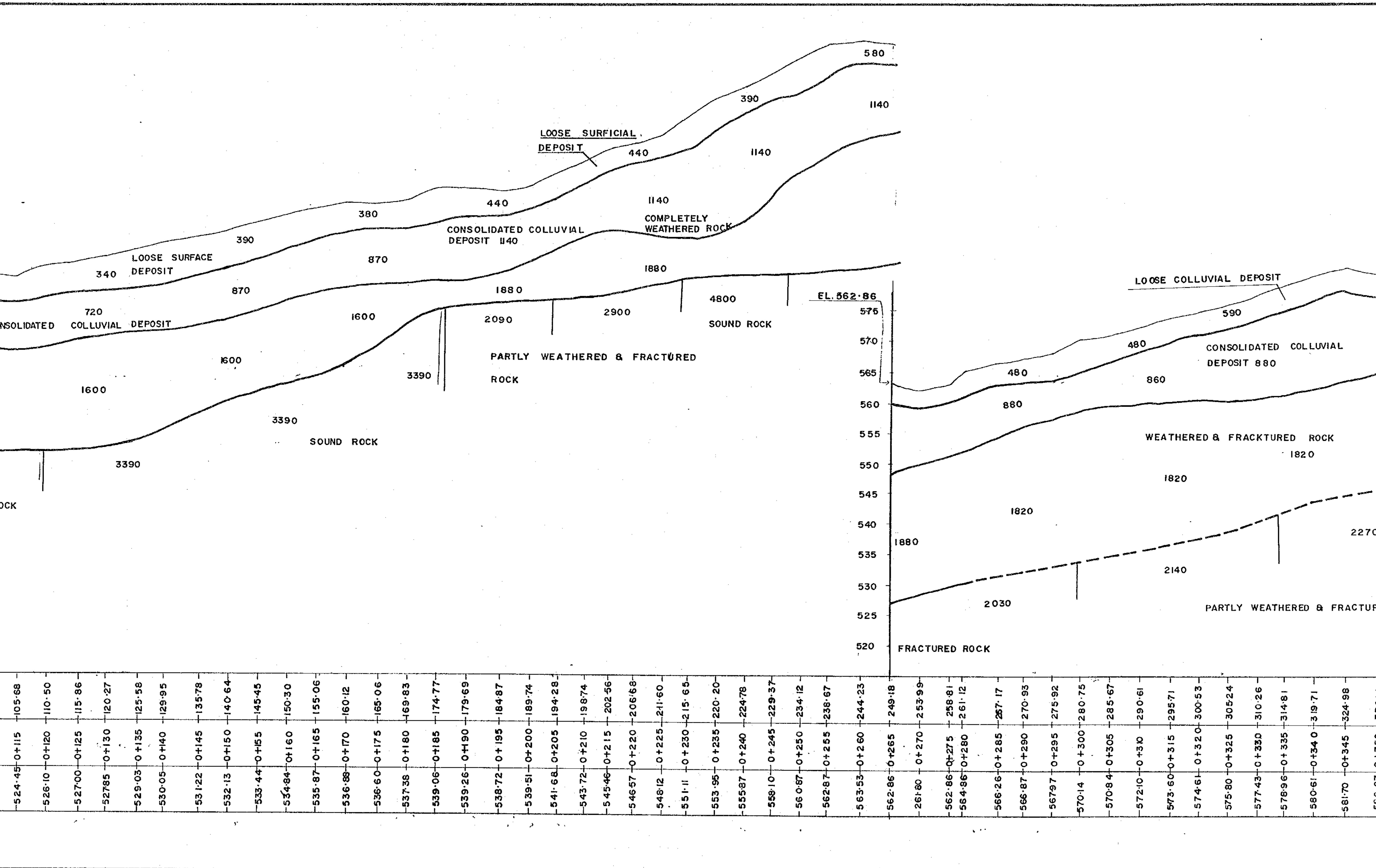
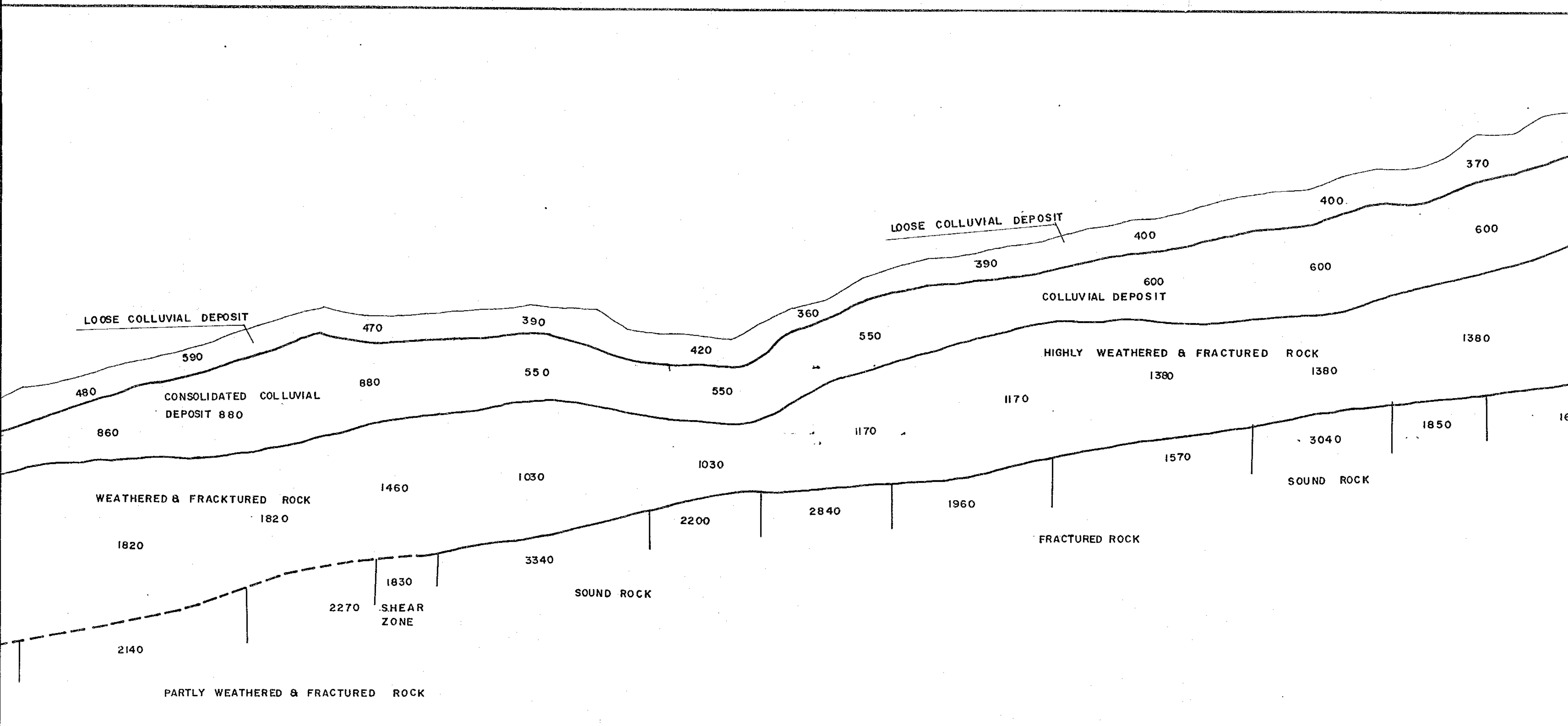
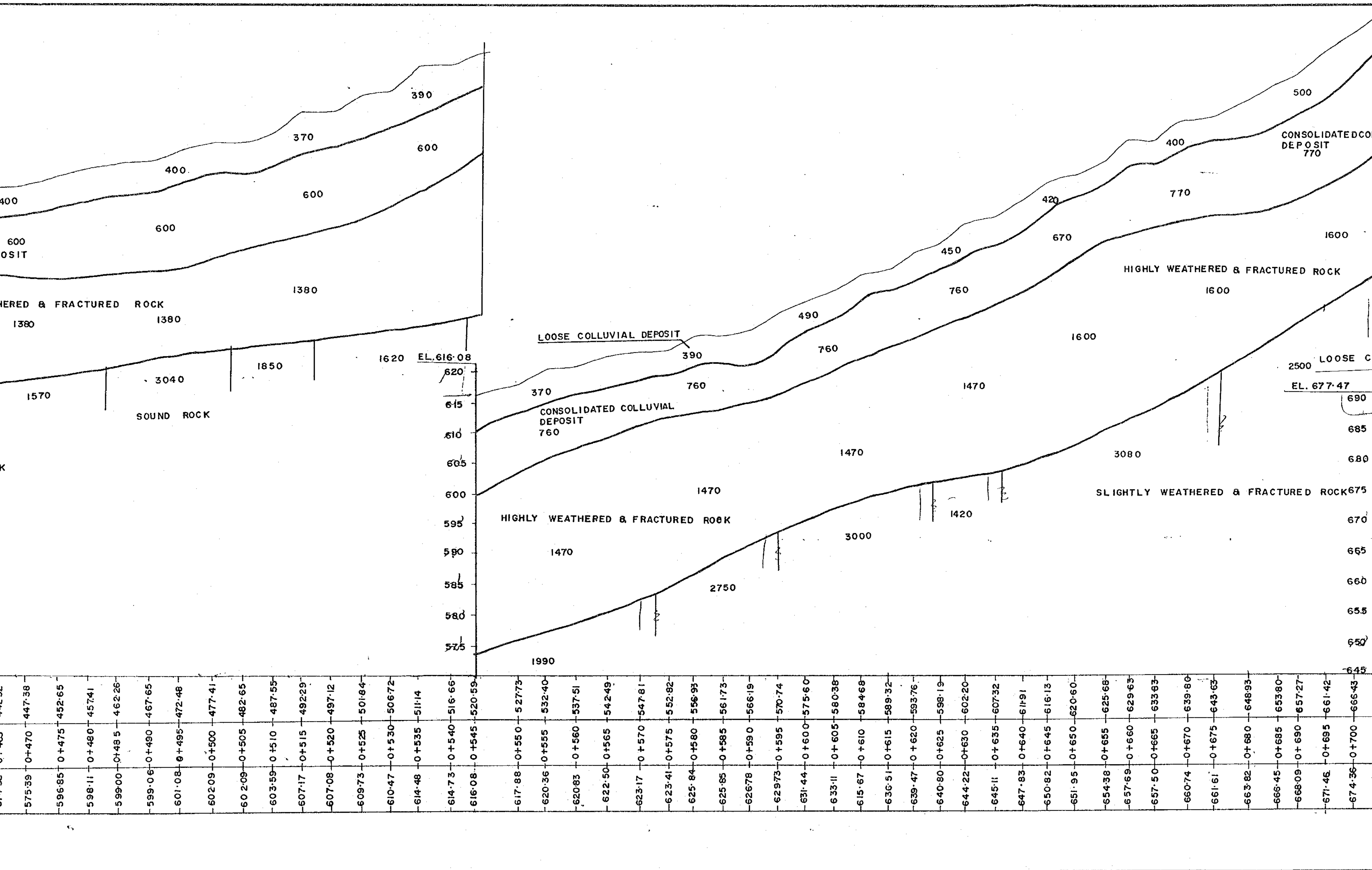
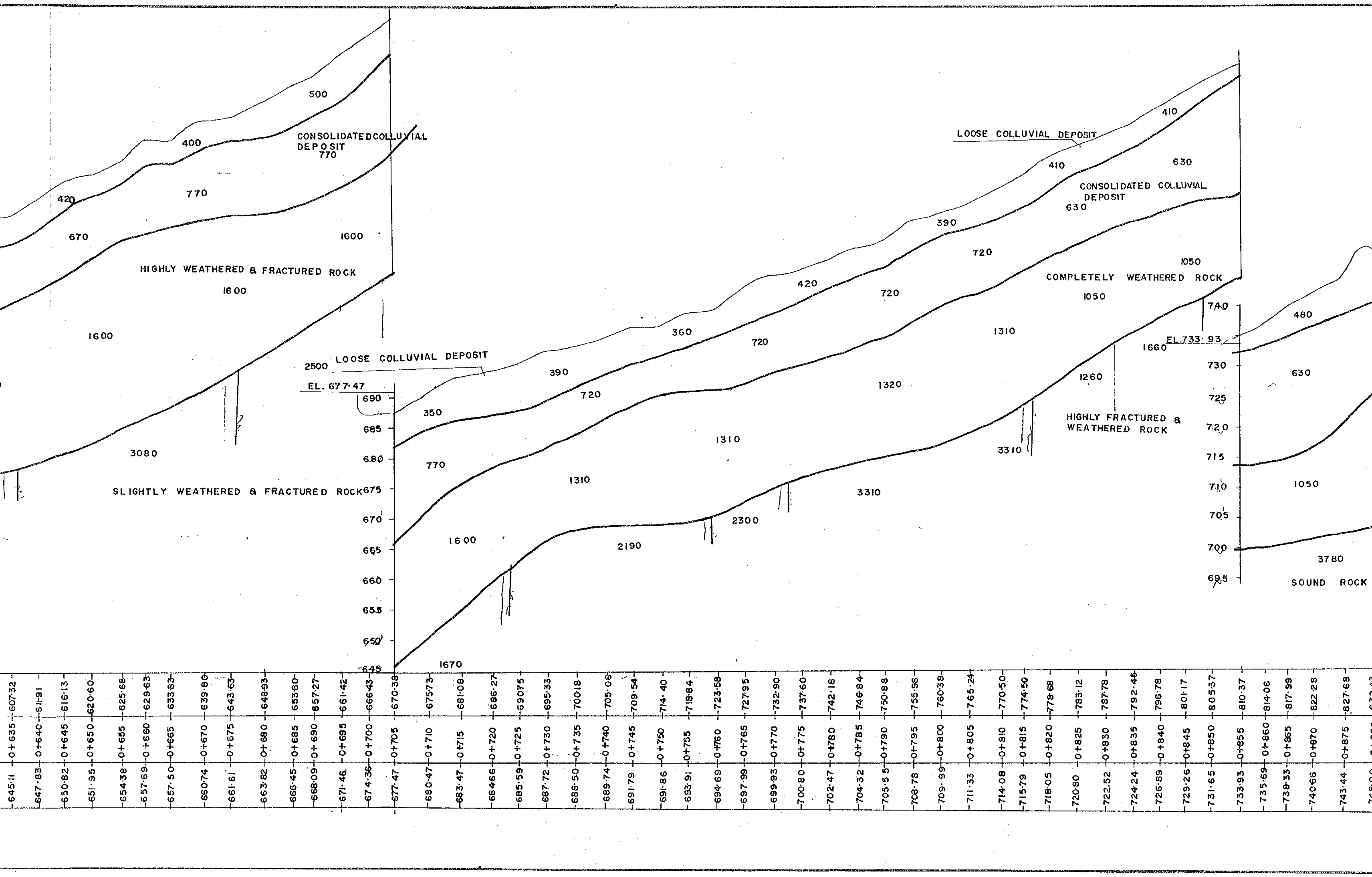

