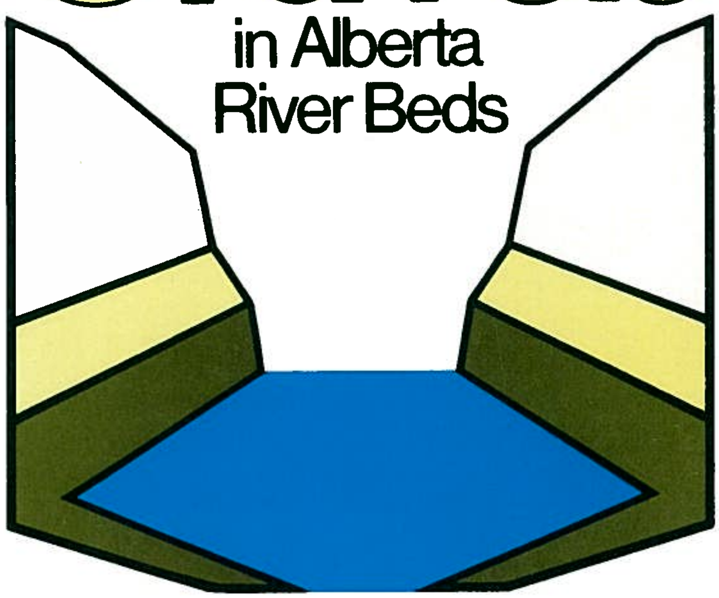
J. Shaw and R. Kellerhals

Bulletin 41

The Composition of Recent Alluvial Gravels in Alberta River Beds



Alberta Geological Survey

Alberta
RESEARCH COUNCIL

J. Shaw and R. Kellerhals

Bulletin 41

The Composition of Recent Alluvial Gravels in Alberta River Beds

Alberta Research Council
1982

ACKNOWLEDGMENTS

Our major gratitude is to Dr. L.B. Halferdahl who collected the data and carried out much of the primary compilation and analysis. Jean Frost, George Lovell, and Christine Stewart assisted with subsequent analysis. Peter Redberger carried out much of the computer work. We also thank Geoffrey Lester, Inge Wilson, Stephanie Kucharyshyn, and Kim Davis for the cartography and drafting.

Copies of this report
are available from:

Publication Sales
Alberta Research Council
5th Floor, Terrace Plaza
4445 Calgary Trail South
Edmonton, Alberta
T6H 5R7

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

ABSTRACT

A large data set of grain-size distributions and lithologic composition is presented for bed material in 12 Albertan rivers over a total sampled length of 7 500 km. The hydraulic, hydrologic, and geomorphic characteristics of the rivers are described briefly. Details of sample collection including geographic location and site descriptions are given. The data are presented in tables of grain-size distributions and percentage contributions of lithologic types to grain-size classes coarser than 2 mm. An estimate of significance of the constituent grain-size distributions is given. Eight grain-size parameters are estimated from the sample distributions: geometric means (DG) for the granite, limestone, quartzite, and total gravel fractions; and D_{50} and D_{90} for the total samples and the gravel fractions. Plots are given for downstream changes in lithological composition and grain-size parameters.

The downstream change in lithological composition reflects the relative resistance of quartzite and limestone in upstream reaches, and also illustrates the increasing importance of erratic, granitic Shield lithologies which have been introduced to downstream reaches by continental glaciation. The westward limit of Shield erratics in stream bed materials is used to estimate the maximum limit of Laurentide glaciers. These estimates are shown to correspond closely with mapped limits, with the exception of the Athabasca and McLeod estimates which lie much further west than the mapped limits. The variability of grain size in large gravel-bedded streams is treated by analysis of variance. Variance between samples (at a site) is highly significant, while downstream variance is even more significant. Downstream changes in grain size are considered in the course of this study in relation to the region's geomorphic history and the processes of differential fluvial transport and abrasion.

Three distinctive reaches are noted in the large, well-sampled rivers. The first, the mountain reach, in which aggradation in lakes and behind alluvial fans takes place, shows an increase in grain size as one moves downstream. Then, there is the central gravel reach which shows an exponential decrease in grain size with distance, corresponding to Sternberg's relationship. This central reach terminates abruptly, however, with a change from a gravel to a sand bed, which constitutes the third type of reach observed. The sand shows little change in size regardless of downstream location.

Diminution coefficients for rivers and alluvial fans are presented to show the dominant influence of differential transport in the aggrading fan environment. Comparison of diminution coefficients for various river gravels with abrasion coefficients established in controlled experiments, reveals that abrasion coefficients consistently underestimate diminution coefficients. Analysis, which uses diminution and abrasion coefficients for different lithologies, reveals that the abrasion coefficient for rivers can be subdivided into two components — "abrasion during transport" and "abrasion at rest." The analysis indicates that the condition of "abrasion at rest" is dominant in Albertan rivers. Grain-size distributions for alluvial gravels are commonly bimodal. The gravels of this study show a deficiency in the range from coarse sand to granules. This deficiency relates to the style of sediment transport, whether suspended or bed load.

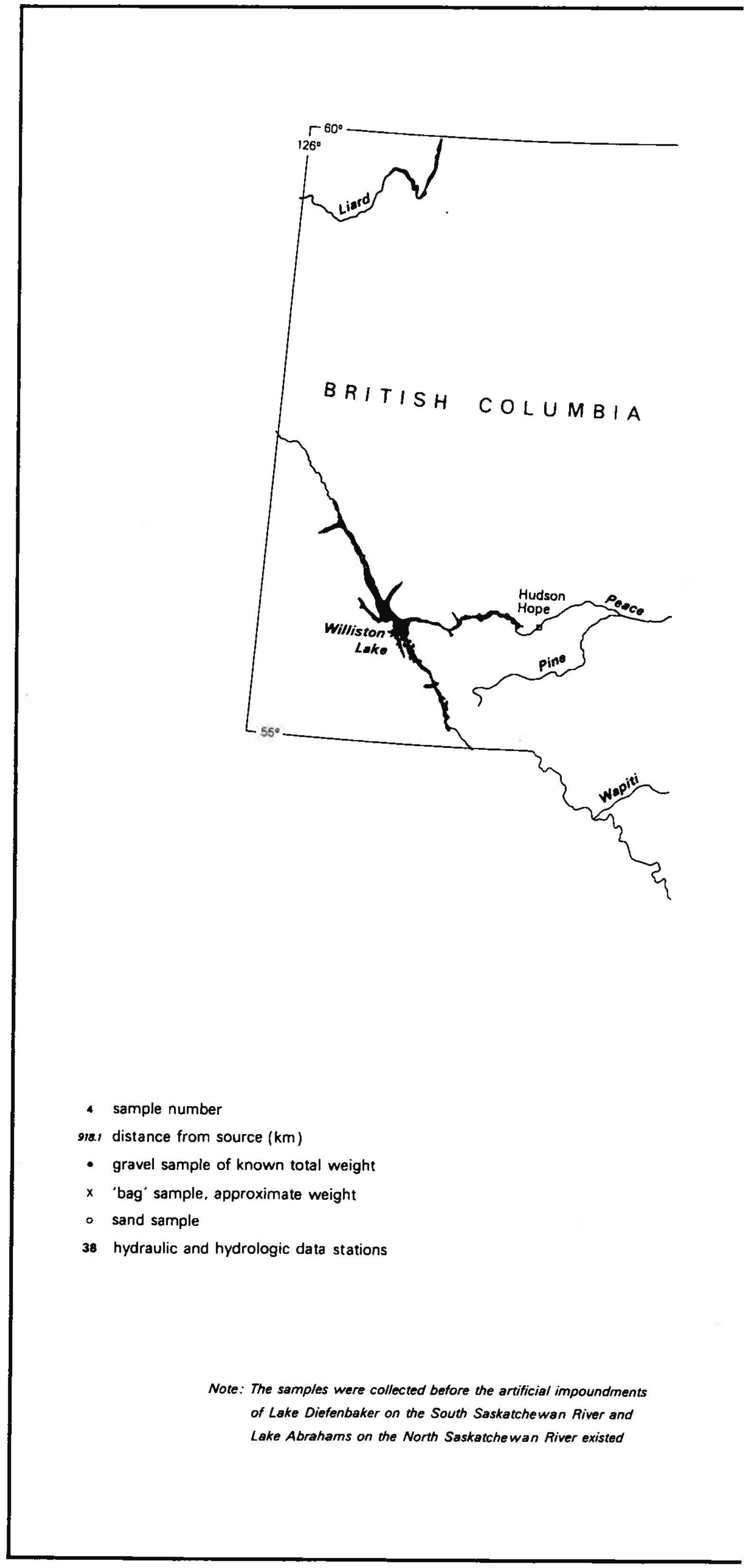
INTRODUCTION

BACKGROUND

During the years 1956 to 1965, L.B. Halferdahl of the Geology Division of the Alberta Research Council was engaged in conducting an extensive search for industrial minerals in recent alluvial deposits in the major rivers of Alberta, with some minor excursions into regions of Saskatchewan. Detailed lithological and grain-size analyses were carried out on 174 samples which were collected along 12 rivers having a total channel length of 7 500 km. Only those aspects of the data relevant to the primary objective of the study have so far been analyzed: Halferdahl (1969), in particular, discussed the possibility of utilizing as a source of industrial silica the almost 100 percent quartzitic gravels which are found along some river reaches. Also, considerable unpublished work on placer deposits of heavy minerals has been carried out. Kellerhals *et al.* (1972) gave a brief, tabulated summary of the grain-size analyses without any attempt at interpretation. It has long been the authors' belief that this massive set of unique data might be useful in solving several outstanding problems in fluvial sedimentology, besides being of practical value to those involved in Alberta river-engineering projects now in developmental phases. The two main objectives of the present report are therefore: (a) to present the data in a readily usable form and, (b) to make some initial analyses from a sedimentalogic point of view.

HYDROLOGY AND HYDRAULIC GEOMETRY

Both the amount and distribution of flows in a river and the hydraulic geometry of the river channel control the transport of bed materials and are, therefore, essential to any study of recent alluvial deposits. Extensive data on both streamflow and channel dimensions are available for all the rivers of interest in Alberta. Neill *et al.* (1970) presented a broad overview of streamflow regimes in Alberta from a purely hydrological point of view, assembling tabulated and graphical presentations of streamflow statistics for approximately 60 hydrometric gauging stations. Kellerhals *et al.* (1972) presented more detailed data on hydrologic, hydraulic, and geomorphic aspects of rivers in Alberta. The following two items are of particular interest in the context of the present study: 1) longitudinal river profiles, which will be discussed in the next section, and 2) a large table with extensive data (48 columns) on 108 surveyed river reaches located at hydrometric sites throughout Alberta, with 45 of these sites located on the rivers of this study.



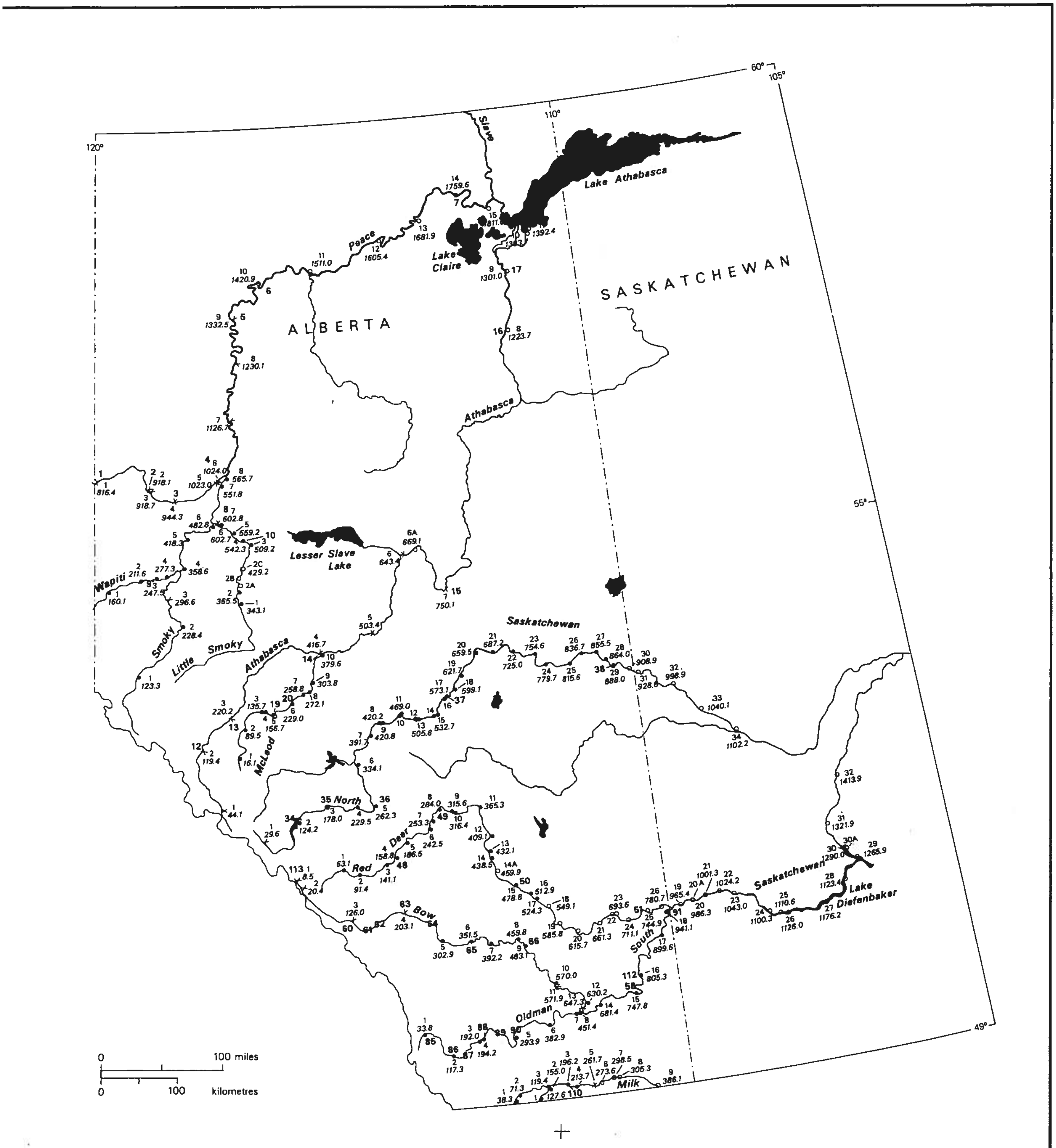


Figure 1. Location map

The hydrologic data consist of means, maxima, and minima of streamflows, as well as information on both flood frequency and flow duration. The hydraulic geometry is defined by a mean slope, and mean channel dimensions for five flows, including an estimate of bankfull conditions and comments on the representativeness of the surveyed reach for the river in the general region, are provided.

The geomorphic data consist of brief comments on the more prominent fluvial features along the reach and on active fluvial processes. Bed and bank materials are also described. Table 1 gives a brief summary of hydrologic and hydraulic data for these 45 river reaches. The locations of the reaches are indicated on figure 1 and described in table 2 (Appendix). The site numbers refer to the numbering system used in Kellerhals *et al.* (1972).

Recent alluvial deposits in Alberta's river valleys can, quite conceivably, be associated with any flow condition that has occurred since the valleys were excavated during deglaciation. Unfortunately, the paleohydrologic conditions of this time period are unknown. During deglaciation, flows were probably somewhat higher than at present but, with the time scale of deglaciation presently unknown, quantitative estimates of these flows cannot be made. One possibility is that the drainage of glacial lakes may have resulted in extremely large flows of short duration. However, incomplete evidence from postglacial lake sediments indicates there has been at least one period of extemely low water levels and likely, therefore, correspondingly low river flows (R. Green, pers. comm.).

Since the samples on which this study is based were collected from river beds in active river channels, there appears to be some justification for assuming that the hydrologic conditions of the last few decades, as summarized in table 1, and the vast majority of alluvial deposits described here are causally related. It is conceivable, however, that a few of the samples describe lag-deposits associated with earlier, different hydrologic conditions.

GEOMORPHOLOGIC HISTORY

In order to explain downstream changes in grain size and lithology, it is necessary to know something of the geomorphic history of an area. The pattern of grain size and lithology is generally related to the nature and provenance of the material supplied, as well as to the subsequent fluvial processes.

Rivers do not simply receive material at their source; tributaries and bank and bed erosion furnish load along the entire course. Primary source material which breaks down relatively rapidly may, however, not have a significant effect on the bed material. Such is the case for much of the Cretaceous bedrock from which most Albertan rivers have excavated their valleys. The sources of limestones and quartzites, which dominate the bed materials, are confined to a narrow belt of Proterozoic and Paleozoic sediments in the Rocky Mountains (Green, 1972). Thus, it might be thought that, in terms of provenance, the Albertan rivers are a simple case, with bed material supply being confined to the headwater reaches; unfortunately, this is not so. In the first instance, the Prairie physiographic region has been blanketed by quartzitic gravels ranging in age from the Oligocene Cypress Hills Formation to the Quaternary Saskatchewan gravels and sands. These gravels are associated with a variety of residual levels and are the product of multiple transport phases. Each phase of transport contributed to changes in grain size from the mountain source. Since present rivers receive material from these quartzitic gravels, bed material shows the effects of a complex fluvial history which cannot be reconstructed. In addition, the rivers obtain much of their sediments from glacial deposits which are products of a succession of Continental or Cordilleran glaciers. Owing to the complexity of the glacial history and the immense range of depositional environments during the Quaternary, the influence of glaciation on the fluvial environment is largely indeterminate. Sorting and attrition processes during glacial transport are very different from those in fluvial environments, and glaciers are also able to transport material up drainage slopes and across drainage divides, thus making interpretation a difficult task. The net result is that the rivers are furnished with relatively coarser material than would be available under purely fluvial activity and, in Alberta's case, exotic lithologies from the Precambrian Shield are added to the bed material. Consequently, bed material characteristics cannot be explained entirely in terms of fluvial processes.

Changes in grain size downstream are largely the result of either abrasion or differential transport. The relative importance of these two processes depends on whether the river is actively degrading, in which case abrasion is dominant, or aggrading, in which case differential transport dominates. Any explanation of the observed pattern of grain-size change in a river must therefore involve a description of the vertical movements of the stream.

The evidence for systematic vertical movements in Albertan rivers is varied. All Albertan river valleys contain suites of terraces which indicate former floodplain levels (Horberg, 1954; Rutter, 1966; McPherson, 1970; Westgate, 1969; Roed, 1968). There is some discussion as to whether terraces are paired and represent distinct stages, as suggested for the upper and lower valley trains of the Athabasca River by Roed (1968) and for the terraces of the North Saskatchewan near Edmonton as mentioned by Westgate (1969); or alternatively, whether a stage of more or less continuous downcutting produced unpaired terraces (McPherson, 1970). Nevertheless, terraces do show a net degradation. This is, however, only the latest event; closer inspection of the valleys reveals a more complex history. It is convenient then to consider first the mountain reaches and then the plains.

The major valleys of the Rocky Mountains exist as a consequence of downcutting associated with orogenesis; but glaciation has interrupted the fluvial denudation process on several occasions. Glaciers over-deepened certain valley reaches producing numerous lake basins, most of which are now infilled. During deglaciation, deposition replaced erosion as the dominant process. Valley fill, comprised of a complex of till, glaciofluvial and lacustrine deposits, is found in all the major valleys.

With the end of glaciation, sediment supply diminished because of reduced glacial erosion, lacustrine sedimentation in some upper reaches, and vegetation colonization. Degradation has resulted along many mountain reaches. However, local effects such as those from alluvial fans of tributaries or from slides still cause numerous changes from aggrading to degrading conditions over short distances.

On the Plains, the present valley floors are below residual levels, which are themselves underlain by quartzite gravels, and situated below plains surfaces, underlain again by complexes of glacigenic sediments. The preglacial valleys were similarly incised (Farvolden, 1963). Babcock (1973, p. 1770) used joint patterns to postulate recent, widespread epeirogenic uplift in the plains regions; and it is possible that incision is explained, in part, as a response to this uplift. The preglacial valleys were partly or wholly filled with glacigenic sediments. In some cases they have been re-excavated and deepened further; alternatively, new postglacial valleys have been incised below the plains surface. Near Edmonton for example, the North Saskatchewan River deposited gravels at the plains level (Bayrock and Hughes, 1962) and later cut the present postglacial valley.

It can be assumed that incision has been the predominant postglacial process in the plains reaches. Figure 2, adapted from Kellerhals *et al.* (1972, Fig. 2-3), shows the depth of incision of the major rivers of this study below the surrounding land surface. Comparison of depth of incision along reaches occupying postglacial valleys and those occupying preglacial valleys (Farvolden, 1963, Fig. 15, p. 65) reveals a greater depth of incision along postglacial valleys compared to adjacent preglacial sections. A further complicating factor, however, must be considered in the eastern part of the Plains. As the continental ice was thicker toward the northeast, isostatic depression was greatest in the downstream sections of Albertan rivers. In immediate postglacial times, these downstream sections must have been oversteepened (Fig. 3) compared to interglacial and preglacial rivers. Some indication of the magnitude of this effect can be obtained from the free air anomaly map presented by Walcott (1970). In the area southwest of Hudson Bay, there is a difference in the anomaly of -30 milligals over a distance of 768 km. Using Walcott's assumption of displacement of mantle material of density 3.3 g/cm^3, the land-surface slope toward the northeast is increased by 0.00027. A similar effect could have occurred in the eastern part of Alberta at the end of the Wisconsin glaciation, thereby doubling the preglacial stream slopes in the period immediately following deglaciation. Oversteepening causes increased downcutting and figure 3 illustrates how this may lead to a remnant steepened zone or knick point. Following isostatic rebound, the downstream reaches may have entered into an aggrading phase, and this could have some bearing on the location of the abrupt transition from gravel to sand-beds in the South Saskatchewan, Red Deer, and North Saskatchewan rivers (Fig. 3).

THE BASIC DATA

SAMPLE COLLECTION AND ANALYSIS

The procedures followed in collecting and analyzing the 174 samples are described by Halferdahl (1969, p. 3):

> The samples from which the data presented in this report were obtained were collected during a large project on the composition of alluvial sediments in Alberta. The samples were collected systematically where convenient along each of the rivers studied. The coarsest gravel at any place was selected for sampling, and the places sampled were the top foot or so of the river beds as far from the bank as possible at low water: in general, at the upstream end of island bars, at the middle of point bars, and in straight stretches, in order of decreasing preference. Some samples were collected at more than one of these types of places or other types of places such as

Longitudinal profile of the Athabasca River

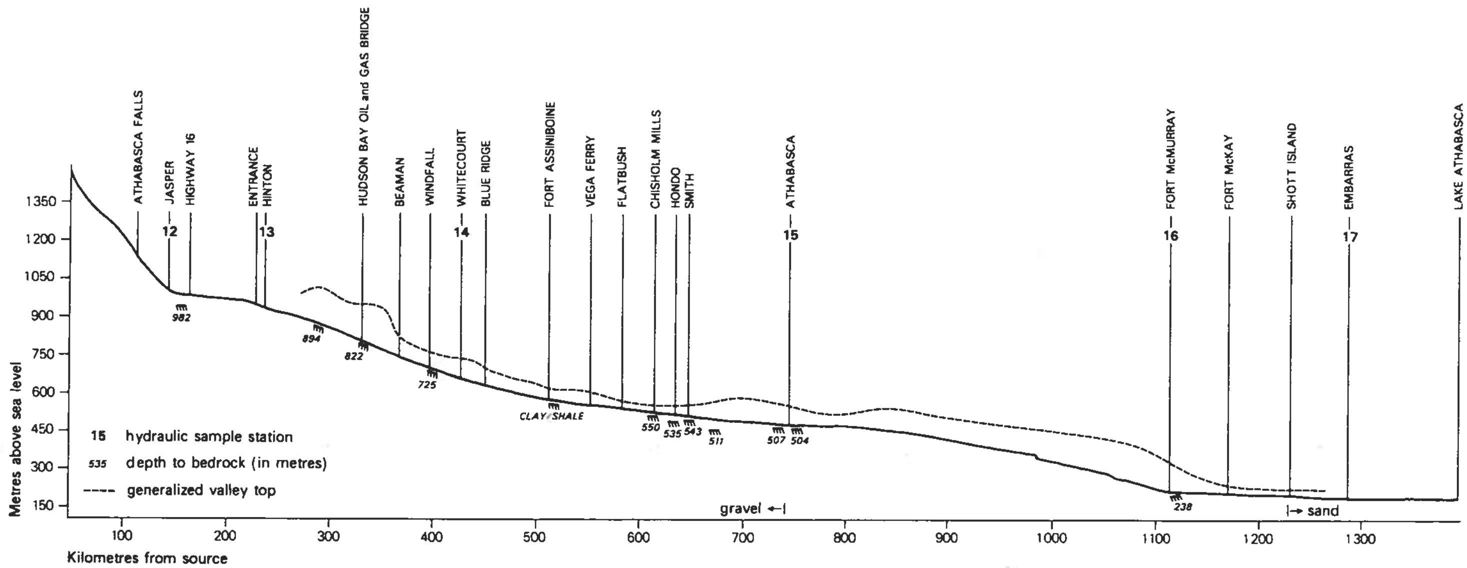
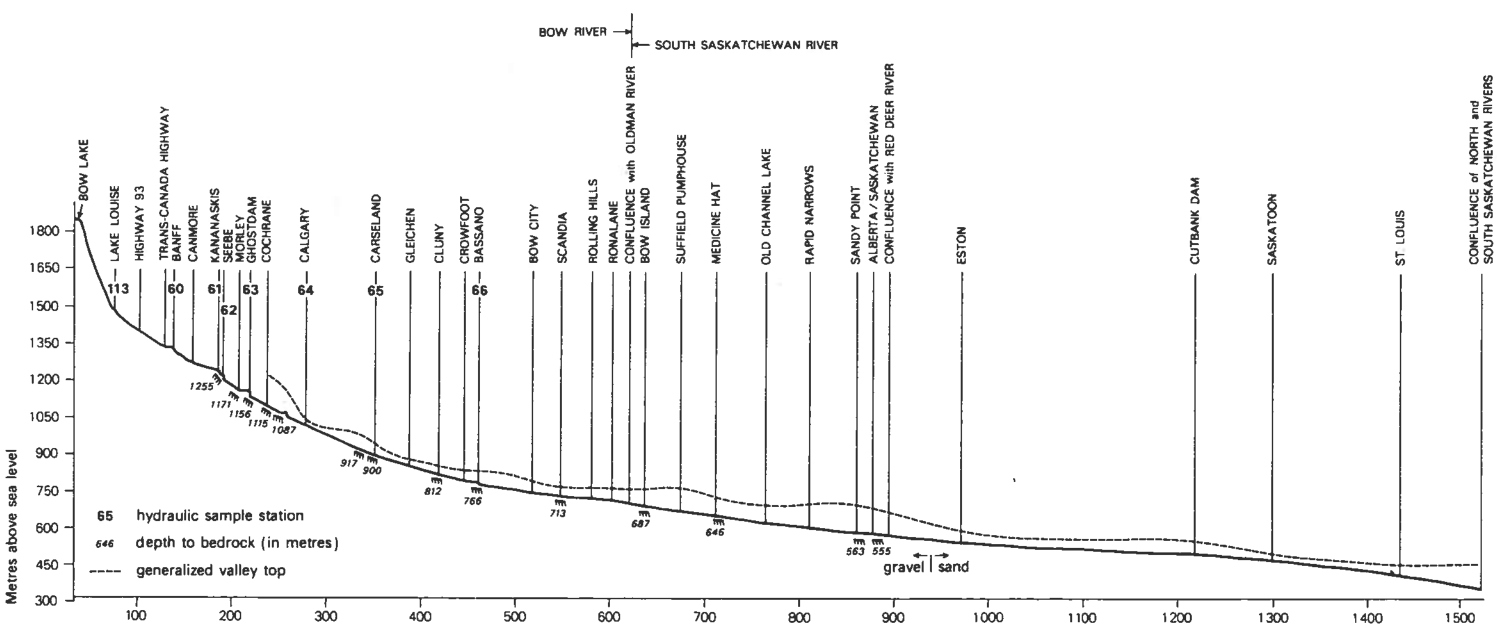


Figure 2. Long profiles

Longitudinal profile of the Bow and South Saskatchewan Rivers



Longitudinal profile of the North Saskatchewan River

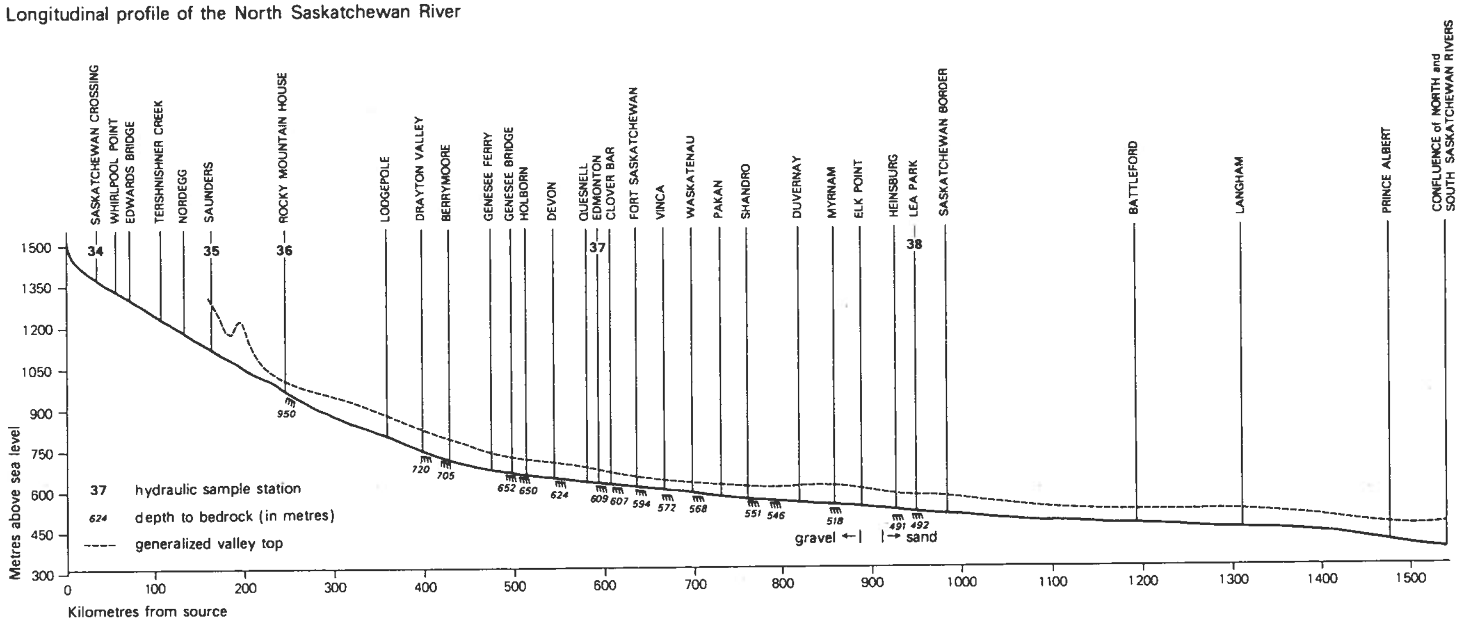
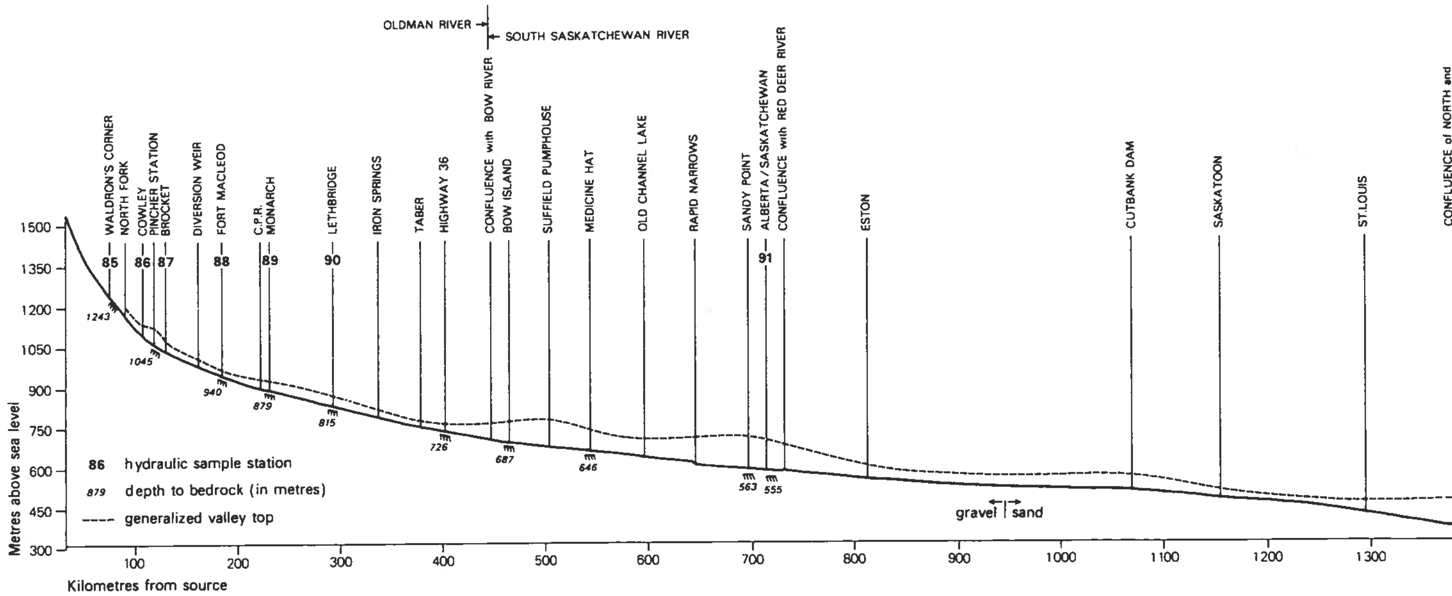


Figure 2. (continued)

Longitudinal profile of the Oldman and South Saskatchewan Rivers



Longitudinal profile of the Peace River

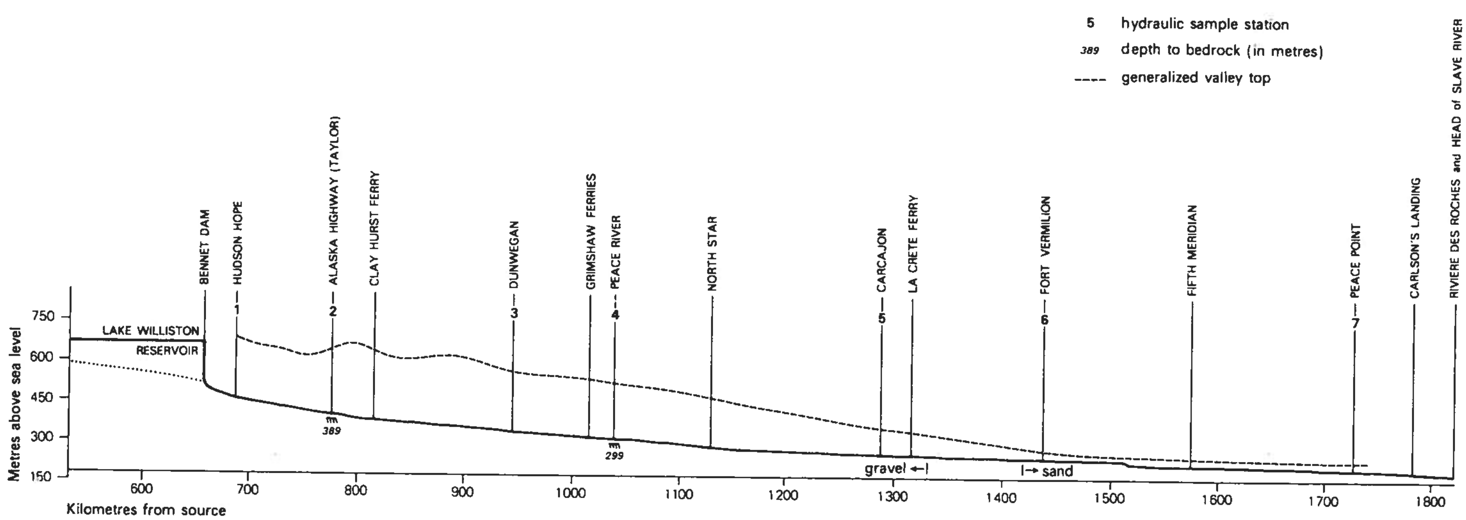
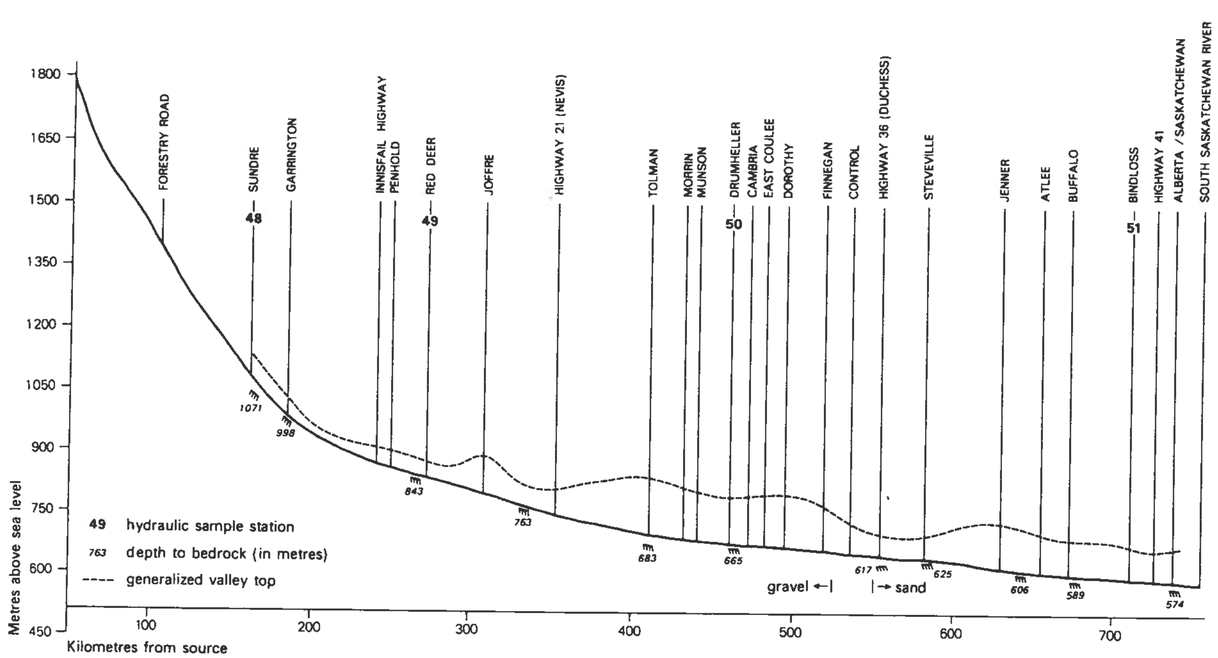


Figure 2. (continued)

Longitudinal profile of the Red Deer River



the sides of island bars in the same general locality . . . At sample locations along most of the rivers, the coarser fractions of gravel samples ranging in volume from 1.0 to 8.0 cubic feet (depending on the coarseness) were sieved and sorted into several lithologic types in the field. Parts of the finer fractions were sieved and sorted lithologically in the laboratory. Data for samples from the Athabasca and Peace rivers, the upper part of the Bow River, and one place on the Smoky River were obtained from smaller samples of about 40 pounds in the laboratory and so can be expected to be less precise than those from other rivers. At many of the sample sites, the dimensions, weight, and lithology of the largest pebbles, cobbles, or boulders within 30 feet or so of the place sampled were recorded. At some sample locations, cobbles or boulders which were judged to have reached their present positions by means other than movement by water flowing in the river were not included.

Table 3 gives a brief summary of the data and shows the number of samples from each river and the average sample spacing. Pairs of samples were collected occasionally within 3 km of river chainage to investigate the effects of sampling from geomorphologically different sites (for example, point bars versus mid-channel bars). But the number of such pairs proved to be insufficient for any meaningful conclusions. Pairs are treated as one sample when computing "average spacing" in table 3. Elsewhere, all samples are given equal weight.

The sorting into lithologic types was done for all sieve fractions down to the 2 mm (-1ϕ) size. For the finer fractions, down to 0.062 mm (4ϕ), there are only sieve data available. The sieve interval used was 0.5ϕ from 0.062 mm (4ϕ) to 2 mm (-1ϕ) and 1ϕ from 2 mm (-1ϕ) to 512 mm (-9ϕ).

PRESENTATION OF DATA

Grain-size Distributions (Sieve Curves)

All grain-size data are listed in table 4 in terms of "percentage retained" on each sieve. Exact total sample weights for the earlier, relatively small samples are not available and appear as "-1" in the table. In figure 4, all 174 sieve curves are superimposed and histograms are given for combined river data (Figs. 5 and 6), while figure 7 shows the data for the North Saskatchewan River both as histograms and as cumulative frequency (sieve) curves.

In figure 8, the size distribution data for the 125 samples with significant gravel fractions (more than 20% > 2 mm) are plotted against thalweg chainage for all 12 rivers. Samples containing mainly sand are ignored.

Lithologic Composition

The lithologic components of all gravel fractions (coarser than 2 mm) in samples containing significant amounts of gravel are listed in table 5. Unknown sample weights appear again as "-1", while in the table of percentages, "-1" indicates "trace." The left "total" column is identical to the percentages listed in table 4.

The lithologic data for an entire river are difficult to present graphically because the data set is essentially three-dimensional (river chainage - grain-size - lithology). The changing lithology along all rivers, ignoring aspects of grain size, is presented in figure 9 for the six main constituents, and in figure 10 for the remaining four minor constituents.

Figure 11 shows the changing contributions of the three main constituents, limestone, quartzite and granite, while ignoring all others. This type of plot reduces scatter because some samples show significant fractions of sandstones and shales derived from local bedrock which persist for only short distances downstream from major bedrock banks under active river attack. The grain-size distribution of the three main constituents is illustrated in figure 12 for the North Saskatchewan River only.

Significance of Samples

Although Halferdahl attempted to collect large and representative samples, the coarseness of the gravels and the two-dimensional partition by both size and lithology result in rather small sample contents in many of the final partitions. Both the overall grain-size distribution and the overall lithologic partitions should be acceptable for all those samples for which a sample weight is stated, but the significance of many constituent grain-size distributions is doubtful.

To provide some means of assessing the significance of the constituent grain-size distributions, they were tested against two rather lenient criteria.

Initially, the number of grains in each partition was estimated by assuming that all grains are spherical with a specific weight of 2.65, and have a diameter equal to the geometric mean of the size limits. Missing sample weights were assumed to be 20 kg (see Section, "Sample Collection and Analysis"). A table, listing all grain number estimates is available on request.

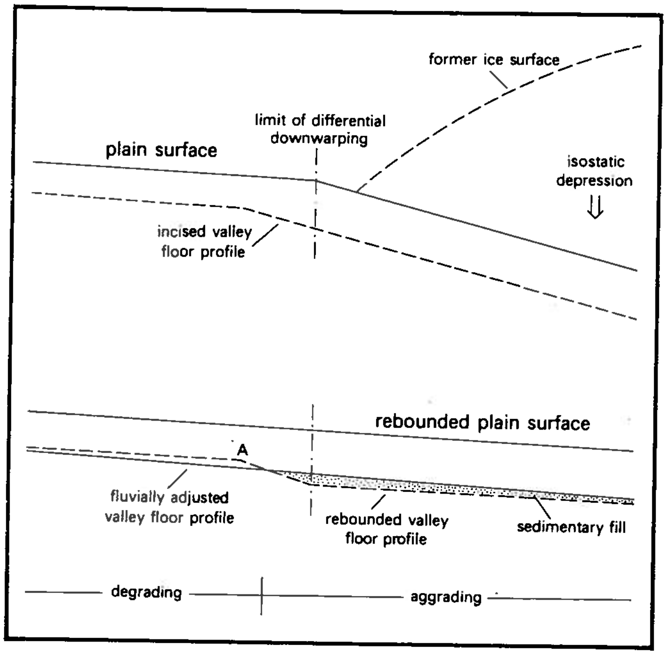


Figure 3. Effects of isotasy on stream long profiles.

Tests were then performed to see (a) whether the largest size fraction of any lithology contained at least four particles; and (b) whether the weight of one particle in the largest size fraction of each lithology is less than 10 percent of the total weight for the lithology.

The test results are shown in table 6. Failure is indicated by an "X", with the first test result being printed on the left. The vast majority of samples fail one or both tests, indicating that considerable scatter in the results is probably attributable to inadequate sample size.

Grain-size Parameters

Grain-size variations along a river channel can be considered on the basis of plots such as figure 8, but it is more customary to characterize each size distribution with some parameters such as a mean or a median value, and to base the analysis on the variations of these parameters. Eight such parameters have been computed for the present study: geometric means, DG, for the granite, limestone, quartzite and total gravel fractions, and also D_{50} (median) and D_{90} (90 percent finer than) for both the total samples and the gravel fractions. The results are listed in table 7 and plotted against distance in figure 13.

Additional Grain-size Data for Peace River between Hudson Hope and Alberta Border

Of the 12 rivers considered here, only the Wapiti and Peace rivers do not originate in Alberta. The Peace River originates west of the Rockies in the Omineca Mountains, the other 11 rivers rise in the Rockies. An extensive set of bed material grain-size data exists for the 138.4 km reach of the Peace River from the Alberta border upstream to Hudson Hope, British Columbia where the river emerges from a postglacial bedrock canyon (Church and Kellerhals, 1978). The data consist of 10 sieve curves and 78 grid samples from sites selected according to the criteria stated previously. The sieve curves are based on sample size criteria and sieving procedures closely corresponding to those of Halferdahl, and the grid samples consist of measured intermediate axes of 50 stones selected at grid points (foot marks of a survey tape stretched across the area to be sampled) as suggested by Kellerhals and Bray (1971). The grid samples are grouped with one to four separate samples at each of 39 locations.

The data are mentioned here because they extend grain-size (but not lithology) coverage along the Peace River to the Foothills. Also, the grouped data allow separation of the observed grain-size variability into components. In this paper only D_{90} and D_{50} of the sieve samples are presented (Table 8).

THE RESULTS OF THE ANALYSES

LITHOLOGY

The Nature of the Bedrock Geology

The lithologic composition of river bed gravels depends largely on the composition of the coarse material supplied and the durability of the components. For instance, if large quantities of a durable material are supplied to a river, then this lithology will be represented in the bed material at extensive downstream distances. Less durable materials may be supplied in such large quantities that they dominate the bed material composition at the outcrop location. However, they are broken or abraded to less than 2 mm after short transport distances, and consequently, their contribution to the gravel fraction is only local. Complications are introduced by burial, which enhances the influence of local lithologies, and by the formation of lag concentrations of lithologies of high specific gravity.

Green (1972) describes the major bedrock lithologies of Alberta. The major lithologies of the Rocky Mountains

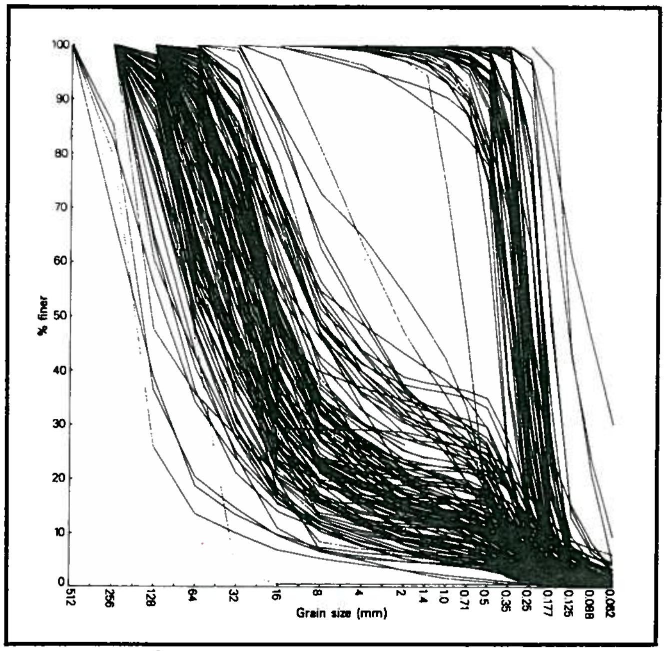


Figure 4. Cumulative grain-size distributions

and Foothills show systematic change from generally non-resistant to resistant lithologies with increasing age. Shales, mudstones, and sandstones are the primary lithologies of the Cenozoic and Late Mesozoic rocks. Dolomite and limestone form major components of the Mesozoic rocks of Early Cretaceous and older ages. Limestones are dominant in the Late Paleozoic, and quartzites compose large thicknesses of the Early Paleozoic. The Proterozoic rocks are characteristically well-indurated argillites, limestones, dolomites and quartzites. In Central and Eastern Alberta, only Cenozoic and Late Mesozoic rocks are exposed at the surface. The dominant lithologies are mudstones and shales, although sandstones, usually poorly indurated, and concretionary ironstones are important locally. Coal and bentonite beds also occur, and hills commonly carry a cap of conglomerate or gravel of Tertiary age.

The North Saskatchewan River Valley Gravels: A Typical Case

Taking the North Saskatchewan River as an example and using Green's symbolization (1972), we note that in the headwaters the river flows parallel to the strike and is confined to relatively few stratigraphic divisions, namely Pzl and Pzu. The river then cuts eastward across the strike and across rapidly repeating outcrop patterns produced by numerous thrust planes. From west to east the outcrop succession is Pm, Pzl, Pm, Pzl, Pm, Mz, Pzu, Pm, Mz, Pzu, Mz, Pzu, Pzl, Mz, Ka, Mz, Ka, Mz, Pzu, Ka (Green, 1972). In its middle and lower reaches within Alberta, the North Saskatchewan River flows generally northeastward across broad outcrops of gently dipping Tertiary and Cretaceous beds (Tkp, Ksc, Kwb, Kbr, (Kbp?), Klp (Green, 1972)).

The headwater reaches are confined to Proterozoic and Paleozoic rocks which are predominantly limestones and quartzites. Figure 11 shows the dominance of these two lithologies in the bed material of the upper reaches. However, it is clearly apparent that quartzite is much more persistent than limestone in downstream samples. As will be discussed more thoroughly in a following section, this is a direct result of the greater resistance to wear of quartzite compared to limestone. There is an increasing proportion of sandstone in the bedrock outcrops of the Foothills, particularly the Triassic, Jurassic, and Early Cretaceous strata. Consequently, sandstone attains extremely high local proportions (sample number 3, Table 5). The effect is local due to the friable nature of the sandstones which break down to their constituent grains after only short distances of transport. The Tertiary and Cretaceous rocks of the Plains continue to contribute some sandstone, but they mainly comprise argillaceous sediments which contribute little to the river bed materials. A major exception is the occurrence of concretionary ironstones in the eastern outcrops, Kbr and Klp. The sudden, and in some cases large, contributions of the minor constituents (Fig. 9) in the central and eastern reaches of the river are usually attributable to an influx of ironstone (Fig. 10). It is noteworthy that, at the point where the ironstone proportion is highest, the river is flowing in a bedrock channel eroded postglacially. The ironstones tend to fracture easily and so break up after relatively short distances of transport. Consequently, as was the case for sandstone, their influence on the bed materials is local only. Nevertheless, it is common to find gravel bar surfaces dominated by ironstone, and it may be that their local influence is enhanced by their appearance as lag concentrates.

In broad terms, all the rivers flowing through the full range of outcrops show patterns of bed material similar to that in the North Saskatchewan River. An additional factor is introduced in the South Saskatchewan system. Basic volcanic rocks are characteristic of the Proterozoic Purcell group and also occur in the Mesozoic Blairmore group. These volcanic rocks contribute considerably to the South Saskatchewan system, particularly by way of the Oldman River. The downstream persistence of the volcanics, despite their relatively low proportions, indicates high durability.

