SUSITNA HYDROELECTRIC PROJECT

TRIBUTARY STABILITY ANALYSIS

DECEMBER 1982

PREPARED BY:

R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

ALASKA POWER AUTHORITY

DCNO 42
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ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

TASK 3 - HYDROLOGY

TRIBUTARY STABILITY ANALYSIS

DECEMBER 1982

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TRIBUTARY STABILITY ANALYSIS

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ACKNOWLEDGMENTS

The assistance of several people in preparation of this report is gratefully acknowledged. Carol Larson did the particle-size analyses and helped with other tables and figures. Carl Schoch prepared the stream thalweg and cross-section plots which appear in Attachment A. The field surveys were performed by R&M survey crews in the summer of 1982. Typing was done by Kyin-Kyin Chen, and review comments were provided by Steve Bredthauer. The report was authored by Jeff Coffin.

1 - INTRODUCTION

1.1 - General

The purpose of this analysis was to determine whether creeks tributary to the Susitna River and downstream of the proposed Devil Canyon Damsite will be impacted by operation of the Susitna Hydroelectric Project. The "impact" considered here was the project's effect on stability of the stream. Regulation of the Susitna River flows by the Watana and Devil Canyon Reservoirs will provide lower average discharges during the summer open-water season than are currently experienced. Specifically, the average discharge for the May-September period will decrease from the existing level of 20,100 cfs (based on 32 years of record at Gold Creek) to a post-project operating level of 10,000 cfs under Case C* (based on 32 years of power study projections by Acres American; reference Acres American, 1982, Table E.2.36).

A potentially more important effect of project operation and flow regulation, however, will be a reduction in the level of the mean annual flood in the river. The pre-project mean annual flood peak is about 50,000 cfs at Gold Creek, but it will be reduced to about 13,500 cfs during project operation (R&M Consultants, 1982b). This translates to a drop in river stage at the mouths of the study tributaries of from 3.2 to 7.6 feet. Essentially, the tributary mouths will not experience the "flushing" action they currently receive annually. The river also provides a source of "backwater" for many of the streams in their present state, a condition that will be affected as well.

The influence of the Susitna River backwater on the tributaries discharging into it is threefold. First, deep water is maintained at the confluences, which permits easy access to the streams for fish. Second, an abrupt decrease is created in the stream's hydraulic gradient, which generally causes a reduction in flow velocity. This can lead to immediate deposition of the stream's bedload and even much of its suspended load. Third, the backwater causes a reduced flow velocity for some distance up the stream. Related to effect number two, less scouring of the streambed in the affected reach results.

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* Case C is operation to compromise between minimal impact on salmon spawning areas and optimal power production.

Removal of the backwater from the creek mouths can thus potentially cause difficulty for fish swimming into the streams, it can lead to less sediment deposition at the mouths, and it can increase scour of the bed above the mouths. If the mouth of a stream is able to be scoured sufficiently by creek flows, fish access may be maintained. If the creek mouth remains perched, however, due to inadequate sediment movement, fish access to the stream may be hindered. Additionally, if the creek does degrade and scour back from the mouth, erosion could take place at railroad crossings further upstream. The primary criteria determining whether the streambed will degrade are its slope, flow velocities, and the size of the bed material.

The scope of the present study limited consideration to 19 streams between Devil Canyon Damsite and the Susitna-Chulitna confluence near Talkeetna. The locations of the study tributaries are shown on the location map of the Portage Creek-to-Talkeetna-Reach in Fig. 1.1 and in greater detail, in Figures 1.2 through 1.8. Streams were selected which were known to be used for fish migration or which were expected to encounter a possible impact on Alaska Railroad structures crossing them. No streams above Devil Canyon were considered as any affected there will be inundated by the reservoir. Also, only streams above Talkeetna were included since these are the ones to be most impacted by the reduced summer flows. While the stage in the Susitna River below Talkeetna will also be somewhat lower during project operation, the magnitude of the change will be markedly less due to the addition of Chulitna and Talkeetna River flows at Talkeetna.

1.2 - Limitations of Analysis

Any statement about the stability of an alluvial channel must be qualified. If one waits long enough, sufficiently large streamflows will be experienced to move and scour even the large boulders in the streambed. Conversely, even through a given stream is predicted to degrade, this process will take some time and will likely not proceed significantly except during high flows in the creek. Thus, some "perching" will still be present at low flows, which is currently the case when the Susitna stage is low (as was experienced in August 1982). Downcutting of these perched creeks will occur during extreme flood events, perhaps during the mean annual flood.

As will be discussed in Section 4, consideration of streambed stability is very complex. There are several complicating factors in the analysis, among these being the need to analyze bank material rather than bed material for particle-size distribution (due to high water conditions), the unknown quantity of sediment transport in the streams, and the effect of low flows in the creeks. It is the low flows that actually limit fish access, but there is still certainly some ability for migrating fish (e.g. king salmon) to jump into "perched" streams.

Considering the above discussion, analyses in the present report are directed toward predicting the most likely long-term stability of each creek. "Long-term" means several years; for example, an estimated five or more years following the start of project operation.

1.3 - Creek Nomenclature

Where applicable, official creek names appearing on USGS topographic maps were used to identify tributaries. Creeks in this category include Portage Creek, Indian River, Gold Creek, Deadhorse Creek (at Curry and also occasionally known as "Curry Creek"), Portage Creek (about 3 miles downstream of Curry and known herein as Little Portage Creek to distinguish from the other Portage Creek 31 miles upstream), McKenzie Creek, Lane Creek, and Whiskers Creek.

In a few other cases, official map names are not available, but frequent usage has attached certain names adopted by most of the present Susitna Hydroelectric Feasibility Study participants. These were primarily related by the Alaska Department of Fish and Game and include Jack Long Creek (at river mile [RM] 144.8), Sherman Creek (at RM 130.9), Skull Creek (at RM 124.4), and Gash Creek (at RM 111.5).

The remaining six tributaries are unnamed, to the knowledge of the author, and are designated simply by river mile location of the mouth. River miles used are 132.0, 128.5, 127.3, 123.9, 121.0, and 110.1. Attempts have been made herein to keep use of river miles consistent, but different interpretations around bars and islands sometimes yield slightly different values. The intended "standard" river miles are presented for the study reach in Figures 1.2 through 1.8, which were taken from the Susitna River Mile Index (R&M Consultants, Inc., 1982a).

The 19 study tributaries are listed in Table 1.1, along with their river mile locations, the bank of the Susitna where the creek mouth is located, and their reason for inclusion in the study.

1.4 - Report Organization

Prior analyses, consisting of the 1982 report "River Morphology", by Steve Bredthauer and Brent Drage (R&M Consultants, 1982b), and the 1981 Aquatic Habitat and Instream Flow Project Report by ADF&G (1981b), are summarized in Section 2. Section 3 presents the results of a qualitative analysis of each of the creeks, an overview that preceded quantitative analysis and eliminated a few streams from further consideration. The quantitative analysis is described in Section 4, and references used are listed in Section 5.

Supporting information and survey data from each tributary are presented in the Attachments. Attachment A contains plan-view aerial photos and thalweg and cross-section plots for each creek. Attachment B has tabulated values of discharges measured or observed in the tributaries during 1982. Finally, Attachment C presents photos of the bed material and plots of the particle-size distributions for creeks where available.

TABLE 1.1
SUSITNA TRIBUTARY STABILITY ANALYSIS
TRIBUTARIES CONSIDERED IN ANALYSIS

No.	Name	River Mile	Bank of Susitna[1]	Reason for Concern
1	Portage Creek	148.9	RB	fish
2	Jack Long Creek	144.8	LB	fish
3	Indian River	138.5	RB	fish
4	Gold Creek	136.7	LB	fish
5	Trib. @ 132.0	132.0	LB	RR
6	Fourth of July Creek	131.1	RB	fish
7	Sherman Creek	130.9	LB	RR, fish
8	Trib. @ 128.5	128.5	LB	RR
9	Trib. @ 127.3	127.3	LB	RR
10	Skull Creek	124.7	LB	RR
11	Trib. @ 123.9	123.9	RB	fish
12	Deadhorse Creek	121.0	LB	fish, RR
13	Trib. @ 121.0	121.0	RB	fish
14	Little Portage Creek	117.8	LB	RR
15	McKenzie Creek	116.7	LB	fish
16	Lane Creek	113.6	LB	fish
17	Gash Creek	111.7	LB	fish
18	Trib. @ 110.1	110.1	LB	RR
19	Whiskers Creek	101.2	RB	fish

1 Referenced by facing downstream (LB = left bank, RB = right bank).

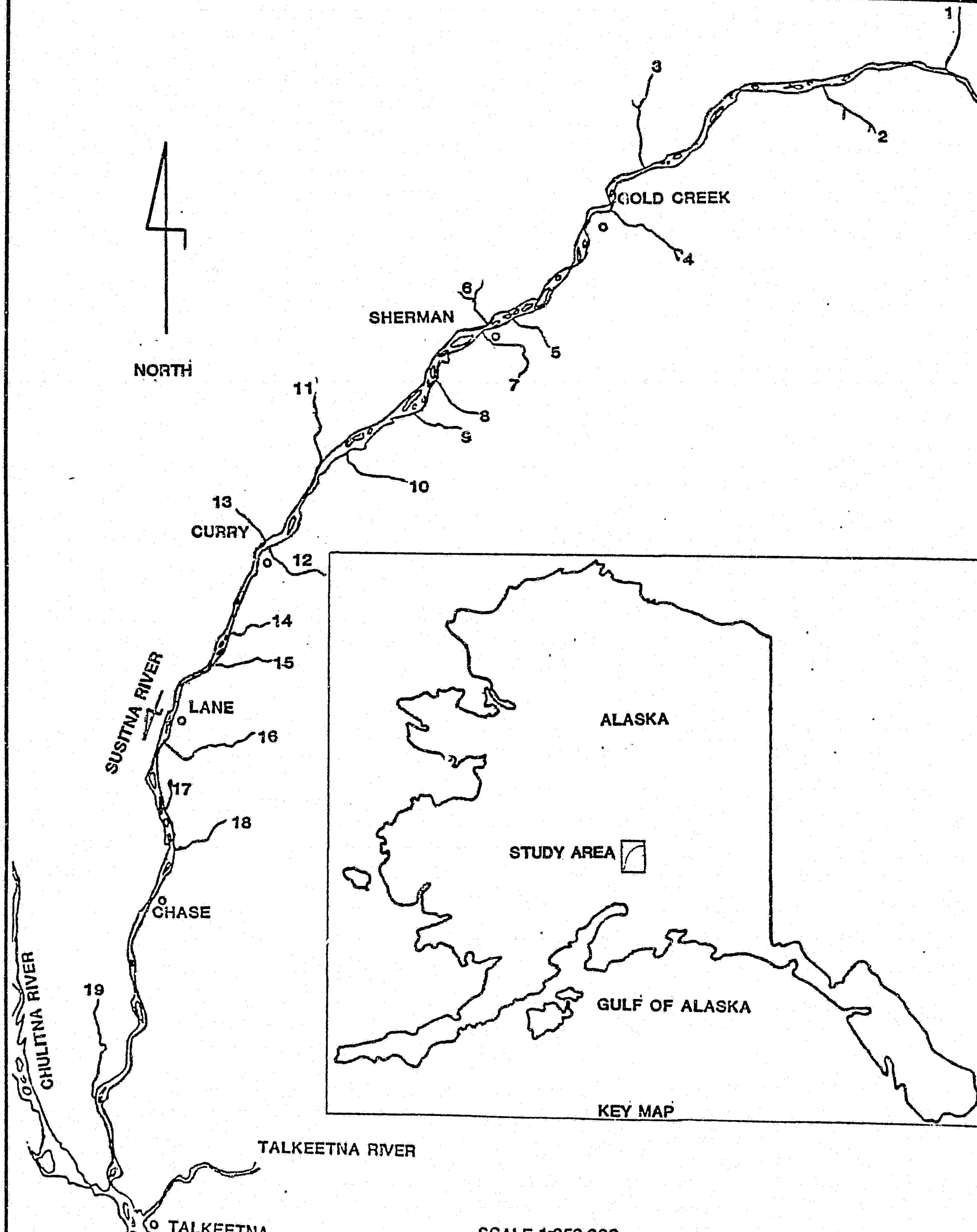

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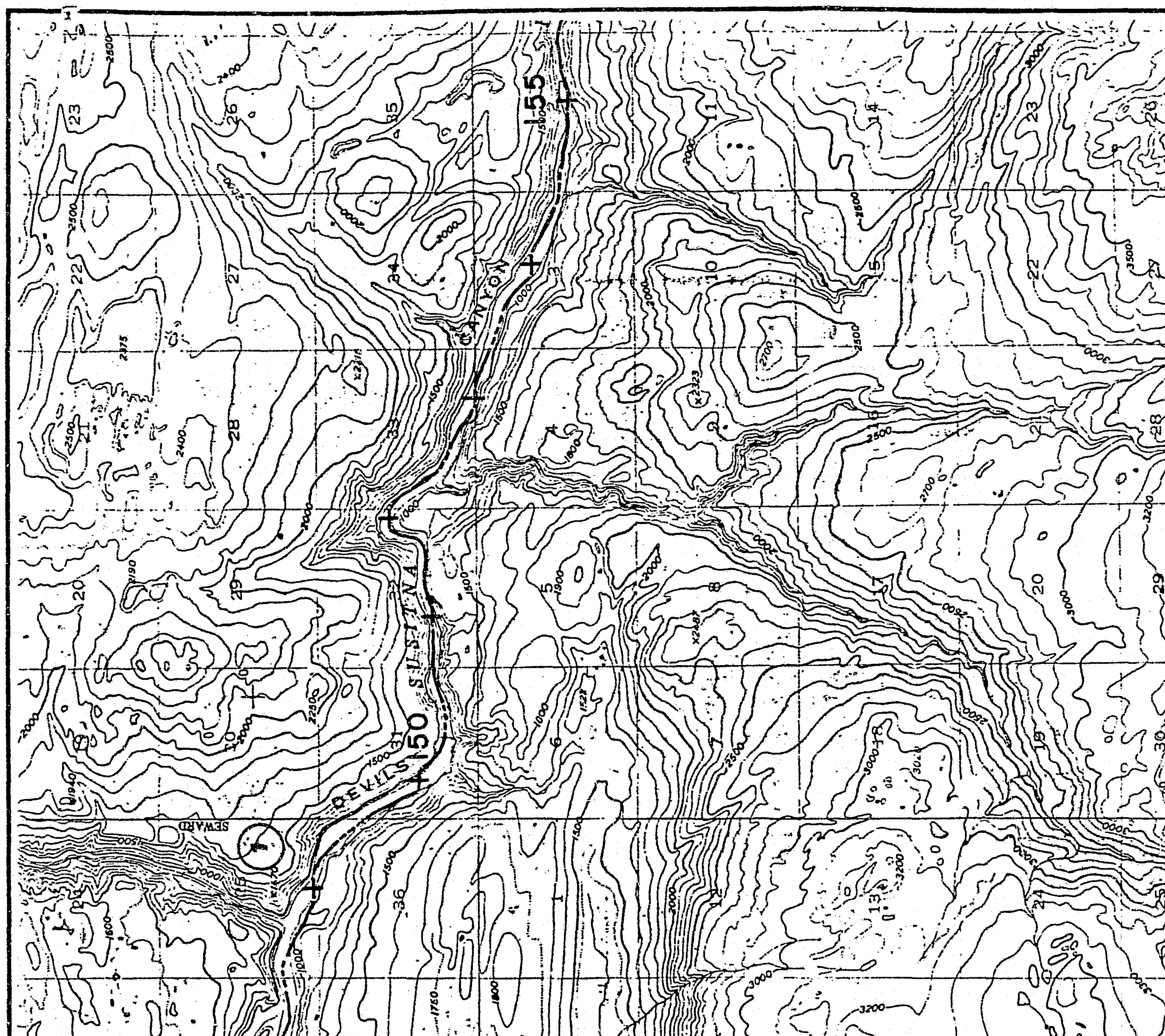
FIGURE 1.1

LOCATION MAP FOR SELECTED TRIBUTARIES OF THE SUSITNA RIVER BETWEEN RM 97 AND RM 150



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SUSITNA RIVER MILE INDEX

MILES 145 TO 155

(FROM U.S.G.S. TALKEETNA MNTS. D-5)

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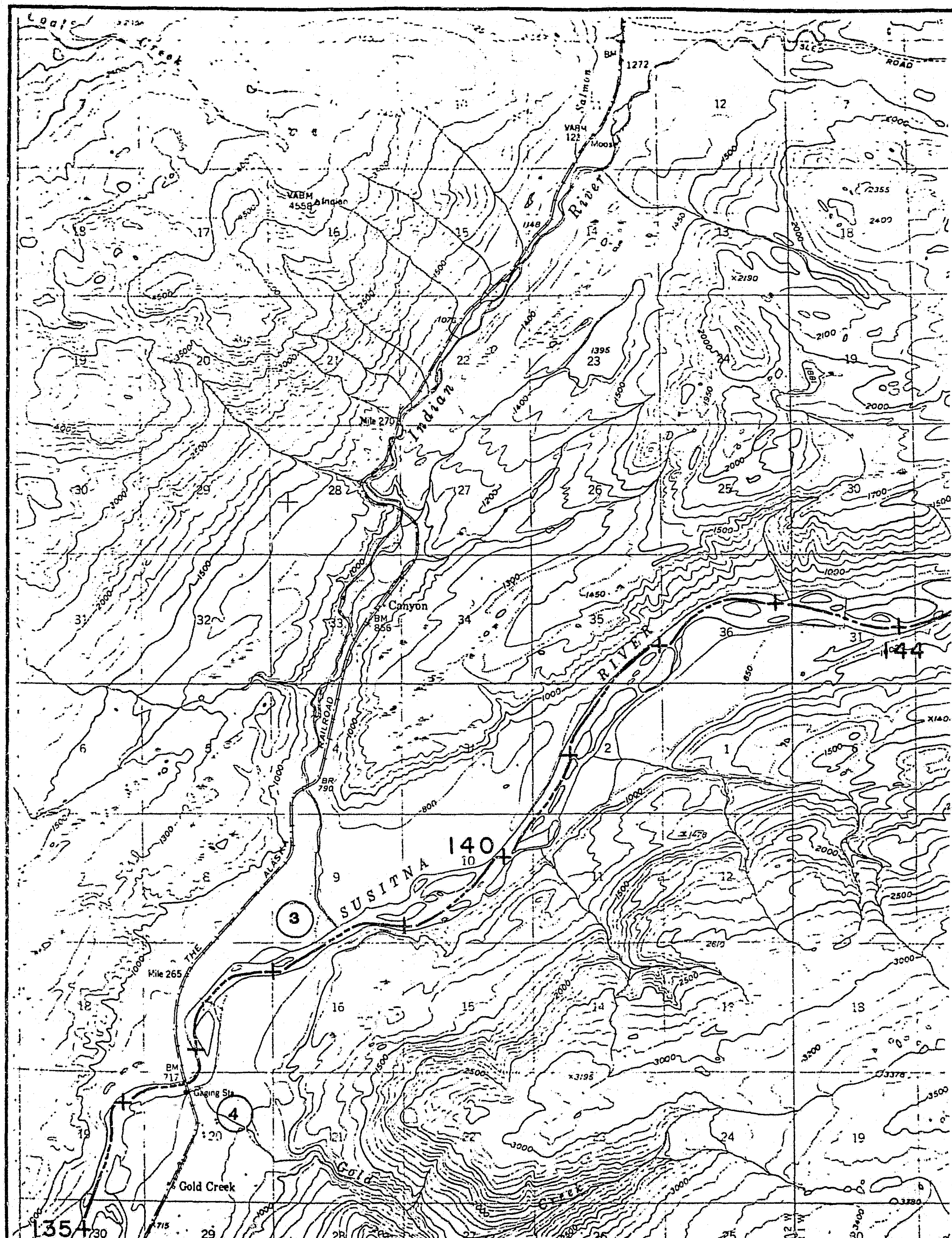
1-7 FIGURE 1.2



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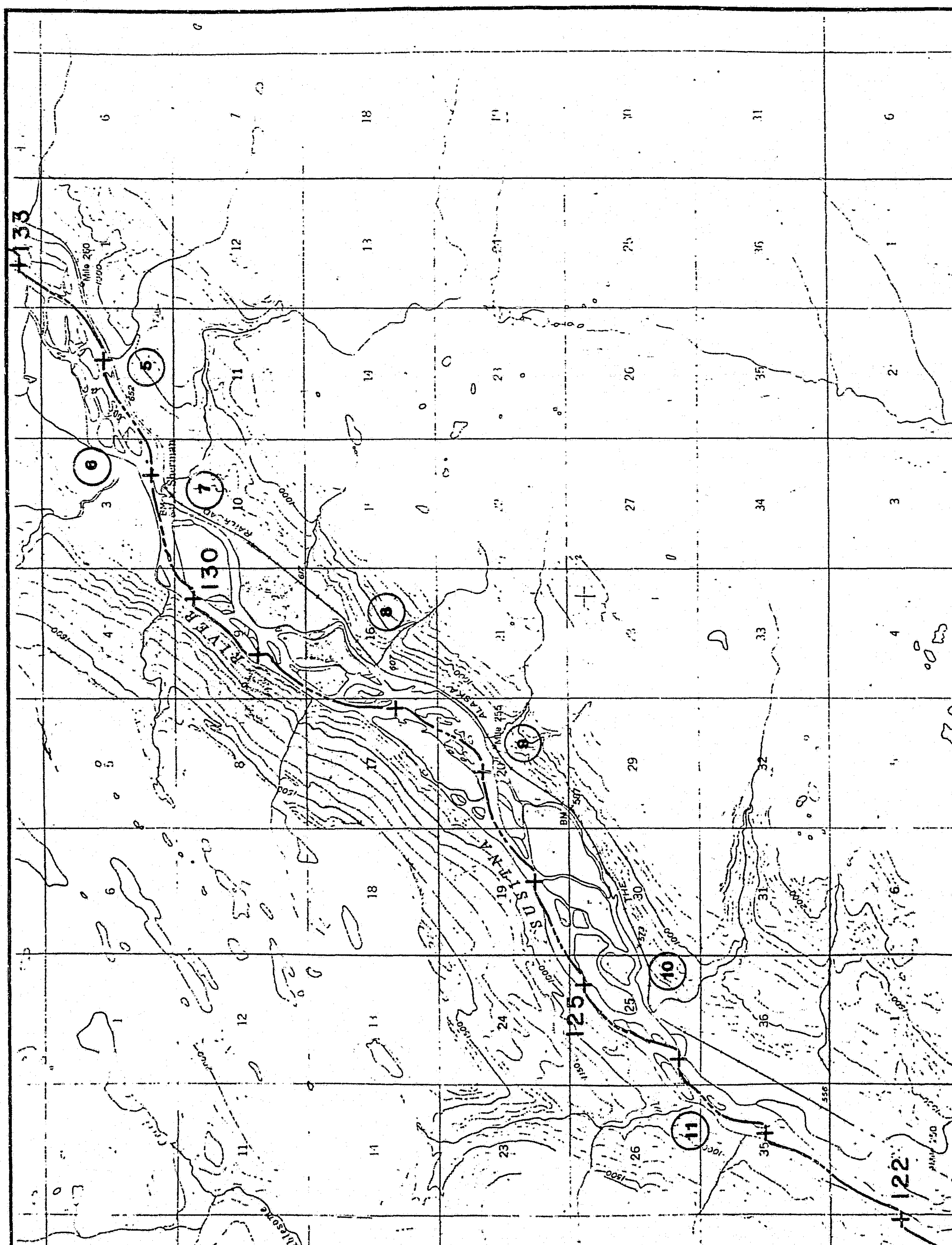
SUSITNA RIVER MILE INDEX

MILES 135 TO 144

(FROM U.S.G.S. TALKEETNA MNTS. D-6)

1-8 FIGURE 1.3

ACRES



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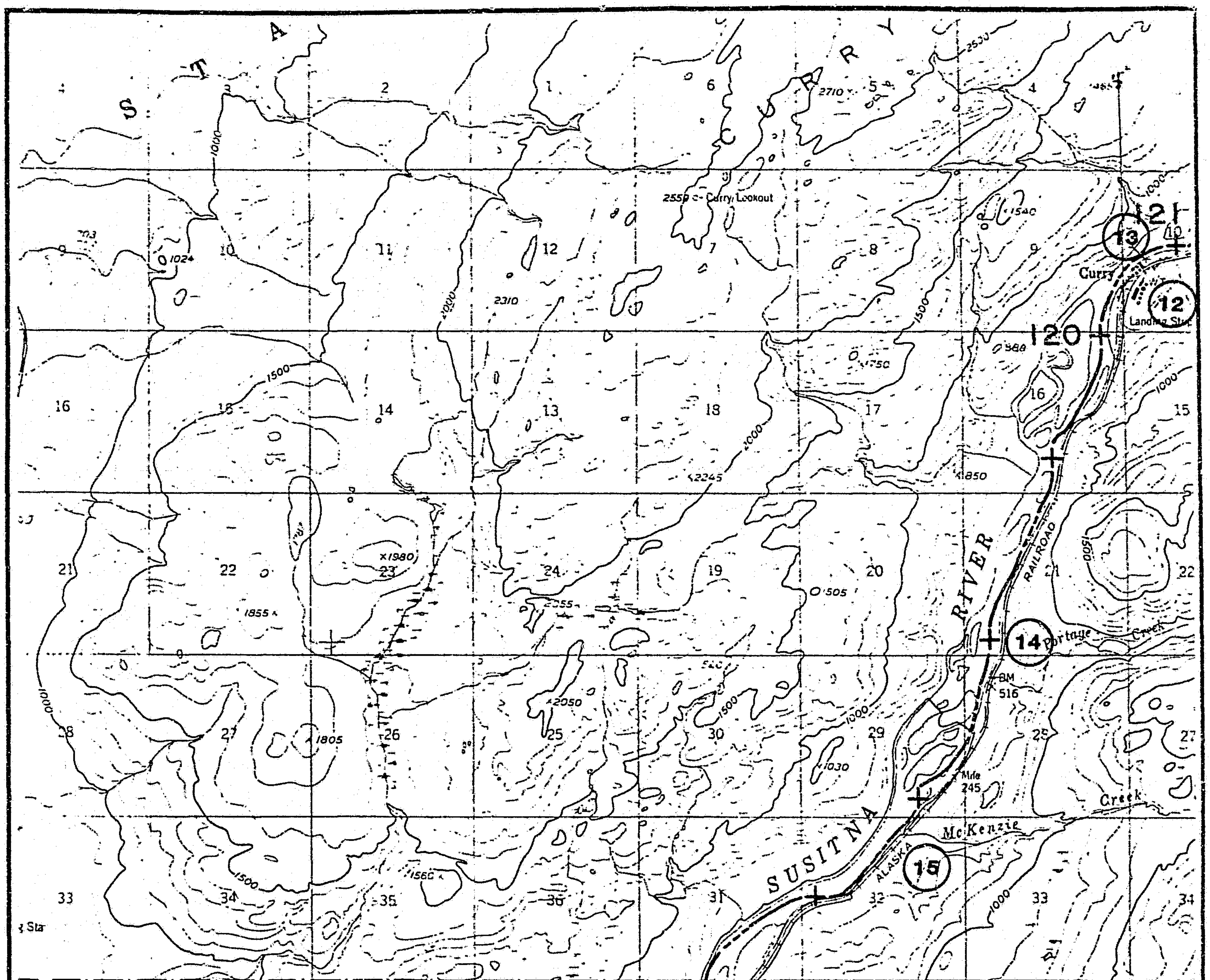
SUSITNA RIVER MILE INDEX
MILES 122 TO 133

(FROM U.S.G.S. TALKEETNA MNTS. C-6)

FIGURE 1.4

ACRES



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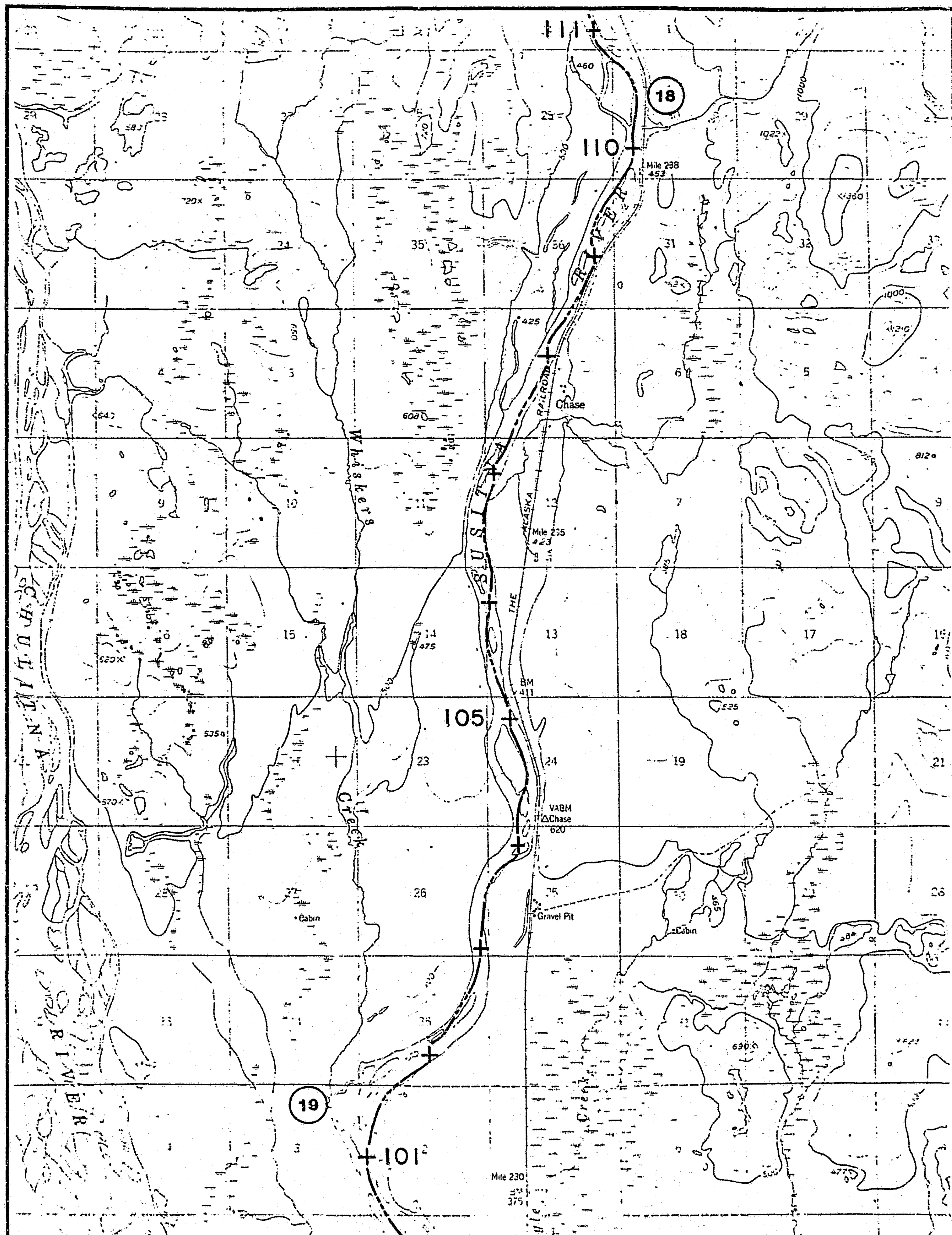
SUSITNA RIVER MILE INDEX
MILES 112 TO 121

(FROM U.S.G.S. TALKEETNA C-1)

FIGURE 1.5

ACRES



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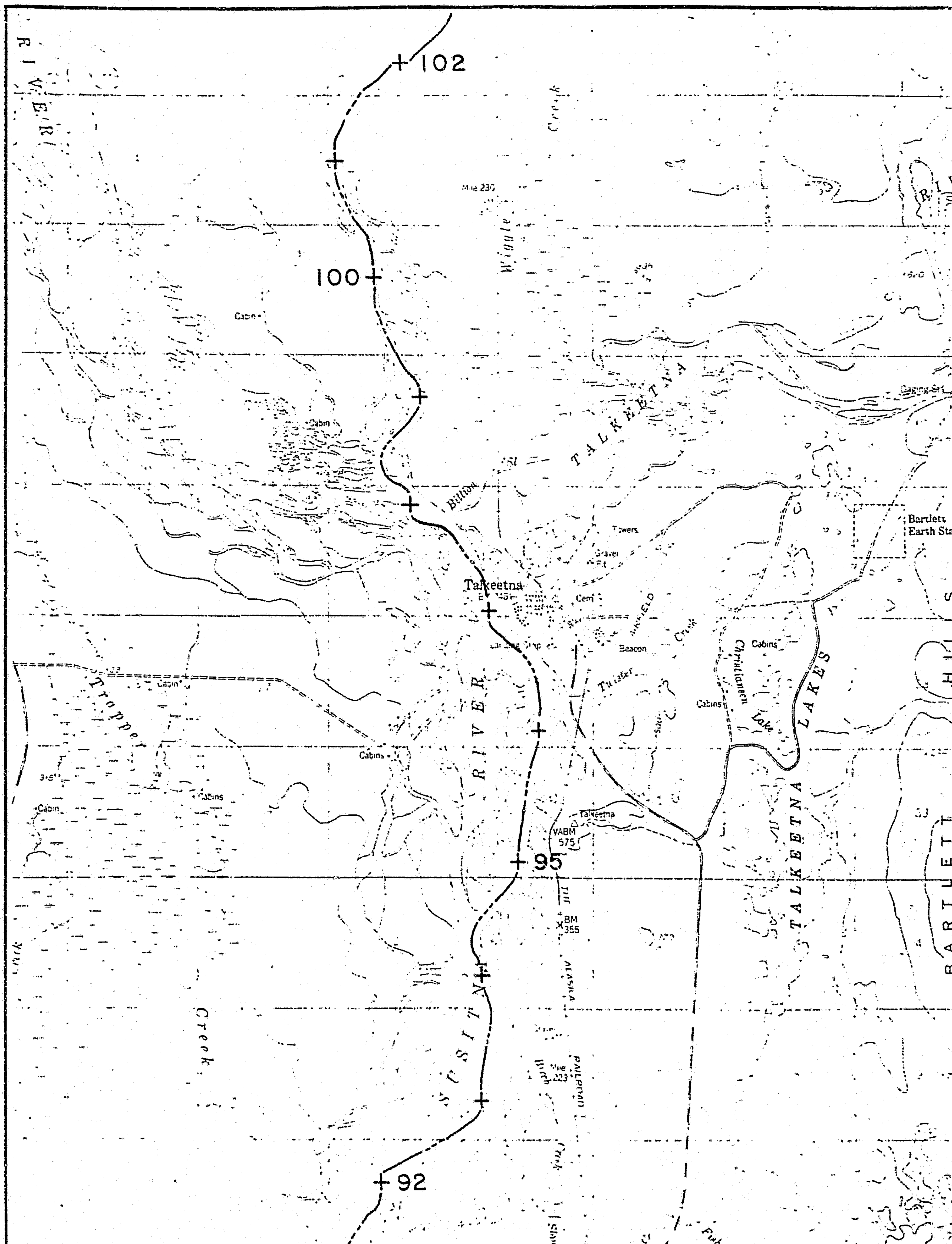
SUSITNA RIVER MILE INDEX
MILES 101 TO 111

(FROM U.S.G.S. TALKEETNA B-1)

FIGURE 1.6



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SUSITNA RIVER MILE INDEX
MILES 92 TO 102

(FROM U.S.G.S. TALKEETNA B-1)

FIGURE 1.7

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2 - PRIOR ANALYSES

Prior references to specific tributaries in the study reach were contained in the report "River Morphology" (R&M Consultants, Inc., 1982b). The pertinent analysis therein was strictly qualitative, but six of the streams under present consideration were addressed. The question of creek stability was discussed in several instances, and reference was also made to bedload movement or the stream's post-project effect on the Susitna River in other cases. The tributaries mentioned in the report include Portage Creek, Jack Long Creek, Indian River, Gold Creek, Fourth of July Creek, and Whiskers Creek.

Site-specific comments of a descriptive nature were also made by the Alaska Department of Fish and Game (ADF&G) in their report of 1981 field work (ADF&G, 1981). The sites were characterized as fish habitat and were related to several factors. Streams analyzed were Portage Creek, Indian River, Fourth of July Creek, Lane Creek, and Whiskers Creek. Applicable comments from each report are summarized below.

2.1 - Portage Creek

Portage Creek was expected in the R&M report to move the fan at its mouth out into the Susitna River to re-establish equilibrium with the reduced river stage and thus not become perched. It was noted that the stream delivers substantial bedload, consisting of coarse gravels, cobbles, and a few boulders, at high flows.

ADF&G's main study area extended 475 feet up the creek from its mouth. Their report noted that the width was about 250 feet at medium to high discharges and that the creek changed from single-channel conditions upstream to having two main bars at the mouth. Substrate consisted of rubble and cobble in the creek and on the high part of the bars. The creek is rapid, clear, and 3-5 feet deep. Adult chinook salmon have been reported there.

Three other sites on the creek were also studied by ADF&G. They were 4.5, 9.2, and 15.5 miles above the mouth. Rubble and cobble were again identified as the primary substrate, with gravel and sand also present at the uppermost site.

2.2 - Jack Long Creek

Referenced in the original R&M report as "the tributary at RM 144.8", Jack Long Creek was identified as possessing coarse bed sediments of boulders and cobbles. It thus may become perched, not being able to regrade them to the regulated Susitna

River level. With its narrow, stable streambed, it was not seen as delivering much sediment to the river.

2.3 - Indian River

The bed of Indian River was expected by R&M to degrade to the lowered post-project stage of the Susitna, and its alluvial fan would keep extending into the river. The river is steep and transports significant bedload during high flows. The accumulated material at the mouth consists of coarse gravel and cobbles, which help stabilize the bank of the Susitna River there and extend upstream and downstream for several hundred feet on the Susitna from the Indian River mouth. Most of the finer material gets carried away by the Susitna. The gradient of the tributary was seen as easily-adjusted to the varied level of the Susitna.

The main ADF&G study site covered the lower 500 feet of the river, which was reported to support coho, chinook, and chum salmon. ADF&G noted considerable deadfall and debris on gravel bars throughout the area. They identified the mouth as dynamic, constantly changing its bed structure and geomorphology, and they described the substrate as varied from sand to gravel and rubble.

As on Portage Creek, three upriver sites were also investigated by ADF&G: 2.7, 7.2, and 12.0 miles above the mouth. Gravel, rubble, and cobble bed material dominated the substrate. The morphology varied between single-channel and split-channel, meandering and braided. Again, as in the lower reach, considerable debris was noted on the bars.

2.4 - Gold Creek

Gold Creek's bed, described in the R&M report, consists of cobbles and boulders and is presently very steep at its mouth, so it was expected to resist degrading to the lowered Susitna stage. It is also located at the outside of a river meander, which provides adequate velocities to transport the creek's bedload sediments away from the mouth. The creek will thus have difficulty adjusting its bed to the lower, stabilized river.

2.5 - Fourth of July Creek

R&M expected the relatively flat gradient of Fourth of July Creek to easily adjust to the reduced Susitna River level. The presence of little sediment build-up at the mouth was seen as an indicator of low sediment transport.

The ADF&G report, however, described considerable bedload during their field work there. They noted drastic rerouting of the lower creek channels due to shifting of the gravel and rubble deposits. Several deep holes from the beginning of the summer were filled in with gravel, leveling the bed. Adult salmon which inhabited the creek mouth vicinity were pinks, chinook, and coho.

2.6 - Lane Creek

ADF&G noted that the mouth of Lane Creek was dynamic, undergoing constant change in bed structure and geomorphology. The creek was described as relatively narrow, shallow, fast-running, clearwater, and containing many pools and riffles. Substrate was typically gravel, rubble, and cobble, with some sand, silt, and boulders, and there was aquatic vegetation present. Adult salmon identified were chinook, chum, and pink.

2.7 - Whiskers Creek

Whiskers Creek's bed was identified in the R&M report as cobble-sized material overlain by a thin layer of fine sediments. River sediments are transported away from the mouth due to its location on the outside of a meander.

The Fish and Game report described the creek as relatively narrow, meandering, and containing may riffles and pools. Substrate was typically gravel and rubble with a partial cover of silt in some areas and some aquatic vegetation present. Chum and chinook adult salmon were reported to have been in the study area.

3 - QUALITATIVE ASSESSMENT OF CREEK STABILITY

Based on field surveys of the tributaries and field observations by the author and others, a qualitative analysis has been done of their likely stability under post-project conditions. In many cases, conditions are such that a qualitative examination was felt to be conclusive. In other cases, a more detailed look was necessary, and a quantitative analysis was undertaken. These are discussed preliminarily here and in greater depth in the next section. The primary reason of concern about the creek is given in parentheses after its name.

3.1 - Portage Creek (fish)

Portage Creek transports a substantial amount of bed material, as evidenced by the large bar at its mouth. Fairly large discharges have been observed in the creek, with accompanying high velocities, so it is anticipated that the streambed will remain scoured down to the confluence with the Susitna River. With the stage of the post-project mean annual flood in the Susitna being over seven feet lower than the existing mean annual flood level (see Table 4.3), the creek will likely push its sediment further out into the river channel. Considering the importance of the creek to anadromous fish migration and the creek's significant bedload, a more quantitative investigation was warranted. This may be found in Section 4.

3.2 - Jack Long Creek (fish)

This creek, which has it mouth at River Mile (RM) 144.8, has very coarse bed material, visible on the beach just downstream of the mouth. The cobble-sized material is probably transported only during very high discharges. An initial assessment indicates the creek will not degrade to the lowered level of the Susitna, but a quantitative analysis was performed.

3.3 - Indian River (fish)

The braided state of lower Indian River indicates ample bedload transport. Its tendency to shift major channels at its mouth also indicates it is an active river and one prone to fluctuation of discharge and sediment quantities. These factors, combined with the fairly small particle size, will most likely permit the river to downcut and maintain adequate depth into the Susitna. The constriction of the Susitna River by bedrock across from the Indian River confluence will keep the delta from expanding excessively and may contribute to growth of the gravel bar downstream. More detailed discussion is presented in Section 4.

3.4 - Gold Creek (fish)

Closer inspection of Gold Creek indicated more susceptibility to erosion than had been anticipated previously (Section 2.4). Gold Creek becomes extremely turbid during high flows, as observed on September 15, 1982. At that time, large boulders were also heard rolling along the creek bed near the mouth. Substantial bedload is thus expected. Despite the large size of the bed material present, the high velocities are expected to adequately scour the channel during post-project conditions. Analysis is given in Section 4.

3.5 - Tributary at RM 132.0 (railroad)

This creek cascades over very large rocks from the Alaska Railroad bridge down to its mouth. It is currently in a perched state, and further lowering of the Susitna River during project operation will have no noticeable effect at the bridge. The creek will remain perched above the Susitna.

3.6 - Fourth of July Creek (fish)

Fourth of July Creek, across the Susitna River from Sherman, carries substantial bedload. This is evidenced by ADF&G's loss of a staff gage, buried in the creek during a summer flood in 1981, and also by the growth and movement of several bars near the mouth of the creek. This leads one to believe that adequate scour will exist to keep the creek "deep" during post-project conditions. A closer examination is presented in Section 4.

3.7 - Sherman Creek (railroad, fish)

Sherman Creek receives high-velocity flows during peak events (observed at 8.5-9 ft/sec on 9/15/82), but the bed appears that it may be well armored. There is some large material near the mouth that may lead to perching of the creek. The creek mouth is sufficiently far below the railroad bridge (450 feet) that the bridge will not be threatened if any downcutting of the bed is initiated. A more in-depth analysis is given in Section 4.

3.8 - Tributary at RM 128.5 (railroad)

This creek comes from a very small drainage area (1.0 mi^2) above the railroad, and flows into Slough 9 just below the tracks. The bed material is large and not easily moved by the creek, which currently cascades into the slough. Since the creek is already perched, lowering of the river will have no significant impact on its stability.

3.9 - Tributary at RM 127.3 (railroad)

A large bar at the mouth of this creek indicates there is much movement of bed material. Fairly high flow velocities have also been observed (estimated from the air at 8 ft/sec on 9/15/82), so degradation of the creek bed seems likely. Since the railroad bridge is less than 50 feet from the creek mouth, some scour may be noted at the pile supports there. A quantitative assessment is presented in Section 4.

3.10 - Skull Creek (railroad)

The bed material currently exposed at the mouth of Skull Creek appears small enough to be easily transported at moderate flows. However, it is uncertain how representative this material is of the natural material in the channel since the railroad has apparently done some recent grading and channelization work above and below its bridge over the creek. They had evidently been experiencing some erosion problems there. Lowering of the Susitna during project operation will likely lead to downcutting of the creek channel to stabilize itself. Thus, the creek could continue to be a maintenance concern to the railroad and could require additional preventive or remedial measures to protect the integrity of the bridge. Section 4 presents a more detailed analysis.

3.11 - Tributary at RM 123.9 (fish)

This creek on the west side of the Susitna River has substantial bedload during large floods, evidenced by the sizeable gravel bar on the downstream side of its confluence with the Susitna. The bed appears quite well armored at present, however, and may be perched until very high-flow events are received at the mouth. This may be on the order of 2-3 years after the start of project operation. A quantitative analysis is contained in Section 4.

3.12 - Deadhorse Creek (fish, railroad)

Deadhorse Creek has a large range of bed material sizes, from sand to boulders. Its bed appears armored, and it will probably not degrade until particularly large floods are experienced in the creek.

3.13 - Tributary at RM 121.0 (fish)

This small creek (1.5 mi^2), across the river from Curry Creek, has large deposits of gravel at its mouth, indicating ample movement of bed material. The creek probably will downcut during lowered Susitna River stages. Section 4 has a more detailed discussion.

