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PRELIMINARY GEOLOGICAL INVESTIGATION OF STAPLETON CREEK DAMSITE, NORTHERN TERRITORY, 1966.

by

J.C. Braybrooke

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SUMMARY

In the course of an investigation into the development and control of the Adelaide River drainage system, Stapleton Creek has been suggested as a site for a 40-foot-high dam to control flooding and to impound water for irrigation. The site lies across the Stuart Highway, 67.2 miles south of Darwin; it extends from a low central knoll, east of the highway, across Stapleton Creek to the north-east, and across a low-lying flat to the west.

Rocks of the Lower Proterozoic Goodparla and Finniss River Groups occur within the catchment area. Most of the area is covered by Recent alluvium; rocks of the Burrell Creek Formation, within the Finniss River Group, crop out in elevated areas.

Maximum top water level is limited by low, gently sloping, soil-covered ridges to the north and north-east of the reservoir. No measures to prevent leakage from the storage area should be necessary other than below the dam foundations.

Geological mapping of the damsite was done by plane-tabling on a scale of 1 inch=80 feet. Both left and right banks, and the area between the central knoll and the right bank, are underlain by folded phyllite. Highly weathered phyllite at the surface is very weak. Extreme weathering is likely to occur to depths of 20 feet or more.

The central knoll contains a tightly folded sequence of moderately to highly weathered meta-greywacke and phyllite. Quartz veins are numerous in places.

Twelve feet, and possibly up to 30 feet, of alluvium covers bedrock beneath the Stapleton Creek flats.

Secondary copper minerals are associated with closely-spaced quartz veins in a small area on the left bank.

The site appears suitable for a rock or earth-fill dam: a spillway channel could be excavated in the central knoll. Adequate supplies of rock-fill are probably available in the meta-siltstone/greywacke sequence in the left bank, downstream from the damsite. Sufficient quantities of suitable earthfill material should be found in alluvial flats either up or downstream of the damsite.

INTRODUCTION

A study of the possible development of the Adelaide River lands is being made by the Northern Territory Administration. One measure being considered is a 40-foot-high dam on Stapleton Creek, to control flooding and to impound water for irrigation.

At the request of Water Resources Branch of the Northern Territory Administration (W.R.B.), the present investigation was initiated to determine the geological feasibility of constructing a dam at the site selected.

LOCATION AND ACCESS

The proposed site lies across the Stuart Highway, 67.2 miles south of Darwin, hence an excellent, sealed, all-weather road serves the site.

PRESENT INVESTIGATIONS

Surveying

A 200-foot grid, covering the damsite area, was set out by theodolite and steel tape. This work was done by surveyors of the Water Resources Branch.

Mapping

Six days were spent plane-tabling the damsite at a scale of 1 inch=80 feet. All outcrops and relevant features up to 200 to 400 feet on either side of the proposed axis were mapped, (see Plate 4).

A further two days were spent on regional reconnaissance in the catchment area and on mapping a possible quarry site. This work was plotted directly onto large-scale aerial photographs (see Plate 3).

PHYSIOGRAPHY

The area is within the "Uplands" physiographic division of the Northern Territory (Malone, 1958, pp4-6). Relief is about 200 to 250 feet, with long, embayed ridges separated by alluvial plains up to 1½ miles wide. The latter have been partly developed for grazing purposes.

The catchment area lies towards the southern border of the Northern Territory coastal plain. A number of creeks, which flow into different river systems, interdigitate on the black soil plain at the northern boundary of the catchment. This factor limits the maximum top water level to about reduced level (R.L.) 225 feet above mean sea level, giving a storage capacity of roughly 20,000 to 25,000 acre-feet.

Slopes within the storage area are very gentle. Adequate deep storage may not be available since evaporation losses would be high (annual rate of evaporation at Darwin is at least 7 feet: Bureau of Meteorology records).

The proposed damsite has a low central knoll separated from higher ridges by the Stapleton Creek and alluvial flats to the north-east, and a low-lying flat to the west; the Stuart Highway crosses the proposed axis of the damsite over the western flat.

REGIONAL GEOLOGY

The stratigraphy and rock types to be found in the catchment area are summarised in Table 1, which is based on Malone (1962). Plate 2 shows the distribution of the units.

Table - 1 Summary of Stratigraphy and Lithology of the Stapleton Creek catchment area.

Age	Rock Unit	Lithology	Remarks.
Recent		Alluvium, soil, sand, and iron-cemented deposits.	Covers much of area.
Lower Proterozoic	FINNISS RIVER GROUP		
	Burrell Creek Formation	Greywacke; siltstone; phyllite.	Conformably overlies Golden Dyke Formation in places.
	Noltenius Formation	Quartz greywacke; siltstone; quartz pebble conglomerate	Lateral facies assemblage with Burrell Creek Formation
	GOODPARLA GROUP		
	Golden Dyke Formation	Quartz siltstone; carbonaceous siltstone, pyritic in places; micaceous siltstone. Thin-bedded siltstone, marl and dolomite.	

As much of the storage area has not been mapped in the course of the present investigation, most of the following information is of an interpretive nature and is based on the Batchelor, 1 inch=1 mile geological sheet.

Apart from rocks of the Noltenius Formation occurring in the south-west corner, the ridges enclosing the storage area consist of Burrell Creek Formation. In the southern part of the area this formation consists of phyllite and sandstone. The phyllite is closely cleaved at the surface; thin beds within it show minor sedimentary features such as micro-cross-bedding, ripple-marks, ball and pillow structures, and load casts.