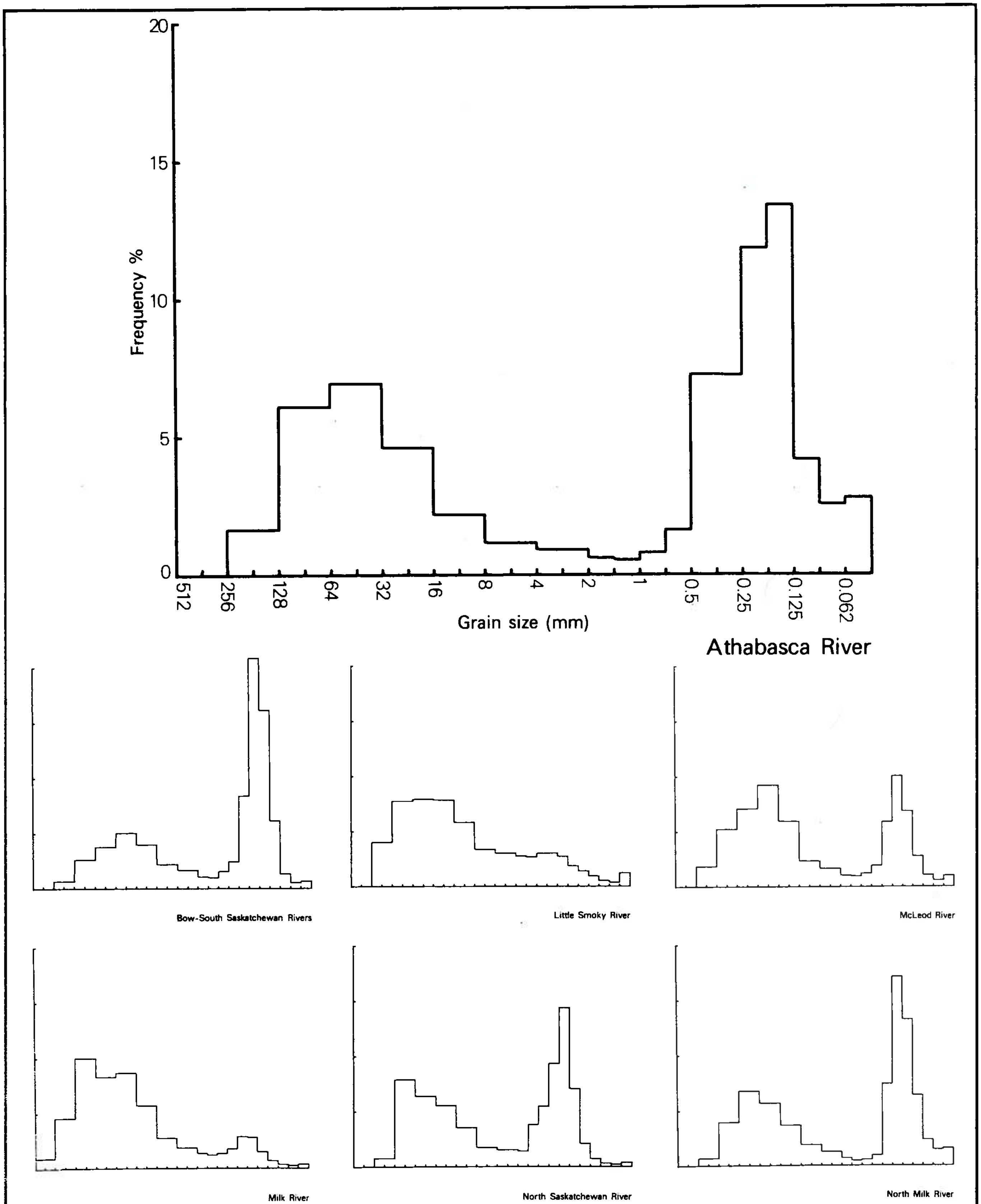


Figure 5. Histograms of grain-size distributions. All samples for each river combined, and all samples for all rivers combined.

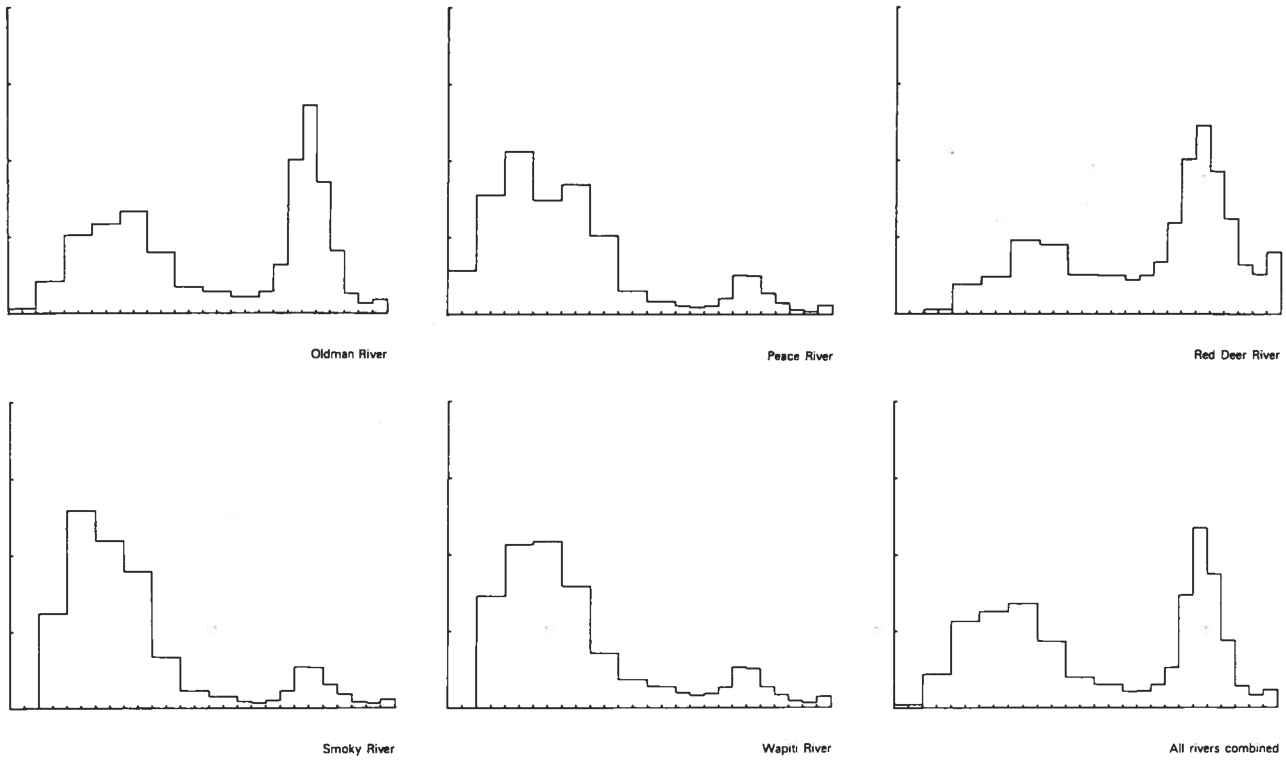


Figure 5. (continued)

The Influence of Glaciation on Lithologic Composition of Gravels

To this point no mention has been made of the major influence of exotic lithologies introduced by continental, Laurentide glaciation. Granite and gneiss pebbles (simply referred to as granite in this report) and Paleozoic carbonate rocks appear in increasing quantities toward the east. These lithologies are derived exclusively from Laurentide glacigenic sediments which have been reworked by fluvial processes. In the eastern reaches, the granite proportions are commonly of the same order as those of the quartzites; and generally, the granite fraction increases progressively as the quartzite fraction declines (Fig. 11).

The problem of fixing the maximum western extent of Laurentide ice is generally approached by field-mapping surficial deposits. The nature of the eastward drainage of Alberta implies that the most westerly occurrence of Laurentide erratics can be taken as an approximation of the ice margin at maximum advance. Unless the deposits can be assigned to a reliable lithostratigraphic system, the age of the ice maximum remains unknown. The information in table 5 provides an alternative method for assessing ice maxima. The maximum limit is expected to occur upstream of the last site at which Precambrian granites and high-grade metamorphic rocks are recorded. The wide spacing of sample stations implies that the ice limit will not be fixed precisely. However, figure 14 illustrates that comparisons with field-mapped ice marginal positions are remarkably good for the Red Deer, Bow, Oldman, and Smoky rivers (Harris and Boydell, 1972; Stalker, 1962; Bayrock, unpublished). In each case, the mapped position lies between the last station recording granite and the next station upstream. Thus, it is surprising that bed material results suggest a much greater extent of Laurentide ice in the McLeod and Athabasca valleys than indicated by Roed's mapping (1970). Roed mapped only surface exposure, and therefore, it is possible that buried Laurentide tills extend farther west than the boundaries shown (Fig. 14). It is also possible that some of the metamorphic rocks carried into the Athabasca valley from across the continental divide (Roed *et al.*, 1967) were incorrectly classified as granites causing an apparent discrepancy in the westward extent of the Laurentide ice. However, this explanation does not apply to the McLeod valley which shows a westward ice limit similar to that in the Athabasca valley. Although the findings are not conclusive, it appears that the proposed estimate of maximum ice extent in the North Saskatchewan River valley and more southerly river valleys is reasonable, but the limit of Laurentide ice in some of the more northerly valleys may lie to the west of limits previously proposed.

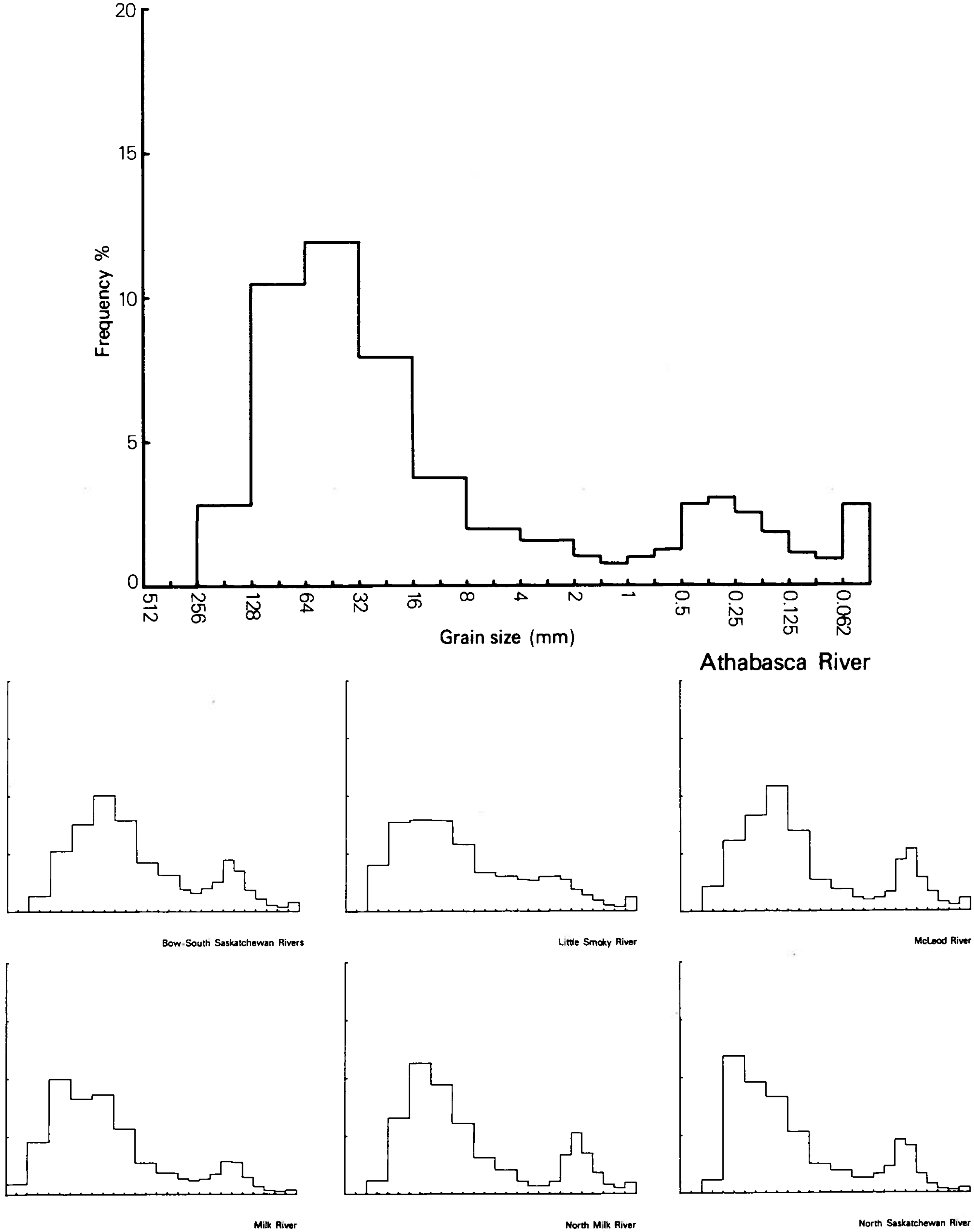


Figure 6. Histograms of grain-size distributions. Gravel samples (D_{50} >2mm) for each river and all rivers combined.

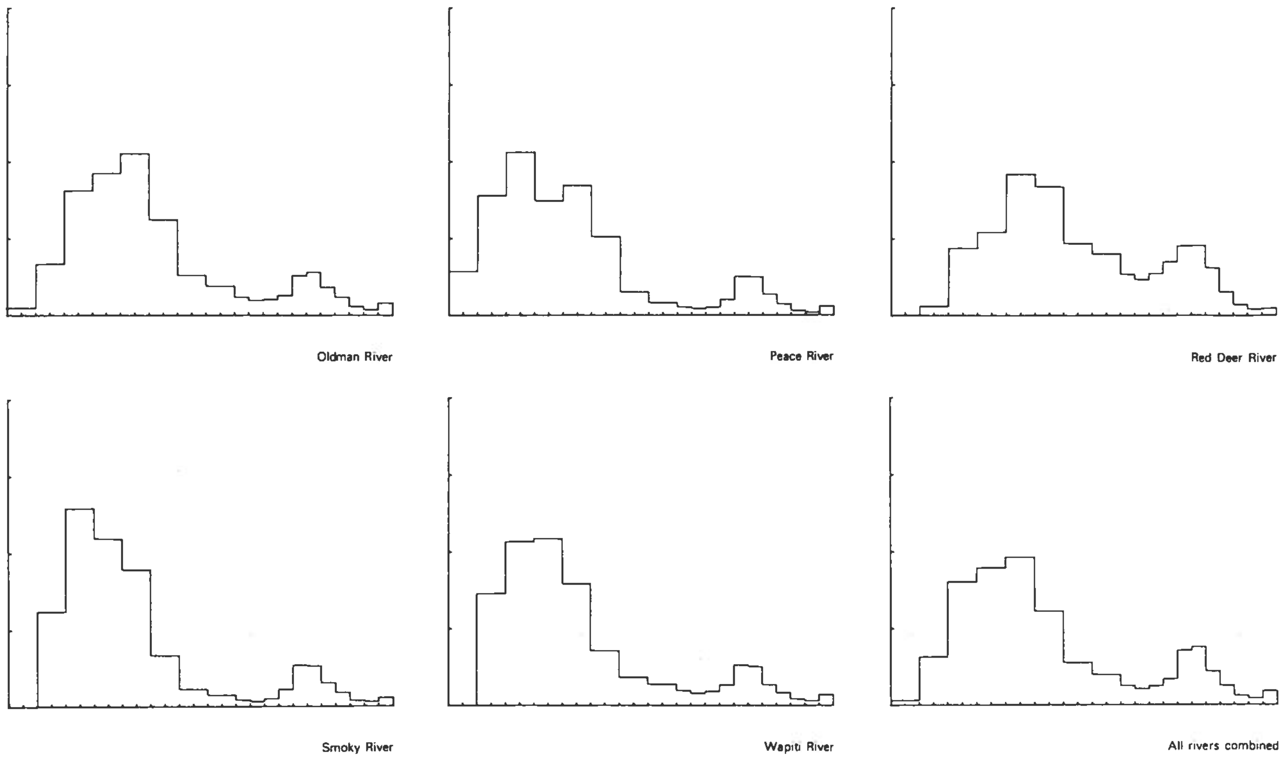


Figure 6. (continued)

In the Peace River valley, preglacial gravels contain granites and volcanic rocks which were derived from the interior of British Columbia (R. Green, pers. comm.). If this is true for the Athabasca valley, it might explain the discrepancy between previously mapped ice limits and the distribution of erratic lithologies.

VARIABILITY OF GRAIN-SIZE IN LARGE GRAVEL-BEDDED STREAMS

Statistical Aspects of defining Grain size

Before discussing the physical aspects of downstream changes in grain size (see following section), the statistical aspects of defining grain size and its variation along a river will be considered briefly. Church and Kellerhals (1978) addressed this topic in a detailed study based on 78 grid samples of 50 stones each, conducted along the 130 km reach of the Peace River between Hudson Hope, British Columbia and the Alberta border. Some of their conclusions should be applicable to the present data since their grid samples, with frequencies determined by number, are geometrically equivalent to sieve samples with frequencies determined by weight (Kellerhals *et al.,* 1975). Bray (1971) also showed that grid samples give size distribution curves closely similar to sieve curves for the same material, as long as all material finer than 8 mm in the sieve sample is ignored.

Since the standard deviation of a grain-size parameter, D, in the grid samples was found to increase linearly with D, the data were logarithmically transformed to eliminate this dependence. The 78 samples come from 39 sites, with up to four samples per site. A site was defined as a geomorphologically homogeneous area (for example, the upstream zone of a mid-channel bar) of apparently homogeneous materials. Each site might be up to 100 m^2, but was generally less. With such grouped data it was possible to split the overall variance of stone size into three components, as shown in table 9. The main points to note are: (a) the variance between samples (at a site) is highly significant and (b) variance is much larger than one would expect as a result of chance alone. This would suggest that there is considerable grain-size variation even within the apparently homogeneous sample sites. Downstream variation is even more significant, thereby justifying the search for a physical explanation of a downstream grain-size decrease.

The simplest possible situation is linear variation with distance according to the equation

$$\ln D = a_D\, x + \ln D_0 \qquad (1)$$

Fitting this equation to the observed values of both D_{90} and D_{50} gives similar results. In both cases the regression

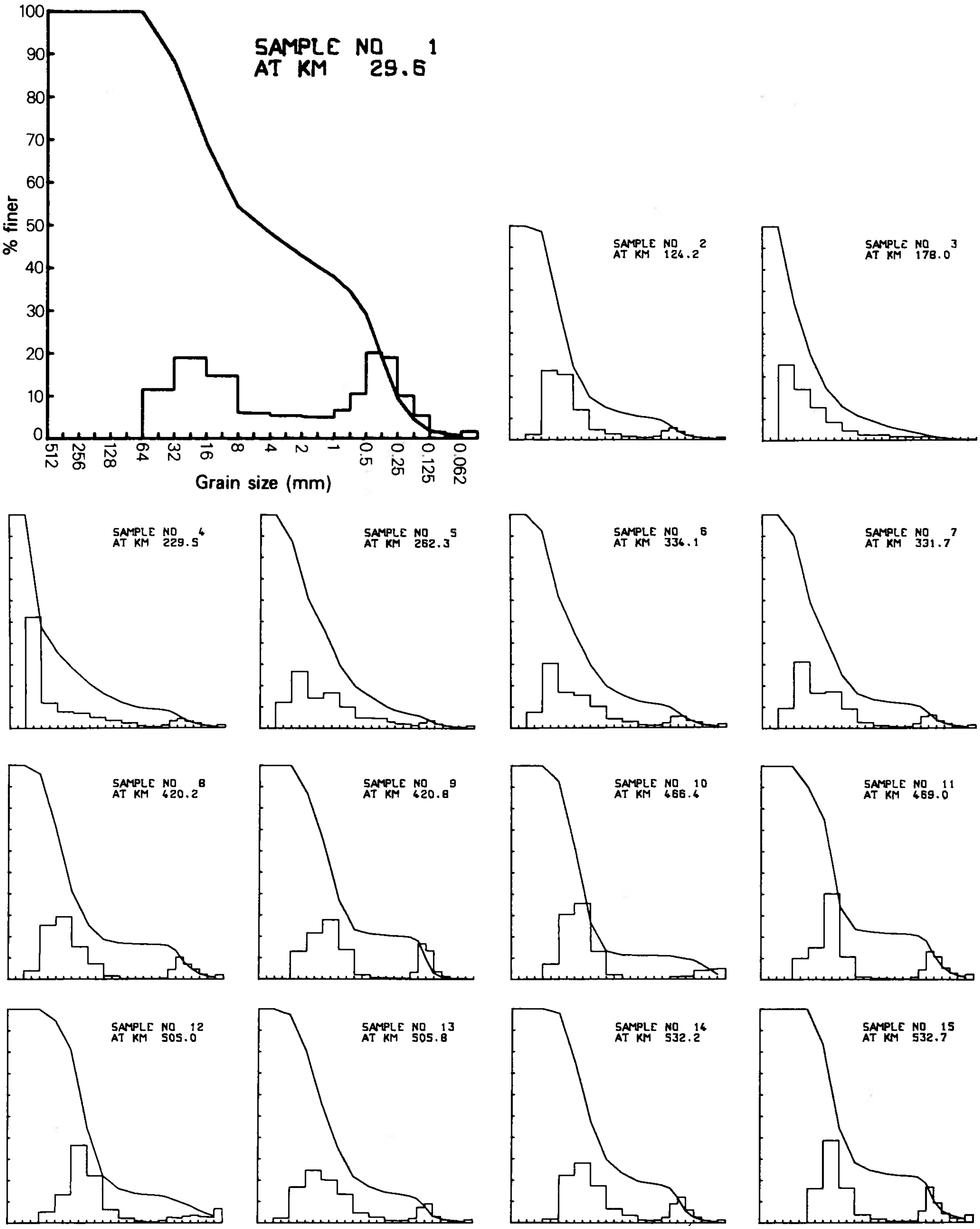


Figure 7. Cumulative curves and histograms of grain-size distributions. North Saskatchewan River samples.

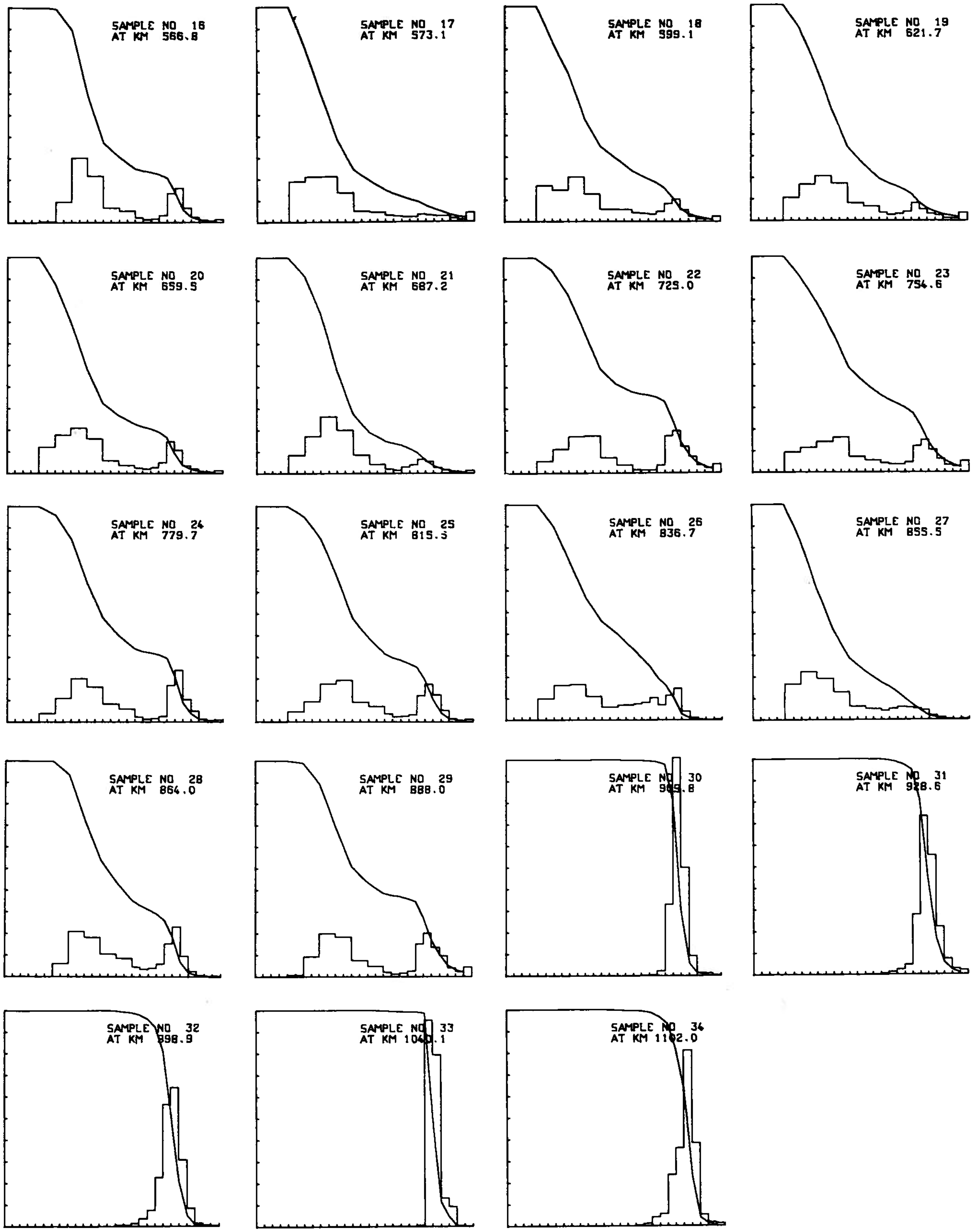
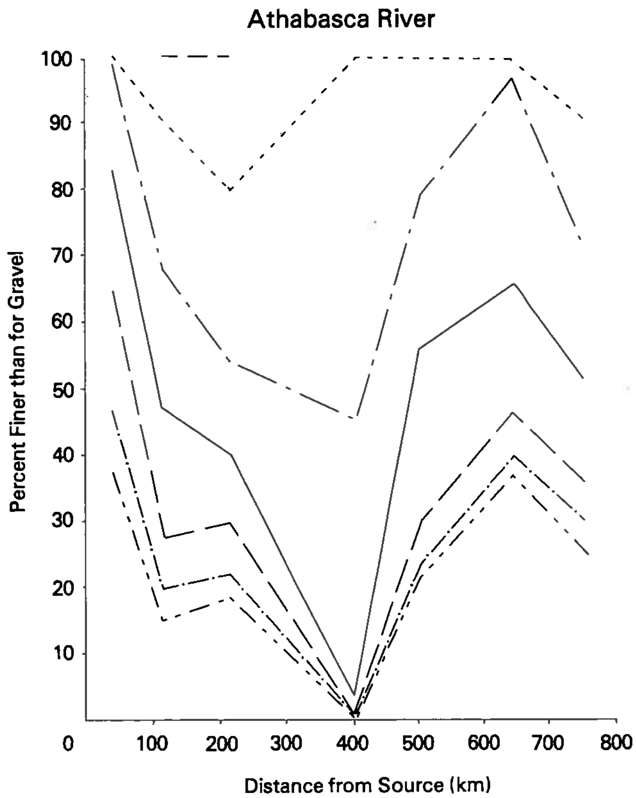


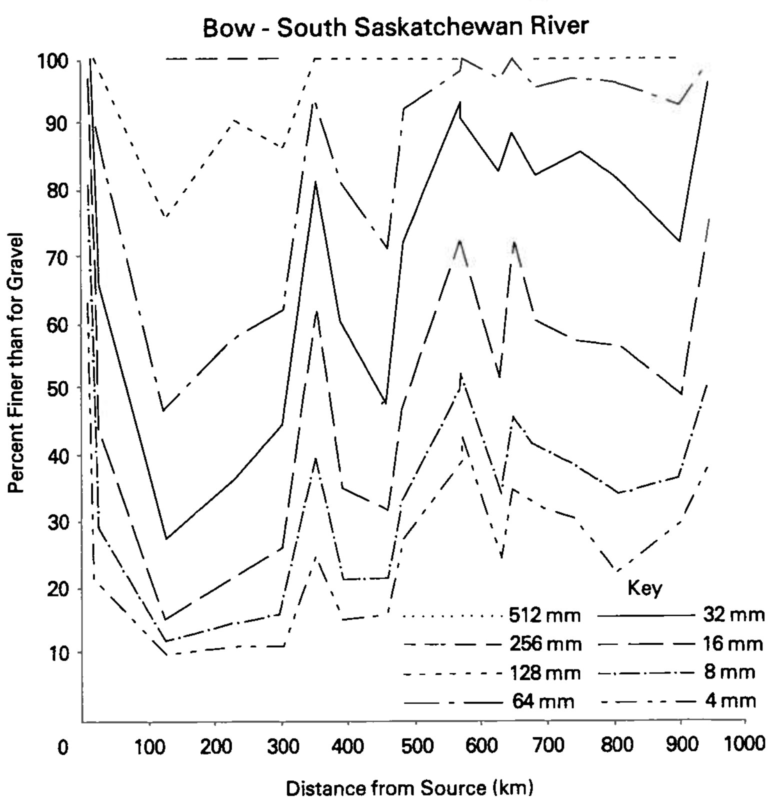
Figure 7. (continued)



is highly significant, but so are the deviations from the regression (Table 10). After studying the residuals, Church and Kellerhals (1978) concluded that the most reasonable explanation of downstream variation appeared to be an overall downstream decrease according to Equation (1); superimposed on this decrease there are similar, but more extreme, decreases according to the same functional law along reaches between major tributaries. Figure 15 which shows plots of the 78 grid samples smoothed by taking averages over 10 km reaches illustrates this point.

The samples of the present study are not sufficiently closely spaced to identify similar effects clearly, but several of the graphs in figure 13 appear to show short, abrupt decreases in grain size superimposed on more gradual general decreases in grain size along the gravel reaches, the North Saskatchewan River being a particularly good example. Another good example is the Peace River. Grain-size along the upstream reach from Hudson Hope to the Alberta border decreases four to six times as much as the overall decline along the entire gravel-bed reach.

In the first part of table 11, Equation (1) is fitted to the better sampled gravel-bed reaches of the present study.



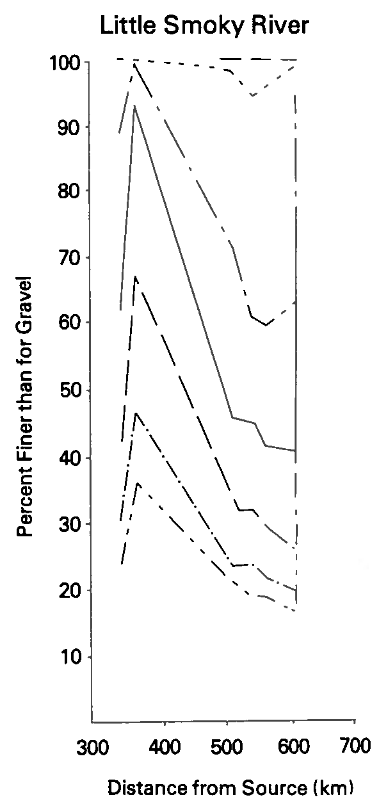


Figure 8. Downstream changes in the cumulative frequency for the normalized gravel fraction.

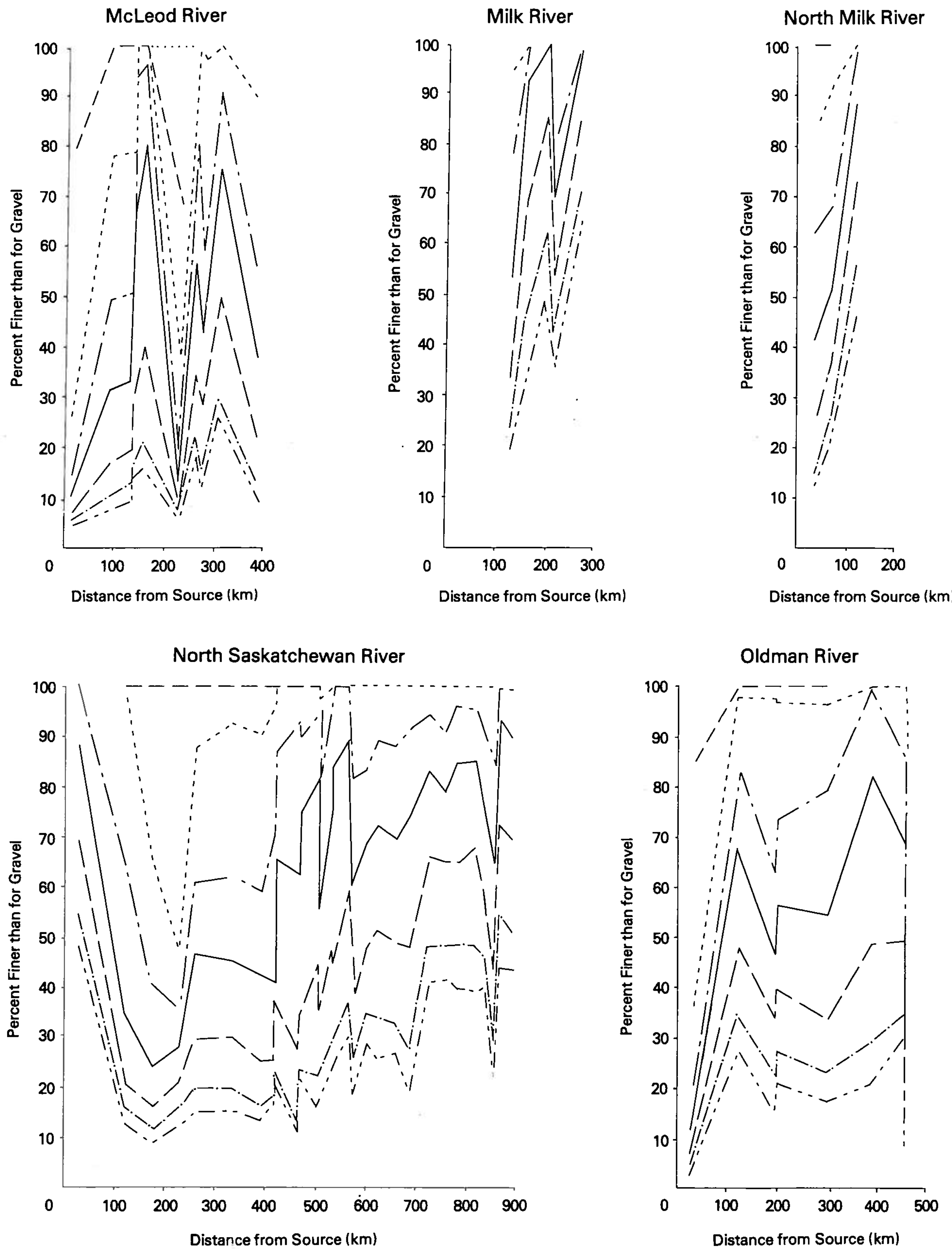


Figure 8. (continued)

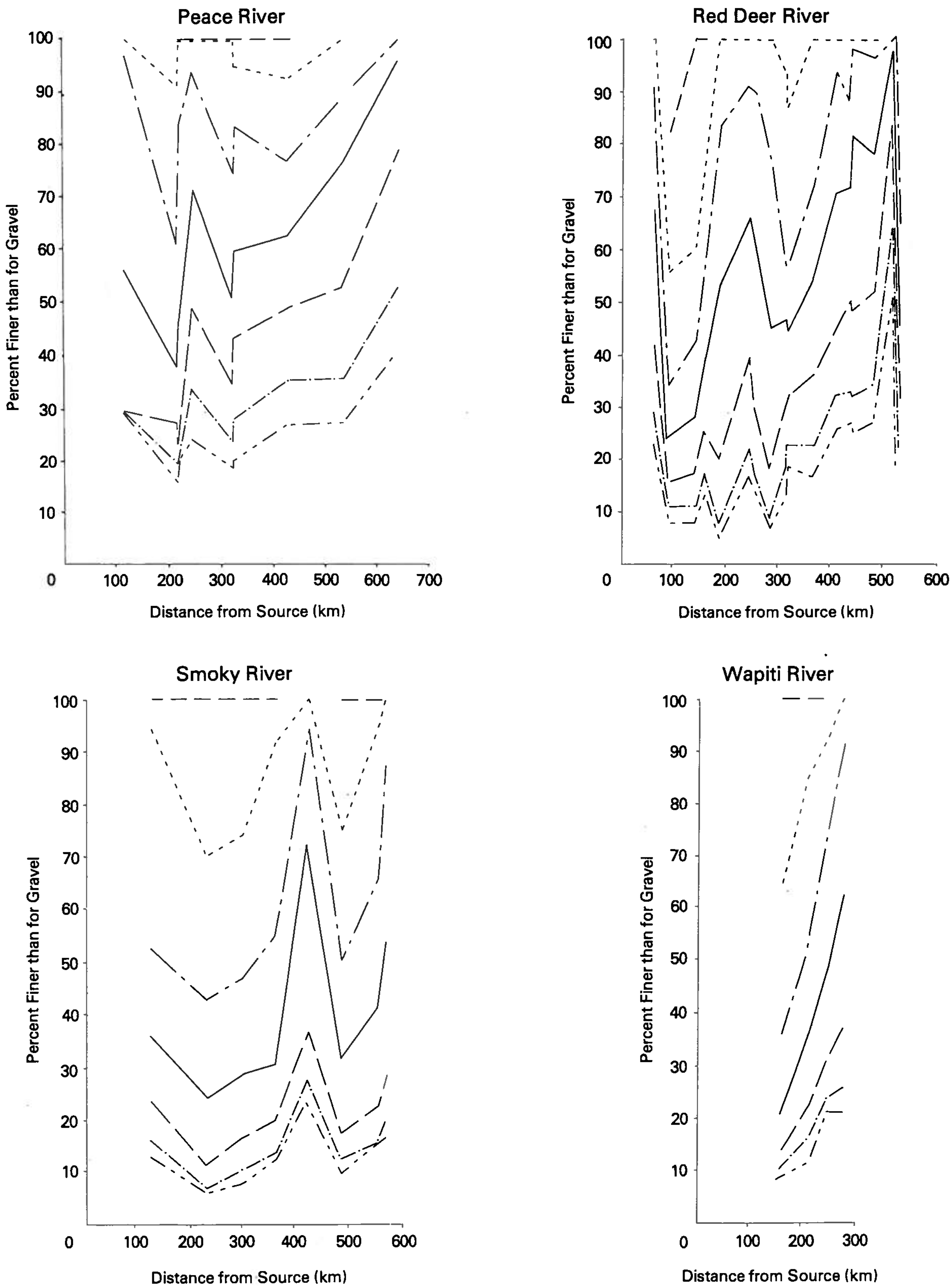
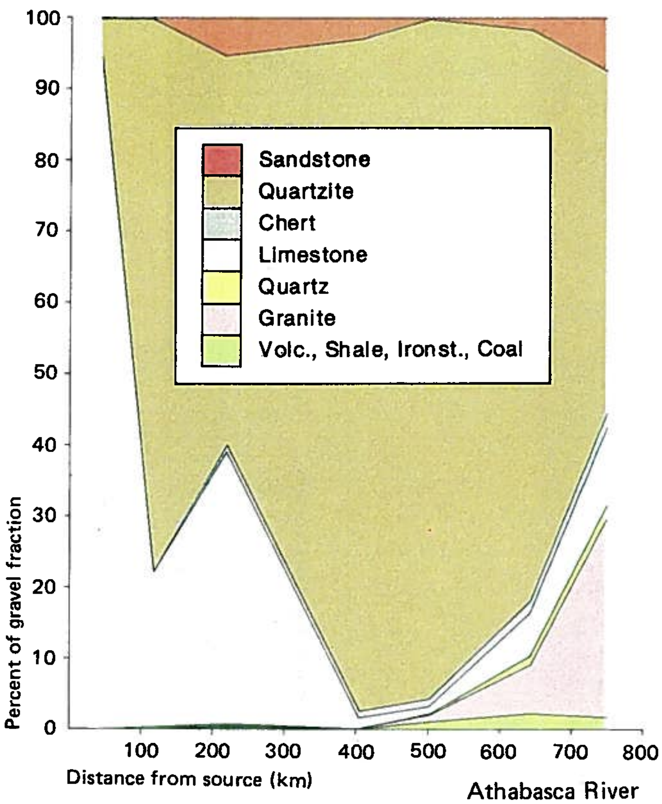


Figure 8. (continued)



Sand samples and the irregular samples within the mountains, where grain size is affected by infilling lake basins and by various local gravel sources, are neglected.

The last column of table 10 corresponds to the mean square for "between group deviation from regression". The five values listed for D_{50} cover a range from 0.106 to 0.250, with a mean of 0.155 which is close to the corresponding value of 0.138 in table 10. These indicate that grain size in gravel-bed channels appears to be exceedingly variable with a one standard deviation range of D_{50} about the regression line of the order of ± 50 percent for samples collected from as uniform a sedimentary environment as possible (Note: $e^{0.155} = 1.48$). Had the samples been collected at a rigorously fixed spacing along each river, ignoring the geomorphological setting of the sample sites, variability would be even greater.

The second part of table 11 shows the regressions for the two best covered sand-bed reaches. These show a slower and much more regular decrease in grain size, confirming the well-known fact that grain size tends to be much less erratic in sand-bed channels than in gravel-bed channels.

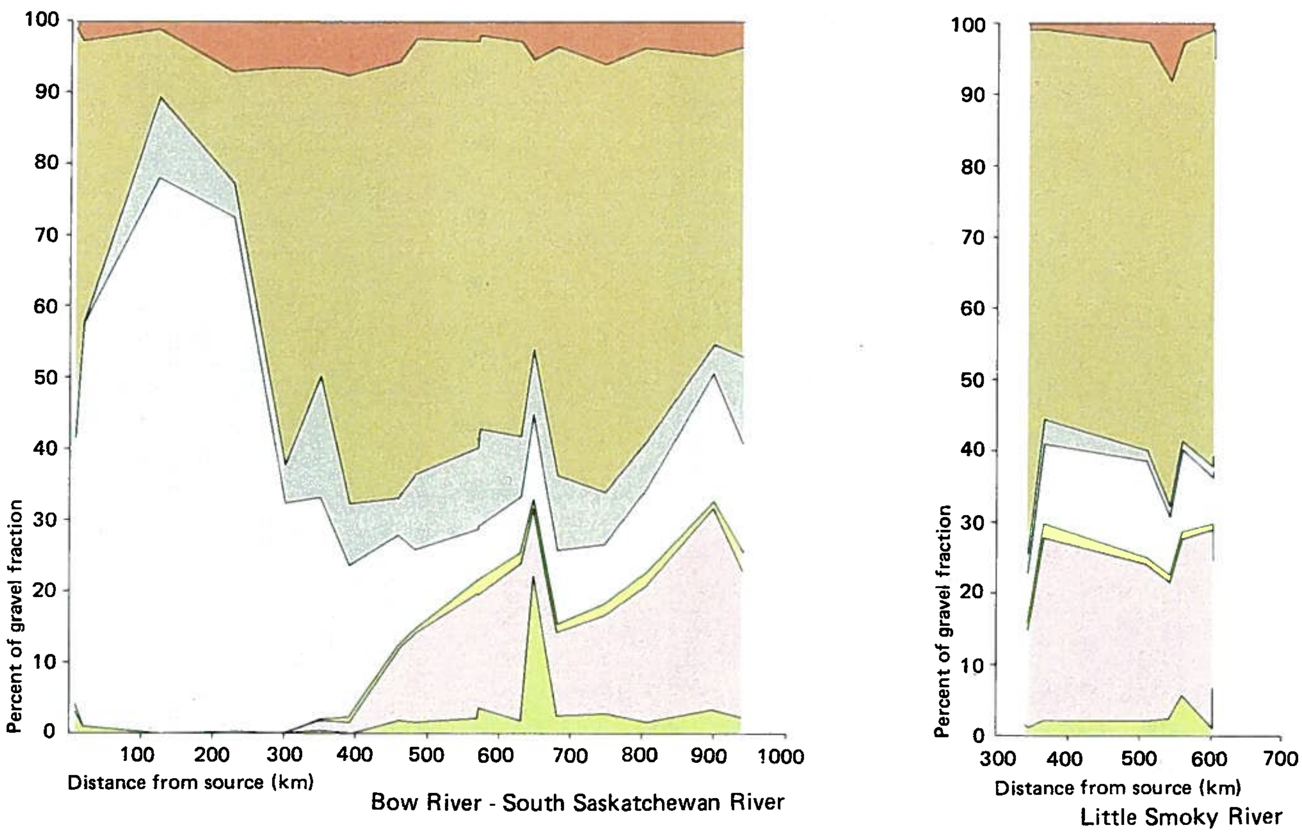


Figure 9. Downstream changes in the lithologic proportions (minor constituents combined).

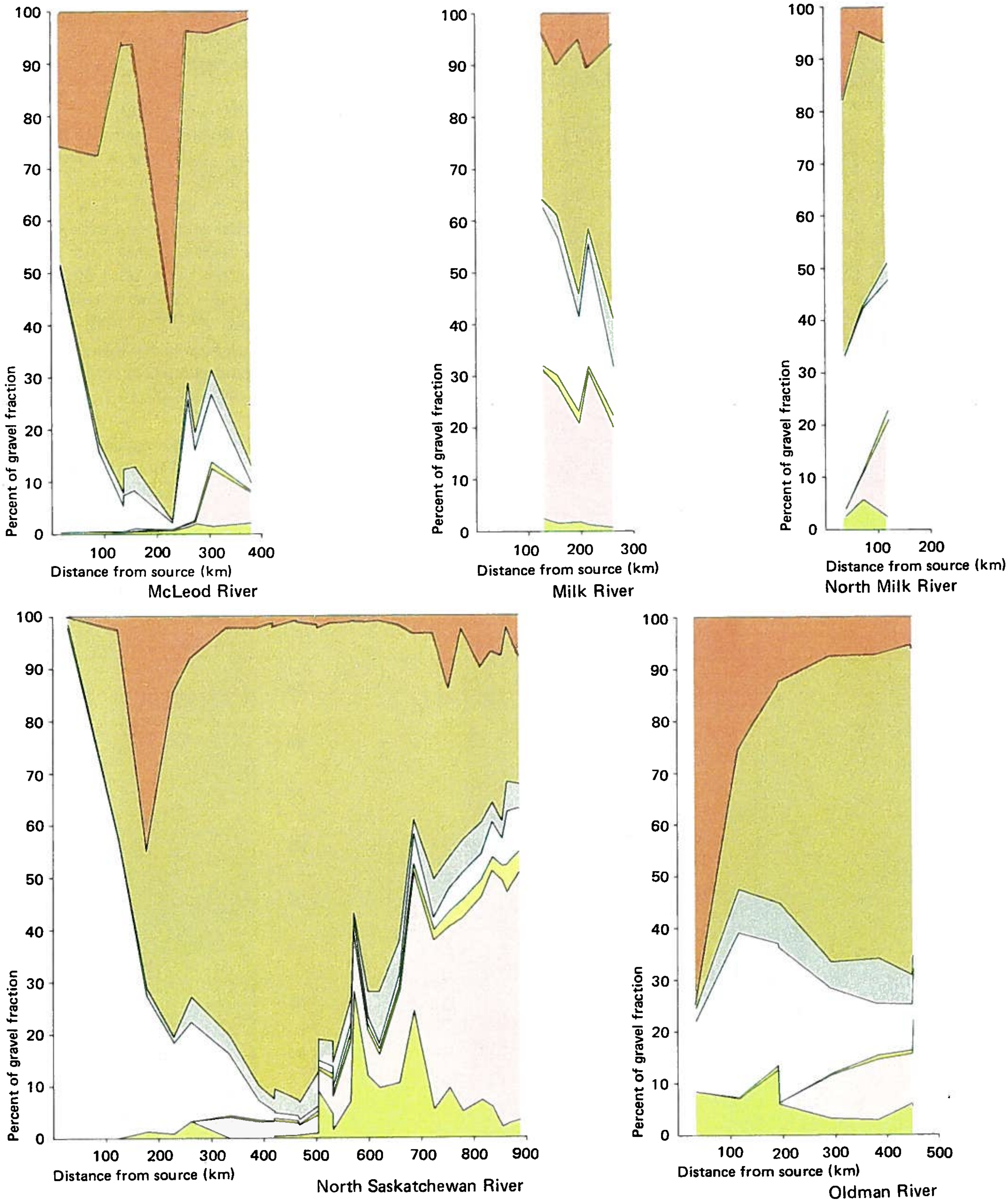


Figure 9. (continued)

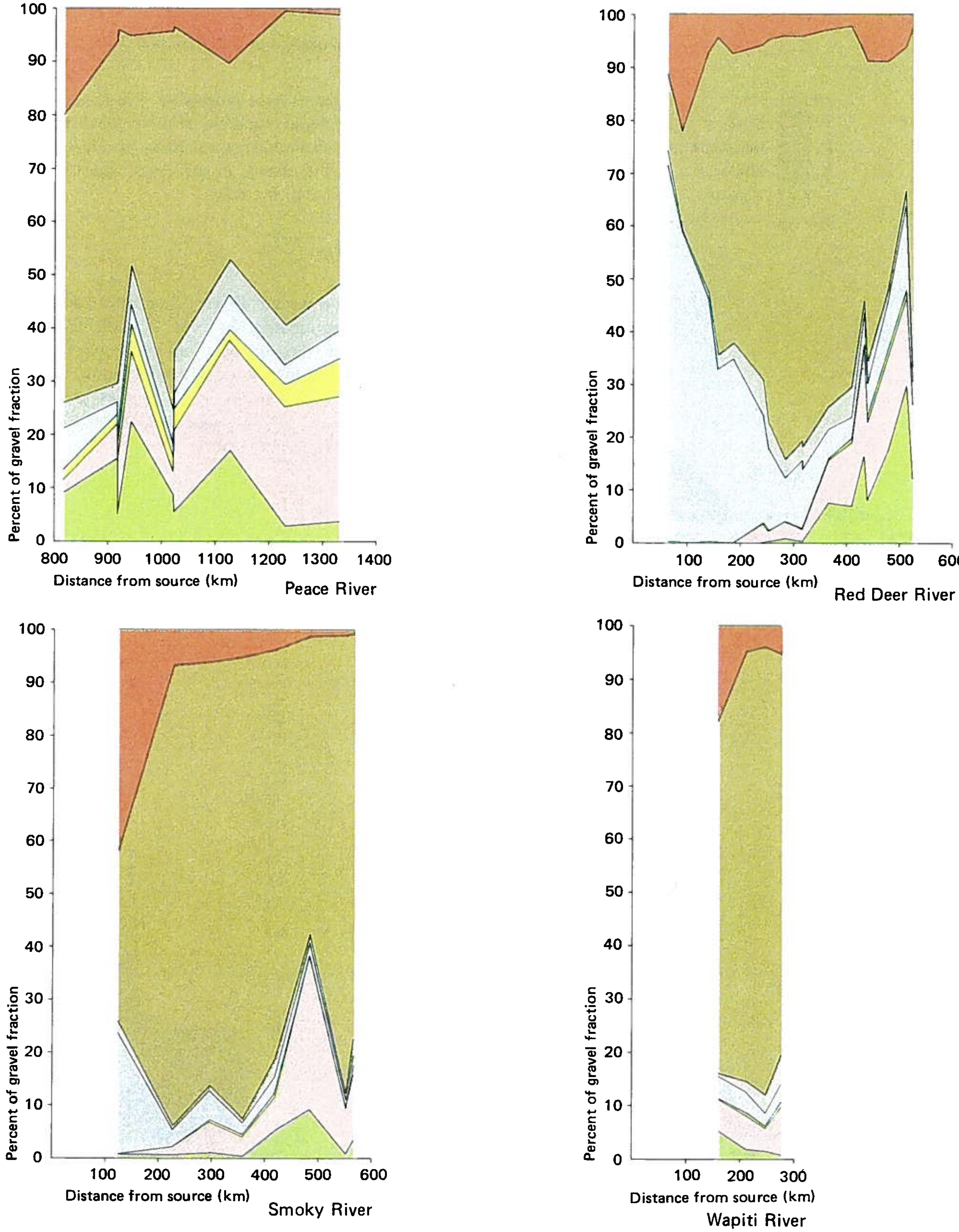


Figure 9. (continued)

DOWNSTREAM CHANGES IN GRAIN-SIZE

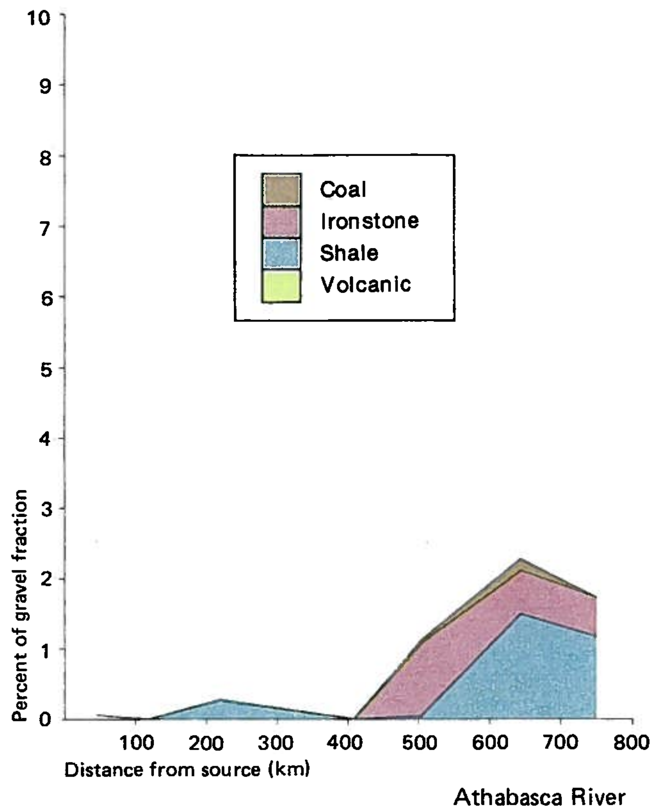
The Effects of Abrasion and Differential Transport

Although researchers have repeatedly noted that grain size of river-bed material becomes smaller downstream, the processes by which diminution occurs are poorly understood. In many rivers the change in grain size appears to fit an exponential decline of the form

$$W = W_0 e^{-a_w x} \tag{2}$$

where W_0 is the weight of a characteristic particle at an arbitrary starting location (x = 0), W is the characteristic weight at some distance x measured downstream, and a_w is the coefficient of weight diminution. It follows from Equation (2) that for a short reach of length Δx the weight decrease, ΔW, is proportional to the characteristic particle weight, W, in the reach:

$$\frac{dW}{dx} = -a_w W \tag{3}$$



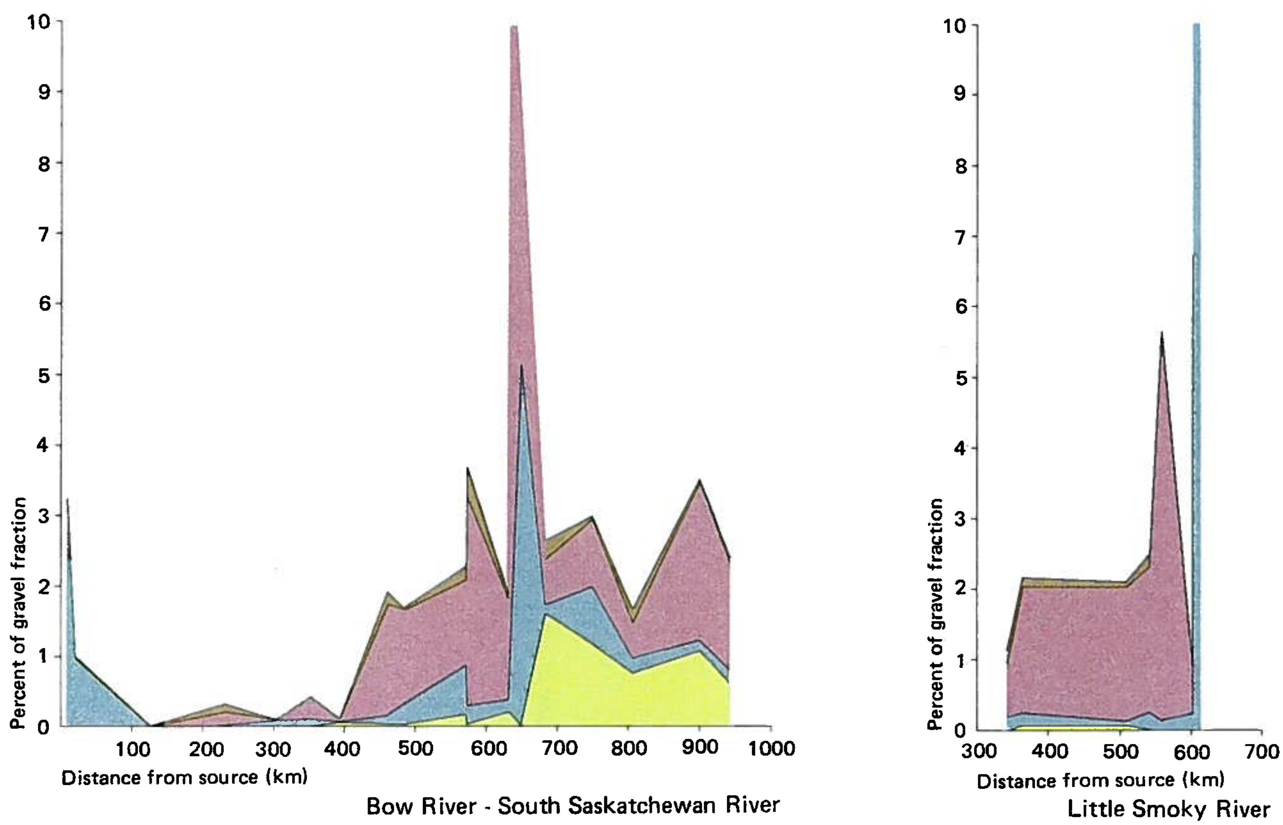


Figure 10. Downstream changes in the proportions of the minor lithologic constituents.

