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NOTES ON A PRELIMINARY GROUNDWATER ASSESSMENT FOR THE EAST KOOTENAY VALLEY (LIBBY RESERVOIR)

INTRODUCTION

At the request of Mr. R.G. Harris, Chief, Water Supply and Investigations Division, a preliminary assessment has been made on the possibility of obtaining groundwater supplies for irrigation in the East Kootenay Valley. The study area lies between the Libby Reservoir and the eastern wall of the Rocky Mountain Trench - the width is about 4 miles. The area extends from the International Border north for about 10 miles to the Elk River.

The preliminary groundwater assessment has been divided into three parts:

1. A review of available data.
2. Preparations of a preliminary groundwater assessment report including:
   (a) a 1-inch to ½ mile surficial geology map based on air-photo interpretation, field reconnaissance and Clague's report and map;
   (b) a proposal for some test holes for subsurface information and for completion as monitor wells.
3. Production well construction and costs estimates.

Test production wells by cable-tool method would only be warranted, if results are sufficiently encouraging from the test hole program.

It is recommended that a decision to complete geophysical surveys and deep rotary test holes to the bedrock profile of the valley floor should not be made until the results of a shallower test hole program can be evaluated.

1. REVIEW OF AVAILABLE DATA

(a) Preliminary Evaluation of Bank Storage Associated with Libby Reservoir in Northwestern Montana. Geological Survey Water Supply Paper 1899 - 1970.

The magnitude of active bank storage is controlled by transmissivity and storage coefficient. The model study indicates that geologic data necessary to evaluate bank storage accurately need only be collected on about one fourth of the length of the reservoir (specifically between Rexford and 8 miles south of the Elk River mouth) and within 2 miles of the reservoir edge. According to this paper, as ice moved down the trench, it ground and compacted the underlying deposits into clay till. Following damming of a 400-foot deep lake, streams from the adjacent mountains deposited their load along the foot of the steep walls of the trench. The outwash deposits range in size from sand to boulders and contain less than 20 percent clay. Further sorting produced deltas of coarse sand to medium gravel which interfinger lakeward with lake bottom deposits of clay, silt and sand. The lake deposits rest on till. After recession of glacial conditions, the glacial lake drained and the Kootenay River entrenched itself 200 to 300 feet into the lake bottom deposits. Figure 3 in this paper shows a diagrammatic geologic section across the Tobacco Plains below the International Border. Adjacent to the maximum stage level of the Libby Reservoir are the glacial lake bottom deposits. These grade with interfingering to the east into deltaic deposits which in turn interfinger with outwash deposits near the valley mountain wall.

Comments:

From the 1970-foot fluctuations of reservoir storage it would appear from this paper we could expect between 80 and 120-foot fluctuations in the study area. Groundwater level fluctuations, due to active storage, are expected to be less than 10 feet at a distance of two miles or more from the reservoir and less than 20 to 50 feet closer to the reservoir. The rise in level over a period of years due to inactive bank storage may be as high as 50 feet. However, it is apparent that the distance from the river and the "lag time" are important factors governing groundwater level fluctuations. From the graphs, the period mid May to Mid June may be a period of minimum active storage during the start of the irrigation season and may affect available drawdown and well yield of wells located close to the reservoir. However, demand should

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be minimal for irrigation during this period. It would appear, however, that much active bank storage will not be available for irrigation production wells. From Graph No. 6 it is apparent that it will take several years for inactive bank storage to build up. It could be concluded from this paper that an assessment of the groundwater potential should be, at this time, based on conditions prior to the filling of the Libby Reservoir and that the installation of monitor wells will provide continuing data required for further reassessments of bank storage and groundwater potential at a later date.

Well construction in the glacial lake deposits will be very difficult and expensive if very fine aquifer materials are encountered, and well completion under these conditions may be questionable unless a cheap long sand pack screen design is feasible.

(b) Late Cenozoic Geology of the Southern Rocky Mountain Trench, British Columbia by J.J. Clague, University of British Columbia, November, 1973.

