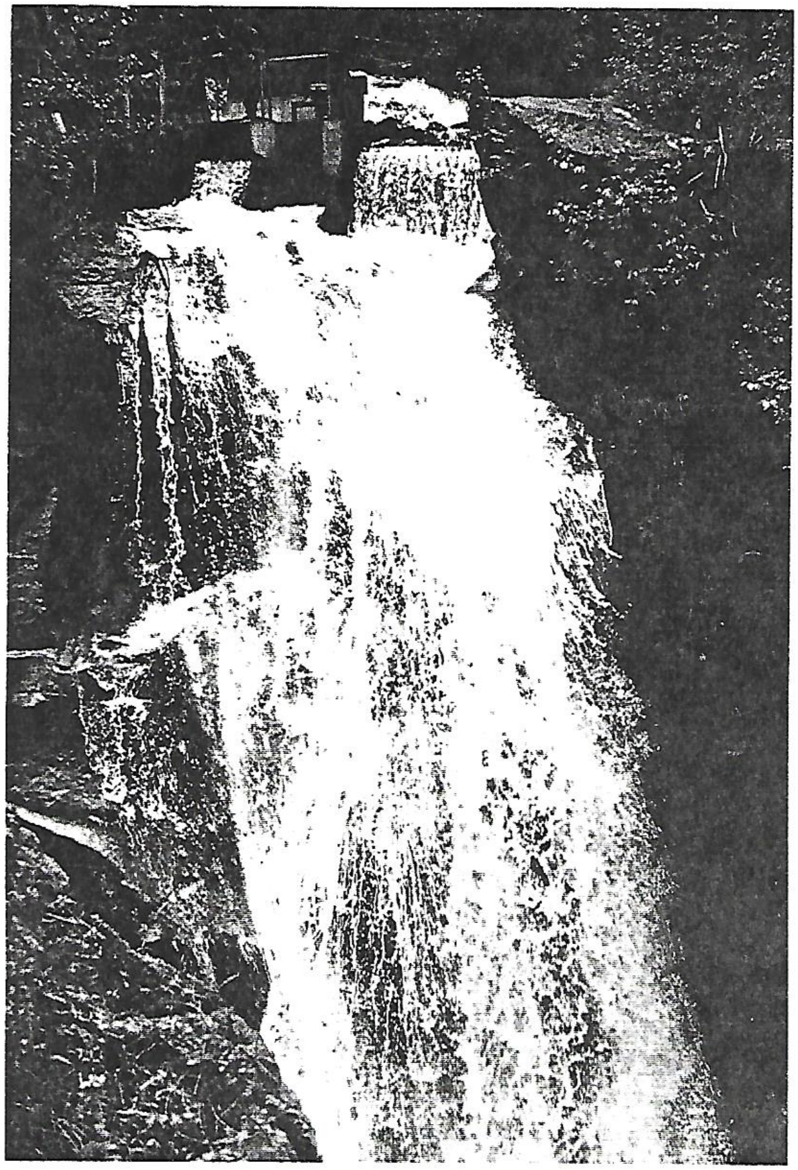
APPENDIX

PHOTOS

Photo #1

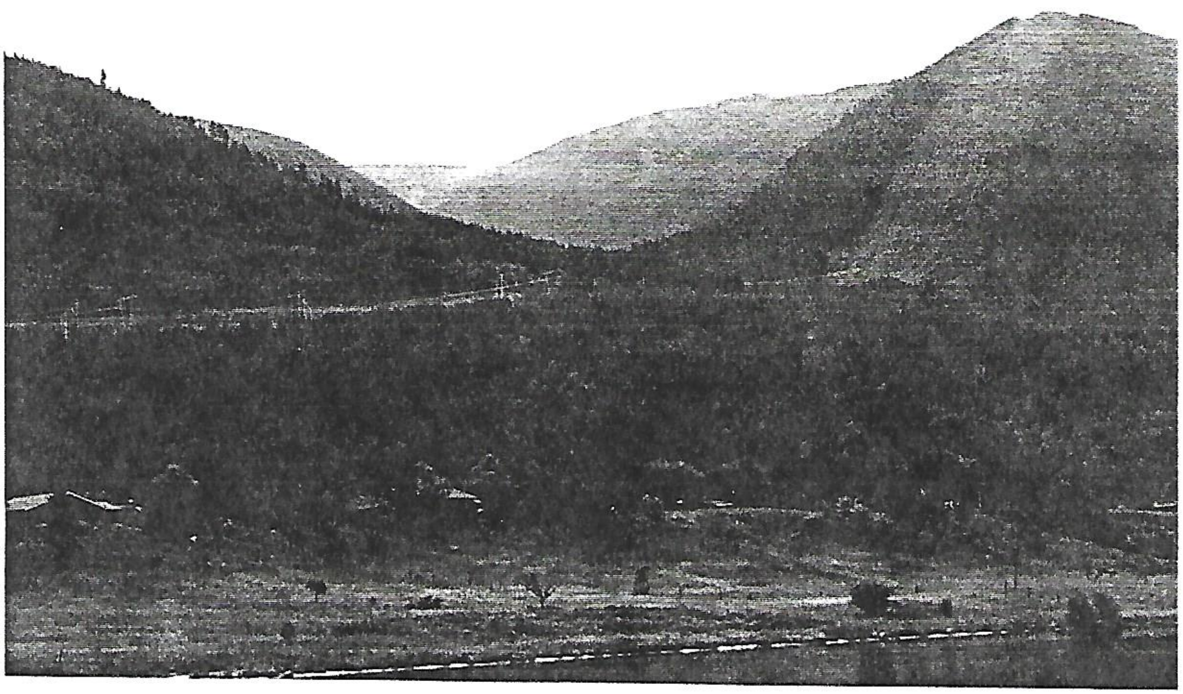


DAM FOR WATER SYSTEM FOR GLADE

Photo #2

STREAM CHANNEL OF GLADE CREEK
AT LOWER END OF STREAM

Photo #3



GLADE WATERSHED FROM THE VALLEY BOTTOM

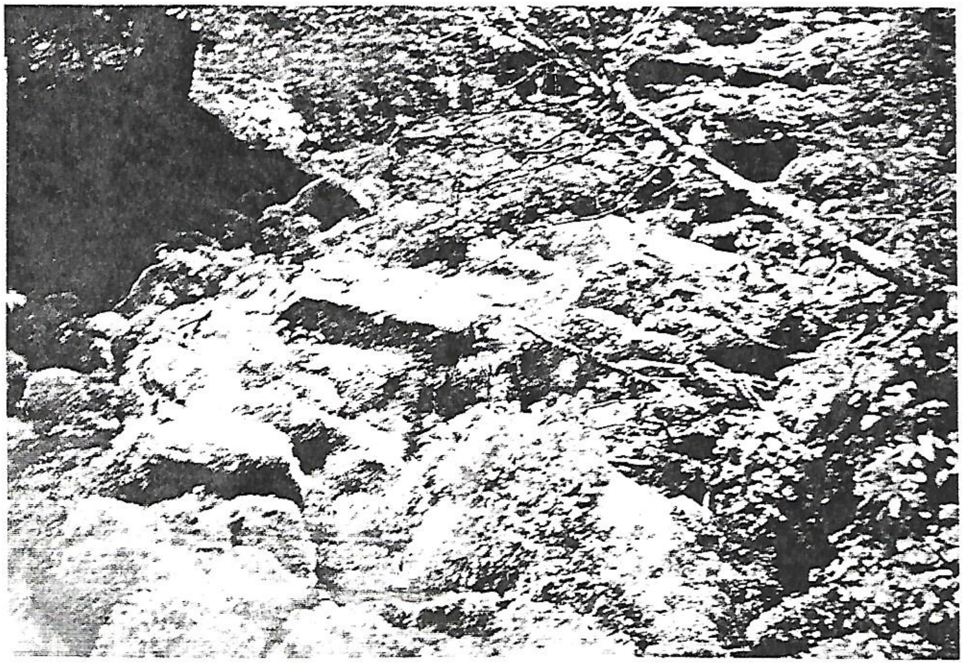
Photo #4

GLADE CREEK WATERSHED SHOWING SOUTH FORK
WITH GRANITE CREEK IN BACKGROUND
NOTICE STEEP PARALLEL WATER COURSES

Photo #5

