DRES

SUFFIELD MEMORANDUM

NO. 1037

PRELIMINARY EJECTA STUDY -
RELIEVED FACE CRATERING (U)

by

G.K. Briosi and R.W. Hemrich

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ABSTRACT

The Canadian Forces employ "Relieved Face" craters as barriers to vehicle movement. When producing these craters a safety distance of 275 m is generally used. Because of reported incidents which indicated that this distance might be inadequate DRES was asked to investigate the subject.

In limited tests conducted in partially frozen and unfrozen, hard and soft clays, the maximum ejecta travel observed was less than 180 m, thus indicating that a 275 m safety distance was adequate under these conditions.

It is, however, recommended that further data be obtained, preferably by recording ejecta travel during military training exercises. In the meantime, until sufficient data is available, it is recommended that the safety distance be increased by one increment in the safety distance tables to 450 m.

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1. INTRODUCTION

The Canadian Forces employ "Relieved Face" craters as barriers to vehicle movement. The craters are designed to form a continuous obstacle extending across the full width of the target and beyond either edge. The number of charges on the enemy side is generally one less than on the home side and the typical orientation is indicated in Figure 1. The 15 kg charges (enemy side) are located 1.2 m below the surface, while the 20 kg charges (home side) are located 1.5 m below the surface. The shallow charges are detonated first and lift the soil surrounding them. The deeper charges, which are fired after a delay of approximately 1.5 seconds, provide a horizontal impulse to the loosened material to create the type of crater shown in Figure 2.

In general, a danger area radius for cratering, based on the size of the charge, can be found in Reference 1. A specific distance for "Relieved Face" cratering operations, which employ multiple charges, is not indicated in the tables, but a safety distance of 275 m has been customarily employed. Reference 2, however, reported some experience with "Relieved Face" cratering operations in which lumps of ejecta exceeding 15 kg were thrown up to 325 m from Ground Zero, while smaller lumps were found at up to 400 m. Accordingly, DRES was asked to investigate this subject and make recommendations concerning safety distance (3).

2. DRES EXPERIMENTAL APPROACH

Specific information was not available concerning the location of the tests referred to in Reference 2 nor of the type of soil involved. However, previous work in explosive cratering at DRES suggested that, of the variety of soil types and conditions available on the DRES range, a high strength cohesive clay would likely produce the largest lumps of ejecta, and that the most hazardous condition with regard to ejecta might be associated with a seasonally frozen top layer condition. In keeping with this projection, two sites were chosen for these tests. Site 1 was an area of wet, low strength plastic clay while Site 2 contained a high strength clay of relatively low moisture content.

One "Relieved Face" explosive system was employed at each site

(a) with the ground unfrozen, and

(b) with the ground frozen to a depth of about 1 m.

Thus, a total of four tests were conducted.

For each "Relieved Face" cratering test, five 2.5 inch diameter holes were produced with a power auger in the configuration specified in Reference 1 and illustrated in Figure 1. Moulded C4 charges, designed according to the recommendations in Reference 4, were used to spring the boreholes and ensure adequate volumes to accommodate the specified cratering charges. The cratering charges were then loaded and tamped and the holes stemmed with soil. The delay between the initiation of the two rows of charges was provided by commercial 1.5 second delay detonators.

3. RESULTS

Cross-sectional sketches of the craters produced in these experiments are given in Figures 3 to 6. Figures 7 and 8 show aerial photographs of the two craters produced in the partially frozen soils.

No significant differences in ejecta patterns were observed between the tests conducted in frozen and unfrozen soils nor between the tests conducted on Sites 1 and 2. In all tests, the ejecta were confined to within approximately 180 m of Ground Zero while the major quantity of ejecta was found within 45 m.

4. DISCUSSION

Although the DRES tests were done in conditions considered likely to give maximum ejecta travel, the maximum travel achieved (< 180 m) differed greatly from the 325 m reported by Reference 2.

The reasons for this difference are not clear. However, there are a number of possible causes.

It is possible that the amount of explosive or the burial depths of the charges may have been different in the CF trials discussed in Reference 2. This suggestion is not meant to imply any criticism but merely to recognise the fact that the use of explosives under field conditions does not always facilitate precise measurements.

The type and condition of the soil could also influence the nature of ejecta and the ejecta travel distance.

