4502**

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Attn: **Jim Lowden**
Director of Special Projects
Email: jim.lowden@vancouver.ca

Subject: **Structural Assessment of the Hollow Tree**
Stanley Park Drive, Stanley Park

Further to our meeting on Feb 22, 2008, we are pleased to submit our final report attached concerning our structural assessment of the Hollow Tree.

The Hollow Tree is structural unstable and in poor condition and will likely collapse if left in its present state. We identified only one realistic option to stabilize and reinforce the Hollow Tree involving shoring the Hollow Tree with steel braces, restraining the base of the tree with concrete foundations and reinforcing the tree with steel straps and frames. However, this option will be visually disruptive and costly. The repairs will not stop the natural deterioration of the Hollow Tree nor eliminate the risks to the public. Moreover, the lifespan of the Hollow Tree is limited, given its advanced age and recent movements and damage. In consideration of these factors, we concur with you that the prudent and long-term approach in this situation would be to take down the Hollow Tree.

We trust our report addresses your concerns regarding the Hollow Tree. Please contact us should you have any questions or concerns.

Sincerely,
David Nairne + Associates Ltd

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA Jerry Y. M. Lum

Jerry Y.M. Lum, P.Eng.
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Senior Structural Engineer

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1.0 TERMS OF REFERENCE

The Hollow Tree is a historic Stanley Park landmark and a popular tourist attraction. The Hollow Tree consists of 100+ year old hollowed out cedar tree trunk located on the west edge Stanley Park Drive near Siwash Rock. Recent windstorms have damaged the Hollow Tree and have caused it to lean further to the east. Due to concerns about the safety of the Hollow Tree and the potential for the tree to fall over, Vancouver Parks & Recreation (VPR) retained DNA to carry out a structural assessment in order to identify options for stabilizing the Hollow Tree.

2.0 THE HOLLOW TREE

The Hollow Tree measures over 13.4 m tall and 6.7m at its widest point. The trunk leans approximately 11 degrees to the east with two tree trunks rooted to the base of the Hollow Tree, one at the east side of the trunk and the other at the west side of the trunk. All of these tree trunks have been topped several times for safety reasons down to the height of Hollow Tree. Previous attempts by the VPR to reinforce portions of the Hollow Tree have included installed steel rods and plates through the tree and wrapping the tree with steel cable.

3.0 TEMPORARY BRACING

VPR observed significant damage and movements to the Hollow due to windstorms in the fall of 2007. VPR started survey monitoring of the Hollow Tree on October 29, 2007 and found that the tree had leaned 40 mm further to the east by November 14, 2007. Due to concerns about the stability of the tree, VPR fenced off the immediate area around the Hollow Tree on November 28, 2007, removed the two small trees growing out of the northeast corner of the trunk and tied Hollow Tree back to the Hemlock growing out of the base of the trunk at the west side of the tree.

Photo 1: Hollow Tree temporarily tied back to hemlock trunk

Photo 2: Hemlock trunk rooted to base of the Hollow Tree

Photo 3: Steel washers and bolts no longer effective

At the request of VPR, DNA prepared details and specifications to temporarily brace the Hollow Tree from falling over until VPR could decide on what to do with the tree, see Appendix A. The temporary bracing scheme involved installing three pairs of steel braces to against the east half of the tree. The braces would be welded to steel plates bolted through the face of the tree to an internal steel frame and bolted down to precast concrete blocks. VPR own forces have recently completed the installation of the bolted steel plates and the internal steel frame.

4.0 STRUCTURAL ASSESSMENT

Our structural assessment of the Hollow Tree is based on structural analysis of the tree subjected to gravity and lateral loads, physical examination of the tree, review of site conditions, consultation with a wood consultants and discussions with parks staff. The structural assessment identified two major structural issues regarding the Hollow Tree concerning the stability and integrity of the tree.

Photo 4: Hollow Tree leaning 11° to the east

4.1 Structural Stability

The Hollow Tree is structurally unstable due to its present lean, its poor condition and the lack of competent root structure at the base of the trunk. The support of the Hollow Tree at the base of the trunk is tenuous with much of the trunk no longer in contact with the ground or severely decayed. The Hollow Tree is likely to sustain further damage and fall over if left in its present state.

4.2 Structural Integrity

The structural integrity of the Hollow Tree is poor due to its present configuration and extent of deterioration. The tree is hollow through its full height and resembles a "C" shape in cross section due to a wide gap (varying between 3000 mm at the base to 600 mm at the top) at the east face of the tree. There are several deep vertical splits running up the face of the tree. Several of the splits penetrate the full thickness of the face, which varies in thickness between 400 mm to 600 mm. The wide gap and vertical splits have significantly weakened the tree and give rise to the potential for the tree to collapse in on itself. In addition, the tree is deteriorating with wood decay occurring throughout the tree due to exposure to weather and moisture. The bark of the tree is soft and loose with portions of the bark readily removed by hand.