The most likely leakage paths through the Burrell Creek Formation are along bedding planes or fractures. As these rocks are folded and dip steeply, such paths are unlikely to be continuous beneath the water table. Hence, no leakage is expected through the Burrell Creek Formation.

The remainder of the storage area is covered with Recent alluvium. There is a possibility of leakage through low, alluvium-covered divides to the north and north-east. However, from the limited information available, leakage paths appear to be over two miles in length, consequently there is no risk of leakage. Seepage, including capillarity, may locally affect the ground-water regime; some studies of this aspect may be necessary.

A number of minor faults have been recognised within the area. Where exposed, they are above maximum top water level.

DAMSITE GEOLOGY

LITHOLOGY

Rocks within the damsite area consist of phyllite, fine-grained sandstone, and graded meta-greywacke beds.

Phyllitic sequences occur in both left and right abutments. The strata, before metamorphism, were siltstone, shale, and mudstone, with a few fine-grained sandstone beds. Some bands in the sequences, especially on the right abutment, show sedimentary structures such as slumping and fine cross-bedding. Except where the shallow soil cover has been removed by man, outcrop is sparse; exposed rocks are normally moderately to highly weathered microscopically, the phyllite consists of very fine-grained quartz, sericite and chlorite: it is a fissile rock.

Meta-greywacke crops out in the central knoll. Beds, up to 20 to 30 feet thick, grade from medium to coarse grained greywacke through to phyllite. Microscopically, the meta-greywacke consists of angular to sub-rounded quarts grains set in a fine groundmass of quartz and sericite with subsidary amounts of chlorite. The quartz grains show undulose extinction, owing to strain, and many are granulated.

Iron-cemented scree is common at the base of slopes within the phyllitic sequence. The scree is up to 5 feet thick and consists of highly weathered phyllite fragments in a ferruginous clayey matrix.

Sandy-clay forms the Stapleton Creek alluvial flats, and is more than 12 feet deep in places.

STRATIGRAPHY

Minor folding and lack of continuous exposure makes the elucidation of stratigraphy difficult. Phyllite, possibly stratigraphically similar to that in the right bank, occurs within an anticlinal core exposed in the central knoll. It is overlain by the meta-greywacke beds. The stratigraphic relation between phyllite on the left and right banks cannot be determined until the structure beneath Stapleton Creek is known. Many more exposures are required before any detailed knowledge of the stratigraphy can be obtained.

MINERALISATION

Close quartz veins occur in many areas within the damsite and environs. Veins are up to 4 feet wide, but more commonly the quartz occurs in ramifying networks of thin veinlets. Many veins greater than 1 inch in width, contain quartz rosettes and druses.

In places, hexagonal crystal cavities occur within phyllite on both sides of quartz veins. Some of the cavities up to half an inch square, contain an iridescent hematite or limonite boxwork; others show striated faces and are probably pseudomorphs after pyrite. Partly oxidized arsenopyrite is also present in some massive quartz veins.

On the left bank, close quartz veins are associated with fine-grained sandstone and siltstone bands; a thin gossanous cover is also present. Some joints and quartz veins in this area contain small amounts of malachite, a hydrated copper carbonate formed by the oxidation of copper sulphide minerals. (See Plate 4 for locations of copper mineralisation). Small blebs of malachite also occur within the matrix of fine-grained, silicified sandstone.

The mineralisation appears to be of small extent and of a type commonly found within Lower Proterozoic rock of the region.

STRUCTURE

Folding

The left bank contains an anticlinal axis that plunges 40 to 50 degrees towards the north-west.

Evidence of minor folds, with steep dips to east and west, occurs in the central knoll. At least two anticlinal axes are present but there is not enough exposure to attempt correlation between beds.

The right bank is on the east limb of a steeply dipping syncline. Two observations of west-dipping beds indicate minor folding within the sequence.

Faulting

There is no conclusive evidence for faulting. However, the number of quartz reefs, up to 4 feet wide, and patches with abundant quartz veinlets, indicate possible shearing within the area. The most noticeable areas of quartz veins within the damsite are the central knoll and the siltstone and fine-grained sandstone bands of the left bank (see Plate 4).

On the regional map, the north-striking Adelaide River Fault has been traced to within 1.6 miles south of, and in line with, the damsite. Other faults, of similar strike, have been identified 2 miles, and more, north of the site.

The quartz reefs at the site are possibly healed tension gashes associated with a fault (Adelaide River Fault ?), passing through or close to the damsite, or ending at some position near-by. As the fracture zones are infilled with quartz, they are probably not zones of weakness; however, the permeability of the bedrock may be higher within or adjacent to the fracture zones.

Jointing

Within the phyllite the most prominent parting is cleavage. At the surface, spacing between open cleavage planes ranges from ½ to 6 inches. From drilling results at Adelaide River Gorge Damsite No. 1 (Braybrooke, 1967) thin clay seams probably occur along cleavage planes.

Insufficient joint measurements were made to determine accurately the joint pattern for the area; the major joint sets appear to strike and dip:

046-078°/20-36°SE
084-096°/37-51°N
123-160°/14-51°NE

Within the last set, marked concentrations occur at 132-140°/28-46° NE (many of these joints are infilled by quartz), and at 144-152°/24-27°NE.

(All bearings are magnetic)

WEATHERING

Towards the base of slopes within phyllite, scree is up to 5 feet thick, and is partly iron-cemented: completely decomposed rock fragments are cemented by a weak, mottled pink and white, ferruginous clayey matrix. This material is underlain by iron-cemented phyllite.