This 274 page paper is divided into six main chapters: 1. Introduction; 2. The St. Eugene Formation and the Development of the Southern Rocky Mountain Trench; 3. Glacial Flow Patterns and the Origin of Lake Wisconsinan Till; 4. Sedimentology and Paleohydrology of Lake Wisconsinan Outwash; 5. Geographic History; 6. Applications of Geological Knowledge.

Bedrock Geology is summarized from Clague as follows:
The Galton Range, which lies to the east of our study area, is underlain by Upper Purcell rocks (siltstone, sandstone argillites) of Precambrian age. Younger Cambrian rocks crop out at the north end of the Galton Range near its crest. The McGillivray Range to the west is composed of Upper Purcell rocks.

Surficial Geology:

Thick deposits of semi-consolidated and unconsolidated sediments are limited to the major valley bottoms and are of Tertiary and Quaternary age; the drift cover is thin or absent on the uplands. A deep basin showing up to 1,500 meters of Tertiary sediments has been outline by Gravity Surveys in the Elk River area. See attached Figure 6 taken from Clague's report. The St. Eugene Formation, which represents the only exposed part of these sediments, consists of floodplain and fan facies which filled tectonic depressions caused by half graben block faulting.

The floodplain facies includes both high energy river gravels deposited off tributary valleys and shallow lake or slack water silt and sand. The fan facies consist of talus and fanglomerate deposited along the margins of the proto-Rocky Mountain Trench and derived from adjacent fault bounded uplands. More discussion on the St. Eugene Formation in the Elk River area is discussed further at the end of this section. The thickness of Quaternary deposits has been estimated by Clague from stratigraphic exposures along the major river valleys in the Trench and from seismic records where low velocity Quaternary sediments are distinguishable from intermediate velocity Tertiary deposits. In general, Quaternary deposits are about 100 meters or less in thickness along the sides of the Trench, but are locally much thicker along the Trench axis.

Listed in order of decreasing age, the known deposits in the southern Rocky Mountain Trench include the following: the St. Eugene Formation, interglacial sediments, older drift, inter-drift sediments, younger drift and post glacial sediments. A generalized composite section is shown in Figure 8 from Clague's report. The younger drift is also called the Wycliffe till, it is a "massive unsorted deposit of clay, silt, sand and clasts ranging widely in size . . . Lenses of water worked sand and gravel are present within the till sheet. Horizontally stratified lake silts from 3 to 15 meters thick occur within the Wycliffe till ....Immediately prior to deglaciation, Wycliffe till covered the entire Trench floor. This constructional surface was modified by lateral proglacial and subglacial meltwater as the glaciers receded. The till, thus, was reworked locally into outwash; it was removed completely along the major river valleys during the following Halocene Epoch". The Wycliffe till is dissected in the Rocky Mountain Trench by meltwater channels, outwash underlying the channels is coarse and poorly sorted, large valley trains, and Kame terraces occur along the margins of the Trench. On the east side of the Trench, for example, between Elko and Red Canyon Creek is a large terraced and channeled outwash plain. Individual meltwater channels trend south and northwest from this outwash surface towards the axis of the Trench. These deposits came from floods from breaches of the ice dam in glacial Lake Elk. According to Clague both samples of the outwash consist of from over 50 percent to more than 90 percent gravel. The sediment is much coarser than the modern alluvium of Kootenay River. Coarse channeled outwash near the Kootenay River is overlain by silty sand. The fine sediment probably accumulated during later stages of channel flow as backwater deposits where the channel intersected the ancestral Kootenay River. Meltwater channels are conspicuous features of the present landscape in the southern Rocky mountain Trench. According to Clague, the channels vary in morphology and include the following types:

(1) Narrow, relatively deep channels cutting across drumlins.

(2) Strictly lateral single walled channels.

(3) Wide, relatively shallow, double walled channels underlain by outwash. Most of the channels are cut in till and contain an outwash fill which is generally a few meters in thickness but in places is thicker than 15m. Cross stratification and pebble imbrication show, according to Clague, that the outwash was deposited from water flowing to the south, southwest and southeast away from the ice front. The distance between the active ice front and the depositional site was probably short as most meltwater channels are pitted with kettles. Clague briefly discusses groundwater in his report. He believes the most accessible source of groundwater is ~~Lake~~ late Wisonsinan outwash gravel underlying major meltwater channels which in turn overly till or impermeable

clay and silt.

