Appendix D

JOB CATAWISSA CREEK

SHEET NO. ______ OF ______

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

AUDENRIED TUNNEL

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB: CATAWISSA CREEK
SHEET NO ______ OF ______
CALCULATED BY: SMM DATE: 9/81
CHECKED BY ______ DATE ______

AUDENRIED TUNNEL

SEVEN INDIVIDUAL HYDROGRAPHS WERE EXAMINED IN ORDER TO EVALUATE PEAK TUNNEL DISCHARGES

DATE	Q_P	Q_B	ΔQ	PRECIPITATION 24	48	96	192	LAG (hr)	5 DAY PREC.	REMARKS
8/12	18.3	13.3	5.0	.44	.71	.71	.71	35	1.0	?
8/25	16.7	11.5	5.2	.95	1.2	2.1	2.1	40	.86	3 peaks on hydrG.
9/20	17.7	8.5	9.2	1.25	1.25	1.45	1.75	24	1.16	3 peaks
12/13	18.3	12.8	5.5	1.3	1.5	1.5	1.9	28	.96	
4/13	23.2	16.7	6.5	.45	.60	.60	1.25	14	1.3	snow melt ?
4/27	25.0	17.2	7.8	1.05	1.25	1.25	1.25	19	0.8	
5/23	43.4	20.0	23.4	2.5	3.7	3.95	4.65	34	2.68	

PROBLEM #1 - DETERMINE WETHER PEAK DISCHARGES ARE CAUSED BY DIRECT SURFACE RUNOFF INTO MINE POOL OR BY INFILTRATION

ESTIMATE LAG TIME FOR DIRECT RUNOFF INTO MINE POOL

SURFACE TRAVEL ≈ 2mi @ 2fps ave t_t = 1.5 hrs
SUBSURFACE TRAVEL ≈ 30000 ft @ 4 fps t_t = 2.1 hrs
EST LAG @ t_t to .6 t_t
OR LAG = 2 to 3 hours.

ACTUAL LAG TIMES 20 TO 40 hrs
w/ max travel time = 1.5± fps to 0.5 fps.

IF HYDROGRAPH FOR AN INTENSE STORM IS EXAMINED 3 SEPARATE PEAKS ARE APPARENT FOR A SINGLE STORM EVENT

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

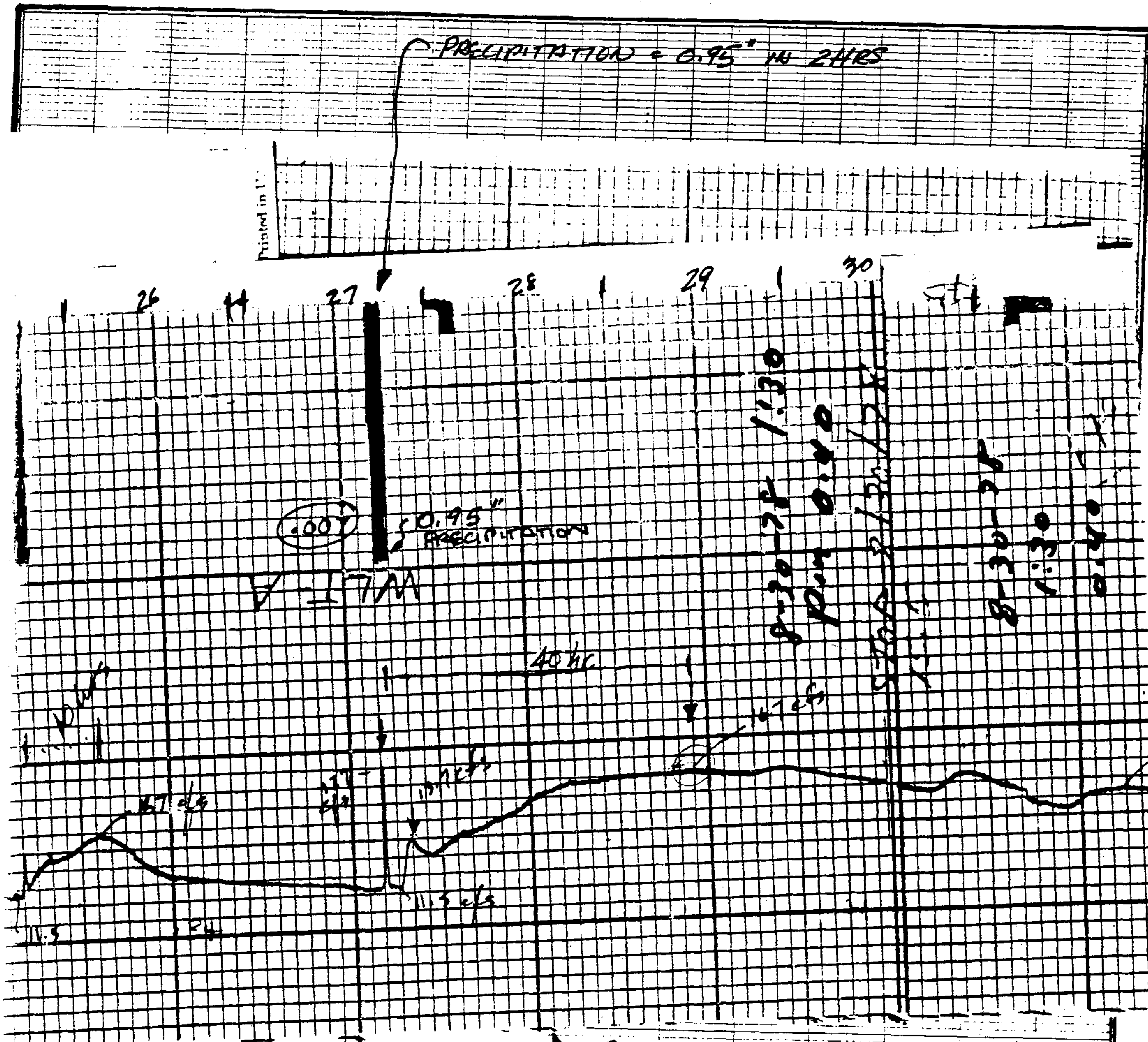
...CE CATAWISSA CREEK

SHEET NO ______ OF ______

CALCULATED BY ______ DATE 9/81

CHECKED BY ______ DATE ______

SCALE ______



RECORDER CHART 8/26 - 8/30/78

STAGE TIME RECORD INDICATES:

(a) A PEAK FROM DIRECT SURFACE RUNOFF INTO THE OUTLET CHANNEL BEFORE THE GAGE. NOTE FOR A SHORT DURATION INTENSE STORM THIS CAN CAUSE THE GREATEST PEAK (17.7 cfs.)