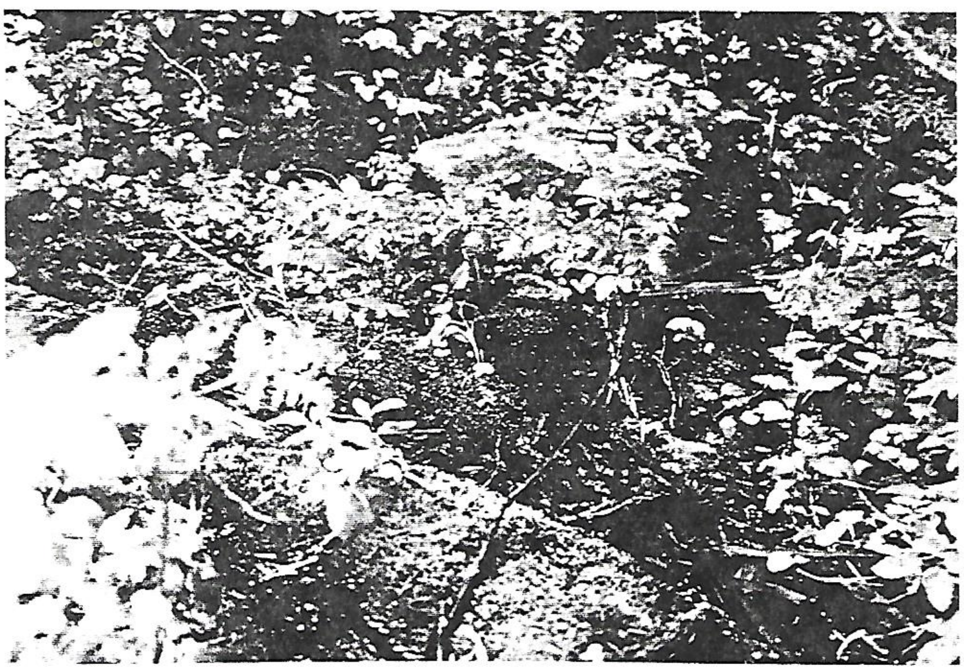
GLADE CREEK LOOKING DOWN NORTH FORK SHOWS
UNSTABLE LAND FORM

Photo #6



GLADE CREEK AT ROAD CROSSING IN
UPPER WATERSHED

Photo #7



WATER AND FLOW ON ROAD LOCATION

Photo #8

WATER SEEPING ALONG ROAD LOCATION
IN GLADE CREEK

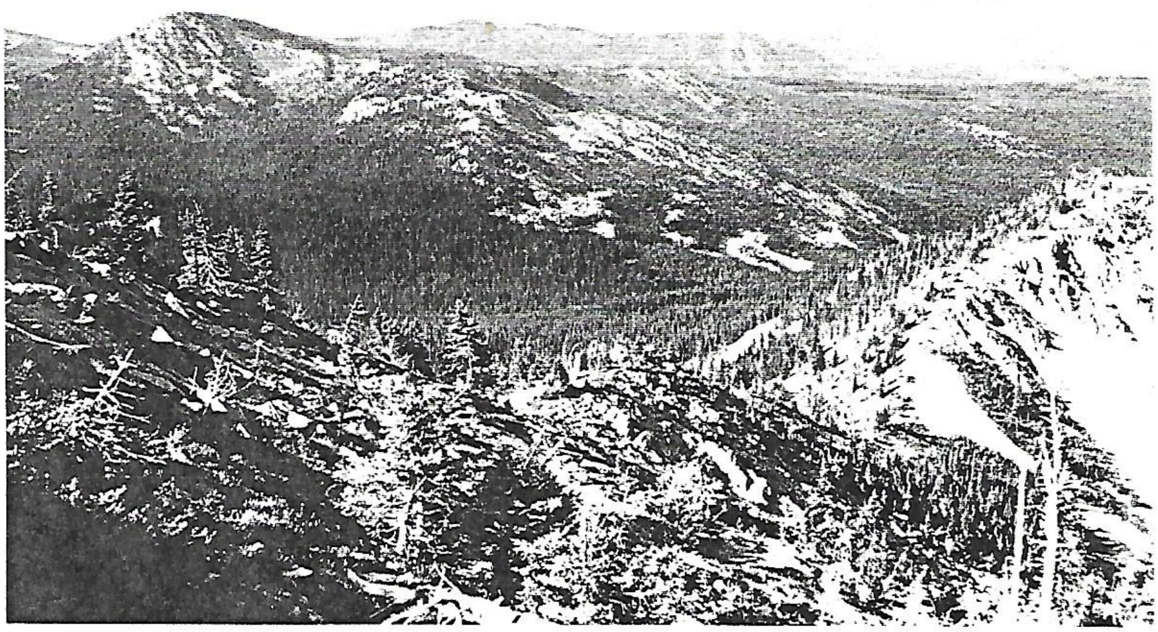
Photo #9

SEEPAGE AND WATER ON ROAD LOCATION

Photo #10

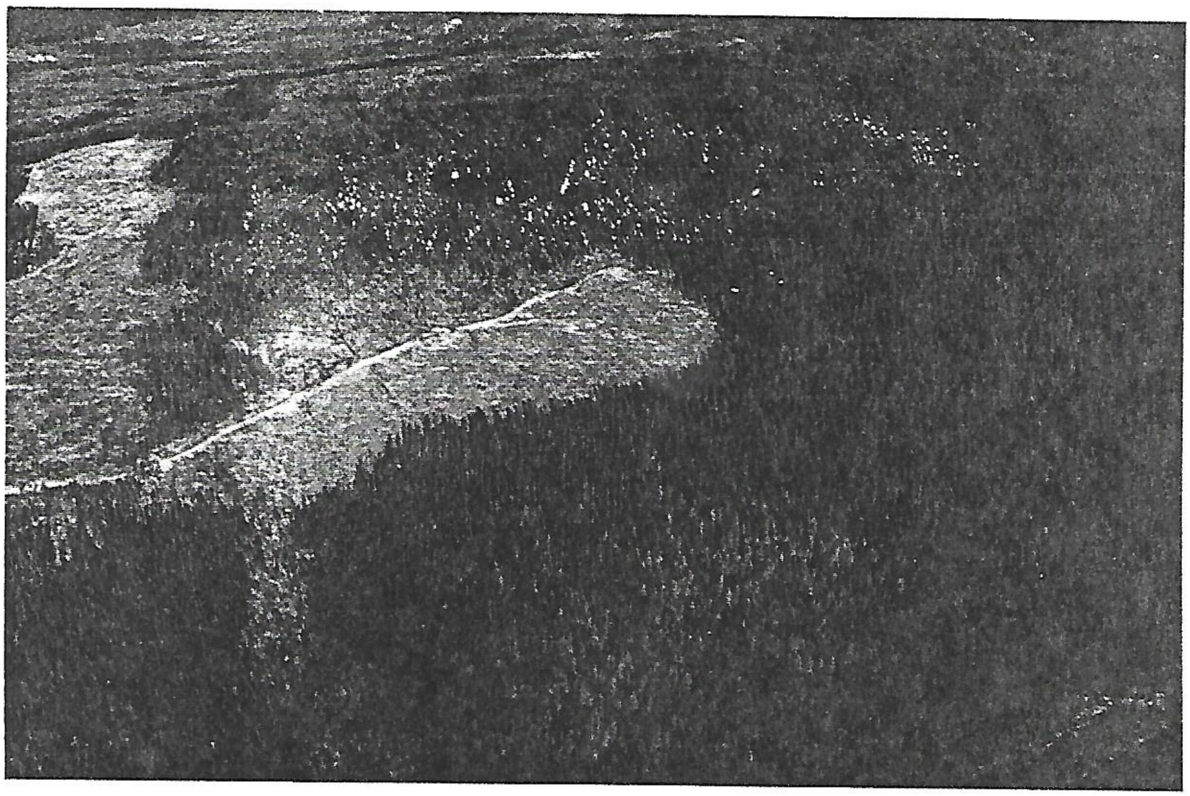
UPPER GLADE CREEK AT ROAD CROSSING

Photo #11