580
390
1140
LOOSE SURFICIAL DEPOSIT
440
1140
440
1140
380
COMPLETELY WEATHERED ROCK
CONSOLIDATED COLLUVIAL DEPOSIT 1140
390
LOOSE SURFACE DEPOSIT
870
340
1880
870
1880
720
4800
NSOLIDATED COLLUVIAL DEPOSIT
1600
2090
2900
SOUND ROCK
PARTLY WEATHERED & FRACTURED ROCK
1600
1600
3390
3390
SOUND ROCK
3390
OCK
EL. 562·86
575
570
565
560
555
550
545
540
535
530
525
520
LOOSE COLLUVIAL DEPOSIT
590
480
CONSOLIDATED COLLUVIAL DEPOSIT 880
480
860
880
WEATHERED & FRACKTURED ROCK
1820
1820
1820
2270
1880
2140
2030
PARTLY WEATHERED & FRACTUR
FRACTURED ROCK
105·68 110·50 115·86 120·27 125·58 129·95 135·78 140·64 145·45 150·30 155·06 160·12 165·06 169·83 174·77 179·69 184·87 189·74 194·28 198·74 202·56 206·68 211·60 215·65 220·20 224·78 229·37 234·12 238·67 244·23 249·18 253·99 258·81 261·12 267·17 270·93 275·92 280·75 285·67 290·61 295·71 300·53 305·24 310·26 314·81 319·71 324·98
0+115 0+120 0+125 0+130 0+135 0+140 0+145 0+150 0+155 0+160 0+165 0+170 0+175 0+180 0+185 0+190 0+195 0+200 0+205 0+210 0+215 0+220 0+225 0+230 0+235 0+240 0+245 0+250 0+255 0+260 0+265 0+270 0+275 0+280 0+285 0+290 0+295 0+300 0+305 0+310 0+315 0+320 0+325 0+330 0+335 0+340 0+345
524·45 526·10 527·00 527·85 529·03 530·05 531·22 532·13 533·44 534·84 535·87 536·88 536·60 537·38 539·06 539·26 538·72 539·51 541·68 543·72 545·46 546·57 548·12 551·11 553·95 555·87 558·10 560·67 562·87 563·53 562·86 561·80 562·86 564·86 566·26 566·87 567·97 570·14 570·84 572·10 573·60 574·61 575·80 577·43 578·96 580·61 581·70




| | | |
|---|---|---|
| 280·75 | 0+300 | 570·14 |
| 285·67 | 0+305 | 570·84 |
| 290·61 | 0+310 | 572·10 |
| 295·71 | 0+315 | 573·60 |
| 300·53 | 0+320 | 574·61 |
| 305·24 | 0+325 | 575·80 |
| 310·26 | 0+330 | 577·43 |
| 314·81 | 0+335 | 578·96 |
| 319·71 | 0+340 | 580·61 |
| 324·98 | 0+345 | 581·70 |
| 330·14 | 0+350 | 580·67 |
| 335·06 | 0+355 | 580·92 |
| 340·03 | 0+360 | 581·16 |
| 345·08 | 0+365 | 581·45 |
| 350·04 | 0+370 | 581·80 |
| 355·16 | 0+375 | 582·22 |
| 359·16 | 0+380 | 581·85 |
| 365·16 | 0+385 | 581·57 |
| 369·36 | 0+390 | 579·02 |
| 374·36 | 0+395 | 578·27 |
| 377·66 | 0+400 | 578·93 |
| 384·86 | 0+405 | 577·52 |
| 389·05 | 0+410 | 580·07 |
| 393·56 | 0+415 | 582·02 |
| 398·34 | 0+420 | 583·35 |
| 403·10 | 0+425 | 586·37 |
| 407·89 | 0+430 | 587·90 |
| 412·78 | 0+435 | 589·21 |
| 417·75 | 0+440 | 589·59 |
| 422·62 | 0+445 | 590·56 |
| 427·53 | 0+450 | 591·46 |
| 432·36 | 0+455 | 592·42 |
| 437·69 | 0+460 | 493·64 |
| 442·52 | 0+465 | 574·98 |
| 447·38 | 0+470 | 575·39 |
| 452·65 | 0+475 | 596·85 |
| 457·41 | 0+480 | 598·11 |
| 462·26 | 0+485 | 599·00 |
| 467·65 | 0+490 | 599·06 |
| 472·48 | 0+495 | 601·08 |
| 477·41 | 0+500 | 602·09 |
| 482·65 | 0+505 | 602·09 |
| 487·55 | 0+510 | 603·59 |
| 492·29 | 0+515 | 607·17 |
| 497·12 | 0+520 | 607·08 |
| 501·84 | 0+525 | 609·73 |



HERED & FRACTURED ROCK
SOUND ROCK
LOOSE COLLUVIAL DEPOSIT
EL. 616·08
CONSOLIDATED COLLUVIAL DEPOSIT
HIGHLY WEATHERED & FRACTURED ROCK
SLIGHTLY WEATHERED & FRACTURED ROCK
CONSOLIDATED COL DEPOSIT
LOOSE CO
EL. 677·47


CONSOLIDATED COLLUVIAL DEPOSIT
HIGHLY WEATHERED & FRACTURED ROCK
SLIGHTLY WEATHERED & FRACTURED ROCK
LOOSE COLLUVIAL DEPOSIT
EL. 677·47
CONSOLIDATED COLLUVIAL DEPOSIT
COMPLETELY WEATHERED ROCK
HIGHLY FRACTURED & WEATHERED ROCK
LOOSE COLLUVIAL DEPOSIT
EL.733·93
SOUND ROCK
500
400
770
420
670
1600
3080
2500
350
390
360
420
720
1310
1320
2190
2300
3310
1670
410
630
1050
1260
1660
480
3780
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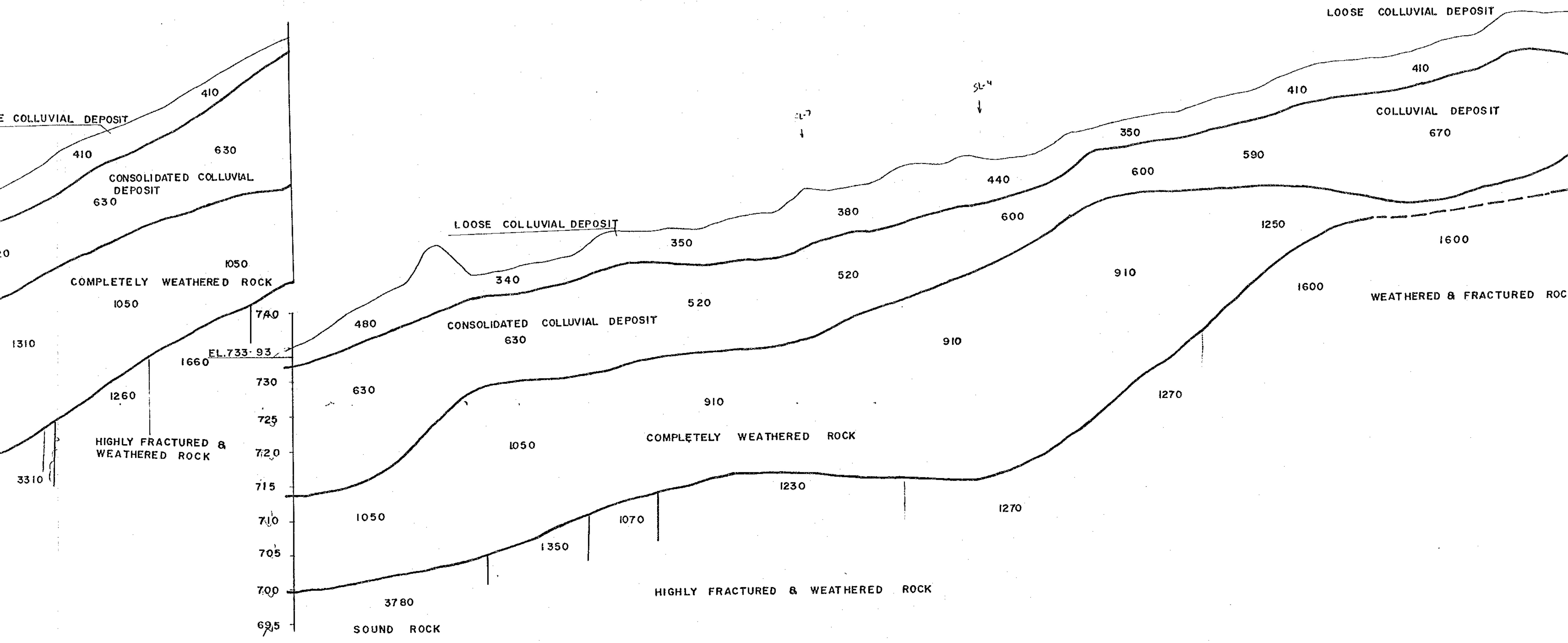
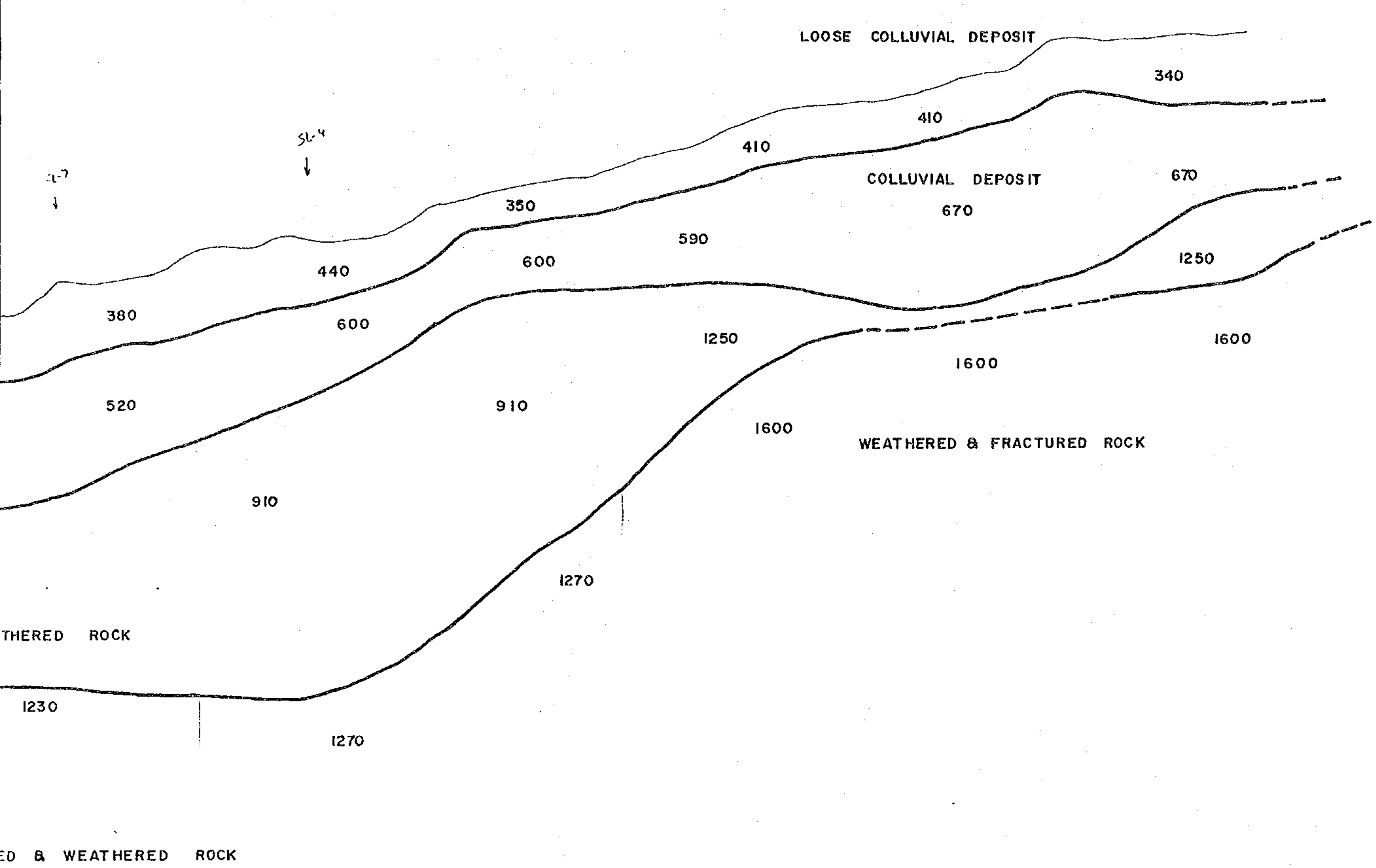
715
710
705
700
695