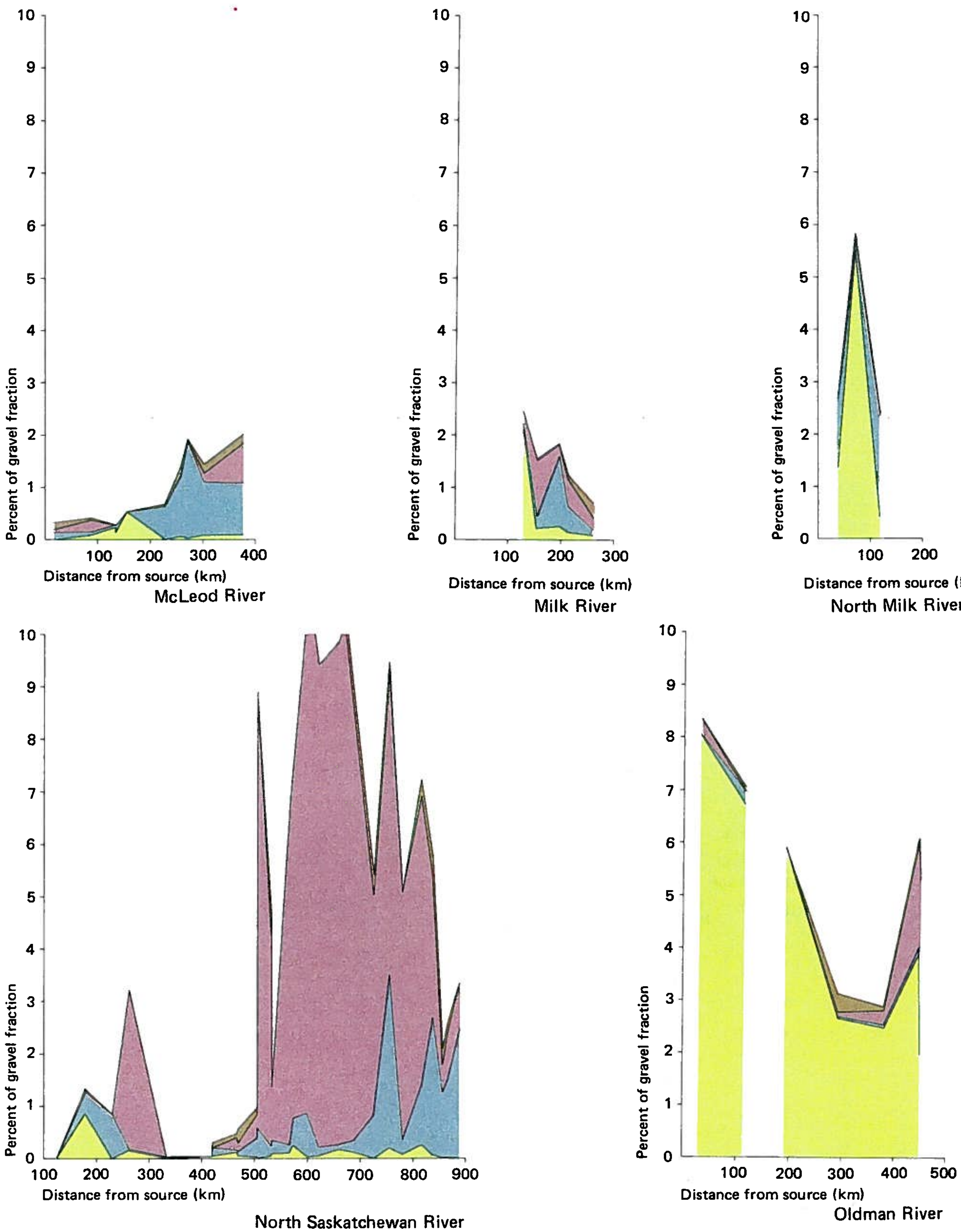
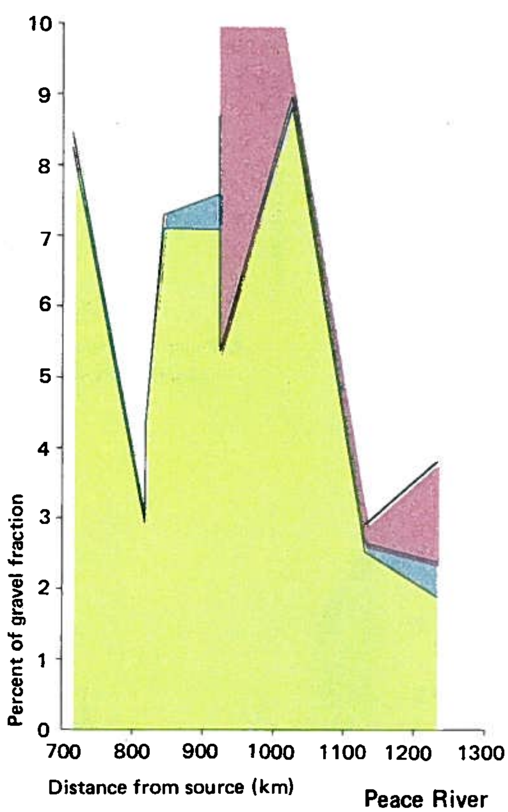


Figure 10. (continued)



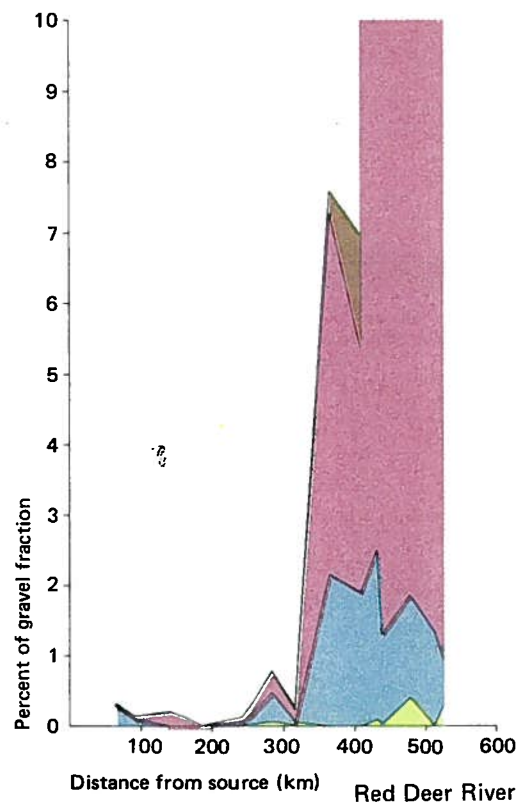


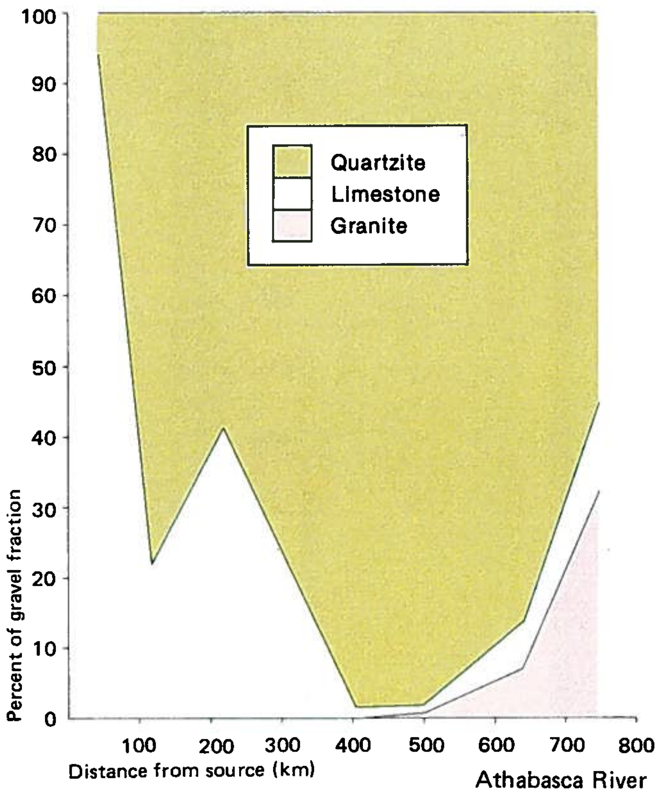
Figure 10. (continued)

Düll (1930) questioned Equation (3) on the basis of rolling mill data and proposed an alternative relationship

$$\frac{dW}{dx} = -a_1 W^{0.55} \tag{4}$$

with a_1 depending on the abrasion resistance of the rocks. While his data are equally well-fitted by relationships other than Equation (4), there is growing evidence that Equation (3) is inadequate. Kuenen (1956) found that abrasion in rolling mills produced a slow decrease in $\frac{dW}{Wdx}$ down to fine gravel sizes and then a rapid decline to virtually zero. This result agrees with the observation of negligible abrasion of sand-sized materials in the field (Russell and Taylor, 1937) and in abrasion mills (Schubert, 1964). Equation (2) can, therefore, be accepted as an approximation for gravels; but it is not applicable to sand-bedded streams. Confirmation of the applicability of the relationship to gravel-bedded streams is extensive, beginning with Sternberg (1875) after whom the relationship of Equation (2) is named. However, the change in particle size downstream may not be solely due to abrasion, but may also be due to effects of differential transport. To accommodate the two components Equation (2) is commonly written:

$$W = W_0 e^{-(\alpha + \beta)x} \tag{5}$$



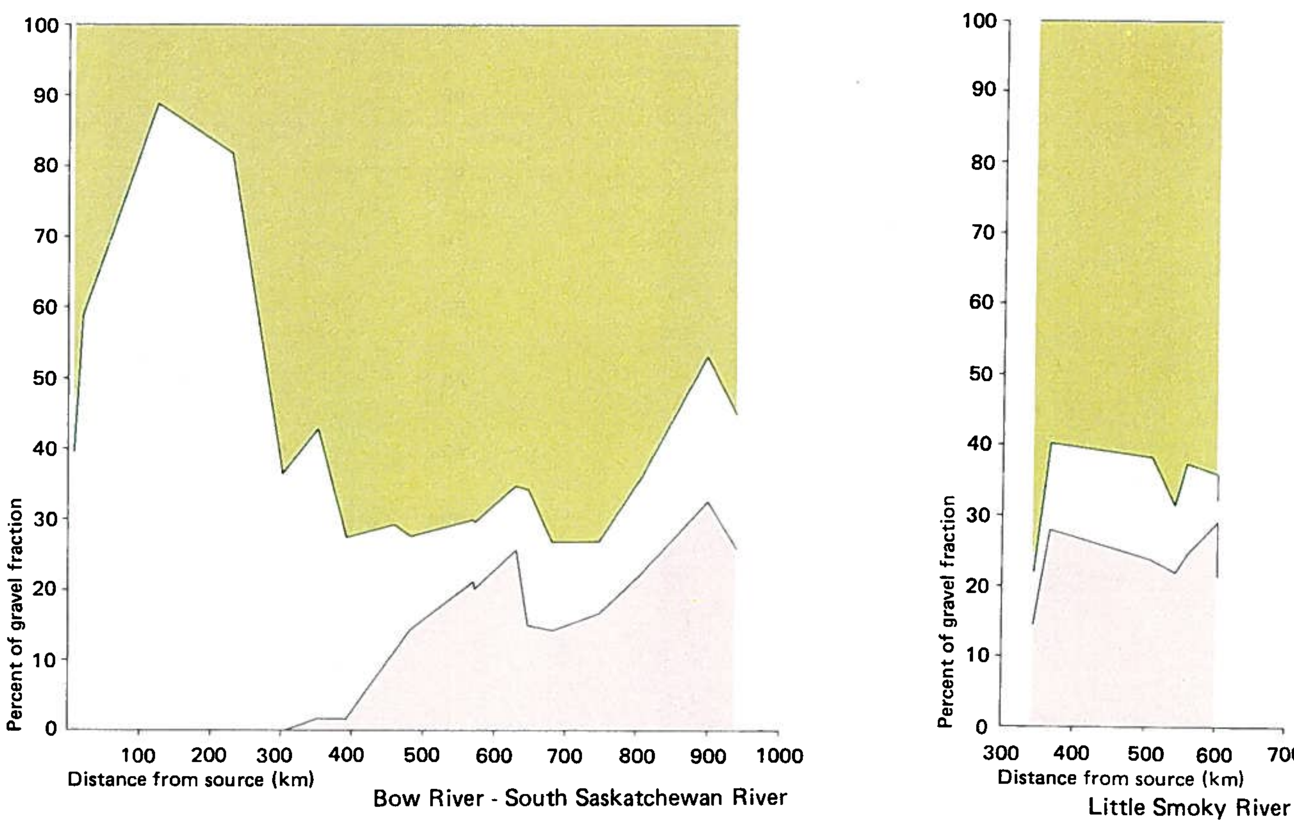


Figure 11. Downstream changes in the normalized proportions of limestone, quartzite and granite.

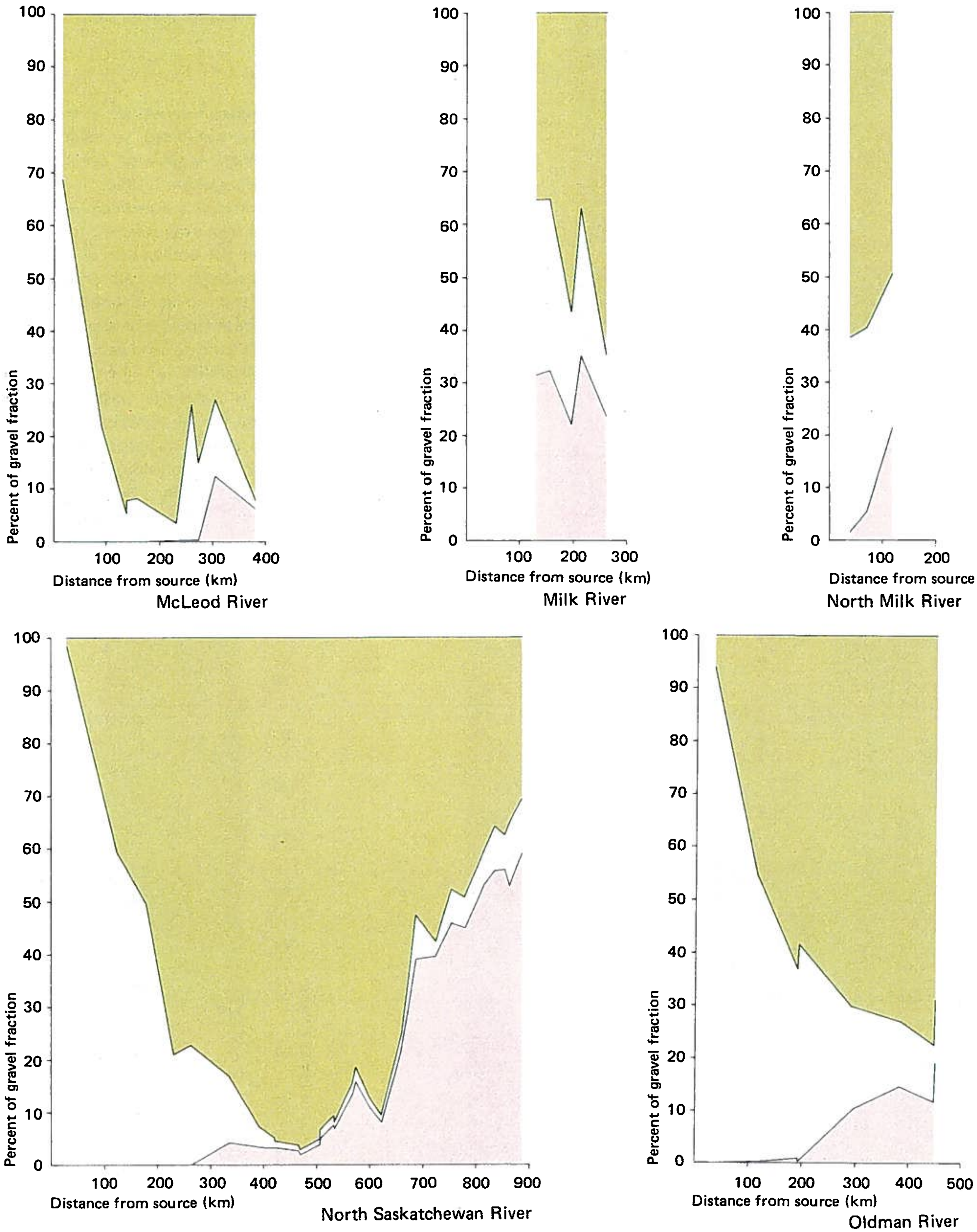


Figure 11. (continued)

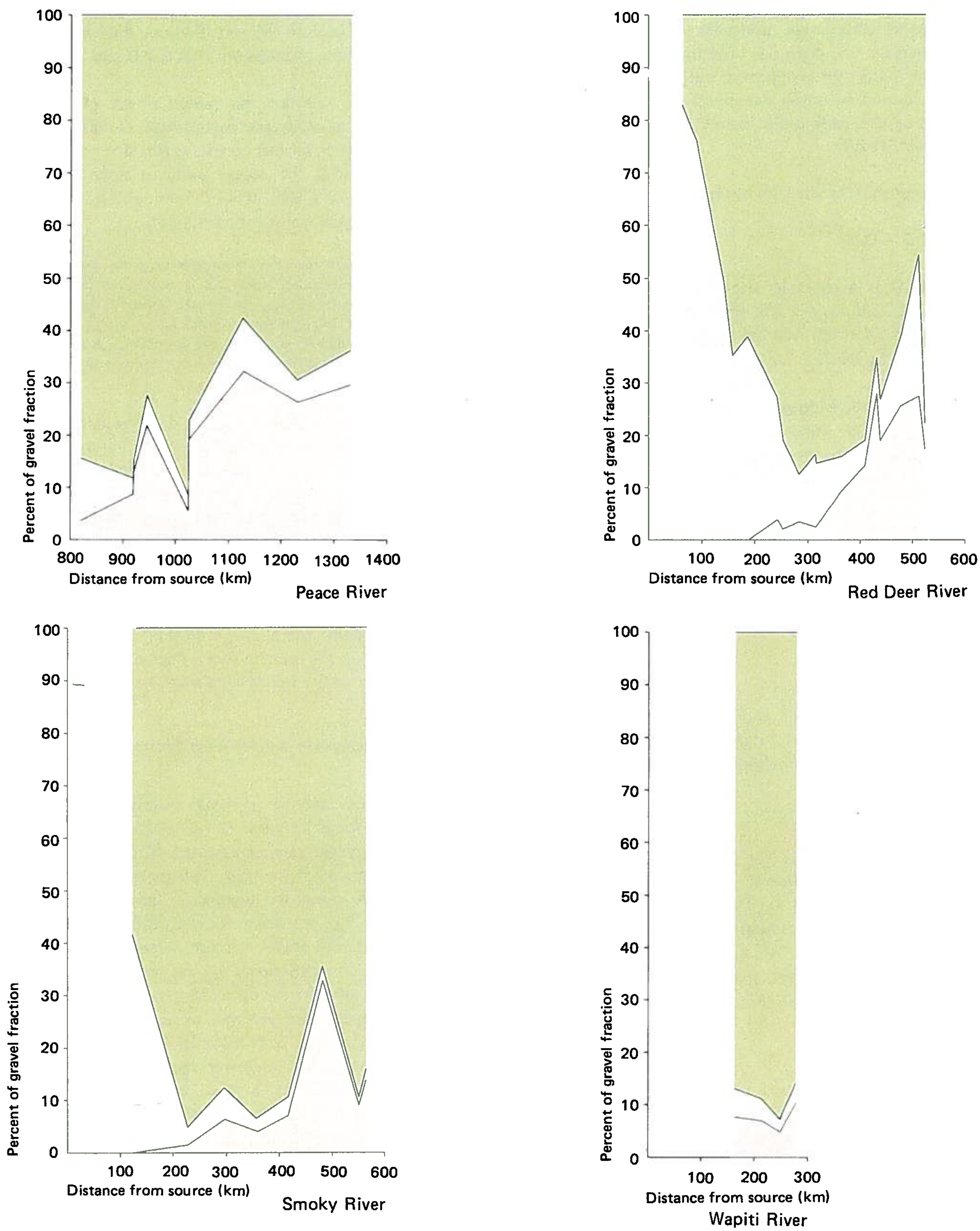


Figure 11. (continued)

in which α represents the component of attrition and β represents differential transport. Equation (5) implies that decrease in grain size resulting from differential transport follows an exponential decline. This is supported by the commonly noted exponential decrease in the size of grains on alluvial fans due mainly to differential transport (Krumbein, 1942).

The relationship for size diminution is given by

$$D = D_0 e^{-a_D x} \qquad (6)$$

in which D is a characteristic linear dimension at some distance x and D_0 is the corresponding dimension at $x = 0$. Equation (6) follows directly from Equation (2) since $W \propto D^3$ gives $3a_D = a_W$.

According to Scheidegger (1970), Lokhtin applied the concept that the slope of the river bed determines the particle size found there. For any single river, a balance on the bed is considered to exist such that

$$c_f = \frac{D}{S} \qquad (7)$$

where c_f is a constant coefficient of fixation, D is a characteristic linear dimension of the bed material, and S is slope. Equation (7) gives

$$W = c_1 S^3 \qquad (8)$$

where c_1 is a constant and W is the particle weight. However, Shulits (1941) noted that for several rivers, slope is proportional to particle weight and used Equation (2) to obtain:

$$S = S_0 e^{-a_W x} \qquad (9)$$

where a_W is the coefficient of weight diminution and S_0 is the slope at $x = 0$. The correspondence between Equation (9) and many actual river profiles is remarkable, implying the existence of a high correlation between particle weight and river slope. Scheidegger combined Equations (8) and (9) such that:

$$W = c_2 e^{-3a_W x} \qquad (10)$$

The constant c_2 corresponds to W_0 of Equation (2). He argued (p. 223) that the physical explanation for Equation (10) is different from that for Sternberg's equation (Equation 2), although the form is the same. This is, however, not the case as Shulits (1941) obtained Equation (9) directly from Sternberg (1875). It is thus not permissible to combine Equation (8) and (9) since they are developed on the conflicting assumptions that $S \propto D$ and $S \propto W$.

Equation (5) includes the added effect of differential transport on downstream particle-size reduction. If finer particles outrun coarser ones, grain size will be finer downstream until the coarse particles catch up with the finer ones. Allen (1965, p. 129) summarized the operation of the differential transport mechanism.

> Sand is moved over a wide range in stage, but less rapidly than the suspended load, and is subject to temporary storage chiefly in bars. Gravel size debris is transported slowly and infrequently and for only short distances during the highest stream discharges. The coarsest debris of all, cobbles and boulders, may be removed only during exceptional floods.

However, if the stream is aggrading, then the coarse particles will be progressively buried before "catching up" with the fine. In this way, particle size becomes smaller downstream and hence the coefficient β in Equation (5). Meland and Norrman (1969) have proposed a mechanism in which coarse material is preferentially stored in floodplain deposits, producing downstream fining without the necessity of vertical aggradation of the valley floor. However, this remains an interesting aside to the fact that, given an aggrading system, grain size will fine downstream more rapidly than if the system were degrading. This point is of importance to the following discussion.

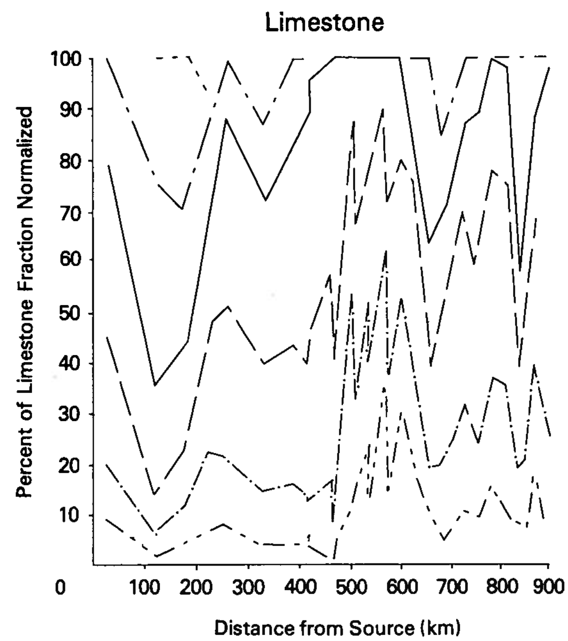
Grain-size Changes in the Albertan Rivers

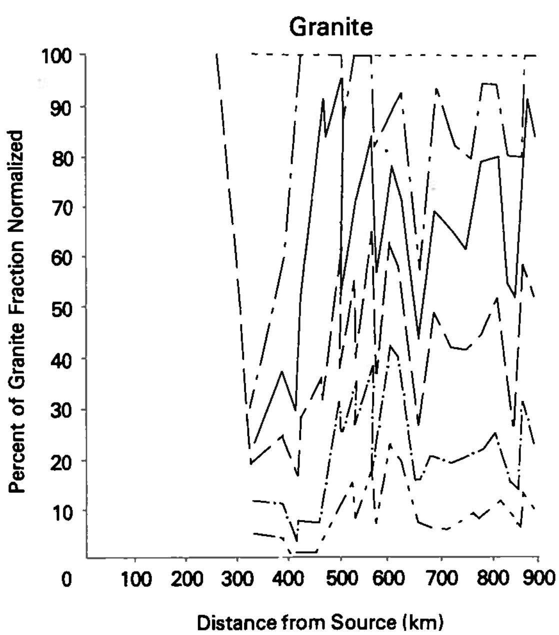
This discussion will be confined to changes in grain size downstream along the Peace, North Saskatchewan, Red Deer, and Bow-South Saskatchewan rivers. The other eight rivers are either too short or have inadequate sample coverage. The data are presented graphically in figure 13. Values of D_{50} and D_{90} are given for both the total sample and, when present, the gravel fraction at each sampling point. The diminution coefficients a_D are presented in table 11. The samples selected for calculating the a_D values are from the central gravel-bed reaches, as some streams show an increase in grain-size with distance for the upper reaches, but are sand-bedded in lower reaches. The coefficients, a_D, were obtained by a least squares regression fit of distance, x against log D. Diminution coefficients for two sand-bed reaches are also computed for comparison. Of the gravel data, the North Saskatchewan River shows the best fit to the regression equation, but all coefficients show similar values.

With the exception of the upper reaches of the Peace River, all values of a_D for gravel reaches based on D_{50} are less than those based on D_{90}. A partial explanation of this is that many of the D_{50} values are affected by the shoulder (Fig. 4) associated with deficient grain-size classes centered at about 1 mm. This shoulder causes a greater rate of change with distance for D_{50} than D_{90} with consequent higher values for a_D. As most previous workers have used some measure of the coarsest particles to determine a_D, we shall use D_{90} of the total sample unless otherwise stated.

The changes in grain size downstream can be best discussed by considering the rivers in three stretches. Using the North Saskatchewan River as an example, there is an upstream stretch from 0 km to 250 km in which grain size actually increases with distance downstream; in a central stretch of this river, from 250 km to 900 km, there is a relatively continuous decrease in grain size expressed in ϕ values; with distance, at 900 km, a very sharp decrease in grain size is followed by a stretch over which no appreciable decrease occurs (Fig. 13).

Comparison of figures 11 and 13 reveals that the increase in D_{90} in the headwater regions exactly parallels the increase in the percentage of the quartzite fraction relative to limestone. The quartzites tend to break down into blocks larger in size than those produced by the generally more intensely jointed limestones. Consequently, with increasing proportions of quartzite, there is a corresponding increase in grain size. The relatively small grain size in the higher reaches is partially the result of the headwater reaches receiving large quantities of their load directly from high altitude zones of intense periglacial rock disintegration, and partially the effect of burial of coarse





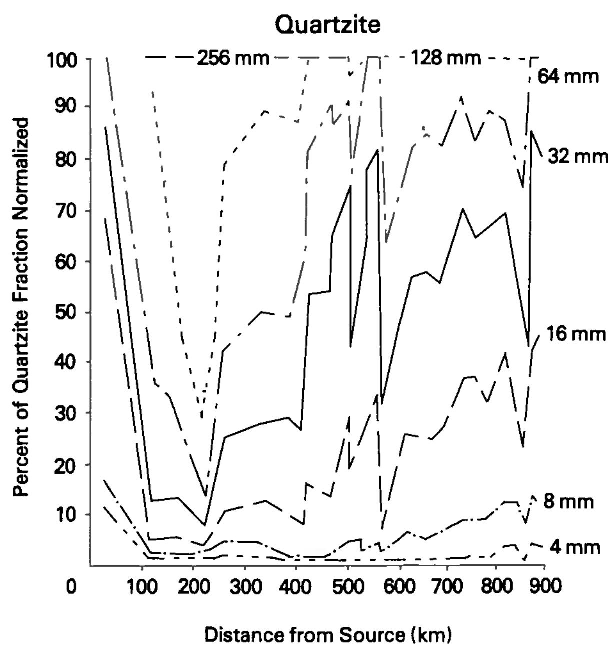


Figure 12. Downstream changes in the cumulative frequency for the normalised grain-size distributions of the three major constituents (North Saskatchewan River).

sediment in the infilling or infilled lake basins of the higher reaches.

As indicated in the section on geomorphology, the mountains, foothills, and western plains reaches of the rivers have been degrading in the final stages of their history. Thus, the dominant process determining decrease in grain size is likely abrasion. This hypothesis can be tested by use of the diminution of limestone in the headwater region.

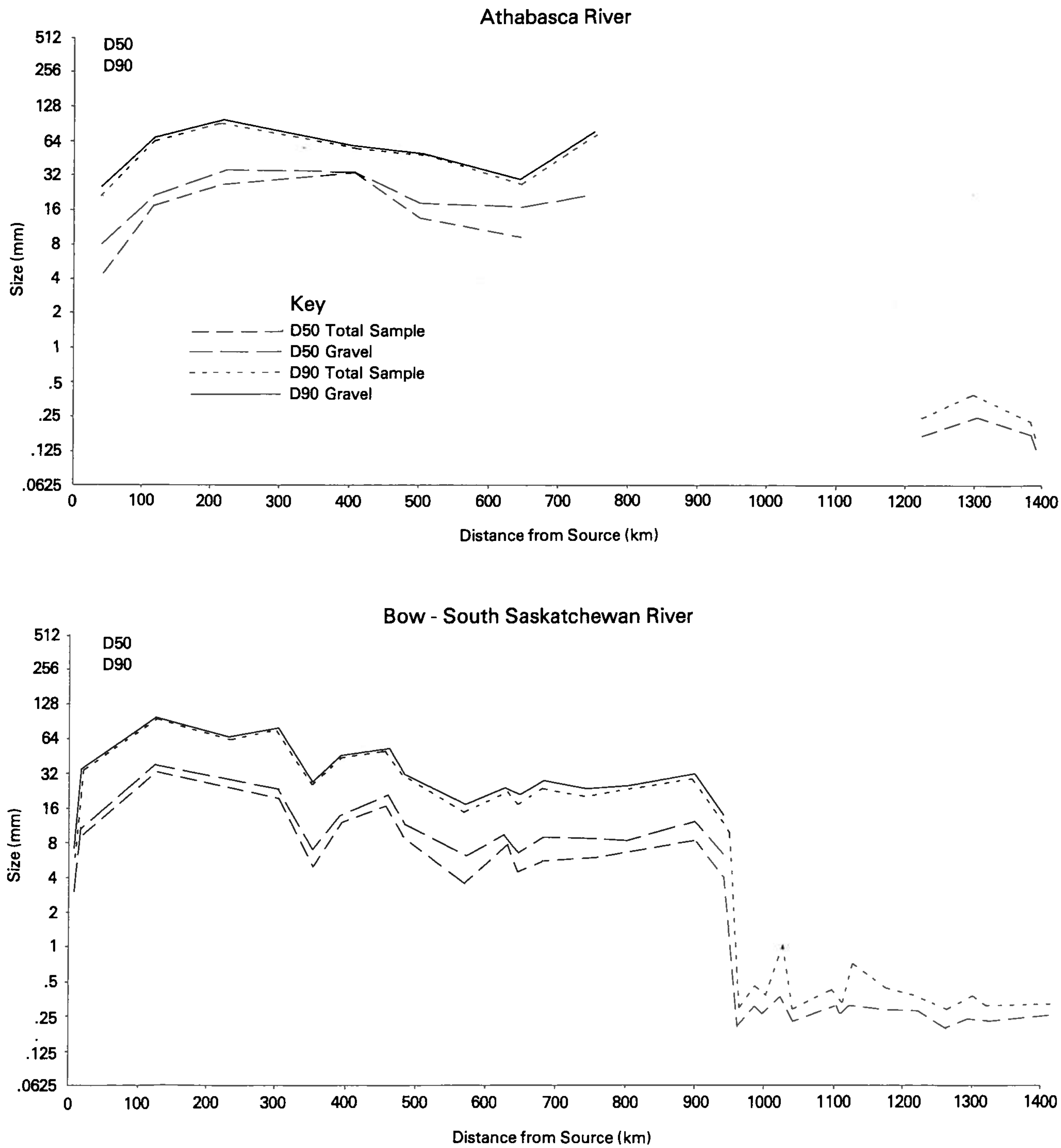


Figure 13. Downstream changes in grain-size parameters.

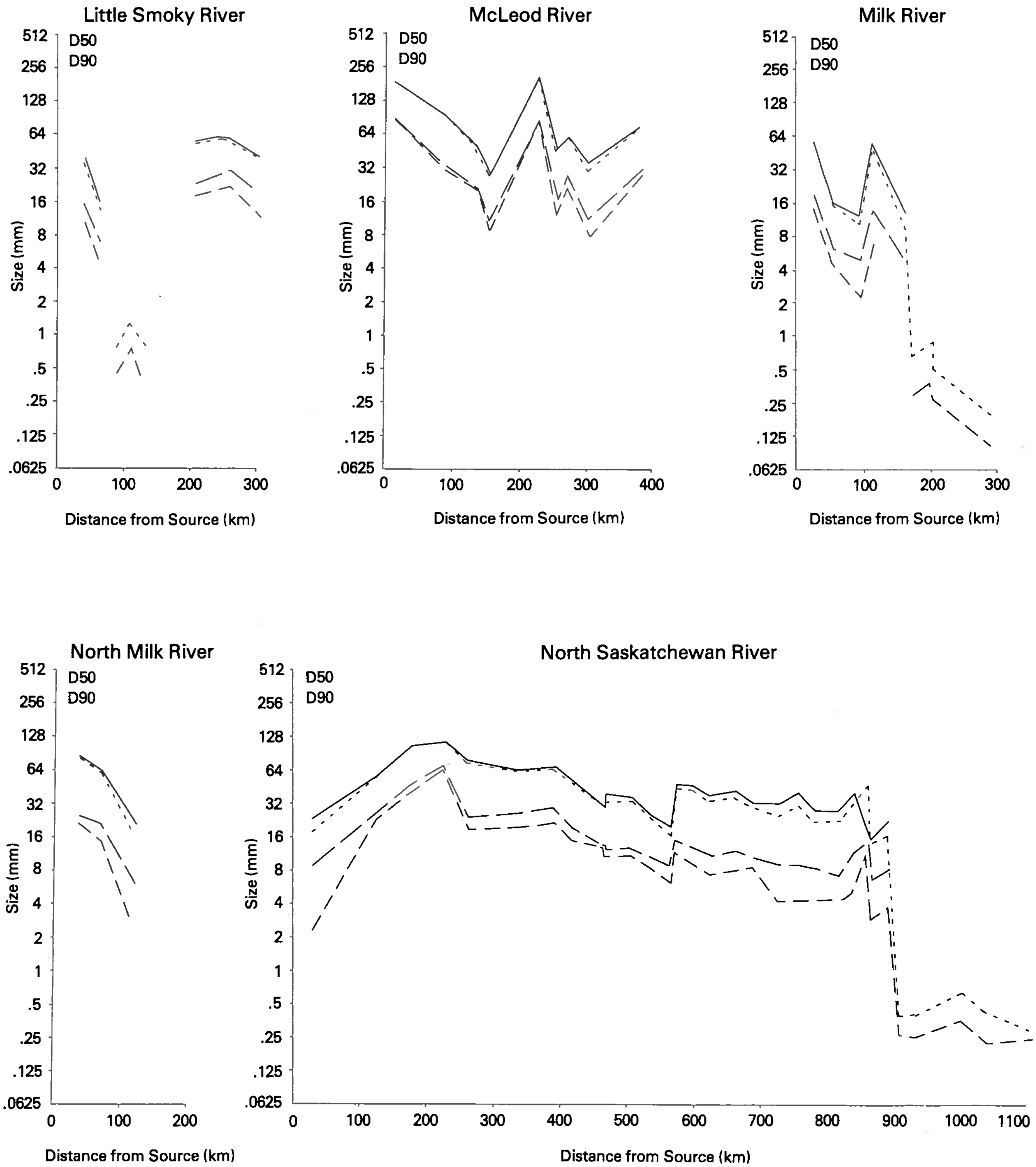
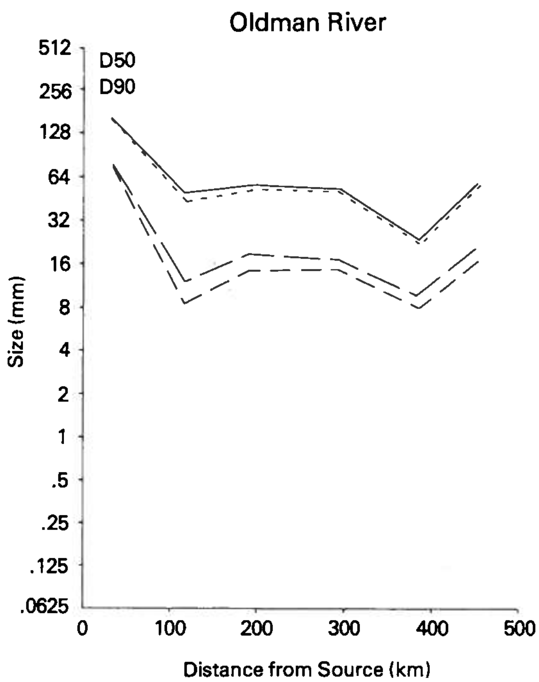


Figure 13. (continued)



Relative Effects of Abrasion and Differential Transport

Since lithologic proportions are recorded only for particles coarser than 2 mm, smaller sized particles do not appear in counts. We may then assume that, at the point on the lithologic plots (Fig. 11) where the percentage of limestone becomes negligible, all the limestone particles are smaller than 2 mm. Note that some limestone is introduced to the rivers by erosion of till and that the limestone proportion does not drop to zero. The size of the coarsest limestone, D_0, is estimated from figure 12 and the distance, x, from the point of coarsest limestone, x = 0, to the point where the limestone fraction becomes negligible can be measured. Substituting the values D_0, D = 2 mm, and x in Equation (6) allows a_D (lmst) to be estimated for each river. The values of a_D (lmst) obtained for the Athabasca, North Saskatchewan, and Red Deer rivers are 0.0119 km^{-1}, 0.0097 km^{-1}, and 0.0118 km^{-1}, respectively.

Components of the Abrasion Coefficient

Since the early work of Daubrée (1870), researchers have realized that abrasion coefficients, *a*, obtained from rolling-mill experiments are generally insufficient to explain rates of decrease in grain size downstream. Kuenen (1956) claimed that rolling mills are not suitable models of rivers,

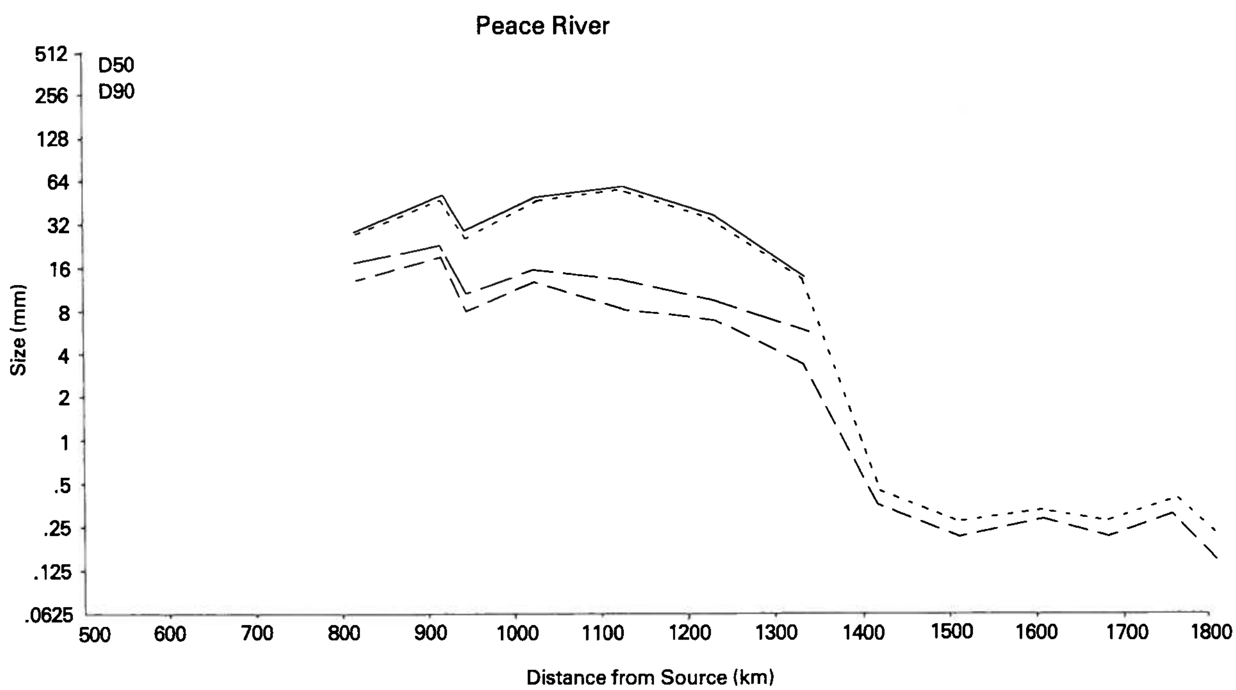
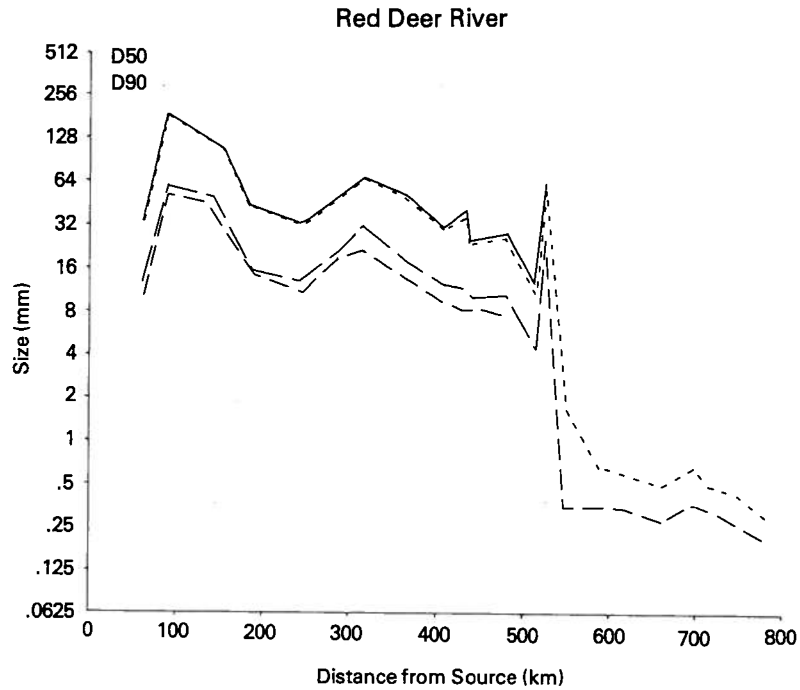
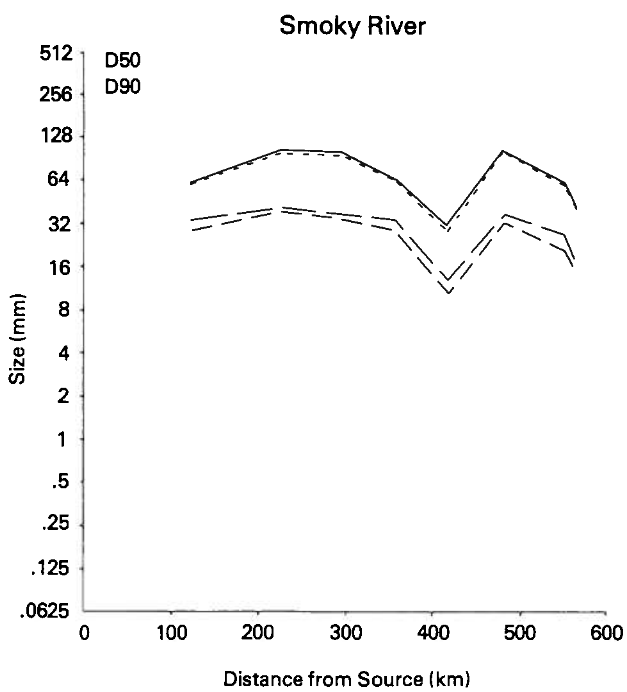


Figure 13. (continued)





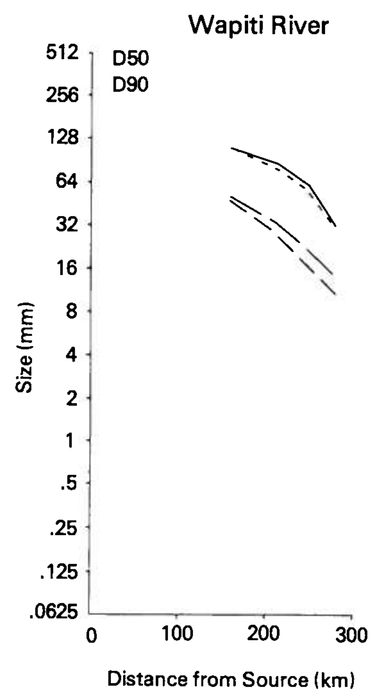


Figure 13. (continued)

and consequently designed a circular flume in which the flow could be driven by paddles. His findings clearly show the influence of the experimental conditions on abrasion coefficients. Of particular interest is the contrast between the low values of the abrasion coefficient obtained on a concrete bed and the values obtained on a pebble bed (Table 12). The velocity of pebble movement and the presence or absence of sediment in suspension also influence the results. Kuenen's experiments were run with the pebbles continually rolling. Of course, this does not represent natural conditions where pebbles are at rest for long periods. Kuenen (1955) acknowledged this problem, but pointed out that wet-sand blasting is not an effective mechanism for size reduction of rocks of size smaller than cobbles. However, Schumm and Stevens (1973) indicated that Kuenen's work may still underestimate the actual abrasion coefficient for rivers because attrition occurs during vibration of stones at flow velocities below those critical for erosion. In this way, particles are comminuted without being transported.

Bradley (1970) further explained the experimental underestimation of field diminution coefficients. He claimed that the discrepancy is due to the use of fresh particles in experiments whereas weathered particles, which abrade more readily, are found in rivers. Bradley used a Kuenen-type flume to show an order of magnitude difference between a_D values for fresh and weathered granite. By using geomorphological arguments to discard the possibility of selective transport in the Colorado River between Austin and Eagle Lake, Texas, Bradley was able to show that the size decrease for granite could be completely explained in terms of abrasion of weathered granite. However, the increased value of the abrasion coefficient with weathering does not explain the discrepancy between his experimentally based coefficient and the actual river coefficients for chert and quartz.

