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ENY	1201
CNY	
Parish	1012/1013
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NYS 7565

**GROUND-PENETRATING RADAR  
SURVEY OF CATTERICK BRIDGE  
BROMPTON-ON-SWALE, N. YORKS**

A PROGRAMME OF RESEARCH CARRIED OUT  
ON BEHALF OF

**NORTH YORKSHIRE COUNTY COUNCIL**

By

**GeoQuest Associates**

## INTRODUCTION

This report presents the results of a geophysical survey, using ground penetrating radar, of Catterick Bridge in the village of Brompton on Swale, North Yorkshire (Figure 1). The investigation was carried out on behalf of North Yorkshire County Council (Department of Highways and Transportation) with the aim of locating any defects within the bridge which might affect its carrying capacity.

## NATURE OF THE BRIDGE STRUCTURE

The project called for the internal investigation of the bridge span using radar reflection survey operating from the roadway. Little detail is known of the internal structure of this historic bridge although the following general comments can be made:

- 1 The bridge (an historic Listed Building) spans the River Swale as three round arches on three piers and is cased in dressed stone. The bridge was constructed originally, on the west upstream side, in 1422 and then rebuilt in 1565-1590. It has subsequently been widened on the eastern side.
- 2 A chapel is recorded as once having once stood on the bridge.
- 3 Trial pits excavated as part of a structural and archaeological investigation (Figure 1) provided evidence for an older roadway than that used at present. At the points where the pits were excavated the bridge was found to be filled with soil.
- 4 Lighting ducts made of tubular steel have been inserted beneath the roadway between the lamp posts shown in Figure 1.
- 5 Service trenches have been cut for communication cables along the line shown in Figure 1 and also beneath the pavement on the east side of the bridge.

## INTRODUCTION TO GROUND PENETRATING RADAR

Ground penetrating radar provides a rapid and non-invasive technique for the location of shallow discontinuities in geological and engineering media. The method relies upon the downward transmission and subsequent reflection of a short pulse of high-frequency electromagnetic radiation from targets beneath the antenna. Reflections arise whenever changes in electrical conductivity and dielectric strength occur on a scale which is comparable to the wavelength of the transmitted pulse.

The maximum *depth of investigation* depends upon the mineralogy and electrical conductivity of the substrata since these govern the absorption of the radar pulse. Research indicates that wet, clay-rich earth materials are strong attenuators of radar energy and that the absorption increases rapidly with frequency.

The *vertical resolution* of the radar survey also rises with frequency and is comparable to the wavelength of the transmitted pulse. Thus, in any given investigation, a radar frequency is chosen to provide a working compromise between the depth of investigation and vertical resolution. The *horizontal resolution* depends upon the speed of the traversing antenna and the repetition rate of the radar pulse.

## THE SITE INVESTIGATION

On the basis of information provided by the Department of Highways and Transportation, it was decided to carry out the site assessment using the SIR8 ground penetrating radar system manufactured by Geophysical Survey Systems, with a 500MHz antenna. This instrument records the radar reflections directly onto electrostatic paper in a chart recorder and was powered from a vehicle car battery. NYCC highways staff provided traffic management during the survey.

Figure 1 shows the locations and directions of radar traverses between points A, B, C, etc, along the midlines of the west and east carriageways of the bridge. The antenna was towed at a velocity of about 30cm/s and marks were recorded on the paper chart at metre intervals (eg. Figure 2). A recording timebase was chosen to give the optimum compromise between signal attenuation (giving depth of investigation) and resolution.

## DISCUSSION

### General

The radar sections have provided structural information to a maximum depth of about 3m beneath the roadway. A computer-aided drafting program was used to extract significant artifacts in the radar sections and transpose these onto the traverse lines A-B, B-C, etc in Figure 3.

Three styles of radar reflector have been identified in the sections and are shown using the blue symbols defined in the key to Figure 3:

<b>Discontinuity</b>	A marked disturbance or break in a reflecting layer shown on the plan as a solid <i>blue rectangle</i> with width proportional to the intensity of the disturbance and length equal to that of the anomaly.
<b>Dipping Layer</b>	An apparent gradient in a radar reflector. These anomalies are marked by <i>blue arrows</i> pointing in the downslope direction.



**Random Reflectors** A zone within which no coherent reflecting layers have been detected and where most of the electromagnetic energy is being scattered by inhomogeneities on a scale comparable to the wavelength of the pulse, viz. about 60cm. Such zones are shown by hatched rectangles.