Intensity and effect of weathering depend markedly on lithology and on the topographic position of the rock material. Outcropping phyllite is highly weathered on slopes and completely decomposed on basal flats. The depth of weathering is not known; however, the following observations are of relevance:

(a) The profile of pits in phyllite on the right bank at R.L. 215 feet are: 0-3 feet highly weathered, very closely jointed phyllite.
3-10 feet - moderately weathered, moderately strong, closely jointed phyllite.

(b) In the low-lying area between the right bank and the central knoll, at R.L. 180 feet, a 6-foot-deep erosion gully exposes the profile:
0-1 feet - silty clay.
1-3 feet - phyllite fragments in clay.
3-6 feet - highly weathered, fragmented, contorted phyllite.

(c) In the log of water bore No. 1879 - De Cesares (water bore records, W.R.B.), sunk about 70 yards north of the 67-mile peg on the Stuart Highway, the following notes were recorded (interpretive comments in parenthesis are by J.C. Braybrooke):
0-3 feet - gravel and clay overburden.
3-19 feet - red clay and shale (probably partly ferruginised, highly weathered phyllite).
19-36 feet - brown shale, becoming darker (moderately weathered phyllite).
36-45 feet - black slate, hard and soft veins (slightly weathered phyllite).
45-82½ feet - hard drilling, black slate with quartz leaders (fresh phyllite).

(d) In the log of water bore No. 226 (water bore records, W.R.B.), sunk 20 yards east of the Stuart Highway at the 66½-mile point, the following notes were recorded (interpretive comments in parenthesis):
0-16 feet - brown surface clay, some gravel (alluvium).
16-24 feet - white clay.
24-44 feet - blue clay with occasional gravel seams.
44-89 feet - brown slate with some quartz seams (moderately weathered phyllite).
Standing water level 32 feet.

(e) Drilling at Adelaide River Gorge Damsite No.1 (Braybrooke, 1967) showed that highly weathered phyllite ranges in thickness from 20 to 75 feet; moderately weathered phyllite occurs at depths of up to 130 feet.

It is concluded that highly weathered phyllite will probably be found to be at least 20 feet thick beneath low-lying areas; moderately weathered phyllite probably occurs to at least 36 feet in depth.

The meta-greywacke is moderately to highly weathered at the surface. From experience at Adelaide River, it is considered that the depth of highly weathered material is less than 10 feet. Greater depths of highly weathered rock doubtless occur within fold axes, and phyllitic interbeds may be highly weathered to at least 30 feet in depth.

ENGINEERING GEOLOGY

The location of the proposed damsite was selected because of favourable topography. However, without the construction of cut-off walls at the northern end of the storage area, catchment topography limits the wall height to a maximum of 40 to 50 feet. The valley profile is suitable for either a rock or earth-fill dam.

Initial investigations were planned to:

(a) determine whether the site is geologically suitable for the construction of a 40-foot-high dam, and
(b) locate suitable fill material.

FOUNDATIONS

Left Bank

Most of the outcrop on either side of the proposed centre-line is exposed in either a former borrow area or along an old track. The rock is mainly phyllite with a few long, thin, fine-grained sandstone ribs, within the southern limb of an anticlinal fold. Ferruginised slope-wash covers much of the lower slope. Phyllite is highly weathered, bittle to soft, and very closely cleaved to finely fragmented at the surface. Extreme weathering can be expected to at least 20 feet below the surface, forming zones of mica-rich silty clay. This material is believed to have a low cohesion and would not withstand high stresses. Soil testing procedures will be required to investigate this highly weathered zone.

Creek Bed

A depth of over 12 feet, and possibly 20 to 30 feet, of alluvium covers weathered bedrock. The alluvium is a sandy to silty clay which may be suitable for earth-fill.

Phyllite, which forms part of the bedrock, is probably moderately to highly weathered, possibly with physical properties similar to, or not as good as, those of the alluvium. An extension of the Adelaide River Fault may also pass through the section, and have affected the bedrock. Factors suggesting this are:

(a) the abundant quartz veins in the area, and
(b) a projection of the Adelaide River Fault as known, passes through the valley.

Seismic work, in conjunction with the pattern percussion drilling or augering, will be required to determine the depth of alluvium and highly weathered bedrock. Some diamond drilling may be necessary to test suspected shear and fault zones, or other zones of low velocity.

Central Knoll

The proposed dam axis passes across at least two anticlinal fold axes within the tightly folded sequence of graded meta-greywacke and phyllite. Most exposures occur either in the road cutting on the south-west face of the knoll, or immediately above the nick point where alluvium abuts against the knoll.

On the northern side of the knoll, a highly weathered, soft, phyllitic sequence containing narrow, moderately hard, meta-siltstone and fine-grained sandstone beds, occurs on both sides of the proposed axis.

On the south-western side, moderate to highly weathered, soft to moderately hard, graded meta-greywacke occurs. Beds are steeply dipping and tightly folded. Extreme weathering may occur to 20 or 30 feet deep along fold axes and to lesser depths on fold limbs; the phyllite interbeds tend to be more highly weathered than the meta-greywacke. Very close, open fractures may extend to depths of 50 feet or more, presenting potential leakage paths. Also, leakage could occur along the steeply dipping bedding planes.

No bearing capacity problems are expected for a low dam.