Table 12 and figure 17 present results of abrasion experiments and observations of diminution coefficients from field studies. The results are presented in three groups:

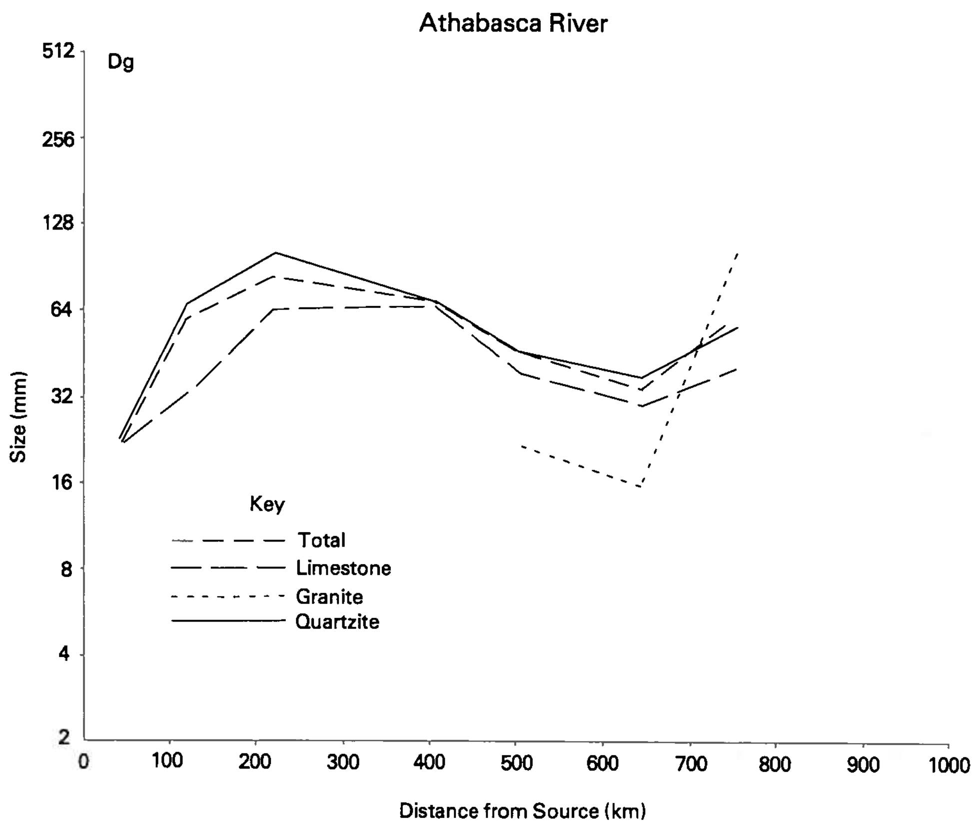


Figure 13. (continued)

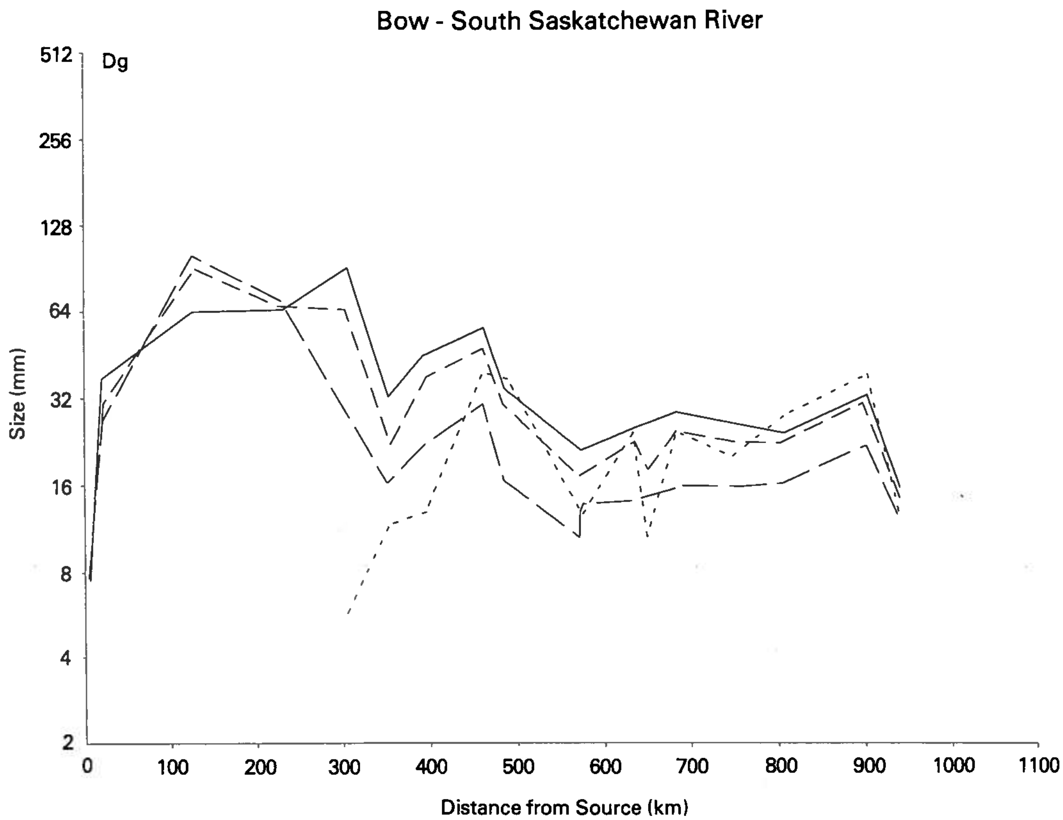


Figure 13. (continued)

first, the experimental abrasion coefficients; secondly, the diminution coefficients for rivers; and finally, the diminution coefficients for alluvial fans and ancient gravel deposits. The values of the coefficients are expected to increase sequentially from experimental figures, through river coefficients, and finally to results obtained from alluvial fans and ancient gravel deposits. Figure 17 shows that the expected sequence exists, although there is some overlap between categories. This overlap does not exist if the data are plotted for individual lithologies. For instance, the overlap between abrasion coefficients and diminution coefficients occurs because the abrasion coefficient for relatively non-resistant rocks is greater than the diminution coefficients for rivers with resistant bed material.

It is apparent that the abrasion coefficient obtained by experiment, a_T, does not fully explain the amount of abrasion occurring in rivers. Two further processes may be responsible for the remaining, unexplained, abrasion. First, vibration of particles occurs with streamflows slightly below those flows necessary for the initiation of particle motion (Schumm and Stevens, 1973). Second, pot-holing and rounding of bedrock exposed in stream beds shows that coarse material at rest is abraded by collisions with particles in transport. We may introduce a second abrasion coefficient, a_V, to represent *in situ* attrition, and a_D may now be expressed as

$$a_D = a_T + a_V \tag{11}$$

The components of the diminution coefficient become

$$a_D = a_T + a_V + \beta \tag{12}$$

Equation (12) is not physically consistent, as a_V is related to the time of exposure to abrasion and is not directly related to distance of travel. However, it may be assumed that a_V is related to the proportion of time a particle is at rest during transport over distance x. In this way, a_V is related to distance x and Equation (12) becomes consistent with Equation (6).

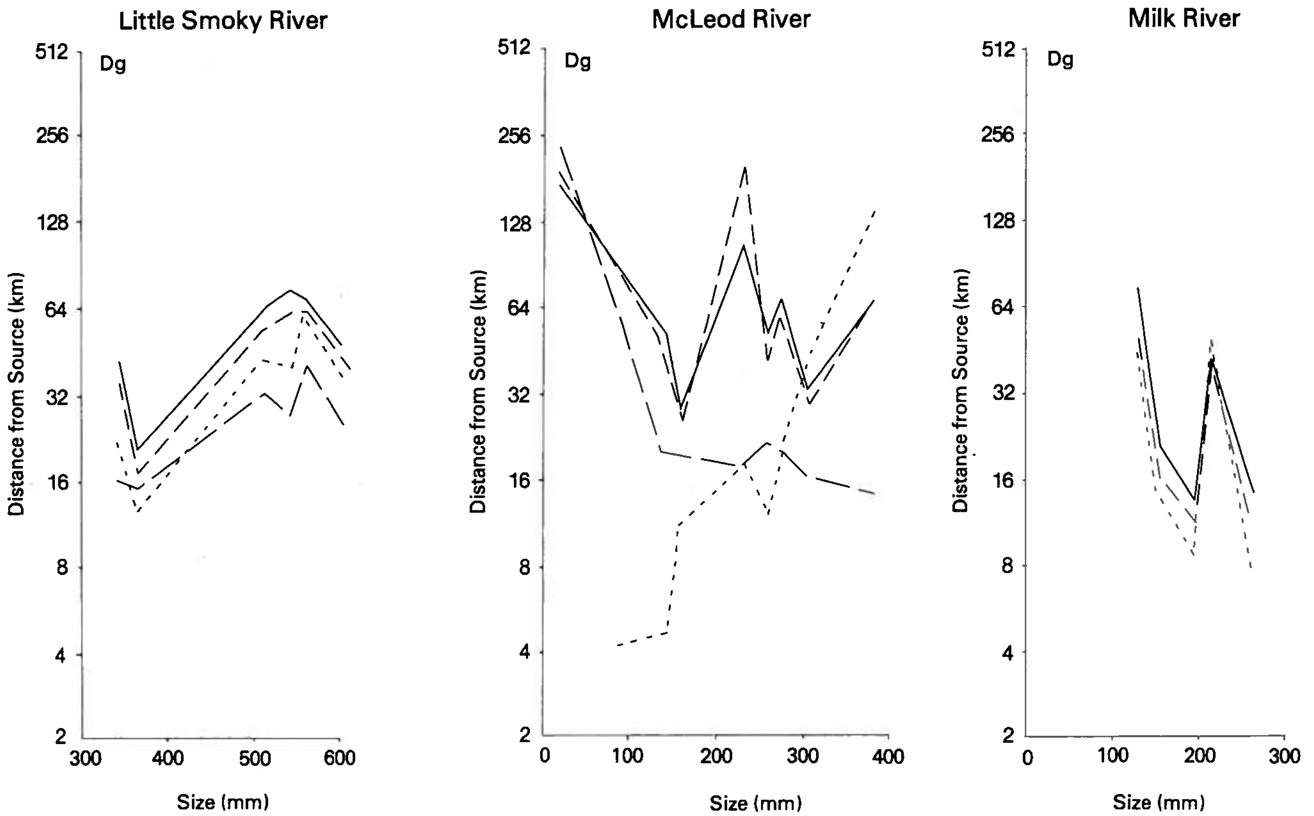


Figure 13. (continued)

For experiments run under similar conditions on two rock types, there should be a constant ratio between the abrasion coefficients, α_T, of the two materials. Also, since the effect of attrition *in situ* depends on the same rock properties as the effects of attrition during transport, the ratio between the α_V values should be the same as that for α_T. Thus

$$\alpha_{T1} = c_{12}\alpha_{T2} \text{ and } \alpha_{V1} = c_{12}\alpha_{V2} \tag{13}$$

where the subscripts 1 and 2 indicate two lithologies, with c_{12} a constant for these lithologies. From Equations (12) and (13), we obtain the diminution ratio as:

$$\frac{a_{D1}}{a_{D2}} = \alpha_{T1} + \alpha_{V1} + \beta \,/\, \frac{\alpha_{T1} + \alpha_{V1}}{c_{12}} + \beta \tag{14}$$

Equation (14) includes the assumption that the differential transport coefficient is independent of lithology. This is reasonable for materials of similar density. The geomorphological arguments presented earlier illustrate an erosional history for the postglacial development of the middle reaches of the Albertan rivers. Consequently, as a first approximation, $\beta = 0$, which gives $a_{D1} / a_{D2} = c_{12}$ from Equation (14). Estimates for c_{12} can be obtained using values of abrasion coefficients obtained for two lithologies under similar experimental conditions. Values for c (quzte/lmst) obtained in this way are as follows: circular flume cement floor c (quzte/lmst) = 0.17 (Kuenen, 1956); circular flume pebble floor c (quzte/siliceous lmst) = 0.17 (Kuenen, 1956); rolling mill c (quzte/non-Tertiary lmst) = 0.52 (Adams, pers. comm.) with $\overline{\alpha}_T$ for the quartzite based on 12 values and on 17 values for the non-Tertiary limestone. Rolling mill experiments to determine c (quzte/lmst) for the rivers of this study were conducted on samples from the Athabasca River. The results obtained were α_T (quzte) = 0.000196 km^{-1}, α_T (lmst) = 0.000679 km^{-1}, and c (quzte/lmst) = 0.289. Diminution coefficients obtained for bed material in the Albertan rivers are available for quartzite but are unreliable for limestone.

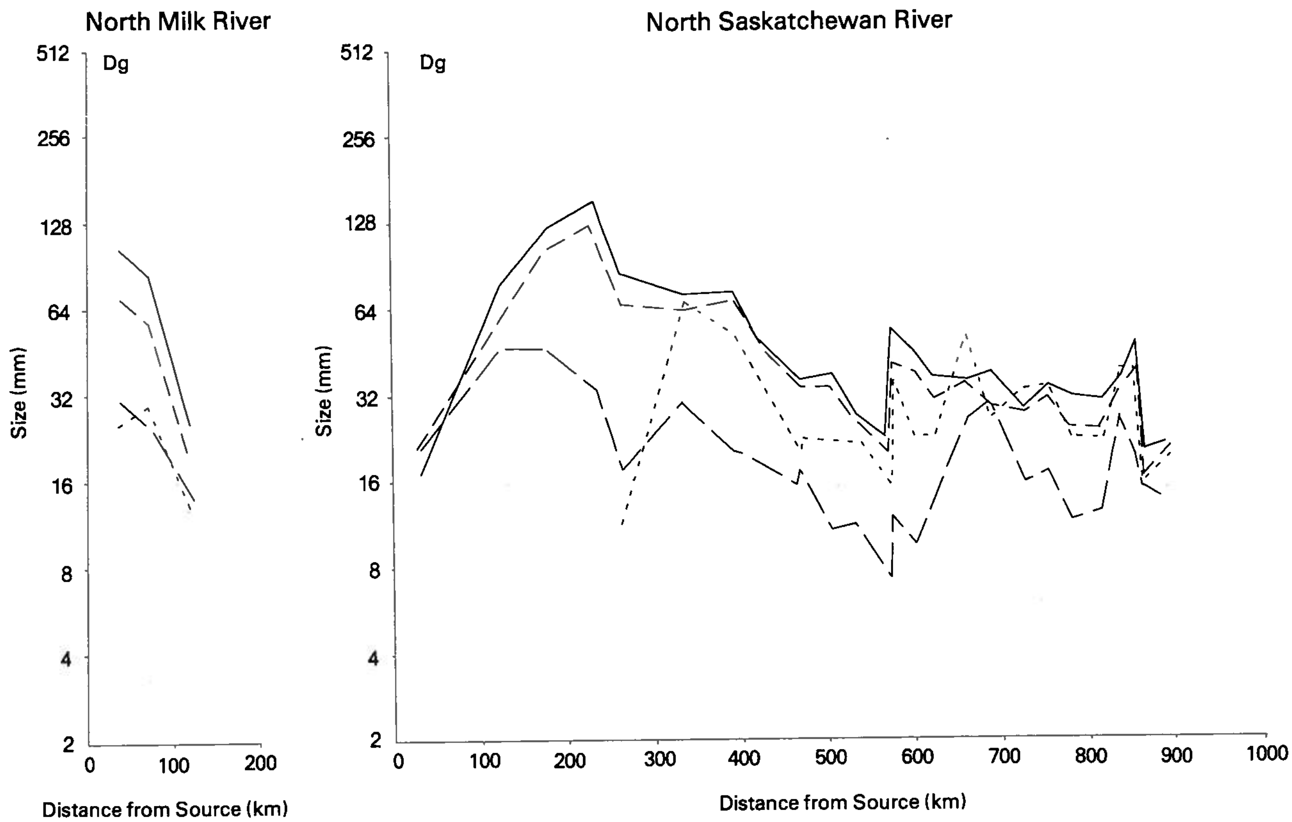


Figure 13. (continued)

Taking the value a_D (quzte) = 0.0017 km^{-1} obtained from the regression log D_{90} (quzte) vs x for the North Saskatchewan data (Table 11) and the value c (quzte/lmst) = 0.289, we can estimate:

$$a_D\ (\text{lmst}) = \frac{a_D\ (\text{quzte})}{c\ (\text{quzte/lmst})} = \frac{0.0017}{0.289} = 0.006\ km^{-1}$$

The value a_D (lmst) obtained coincides closely with the values which give a full and complete explanation of the downstream change in grain size by abrasion. The assumption that no contribution to downstream change in grain size is made by differential transport appears to be supported by the above inductive approach, but this could be partly fortuitous as shown by the following:

Rearranging Equation (14) with $\beta/(a_{T1} + a_{V1})$ written as y, and a_{D1}/a_{D2} written as z gives:

$$y = ((z/c_{12}) - 1)/(1 - z) \qquad (15)$$

and differentiation shows:

$$\frac{dy}{dz} = (1 - c_{12})/c_{12}(1 - z)^2 \qquad (16)$$

Equation (16) gives high rates of change of the ratio $y = \beta/(a_{T1} + a_{V1})$ with respect to the diminution ratio z. For example, given that c_{12} = 0.17, an underestimate of the diminution ratio by 33.3 percent (estimated value = 0.2, true value = 0.3) involves an underestimate of y by 80 percent (estimated value = 0.22, true value = 1.09). In other words, the experimental value of c_{12} and the ratio of diminution coefficients, z, needs to be known precisely if one wishes to draw conclusions concerning the contribution of differential transport.

The most probable source of error in the present study lies in the estimation of a_D (lmst), particularly since limestone pebbles are subject to diminution by solution. Ideally, the analysis should be applied to a single stream with bed material that would include two plentiful lithologies upon which laboratory abrasion experiments and field sampling experiments could be conducted.

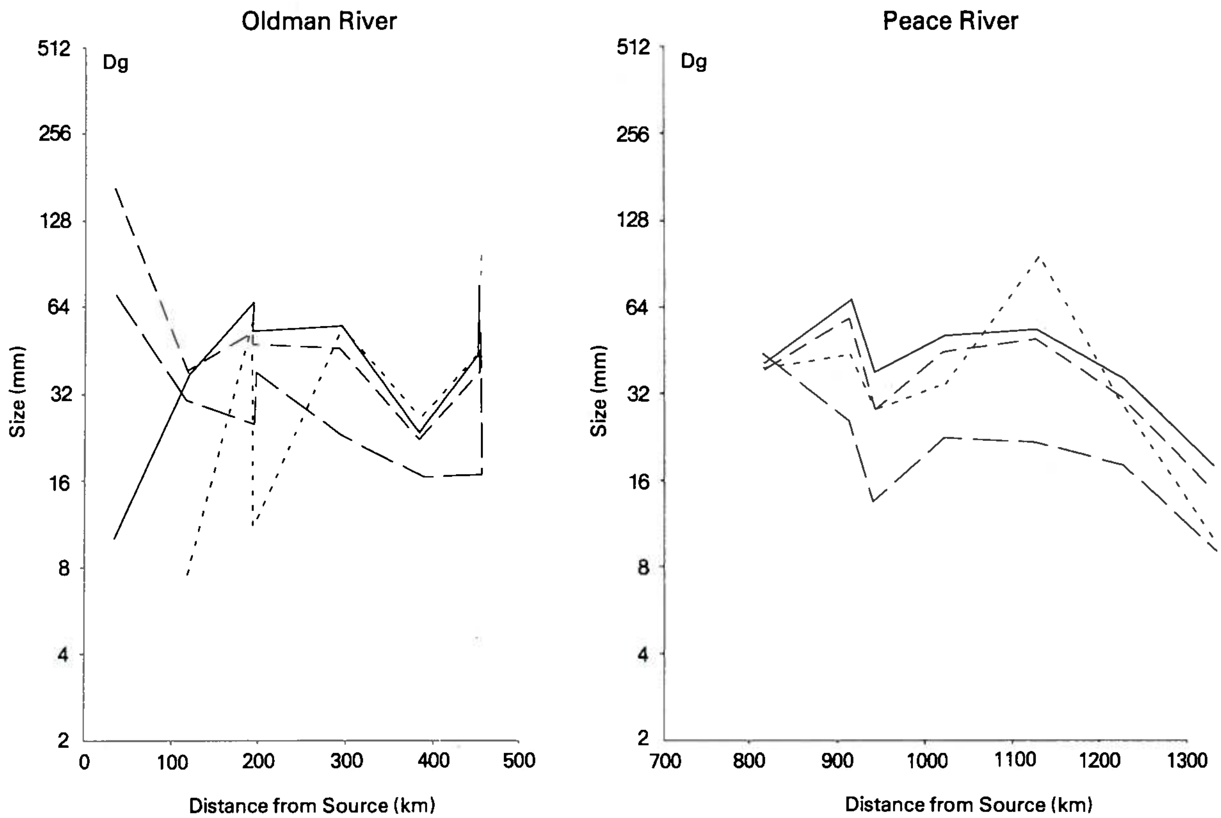


Figure 13. (continued)

A final product of the analysis is the relative contribution of a_T and a_V to the abrasion of quartzite. Assuming that abrasion experiments which involve continuous movement can estimate a_T, a_V can also be estimated from the difference a_D - a_T. Using the abrasion rates determined from abrasion mill experiments on quartzites from the Athabasca River gives a_T = 0.000196 km^{-1}. As the quartzites in the Athabasca River are lithologically similar to those in the North Saskatchewan River, we may use the a_D (quzte) value of 0.00169 km^{-1} to obtain a_V = 0.0018 and the ratio a_T/a_V = 0.107. Thus, the data for the North Saskatchewan River indicate that almost 90 percent of abrasion occurs as a result of *in situ* processes.

However, this conclusion does not necessarily imply that the *in situ* abrasion processes are more effective than abrasion during transport. In fact, it is much more reasonable to expect the opposite. Earlier we noted that distance was substituted for time to justify the use of a_V in the diminution equations. In the Albertan rivers, the length of time that a gravel particle is *in situ* far exceeds the length of time it is in transport. Consequently, the cumulative effects of attrition *in situ* far outweigh the effects of attrition in transport.

Secondary Effects

The discussion of diminution coefficients for Albertan rivers has examined overall diminution downstream within the central gravel reaches. However, restricted reaches show marked deviations from the general trend. These deviations are commonly in the form of a much more rapid exponential decrease in grain size with distance downstream. Good examples of this are given by the grain-size changes over the North Saskatchewan River reach between sample points 7 and 16 (Fig. 13) and in the Peace River reach discussed by Church and Kellerhals (1978). In both of these cases, the local trends are associated

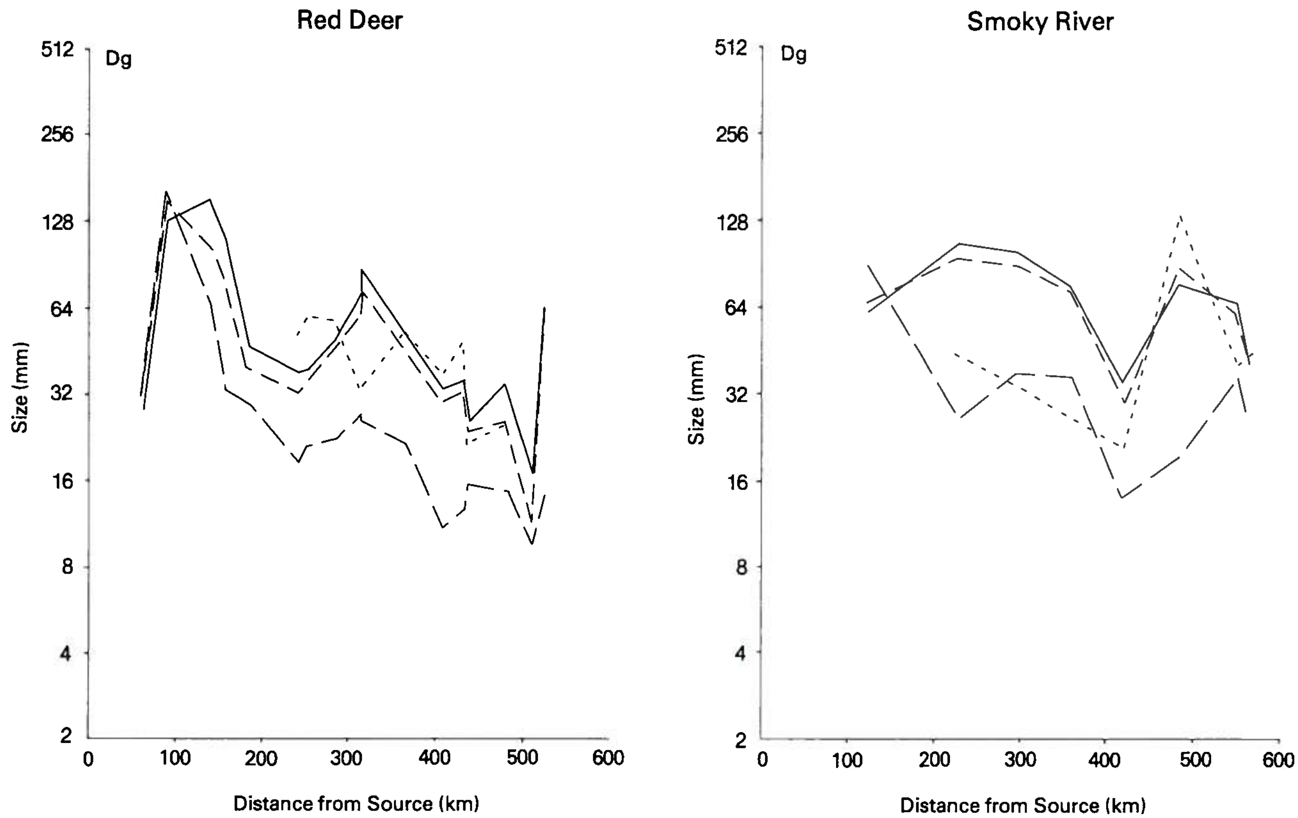


Figure 13. (continued)

with large tributaries: the Brazeau River enters the North Saskatchewan River upstream from sample point 7, and the Halfway, Moberly, and Pine rivers enter the Peace River in the British Columbia reach. The local increase in the negative value of the diminution coefficient could be explained if the tributaries cause aggrading reaches downstream from the confluence. In this case, differential transport is of local importance, and consequently the decrease in grain size is rapid. However, this does not explain why particle sizes at the downstream end of the local reaches are less than those given by the general trend. This phenomenon must be explained by the association of local trend and the general trend with events of different magnitude and frequency. It may be that the general trend is inherited from trends in earlier fluvial deposits and the superimposed local trends represent present-day processes. Alternatively, the general trends may represent effects of high magnitude, but low frequency flood events, and local downstream diminution represents aggradation under high frequency, but low magnitude events.

BIMODAL GRAIN-SIZE DISTRIBUTIONS

The most striking aspect of figures 4 and 5 is the strongly bimodal nature of almost all composite samples and the relative dearth of material in the size fractions between 0.71 mm and 2 mm compared to the contents of adjoining finer and coarser fractions. The modal sizes in the sand and gravel ranges and the minima between them are summarized in table 13, both for the composite of all gravel samples (samples containing more than 20 percent coarser than 2 mm) and for the total composite samples of each river. Results for the overall composite samples for all rivers combined are also listed.

Figure 4 indicates that the split into "sand" samples and "gravel" samples, stated here as 20 percent greater than 2 mm for gravel, is not arbitrary. Instead of 20 percent, one could use any value from 10 percent to 45 percent without reclassifying a single sample. There are 125 gravel samples and 49 sand samples for a total, from all 12 rivers, of 174 samples.

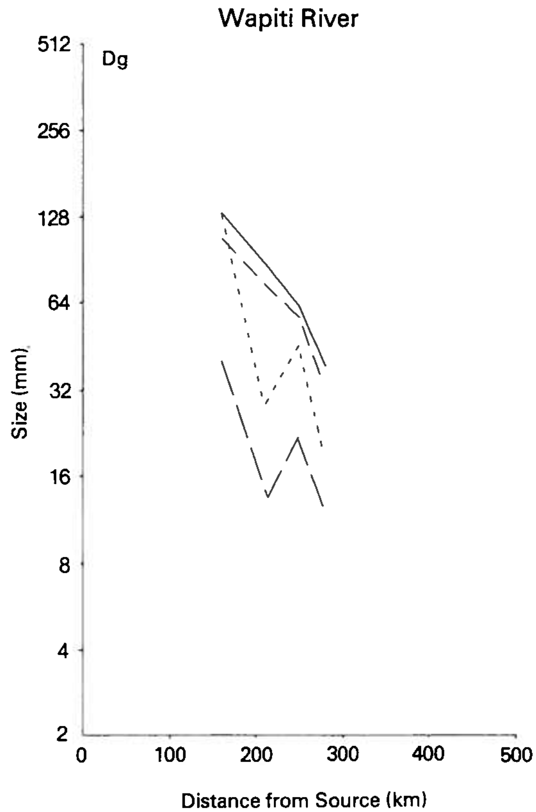


Figure 13. (continued)

The location of the minimum between sand and gravel is quite constant, particularly so in the case of the composite gravel samples where the minimum falls into the 1 to 1.41 mm range for all rivers. Inclusion of the sand samples shifts the minimum to the 1.41 to 2 mm range for a few rivers. This is probably not particularly significant since all three size fractions between 0.71 and 2 mm have almost equally low contents. The modes of the sand range are almost evenly distributed on the two size ranges between 0.25 and 0.5 mm. The unusual sand mode of the Athabasca River (0.125 to 0.177 mm) is caused by the fact that two of the five sand samples were taken along the deltaic reach immediately upstream of Lake Athabasca. The gravel sizes have more variable modes, but all of the modes coarser than 32 mm occur in rivers either that join another larger river sufficiently near to the mountains so that the bed material is still coarse at the confluence (Little Smoky, McLeod, North Milk, Oldman, Smoky, Wapiti rivers), or else in a river that is poorly sampled over a major reach near the end of the gravel section (Peace River), or even in a river with a major non-alluvial, steep reach between the gravel-bed and sand-bed zones (Athabasca River). All the rivers with reasonably regularly spaced samples from the mountains into the sandy reaches show a gravel range mode of 16-32 mm (Bow-South Saskatchewan, Milk, North Saskatchewan, and Red Deer rivers).

A so-called deficiency of 1 to 4 mm range grains in certain sediments has often been noted in the literature. Shea (1974) quoted many earlier references to this "deficiency" and examined the data on which statements by various authors are based. He also examined the question of what constitutes a deficiency. The word "deficient" immediately gives rise to the question "with respect to what?" Seeing that there is no accepted standard size distribution for fluvial sediments, that question has no ready answer. The term appears to have been used loosely to describe a histogram valley between modes in the sand and gravel ranges. Also, there is no accepted standard for defining the width of the deficiency; it appears to have been done on a purely subjective basis. Referring to figure 5, the overall composite gravel sample, the deficiency could be defined as extending from mode to mode, giving a range from 0.35 mm to 16 mm; or else the deficiency could be explained as ranging from the lower mode horizontally across the valley, thereby reducing the range to 0.35 mm to 2 mm. Both definitions are somewhat unsatisfactory because they fail to note the pronounced valley floor extending from 0.5 mm to 2 mm, which is probably the deficiency range that most previous authors would have identified. The curves for the Milk and Little Smoky rivers given in figure 6 are examples for which it is particularly difficult to define a deficiency range objectively. In view of these problems, it is best to continue the discussion in terms of modes and intervening valley low or minimum fractions, as is done in table 13.

A cursory examination of figure 4 indicates that not all size distributions are bimodal and that there is a wide variation in the depth of the "valley". Detailed inspection of all size distribution data shows the following trends and conclusions.

First of all, of the 49 sand sample distribution curves, only one has a secondary mode in the gravel range, although many of these sieve curves extend to 8, 16, and even 32 mm. Less than 2 percent of the bimodal sample (North Saskatchewan - 33) is coarser than 1 mm.

Secondly, of the 125 gravel samples, only the following three do not have a secondary sand mode: McLeod - 1, North Milk - 2, and Oldman - 1. Note that they are from headwater reaches in the mountains or foothills. A further

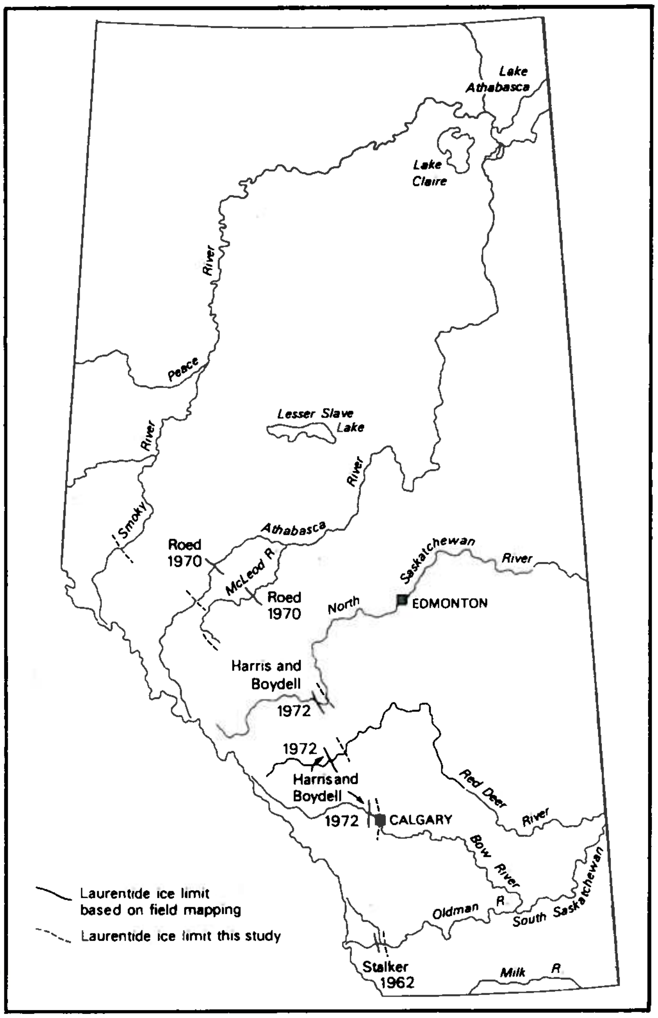


Figure 14. Laurentide ice limits determined by field mapping, and by the occurrence of granite in river-bed materials.

19 gravel samples can be classified as "weakly bimodal" in the sense that the secondary sand mode is less than twice as high as the low point of the valley. Of those, only four (Bow-South Saskatchewan - 12, North Saskatchewan - 17 and 27, and Red Deer - 17) are not from a headwater reach. The 15 others are Bow-South Saskatchewan - 1, - 2, and - 5, Milk - 1 and - 2, North Milk - 1 and - 3, North Saskatchewan - 3, Oldman - 2, - 3, and - 4, Red Deer -1 and - 4, and Wapiti - 1 and - 2. Note that some of the headwater reaches (for example, in the Peace and Smoky rivers) are only poorly sampled if they are sampled at all. The 2 samples named above are not lithologically distinguishable from the remainder. Generally being from close to the mountains, some contain high percentages of limestone, but many do not. One sample (Oldman - 1) has a high percentage of sandstone.

The data appear to indicate that the bed material of major gravel-bed rivers on the Northern Great Plains is generally characterized by a distinct low in the histogram at around 1 mm. Along the steeper headwater reaches in the mountains and foothills, the low is often, but by no means always, less pronounced and sometimes it is absent. The size of the river appears to play a significant role in the headwater areas, as the low is more pronounced along the larger rivers like the North Saskatchewan River.

A variety of mechanisms have been postulated for explaining the low content of material in the 1-2 mm range in many alluvial gravels. Shea (1974) gave a detailed review of the literature. The main causes postulated are three: the mechanical instability of particles in the deficient grain sizes; the mixing of independent populations; and selective transport.

On the matter of mechanical instability of particles in the deficient grain sizes, it has been argued (for example, Krumbein and Tisdel, 1940) that grains smaller than 1 mm frequently consist of single mineral crystals, while grains larger than 4 mm are normally rock fragments consisting of many tightly interlocked crystals. The particles in the intermediate range often contain only a few crystals which might readily disaggregate during transport.

While the basic statement concerning the composition of naturally disintegrated, untransported source rock has some observational support (for example, Blatt, 1967), the postulated mechanism calls for a general lack of material in the 1 mm to 4 mm range in sedimentary deposits, a notion clearly disproved by Shea's (1974) analysis of over 10,000 grain-distributions of sediment from a wide variety of localities and environments. Rolling mill experiments (for example, Schubert, 1964) also fail to confirm mechanical instability of grains in the 1 mm to 4 mm range. They show a gradual, systematic grain-size reduction down to sand sizes, but with little abrasion beyond.

Two aspects of the present results also conflict with a mechanism based on mechanical instability. The sand samples should have the same low point in their histogram as the gravel samples do and it appears most improbable that the location of the low could be unaffected by lithology, yet no such effect could be detected.

When considering the idea of mixing of independent populations, bimodal grain-size distributions can be obtained by mixing two single-moded materials, a phenomenon which might occur downstream of a river confluence or as a result of two predominantly different source materials. But the mechanism could not possibly explain the general bimodality of alluvial gravels shown here in these present results, or the abrupt transition to sand when the median size drops to around 8 mm.

Unfortunately, there is little known about the size distribution of materials supplied to the mainstem rivers by small, steep tributaries originating in the main sediment source areas of the mountains and foothills. McPherson (1971) has investigated the sediments of one typical, steep tributary to the North Saskatchewan River at approximately kilometre 70. None of his 12 channel samples have a low in their histogram in the 1 mm to 4 mm range, yet the nearby sample North Saskatchewan - 2 is distinctly bimodal.

Finally on the issue of selective transport, Sundborg (1956), Russell (1968), and others have proposed selective transport as an alternate mechanism which might explain the relative dearth of coarse sand and fine gravel in some fluvial sediments. If grains of a certain size are moved preferentially over beds of predominantly coarser and predominantly finer sediments, those grains will be in motion more frequently than other grains and will therefore abrade more rapidly and will consequently be relatively rare. While this argument could explain a general dearth of materials in some grain-size ranges, as seen in combined samples, which cover a river from the gravel reaches to the sand, it explains neither the bimodality of individual samples taken along gravel reaches of the present rivers nor the absence of bimodality in sand samples.

There is much evidence, both from the field and from the laboratory, showing that the largest grains of relatively coarse sediment mixtures (predominantly gravel) are most stable. The most convincing field evidence consists of the well-known fact that falling river stages expose gravel bar surfaces from which the fines have been removed. Bray (1971, p. 70) examined the bed material of many Alberta rivers and found "on most surfaces of gravel rivers it is difficult to find an appreciable amount of material finer than 8 mm." Sediment transport observations (Amt für Wasserwirtschaft, 1939; Emmett, 1976) generally showed an increasing coarseness of the load with increasing flow. Sundborg (1956, p. 186) summarized the early laboratory evidence, and recent work on sediment entrainment and armouring (Neill, 1968; Gessler, 1970) has not changed the basic conclusion that the coarsest grains are most stable. In order to explain the predominantly bimodal gravel samples, there has to be a mechanism accumulating medium sand in the gravel, yet it has never been suggested that coarse sand and fine gravel (0.71 mm to 4 mm) move more readily over gravel beds than medium sand (0.25 mm to 0.5 mm), yet this would have to be so if preferential transport alone was to explain the bimodal histograms.

Two mechanisms could account for the sand mode. As pointed out earlier, sand is not effectively abraded by fluvial transport. Abrasion could therefore account for a gradual downstream accumulation of sand in the streambeds. Alternatively, deposition of the coarsest suspended sediments might possibly play some role. Detailed suspended sediment records exist for several sites along the rivers of the present study on both gravel and sand reaches (Environment Canada, 1976). With few exceptions the suspended sediment size distributions peak in the silt range and extend to 0.5 mm or 1 mm, but contain less than 10 percent material coarser than 0.25 mm. It is therefore conceivable that medium sand from the suspended load gets deposited between the grains of a gravel streambed.

The evidence concerning preferential transport over predominantly sandy beds is not as clear as in the case of gravels. If mixtures of sand and fine gravel are transported in laboratory flumes at relatively high rates, Straub (1935), Chang (1939), and Kellerhals (1967) have observed that smooth sand-beds become established over which the coarsest sand and fine gravel move preferentially. There obviously must be an upper grain size which would no longer move preferentially; but no studies concerning that size have ever been undertaken. Kellerhals noted that if the upstream supply of sediment is stopped, the sand bed gradually degrades leaving a coarser and hydraulically much rougher erosion pavement behind. Similar processes have been observed downstream of major dams on sand-bed rivers (Pemberton, 1976; Livesay, 1965) where active sand beds have gradually been converted to stable gravel beds.

Several experimenters have noted (Guy *et al.*, 1966; Hooke, 1968) that sediment transport over dune beds tends to accumulate the coarsest grains in the troughs between dunes. Small gravel and coarse sand tends to move preferentially up the stoss side of sand dunes but become entrapped in the troughs. The observations of Nordin and Culbertson (1961) along a 300 km reach of the Rio Grande River in New Mexico are interesting in this context. The river has a sand bed along the entire reach with a gradual downstream decrease in grain size, but along the first 50 km the sand bed appears to consist of only a thin sheet of sand overlying bimodal gravel. At very high flows, some of the gravel becomes exposed which leads to a general coarsening of the bed material.

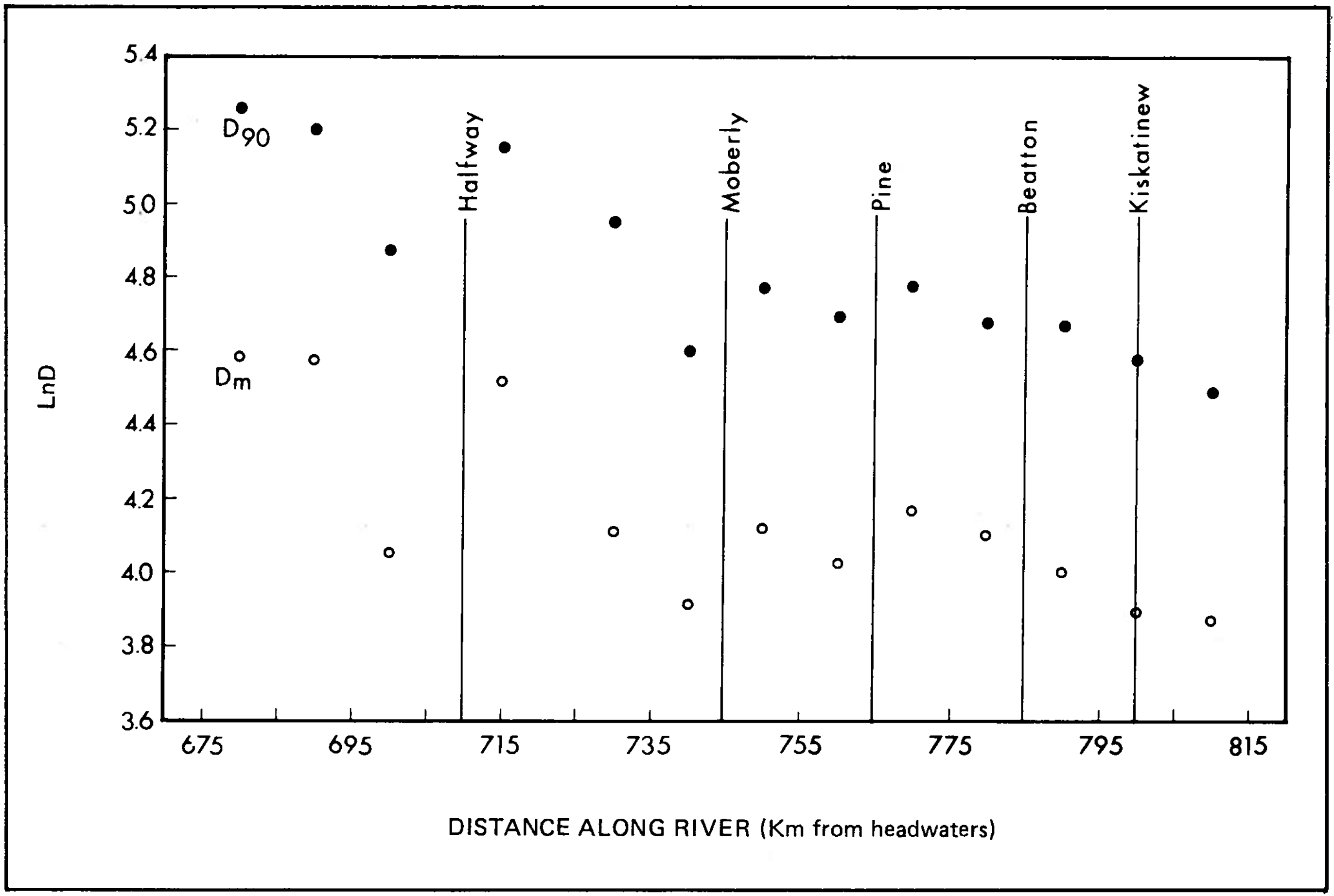


Figure 15. Peace River grid sample data smoothed by grouping in 10 km segments. The locations of the major tributaries are shown.

A possible explanation of the grain-size distributions of streambed sediments collected along the major rivers of Alberta might be that fluvial transport in steep headwater streams appears to produce a coarse, unimodal alluvial gravel. Granule and coarse sand-sized particles (1.0 mm to 4 mm) are transported as part of the bed load. Because they are the smallest grains prevailing on the bed, they are frequently moved and subject to intense crushing and abrasion. Most of the finer material generated is removed as suspended load. In the flatter, less turbulent reaches of mainstem rivers, suspension is less effective in moving the medium to fine sand generated by abrasion, and a bimodal gravel-bed material with a secondary mode in the medium sand range appears. Sand rarely appears on the river bed surface in positions where it is exposed to the flow, but there appears to be sufficient sand moving in close contact with the bed to fill spaces between deposited grains and to accumulate in sheltered locations. As the gravel is moved downstream and gradually abraded, the percentage of medium to fine sand increases. Once the predominant size of the gravel fraction reaches the 8 to 16 mm range, the rate of gravel diminution increases drastically and sand becomes dominant. It is probable that the increase in sand and rapid diminution of gravel are interdependent. The increase in volume of sand produces a smooth bed which allows preferential transport of fine gravel. Preferential transport causes increased attrition which in turn produces more sand. The gravels are clearly unstable at this stage and may also become buried in scour troughs associated with sand-bed forms. The rapid transition from gravel to sand (Fig. 13) is explained by the above. For relatively short sand reaches, the fine gravel could accumulate on beaches close to river mouths as suggested by Russell (1968).

In aggrading systems, such as the fans studied by Yatsu (1957), where the river slope is determined by the supply

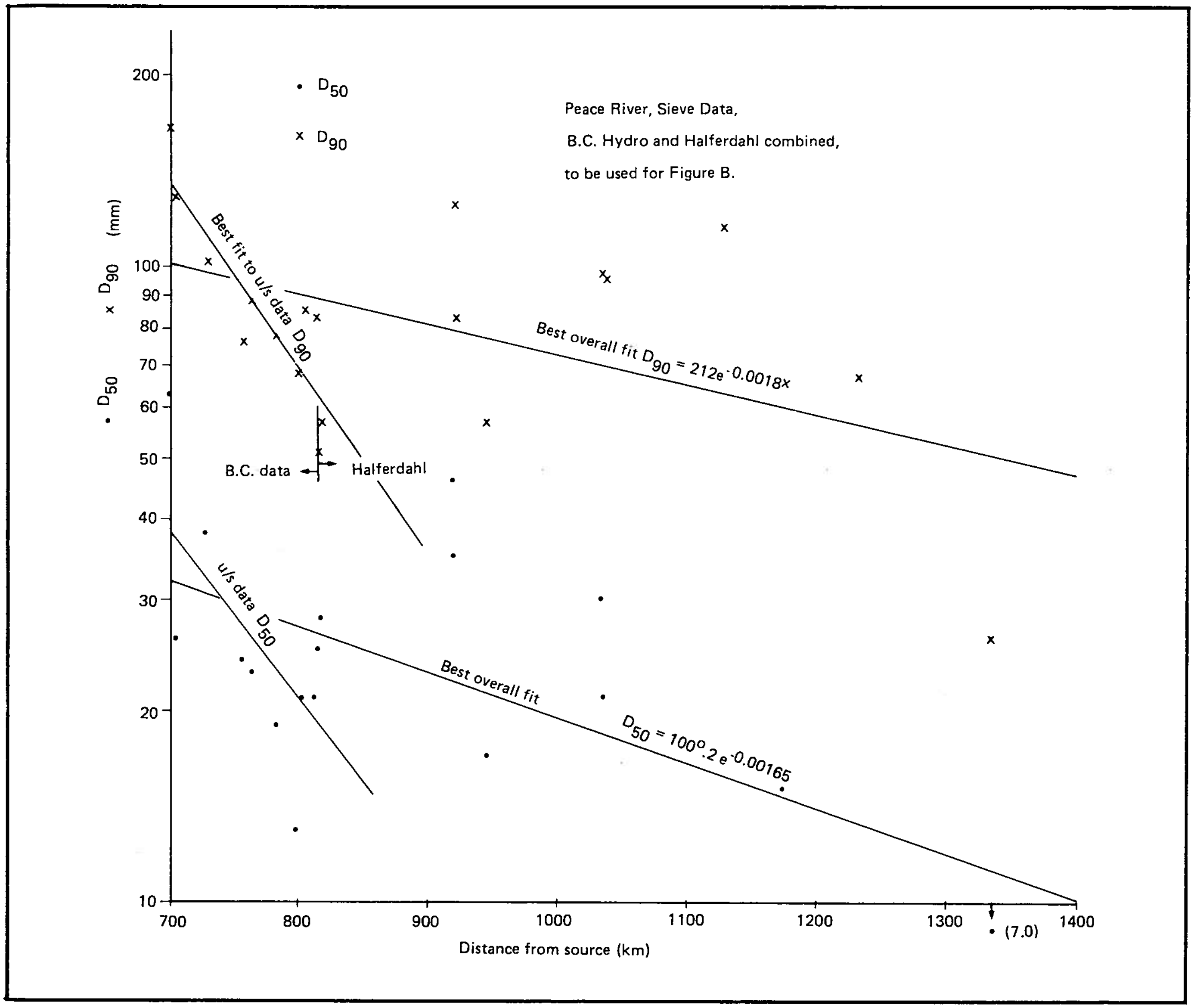


Figure 16. Peace River sieve data with overall and local regression lines shown (from Church & Kellerhals, 1978).

of water and sediment from upstream, the sudden transition to sand beds is always associated with a break in slope. The postulated mechanism does not, however, require a slope break and the present rivers, whose slopes are essentially predetermined by the general north-eastward dip of the Northern Great Plains, do not show such a break. It appears that river morphology in general provides sufficient degrees of freedom for these rivers to achieve equilibrium within relatively wide ranges of slope and bed material size.

Eight of the 125 gravel samples have a second histogram low which is located in the 32 to 64 mm fraction in all cases. Since six of these eight samples occur in adjoining or almost adjoining pairs on the Bow-South Saskatchewan (- 4, - 5), North Saskatchewan (- 5, - 7), and Red Deer (- 9, - 11), sampling inaccuracies are unlikely to be the cause. (The other two samples are Athabasca - 1 and Milk - 4.) Lithology also does not appear to offer a clue, as some samples are predominantly limestone, while others are predominantly quartzite, with the majority having significant fractions of both. Sandstone occurs in significant amounts in five of the samples.

SUMMARY AND CONCLUSIONS

This report is primarily a presentation of data on downstream changes in grain size and lithologic content of alluvial gravels in Alberta. Some preliminary analysis of this data is presented together with explanations of the observed relationships. The major conclusions concern the geomorphic history of the rivers, and the processes which lead to characteristic bimodal grain-size distributions in certain reaches and to a general decrease in grain size with distance in the central gravel reaches of the Albertan rivers.

The assumption that there is a causal relationship between the present hydraulic conditions in the Albertan rivers and their bed materials is justified by the observation of active channels. Nevertheless, distributions of source materials and valley characteristics are largely a product of past geologic and geomorphologic events. In particular, the exposure of resistant Proterozoic and Paleozoic rocks in the mountains and less resistant rocks in the plains leads to the dominance of limestone and quartzite in the river bed material. In terms of the study of downstream changes, this restriction of the dominant lithologies to a relatively restricted zone of exposure is a decided advantage. However, this is in part offset by the complicating effects of glaciation with the introduction of exotic lithologies from the Canadian Shield, and the alternate periods of valley fill and excavation. A further influence of glaciation is that of isostasy on river slopes. Arguments are presented to suggest that isostatic depression may well have caused postglacial steepening of river slopes resulting in knick points and distinct local zones of aggradation and denudation.