(b) A PEAK AT 3± hours LATER WHICH WOULD BE SURFACE RUN OFF INTO THE MINE (13.7 cfs)

(c) A PEAK CAUSED BY INFILTRATION 40 HOURS LATER (16.7 cfs)

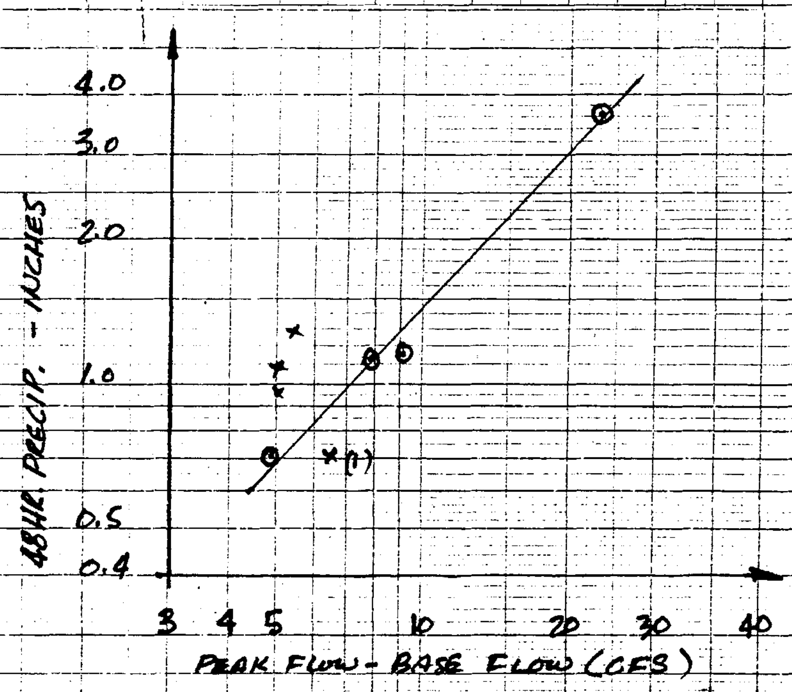
GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB: CATAWISSA CREEK
SHEET NO ______ OF ______
CALCULATED BY: [illegible] DATE: 9/81
CHECKED BY ______ DATE ______
SCALE ______

FOR LESS INTENSE STORMS THE TRIPLE PEAK EFFECT IS OBSCURED BY THE RISING LIMB OF THE MAIN (INFILTRATION) HYDROGRAPH

THIS EFFECT IS SIMILAR TO HYDROGRAPHS OF STREAMS AFFECTED BY CAVERNOUS LIMESTONE CONDITIONS. SIMILAR RESULTS WERE ENCOUNTERED DURING A STUDY OF THE LETORT SPRING RUN IN CARLISLE PA. . FOR THE LETORT THE PEAK DISCHARGE APPEARED TO BE A FUNCTION OF THE RAINFALL VOLUME FALLING OVER A TIME PERIOD EQUAL TO TWICE THE HYDROGRAPH LAG TIME

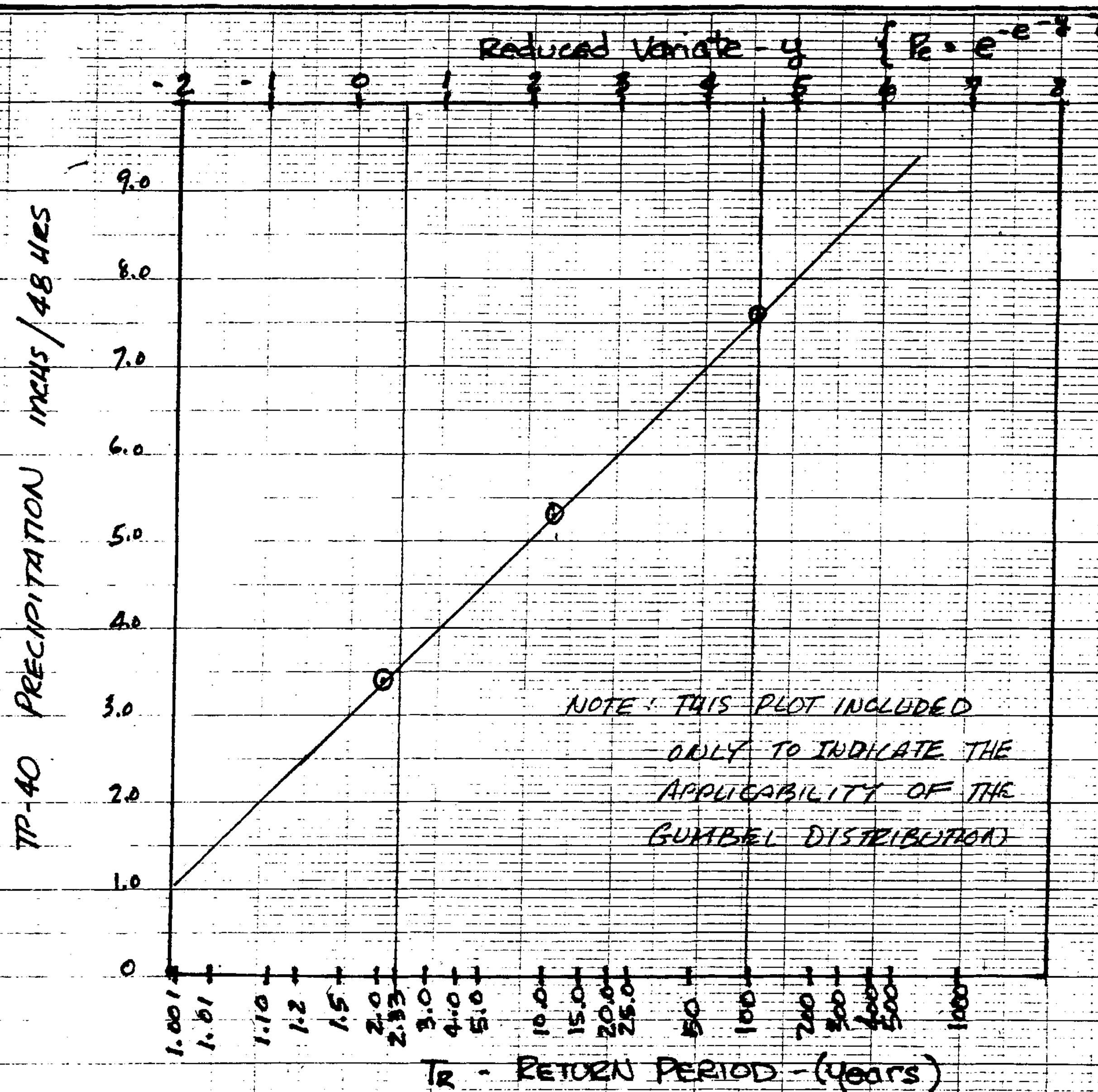
48 HR PRECIPITATION VOLUMES APPEAR TO CORRELATE WELL WITH THE OBSERVED AUDENRIED PEAKS