## Interpretation

The radar survey has detected the following features beneath each traverse:

- 1 A length of about 20m of the southern end of the bridge and the abutment within which a number of strong radar discontinuities have been detected at typical depths of 0.5-1.0m (**Zone B**). This section of the bridge is also characterised by at least 3 regions where strong inhomogeneity in the fill (cavities?) has been detected. It seems possible that the structural anomalies at the southern end of the bridge are a reflection of strain occurring at or near the abutment.
- 2 A significant concentration of major radar anomalies have been detected within the northern third of the bridge which is denoted **Zone A** in Figure 3. These anomalies include: a strong reflector beneath the eastern carriageway, north of the pier, which dips south and then terminates at a depth of about 1.5m; at least 3 inhomogeneous zones probably reflecting rubble fill which may contain cavities; evidence for defects in the form of radar discontinuities both north and south of the arch immediately N of point E, at a depth of 2-3m. These can be seen in the profile of Figure 2.
- 3 Several smaller radar anomalies have been detected between **Zones A** and **B**. However the survey results suggest that this section of the bridge structure contains relatively fewer structural defects.

## SUMMARY AND CONCLUSIONS

The results of this research can be summarised as follows:

- 1 Radar surveys of Catterick Bridge have provided information concerning possible structural defects within the arches and abutments of the monument.
- 2 A number of major internal discontinuities were detected beneath a 30m length of roadway centred on the northernmost pier of the bridge. These features may comprise voids within the rubble or soil fill or may be a reflection of changes in structural style of the bridge.
- 3 Evidence was found for internal anomalies (mainly in the form of random radar reflectors) beneath a 20m section of roadway on the southern abutment. These features may again indicate variation in the bridge fill, voids or some other form of structural defect.

- 4 A programme of limited trial trenching may be necessary to confirm and calibrate the indications of the radar survey.

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*Report:* M.J. Noel

*Date:* 11/2/95

**Note** Whilst every effort has been taken in the preparation and submission of this report in order to provide as complete an assessment as possible within the terms of the brief, GeoQuest Associates cannot accept any responsibility for consequences arising as a result of unknown and undiscovered defects or services.