Central Knoll to Right Bank

The Stuart Highway passes through this area which rises gently towards the right bank. The rock consist of soft, highly weathered phyllite, in places overlain by shallow soil. The highly weathered material is possibly up to 30 feet deep near the Stuart Highway.

Seismic work and augering will be required to determine the depth of highly weathered bedrock.

Right Bank

The moderate to steeply dipping (50 to 90 degrees) northern limb of an anticlinal fold occurs within the right bank. Only scattered outcrops of highly weathered phyllite are present. However, 5 feet below the surface at R.L. 215 feet, weak material passes into a moderately strong, closely jointed phyllite. If this condition persists down-slope, little stripping would be required to expose moderately strong foundation rock.

Because of the mineralisation within the area, pyrite is expected below the zone of oxidation, especially within the phyllite. It is not at present known whether pyrite occurs in sufficient quantity to seriously affect any cement grout used for foundation treatment.

SPILLWAY

The central knoll provides a suitable spillway site. The spillway channel could run down the eastern side of the knoll; it would pass over graded meta-greywacke and phyllite beds at a small angle to their strike. A spillway channel in this location would pass over a number of fold axes, and hence, over variable depths of highly weathered rock.

If the weathering is not deep, overall, a free-standing channel structure could be used to obviate excessive excavation. Spoil from the channel could probably be used as fill material.

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Costeaning will be necessary to expose the full sequence and to determine the degree and extent of weathering.

CONSTRUCTION MATERIALS

Rockfill

About 250,000 cubic yards of material would be needed for a 40-foot-high rock-fill dam.

A steeply dipping body of meta-siltstone, fine-grained sandstone, and meta-greywacke, exposed in a ridge on the left bank, 400 yards downstream from the damsite, is believed to contain over 3 million cubic yards of suitable rock. The material is highly weathered at the surface and ranges from soft and weak to moderately strong. Though weathering is deep, moderately weathered meta-siltstone and greywacke should be strong enough to be used in a 40-foot-high dam.

A medium-grained sandstone and meta-greywacke sequence also occurs at the bend in the valley to the north-east of the ridge described above (see Plate 3). Ample, suitable material is believed to be available but there may be some difficulty in opening a quarry in the confined area. The site is readily accessible.

Detailed mapping and drilling would be required to prove adequate volumes of suitable material, and to determine the depth of weathering. Representative samples will have to be tested for strength and durability.

Impervious Material

The only material suitable for use as earth-fill occurs within the alluvial flats, both up and downstream of the damsite. From observations, the top 2 feet of soil is black, humic soil. In places the black soil is underlain by soft to firm, red, sandy clay with moderate cohesion. The relevant physical properties of the soil will need to be determined by sampling and laboratory tests; the volume of material will have to be proved by pitting.

Sand and Gravel

No deposits of sand or gravel were located. A number of disused sand pits are present along the Adelaide River below Stapleton Creek. However, it may prove to be more economical to use sand and gravel from operating quarries, 25 to 30 miles away.

CONCLUSIONS

1) The proposed site appears geologically suitable for a 40-foot-high rock or earth-fill, dam. Additional investigations are needed to verify this conclusion and to provide design data.

2) Folded phyllite sequences underlie both left and right banks. The phyllite is highly weathered, possibly to depths of 20 feet or more; this material is weak. Pyrite is expected below the zone of oxidation.
The central knoll is formed by a tightly folded sequence of moderately to highly weathered meta-greywacke and phyllite. Over 12 feet, and possibly up to 30 feet, of alluvium covers bedrock beneath Stapleton Creek flats.

3) A possible fault occurs in the creek bed.

4) The material of which the central knoll is composed could support an excavated spillway; depth of excavation needed is not at present known.

5) Adequate supplies of rock, probably suitable for a low rock-fill dam, are present close to the site. Sufficient quantities of earth-fill material are probably available within alluvial flats, either up or downstream of the damsite. Filter gravels and sands may have to be obtained from outside the area.

6) No leakage of any consequence is expected from the storage area unless top water level is greater than R.L. 220 feet. Treatment of the dam foundations and abutments will be necessary.

7) A small area, (200 square feet), on the left bank above the proposed dam crest, has scattered secondary copper mineralisation at the surface.

RECOMMENDATIONS

Additional geological information will be required before a dam can be designed for the site. Surface geological information is sparse, subsurface information, especially regarding weathering, is interpretive, and nothing is known about the foundations beneath the creek bed. The properties and volumes of construction materials have still to be determined.

The following additional investigations are recommended for design purposes:

1) Seismic testing, to determine the thickness of alluvium and highly weathered material throughout the proposed foundation and abutment areas of the dam, is required with drill and auger-hole control.

2) Depth of weathering, permeability, and physical properties of the foundations should be established by diamond drilling, water pressure testing, and laboratory testing of core samples. Drill holes should also be designed to test suspected shear and fault zones, or other zones of low velocity.

3) The entire length of the spillway channel should be costeaned to provide information on the structure and rocks present.

4) Geological mapping, costeaning and drilling of potential quarry sites will be necessary. Representative samples of drill core, or bulk samples, should be tested for strength and durability. Pitting and soil testing of potential earth-fill borrow areas within alluvial flats will also be needed.

REFERENCES

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APPENDIX 1

DEFINITIONS OF SEMI-QUANTITATIVE DESCRIPTIVE TERMS

Grade Scale

Coarse-grained sand	$\frac{1}{2}$ to 1 mm.
Medium-grained sand	$\frac{1}{4}$ to $\frac{1}{2}$ mm.
Fine-grained sand	$\frac{1}{8}$ to $\frac{1}{4}$ mm.