Another possible difference arises from the fact that, in CF field operations, the 1.5 second delay between the two sets of charges is apparently accomplished manually, i.e., the operator waits until the first set is functioned, then manually triggers the second. Thus, the chances of substantial variation are significant. The effect of variations in the delay on ejecta travel is unknown.

Other factors which could influence ejecta travel distance include the distances between shot holes, the depth, type and density of the explosive charges, and the presence of any unusual discontinuities (e.g., air pockets, rock fragments) in the soil.

5. RECOMMENDATIONS

Safety Distance

The DRES tests suggest that the conventional safety distance of 275 m is adequate for the "Relieved Face" cratering system. Nevertheless, as a temporary safety precaution, it is recommended that the safety distance be increased by one increment to 450 m until it can be established statistically under a variety of soil conditions that 275 m is adequate.

Further Experiments

If further research is to be conducted, the experimental variables should include soil type, charge depth and separation, and delay times. A very large number of tests would be needed to compensate for the inherent lack of reproducibility in field experiments conducted in soils.

Such a major program might be difficult to justify. However, much useful data could be acquired if a record of ejecta travel were gathered during training exercises. Such a record of the results of regular field usage might well provide more realistic information than controlled experiments conducted at DRES. Because of this, and because of the relative simplicity of such an approach, it is urged that an effort be made to establish an appropriate system for recording this information.

REFERENCES

1. CFP 320(2) Interim Engineer Field Manuals, Volume 2. Engineer and Infantry Assault Pioneer Pocketbook. February 1977. RESTRICTED.

2. FMC 11375-1 (SA COMD) dated 13 July 1977.

3. 11375-1 (DTAL-2) dated 19 September 1977.

4. Briosi, G.K. and Nolting, G.C. "Preliminary Report on Borehole Springing (U)". Suffield Memorandum No. 33/76. November 1976. UNCLASSIFIED.