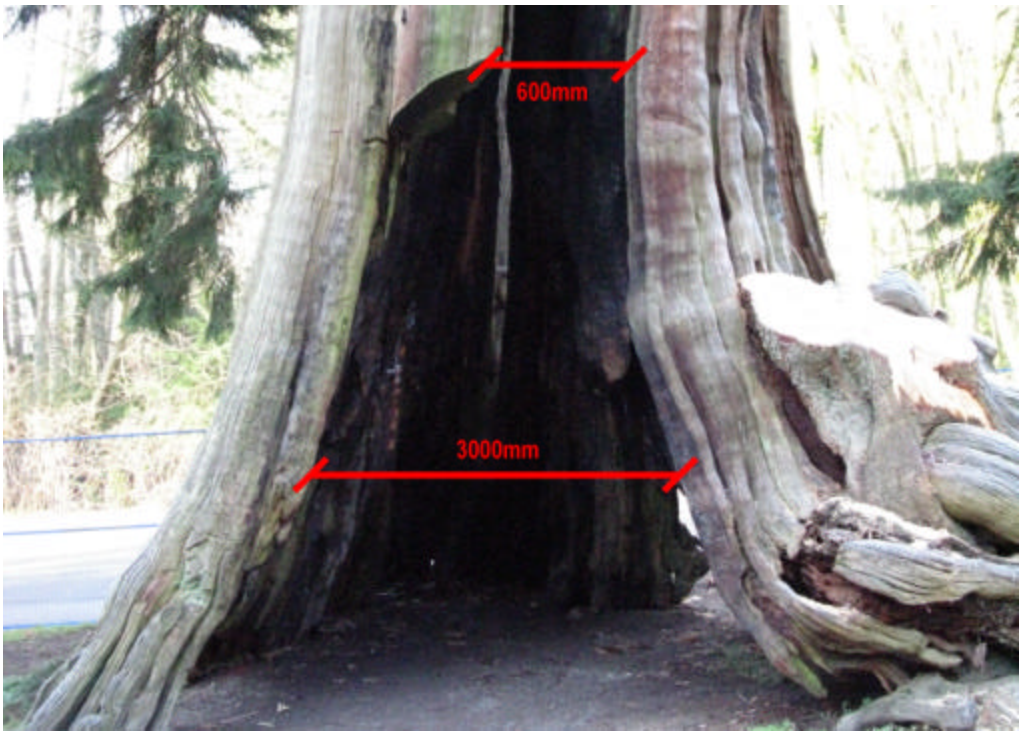

Photo 5: Wide gap at east face of Hollow Tree

Photo 6: Looking down centre of Hollow Tree at weaken "C" shaped cross section

Photo 7: Top of trunk showing decay of exposed end grain

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5.0 STRUCTURAL REPAIRS

5.1 Criteria

Any attempts to save the Hollow Tree in its current state will require both the stabilization and restoration of the tree in a cost effective manner that will maintain safe public access to the base of the tree and minimize the visual impact to the tree and immediate site.

5.2 Stabilization Options

DNA reviewed and discussed with VPB staff a range of options and approaches to saving the Hollow Tree. Three of these options are summarized below;

Option	Description
Option A Braces	Brace tree against direction of lean with six steel braces placed against the east face of trunk. Anchor each brace with concrete footings. Support weight of tree with concrete foundations and prevent bottom of tree from sliding with concrete slab. Our preliminary cost estimate for this option is in the order of $ 60,000 to $ 70,000.
Option B Tied Poles	Tie back tree with steel strut to three steel poles placed around west face of tree. Anchor each pole with concrete footings to prevent overturning. Support weight of tree with concrete foundations and prevent bottom of tree from sliding with concrete slab.
Option C Centre Pole	Remove, modify and re-erect tree in plumb position over top of steel pole running up centre of tree. Anchor steel pole to concrete foundation to prevent overturning.