3.14 - Little Portage Creek (railroad)

The bed of this creek at RM 117.4 is well armored, and its mouth is about 600 feet downstream of the railroad bridge. It will remain perched and thus not threaten the railroad crossing.

3.15 - McKenzie Creek (fish)

The bed material in McKenzie Creek is small enough that its observed velocities (6 ft/sec on 9/15/82) should keep it well cut-down. The large bar at the mouth indicates there is considerable movement of the stream gravels. Section 4 has a quantitative assessment.

3.16 - Lane Creek (fish)

The bed of Lane Creek appears armored but still transports quite a bit of bedload at moderate flows. It has apparent capacity to degrade, as indicated by its recent shift in flow distribution. The creek formerly flowed primarily into the slough upstream of the creek mouth and had only a small portion of the flow going directly into the Susitna. As of the end of the 1982 open-water season, however, most of the discharge now enters the river directly. Perching of the creek is not expected as an equilibrium condition.

3.17 - Gash Creek (fish)

Close inspection of this creek was not made in the field, due to inaccessibility, but an aerial reconnaissance revealed fairly fine-grained sediments. These are expected to be scoured easily enough that fish access to the stream will be maintained.

3.18 - Tributary at RM 110.1 (railroad)

Again, only aerial inspection was possible at this creek, but large gravel deposits at its mouth indicate significant bedload. The creek probably will degrade, which could cause problems at the railroad bridge less than 50 feet upstream of the mouth.

3.19 - Whiskers Creek (fish)

Whiskers Creek flow into Whiskers Slough several hundred feet above the slough's confluence with the river. The mouth of the creek has a very flat gradient, substantial depth, and a fairly low velocity due to backwater effects from the Susitna. Its bed is not expected to be affected by the lowered level of the river. The depth of flow in the creek will also probably not change appreciably, though it could be reduced somewhat due to the removal of the backwater condition.

4 - QUANTITATIVE ANALYSIS

4.1 - Analysis

Numerical analysis of the tributaries' sediment regimes has been undertaken to attempt to more closely define their post-project stability. More correctly, this assessment should be termed "semi-quantitative", rather than strictly quantitative. A rigorous mathematical development has not been performed, as such an undertaking would have involved a large data-collection effort at numerous sites, determined beyond the scope of the present study. Rather, examination has been made through use of a proportional relationship for bed material transport.

An appropriate relationship for analyzing bed stability has been presented by Simons, Li & Associates (SLA) (1982). Their statement of proportionality is that

$$QS \propto Q_S D_{50}$$

Where:

Q = water discharge
S = channel slope
Q_S = sediment discharge, and
D_{50} = bed material fall diameter

This is essentially the relationship proposed by Lane (1955), except that fall diameter, which considers the effect of temperature on sediment transport, has been substituted for Lane's physical median diameter.

The concept is applied to the Middle Susitna case by considering the project effects at the tributary mouths. The general effect of project operation will be lowering of the stage in the river, which has the immediate result of increasing the creek's slope locally at its mouth. This momentarily upsets the proportionality stated above, so one or more of the other parameters must consequently adjust. The stream discharge Q is assumed to be constant. Whichever appropriate discharge level is selected (such as the mean annual flood used herein), there is no known reason that it should change after construction of the project. Therefore, Q_S or D_{50} must change so that their product increases accordingly with the slope. If mean particle size is unchanged, the sediment discharge rate will increase. Thus, local scour is likely to increase, eventually leading to headcutting back up the stream channel until the slope is re-stabilized up to a geologic control point. This process is illustrated in Figure 4.1.

In the example just given, it is possible that the D_{50} may increase, rather than the sediment discharge. This could be the case if increased channel slope at the mouth increased local velocities but only enough to remove and transport the finer-grained particles from the bed. This would increase the mean particle size in the bed (and also the fall diameter, as SLA addressed) and would effectively "armor" the channel for that discharge. The creek mouth would thus be stabilized at its steepened slope.

The important parameters in the relationship, then, are the existing channel slope, the sediment discharge rate, the bed material size distribution, and the degree of lowering expected in the river stage at the mouth. These have been quantified here, except for the sediment discharge rate. Channel slopes are tabulated in Table 4.1, and Table 4.2 presents bed particle sizes. Also, there is considerable uncertainty in the particle size distribution (which is presented rather than the fall diameter), due to on-site difficulties in obtaining representative samples during high creek flows.

The change in Susitna River stage caused by project operation is another quantity difficult to define precisely with existing data. For lack of better information, linear interpolation was used between cross-sections to obtain estimates of pre-project and post-project stages at tributary mouths (see Table 4.3). This does not consider local effects of islands, bars, and sloughs, so the actual elevations tabulated may not be reliable. Instead, these numbers should be interpreted as a guide to the magnitude of the change in water surface elevation to be expected. Mean annual floods, computed by three regional methods, are presented for comparison in Table 4.4.

Results of the semi-quantitative assessment are tabulated in Table 4.5, along with a summary of the pertinent parameters from SLA's relationship. An indication is given also as to each creek's expected stability following slope increase due to river lowering at the mouth. The six creeks where a possible impact is foreseen are discussed in Section 4.2.

In their development of methodologies for qualitative analysis, SLA noted that, "quantitative prediction of response can be made if all of the required data are known with sufficient accuracy." Following discussion of a case study in the text, they explain further:

> The problem of predicting river response below a dam and the extent to which development of an armor layer will limit degradation is extremely complex. While it is recognized that bank erosion, discharge variability, meandering, and sediment inflow from tributaries affect channel response below dams,

> analytical techniques currently available in the literature do not address response in the complex environment implied by these variables. Physical-process computer modeling offers the most promising approach to solving this complex problem" (SLA, 1982).

Certain of the Susitna River tributaries below Devil Canyon may be found subsequent to this analysis to justify collection of field data for physical-process computer modeling. This could be in cases where uncertainty still exists about the post-project stability of the streams and also where a major resource is at stake, such as an important salmon run or a railroad crossing likely to require substantial maintenance expenditures.

4.2 - Discussion of Impacts

Table 4.5 identified six of the nineteen study tributaries as likely to experience impacts on existing uses of the creeks due to project operation. Of these six, three may affect fish migration, and three may affect bottom stability at railroad bridges.

4.2.1 - Fishery Impacts

In considering the magnitude of the impact at the mouths of the fish-access streams, it is necessary to estimate the change in river level during the time of year when the fish make their entrance to the stream. Table 4.3 presented the change in Susitna mean annual flood stage at the creek mouths, which is important to consider in the scour and degration analysis. Mean annual flood flows, however, are not necessarily the times during which fish enter the streams, since the floods usually occur only about every other year. Rather, the mean monthly river flow during the time of migration would be a more appropriate indicator of the Susitna River level currently experienced by the fish.

Estimates of the times that creek access is required by spawning salmon were made by reviewing the 1981 observations of ADF&G (ADF&G, 1981a and ADF&G, 1982). Species observed in each creek were noted, as were the total length of time each species was observed spawning in the system. This is only one year's observations, and dates may vary from year to year, but timing is expected to be representative of the general case. Tables 4.6 (A&B) summarize the reports' observations. It can be seen from the table that all three creeks are used in July, August, and September, and Jack Long Creek is used in June as well.

Mean monthly flows for the months of interest are shown for existing and post-project conditions in Table 4.7.

Corresponding Susitna water-surface elevations are also given for the creek mouths, with the resulting stage decreases tabulated. The same methodology was used in preparing Table 4.7 as had been used for Table 4.3. It is apparent from the table that the greatest changes from existing conditions will occur in June and July, where the river level will drop from 2.8 to 3.9 feet (on a mean monthly basis). Also, comparing the three streams, Jack Long Creek will receive the greatest impact in terms of reduced river stage.

The true impact of the lowered river levels in the perched tributaries depends on several factors: the actual minimum depths in the reach between the Susitna River and the creek, the distance over which this minimum depth extends in the creek, and the ability of the migrating fish to travel over or through this "limiting zone". The depth of water at the mouth of the perched stream will be more a function of the stream's flow than the Susitna River's flow, though backwater effects from the Susitna will influence the depth as well. Thus, the numbers in the last column of Table 4.7 may be used as indicators of the change to be realized at the streams by the fish. However, they should not be applied literally since channel geometry and hydrology of the tributary will affect the actual stream depth. Analysis of these conditions to determine specific impacts on the salmon is judged to be beyond the scope of this study.

To comment further on the importance of the subbasin hydrology, the precipitation received in the watershed prior to and during the salmon runs will have probably the greatest effect on the stream's ability to support the migration. If the stream has high streamflow, fish will possibly be able to negotiate the channel even over the "perched" mouths. However, if the stream is excessively low, fish will probably be unable to travel upstream, whether the creek mouth is perched or not. Barrett related that a creek which appears to be Sherman Creek (based on location and shape), was reported by local residents to ADF&G field personnel to have had its "'last "large" escapement of pink salmon in 1966. During the summer of 1967 the stream de-watered in all but its "upper" section. Spawning salmon have not been observed in this stream since 1966.' In 1974 during the months of July and August stream flow was subsurface in the first one hundred yard section of the stream; surface flow occurred at the mouth of the stream in early September" (Barrett, 1974).

4.2.2 - Railroad Crossing Impacts

Degradation of the creek bed is the concern in the railroad streams, so the pertinent river stage change to consider is the decrease in mean annual flood. The floods in the creeks are the primary initiators of the downcutting process. This is particularly true since pre-project floods essentially coincide in the tributaries and mainstem, but post-project tributary floods will occur when the Susitna level is substantially lower than the creek mouths. The reduction in river stage is about 3.6 feet at RM 127.3, 4.2 feet at Skull Creek, and 7.0 feet at RM 110.1 (from Table 4.5).

Whether scouring of the creek bed becomes a problem at the railroad crossings and threatens to scour any of the bridge piers depends additionally on the depth of the piers, the location of geologic controls to restrict the degradation, the existing channel slope, and the distance from the creek mouth. The primary effect of distance will be the time required to achieve the "stabilized" degradation condition. In general, the amount of degradation at the mouth is expected to proceed fully upstream, as illustrated in Figure 4.1. If the anticipated scour is determined to be excessive, based on the existing bridge pier installations, a couple of mitigative measures are available. Piers could be installed to greater depths, or the streambed could be manually armored with larger-size material to prevent downcutting. This latter technique could likely be quite effective even if placement is only over a short distance downstream of the bridge.

Inspection of the stream profiles (thalweg plots) in Attachment A gives a rough indication of the location of the geologic control for the streams. Lacking other data, a uniform channel slope could be interpreted as a reach where the stream is essentially alluvial, and the bed material has stabilized at a slope based on hydraulic and morphologic factors. Likewise, a "hump" upward likely indicates existence of a bedrock feature, which would be a limit to stream-degradation. The profile for the tributary at RM 127.3 shows such a hump about 350 feet upstream from the mouth. Since the railroad bridge is less than 50 feet from the mouth, it is almost certain to receive the same degradation expected at the mouth (i.e. 3.6 feet).

Skull Creek's profile indicates a possible geologic control near Station 850, about 250 feet from the mouth. This is right near the railroad bridge, and, since it is a hump of only 1-2 feet, it is probably not significant. As discussed in Section 3.10, the railroad had evidently done some recent gravel-filling in the creek to help stabilize the channel; this may have accounted for the rise in the bed near the bridge. More significant, however, is a marked flattening in the bed slope near Station 500, probably due to bedrock influence. If the upstream migration of the scour is not limited below this, then the bridge will experience some degradation. A conservative estimate would again be the same amount anticipated for the mouth of the creek, 4.2 feet.

The profile of the tributary at RM 110.1 shows a significant decrease in the channel slope about 100 feet from the mouth. The average gradient from 1000 feet upstream to that point is 412 feet per mile, and from there to the mouth it flattens to 270 feet per mile, about one-third less. This break in slope is just above the railroad bridge and indicates the creek's likely capacity to degrade at least to the bridge. The stream will probably downcut the full amount of the river change, which is 7.0 feet.

TABLE 4.1

SUSITNA TRIBUTARY STABILITY ANALYSIS

EXISTING THALWEG SLOPES NEAR MOUTHS

No.	Name	Approx. Channel Width near Mouth (ft)	Distance[1] (Surveyed) (ft)	Thalweg Elevations Mouth (ft, msl)	Thalweg Elevations Upper End (ft, msl)	Change in Elevation (ft)	Average Slope (ft/ft)
1	Portage	250	400	834.7	841.0	6.3	.0158
2	Jack Long	40	900	786.4	811.2	24.8	.0276
3	Indian	250	600	705.5	714.5	9.0	.0150
4	Gold	45	1000	687.8	707.2	19.4	.0194
5	132.0	15	350	630.9	675.7	44.8	.1280
6	4th of July	85	950	616.4	637.2	20.8	.0219
7	Sherman	30	1000	618.8	659.1	40.3	.0403
8	128.5	20	300	593.8	612.0	18.2	.0607
9	127.3	50	600	584.6	620.4	35.8	.0597
10	Skull	50	552	558.1	566.9	8.8	.0159
11	123.9	30	426	551.8	561.6	9.8	.0230
12	Deadhorse	70	942	528.1	560.5	32.4	.0344
13	121.0	40	362	526.5	544.0	17.5	.0483
14	L. Portage	25	500	497.6	500.0	2.4	.0048
15	McKenzie	35	1115	487.6	522.8	35.2	.0316
16	Lane	40	1125	465.3	489.4	24.1	.0214
17	Gash	N/A	N/A	N/A	N/A	N/A	N/A
18	110.1	20	1000	442.8	518.5	75.7	.0757
19	Whiskers	45	850	362.9	363.8	0.9	.0011

1 Slopes are the average slopes to the mouths from either a major break in gradient an appreciable distance upstream or from the upper extent of the thalweg profile survey, whichever occurs first. The tabulated values are the distances over which the elevation changes are measured.

TABLE 4.2
SUSITNA TRIBUTARY STABILITY ANALYSIS
BED MATERIAL PARTICLE-SIZE DISTRIBUTIONS

No.	Name	Bed Particle Size D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Remarks
1	Portage	14	33	78	Larger material in channel.
2	Jack Long	-	-	-	No analysis and no gravel bars.
3	Indian	33	50	76	Probably representative.
4	Gold	17	36	76	Much larger material moving in channel.
5	132.0	-	-	-	Very large, already perched.
6	4th of July	14	25	45	Channel material larger.
7	Sherman	16	30	58	Channel material larger.
8	128.5	-	-	-	No analysis.
9	127.3	-	-	-	No analysis.
10	Skull	10	20	39	Perhaps representative.
11	123.9	-	-	-	No analysis but bed appears armored.
12	Deadhorse	8	19	43	Representative?
13	121.0	7	20	50	Representative?
14	L. Portage	13	26	51	Representative?
15	McKenzie	9	18	37	Probably representative.
16	Lane	5	13	35	Channel material larger.
17	Gash	-	-	-	No analysis.
18	110.1	-	-	-	No analysis.
19	Whiskers	-	-	-	No analysis.

Notes:

1. Analysis was done using the grid-sampling method described by Kellerhals and Bray (1970), using bed material/grid photographs taken by the author at the creek mouths on September 15, 1982.

2. Comments in the Remarks column give the author's opinion as to how representative the bed material photographed and analyzed was of the true channel material. In some cases, the need for expedience on-site precluded careful selection of exposed material, and subsequent consideration indicated other material may have been more representative. In other cases, high water prevented adequate inspection of the material actually in the channel, so a bank or bar was selected alternatively. Remarks for creeks where analysis was not done are comments based on visual inspection or other general information.

3. Photos of the bed material and plots of the particle-size distributions are presented in Attachment C.

TABLE 4.3
SUSITNA TRIBUTARY STABILITY ANALYSIS
PROJECT EFFECTS ON MEAN ANNUAL FLOOD STAGES
AT TRIBUTARY MOUTHS

No.	Name	Susitna W.S.E.[1] at Creek Mouth Pre-Project[2] (ft., msl)	Post-Project[2] (ft., msl)	Change (ft.)
1	Portage	843.3	835.7	-7.6
2	Jack Long	793.9	787.8	-6.1
3	Indian	711.6	706.1	-5.5
4	Gold	690.8	685.7	-5.2
5	132.0	632.2	629.1	-3.2
6	Fourth of July	626.6	620.5	-6.1
7	Sherman	622.9	618.5	-4.4
8	128.5	597.5	593.5	-4.0
9	127.3	587.2	583.6	-3.6
10	Skull	562.1	557.9	-4.2
11	123.9	554.6	549.6	-5.0
12	Deadhorse	529.3	524.9	-4.4
13	121.0	529.2	524.8	-4.4
14	L. Portage	505.9	500.9	-5.0
15	McKenzie	496.2	490.0	-6.2
16	Lane	471.7	466.7	-5.0
17	Gash	455.2	450.0	-5.2
18	110.1	443.6	436.6	-7.0
19	Whiskers	368.4	364.9	-3.5

1 W.S.E. = Water-surface elevation. Elevations were estimated by linear interpolation between cross-sections from water-surface profile computation results (R&M Consultants and Acres American, 1982). See qualifications regarding linear interpolation in text, Section 4.

2 Magnitudes assumed for mean annual Susitna River flood peaks were 52,000 cfs and 13,400 cfs at Gold Creek for pre-project and post-project, respectively. These values were used for calibration runs of the HEC-2 model and also agree fairly closely with the estimated mean annual flood peaks (reference R&M Consultants, 1981, Table 3.14, 2-year recurrence).

TABLE 4.4

SUSITNA TRIBUTARY STABILITY ANALYSIS

MEAN ANNUAL FLOOD PEAKS

		Basin Characteristics					Discharge			Average Q (Mean Annual)
	Creek	A (mi^2)	LP (%)	P (in)	T (°F)	F (%)	$Q_{2(FS)}$ (cfs)	$Q_{2(L)}$ (cfs)	$Q_{B(E)}$ (cfs)	(cfs)
1.	Portage	175.6	1	30	-5	25	1450	1850	1730	1680
2.	Jack Long	18.0	1	30	-4	60	159	195	190	181
3.	Indian	82.2	1	30	-5	46	696	834	828	786
4.	Gold	24.1	1	30	-4	13	212	316	252	260
5.	132.0	1.48	1	30	-4	25	14	21	17	17
6.	4th of July	20.8	4	30	-4	32	138	205	218	187
7.	Sherman	6.76	2	30	-4	14	54	88	73	72
8.	128.5	1.03	0	30	-4	25	12	17	12	14
9.	127.3	2.11	0	30	-4	15	25	36	24	28
10.	Skull	4.49	1	30	-4	18	42	63	49	51
11.	123.9	6.86	3	30	-4	35	50	75	75	67
12.	Deadhorse	4.61	1	30	-4	34	43	59	51	51
13.	121.0	1.52	2	30	-3	50	13	18	17	16
14.	L. Portage	2.45	4	30	-3	76	17	25	27	23
15.	McKenzie	2.07	2	30	-3	98	17	22	23	21

Table 4.4 (Continued)

	Creek	Basin Characteristics A (mi^2)	LP (%)	P (in)	T (°F)	F (%)	Discharge $Q_{2(FS)}$ (cfs)	$Q_{2(L)}$ (cfs)	$Q_{B(E)}$ (cfs)	Average Q (Mean Annual) (cfs)
16.	Lane	10.0	0	30	-3	50	112	131	107	117
17.	Gash	0.43	9	30	-3	91	3	4	5	4
18.	110.1	1.98	1	30	-3	88	19	23	22	21
19.	Whiskers	15.4	16	30	-3	84	71	107	163	114

Explanation of Columns:

A — Basin drainage area, planimetered from USGS topographic maps.
LP — Percentage of basin area in lakes and ponds.
P — Mean annual precipitation (Lamke, 1979, Fig. 4-16).
T — Mean minimum January temperature (Lamke, 1979, Fig. 4-16).
F — Percentage of basin area that is forested (USGS 1:63,360 quad sheets).

$Q_{2(FS)}$ — Mean annual flood peak (2-year recurrence interval), computed by the regression equation:
$Q_2 = (0.154)A^{0.97}\ (LP+1)^{-0.31}\ P^{1.28}$ (Freethey and Scully, 1980).

$Q_{2(L)}$ — Mean annual flood peak, computed by the regression equation:
$Q_2 = 2.07\ [A^{.934}\ P^{.744}\ (T+30)^{.012}\ ]\ /\ [(LP+1)^{.188}\ (F+1)^{1.45}\ ]$, (after Lamke, 1979).

$Q_{B(E)}$ — Bankfull discharge, computed as a function of drainage area from the regression equation:
$Q_B = 11.5A^{.097}$ (after Emmett, 1972, Fig. 8), developed for Southcentral Alaska.

TABLE 4.5

SUSITNA TRIBUTARY STABILITY ANALYSIS

SUMMARY OF SEMI-QUANTITATIVE ASSESSMENT

No.	Name	Q_2[1] (cfs)	S[2] (ft/ft)	D_{50}[3] (mm)	ΔE[4] (ft)	Reason for Concern	Response to Increased Slope at Mouth	Impacts Foreseen
1	Portage	1680	.0158	33	7.6	fish	degrade	
2	Jack Long	181	.0276	-	6.1	fish	perch	possible restriction of fish access
3	Indian	786	.0150	50	5.5	fish	degrade	
4	Gold	260	.0194	36	5.2	fish	degrade	
5	132.0	17	.1280	-	3.2	RR	perch	
6	4th of July	187	.0219	25	6.1	fish	degrade	
7	Sherman	72	.0403	30	4.4	RR, fish	perch	possible restriction of fish access
8	128.5	14	.0607	-	4.0	RR	perch	
9	127.3	28	.0597	-	3.6	RR	degrade	possible limited scour at RR bridge
10	Skull	51	.0159	20	4.2	RR	degrade	possible limited scour at RR bridge
11	123.9	67	.0230	-	5.0	fish	perch	
12	Deadhorse	51	.0344	19	4.4	fish, RR	perch	possible restriction of fish access
13	121.0	16	.0483	20	4.4	fish	degrade	
14	L. Portage	23	.0048	26	5.0	RR	perch	
15	McKenzie	21	.0316	18	6.2	fish	degrade	
16	Lane	117	.0214	13	5.0	fish	degrade	
17	Gash	4	N/A	-	5.2	fish	degrade	
18	110.1	21	.0757	-	7.0	RR	degrade	possible limited scour at RR bridge
19	Whiskers	114	.0011	-	3.5	fish	perch (but backwater)	

[1] Mean annual flood, from Table 4.4.
[2] Average channel slope, from Table 4.1.
[3] Median bed particle size, from Table 4.2.
[4] Decrease in Susitna River stage at mouth, from Table 4.3.

TABLE 4.6
SUSITNA TRIBUTARY STABILITY ANALYSIS
1981 SALMON RUN TIMING AND SPECIES IN SELECTED CREEKS
(UPSTREAM OF TALKEETNA)

TABLE 4.6A

Species of Salmon	First Observed	Last Out
Chinook	6/15/81	9/7/81
Chum	7/17/81	9/15/81
Coho	7/27/81	9/19/81
Pink	7/18/82	8/20/81
Sockeye	7/5/81	9/29/81

TABLE 4.6B

Creek	Species Present	Earliest Observed (1981)	Latest Out (1981)
Jack Long	Chinook, pink, maybe coho & chum	6/15	9/7 - 9/19
Sherman	Chum, pink	7/17	9/15
Deadhorse	Coho, chum, pink	7/17	9/19

NOTE: Information on species observed in creeks and timing of the runs was obtained from ADF&G (1981a and 1982).

TABLE 4.7
SUSITNA TRIBUTARY STABILITY ANALYSIS
DECREASE IN MEAN MONTHLY SUSITNA RIVER STAGE AT SELECTED CREEK MOUTHS

Creek	Month	Mean Monthly Pre-Project Flow* (cfs)	W.S.E. at Creek Mouth** (ft, msl)	Mean Monthly Post-Project Flow* (cfs)	W.S.E. at Creek Mouth** (ft, msl)	Change in W.S.E. (ft)
Jack Long	June	27,700	790.8	9,900	786.8	-3.9
	July	24,400	790.2	8,400	786.4	-3.9
	August	22,000	789.8	12,600	787.4	-2.5
	September	13,200	787.8	10,500	787.0	-0.8
Sherman	July	24,400	620.1	8,400	617.3	-2.8
	August	22,000	619.7	12,600	618.0	-1.7
	September	13,200	618.1	10,500	617.8	-0.3
Deadhorse	July	24,400	526.7	8,400	523.9	-2.8
	August	22,000	526.3	12,600	524.8	-1.5
	September	13,200	524.9	10,500	524.3	-0.6

* Flows in the Susitna River at Gold Creek. Pre-project flows are 32-year averages, through 1981; and post-project flows were obtained from simulated power operations assuming both projects, Case C (Acres American, 1982).

** Water-surface elevation corresponding to stated Gold Creek flow. Elevations were computed in the same manner as in Table 4.3.

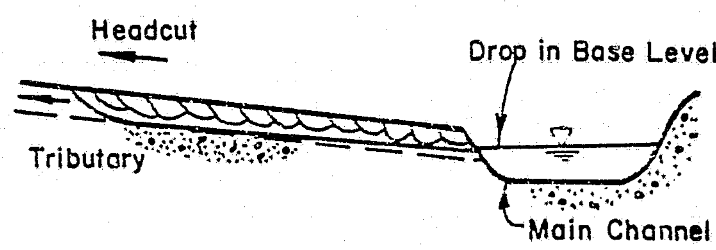

Figure 4.1 Lowering of base level for tributary stream.

Source: SLA, 1982, Fig. 8.7.

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ATTACHMENT A

PLAN-VIEW PHOTOS, THALWEG PROFILES, AND CROSS-SECTIONS AT MOUTH FOR STUDY TRIBUTARIES

ATTACHMENT A - GENERAL NOTES

1. All plan-view photos are reproduced from the river hydrographic surveys series and are at a scale of 1" = 500'.

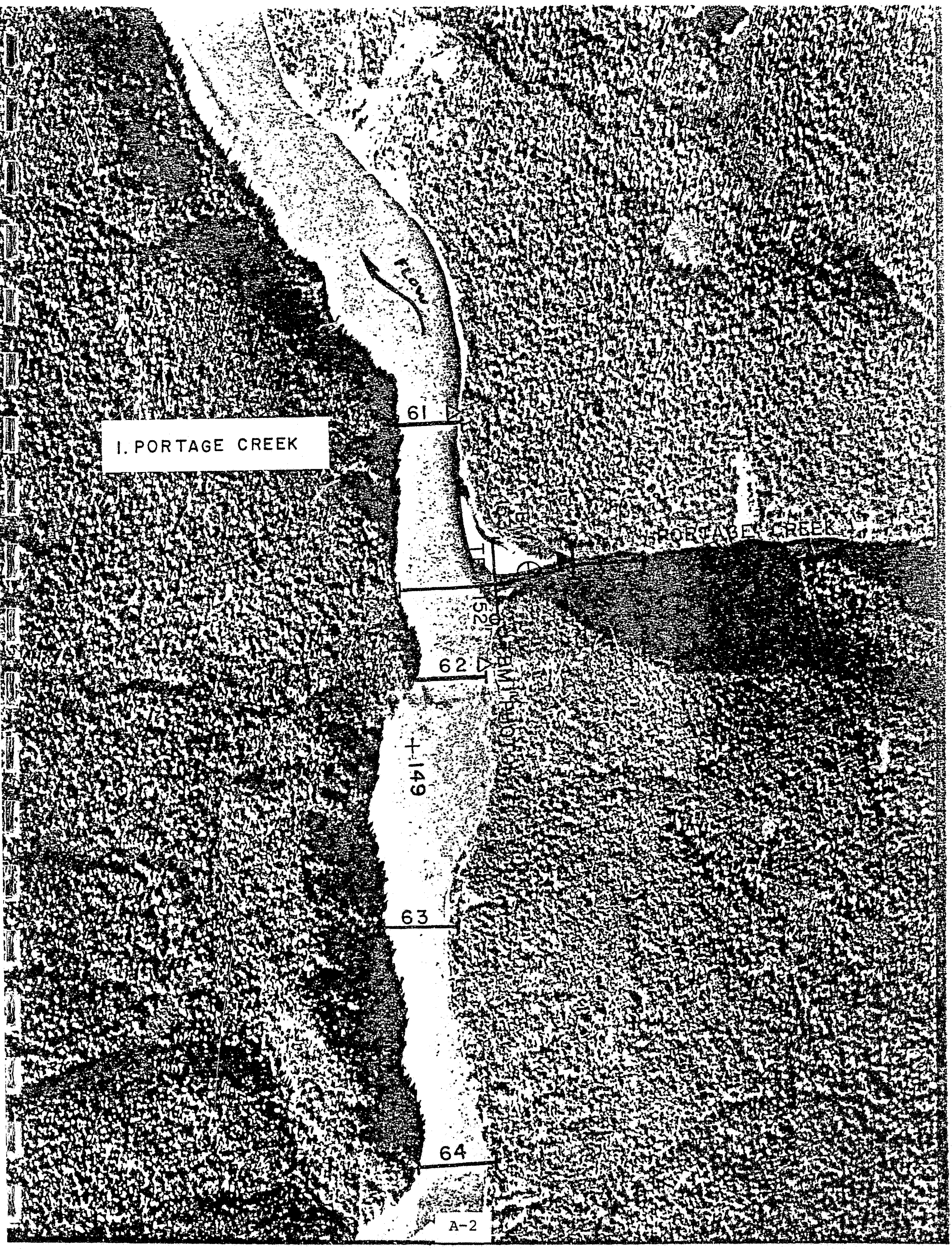
2. Heavy lines in the creeks from the mouth upstream indicate the length of the thalweg profile survey.

3. All survey work in the tributaries was done by R&M Consultants during the summer of 1982. Most of the mainstem cross-sections were surveyed in 1980, also by R&M.

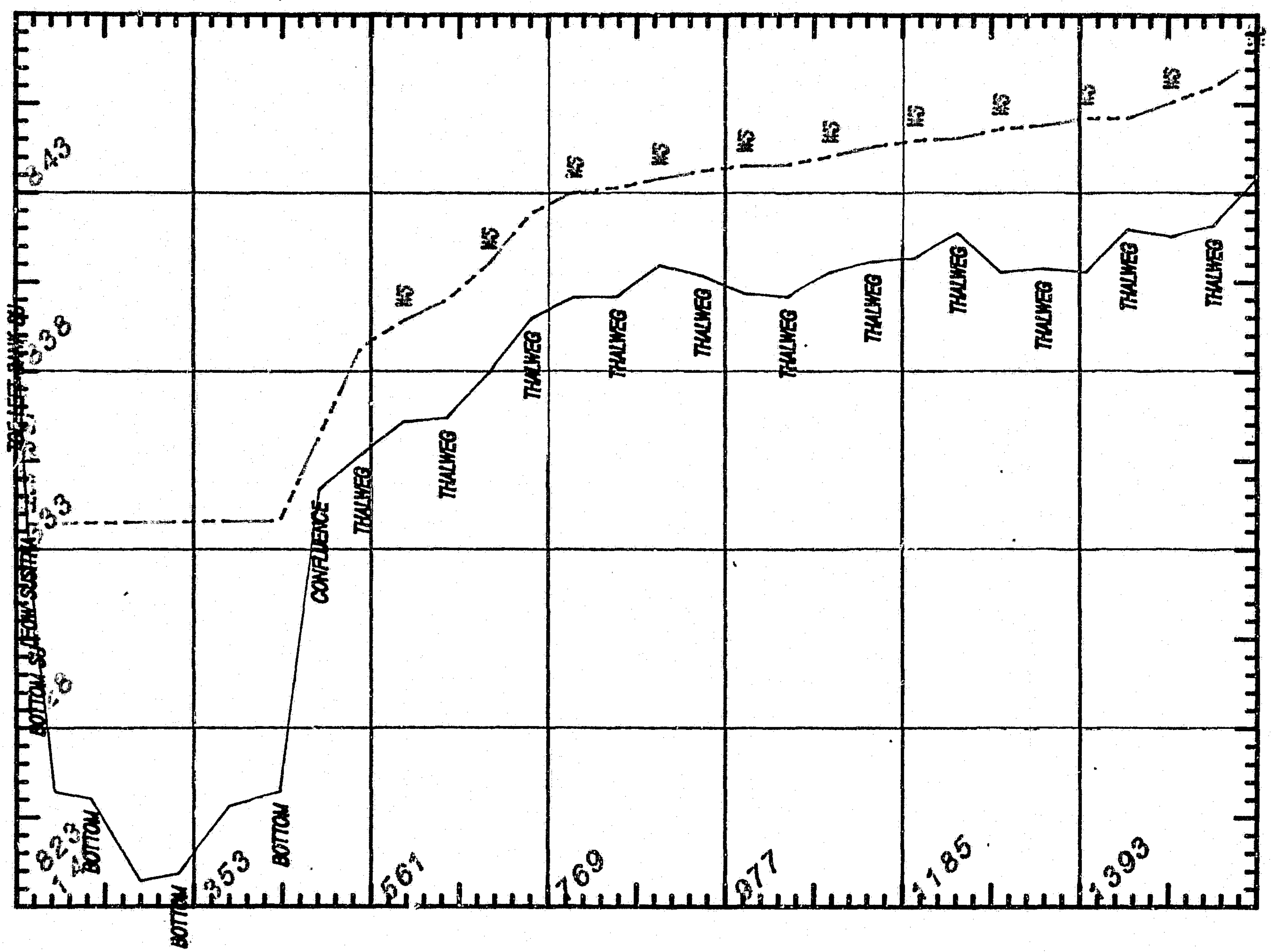
4. Creek thalwegs in some cases were surveyed on different days from the corresponding river cross-sections at the mouths. There may thus be some discontinuity in the plotted water surfaces from the stream to the river.

5. Gash Creek (tributary Number 17) was not surveyed and thus has no thalweg profile or cross-section included.

6. All cross-sections are viewed looking downstream.


Flow
61
I. PORTAGE CREEK
PORTAGE CREEK
152
62
149
63
64

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

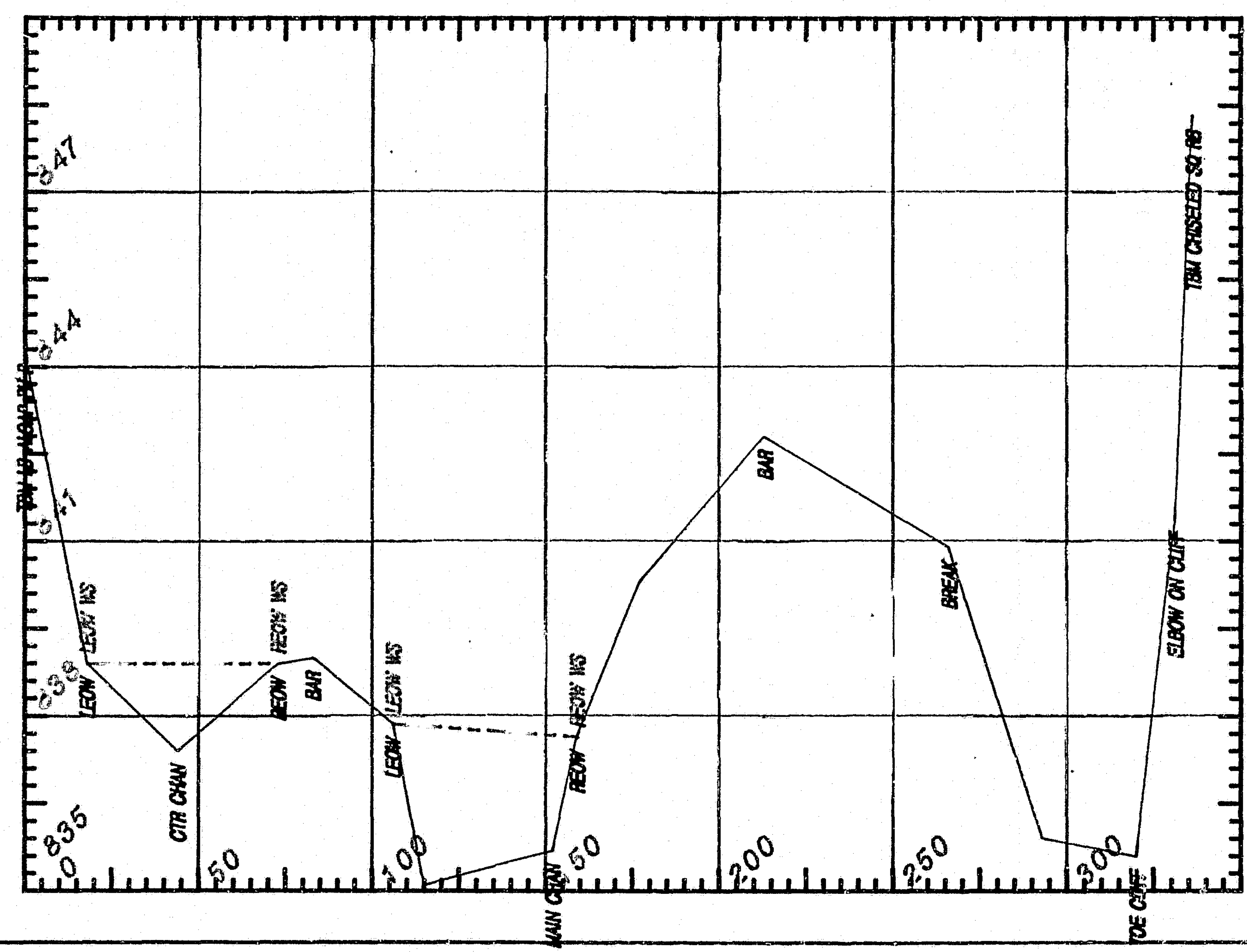
R&M CONSULTANTS, INC.

THALWEG PORTAGE CREEK

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



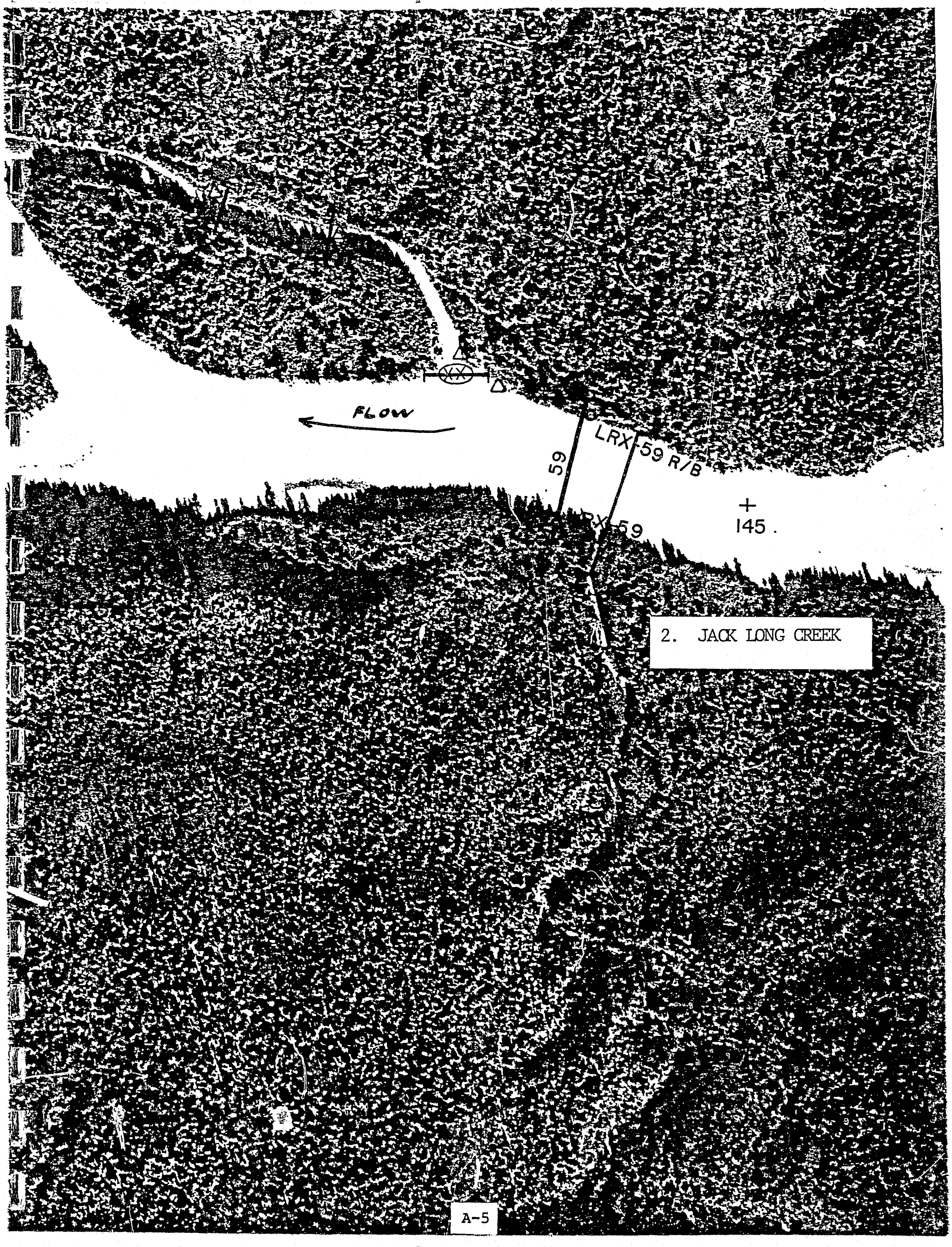
PREPARED BY:

R&M CONSULTANTS, INC.

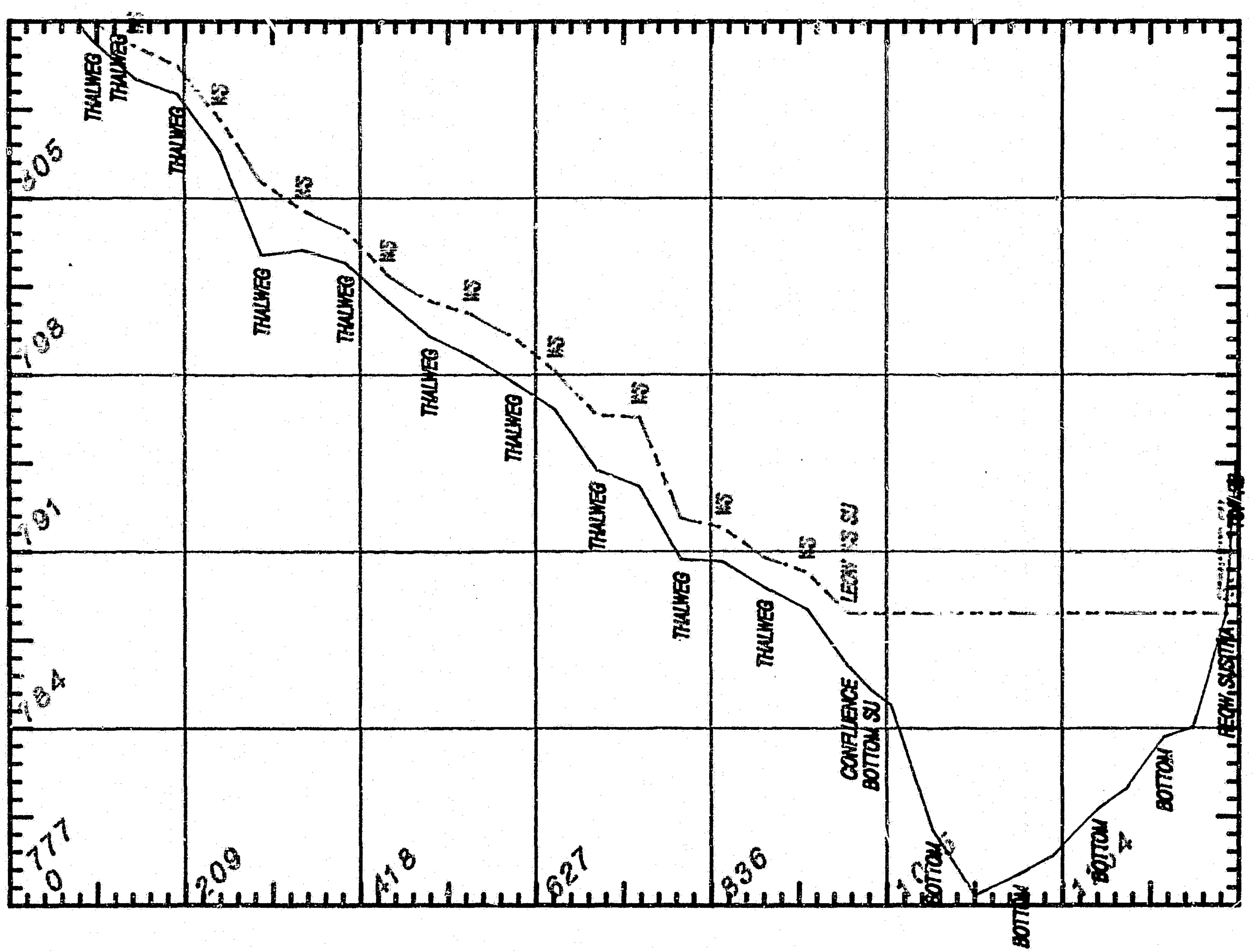
MOUTH OF PORTAGE CREEK X-SEC

PREPARED FOR:

ACRES


FLOW
LRX-59 R/B
59
RX-59
145
2. JACK LONG CREEK

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

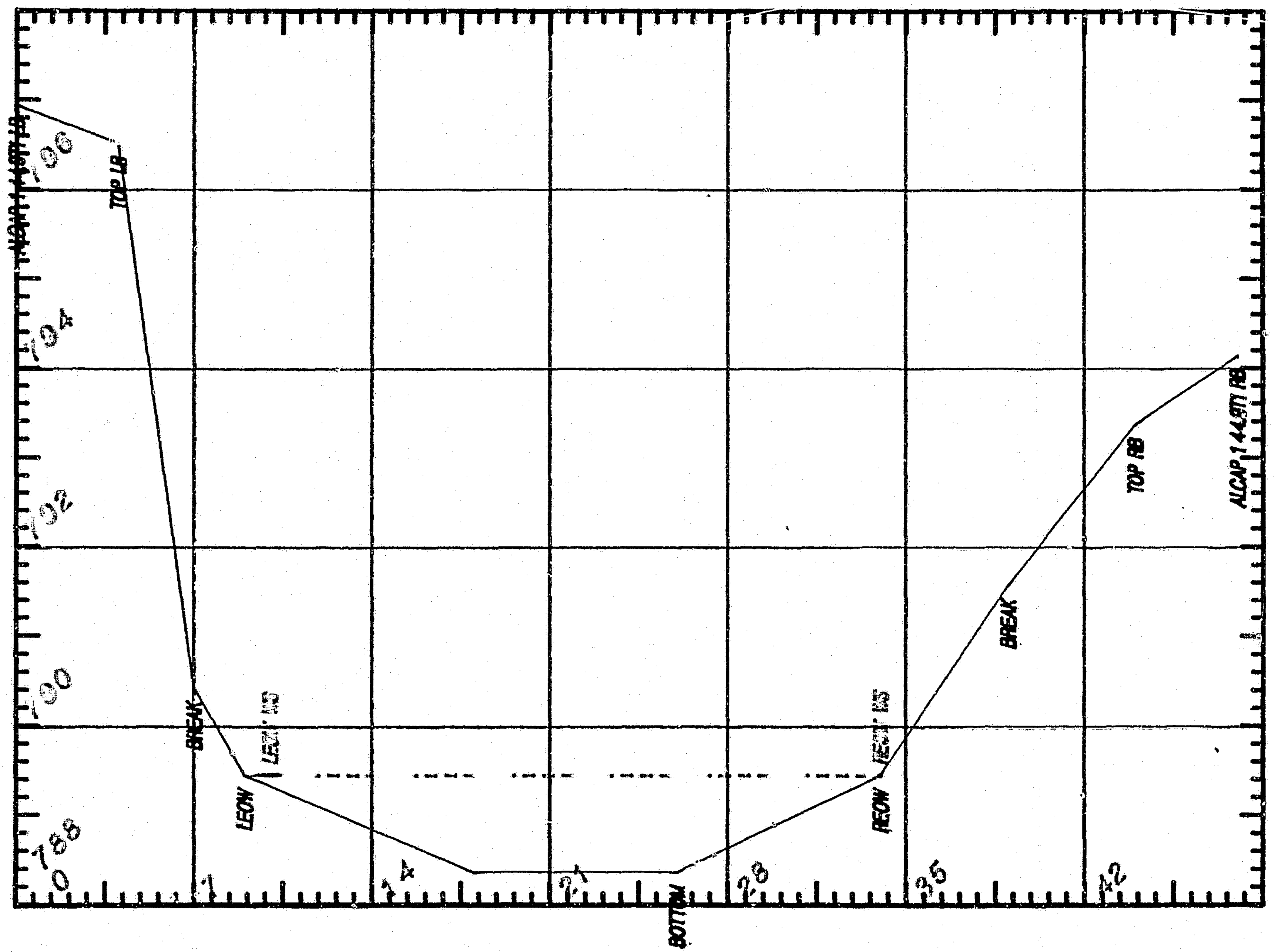
R&M CONSULTANTS, INC.