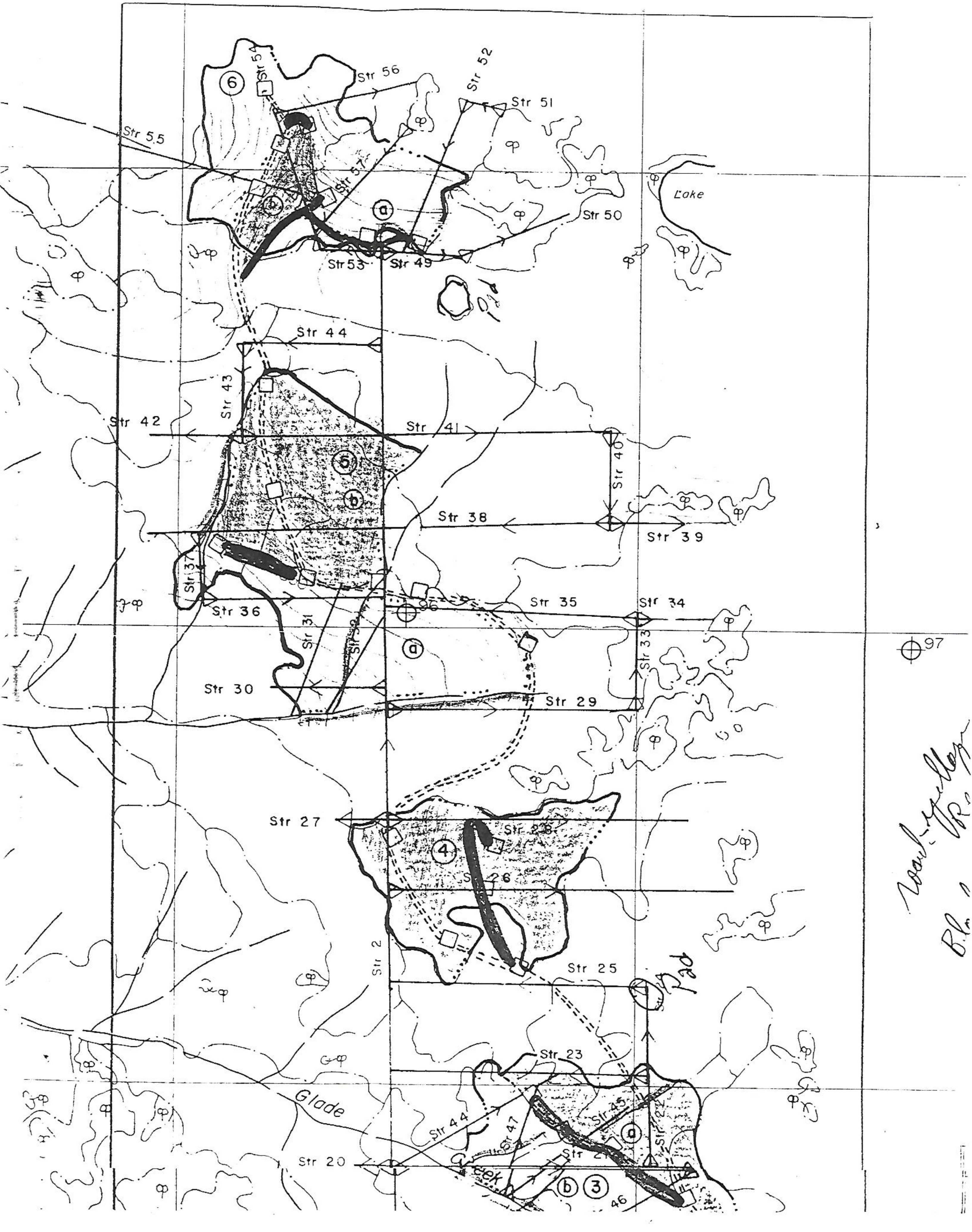
UPPER GLADE WATERSHED - SHOWING MATURE TIMBER IN PLANNED HARVEST

Photo #12



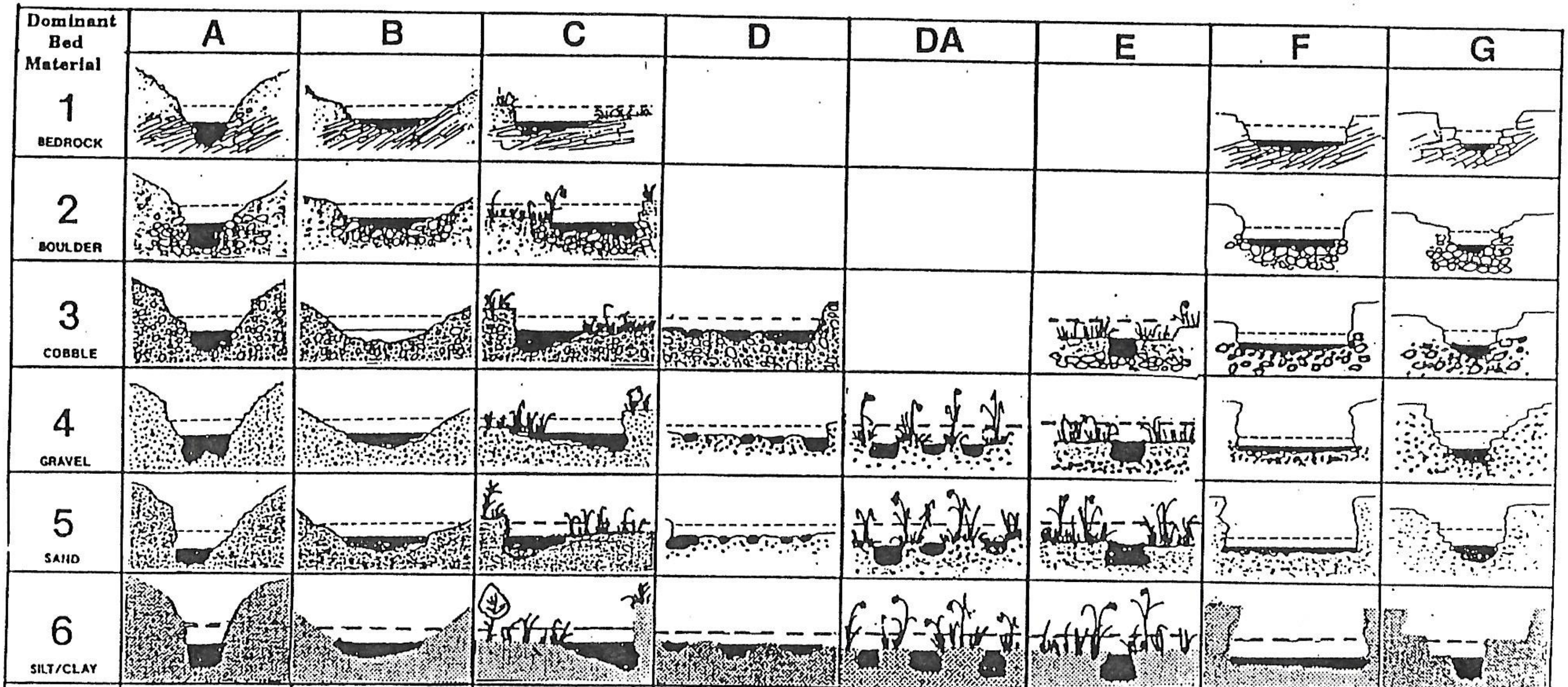
AERIAL PHOTO OF CLEAR CUT
ADJACENT TO GLADE, SEE ROADS REMOVING
WATER QUICKLY

MAP OF PROPOSED ACTIVITY



Str 54
Str 56
Str 52
Str 51
Str 5.5
Str 57
Lake
Str 50
Str53
Str 49
Str 44
Str 43
Str 42
Str 41
Str 40
Str 38
Str 39
Str 37
Str 36
Str 35
Str 34
96
97
Str 31
Str 33
Str 30
Str 29
Str 27
Str 26
Str 2
Str 25
Pad
Str 23
Glade
Creek
Str 47
Str 45
Str 20
46

ROSGEN CHANNEL TYPING



	A	B	C	D	DA	E	F	G
ENTRH.	<1.4	1.4–2.2	>2.2	N/A	>2.2	>2.2	<1.4	<1.4
SIN.	<1.2	>1.2	>1.4	<1.1	1.1-1.6	>1.5	>1.4	>1.2
W/D	<12	>12	>12	>40	<40	<12	>12	<12
SLOPE	.04–.099	.02–.039	<.02	<.02	<.005	<.02	<.02	.02–.039

Figure 4. Illustrative guide showing cross-sectional configuration, composition and delineative criteria of major stream types.