Fracture Spacing

Very wide fracturing	greater than 10 feet.
Wide fracturing	3 to 10 feet.
Moderate fracturing	1 to 3 feet.
Close fracturing	4 inches to 1 foot.
Very close fracturing	1 inch to 4 inches.
Fragmented	$\frac{1}{2}$ inch to 1 inch.
Finely fragmented	less than $\frac{1}{2}$ inch.

Hardness

Hard to very hard	Impossible to scratch with knife blade.
Moderately hard	Shallow scratches with knife blade.
Soft	Deep scratches with knife blade.

Percussive Strength of Rock

Strong to very strong	Not broken by repeated blows with a 2 lb geological hammer.
Moderately strong	Rock broken by 3 or 4 heavy blows with a 2 lb. geological hammer.
Weak	Rock broken by one blow. (includes brittle, fissile, friable, and flaky rocks.)

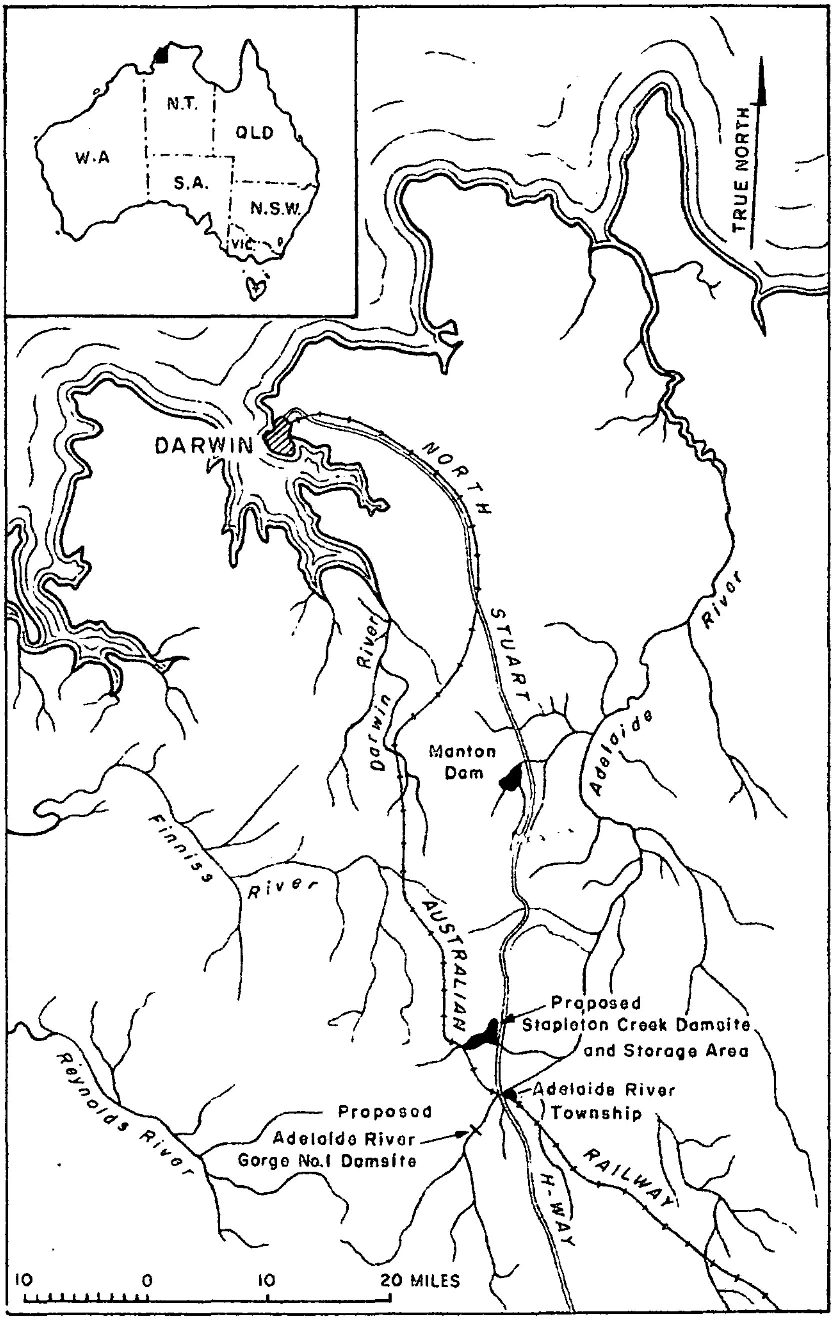
Degrees of Weathering

Completely weathered	Relict rock fabric; behaves mechanically as soil.
Highly weathered	Much clay associated with siltstone and phyllite which crumbles when crushed in hand; meta-greywacke friable and can be broken across the fabric by unaided hands.
Moderately weathered	Clay along fractures in phyllite; phyllite crumbles under a 2 lb. geological-hammer blow. Meta-greywacke breaks under a moderate hammer blow; some of rock may withstand hard hammer blows.

Slightly weathered	Rock slightly discoloured and stained along fractures; kernels of fresh rock between fractures. Strength slightly reduced from that of fresh rock.
Fresh	Rock dark to light grey; no iron staining. Phyllite may bruise and break along cleavage planes when struck by a 2 lb geological hammer. Meta-greywacke rings when struck by hammer.

PLATE I.