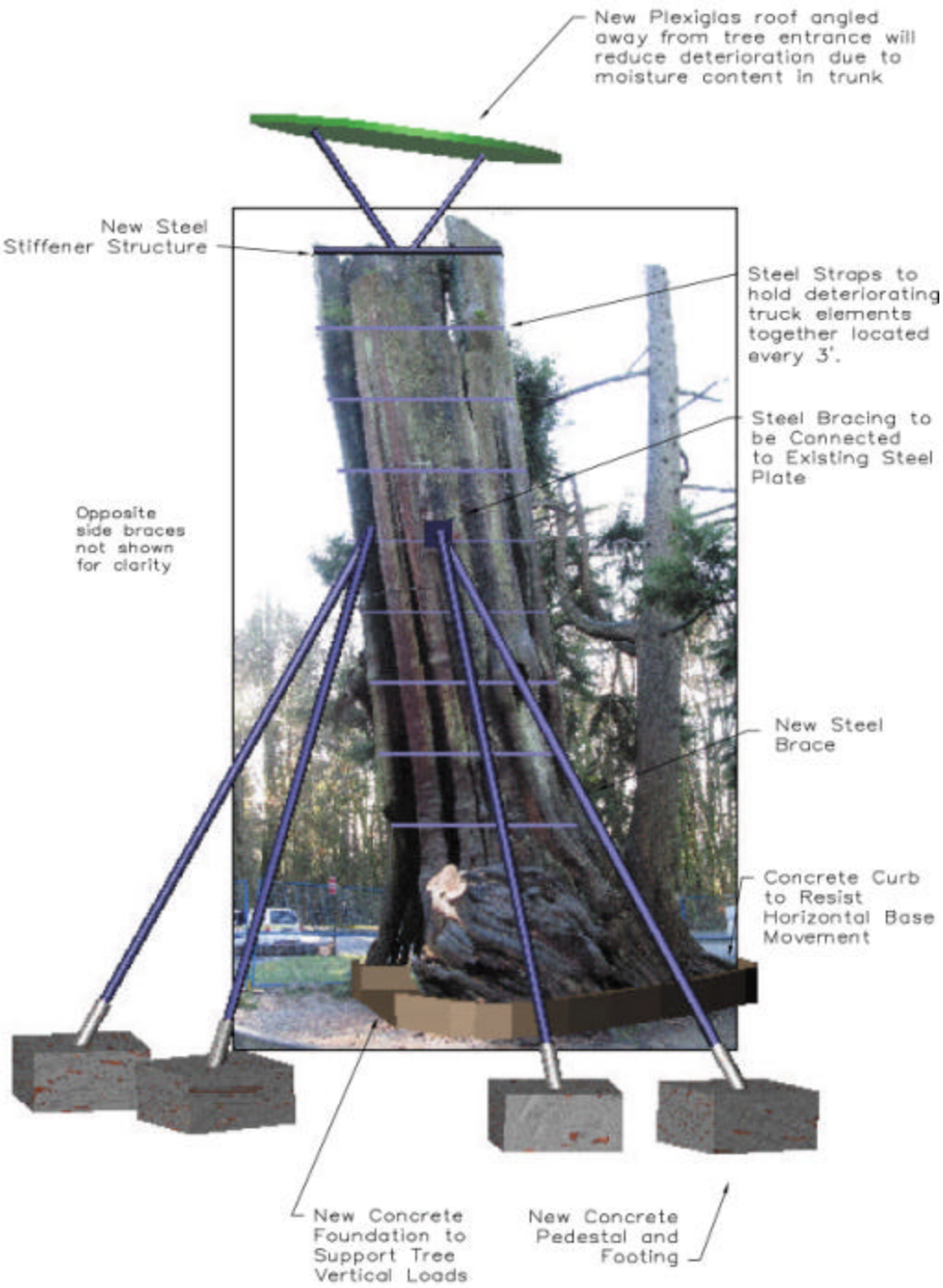

Photo 8: Concept illustration of Option A Braces

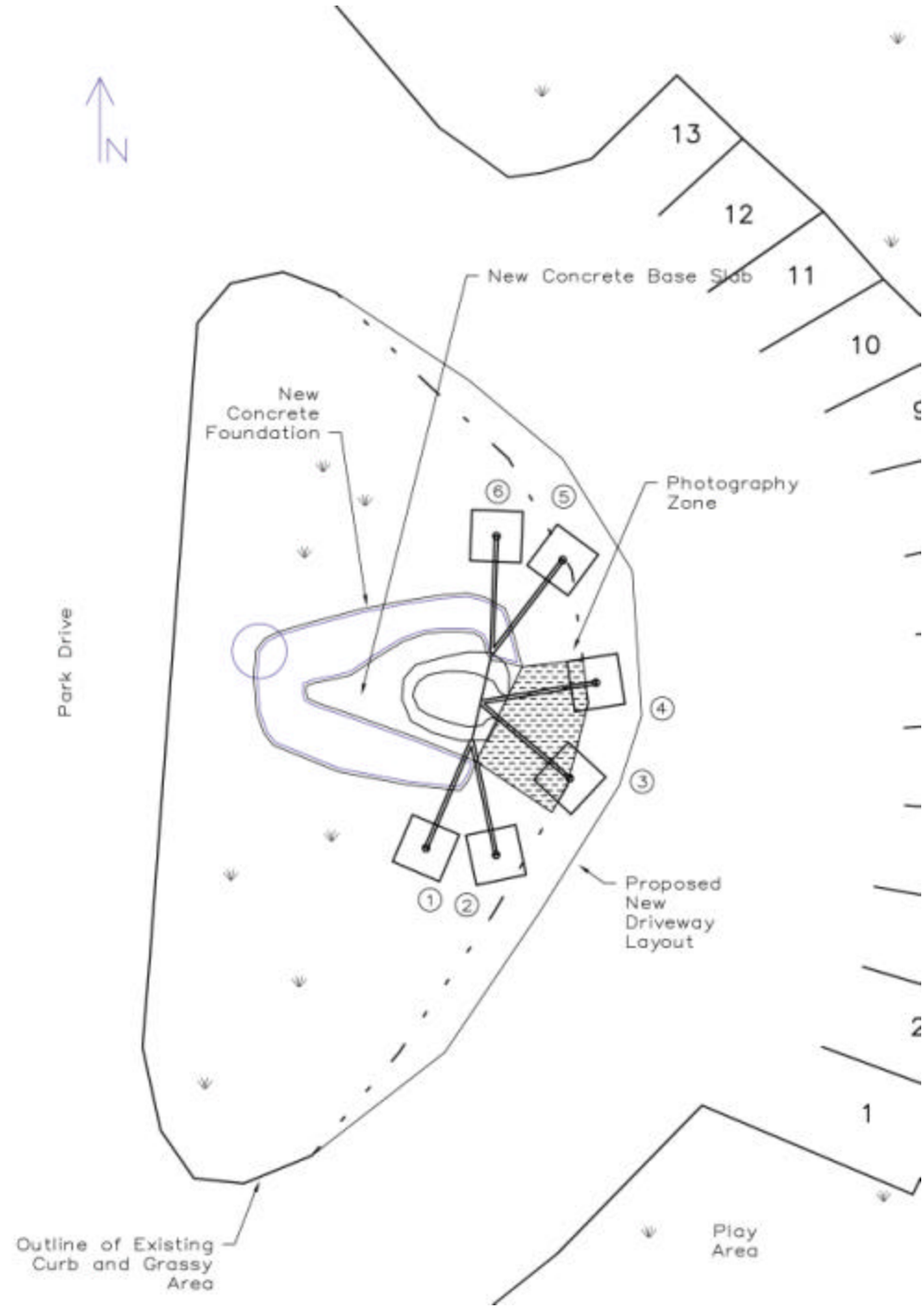

Photo 9: Site Plan of Option A Braces

5.3 Reinforcing the Hollow Tree

Due to the poor condition of the tree, extensive measures will be required to restore the structural integrity of the Hollow Tree and to prevent portions of the tree from falling off. A mechanical approach to reinforcing the tree would involve installing a grid of closely spaced steel straps and plates bolted or screwed to both the exterior and interior faces of the tree in an attempt to hold the tree together. Internal steel frames will also have to be installed to prevent the tree from collapsing in on itself. There is a risk that this reinforcing work may be in fact, increase the rate of deterioration to the tree by introducing new holes for moisture to infiltrate and by causing further splitting. We note that there may be other non-mechanical methods and techniques to reinforce the tree using specialty coatings. Such restoration methods are beyond the scope of our work and expertise.

6.0 FINDINGS & RECOMMENDATIONS

6.1 The Hollow Tree is structurally unstable and in poor condition. If left in its present state, the Hollow Tree will likely sustain further damage or will collapse. The Hollow Tree must either be stabilized and reinforced to prevent further damage and collapse or be taken down.

6.2 DNA has prepared a temporary bracing scheme to stabilize the Hollow Tree until long term plans are made. Work on installing the temporary bracing has been started but has not been yet completed.

6.3 All of the three structural repair options considered are costly and will severely impact of the aesthetics of the Hollow Tree and its immediate surroundings. We believe that only Option A to be structurally feasible and cost effective (preliminary cost estimate between $ 60,000 to $ 70,000. It is important to note that Option A will not prevent the natural deterioration of the tree nor eliminate all of the risks to the public inherit with a dead tree. Furthermore, the Hollow Tree has a limited lifespan given its age, poor condition, recent damage and movements.

6.4 Although the Hollow Tree can be structurally braced and reinforcing as proposed in Option A, we do not believe that this represents a safe and cost effective long term solution. We therefore recommend that no further structural repairs be carried out to the Hollow Tree and that the Hollow Tree be taken down.