THALWEG JACKLONG CREEK

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



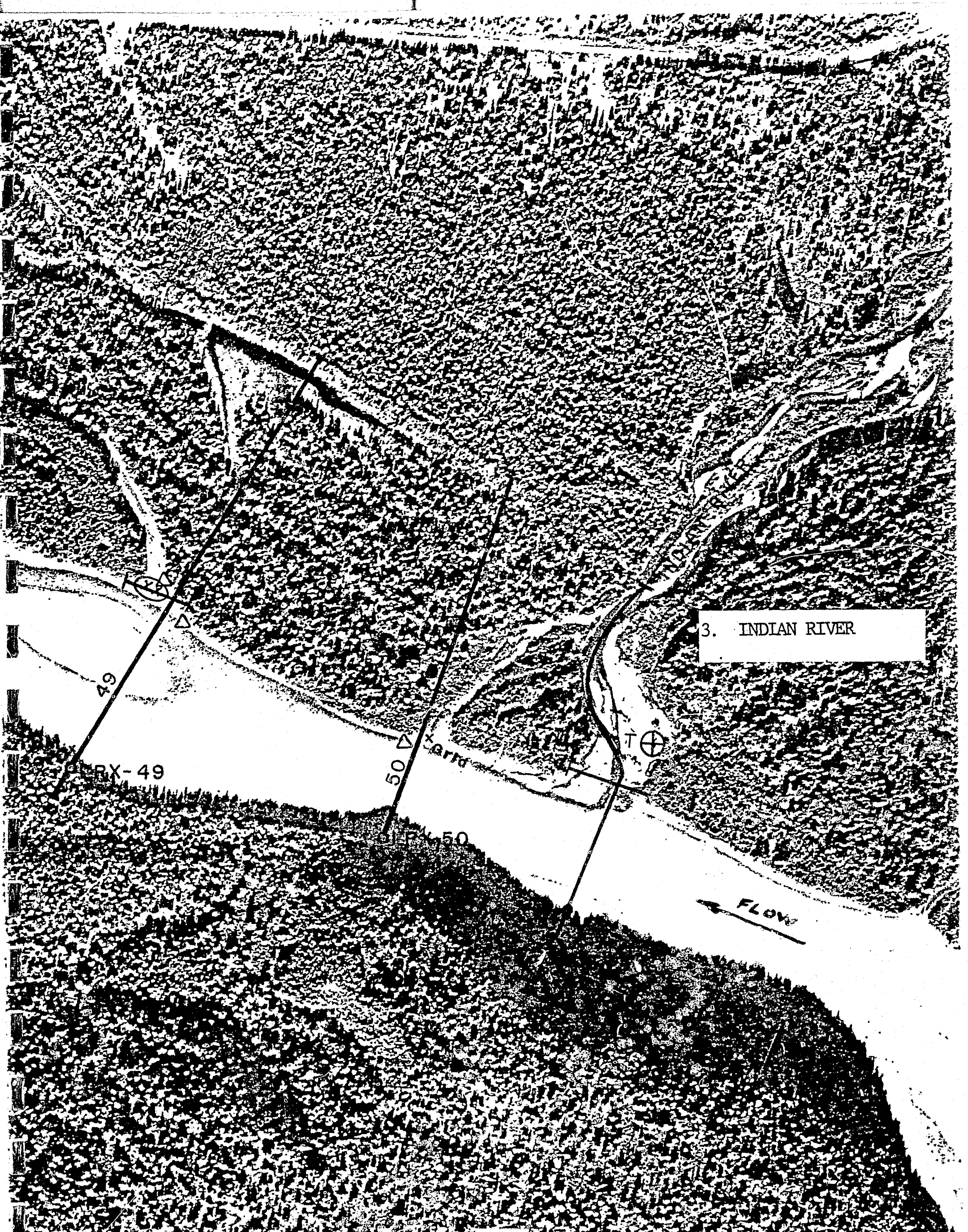
PREPARED BY:

R&M CONSULTANTS, INC.

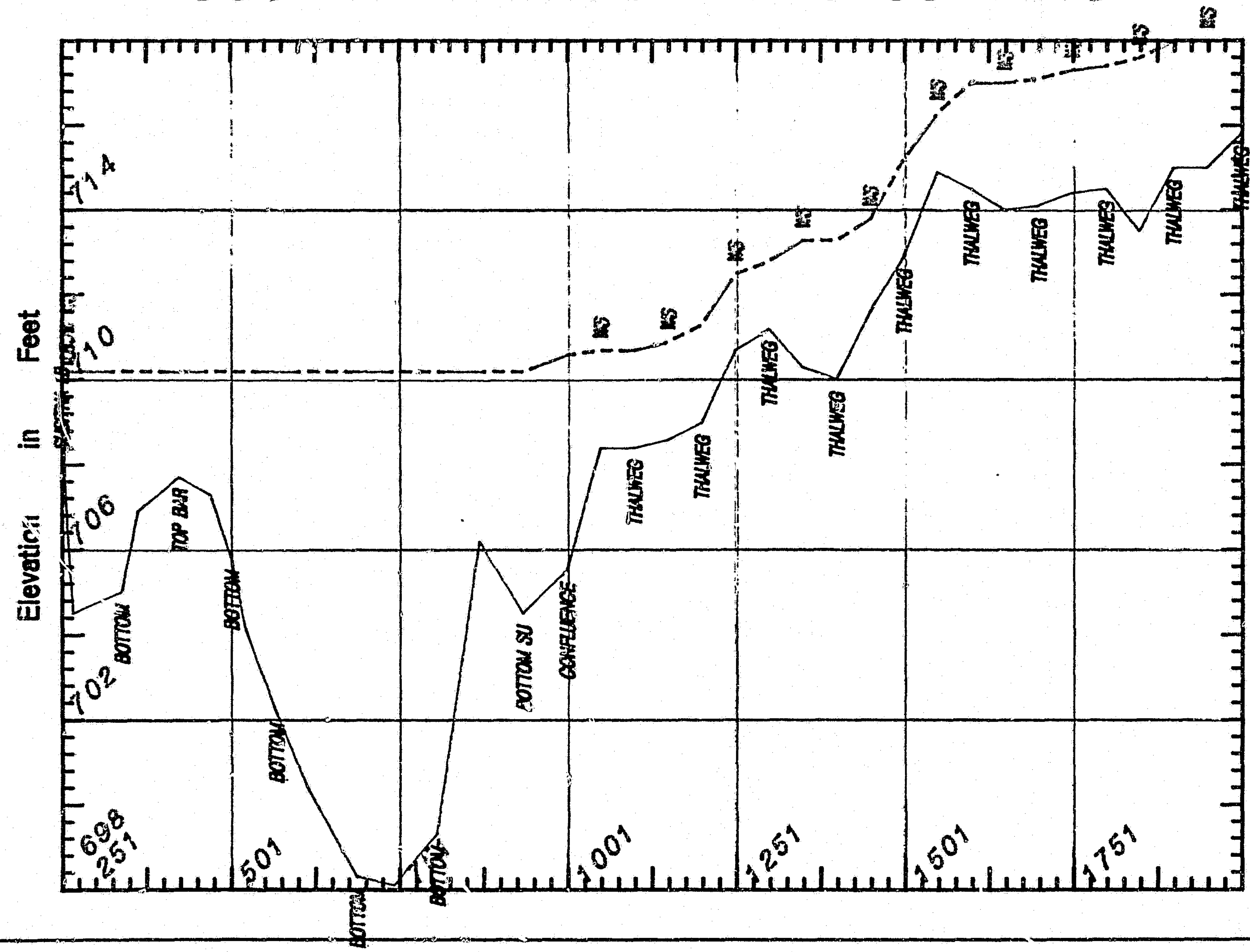
MOUTH JACKLONG CREEK X-SEC

PREPARED FOR:

ACRES


49
LRX-49
50
50
FLOW
3. INDIAN RIVER

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

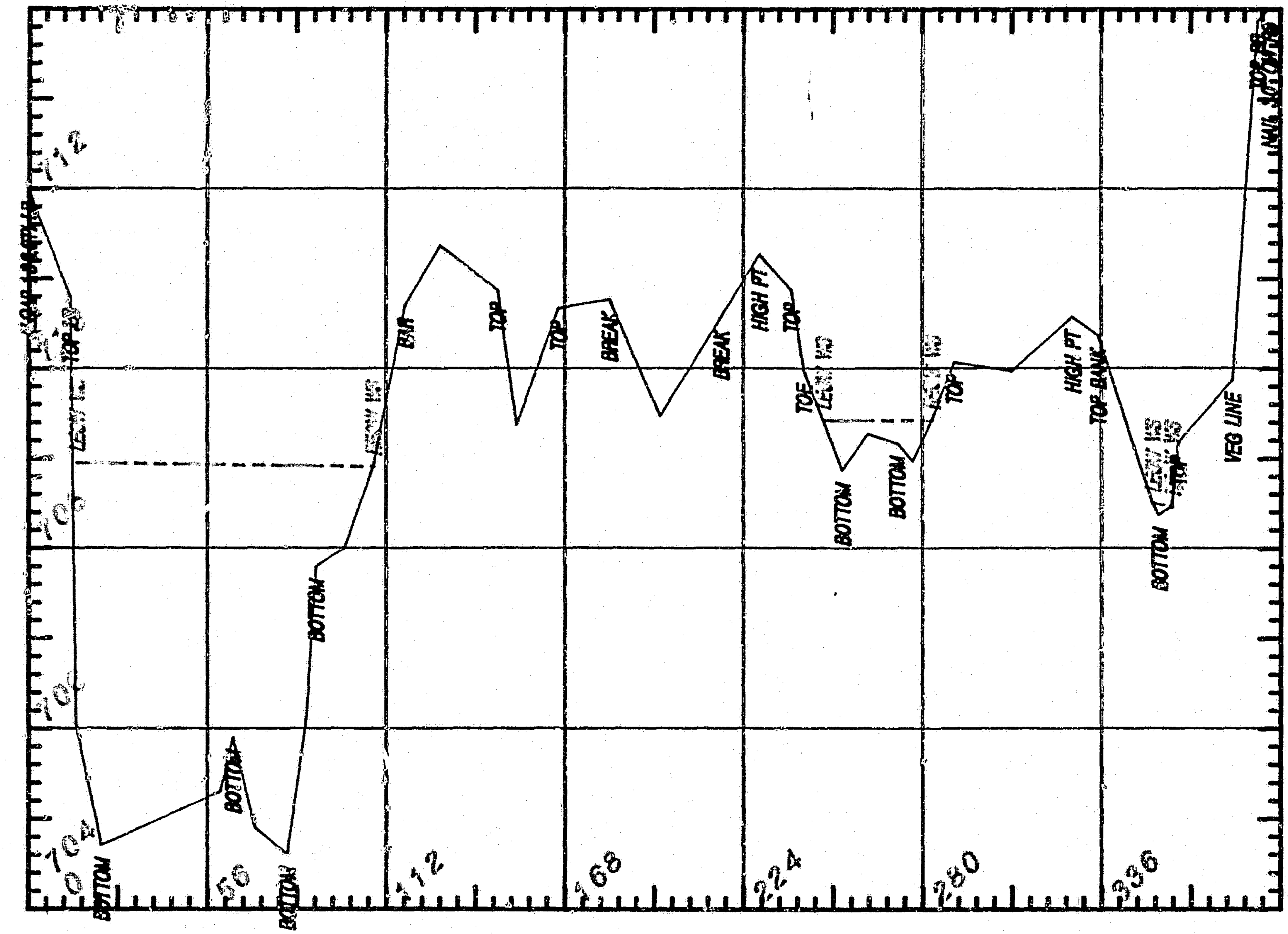
R&M CONSULTANTS, INC.

THALWEG INDIAN RIVER
Date of Survey: JULY 24, 1982

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



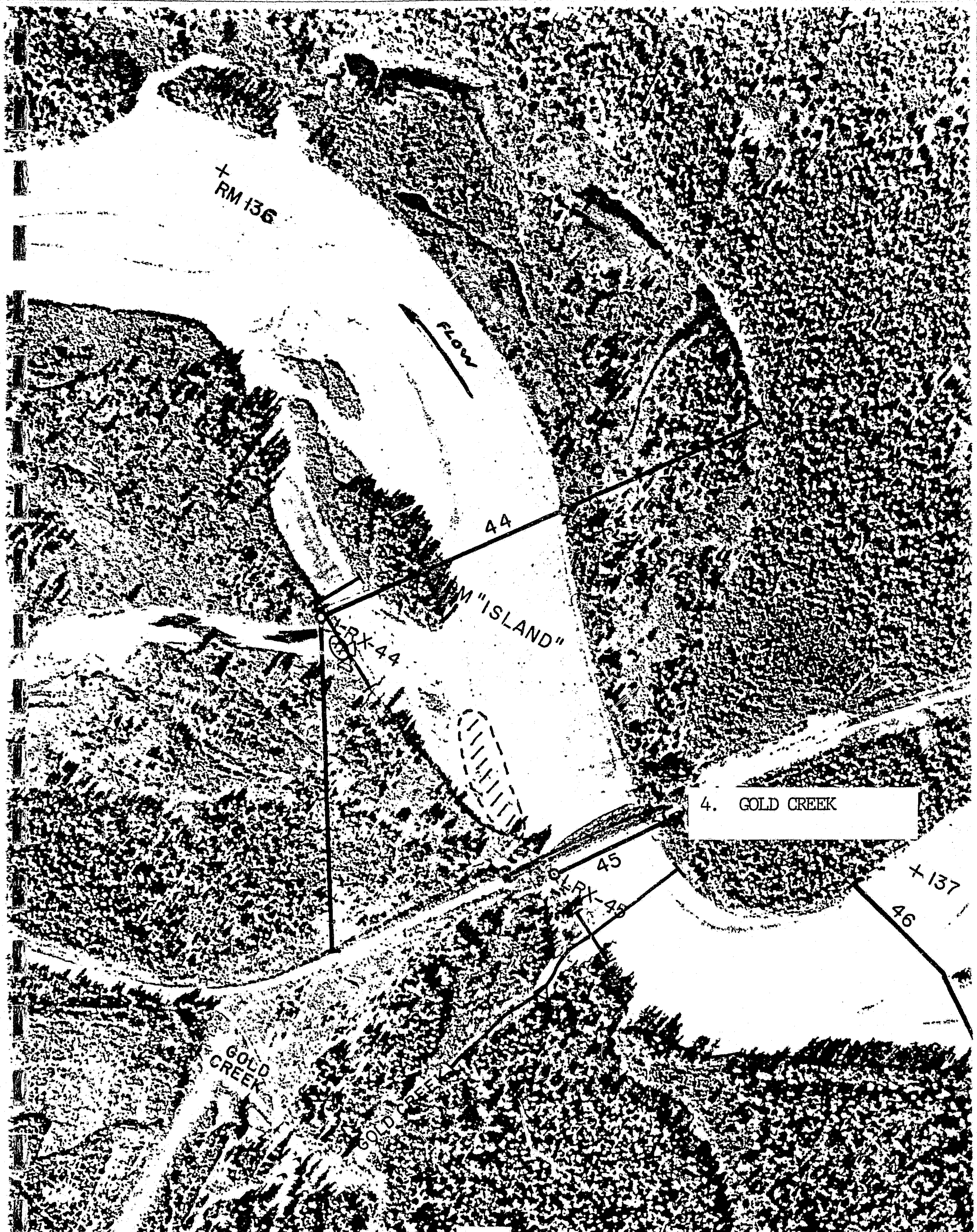
PREPARED BY:

R&M CONSULTANTS, INC.

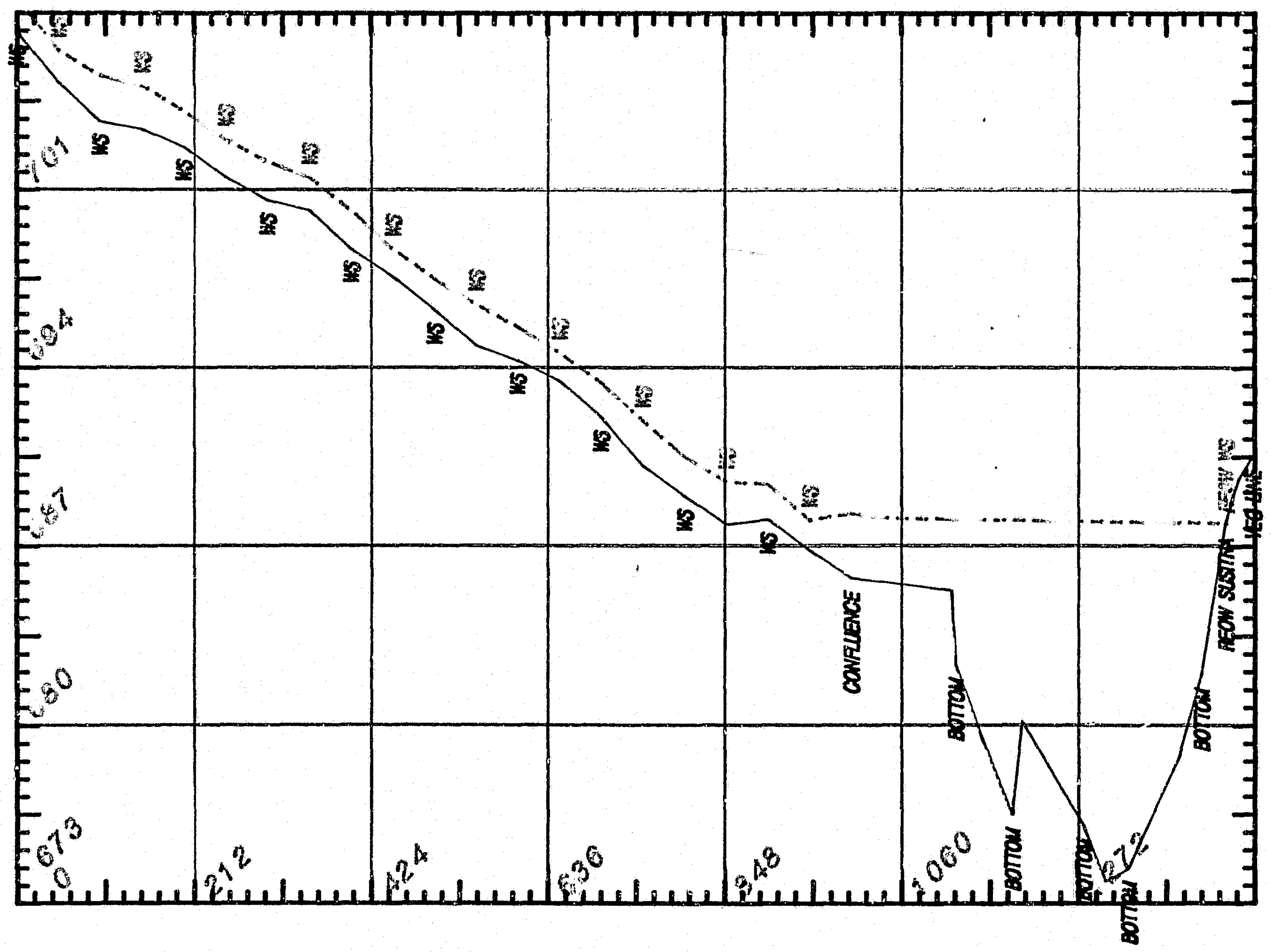
MOUTH INDIAN RIVER X-SEC

PREPARED FOR:

ACRES


RM 136
FLOW
44
M "ISLAND"
LRX-44
4. GOLD CREEK
45
LRX-45
+137
46
GOLD CREEK

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

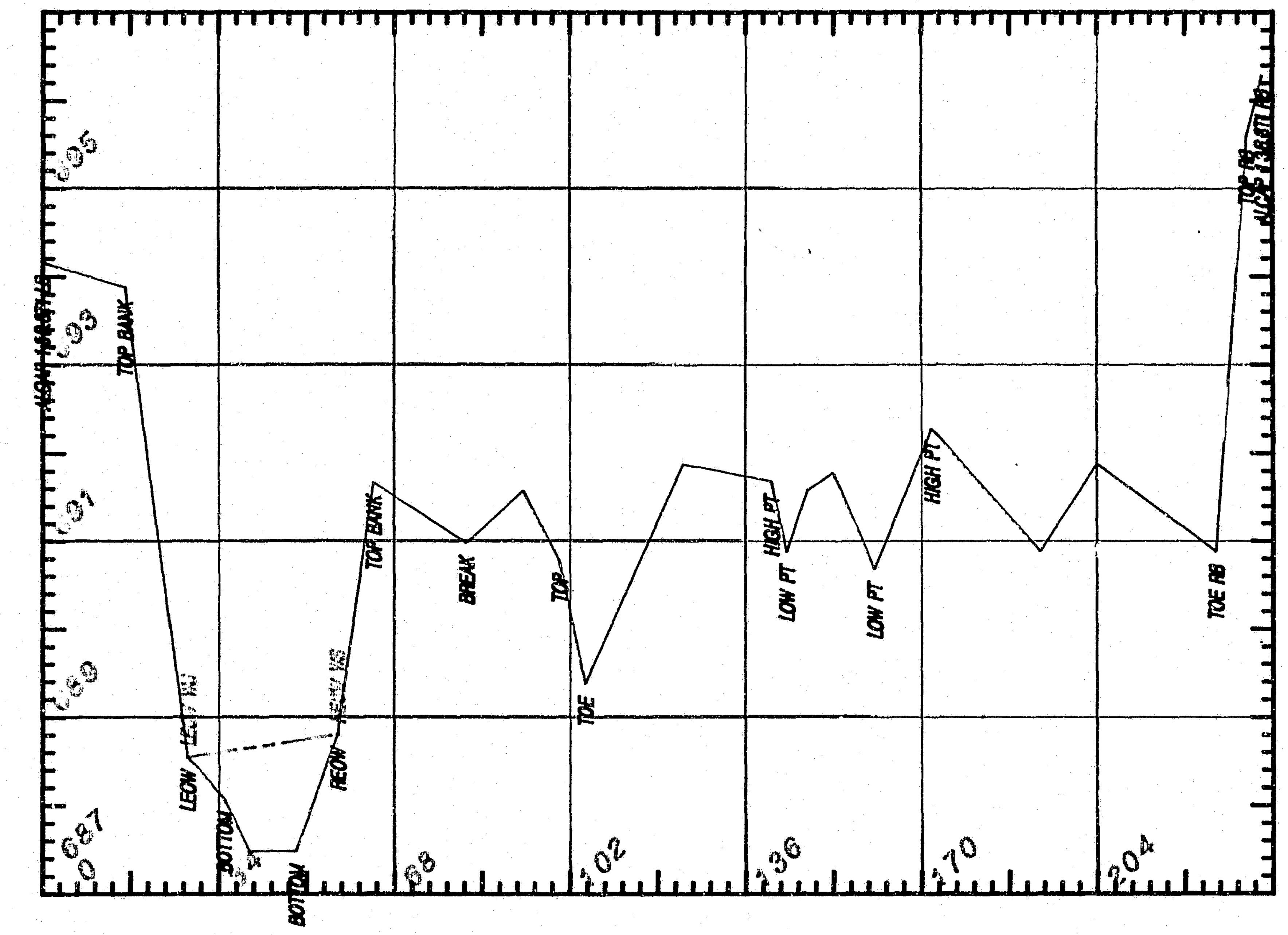
R&M CONSULTANTS, INC.

THALWEG GOLD CREEK

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



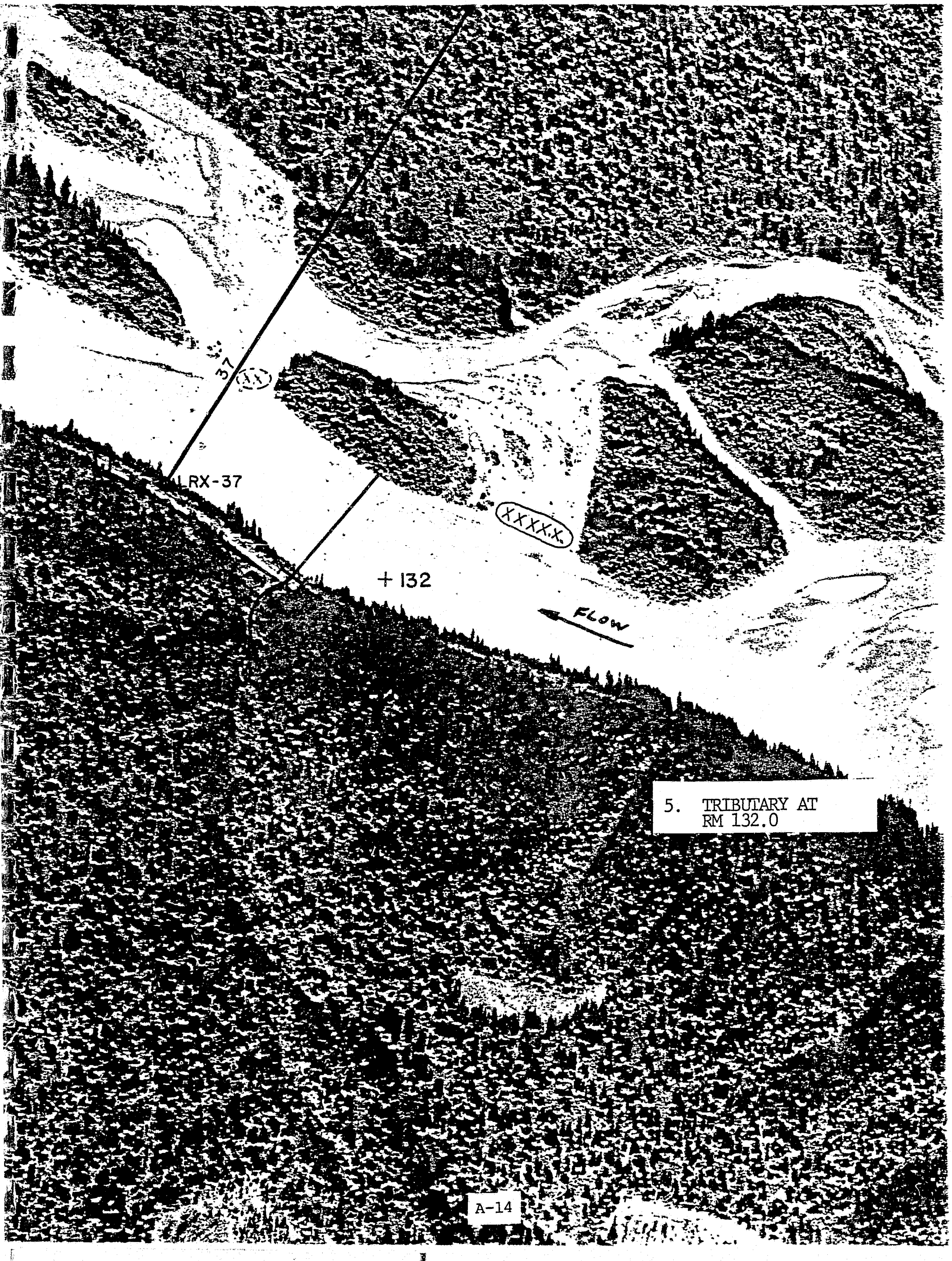
MOUTH GOLD CREEK X-SEC

PREPARED BY:

R&M CONSULTANTS, INC.

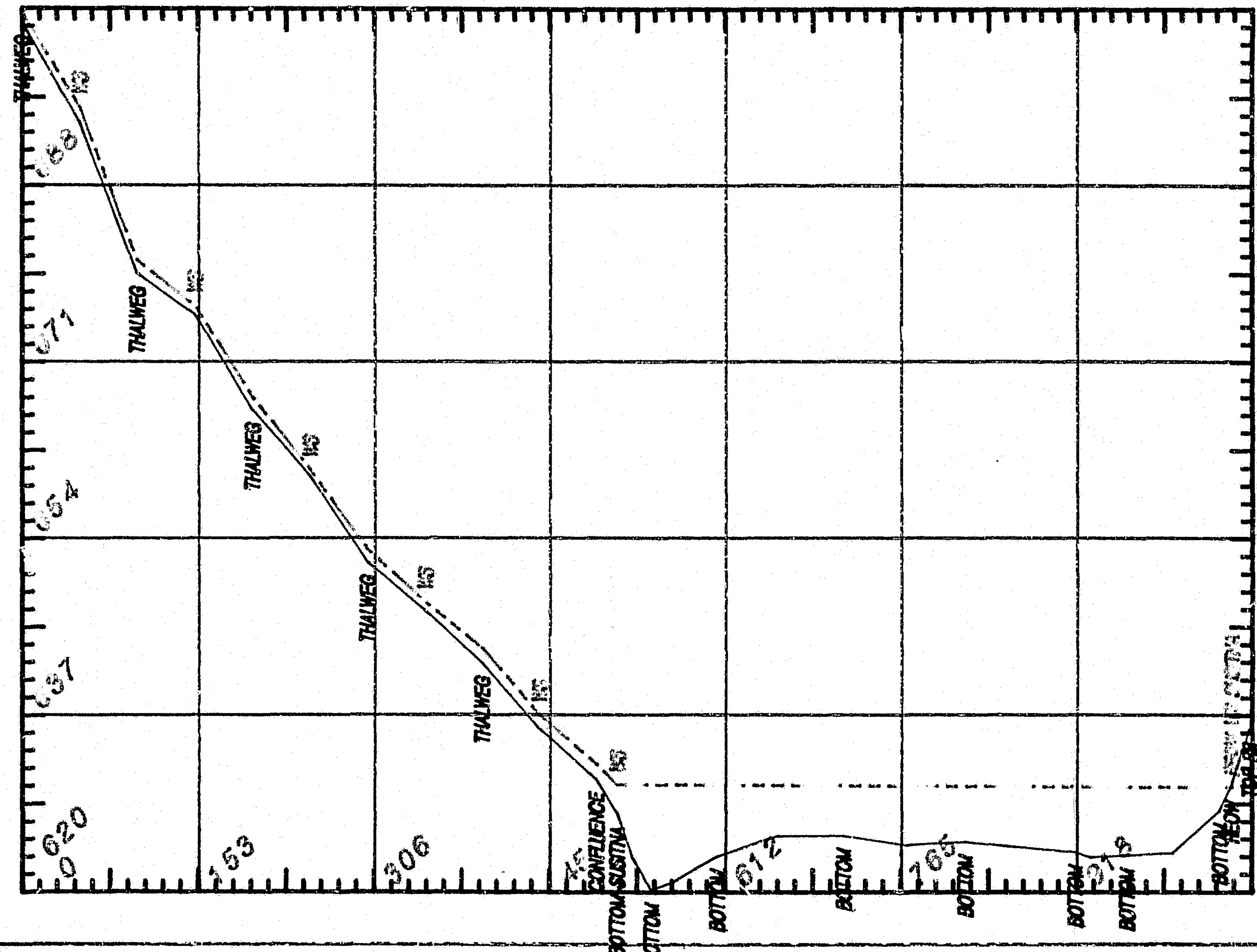
PREPARED FOR:

ACRES



5. TRIBUTARY AT RM 132.0

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

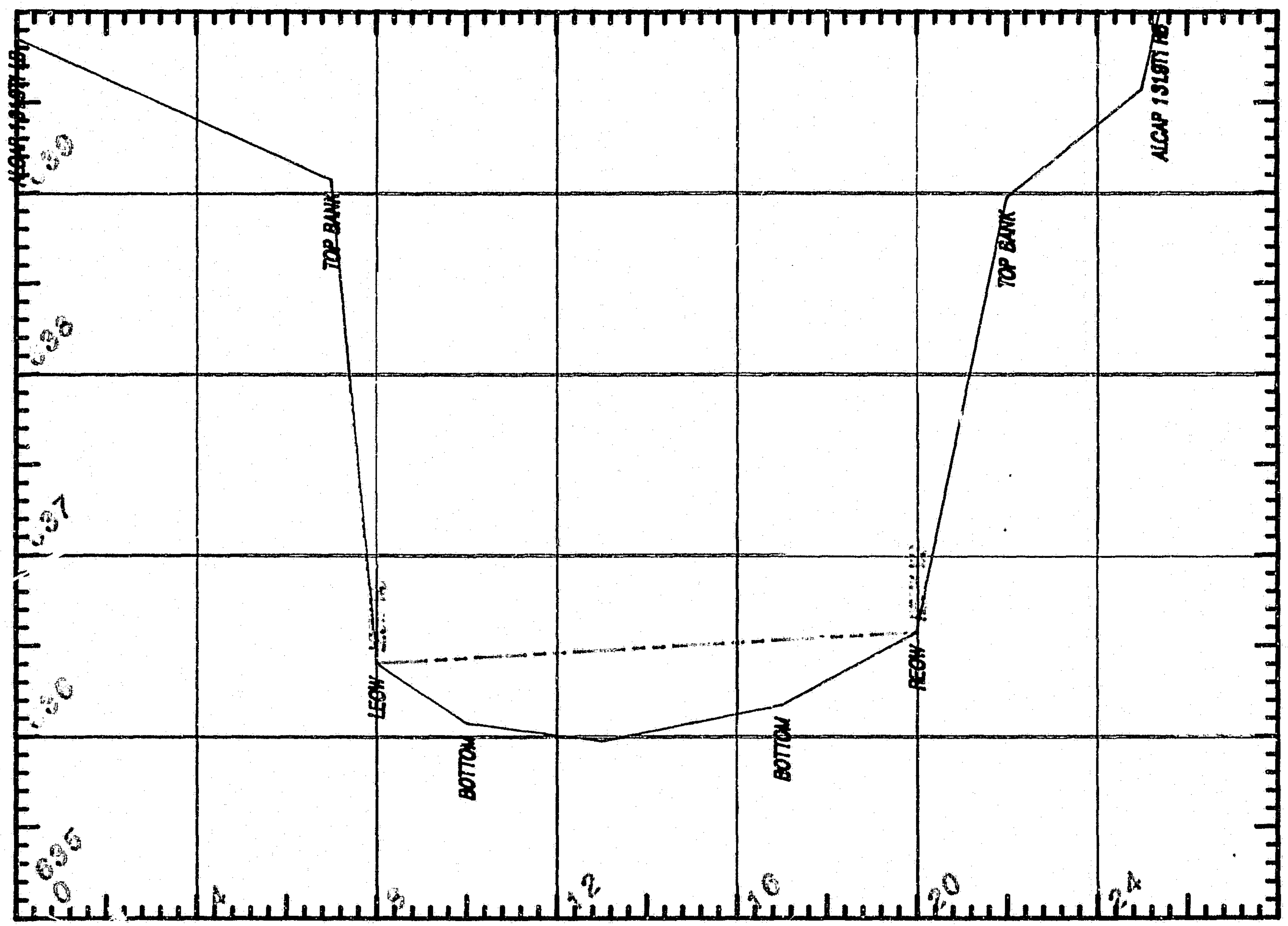
R&M CONSULTANTS, INC.

THALWEG TRIBUTARY AT **RM 132.0**

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



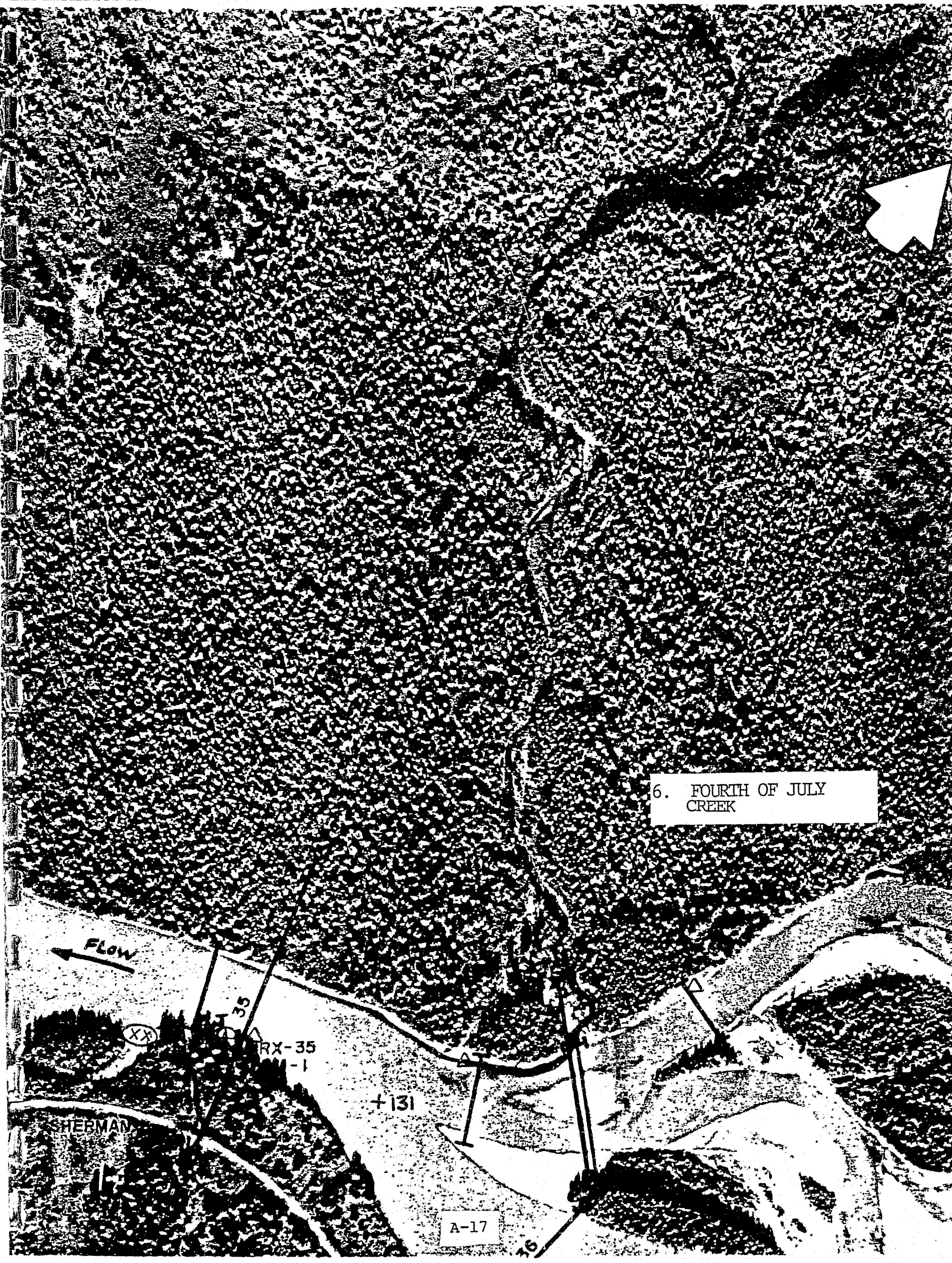
PREPARED BY:

R&M CONSULTANTS, INC.