(1) BASE FLOW VALUES APPEAR TO AFFECT PEAK IN THIS REGION

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB: CATAWISSA CREEK
SHEET NO. ____ OF ____
CALCULATED BY: JFW DATE: 9/81
CHECKED BY: ____ DATE: ____
AUDENRIED TUNNEL



PLOT OF TP-40 PRECIP. ON GUMBEL EXTREME PROBABILITY PLOT INDICATING PRECIPITATION DATA / PEAK DISCHARGE RELATIONSHIP IS PROBABLY VALID USING SAME DISTRIBUTION

PLOT AUDENRIED PEAKS AT THEIR CORRESPONDING TR VALUES - NEXT SHEET

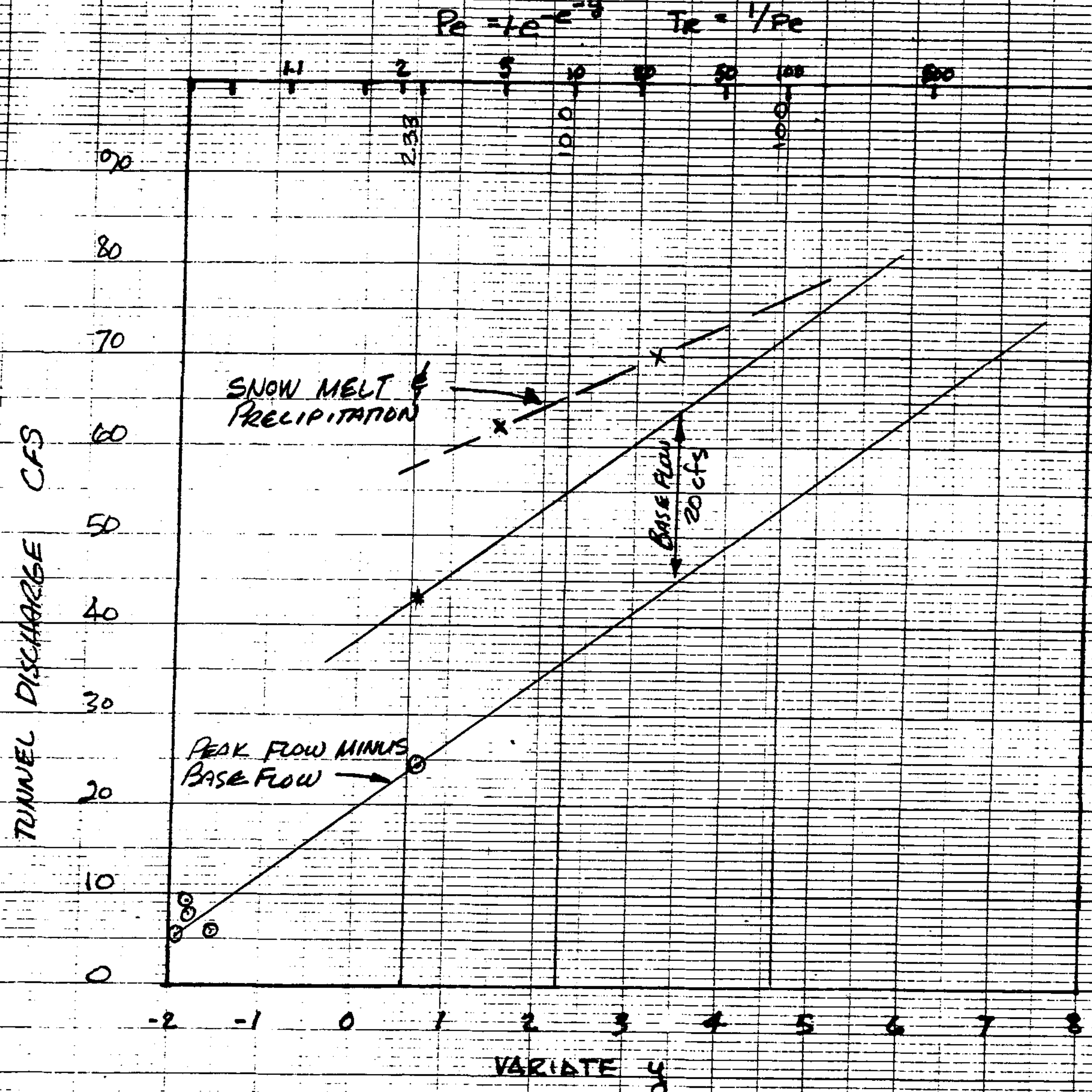
GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

SHEET NO ________ OF ________

CALCULATED BY ________ DATE ________

CHECKED BY ________ DATE ________

SCALE ________



DATA PTS	
FLOW	y
23.4	0.7
7.8	-1.8
5.5	-1.55
62	1.5
27	3.2

SNOW MELT 1979 $T_R = 5yr$ $Q_p = 62$

1970 $T_R = 27yr$ $Q_p = 70$

JOB CATAWISSA CREEK

SHEET NO. ______ OF ______

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE AUDENRIED TUNNEL

SNOWMELT FREQUENCY CONTROLS USE:

TR. (yr.)	DESIGN Qp (cfs)	
2.33	57	
10	65	
50	72	*
100	76	*

DESIGN FLOWS:

IDEALLY PROVIDE MAIN TREATMENT UNIT FOR 98% OF NORMAL FLOW CONDITIONS WITH A BYPASS TREATMENT CAPACITY BETWEEN MEAN ANNUAL (2.33) AND 10 YEAR

JUDGEMENT REQUIRED AS FLOW FOR STUDY PERIOD WAS GREATER THAN NORMAL (SEE NEXT SH.)