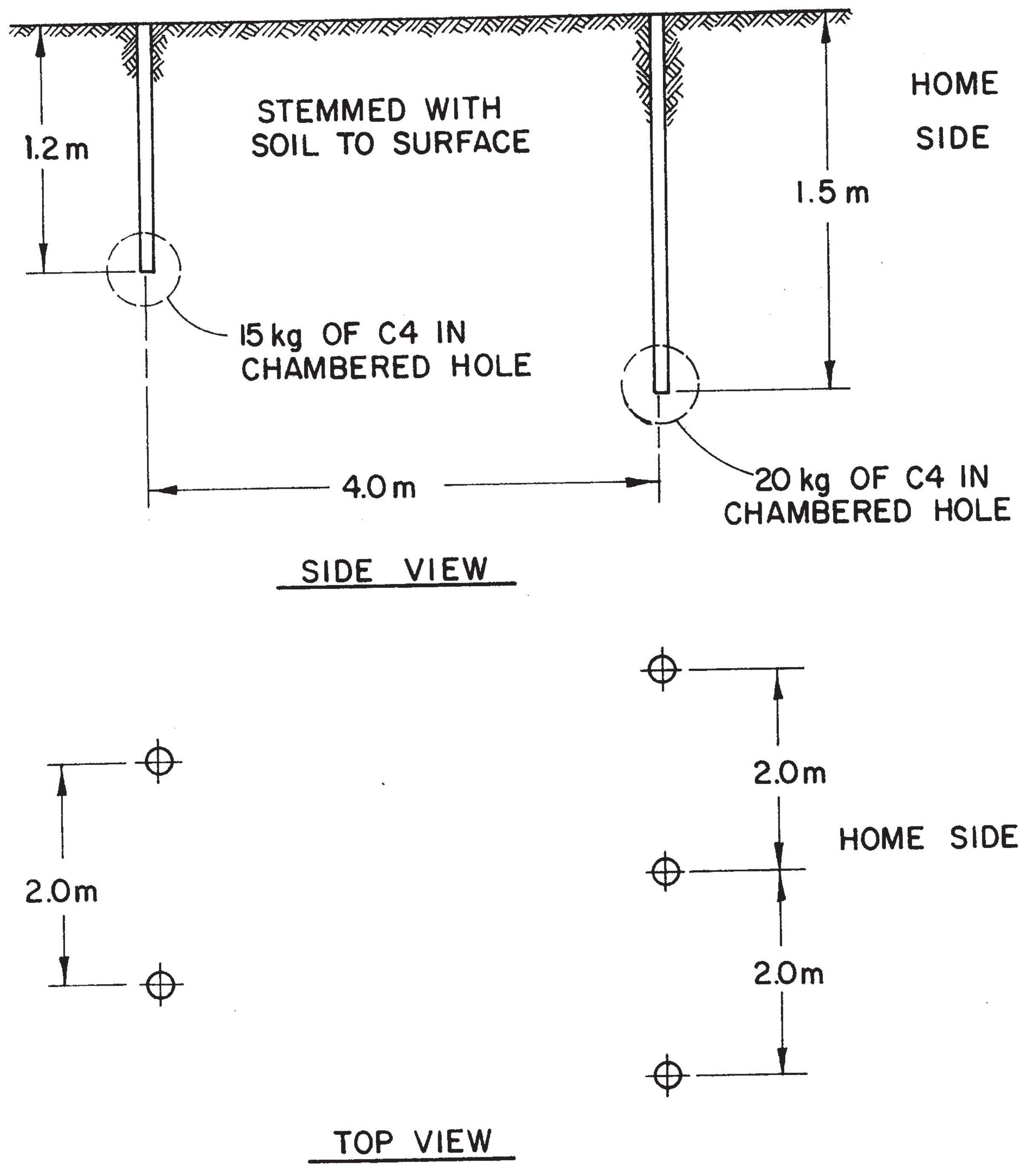

FIGURE 1: CHARGE ORIENTATION FOR A RELIEVED FACE CRATER

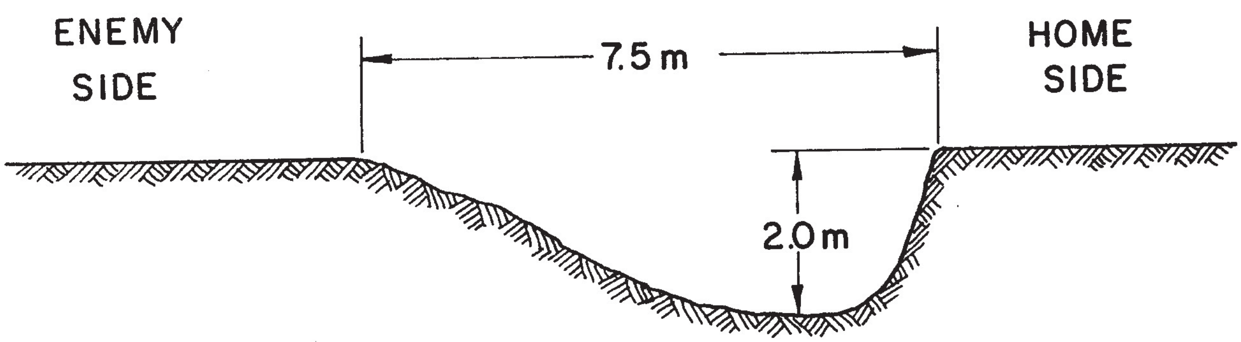