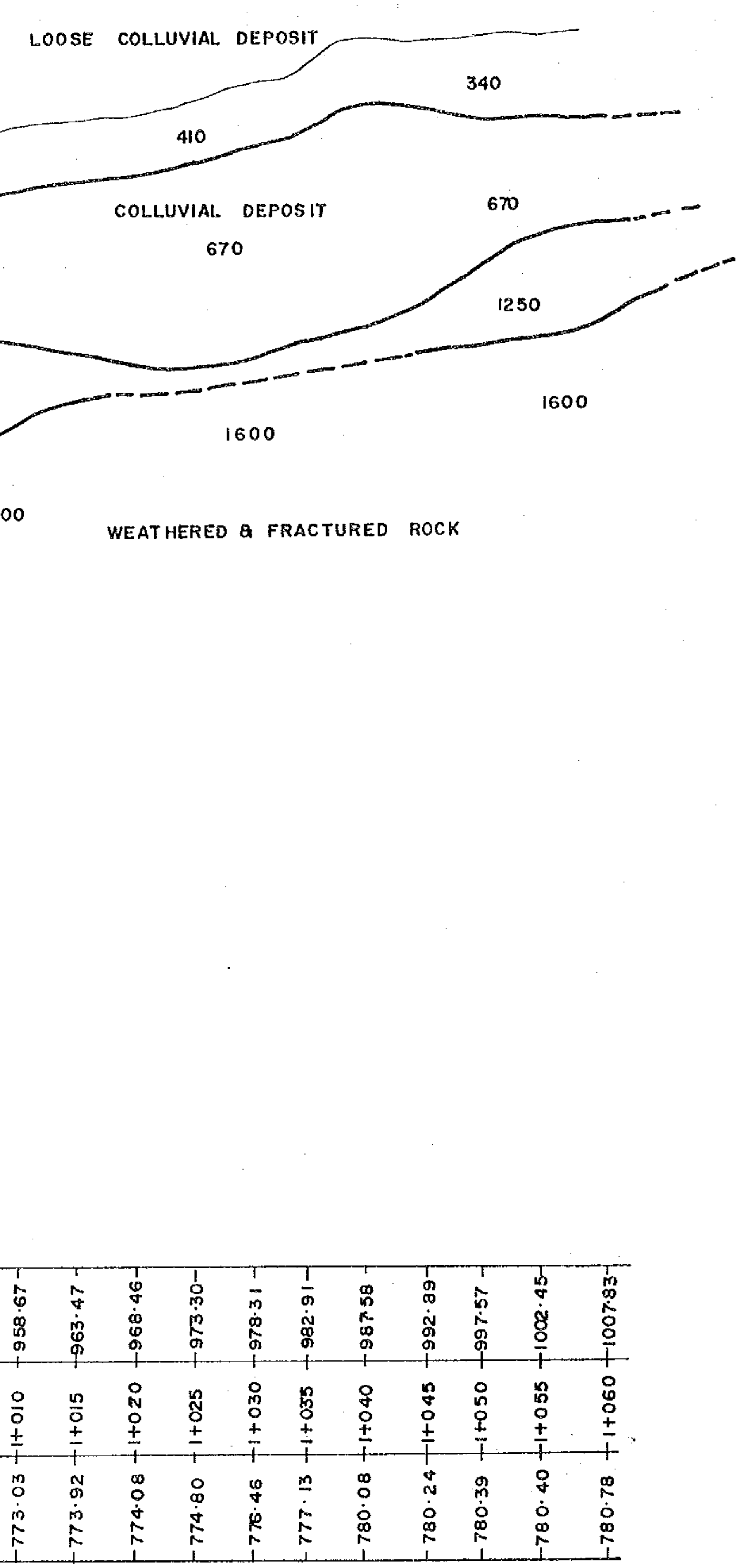



| | | |
|---|---|---|
| 770.50 | 0+810 | 714.08 |
| 774.50 | 0+815 | 715.79 |
| 778.68 | 0+820 | 718.05 |
| 783.12 | 0+825 | 720.80 |
| 787.78 | 0+830 | 722.52 |
| 792.45 | 0+835 | 724.24 |
| 796.78 | 0+840 | 726.89 |
| 801.17 | 0+845 | 729.26 |
| 805.37 | 0+850 | 731.65 |
| 810.37 | 0+855 | 733.93 |
| 814.06 | 0+860 | 735.69 |
| 817.99 | 0+865 | 738.33 |
| 822.28 | 0+870 | 740.66 |
| 827.68 | 0+875 | 743.44 |
| 832.43 | 0+880 | 748.90 |
| 837.63 | 0+885 | 744.60 |
| 842.27 | 0+890 | 745.04 |
| 847.41 | 0+895 | 746.33 |
| 852.03 | 0+900 | 747.20 |
| 856.67 | 0+905 | 750.15 |
| 861.48 | 0+910 | 750.51 |
| 866.60 | 0+915 | 750.84 |
| 871.47 | 0+920 | 751.13 |
| 876.30 | 0+925 | 752.52 |
| 880.67 | 0+930 | 753.35 |
| 885.71 | 0+935 | 756.38 |
| 890.54 | 0+940 | 756.46 |
| 895.17 | 0+945 | 756.96 |
| 900.40 | 0+950 | 758.97 |
| 905.19 | 0+955 | 759.46 |
| 909.86 | 0+960 | 760.80 |
| 914.65 | 0+965 | 760.50 |
| 919.60 | 0+970 | 761.22 |
| 924.43 | 0+975 | 763.98 |
| 929.57 | 0+980 | 765.04 |
| 934.16 | 0+985 | 766.08 |
| 939.04 | 0+990 | 766.47 |
| 944.15 | 0+995 | 768.11 |
| 948.72 | 1+000 | 769.22 |
| 953.34 | 1+005 | 770.82 |
| 958.67 | 1+010 | 773.03 |
| 963.47 | 1+015 | 773.92 |
| 968.46 | 1+020 | 774.08 |
| 973.30 | 1+025 | 774.80 |
| 978.31 | 1+030 | 776.46 |
| 982.91 | 1+035 | 777.13 |
| 987.58 | 1+040 | 780.08 |
| 992.89 | 1+045 | 780.24 |

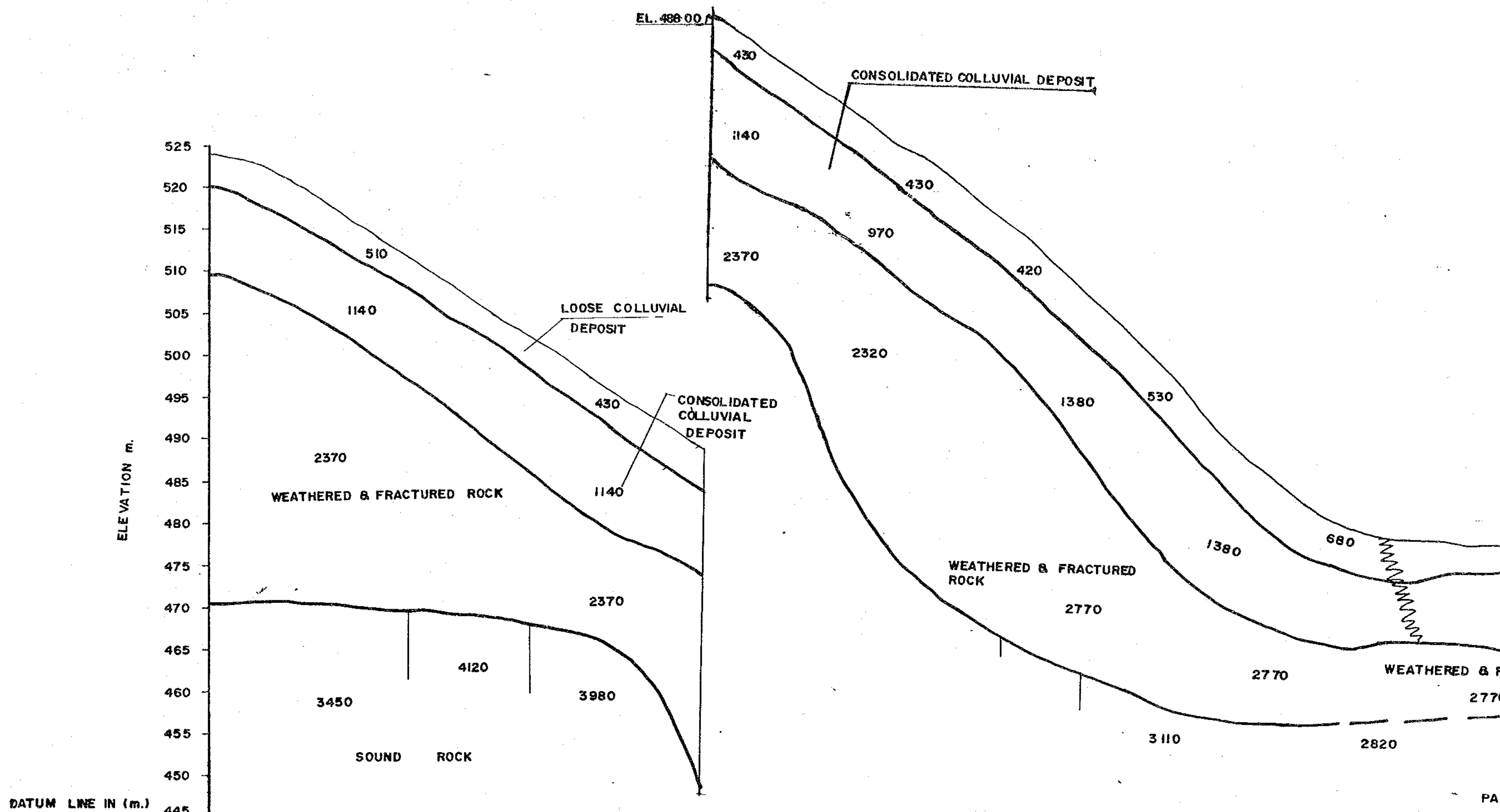



| | | |
|---|---|---|
| 880·67 | 0+930 | 753·35 |
| 885·71 | 0+935 | 756·38 |
| 890·54 | 0 +940 | 756·46 |
| 895·17 | 0+ 945 | 756·96 |
| 900·40 | 0+950 | 758·97 |
| 905·19 | 0+955 | 759·46 |
| 909·86 | 0+960 | 760·80 |
| 914·65 | 0+965 | 760·50 |
| 919·60 | 0+970 | 761·22 |
| 924·43 | 0+975 | 763·98 |
| 929·57 | 0+980 | 765·04 |
| 934·16 | 0+985 | 766·08 |
| 939·04 | 0+990 | 766·47 |
| 944·15 | 0+995 | 768·11 |
| 948·72 | 1+000 | 769·22 |
| 953·34 | 1+005 | 770·82 |
| 958·67 | 1+010 | 773·03 |
| 963·47 | 1+015 | 773·92 |
| 968·46 | 1+020 | 774·08 |
| 973·30 | 1+025 | 774·80 |
| 978·31 | 1+030 | 776·46 |
| 982·91 | 1+035 | 777·13 |
| 987·58 | 1+040 | 780·08 |
| 992·89 | 1+045 | 780·24 |
| 997·57 | 1+050 | 780·39 |
| 1002·45 | 1+055 | 780·40 |
| 1007·83 | 1+060 | 780·78 |