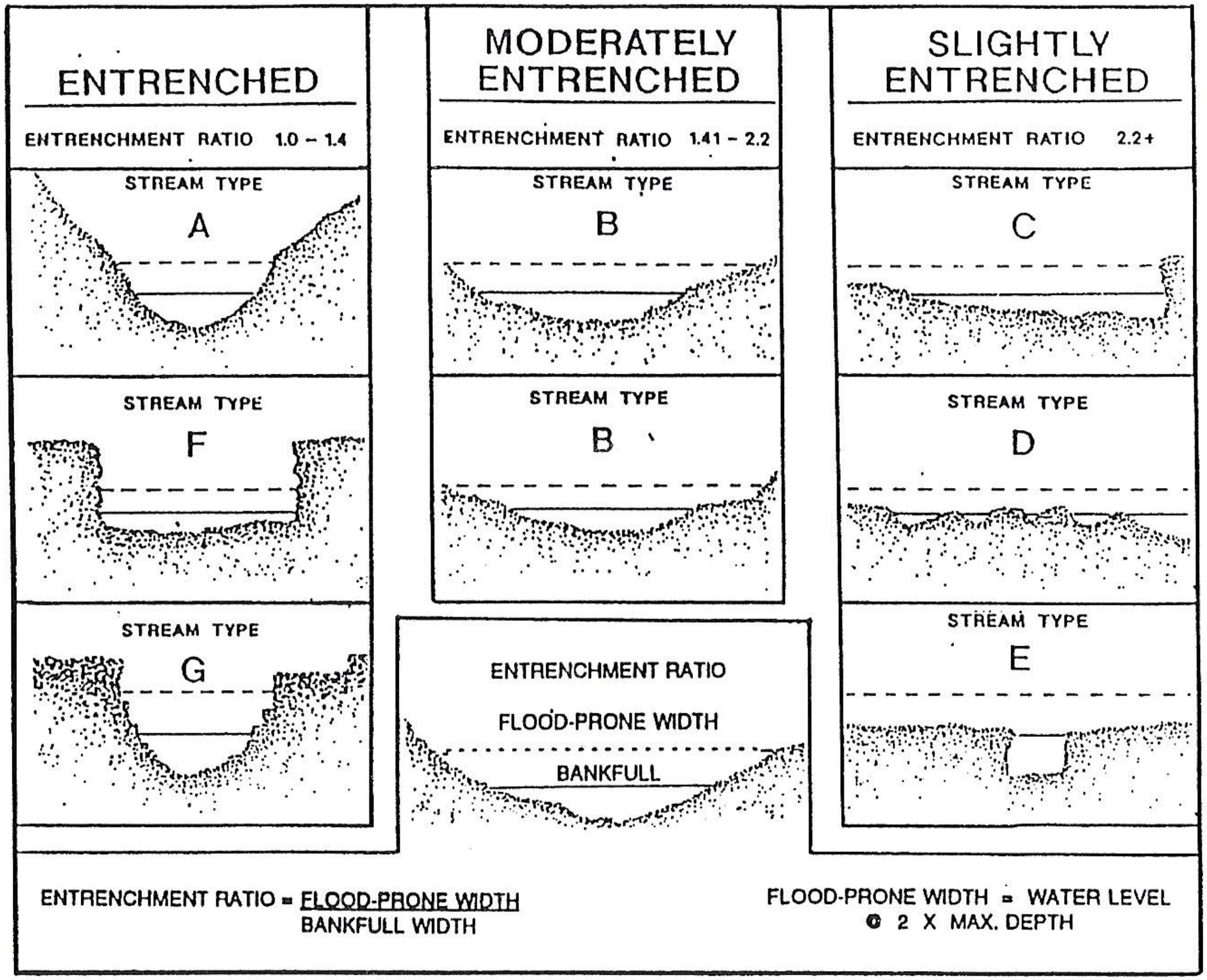
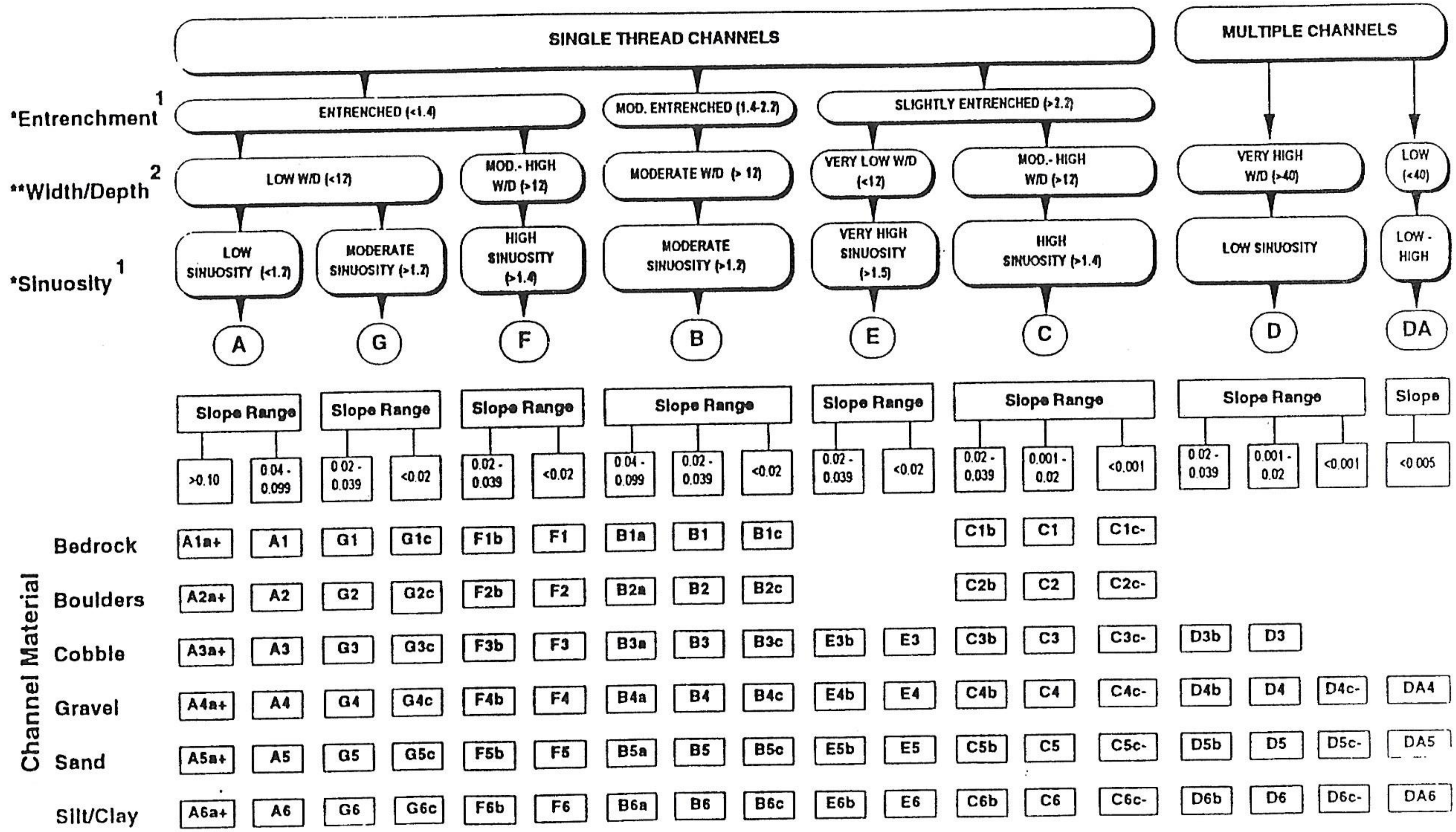