FIGURE 2: TYPICAL RELIEVED FACE CRATER

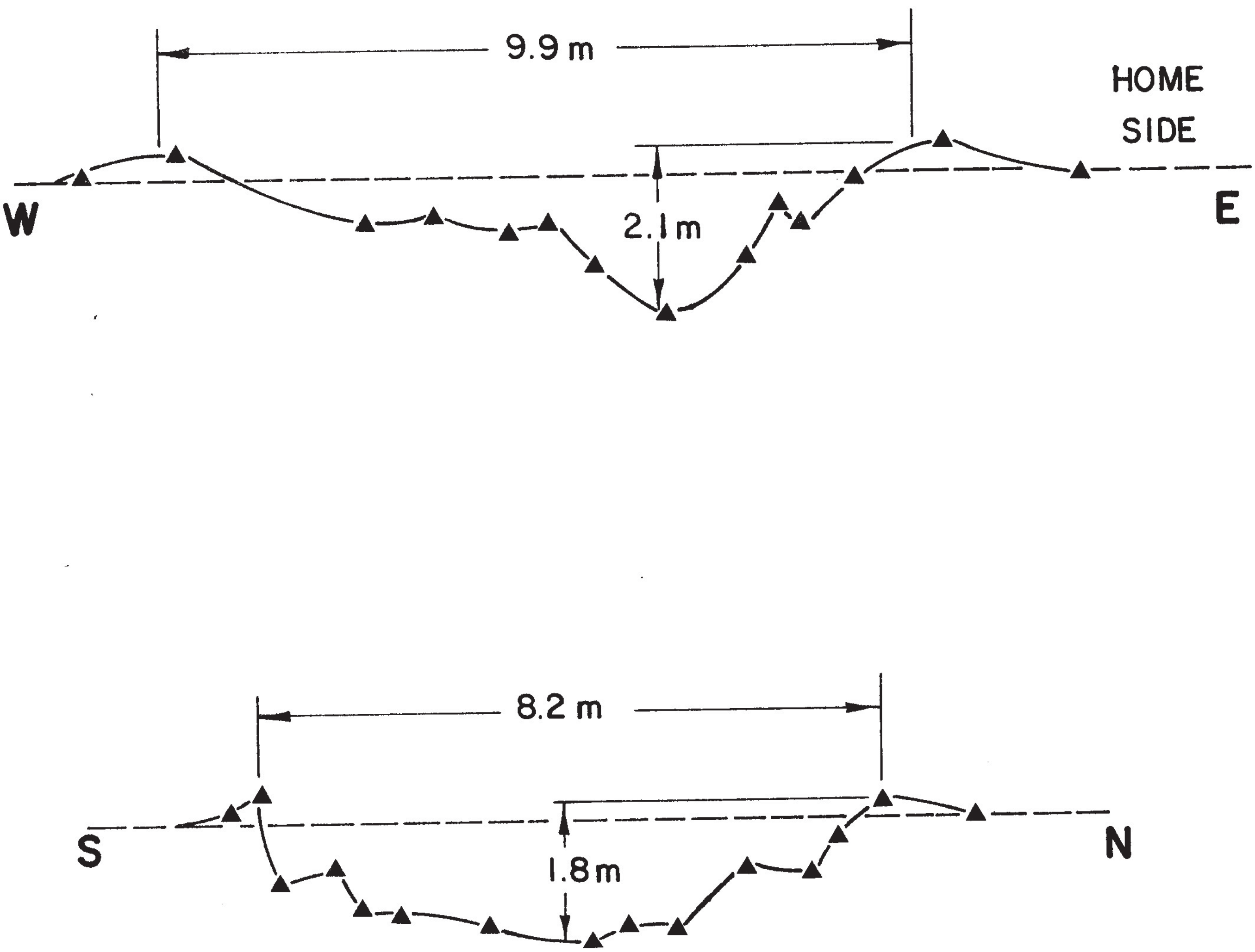

FIGURE 3: PERPENDICULAR CROSS SECTIONS AT SITE I (unfrozen)