APPENDIX A

INTERIM REPORT

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11 December 2007 **DNA 4502**

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Attn: Eric Meagher
Supervisor Stanley Park Maintenance
email: eric.meahter@vancouver.ca

Subject: Interim Report
Structural Assessment & Temporary Bracing
Hollow Tree, Stanley Park

This interim report summarizes our findings to date regarding our structural assessment of the Hollow Tree and details for its temporary bracing.

1.0 TERMS OF REFERENCE

DNA was retained by Vancouver Parks & Recreation (VPR) to assess the structural condition of the Hollow Tree and prepare a report identifying options to stabilize the trunk to prevent it from falling over.

2.0 BACKGROUND

DNA first visited the site on November 5, 2007 to view the Hollow Tree and to meet with VPR staff to discuss their concerns. VPR staff reported visible movements and damage to the Hollow Tree due to recent storm activity. The trunk of the Hollow Tree at the time was found leaning approximately 11 degrees to the east with two trees growing out of the base of the trunk on the east and one tree growing out of the base of trunk on the west. Due to concerns about the stability of the Hollow Tree, VPR started survey monitoring of movements to the top of the trunk on October 29, 2007.

On November 14, 2007, VPR survey monitoring measured additional movements in the Hollow Tree with two separate points near the top of the trunk leaning further to the east approximately 40 mm and 20 mm respectively. Due to growing concerns about the safety of the Hollow Tree, VPR closed the adjacent parking lot and fenced off the immediate area around the Hollow Tree on November 28, 2007. In addition, VPR removed the two small trees growing out of the northeast corner of the trunk and tied the Hollow Tree back to the Hemlock growing out of the base of the trunk at the west side of the tree.

On December 6, 2007 DNA revisited the site at VPR's request to assess the stability of the Hollow Tree and propose measures to temporarily brace the tree from falling over.

3.0 STRUCTURAL ASSESSMENT

3.1 Structural Stability

\The mass of the Hollow Tree is substantial with an estimated weight of 52,000 lbs and overall height of 44 feet. The lean of approximately 11 degrees in the trunk of the Hollow Tree is significant given the age, condition and lack of firm support at the base of the trunk. Based on our observations, we conclude that the Hollow Tree is now structurally unstable and must be braced to prevent further damage to the trunk and to prevent the trunk from falling over. Based on the direction of lean of the trunk and measurements of recent movements to the top of the trunk, the fall axis of the Hollow Tree is likely to be to the northeast.

3.2 Structural Integrity

The Hollow Tree is completely hollow structurally weak along the east face of the trunk due to a wide gap running the full height of the trunk. The gap varies from 3000 mm wide between the base to 3 m up the trunk and is 600 mm wide the rest of the trunk. As a result of the gap, the cross section of the trunk resembles either a "V", "U" or "C" shape as opposed to a "O" shape. There are several deep splits running part way up the trunk. Due to the large size and long length of these vertical splits, the trunk can be described as a collection of partially attached vertical planks as opposed to a solid circular trunk. Based on our observations, we judge the structural integrity and physical condition of the Hollow Tree to be poor.

Portions of the trunk have been wrapped with steel cables in an attempt to prevent portions of the trunk from buckling outwards. Several steel rods driven through the tree at mid height and near the top of the trunk some years ago are no longer effective as the steel washer plates are no longer in contact with the trunk.

Specific techniques and measures are required to restore the structural integrity of the Hollow Tree are beyond the scope of DNA's terms of reference.

4.0 TEMPORARY BRACING

4.1 Objectives of Temporary Bracing

The objective of the bracing is to temporarily stabilize the trunk of the Hollow Tree to prevent the trunk from falling over. The temporary bracing is to remain in place until VPR decides to either restore and permanently brace the Hollow Tree or to cut down the Hollow Tree. The temporary bracing will not restore the structural integrity of the trunk or address the poor condition of the trunk.

4.2 Description of Temporary Bracing

The temporary bracing design incorporates readily available components, steel braces and precast concrete blocks were utilized in our bracing design where possible in combination with site fitted and welded steel members where necessary. The temporary bracing scheme involves placing three pairs of steel braces around the east, north and south faces of the trunk approximately 6.4 m from the ground (see drawings in Appendix A). Each brace will be welded to a pair of steel plates bolted through the trunk. The trunk at the bracing point will be reinforced by introducing a triangular shaped internal steel frame welded to the backside of these steel plates. The steel braces will be bolted precast concrete blocks placed on the ground around the base of the trunk. Some new steel cables will be wrapped and anchored to the trunk to help prevent some of the large split portions of the trunk from falling off.

We understand that most of this work to install the temporary bracing will be carried out by VRP own forces.

5.0 PERMANENT BRACING

DNA is currently developing options to permanently stabilize the Hollow Tree and will be submitting a final report accordingly.