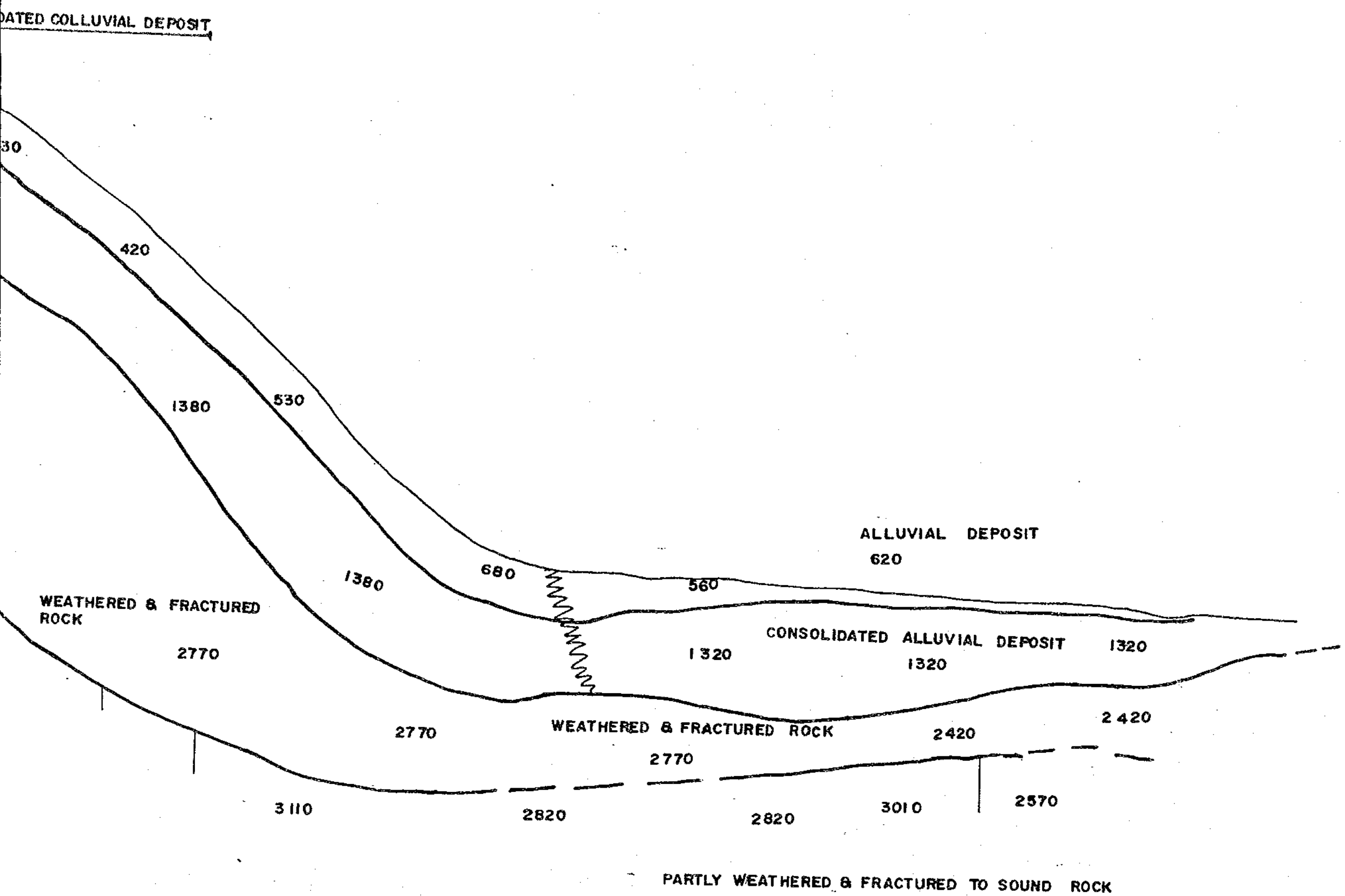
SEISM



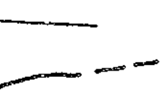

SEISMIC DEPTH SECTION ALONG SL-5



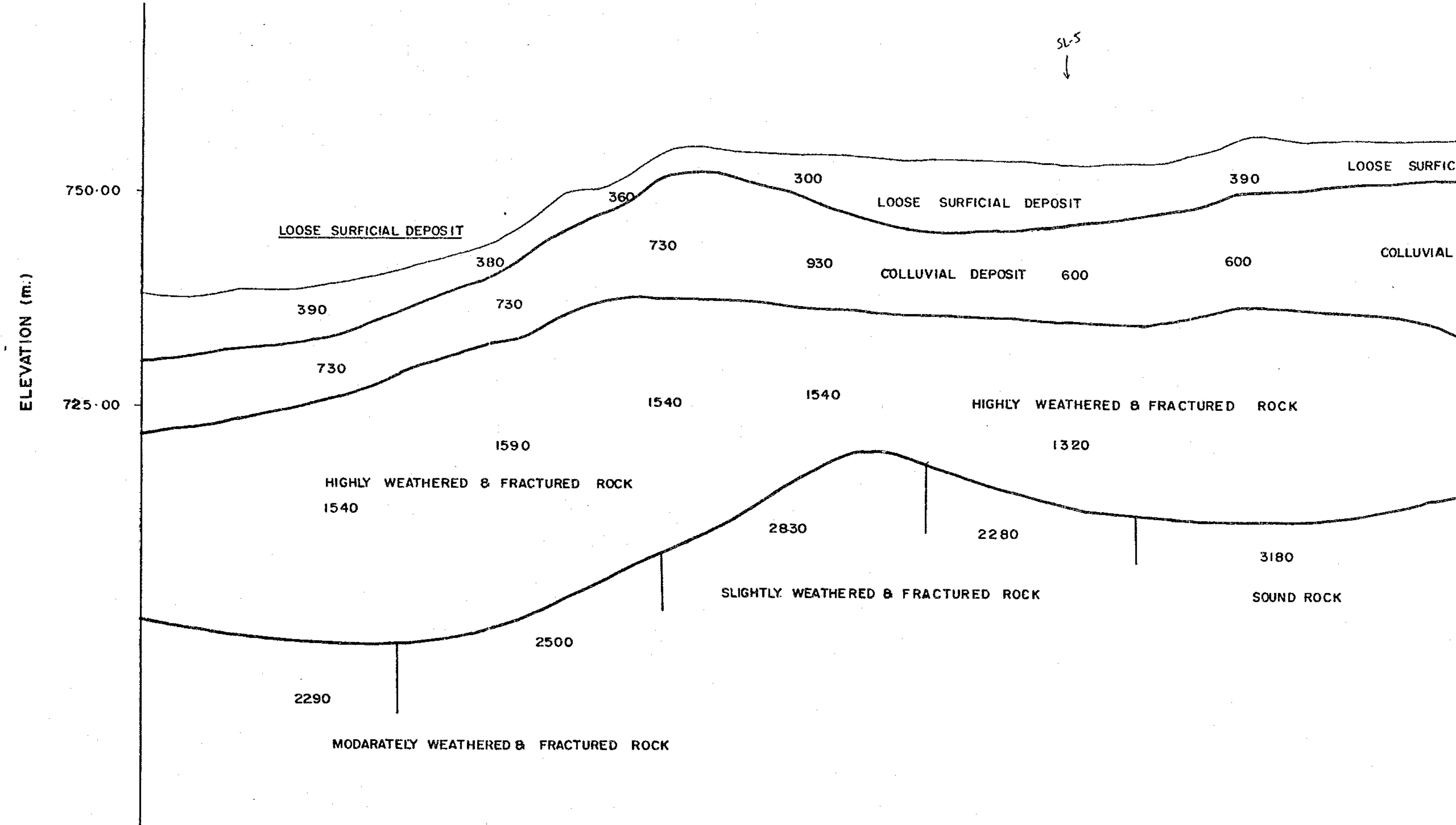

| HORIZONTAL DISTANCE (m) | CHAINAGE (m.) | ELEVATION (m.) |
|---|---|---|
| 0·000 | 0+000 | 524·13 |
| 5·05 | 0+005 | 523·30 |
| 9·45 | 0+010 | 520·40 |
| 13·55 | 0+015 | 518·62 |
| 17·64 | 0+020 | 515·60 |
| 21·67 | 0+025 | 512·89 |
| 25·68 | 0+030 | 510·23 |
| 29·71 | 0+035 | 507·20 |
| 33·87 | 0+040 | 504·58 |
| 37·28 | 0+045 | 502·27 |
| 40·14 | 0+050 | 500·43 |
| 46·22 | 0+055 | 496·13 |
| 50·36 | 0+060 | 493·35 |
| 54·40 | 0+065 | 490·80 |
| 58·39 | 0+070 | 488·00 |
| 62·44 | 0+075 | 485·46 |
| 67·12 | 0+080 | 482·57 |
| 71·04 | 0+085 | 479·98 |
| 94·18 | 0+90 | 477·96 |
| 78·23 | 0+095 | 475·36 |
| 81·52 | 0+100 | 472·02 |
| 85·14 | 0+105 | 468·92 |
| 88·88 | 0+110 | 465·57 |
| 92·53 | 0+115 | 462·71 |
| 96·23 | 0+120 | 459·02 |
| 99·94 | 0+125 | 455·39 |
| 102·63 | 0+130 | 451·88 |
| 106·26 | 0+135 | 449·03 |
| 110·18 | 0+140 | 445·22 |
| 115·80 | 0+145 | 440·71 |
| 116·73 | 0+150 | 439·68 |
| 123·38 | 0+155 | 438·86 |
| 128·29 | 0+160 | 438·69 |
| 133·21 | 0+165 | 438·26 |
| 138·25 | 0+170 | 437·97 |
| 143·28 | 0+175 | 438·21 |
| 148·27 | 0+180 | 437·91 |




| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 85·14 | 88·88 | 92·53 | 96·23 | 99·94 | 102·63 | 106·26 | 110·18 | 115·80 | 118·73 | 123·38 | 128·29 | 133·21 | 138·25 | 143·28 | 148·27 | 153·74 | 158·25 | 163·22 | 168·21 | 173·22 | 178·23 | 183·18 | 188·16 | 193·17 | 198·20 |
| 0+105 | 0+110 | 0+115 | 0+120 | 0+125 | 0+130 | 0+135 | 0+140 | 0+145 | 0+150 | 0+155 | 0+160 | 0+165 | 0+170 | 0+175 | 0+180 | 0+185 | 0+190 | 0+195 | 0+200 | 0+205 | 0+210 | 0+215 | 0+220 | 0+225 | 0+230 |
| 468·92 | 465·57 | 462·71 | 459·02 | 455·39 | 451·88 | 449·03 | 445·22 | 440·71 | 439·68 | 438·96 | 438·69 | 438·26 | 437·97 | 438·21 | 437·91 | 437·47 | 437·22 | 437·00 | 436·69 | 436·96 | 436·88 | 435·77 | 435·93 | 436·03 | 436·00 |

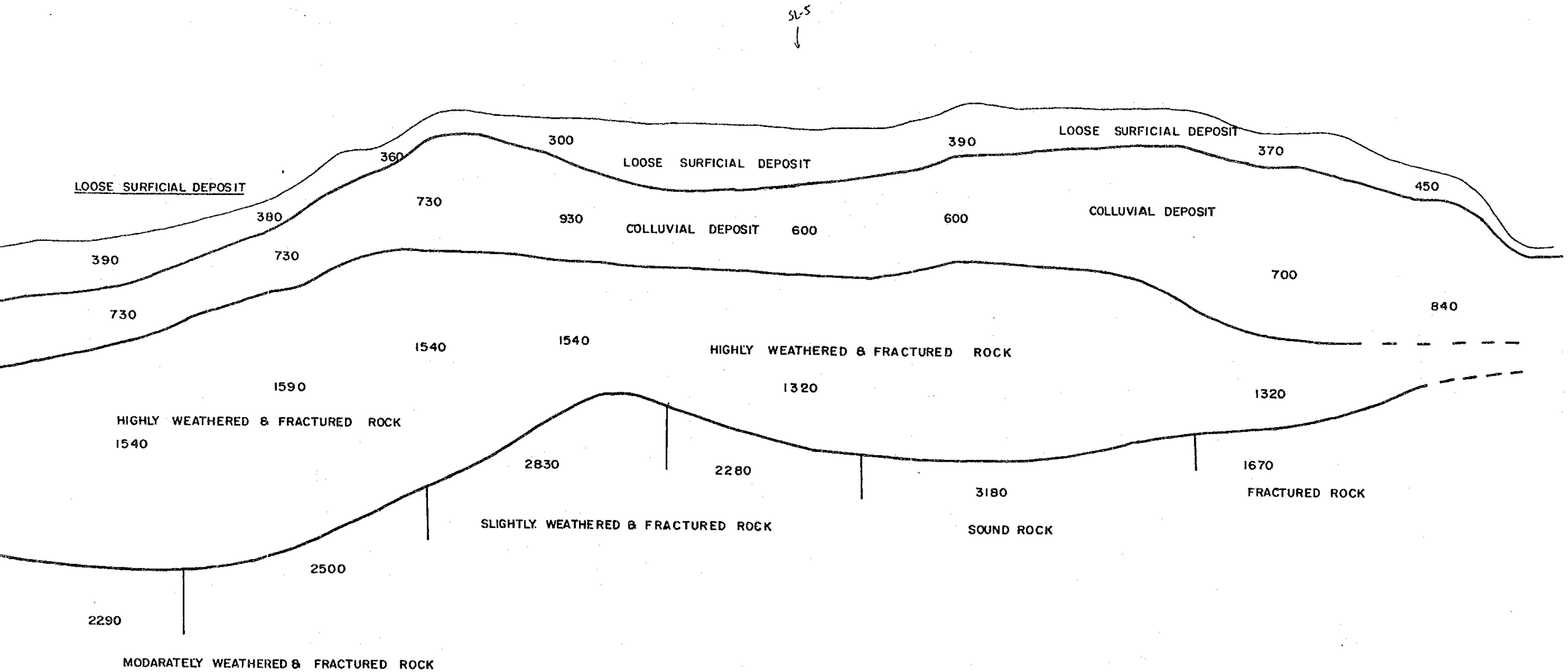


SEISMIC DEPTH SECTION ALONG
SL-6

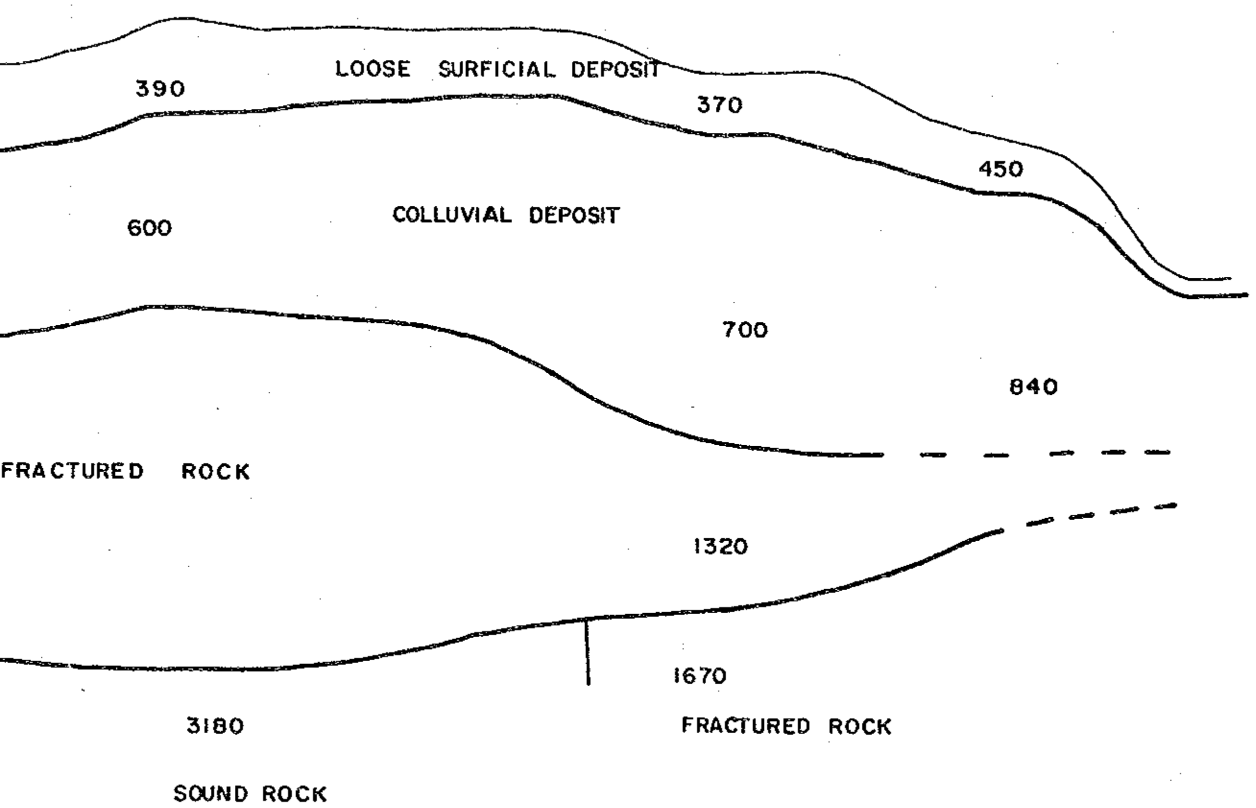



| HOR. DISTANCE (M) | 0·00 | 9·63 | 10·74 | 15·52 | 20·38 | 25·25 | 28·84 | 34·82 | 10·14 | 44·78 | 48·47 | 53·24 | 58·20 | 62·14 | 67·11 | 71·91 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHAINAGE (M) | 0+000 | 0+005 | 0+010 | 0+015 | 0+020 | 0+025 | 0+030 | 0+035 | 0+040 | 0+045 | 0+050 | 0+055 | 0+060 | 0+065 | 0+070 | 0+075 |
| ELEVATION (M) | 739·41 | 737·76 | 738·87 | 738·82 | 739·20 | 740·53 | 741·25 | 742·45 | 743·88 | 746·54 | 749·70 | 750·58 | 753·56 | 755·63 | 755·22 | 754·90 |

| HOR. DISTANCE (M) | 77·03 | 82·08 | 87·08 | 92·09 | 97·09 | 102·48 | 106·88 | 111·67 | 116·68 | 121·56 | 126·34 | 131·07 | 136·22 | 141·25 | 146·28 | 151·06 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHAINAGE (M) | 0+080 | 0+085 | 0+090 | 0+095 | 0+100 | 0+105 | 0+110 | 0+115 | 0+120 | 0+125 | 0+130 | 0+135 | 0+140 | 0+145 | 0+150 | 0+155 |
| ELEVATION (M) | 754·61 | 754·33 | 754·06 | 754·00 | 754·03 | 753·73 | 753·35 | 753·50 | 753·62 | 754·26 | 756·54 | 756·68 | 755·94 | 756·16 | 756·11 | 756·00 |