Clague also mentions that the character of sediments beneath the St. Eugene Formation is not known but that these sediments fill a structural basin near the Elk River 1,500 meters deep. The deeper sediments below the upper till may be permeable enough to transmit abundant groundwater.

2. PREPARATION OF A PRELIMINARY GROUNDWATER ASSESSMENT REPORT

(a) One Inch to ½ Mile Surficial Geology Map

Air photos were used to obtain details of the glacial and interglacial features of the project area. These photos are on file for detailed inspection when required. Clague's report and map, associated soils maps for the area, field work by the writer, and the air photo study mentioned above, together formed the basis for the attached one-inch to ½ mile surficial geology map of the area. The reconnaissance field work was carried out by the writer on July 5,8 to July 12 inclusive.

Large areas of the attached surficial geology map prepared for this report are covered with till (Wycliffe till), an unsorted deposit covering a wide range of grain sizes from silt and clay up to boulders. Prominent meltwater channels disect the till sheet. Till thicknesses in the project area are expected to be 50 to 100 feet thick, the till is expected to be underlain by further silts and clays down to river level. Occasional lenses of gravels may be expected below the till also. The meltwater channels (yellow) cut into the till surface contain coarse and poorly sorted outwash. The silty sand (orange) overlying the outwash (yellow) near the Kootenay River Valley (now Lake Kootcanusa) is expected in many areas to be just a veneer over the coarser outwash below. Fine glacial lake deposits would appear, however, to be extensive near present Lake Kootcanusa and may indicate limited active bank storage for well development in this border area.

(b) Proposal for Test Hole Program and Construction of Monitor Wells

Shallow test drilling is recommended in order to obtain further shallow sub-surface information on the groundwater potential of the area. The test holes, if successful, in encountering shallow outwash aquifers should be completed as monitor wells. Careful sampling would be very important in this test hole program particularly in potential aquifer zones - Representative formation samples must be obtained at all times particularly if a sand pack screen design is necessary. It is recommended that a decision to complete geophysical surveys and deep exploratory test holes into the St. Eugene Formation of the Elk River area mentioned in Clague's report should not be made until the results of a shallower test hole program can be evaluated.

The proposed shallow test hole sites are confined to main access roads to the project area and are located with two objections in mind:

(i) to assess and monitor the recharge effects from Lake Kootcanusa on shallow outwash aquifers and lacustrine deposits located near the south end of the project area, and the west side of the area;
(ii) to assess and monitor the groundwater potential of shallow outwash deposits overlying till in other parts of the project area.

It is believed that shallow exploration of the groundwater potential of the impermeable relatively brown coloured till area shown on the surficial geology map is not warranted.

Deep test hole drilling should not be part of the initial program. It requires different drilling methods and equipment and techniques.

The location of the test holes are shown on the attached map. Test hole numbers 1, 2 and 3 are located on the west side of Lake Kootcanusa at the south end of the project area.

They are expected to pass through a limited thickness less than 30 feet of glacio fluvial and glacio lacustrine clay, silt and sand into underlying glacio fluvial gravel which in turn is underlain by till or clays and silts. These three test holes are expected to be between 150 and 200 feet deep and are intended to penetrate the surficial deposits as deep as the former river level of the Kootenay River. It is possible that some recharge may be available to these three wells from Lake Kootcanusa. The wells are located approximately 10, 40 and 20 feet, respectively, above expected high water elevation in Lake Kootcanusa, i.e., elevation 2,470, 2,500 and 2,480 feet above sea level, respectively.