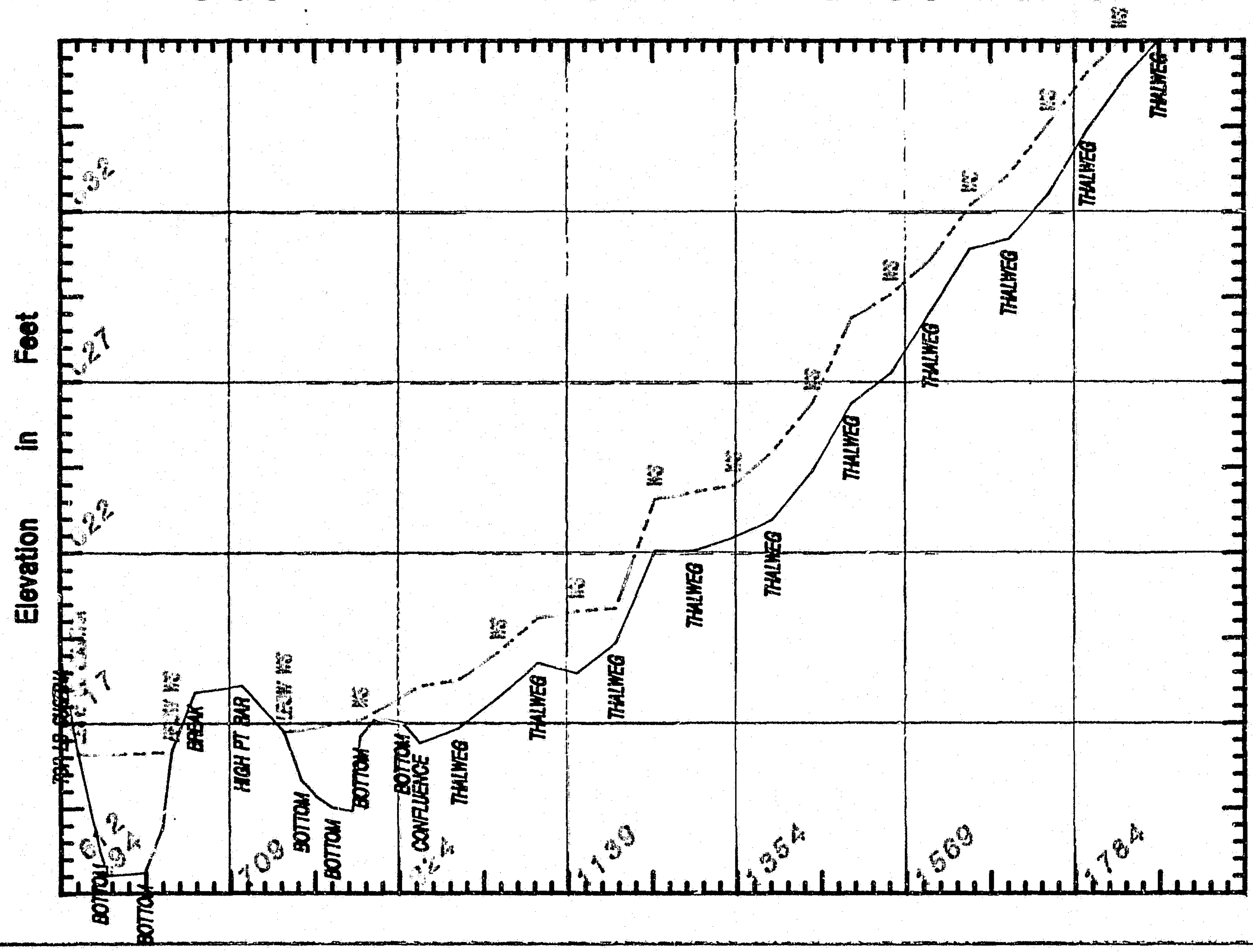
TRIBUTARY AT **RM 132.0 X-SEC**

PREPARED FOR:

ACRES


6. FOURTH OF JULY CREEK
FLOW
XX
35
RX-35
131
SHERMAN
36

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

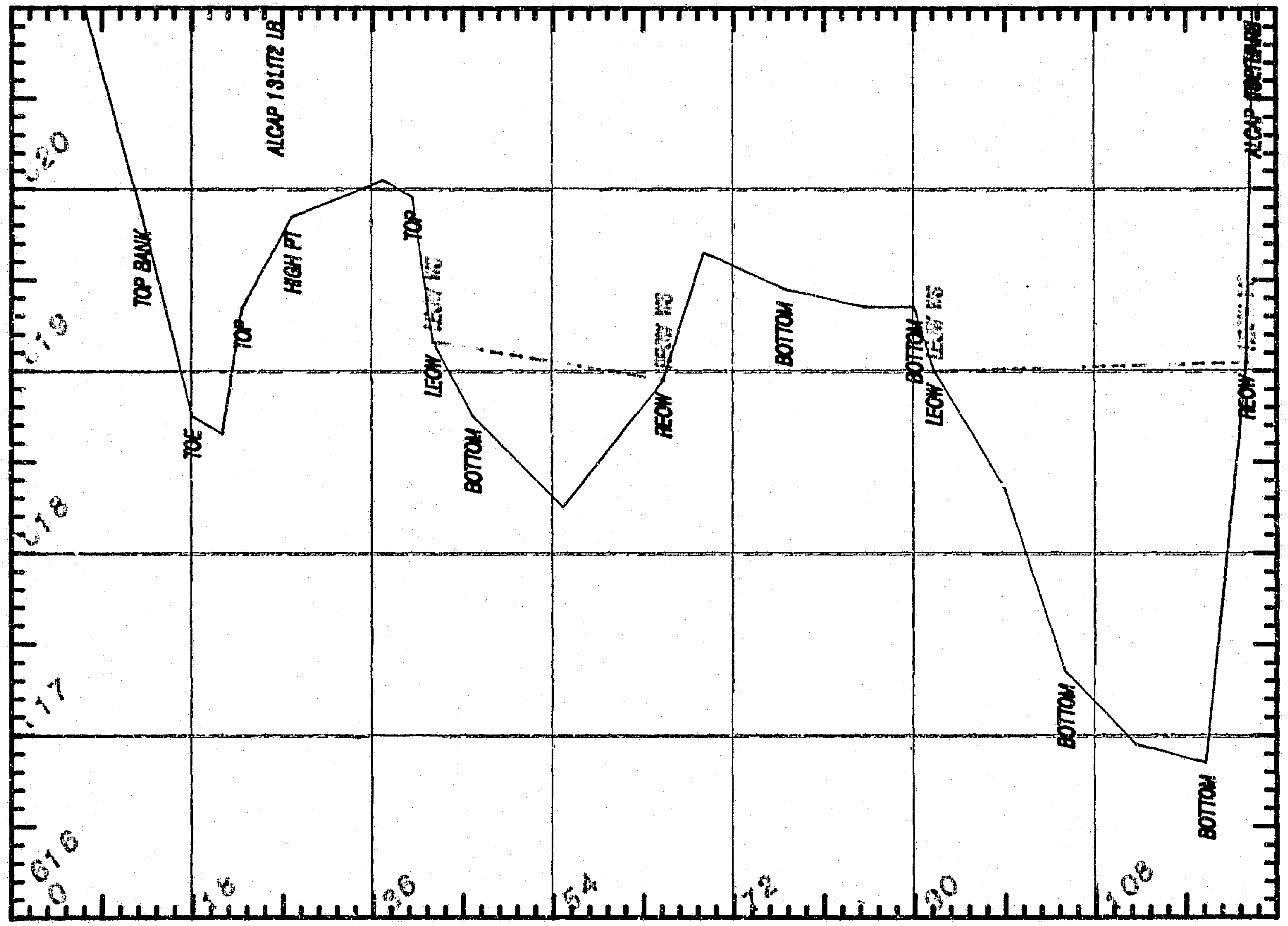
R&M CONSULTANTS, INC.

THALWEG 4TH OF JULY CREEK

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



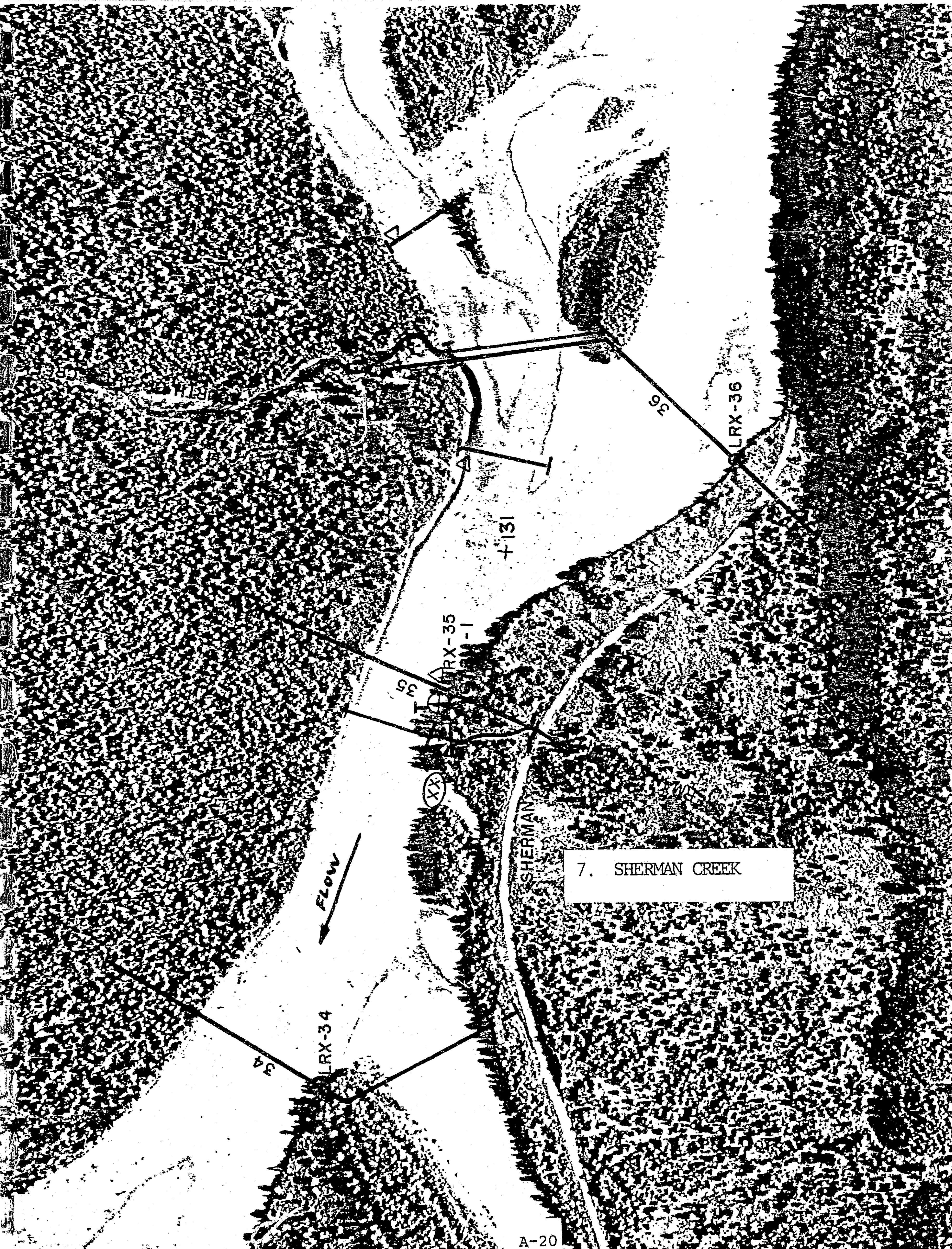
PREPARED BY:

R&M CONSULTANTS, INC.

4TH OF JULY CREEK MOUTH X-SEC

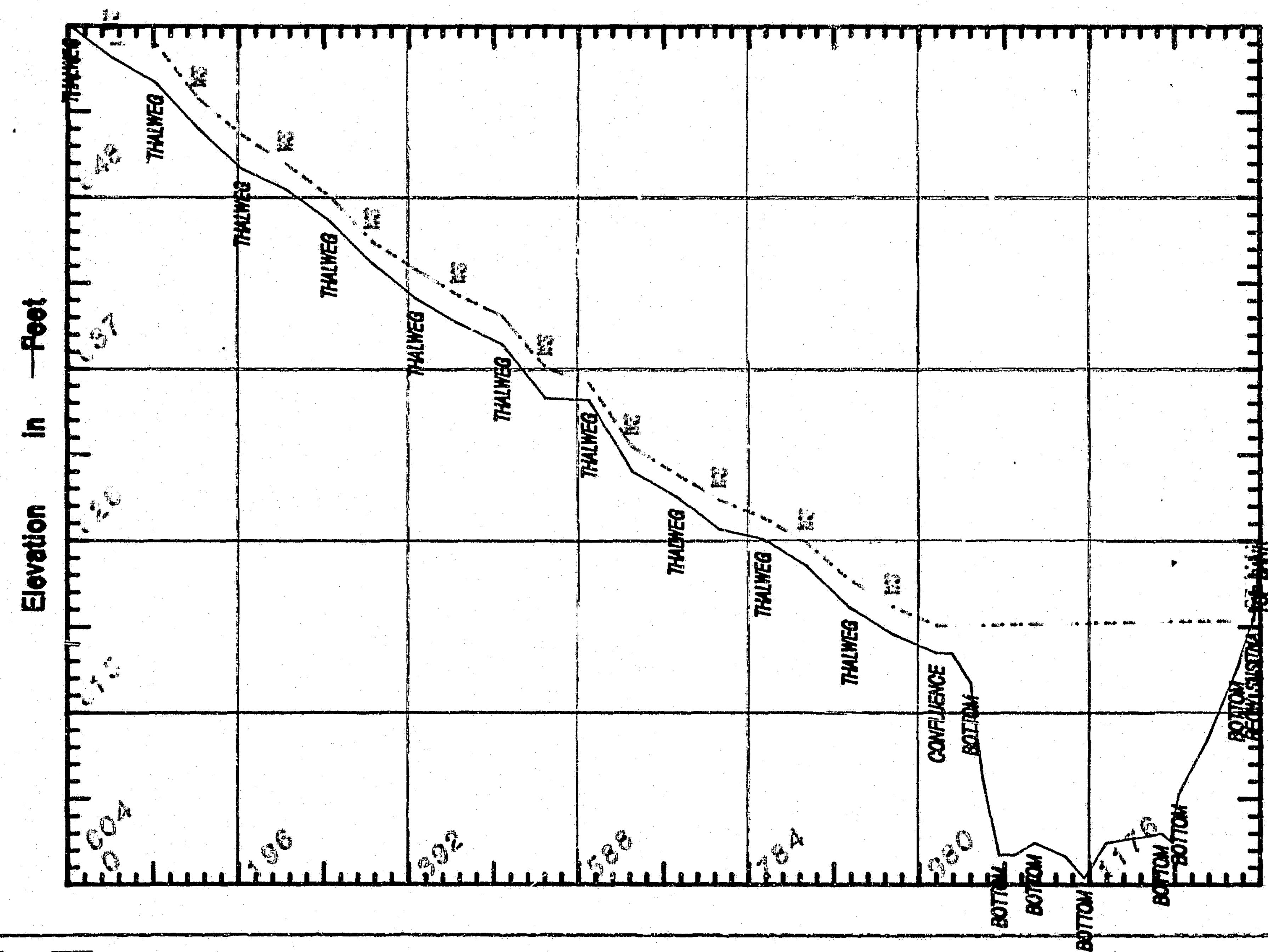
PREPARED FOR:

ACRES



7. SHERMAN CREEK

SUSITNA HYDROGRAPHIC SURVEYS



THALWEG SHERMAN CREEK

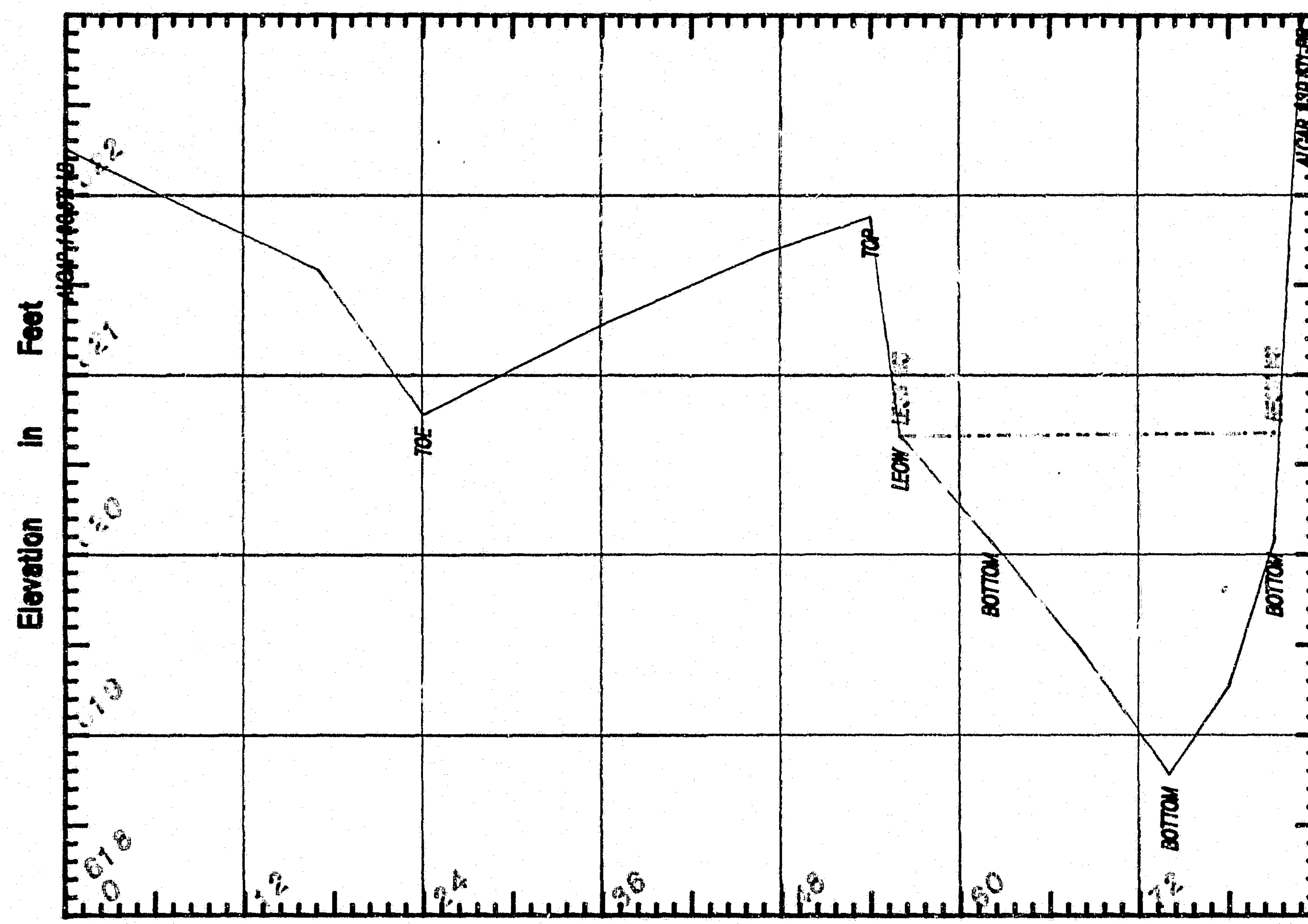
PREPARED BY:

R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

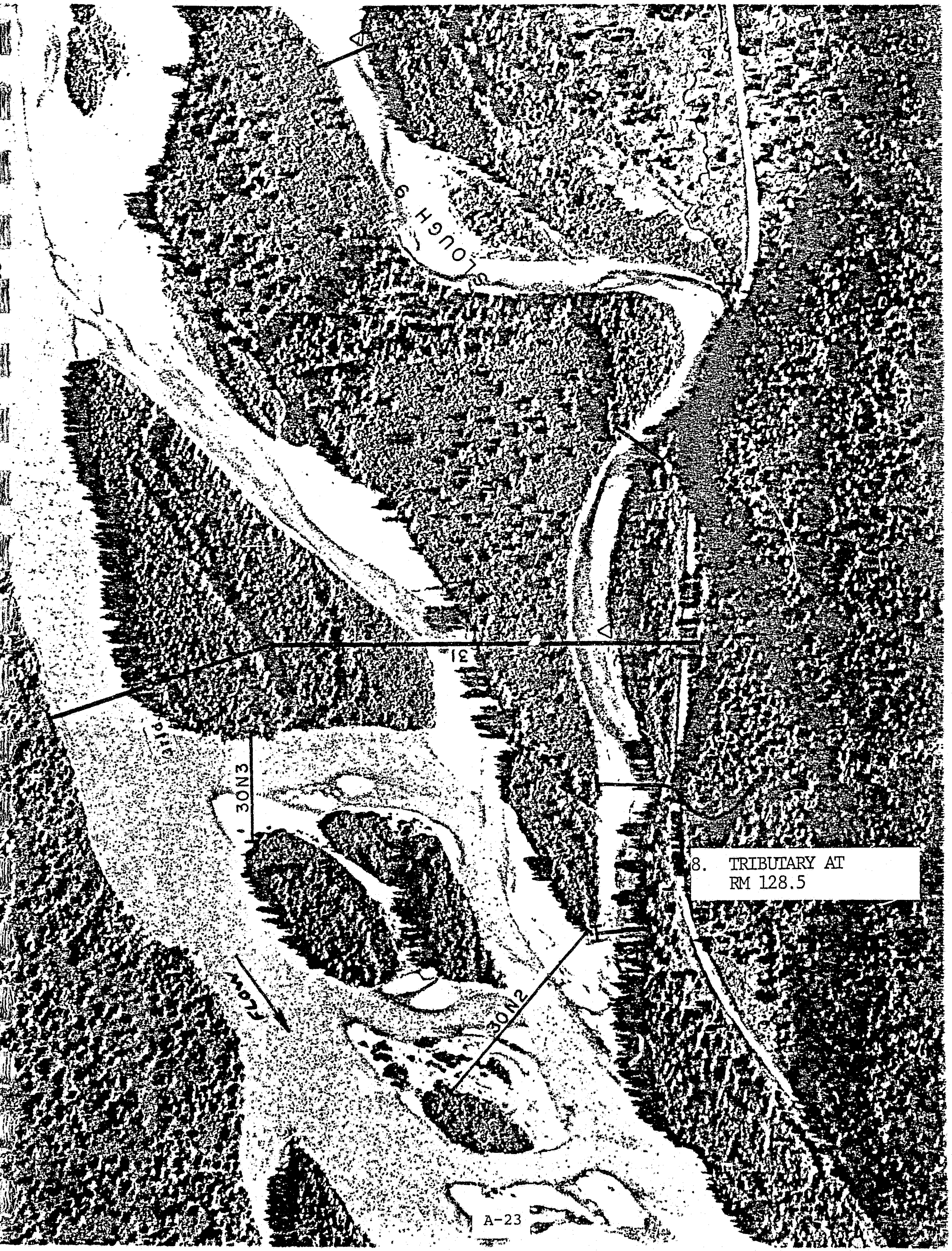
SUSITNA HYDROGRAPHIC SURVEYS



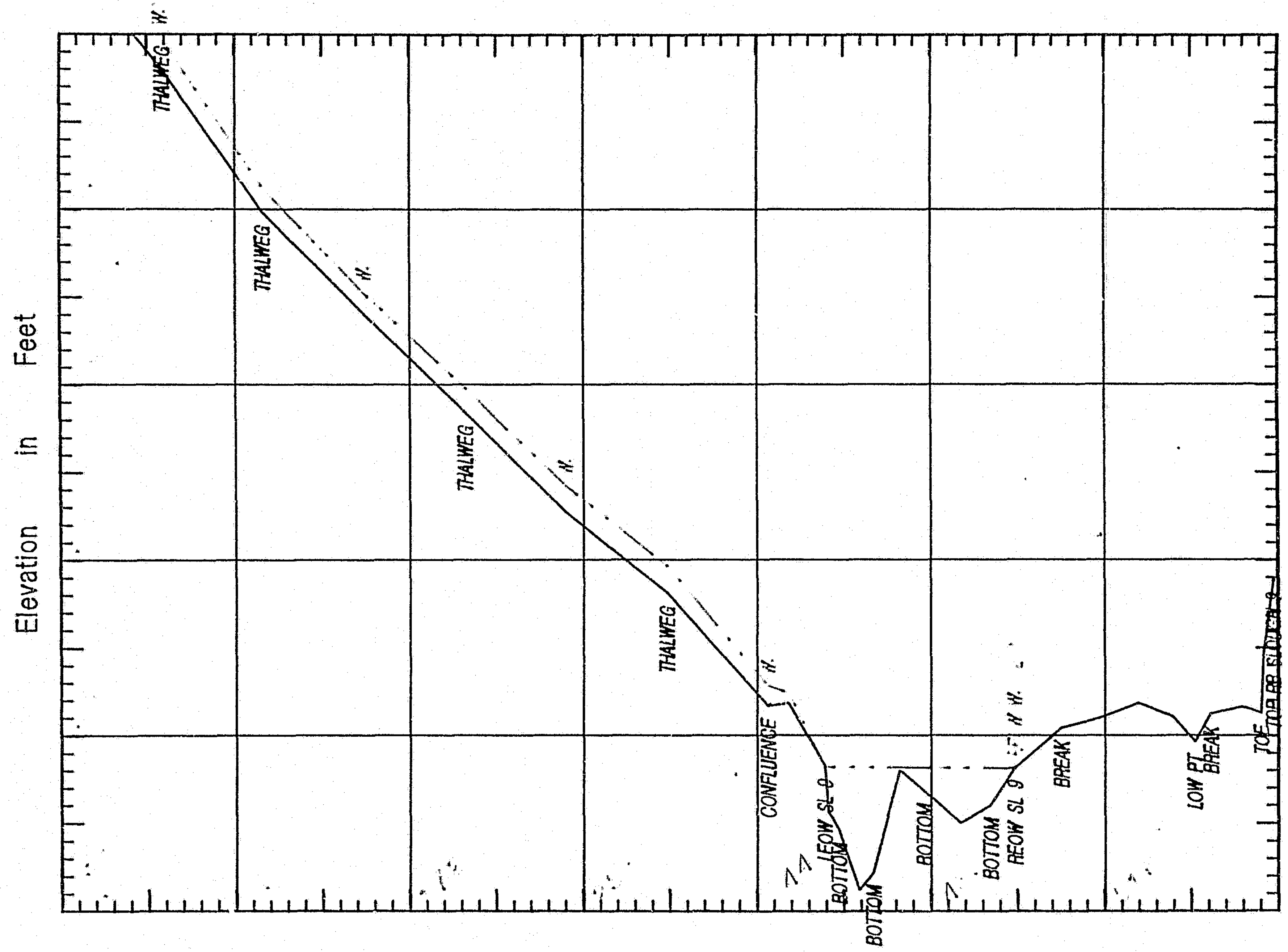
PREPARED BY: R&M CONSULTANTS, INC.

MOUTH SHERMAN CREEK X-SEC
Date of Survey: JULY 30,1982

PREPARED FOR: ACRES


SLOUGH 9
31
30N3
30N2
FLOW
8. TRIBUTARY AT
RM 128.5

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

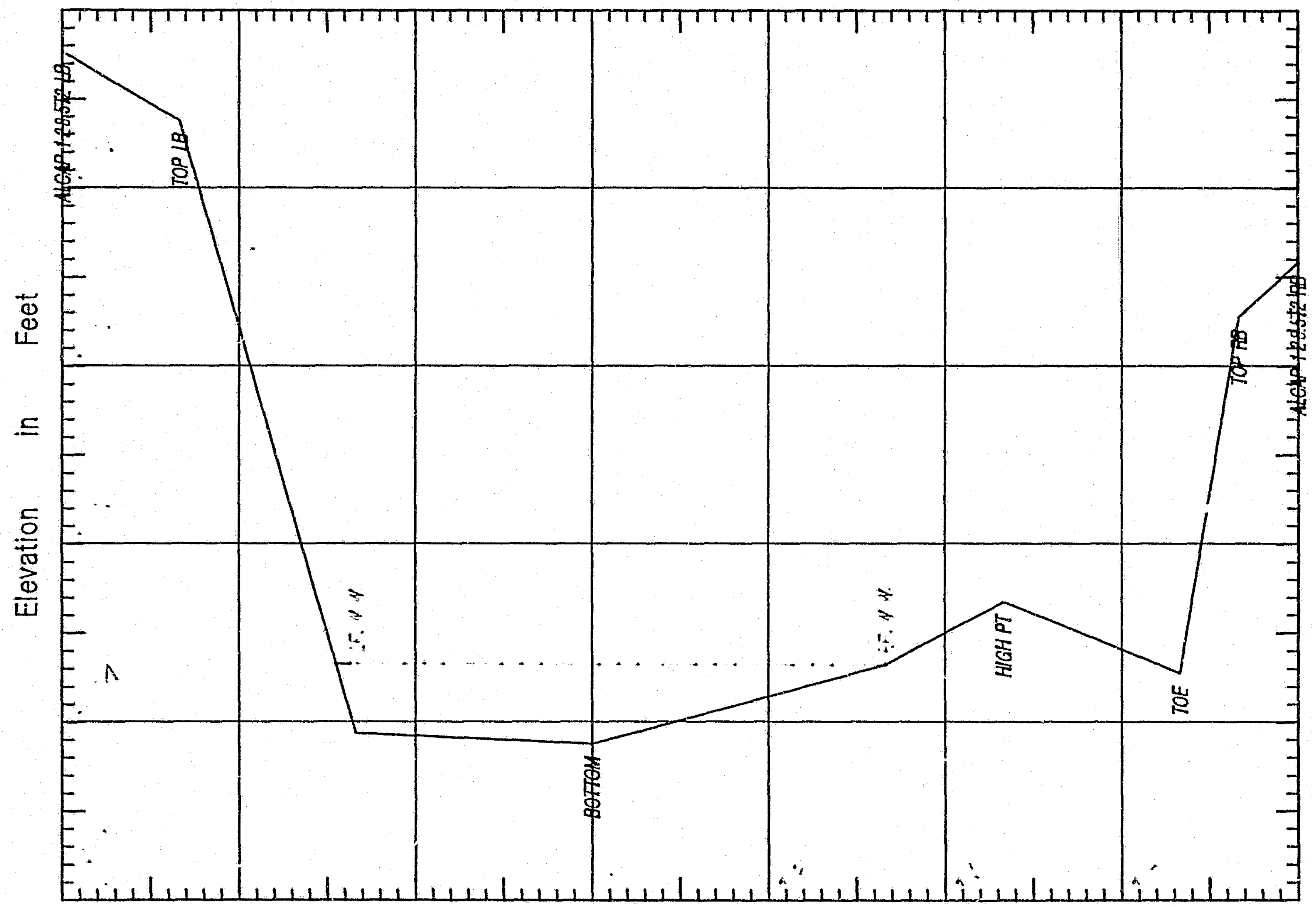
R&M CONSULTANTS, INC.

THALWEG TRIBUTARY AT RM1 28.5

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



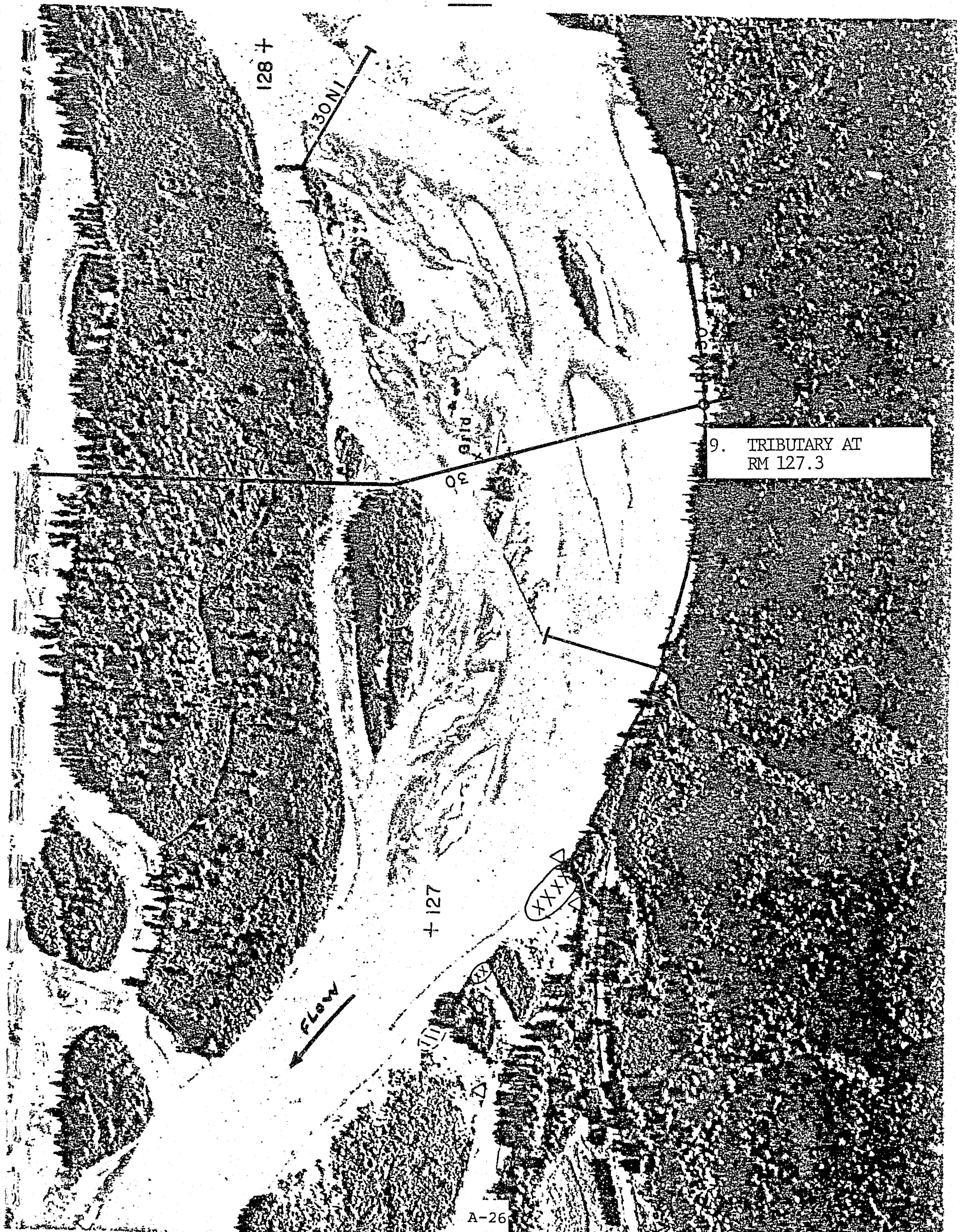
PREPARED BY:

R&M CONSULTANTS, INC.

TRIBUTARY AT RM 128.5 X-SEC
Date of Survey: AUGUST 2,1982

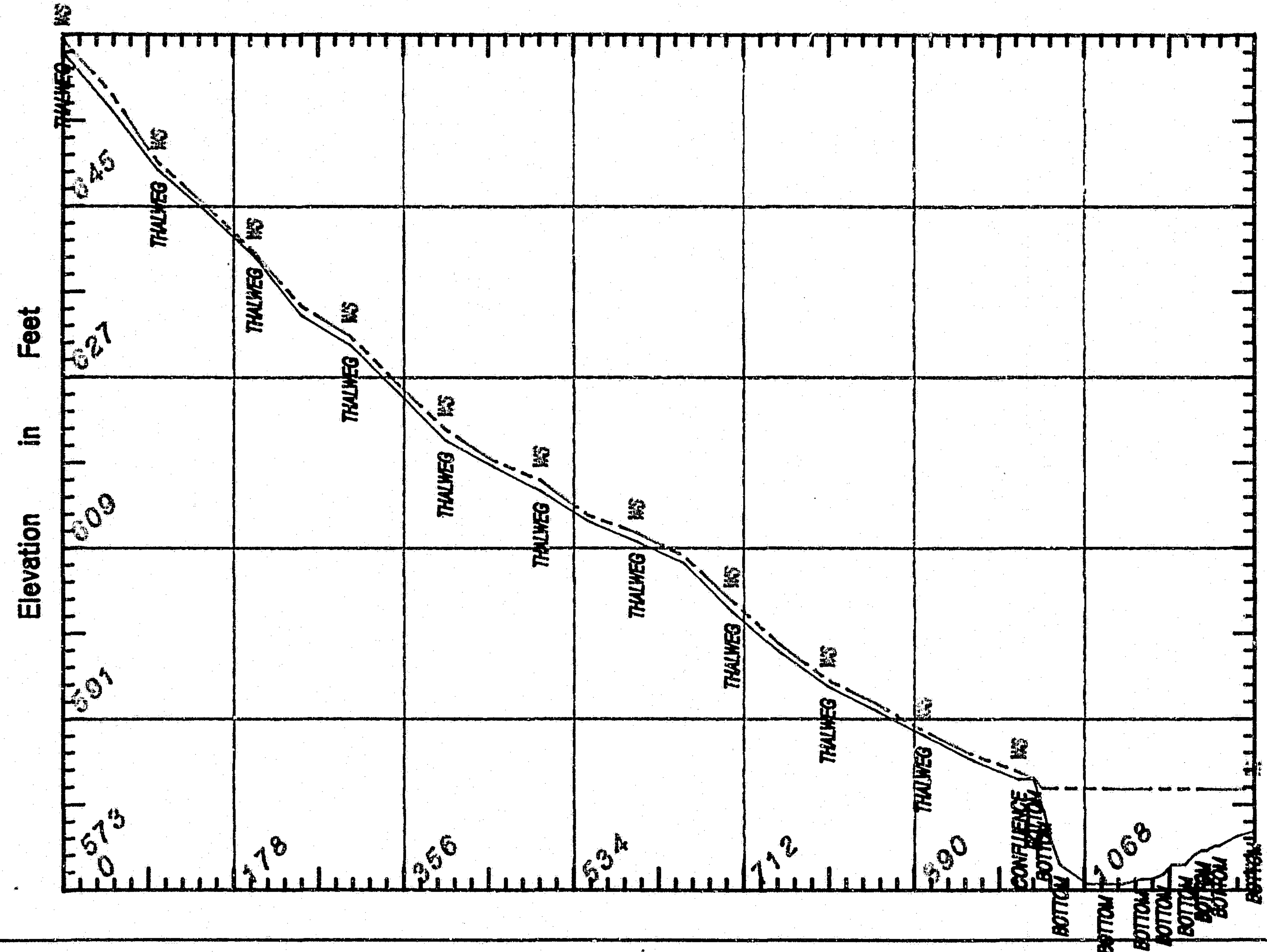
PREPARED FOR:

ACRES



9. TRIBUTARY AT RM 127.3

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

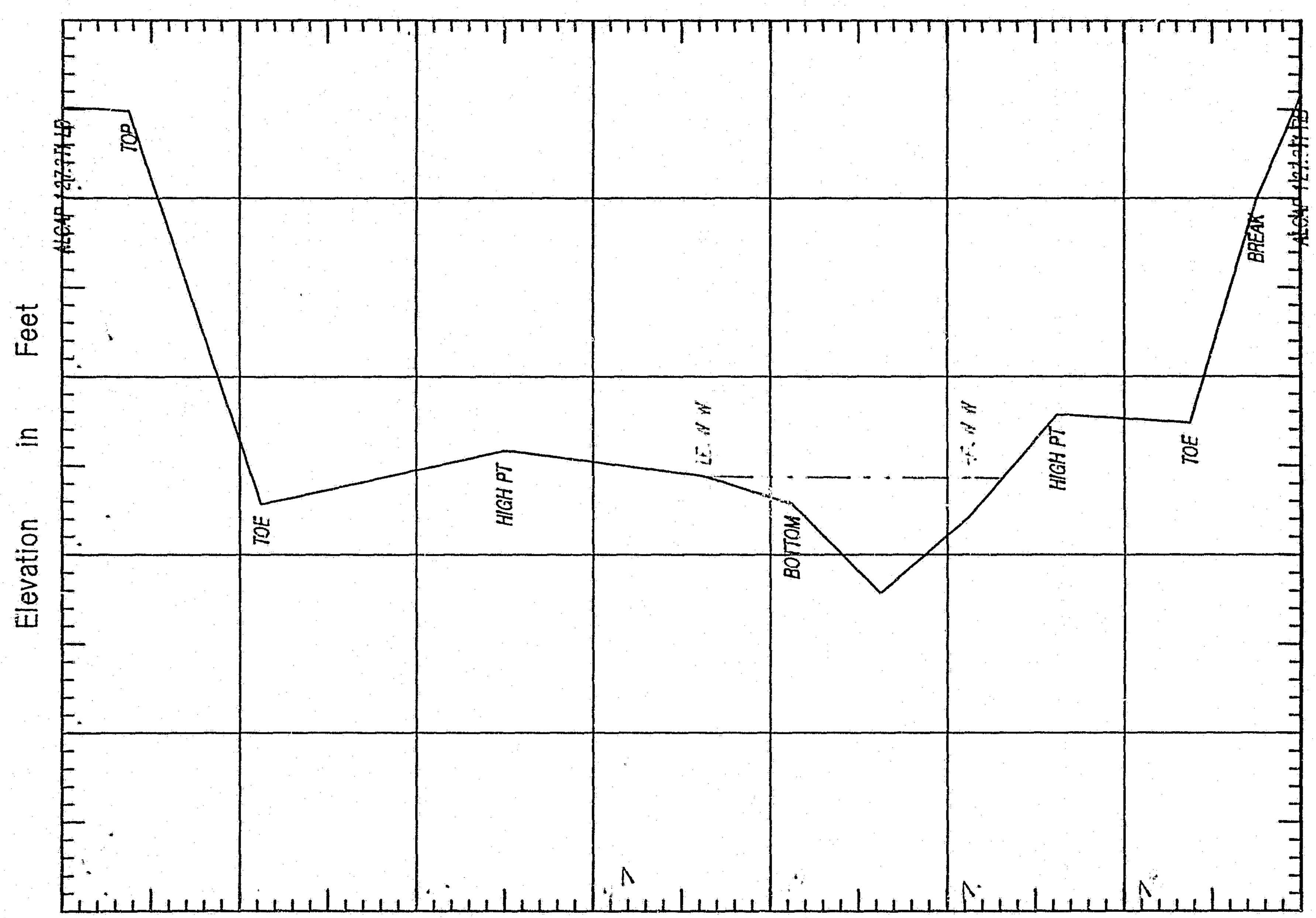
R&M CONSULTANTS, INC.

THALWEG TRIBUTARY 127.3
Date of Survey: AUGUST 5, 1982

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



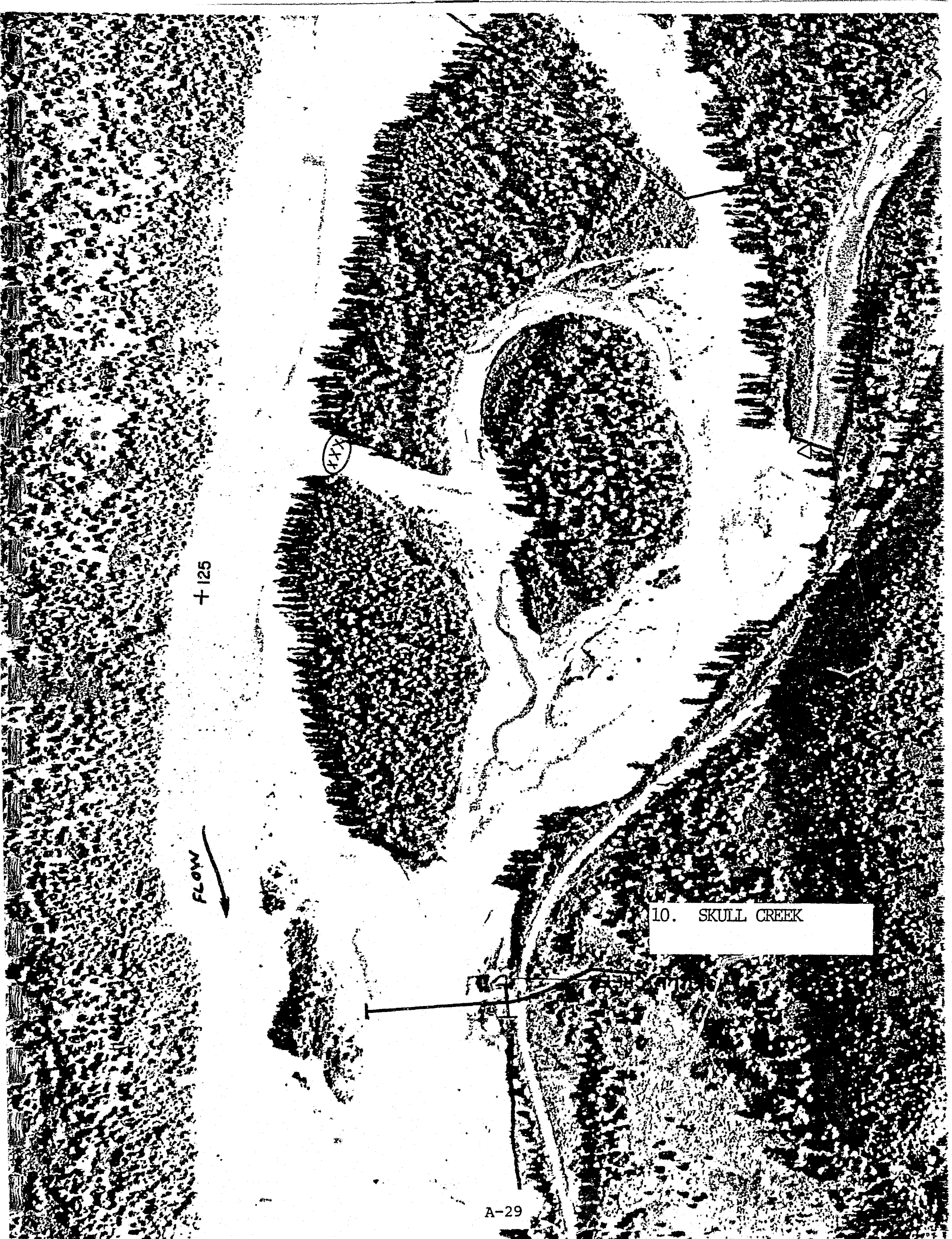
PREPARED BY:

R&M CONSULTANTS, INC.