Figure 6. Examples and calculations of channel entrenchment.



1 Values can vary by ± 0.2 units as a function of the continuum of physical variables within stream reaches.
2 Values can vary by ± 2.0 units as a function of the continuum of physical variables within stream reaches.

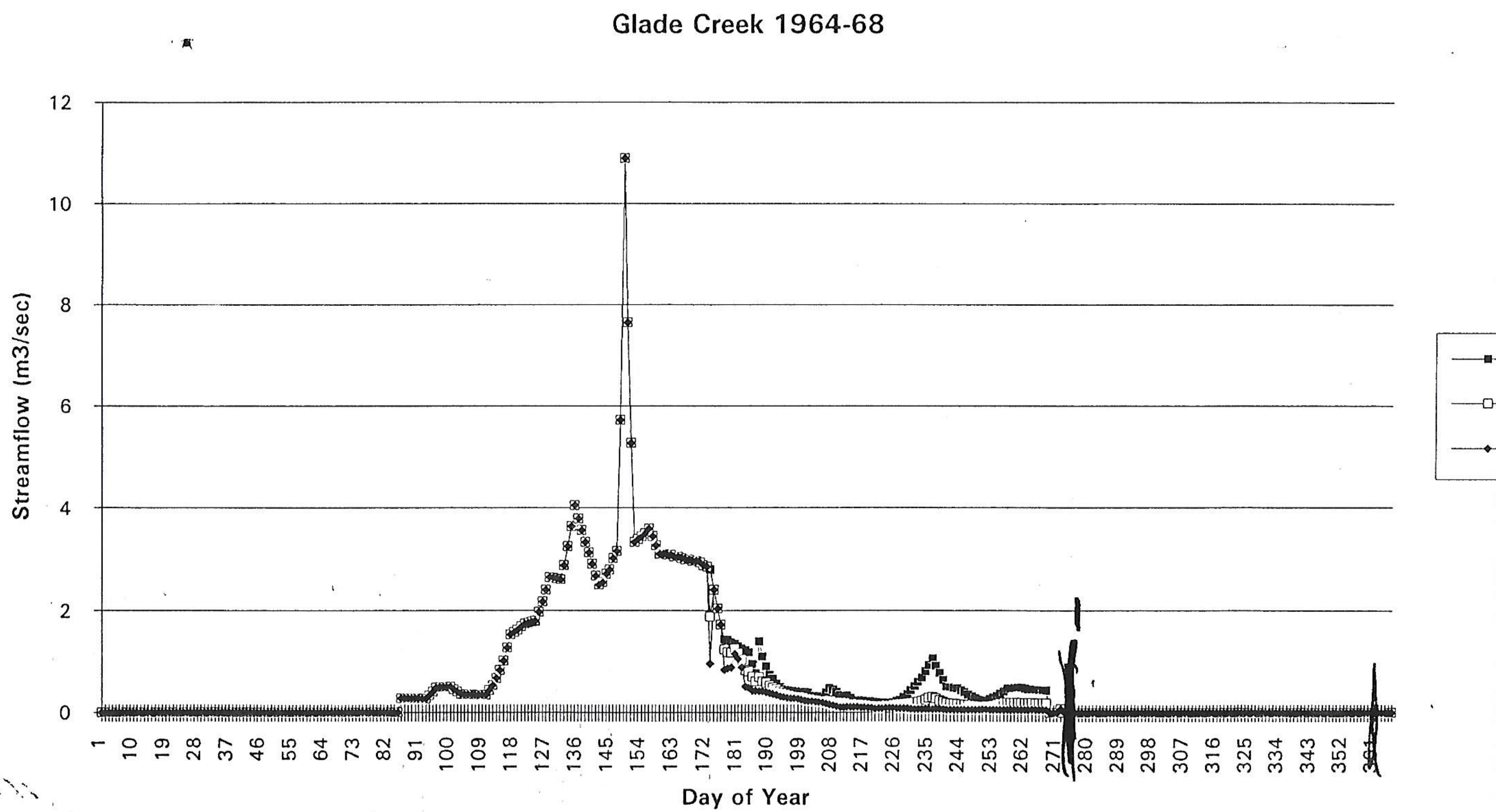
Figure 5. Key to classification of natural rivers.