Grain-size distribution and cumulative curves are presented. Lithologic components are given for the gravel fraction (> 2 mm) and separate plots are given of the downstream variation in lithology for the major components, quartzite, limestone, and granite, and for the minor constituents. Grain-size distributions of the major components are presented for the North Saskatchewan River only. Most samples do not pass a significance test to show their representativeness in terms of the bias introduced by the largest particle sizes. Consequently scatter in the results can be attributed in part to inadequate sample sizes. Grain-size parameters obtained from the distributions include geometric means, DG, for the granite, limestone, and quartzite subsamples, and total gravel fractions. Values of the D_{50} (median) and D_{90} (90 percent finer than) are given for each total sample and its gravel fraction.

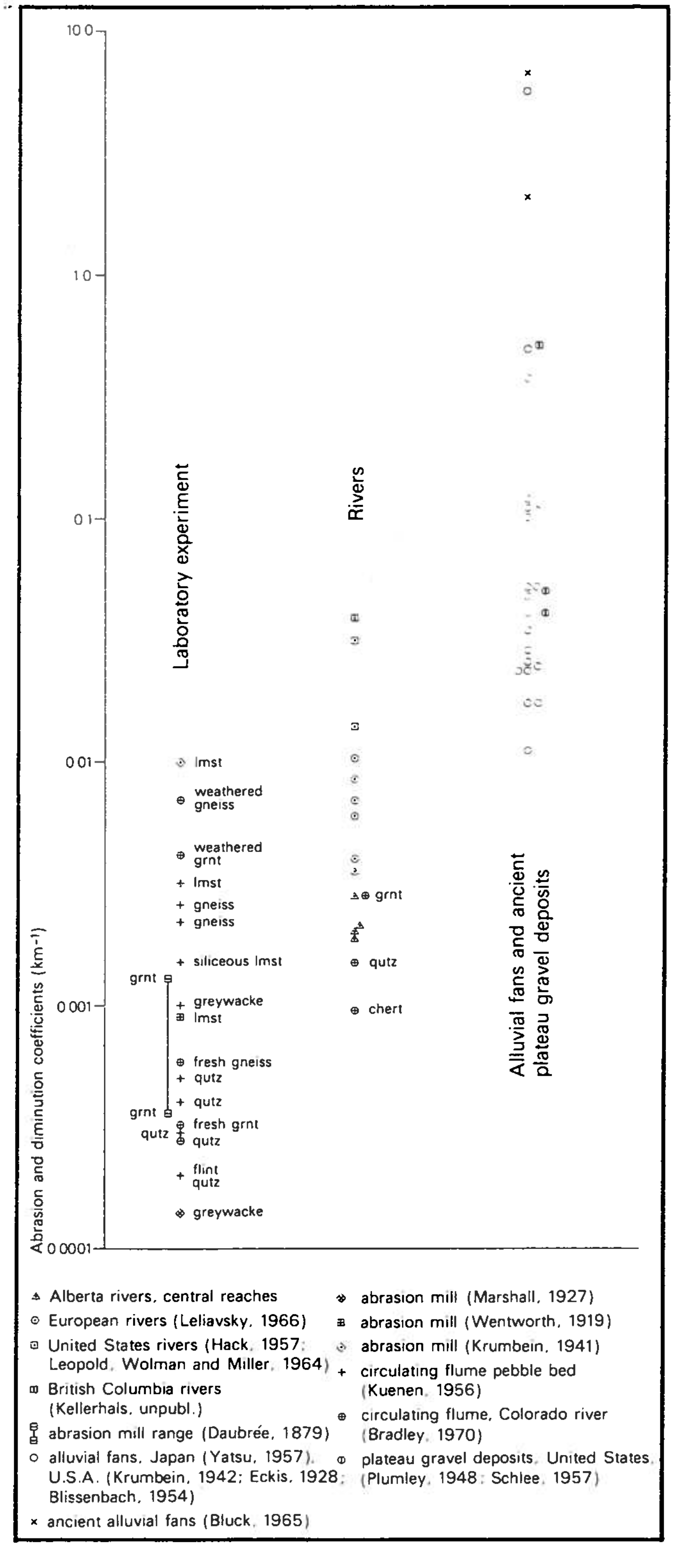


Figure 17. Abrasion and diminution coefficients.

High variability in grain size at a site is noted for a separate sampling experiment on the Peace River. This occurs despite stratification of the samples on sedimentologic and geomorphic criteria. However, downstream variation is shown to be even more significant and the use of Sternberg's relationship to describe downstream variation in grain size is justified for the central reaches of the large rivers in Alberta. Deviations from this relationship reflect superimposed local trends often associated with tributary streams.

The rivers can be divided into three reaches: a mountain reach in which there is a tendency to increasing grain size with distance; a central, gravel reach in which decrease in grain size follows Sternberg's relationship; and a lower reach which is sand bedded.

Grain-size changes with distance in the mountain reach are highly variable but do show a tendency to increasing size downstream. Explanation for these observations probably lies in the complex historical and present-day geomorphologic processes in these reaches.

The central reaches are considered to be zones of downcutting in the most recent past. The information obtained from these reaches permits a detailed discussion of the components which contribute to the exponential diminution coefficient, a_D, in the Sternberg relationship. On theoretical grounds, this coefficient is divided into two components: one representing attrition, and the other differential transport. In this study, the diminution coefficient, a_D, is obtained by a least squares regression fit of distance, x, against log D, where D is some grain-size parameter. Values of a_D based on D_{50} are less than those based on D_{90}. This is explained partly by the influence of the shoulder seen in the cumulative grain-size distribution curves (Fig. 4) and associated with deficient grain-size classes centered at about 1 mm.

The diminution coefficient for limestone is obtained using the lithologic plots (Fig. 11) and information on the size of coarsest limestone clasts (Fig. 12); values found for the Athabasca, North Saskatchewan and Red Deer rivers are 0.0119 km^{-1}, 0.0097 km^{-1}, and 0.0118 km^{-1} respectively. An independent calculation based on the assumption that differential transport has had a relatively unimportant influence on downstream changes in grain size along the central reaches gave a value a_D (lmst) = 0.006 km^{-1}.

These values are fairly coincident and support the initial assumption that differential transport has been relatively unimportant.

A brief summary of the literature and compilation of values of a_D for alluvial fans, rivers, and abrasion mill experiments show higher values of a_D for alluvial fans than rivers. This illustrates the important contribution of differential transport which results from aggradation in the fan environment. Rivers also show consistently higher values of a_D than do abrasion mills. The abrasion component of the diminution coefficient is divided into two parts, abrasion during transport and abrasion at rest. The abrasion during transport component corresponds to that measured in abrasion mills. A method is presented in which the two parts may be separated for a given lithology, in this case quartzite, and for the North Saskatchewan River almost 90 percent of abrasion is attributed to *in situ* processes. It is suggested that this reflects the much greater time that gravel is *in situ* than in transport. The alternative that the *in situ* processes are more vigorous than the transport one is clearly unrealistic.

Input from large tributaries is one important mechanism producing deviations from the general downstream decrease in grain size. The general trend may be inherited from trends in earlier, fluvial deposits with the superimposed trends representing present-day processes. Alternatively, the general trends may represent high magnitude but low frequency flood events, and the local trends at tributaries represent aggradation under high frequency but low magnitude flow events.

A marked deficiency of material in the size range 0.71 mm to 2 mm is noted for most of the gravel samples. Of 125 gravel samples only three do not have a secondary sand mode and these samples are from headwater regions. Furthermore, of the samples classified as weakly bimodal, most occur in headwater reaches. The previously proposed mechanisms producing the grain-size deficiency are shown to be inapplicable. Alternatively, we suggest that the coarsest gravel material is the most stable and the problem becomes one of explaining the elimination of coarse sand and granule sizes and the addition of medium sand. This problem is answered in terms of the mode of transport. Medium sand is the coarsest material transported in suspension and it follows that coarse sand and granules are the finest materials transported as bedload during high flow stages. Consequently, the coarse sand and granules suffer maximum attrition by crushing and abrasion and are eliminated. Medium sands are deposited from suspension into the interstices of the gravel to produce the observed bimodal distributions.

Contrary to the case for the gravel samples, only one of the 49 samples consisting predominantly of sand is bimodal, although most of these samples contain some gravel, with sizes up to 32 mm. The literature on transport experiments with mixtures of sand and fine gravel as bed material suggests that in this range of sizes the coarsest grains are no longer the most stable ones and they may, under the right circumstances, be the first ones to be transported. This fact can explain the sudden transition from gravel to sand that occurs along all the rivers studied here, whenever the D_{50} grain size drops to approximately 8 mm. It also explains the almost instantaneous disappearance of the above-noted grain-size deficiency in the coarse sand - fine gravel range, as soon as the bed material changes from predominantly gravel to predominantly sand.

REFERENCES

Allen, J.R.L. (1965): A review of the origin and characteristics of recent alluvial sediments; Sedimentology, Vol. 5, No. 2, p. 91-191.

Amt Für Wasserwirtschaft, (1939): Untersuchungen in der Natur über Bettbildung, Geschiebe und Schwebestofführung; Mitteilung No. 33, 114 pages. Bern, Switzerland.

Babcock, E.A. (1973): Regional jointing in Southern Alberta; Canadian Journal of Earth Sciences, Vol. 10, p. 1769-1781.

Bayrock, L.A., and Hughes, G.M. (1962): Surficial geology of the Edmonton District, Alberta; Research Council of Alberta Prelim. Report 62-6, 40 pages.

Blatt, H. (1967): Original characteristics of clastic quartz grains; Journal of Sedimentary Petrology, Vol. 37, p. 401-424.

Blissenbach, E. (1954): Geology of alluvial fans in semi-arid regions; Geological Society of America Bulletin, Vol. 65, p. 175-190.

Bluck, B.J. (1965): The sedimentary history of some Triassic conglomerates in the Vale of Glamorgan, South Wales; Sedimentology, Vol. 4, p. 225-245.

Bradley, W.C. (1970): Effects of weathering on abrasion of granitic gravel, Colorado River, Texas; Geological Society of America Bulletin, Vol. 81, p. 61-80.

Bray, D.I. (1971): Generalized regime-type analysis of Alberta rivers; Ph.D. thesis, Department of Civil Engineering, University of Alberta, Edmonton, 232 pages.

Chang, Y.L. (1939): Laboratory investigation of flume traction and transportation; Transactions, American Society of Civil Engineers, Vol. 104, p. 1272.

Church, M. and Kellerhals, R. (1978): On the statistics of grain size variation along a gravel river; Canadian Journal of Earth Sciences, Vol. 15, p. 1151-1160.

Daubrée, A. (1870): Etudes synthetiques de géologie experimentale, Dunod, Paris, 2 volumes.

Düll, F. (1930): Das Gesetz des Gesschiebeabriebes. Mitteilungen aus dem Gebiete des Wasserbaues und der Baugrundforschung, Heft 1, W. Ernst and Sohn, Berlin.

Eckis, R. (1928): Alluvial fans in the Cucamonga district, Southern California; Journal of Geology, Vol. 36, p. 224-247.

Emmett, W.W. (1976): Bedload transport in two large gravel-bed rivers, Idaho and Washington; Proceedings of the Third Federal Interagency Sedimentation Conference, prepared by the Sedimentation Committee, Water Resources Council, U.S.A., p. 4-101 - 4-114.

Environment Canada (1976): Sediment data, Canadian Rivers, 1974. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, 432 pages.

Farvolden, R.N. (1963): Bedrock channels of Southern Alberta; *in* Early contributors to the groundwater hydrology of Alberta. Research Council of Alberta, Bulletin 12, p. 63-75.

Gessler, J. (1970): Self-stabilizing trends of alluvial channels; Journal of the Waterways and Harbors Division, American Society of Civil Engineers, Vol. 96, Proceedings Paper 7263, p. 235-249.

Green, R. (1972): Geological map of Alberta. Research Council of Alberta, Map 35.

Guy, H.P., Simons, D.B., and Richardson, E.V. (1966): Summary of alluvial channel data from flume experiments; U.S. Geological Survey, Professional Paper 426-I, 185 pages.

Hack, J.T. (1957): Studies of longitudinal stream profiles in Virginia and Maryland; U.S. Geological Survey Professional Paper, 294-B, p. 45-97.

Halferdahl, L.B. (1969): Alluvial quartzite pebbles as a source of industrial silica; Research Council of Alberta, Report 69-2, 22 pages.

Harris, S.A., and Boydell, A.N. (1972): Glacial history of the Bow River and Red Deer River areas and the adjacent foothills; *in* Slaymaker, O. and McPherson, H.J. (eds.), Mountain Geomorphology, Tantalus, Vancouver, 274 pages.

Hooke, R. LeB. (1968): Laboratory study of the influence of granules on flow over a sand-bed; Geological Society of America Bulletin, Vol. 79, p. 495-500.

Horberg, L. (1954): Rocky Mountain and Pleistocene deposits in the Waterton region, Alberta, Canada; Geological Society of America Bulletin, Vol. 65, p. 1093-1150.

Kellerhals, R. (1967): Stable channels with gravel-paved beds; Journal of the Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers, Vol. 93, No. WWI, Proceedings Paper 5091, p. 63-84.

Kellerhals, R. and Bray, D.I. (1971): Sampling procedures for coarse fluvial sediments; Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 97, p. 1165-1180.

Kellerhals, R., Neill, C.R., and Bray, D.I. (1972): Hydraulic and geomorphic characteristics of rivers in Alberta; Research Council of Alberta, River Engineering and Surface Hydrology Report 72-1, 52 pages.

Kellerhals, R., Shaw, J., and Arora, V.K. (1975): On grain-size from thin section; Journal of Geology, Vol. 83, p. 79-96.

Krumbein, W.C. (1941): The effects of abrasion on the size, shape, and roundness of rock fragments; Journal of Geology, Vol. 49, p. 482-520.

Krumbein, W.C. (1942): Flood deposits of Arroyo Seco, Los Angeles County, California; Geological Society of America Bulletin, Vol. 53, p. 1355-1402.

Krumbein, W.C. and Tisdel, F.W. (1940): Size distributions of source rocks of sediments; American Journal of Science, Vol. 238, p. 296-305.

Kuenen, Ph. H. (1955): Experimental abrasion of pebbles. 1. Wet sand blasting; Leidse Geologische Mededelingen, Vol. 20, p. 131-137.

Kuenen, Ph. H. (1956): Experimental abrasion of pebbles. 2. Rolling by current; Journal of Geology, Vol. 64, p. 336-368.

Leliavsky, S. (1966): An introduction to fluvial hydraulics, Dover, New York, 257 pages.

Leopold, L.B., Wolman, M.G., and Miller, J.P. (1964): Fluvial processes in geomorphology, Freeman, San Francisco, 522 pages.

Livesay, R.H. (1965): Channel armoring below Fort Randall Dam; Proceedings of the Federal Interagency Sedimentation Conference, U.S. Department of Agriculture, Miscellaneous Publication No. 970, Washington.

Marshall, P. (1927): The wearing of beach gravels; New Zealand Institute Transactions, Vol. 58, p. 507-532.

McPherson, H.J. (1969): Flow, channel and floodplain characteristics of the lower Red Deer River, Alberta; *in* Nelson J.G. and Chambers M.J. (eds.), Geomorphology, Methuen, p. 257-281.

McPherson, H.J. (1970): Landforms and glacial morphology of the upper North Saskatchewan Valley, Alberta, Canada; Canadian Geographer, Vol. 14, p. 10-26.

McPherson, H.J. (1971): Downstream changes in sediment character in a high-energy mountain stream channel; Arctic and Alpine Research, Vol. 3, p. 65-79.

Meland, N. and Norrman, J.O. (1969): Transport velocities of individual size fractions in heterogeneous bed load. Geografiska Annaler, Vol. 51, p. 127-144.

Morisawa, M. (1968): Streams: Their dynamics and morphology, McGraw-Hill, New York, 175 pages.

Neill, C.R. (1968): A re-examination of the beginning of movement of coarse granular bed materials. Report, Hydraulics Research Station, Wallingford, England.

Neill, C.R., Bray, D.I., Schouten, M.F., and Card, J.R. (1970): Selected characteristics of streamflow in Alberta. Research Council of Alberta, River Engineering and Surface Hydrology Report 70-1.

Nordin, C.F. and Culbertson, J.K. (1961): Particle-size distribution of stream bed material in the Middle Rio Grande Basin, New Mexico; U.S. Geological Survey Professional Paper 424, p. c-323 - c-326.

Pemberton, E.L. (1976): Channel changes in the Colorado River below Glen Canyon dam. Proceedings of the Third Federal Interagency Sedimentation Conference, prepared by the Sedimentation Committee, Water Resources Council, U.S.A., p. 5-61 - 5-73.

Pettijohn, F.J. (1957): Sedimentary rocks. Harper and Row, New York, Second Edition, 718 pages.

Plumley, W.J. (1948): Black Hills terrace gravels: a study in sediment transport; Journal of Geology, Vol. 56, p. 526-577.

Roed, M.A. (1968): Surficial geology of the Edson-Hinton area, Alberta, Unpubl. Ph. D. Thesis University of Alberta.

Roed, M.A. (1970): Surficial geology Edson; Research Council of Alberta Map 33.

Roed, M.A., Mountjoy, E.W., and Rutter, N.W. (1967): The Athabasca Valley erratics train and Pleistocene ice movements across the continental divide; Canadian Journal of Earth Sciences, Vol. 4, p. 625-632.

Russell, R.J. (1968): Where most grains of very coarse sand and fine gravel are deposited; Sedimentology, Vol. 11, p. 31-38.

Russell, R.D. and Taylor, R.E. (1937): Roundness and shape of Mississippi river sands; Journal of Geology, Vol. 45, p. 225-267.

Rutter, N.W. (1966): Glacial history of the Bow Valley, Banff area, Alberta; Canadian Alpine Journal, Vol. 49, p. 157-173.

Scheidegger, A.E. (1970): Theoretical geomorphology; George Allen and Unwin, London, Second Edition, 435 pages.

Schlee, J. (1957): Upland gravels of Southern Maryland; Geological Society of America Bulletin. Vol. 68, p. 1371-1410.

Schubert, C. (1964): Size-frequency distribution of sand-sized grains in an abrasion mill; Sedimentology, Vol. 3, p. 288-295.

Schumm, S.A., and Stevens, M.A. (1973): Abrasion in place a mechanism for rounding and size reduction of coarse sediment in rivers; Geology, Vol. 1, p. 37-40.

Shea, J.H. (1974): Deficiencies of clastic particles of certain sizes; Journal of Sedimentary Petrology, Vol. 4, p. 985-1003.

Shulits, S. (1941): Rational equation of river bed profile; Transactions of the American Geophysical Union, Vol 222, p. 622-631.

Stalker, A.M. (1962): Surficial geology Fernie (east half), Geological Survey of Canada, Map 31-1961.

Sternberg, H. (1875): Untersuchungen über Längen und Querprofil geschiebeführende Flüsse, Z. Bauwesen, Vol. 25, p. 483-506.

Straub, L.G. (1935): Some observations of sorting of river sediments; Transactions, American Geophysical Union, p. 463-467.

Sundborg, A. (1956): The river Klarälven, a study of fluvial processes, Bulletin No. 52 of the Institute of Hydraulics at the Royal Institute of Technology, Stockholm, Sweden, 316 pages.

Walcott, R.I. (1970): Isostatic response to loading of the crust in Canada; Canadian Journal of Earth Sciences, Vol. 7, p. 716-727.

Wentworth, C.K. (1919): A laboratory and field study of cobble abrasion; Journal of Geology, Vol. 27, p. 507-522.

Westgate, J.A. (1969): The Quaternary Geology of the Edmonton area, Alberta; *in* Pawluk, S. (ed.), Pedology and Quaternary Research Symposium, National Research Council of Canada, p. 129-152.

Yatsu, E. (1957): On the discontinuity of grain-size frequency distribution of fluvial deposits and its geomorphological significance; Proceedings, International Geographical Union, Regional Conference, Japan, p. 224-237.

GLOSSARY

aggradation: the raising of a river bed or floodplain by deposition of fluvially transported materials.

argillites: lithified sediments in which clay and silt sized particles predominate.

armouring: the process by which removal of fine particles leads to a surface concentration of coarse particles on the river bed.

bentonite: plastic clay usually composed of the clay mineral montmorrillonite.

bimodal size distribution: a size distribution in which the frequency curve shows two separate peaks.

comminution: the breakdown of rock material to smaller particle sizes.

degradation: lowering of a river bed or floodplain by erosion.

downcutting: progressive lowering of a stream bed by erosion.

entrainment: the initiation of the transport of particles by a river.

geological time scale: see following page.

glacigenic sediments: sediments deposited in glacial environments under the direct or indirect influence of glaciers and glacier meltwater.

ice maximum: the position of farthest advance of a glacier or ice sheet.

induration: hardening of rock, often by the addition of cementing agents.

isostasy: the principle which holds that pressures at some depth beneath the earth's surface are in equilibrium with the overburden pressure.

isostatic rebound: uplift subsequent to the removal of load on the earth's crust.

knick point: point of abrupt change in the longitudinal slope of a river.

lag concentrations: particles which are not removed during winnowing and consequently become concentrated on the stream bed.

modal size: the size range in which the highest frequency occurs.

Oligocene: the third epoch of the Tertiary period (see Geological Time Scale).

orogenesis: mountain building often with associated folding and thrusting of rock masses.

oversteepening: increase in the longitudinal slope of a river by some external effect such as isostatic movements.

Paleozoic: the geological era immediately following the Precambrian (see Geological Time Scale).

placer deposit: a deposit which becomes concentrated in an area of the stream bed as a result of the coarse nature and high specific weight of the particles.

preferential transport: the preferred movement of particles of a given size or composition.

Quaternary: the second period of the Cenozoic era, covering the last two to three million years (see Geological Time Scale).

scour trough: a depression in a stream bed created by erosion of the bed material.

stoss side: the upstream face of a dune or ripple or bar.

thalweg: a line joining the deepest points of a channel.

thalweg chainage: distance measured along the thalweg.

Geological Time Scale

ERA	PERIOD	EPOCH	APPROXIMATE TIME BEFORE PRESENT (IN MILLIONS OF YEARS)	EON
CENOZOIC Recent Life	Quaternary	Recent	0.01	Age of man
		Pleistocene	1.5	
	Tertiary	Pliocene	7	Age of mammals
		Miocene	26	
		Oligocene	38	
		Eocene	54	
		Paleocene	65	
MESOZOIC Middle Life	Cretaceous	Upper	100	Age of reptiles (including dinosaurs)
		Lower	136	
	Jurassic	Upper	162	
		Middle	172	
		Lower	192	
	Triassic	Upper	205	
		Middle	215	
		Lower	225	
PALEOZOIC Ancient Life	Permian	Upper	240	Age of amphibians
		Lower	280	
	Carboniferous	Pennsylvanian	325	
		Mississippian	345	
	Devonian	Upper	359	Age of fishes
		Middle	370	
		Lower	395	
	Silurian		430	
	Ordovician	Upper	445	Age of marine invertebrates
		Lower	500	
	Cambrian	Upper	515	
		Middle	540	
		Lower	570	
PRECAMBRIAN				Earliest life forms known (all soft bodied)
	FORMATION OF THE EARTH		4500	

Dates from
R. K. Wanless et al., Age Determinations and Geological Studies K-Ar Isotopic Ages, Report 12; Geol. Surv. Can. Paper 74-2, 1974.

TABLES

TABLE 1
Summary of hydrologic and hydraulic data for 45 sites
(from Kellerhals, et al., 1972)

River	Site No.	Site	Distance from Source (km)	Drainage Area (km^2)	Mean [m^{3}s^{-1}]	2 Year Peak [m^{3}s^{-1}]	Flows 10 Year Peak [m^{3}s^{-1}]
Peace	1	at Hudson Hope	584.0	71,168	1,120.68	6,084.5	7,358.0
	2	near Taylor	680.0	98,048	1,463.11	7,216.5	8,773.0
	3	at Dunvegan Bridge	860.8	128,512	1,584.80	8,207.0	10,612.5
	4	at Peace River	963.2	184,320	1,802.71	8,914.5	12,310.5
	5	near Carcajou	1,227.2	207,360	1,884.78	9,622.0	12,876.5
	6	at Fort Vermilion	1,388.8	220,160	2,130.99	9,622.0	11,603.0
	7	at Peace Point	1,679.6	289,280	2,278.15	9,056.0	11,603.0
Smoky	8	at Watino	486.4	47,360	379.22	2,405.5	4,103.5
Wapiti	9	near Grande Prairie	235.2	11,136	116.03	834.9	2,235.7
Little Smoky	10	near Guy	523.2	10,573	56.03	679.2	1,075.4
Athabasca	12	at Jasper	104.0	4,045	90.28	452.8	594.3
	13	at Hinton	203.2	10,240	186.78	905.6	1,188.6
	14	near Whitecourt	406.4	18,688	275.36	1,315.9	2,094.2
	15	at Athabasca	747.2	75,776	430.16	1,867.8	3,396.0
	16	below McMurray	1,147.2	128,000	645.24	2,207.4	3,367.7
	17	at Embarras Airport	1,328.0	150,272	766.93	2,603.6	3,995.9
McLeod	19	above Embarras River	166.4	2,560	20.40	158.5	367.9
	20	near Wolf Creek	238.4	6,426	38.77	305.6	735.8
North Saskatchewan	34	at Saskatchewan Crossing	40.0	1,259	---------	---------	---------
	35	at Saunders	152.0	5,069	98.76	481.1	659.4
	36	near Rocky Mountain House	228.8	10,803	143.75	690.5	1,103.7
	37	at Edmonton	529.6	26,880	219.89	1,118.6	2,264.0
	38	at Lea Park	820.8	54,528	231.49	1,273.5	2,320.6
Red Deer	48	near Sundre	142.4	2,442	24.90	169.8	424.5
	49	at Red Deer	259.2	11,315	51.22	339.6	919.7
	50	at Drumheller	460.8	24,730	59.99	350.9	990.5
	51	near Bindloss	726.4	43,008	69.05	396.2	919.7
Bow and South Saskatchewan	113	at Lake Louise	38.4	442	11.38	53.8	97.7
	60	at Banff	100.8	2,196	39.90	206.6	297.1
	61	at Kananaskis	152.0	4,122	71.88	317.0	602.8
	62	near Seebe	156.8	5,018	80.09	367.9	602.8
	63	below Ghost Dam	193.6	6,400	85.47	314.1	464.1
	64	at Calgary	249.6	7,706	92.54	438.6	707.5
	65	below Carseland Dam	328.0	15,360	99.62	481.1	1047.1
	66	below Bassano Dam	444.8	19,482	124.80	749.9	1,867.8
	58	at Medicine Hat	547.2	57,600	211.40	990.5	2,433.8
	112	at Highway 41	707.2	65,536	214.38	1,058.4	2,603.6
Oldman	85	near Wadron's Corner	65.6	1,411	13.89	104.7	223.6
	86	near Cowley	96.0	1,869	15.90	101.9	229.2
	87	near Brockett	118.4	4,352	31.13	226.4	556.0
	88	near Fort McLeod	176.0	5,709	38.20	300.0	764.1
	89	near Monarch	224.0	8,832	45.56	413.2	679.2
	90	near Lethbridge	289.6	16,973	91.41	566.0	1,782.9
	91	near the mouth	435.2	28,160	91.41	891.4	---------
Milk	110	at Milk River	195.2	2,662	8.58	46.69	100.5

TABLE 1 (continued)

Extreme Discharge on Record [m^3s^{-1}]	No. of Years On Record	Slope	Hydraulic Geometry at 2-Year Flood: Water Surface Width [m]	Mean Depth [m]	Mean Velocity [ms^{-1}]
8,806.5	14	0.00074	475.5	5.0	2.56
11,603.0	14	0.00069	545.9	6.8	1.95
11,065.3	8	0.00022	469.7	6.9	2.53
15,536.7	25	0.00035	567.3	5.7	2.74
12,140.7	8	0.000074	619.1	9.3	1.67
11,914.3	8	0.000041	832.6	7.9	1.46
11,914.3	7	0.000074	725.9	8.2	1.52
5,518.5	16	0.00052	271.4	4.2	2.10
2,728.1	6	0.00051	168.4	2.6	1.86
1,061.2	6	0.00094	99.4	2.8	2.44
616.9	14	0.0030	114.9	1.7	2.25
1,499.9	26	0.00092	191.2	2.6	1.83
2,128.2	6	0.0012	---------	----	-------
5,648.7	30	0.00029	317.2	3.8	1.55
4,262.0	8	0.00023	539.8	3.1	1.31
--------------	8	0.000090	442.2	5.3	1.09
905.6	12	0.0012	67.4	2.1	1.12
2,264.0	17	0.00084	110.7	1.7	1.67
315.0	----	--------------	---------	-----	------
1,240.7	6	0.0026	94.85	2.4	2.13
4,103.5	30	0.0025	150.9	1.8	2.56
5,787.3	55	0.00035	183.3	3.4	1.92
3,396.0	20	0.00019	278.7	3.7	1.37
653.8	12	0.0049	71.7	1.2	1.95
1,931.5	49	0.0012	111.9	1.8	1.67
1,216.9	14	0.00035	111.3	2.3	1.37
1,307.5	29	0.00030	203.4	2.1	0.94
123.4	9	0.0035	43.9	0.8	1.52
399.0	56	0.00013	79.3	2.7	0.94
600.2	10	0.0018	175.9	1.2	1.52
902.8	39	0.0040	94.5	1.6	2.44
605.6	24	0.0020	104.0	1.4	2.10
1,516.9	51	0.0018	125.7	1.7	2.04
1,248.0	11	0.0012	160.4	1.6	1.89
2,538.5	12	0.00081	165.6	2.4	1.86
4,295.9	50	0.00041	207.4	3.0	1.59
2,125.3	50	0.00036	234.8	3.5	1.28
425.8	15	0.0038	45.1	1.1	2.13
772.6	20	0.0046	44.5	1.0	2.28
738.63	20	0.0016	115.9	1.8	1.09
2,221.6	32	0.0017	109.8	1.58	1.73
1,910.2	18	0.0012	109.2	1.92	1.98
4,216.7	42	0.00094	118.9	2.6	1.83
1,930.1	42	0.00044	179.9	2.6	1.89
247.1	55	0.00059	36.6	1.12	1.12

TABLE 2

Sample Locations

ATHABASCA RIVER

NTS Map Sheet	Distance from Source (km)	Sample No./ Location*	Details of Location
83 C/5	44.1	1 9-10-40-26-W.5	Left side of island bar near right bank. River was in flood when this sample was collected.
83 D/16	119.4	2 7-27-45-1-W.6	Right side of island bar near left bank, 150 feet from left bank, about 500 feet upstream from bridge.
83 F/6	220.2	3 1-23-52-24-W.5	River bed about 25 feet from right bank and about 150 feet upstream from mouth of creek.
83 J/4	406.7	4 3-3-60-12-W.5	River bed about 100 feet from right bank, about 150 feet downstream from highway bridge.
83 J/7	503.4	5 9-31-61-5-W.5	Left bank on point bar about half way between right and left banks, about 300 feet downstream from abandoned ferry at Holmes Crossing.
83 0/1	643.4	6 8-22-71-1-W.5	Right bank 50 feet upstream from first lower pier of railway bridge at foot of bank.
83 P/4W	669.1	6.1 4-8-72-25-W.4	Right side of island near upstream end. Island is near left bank.
83 1/11W	750.1	7 16-19-66-22-W.4	Right side of upstream end of island bar near left bank. This bar was barely exposed as the river was high. The material in it was probably not being moved by the river.
74 E/12	1223.7	8 1-27-98-10-W.4	Left side of island bar near right bank.
74 L/3W	1301.0	9 10-15-106-9-W.4	River bed at upstream end of island near left bank. Island is across river from Embarras air field.
74 L/11	1383.7	10 8-15-110-7-W.4	Right side of island near its downstream end. Island is to left of main part of Fletcher Channel.
74 L/10	1392.4	11 13-8-111-6-W.4	Right side of island bar whose top 6 inches consists of mud with sand below. Bar is near left bank of Fletcher Channel.

*Explanation of sample locations

Legal Subdivision	Section	Range	Township	West of 5th Meridan
	10	40	26	W.5

TABLE 2 (CONTINUED)

BOW RIVER - SOUTH SASKATCHEWAN RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
82 N/9	1 11-23-31-18-W.5	8.5	Left shore of Bow Lake about 50 feet downstream from mouth of creek.
82 N/9	2 3-3-31-17-W.5	20.4	Upstream end of island bar in middle of river.
82 0/4	3 6-32-25-11-W.5	126.0	Left side of island bar near right bank.
82 0/1W	4 5-35-25-4-W.5	230.1	Left bank 125 feet downstream from bridge.
82 I/13W	5 9-8-22-29-W.4	302.9	Point bar (or head of island at high water) about 100 feet from left bank.
82 I/14	6 14-32-21-25-W.4	351.5	Left side of island bar near right bank at upstream end about 125 feet from right bank.
82 I/14	7 15-17-21-23-W.4	392.2	Point bar about 50 feet from beginning of vegetation and about 200 feet from bushes on left bank.
82 I/15	8 16-23-21-20-W.4	459.8	Point bar about 40 feet from right bank and about 300 feet downstream from confluence of Crowfoot Creek.
82 I/10	9 15-23-20-19-W.4	483.1	River bed about 20 feet from left bank.
82 I/1E	10 7-12-15-16-W.4	570.0	River bed about 100 feet from right bank and about 600 feet downstream from bridge.
82 I/1	11 2-1-15-16-W.4	571.9	River bed 60 feet from left bank, and 50 feet downstream from abandoned ferry landing.
72 L/4E	12 9-33-12-12-W.4	630.2	Point bar about 150 feet from right bank and about 1500 feet downstream from bridge.
72 E/13	13 10-27-11-13-W.4	647.3	Point bar about 150 feet from right bank and about 50-foot high bank.
72 E/14	14 2-11-12-11-W.4	681.4	Point bar about 50 feet out from right bank.
72 L/2E	15 12-35-12-6-W.4	747.8	Upstream end of right side of island bar near left bank.
72 L/2	16 3-10-15-5-W.4	805.3	Point bar about 30 feet out from left bank.
72 L/9E	17 5-26-19-2-W.4	899.6	Point bar about 150 feet out from left bank.
72 L/16	18 9-23-22-1-W.4	941.1	Point bar about 200 feet out from right bank.

TABLE 2 (CONTINUED)

BOW RIVER - SOUTH SASKATCHEWAN RIVER (continued)

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
72 K/13W	19 14-11-23-28-W.3	965.4	Point bar about 600 feet from right bank; about one-half mile upstream from feery and a short distance downstream from island.
72 K/13E	20 11-20-23-26-W.3	986.3	Right side of island near its upstream end, and about 1000 feet from left bank.
72 K/13E	20.1 11-20-23-26-W.4	986.3	Right side of island near its upstream end, and about 1000 feet from left bank.
72 K/14W	21 8-27-23-25-W.3	1001.3	Right side of island bar near its upstream end, out about 400 feet from right bank and about one-quarter mile downstream from ferry.
72 N/3E	22 4-11-24-23-W.3	1024.2	Right side of island near its upstream end, about 1000 feet upstream from vegetation on island, and about 400 feet from left bank. Island is near left bank and about one mile downstream from ferry.
72 K/15W	23 16-21-23-21-W.3	1043.0	Left side of what is an island at high stages, near its upstream end, out about 600 feet from right bank, and about one-half mile downstream from ferry.
72 K/9W	24 10-17-20-17-W.3	1100.0	Upstream end of small island bar out about 1500 feet from right bank.
72 K/9E	25 10-5-20-16-W.3	1110.6	Left side of small island bar whose downstream end was connected to right bank, out about 150 feet from right bank; about one-quarter mile upstream from former ferry landing and about 250 feet upstream from second stream coulee above ferry landing.
72 J/12W	26 12-35-19-15-W.3	1126.0	Left side of island bar at its upstream end, out about 100 feet from right bank, about 3000 feet upstream from highway bridge and about 600 feet upstream from mouth of small creek that flows in on right bank.
72 J/11W	27 13-18-20-10-W.3	1176.2	Upstream end of bar used by ferries in middle of river, about 400 feet upstream from ferry landings and about 300 feet out from left bank.
72 J/15W	28 4-32-22-7-W.3	1223.4	Point bar out about 1500 feet from right bank, about 2000 feet upstream from ferry and about 800 feet downstream from small island.
72 O/2E	29 10-9-25-5-W.3	1265.9	Point bar out about 450 feet from left bank, about half way between Elbow bridge and South Elbow station.
72 O/7W	30 6-36-26-7-W.3	1290.0	Point bar at low water, upstream end of island bar at highwater, out about 1250 feet from right bank.
72 O/7W	30.1 6-36-26-7-W.3	1290.0	Point bar at low water, upstream end of island bar at highwater, out about 1250 feet from right bank.
72 O/6E	31 12-9-29-8-W.3	1321.9	Upstream end of island bar in middle of river, about 300 feet out from left bank across main channel, and about 600 feet from right bank.
73 B/2E	32 2-10-35-5-W.3	1413.9	Upstream end of island bar near left bank and about 125 feet from left bank opposite storm drain; about 1 mile downstream from railway bridge.

TABLE 2 (CONTINUED)

LITTLE SMOKY RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 K/11	1 1-25-66-22-W.5	343.1	Upstream end of island bar about 50 feet from right bank, and about 400 feet upstream from bridge.
83 K/14	2 1-2-68-22-W.5	365.5	River bed about 20 feet from left bank on a straight stretch and about 200 feet downstream from old bridge pilings.
83 K/14	2.1 14-31-68-21-W.5	389.5	Point bar about 40 feet from left bank and about 1000 feet upstream from bridge.
83 N/3E	2.2 9-1-70-22-W.5	410.5	Point bar about 100 feet from left bank.
83 N/3E	2.3 1-28-70-21-W.5	429.2	Point bar about 50 feet from left bank and about 600 feet downstream from bridge.
83 N/7	3 4-6-74-19-W.5	509.2	Point bar about 150 feet from left bank.
83 N/6E	4 13-34-74-21-W.5	542.3	On left side of island bar near its upstream end, about 250 feet from right bank and about 1/3 mile downstream from bridge.
83 N/11W	5 12-24-75-22-W.5	559.2	River bed about 100 feet from left bank at mouth of creek.
83 N/11W	6 16-14-77-24-W.5	602.7	Point bar about 140 feet from right bank.
83 N/11W	7 16-14-77-24-W.5	602.8	Point bar about 140 feet from right bank.

McLEOD RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 C/14	1 4-30-46-23-W.5	16.1	Right bank.
83 F/6	2 9-26-50-23-W.5	89.5	Left side of island bar in middle of river.
83 F/10W	3 14-27-52-20-W.5	135.7	Left side of island bar about 75 feet downstream from upstream end. Bar is about 250 feet long in middle of river.
83 F/10W	4 14-27-52-20-W.5	135.8	Left side of island bar about 76 feet downstream from upstream end. Bar is about 250 feet long in middle of river.
83 F/7	5 12-14-52-19-W.5	156.7	Point bar about 30 feet from left bank at upstream end of riffle.
83 F/9	6 9-20-53-16-W.5	229.0	River bed about 50 feet from left bank and about 60 feet upstream from highway bridge.
83 F/9	7 16-22-54-15-W.5	258.8	Point bar about 150 feet from right bank.

TABLE 2 (CONTINUED)

McLEOD RIVER (continued)

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 G/12 83 F/9	8 14-33-54-14-W.5	272.1	Point bar about 200 feet from left bank, and about one-quarter mile downstream from bridge.
83 G/13	9 12-8-56-13-W.5	303.8	Point bar about 75 feet from left bank. Across river on right bank is sandstone cliff about 50 feet high.
83 J/4	10 5-35-59-12-W.5	379.6	River bed about 125 feet from left bank, and about one-quarter mile downstream from bridge.

MILK RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
82 H/2	1 2-18-1-19-W.4	127.6	River bed about 300 feet downstream from ford.
82 H/1	2 8-18-2-18-W.4	155.0	River bed near left bank.
82 H/1	3 15-21-2-16-W.4	196.2	Right side of bar near left bank and about 40 feet from left bank about 200 feet upstream from railway bridge.
72 E/4	4 13-5-2-15-W.4	213.7	Island bar near left bank and about 40 feet from left bank.
72 E/4	5 16-34-1-13-W.4	261.7	Point bar from left bank. Left bank is not marked by vegetation or change in slope here and so distance cannot be specified.
72 E/4	6 3-3-2-12-W.4	273.6	Point bar about 25 feet from left bank and about 150 feet upstream from bridge.
72 E/3	7 2-29-2-10-W.4	298.5	River bed about 50 feet from right bank and about 125 feet downstream from bridge.
72 E/3	8 6-30-2-9-W.4	305.3	Left side of island bar near right bank, near upstream end of bar.
72 E/3	9 6-3-1-5-W.4	386.1	Left bank about 200 feet upstream from under cut bank on same side of river.

NORTH MILK

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
82 H/2	1 4-13-1-34-W.4	38.3	Right bank gravel which has light growth of vegetation.
82 H/2	2 16-10-2-21-W.4	71.3	Right bank opposite cliff about 50 feet high on left bank. About 20 feet of gravel overlying bedrock are exposed in the cliff.
82 H/1	3 8-19-2-18-W.4	119.4	Point bar 25 feet from right bank.

TABLE 2 (CONTINUED)

NORTH SASKATCHEWAN RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 C/2	1 12-20-36-21-W.5	29.6	Left side of main channel about 40 feet from right bank, near campground at foot of Mt. Coleman.
83 C/8	2 3-34-38-17-W.5	124.2	Right side of island bar near left bank and about 200 feet from left bank.
83 B/5	3 8-22-40-13-W.5	178.0	Point bar about 50 feet from left bank and about 70 feet downstream from mouth of Shundo Creek.
83 B/6	4 3-4-40-9-W.5	229.5	Right side of island bar near left bank about 150 feet downstream from downstream end of island.
83 B/7	5 15-33-39-7-W.5	262.3	Point bar about 200 feet from left bank.
83 B/14	6 11-13-45-9-W.5	334.1	Point bar about 400 feet from treeline on right bank.
83 G/2	7 13-35-48-7-W.5	391.7	Right side of island bar near left bank and about 400 feet from left bank about one mile upstream from highway bridge.
83 G/W	8 8-14-50-6-W.5	420.2	Left side of island bar near right bank and about 150 feet from right bank and about 500 feet upstream from Berrymoor ferry.
83 G/7W	9 12-13-50-6-W.5	420.8	River bed about 300 feet from left bank and about 900 feet downstream from Berrymoor ferry.
83 G/8	10 4-15-51-3-W.5	466.4	Point bar about 150 feet from left bank and 500 feet downstream from former Genesee ferry.
83 G/8W	11 1-21-51-3-W.5	469.0	Right side of island near left bank about 75 feet upstream from its upstream end and 330 feet from left bank.
83 G/8E	12 15-27-50-1-W.	505.0	Point bar 400 feet from right bank and about 1000 feet downstream from the ferry. Left bank here is a high cliff of bedrock.
83 G/8E	13 13-27-50-1-W.5	505.8	River bed about 75 feet from left bank and about 500 feet upstream from Holborn ferry.
83 H/5W	14 13-33-50-26-†.4	532.2	Right side of island bar near left bank about 200 feet from left bank and about 1000 feet upstream from bridge.
83 H/5	15 7-3-51-26-W.4	532.7	River bed about 30 feet from left bank and about 500 feet downstream from bridge.
83 H/12E	16 10-24-52-25-W.4	566.8	Middle of left side of island bar in middle of river.
83 H/12E	17 830-52-24-W.4	573.1	River bed about 70 feet from left bank, 50 feet upstream from drain pipe and about one-third mile upstream from High Level Bridge.

TABLE 2 (CONTINUED)

NORTH SASKATCHEWAN RIVER (continued)

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 H/11W	18 10-34-53-23-W.4	599.1	River bed just downstream from prominent meander bend, 175 feet from left bank and about 1000 feet upstream from head of island near left bank.
83 H/11E	19 River lot 2, Fort Saskatchwan Settlement 12-14-55-22-W.4	621.7	Point bar about 60 feet from left bank.
83 I/2	20 4-12-58-20-W.4	659.5	River bed about 350 feet from left bank and about 300 feet upstream from upstream end of island near left bank.
83 H/15	21 2-12-58-12-W.4	687.2	Point bar about 80 feet from left bank.
83 H/16	22 14-34-57-15-W.4	725.0	Point bar about 70 feet from left bank and about 600 feet upstream from former Shandro ferry.
73 E/13	23 7-18-57-15-W.4	754.6	Point bar about 100 feet from right bank and about 500 feet downstream from a small rapid.
72 E/13	24 4-32-55-11-W.4	779.7	Middle of left side of island bar in middle of river.
73 E/14	25 14-16-55-8-W.4	815.6	River bed about 75 feet from left bank.
73 E/15	26 14-19-56-6-W.4	836.7	Point bar about 60 feet from right bank and about one-half mile downstream from bridge.
73 E/15	27 8-22-56-5-W.4	855.5	River bed about 150 feet from right bank and about halfway between ferry and head of island.
73 E/9	28 11-5-56-4-W.4	864.0	Right side of island about 200 feet upstream from its upstream end as marked by vegetation. Island is near left bank.
73 E/9	29 6-14-54-3-W.4	888.0	Point bar about 120 feet from left bank and about 600 feet upstream from bridge.
73 E/9	30 12-4-54-1-W.4	908.8	River bed about 200 feet from right bank and about 500 feet upstream from former Forbesville ferry.
73 F/12	31 12-19-53-27-W.3	928.6	Upstream end of island bar about 400 feet from right bank and about halfway between Meridan Ferry and island.
73 F/6W	32 13-11-51-23-W.3	998.9	Upstream end of island bar about 300 feet from right bank oppoiste breakwater upstream from ferry.
73 F/2	33 7-1-48-21-W.3	1040.1	Point bar about 800 feet from left bank, almost halfway across river, and about 400 feet upstream from small island.
73 C/16W	34 2-6-44-16-W.3	1102.0	On left side of sand expanse, about 350 feet up-stream from island crossed by highway.

TABLE 2 (CONTINUED)

OLDMAN RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
82 G/16	1 3-35-11-4-W.5	33.8	Below chain across road, on left bank of river. River here is in bedrock.
82 H/12W	2 5-30-7-29-W.4	117.3	Left side of island bar near right bank about 50 feet upstream from centre pier of bridge.
82 H/11	3 7-13-9-26-W.4	192.0	River bed about 200 feet from left bank, about 1000 feet downstream from bridge, beside a riffle.
82 H/11	4 5-19-9-25-W.4	194.2	Left side of island bar in middle of river near its upstream end.
82 H/15	5 13-1-9-22-W.4	293.9	River bed about 250 feet from left bank, and about 450 feet downstream from piers that carry power lines downstream from highway bridge.
82 H/16	6 13-7-10-17-W.4	382.9	Left side of island bar near right bank between first and second concrete piers of bridge counting from right bank, and about 60 feet upstream from bridge.
72 E/13	7 6-21-11-13-W.4	449.2	Middle of right side of island bar near left bank, and about 250 feet from left bank.
72 E/13	8 1-28-11-13-W.4	451.4	River bed about 150 feet from right bank.

PEACE RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
84 D/4	1 10-27-82-13-W.6	816.4	River bed about 100 feet from left bank.
84 D/2	2 13-20-81-6-W.6	918.1	River bed from left side of upstream and of island near right bank.
84 D/2	3 11-20-81-6-W.6	918.7	River bed from middle of left side of island near right bank.
83 M/15	4 14-7-80-4-W.6	944.3	About 300 feet from left bank on right side of island bar, and about 400 feet downstream from mouth of Hines Creek.
84 C/4	5 9-8-82-23-W.5	1023.0	River bed about 100 feet from right bank.
84 C/4	6 3-16-82-23-W.5	1024.0	River bed from right side of upstream end of island near left bank.
84 C/11	7 13-32-89-21-W.5	1126.7	River bed on right side of island near its upstream end. Island is near left bank.
84 F/6	8 3-1-97-20-W.5	1230.1	River bed on right side of island near its upstream end. Island is near left bank.
84 F/14	9 16-20-102-19-W.5	1332.5	River bed on left side of upstream end of island near right bank.

TABLE 2 (CONTINUED)

PEACE RIVER (continued)

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
84 K/7	10 11-11-107-16-W.5	1420.9	River bed on right side of island near its upstream end. Island is near left bank.
84 J/6	11 14-16-108-9-W.5	1511.0	River bed on left side of upstream end of island near right bank.
84 J/9	12 9-12-111-1-W.5	1605.4	Middle of left side of island bar in middle of river.
84 I/14	13 4-35-113-19-W.4	1681.9	Point bar from left bank.
84 P.1	14 12-19-116-13-W.4	1759.6	River bed on right side of upstream end of island near left bank.
74 L/13	15 9-35-114-10-W.4	1811.6	River bed on left side on upstream end of island near right bank.

RED DEER RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
82 O/12	1 7-12-32-12-W.5	63.1	Near upstream end of right side of bar near left bank.
82 O/11	2 12-13-31-10-W.5	91.4	Middle of right side of bar near left bank.
82 O/15	3 10-21-32-6-W.5	141.1	Right side at upstream end of island bar in middle of river, 350 feet from left bank.
82 O/15E	4 13-11-33-5-W.5	158.8	River bed about 20 feet from right bank.
82 O/16	5 13-31-34-3-W.5	186.5	Very small bar in river bed about 40 feet from right bank.
83 A/4	6 15-6-36-28-W.4	242.5	River bed about 50 feet out from left bank and 200 feet upstream from bridge.
83 A/4	7 7-5-37-28-W.4	253.3	Upstream end of right side of island bar about 100 feet from left bank.
83 A/5	8 16-33-38-27-W.4	294.0	Point bar about 150 feet from left bank.
83 A/5	9 13-13-38-26-W.4	315.6	Right side of upstream end of island bar about 150 feet from left bank.
83 A/5	10 11-13-38-26-W.4	316.4	River bed about 200 feet from right bank and about 300 feet downstream from bridge.

TABLE 2 (CONTINUED)

RED DEER RIVER (continued)

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 A/6	11 4-34-38-22-W.4	365.3	River bed about 75 feet from left bank and about 600 feet downstream from bridge.
83 P/15	12 1-3-35-21-W.4	409.1	About 100 feet from left side of island in middie of river near upstream end of island.
82 P/14	13 3-13-33-22-W.4	432.1	Point bar about 2/3 of the way from right bank toward left bank, and about one mile downstream from Tolman ferry.
82 P/15	14 16-30-32-21-W.4	438.5	Upstream end of island bar in middle of river, about 150 feet from both right and left banks.
82 P/10	141 15-27-30-21-W.4	459.9	Point bar about 60 feet from right bank.
82 P/7	15 2-18-29-20-W.4	478.8	Left side of island bar in middle of river about 300 feet downstream from tributary stream entering left bank, and 100 feet upstream from pipeline.
82 P/8	16 11-22-27-18-W.4	512.9	Left side of island in middle of river, near upstream end of island.
82 P/8	17 4-3-27-17-W.4	524.3	River bed near left bank about 50 feet across channel from right bank and about 1500 feet downstream from ferry.
82 P/1	18 3-18-25-15-W.4	549.1	Right side of island bar near left bank about 1000 feet upstream from ferry.
72 L/13	19 15-32-22-14-W.4	585.8	At upstream end of island bar in middle of river, about 100 feet from right bank and about 600 feet upstream from bridge.
72 L/13	20 15-33-21-12-W.4	615.7	River bed about 50 feet from right bank, 320 feet upstream from ferry.
72 L/14	21 11-4-22-9-W.4	661.3	About 100 feet from right bank at upstream end of island bar near right bank.
72 L/15W	22 6-2-23-7-W.4	691.8	About 130 feet from right bank at upstream end of island bar and about 600 feet upstream from former ferry crossing.
72 L/15	23 5-36-22-7-W.4	693.6	Channel between right bank and island.
72 L/15E	24 16-1-22-6-W.4	711.1	About 100 feet from right bank at upstream end of island bar near right bank and about 500 feet upstream from bridge.
72 L/16	25 10-5-23-3-W.4	744.9	About 250 feet from left bank at upstream end of island bar near left bank.
72 L/16	26 11-15-23-1-W.4	780.7	Left side of island bar near right bank.

TABLE 2 (CONTINUED)

SMOKY RIVER (continued)

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 E/14E	1 13-20-57-8-W.6	123.3	River bed about 100 feet from right bank and about 200 feet downstream from ferry formerly operated by U.S. Steel.
83 L/8	2 15-30-63-2-W.6	228.4	River bed about 200 feet from right bank and about 200 feet upstream from small creek.
83 L/15	3 7-31-67-4-W.6	296.6	Upstream end of right side of island near left bank.
83 M/1	4 2-71-67-4-W.6	358.6	Upstream end of left side of island in middle of river.
83 M/8E	5 11-1-75-2-W.6	418.3	Point bar about 150 feet out from left bank.
83 N/12	6 13-35-76-24-W.5	482.8	Point bar about 400 feet from right bank.
84 C/3	7 2-1-82-23-W.5	551.8	Upstream end of left side of island bar in middle of river.
84 C/3	8 4-1-83-22-W.5	565.7	Right side of island bar in middle of river.