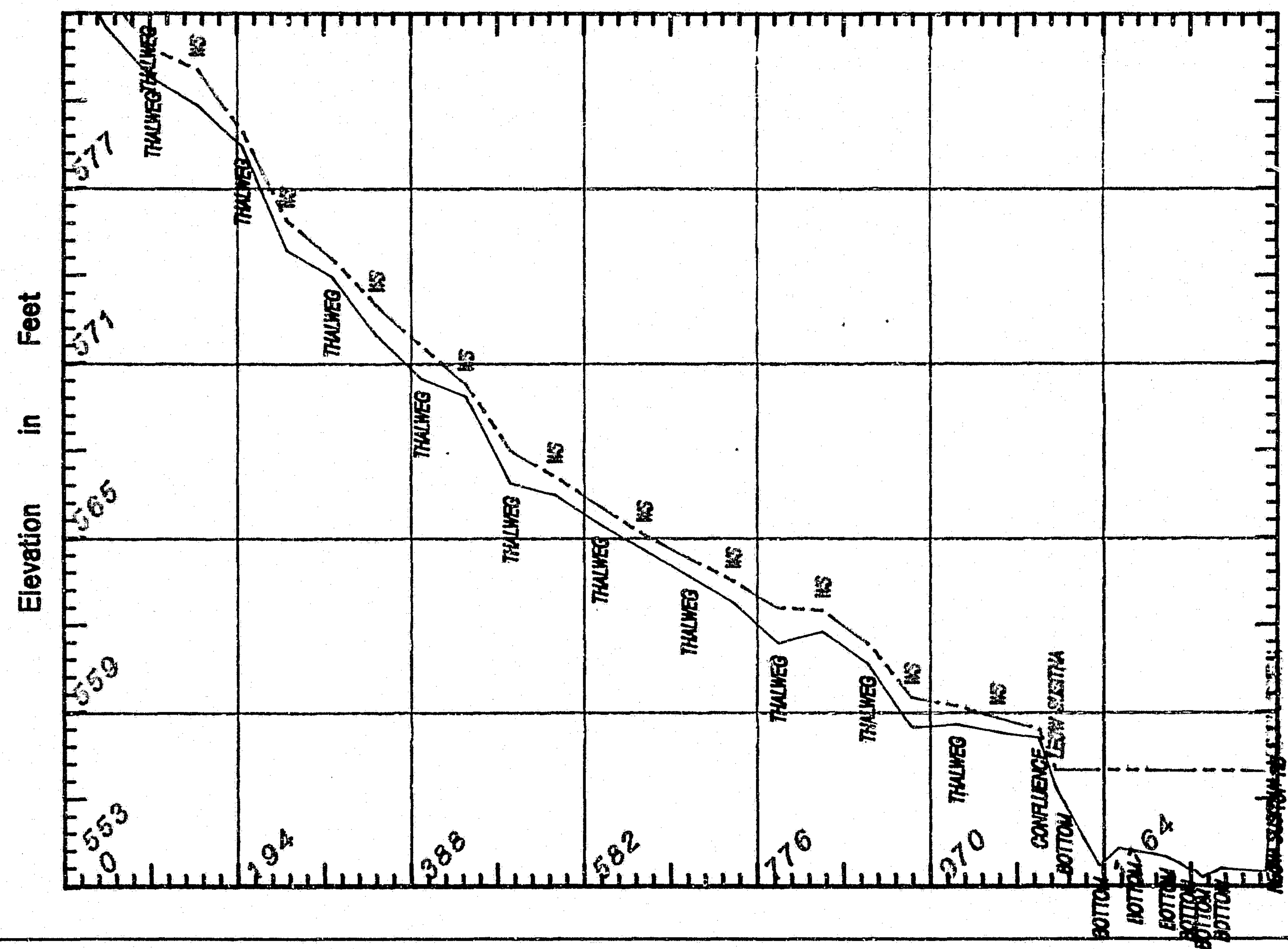
TRIBUTARY AT RM1 27.3 X-SEC

PREPARED FOR:

ACRES


10. SKULL CREEK
FLOW
125
XXX

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

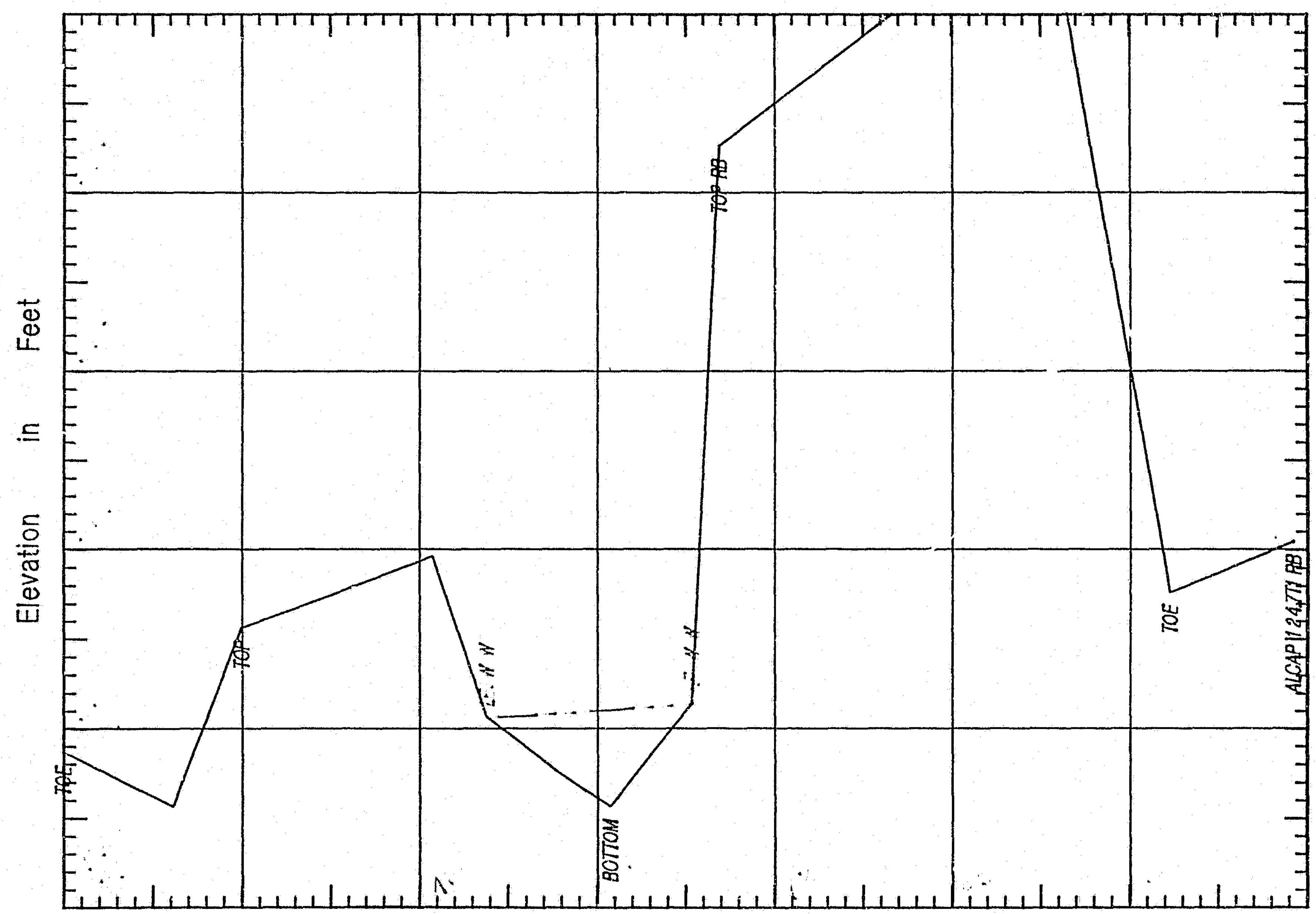
R&M CONSULTANTS, INC.

THALWEG SKULL CREEK

PREPARED FOR:

ACRES

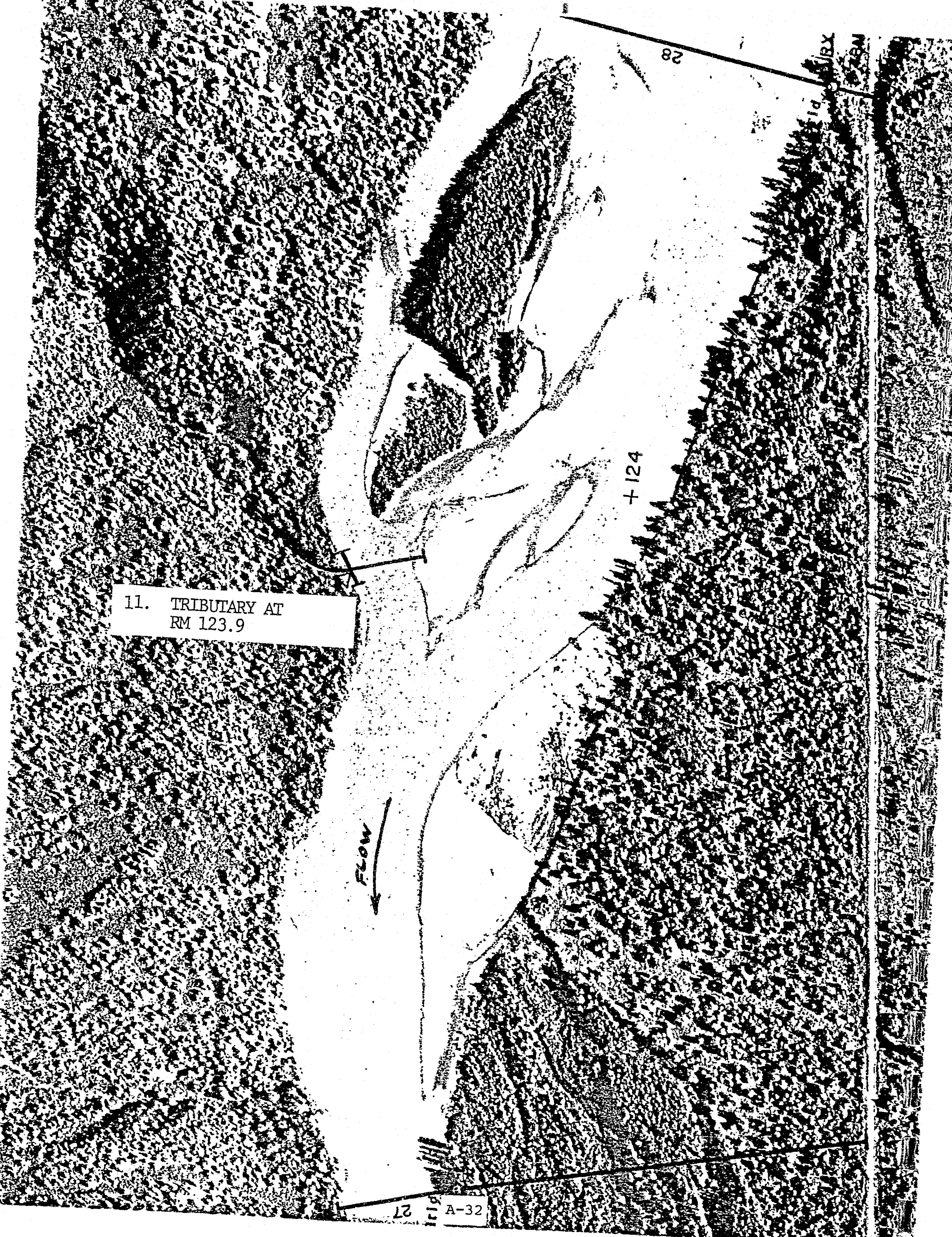
SUSITNA HYDROGRAPHIC SURVEYS



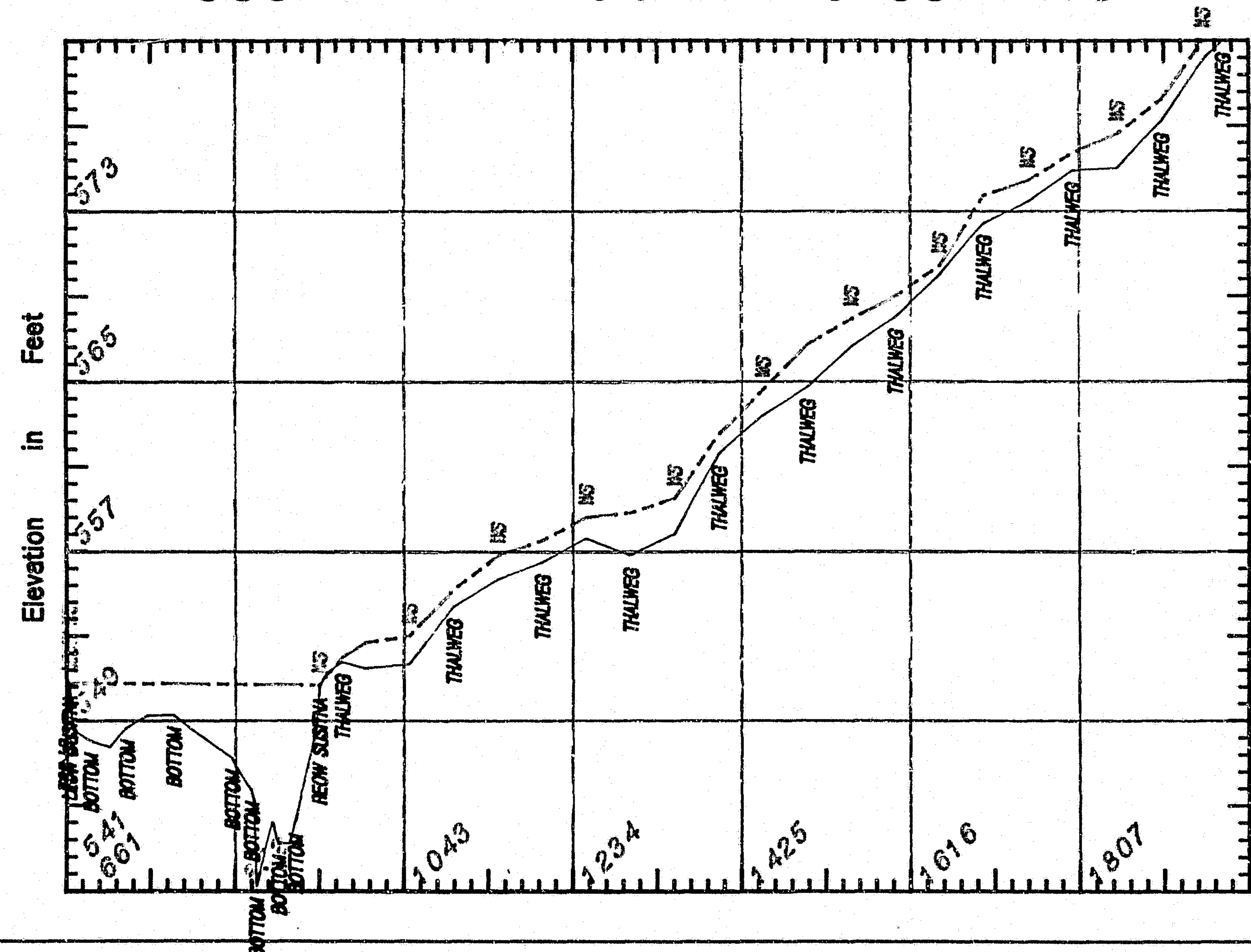
PREPARED BY: R&M CONSULTANTS, INC.

SKULL CREEK MOUTH X-SEC

PREPARED FOR: ACRES


11. TRIBUTARY AT
RM 123.9
FLOW
+124
28
27
A-32

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

R&M CONSULTANTS, INC.

THALWEG TRIBUTARY AT RM123.9

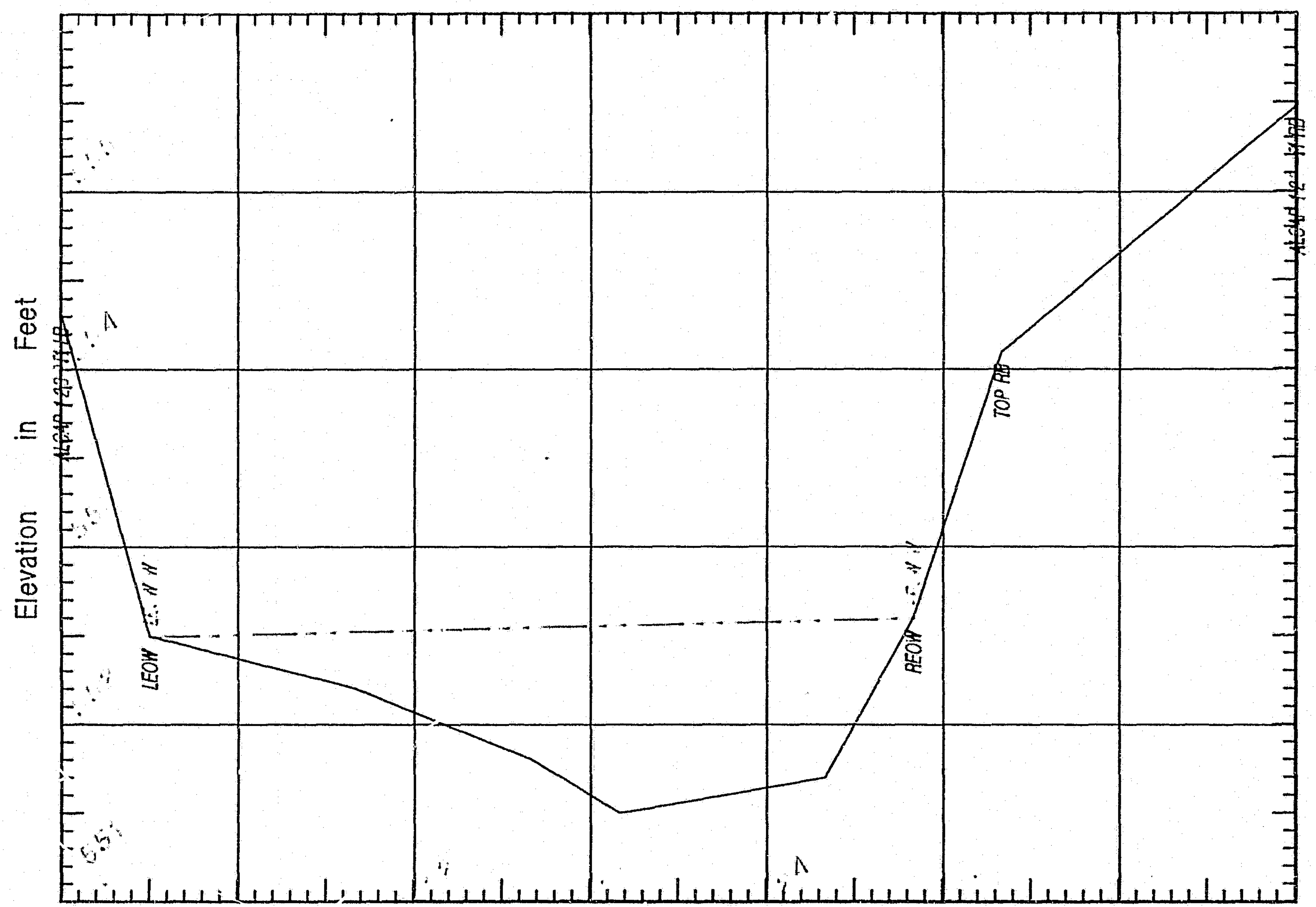
Date of Survey: AUGUST 6, 1982

PREPARED FOR:

ACRES

A-33

SUSITNA HYDROGRAPHIC SURVEYS



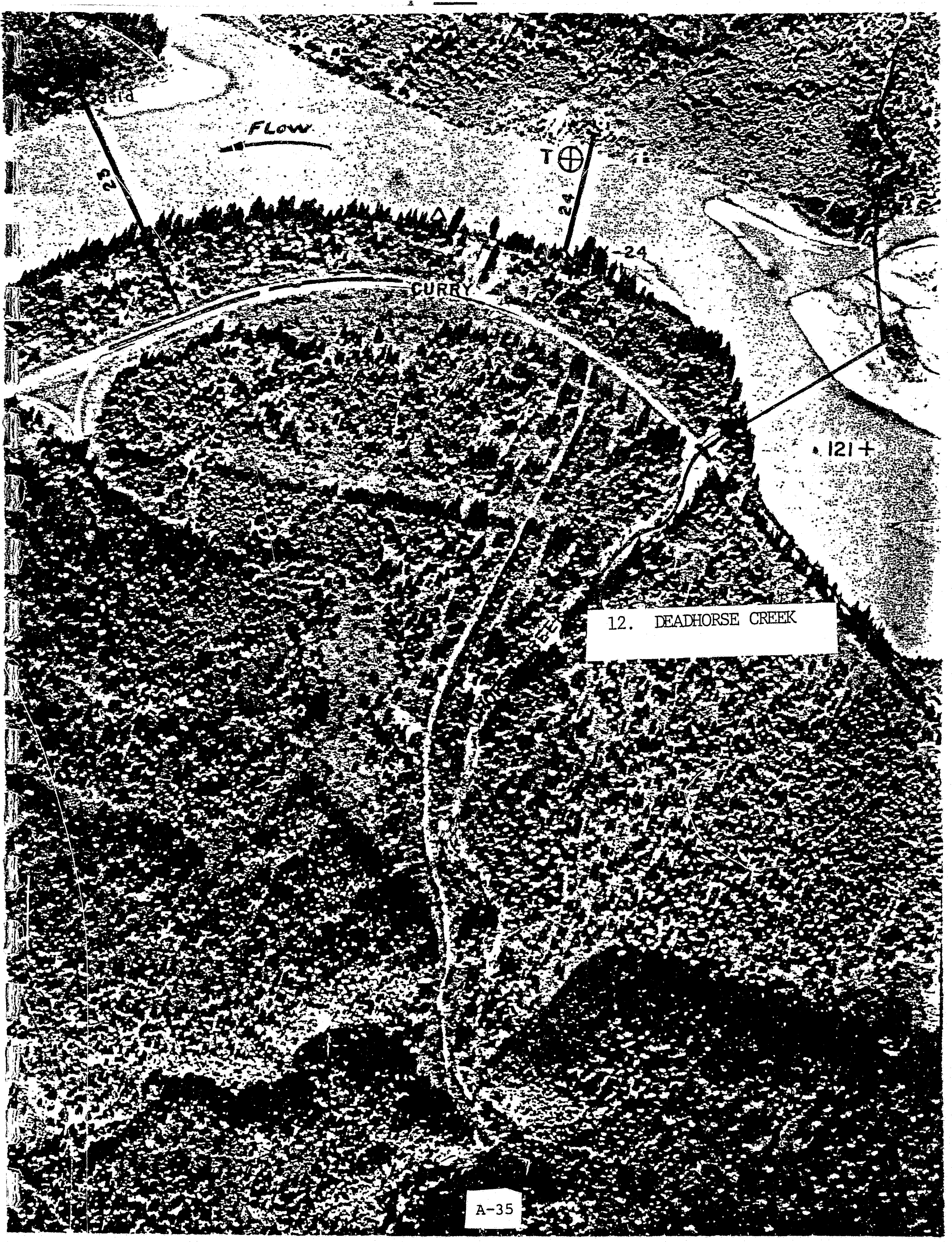
PREPARED BY:

R&M CONSULTANTS, INC.

TRIBUTARY AT RM 123.9 X-SEC

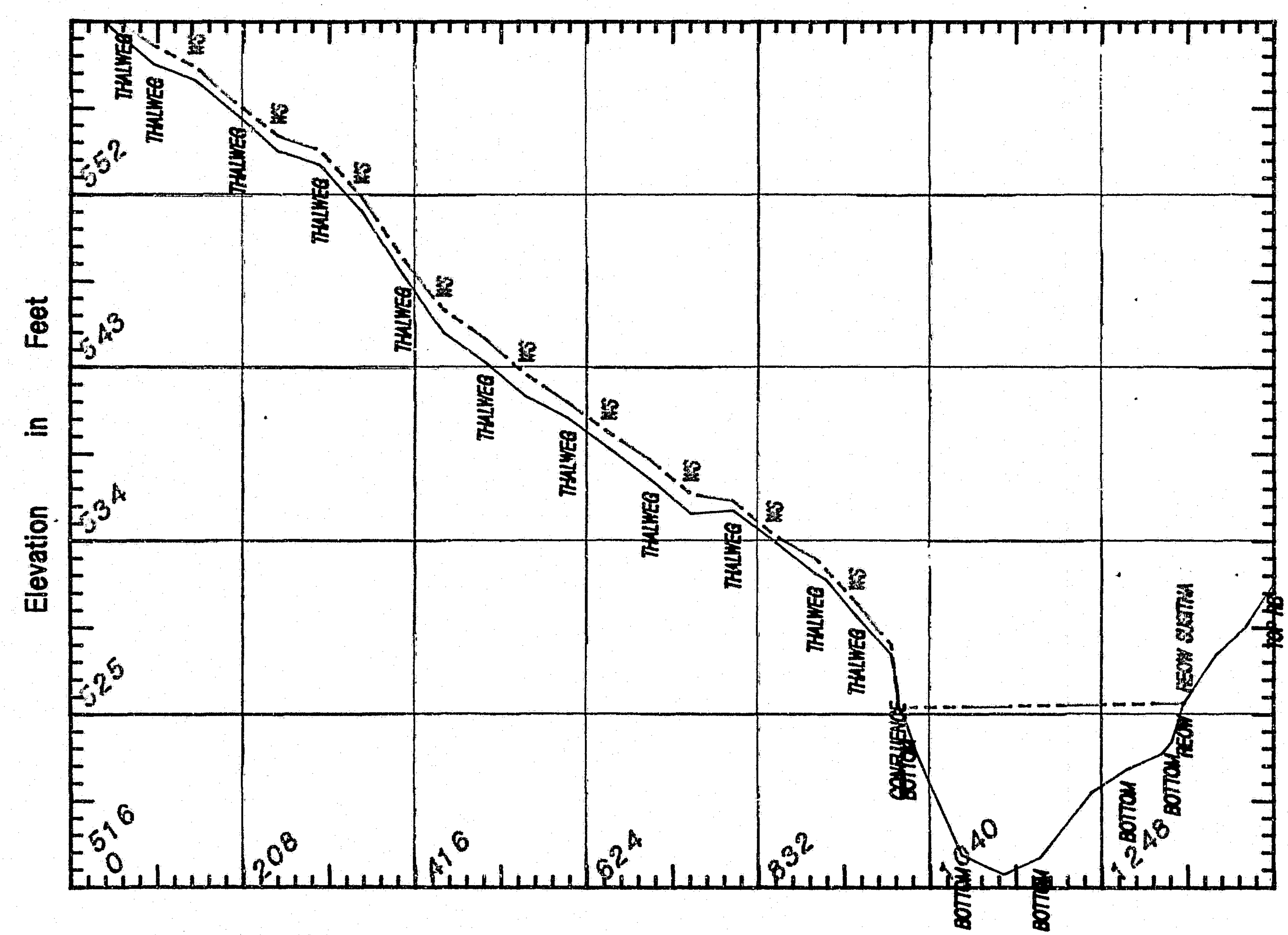
PREPARED FOR:

ACRES



12. DEADHORSE CREEK

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

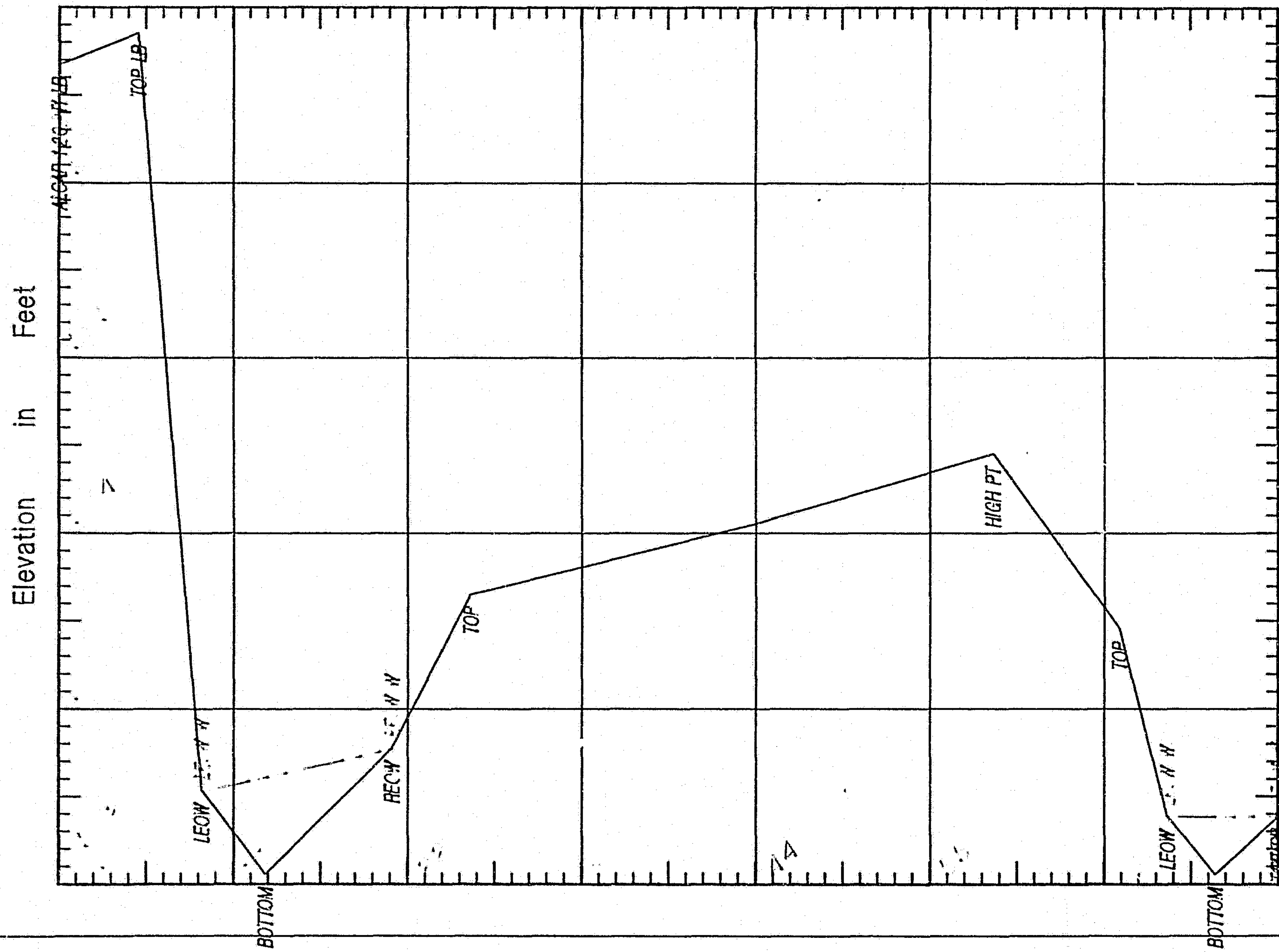
R&M CONSULTANTS, INC.

DEADHORSE CREEK THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



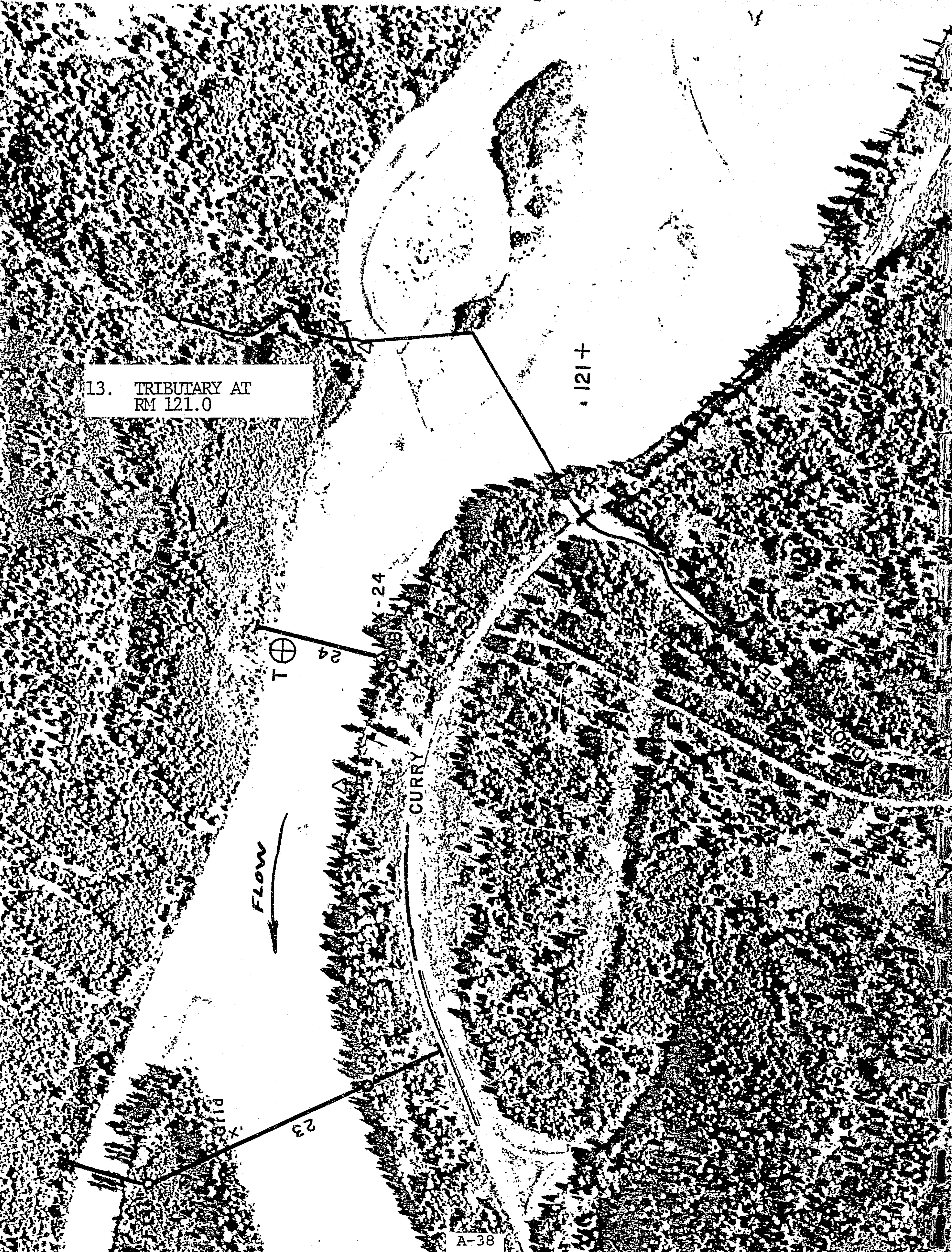
PREPARED BY:

R&M CONSULTANTS, INC.

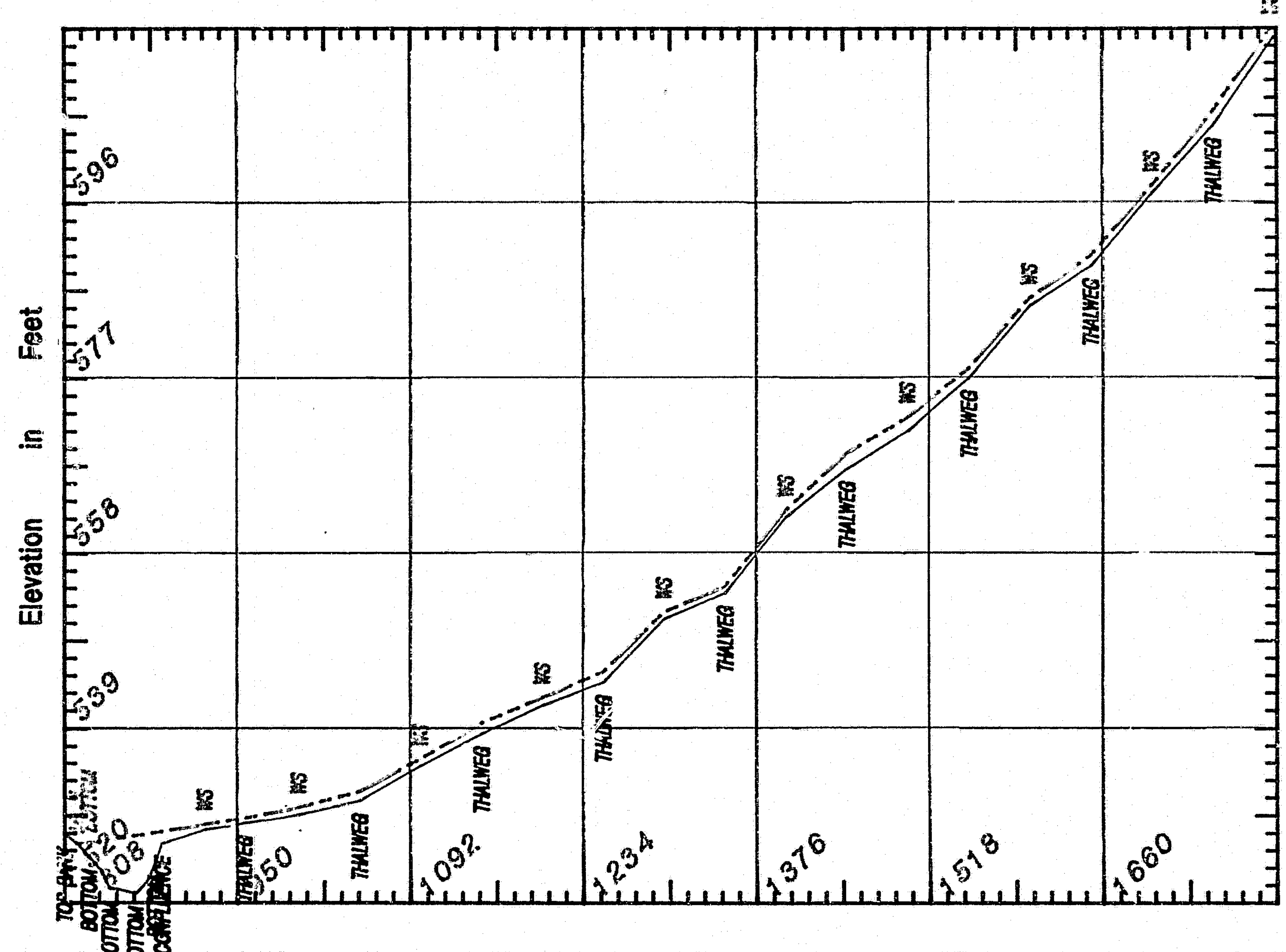
DEADHORSE CREEK MOUTH X-SEC

PREPARED FOR:

ACRES


13. TRIBUTARY AT
RM 121.0
121 +
24
T
FLOW
CURRY
23

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

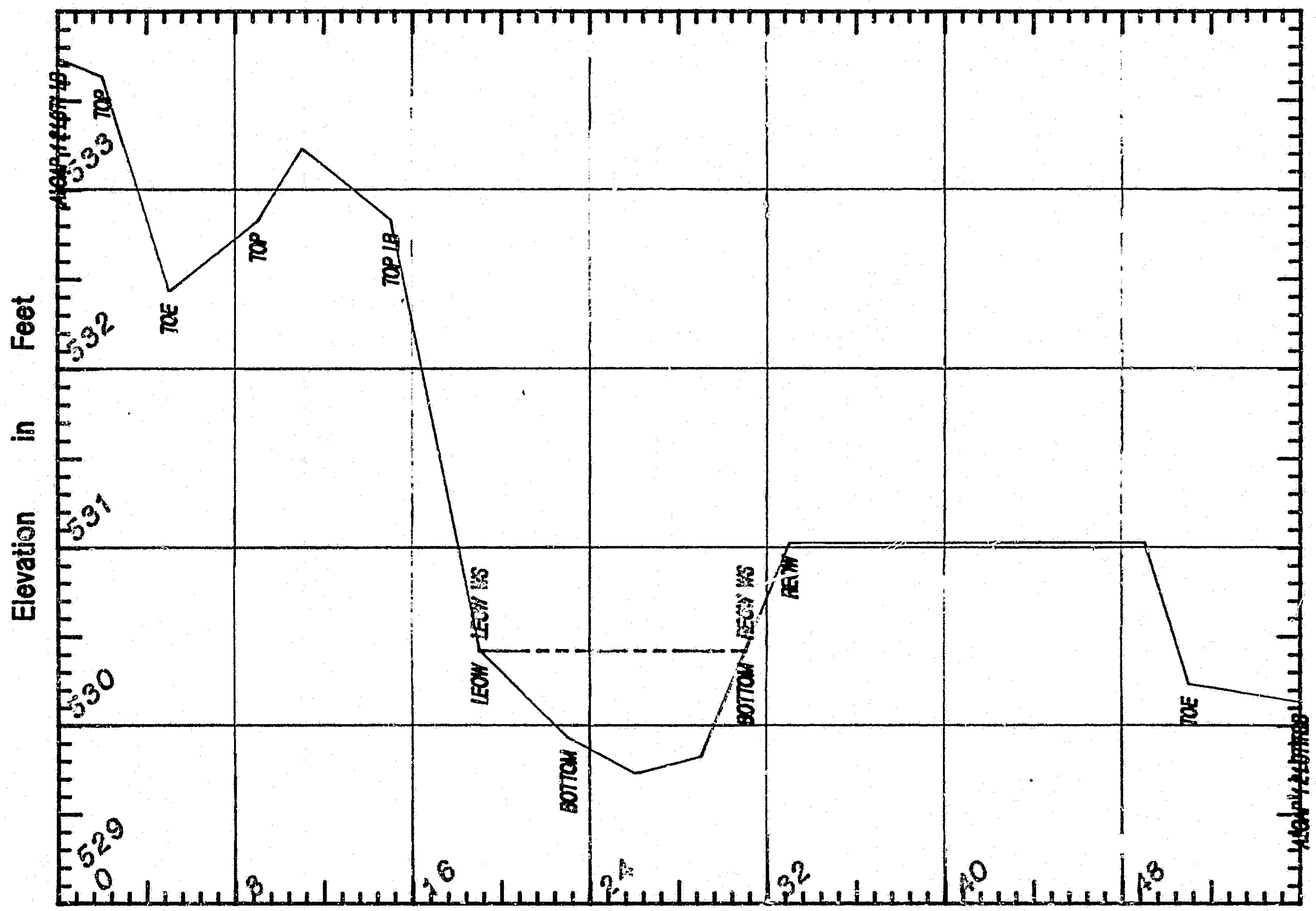
R&M CONSULTANTS, INC.

TRIBUTARY AT RM 121.0 THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

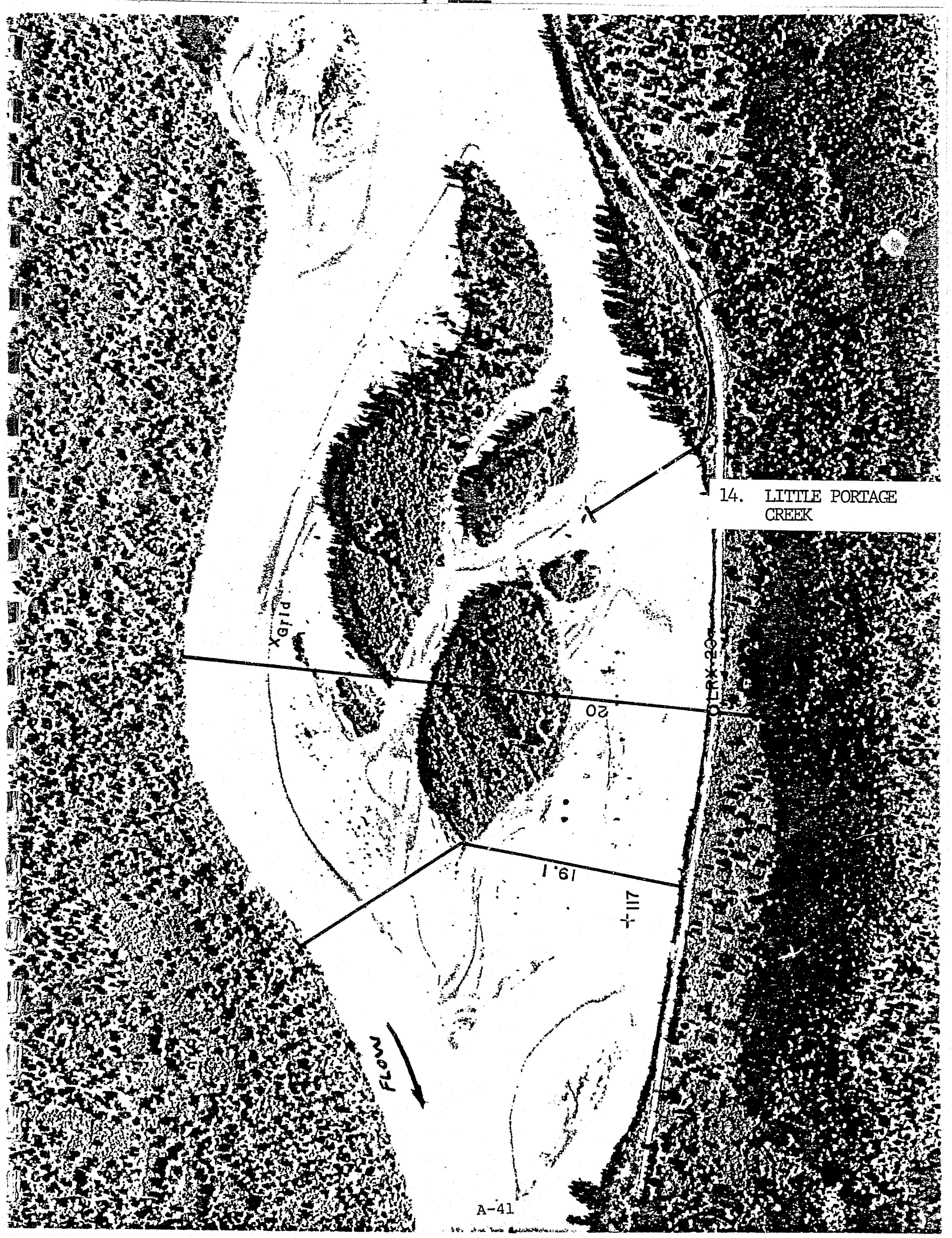
R&M CONSULTANTS, INC.