Test hole numbers 4, 5 and 6 are located on the east side of Lake Kootcanusa in the middle and the south end of the project area. It was originally decided to run a series of three test holes east from the shoreline of Lake Kootcanusa along the easterly access road from the Lake to Roosville. However, the presence of till outcrops immediately north of the road in the site locations could indicate that till would be at shallow depths below the surface. Consequently, only test hole No. 4 was sited in the area adjacent to the shoreline. Test hole No. 5 is located just east of the access near a small kettle. The site location of the test hole No. 6 is just south of what used to be called "Flagstone". Reworked gravels may indicate better aquifer materials at shallow depths at this site. All three holes should be drilled to the river level, that is, 170, 180 and 165 feet deep for holes 4, 5 and 6, respectively. The holes are also located, respectively, 30, 40 and 40 feet above expected high water elevation in Lake Kootcanusa, i.e., elevation 2,490, 2,500 and 2,500 feet above sea level, respectively.

The groundwater potential at test hole sites 7, 8, 9 and 10 would be dependent largely on groundwater recharge from the eastern border mountains to the south of the Elk River and arrangements are being made by Mr. R.G. Harris to obtain the services of the Hydrology Division for a preliminary assessment of the watersheds draining from the border mountains to this eastern border area.

Test hole No. 7 is located in one of three alluvial fan deposits

(A, B or C on the surficial geology map accompanying these notes) Test holes 8, 9 and 10 are located in outwash deposits south of Grasmere, the depth of all four holes is expected to be less than 100 feet and the bottom of these holes will be well above expected high water in Lake Kootcanusa. Hole No. 9 is the only site selected within Indian Reserve boundaries.

Test holes No. 11, 12 and 13 are located in the central part of the project area in outwash deposits associated with meltwater channels. A limited thickness of more impermeable overlying glacio fluvial and lacustrine clay, silts and sands is expected in holes 11 and 13. Test holes 11 and 12 are expected to be less than 100 feet deep. Hole No. 13 is located less than 1/4 mile from Lake Kootcanusa and may receive limited recharge from this source. Therefore, the No. 13 test hole should be drilled to old river level, i.e., 240 feet deep. Elevation of hole No. 13 is 2,600 feet or 140 feet above expected high water level in Lake Kootcanusa.

Test hole No. 14 is located in the prominent terraced and channeled outwash plain situated between Elko and Red Canyon. The expected depth of this test hole is between 100 and 150 feet.

In summary, these 14 test hole sites have been selected for a preliminary test drilling program.

Hole Nos. 1-3 are expected to be 150-200 feet deep, hole Nos. 4, 5 and 6 are expected to be 170, 180 and 165 feet deep, respectively. Hole Nos. 7, 8, 9, 10, 11 and 12 are expected to each be 100 feet deep. Hole No. 13 is expected to be 140 feet deep. Hole 14 is expected to be between 100 and 150 feet deep.

Total minimum expected footage for 14 holes is 1,800 feet, the maximum footage expected is about 2,000 feet. Deepest holes expected are Nos. 1-3 which may be as deep as 200 feet, the minimum drilling depth in any

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hole will be about 100 feet. Note any future contract specifications should allow the field engineer to complete these holes at a lesser depth if required.

Estimated costs for the test drilling program are as follows:

Mobilization	$ 2,000
Site clearing (especially test holes Nos 5 and 11)	$ 1,000
Drilling and casing 6-inch diameter holes at $20.00 per foot	
Minimum 1,800 feet of drilling	$36,000
Maximum 2,000 feet of drilling	$40,000
Development and well completions	
Setting screen and development per hole	$ 500
Cost of screen and fittings per hole	$ 750
Cost for development and well completions in say 10 hole	$12,500
Total estimated cost of program	
Minimum	$51,500
Maximum	$55,500

No estimate is included here for costs of supervisory personnel and special well construction or drilling problems.

3. PRODUCTION WELL CONSTRUCTION AND ESTIMATED COSTS

Test production wells by cable-tool method would only be warranted, if results of test hole drilling are sufficiently encouraging. Only after the completion of the test hole program will it be possible to give meaningful cost figures for test production wells capable of supplying these limited acreages within the study area.

On the basis of our preliminary groundwater assessment some tentative costs have been prepared for production well drilling at the request of Mr. R.G. Harris. The production wells would have a minimum capacity (of 350 U.S. gallons per minute - enough to irrigate a 50 acre unit up

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to a probable maximum of 1,000 U.S. gallons per minute wells for irrigation of 150 acre units.