Locality Map Stapleton Creek Damsite



To accompany Record 1967/133. D52/A8/239

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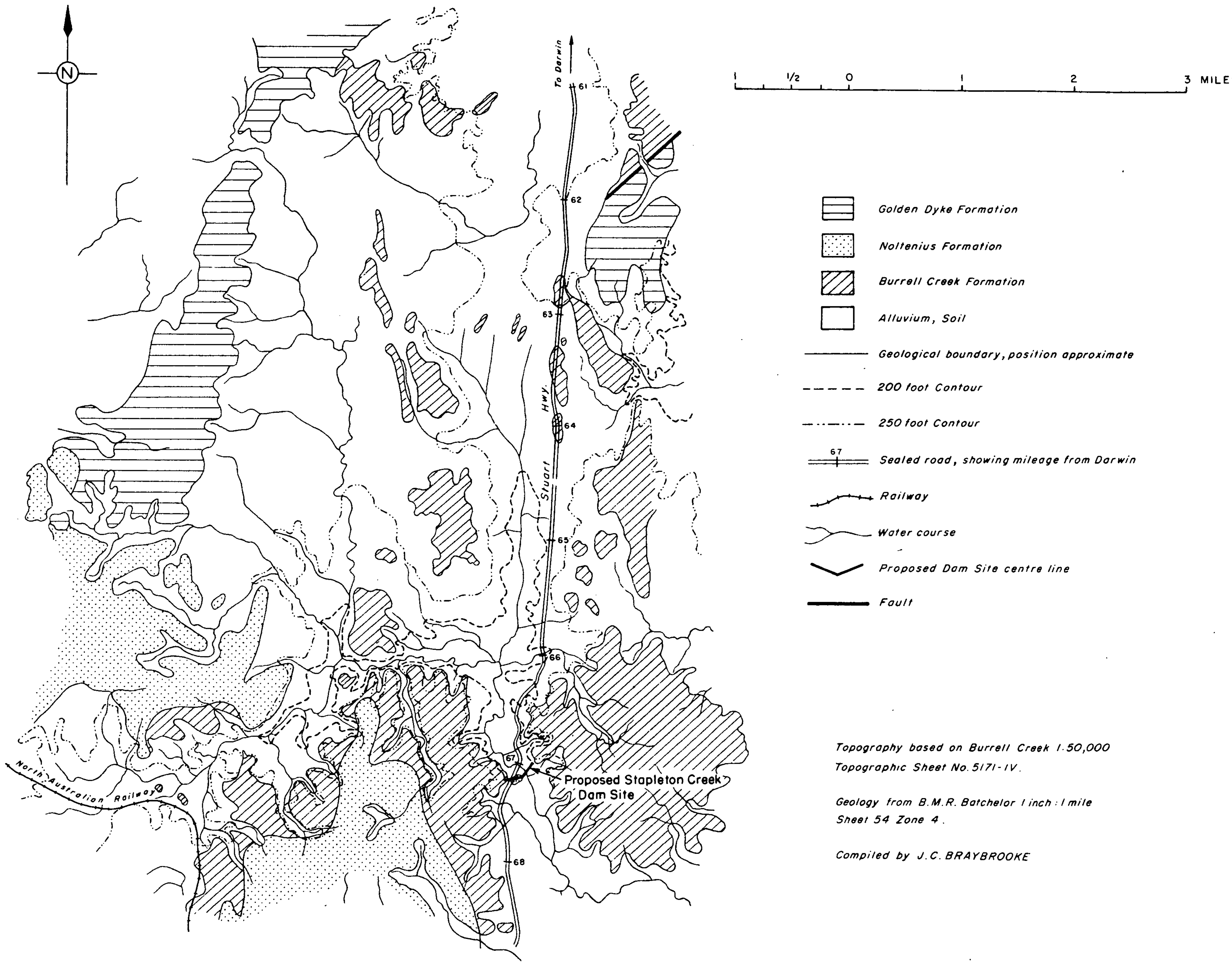
STAPLETON CREEK DAM SITE
Geological Sketchmap of Storage and Catchment Area