TRIBUTARY AT RM 121.0 MOUTH X-SEC

PREPARED FOR:

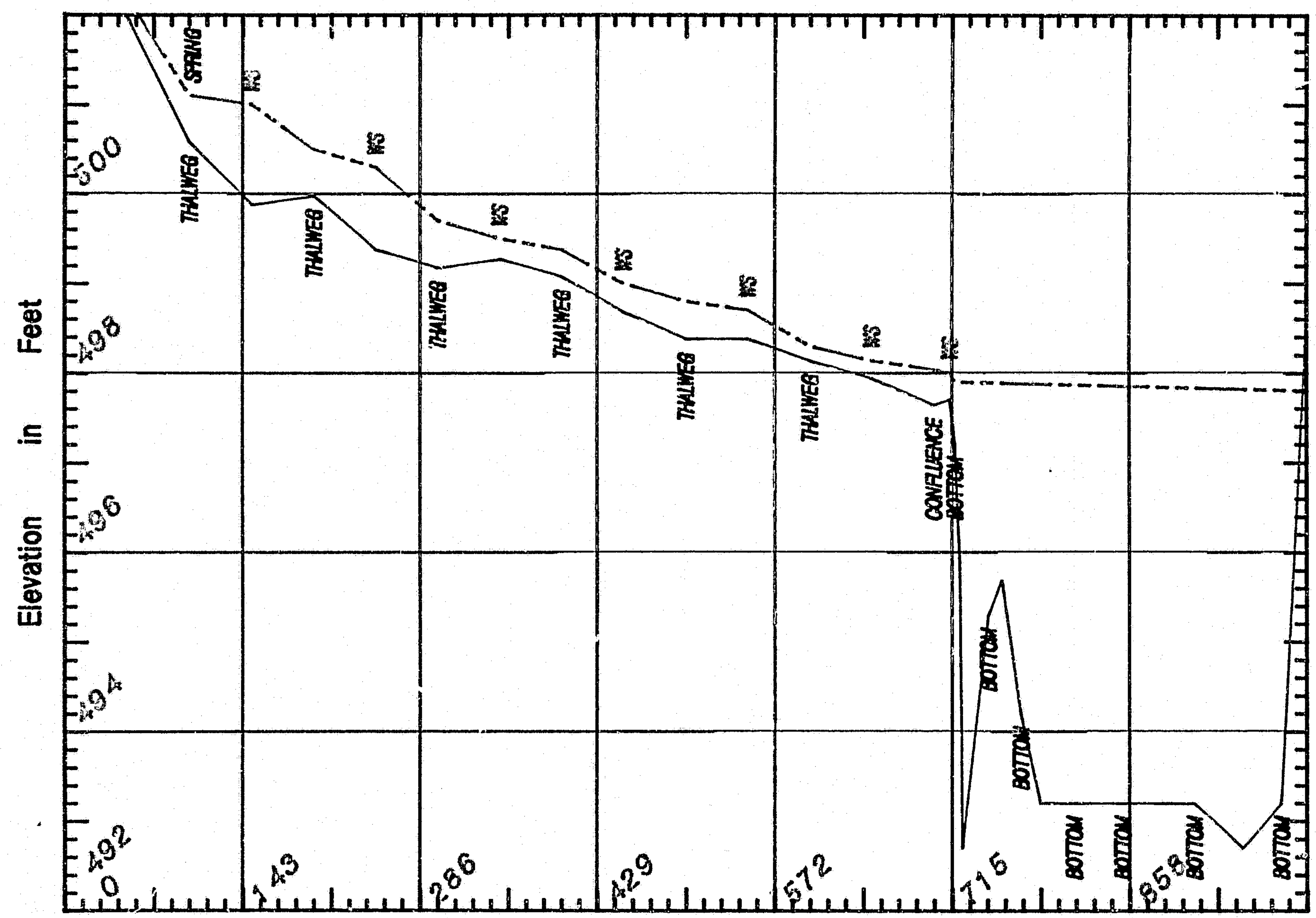
ACRES

A-40



14. LITTLE PORTAGE CREEK

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

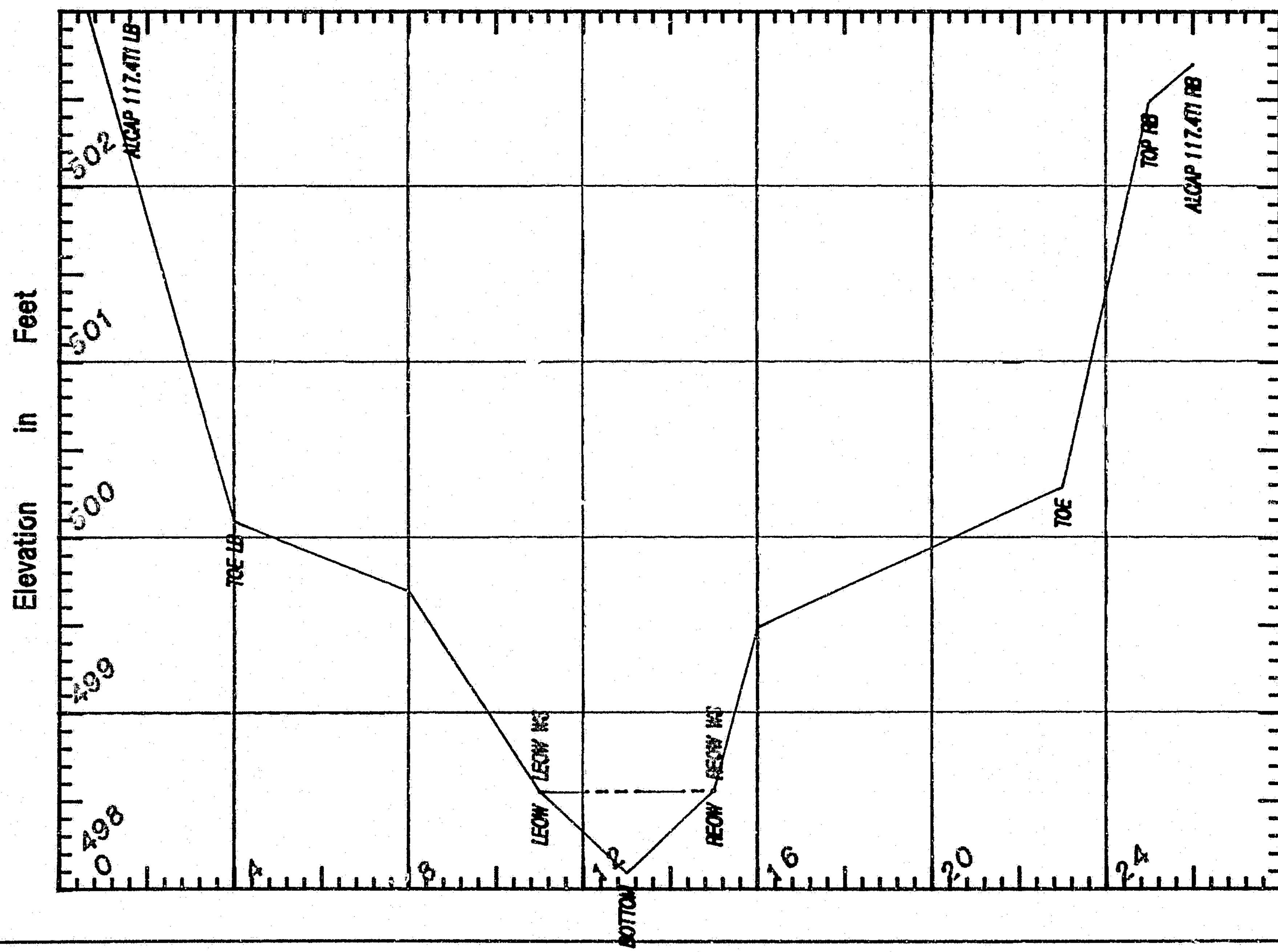
R&M CONSULTANTS, INC.

LITTLE PORTAGE CREEK THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



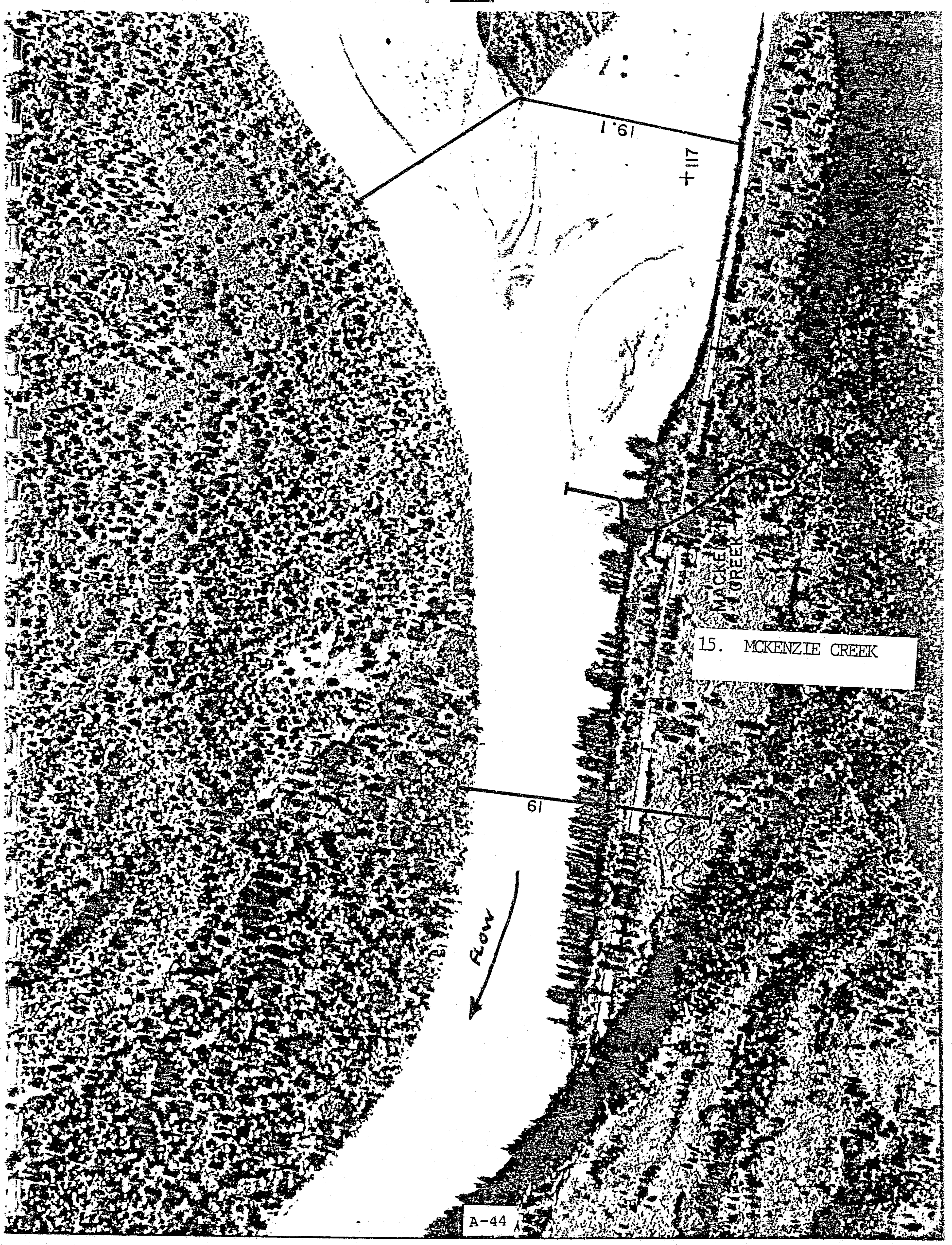
PREPARED BY:

R&M CONSULTANTS, INC.

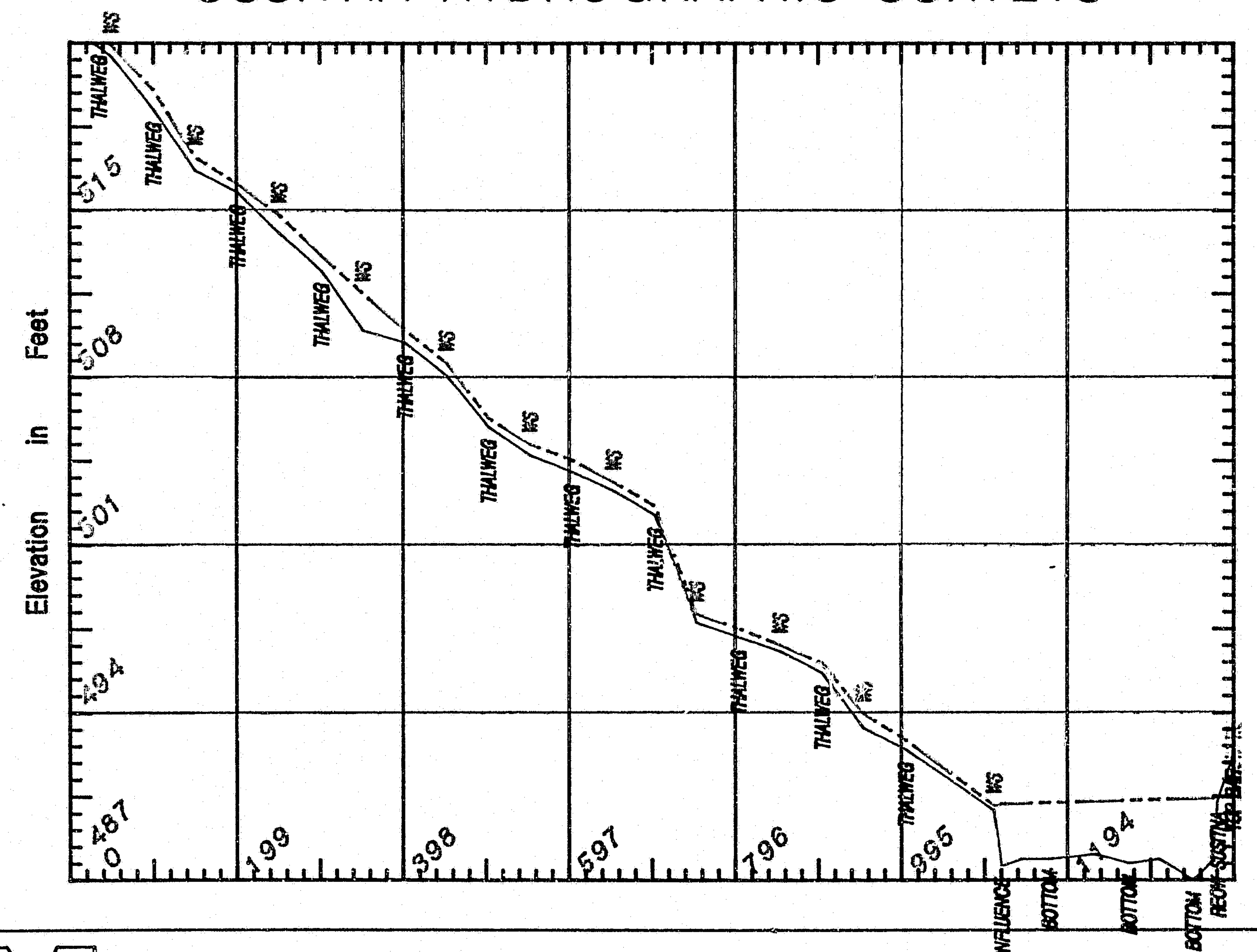
LITTLE PORTAGE CREEK MOUTH X-SEC

PREPARED FOR:

ACRES


117
MACKENZIE CREEK
15. MCKENZIE CREEK
FLOW

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

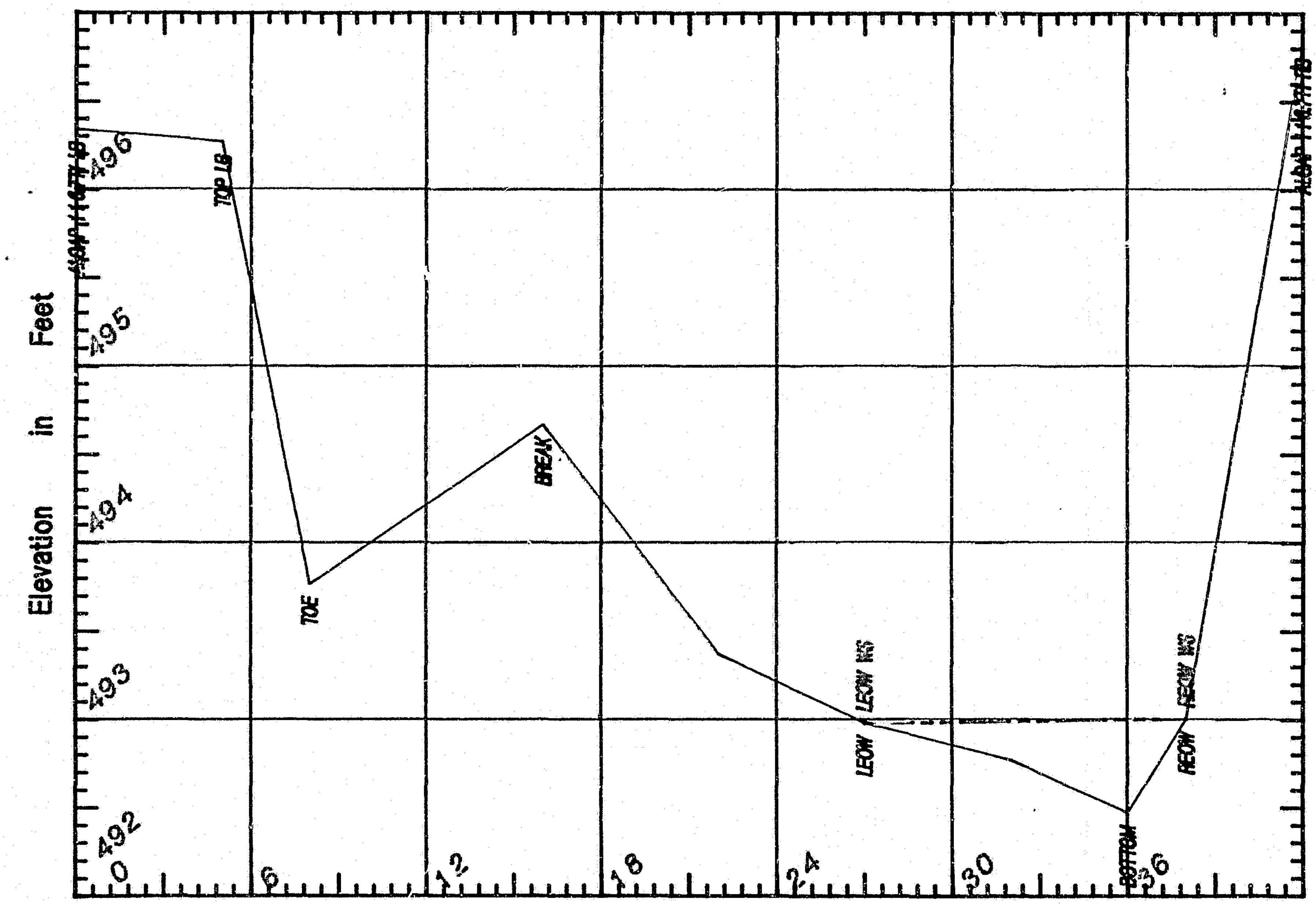
R&M CONSULTANTS, INC.

MACKENZIE CREEK THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



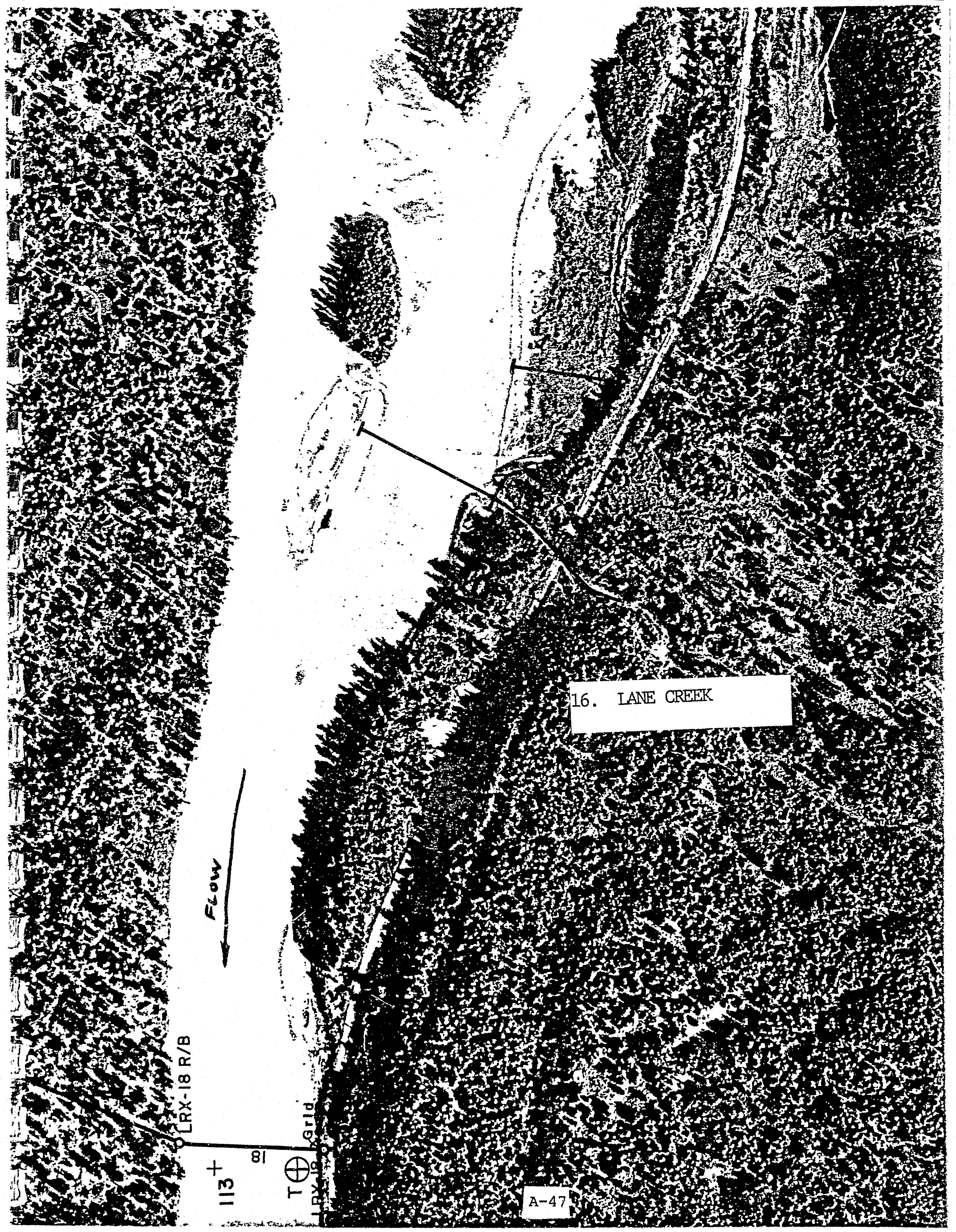
PREPARED BY:

R&M CONSULTANTS, INC.

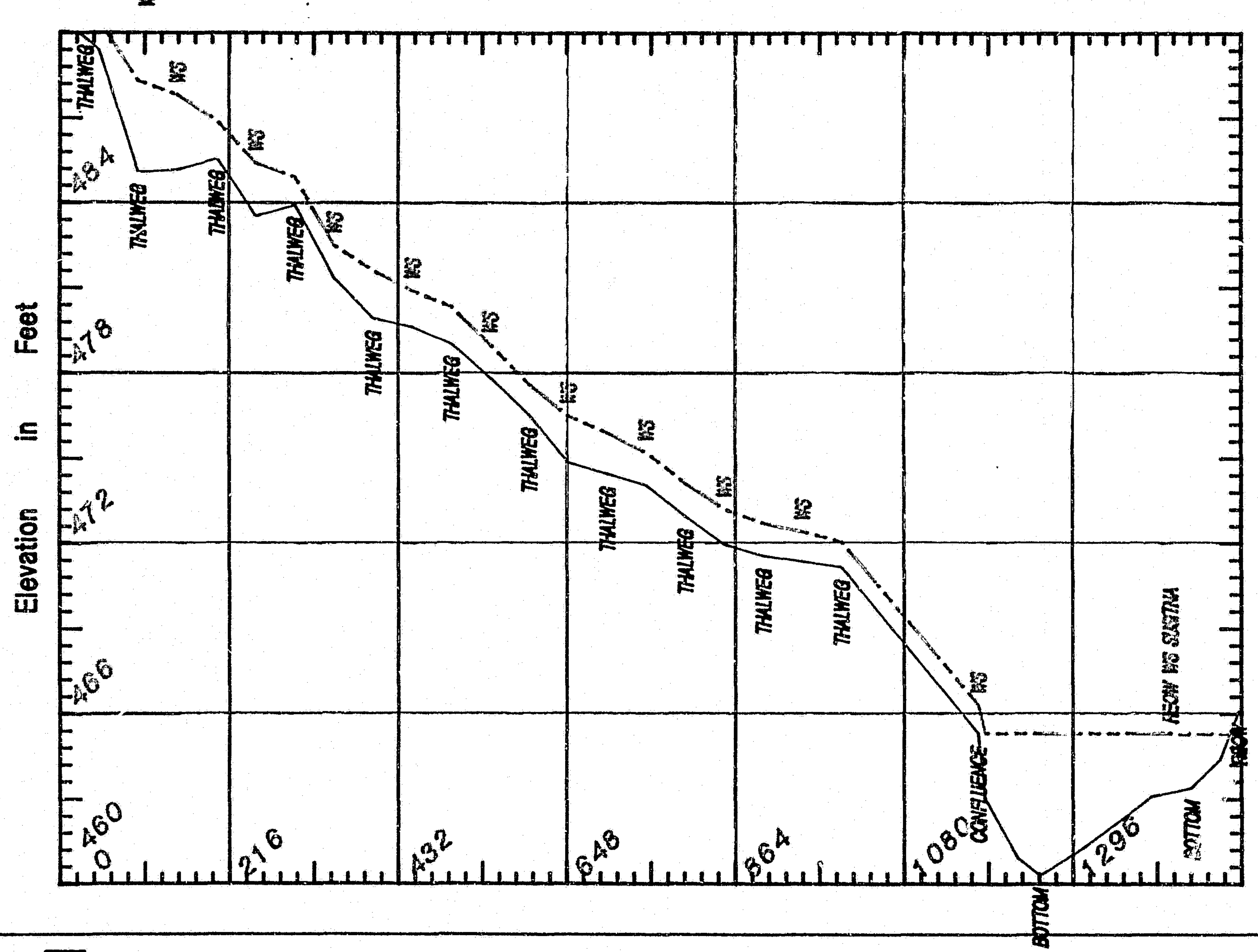
MACKENZIE CREEK MOUTH X-SEC

PREPARED FOR:

ACRES


16. LANE CREEK
FLOW
LRX-18 R/B
Grid
81
113+

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

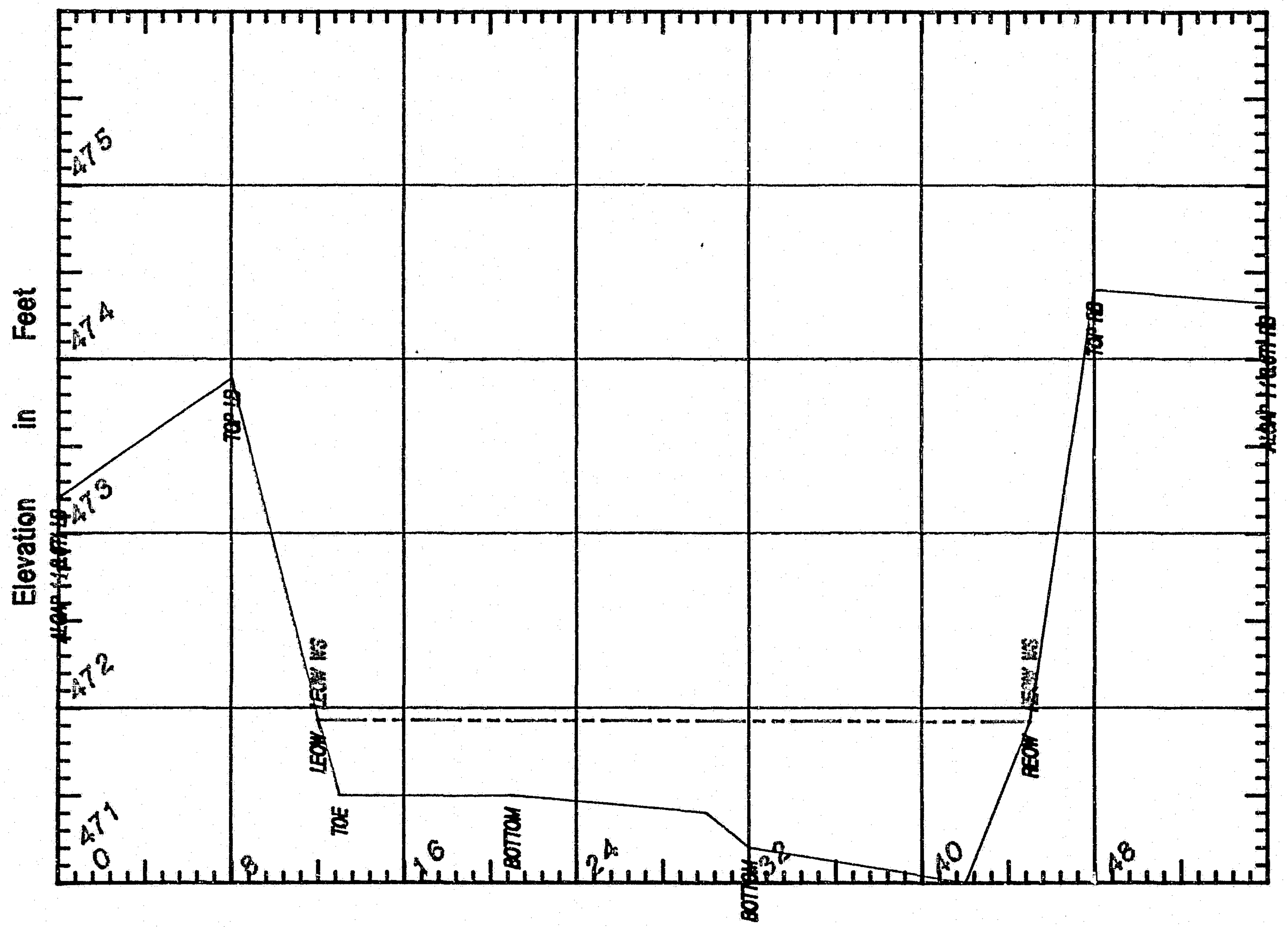
R&M CONSULTANTS, INC.

LANE CREEK MOUTH THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



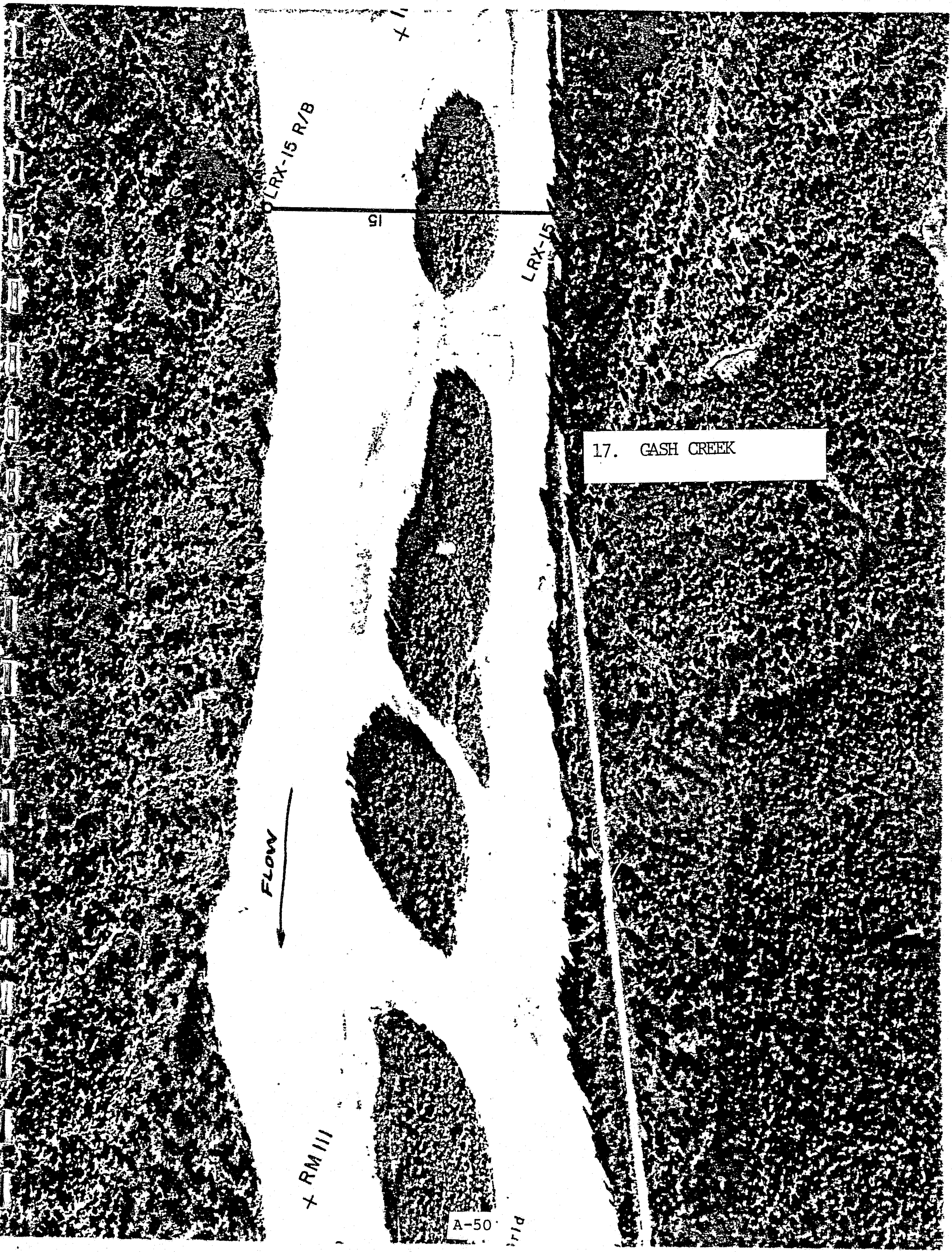
PREPARED BY:

R&M CONSULTANTS, INC.

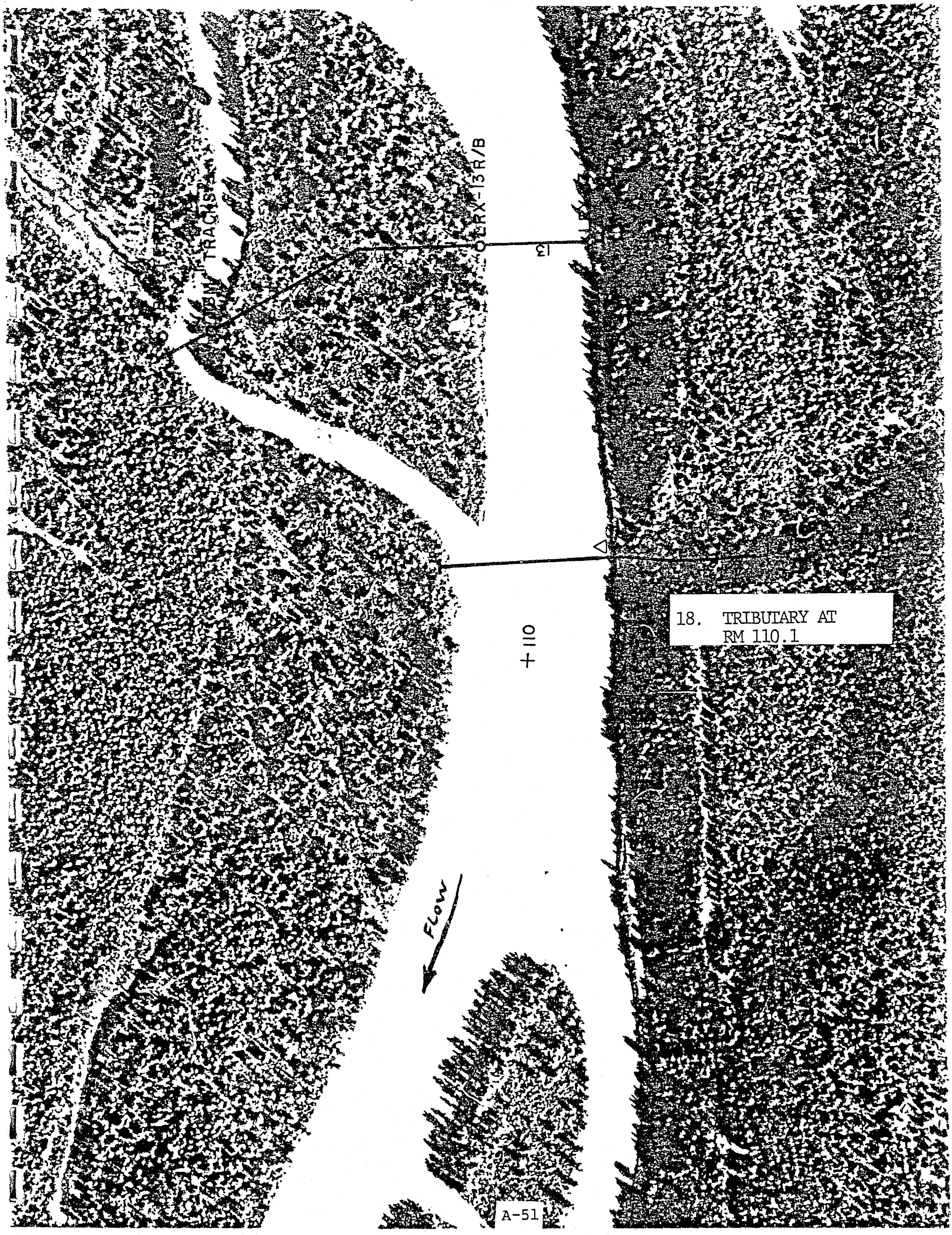
LANE CREEK MOUTH X-SEC

PREPARED FOR:

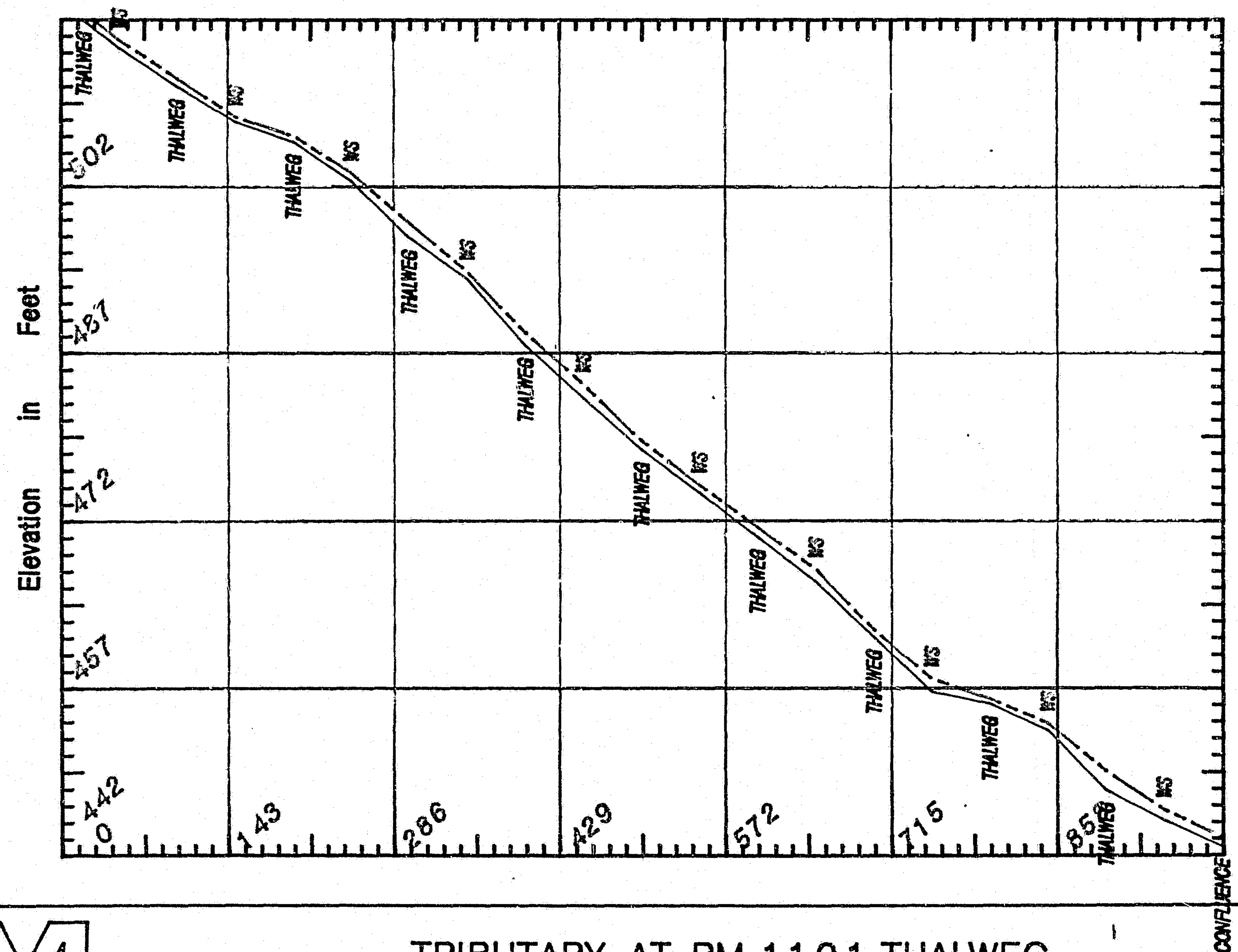
ACRES



17. GASH CREEK


18. TRIBUTARY AT RM 110.1
LRX-13 R/B
TRACKS
13
110
FLOW

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

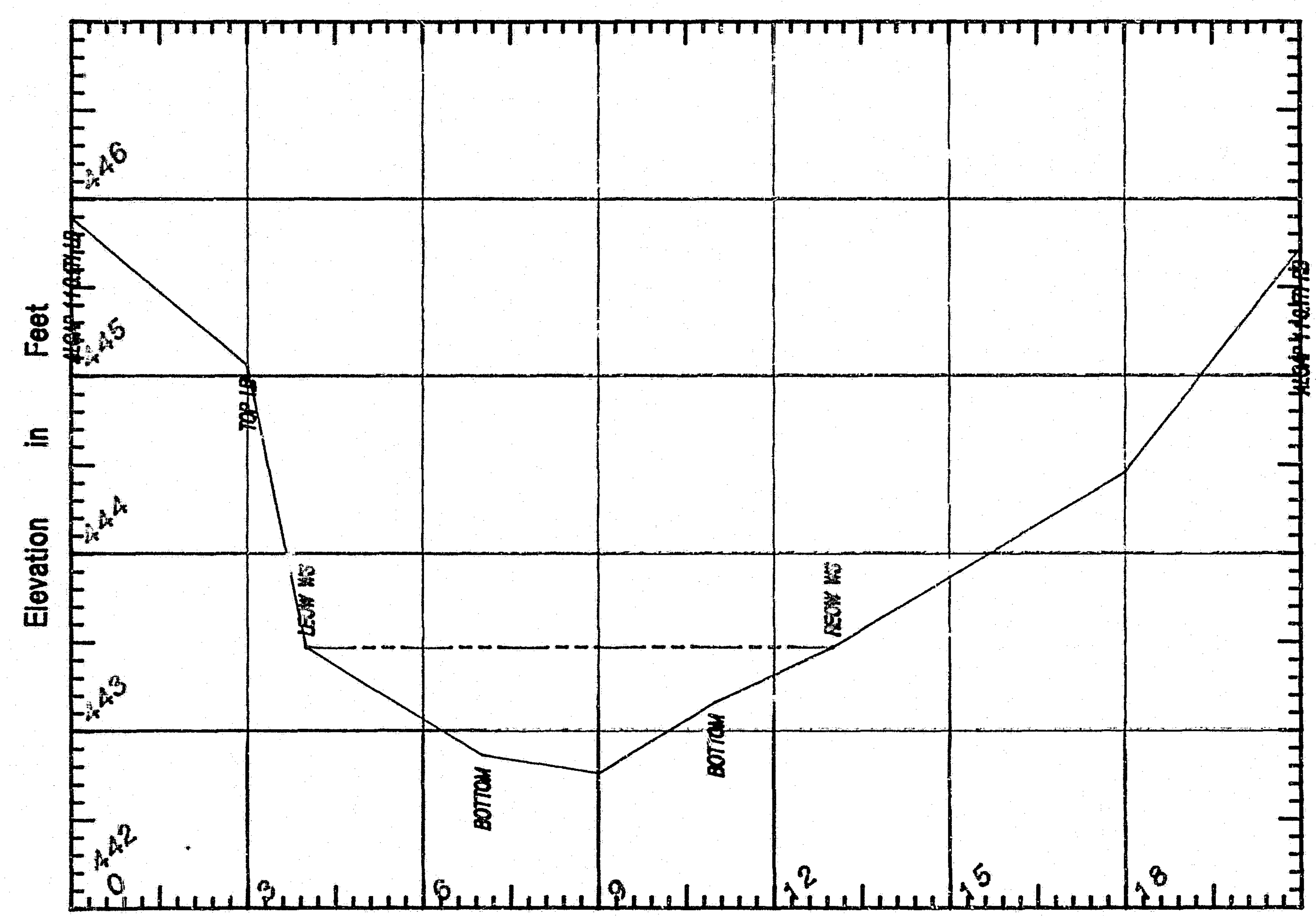
R&M CONSULTANTS, INC.

TRIBUTARY AT RM 110.1 THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



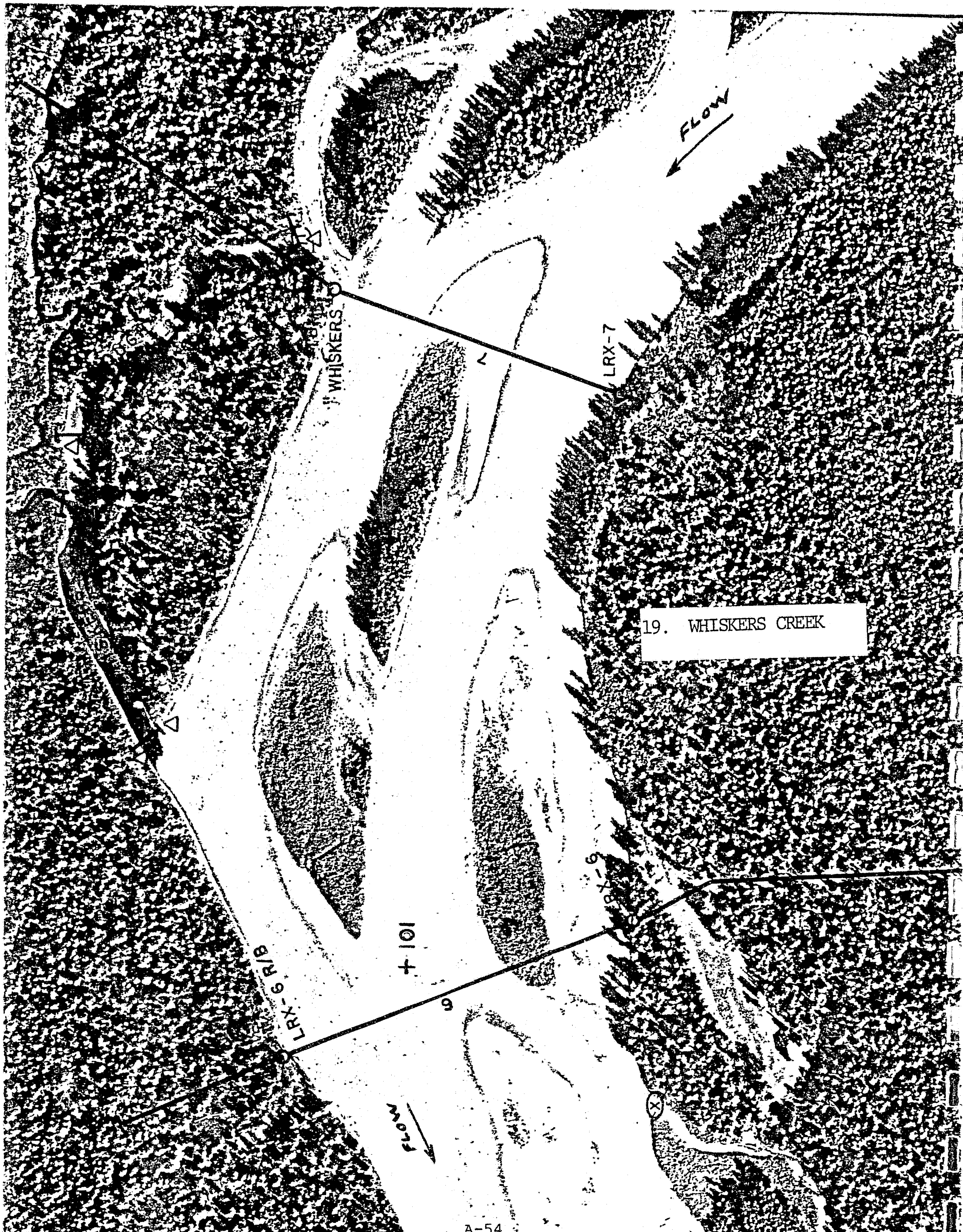
PREPARED BY:

R&M CONSULTANTS, INC.