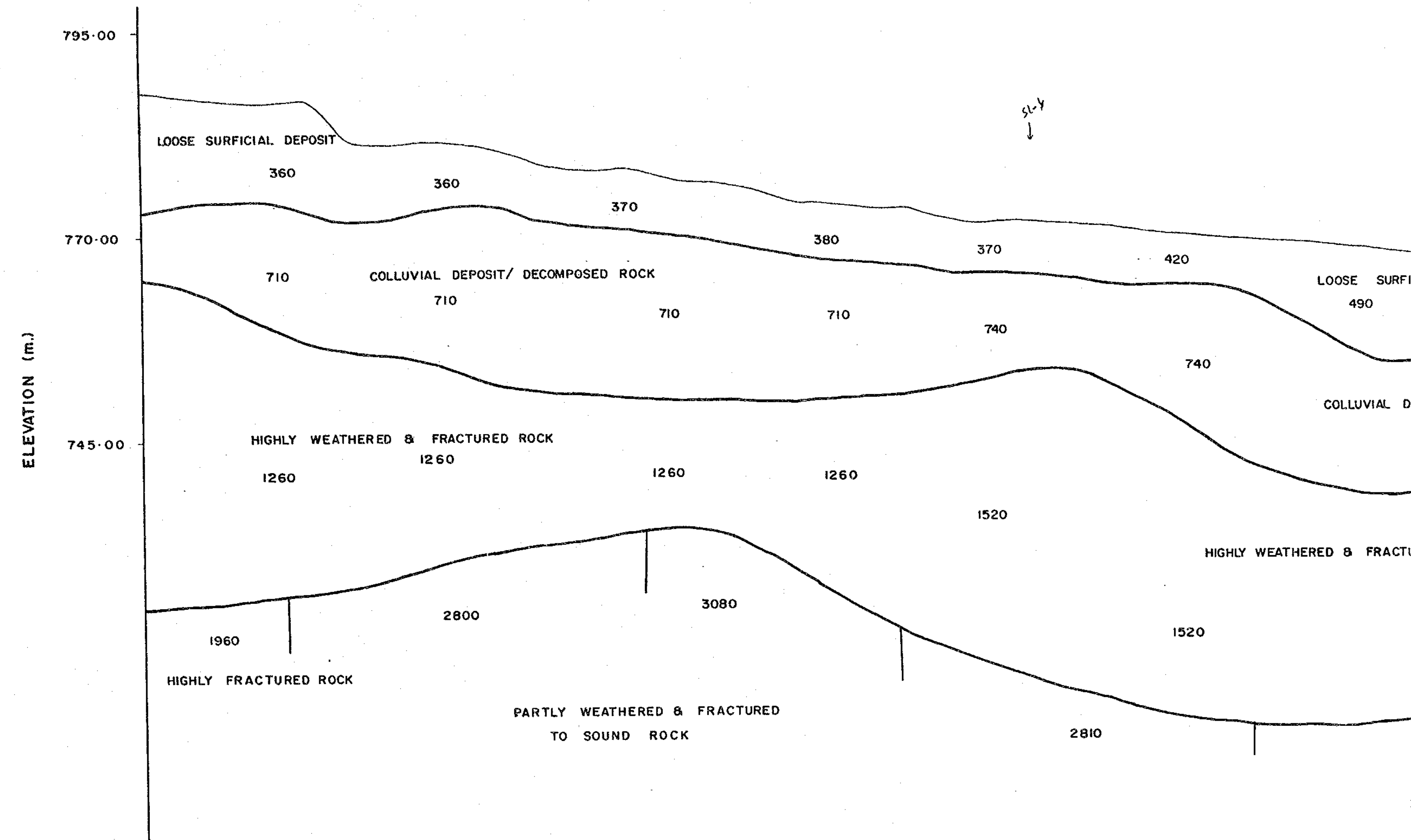



| | | |
|---|---|---|
| 10·74 | 0+010 | 738·87 |
| 15·52 | 0+015 | 738·82 |
| 20·38 | 0+020 | 739·20 |
| 25·25 | 0+025 | 740·53 |
| 28·84 | 0+030 | 741·25 |
| 34·82 | 0+035 | 742·45 |
| 10·14 | 0+040 | 743·88 |
| 44·78 | 0+045 | 746·54 |
| 48·47 | 0+050 | 749·70 |
| 53·24 | 0+055 | 750·58 |
| 58·20 | 0+060 | 753·56 |
| 62·14 | 0+065 | 755·63 |
| 67·11 | 0+070 | 755·22 |
| 71·91 | 0+075 | 754·90 |
| 77·03 | 0+080 | 754·61 |
| 82·08 | 0+085 | 754·33 |
| 87·08 | 0+090 | 754·06 |
| 92·09 | 0+095 | 754·00 |
| 97·09 | 0+100 | 754·03 |
| 102·48 | 0+105 | 753·73 |
| 106·88 | 0+110 | 753·35 |
| 111·67 | 0+115 | 753·50 |
| 116·68 | 0+120 | 753·62 |
| 121·56 | 0+125 | 754·26 |
| 126·34 | 0+130 | 756·54 |
| 131·07 | 0+135 | 756·68 |
| 136·22 | 0+140 | 755·94 |
| 141·25 | 0+145 | 756·16 |
| 146·28 | 0+150 | 756·11 |
| 151·06 | 0+155 | 756·00 |
| 156·15 | 0+160 | 755·84 |
| 160·90 | 0+165 | 754·30 |
| 165·49 | 0+170 | 753·21 |
| 170·41 | 0+175 | 753·15 |
| 174·48 | 0+180 | 753·23 |
| 179·90 | 0+185 | 750·04 |
| 184·74 | 0+190 | 748·81 |
| 189·59 | 0+195 | 747·77 |
| 193·35 | 0+200 | 744·98 |
| 197·28 | 0+205 | 739·51 |
| 201·67 | 0+210 | 738·79 |



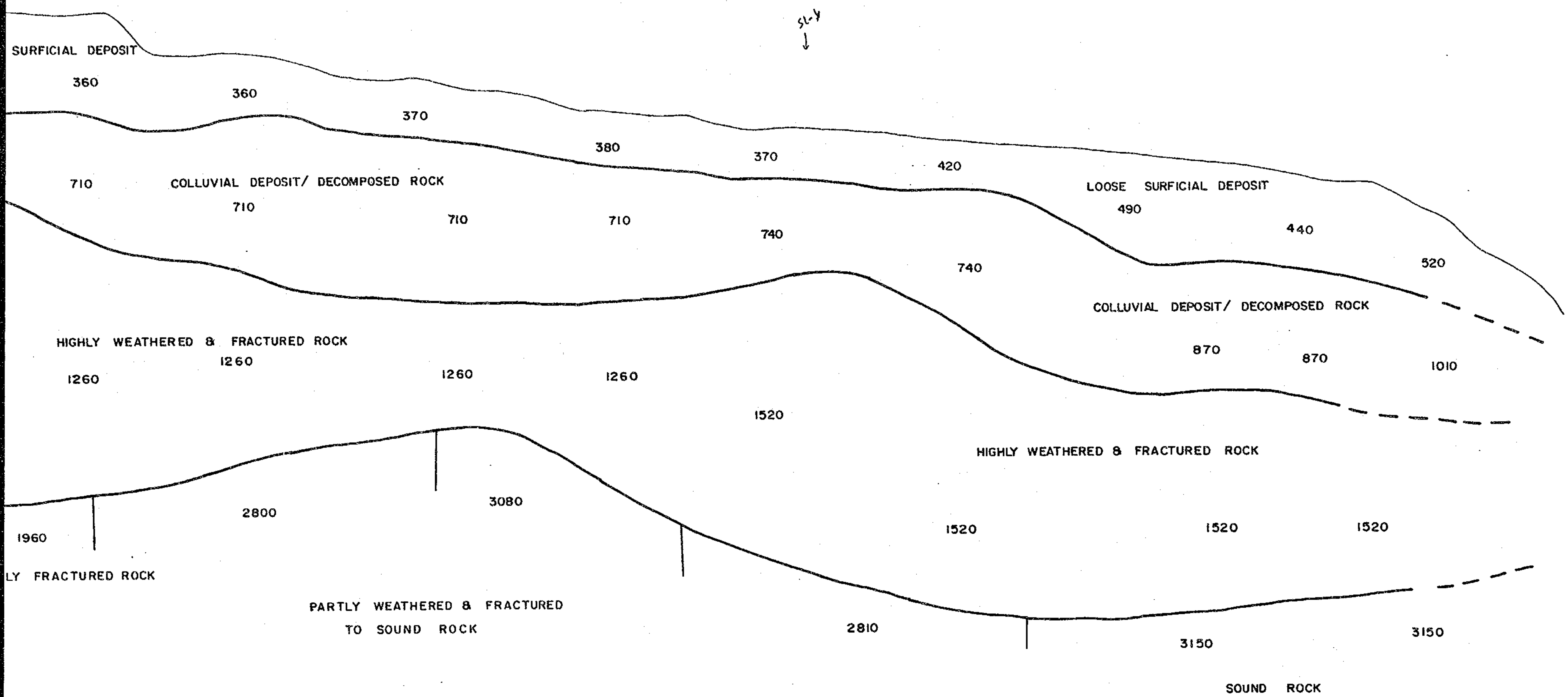

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 121·56 | 126·34 | 131·07 | 136·22 | 141·25 | 146·28 | 151·06 | 156·15 | 160·90 | 165·49 | 170·41 | 174·48 | 179·90 | 184·74 | 189·59 | 193·35 | 197·28 | 201·67 |
| 0+125 | 0+130 | 0+135 | 0+140 | 0+145 | 0+150 | 0+155 | 0+160 | 0+165 | 0+170 | 0+175 | 0+180 | 0+185 | 0+190 | 0+195 | 0+200 | 0+205 | 0+210 |
| 754·26 | 756·54 | 756·68 | 755·94 | 756·16 | 756·11 | 756·00 | 755·84 | 754·30 | 753·21 | 753·15 | 753·23 | 750·04 | 748·81 | 747·77 | 744·98 | 739·51 | 738·79 |

**SEISMIC DEPTH SECTION ALONG SL-7**

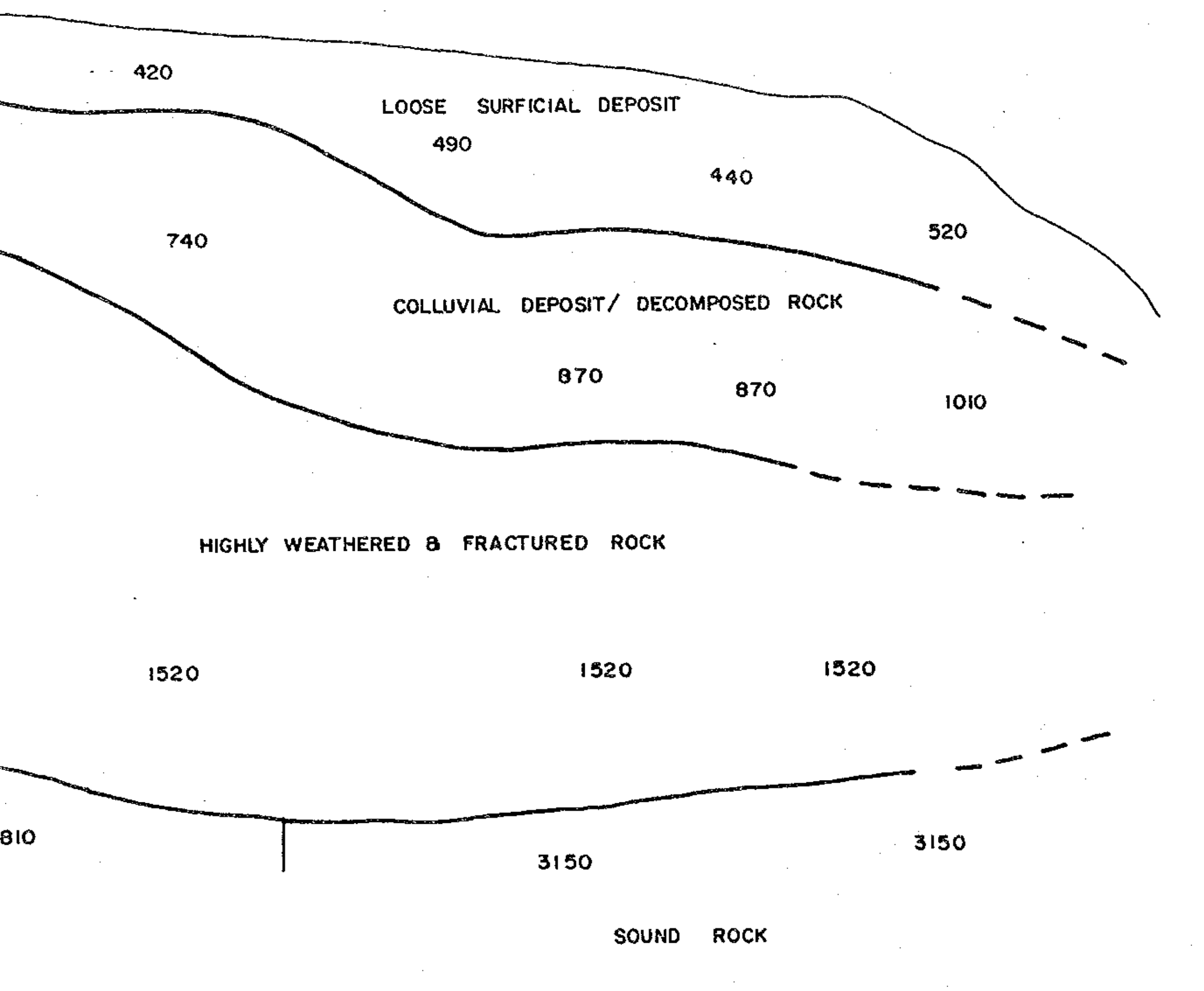



| HOR. DISTANCE (M) | 0·00 | 3·88 | 9·67 | 14·53 | 17·50 | 24·69 | 29·56 | 34·29 | 37·40 | 44·05 | 48·89 | 54·01 | 59·09 | 64·16 | 69·48 | 74·12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHAINAGE (M) | 0+000 | 0+005 | 0+010 | 0+015 | 0+020 | 0+025 | 0+030 | 0+035 | 0+040 | 0+045 | 0+050 | 0+055 | 0+060 | 0+065 | 0+070 | 0+075 |
| ELEVATION (M) | 787·65 | 787·26 | 786·60 | 756·40 | 786·56 | 782·81 | 782·24 | 781·48 | 781·14 | 780·14 | 778·35 | 777·92 | 777·35 | 776·73 | 776·38 | 775·66 |

| HOR. DISTANCE (M) | 79·36 | 84·09 | 87·23 | 94·23 | 99·23 | 104·01 | 108·00 | 113·96 | 118·91 | 124·07 | 127·00 | 133·79 | 138·75 | 143·70 | 148·66 | 158·61 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHAINAGE (M) | 0+080 | 0+085 | 0+090 | 0+095 | 0+100 | 0+105 | 0+110 | 0+115 | 0+120 | 0+125 | 0+130 | 0+135 | 0+140 | 0+145 | 0+150 | 0+155 |
| ELEVATION (M) | 774·13 | 773·86 | 773·06 | 773·00 | 771·75 | 771·44 | 771·34 | 771·04 | 770·55 | 769·96 | 769·57 | 769·00 | 768·94 | 768·43 | 767·97 | 767·44 |