6.0 FINDINGS & RECOMMENDATIONS

6.1 The Hollow Tree is structurally unstable and must be temporarily braced as soon as possible to prevent the trunk from falling over.

6.2 The temporary bracing will not restore the structural integrity of the trunk or address its poor condition and portions of the trunk may fall off without warning.

6.3 The Hollow Tree should remain temporarily braced and fenced off until a decision is reached regarding whether to save and permanently brace the Hollow Tree or to cut down the Hollow Tree.

6.4 DNA has prepared a temporary bracing scheme found in Appendix A of this report.

6.5 The structural integrity and physical condition of the Hollow Tree is poor. We recommend that a tree restoration specialist be consulted to address the structural integrity of the trunk accordingly.

Please contact us should you have any questions or concerns.

Sincerely,
David Nairne + **Associates Ltd**

Jerry Y.M. Lum, P.Eng.
Head Structural Engineering
Associate

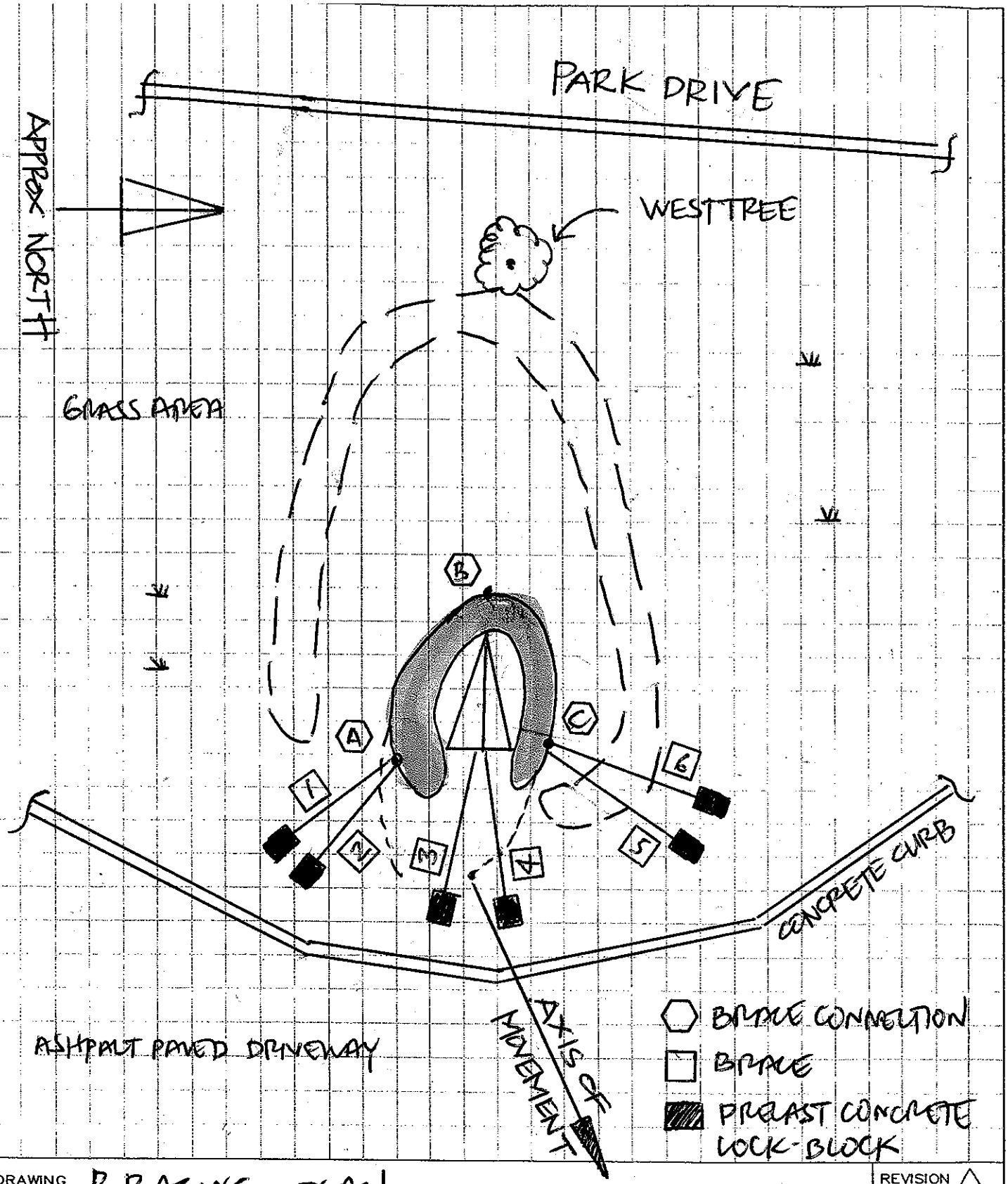
APPENDIX A

TEMPORARY BRACING DRAWINGS

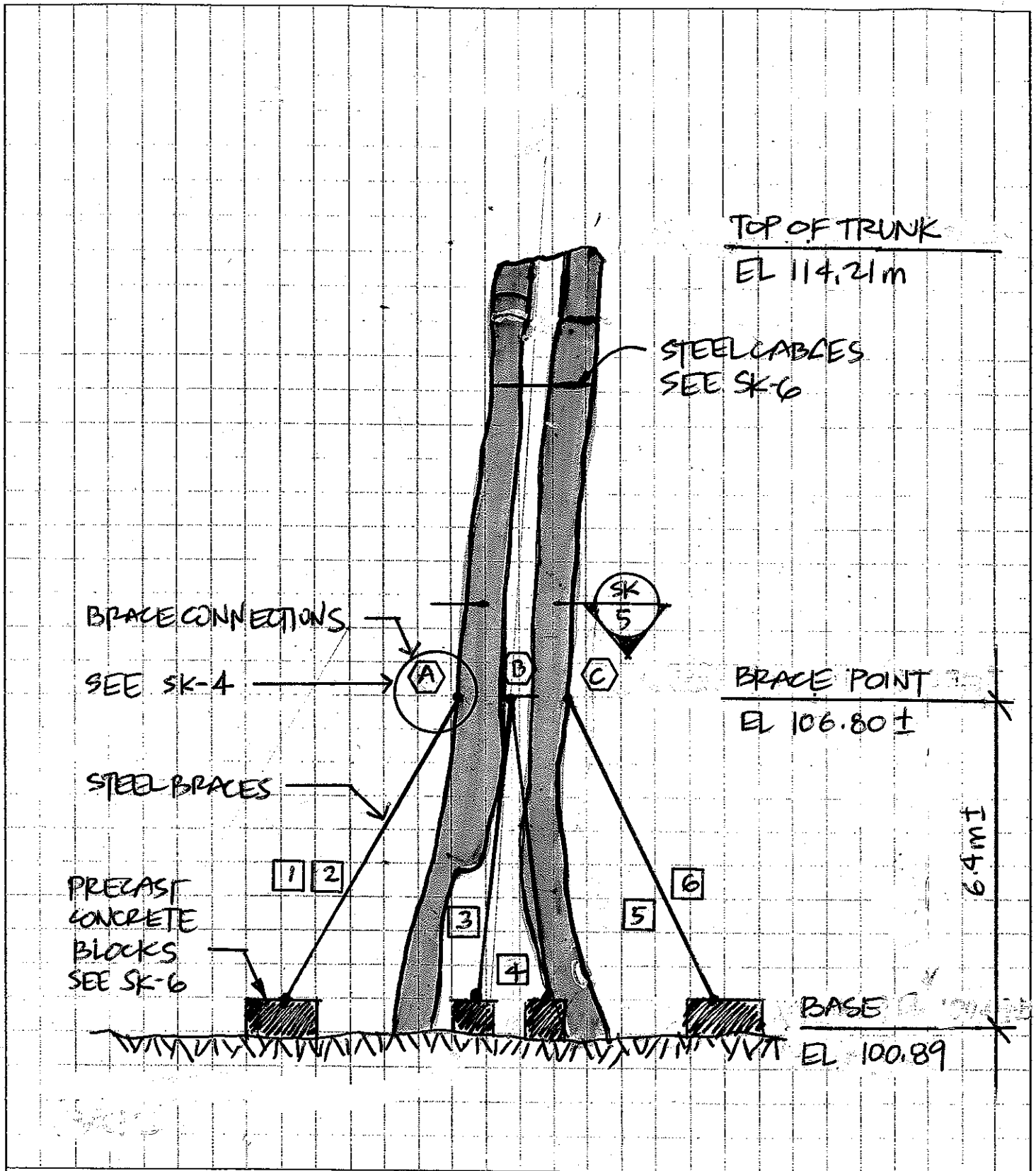
SK-1
SK2
SK3
SK4
SK5
SK6

APPENDIX B

TEMPORARY BRACING



DRAWING BRACING PLAN			REVISION NUMBER
PROJECT TEMPORARY BRACING		ACAD FILE No.	
ADDRESS HOLLOW TREE, STANLEY PARK		REF DRAWING	JOB NUMBER 4502
DNA David Nairne+Associates Ltd 250–171 W Esplanade North Vancouver BC V7M 3J9 T (604) 984–3503 F (604) 984–0627	DATE DEC 11/07 DESIGNED LUM DRAWN LUM	CHECKED BF REVISED SCALE NTS	DWG NUMBER 43SK-2