# CATTERICK BRIDGE

LOCATION OF RADAR TRAVERSES

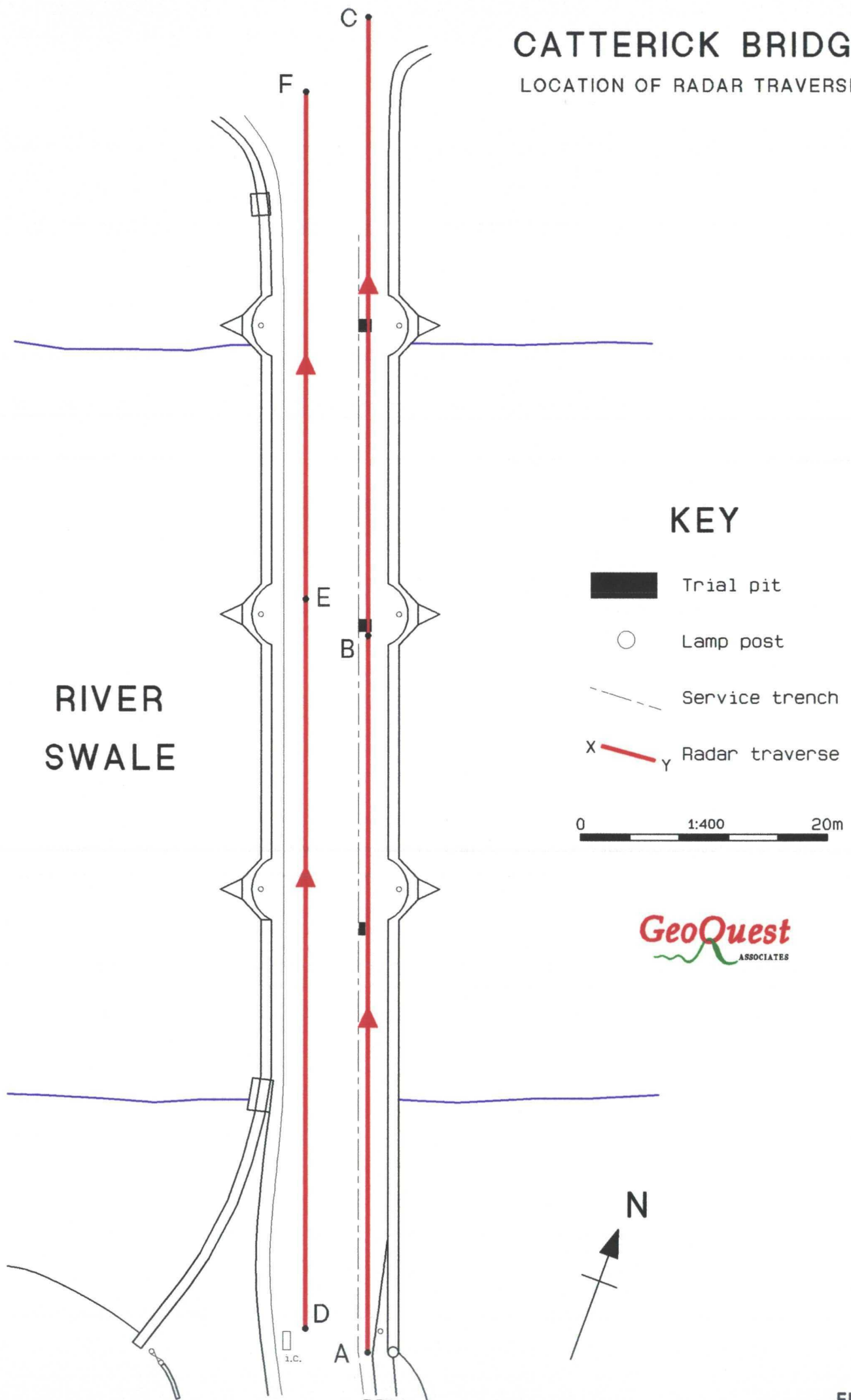


FIGURE 1



# CATTERICK BRIDGE

## RADAR INTERPRETATION

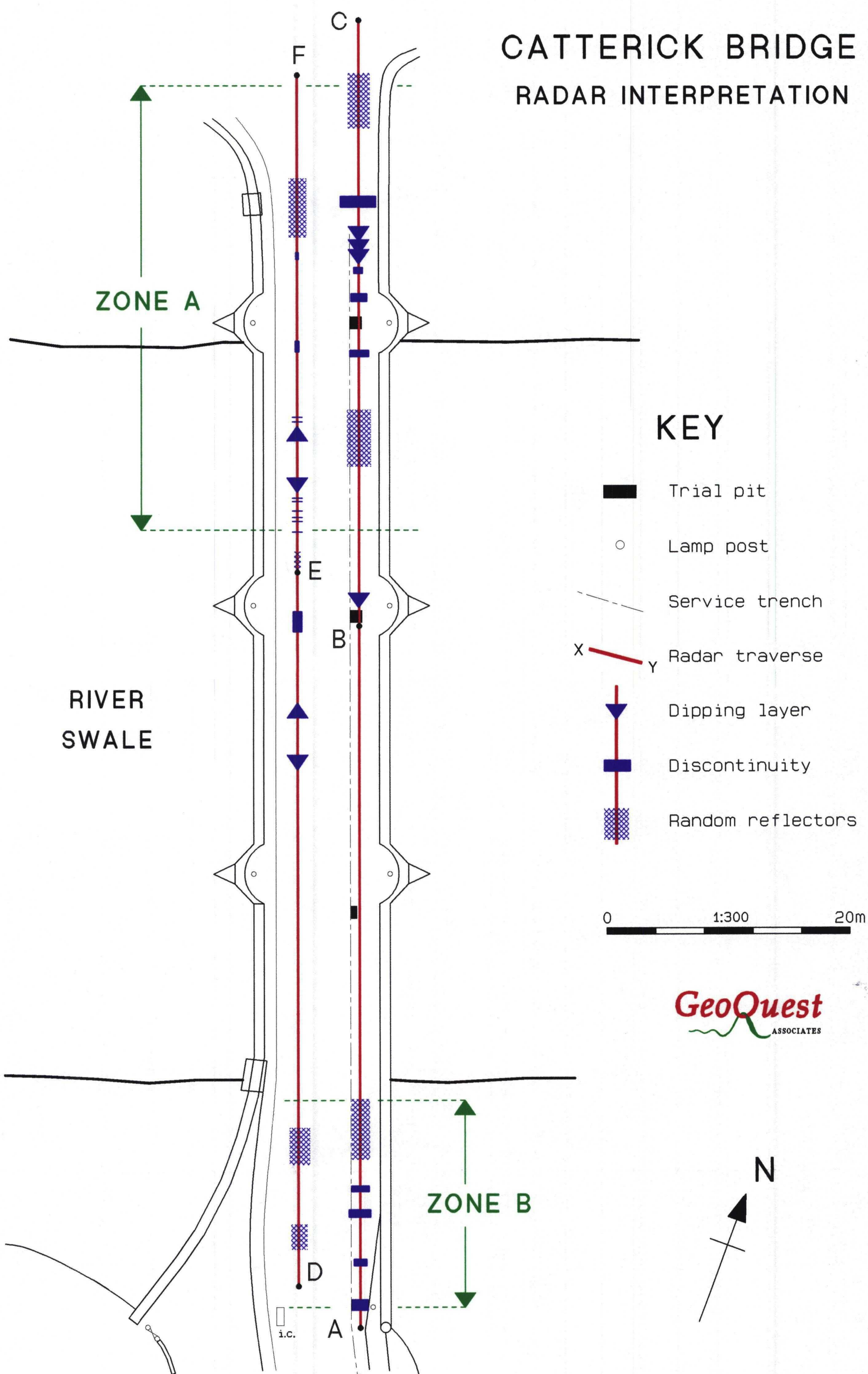


FIGURE 3

## NOTES

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SNY7565

GPR data plot not scanned

Please see Parish File for originals