Table 3. Management interpretations of various stream types.

Stream Type	Sensitivity to Disturbance[1]	Recovery Potential[2]	Sediment Supply[3]	Streambank Erosion Potential	Vegetation Controlling Influence[4]
A1	very low	excellent	very low	very low	negligible
A2	very low	excellent	very low	very low	negligible
A3	very high	very poor	very high	high	negligible
A4	extreme	very poor	very high	very high	negligible
A5	extreme	very poor	very high	very high	negligible
A6	high	poor	high	high	negligible
B1	very low	excellent	very low	very low	negligible
B2	very low	excellent	very low	very low	negligible
B3	low	excellent	low	low	moderate
B4	moderate	excellent	moderate	low	moderate
B5	moderate	excellent	moderate	moderate	moderate
B6	moderate	excellent	moderate	low	moderate
C1	low	very good	very low	low	moderate
C2	low	very good	low	low	moderate
C3	moderate	good	moderate	moderate	very high
C4	very high	good	high	very high	very high
C5	very high	fair	very high	very high	very high
C6	very high	good	high	high	very high
D3	very high	poor	very high	very high	moderate
D4	very high	poor	very high	very high	moderate
D5	very high	poor	very high	very high	moderate
D6	high	poor	high	high	moderate
DA4	moderate	good	very low	low	very high
DA5	moderate	good	low	low	very high
DA6	moderate	good	very low	very low	very high
E3	high	good	low	moderate	very high
E4	very high	good	moderate	high	very high
E5	very high	good	moderate	high	very high
E6	very high	good	low	moderate	very high
F1	low	fair	low	moderate	low
F2	low	fair	moderate	moderate	low
F3	moderate	poor	very high	very high	moderate
F4	extreme	poor	very high	very high	moderate
F5	very high	poor	very high	very high	moderate
F6	very high	fair	high	very high	moderate
G1	low	good	low	low	low
G2	moderate	fair	moderate	moderate	low
G3	very high	poor	very high	very high	high
G4	extreme	very poor	very high	very high	high
G5	extreme	very poor	very high	very high	high
G6	very high	poor	high	high	high

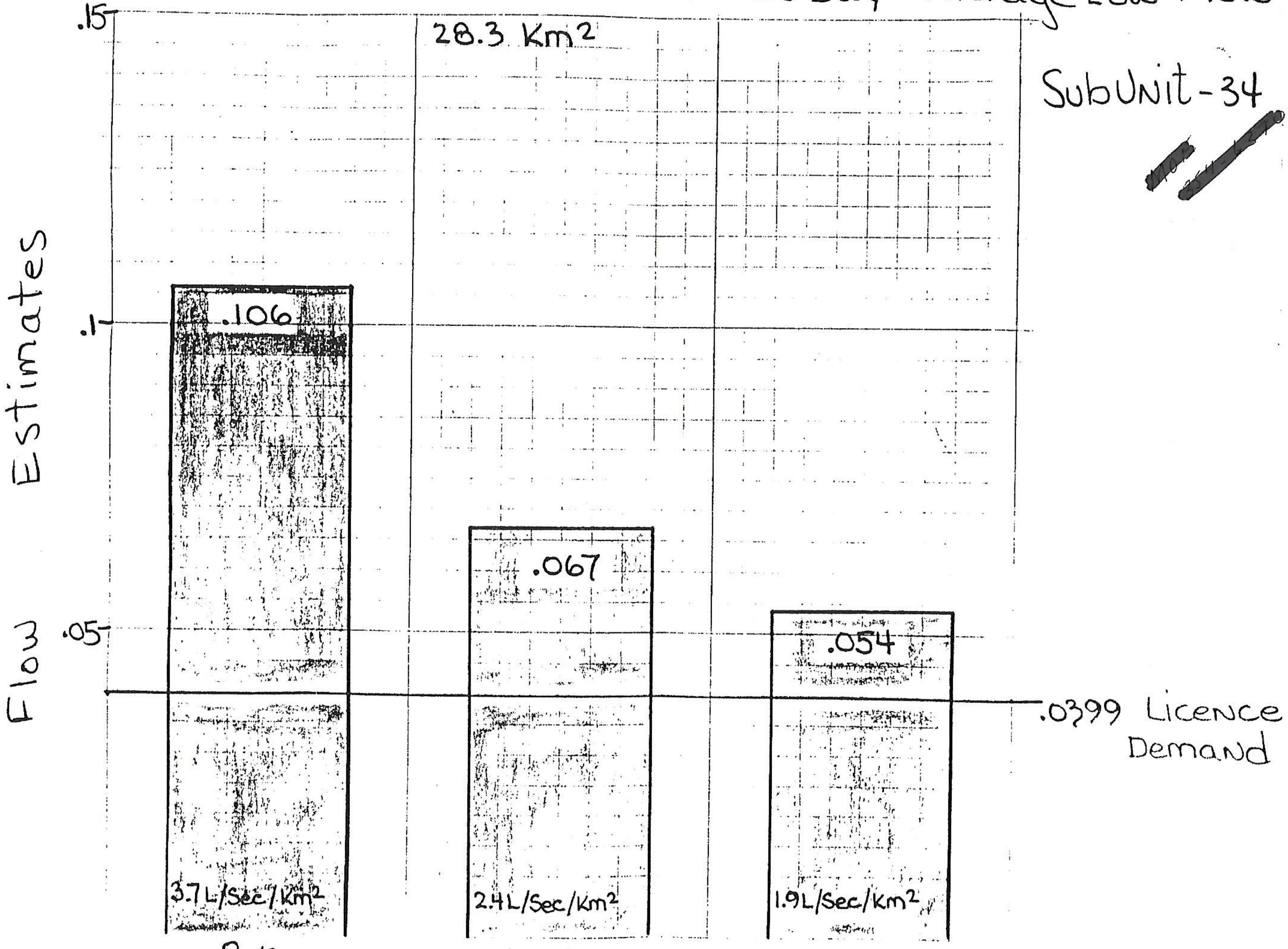
[1] Includes increases in streamflow magnitude and timing and/or sediment increases.
[2] Assumes natural recovery once cause of instability is corrected.
[3] Includes suspended and bedload from channel derived sources and/or from stream adjacent slopes.
[4] Vegetation that influences width/depth ratio-stability.