* PEAK DISCHARGES ARE CAUSED BY GROUNDWATER RECHARGE INTO THE MINES. THERE FOR AT HIGH RETURN PERIODS THE DISCHARGE IS CONTROLLED BY THE PHYSICAL CHACTERISTICS OF THE AQUIFERS RATHER THAN PRECIP. THEREFOR RELATIVELY LOW DISCHARGES CAN BE ANTICIPATED AT HIGH RETURN FREQUENCIES AS RECHARGE IS PHYSICALLY LIMITED

JOB Catawissa Creek

SHEET NO. ____ OF ____

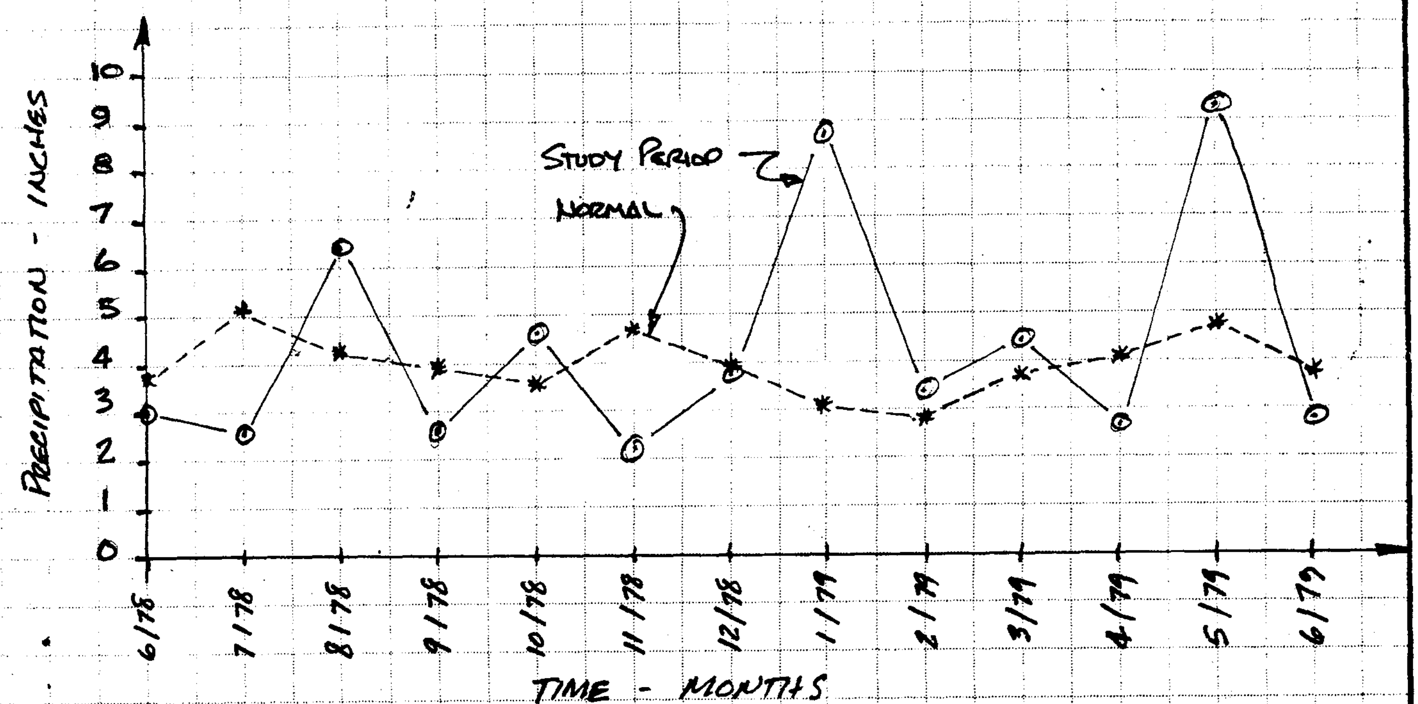
GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

CALCULATED BY sfm DATE 9/81

CHECKED BY ____ DATE ____

AUDENRIED TUNNEL - DESIGN FLOWS

PRECIPITATION FOR YEAR OF RECORD



FOR JUNE 78 to DEC. 78 PRECIP. IS 3.4" BELOW NORMAL
FOR JAN. 79 to JUNE 79 PRECIP IS 9.8" ABOVE NORMAL
NORMAL PRECIP. FOR SAMPLING PERIOD = 47.2"
ACTUAL PRECIP. " " " = 54.5"
OR 7" ABOVE NORMAL