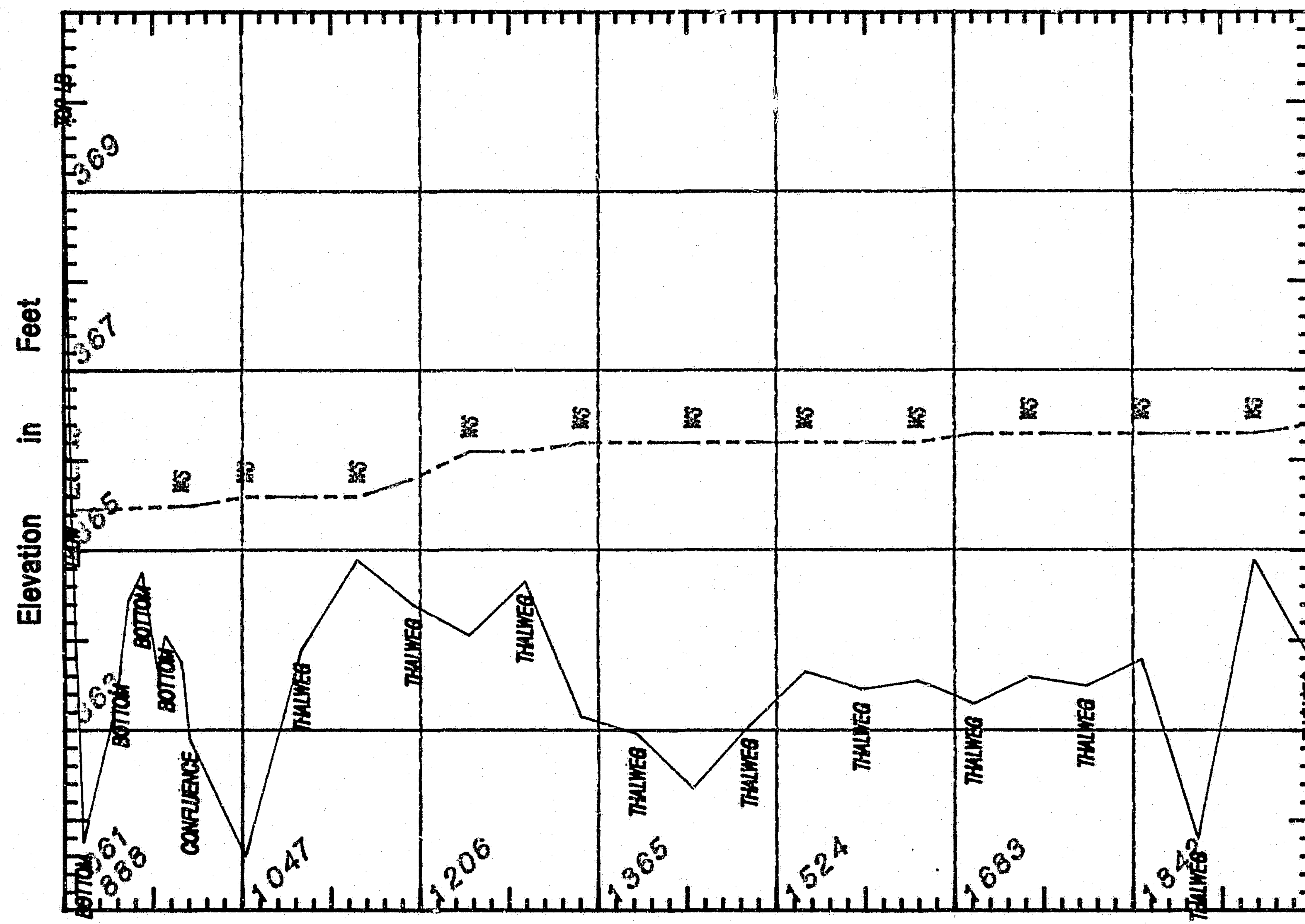
TRIBUTARY AT RM 110.1 X-SEC MOUTH

PREPARED FOR:

ACRES


FLOW
WHISKERS
LRX-7
7
19. WHISKERS CREEK
LRX-6 R/B
101
6
LRX-6
FLOW

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

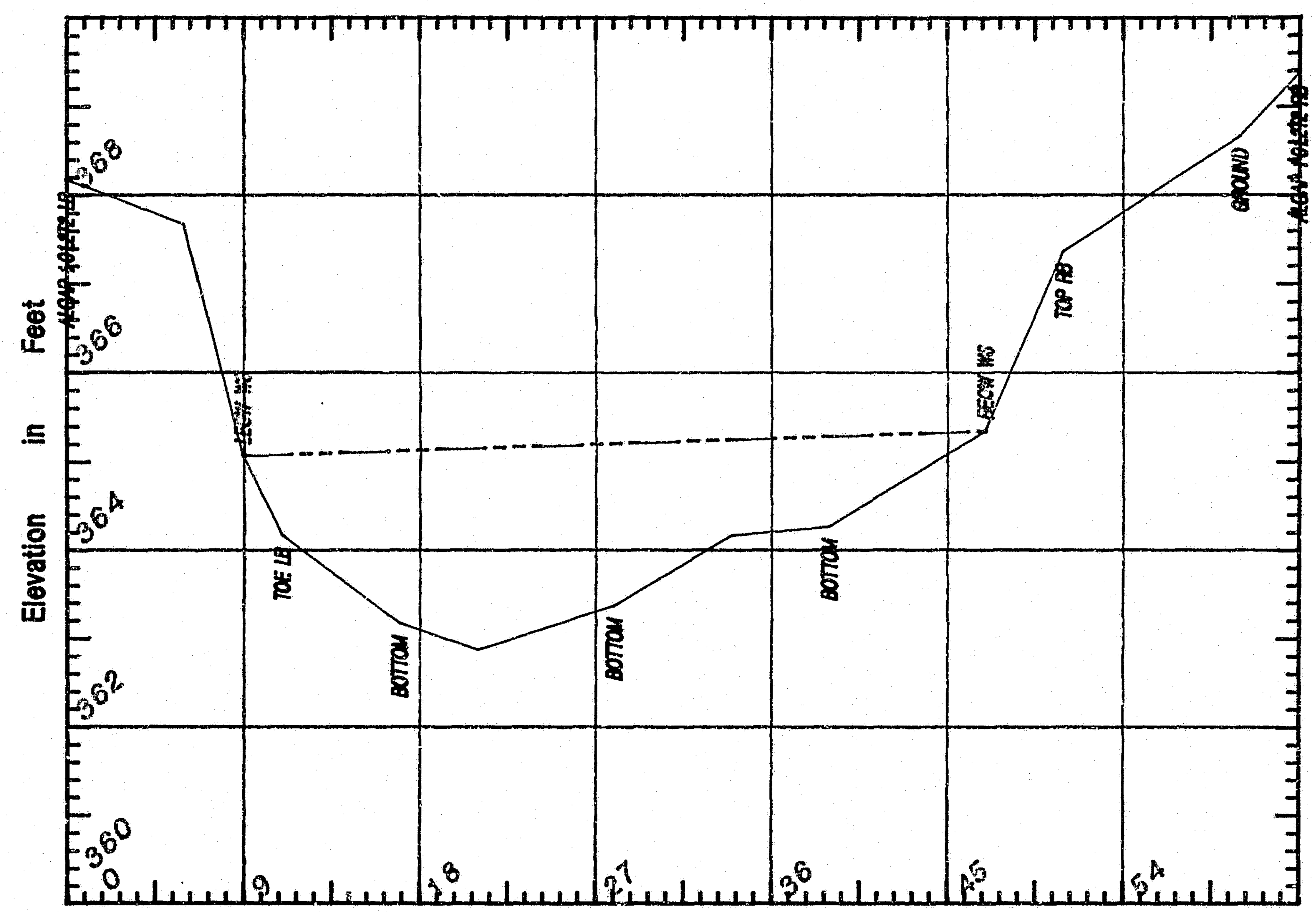
R&M CONSULTANTS, INC.

WHISKERS CREEK THALWEG

PREPARED FOR:

ACRES

SUSITNA HYDROGRAPHIC SURVEYS



PREPARED BY:

R&M CONSULTANTS, INC.

WHISKERS CREEK X–SEC MOUTH

PREPARED FOR:

ACRES

s17/m3

ATTACHMENT B

1982 MEASUREMENTS AND FIELD ESTIMATES OF DISCHARGES IN STUDY TRIBUTARIES

TABLE B.1
SUSITNA TRIBUTARY STABILITY ANALYSIS
1982 MEASURED AND ESTIMATED DISCHARGES

		Measured									Estimated		
No.	Name	Date [1]	W.S.E. or Gage Height (ft) [2]	Q (cfs)	Date [1]	W.S.E. or Gage Height (ft) [2]	Q (cfs)	Date [1]	W.S.E. or Gage Height (ft) [2]	Q (cfs)	Date [1]	Q (cfs)	Method [3]
1	Portage	7/8	841.9 842.2	1190 2160		840.9	620		841.0	666	9/15	1700	floating-stick
2	Jack Long	7/9	789.4	28							9/15	280	aerial
3	Indian	7/14	G.H. = 4.8	310		G.H. = 4.75	270		G.H. = 5.8	930	9/15	1370	floating-stick
4	Gold	7/13	691.6	48							9/15	900	floating-stick
5	132.0	7/31	635.8	24							9/15	56	floating-stick
6	4th of July	7/16	616.6	29		617.1	38				9/15	530	floating-stick
7	Sherman	7/16	620.95	3.9							9/15	250	floating-stick
8	128.5	9/21	TBM - 2.45	7.3							-	-	-
9	127.3	9/10	?	3.3							9/15	190	aerial
10	Skull	9/7	G.H. = 7.3	11							9/15	150	floating-stick
11	123.9	9/7	G.H. = 0.3	31							9/15	210	floating-stick
12	Deadhorse	9/7	?	12							9/15	120	floating-stick
13	121.0	9/7	G.H. = 0.55	11							9/15	80	floating-stick
14	L. Portage	8/15	498.05	0.2							9/15	36	floating-stick
15	McKenzie	9/7	TBM - 0.5	5.7							9/15	60	floating-stick
16	Lane	8/16	475.75	36		475.95	57		475.8	52	9/15	270	floating-stick
17	Gash										9/15	15	aerial
18	110.1	8/16	443.5	2.8							9/15	20	aerial
19	Whiskers	8/12	365.35	36	9/2	G.H. = 1.55	48				9/15	80	aerial

1 All dates are in 1982.

2 All are water-surface elevations (W.S.E.) unless noted as G.H. Datum for W.S.E. is mean sea level and for gage heights is arbitrary gage datum.

3 "Floating-stick" means average velocity measured by timing floating object over known distance. Average widths and depths were measured or estimated. "Aerial" means velocity, depth, and width were estimated from a helicopter.

ATTACHMENT C

BED MATERIAL PHOTOS AND PARTICLE-SIZE DISTRIBUTIONS

ATTACHMENT C - GENERAL NOTES

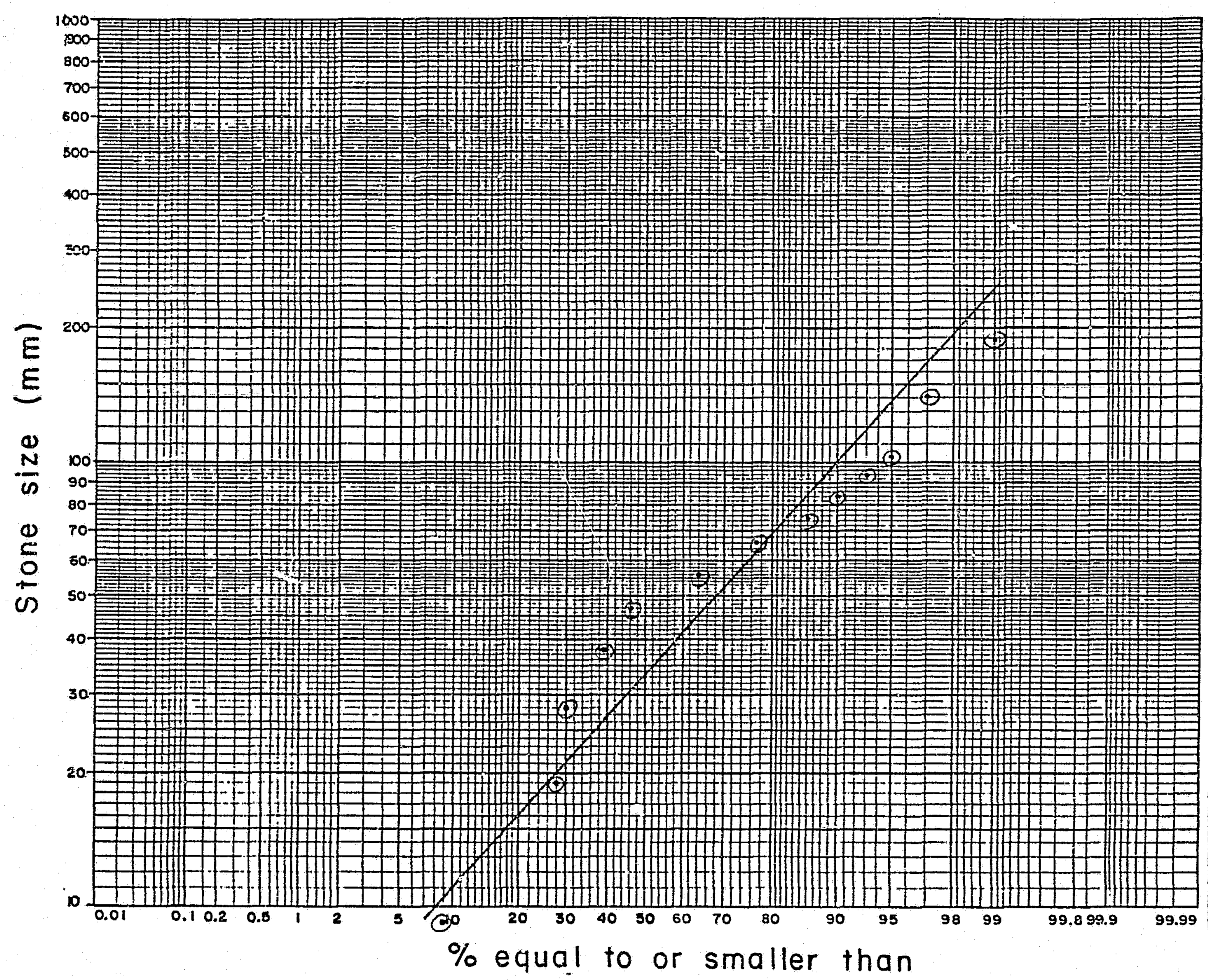
1. Samples presented are from the following creeks:

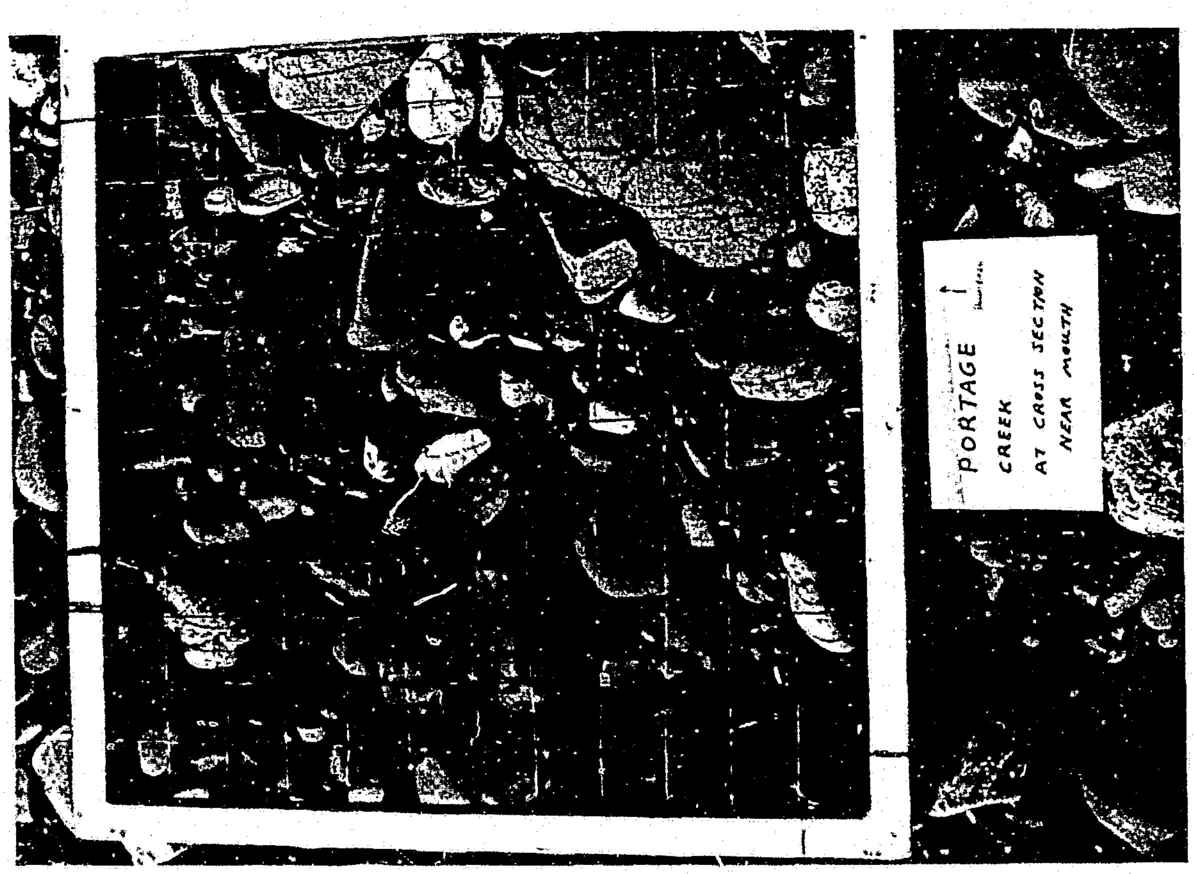
    a. Portage Creek
    b. Indian River
    c. Gold Creek
    d. Fourth of July Creek
    e. Sherman Creek
    f. Skull Creek
    g. Deadhorse Creek
    h. Trib. @ RM 121.0
    i. Little Portage Creek
    j. McKenzie Creek
    k. Lane Creek

2. Photos were all taken near creek mouths on September 15, 1982.

3. Analysis was done using the grid-sampling method described by Kellerhals and Bray (1970).

4. Grid spacing is 50 mm.



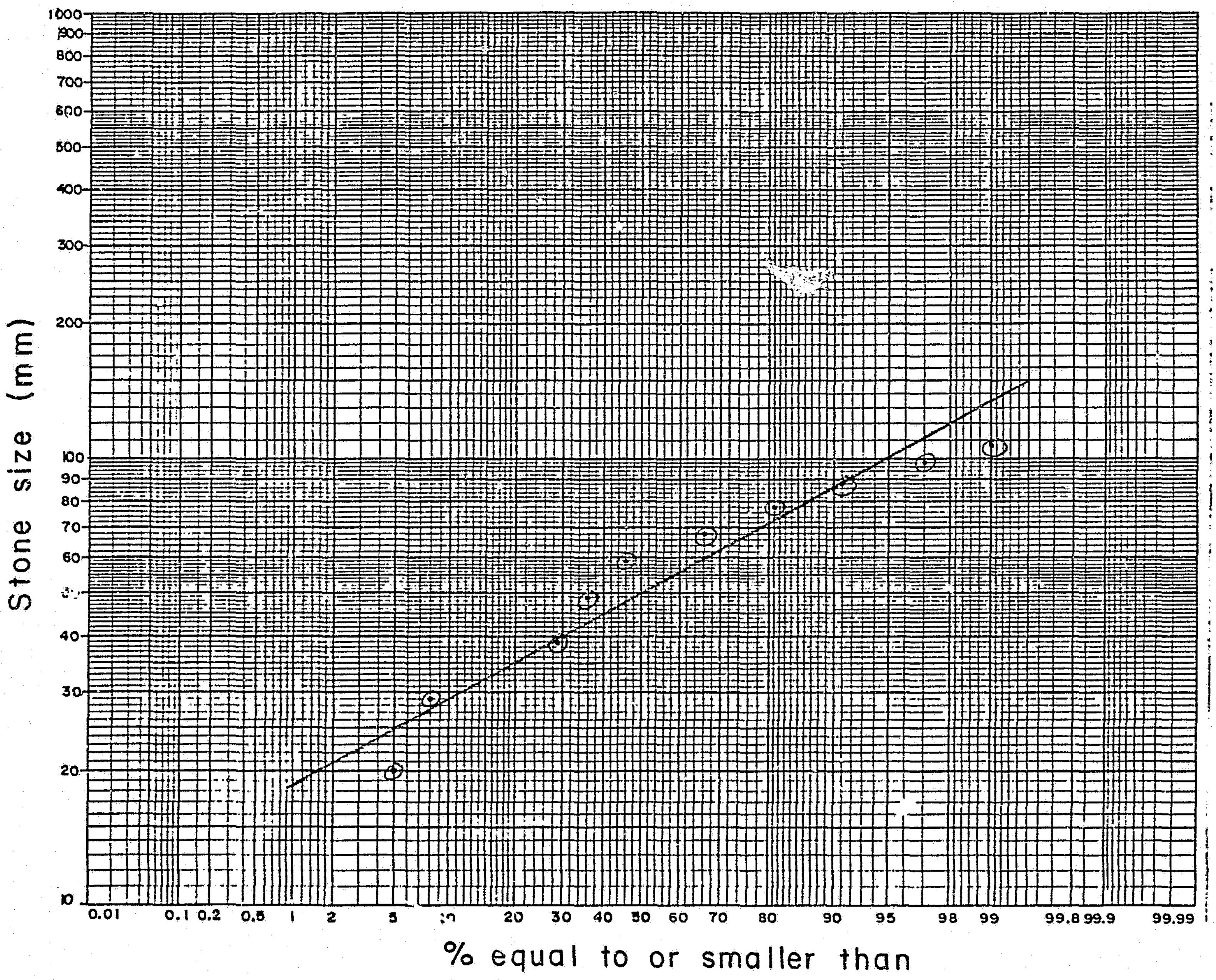


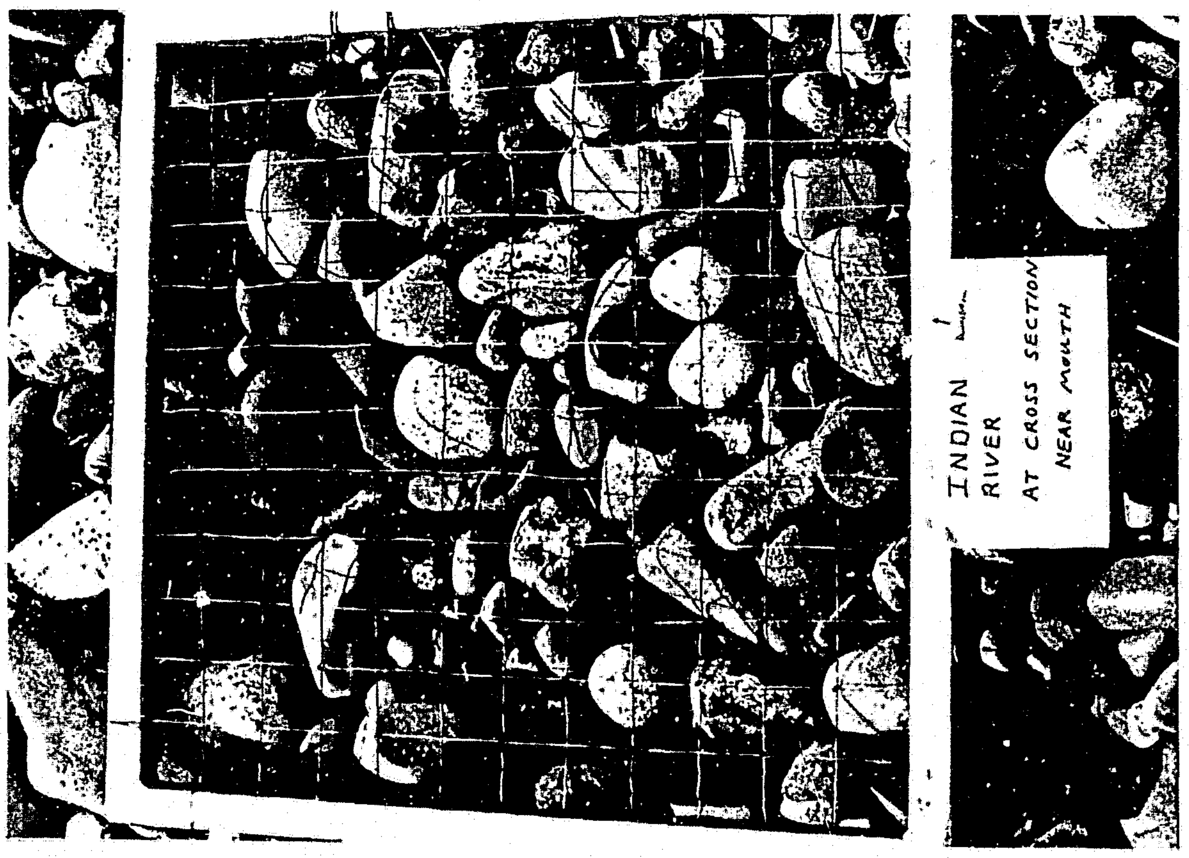
LRX = PORTAGE CREEK

D_{16} = 14mm

D_{50} = 33mm

D_{84} = 78mm





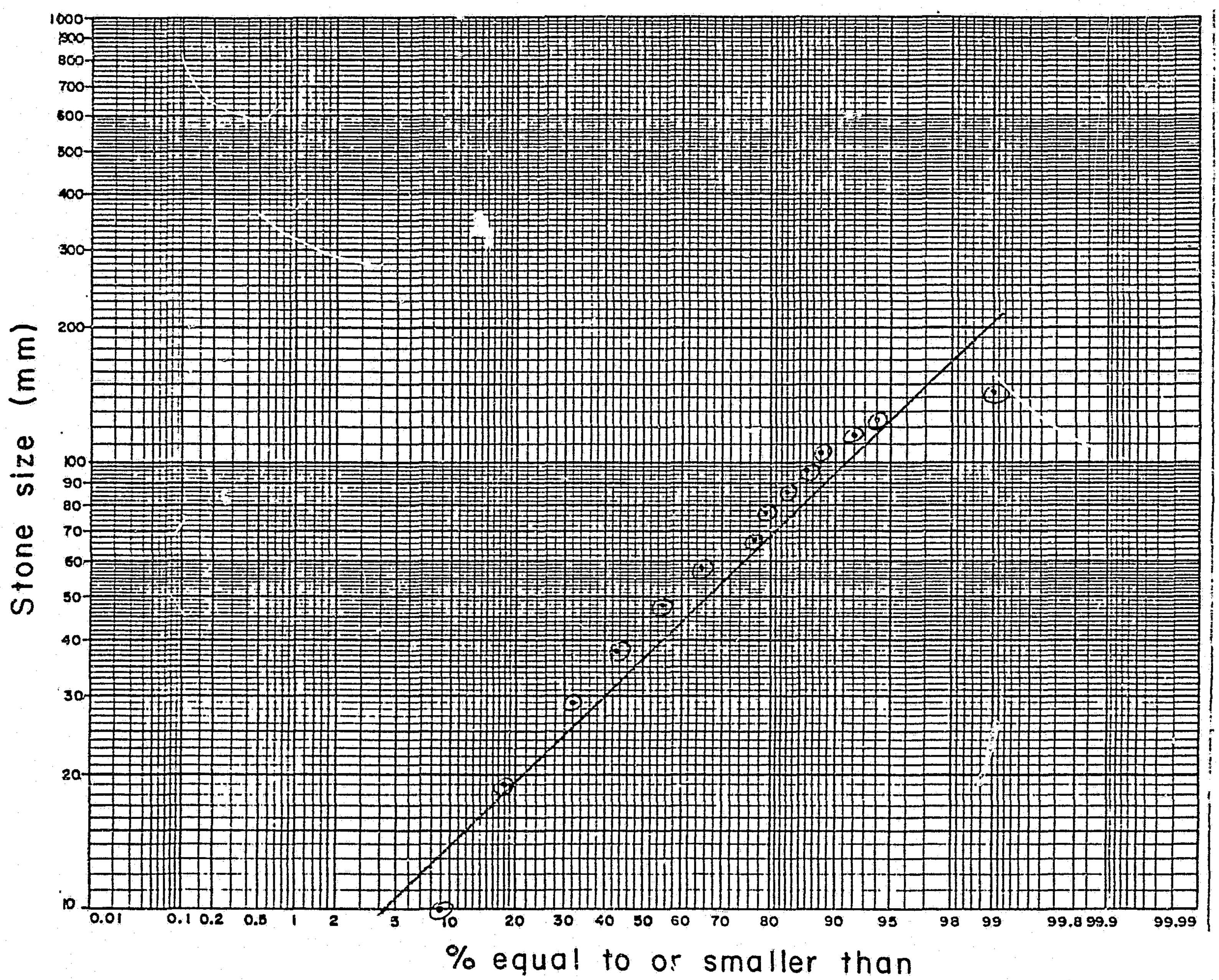
3

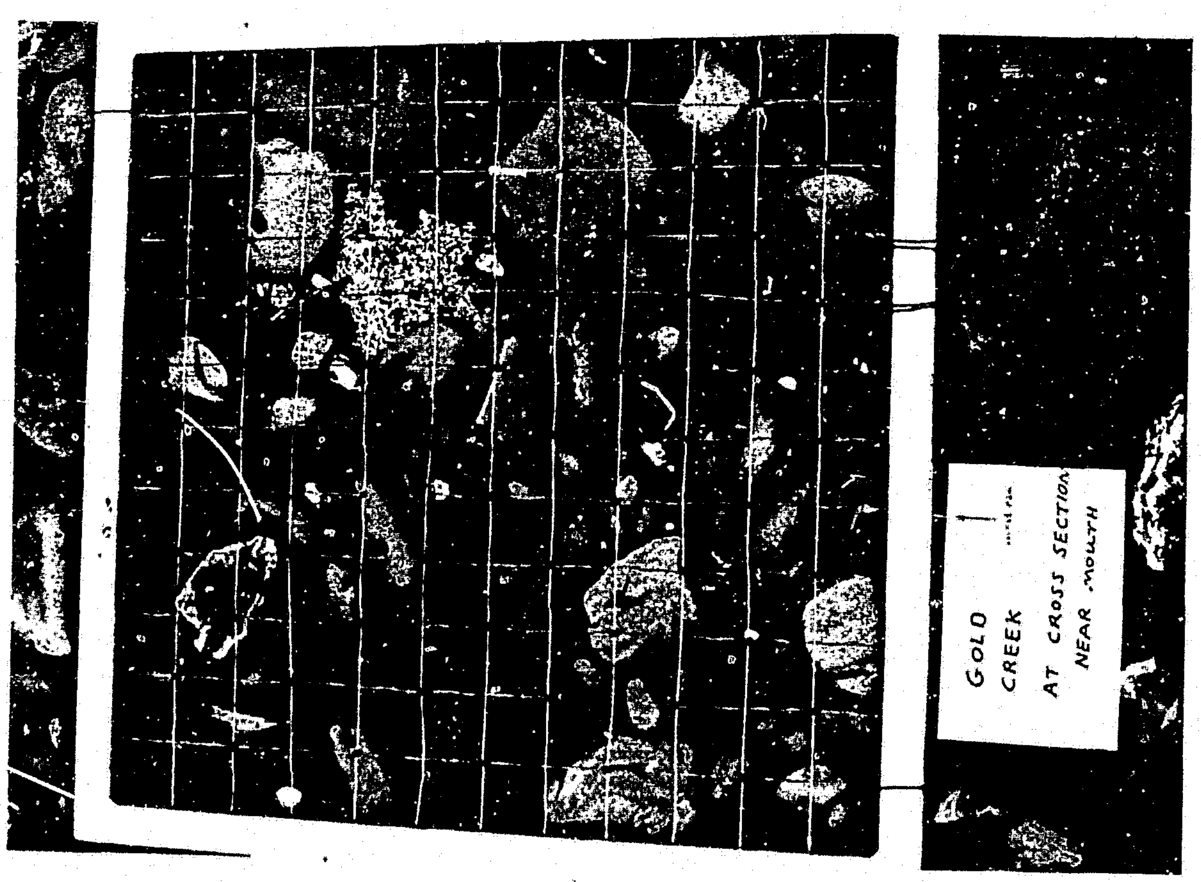
LRX = INDIAN RIVER

D_{16} = 33 mm

D_{50} = 50 mm

D_{84} = 76 mm





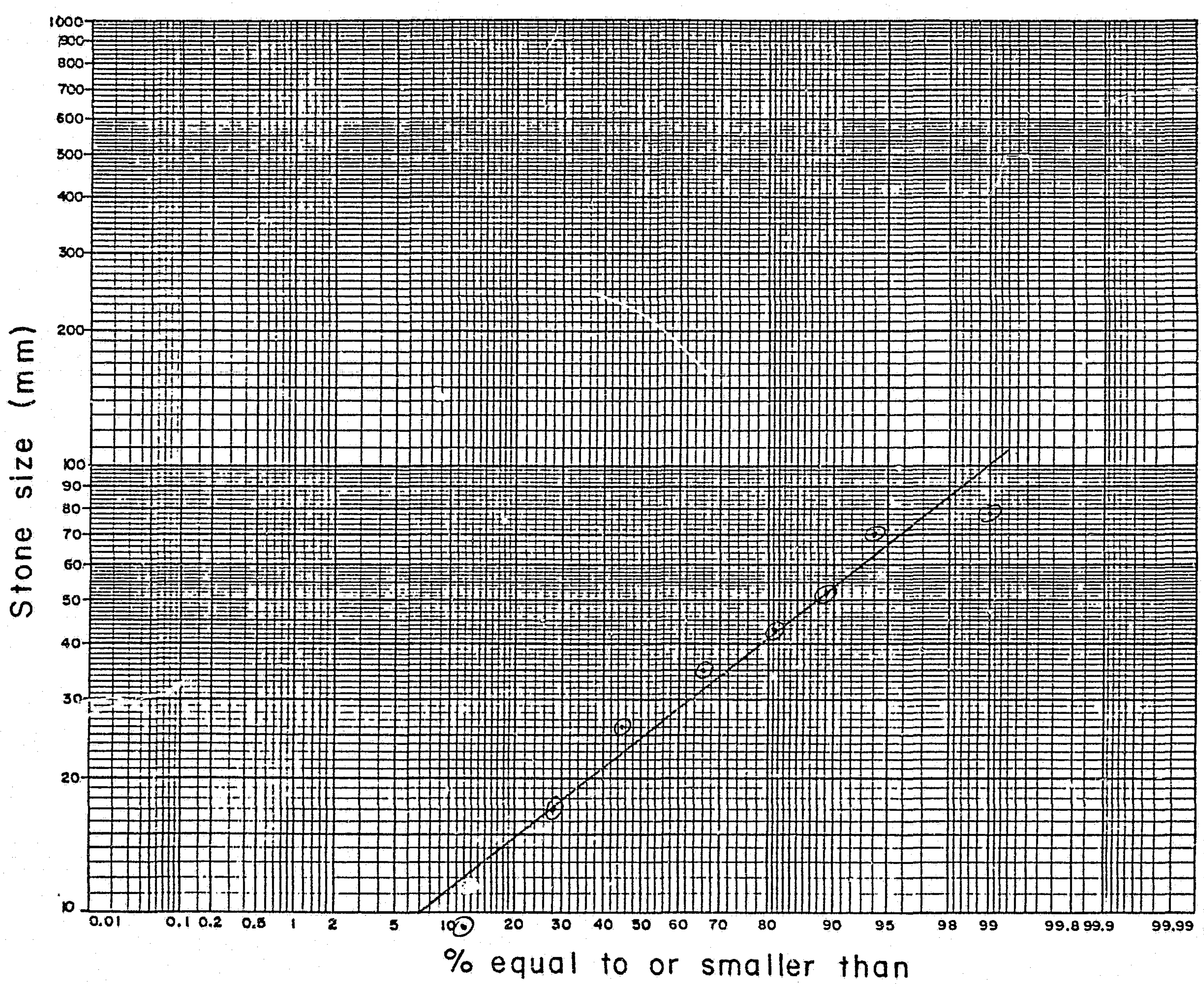
4

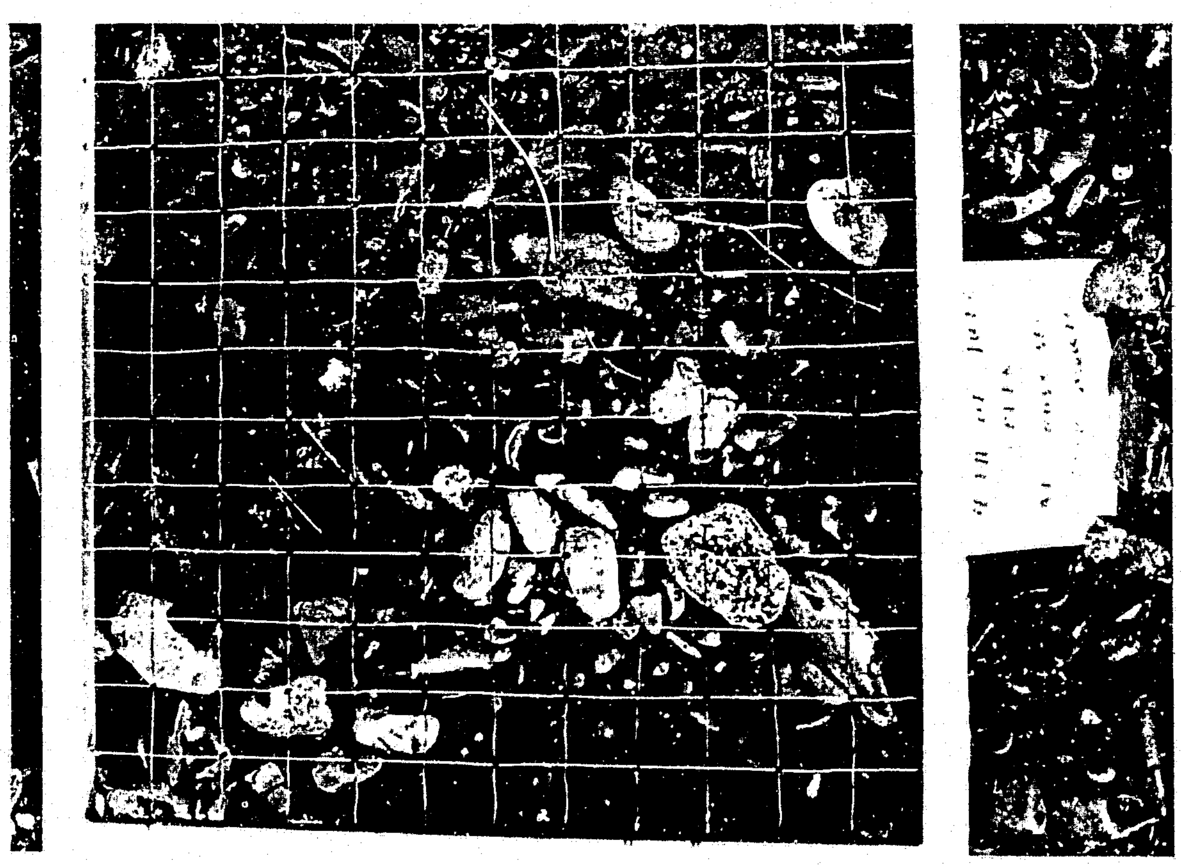
LRX = GOLD CREEK

D_{16} = 17mm

D_{50} = 36mm

D_{84} = 76mm





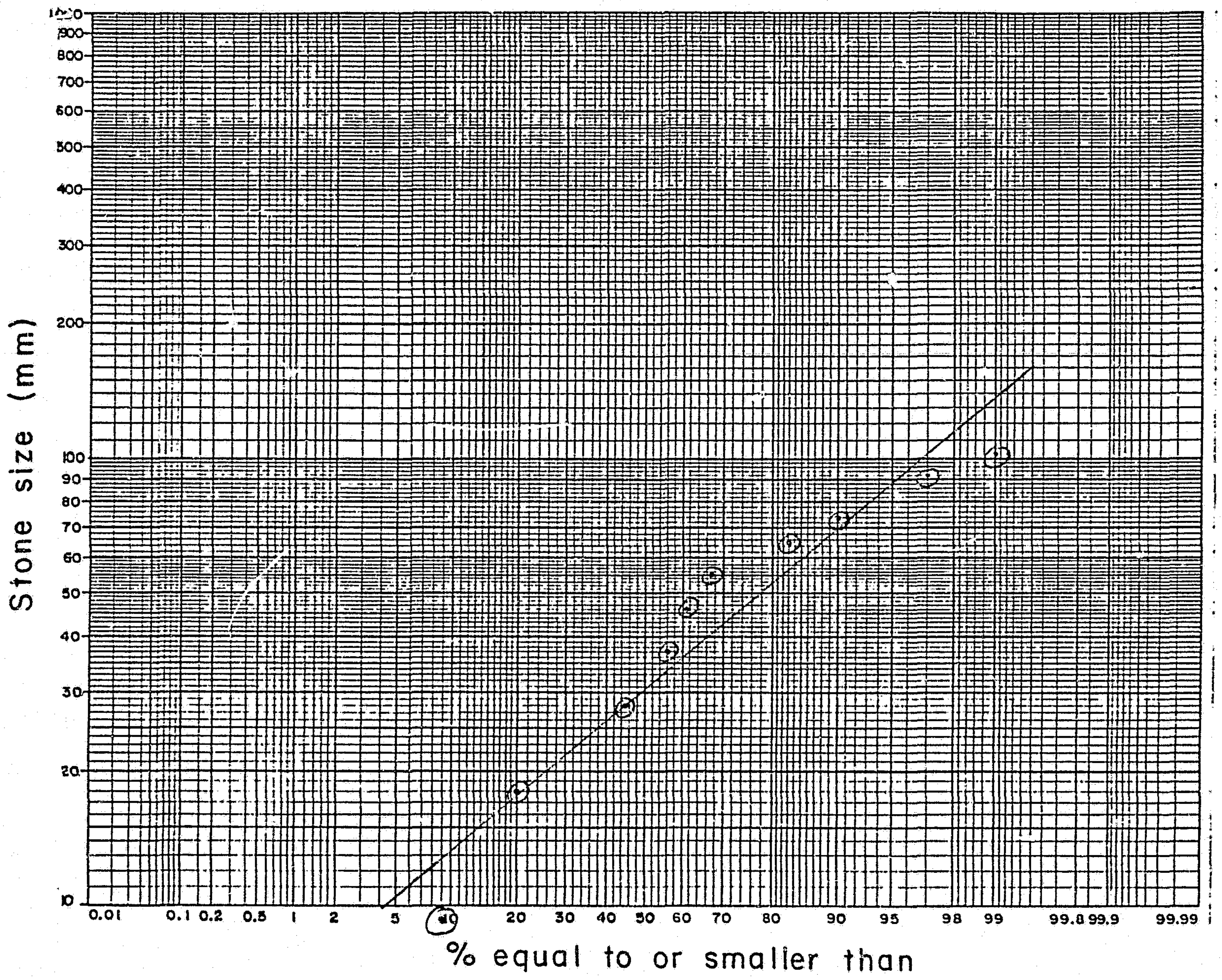
6

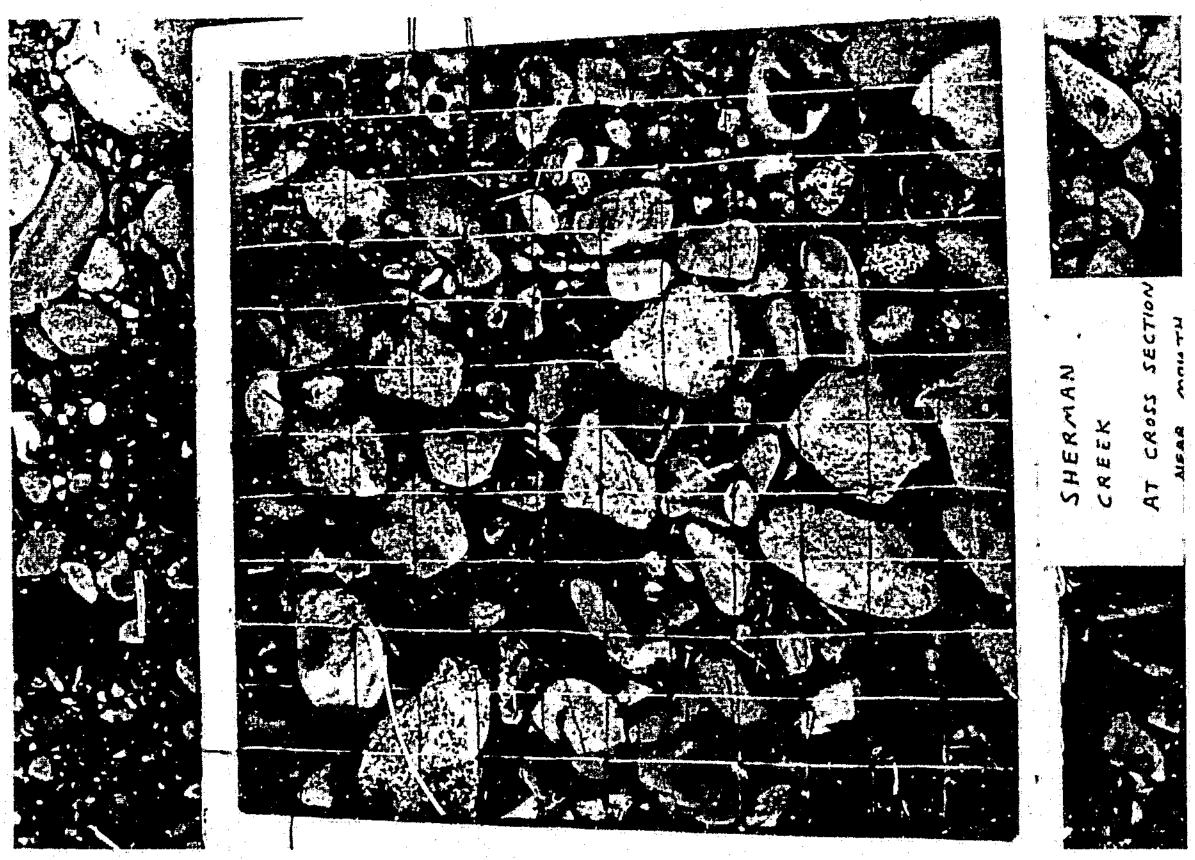
LRX = 4TH OF JULY CK

D_{16} = 13.5 mm

D_{50} = 25 mm

D_{84} = 45 mm.