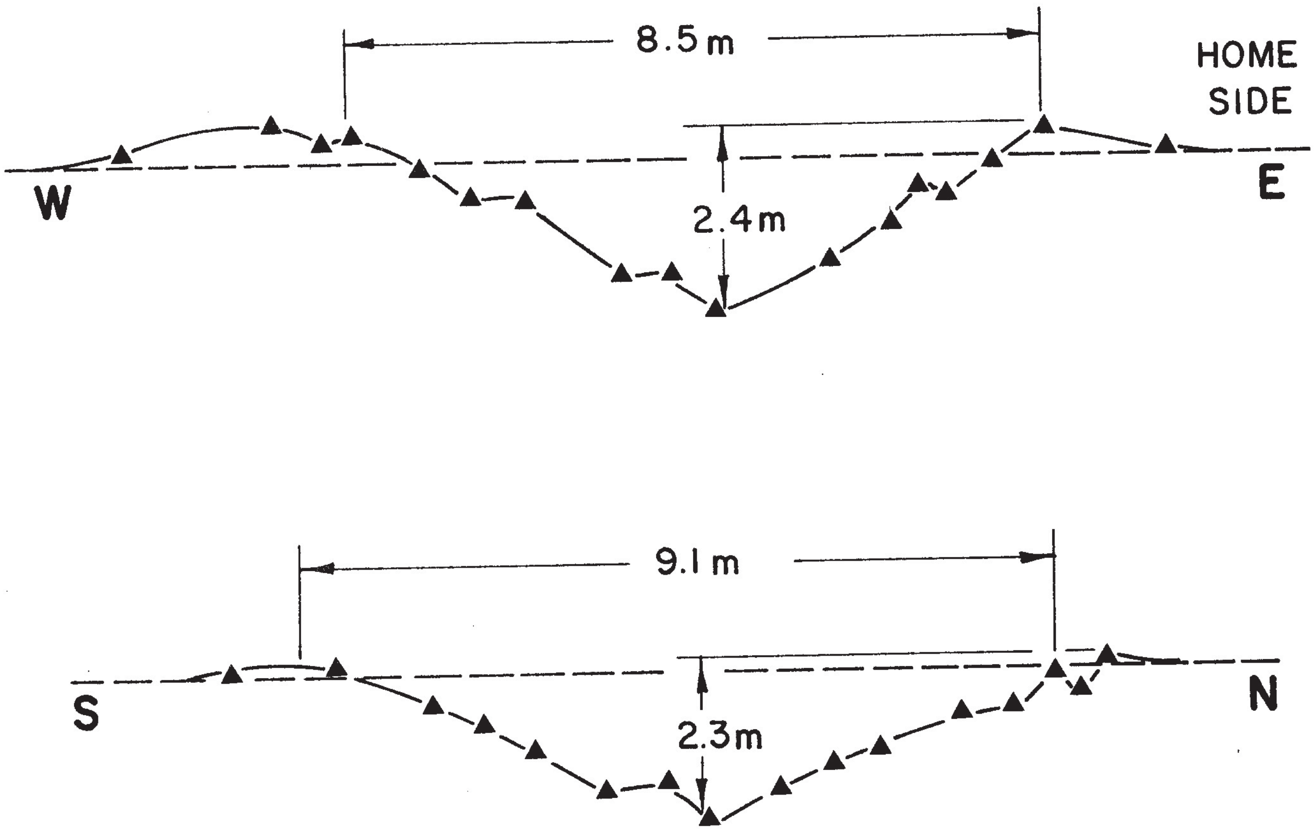

FIGURE 4: PERPENDICULAR CROSS SECTIONS AT SITE 2 (unfrozen)