AVE FLOW RATES

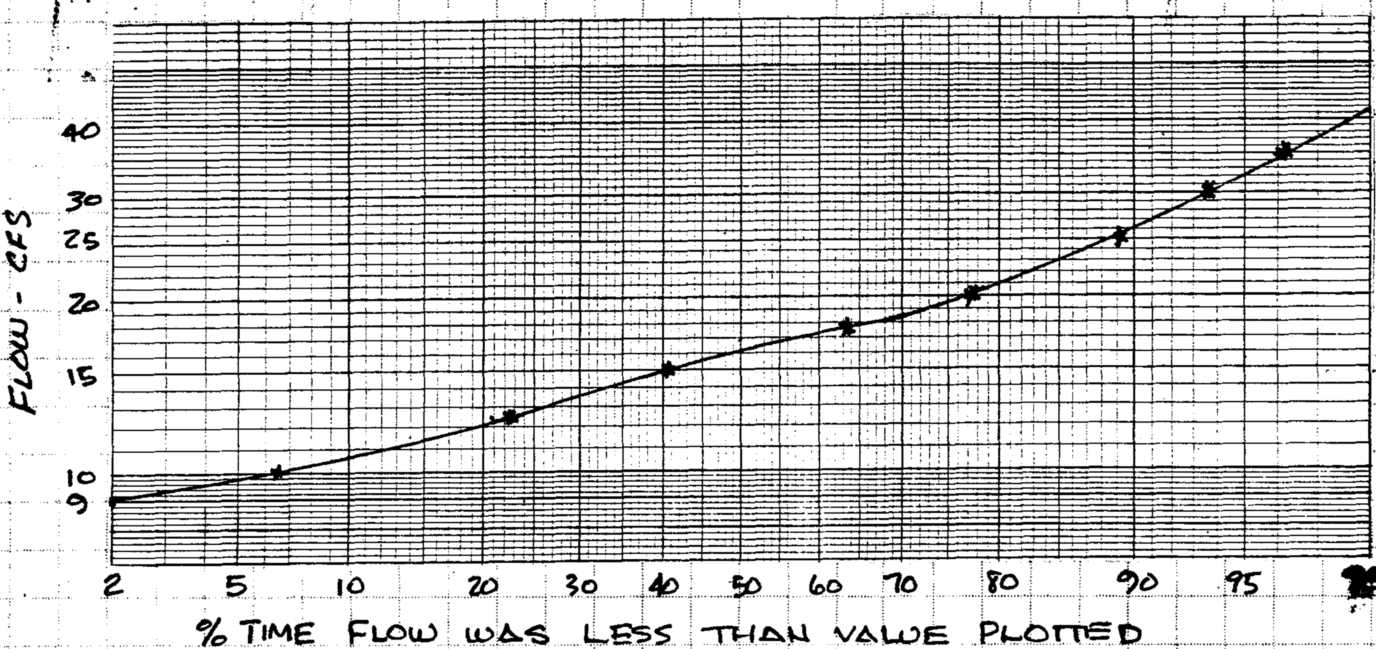
SUMMER/FALL	12 cfs
WINTER/SPRING	23 cfs

D8

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB: CATAWISSA CREEK
SHEET NO. ____ OF ____
CALCULATED BY: [signature] DATE: 9/81
CHECKED BY: ____ DATE: ____
AUDENRIED TUNNEL

FLOW DISTRIBUTION FOR STUDY PERIOD



ie 98% OF THE FLOW WAS LESS THAN 40 cfs
& 50% of THE FLOW WAS LESS THAN 16 cfs
OR A DISCHARGE OF 26 cfs WAS EXCEEDED FOR 10% OF THE TIME (40± DAYS)

RECOMMENDED
DESIGN FLOWS

(a) 25 cfs main treatment units will handle flow 89% OF THE YEAR (ie 325 days)

(b) 75 cfs - MAX. TREATMENT w/ BY PASS DRUMS

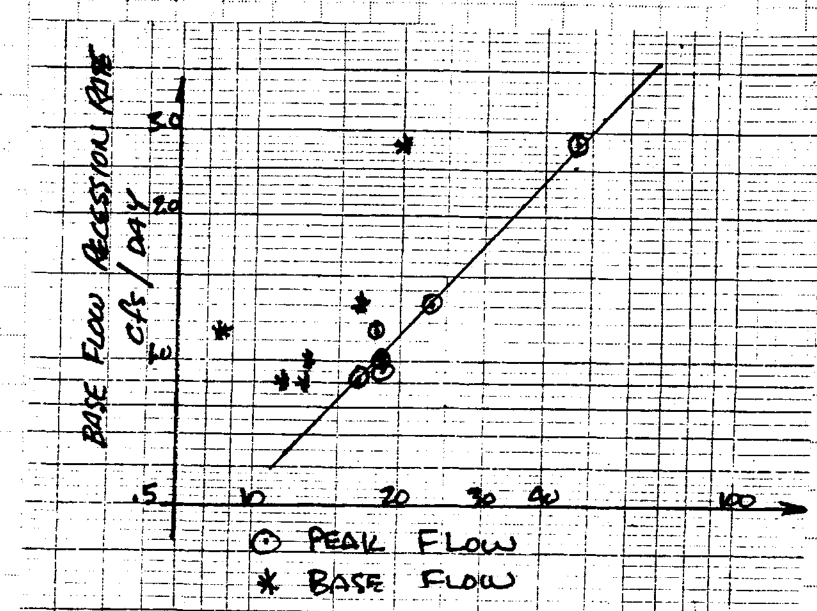
(c) 150 cfs EMERGENCY BY PASS CAPABILITY

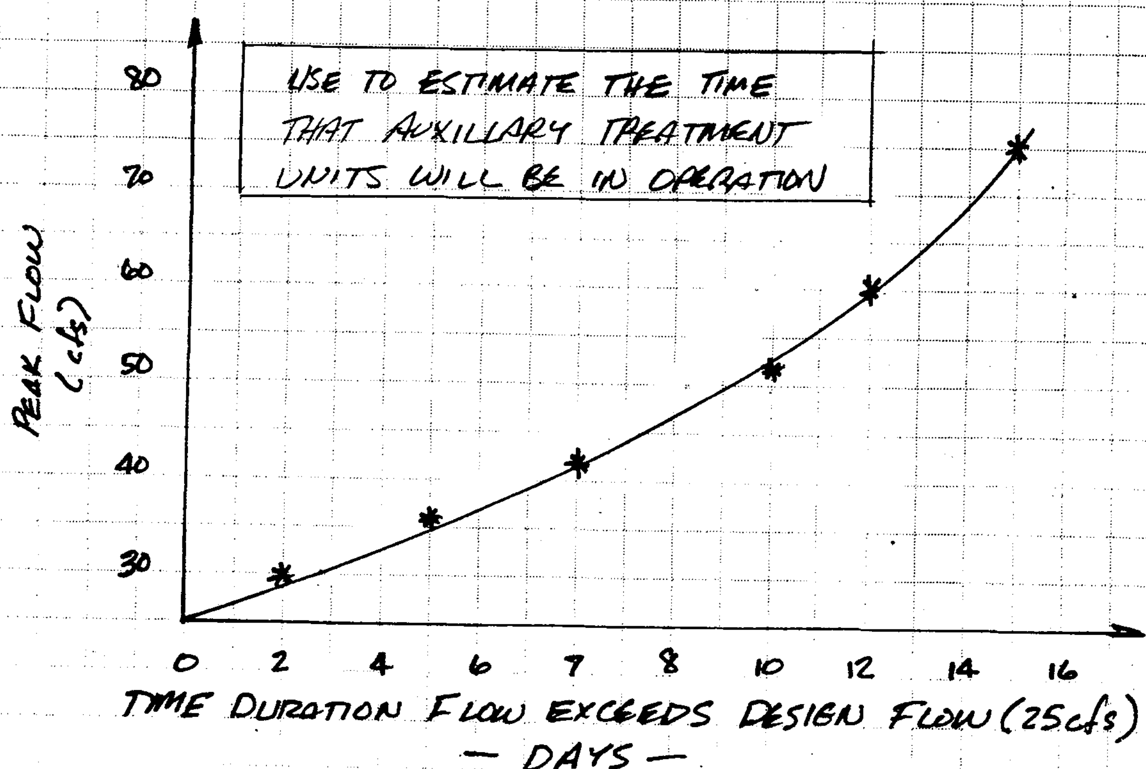
GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB: CATAWISSA CREEK
SHEET NO. ______ OF ______
CALCULATED BY: SJM DATE: 9/81
CHECKED BY: ______ DATE: ______
AUDENRIED TUNNEL