WAPITI RIVER

NTS Map Sheet	Sample No./ Location	Distance from Source (km)	Details of Location
83 L/13	1	160.1	Point bar about 60 feet from left bank.
83 M/3E	2 7-11-70-8-W.6	211.6	Right side of island bar about 300 feet from left bank.
83 M/2E	3 11-14-70-5-W.6	247.5	River bed 60 feet from left bank, and about 1000 feet downstream from mouth of Big Mountain Creek.
83 M/1W	4 6-13-71-3-W.6	277.3	Point bar about 60 feet from right bank.

TABLE 3
Summary of Halferdahl data

River	Total Number of Samples	Number of Sample Pairs	Independent Sample Locations	Length of River Reach (km)	Average Sample Spacing (km)
Athabasca	12	1	11	1348.3	122.6
Bow-South Saskatchewan	34	4	30	1405.4	46.9
Little Smoky	10	1	9	259.7	28.9
McLeod	10	1	9	363.5	40.4
Milk	9	0	9	258.5	28.7
North Milk	3	0	3	81.8	27.0
North Saskatchewan	34	4	31	1072.4	34.6
Oldman	8	2	6	417.6	69.6
Peace	15	2	13	995.2	76.6
Red Deer	27	1	26	717.6	27.6
Smoky	8	0	8	442.4	55.3
Wapiti	4	0	4	117.2	29.3
Total	174	16	159		

TABLE 4 Grain-size data

Athabasca

Sample No.	1	2	3	4	5	6	6.1	7	8
Distance (km)	44.1	119.4	220.2	406.7	503.4	643.4	669.1	750.1	1223.7
Weight (kg)	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
					Percentages Retained				
256									
128		9.80	20.10					9.80	
64	1.10	22.60	25.90	54.60	20.90	3.20		18.40	
32	16.30	20.60	14.10	41.90	23.10	30.80		20.30	
16	18.00	19.40	10.10	2.90	25.80	19.50		15.30	
8	17.80	7.60	7.80		6.70	6.60		5.90	
4	9.40	5.00	3.60		2.20	2.90		4.50	
2	6.80	4.30	2.80		1.10	2.30	0.20	4.50	
1.41	2.40	1.20	0.80		0.30	0.90	0.40	1.50	
1.00	1.90	0.60	0.50		0.30	0.90	0.90	1.10	0.10
.71	1.70	0.50	0.60		0.50	2.80	2.00	1.00	0.10
.50	1.30	0.80	0.60		1.80	3.30	8.10	1.10	0.30
.35	2.20	1.80	1.00		4.60	8.30	50.90	1.90	1.70
.25	4.30	2.50	1.60		4.70	5.40	21.80	2.90	7.60
.177	4.70	1.40	1.90	0.10	3.50	2.90	10.40	3.00	38.90
.125	3.40	0.80	1.60	0.20	1.60	2.50	3.20	2.70	38.30
.088	1.50	0.30	1.30	0.10	1.00	1.90	0.80	1.70	6.70
.062	1.20	0.20	1.10	0.10	0.70	1.80	0.50	1.30	3.10
<.062	6.00	0.60	4.60	0.10	1.20	4.00	0.80	3.10	3.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

9	10	11
1301.0	1383.7	1392.4
-1.00	-1.00	-1.00
0.10		
0.50		
2.20		
14.20	0.50	
33.90	2.20	
22.20	48.80	4.20
20.30	34.00	52.00
3.90	7.50	23.20
1.50	2.90	16.00
1.20	4.10	4.60
100.00	100.00	100.00

Bow-South Saskatchewan

Sample No.	1	2	3	4	5
Distance (km)	8.5	20.4	126.0	230.1	302.9
Weight (kg)	-1.00	-1.00	-1.00	-1.00	165.08
		Percentages Retained			
256					
128			24.10	9.40	13.30
64		10.10	29.20	32.30	24.40
32		21.00	19.30	21.80	17.30
16	2.90	24.00	12.10	14.70	18.60
8	16.50	14.90	3.30	6.80	10.00
4	17.40	9.00	1.80	3.40	4.90
2	16.20	8.40	1.70	2.70	3.40
1.41	6.20	2.90	0.70	0.60	0.90
1.00	5.40	2.30	0.70	0.50	0.60
.71	6.30	1.90	1.00	0.50	0.60
.50	7.10	1.20	0.80	0.50	0.70
.35	10.00	1.70	1.80	1.20	1.20
.25	5.70	1.10	1.60	1.60	1.20
.177	2.50	0.50	0.70	1.50	0.80
.125	1.70	0.30	0.40	1.00	0.60
.088	0.90	0.20	0.20	0.50	0.50
.062	0.50	0.20	0.20	0.40	0.30
<.062	0.70	0.30	0.40	0.60	0.70
Total	100.00	100.00	100.00	100.00	100.00

TABLE 4 (continued)

Bow-South Saskatchewan (continued)

Sample No.	6	7	8	9	10	11	12	13	14
Distance (km)	351.5	392.2	459.8	483.1	570.0	571.9	630.2	647.3	681.4
Weight (kg)	92.73	95.58	139.07	113.91	99.81	-1.00	98.83	-1.00	90.80
					Percentages Retained				
256									
128									
64	5.90	18.60	28.50	7.80	1.70		3.00		4.10
32	12.40	21.30	23.80	20.20	4.60	9.40	14.80	11.30	13.70
16	19.40	24.60	15.90	24.70	21.30	19.40	30.70	16.80	21.70
8	22.10	13.90	10.20	13.70	22.60	18.60	17.50	25.90	19.00
4	15.00	6.10	5.20	6.00	10.70	9.40	9.20	10.70	8.70
2	10.60	4.60	3.90	4.70	7.80	9.20	9.30	5.00	5.10
1.41	2.00	1.70	1.50	1.40	2.10	3.40	3.00	1.00	1.30
1.00	1.30	0.90	1.40	2.00	2.40	2.50	2.50	0.80	1.00
.71	1.30	1.00	1.90	5.20	3.10	3.10	2.50	1.80	1.40
.50	1.30	1.40	2.70	4.90	5.70	3.80	2.60	2.30	4.50
.35	2.90	2.70	3.00	3.20	8.80	5.80	2.90	6.30	9.70
.25	2.30	1.50	0.90	2.60	4.60	5.80	1.30	5.80	5.30
.177	1.00	0.70	0.40	1.40	2.00	3.60	0.30	3.20	2.10
.125	0.80	0.40	0.30	0.80	1.00	2.10	0.10	2.60	1.00
.088	0.50	0.20	0.10	0.40	0.50	1.10	0.10	1.80	0.40
.062	0.40	0.20	0.10	0.30	0.30	0.90	0.10	1.50	0.20
<.062	0.80	0.20	0.20	0.70	0.80	1.90	0.10	3.20	0.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

15	16	17	18	19	20	20.1	21	22	23	24
747.8	805.3	899.6	941.1	965.4	986.3	986.3	1001.3	1024.2	1043.0	1100.0
96.17	85.59	118.07	102.21	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Percentages Retained										
2.70	3.70	7.00								
11.60	14.60	21.00	3.11							
28.50	25.00	22.80	22.23					0.50		
18.80	22.30	12.60	24.41				0.02	2.00		
8.10	11.90	6.50	12.07		0.10	0.30	0.10	2.10	0.10	0.20
3.90	6.40	4.70	8.37		0.20	0.60	0.03	2.20	0.10	0.40
0.90	1.40	1.50	2.70		0.20	0.30	0.03	1.30	0.03	0.20
0.70	0.80	1.10	2.10		0.50	0.40	0.10	1.70	0.04	0.40
0.80	0.80	1.10	2.60	0.40	0.90	0.90	0.30	3.10	0.10	1.10
1.40	1.00	2.30	4.20	0.60	2.80	2.80	1.00	8.90	0.20	3.00
4.60	1.60	8.70	8.30	1.20	27.20	17.40	16.70	30.50	0.50	24.30
9.30	2.60	6.40	7.20	33.00	43.70	39.10	43.80	36.70	33.60	51.30
5.20	3.60	2.00	1.30	38.70	15.60	28.10	27.20	7.80	46.30	14.20
2.10	2.30	0.80	0.60	18.20	6.40	7.40	7.50	2.40	15.40	3.80
0.60	0.70	0.30	0.30	5.10	1.30	1.70	1.90	0.50	2.30	0.70
0.20	0.40	0.20	0.10	1.50	0.50	0.60	0.80	0.20	0.80	0.20
0.60	0.90	1.00	0.40	1.30	0.60	0.40	0.50	0.10	0.50	0.20
100.00	100.00	100.00	99.99	100.00	100.00	100.00	99.98	100.00	99.97	100.00

TABLE 4 (continued)

Bow-South Saskatchewan (continued)

Sample No.	25	26	27	28	29	30	30.1	31	32
Distance (km)	1110.6	1126.0	1176.2	1223.4	1265.9	1290.0	1290.0	1321.9	1413.9
Weight (kg)	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
					Percentages Retained				
256									
128									
64									
32									
16									
8		0.20							
4		0.90	0.20					0.02	
2		1.10	0.70			0.40		0.06	
1.41		0.70	0.40			0.40		0.03	
1.00		1.40	0.80			0.90		0.06	
.71	0.50	6.70	1.30	0.30	0.10	2.10	0.10	0.30	0.20
.50	0.60	8.60	3.40	0.60	0.20	4.30	0.20	0.40	0.40
.35	9.40	24.70	15.80	15.20	1.20	18.50	0.90	2.30	2.30
.25	44.40	33.30	40.00	50.70	23.40	46.00	17.00	31.70	49.10
.177	34.00	16.80	28.30	26.10	39.80	18.90	52.60	50.00	33.70
.125	7.70	3.50	6.90	5.90	30.40	5.70	25.30	13.50	11.60
.088	2.10	0.90	1.60	0.80	3.60	1.60	3.00	1.20	1.80
.062	0.60	0.60	0.40	0.30	1.00	0.50	0.60	0.20	0.60
<.062	0.70	0.60	0.20	0.10	0.30	0.70	0.30	0.20	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	100.00

Little Smoky

Sample No.	1	2	2.1	2.2	2.3	3	4	5	6
Distance (km)	343.1	365.5	389.5	410.5	429.2	509.2	542.3	559.2	602.7
Weight (kg)	142.56	96.64	-1.00	-1.00	-1.00	144.29	173.91	188.18	191.59
	Percentages Retained								
256									
128						2.10	5.60	4.40	1.90
64	11.10	0.60				26.20	33.70	36.00	34.80
32	26.80	6.10				26.00	16.00	17.80	22.40
16	19.70	26.10				13.80	13.00	12.10	15.10
8	12.10	20.60	0.20	0.05	0.10	8.40	8.30	7.90	6.20
4	6.20	10.50	0.20	0.30	0.50	2.70	4.60	3.20	2.90
2	4.50	7.40	0.40	2.60	1.50	2.40	3.80	2.50	2.50
1.41	1.50	2.00	0.60	2.50	1.60	1.20	1.20	0.90	1.10
1.00	1.90	1.40	2.20	21.20	3.20	1.50	1.00	0.80	1.10
.71	2.00	2.30	6.20	26.45	6.60	2.10	1.10	1.30	1.20
.50	2.50	3.60	26.30	31.50	12.30	2.80	1.20	1.90	1.90
.35	3.70	8.00	40.80	11.60	49.50	4.60	3.10	3.50	4.60
.25	4.20	7.60	17.90	2.40	18.80	3.30	3.60	3.20	2.40
.177	2.10	2.20	3.60	0.80	4.30	1.40	1.80	1.70	0.80
.125	0.80	0.80	1.10	0.30	0.60	0.70	0.80	0.90	0.50
.088	0.30	0.30	0.20	0.10	0.40	0.30	0.40	0.50	0.30
.062	0.20	0.20	0.10	0.10	0.20	0.20	0.30	0.40	0.10
<.062	0.40	0.30	0.20	0.10	0.40	0.30	0.50	1.00	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4 (continued)

Little Smoky (continued)	
Sample No.	7
Distance (km)	602.8
Weight (kg)	-1.00
256	
128	
64	6.44
32	16.98
16	22.79
8	13.28
4	6.64
2	5.60
1.41	
1.00	
.71	
.50	
.35	
.25	
.177	
.125	
.088	
.062	
<.062	
Total	71.73

McLeod					
Sample No.	1	2	3	4	5
Distance (km)	16.1	89.5	135.7	135.8	156.7
Weight (kg)	296.42	168.32	62.76	194.30	85.30
	Percentages Retained				
256	20.40				
128	53.50	22.10	21.00		
64	12.40	28.50	27.90	6.36	3.40
32	3.60	18.00	17.50	27.18	16.40
16	3.10	14.80	13.70	36.46	39.90
8	1.60	6.20	7.00	13.59	19.20
4	1.10	2.80	3.20	2.63	4.70
2	1.00	1.10	2.50	0.85	2.00
1.41	0.50	0.50	0.90		0.50
1.00	0.50	0.30	0.70	no	0.40
.71	0.40	0.30	0.60	sand	0.60
.50	0.40	0.40	0.70	data	1.10
.35	0.40	1.20	1.40		3.30
.25	0.30	1.70	1.10		4.60
.177	0.20	1.00	0.80		2.30
.125	0.10	0.50	0.50		0.80
.088	0.10	0.20	0.20		0.30
.062	0.10	0.10	0.10		0.10
<.062	0.30	0.30	0.20		0.40
Total	100.00	100.00	100.00	87.07	100.00

6	7	8	9	10
229.0	258.0	272.1	303.8	379.6
531.67	133.05	180.38	122.68	181.19
31.20				
30.00		2.70		11.10
20.00	19.80	37.70	8.90	32.60
5.30	23.10	16.30	15.80	17.70
3.70	22.30	14.70	25.10	14.90
2.40	12.30	12.90	20.00	10.60
0.90	4.30	3.70	4.20	2.50
0.60	1.80	1.70	2.40	1.40
0.20	0.40	0.50	0.80	0.50
0.30	0.30	0.40	0.60	0.40
0.40	0.60	0.50	0.80	0.60
0.70	2.10	1.30	1.60	1.00
1.20	4.70	2.50	7.00	1.20
1.20	3.70	1.70	6.30	1.70
0.60	1.80	0.80	3.40	1.40
0.40	1.00	0.60	1.60	1.10
0.20	0.40	0.40	0.50	0.50
0.10	0.30	0.30	0.30	0.30
0.60	1.10	1.30	0.70	0.50
100.00	100.00	100.00	100.00	100.00

Milk

Sample No.	1	2	3
Distance (km)	127.6	155.0	196.2
Weight (kg)	124.40	78.52	61.90
	Percentages Retained		
256			
128	5.00		
64	16.70	0.60	
32	24.70	6.60	
16	20.00	23.50	14.50
8	9.90	22.40	23.10
4	4.00	13.60	13.30
2	3.30	12.00	12.40
1.41	1.50	4.20	3.50
1.00	1.80	2.90	3.10
.71	2.40	2.20	4.20
.50	2.80	1.70	6.70
.35	2.80	2.30	8.20
.25	2.60	3.30	5.20
.177	1.30	2.40	2.80
.125	0.60	1.10	1.50
.088	0.30	0.40	0.60
.062	0.10	0.20	0.40
<.062	0.20	0.60	0.50
Total	100.00	100.00	100.00

TABLE 4 (continued)

Milk (continued)

Sample No.	4	5	6	7	8	9
Distance (km)	213.7	261.7	273.6	298.5	305.3	386.1
Weight (kg)	121.39	-1.00	-1.00	-1.00	-1.00	-1.00
			Percentages Retained			
256						
128						
64	17.80					
32	12.10	0.60				
16	15.70	13.00				
8	11.70	13.90	0.10			
4	6.50	7.80	0.60	0.20		
2	4.40	10.60	1.20	1.40	0.10	0.01
1.41	1.50	5.90	1.20	1.90	0.30	0.01
1.00	1.60	6.20	2.80	3.80	0.50	0.01
.71	2.20	8.90	3.70	5.50	1.30	0.02
.50	2.80	14.30	7.70	12.20	5.20	0.05
.35	4.80	12.80	13.50	27.70	18.80	0.10
.25	7.20	3.20	32.20	24.30	30.40	2.40
.177	5.80	1.00	24.80	11.50	18.60	15.70
.125	2.90	0.80	10.90	7.80	9.40	20.90
.088	1.50	0.30	0.80	2.20	7.00	15.80
.062	0.90	0.20	0.30	0.90	5.30	15.00
<.062	0.60	0.50	0.20	0.60	3.10	30.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

North Milk

Sample No.	1
Distance (km)	38.3
Weight (kg)	112.11
256	
128	16.10
64	21.30
32	21.10
16	16.70
8	9.10
4	3.90
2	2.70
1.41	0.90
1.00	0.70
.71	0.70
.50	0.90
.35	1.00
.25	0.90
.177	0.90
.125	0.80
.088	0.50
.062	0.30
<.062	1.50
Total	100.00

2	3
71.3	119.4
129.90	127.55
8.10	
24.00	1.20
16.30	10.20
14.80	15.70
9.50	16.30
5.80	10.50
5.90	9.50
2.40	4.90
1.90	5.40
1.80	6.50
1.80	6.40
1.70	5.40
1.50	3.20
1.40	1.90
1.00	1.00
0.50	0.50
0.40	0.40
1.20	1.00
100.00	100.00

North Saskatchewan

Sample No.	1	2	3	4	5	6
Distance (km)	29.6	124.2	178.0	229.5	262.3	334.1
Weight (kg)	-1.00	183.68	286.00	392.27	128.19	186.14
			Percentages Retained			
256						
128		2.60	35.50	52.30	1.230	7.50
64		32.50	24.10	11.90	26.80	30.40
32	11.60	30.50	15.60	7.70	14.20	16.80
16	19.00	14.00	8.50	7.10	16.80	15.40
8	14.80	4.80	4.60	5.10	10.00	10.00
4	6.10	2.70	2.60	3.60	4.90	4.30
2	5.40	1.60	2.60	2.40	4.70	2.90
1.41	2.50	0.50	0.90	0.50	1.50	0.70
1.00	2.50	0.50	0.90	0.30	1.10	0.50
.71	3.40	0.90	0.80	0.40	1.00	0.60
.50	5.30	2.10	0.70	0.70	0.70	1.10
.35	10.10	2.80	0.90	1.70	1.40	2.60
.25	9.50	1.90	0.70	2.20	1.90	2.70
.177	5.00	1.00	0.50	1.50	1.00	1.60
.125	2.70	0.60	0.40	1.10	0.60	1.30
.088	0.80	0.30	0.20	0.50	0.30	0.50
.062	0.40	0.20	0.20	0.30	0.20	0.20
<.062	0.90	0.50	0.30	0.70	0.60	0.90
Total	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4 (continued)

North Saskatchewan (continued)

Sample No.	7	8	9	10	11	12	13	14	15
Distance (km)	391.7	420.2	420.8	466.4	469.0	505.0	505.8	532.2	532.7
Weight (kg)	189.60	162.83	120.88	92.19	109.80	62.89	127.90	96.93	59.03
					Percentages Retained				
256									
128	9.60	4.00					2.40		
64	31.20	25.40	13.10	7.20	10.10	5.30	16.90	1.90	
32	16.60	29.40	21.70	30.50	15.00	13.40	24.80	22.40	16.30
16	17.20	15.30	27.90	35.80	40.40	36.60	20.20	28.30	38.80
8	9.00	7.20	13.90	13.10	10.70	22.20	13.60	17.40	16.40
4	2.80	1.60	2.00	2.00	1.30	6.20	4.80	6.60	3.80
2	1.20	0.40	0.70	0.13	0.60	2.20	2.70	3.60	1.70
1.41	0.40	0.10	0.30	0.04	0.20	0.50	0.60	0.70	0.40
1.00	0.30	0.10	0.20	0.04	0.10	0.30	0.50	0.50	0.30
.71	0.40	0.10	0.30	0.06	0.20	0.30	0.60	0.70	0.30
.50	1.10	0.30	1.70	0.13	0.60	0.60	1.10	1.40	0.40
.35	2.80	2.30	8.40	0.60	2.40	1.40	3.70	4.50	2.80
.25	3.10	5.20	6.70	0.70	6.60	1.20	4.50	6.10	8.40
.177	1.70	3.50	1.80	0.70	5.40	1.60	1.50	3.00	4.60
.125	1.10	2.40	0.70	2.00	2.70	1.90	0.70	1.40	2.10
.088	0.50	1.20	0.20	2.10	1.50	1.50	0.40	0.50	1.00
.062	0.20	0.50	0.20	2.40	0.90	1.40	0.20	0.30	0.90
<.062	0.80	1.00	0.20	2.50	1.30	3.40	0.80	0.70	1.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

16	17	18	19	20	21	22	23	24	25	26
566.8	573.1	599.1	621.7	659.5	687.2	725.0	754.6	779.7	815.6	836.7
124.81	129.09	138.47	133.49	98.52	92.06	125.58	116.09	107.60	125.26	147.95
					Percentages Retained					
0.50	19.00	16.80	10.80	12.20	8.50	5.70	9.40	4.00	4.90	10.10
9.80	21.20	14.50	16.90	17.90	17.30	11.20	11.60	11.10	9.60	16.30
30.30	21.40	20.70	20.80	21.10	26.40	17.10	14.20	20.30	17.80	16.60
21.80	13.70	12.80	17.20	16.00	20.00	17.40	16.20	16.20	19.40	11.00
6.90	5.10	5.80	8.10	5.90	8.50	7.30	7.20	8.40	9.30	6.00
5.40	4.60	5.60	6.60	3.80	4.20	3.80	5.50	6.00	7.20	7.10
1.10	1.60	2.00	1.90	1.30	1.00	0.80	2.10	1.20	1.90	3.80
0.70	1.40	1.90	1.40	1.00	0.80	0.70	1.90	0.70	1.20	4.10
0.90	1.20	1.70	1.60	1.40	1.50	0.80	1.90	0.90	1.40	5.20
1.70	1.20	2.40	2.10	2.50	2.00	1.90	2.40	1.40	1.70	3.50
6.80	1.80	4.20	4.10	7.40	3.30	8.60	6.10	8.50	6.10	5.80
8.00	1.50	5.20	2.60	5.40	2.80	9.80	7.50	12.00	8.80	7.40
3.40	1.40	2.70	1.60	1.80	1.40	6.10	5.20	5.20	6.30	2.00
1.20	1.40	1.20	1.30	1.00	0.90	3.80	3.10	2.50	2.70	0.50
0.50	0.90	0.70	0.60	0.40	0.40	1.80	1.70	0.70	0.70	0.20
0.30	0.50	0.50	0.50	0.20	0.30	1.20	1.40	0.40	0.40	0.10
0.70	2.10	1.30	1.90	0.70	0.70	2.00	2.60	0.50	0.60	0.30
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4 (continued)

North Saskatchewan (continued)

Sample No.	27	28	29	30	31	32	33	34
Distance (km)	855.5	864.0	888.0	908.8	928.6	998.9	1040.1	1102.0
Weight (kg)	124.69	101.15	104.70	-1.00	-1.00	-1.00	-1.00	-1.00
			Percentages Retained					
256								
128								
64	16.70		0.90					
32	22.40	6.30	9.40					
16	19.20	21.00	20.10					
8	12.90	18.30	18.40	0.03				
4	6.20	10.50	7.50	0.03	0.10	0.30	0.05	0.20
2	5.00	8.50	4.90	0.10	0.20	0.80	0.20	0.30
1.41	2.10	2.30	1.00	0.10	0.30	0.80	0.20	0.30
1.00	2.60	1.80	0.60	0.20	0.70	1.90	0.20	0.60
.71	3.00	2.00	0.90	0.30	1.30	3.80	0.10	2.10
.50	2.90	3.00	1.40	1.20	2.40	11.40	0.10	2.90
.35	2.60	7.70	7.60	16.50	13.90	28.20	0.40	11.90
.25	2.30	11.60	10.10	50.50	36.60	32.10	47.70	18.00
.177	1.00	4.80	6.80	25.00	27.50	15.40	39.60	40.50
.125	0.50	1.30	4.90	4.60	11.00	4.20	6.50	19.10
.088	0.20	0.40	2.00	0.70	3.60	0.70	4.60	2.60
.062	0.10	0.20	1.20	0.60	1.40	0.30	0.30	0.90
<.062	0.30	0.30	2.30	0.20	1.00	0.10	0.10	0.60
Total	100.00	100.00	100.00	100.06	100.00	100.00	100.05	100.00

Oldman

Sample No.	1	2	3	4	5	6	7	8
Distance (km)	33.8	117.3	192.0	194.2	293.9	382.9	449.2	451.4
Weight (kg)	444.76	131.56	191.58	124.07	114.35	90.14	134.63	234.36
	Percentages Retained							
256	14.90							
128	48.80	2.60	2.30	3.40	3.80			12.20
64	16.00	14.30	34.50	22.90	16.70	0.60	15.20	40.10
32	5.80	15.30	16.90	17.50	25.20	17.20	16.20	18.30
16	5.00	19.90	13.40	16.70	20.60	33.30	18.80	11.10
8	2.90	13.70	10.40	12.30	10.50	19.60	15.00	6.60
4	1.60	7.00	6.80	6.50	5.80	8.20	4.60	3.20
2	1.80	6.30	5.40	5.40	3.10	3.40	2.70	1.80
1.41	0.80	3.30	1.50	2.30	1.00	0.90	0.50	0.50
1.00	0.70	3.70	1.10	2.00	0.80	0.70	0.40	0.30
.71	0.40	4.20	1.10	1.80	1.30	1.20	0.60	0.30
.50	0.30	4.30	1.10	2.00	1.90	3.10	1.20	0.40
.35	0.30	2.90	1.80	2.20	2.30	6.50	6.70	0.40
.25	0.20	1.30	1.60	2.10	2.60	3.10	10.50	0.90
.177	0.10	0.50	1.00	1.40	1.60	1.00	4.90	1.30
.125	0.10	0.30	0.50	0.70	0.70	0.50	1.60	1.10
.088	0.10	0.10	0.20	0.30	0.60	0.20	0.50	0.60
.062	0.10	0.10	0.20	0.20	0.50	0.20	0.20	0.30
<.062	0.10	0.20	0.20	0.30	1.00	0.30	0.40	0.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4 (continued)

Peace

Sample No.	1	2	3	4	5	6	7	8	9
Distance (km)	816.4	918.1	918.7	944.3	1023.0	1024.0	1126.7	1230.1	1332.5
Weight (kg)	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
	Percentages Retained								
256									
128		9.10				4.80	7.50		
64	3.20	29.60	16.10	6.10	24.90	12.20	15.70	10.80	
32	41.00	23.60	38.30	22.80	23.70	23.10	14.10	12.80	4.60
16	26.50	10.70	22.20	22.40	16.90	16.80	13.90	23.50	17.40
8	0.20	7.50	3.60	15.80	11.10	15.30	13.60	17.30	25.50
4	0.03	3.60	0.60	9.00	5.10	8.30	8.50	8.60	12.70
2	0.40	2.80	0.30	6.50	2.80	5.30	7.50	4.80	7.00
1.41	0.80	0.80	0.10	1.80	0.80	1.10	1.80	1.30	1.50
1.00	1.00	0.40	0.10	1.20	0.60	0.60	0.70	1.00	0.90
.71	1.10	0.30	0.20	1.10	0.70	0.50	0.50	1.10	1.20
.50	1.00	0.30	0.30	1.10	1.50	0.90	0.60	1.00	3.20
.35	2.60	0.60	2.60	2.00	2.70	3.10	1.90	1.70	13.50
.25	8.80	3.10	8.30	3.80	2.20	4.80	5.80	3.00	7.90
.177	7.00	3.40	3.80	2.30	2.10	2.10	5.00	4.90	1.30
.125	3.60	1.80	1.60	1.30	1.60	0.60	1.50	3.70	1.00
.088	1.20	0.80	0.70	0.70	1.10	0.20	0.50	1.60	0.80
.062	0.60	0.60	0.40	0.60	0.70	0.10	0.30	1.10	0.50
<.062	1.00	1.00	0.80	1.50	1.50	0.20	0.60	1.80	1.00
Total	100.03	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

10.	11	12	13	14	15
1420.9	1511.0	1605.4	1681.9	1759.6	1811.6
-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
		Percentages Retained			
		0.02			
0.01		0.02	0.03	0.02	
0.10		0.01	0.01	0.02	
0.10	0.01	0.01	0.01	0.01	
0.20	0.01	0.10	0.01	0.02	
1.00	0.03	0.40	0.02	0.30	0.10
3.10	0.10	0.40	0.10	0.60	0.10
41.90	0.60	8.70	1.00	27.90	0.20
40.30	21.90	68.70	18.50	56.20	3.20
5.90	51.50	17.10	57.10	11.20	23.80
2.90	19.90	3.90	19.60	2.70	29.80
1.30	3.30	0.40	2.00	0.50	19.80
1.10	0.60	0.20	0.90	0.30	13.80
2.10	2.10	0.10	0.70	0.30	9.20
100.01	100.05	100.06	99.98	100.07	100.00

Red Deer

Sample No.	1	2
Distance (km)	63.1	91.4
Weight (kg)	82.55	374.08
256		17.70
128		26.60
64	9.10	21.70
32	23.70	10.40
16	25.40	8.00
8	12.70	4.60
4	6.20	3.20
2	5.00	2.50
1.41	2.50	0.70
1.00	2.70	0.40
.71	3.30	0.40
.50	2.90	0.30
.35	2.60	0.50
.25	1.60	0.70
.177	0.90	0.70
.125	0.60	0.60
.088	0.30	0.30
.062	0.20	0.20
<.062	0.30	0.50
Total	100.00	100.00

TABLE 4 (continued)

Red Deer (continued)

Sample No.	3	4	5	6	7	8	9	10	11
Distance (km)	141.1	158.8	186.5	242.5	253.3	284.0	315.6	316.4	365.3
Weight (kg)	209.79	195.12	93.35	90.94	94.61	84.52	146.55	209.44	128.90
	Percentages Retained								
256									
128	39.70	22.10					6.60	13.20	
64	17.70	23.10	16.80	8.50	9.50	22.70	36.00	30.30	27.70
32	14.90	15.40	29.60	25.00	29.60	32.00	10.70	12.20	17.40
16	10.30	13.70	33.50	27.50	31.20	27.80	15.70	12.10	18.80
8	6.40	8.60	12.90	17.10	12.40	9.10	11.80	9.40	13.60
4	3.20	4.50	1.80	5.40	3.20	1.30	6.10	4.30	5.80
2	2.40	3.80	0.60	2.70	1.30	0.40	3.40	3.00	3.20
1.41	0.70	1.30	0.10	0.80	0.30	0.10	0.50	0.70	0.90
1.00	0.40	1.10	1.10	0.70	0.20	0.20	0.30	0.40	0.70
.71	0.40	0.80	0.10	0.80	0.30	0.20	0.40	0.40	0.70
.50	0.50	0.60	0.20	1.80	0.60	0.40	0.90	0.70	0.60
.35	0.90	0.90	0.70	3.80	1.50	1.20	3.50	3.20	1.40
.25	0.90	0.80	1.30	2.30	2.50	1.80	2.50	3.30	3.30
.177	0.60	0.80	1.00	1.50	2.30	1.10	0.90	2.00	2.40
.125	0.40	0.80	0.70	1.00	1.70	0.70	0.30	1.60	1.50
.088	0.20	0.50	0.30	0.40	1.20	0.30	0.10	1.10	0.60
.062	0.10	0.40	0.20	0.20	0.80	0.20	0.10	0.80	0.40
<.062	0.30	0.80	0.10	0.50	1.40	0.50	0.20	1.30	1.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

12	13	14	14.1	15	16	17	18	19	20	21
409.1	432.1	438.5	459.9	478.8	512.9	524.3	549.1	585.8	615.7	661.3
103.38	106.28	95.59	-1.00	87.47	67.51	178.26	-1.00	-1.00	-1.00	-1.00

Percentages Retained

						6.00				
6.90	11.40	1.70		3.40		30.20				
22.40	16.60	17.20		18.60	1.10	17.90				
25.10	22.10	32.70	0.10	26.10	15.60	13.40	0.30			
13.30	16.90	16.60	0.10	17.60	18.70	10.00	1.40			
6.40	6.10	6.80	0.20	7.20	13.90	3.20	1.90	0.20	0.02	0.10
5.40	5.20	5.30	0.40	4.30	13.30	3.10	4.50	1.10	0.40	0.80
1.90	2.10	1.40	0.30	1.30	3.80	1.20	2.80	1.30	0.60	0.70
1.60	1.70	1.20	0.50	1.20	2.90	1.00	2.80	2.40	1.00	0.80
1.50	1.80	1.00	1.60	1.60	3.10	1.10	3.50	3.80	3.20	1.50
1.60	2.00	1.00	1.20	2.60	4.60	1.20	4.80	12.80	12.00	5.60
3.00	3.50	1.70	6.00	6.90	7.70	1.50	25.40	24.30	27.70	19.50
5.60	4.20	4.20	50.20	4.10	7.60	1.40	32.80	26.60	24.80	26.40
2.80	2.10	4.90	20.10	2.00	3.90	1.50	9.30	18.50	12.80	32.60
1.30	1.40	2.40	11.40	1.20	2.20	1.70	4.50	7.50	9.50	9.00
0.50	0.80	0.80	3.70	0.60	0.80	1.30	3.30	1.10	3.60	2.00
0.30	0.70	0.40	1.70	0.40	0.40	0.90	1.40	0.20	2.00	0.70
0.40	1.40	0.70	2.50	0.90	0.40	3.40	1.30	0.20	2.40	0.30
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.02	100.00

TABLE 4 (continued)

Red Deer (continued)

Sample No.	22	23	24	25	26
Distance (km)	691.8	693.6	711.1	744.9	780.7
Weight (kg)	-1.00	-1.00	-1.00	-1.00	-1.00
			Percentages Retained		
256					
128					
64					
32					
16		0.04			
8		0.50			
4	0.10	0.70	0.20		
2	0.60	1.80	0.30	0.10	
1.41	0.70	1.70	0.30	0.10	
1.00	0.90	2.50	0.60	0.20	
.71	2.00	3.30	1.10	0.60	0.30
.50	7.90	11.20	5.80	1.70	0.30
.35	23.90	42.20	37.00	19.60	0.70
.25	38.60	24.70	43.90	32.90	17.80
.177	18.90	5.70	7.30	20.90	53.70
.125	4.20	3.90	2.50	14.40	22.40
.088	1.10	1.00	0.50	4.90	3.50
.062	0.60	0.40	0.20	2.60	0.70
<.062	0.50	0.40	0.30	2.00	0.60
Total	100.00	100.04	100.00	100.00	100.00

Smoky

Sample No.	1
Distance (km)	123.3
Weight (kg)	159.48
256	
128	5.60
64	41.90
32	16.60
16	12.40
8	7.40
4	3.20
2	2.60
1.41	1.00
1.00	0.90
.71	1.20
.50	1.30
.35	2.40
.25	1.50
.177	0.70
.125	0.50
.088	0.20
.062	0.20
<.062	0.40
Total	100.00

2	3	4	5	6	7	8
228.4	296.6	358.6	418.3	482.8	551.8	565.7
191.52	-1.00	207.85	98.46	145.10	138.29	115.65
Percentages Retained						
29.70	25.40	8.30		25.00	5.30	
27.40	27.30	36.90	5.50	24.90	29.20	13.70
18.60	18.50	24.10	22.10	18.80	24.10	32.70
13.30	12.40	10.50	35.80	13.70	18.60	26.30
4.10	6.00	6.40	9.10	5.30	7.20	7.70
1.10	2.80	1.30	4.20	2.50	0.04	2.90
0.90	1.80	0.70	3.00	1.20	0.05	1.90
0.30	0.50	0.20	0.60	0.30	0.03	0.60
0.20	0.30	0.20	0.30	0.20	0.04	0.60
0.10	0.20	0.20	0.60	0.40	0.10	1.50
0.20	0.30	0.60	1.90	1.00	0.90	2.90
0.30	0.70	2.90	6.30	2.50	3.80	2.80
0.80	1.10	3.60	6.10	1.40	5.10	1.50
0.90	0.90	1.90	2.10	0.90	3.00	1.80
0.80	0.70	1.00	0.90	0.60	1.40	1.30
0.40	0.30	0.40	0.40	0.30	0.50	0.60
0.30	0.30	0.30	0.30	0.30	0.30	0.40
0.60	0.50	0.50	0.80	0.70	0.40	0.80
100.00	100.00	100.00	100.00	100.00	100.00	100.00

Wapiti

Sample No.	1
Distance (km)	160.1
Weight (kg)	307.72
256	
128	36.50
64	27.30
32	15.20
16	7.00
8	3.20
4	2.10
2	2.20
1.41	0.90
1.00	0.70
.71	0.60
.50	0.50
.35	0.50
.25	0.60
.177	0.90
.125	0.70
.088	0.40
.062	0.20
<.062	0.50
Total	100.00

TABLE 4 (continued)

Wapiti (continued)		
2	3	4
211.6	247.5	277.3
175.22	154.72	101.33
Percentages Retained		
14.60	7.30	
32.20	17.50	8.50
16.80	26.30	28.70
13.80	17.20	25.40
6.10	7.70	11.50
4.90	2.80	4.80
3.60	1.40	3.80
1.20	0.30	1.50
1.00	0.20	1.30
0.90	0.50	1.70
0.70	1.70	2.50
0.70	5.20	4.20
0.80	5.60	3.20
0.70	2.50	1.30
0.60	1.50	0.50
0.30	0.70	0.30
0.30	0.60	0.20
0.80	1.00	0.60
100.00	100.00	100.00

TABLE 5
Lithology and grain size of the gravel fraction.

Athabasca

Sample No. 1 — *Distance from source = 44.1* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64			1.00		0.10						1.10
32			15.40		0.85						16.25
16			16.53	0.24	1.23						18.00
8		0.01	16.75	0.13	0.93						17.82
4		0.01	8.70	0.15	0.52		0.02	0.01			9.41
2		-1.00	6.29	0.16	0.24		0.07	0.03			6.79
Total		0.02	64.67	0.68	3.87		0.09	0.04			69.37

Sample No. 2 — *Distance from source = 119.4* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			0.80		9.00						9.80
64			2.29		20.31						22.60
32			3.10		17.50						20.60
16			3.25		16.00		0.12				19.37
8		0.03	4.02	0.09	3.15						7.65
4		0.08	3.01	0.03	1.84		0.01				4.97
2		0.12	2.98	0.02	1.19		0.01		-1.00		4.32
Total		0.23	19.45	0.14	69.35		0.14				89.31

Sample No. 3 — *Distance from source = 220.2* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			5.38		14.70						20.08
64			6.80		18.27		0.83				25.90
32	0.03		7.20		5.34		1.50				14.07
16	0.05		5.60	0.15	3.31		1.02				10.13
8		0.08	4.33	0.25	2.54		0.58	0.04			7.82
4	0.01	0.02	1.89	0.13	1.30		0.22	0.05	0.01		3.63
2	0.03	0.10	1.21	0.30	0.63		0.36	0.13	0.01		2.77
Total	0.12	0.20	32.41	0.83	46.09		4.51	0.22	0.02		84.40

TABLE 5 (continued)

Athabasca

Sample No. 4 *Distance from source = 406.7* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64			0.78	0.10	51.80		1.90				54.58
32			0.59	0.24	40.00		1.07				41.90
16			0.21	0.62	2.07						2.90
Total			1.58	0.96	93.87		2.97				99.38

Sample No. 5 *Distance from source = 503.4* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.06		0.20	0.05	20.55						20.86
32	0.04		0.07	0.06	22.86				0.11		23.14
16	0.19		0.31	0.18	24.91				0.18		25.77
8	0.20	0.08	0.10	0.28	5.53	0.01	0.02	0.02	0.44		6.68
4	0.13	0.05	0.08	0.20	1.60		0.02	0.01	0.06		2.15
2	0.07	0.03	0.03	0.12	0.75		0.03	-1.00	0.04	0.03	1.10
Total	0.69	0.16	0.79	0.89	76.20	0.01	0.07	0.03	0.83	0.03	79.70

Sample No. 6 *Distance from source = 643.4* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.10		0.15	0.15	2.80						3.20
32	0.60		1.40	0.25	28.00		0.16	0.40			30.81
16	0.40	0.14	1.45	0.32	16.70		0.21	0.26	0.02		19.50
8	1.40	0.22	0.52	0.16	3.81		0.28	0.09	0.07	0.05	6.60
4	1.05	0.25	0.30	0.10	0.67		0.20	0.10	0.15	0.03	2.85
2	0.89	0.26	0.15	0.07	0.48		0.14	0.13	0.16	0.03	2.31
Total	4.44	0.87	3.97	1.05	52.46		0.99	0.98	0.40	0.11	65.27

Sample No. 7 *Distance from source = 750.1* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	9.80										9.80
64	2.25		0.85		15.34						18.44
32	1.95		4.98	0.36	11.41		1.60				20.30
16	1.83	0.42	1.45	0.62	6.93		3.80	0.23	0.02		15.30
8	2.05	0.26	0.48	0.32	2.32		0.18	0.17	0.08		5.86
4	2.18	0.23	0.50	0.16	1.05		0.08	0.17	0.14		4.51
2	2.10	0.59	0.39	0.25	0.49		0.11	0.36	0.19		4.48
Total	22.16	1.50	8.65	1.71	37.54		5.77	0.93	0.43		78.69

Sample No. 1 *Distance from source = 8.5* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
16			1.18		1.63		0.12				2.93
8			6.91	0.06	9.24		0.11	0.15			16.47
4		0.20	5.90		10.72			0.56	0.01		17.40
2		0.34	5.74		8.94		0.22	0.98	0.01		16.23
Total		0.54	19.73	0.06	30.53		0.45	1.69	0.02		53.03

Sample No. 2 *Distance from source = 20.4* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64			3.36		6.70						10.06
32			10.94		9.16		0.83	0.12			21.05
16			14.84	0.12	8.04		0.78	0.24			24.02
8			9.60	0.04	4.76		0.38	0.09			14.87
4			5.68		3.15		0.09	0.05	-1.00		8.97
2		0.03	4.91	-1.00	2.78		0.33	0.35	0.02		8.42
Total		0.03	49.33	0.16	34.59		2.41	0.85	0.02		87.39

Sample No. 3 *Distance from source = 126.0* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			23.05		1.07						24.12
64			24.58	2.46	2.14						29.18
32			12.94	2.82	3.15		0.42				19.33
16			6.47	3.84	1.48		0.25				12.04
8		0.01	2.22	0.40	0.51		0.19		-1.00		3.33
4		0.01	1.18	0.26	0.25		0.06	-1.00		-1.00	1.76
2			0.90	0.41	0.26		0.12			-1.00	1.69
Total		0.02	71.34	10.19	8.86		1.04				91.45

TABLE 5 (continued)

Bow-South Saskatchewan (continued)

Sample No. 4 *Distance from source = 230.1* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			8.77		0.61						9.38
64			22.36	0.64	6.70		2.57				32.27
32			15.70	1.00	3.30		1.82				21.82
16			10.10	1.40	2.04		1.01		0.05	0.10	14.70
8		0.02	4.80	0.42	0.97		0.59	0.01	0.02		6.83
4		-1.00	2.36	0.24	0.41		0.32		0.03	-1.00	3.36
2		0.01	1.67	0.38	0.33		0.20	0.01	0.07		2.67
Total		0.03	65.76	4.08	14.36		6.51	0.02	0.17	0.10	91.03

Sample No. 5 *Distance from source = 302.9* *Sample weight = 165.079*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					13.35						13.35
64			2.75		18.63		3.00				24.37
32			6.95	0.47	8.55		1.29				17.26
16			11.02	1.43	5.36		0.80		-1.00		18.61
8			5.57	0.92	3.18		0.31	0.02			10.00
4	0.01	0.03	2.22	0.88	1.56		0.22	0.02	0.01		4.95
2	-1.00	0.02	1.13	1.11	0.82		0.33	0.04	-1.00		3.45
Total	0.01	0.05	29.64	4.81	51.45		5.95	0.08	0.01		91.99

Sample No. 6 *Distance from source = 351.5* *Sample weight = 92.731*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					5.87						5.87
32			3.13	0.68	7.29		1.32				12.42
16	0.39		6.51	2.10	8.90		1.47				19.38
8	0.27	0.03	8.99	4.05	7.45		1.30		0.01		22.11
4	0.31	0.02	5.78	2.79	5.30		0.51	0.01	0.24		14.96
2	0.25	0.16	2.12	4.87	2.14		0.94	0.08	0.02	-1.00	10.58
Total	1.22	0.21	26.53	14.49	36.95		5.54	0.09	0.27		85.32

Sample No. 7 *Distance from source = 392.2* *Sample weight = 95.580*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64		0.43			15.33		2.89				18.65
32			4.46	0.33	14.71		1.76				21.26
16	0.52	0.09	6.74	2.18	13.95	0.05	1.09				24.63
8	0.28	0.01	4.67	2.16	6.42		0.31		-1.00	0.01	13.86
4	0.23	0.04	1.85	1.45	2.17		0.31		0.01	-1.00	6.06
2	0.29	0.11	1.21	1.63	0.93		0.40	0.01	0.02		4.60
Total	1.32	0.68	18.93	7.75	53.51	0.05	6.76	0.01	0.03	0.01	89.06

Sample No. 8 *Distance from source = 459.8* *Sample weight = 139.066*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.86		2.02		22.02		2.61				28.51
32	3.00		1.89	0.75	16.83		1.34				23.81
16	0.95	0.03	4.93	1.11	7.67	0.03	0.59	0.03	0.49	0.07	15.88
8	0.80	0.09	3.04	1.09	4.51		0.26	0.04	0.32	0.04	10.18
4	0.95	0.08	1.15	0.83	1.67	-1.00	0.12	0.03	0.30	0.02	5.15
2	1.13	0.34	0.52	0.77	0.75		0.12	0.01	0.26	0.04	3.94
Total	8.69	0.54	13.55	4.55	53.45	0.03	5.04	0.11	1.37	0.17	87.47

Sample No. 9 *Distance from source = 483.1* *Sample weight = 113.912*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.23				5.57						7.80
32	1.95		0.80	1.27	15.73		0.36		0.04		20.15
16	1.71	0.04	3.03	2.51	16.09		0.96		0.40		24.73
8	1.34	0.16	2.56	2.42	6.68	0.02	0.29	0.10	0.16	-1.00	13.74
4	1.15	0.16	1.29	1.06	1.95	-1.00	0.17	0.04	0.19		6.01
2	1.20	0.23	0.86	0.86	1.17		0.05	0.08	0.24	0.02	4.71
Total	9.58	0.59	8.54	8.12	47.19	0.02	1.83	0.22	1.03	0.02	77.14

TABLE 5 (continued)

Bow-South Saskatchewan (continued)

Sample No. 10 *Distance from source = 570.0* *Sample weight = 99.807*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					1.73						1.73
32	0.91		0.05		3.45		0.23				4.64
16	2.27	0.09	0.77	1.27	15.86	0.05	0.77	0.02	0.14	0.02	21.27
8	3.35	0.28	1.96	3.87	12.12	0.07	0.59	0.22	0.13	0.01	22.59
4	3.18	0.44	1.00	1.49	4.08		0.14	0.05	0.26	0.03	10.67
2	2.28	0.58	1.04	1.27	1.88		0.18	0.19	0.30	0.07	7.79
Total	11.99	1.39	4.82	7.90	39.12	0.12	1.91	0.48	0.83	0.13	68.69

Sample No. 11 *Distance from source = 571.9* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32	0.91		0.39	0.69	7.26		0.13				9.38
16	1.67		1.02	2.03	13.75		0.32	0.06	0.58		19.43
8	2.59	0.25	1.46	3.12	10.30	0.02	0.49	0.04	0.31	0.06	18.64
4	2.37	0.35	0.97	1.71	3.35		0.17	0.02	0.37	0.05	9.36
2	2.97	0.91	1.00	1.41	1.86		0.15	0.06	0.68	0.18	9.22
Total	10.51	1.51	4.84	8.96	36.52	0.02	1.26	0.18	1.94	0.29	66.03

Sample No. 12 *Distance from source = 630.2* *Sample weight = 98.830*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.98				0.96						2.94
32	2.94		0.50	0.28	10.33	0.09	0.69				14.82
16	4.36	0.05	1.61	1.70	21.80	0.05	1.10		0.05		30.70
8	3.54	0.19	2.08	2.51	8.49	0.04	0.36	0.12	0.21	-1.00	17.53
4	2.35	0.26	1.06	0.99	4.11		0.08		0.37	0.01	9.23
2	3.57	0.83	1.25	1.63	1.29		0.12	0.02	0.58	0.05	9.34
Total	18.74	1.33	6.50	7.11	46.98	0.18	2.35	0.14	1.21	0.06	84.56

Sample No. 13 *Distance from source = 647.3* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32	0.26		1.65		4.48		0.42	0.33	4.17		11.31
16	0.50		1.87	1.05	6.58		1.00	0.90	4.88		16.78
8	2.97	0.33	1.95	2.97	12.82		2.03	1.02	1.81		25.90
4	1.94	0.24	1.88	1.29	3.45	0.01	0.21	0.93	0.75	0.04	10.74
2	0.78	0.21	1.04	1.00	0.95		0.10	0.40	0.40	0.08	4.94
Total	6.45	0.78	8.39	6.31	28.28	0.01	3.76	3.58	12.01	0.12	69.69

Sample No. 14 *Distance from source = 681.4* *Sample weight = 90.797*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.70				3.40						4.10
32	1.70	0.10	1.00	0.35	9.94	0.25	0.25		0.10		13.69
16	1.65	0.05	1.65	1.30	15.49	0.35	1.15		0.02	0.02	21.68
8	2.13	0.21	2.16	3.09	10.23	0.38	0.70	-1.00	0.11	0.02	19.03
4	1.21	0.15	1.55	1.81	3.38	0.16	0.28	0.03	0.10	0.06	8.73
2	1.15	0.29	1.12	0.98	1.13	0.02	0.15	0.06	0.14	0.09	5.13
Total	8.54	0.80	7.48	7.53	43.57	1.16	2.53	0.09	0.47	0.19	72.36

Sample No. 15 *Distance from source = 747.8* *Sample weight = 96.168*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					2.69						2.69
32	2.26	0.38	0.75	0.52	6.79		0.80	0.09			11.60
16	2.78	0.09	1.56	1.04	20.42	0.24	1.98	0.14	0.24		28.49
8	2.71	0.27	1.25	1.70	10.87	0.38	1.39	0.12	0.12	0.01	18.82
4	1.44	0.19	1.76	1.22	2.84	0.21	0.17	0.08	0.17	0.01	8.09
2	0.94	0.27	0.83	0.83	0.57	0.02	0.07	0.17	0.18	0.01	3.89
Total	10.13	1.20	6.15	5.31	44.18	0.85	4.41	0.60	0.71	0.03	73.58

TABLE 5 (continued)

Bow-south Saskatchewan (continued)

Sample No. 16 *Distance from source = 805.3* *Sample weight = 85.586*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.38				1.27						3.66
32	2.54		1.43		9.86		0.74	0.05			14.63
16	3.02	0.21	2.33	0.64	17.33	0.11	1.06	0.05	0.11	0.11	24.96
8	2.84	0.35	1.91	2.56	13.20	0.28	1.07	-1.00	0.10	0.01	22.31
4	3.06	0.48	2.23	1.54	4.23	0.14	0.08	0.04	0.09	0.02	11.91
2	2.28	0.53	1.80	0.92	0.57	0.10	0.05	0.04	0.12	0.03	6.44
Total	16.12	1.57	9.70	5.66	46.46	0.63	3.00	0.18	0.42	0.17	83.91

Sample No. 17 *Distance from source = 899.6* *Sample weight = 118.071*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	3.61				3.34						6.95
32	8.11		3.42	0.31	8.22		0.85		0.12		21.01
16	3.84	0.02	4.46	0.73	11.14	0.27	2.00	0.02	0.31	0.02	22.80
8	2.42	0.22	2.24	0.98	5.43	0.17	0.54	0.02	0.59	-1.00	12.60
4	1.57	0.20	1.76	0.56	1.70	0.22	0.10	0.02	0.35	-1.00	6.48
2	1.56	0.26	1.43	0.44	0.44	0.14	0.05	0.05	0.31	-1.00	4.68
Total	21.11	0.70	13.31	3.02	30.27	0.80	3.54	0.11	1.68	0.02	74.52