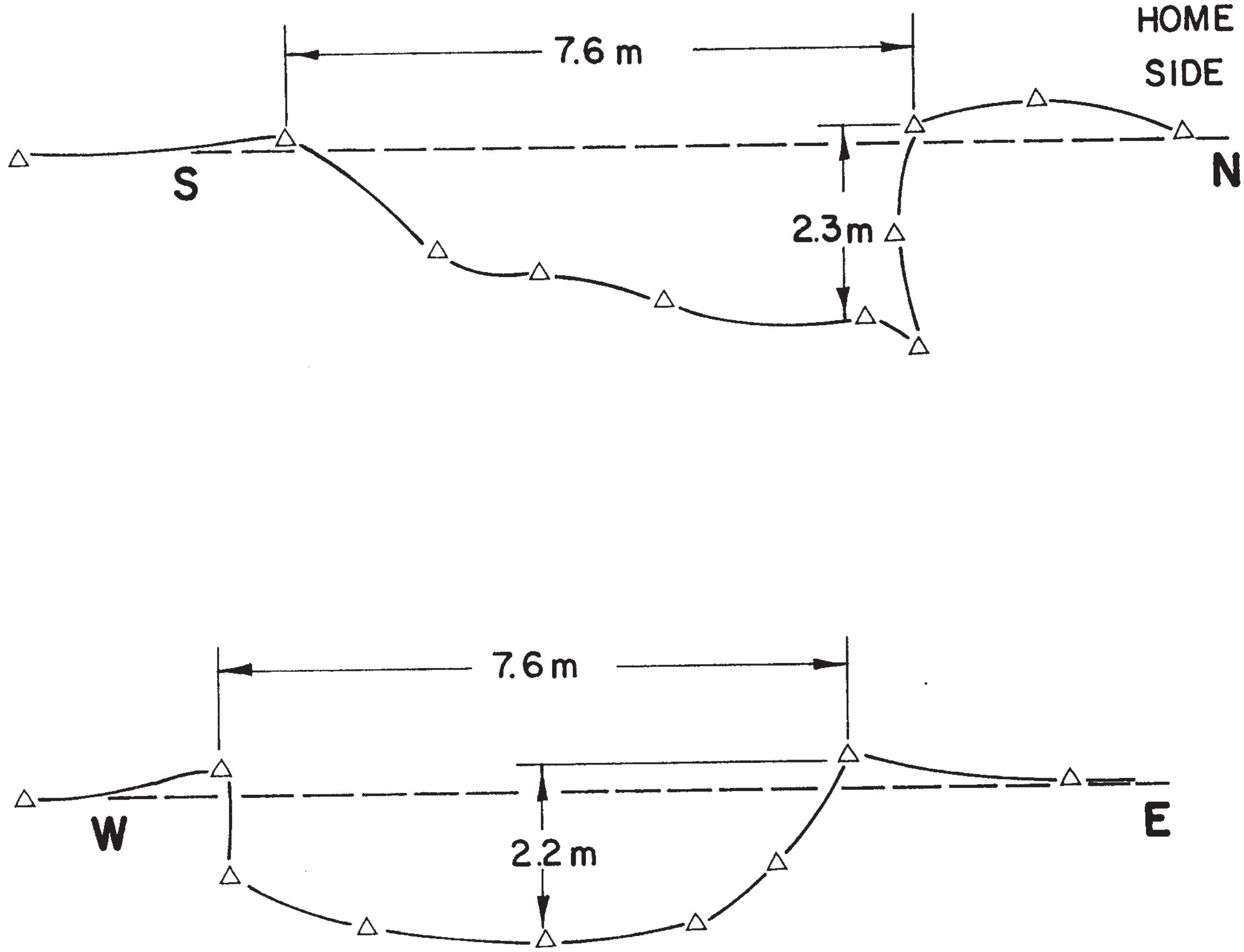

FIGURE 5: PERPENDICULAR CROSS SECTIONS AT SITE 1 (frozen layer)

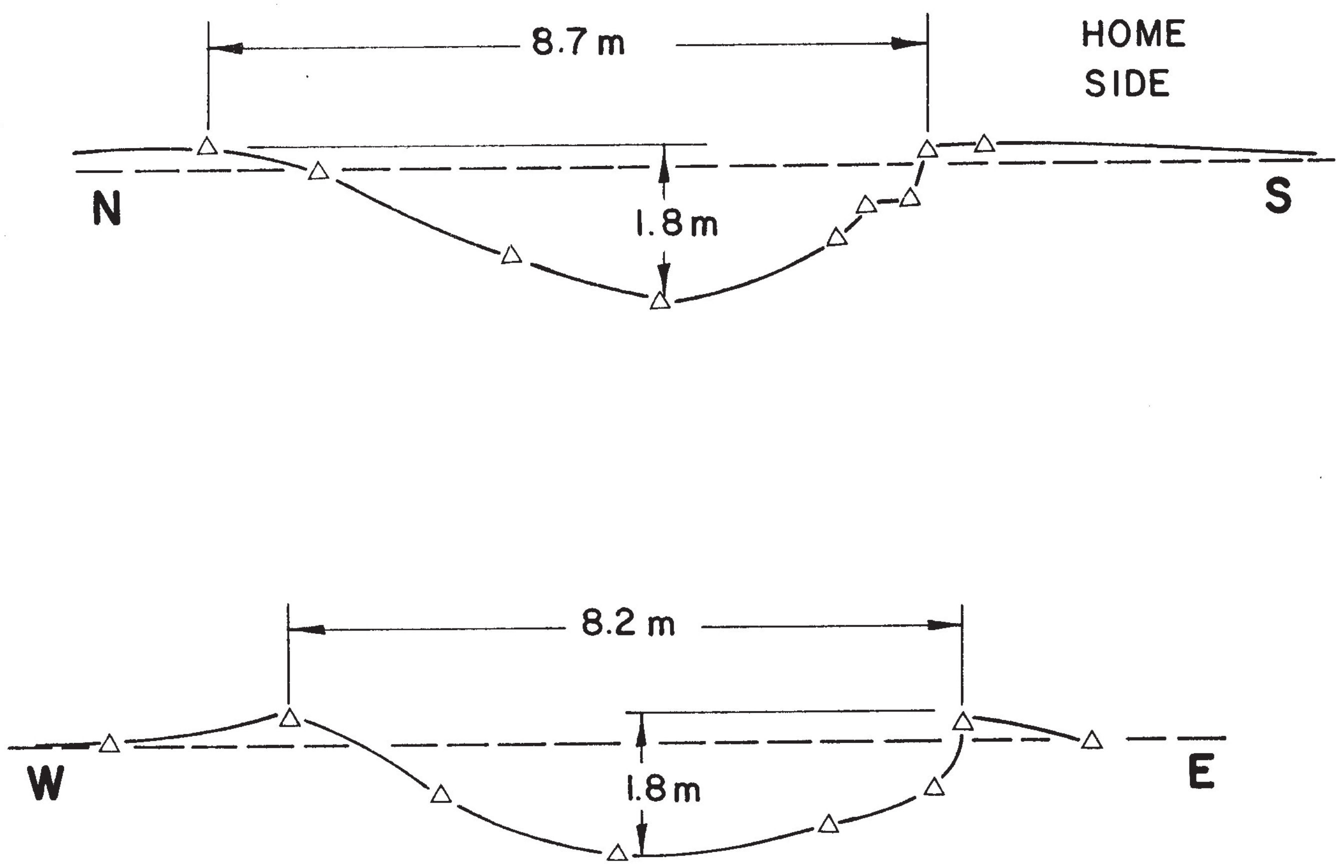

FIGURE 6: PERPENDICULAR CROSS SECTION AT SITE 2 (frozen layer)