DRAWING EAST FACE OF TRUNK			REVISION NUMBER
PROJECT TEMPORARY BRACING		ACAD FILE No.	
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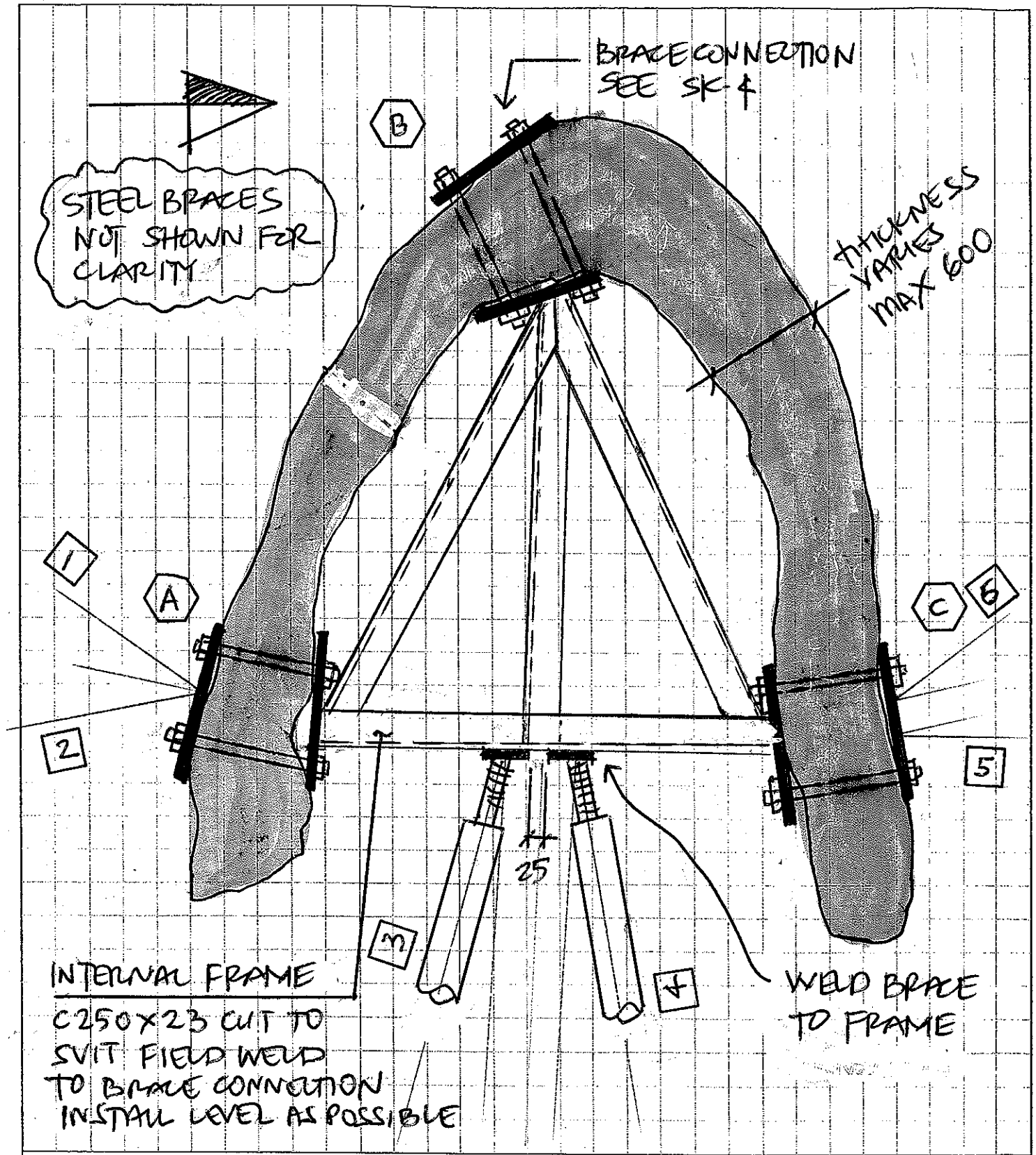
DNA David Nairne+Associates Ltd 250–171 W Esplanade North Vancouver BC V7M 3J9 T (604) 984–3503 F (604) 984–0627	DATE DEC 11/07 DESIGNED LM DRAWN LM	CHECKED BF REVISED SCALE NTS	DWG NUMBER 4502-SK-3



DRAWING INTERNAL BRACE		REVISION NUMBER
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DATE DEC 11/07	CHECKED BF	DWG NUMBER	
DESIGNED MM	REVISED	45 SK5	
DRAWN MM	SCALE NTS		