Sample No. 18 *Distance from source = 941.1* *Sample weight = 102.208*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32	0.49		0.44	2.17							3.11
16	4.04	0.18	1.82	0.98	13.98	0.04	1.11		0.09		22.23
8	4.12	0.53	3.30	3.21	12.04	0.11	0.87	0.01	0.21	0.01	24.41
4	3.06	0.48	2.69	1.33	3.74	0.12	0.29	0.02	0.32	0.02	12.07
2	2.65	0.70	2.43	0.80	0.86	0.16	0.21	0.11	0.44	0.01	8.37
Total	14.36	1.89	10.68	8.49	30.62	0.43	2.48	0.14	1.06	0.04	70.19

Sample No. 1 *Distance from source = 343.1* *Sample weight = 142.564*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.73				10.37						11.10
32	1.65		0.67	0.22	24.15		0.16				26.85
16	2.16	0.10	1.34	0.29	15.43		0.16		0.13	0.06	19.66
8	2.67	0.25	1.88	0.73	5.82		0.32	0.10	0.27	0.02	12.06
4	1.94	0.30	1.05	0.51	2.17		0.07	0.02	0.15	0.03	6.24
2	1.66	0.36	0.66	0.39	1.21		0.06	0.03	0.06	0.04	4.47
Total	10.81	1.01	5.60	2.14	59.15		0.77	0.15	0.61	0.15	80.38

Sample No. 2 *Distance from source = 365.5* *Sample weight = 96.642*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					0.56						0.56
32	0.89		0.66		4.46		0.09				6.10
16	4.74	0.14	2.02	0.33	18.31		0.19	0.02	0.38		26.12
8	4.96	0.32	2.97	0.64	10.87	0.03	0.26	0.04	0.49	0.01	10.60
4	4.04	0.33	1.64	0.83	3.44	0.02	0.01	-1.00	0.21	0.02	10.54
2	3.71	0.54	0.76	0.56	1.49		0.05	0.07	0.20	0.06	7.44
Total	18.34	1.33	8.05	2.36	39.13	0.05	0.60	0.13	1.28	0.09	71.36

Sample No. 3 *Distance from source = 509.2* *Sample weight = 144.290*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					2.14						2.14
64	4.59		1.16		19.24		1.19				26.19
32	5.06	0.13	3.52	0.16	16.28		0.50		0.30		25.95
16	3.77	0.06	2.99	0.25	5.60	0.06	0.22	0.03	0.85		13.83
8	2.63	0.24	2.33	0.30	2.47		0.16	0.01	0.22		8.36
4	0.98	0.11	0.65	0.19	0.61		0.01	0.01	0.10	0.02	2.68
2	0.97	0.14	0.49	0.19	0.46		0.02	0.01	0.08	0.04	2.40
Total	18.00	0.68	11.14	1.09	46.80	0.06	2.10	0.06	1.55	0.06	81.55

TABLE 5 (continued)

Little Smoky (continued)

Sample No. 4 — *Distance from source = 542.3* — *Sample weight = 173.915*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					5.58						5.58
64	4.75		0.86		23.16		4.93				33.70
32	2.24		0.95		11.45		1.25		0.05	0.08	16.00
16	3.29	0.13	1.88	0.16	6.23		0.52	0.13	0.63	0.03	12.99
8	2.65	0.18	1.66	0.39	2.72		0.20	0.06	0.49	0.01	8.35
4	1.78	0.14	0.93	0.30	1.06	0.01	0.03	0.01	0.38	-1.00	4.64
2	1.56	0.29	0.73	0.32	0.55		0.06	0.01	0.22	0.02	3.76
Total	16.27	0.74	7.01	1.17	50.75	0.01	6.99	0.21	1.77	0.14	85.02

Sample No. 5 — *Distance from source = 559.2* — *Sample weight = 188.178*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	2.24				2.17						4.41
64	6.12	0.41	2.84		24.59		0.77		1.28		36.01
32	2.99		1.04	0.04	11.09		0.84		1.78		17.78
16	2.63	0.02	2.15	0.22	5.62		0.43		1.01	0.01	12.09
8	2.39	0.23	2.16	0.25	2.34	0.01	0.20	0.07	0.27		7.93
4	1.11	0.12	0.91	0.16	0.62	-1.00	0.05	0.03	0.15	0.01	3.16
2	0.91	0.18	0.60	0.22	0.37		0.05	0.02	0.13	-1.00	2.48
Total	18.39	0.96	9.70	0.89	46.80	0.01	2.34	0.12	4.62	0.02	83.86

Sample No. 6 — *Distance from source = 602.7* — *Sample weight = 191.589*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					1.94						1.94
64	12.43		0.64		21.73						34.80
32	4.07	0.02	1.49		16.00		0.52	0.17	0.17		22.44
16	3.60	0.17	1.42	0.26	9.23		0.14		0.21	0.02	15.06
8	1.88	0.21	1.04	0.32	2.55		0.09	0.01	0.11		6.20
4	1.03	0.13	0.50	0.28	0.83	0.01	0.03	0.01	0.04	0.01	2.87
2	1.05	0.21	0.52	0.26	0.40		0.03	0.01	0.05	0.01	2.54
Total	24.06	0.74	5.61	1.12	52.68	0.01	0.81	0.20	0.58	0.04	85.85

Sample No. 7 *Distance from source = 602.8* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.40		0.48		5.25		0.31				6.44
32	1.90	0.09	1.01		12.63		1.30	0.05			16.98
16	2.40	0.20	1.52	0.22	15.81	0.04	0.78		1.82		22.79
8	4.48	0.60	2.29	0.66	4.11		0.18	0.01	0.91	0.04	13.28
4	2.59	0.28	1.25	0.45	1.62	0.01	0.04	0.02	0.37	0.01	6.64
2	1.07	0.25	0.86	0.38	0.51		0.97	1.22	0.28	0.06	5.60
Total	12.84	1.42	7.41	1.71	39.93	0.05	3.58	1.30	3.38	0.11	71.73

Mcleod

Sample No. 1 *Distance from source = 16.1* *Sample weight = 296.423*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
256			20.44								20.44
128			20.31		19.94		13.27				53.51
64			2.86		1.55		8.03				12.44
32			1.84	0.05			1.70				3.58
16			1.70	0.11	0.14		1.01	0.08	0.03	0.02	3.08
8		-1.00	0.85	0.10	0.16		0.41	-1.00		0.02	1.55
4			0.90	0.02	0.06		0.06		0.01	0.04	1.09
2	-1.00	-1.00	0.46	0.06	0.09		0.31	0.06	0.01	0.05	1.04
Total			49.36	0.34	21.94		24.79	0.14	0.05	0.13	96.73

Sample No. 2 *Distance from source = 89.5* *Sample weight = 168.323*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			2.56		8.65		10.89				22.10
64			0.46		21.96		6.12				28.54
32			3.10	0.16	10.43	0.03	4.12		0.16		18.00
16			5.09	0.46	6.82	0.01	2.37	0.01	0.03	0.01	14.81
8		0.03	2.01	0.58	2.12	0.02	1.42	0.02	0.02	-1.00	6.23
4	0.01	0.04	0.86	0.43	0.98	0.01	0.48	0.01	0.01	0.01	2.84
2	0.01	0.06	0.18	0.32	0.26	0.01	0.25	0.02	-1.00	0.02	1.13
Total	0.02	0.13	14.26	1.95	51.22	0.08	25.65	0.06	0.22	0.04	93.65

McLeod (continued)

Sample No. 3 *Distance from source = 135.7* *Sample weight = 62.761*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					18.44		2.57				21.01
64					27.43		0.49				27.92
32			0.72	0.05	15.85	0.05	0.86				17.53
16		0.02	1.68	0.35	11.28	0.02	0.28	0.01			13.65
8		0.01	1.45	0.69	4.09	0.06	0.71	0.01		-1.00	7.03
4	0.02	0.05	0.43	0.53	1.98	0.05	0.13	0.01	-1.00		3.20
2	0.02	0.13	0.26	0.79	0.97	0.04	0.25	0.01	-1.00		2.47
Total	0.04	0.21	4.54	2.41	80.04	0.22	5.29	0.04			92.81

Sample No. 4 *Distance from source = 135.8* *Sample weight = 194.305*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					6.36						6.36
32			0.72	0.51	23.20		2.75				27.18
16			2.60	1.81	30.50	0.04	1.45	0.07			36.46
8		0.03	2.29	1.23	8.85	0.05	1.12	0.02		-1.00	13.59
4	0.04	0.04	0.35	0.52	1.45	0.02	0.20	0.01		-1.00	2.63
2	0.01	0.05	0.03	0.34	0.29	0.01	0.10	0.01	-1.00	0.01	0.85
Total	0.05	0.12	5.99	4.41	70.65	0.12	5.62	0.11		0.01	87.07

Sample No. 5 *Distance from source = 156.7* *Sample weight = 85.305*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
64					3.46						3.46
32			0.80		15.26	0.05	0.27				16.38
16			2.55	0.58	33.77	0.21	2.77				39.88
8	0.06	0.22	2.13	1.65	13.29	0.14	1.70				19.20
4	-1.00	0.12	0.62	1.03	2.56	0.04	0.32	-1.00		-1.00	4.69
2	-1.00	0.04	0.15	0.70	0.94	0.01	0.18	0.01	-1.00		2.03
Total	0.06	0.38	6.25	3.96	69.28	0.45	5.24	0.01			85.64

Sample No. 6 *Distance from source = 229.0* *Sample weight = 531.672*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
256							31.20				31.20
128					12.37		17.67				30.04
64					15.29		4.69				19.98
32	0.03		0.12		4.27		0.88				5.29
16	0.02		0.47	0.03	2.05	0.01	1.06	0.10	0.01		3.74
8	0.03	0.03	0.42	0.15	1.31	-1.00	0.30	0.17		0.01	2.42
4	0.03	0.01	0.17	0.11	0.30	-1.00	0.16	0.15	-1.00	0.01	0.94
2	0.02	0.02	0.04	0.08	0.16		0.08	0.17	-1.00	0.01	0.58
Total	0.13	0.06	1.22	0.37	35.75	0.01	56.04	0.59	0.01	0.03	94.19

Sample No. 7 *Distance from source = 258.8* *Sample weight = 133.050*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
64					19.33		0.48				19.81
32			3.99	0.17	17.97		1.02				23.15
16	0.10	0.07	7.33	0.75	13.50	0.02	0.41	0.14		0.02	22.33
8	0.09	0.11	6.36	0.70	4.00	0.04	0.67	0.27	-1.00	0.03	12.27
4	0.06	0.04	1.65	0.77	1.13	-1.00	0.27	0.34	-1.00	0.03	4.29
2	0.06	0.08	0.53	0.39	0.32		0.13	0.21	-1.00	0.06	1.78
Total	0.31	0.30	19.86	2.78	56.25	0.06	2.98	0.96		0.14	83.63

Sample No. 8 *Distance from source = 272.1* *Sample weight = 180.385*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					2.74						2.74
64					35.76		1.91				37.67
32	0.05		2.04	0.10	13.70		0.38				16.27
16	0.13		4.30	0.53	9.35		0.33	0.05			14.69
8	0.10	0.21	4.22	1.31	5.87	0.02	0.49	0.69		0.01	12.93
4	0.07	0.04	1.06	0.74	1.12	0.01	0.15	0.47		0.01	3.67
2	0.02	0.04	0.31	0.44	0.30		0.12	0.47	-1.00	0.01	1.71
Total	0.37	0.29	11.93	3.12	68.84	0.03	3.38	1.68		0.03	89.68

TABLE 5 (continued)

McLeod (continued)

Sample No. 9 *Distance from source = 303.8* *Sample weight = 122.680*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.92		0.33		5.07		0.59				8.91
32	0.59		0.52	0.07	14.05		0.26	0.30			15.74
16	2.00	0.07	1.70	0.85	19.37	0.02	0.81	0.18	0.04		25.05
8	1.84	0.59	5.69	1.63	8.82	0.04	1.17	0.17	0.01	0.04	20.00
4	0.68	0.14	1.14	0.67	1.28	0.01	0.18	0.08	0.04	0.01	4.23
2	0.44	0.10	0.55	0.35	0.65		0.15	0.05	0.04	0.08	2.41
Total	8.47	0.90	9.93	3.57	49.24	0.07	3.16	0.78	0.13	0.13	76.34

Sample No. 10 *Distance from source = 379.6* *Sample weight = 181.190*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	3.76				7.34						11.09
64	0.30				31.99		0.30				32.59
32	0.35				16.92		0.08		0.40		17.75
16	0.30	0.03	0.55	0.40	12.97	0.08	0.25		0.28	0.03	14.87
8	0.37	0.16	0.56	1.69	7.14		0.51	0.08	0.03	0.02	10.56
4	0.16	0.01	0.21	0.47	1.16	0.01	0.08	0.31	-1.00	0.06	2.47
2	0.09	0.02	0.08	0.38	0.26		0.06	0.51	-1.00	0.04	1.44
Total	5.33	0.22	1.40	2.94	77.78	0.09	1.28	0.90	0.71	0.15	90.77

Milk

Sample No. 1 *Distance from source = 127.6* *Sample weight = 124.404*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					5.00						5.00
64	6.27		3.72		6.71						16.70
32	8.13	0.07	6.71		7.26	1.24	1.31				24.72
16	4.52		7.88	0.44	5.65	0.33	1.09		0.02		19.93
8	2.91	0.13	4.02	0.47	1.78	0.01	0.49	0.06	0.05	-1.00	9.92
4	1.15	0.12	1.83	0.10	0.52	0.16	0.10	-1.00	0.06	-1.00	4.04
2	1.22	0.24	1.37	0.10	0.20	0.07	0.06	0.01	0.06	-1.00	3.33
Total	24.20	0.56	25.53	1.11	27.12	1.81	3.05	0.07	0.19		83.64

Sample No. 2 *Distance from source = 155.0* *Sample weight = 78.519*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.64										0.64
32	1.39		0.58	0.12	3.58		0.87	0.06	0.06		6.59
16	3.99	0.06	5.43	0.52	9.82	0.06	3.18		0.46		23.51
8	5.32	0.27	6.20	1.29	6.67	0.03	2.38	0.13	0.04	0.01	22.36
4	4.48	0.33	5.36	0.61	1.69	0.06	0.93	0.02	0.07	0.01	13.56
2	5.28	0.78	3.58	0.62	1.08	0.03	0.42	0.02	0.22		12.03
Total	21.10	1.44	21.15	3.16	22.84	0.18	7.78	0.17	0.85	0.02	78.69

Sample No. 3 *Distance from source = 196.2* *Sample weight = 61.899*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
16	1.69		0.88	0.22	10.11	0.04	1.32	0.22	0.07		14.55
8	3.18	0.26	3.08	1.45	13.43	0.07	1.39	0.20	0.02		23.08
4	2.79	0.21	4.23	0.68	4.86	0.04	0.46	0.03	0.03	-1.00	13.33
2	4.51	0.87	3.41	0.50	2.63	0.02		0.40	0.02	0.01	12.37
Total	12.17	1.34	11.60	2.85	31.03	0.17	3.17	0.85	0.14	0.01	63.33

Sample No. 4 *Distance from source = 213.7* *Sample weight = 121.388*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	7.92		2.69		5.61		1.61				17.82
32	3.96		2.47		4.19		1.46				12.07
16	3.33	0.02	4.45	0.22	5.49	0.07	1.76	0.15	0.15	0.02	15.66
8	2.12	0.22	3.22	0.81	3.45		1.61	0.13	0.09	0.01	11.66
4	1.48	0.06	2.13	0.62	1.62	0.02	0.44	0.02	0.07	0.03	6.49
2	1.48	0.29	1.16	0.25	0.83	0.01	0.34	0.04	0.04		4.44
Total	20.29	0.59	16.12	1.90	21.19	0.10	7.22	0.34	0.35	0.06	68.14

TABLE 5 (continued)

Milk (continued)

Sample No. 5 *Distance from source = 261.7* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
32					0.62						0.62
16	1.31	0.11	0.96	0.61	8.85		1.15				12.99
8	1.50	0.09	1.70	0.67	9.00	0.02	0.80	0.04	0.06	0.02	13.90
4	1.74	0.18	0.62	0.91	3.98	0.01	0.31	0.01	0.03	0.02	7.81
2	4.31	0.67	1.08	1.99	1.98	0.01	0.43		0.02	0.09	10.58
Total	8.86	1.05	4.36	4.18	24.43	0.04	2.69	0.05	0.11	0.13	45.90

North Milk

Sample No. 1 *Distance from source = 38.3* *Sample weight = 112.109*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					16.06						16.06
64			2.31		12.62		6.35				21.28
32	0.40		8.17		8.21	0.16	4.17				21.12
16	0.28		7.12	0.04	4.37	0.69	3.64	0.61			16.75
8	0.13	0.01	5.02	0.01	1.97	0.27	1.41	0.29			9.10
4	0.08	0.01	2.34	0.02	0.67	0.08	0.48	0.20	0.02	-1.00	3.90
2	0.18	0.03	1.61	0.01	0.42	0.04	0.30	0.09	0.01		2.69
Total	1.07	0.05	26.57	0.08	44.32	1.24	16.35	1.19	0.03		90.90

Sample No. 2 *Distance from source = 71.3* *Sample weight = 129.903*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					8.14						8.14
64	0.73		1.40		21.27		0.63				24.02
32	0.71		6.29		5.59	2.65	1.05				16.27
16	0.35		6.56	0.17	4.96	1.59	1.08	0.04			14.74
8	0.63	0.07	5.55	0.12	2.30	0.13	0.63	0.08	0.02		9.53
4	0.67	0.10	3.47	0.10	0.99	0.17	0.25	0.02	0.03		5.80
2	1.04	0.35	2.75	0.14	1.17	0.12	0.29	0.03	0.04		5.93
Total	4.13	0.52	26.02	0.53	44.42	4.66	3.93	0.17	0.09		84.43

North Milk (continued)

Sample No. 3 — *Distance from source = 119.4* — *Sample weight = 127.549*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					1.24						1.24
32	1.74		1.63	0.04	5.69		1.14				10.24
16	1.07	0.04	3.34	0.28	9.78	0.11	1.07	0.02			15.70
8	2.47	0.24	4.73	0.76	6.18	0.13	1.36	0.38	0.01		16.25
4	2.89	0.30	3.37	0.55	2.33		0.50	0.52	0.01		10.47
2	3.51	0.75	2.63	0.65	1.34	0.02	0.30	0.31	0.02		9.53
Total	11.68	1.33	15.70	2.28	26.56	0.26	4.37	1.23	0.04		63.43

North Saskatchewan

Sample No. 1 — *Distance from source = 29.6* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32			11.51	0.03	0.10						11.64
16			18.80	0.06	0.13						18.99
8		0.02	14.27	0.20	0.36						14.85
4			5.98	0.04	0.04						6.06
2			5.14	0.11	0.08		0.05				5.38
Total		0.02	55.70	0.44	0.71		0.05				56.92

Sample No. 2 — *Distance from source = 124.2* — *Sample weight = 183.676*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					2.57						2.57
64			12.05		19.63		0.86				32.55
32			21.04		8.64		0.78				30.45
16			10.84	0.15	2.72		0.32				14.03
8			3.66	0.21	0.83		0.14			-1.00	4.82
4		0.03	2.08	0.09	0.43		0.03	-1.00		-1.00	2.66
2		0.03	1.04	0.13	0.27		0.10	-1.00	-1.00		1.57
Total		0.06	50.71	0.58	35.09		2.23				88.65

TABLE 5 (continued)

North Saskatchewan (continued)

Sample No. 3 *Distance from source = 178.0* *Sample weight = 286.005*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					13.21		22.25				35.46
64			7.45		4.17		12.53				24.15
32			6.31	0.29	4.01		4.77	0.06	0.16		15.61
16			4.85	0.32	2.00		1.16	0.05	0.11	0.01	8.49
8		-1.00	2.78	0.25	0.70		0.54	0.26	0.04	0.01	4.58
4		-1.00	1.76	0.16	0.27	-1.00	0.24	0.15	0.04	0.01	2.63
2		0.02	1.15	0.27	0.31		0.54	0.28	0.04	0.03	2.64
Total		0.02	24.30	1.29	24.67		42.03	0.80	0.39	0.06	93.56

Sample No. 4 *Distance from source = 229.5* *Sample weight = 392.268*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			1.18		42.88		8.20				52.26
64			0.06		8.65		2.64				11.89
32			2.21	0.15	3.60		1.60		0.19		7.74
16			4.37	0.08	1.87		0.38		0.37		7.08
8			3.82	0.16	0.88		0.23	0.01	0.03		5.13
4		0.01	2.42	0.21	0.80	-1.00	0.07		0.08	-1.00	3.59
2		0.01	1.16	0.40	0.55		0.15		0.08	0.01	2.36
Total		0.02	15.76	1.00	59.23		13.27	0.01	0.75	0.01	90.05

Sample No. 5 *Distance from source = 262.3* *Sample weight = 128.188*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					12.31						12.31
64				0.67	21.16		2.41			2.58	26.82
32			2.02	0.25	9.73		2.23				14.22
16			6.37	0.42	8.42		1.49	0.02		0.04	16.76
8	0.01	-1.00	4.98	0.86	3.52		0.53	0.01		0.04	9.94
4	-1.00	0.02	2.31	0.70	1.62	-1.00	0.14	0.02	0.01	0.03	4.85
2	-1.00	0.03	1.38	1.28	1.20		0.65	0.09	-1.00	0.04	4.67
Total	0.01	0.05	17.06	4.18	57.96		7.45	0.14	0.01	2.73	89.57

Sample No. 6 *Distance from source = 334.1* *Sample weight = 186.136*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					7.51						7.51
64	2.36		1.36		26.61						30.34
32	0.34		1.63		14.55		0.27				16.79
16	0.12		3.29	0.29	11.11	0.01	0.61			-1.00	15.44
8	0.26	0.16	2.65	1.09	5.20		0.63		-1.00		9.99
4	0.22	0.05	1.13	0.80	2.00	0.01	0.08		-1.00	-1.00	4.29
2	0.19	0.03	0.43	0.85	1.09		0.33	-1.00	0.01		2.93
Total	3.49	0.24	10.49	3.03	68.07	0.02	1.92		0.01		87.29

Sample No. 7 *Distance from source = 391.7* *Sample weight = 189.602*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					9.62						9.62
64	1.17				29.55		0.48				31.20
32	0.55		0.53		15.05		0.43		0.02		16.58
16	0.38	0.01	1.32	0.38	14.69	0.01	0.36				17.15
8	0.40	0.13	0.91	1.01	6.08		0.51				9.04
4	0.18	0.02	0.41	0.56	1.59	0.01	0.09				2.86
2	0.12	0.04	0.13	0.46	0.34		0.14	0.01	-1.00	-1.00	1.24
Total	2.80	0.20	3.30	2.41	76.92	0.02	2.01	0.01	0.02		87.69

Sample No. 8 *Distance from source = 420.2* *Sample weight = 162.833*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					3.96						3.96
64	0.31				24.93		0.22				25.46
32	1.53		0.17	0.06	27.33		0.33				29.42
16	0.33	0.01	0.81	0.31	13.54		0.31				15.31
8	0.32	0.06	0.41	0.97	5.16		0.23	0.01			7.16
4	0.08	0.02	0.14	0.40	0.85		0.03	0.01		0.01	1.54
2	0.02	0.01	0.09	0.13	0.16		0.01	0.01	-1.00	-1.00	0.43
Total	2.59	0.10	1.62	1.87	75.93		1.13	0.03		0.01	83.28

TABLE 5 (continued)

North Saskatchewan (continued)

Sample No. 9 *Distance from source = 420.8* *Sample weight = 120.879*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					12.57		0.49				13.06
32	1.13		0.04		20.38		0.11				21.65
16	0.64	0.04	0.49	0.64	25.44	0.04	0.64			0.02	27.94
8	0.47	0.18	0.30	1.94	10.56		0.44			0.02	13.92
4	0.13	0.03	0.09	0.62	1.00		0.06	0.05	-1.00	0.02	2.00
2	0.05	0.04	0.03	0.31	0.15		0.03	0.08	-1.00	0.02	0.71
Total	2.42	0.29	0.95	3.51	70.10	0.04	1.77	0.13		0.08	79.28

Sample No. 10 *Distance from source = 466.4* *Sample weight = 92.193*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					7.18						7.18
32	0.20				30.16	0.10	0.05				30.50
16	1.23	0.02	0.39	0.74	32.92		0.39		0.10	0.01	35.80
8	0.65	0.16	0.39	1.37	10.00	0.01	0.39	0.02	0.10	-1.00	13.09
4	0.13	0.04	0.15	0.48	1.09		0.04	0.02		0.02	1.97
2	0.02	0.01	0.01	0.04	0.01		-1.00	-1.00	-1.00	0.03	0.12
Total	2.23	0.23	0.94	2.63	81.36	0.11	0.87	0.04	0.20	0.06	88.66

Sample No. 11 *Distance from source = 469.0* *Sample weight = 109.796*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					10.12						10.12
32	0.25				14.58		0.17				15.00
16	0.74	0.04	0.41	0.78	37.76	0.04	0.45		0.12	0.02	40.38
8	0.31	0.09	0.22	1.36	8.48	-1.00	0.26	0.02		-1.00	10.74
4	0.08	0.01	0.03	0.29	0.87		0.01	0.01	0.01	0.03	1.34
2	0.06	0.02	0.03	0.13	0.14		0.03	0.03	-1.00	0.16	0.60
Total	1.44	0.16	0.69	2.56	71.95	0.04	0.92	0.06	0.13	0.21	78.18

Sample No. 12 *Distance from source = 505.0* *Sample weight = 62.890*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					5.27						5.27
32	0.15				13.20		0.07				13.42
16	0.87	0.04	0.07	1.08	33.90		0.50	0.04	0.07	0.04	36.60
8	0.92	0.46	0.28	2.33	17.29		0.62	0.12	0.19	0.01	22.21
4	0.68	0.11	0.33	1.31	3.39	0.03	0.18	0.08	0.07	0.03	6.21
2	0.35	0.08	0.09	1.00	0.43		0.11	0.07	0.06	0.03	2.22
Total	2.97	0.69	0.77	5.72	73.48	0.03	1.48	0.31	0.39	0.11	85.93

Sample No. 13 *Distance from source = 505.8* *Sample weight = 127.899*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					2.41						2.41
64	0.53				14.68		0.92		0.74		16.88
32	1.28				22.34		0.18		0.96		24.75
16	0.50		0.39	0.39	15.42		0.39	0.02	3.12		20.23
8	0.45	0.14	0.40	1.12	9.38		0.43	0.11	1.54	0.04	13.26
4	0.52	0.10	0.20	0.92	2.44	-1.00	0.07	0.15	0.42	0.01	4.83
2	0.38	0.14	0.17	0.91	0.57		0.05	0.22	0.21	0.07	2.72
Total	3.66	0.38	1.16	3.34	67.24		2.04	0.50	6.99	0.12	85.44

Sample No. 14 *Distance from source = 532.2* *Sample weight = 96.931*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					1.87						1.87
32	1.64			0.23	20.31		0.19				22.37
16	0.80	0.02	0.28	0.23	25.83		0.47		0.66	0.02	28.31
8	1.05	0.22	0.31	1.73	12.80	0.03	0.31	0.02	0.91	0.02	17.41
4	1.04	0.13	0.35	1.03	2.78	0.01	0.12	0.06	0.97	0.09	6.58
2	0.96	0.27	0.29	0.58	0.60		0.06	0.07	0.68	0.14	3.65
Total	5.49	0.64	1.23	3.80	64.19	0.04	1.15	0.15	3.22	0.27	80.19

TABLE 5 (continued)

North Saskatchewan (continued)

Sample No. 15 *Distance from source = 532.7* *Sample weight = 59.026*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32	1.46			0.08	14.75						16.29
16	1.46	0.15	0.23	0.85	35.12	0.04	0.69		0.23		38.77
8	0.69	0.15	0.28	1.78	12.90	0.03	0.33	0.02	0.17	0.02	16.37
4	0.77	0.14	0.22	0.71	1.58	-1.00	0.02	0.11	0.18	0.03	3.76
2	0.47	0.12	0.09	0.27	0.34		0.09	0.07	0.19	0.02	1.66
Total	4.85	0.56	0.82	3.69	64.69	0.07	1.13	0.20	0.77	0.07	76.85

Sample No. 16 *Distance from source = 566.8* *Sample weight = 124.806*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					0.51						0.51
32	1.27	0.07			7.92		0.40		0.18		9.85
16	1.67	0.04	0.11	0.62	26.57	0.04	0.29		0.98		30.31
8	2.22	0.17	0.36	1.45	16.10	0.04	0.19		1.22	0.02	21.77
4	1.82	0.24	0.39	0.57	2.65		0.04	0.03	1.16	0.02	6.92
2	1.61	0.73	0.50	0.63	0.44		0.07	0.09	1.34	0.04	5.45
Total	8.59	1.25	1.36	3.27	54.19	0.08	0.99	0.12	4.88	0.08	74.81

Sample No. 17 *Distance from source = 573.1* *Sample weight = 129.088*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.79				17.18						18.97
32	2.49			0.18	16.02	0.21	0.04		2.28		21.22
16	1.55	0.02	0.49	0.25	10.01		0.53		8.47	0.07	21.38
8	1.73	0.21	0.58	0.36	3.33		0.26	0.07	7.10	0.10	13.74
4	0.86	0.09	0.39	0.15	0.67		0.05	0.11	2.62	0.12	5.06
2	0.77	0.22	0.27	0.13	0.36		0.03	0.26	2.31	0.26	4.61
Total	9.19	0.54	1.73	1.07	47.57	0.21	0.91	0.44	22.78	0.55	84.98

Sample No. 18 — *Distance from source = 599.1* — *Sample weight = 138.474*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.92			0.40	15.00		0.49				16.80
32	0.49				12.84		0.03		1.13		14.48
16	1.05	0.03	0.23	0.33	15.43	0.02	0.20	0.03	3.34	0.03	20.69
8	1.41	0.10	0.32	1.07	7.91		0.16	0.25	1.61	0.03	12.84
4	1.36	0.23	0.28	0.63	2.17	-1.00	0.05	0.18	0.90	0.03	5.83
2	1.53	0.44	0.38	1.06	0.62		0.09	0.18	1.27	0.05	5.62
Total	6.76	0.80	1.21	3.49	53.97	0.02	1.02	0.64	8.25	0.14	76.26

Sample No. 19 — *Distance from source = 621.7* — *Sample weight = 133.491*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.37			0.44	9.99						10.81
32	1.09		0.10	0.55	14.68		0.03		0.44		16.89
16	0.78	0.03	0.14	0.82	17.40	0.02	0.31		1.26	0.03	20.78
8	0.92	0.24	0.29	2.58	11.36	0.01	0.28	0.05	1.49	0.01	17.23
4	0.92	0.21	0.19	2.07	2.75	0.01	0.12	0.04	1.77	0.02	8.10
2	1.05	0.36	0.16	1.51	0.87		0.09	0.05	2.44	0.04	6.57
Total	5.13	0.84	0.88	7.97	57.05	0.04	0.83	0.14	7.40	0.10	80.38

Sample No. 20 — *Distance from source = 659.5* — *Sample weight = 98.516*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	5.66				6.58						12.25
32	2.03		0.60	0.23	12.85		0.55		1.66		17.91
16	2.26	0.05	0.41	0.51	15.39	0.05	0.46		1.93	0.02	21.06
8	1.51	0.29	0.30	1.92	9.25	0.08	0.20	0.03	2.33	0.06	15.98
4	1.07	0.18	0.16	1.54	1.87		0.09	0.01	0.90	0.05	5.87
2	1.00	0.31	0.15	0.75	0.57		0.03	0.04	0.56	0.34	3.75
Total	13.53	0.83	1.62	4.95	46.51	0.13	1.33	0.08	7.38	0.47	76.82

TABLE 5 (continued)

North Saskatchewan (continued)

Sample No. 21 — *Distance from source = 687.2* — *Sample weight = 92.059*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.53		0.84		5.47		0.64				8.48
32	5.42		0.64		8.08	0.10	0.99		2.12		17.34
16	4.34	0.05	0.84	0.25	8.62		0.84	0.05	11.38	0.02	26.39
8	6.68	0.71	1.57	1.06	6.05		0.38	0.09	3.41	-1.00	19.96
4	3.29	0.34	0.76	0.52	1.54		0.11	0.01	1.95	0.01	8.53
2	1.31	0.31	0.23	0.35	0.58		0.02	0.04	1.30	0.06	4.20
Total	22.57	1.41	4.88	2.18	30.34	0.10	2.98	0.19	20.16	0.09	84.90

Sample No. 22 — *Distance from source = 725.0* — *Sample weight = 125.584*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	3.68				2.06						5.74
32	3.36		0.18	0.14	6.79		0.69		0.07		11.23
16	4.62	0.15	0.22	0.61	9.93		0.90	0.09	0.51	0.02	17.05
8	4.64	0.48	0.53	2.34	8.21	-1.00	0.40	0.28	0.57	0.01	17.45
4	2.46	0.32	0.30	1.14	2.11	-1.00	0.08	0.07	0.76	0.05	7.29
2	1.46	0.34	0.15	0.41	0.39		0.07	0.07	0.73	0.14	3.76
Total	20.22	1.29	1.38	4.64	20.49		2.14	0.51	2.64	0.22	62.52

Sample No. 23 — *Distance from source = 754.6* — *Sample weight = 116.093*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	4.10				3.59		1.68				9.38
32	3.48	0.12	0.31	0.12	3.71		3.36	0.39	0.08		11.57
16	4.06	0.35	0.91	0.31	5.55	0.12	1.84	0.51	0.47	0.08	14.18
8	4.11	0.42	0.94	1.89	5.84		1.41	0.50	1.13		16.25
4	2.18	0.41	0.40	0.90	1.54	0.01	0.40	0.34	0.98	0.03	7.19
2	1.83	0.53	0.28	0.61	0.40		0.39	0.39	1.01	0.03	5.47
Total	19.76	1.83	2.84	3.83	20.63	0.13	9.08	2.13	3.67	0.14	64.04

Sample No. 24 *Distance from source = 779.7* *Sample weight = 107.603*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.31				2.70						4.00
32	3.79	0.30		0.25	6.28		0.51				11.13
16	8.43	0.42	0.76	0.34	9.15	0.04	0.97		0.17		20.28
8	5.72	0.49	1.31	1.49	6.28	0.01	0.24	0.15	0.55		16.23
4	3.10	0.49	0.73	1.23	1.97		0.03	0.01	0.88		8.44
2	2.03	0.61	0.51	0.88	0.39		0.04	0.02	1.51	0.01	6.00
Total	24.38	2.31	3.31	4.19	26.77	0.05	1.79	0.18	3.11	0.01	66.08

Sample No. 25 *Distance from source = 815.6* *Sample weight = 125.264*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.63				2.68		0.62				4.92
32	3.62	0.07	0.07		3.44	0.11	2.28				9.60
16	7.35	0.29	0.76	0.25	5.50	0.07	2.75	0.14	0.44	0.07	17.82
8	7.04	0.74	1.30	1.93	6.09	-1.00	0.83	0.50	0.93	0.01	19.37
4	3.59	0.57	0.79	1.09	1.68	-1.00	0.20	0.13	1.20	0.05	9.30
2	3.01	0.67	0.33	0.90	0.80		0.21	0.02	1.19	0.08	7.21
Total	26.42	2.34	3.25	4.17	20.19	0.18	6.89	0.79	3.76	0.21	68.22

Sample No. 26 *Distance from source = 836.7* *Sample weight = 147.955*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	6.32				3.44		0.31				10.06
32	7.79	0.03	1.96		4.63		1.44	0.43		0.06	16.34
16	7.11	0.25	0.77	0.18	5.06	0.03	2.27	0.61	0.34	0.03	16.65
8	4.02	0.25	0.95	0.72	3.95	0.01	0.26	0.21	0.53	0.10	11.01
4	2.23	0.37	0.49	0.85	1.50	-1.00	0.06	0.04	0.40	0.03	5.97
2	2.82	0.82	0.38	0.77	0.82	-1.00	0.38	0.48	0.57	0.04	7.08
Total	30.29	1.72	4.55	2.52	19.40	0.04	4.72	1.77	1.84	0.26	67.11

TABLE 5 (continued)

North Saskatchewan (continued)

Sample No. 27 *Distance from source = 855.5* *Sample weight = 124.691*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	8.00				7.93		0.76				16.70
32	11.50		0.87		7.06		2.95		0.07		22.45
16	9.06	0.33	1.05	0.33	5.57	0.02	2.33	0.33	0.04	0.11	19.15
8	5.09	0.69	1.48	1.11	3.62		0.28	0.57	0.06	0.01	12.91
4	2.74	0.54	0.71	0.68	1.30		0.03	0.05	0.09	0.02	6.16
2	2.44	0.66	0.32	0.53	0.56		0.10	0.08	0.16	0.11	4.96
Total	38.83	2.22	4.43	2.65	26.04	0.02	6.45	1.03	0.42	0.25	82.33

Sample No. 28 *Distance from source = 864.0* *Sample weight = 101.154*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32	2.47		0.72		2.73		0.13	0.27			6.32
16	9.10	0.54	1.30	0.31	8.25		1.08	0.31		0.04	20.94
8	8.24	0.87	1.84	1.36	5.34	-1.00	0.19	0.34	0.09	0.01	18.30
4	4.75	0.68	1.60	1.13	2.06	0.01	0.11	0.03	0.14	0.01	10.52
2	4.06	1.32	1.02	0.95	0.74		0.02	-1.00	0.33	0.07	8.51
Total	28.62	3.41	6.48	3.75	19.12	0.01	1.53	0.95	0.56	0.13	64.59

Sample No. 29 *Distance from source = 888.0* *Sample weight = 104.705*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64							0.95				0.95
32	4.55	0.04	0.13		3.08		1.60				9.40
16	10.22	0.43	1.39	0.30	4.85		1.91	0.82	0.13		20.06
8	7.88	0.75	2.15	1.22	5.28	0.02	0.29	0.64	0.12	-1.00	18.37
4	3.83	0.56	0.88	0.74	1.37	-1.00	0.04	0.01	0.11	0.01	7.55
2	2.58	0.65	0.47	0.50	0.47		0.06	0.04	0.16	0.01	4.94
Total	29.06	2.43	5.02	2.76	15.05	0.02	4.85	1.51	0.52	0.02	61.27

Sample No. 1 *Distance from source = 33.8* *Sample weight = 444.764*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
256							14.87				14.87
128			1.91			7.54	39.41				48.86
64			4.50	0.27			11.20				15.97
32			2.48	0.18			2.88		0.22		5.85
16			1.55	0.46	0.12	0.06	2.68	0.02	0.08		4.98
8			1.13	0.70	0.34	0.08	0.61	0.01		-1.00	2.87
4			0.71	0.46	0.18	0.05	0.18	-1.00	-1.00	-1.00	1.58
2			0.75	0.31	0.16	0.01	0.59	0.01	0.01	-1.00	1.84
Total			13.03	2.38	0.80	7.74	72.42	0.04	0.31		96.82

Sample No. 2 *Distance from source = 117.3* *Sample weight = 131.565*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128							2.62				2.62
64			3.10		5.10		6.07				14.27
32			5.72	0.55	3.31	2.21	3.55				15.34
16		0.03	6.45	1.65	5.52	1.83	4.34			0.02	19.84
8	0.05	0.01	4.68	1.87	4.30	0.62	2.19			0.01	13.72
4	0.02	-1.00	2.69	1.25	1.88	0.44	0.67		-1.00	0.03	6.98
2	0.03	0.01	2.59	1.30	1.21	0.20	0.80	0.21	-1.00	0.01	6.36
Total	0.10	0.05	25.23	6.62	21.32	5.30	20.24	0.21		0.07	79.13

Sample No. 3 *Distance from source = 192.0* *Sample weight = 191.583*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128							2.34				2.34
64	0.40		1.82	2.01	23.18	2.79	4.31				34.52
32			3.69	0.50	6.06	4.57	1.92		0.17		16.91
16	0.02		5.61	0.92	3.20	2.30	1.37				13.43
8	0.09	-1.00	5.03	1.24	2.27	0.76	0.95			0.01	10.35
4	0.04	0.01	3.05	0.89	1.85	0.53	0.37		0.01		6.75
2	0.07	0.05	2.02	1.37	0.96	0.24	0.71		0.01		5.43
Total	0.62	0.06	21.22	6.93	37.52	11.19	11.97		0.19	0.01	89.73

TABLE 5 (continued)

Oldman (continued)

Sample No. 4 *Distance from source = 194.2* *Sample weight = 124.066*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128							3.40				3.40
64			6.11	0.55	15.28		0.95				22.89
32			4.24	0.66	7.79	2.41	2.41				17.51
16	0.04		5.74	1.35	6.03	1.43	2.08				16.67
8	0.10	0.05	5.28	1.83	3.23	0.64	1.23				12.36
4	0.05	0.02	2.54	1.22	1.93	0.37	0.36		-1.00		6.49
2	0.03	0.04	1.46	1.71	1.70	0.16	0.34		-1.00		5.44
Total	0.22	0.11	25.37	7.32	35.96	5.01	10.77				84.76

Sample No. 5 *Distance from source = 293.9* *Sample weight = 114.352*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					3.81						3.81
64	3.41				11.86		1.39				16.66
32	1.47		4.05	0.79	15.55	0.71	2.58			0.04	25.19
16	0.95	0.02	4.32	0.95	11.54	0.92	1.67		0.02	0.16	20.55
8	0.49	0.09	2.89	1.15	4.84	0.39	0.67	0.01	0.01	0.02	10.55
4	0.52	0.05	2.06	0.72	2.06	0.18	0.09	0.01	0.02	0.05	5.76
2	0.42	0.09	0.77	0.70	0.80	0.07	0.16	0.01	0.02	0.04	3.08
Total	7.26	0.25	14.09	4.31	50.46	2.27	6.56	0.03	0.07	0.31	85.60

Sample No. 6 *Distance from source = 382.9* *Sample weight = 90.142*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.60										0.60
32	2.47		0.65	0.60	11.72	0.20	1.46		0.10		17.21
16	2.57	0.05	2.87	2.21	21.29	1.01	3.22		0.05		33.26
8	1.89	0.18	2.95	2.11	11.01	0.54	0.84	0.02	0.03	0.01	19.57
4	1.24	0.22	1.37	1.41	3.30	0.20	0.39	0.03	0.02	0.03	8.21
2	0.84	0.25	0.35	0.88	0.77	0.08	0.18	0.01	0.02	0.02	3.40
Total	9.61	0.70	8.19	7.21	48.09	2.03	6.09	0.06	0.22	0.06	82.25

Sample No. 7 *Distance from source = 449.2* *Sample weight = 134.632*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.29				12.94						15.23
32	1.01		0.98	0.30	11.72	0.34	1.52		0.27		16.14
16	1.35	0.10	1.35	0.98	11.52	1.01	1.68	0.07	0.71	0.03	18.80
8	1.23	0.19	2.42	1.74	7.66	0.89	0.54		0.31	0.01	14.99
4	0.56	0.08	1.12	0.56	1.65	0.45	0.12	0.01	0.08	0.01	4.64
2	0.50	0.18	0.53	0.43	0.68	0.12	0.13	0.01	0.08	0.02	2.68
Total	6.94	0.55	6.40	4.01	46.17	2.81	3.99	0.09	1.45	0.07	72.48

Sample No. 8 *Distance from source = 451.4* *Sample weight = 234.358*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	4.06		2.03		6.12						12.21
64	7.28		2.63	0.29	25.26		3.45		1.24		40.14
32	2.01		1.61	0.06	12.10	0.77	0.83		0.91		18.29
16	0.70	0.02	1.63	0.29	6.62	0.60	0.72	0.80	0.45		11.09
8	0.53	0.03	0.77	0.67	3.54	0.31	0.48	0.05	0.15		6.54
4	0.53	0.07	0.57	0.32	1.37	0.12	0.16	0.03	0.07		3.24
2	0.37	0.11	0.28	0.34	0.43	0.02	0.07	0.04	0.10		1.76
Total	15.48	0.23	9.52	1.97	55.44	1.82	5.71	0.20	2.92		93.27

Peace

Sample No. 1 *Distance from source = 816.4* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64			0.55		1.95		0.69				3.20
32	1.23	0.55	3.48	2.04	25.02	3.00	5.68				41.00
16	0.42	0.86	1.45	1.49	10.98	2.89	7.96		0.44		26.49
8					0.16		0.03			0.01	0.20
4							0.01	-1.00		0.02	0.03
2	0.02	0.01	0.01	0.02	0.02	-1.00	0.09	0.14	0.05	0.02	0.38
Total	1.67	1.42	5.49	3.55	38.14	5.89	14.46	0.14	0.49	0.05	71.30

TABLE 5 (continued)

Peace (continued)

Sample No. 2 — *Distance from source = 918.1* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					9.10						9.10
64	0.31			0.82	28.18		0.30				29.61
32	3.62	0.39	0.49	1.04	12.80	1.36	3.90				23.60
16	0.57	0.51	0.72	0.58	2.88	0.68	0.48		4.28		10.70
8	0.28	0.57	0.32	0.37	1.96	0.31	0.28		3.44		7.53
4	0.43	0.10	0.28	0.15	0.54	0.11	0.17	0.01	1.81	-1.00	3.60
2	0.39	0.09	0.14	0.16	0.21	0.09	0.10	0.08	1.53		2.79
Total	5.60	1.66	1.95	3.12	55.67	2.55	5.23	0.09	11.06		86.93

Sample No. 3 — *Distance from source = 918.7* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.05				14.05						16.10
32	3.63	0.88	0.38	3.00	28.19	1.37	0.87				38.32
16	2.37	1.01	0.76	4.39	9.82	1.78	1.89		0.20		22.22
8	0.09	0.50	0.06	0.63	1.60	0.29	0.30		0.11		3.58
4	0.08	0.03	0.03	0.09	0.18	0.06	0.03	-1.00	0.08	-1.00	0.58
2	0.05	0.02	0.02	0.04	0.03	0.01	0.02	-1.00	0.07	-1.00	0.26
Total	8.27	2.44	1.25	8.15	53.87	3.51	3.11		0.46		81.06

Sample No. 4 — *Distance from source = 944.3* — *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.21				5.89						6.10
32	5.08	0.27	0.28	0.32	12.26	1.18	2.19	0.02	1.18		22.78
16	1.65	0.41	0.54	0.64	7.15	1.58	1.61	0.03	8.79		22.40
8	1.43	1.74	0.77	1.85	6.57	1.75	0.20	-1.00	1.52		15.83
4	1.23	0.86	0.68	1.60	2.76	1.04	0.13	0.03	0.68		9.01
2	1.28	0.87	0.61	1.81	0.97	0.32	0.06	0.07	0.50		6.49
Total	10.88	4.15	2.88	6.22	35.60	5.87	4.19	0.15	12.67		82.61

Sample No. 5 *Distance from source = 1023.0* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64			0.06		24.84						24.90
32	0.80	0.30	0.32	1.01	18.24	1.57	1.38	0.09			23.71
16	1.21	0.70	0.68	1.35	7.92	2.68	1.82	0.10	0.44		16.90
8	0.65	0.89	0.22	1.48	6.20	1.19	0.17	0.02	0.26		11.08
4	0.42	0.37	0.16	1.00	2.42	0.50	0.07	-1.00	0.16		5.10
2	0.63	0.15	0.56	0.54	0.46	0.04	0.11	0.22	0.09	0.01	2.81
Total	3.71	2.41	2.00	5.38	60.08	5.98	3.55	0.43	0.95	0.01	84.50

Sample No. 6 *Distance from source = 1024.0* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	1.22				3.04		0.54				4.80
64	2.50		0.26		8.50		0.94				12.20
32	4.51	0.05	0.32	0.54	16.76	0.40	0.52				23.10
16	1.68	0.60	0.58	1.10	11.79	0.58	0.43		0.02		16.78
8	1.21	1.83	0.29	2.76	6.84	2.16	0.24		0.02		15.35
4	1.13	0.49	0.33	1.46	3.65	0.97	0.07	-1.00	0.17	-1.00	8.27
2	0.79	0.61	0.52	1.01	1.75	0.50	0.10	-1.00	0.02	-1.00	5.30
Total	13.04	3.58	2.30	6.87	52.33	4.61	2.84		0.23		85.80

Sample No. 7 *Distance from source = 1126.7* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	7.50										7.50
64	1.22				12.48		2.00				15.70
32	1.01	0.16	1.44	0.73	6.66	0.70	2.61	0.04	0.75		14.10
16	0.93	0.28	1.49	1.00	2.79	1.09	2.00	0.04	4.28		13.90
8	1.50	0.45	0.46	1.27	4.92	2.77	1.30	0.02	0.91	-1.00	13.60
4	1.89	0.32	0.84	0.83	2.26	1.75	0.29	0.01	0.31	-1.00	8.50
2	2.66	0.42	1.09	1.40	0.68	0.82	0.12	0.01	0.35		7.55
Total	16.71	1.63	5.32	5.23	29.79	7.13	8.32	0.12	6.60		80.85

TABLE 5 (continued)

Peace (continued)

Sample No. 8 *Distance from source = 1230.1* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.23				8.54						10.77
32	2.97	0.06	0.52	0.21	8.82	0.14		0.04			12.76
16	4.23	0.55	0.59	1.52	15.83	0.55	0.12	0.05	0.11		23.55
8	2.87	1.61	0.69	2.06	9.26	0.73	0.09	0.01	0.01		17.33
4	2.56	0.63	0.58	1.44	2.77	0.48	0.07	-1.00	0.03	-1.00	8.56
2	2.60	0.41	0.45	0.61	0.60	0.06	0.02	0.02	0.04	-1.00	4.81
Total	17.46	3.26	2.83	5.84	45.82	1.96	0.30	0.12	0.19		77.78

Sample No. 9 *Distance from source = 1332.5* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32					4.26				0.32		4.58
16	3.25	1.04	0.53	1.28	10.39	0.24	0.45	0.17	0.07		17.42
8	5.04	2.73	1.04	2.32	13.40	0.62	0.15	0.05	0.14	-1.00	25.49
4	4.03	0.73	0.90	1.65	4.70	0.35	0.08	0.02	0.21		12.67
2	3.48	0.32	1.03	0.79	1.02	0.05	0.03	0.11	0.21		7.04
Total	15.80	4.82	3.50	6.04	33.77	1.26	0.71	0.35	0.95		67.20

Red Deer

Sample No. 1 *Distance from source = 63.1* *Sample weight = 82.554*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64			5.88				3.19				9.07
32			15.93	0.49	5.00		2.25				23.68
16			19.23	0.60	3.85		1.70				25.38
8			9.01	0.62	1.52		1.55	0.04		-1.00	12.75
4			4.89	0.36	0.68		0.21	0.03	-1.00	0.02	6.19
2			3.68	0.21	0.76		0.20	0.18	0.01	-1.00	5.04
Total			58.62	2.28	11.81		9.10	0.25	0.01	0.02	82.11

Sample No. 2 *Distance from source = 91.4* *Sample weight = 374.083*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
256			17.70								17.70
128			3.72		9.87		13.07				26.66
64			13.10		3.75		4.87				21.72
32			7.02		1.99		1.37				10.38
16			6.04	0.07	0.96		0.90	0.01	0.01		7.98
8			3.58	0.08	0.39		0.47	0.03	-1.00		4.56
4		-1.00	2.77	0.07	0.20	-1.00	0.12	0.01	0.01		3.18
2		-1.00	1.89	0.14	0.32		0.15	0.05	0.01		2.56
Total			55.82	0.36	17.48		20.95	0.10	0.03		94.74

Sample No. 3 *Distance from source = 141.1* *Sample weight = 209.793*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			7.20		32.45						39.65
64			10.66		4.93		2.12				17.71
32			9.36	0.06	2.70		2.68		0.13		14.94
16			7.98	0.28	1.21		0.82	-1.00		-1.00	10.30
8			4.56	0.25	1.06		0.51	0.01	0.01	0.01	6.40
4		0.02	2.16	0.26	0.54		0.21		0.01	0.01	3.21
2			1.57	0.22	0.36		0.20	-1.00	0.02	-1.00	2.37
Total		0.02	43.49	1.07	43.25		6.54	0.01	0.17	0.02	94.58

Sample No. 4 *Distance from source = 158.8* *Sample weight = 195.119*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					22.13						22.13
64			3.81		18.27		1.00				23.08
32			8.02	0.09	6.65		0.65				15.41
16			8.62	0.33	3.84		0.81		0.07		13.67
8	-1.00	0.01	5.33	0.59	1.89		0.77		0.01		8.60
4		0.01	2.51	0.57	0.89	-1.00	0.55		0.01		4.54
2		0.01	1.58	0.94	1.03		0.23		0.05		3.84
Total		0.03	29.87	2.52	54.70		4.01		0.14		91.27

TABLE 5 (continued)

Red Deer (continued)