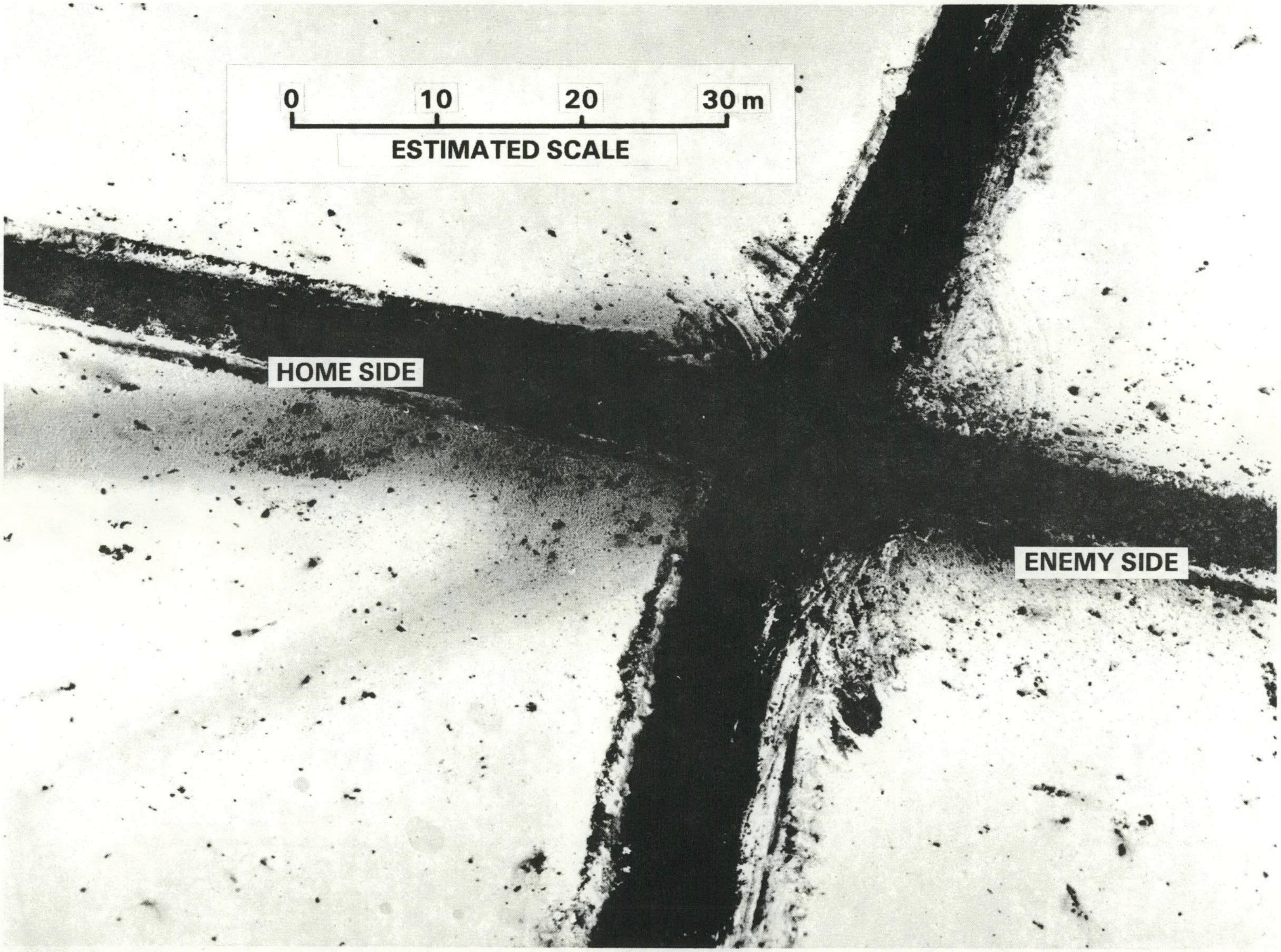

Figure 7. Aerial View of Crater on Site 1 (Frozen Layer)