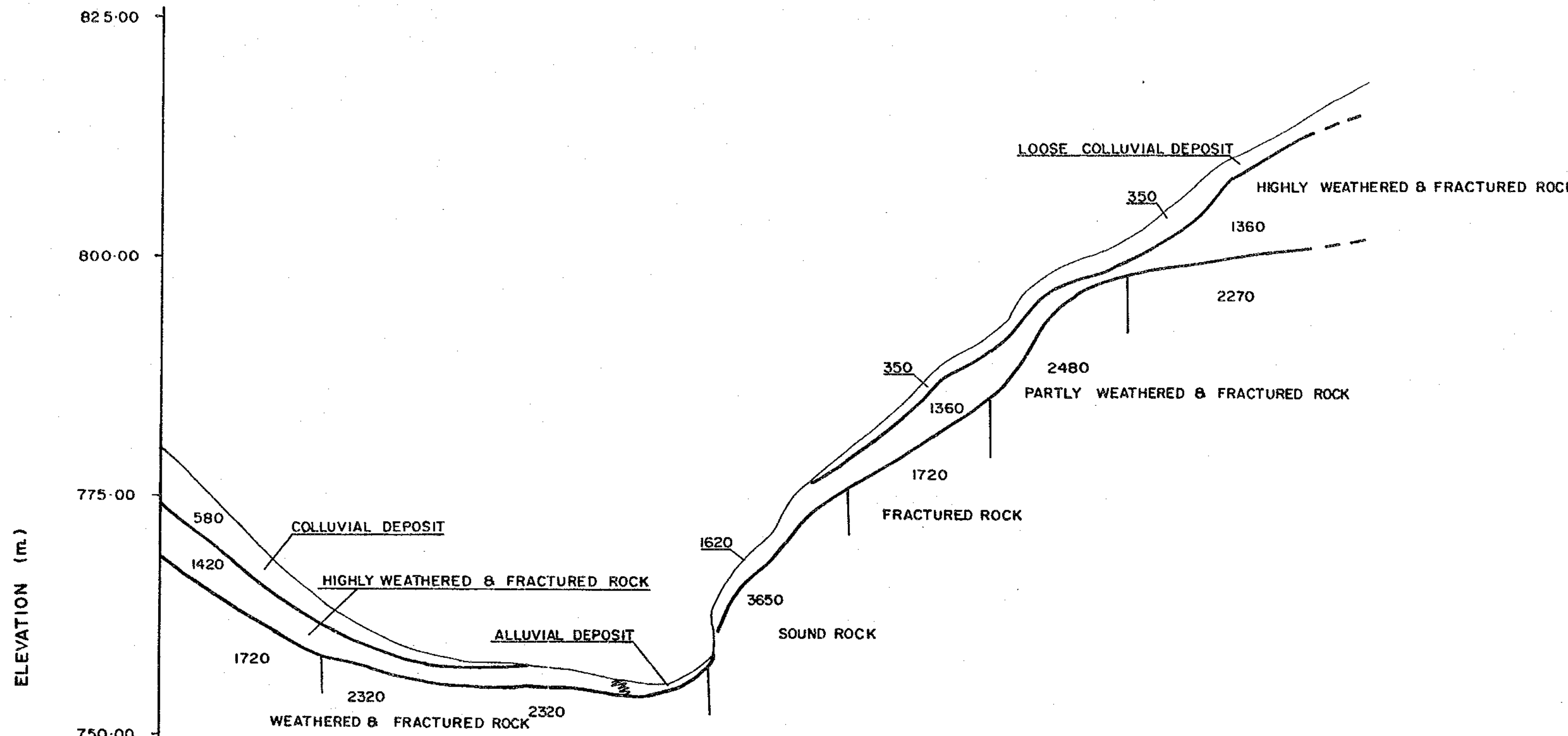



| | | |
|---|---|---|
| 0+010 | 9·67 | 786·60 |
| 0+015 | 14·53 | 756·40 |
| 0+020 | 17·50 | 786·56 |
| 0+025 | 24·69 | 782·81 |
| 0+030 | 29·56 | 782·24 |
| 0+035 | 34·29 | 781·48 |
| 0+040 | 37·40 | 781·14 |
| 0+045 | 44·05 | 780·14 |
| 0+050 | 48·89 | 778·35 |
| 0+055 | 54·01 | 777·92 |
| 0+060 | 59·09 | 777·35 |
| 0+065 | 64·16 | 776·73 |
| 0+070 | 69·48 | 776·38 |
| 0+075 | 74·12 | 775·66 |
| 0+080 | 79·36 | 774·13 |
| 0+085 | 84·09 | 773·86 |
| 0+090 | 87·23 | 773·06 |
| 0+095 | 94·23 | 773·00 |
| 0+100 | 99·23 | 771·75 |
| 0+105 | 104·01 | 771·44 |
| 0+110 | 108·00 | 771·34 |
| 0+115 | 113·96 | 771·04 |
| 0+120 | 118·91 | 770·55 |
| 0+125 | 124·07 | 769·96 |
| 0+130 | 127·00 | 769·57 |
| 0+135 | 133·79 | 769·00 |
| 0+140 | 138·75 | 768·94 |
| 0+145 | 143·70 | 768·43 |
| 0+150 | 148·66 | 767·97 |
| 0+155 | 158·61 | 767·44 |
| 0+160 | 158·55 | 766·83 |
| 0+165 | 163·54 | 766·23 |
| 0+170 | 168·50 | 765·44 |
| 0+175 | 173·43 | 764·23 |
| 0+180 | 178·40 | 764·01 |
| 0+185 | 185·35 | 761·51 |
| 0+190 | 187·80 | 759·82 |
| 0+195 | 191·40 | 756·39 |
| 0+200 | 195·47 | 753·72 |
| 0+205 | 179·51 | 751·43 |
| 0+210 | 202·80 | 747·50 |



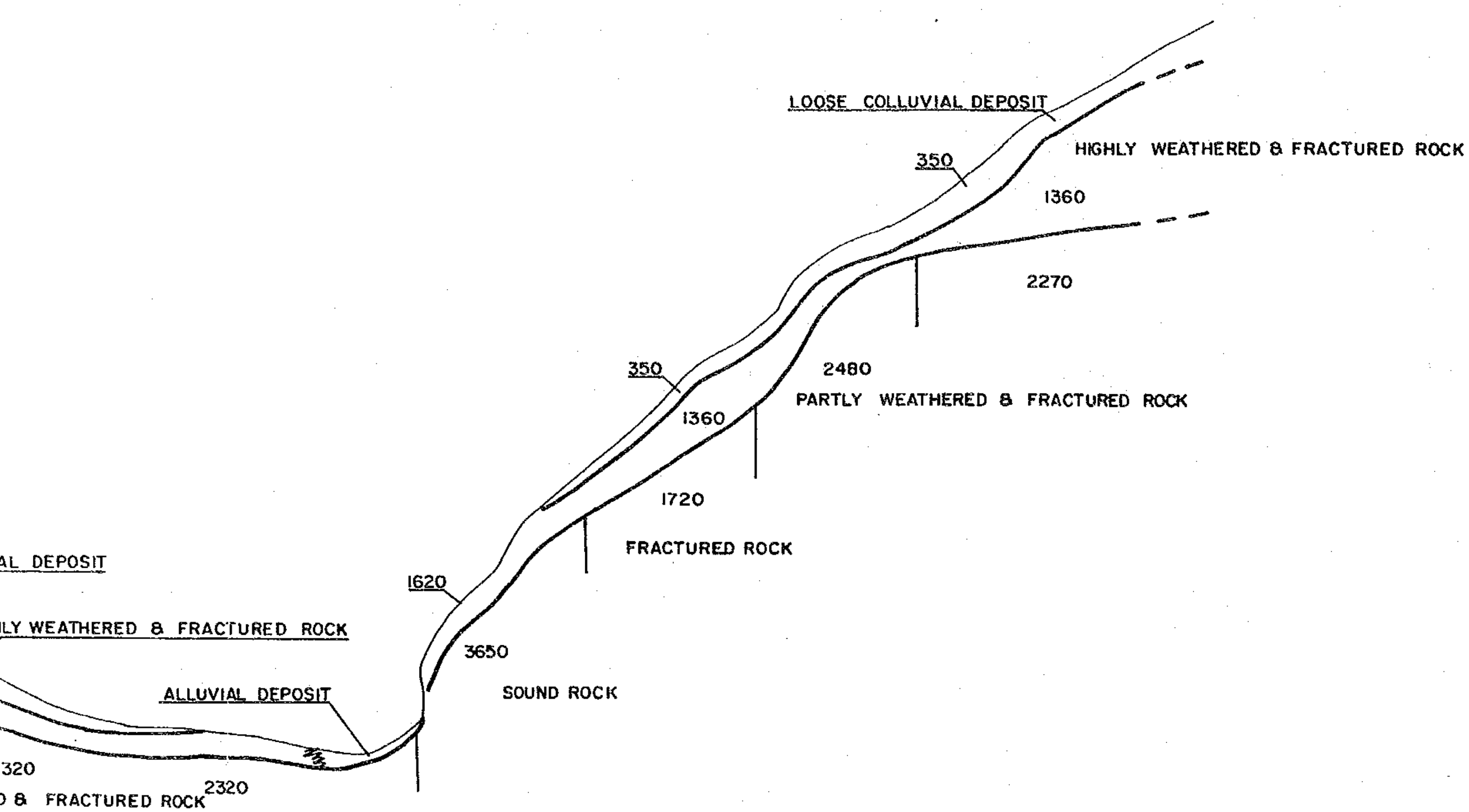

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 118·91 | 124·07 | 127·00 | 133·79 | 138·75 | 143·70 | 148·66 | 158·61 | 158·55 | 163·54 | 168·50 | 173·43 | 178·40 | 185·35 | 187·80 | 191·40 | 195·47 | 179·51 | 202·80 |
| 0+120 | 0+125 | 0+130 | 0+135 | 0+140 | 0+145 | 0+150 | 0+155 | 0+160 | 0+165 | 0+170 | 0+175 | 0+180 | 0+185 | 0+190 | 0+195 | 0+200 | 0+205 | 0+210 |
| 770·55 | 769·96 | 769·57 | 769·00 | 768·94 | 768·43 | 767·97 | 767·44 | 766·83 | 766·23 | 765·44 | 764·23 | 764·01 | 761·51 | 759·82 | 756·39 | 753·72 | 751·43 | 747·50 |

**SEISMIC DEPTH SECTION ALONG SL-8**




| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOR. DISTANCE (M) | 0·00 | 5·46 | 8·41 | 12·45 | 16·30 | 19·37 | 24·00 | 28·49 | 33·37 | 38·26 | 43·28 | 48·28 | 53·34 | 57·67 | 57·82 | 59·78 |
| CHAINAGE (M) | 0+000 | 0+005 | 0+010 | 0+015 | 0+020 | 0+025 | 0+030 | 0+035 | 0+040 | 0+045 | 0+050 | 0+055 | 0+060 | 0+070 | 0+065 | 0+075 |
| ELEVATION (M) | 779·88 | 774·96 | 771·97 | 768·70 | 764·81 | 762·42 | 759·91 | 758·30 | 757·40 | 757·22 | 756·56 | 755·47 | 755·33 | 762·42 | 758·19 | 767·35 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOR. DISTANCE (M) | 63·54 | 65·28 | 69·96 | 72·55 | 77·18 | 80·29 | 88·72 | 88·04 | 90·64 | 97·27 | 101·21 | 105·15 | 109·53 | 115·27 | 118·97 | 125·37 |
| CHAINAGE (M) | 0+080 | 0+085 | 0+090 | 0+095 | 0+100 | 0+105 | 0+110 | 0+115 | 0+120 | 0+125 | 0+130 | 0+135 | 0+140 | 0+145 | 0+150 | 0+155 |
| ELEVATION (M) | 770·45 | 774·32 | 777·97 | 779·97 | 784·45 | 787·78 | 789·78 | 793·16 | 797·03 | 799·78 | 802·52 | 805·26 | 809·28 | 810·94 | 814·03 | 817·81 |




| | | |
|---|---|---|
| 24.00 | 0+030 | 759.91 |
| 28.49 | 0+035 | 758.30 |
| 33.37 | 0+040 | 757.40 |
| 38.26 | 0+045 | 757.22 |
| 43.28 | 0+050 | 756.56 |
| 48.28 | 0+055 | 755.47 |
| 53.34 | 0+060 | 755.33 |
| 57.67 | 0+070 | 762.42 |
| 57.82 | 0+065 | 758.19 |
| 59.78 | 0+075 | 767.35 |
| 63.54 | 0+080 | 770.45 |
| 65.28 | 0+085 | 774.32 |
| 69.96 | 0+090 | 777.97 |
| 72.55 | 0+095 | 779.97 |
| 77.18 | 0+100 | 784.45 |
| 80.29 | 0+105 | 787.78 |
| 88.72 | 0+110 | 789.78 |
| 88.04 | 0+115 | 793.16 |
| 90.64 | 0+120 | 797.03 |
| 97.27 | 0+125 | 799.78 |
| 101.21 | 0+130 | 802.52 |
| 105.15 | 0+135 | 805.26 |
| 109.53 | 0+140 | 809.28 |
| 115.27 | 0+145 | 810.94 |
| 118.97 | 0+150 | 814.03 |
| 125.37 | 0+155 | 817.81 |

**SEISMIC DEPTH SECTION ALONG SL-9**

## ANNEX - II FLOW ANALYSIS (HYDROLOGY)

## ANNEX - II    FLOW ANALYSIS ( HYDROLOGY)

### II.1 Daily Mean Discharge at Gauging Station GS 730 (Puwa Khola) (From 1972 to 1986 and from May 1992 to April 1993 )