CHECK HIGH FLOW DURATION

PLOT FLOW VS RECESSION RATES





010

JOB SL 135-11 Catawissa Creek

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

SHEET NO. ______ OF ______

CALCULATED BY [signature] DATE 10/81

CHECKED BY ______ DATE ______

SCALE AUDENRIED TUNNEL

DESIGN PARAMETERS

FLOW	pH	ACID	Fe	SO_4	MIN. ACID *	CT.
10	3.50	320	3.5	350	32	290
15	3.55	310	3.0	340	30	280
20	3.60	300	2.75	280	26	270
25	3.70	200	2.0	250	20	180
30	3.70	150	1.5	220	20	130
50	3.75	125	1.0	170	16	110
75	3.75	125	1.0	150	16	110

* ESTIMATED BY EQUILIBRIUM CONDITIONS

REQUIRED LOAD FACTORS FOR STATIC BEDS R = 0.5

FLOW	pH_f = 5.0	pH_f = 5.25	pH_f = 5.50
10	48	140	400
15	46	128	360
20	44	112	320
25	40	100	260
30	37	88	240
50	35	72	140
75	32	60	120

ASSUME 5' deep beds

3' fine stone $d = 0.25"$
1' med stone $d = 0.50"$
1' COARSE $d = 1.0"$

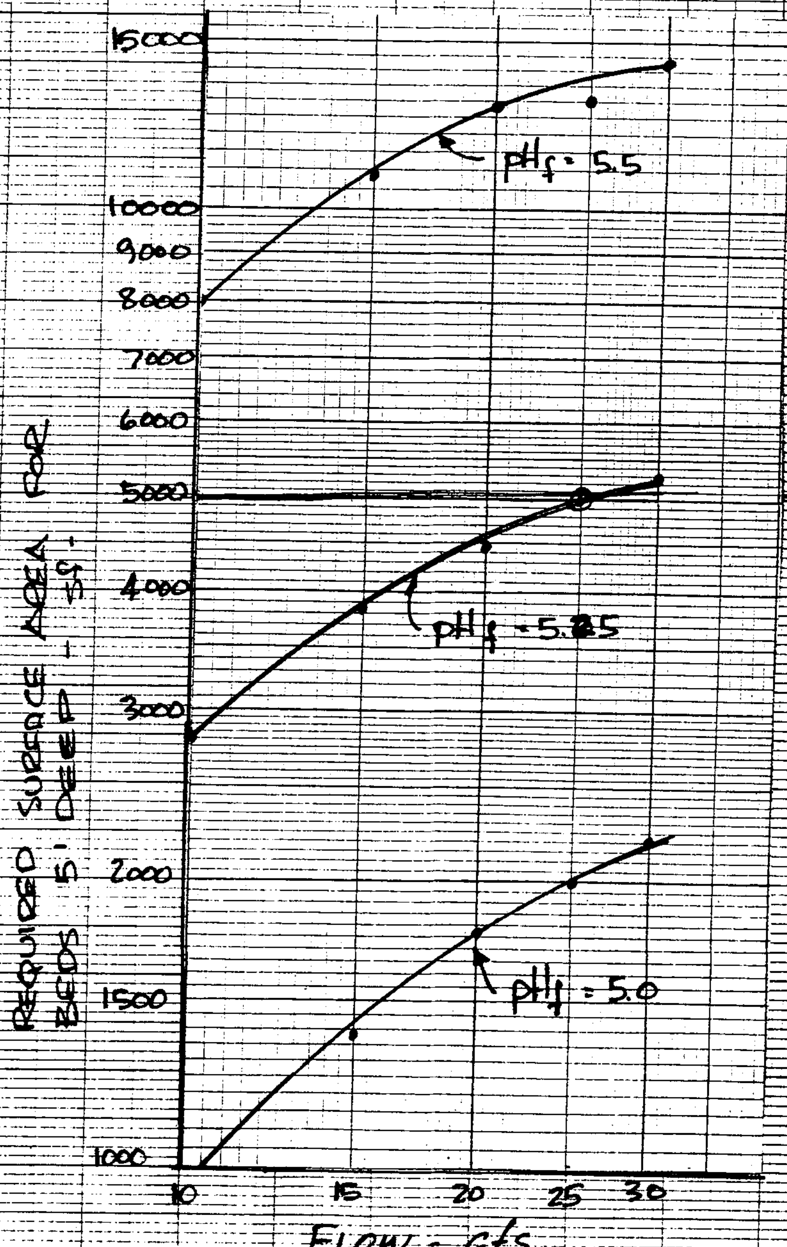
$LF = \frac{W_s}{Q\bar{d}}$ $W_s = \frac{90 \times 5}{2000} = 0.225$ T/SF $\bar{d} = 0.45"$

REQUIRED STONE AREA = $\frac{\bar{d} Q LF}{.225} = 2 Q LF$

JOB: CATTAWISSA CREEK
SHEET NO. ____ OF ____
CALCULATED BY: SJM DATE: 11/81
CHECKED BY: ____ DATE: ____
SCALE: ____

STONE SURFACE AREA

Flow	$pH_f = 5.0$	$pH_f = 5.25$	$pH_f = 5.50$
10	960	2800	8000
15	1380	3840	10800
20	1760	4480	12800
25	2000	5000	13000
30	2220	5280	14400
50	3500	7200	14000 ?
75	4800	9000	18000



RECOMMEND DESIGN
25 cfs & 5000 sf

ESTIMATE BACKWASH FLOW VOLUME FOR SETTLING LAGOON SIZE
(REF. "WATER SUPPLY & POLLUTION CONTROL", CLARK, VIESSMAN & HAMMER)

EXPAND BED >10% & < 25%

$$L_e = L\left(\frac{1-e_o}{1-e_e}\right)$$

$e_o = 0.46$ (porosity)
$L_e/L = 1.1$ ✓ (L = bed depth)

$$e_e = 1 - \left(\frac{1-e_o}{L_e/L}\right) = 0.51$$

FOR INCIPIENT EXPANSION

$$e_e = \left(\frac{V_s}{v_s}\right)^{.22}$$

V_s = FACE VELOCITY
v_s = settling velocity

$$v_s = \left(4/3 \; \frac{g}{C_D} \; \left(\frac{\rho_0 - \rho}{\mu}\right) d\right)^{0.5}$$

C_D = DRAG COEFF.
d = Ave grain diameter

$$C_D = 18.5 / Re^{0.6}$$
$$Re = \rho V_s d / \mu$$

Re = Reynolds No.