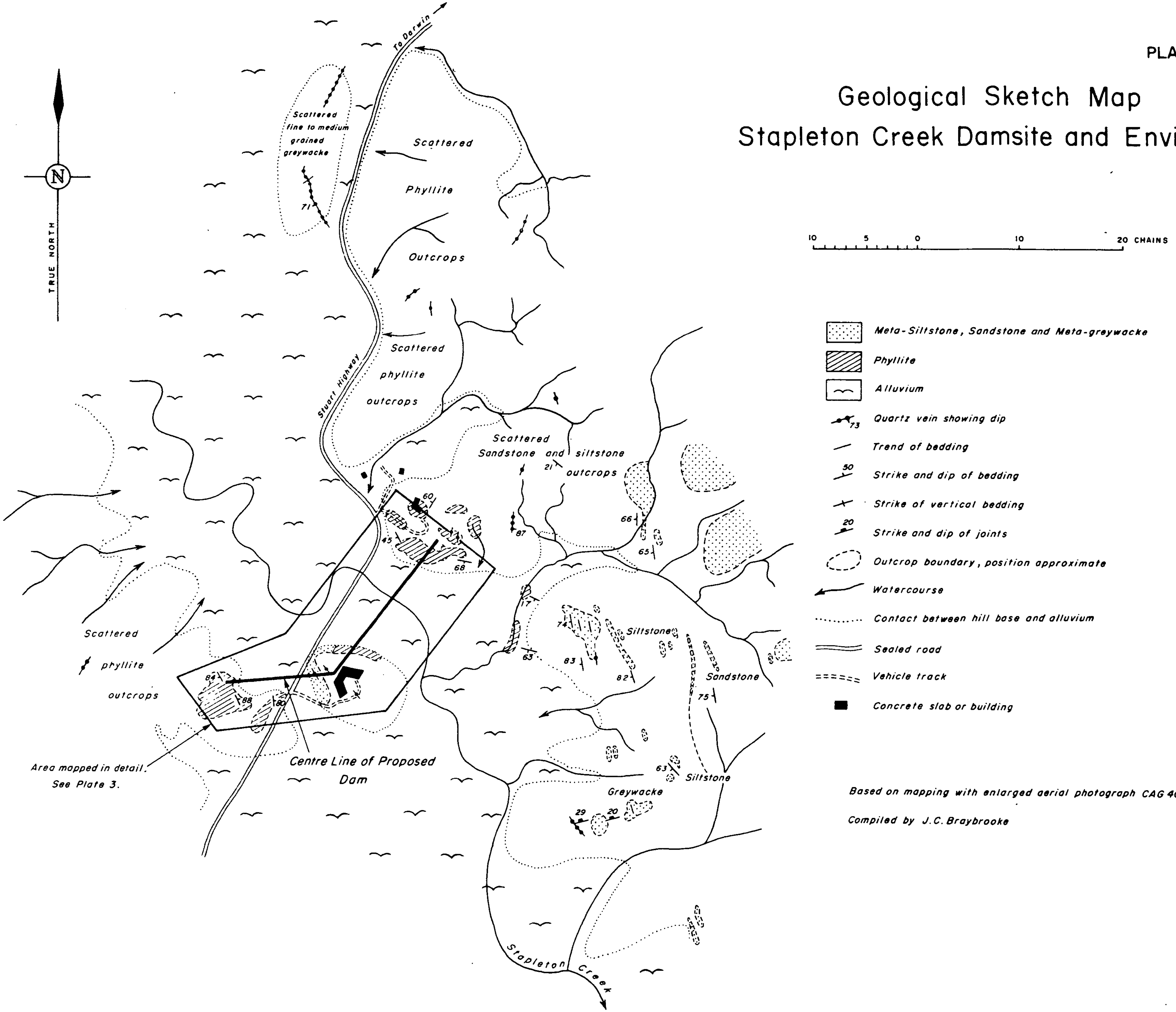
Topography based on Burrell Creek 1:50,000 Topographic Sheet No. 5171-IV.

Geology from B.M.R. Batchelor 1 inch : 1 mile Sheet 54 Zone 4.

Compiled by J.C. BRAYBROOKE

PLATE 3.

Geological Sketch Map
Stapleton Creek Damsite and Environs



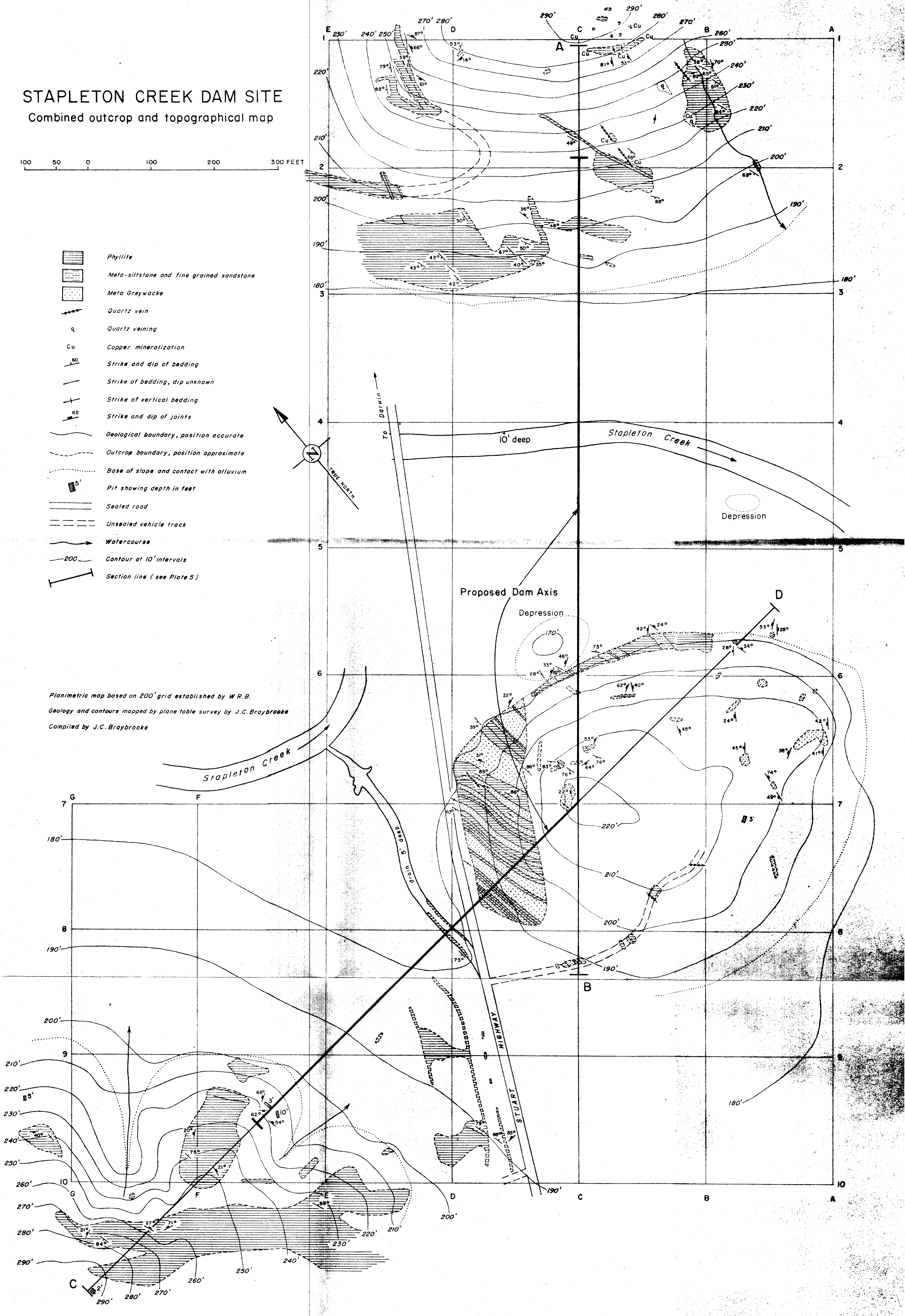
Based on mapping with enlarged aerial photograph CAG 4023-5047