## Table II.1.1 Daily Mean Discharge ( 1972 )

Gauge Station : GS 730
Catchment Area : 125.8 $km^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.4 | 1.8 | 2.0 | 3.1 | 1.7 | 2.0 | 44.6 | 41.1 | 28.6 | 111.5 | 8.1 | 5.8 |
| 2 | 2.3 | 1.8 | 2.0 | 3.1 | 1.7 | 1.9 | 41.8 | 39.7 | 25.8 | 106.7 | 8.1 | 5.8 |
| 3 | 2.3 | 1.8 | 2.0 | 3.0 | 1.6 | 1.9 | 40.4 | 37.6 | 23.7 | 102.5 | 8.1 | 5.6 |
| 4 | 2.3 | 1.8 | 2.0 | 2.9 | 1.6 | 1.9 | 39.0 | 37.6 | 22.3 | 99.0 | 7.8 | 5.4 |
| 5 | 2.2 | 1.8 | 2.0 | 2.9 | 1.6 | 1.8 | 36.2 | 36.2 | 18.3 | 95.5 | 7.8 | 5.4 |
| 6 | 2.2 | 1.8 | 2.0 | 2.8 | 1.6 | 4.5 | 34.8 | 51.6 | 16.6 | 72.5 | 7.8 | 5.3 |
| 7 | 2.2 | 1.7 | 2.0 | 2.8 | 1.6 | 3.8 | 52.3 | 47.4 | 55.8 | 64.8 | 7.6 | 4.9 |
| 8 | 2.2 | 1.7 | 2.0 | 2.7 | 1.6 | 3.2 | 49.5 | 116.4 | 53.0 | 37.6 | 7.6 | 4.9 |
| 9 | 2.2 | 1.7 | 1.9 | 2.7 | 1.6 | 2.7 | 46.7 | 69.0 | 50.9 | 25.8 | 7.3 | 4.9 |
| 10 | 2.2 | 1.7 | 1.9 | 2.7 | 1.6 | 2.5 | 44.6 | 58.5 | 48.1 | 24.4 | 7.3 | 4.8 |
| 11 | 2.2 | 1.7 | 1.9 | 2.6 | 1.5 | 2.2 | 41.1 | 52.3 | 46.7 | 23.0 | 7.1 | 4.8 |
| 12 | 2.2 | 1.7 | 1.8 | 2.6 | 1.5 | 2.0 | 38.3 | 48.8 | 44.6 | 22.3 | 7.1 | 4.6 |
| 13 | 2.2 | 1.7 | 1.8 | 2.6 | 1.5 | 1.8 | 37.6 | 48.1 | 42.5 | 20.9 | 7.1 | 4.5 |
| 14 | 2.2 | 2.0 | 1.8 | 2.5 | 1.5 | 1.6 | 34.8 | 47.4 | 39.7 | 19.5 | 6.9 | 4.5 |
| 15 | 2.2 | 2.6 | 1.8 | 2.5 | 1.5 | 2.5 | 30.7 | 48.8 | 37.6 | 18.9 | 6.9 | 4.3 |
| 16 | 2.1 | 2.4 | 1.8 | 2.4 | 1.5 | 2.2 | 26.5 | 49.5 | 37.6 | 17.7 | 6.6 | 4.2 |
| 17 | 2.1 | 2.3 | 1.8 | 2.4 | 1.4 | 2.2 | 23.0 | 45.3 | 35.5 | 16.6 | 6.4 | 4.1 |
| 18 | 2.1 | 2.3 | 1.8 | 2.3 | 1.3 | 2.1 | 19.5 | 42.5 | 33.4 | 16.6 | 6.4 | 4.1 |
| 19 | 2.1 | 2.2 | 1.8 | 2.3 | 2.9 | 2.0 | 16.6 | 38.3 | 30.7 | 16.1 | 6.4 | 3.9 |
| 20 | 2.1 | 2.2 | 1.7 | 2.2 | 2.2 | 2.0 | 15.0 | 59.2 | 26.5 | 15.6 | 6.2 | 3.8 |
| 21 | 2.1 | 2.2 | 1.7 | 2.2 | 2.0 | 51.6 | 13.6 | 55.1 | 25.1 | 14.6 | 6.2 | 3.7 |
| 22 | 2.1 | 2.2 | 1.7 | 2.2 | 1.8 | 142.2 | 12.4 | 51.6 | 21.6 | 14.1 | 6.2 | 3.6 |
| 23 | 2.0 | 2.2 | 1.7 | 2.2 | 1.8 | 81.6 | 59.2 | 48.8 | 19.5 | 14.1 | 6.0 | 3.4 |
| 24 | 2.0 | 2.1 | 1.7 | 2.2 | 1.7 | 69.0 | 56.5 | 46.0 | 16.6 | 13.6 | 6.0 | 3.2 |
| 25 | 2.0 | 2.1 | 1.7 | 2.2 | 2.2 | 64.1 | 53.7 | 43.9 | 58.5 | 13.2 | 6.0 | 3.1 |
| 26 | 2.0 | 2.1 | 1.7 | 2.1 | 2.2 | 57.8 | 51.6 | 41.8 | 187.6 | 12.8 | 6.0 | 3.0 |
| 27 | 1.9 | 2.1 | 1.6 | 2.1 | 2.1 | 55.8 | 49.5 | 39.7 | 127.6 | 12.8 | 5.8 | 2.9 |
| 28 | 1.9 | 2.1 | 3.3 | 2.1 | 2.1 | 52.3 | 47.4 | 37.6 | 120.6 | 11.2 | 5.8 | 2.8 |
| 29 | 1.9 | 2.0 | 3.2 | 1.8 | 2.0 | 48.8 | 46.0 | 35.5 | 117.1 | 10.5 | 5.8 | 2.7 |
| 30 | 1.9 | | 3.3 | 1.8 | 2.0 | 46.0 | 44.6 | 33.4 | 114.3 | 9.2 | 5.8 | 2.6 |
| 31 | 1.8 | | 3.2 | | 2.0 | | 42.5 | 30.7 | | 8.3 | | 2.6 |
| Avg. | 2.1 | 2.0 | 2.0 | 2.5 | 1.8 | 23.9 | 38.4 | 47.7 | 50.9 | 34.3 | 6.8 | 4.2 |
| Max. | 2.4 | 2.6 | 3.3 | 3.1 | 2.9 | 142.2 | 59.2 | 116.4 | 187.6 | 111.5 | 8.1 | 5.8 |
| Min. | 1.8 | 1.7 | 1.6 | 1.8 | 1.3 | 1.6 | 12.4 | 30.7 | 16.6 | 8.3 | 5.8 | 2.6 |

Ann.Avg. 18.1
Ann.Max. 187.6
Ann.Min. 1.3

## Table II.1.2 Daily Mean Discharge ( 1974 )

Gauge Station : GS 730
Catchment Area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.6 | 2.9 | 2.0 | 2.9 | 2.2 | 41.1 | 61.3 | 83.0 | 55.1 | 32.0 | 8.9 | 4.9 |
| 2 | 2.5 | 2.8 | 2.0 | 2.8 | 2.1 | 12.4 | 112.9 | 133.2 | 53.7 | 31.3 | 8.6 | 4.8 |
| 3 | 2.4 | 2.7 | 2.0 | 2.7 | 2.0 | 7.1 | 101.8 | 115.0 | 50.9 | 30.7 | 8.3 | 4.8 |
| 4 | 2.3 | 2.7 | 2.0 | 2.6 | 2.0 | 4.5 | 92.0 | 80.9 | 48.8 | 30.7 | 8.1 | 4.6 |
| 5 | 2.3 | 2.7 | 1.9 | 2.6 | 2.0 | 4.3 | 86.4 | 74.6 | 47.4 | 30.0 | 7.8 | 4.6 |
| 6 | 2.2 | 2.6 | 1.9 | 2.6 | 2.6 | 4.3 | 48.8 | 71.1 | 44.6 | 30.0 | 7.8 | 4.5 |
| 7 | 2.2 | 2.6 | 1.8 | 2.5 | 2.3 | 6.0 | 46.7 | 69.0 | 42.5 | 28.6 | 7.8 | 4.3 |
| 8 | 2.1 | 2.6 | 1.8 | 2.5 | 2.2 | 3.8 | 46.0 | 66.2 | 39.7 | 27.2 | 7.6 | 4.3 |
| 9 | 2.0 | 2.6 | 1.8 | 2.4 | 2.2 | 3.2 | 46.0 | 60.6 | 38.3 | 26.5 | 7.6 | 4.3 |
| 10 | 2.0 | 2.5 | 1.8 | 2.3 | 2.1 | 8.1 | 45.3 | 55.1 | 38.3 | 23.7 | 7.6 | 4.2 |
| 11 | 2.0 | 2.5 | 1.8 | 2.2 | 2.0 | 6.4 | 43.9 | 50.2 | 36.9 | 23.7 | 7.3 | 4.2 |
| 12 | 1.9 | 2.5 | 1.8 | 2.2 | 2.0 | 5.4 | 41.8 | 48.8 | 34.8 | 23.7 | 7.1 | 4.2 |
| 13 | 1.9 | 2.5 | 1.7 | 2.1 | 7.3 | 4.3 | 41.1 | 47.4 | 50.9 | 22.3 | 6.6 | 4.2 |
| 14 | 1.8 | 2.4 | 1.7 | 2.0 | 4.2 | 8.6 | 39.7 | 43.9 | 48.8 | 22.3 | 6.6 | 4.1 |
| 15 | 1.8 | 2.4 | 1.7 | 2.0 | 3.3 | 6.4 | 55.1 | 40.4 | 47.4 | 21.6 | 6.6 | 4.1 |
| 16 | 1.7 | 2.4 | 1.7 | 1.9 | 2.9 | 4.8 | 51.6 | 36.9 | 46.0 | 20.9 | 6.4 | 4.1 |
| 17 | 1.7 | 2.3 | 1.7 | 1.9 | 2.7 | 4.5 | 89.2 | 34.1 | 50.9 | 20.2 | 6.4 | 4.1 |
| 18 | 1.6 | 2.3 | 1.6 | 3.9 | 2.6 | 4.3 | 71.1 | 32.7 | 53.0 | 20.2 | 6.2 | 4.1 |
| 19 | 1.6 | 2.3 | 1.6 | 3.3 | 2.5 | 9.5 | 58.5 | 32.0 | 57.8 | 19.5 | 6.0 | 3.9 |
| 20 | 1.6 | 2.3 | 1.6 | 2.9 | 2.5 | 8.1 | 54.4 | 39.7 | 56.5 | 18.9 | 6.0 | 3.9 |
| 21 | 1.5 | 2.2 | 1.5 | 2.6 | 2.4 | 7.1 | 51.6 | 36.9 | 51.6 | 17.7 | 5.8 | 3.9 |
| 22 | 1.5 | 2.2 | 1.5 | 2.6 | 2.3 | 6.4 | 50.2 | 34.8 | 50.9 | 17.2 | 5.8 | 3.9 |
| 23 | 1.5 | 2.2 | 1.5 | 2.5 | 2.3 | 15.0 | 50.2 | 31.3 | 49.5 | 16.1 | 5.6 | 3.9 |
| 24 | 1.5 | 2.2 | 1.5 | 2.4 | 2.3 | 45.3 | 57.2 | 30.0 | 48.1 | 15.6 | 5.6 | 3.8 |
| 25 | 1.5 | 2.2 | 1.4 | 2.2 | 2.2 | 35.5 | 78.8 | 42.5 | 45.3 | 15.0 | 5.4 | 3.8 |
| 26 | 1.4 | 2.2 | 1.4 | 2.2 | 2.2 | 31.3 | 69.7 | 43.9 | 43.2 | 14.1 | 5.4 | 3.8 |
| 27 | 1.3 | 2.2 | 1.4 | 2.1 | 2.3 | 26.5 | 97.6 | 56.5 | 40.4 | 13.2 | 5.3 | 3.8 |
| 28 | 1.3 | 2.1 | 1.4 | 2.6 | 4.1 | 23.0 | 95.5 | 46.0 | 38.3 | 12.4 | 5.3 | 3.8 |
| 29 | 1.7 | | 1.4 | 2.2 | 4.6 | 20.2 | 92.7 | 43.2 | 34.8 | 11.2 | 5.3 | 2.3 |
| 30 | 2.9 | | 3.3 | 2.2 | 3.3 | 17.7 | 87.8 | 67.6 | 33.4 | 10.2 | 4.9 | 2.3 |
| 31 | 2.9 | | 3.0 | | 42.5 | | 83.7 | 59.2 | | 9.2 | | 2.3 |
| Avg. | 1.9 | 2.4 | 1.8 | 2.5 | 4.0 | 12.8 | 66.1 | 55.1 | 45.9 | 21.1 | 6.7 | 4.0 |
| Max. | 2.9 | 2.9 | 3.3 | 3.9 | 42.5 | 45.3 | 112.9 | 133.2 | 57.8 | 32.0 | 8.9 | 4.9 |
| Min. | 1.3 | 2.1 | 1.4 | 1.9 | 2.0 | 3.2 | 39.7 | 30.0 | 33.4 | 9.2 | 4.9 | 2.3 |