ASSUME V_s = 15 GPM/SF = 0.033 FT/SEC

$Re = 4.26$
$C_D = 7.75$
$v_s = 0.27$

$$CK \quad e_e = \left(\frac{0.033}{0.27}\right)^{.22} = 0.63 > 0.51 \text{ (BED WILL EXPAND)}$$

ASSUME BACKWASH TIME = 10 MIN
LAGOON VOLUME = 5000 SF × 15 × 10 / 7.48 = 100,267 cf

PROVIDE 100,000 CF LAGOON & ONE STANDBY (SAME SIZE)

JOB	CATAWISSA CREEK
SHEET NO.	OF
CALCULATED BY	SJM — DATE 11/81
CHECKED BY	DATE
SCALE	

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

DEFINE DRUM TREATMENT REQUIREMENTS

$$\text{Eff.}\ \frac{\Delta\ \text{ALK USED}}{\Delta\ \text{ALK PRODUCED}} = 0.67$$

REQ'D PRODUCTION RATE = U_R = 0.33 Δalk Q (#/hr)

Q	Δ ALK	#/hr
10	80	264
15	72	356
20	68	449
25	64	533
30	62	620
50	56	933
75	52	1300

(52) ← ESTIMATED - QUAKAKE REQ'D 40 → 44 mg/l ALK PLUS MINERAL ACIDITY

REQ'D PRODUCTION RATE w/ DOWNFLOW IN OPERATION

Q	Δ ALK	#/HR
10	30	99
15	32	159
20	36	238
25	40	330
30	~~[illegible]~~ 45	~~[illegible]~~ 446
50	30 @ 45 & 20 @ 56 ppm	~~[illegible]~~ 816
75	30 @ 45 & 45 @ 52	1218

D14

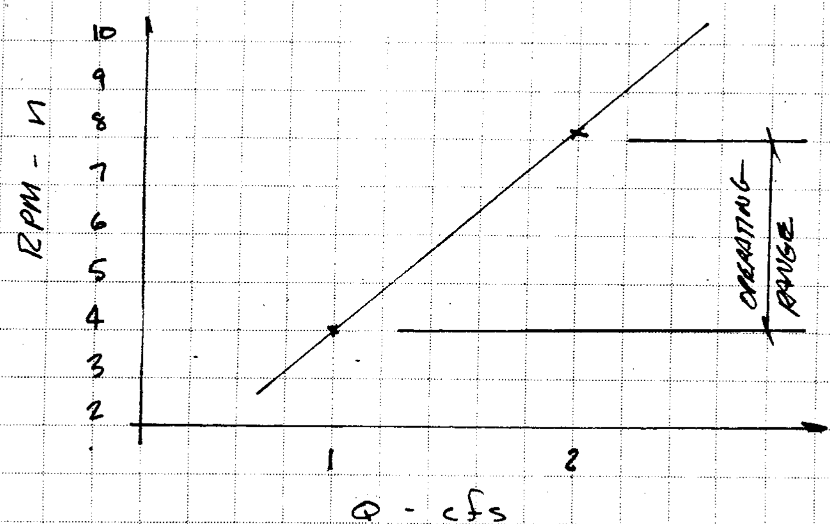
SET DRUM WIDTH FOR MAX OPERATION AT LOW FLOW – 8 cfs

$P = \epsilon_h Q K D \gamma' L = 247\ QL$ ft-lbs/ft

$P = \omega M_T \quad \omega = \frac{2\pi n}{60} \quad n = RPM$
$= 0.10 M_T n$
$= 61.4\ nL$

OR $P_{IN} = P_{OUT}$

$61.4\ nL = 247\ QL$
$n = 4.02\ Q$



SET DRUM WIDTHS @ 4'

FINES PRODUCTION $= \epsilon_T \frac{23.5\ P_I}{550}$

$\epsilon_s = 0.79$
$\epsilon_T = \epsilon_s + \epsilon_n$
ϵ_n = eff. re: RPM

PEAK ϵ_n @ 6 RPM
ASSUME $\epsilon_n =$ [struck out] $= 1 - \left[\frac{6 - \sqrt{(6-n)^2}}{6} \right]$ (for 4cfs)

ie $\epsilon_h = 0.75$ @ 4 RPM & @ 8 RPM & $\epsilon_h = 0.9$
(should be conservative see Rpt. fig 47)

GEO-TECHNICAL SERVICES Consulting Engineers & Geologists	JOB LATOWISSA CREEK SHEET NO. ____ OF ____ CALCULATED BY SJM DATE 11/81 CHECKED BY ____ DATE ____ SCALE ____

DRUM DESIGN

1st TRIAL

FULL TREATMENT $H = \frac{\Delta ALK}{0.13\,A}$ $\quad \Delta alk = 80 \quad A = 30 \quad H = \frac{80}{0.13(30)} = 20.5'$

W/ DOWNFLOW $H = \frac{55}{.13(30)} = 14.1'$

ASSUME TREATMENT OF 70 cfs - USE LARGE DRUMS TO REDUCE TOTAL NO.

TRY 6' DRUMS (4 Tiers for full treatment)

$KD = 6.0$

$K = 1.5$

$D = 4.0$

w/ 20 vanes $\epsilon_h = 0.66$

$\frac{M_T}{LD^3} = 9.6$ or $M_T = 614.4\ L$

ASSUME POWER TAKE OFF FOR DRUM FEED OR AERATION SO THAT $M_T = M_E$

HOWEVER STONE FINES PRODUCTION SHOULD BE REDUCED AS ONLY PORTION OF M_T APPLIES TO STONE GRINDING

FROM REPORT FIGURE 57 AT FLOW/ft > 1.2 ±

$\frac{M_R}{M_T} = \frac{460}{580} = 0.79$ ← USE AS GRINDING Efficiency RATE - E_s FOR FLOWS > 1.2 cfs/ft.