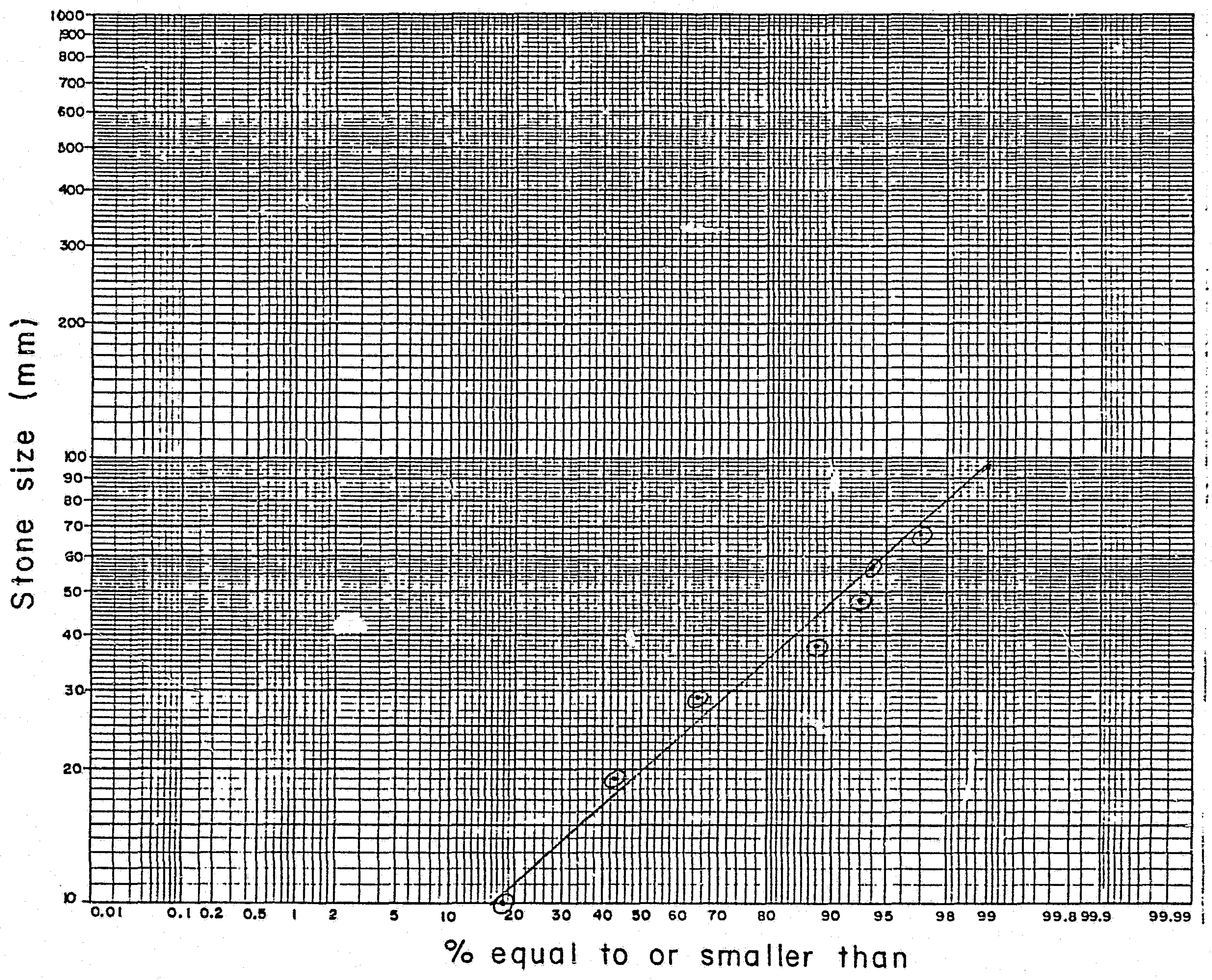
7

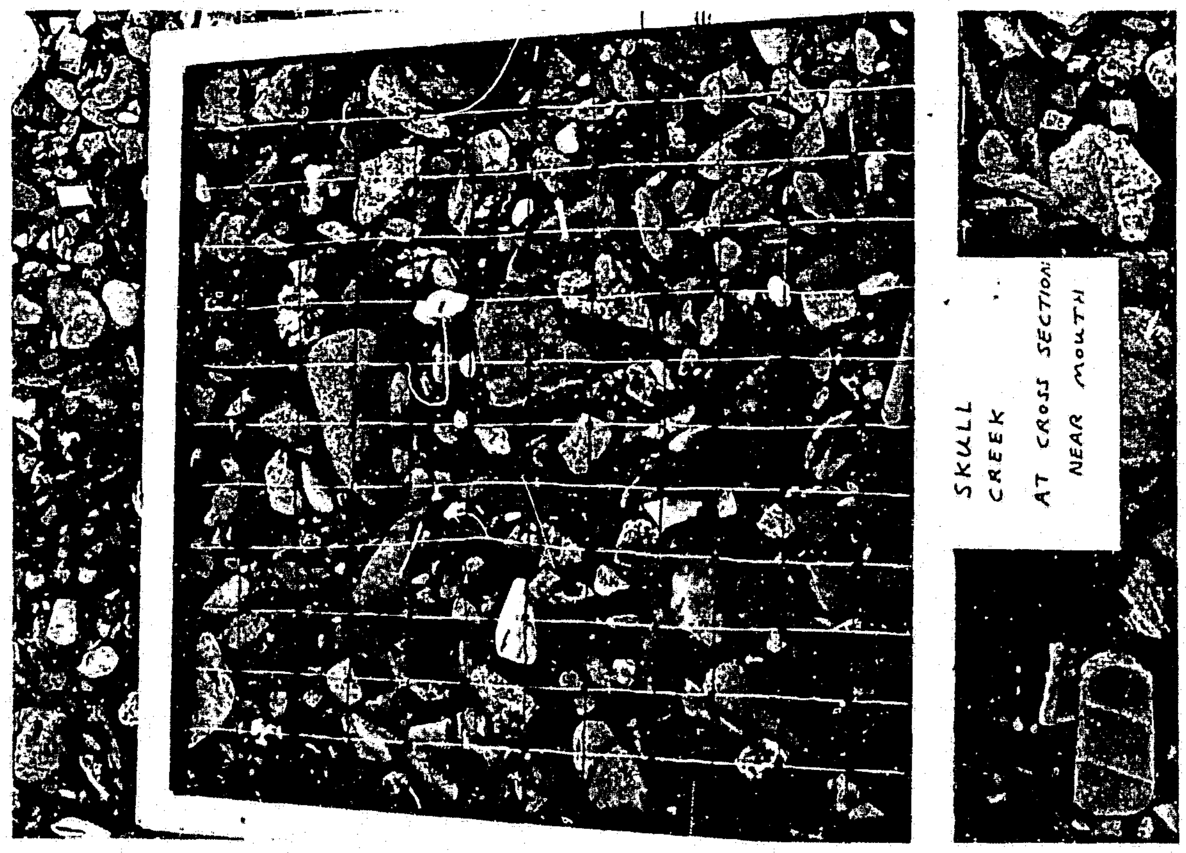
LRX = SHERMAN CK

D_{16} = 16 mm

D_{50} = 30 mm

D_{84} = 58 mm





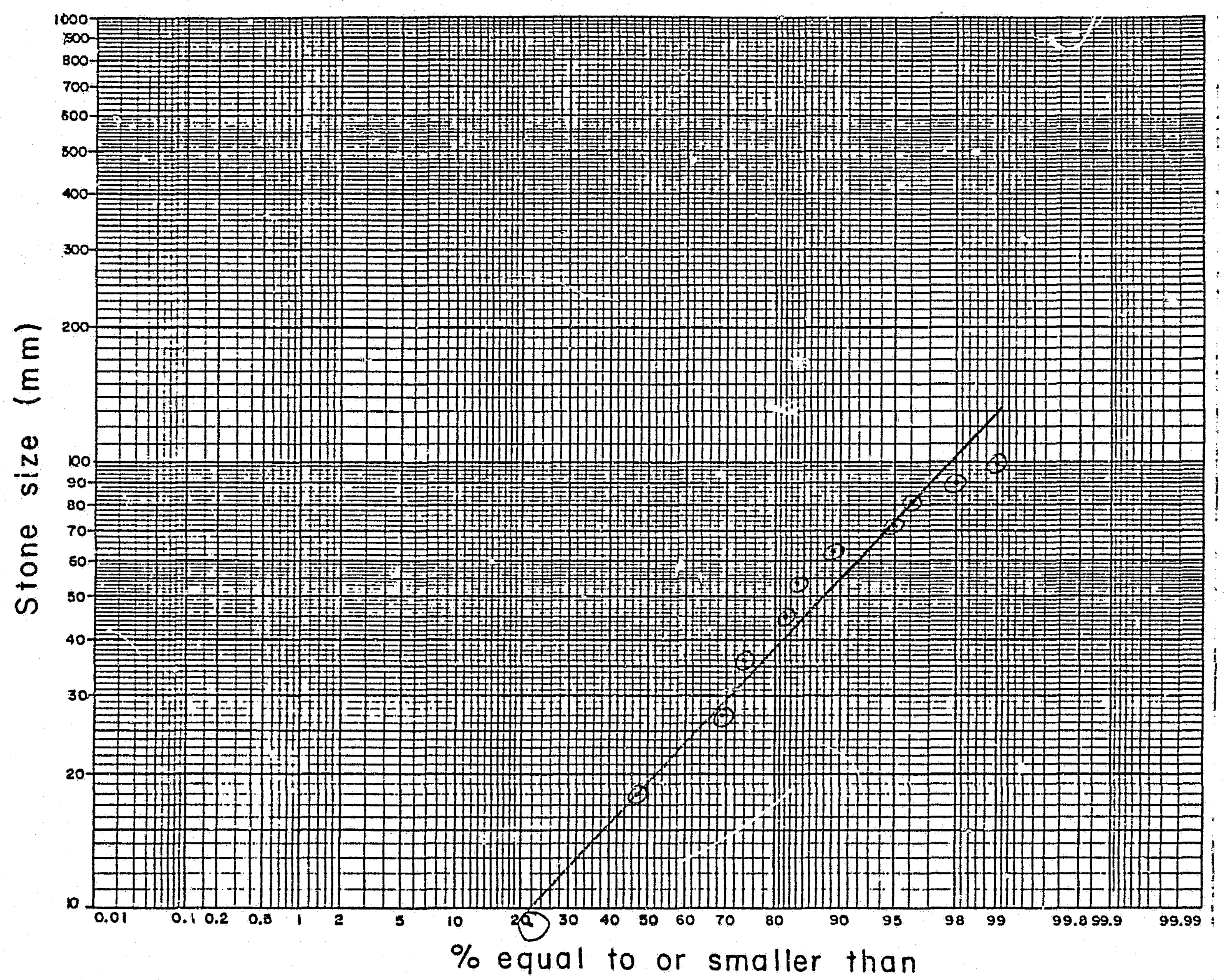
10

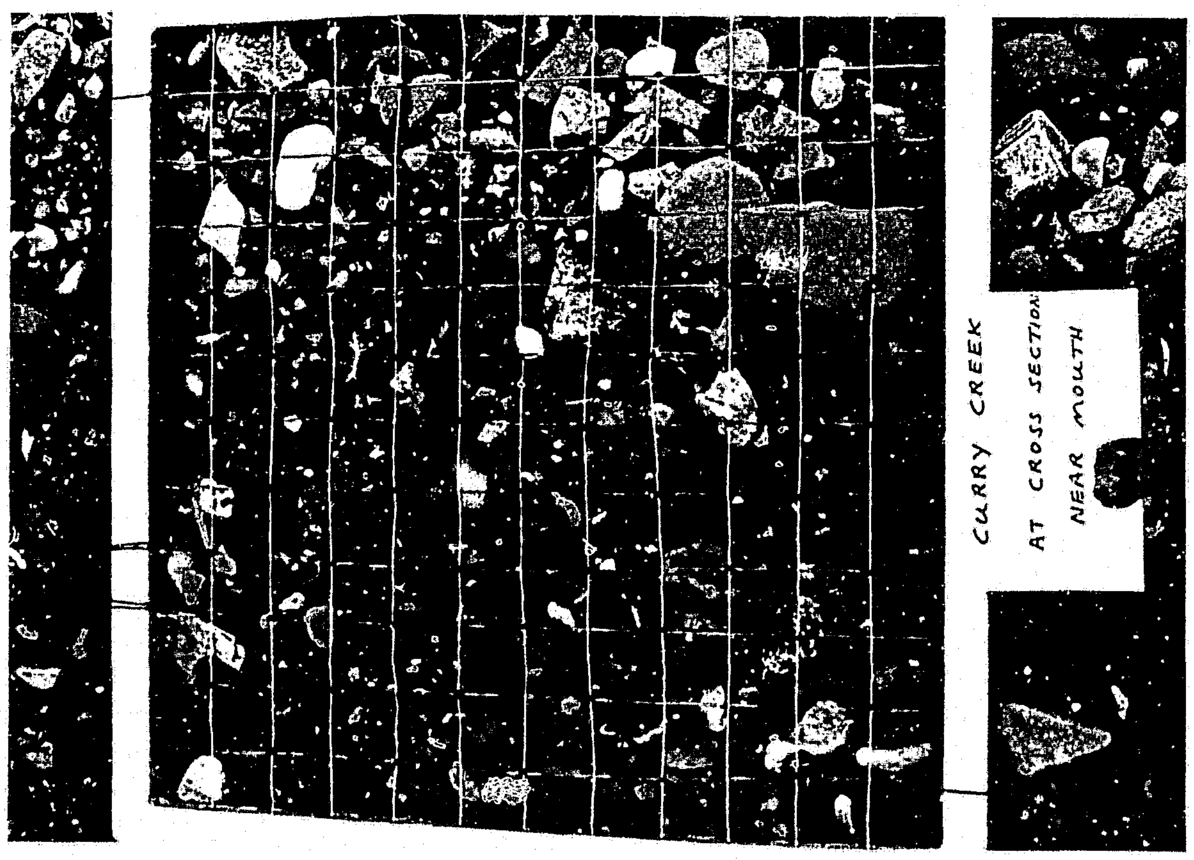
LRX = SKULL CREEK

D_{16} = 10mm

D_{50} = 20mm

D_{84} = 39mm





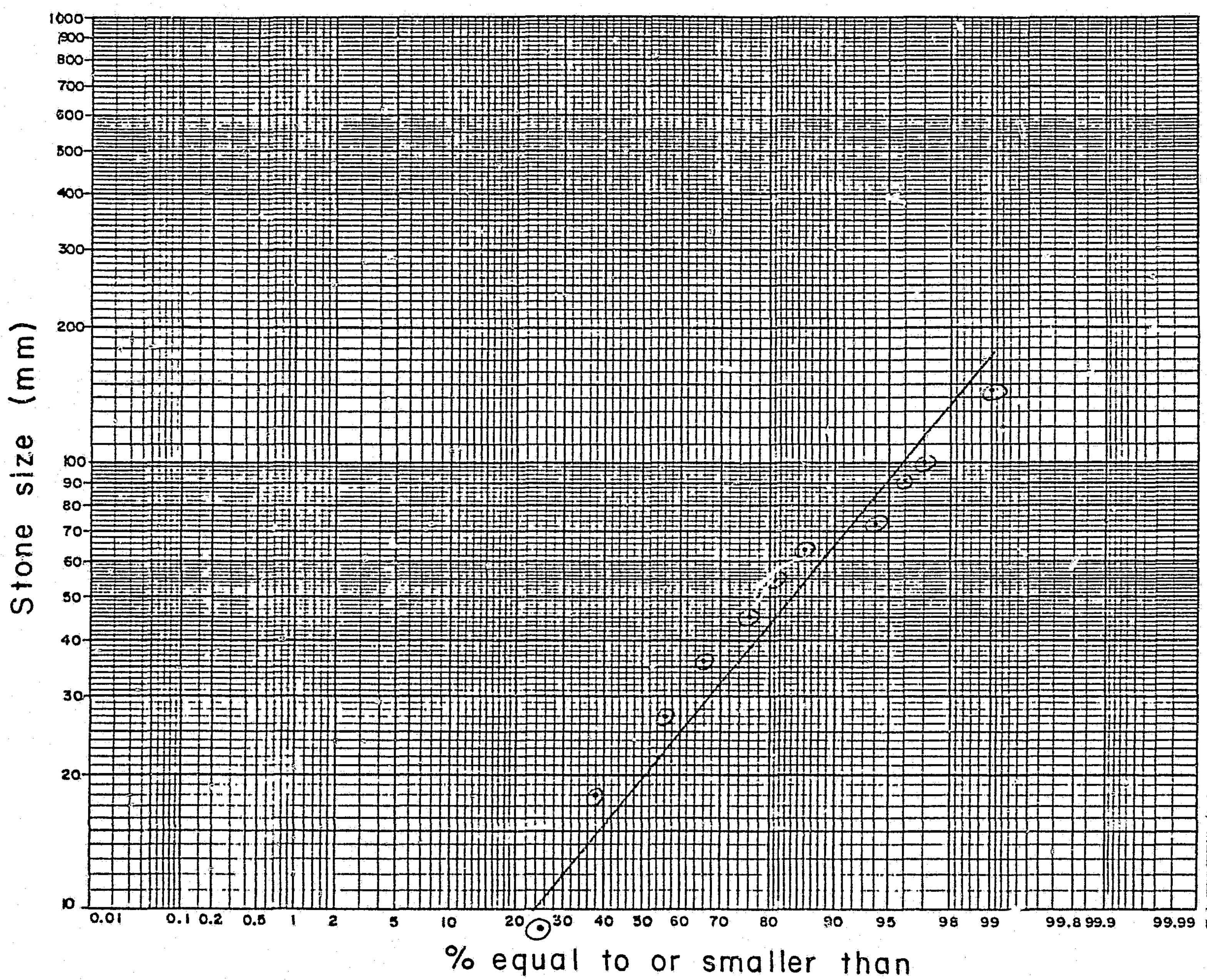
12

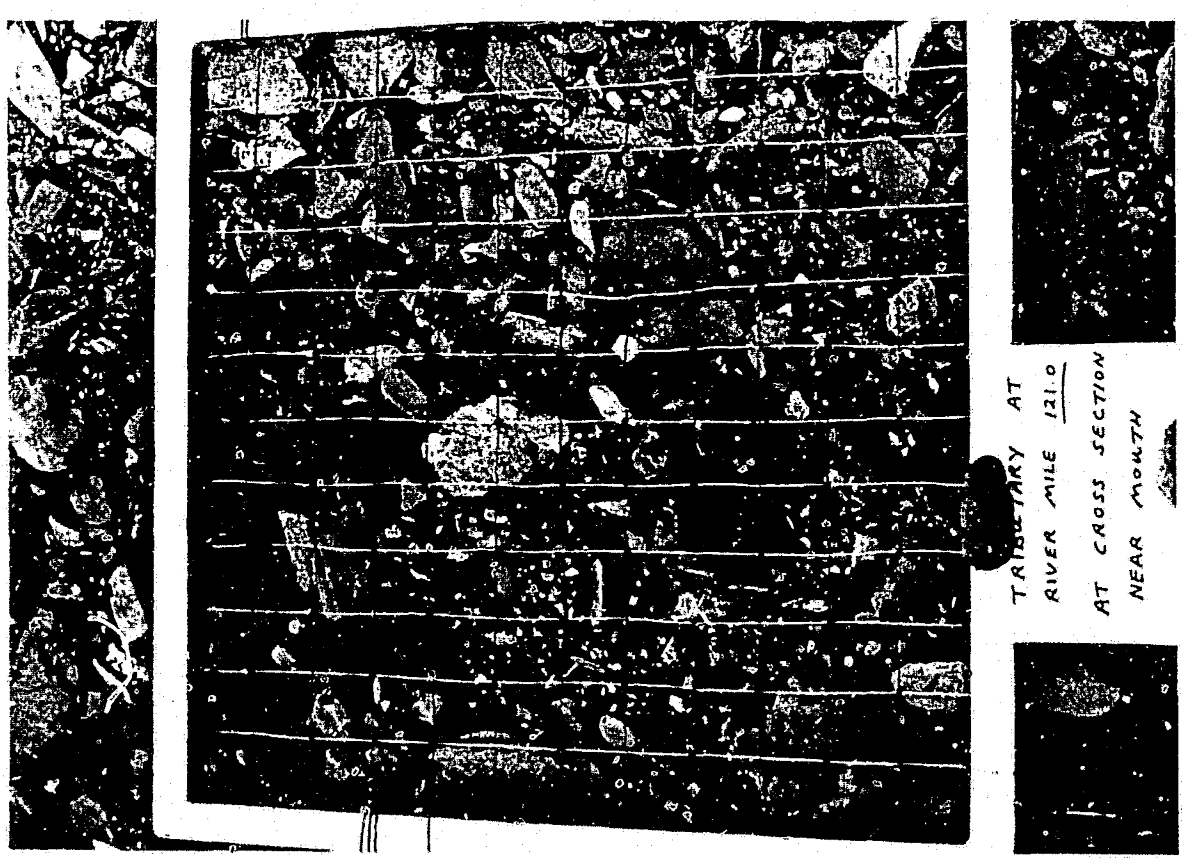
LRX = CREEK

D_{16} = 8mm

D_{50} = 19mm

D_{84} = 43mm





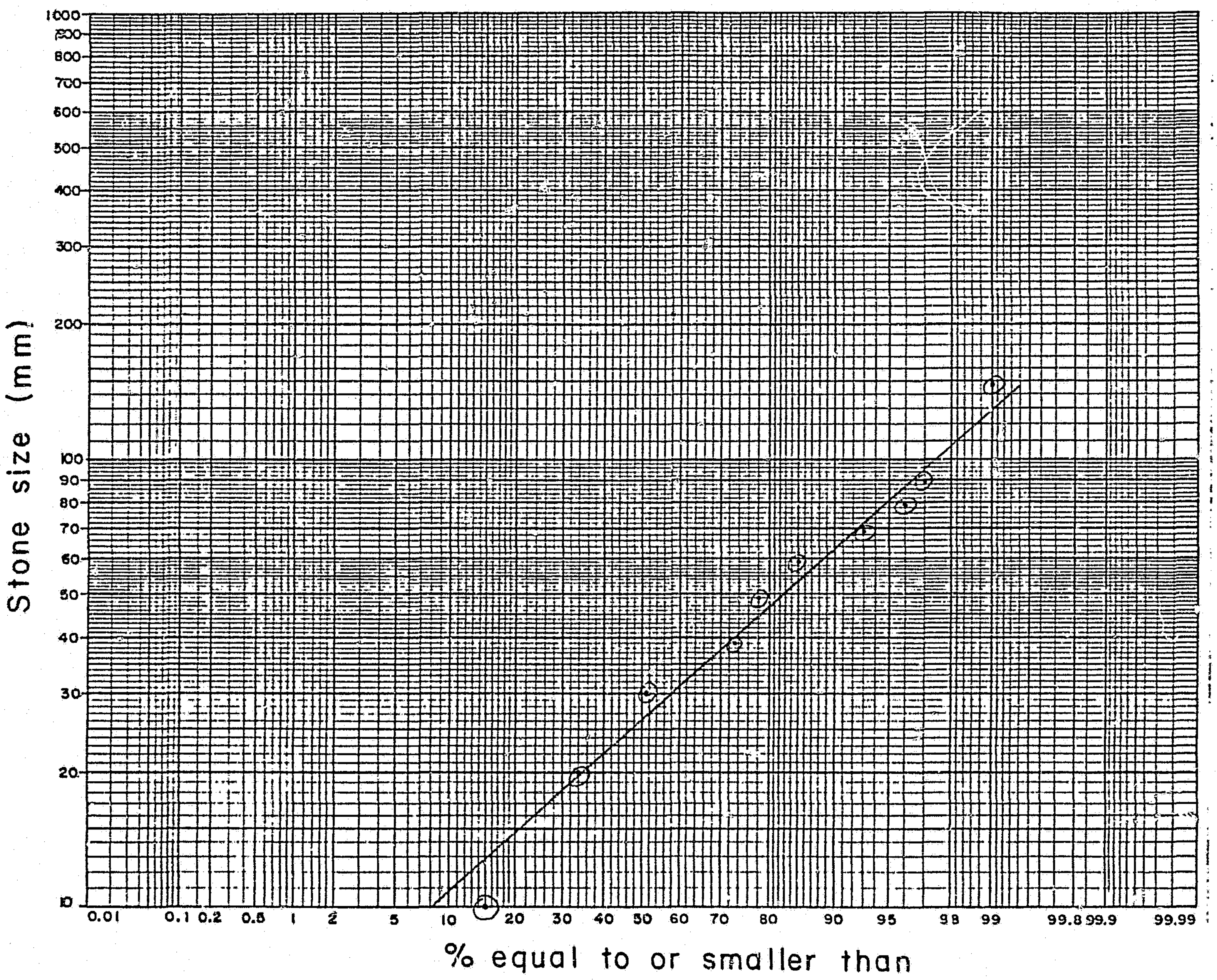
13

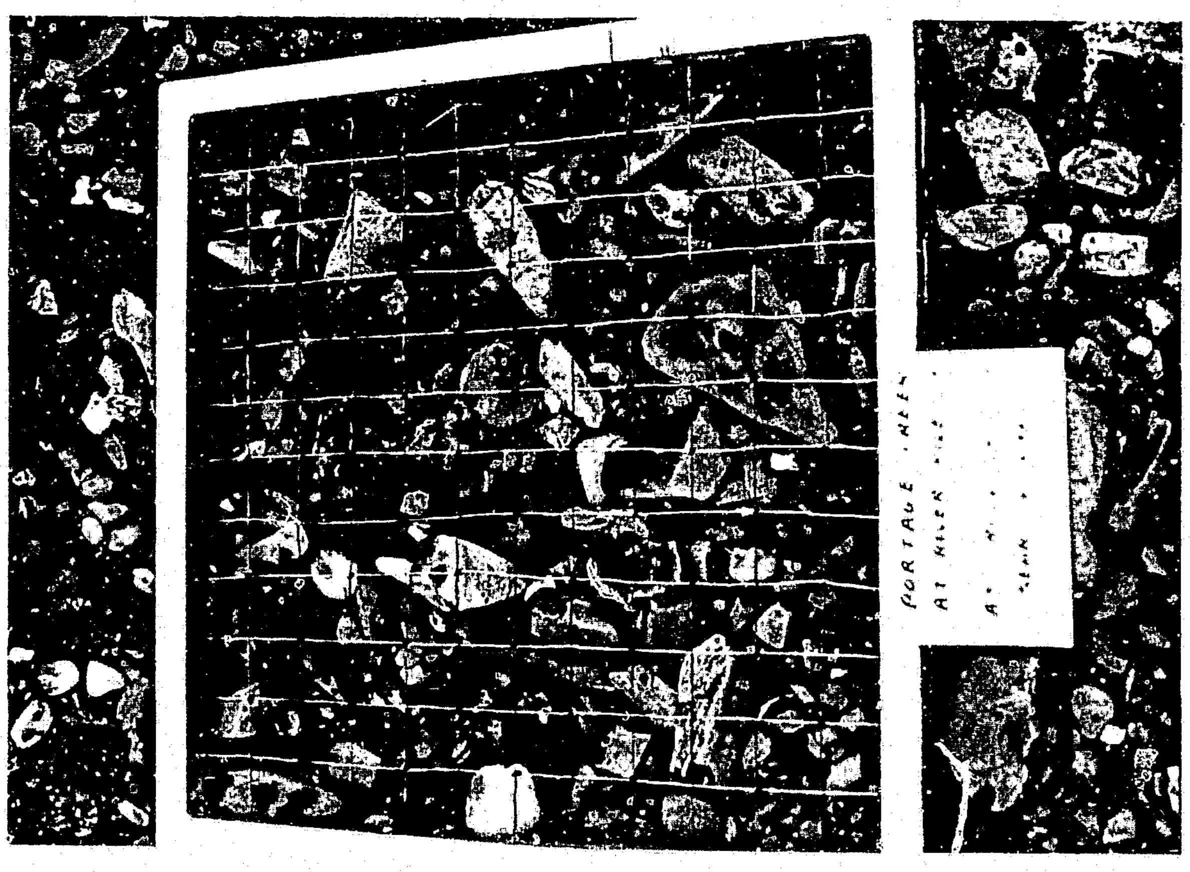
LRX = 121.0

D_{16} = 7mm

D_{50} = 20mm

D_{84} = 50mm





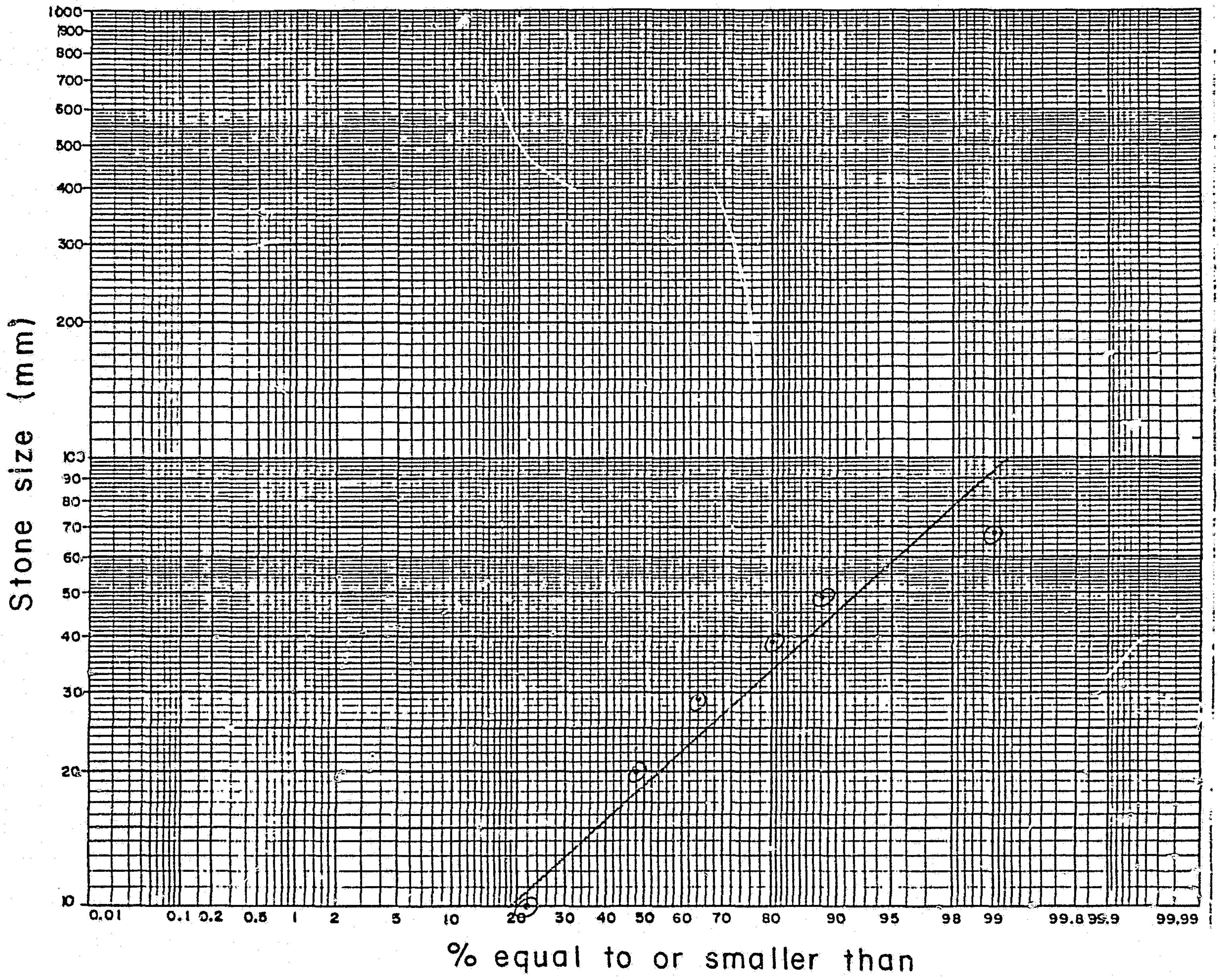
14

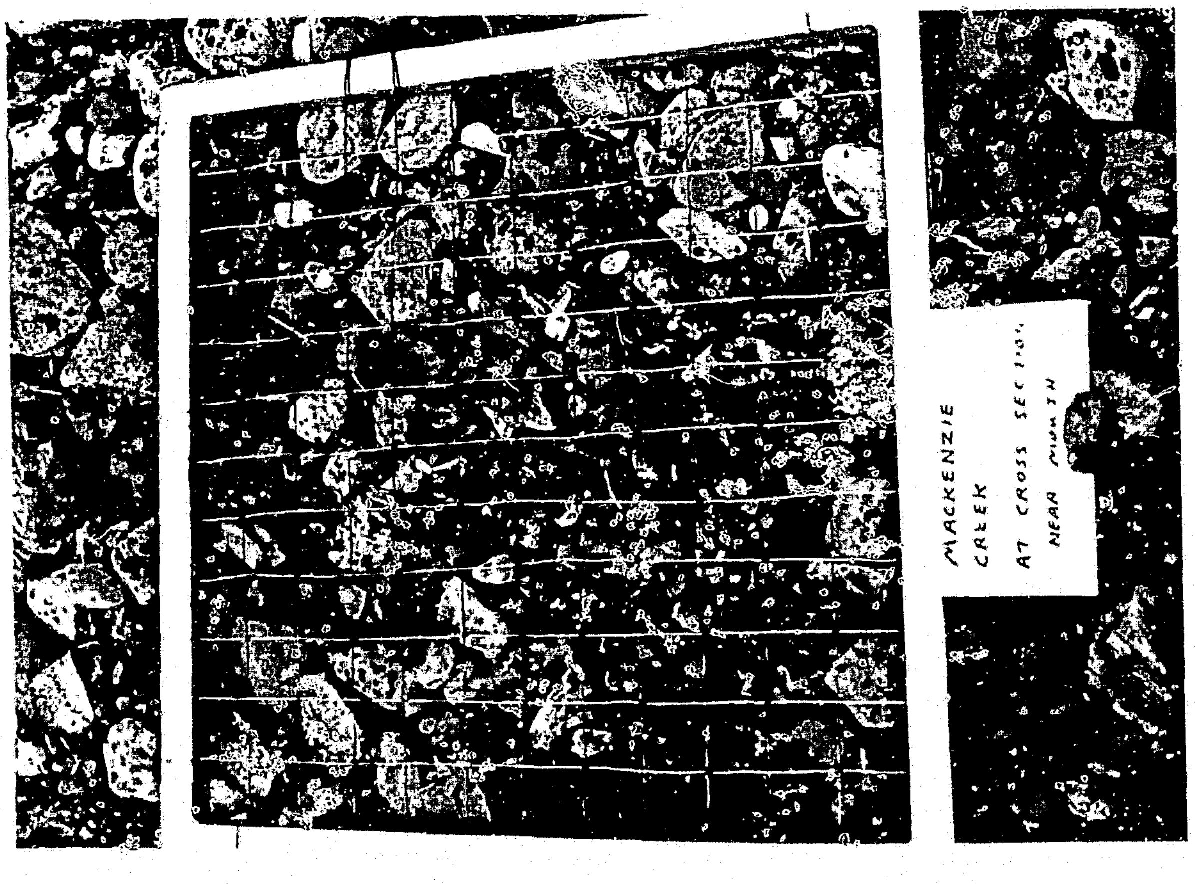
LITTLE
LRX = PORTAGE CREEK

D_{16} = 13 mm

D_{50} = 26 mm

D_{84} = 51 mm





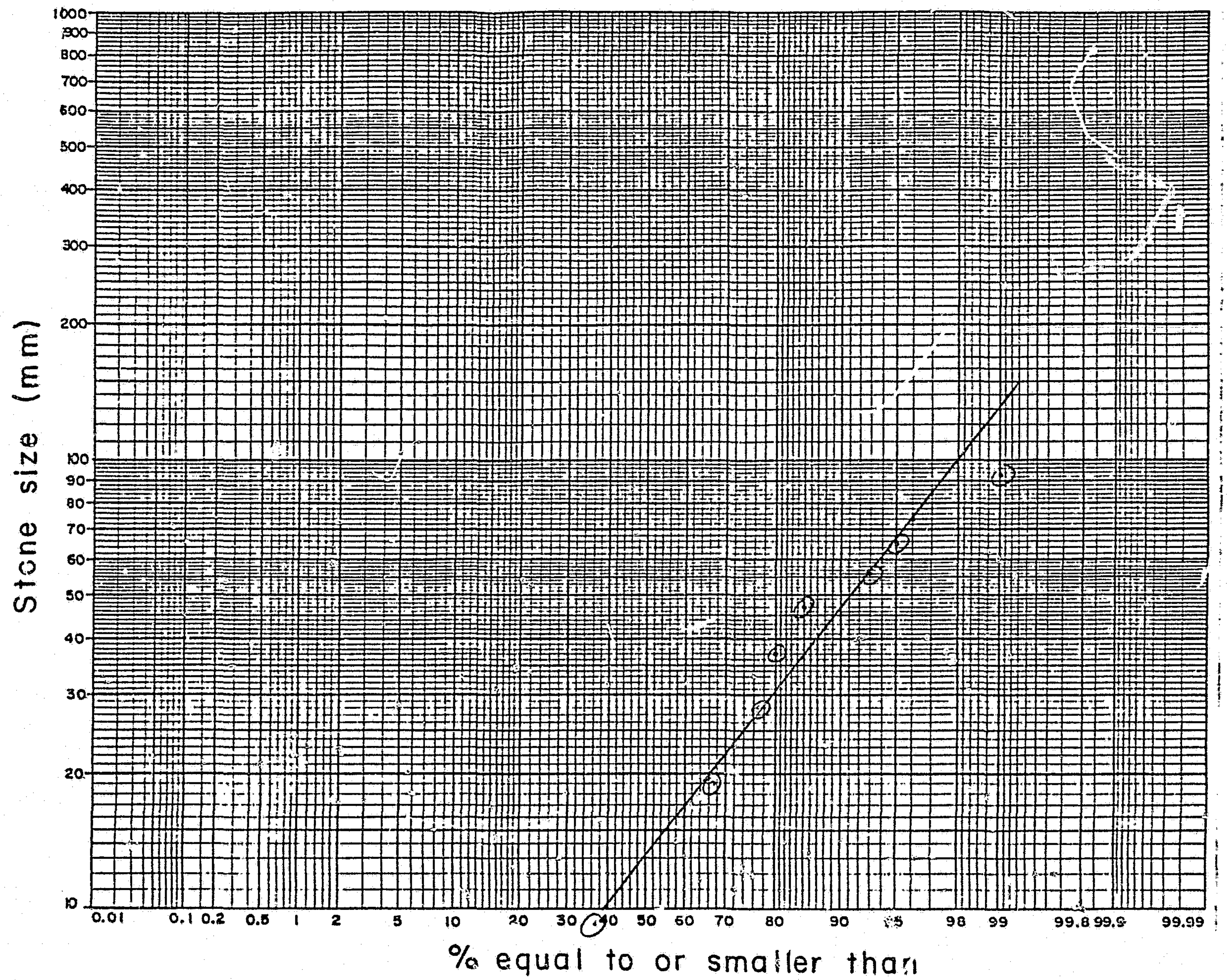
15

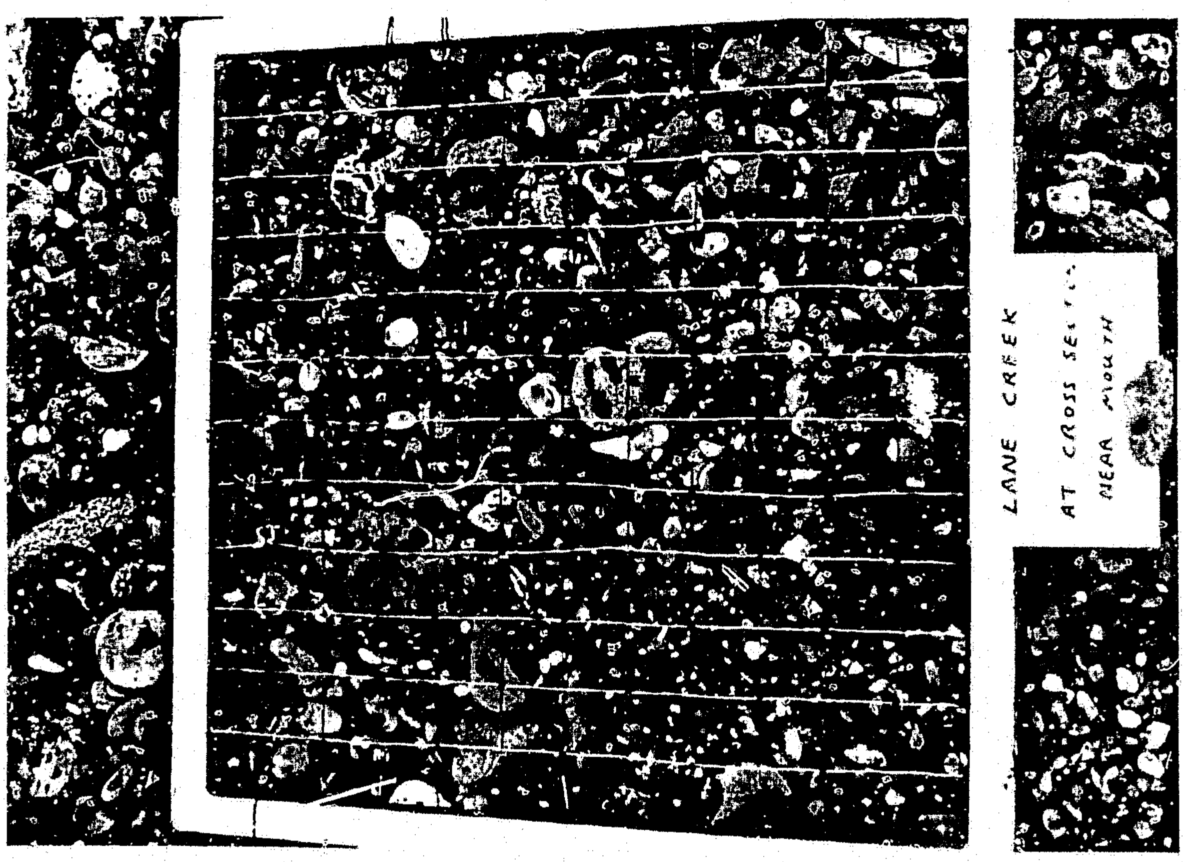
LRX = McKENZIE CREEK

D_{16} = 9mm

D_{50} = 18.5mm

D_{84} = 37 mm





16

LRX = LANE CREEK

D_{16} = 5 mm

D_{50} = 13 mm

D_{84} = 35 mm