Sample No. 5 *Distance from source = 186.5* *Sample weight = 93.346*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
64			1.12		13.56		2.14				16.81
32			9.48	0.24	18.47		1.41				29.60
16	-1.00		16.47	1.17	13.31		2.48				33.44
8			5.24	1.01	5.71		0.96	0.01			12.93
4	-1.00	0.01	0.67	0.35	0.70		0.11				1.84
2		0.01	0.14	0.16	0.20		0.05		-1.00		0.56
Total		0.02	33.12	2.93	51.95		7.15	0.01			95.18

Sample No. 6 *Distance from source = 242.5* *Sample weight = 90.941*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.05				7.48						8.53
32	1.15		2.00	0.50	20.05		1.30				24.99
16	0.20		6.43	1.20	17.86		1.75		0.05		27.48
8	0.24	0.03	6.76	2.11	6.56		1.32	0.03			17.06
4	0.18	0.04	1.71	1.17	1.71	-1.00	0.57	0.02	-1.00	-1.00	5.40
2	0.20	0.09	0.70	0.74	0.91		0.10	0.01	-1.00		2.75
Total	3.02	0.16	17.60	5.72	54.57		5.04	0.06	0.05		86.21

Sample No. 7 *Distance from source = 253.3* *Sample weight = 94.614*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
64	0.96				8.15		0.38				9.49
32	0.14		2.16	0.34	25.31		1.53		0.10		29.58
16	0.29	0.02	5.99	1.39	21.91	0.02	1.53				31.16
8	0.17	0.05	4.08	1.60	5.92	0.01	0.59	0.04			12.46
4	0.08	0.03	0.97	0.62	1.35		0.11	0.02	0.01	-1.00	3.19
2	0.08	0.03	0.21	0.38	0.44		0.10	0.04	-1.00	-1.00	1.28
Total	1.72	0.13	13.41	4.33	63.08	0.03	4.24	0.10	0.11		87.16

Sample No. 8 *Distance from source = 284.0* *Sample weight = 84.518*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
64	1.50				20.72		0.43				22.65
32	0.59		1.18	0.81	27.75		1.45		0.27		32.04
16	0.59		4.29	1.34	20.13		1.29	0.16			27.80
8	0.32	0.03	1.90	0.79	5.38	0.06	0.53	0.04	0.01	-1.00	9.07
4	0.06	0.02	0.28	0.24	0.51		0.13	0.08	-1.00	-1.00	1.32
2	0.03	0.01	0.08	0.06	0.07		0.03	0.10	-1.00	0.01	0.39
Total	3.09	0.06	7.73	3.24	74.56	0.06	3.86	0.38	0.28	0.01	93.27

Sample No. 9 *Distance from source = 315.6* *Sample weight = 146.552*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					6.65						6.65
64	0.40		1.98		32.38		1.27				36.03
32	0.43		0.43		8.82		0.96				10.65
16	0.43		2.66	0.40	11.42		0.74		0.02		15.68
8	0.34	0.01	3.76	1.10	6.02		0.50	0.02	0.08		11.82
4	0.33	0.05	1.90	1.01	2.52	0.01	0.23	0.01	0.04	0.01	6.11
2	0.19	0.05	0.87	0.91	1.19		0.12	0.03	0.02	0.02	3.40
Total	2.12	0.11	11.60	3.42	69.00	0.01	3.82	0.06	0.16	0.03	90.34

Sample No. 10 *Distance from source = 316.4* *Sample weight = 209.442*

Size	Grnt	Qutz	Lmst	Chert	Qutze	Volc	Sndst	Shale	Irnst	Coal	Total
128					13.17						13.17
64	0.19		0.89		27.70		1.54				30.32
32	0.80		1.26	0.24	9.36		0.48		0.06		12.19
16	0.28		3.10	0.37	7.65		0.61		0.06	0.01	12.07
8	0.25	0.10	2.16	1.29	5.04		0.61		-1.00	0.01	9.46
4	0.19	0.04	1.32	1.02	1.54	0.02	0.20	-1.00	0.02	-1.00	4.35
2	0.22	0.10	0.65	0.77	1.12	0.01	0.08	-1.00	0.01	0.03	2.99
Total	1.93	0.24	9.38	3.69	65.58	0.03	3.52		0.15	0.05	84.55

TABLE 5 (continued)

Red Deer (continued)

Sample No. 11 *Distance from source = 365.3* *Sample weight = 128.898*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	3.13		0.42		23.19		0.56		0.42		27.73
32	1.06		0.21		14.50		0.88	0.07	0.70		17.42
16	1.02		1.37	0.39	12.95		0.56	0.28	2.15	0.07	18.79
8	0.81	0.16	1.54	1.53	7.84		0.27	0.63	0.72	0.04	13.55
4	0.51	0.05	0.86	1.32	2.09	-1.00	0.21	0.53	0.22	0.02	5.81
2	0.43	0.12	0.39	0.56	0.92		0.07	0.36	0.22	0.14	3.21
Total	6.95	0.33	4.79	3.80	61.49		2.55	1.87	4.43	0.27	86.51

Sample No. 12 *Distance from source = 409.1* *Sample weight = 103.380*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.59				4.30						6.89
32	1.32			0.35	19.96		0.61			0.18	22.42
16	1.84	0.02	0.79	0.75	19.57		0.61	0.13	0.97	0.39	25.08
8	1.64	0.06	0.96	1.78	7.23		0.40	0.53	0.53	0.17	13.29
4	1.16	0.13	0.77	1.27	2.00		0.11	0.30	0.51	0.13	6.38
2	1.05	0.48	0.63	0.52	0.97		0.07	0.55	0.73	0.40	5.40
Total	9.60	0.69	3.15	4.67	54.03		1.80	1.51	2.74	1.27	79.46

Sample No. 13 *Distance from source = 432.1* *Sample weight = 106.276*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	5.89				5.51						11.40
32	3.41		0.13	0.13	10.24		1.24		1.45		16.60
16	2.22		0.85	0.51	11.52	0.04	2.56	0.09	4.31	0.04	22.15
8	2.14	0.28	1.74	1.19	7.76	0.03	1.14	0.71	1.86	0.01	16.86
4	1.26	0.14	0.73	0.45	1.23	-1.00	0.44	0.39	1.42	0.06	6.12
2	0.91	0.30	0.50	0.16	0.47		0.23	0.70	1.83	0.06	5.16
Total	15.83	0.72	3.95	2.44	36.73	0.07	5.61	1.89	10.87	0.17	78.29

Red Deer (continued)

Sample No. 14 — *Distance from source = 438.5* — *Sample weight = 95.594*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					0.76		0.95				1.71
32	2.99	0.09	0.19	0.24	10.82		2.70		0.19		17.22
16	3.65	0.09	2.04	1.04	22.54	0.02	2.33	0.05	0.85	0.09	32.72
8	2.73	0.09	1.19	1.11	9.04		0.83	0.41	1.05	0.11	16.56
4	1.40	0.15	0.76	0.77	1.99		0.14	0.19	1.36	0.05	6.81
2	1.08	0.43	0.68	0.30	0.59		0.13	0.37	1.64	0.12	5.34
Total	11.85	0.85	4.86	3.46	45.74	0.02	7.08	1.02	5.09	0.37	80.36

Sample No. 15 — *Distance from source = 478.8* — *Sample weight = 87.473*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					3.37						3.37
32	4.10		0.41	0.10	11.36	0.31	2.28				18.56
16	5.29	0.10	2.13	0.31	11.77		3.01	0.10	3.27	0.10	26.08
8	2.85	0.15	2.68	0.78	5.38		1.00	0.24	4.24	0.31	17.63
4	1.12	0.10	1.23	0.30	0.91		0.29	0.38	2.66	0.21	7.20
2	0.62	0.21	0.71	0.21	0.30		0.30	0.40	1.28	0.25	4.28
Total	13.98	0.56	7.16	1.70	33.09	0.31	6.88	1.12	11.45	0.87	77.12

Sample No. 16 — *Distance from source = 512.9* — *Sample weight = 67.509*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
32					0.67		0.20		0.13	0.07	1.08
16	2.62		1.41	0.47	8.20		1.48	0.07	1.21	0.20	15.66
8	3.61	0.20	3.45	0.75	5.44		1.22	0.35	3.63	0.04	18.68
4	2.26	0.31	2.92	0.34	1.66		0.37	0.07	5.84	0.10	13.87
2	1.87	0.33	2.33	0.23	1.02		0.58	0.35	6.41	0.21	13.33
Total	10.36	0.84	10.11	1.79	16.99		3.85	0.84	17.22	0.62	62.62

TABLE 5 (continued)

Red Deer (continued)

Sample No. 17			*Distance from source = 524.3*						*Sample weight = 178.261*		
Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	5.98										5.98
64	1.30				28.63		0.23				30.15
32	1.32		0.13	0.92	14.50	0.13	0.58	0.03	0.30		17.91
16	1.53	0.01	0.99	0.48	6.46	0.05	0.84	0.08	2.85	0.13	13.42
8	0.91	0.16	1.34	0.66	2.96	0.03	0.70	0.22	2.94	0.07	10.00
4	0.39	0.06	0.58	0.12	0.38		0.17	0.15	1.21	0.11	3.17
2	0.39	0.09	0.44	0.06	0.25		0.13	0.12	1.58	0.06	3.12
Total	11.82	0.32	3.48	2.24	53.18	0.21	2.65	0.60	8.88	0.37	83.75

Smoky

Sample No. 1			*Distance from source = 123.3*						*Sample weight = 159.482*		
Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128			5.63								5.63
64			6.97		15.67		19.23				41.87
32			2.42	0.31	5.03		8.82				16.58
16			2.96	0.14	4.27		4.92	0.01	0.11		12.41
8		0.07	1.71	0.61	2.55		2.30	0.09	0.07	-1.00	7.39
4		0.02	0.59	0.37	0.69		1.36	0.09	0.04	0.01	3.17
2		0.04	0.33	0.44	0.47		1.00	0.22	0.05	-1.00	2.55
Total		0.13	20.61	1.87	28.68		37.63	0.41	0.27	0.01	89.60

Sample No. 2			*Distance from source = 228.4*						*Sample weight = 191.518*		
Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					29.70						29.70
64	0.40				26.95						27.36
32	0.31		0.85		14.21		2.96		0.26		18.59
16	0.28		1.42	0.26	8.76	0.01	2.32		0.21	0.01	13.29
8	0.16	0.10	0.45	0.16	2.50		0.74	0.04		-1.00	4.14
4	0.08	0.02	0.14	0.18	0.47		0.16	0.02	0.01	0.02	1.10
2	0.11	0.02	0.09	0.19	0.25		0.14	0.07	0.02	0.03	0.92
Total	1.34	0.14	2.95	0.79	82.84	0.01	6.32	0.13	0.50	0.06	95.10

TABLE 5 (continued)

Smoky (continued)

Sample No. 3 *Distance from source = 296.6* *Sample weight = -1.000*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	0.30		0.20		23.70		1.20				25.40
64	0.54		0.61		24.66		1.49				27.30
32	0.68		1.38		14.27		1.76	0.39			18.48
16	1.44		1.48	0.19	8.26		0.73	0.20	0.10		12.40
8	1.33	0.16	0.80	0.26	2.83		0.36	0.03	0.20	0.01	5.98
4	0.72	0.07	0.48	0.26	1.05		0.12	0.01	0.05	0.01	2.77
2	0.46	0.10	0.32	0.21	0.51		0.10	0.01	0.04	0.01	1.76
Total	5.47	0.33	5.27	0.92	75.28		5.76	0.64	0.39	0.03	94.09

Sample No. 4 *Distance from source = 358.6* *Sample weight = 207.753*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					8.30						8.30
64	0.35		0.44		34.41		1.70				36.90
32	0.48		0.26	0.07	22.12		1.18				24.10
16	0.79	0.01	0.70	0.07	8.03		0.83		0.09		10.51
8	1.24	0.25	0.45	0.33	3.47		0.57	0.04	0.05	0.01	6.40
4	0.28	0.04	0.11	0.13	0.60		0.13	0.01	0.03	-1.00	1.33
2	0.15	0.03	0.08	0.06	0.17		0.10	0.05	0.03	0.01	0.68
Total	3.29	0.33	2.04	0.66	77.10		4.51	0.10	0.20	0.02	88.22

Sample No. 5 *Distance from source = 418.3* *Sample weight = 98.461*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					5.53						5.53
32	0.92				20.45		0.69				22.07
16	1.93	0.28	1.01	0.83	30.18	0.02	1.43		0.14		35.82
8	1.22	0.24	0.65	0.87	4.36	0.02	0.52	0.03	1.17		9.08
4	0.49	0.10	0.52	0.65	0.97	-1.00	0.22	0.02	1.22	-1.00	4.19
2	0.35	0.08	0.25	0.38	0.24		0.09	0.03	1.59	-1.00	3.01
Total	4.91	0.70	2.43	2.73	61.73	0.04	2.95	0.08	4.12		79.70

TABLE 5 (continued)

Smoky (continued)

Sample No. 6 *Distance from source = 482.8* *Sample weight = 145.101*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	17.07				7.97						25.04
64	4.25				18.16		0.47	0.53	1.47		24.88
32	0.75		0.38	0.22	14.26		0.06	0.13	2.97		18.76
16	1.53		0.63	0.31	8.35	-1.00	0.38		2.53		13.73
8	1.44	0.22	0.53	0.47	1.96	0.02	0.09	0.01	0.54		5.28
4	0.81	0.10	0.36	0.33	0.66	-1.00	0.04	0.02	0.15	-1.00	2.47
2	0.35	0.06	0.18	0.21	0.24		0.05	0.01	0.08	0.01	1.19
Total	26.20	0.38	2.08	1.54	51.60	0.02	1.09	0.70	7.74	0.01	91.35

Sample No. 7 *Distance from source = 551.8* *Sample weight = 138.295*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					5.35						5.35
64	1.38				27.81						29.19
32	2.26		0.75	0.20	20.40		0.39		0.07		24.07
16	2.76	0.07	0.49	0.26	14.66	0.03	0.30				18.56
8	0.98	0.04		0.44	4.98		0.20			0.55	7.18
4					0.01					0.04	0.05
2					0.01			-1.00		0.03	0.04
Total	7.38	0.11	1.24	0.90	73.22	0.03	0.89		0.07	0.62	84.44

Sample No. 8 *Distance from source = 565.7* *Sample weight = 115.647*

Size	Grnt	Qutz	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64	2.94				10.71						13.65
32	2.98		0.59	0.12	28.32	0.08	0.12	0.24	0.27		32.71
16	2.82	0.20	0.47	1.02	21.22	0.12	0.24	0.04	0.16	0.02	26.30
8	1.14	0.64	0.40	0.83	3.45	0.63	0.15	0.14	0.32	0.02	7.72
4	0.56	0.15	0.16	0.48	1.02	0.24	0.05	0.12	0.14	0.01	2.93
2	0.40	0.13	0.07	0.53	0.38		0.04	0.22	0.13	0.01	1.91
Total	10.84	1.12	1.69	2.98	65.10	1.07	0.60	0.76	1.02	0.06	85.22

Wapiti

Sample No. 1 *Distance from source = 160.1* *Sample weight = 307.720*

Size	Grnt	Quzt	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128	3.57				32.92						36.48
64	0.63		1.05		17.87		6.13		1.64		27.31
32	0.35		0.96	0.06	7.02		6.13		0.74		15.26
16	0.24		0.65	0.07	2.03		2.65		1.37		7.02
8	0.24	0.02	0.44	0.11	0.86		1.17	0.03	0.29	0.01	3.17
4	0.23	0.03	0.43	0.14	0.50	-1.00	0.45	0.14	0.16	0.02	2.10
2	0.26	0.05	0.42	0.11	0.31	-1.00	0.37	0.40	0.23	0.02	2.17
Total	5.52	0.10	3.95	0.49	61.51		16.90	0.57	4.43	0.05	93.51

Sample No. 2 *Distance from source = 211.6* *Sample weight = 175.225*

Size	Grnt	Quzt	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					14.65						14.65
64	0.83				30.75		0.57				32.15
32	1.06		0.26		13.67		1.29		0.52		16.80
16	1.17	0.01	0.93	0.23	9.94		1.22		0.26	-1.00	13.76
8	0.83	0.12	0.85	0.53	3.04	-1.00	0.58	0.02	0.10	0.06	6.14
4	1.03	0.13	0.86	0.62	1.55	0.01	0.40	0.15	0.09	0.08	4.92
2	0.96	0.23	0.78	0.34	0.45	0.02	0.43	0.21	0.12	0.04	3.58
Total	5.88	0.49	3.68	1.72	74.05	0.03	4.49	0.38	1.09	0.18	92.00

Sample No. 3 *Distance from source = 247.5* *Sample weight = 154.722*

Size	Grnt	Quzt	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
128					7.33						7.33
64	1.29				15.98		0.21				17.47
32	0.44		0.50		24.27		0.94		0.09		26.24
16	0.62	0.01	0.50	0.64	13.84	0.03	1.32	0.01	0.23		17.21
8	0.44	0.14	0.60	0.91	4.58	0.04	0.55	0.03	0.41	0.01	7.71
4	0.42	0.07	0.29	0.66	1.05		0.10		0.16	0.02	2.77
2	0.26	0.09	0.05	0.57	0.28	0.07	0.02		0.09	-1.00	1.43
Total	3.47	0.31	1.94	2.78	67.33	0.14	3.14	0.04	0.98	0.03	80.16

Wapiti (continued)

Sample No. 4				*Distance from source = 277.3*					*Sample weight = 101.334*		
Size	Grnt	Quzt	Lmst	Chert	Quzte	Volc	Sndst	Shale	Irnst	Coal	Total
64					8.55						8.55
32	2.06			0.27	24.80		1.61				28.74
16	1.34	0.04	0.98	1.25	19.83	0.04	1.84		0.02	-1.00	25.36
8	1.61	0.25	0.77	1.58	6.53	0.04	0.60	0.02	0.06	0.01	11.46
4	1.35	0.29	0.59	0.76	1.61		0.09	0.02	0.05	0.04	4.80
2	1.14	0.22	0.51	0.72	0.79	0.02	0.13	0.04	0.10	0.12	3.79
Total	7.50	0.80	2.85	4.58	62.11	0.10	4.27	0.08	0.23	0.17	82.70

TABLE 6
Acceptance criteria (see text for explanation)

Athabasca

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	XX	XO	XX	XO	--	OX	OX	--	--	XO
2	--	XX	XO	OX	XX	--	XX	--	--	--	XX
3	XX	OX	XX	XX	XX	--	XX	OX	OX	--	XX
4	--	--	XX	XX	OX	--	XX	--	--	--	OX
5	XO	OX	XX	XO	OX	XX	XX	XX	XX	OX	OX
6	XO	XX	XO	XX	XO	--	XX	XX	XO	OX	OO
7	XX	OX	XO	XX	XX	--	XX	XX	XO	--	XX

Bow-South Saskatchewan

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	OX	OO	OX	OO	--	XX	OO	OX	--	OO
2	--	OX	XO	XX	XX	--	XX	XX	OX	--	XX
3	--	XX	XX	XX	XX	--	XX	--	--	--	XX
4	--	XX	XX	XX	XO	--	XX	XX	XX	XX	XX
5	OX	OX	OO	OO	XX	--	OX	OX	OX	--	XX
6	OX	OX	OX	OO	OX	--	OX	OX	OO	--	OO
7	OX	XX	OX	XO	OX	XX	XX	OX	OX	OX	OX
8	XX	XO	XX	OX	OX	XX	OX	XX	OX	OX	OX
9	XX	XO	OO	OX	OX	OX	OX	OX	XO	OX	OX
10	OO	OO	XO	OX	XO	OX	XX	XO	OX	XX	XO
11	XO	OX	XO	XO	OX	XX	XX	XX	OX	OX	OX
12	XX	OO	OO	XO	XO	XX	OX	OX	OO	OX	XO
13	XO	OX	XX	OX	OX	OX	XX	XO	OX	OX	OX
14	XO	XX	OX	XO	XO	XX	XO	OX	XX	XX	OO
15	OX	XX	OX	OO	XO	OX	OX	XX	OX	OX	XO
16	XX	OX	OX	OX	XO	OX	OX	XX	OX	OX	OO
17		XO	OX	XX	OX	OX	OX	XX	XO	XX	OO
18	OO	OO	OO	OX	OX	XO	OX	OO	OO	OX	OO

TABLE 6 (continued)

Little Smoky

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	XO	OO	OX	XX	OX	--	XX	OX	OX	OX	OX
2	OO	OX	OO	OX	XO	OX	XX	XX	OX	OX	XO
3	OX	XX	XX	XX	XO	OX	XX	XX	OX	OX	XO
4	OX	OX	XX	OX	XX	OX	OX	OX	XO	XX	XO
5	XX	XX	OX	XO	XO	OX	XX	OX	XX	XX	XO
6	OX	XO	XX	OX	XO	OX	OX	XX	XX	XX	XO
7	XO	XO	XO	XX	XX	XX	XO	XO	OX	OX	OO

McLeod

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	--	XX	XX	OX	--	OX	OX	OX	OX	XX
2	OX	OX	XX	XO	XO	XX	XX	XX	XX	XX	OX
3	OX	XO	OX	XO	OX	XX	XX	XX	--	--	XX
4	OX	OX	OX	OX	XO	OX	OX	OX	--	OX	OO
5	OX	OX	OX	OX	XO	XX	XO	OX	--	--	XO
6	XX	OX	OO	OO	OX	OX	XX	OX	OX	OX	XX
7	OX	OX	OX	XO	OO	XX	XX	OX	--	XX	OX
8	XX	OX	OX	XO	XX	OX	OX	OO	--	OX	XO
9	OX	OO	XO	XO	XX	XX	XX	XX	OX	OX	OX
10	XX	OX	OX	OX	XO	OX	XX	OO	OX	OX	XX

Milk

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	OX	XX	OX	OX	XX	OX	OX	OX	XX	--	XO
2	XO	XO	OO	XO	OX	XX	OX	OX	XO	OX	XO
3	OX	OX	OO	OO	OX	XX	OX	OX	XX	OX	OX
4	OX	XO	OX	OX	OX	OX	XX	OX	OX	XX	OX
5	OX	XX	OX	OX	XO	XX	OX	OX	OX	XX	XO

North Milk

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	OX	OX	XO	XX	XX	XX	OX	OX	OX	--	XX
2	XX	OX	XO	OX	XX	OX	XX	OX	OX	--	XO
3	OX	OO	OX	XO	XO	OX	OX	XO	OX	--	XO

North Saskatchewan

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	XX	OX	XO	XX	--	OX	--	--	--	OX
2	--	OX	OX	OX	XO	--	XX	--	--	--	XO
3	--	OX	OX	OX	OX	--	OX	XO	OX	XX	OX
4	--	OX	XO	OX	OX	--	OX	OX	OX	OX	OX
5	OX	OX	OX	XX	XX	--	XX	XX	OX	OX	XX
6	OX	OX	XX	OO	XX	XX	OX	--	OX	--	XO
7	XX	XO	OX	OX	XX	XX	XX	OX	XX	--	XX
8	XX	XO	XX	XO	XO	--	XX	OX	--	OX	XO
9	OX	OX	XO	OX	OX	OX	XX	OX	--	XX	OX
10	XO	XO	OX	OX	OO	XX	XO	OX	OX	XX	OO
11	XX	XX	OX	OX	OX	XX	XX	OX	OX	XO	OX
12	XO	XO	XO	OX	OO	OX	XO	XX	XX	XX	OO
13	XX	OX	OX	OX	XO	--	XX	XO	XX	OX	XO
14	OX	XO	OX	XO	XO	OX	XX	OX	OX	XO	XO
15	OX	OX	OX	XO	OX	XX	OX	OO	OX	OX	OX
16	OX	XO	OO	OX	XO	OX	OX	OX	XO	OX	XO
17	XX	XO	OX	XX	OX	XX	XO	OX	OX	OX	OX
18	XX	XO	OX	XX	OX	XX	XX	XO	OX	XX	OX
19	XO	XO	XX	XO	OX	XX	XO	OX	OO	XX	OX
20	OX	OO	OX	XO	OX	OX	OX	OX	OX	XO	OX
21	XO	XO	XX	OX	OX	XX	XX	XX	OX	XX	OO
22	OX	OX	XX	XO	XO	--	OX	OX	XO	XO	OO
23	OX	XO	XX	XO	OX	OX	XX	OX	XO	OX	OX
24	XO	XX	OX	XO	XX	XX	OX	OX	OO	OX	OO

TABLE 6 (continued)

North Saskatchewan (continued)

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
25	XO	XO	XO	OO	OX	XX	XO	OX	OX	OX	OO
26	OX	XO	OX	OO	OX	XX	XO	OX	OX	XX	OX
27	OX	OX	OX	OX	OX	XX	XX	OX	XX	OX	OX
28	OO	OX	OX	OO	OX	OX	XO	XX	OX	XX	OO
29	OX	XO	XO	OX	OX	OX	XX	OX	OX	OX	XO

Oldman

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	--	XX	XX	OX	OX	XX	OX	OX	--	XX
2	OX	XX	OX	OO	OX	OX	XX	OX	--	XX	XO
3	XX	OX	OO	OX	OX	OX	XX	--	XX	OX	XO
4	OX	OX	OX	XO	OX	OX	XX	--	--	--	XO
5	OX	XO	OX	OX	XO	OX	XX	OX	XX	XX	XO
6	XO	XO	OO	OO	OX	XO	OX	OX	XX	OX	XO
7	XX	OX	OX	OO	OX	OX	OX	OX	XX	XX	OX
8	XX	XO	XX	XX	XX	OX	OX	OX	XX	--	OX

Peace

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	XX	XX	XX	OX	XO	OX	XO	OX	OX	XX	XO
2	XO	XX	XX	XX	XX	XX	XO	OX	OX	--	XX
3	XX	XX	XX	OX	XX	XX	XX	--	XX	--	OX
4	XO	XO	XO	XO	XX	XX	OX	XX	XO	--	XO
5	XX	XX	XO	XX	OX	XX	XX	XX	OX	OX	OX
6	XO	XO	XX	XO	XO	XO	XX	--	XO	--	XO
7	XX	XO	XX	XX	XX	XO	XX	XX	XX	--	XO
8	XX	XO	XX	XO	XX	XO	XX	XX	XX	--	XX
9	OX	OX	OX	OX	OX	XX	OX	XX	XX	--	OO

Red Deer

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	--	OX	OX	OX	--	XX	OX	OX	OX	OX
2	--	--	XX	OX	OX	--	OX	XO	XX	--	XX
3	--	OX	XX	XO	OX	--	OX	OX	XX	OX	OX
4	--	OX	OX	XO	OX	--	XX	--	OX	--	OX
5	--	OX	XO	XO	OX	--	XX	OX	--	--	OX
6	XX	OX	OX	OO	OX	--	OX	OX	XX	--	OO
7	XX	XX	OX	XO	OX	XX	XO	OX	XX	--	OX
8	XX	OX	OX	OX	OX	OX	XX	OX	XX	OX	OX
9	XX	OO	XX	OX	XO	OX	XX	OX	XX	OX	XO
10	XO	OX	XO	OO	OX	OX	OX	--	XX	XX	OX
11	OX	OX	XO	OX	OX	--	XX	XO	XO	OX	OX
12	XX	XO	OX	XO	OO	--	OX	OO	OX	XX	OO
13	OX	OX	XO	XO	OX	XX	OX	OO	OX	XX	OX
14	OX	XX	XO	XO	XO	XX	XX	XO	XO	OX	XO
15	OX	OX	XO	XO	XX	XX	OX	OO	OX	OX	XO
16	OX	OX	OX	OX	OO	--	XO	XO	XO	XX	OO
17	XX	XO	XO	OX	OX	XX	XO	XO	OO	OX	XO

Smoky

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	--	OX	XX	OX	OX	--	OX	XO	OX	OX	XO
2	XX	OX	OX	OX	OX	XX	OX	OX	OX	XX	OX
3	XO	OX	XO	XX	XX	--	XX	XX	XX	XX	OX
4	XX	XO	XX	XX	XX	--	OX	OX	OX	OX	XO
5	OX	OX	OX	OX	OO	XX	OX	OX	OO	--	OO
6	OX	OX	OX	XX	XX	OX	XX	XX	XX	OX	OX
7	XX	OX	OX	XX	XO	XX	OX	--	XX	OX	XO
8	OX	OX	OX	XO	OX	XO	XX	XX	XX	XX	OX

TABLE 6 (continued)

Wapiti

NO.	GRNT	QUTZ	LMST	CHERT	QUZTE	VOLC	SNDST	SHALE	IRNST	COAL	TOT
1	XX	OX	OX	XX	OX	--	OX	OO	OX	OX	OX
2	XX	XO	OO	OX	OX	OX	XX	OO	OX	OX	OX
3	XX	XO	OX	OX	XX	XX	XO	XX	XO	OX	XO
4	OX	XO	OX	XO	OX	XX	OX	OX	XO	OO	OX

TABLE 7
Grain-size parameters. Distance from source in km; grain size in mm; 'T Samp' is total sample including sand.

Athabasca

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	44.1	21.86		21.93	23.12	9.05	16.41	43.79	49.90
2	119.4	59.53		32.74	67.41	35.41	42.38	127.21	136.11
3	220.2	82.49	21.92	64.95	101.30	52.51	70.82	181.25	191.28
4	406.7	69.45		64.59	69.73	67.84	68.11	112.73	112.82
5	503.4	45.28	21.36	37.92	46.35	27.24	36.24	91.82	98.22
6	643.4	34.05	15.66	29.66	37.11	18.13	33.01	54.93	59.39
61	669.1					0.38		0.52	
7	750.1	61.16	96.97	39.82	55.81	29.96	43.81	127.04	146.72
8	1223.7					0.17		0.25	
9	1301.0					0.25		0.41	
10	1383.7					0.18		0.23	
11	1392.4					0.13		0.16	

Bow-South Saskatchewan

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	8.5	7.49		7.83	7.45	2.27	6.02	11.88	14.48
2	20.4	30.32		26.14	37.07	18.55	22.26	64.27	70.11
3	126.0	89.74		100.41	64.49	69.23	76.62	192.04	196.81
4	230.1	66.38		70.30	64.52	49.10	56.61	126.30	130.64
5	302.9	64.96	5.66	30.08	90.54	39.09	45.91	152.31	158.77
6	351.5	22.23	11.75	16.18	32.01	10.87	13.68	50.83	55.17
7	392.2	38.31	12.92	22.24	45.91	24.09	28.10	88.27	91.93
8	459.8	47.70	39.50	31.16	55.96	34.24	41.09	100.38	103.48
9	483.1	30.86	36.93	16.80	35.39	17.25	23.76	59.34	64.50
10	570.0	17.26	12.92	10.47	21.40	8.05	13.02	28.44	31.49
11	571.9	17.48	12.38	13.55	21.37	6.62	13.68	31.31	39.30
12	630.2	22.57	25.31	14.17	24.92	15.05	18.40	46.01	49.46
13	647.3	18.07	10.83	18.19	18.35	8.90	13.35	34.68	41.76
14	681.4	24.33	24.80	15.90	28.60	10.90	17.77	47.48	54.61
15	747.8	22.87	20.40	15.56	26.11	12.26	18.51	41.36	48.43

TABLE 7 (continued)

Bow-South Saskatchewan (continued)

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
16	805.3	22.60	28.20	16.16	24.28	12.97	16.58	47.40	51.16
17	899.6	30.71	38.91	22.17	32.99	16.37	24.12	57.88	62.96
18	941.1	14.42	12.88	11.28	15.55	7.88	12.13	25.82	28.33
181	941.1					0.22		0.32	
19	965.4					0.22		0.30	
20	986.3					0.28		0.44	
201	986.3					0.31		0.45	
21	1001.3					0.27		0.39	
22	1024.2					0.39		0.97	
23	1043.0					0.23		0.30	
24	1100.0					0.31		0.45	
25	1110.6					0.26		0.35	
26	1126.0					0.33		0.73	
27	1176.2					0.28		0.45	
28	1223.4					0.28		0.38	
29	1265.9					0.20		0.29	
30	1290.0					0.30		0.47	
301	1290.0					0.20		0.28	
31	1321.9					0.23		0.31	
32	1413.9					0.25		0.32	

McLeod

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	16.1	190.95		232.44	171.17	174.54	178.28	364.56	369.65
2	89.5	83.54	4.24	55.30	82.19	65.01	70.22	187.06	190.82
3	135.7	81.21	4.24	19.86	85.62	61.36	68.15	184.04	188.46
4	135.8	32.18	5.09	19.93	34.32	23.40	26.47	58.33	60.29
5	156.7	25.76	11.31	19.51	27.94	18.94	21.46	48.54	51.58
6	229.0	200.66	18.28	17.94	108.52	165.89	177.38	410.15	415.87
7	258.8	42.02	12.23	21.61	51.93	25.72	33.12	90.21	95.53

McLeod (continued)

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
8	272.1	57.38	18.35	20.47	67.37	42.54	53.00	111.99	114.14
9	303.8	30.69	42.76	16.54	33.34	15.83	22.01	61.01	70.69
10	379.6	68.68	138.04	14.42	69.06	50.01	59.89	137.02	145.15

Milk

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	127.6	49.39	44.65	34.41	73.47	28.26	36.41	104.01	111.32
2	155.0	15.91	14.77	12.28	20.68	8.80	12.25	29.50	31.41
3	196.2	11.06	8.44	7.61	13.39	4.20	9.57	19.87	23.67
4	213.7	39.55	49.68	31.50	41.16	12.28	26.60	86.76	98.20
5	261.7	12.06	7.75	10.90	14.66	1.57	10.04	19.40	25.90
6	273.6					0.29		0.70	
7	298.5					0.37		0.84	
8	305.3					0.27		0.47	
9	386.1					0.10		0.20	

North Milk

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	38.3	69.31	25.11	30.65	102.60	42.25	49.05	166.25	172.91
2	71.3	57.74	29.05	24.98	85.52	29.73	41.71	121.31	126.88
3	119.4	18.93	13.46	14.61	25.52	5.18	13.18	35.38	45.32

TABLE 7 (continued)

North Saskatchewan

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	29.6	20.62		20.76	16.89	4.77	17.32	35.29	45.61
2	124.2	58.44		46.23	77.15	45.62	51.91	109.27	111.94
3	178.0	102.37		45.85	121.84	84.33	92.50	210.52	213.18
4	229.5	123.62		33.44	148.00	131.89	140.88	224.17	227.14
5	262.3	65.11	11.31	18.10	83.28	37.68	48.59	145.77	154.59
6	334.1	61.41	67.74	29.45	69.80	38.76	50.39	120.92	124.48
7	391.7	66.43	51.88	20.25	71.61	43.61	56.41	126.92	136.09
8	420.2	57.52	42.04	19.57	60.32	39.42	48.00	108.59	113.65
9	420.8	37.40	29.68	17.77	39.39	21.90	28.32	75.29	84.04
10	466.4	33.83	20.19	15.01	35.39	25.21	28.14	60.03	61.60
11	469.0	33.76	22.35	17.42	35.18	20.88	25.18	64.54	74.94
12	505.0	25.66	14.05	8.93	28.00	17.69	20.21	50.14	53.91
13	505.8	43.67	34.51	12.90	48.28	26.09	33.21	93.73	99.50
14	532.2	25.77	20.55	10.28	28.59	17.03	21.71	49.76	52.91
15	532.7	23.76	23.22	12.04	25.01	17.51	21.54	41.83	46.16
16	566.8	19.76	15.74	7.49	22.22	11.89	17.24	32.83	39.20
17	573.1	39.52	36.60	11.92	53.58	23.28	29.71	88.83	93.84
18	599.1	37.22	23.25	9.49	44.31	17.09	25.44	84.73	93.45
19	621.7	30.76	23.21	14.21	36.96	15.05	21.10	67.42	76.46
20	659.5	34.11	50.35	25.40	35.31	16.65	24.39	72.70	82.88
21	687.2	28.68	25.69	30.06	37.40	16.96	20.68	60.23	63.98
22	725.0	26.60	32.65	15.39	27.95	8.48	17.90	49.21	62.02
23	754.6	30.19	34.64	17.01	33.66	8.48	18.36	61.67	79.75
24	779.7	23.80	23.33	11.36	30.59	8.58	17.35	44.05	54.41
25	815.6	23.09	22.34	12.45	29.88	8.50	15.02	44.36	55.80
26	836.7	32.86	38.02	26.53	35.61	10.33	23.76	64.27	80.62
27	855.5	38.33	39.39	19.14	46.59	21.61	29.76	84.52	90.95
28	864.0	16.26	15.70	14.62	20.10	5.97	13.22	28.34	31.86
29	888.0	20.07	19.11	13.54	21.13	7.15	15.86	32.85	43.70
30	908.9					0.28		0.39	
31	928.6					0.26		0.42	
32	998.9					0.34		0.64	
33	1040.1					0.23		0.44	
34	1102.0					0.25		0.30	

Little Smoky

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	343.1	35.44	21.78	16.02	41.63	20.92	29.58	68.56	77.49
2	365.5	17.26	12.92	14.98	20.79	8.96	14.51	29.29	31.61
21	389.5					0.45		0.71	
22	410.5					0.73		1.27	
23	429.2					0.42		0.84	
3	509.2	53.48	42.65	32.62	64.64	35.88	45.91	103.96	109.16
4	542.3	61.28	39.96	27.03	74.95	40.23	55.65	116.88	120.53
5	559.2	62.61	64.72	39.59	70.05	44.06	60.35	114.94	118.57
6	602.7	57.67	59.05	30.94	62.37	42.50	52.88	109.02	112.13
7	602.8	28.87	19.07	21.45	36.60	13.13	21.92	55.35	62.12

Oldman

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	33.8	166.26		70.55	10.04	155.51	159.06	321.80	324.03
2	117.3	39.45	7.64	30.16	37.48	17.20	24.77	89.44	98.98
3	192.0	53.36	61.45	25.38	66.19	37.36	46.11	109.75	112.04
4	194.2	47.77	10.93	37.56	53.51	24.73	33.86	104.81	109.76
5	293.9	46.30	55.97	23.25	55.42	27.65	34.63	98.94	105.05
6	382.9	22.65	26.54	16.66	24.07	16.36	19.69	43.84	47.09
7	449.2	37.77	43.52	17.20	44.62	16.10	26.75	81.21	92.04
8	451.4	75.26	97.59	76.47	74.68	66.66	70.64	145.10	150.75

Peace

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	816.4	38.54	39.06	43.74	40.90	27.50	36.99	57.06	59.89
2	918.1	66.15	37.76	22.60	87.45	45.95	55.67	125.33	132.03
3	918.7	46.12	48.98	28.24	51.77	34.67	41.15	83.23	90.30
4	944.3	28.31	28.77	13.60	37.71	16.65	21.79	56.85	59.93

TABLE 7 (continued)

Peace (continued)

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
5	1023.0	45.81	20.24	20.14	55.56	30.23	38.55	96.90	101.17
6	1024.0	42.35	54.57	25.11	46.78	21.26	28.51	95.26	103.26
7	1126.7	48.91	93.96	21.04	52.52	16.99	27.39	114.62	124.73
8	1230.1	30.13	27.85	17.40	36.06	14.23	20.36	67.26	77.60
9	1332.5	14.60	10.33	9.08	18.03	6.97	11.67	25.80	29.39
10	1420.9					0.35		0.46	
11	1511.0					0.22		0.28	
12	1605.4					0.29		0.35	
13	1681.9					0.21		0.28	
14	1759.6					0.32		0.41	
15	1811.6					0.14		0.22	

Red Deer

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	63.1	32.40		31.19	28.50	19.98	25.51	62.29	68.35
2	91.4	147.00		157.35	128.39	106.92	116.28	347.29	352.14
3	141.1	103.48		67.61	149.96	85.37	94.92	214.91	216.96
4	158.8	79.28		32.87	111.09	51.60	62.80	187.14	192.33
5	186.5	39.67		29.18	46.84	29.71	31.23	84.75	86.45
6	242.5	31.97	51.62	18.42	38.02	21.12	25.13	61.45	63.85
7	253.3	35.17	59.53	21.29	38.91	25.10	28.95	63.25	67.73
8	284.0	45.46	58.21	22.48	48.96	35.43	38.10	94.26	96.22
9	315.6	60.65	33.79	27.12	70.69	39.75	54.43	120.01	122.26
10	316.4	72.07	33.30	25.74	84.73	44.21	65.81	151.23	164.04
11	365.3	45.30	52.82	21.28	51.25	26.76	34.51	99.69	103.11
12	409.1	30.30	37.90	11.07	33.89	18.06	24.00	58.14	61.95
13	432.1	32.24	48.74	12.75	35.91	16.07	22.58	69.69	79.53
14	438.5	23.84	21.92	15.32	25.88	16.57	20.40	45.85	49.62
141	459.9					0.27		0.35	
15	478.8	25.77	24.72	14.81	34.82	14.79	20.57	49.97	54.43
16	512.9	11.67	11.41	9.30	17.05	3.86	9.31	21.56	25.44

Red Deer (continued)

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
17	524.3	60.48	110.67	13.78	64.50	37.42	51.25	116.70	121.14
18	549.1					0.34		1.60	
19	585.8					0.34		0.68	
20	615.7					0.33		0.59	
21	661.3					0.27		0.48	
22	691.8					0.32		0.54	
23	693.6					0.37		0.74	
24	711.1					0.34		0.49	
25	744.9					0.26		0.41	
26	780.7					0.20		0.28	

Smoky

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	123.3	66.39		89.77	61.95	57.66	66.93	119.07	121.13
2	228.4	95.17	44.14	26.01	104.88	76.54	81.44	202.69	205.02
3	296.6	87.94	34.18	37.96	98.22	68.55	73.89	194.84	198.00
4	358.6	70.87	26.54	35.97	75.78	55.76	65.33	123.97	126.75
5	418.3	30.67	20.95	13.93	35.06	20.75	25.25	55.63	59.29
6	482.8	87.81	136.07	19.23	76.50	63.82	72.04	194.07	198.78
7	551.8	61.60	40.75	36.31	65.51	41.01	51.31	114.62	118.93
8	565.7	40.13	44.46	25.42	42.66	29.08	34.66	77.04	83.04

Wapiti

NO.	DIST	DG GRAVEL	DG GRNT	DG LMST	DG QUZTE	D50 T SAMP	D50 GRAVEL	D90 T SAMP	D90 GRAVEL
1	160.1	106.71	132.12	40.96	129.31	90.82	98.62	211.67	214.30
2	211.6	73.27	28.49	13.45	85.39	56.09	65.12	159.49	165.64
3	247.5	57.28	45.76	21.91	63.02	32.90	42.75	115.13	124.56
4	277.3	34.05	20.35	12.51	39.13	22.61	28.64	61.81	65.48

TABLE 8
Grain-size parameters for the Peace River in British Columbia

Sample Number	Distance from Source km	D_{50} (mm)	D_{90} (mm)
SP 3	694.5	63	165
SP 4	703.1	26	128
GB 4	728.2	38	102
SP 6	755.6	24	76
GB 7	761.2	23	89
SP 11	780.9	19	78
SP 9	797.9	13	68
SP 8	802.2	21	85
SP 7	811.8	21	83
GB 9	813.4	25	51

TABLE 9
Analysis of variance of logarithmically transformed grid sample data (from Church and Kellerhals, in press 1978)

Source of Variance	df	Sum of Squares	Mean Square	F
Between sites (downstream)	38	278.3002	7.3237	6.231***
Between samples (at a site)	39	45.8431	1.1755	2.109**
Within samples (residual)	3822	2130.0790	0.5573	
Total	3899	2454.2223		

***significant at = 0.001
**significant at = 0.005

TABLE 10

Results of regression and analysis of variance of zn D_{50} and zn D_{90} on x, the thalweg distance, for 78 grid samples along a 138 km reach of the Peace River

		D_{50}			D_{90}	
Regression						
Regression coefficient, a_D		-0.00419			-0.00478	
Regression constant, ln. D_O		7.166			8.377	
Percent variance explained, R^2		0.307			0.498	
Correlation coefficient, r		-0.544			-0.706	
Analysis of variance						
	DF	Sum of squares	Mean square	DF	Sum of squares	Mean square
Regression	1	2.140	2.140	1	2.785	2.785
Between group deviation from regression	37	4.832	0.138	37	2.806	0.080
Total between groups	38	6.972	0.194	38	5.591	0.155
Within groups	39	1.137	0.028	39	0.464	0.011
Total	77	8.109		77	6.055	
F - Tests						
Regression/ deviations		15.50			34.73	
Between groups/within groups		6.98			13.72	
Deviations/within groups		4.98			7.08	

TABLE 11
Regression and analysis of variance for the sieve data from selected river reaches. Regression equation of the form $\ln D = a_D x + \ln D_o$

River Reach	Number of Samples	Length of Reach (km)	ln D_O D_{50} D_{90} D_g quzte D_g gravel	a_D (km^{-1}) D_{50} D_{90} D_g quzte D_g gravel	R	F ratio	S^2 Deviation
Peace, Hudson Hope to Alberta border. B.C. data and Halferdahl s.l.	11	116.9	7.753 9.629	-0.00588 -0.00674	-0.641 -0.877	6.26 30.1	0.106 0.0290
Peace, all samples (B.C. and Halferdahl data)	19	633.5	4.607 5.357	-0.00165 -0.00108	-0.608 -0.479	9.96 5.05	0.159 0.135
North Saskatchewan (samples 4-29)	26	658.5	4.738 5.279 4.670 4.580	-0.00310 -0.00182 -0.00169 -0.00177	-0.862 -0.702 -0.697 -0.741	69.72 23.32 22.7 29.2	0.125 0.127 0.113 0.096
Red Deer (samples 3-14)	12	297.4	4.497 5.418 5.02 4.65	-0.00370 -0.00300 -0.00350 -0.00281	-0.754 -0.632 -0.689 -0.650	13.18 6.65 9.10 7.30	0.121 0.158 0.159 0.125
Bow-South Saskatchewan (samples 3-14)	12	711	3.744 4.996 4.44 4.18	-0.00177 -0.00173 -0.00169 -0.00150	-0.618 -0.689 -0.735 -0.674	8.03 11.78 15.30 10.80	0.250 0.162 0.159 0.125
Red Deer (samples 18-26 sand)	9	231.6	-0.0979 3.067	-0.00163 -0.00540	-0.636 -0.849	4.76 18.02	0.0255 0.0733
Bow-South Saskatchewan (samples 19-32 sand)	16	448.5	-0.795 0.0159	-0.000459 -0.00081	-0.352 -0.333	1.98 1.74	0.0317 0.111

TABLE 12
Diminution and abrasion coefficients from experiments and field observations

	Source	Material	D or a_D (km^{-1})	Notes
A. Abrasion experiments	Daubrée (in Pettijohn, 1957)	granite	0.00036-0.0013	abrasion mill
	Krumbein, 1941	limestone	0.010	abrasion mill
	Wentworth, 1919	limestone	0.0009	abrasion mill
	Marshall, 1919, 1927	greywacke	0.00014	abrasion mill
	Kuenen, 1956	quartzite	0.00006	circular flume, cement floor
		quartz	0.00009	
		compact limestone 1	0.00030	
		compact limestone 2	0.00040	
		flint	0.0002	circular flume, pebbly floor
		quartzite 1	0.0002	various velocities various sediments in suspension
		quartzite 2	0.0003	
		quartz	0.0004	
		siliceous limestone	0.0015	
		limestone	0.0032	
		gneiss	0.0022	
		quartzite 1	0.0003	circular flume, pebbly floor
		quartzite 2	0.0005	pebble velocity 113 cm/sec.
		quartz	0.00027	
		greywacke	0.0011	
		gneiss	0.0026	
	Bradley, 1970	quartz	0.00028	Kuenen-type circular flume
		fresh granite	0.00031	
		weathered granite	0.0042	
		fresh gneiss	0.00058	
		weathered gneiss	0.0069	
B. Rivers	Heyne (in Leliavsky, 1966)		0.006	River Mur mean particle size
			0.0106	River Mur Maximum particle size
	Sternberg (in Leliavsky, 1966)		0.004	River Rhine, reduction of mean particle weight.
			0.007	River Mur
			0.0085	River Iller
	Leopold, Wolman and Miller, 1964		0.0327	Rock Creek, Montana, D_{50}
	Hack, 1957		0.0139	Tye River, Virginia, D_{50}
	Bluck, 1965	limestone		Ancient alluvial fan, South Wales maximum particle size
			6.6107	upper fan
			2.123	lower fan
	Eckis, 1928 (in Allen, 1965)		0.5029	Cucamonga, Cailfornia, alluvial
			0.1284	fans maximum particle size

TABLE 12 (continued)

	Source	Material	a_D (km^{-1})	Notes
	Yatsu, 1957		0.0238	Lower Kinu alluvial fan, D_{50}
			0.0253	Upper Kinu, D_{50}
			0.0416	Lower Watrase alluvial fan, D_{50}
			0.0531	Upper Watrase, D_{50}
			0.0532	Upper Tenryn alluvial fan, D_{50}
			0.0104	Lower Kiso alluvial fan, D_{50}
			0.0348	Upper, D_{50}
			0.0173	Lower Nagaro alluvial fan, D_{50}
			0.0446	Upper Nagaro alluvial fan, D_{50}
			0.0288	Upper Sho alluvial fan, D_{50}
			0.0715	Upper Abe alluvial fan, D_{50}
			0.0247	Yahagi alluvial fan, D_{50}
			0.11	Upper Makita alluvial fan, D_{50}
			0.024	Hii alluvial fan, D_{50}
	Kellerhals (unpublished)		0.517	Illecillewaet River fan, British Columbia, D_{90}
	Bradley, 1970	chert	0.00097	Colorado River, Texas
		quartz	0.0015	mean intermediate axis of coarest 50 stones
		granite	0.0028	
	This study			Total sample D_{90}, central reaches in Alberta . . . Athabasca River
			0.00173	Bow-South Saskatchewan River
			0.00182	North Saskatchewan River
			0.00300	Red Deer River
			0.00108	Peace River
	Kellerhals (unpublished)		0.0398	Columbia River, British Columbia D_{90}, stage-discharge relationship confirms aggradation.
C. Alluvial fans and ancient gravel deposits	Schlee, 1957		0.0542	Upland gravels, Maryland, modal size.
	Plumley, 1948	metamorphic	0.0417	Rapid Creek Dakota, terrace gravels, mean
		limestone	0.1116	Bear Butte Creek, Dakota Terrace gravels, mean

TABLE 12 (continued)

Source	Material	a_D (km^{-1})	Notes
Krumbein, 1942		5.840	La Crescenta alluvial fan, maximum boulder weight
Krumbein, 1942	granodiorite	0.1226	Arroyo Seco, California alluvial fan maximum boulder diameter
Blissenback, 1954		0.383	Catalina Mountains Arizona, alluvial fan, maximum particle size

TABLE 13
Grain-size classes containing maximum and minimum frequencies

River	All Samples Combined			Gravel Samples Combined[1]		
	Gravel Maximum mm	Minimum mm	Sand Maximum mm	Gravel Maximum mm	Minimum mm	Sand Maximum mm
1 Athabasca	32 – 64	1.0 – 1.41	.125 – .177	32 – 64	1.0 – 1.41	.25 – .35
4 Bow-South Saskatchewan	16 – 32	1.0 – 1.41	.35 – .50	16 – 32	1.0 – 1.41	.35 – .50
5 Little Smoky	64 – 128	1.41 – 2	.35 – .50	64 – 128	1.0 – 1.41	.35 – .50
6 McLeod	64 – 128	1.0 – 1.41	.35 – .50	64 – 128	1.0 – 1.41	.35 – .50
7 Milk	16 – 32	1.41 – 2	.25 – .35	16 – 32	1.0 – 1.41	.25 – .35
8 North Milk	32 – 64	1.0 – 1.41	.50 – .71	32 – 64	1.0 – 1.41	.50 – .71
9 North Saskactchewan	16 – 32	1.0 – 1.41	.25 – .35	16 – 32	1.0 – 1.41	.25 – .35
10 Oldman	64 – 128	1.0 – 1.41	.35 – .50	64 – 128	1.0 – 1.41	.35 – .50
11 Peace	32 – 64	1.0 – 1.41	.25 – .35	32 – 64	1.0 – 1.41	.25 – .35
13 Red Deer	16 – 32	1.41 – 2	.25 – .35	16 – 32	1.0 – 1.41	.25 – .35
15 Smoky	64 – 128	1.0 – 1.41	.35 – .50	64 – 128	1.0 – 1.41	.35 – .50
16 Wapiti	32 – 64	1.0 – 1.41	.35 – .50	32 – 64	1.0 – 1.41	.35 – .50
All rivers Combined	16 – 32	1.41 – 2	.25 – .35	16 – 32	1.0 – 1.41	.25 – .35

1) All samples containing more than 20 percent gravel (>2 mm)