The following estimates were prepared by Mr. D.J. Johanson and give the construction costs for 100, 200 and 300-foot deep wells. It should be emphasized these figures are based on a number of assumptions which may prove to be invalid on the basis of data obtained from a test hole program

(1) Estimated costs for a 100-foot deep production well capable of delivery between 350 and 1,000 U.S. gallons per minute:

(a)	Drill and case 12-inch diameter hole to 100 feet at $34.00 per foot	$ 3,400
(b)	12-inch drive shoe	$ 150
(c)	25 feet of 12-inch screen at $140.00 per foot	$ 3,500
(d)	12-inch screen fittings	$ 205
(e)	Cost of setting and pulling test pump, moving on and off site - 40 hours at $32.00 per hour	$ 1,280
(f)	Standby - waiting on screen, etc. at $26.00 per hour - estimate 8 hours	$ 208
(g)	24 hour pump test at $24.00 per hour -	$ 576
	Cost of 100 feet deep 12-inch diameter well with 25 feet of screen and 24-hour pump test	$ 9,319

Note part of a $1,000 mobilization and demolization fee must be allotted to each well depending on number of wells drilled. A similar fee must be allotted for pump test equipment. No cost estimate is included here for supervisory personnel and special drilling and well construction problems.

(2) Estimated costs for a 200-foot deep production well capable of delivery between 350 and 1,000 gallons per minute.

Costs for this well will be similar to that for the 100-foot deep well given above except for item No. 1 (a)

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Drill and case 12-inch diameter hole to 200 feet at $34.00 per foot	$6,800
Therefore cost of 200 feet deep 12-inch diameter well with 25 feet of screen and 24-hour pump test will be $9,319 plus $3,400	$12,719

Mobilization charges as above
No cost estimate is included here for supervisory personnel and special drilling and well construction problems.

Costs for a 300-foot deep well would, if required, have to include additional costs for two casing sizes 16-inch and 12-inch. Estimated costs for a 300-foot deep well completed with 25 feet of 12-inch diameter screen and 24-hour pump test will be approximately $19,245. Mobilizations, supervision, etc., as mentioned above.

It was mentioned in the discussion of Clague's paper that the character of the sediments beneath the St. Eugene formation is not known, but that these sediments fill a structural basin near the Elk River, some 4,900 feet deep. These tertiary sediments have been outlined by gravity surveys (see Figure 6 of Clague's report attached) Clague feels these sediments lying below the upper till may be permeable enough to transmit abundant groundwater.

To evaluate this assumption would be very costly and could require further geophysical work and expensive deep rotary test drilling with heavy equipment.