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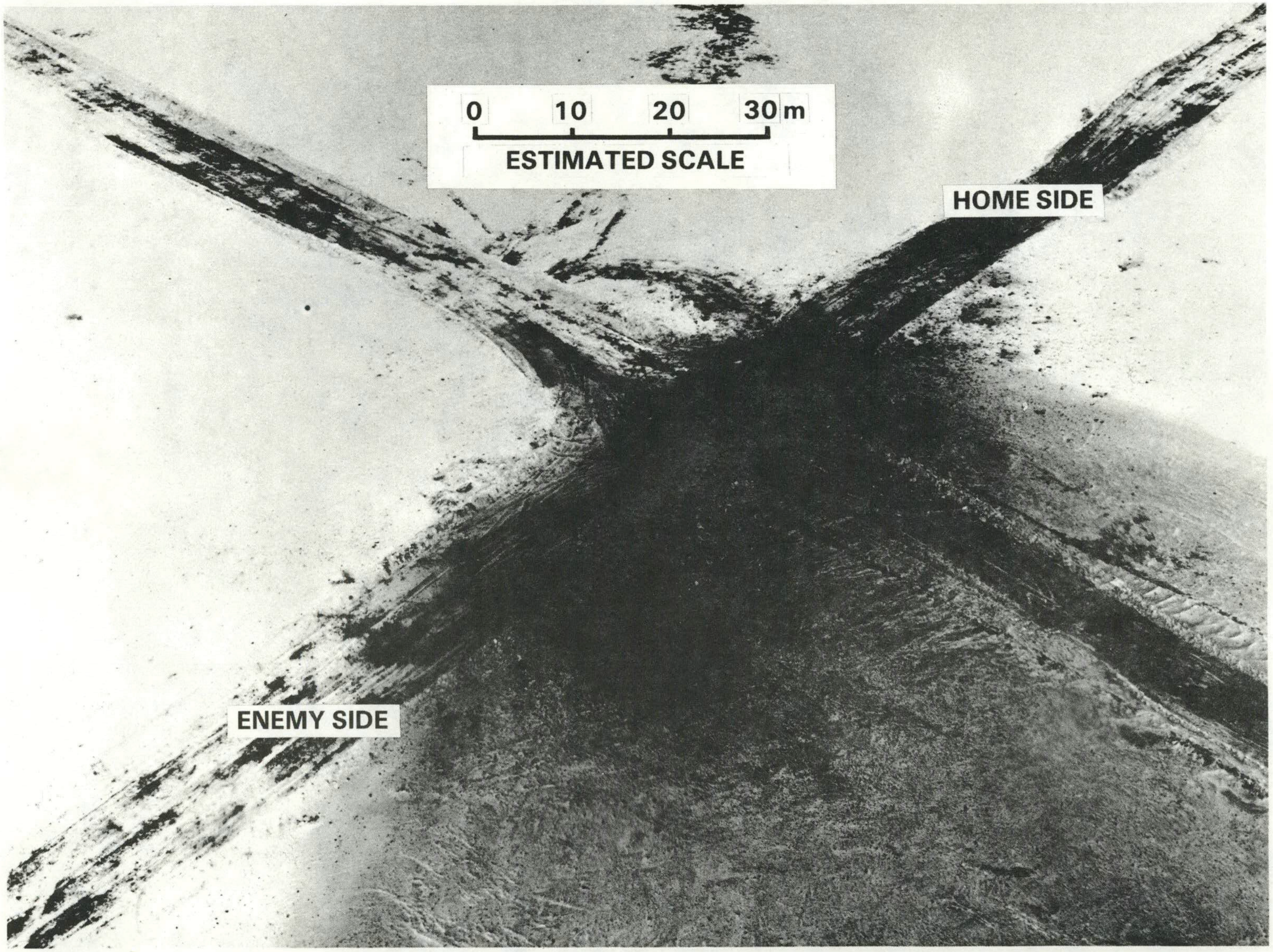

Figure 8. Aerial View of Crater on Site 2 (Frozen Layer)

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Relieved Face Crater
Safety Distance
Danger Area Radius
Directional Blasting
Military Engineering
Cratering
Ditching
Explosives
Explosive Excavation

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