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

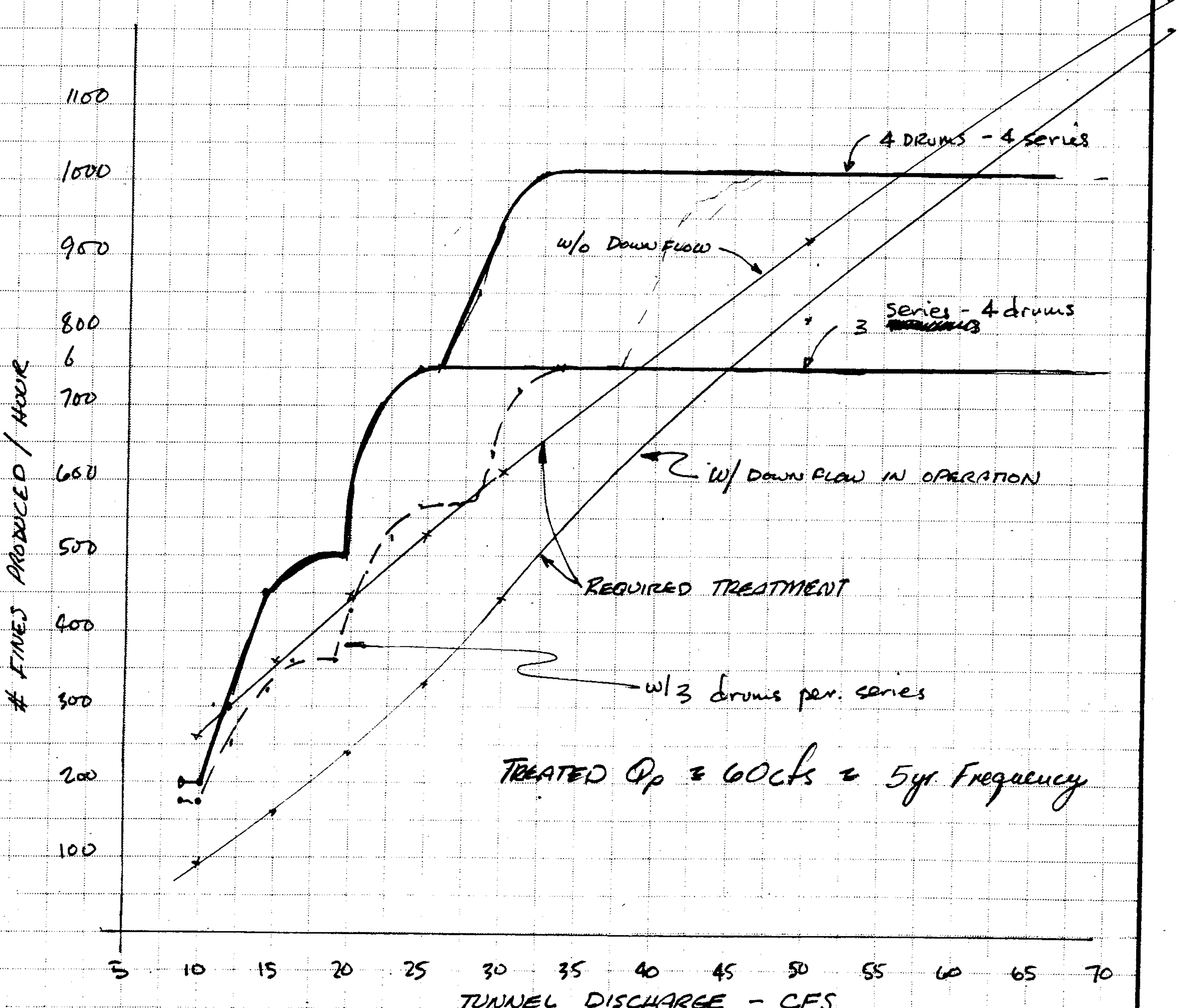
JOB: [illegible] Creek
SHEET NO. ____ OF ____
CALCULATED BY: [illegible] DATE: 11/81
CHECKED BY: ____ DATE: ____
SCALE: ____

FINES PRODUCTION

$$U = E_T \frac{23.5}{550} P_I$$

$$P_I = 247\,Q$$

$U = 33.3\,E_h\,Q \rightarrow$ 4 drums in series
$25.0\,E_h\,Q \rightarrow$ 3 drums in series



D17

JOB CATAWISSA CREEK

SHEET NO. ______ OF ______

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

CALCULATED BY TAG DATE 11/19/81

CHECKED BY ______ DATE ______

~~SCALE~~ AUDENRIED TUNNEL

ANNUAL LIMESTONE USE:

DURATION %	DAYS /yr	FLOW cfs	DRUMS: FINES lbs/hr.	DRUMS: TOT. FINES lbs	DOWNFLOW: ACID mg/l	DOWNFLOW: LBS NEUT. lbs	TOTAL TONS
0-2	7.2	6	150	25920	340	43540	34.7
2-5	11	9	175	46200	330	96852	71.5
5-10	18.3	10	175	76860	320	173604	125.2
10-20	36.5	12	260	227760	316	410318	319.0
20-30	36.5	13	300	262800	314	441698	352.3
30-40	36.5	14	325	284700	312	472645	378.7
40-50	36.5	16	350	306600	308	533240	419.9
50-60	36.5	17	365	319740	306	562889	441.3
60-70	36.5	18	365	319740	304	592105	455.9
70-80	36.5	20	430	376680	300	649238	513.0
80-90	36.5	25	565	494490	200	541031	517.8
90-95	18.3	30	680	298656	150	244131	271.4
95-98	11	40	900	237600	140	182617	210.1
98-100	7.2	70	1010	174528	125	186767	180.6

ANNUAL LIMESTONE CONSUMPTION (TONS): 4291.4

USE RATE FORMULAS*

DRUMS TOT. FINES:

TOTAL FINES = FINES (lbs/hr) × 24 hr/day × days

DOWNFLOW LBS. NEUT:

$$\text{LBS. ACID NEUTRALIZED} = 61\left[\frac{\text{ACIDITY}^{**}(\text{mg/l}) \times \text{FLOW (cfs)} \times 5.3901 \times \text{days}}{2}\right]$$

* Developed from experimental results at Quakake.

** Assumes Complete Acid Removal (conservative limestone use estimate) D18