J.C. Foweraker

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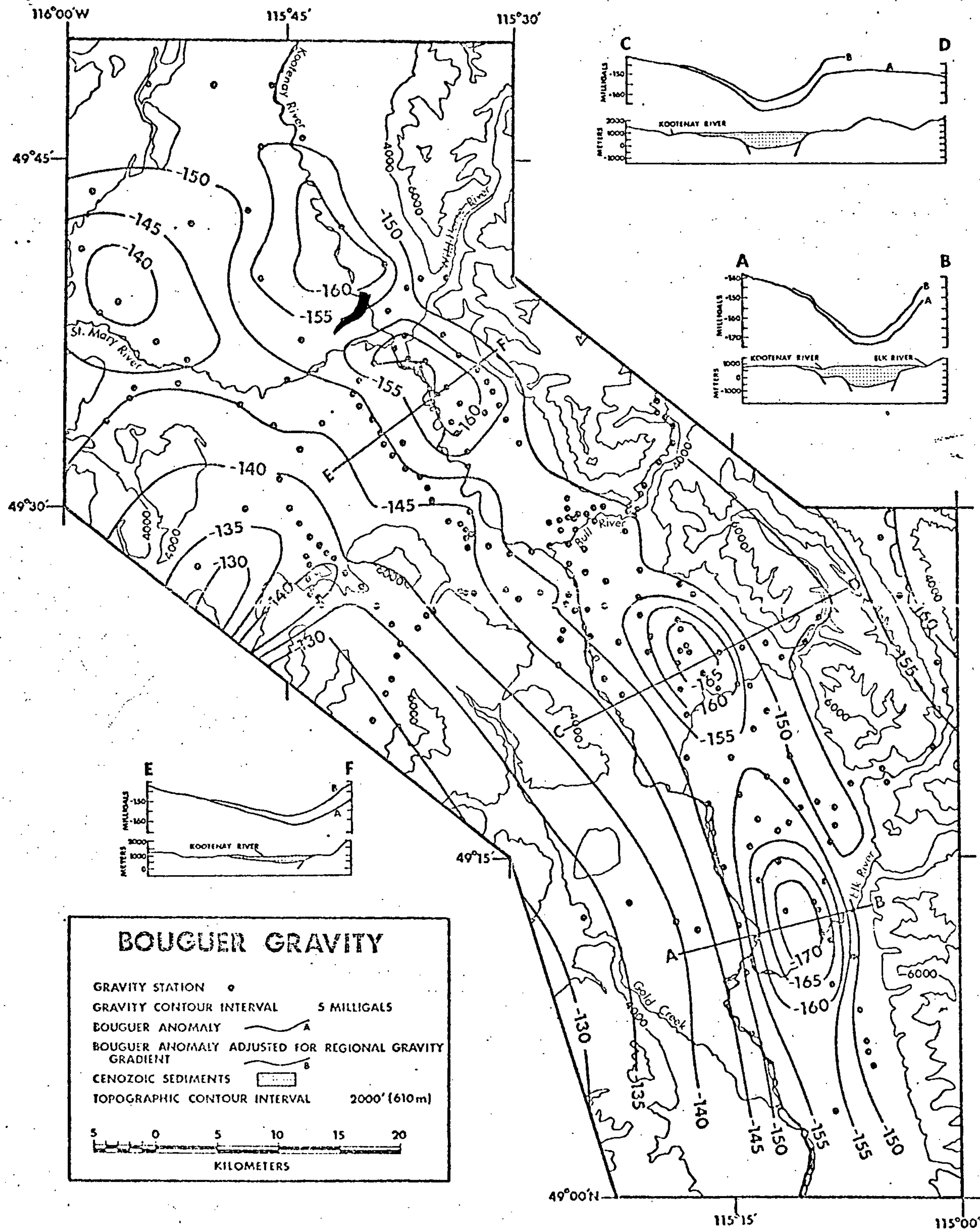
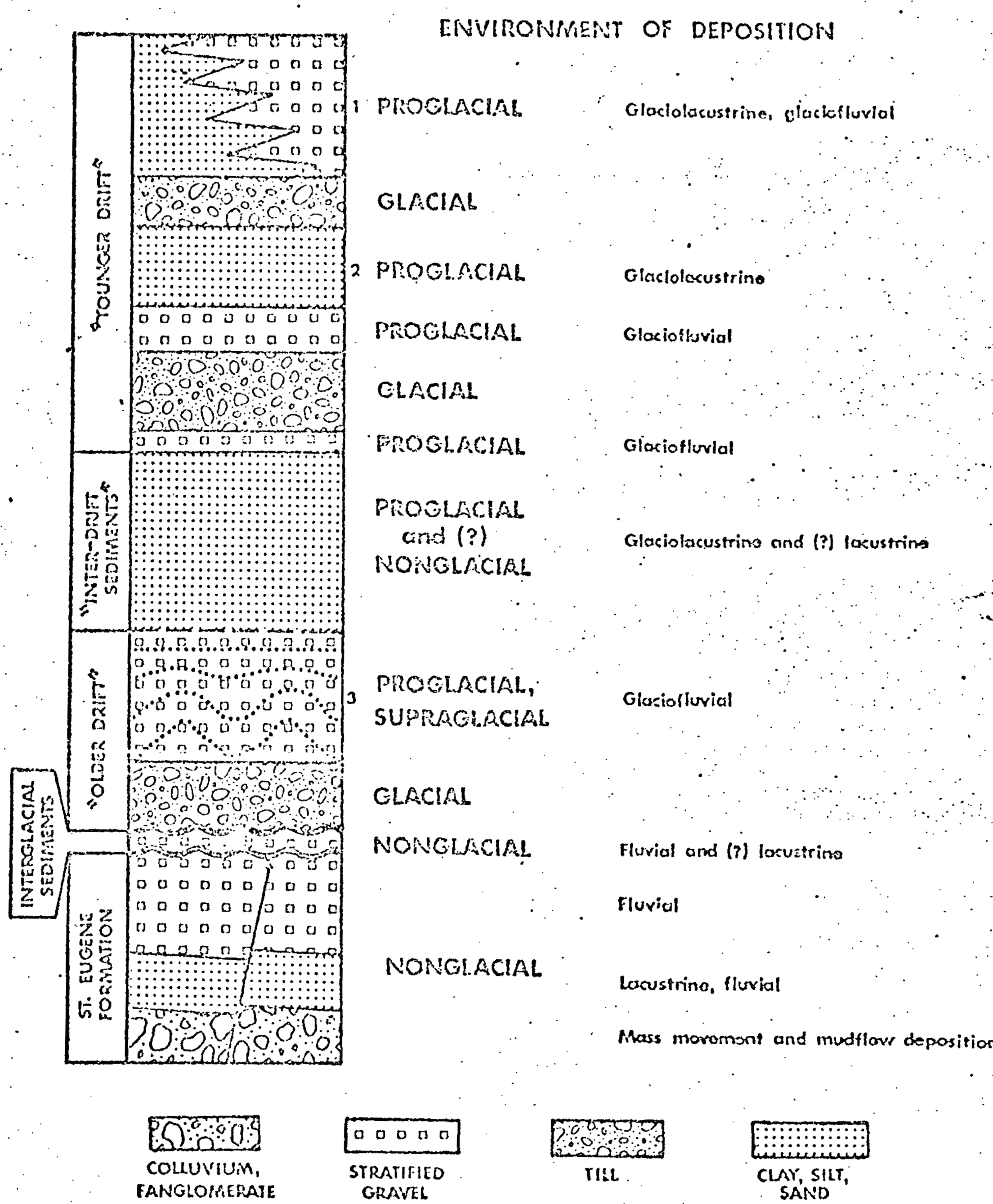