Compiled by J.C. Braybrooke

PLATE 4.

STAPLETON CREEK DAM SITE

Combined outcrop and topographical map



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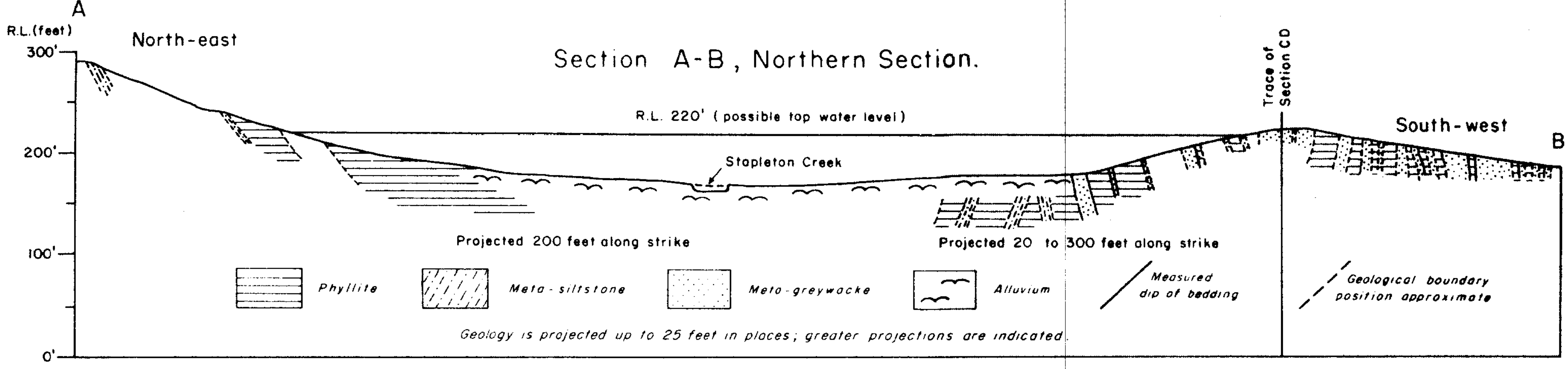
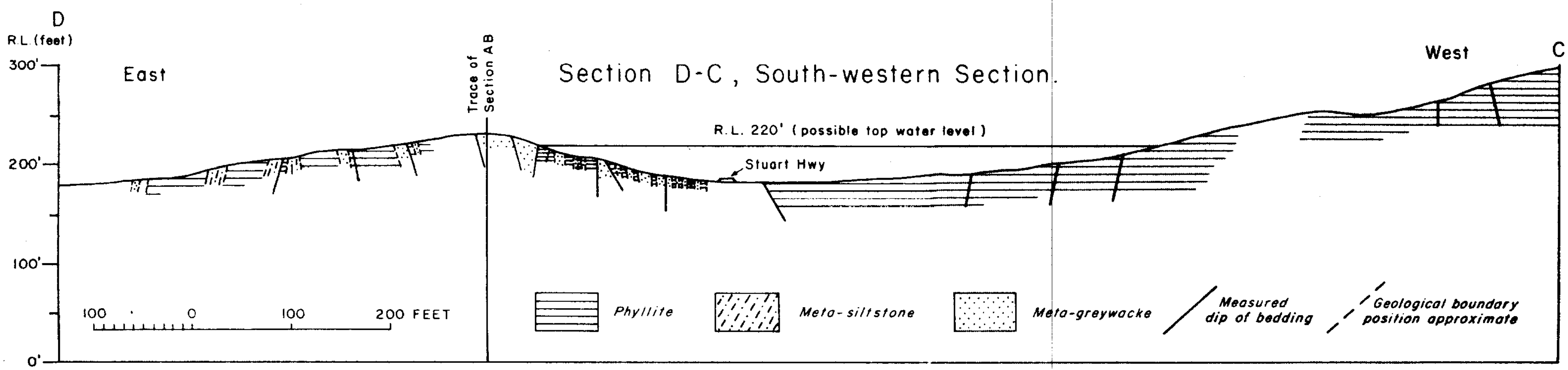
STAPLETON CREEK DAMSITE

PLATE 5.

Geological Sections through Damsite, looking **downstream (see Plate 4)**





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