GLADE HYDROGRAPH



Glade Creek 1964-68
Streamflow (m3/sec)
0
2
4
6
8
10
12
Day of Year
1
10
19
28
37
46
55
64
73
82
91
100
109
118
127
136
145
154
163
172
181
190
199
208
217
226
235
244
253
262
271
280
289
298
307
316
325
334
343
352

GLADE CREEK 30 Day Average Low Flow



SOIL COMPACTION PAPER

SOIL COMPACTION LITERATURE REVIEW

The area impacted by skid trails from conventional tractor logging is 20-38 percent (1, 2, 3, 7, 8, 9, 10, 14, 18, 19). The changes in the soil due to tractor logging are usually measured in terms of soil bulk density, soil permeability, and the percent soil macropore space.

The primary change that occurs is an increase in soil bulk density. This change in bulk density causes many secondary impacts on the soil. The pore space is reduced, biological activity is reduced, infiltrations rates are lowered, soil aeration and gas diffusion are decreased, and permeability is lowered (3, 4, 5, 6, 9, 12, 13). The increase in soil bulk density increases the strength of the soil, retarding root penetration (10, 13, 14).

Various techniques can be used to measure bulk density including the saran clod method, volumetric core methods, and the nuclear densiometer method. In a study done by Steinbrenner and Gessel, 1955, soil bulk density (volumetric core) increased by 35 percent. A study by Froehlich in 1976 measured bulk density (nuclear densiometer) in skid trails at various depths. The results showed 21 percent increase at 2 inches, 18 percent increase at 4 inches, and a 12 percent increase at 6 inches. Another study by Hatchel, Ralston, and Foil, 1970, showed a bulk density (nuclear densiometer) increase of from .75 gm/cm^3 to 1.08 g/cm^3 on primary skid trails. Kuennen et. al. (1979) showed an 18 percent increase (saran clod) at the 4 inch depth.

The increase in bulk density is affected by the number of tractor passes on skid trails. Some studies show that most of the compaction takes place after the first few passes (1, 2, 15). Wet soils are more susceptible than dry soils (2). Wet, fine- and medium-textured soils are the most susceptible to compaction (1). In a study done by Steinbrenner, 1955, most of the damage on wet soil occurred on the first tractor pass.

Increased soil bulk density reduces macropore space (4, 6). Loss of macropore space decreases infiltration and gas diffusion rates. Permeability can be reduced by 35 percent (3). One study shows that after four tractor passes on a wet soil, the soil was almost impervious to water (2). In another study by Klock, 1979, permeability was reduced from 27.2 in/hr to 2.7 in/hr on a primary skid trail (11). Most macropore and permeability loss takes place in the first few passes over the skid trail (2, 7).

Growth loss in a stand can be directly related to an increase of the percent of area in skid trails, and increase in the bulk density of the soil (4, 13, 15, 16, 21). Seedling height was reduced 5-50 percent in compacted soils and total volume loss ranges from 13-50 percent (1, 10, 15).

Recovery of the soil from compaction depends on the soil texture, soil moisture, and the structure of soil (13, 15). Soil that alternately freezes and thaws, and/or wets and dries will recover faster. Coarse textured soils with weak structure recover faster (15). Recovery time for a compacted soil ranges from 5 years to one whole rotation or longer (4, 13, 15). The snowfall on the Kootenai reaches sufficient depths to insulate the soil and prevents the soil from freezing, limiting recovery from compaction.

Alternative logging systems can lower the impact on the ground by reducing the amount of the area that is disturbed by machinery. Three types of alternative systems that have been studied are dedicated skid trails, high lead systems, and over-the-snow logging with tractors. Up to 80 percent of a total logging unit can be impacted by repeated entries (10). In a study by Froehlich, Aulerich, and Curtis, 1979, tractor logging with dedicated skid trails only impacted 7-11 percent of the total area compared to 20 percent for conventional tractor logging. Another study in California by Bradshaw showed 4 percent of area impacted by skid trails compared to 22 percent with conventional tractor. In the first study production was lowered by 11 percent, but the overall cost was slightly better with dedicated skid trails. This time was lost in winching trees to the skid trail. The study showed less residual stand damage with the dedicated skid trails because trees were directionally felled before they were winched to the trail. Bradshaw's study showed no loss of production with dedicated skid trails. He showed a 15-20 percent decrease in damaged residual trees with directional falling, and winching to the dedicated skid trail.

Skyline logging disturbs 2-12 percent of the ground area compared to 26-35 percent for conventional tractor (11, 14). The percent increase in compaction on the skid trails was the same, but a lot more total area was severely disturbed with tractor systems. The trails are also much narrower with the skyline systems.

Over-the-snow logging has proven affective for sensitive soil areas. A study by Klock, 1979, shows 9.9 percent total area severely disturbed compared to 36 percent for conventional tractor logging. Sixty-six percent of the total area had no ground disturbance compared to 26 percent with conventional tractor (11). Logging during the winter of '82-'83 in Griffin Creek on the Tally Lake Ranger District produced similar results. The soils are wet lacustrines and this was probably the only way the area could be logged without excessive soil damage (20).

All of the advanced systems show a decrease in the amount of area impacted in the form of skid trails. The future site productivity is a direct function of increased bulk density. This is shown by reduced heights in seedlings and total volume of the stand (2, 4, 7, 13, 16). Wet soils are the most impacted, and take the longest to recover. For these reasons an alternative logging system should be chosen for wet soils.

The aforementioned discussion pertains only to harvesting with over-the-ground vehicles. Much more land can be impacted by slash disposal and site preparation. During these operations the soils are less protected because of loss of surface organic matter and wetter due to loss of tree canopy.

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