Figure 6. Map of Bouguer gravity in the southern Rocky Mountain Trench, and gravity profiles and inferred geologic sections across the Trench (from Thompson, 1962).



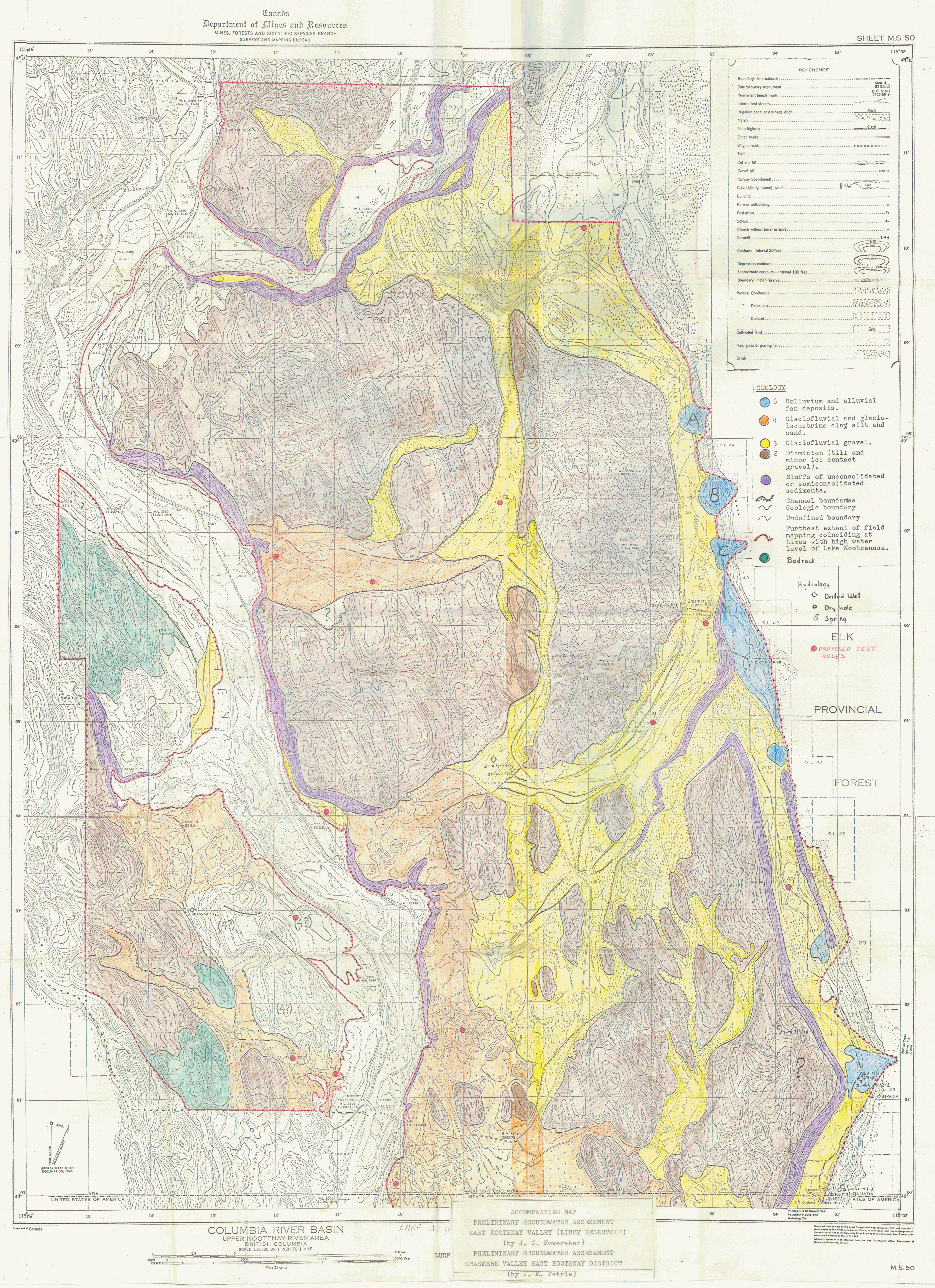
⊙ RADIOCARBON DATE — 26,800 ± 1000

[1] GLACIOLACUSTRINE SEDIMENTS PRESENT IN TRIBUTARY VALLEYS.

[2] SEDIMENTS PRESENT ALONG TRENCH MARGINS.

[3] SEDIMENTS PRESENT IN ROCKY MOUNTAIN TRENCH NEAR TRIBUTARY VALLEYS.

Figure 8. Composite columnar section of late Cenozoic sediments exposed in the southern Rocky Mountain Trench. Column heights are proportional to the maximum exposed thickness of each unit.


Canada
Department of Mines and Resources
MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH
SURVEYS AND MAPPING BUREAU
SHEET M.S. 50
REFERENCE
GEOLOGY
6 Colluvium and alluvial fan deposits.
4 Glaciofluvial and glacio-lacustrine clay silt and sand.
3 Glaciofluvial gravel.
2 Diamicton (till and minor ice contact gravel).
Bluffs of unconsolidated or semiconsolidated sediments.
Channel boundaries
Geologic boundary
Undefined boundary
Furthest extent of field mapping coinciding at times with high water level of Lake Koocanusa.
Bedrock
Hydrology
Drilled Well
Dry Hole
Spring
PROPOSED TEST HOLES
ELK
PROVINCIAL
FOREST
UNITED STATES OF AMERICA
CANADA
COLUMBIA RIVER BASIN
UPPER KOOTENAY RIVER AREA
BRITISH COLUMBIA
SCALE 1:31680 OR 1 INCH TO ½ MILE
ACCOMPANYING MAP
PRELIMINARY GROUNDWATER ASSESSMENT
EAST KOOTENAY VALLEY (LIBBY RESERVOIR)
(by J. C. Foweraker)
PRELIMINARY GROUNDWATER ASSESSMENT
GRASMERE VALLEY EAST KOOTENAY DISTRICT
(by J. M. Petrie)
M.S. 50
82 G/3