| | |
|---|---|
| Ann. Avg. | 18.8 |
| Ann. Max. | 133.2 |
| Ann. Min. | 1.3 |

## Table II.1.3 Daily Mean Discharge ( 1975 )

Gauge Station : GS 730
Catchment area : 125.8 $km^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 26.4 | 48.1 | 22.5 | 38.1 | 23.8 | 6.1 |
| 2 | 1.1 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 26.9 | 44.6 | 53.3 | 37.7 | 23.0 | 5.6 |
| 3 | 1.1 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 48.5 | 42.0 | 47.2 | 37.3 | 22.5 | 5.6 |
| 4 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 26.9 | 39.9 | 44.6 | 41.2 | 21.7 | 4.8 |
| 5 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 23.0 | 47.2 | 44.2 | 39.4 | 20.4 | 4.3 |
| 6 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 21.2 | 55.9 | 42.9 | 38.1 | 19.1 | 3.9 |
| 7 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 20.4 | 50.3 | 69.3 | 37.3 | 17.3 | 3.9 |
| 8 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 19.9 | 47.7 | 65.4 | 39.4 | 16.0 | 3.6 |
| 9 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 3.0 | 18.6 | 45.5 | 60.2 | 37.3 | 14.7 | 3.6 |
| 10 | 1.2 | 1.0 | 0.9 | 0.8 | 0.8 | 1.9 | 17.8 | 41.6 | 58.5 | 36.4 | 13.4 | 3.6 |
| 11 | 1.1 | 1.0 | 0.9 | 0.8 | 0.8 | 1.4 | 16.5 | 38.1 | 49.0 | 35.5 | 12.1 | 3.3 |
| 12 | 1.1 | 1.0 | 0.9 | 0.8 | 0.9 | 1.2 | 22.5 | 34.7 | 45.5 | 35.5 | 11.7 | 3.3 |
| 13 | 1.1 | 0.9 | 0.9 | 0.8 | 1.0 | 74.5 | 40.7 | 31.6 | 58.5 | 35.5 | 11.3 | 3.3 |
| 14 | 1.1 | 0.9 | 0.9 | 0.8 | 0.9 | 55.9 | 31.6 | 28.6 | 53.7 | 34.7 | 10.8 | 3.3 |
| 15 | 1.1 | 0.9 | 0.9 | 0.8 | 0.9 | 47.2 | 29.9 | 27.3 | 70.6 | 34.2 | 10.4 | 3.3 |
| 16 | 1.1 | 0.9 | 0.9 | 0.8 | 0.8 | 36.0 | 28.2 | 37.7 | 67.2 | 34.2 | 10.4 | 3.2 |
| 17 | 1.1 | 0.9 | 0.9 | 0.8 | 0.8 | 31.6 | 26.9 | 34.7 | 64.6 | 33.4 | 10.0 | 3.2 |
| 18 | 1.1 | 0.9 | 0.9 | 0.8 | 0.8 | 40.7 | 25.1 | 32.1 | 48.1 | 32.5 | 10.0 | 3.0 |
| 19 | 1.1 | 0.9 | 0.9 | 0.8 | 0.8 | 26.9 | 24.7 | 30.8 | 42.9 | 31.6 | 9.5 | 3.0 |
| 20 | 1.1 | 0.9 | 0.9 | 0.8 | 0.8 | 23.4 | 23.4 | 29.5 | 41.2 | 31.2 | 9.1 | 3.0 |
| 21 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 | 29.5 | 23.4 | 38.6 | 39.9 | 31.2 | 9.1 | 2.8 |
| 22 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 | 23.4 | 43.8 | 34.7 | 37.7 | 30.8 | 8.7 | 2.8 |
| 23 | 1.0 | 0.9 | 0.8 | 0.9 | 0.8 | 19.9 | 37.7 | 32.1 | 42.0 | 29.9 | 8.7 | 2.8 |
| 24 | 1.0 | 0.9 | 0.8 | 0.9 | 0.8 | 16.0 | 37.3 | 29.0 | 45.1 | 29.0 | 8.7 | 2.7 |
| 25 | 1.0 | 0.9 | 0.8 | 0.8 | 0.9 | 14.7 | 36.8 | 27.3 | 45.5 | 27.7 | 8.7 | 2.7 |
| 26 | 1.0 | 0.9 | 0.8 | 1.0 | 0.8 | 31.6 | 88.4 | 26.4 | 47.2 | 26.4 | 8.2 | 2.7 |
| 27 | 1.0 | 0.9 | 0.8 | 0.9 | 0.8 | 27.3 | 100.1 | 25.1 | 58.9 | 25.6 | 8.2 | 2.6 |
| 28 | 1.0 | 0.9 | 0.8 | 0.9 | 0.8 | 23.4 | 74.5 | 23.4 | 71.1 | 25.6 | 7.8 | 2.6 |
| 29 | 1.0 | | 0.8 | 0.8 | 1.0 | 27.7 | 70.6 | 23.0 | 51.1 | 25.1 | 7.4 | 2.6 |
| 30 | 1.0 | | 0.8 | 0.8 | 2.7 | 23.0 | 68.5 | 23.0 | 40.7 | 24.7 | 6.5 | 2.4 |
| 31 | 1.0 | | 0.8 | | 6.1 | | 65.0 | 22.5 | | 24.7 | | 2.3 |
| Avg. | 1.1 | 1.0 | 0.9 | 0.8 | 1.1 | 19.6 | 37.6 | 35.3 | 51.0 | 32.9 | 12.6 | 3.4 |
| Max. | 1.2 | 1.0 | 0.9 | 1.0 | 6.1 | 74.5 | 100.1 | 55.9 | 71.1 | 41.2 | 23.8 | 6.1 |
| Min. | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 16.5 | 22.5 | 22.5 | 24.7 | 6.5 | 2.3 |

| | |
|---|---|
| Ann. Avg. | 16.5 |
| Ann. Max. | 100.1 |
| Ann. Min. | 0.8 |

## Table II.1.4 Daily Mean Discharge ( 1976 )

Gauge Station : GS 730
Catchment area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.2 | 1.6 | 1.6 | 1.2 | 2.1 | 25.1 | 7.8 | 16.9 | 32.1 | 36.4 | 12.6 | 8.2 |
| 2 | 2.2 | 1.6 | 1.6 | 1.2 | 2.0 | 22.5 | 6.1 | 15.2 | 31.6 | 35.1 | 12.6 | 8.2 |
| 3 | 2.2 | 1.6 | 1.6 | 1.2 | 2.0 | 27.7 | 23.4 | 13.4 | 31.6 | 33.8 | 12.1 | 7.8 |
| 4 | 2.1 | 1.6 | 1.5 | 1.2 | 2.0 | 25.1 | 22.1 | 29.0 | 31.2 | 32.5 | 11.7 | 7.8 |
| 5 | 2.1 | 8.7 | 1.5 | 1.2 | 1.9 | 23.0 | 19.9 | 39.4 | 30.3 | 31.6 | 11.3 | 7.8 |
| 6 | 2.1 | 6.9 | 1.5 | 1.2 | 1.9 | 21.2 | 18.2 | 37.7 | 29.5 | 31.6 | 11.3 | 7.8 |
| 7 | 2.1 | 5.2 | 1.5 | 1.2 | 1.9 | 17.8 | 16.0 | 68.9 | 29.0 | 29.5 | 10.8 | 7.4 |
| 8 | 2.1 | 3.3 | 1.5 | 1.2 | 1.7 | 42.9 | 27.7 | 43.3 | 28.6 | 29.0 | 10.8 | 7.4 |
| 9 | 2.1 | 2.3 | 1.5 | 1.2 | 1.5 | 35.5 | 25.6 | 38.1 | 28.2 | 28.2 | 10.4 | 7.4 |
| 10 | 2.1 | 2.0 | 1.5 | 1.2 | 1.4 | 31.6 | 23.4 | 57.2 | 75.0 | 26.9 | 10.0 | 6.9 |
| 11 | 2.0 | 1.9 | 1.5 | 1.2 | 1.3 | 29.5 | 21.2 | 75.4 | 70.6 | 26.4 | 10.0 | 6.9 |
| 12 | 2.0 | 1.9 | 1.5 | 1.1 | 1.2 | 27.3 | 58.9 | 48.5 | 69.3 | 24.7 | 9.5 | 6.5 |
| 13 | 2.0 | 1.8 | 1.4 | 1.1 | 3.2 | 26.9 | 45.1 | 46.4 | 69.3 | 23.8 | 9.1 | 6.5 |
| 14 | 1.9 | 1.8 | 1.3 | 1.1 | 21.7 | 26.4 | 36.0 | 51.6 | 68.0 | 22.5 | 9.1 | 6.5 |
| 15 | 1.9 | 1.8 | 1.3 | 1.1 | 30.8 | 24.7 | 41.2 | 47.7 | 66.7 | 22.1 | 8.7 | 6.5 |
| 16 | 1.9 | 1.8 | 1.3 | 1.1 | 40.7 | 23.0 | 45.1 | 45.5 | 65.0 | 21.2 | 8.7 | 6.5 |
| 17 | 1.8 | 1.7 | 1.3 | 1.1 | 4.3 | 43.8 | 41.2 | 40.7 | 59.8 | 19.9 | 8.2 | 6.5 |
| 18 | 2.4 | 1.7 | 1.3 | 1.1 | 2.7 | 42.0 | 39.4 | 46.8 | 56.8 | 19.1 | 7.8 | 6.5 |
| 19 | 2.8 | 1.7 | 1.3 | 1.1 | 8.2 | 41.6 | 38.1 | 46.4 | 55.5 | 18.2 | 7.4 | 6.5 |
| 20 | 2.0 | 1.7 | 1.3 | 1.1 | 4.8 | 40.7 | 37.3 | 44.6 | 55.0 | 17.3 | 7.4 | 6.5 |
| 21 | 2.0 | 1.7 | 1.2 | 2.4 | 2.4 | 39.4 | 36.0 | 47.2 | 54.2 | 16.9 | 6.9 | 6.1 |
| 22 | 1.9 | 1.7 | 1.2 | 1.4 | 1.9 | 37.7 | 34.2 | 44.2 | 54.2 | 16.5 | 6.5 | 6.1 |
| 23 | 1.8 | 1.6 | 1.2 | 1.2 | 1.7 | 36.0 | 32.5 | 40.7 | 52.9 | 16.0 | 6.5 | 6.1 |
| 24 | 1.8 | 1.6 | 1.2 | 1.6 | 1.6 | 35.1 | 53.7 | 39.4 | 49.8 | 15.6 | 6.5 | 6.1 |
| 25 | 1.7 | 1.6 | 1.2 | 1.4 | 1.5 | 32.5 | 47.2 | 38.1 | 47.2 | 15.6 | 6.1 | 6.1 |
| 26 | 1.7 | 1.6 | 1.2 | 4.8 | 1.4 | 28.6 | 36.4 | 36.0 | 44.6 | 15.2 | 5.6 | 6.1 |
| 27 | 1.7 | 1.6 | 1.2 | 2.7 | 19.5 | 23.4 | 30.3 | 34.7 | 42.5 | 14.3 | 8.7 | 5.6 |
| 28 | 1.7 | 1.6 | 1.2 | 2.1 | 40.7 | 19.1 | 28.6 | 34.2 | 40.7 | 14.3 | 8.7 | 5.6 |
| 29 | 1.7 | 1.6 | 1.2 | 2.1 | 36.4 | 13.4 | 26.0 | 32.9 | 39.4 | 13.4 | 8.2 | 5.6 |
| 30 | 1.6 | | 1.2 | 2.1 | 32.5 | 10.8 | 21.2 | 32.5 | 37.7 | 13.0 | 8.2 | 5.6 |
| 31 | 1.6 | | 1.2 | | 27.7 | | 18.6 | 32.5 | | 13.0 | | 5.6 |
| Avg. | 2.0 | 2.3 | 1.4 | 1.5 | 9.8 | 29.1 | 30.9 | 40.8 | 48.2 | 22.4 | 9.0 | 6.7 |
| Max. | 2.8 | 8.7 | 1.6 | 4.8 | 40.7 | 43.8 | 58.9 | 75.4 | 75.0 | 36.4 | 12.6 | 8.2 |
| Min. | 1.6 | 1.6 | 1.2 | 1.1 | 1.2 | 10.8 | 6.1 | 13.4 | 28.2 | 13.0 | 5.6 | 5.6 |

| | |
|---|---|
| Ann. Avg. | 17.0 |
| Ann. Max. | 75.4 |
| Ann. Min. | 1.1 |

## Table II.1.5 Daily Mean Discharge (1978)

Gauge Station : GS 730
Catchment area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.6 | 3.0 | 1.5 | 1.4 | 5.6 | 12.1 | 26.9 | 28.2 | 23.4 | 15.2 | 5.6 | 2.8 |
| 2 | 3.6 | 3.0 | 1.5 | 1.5 | 17.8 | 16.0 | 24.7 | 39.0 | 23.0 | 23.0 | 8.7 | 2.7 |
| 3 | 6.1 | 3.0 | 1.5 | 1.6 | 4.3 | 19.1 | 34.2 | 32.5 | 21.7 | 38.1 | 7.4 | 1.5 |
| 4 | 6.1 | 2.8 | 1.5 | 1.5 | 2.1 | 16.5 | 31.2 | 29.9 | 19.5 | 36.8 | 6.1 | 1.4 |
| 5 | 5.6 | 2.8 | 1.5 | 1.5 | 1.9 | 11.3 | 29.0 | 28.6 | 16.9 | 36.0 | 6.1 | 1.4 |
| 6 | 5.6 | 2.8 | 1.4 | 1.5 | 1.8 | 15.2 | 27.3 | 26.9 | 15.6 | 34.2 | 5.6 | 1.4 |
| 7 | 5.2 | 2.8 | 1.4 | 1.4 | 6.9 | 25.1 | 26.0 | 25.6 | 25.1 | 32.5 | 5.6 | 1.4 |
| 8 | 5.2 | 2.7 | 1.4 | 1.4 | 3.9 | 23.8 | 32.9 | 39.9 | 41.2 | 31.6 | 5.6 | 1.4 |
| 9 | 4.3 | 2.7 | 1.4 | 1.4 | 3.3 | 50.7 | 30.3 | 32.5 | 39.4 | 31.2 | 5.2 | 1.4 |
| 10 | 4.3 | 2.7 | 1.4 | 1.4 | 3.2 | 31.2 | 29.0 | 34.7 | 37.7 | 30.8 | 5.2 | 1.3 |
| 11 | 4.3 | 2.6 | 1.4 | 1.4 | 3.0 | 25.1 | 26.9 | 31.6 | 36.0 | 30.8 | 5.2 | 1.3 |
| 12 | 3.9 | 2.2 | 1.4 | 1.4 | 3.0 | 19.9 | 24.3 | 29.5 | 31.6 | 29.5 | 5.2 | 1.3 |
| 13 | 3.9 | 2.1 | 1.4 | 1.4 | 45.9 | 38.1 | 32.5 | 27.3 | 29.0 | 29.0 | 4.8 | 1.3 |
| 14 | 3.6 | 2.1 | 1.4 | 1.7 | 35.1 | 34.2 | 52.4 | 39.4 | 26.9 | 28.2 | 4.8 | 1.3 |
| 15 | 3.6 | 2.1 | 1.4 | 1.6 | 30.8 | 34.2 | 50.3 | 45.5 | 24.3 | 26.9 | 4.3 | 1.3 |
| 16 | 3.3 | 2.1 | 1.4 | 1.5 | 28.2 | 47.2 | 31.2 | 38.6 | 22.5 | 25.6 | 4.3 | 1.3 |
| 17 | 3.3 | 6.1 | 1.3 | 1.6 | 24.7 | 46.8 | 36.0 | 38.1 | 21.2 | 24.7 | 4.3 | 1.3 |
| 18 | 3.3 | 7.4 | 1.3 | 1.9 | 19.1 | 42.9 | 38.1 | 36.4 | 20.8 | 24.3 | 3.9 | 1.2 |
| 19 | 3.3 | 4.3 | 1.6 | 1.7 | 3.3 | 40.3 | 36.0 | 34.7 | 20.8 | 23.4 | 3.9 | 1.2 |
| 20 | 3.3 | 2.8 | 2.0 | 1.4 | 2.1 | 38.6 | 35.1 | 32.5 | 19.9 | 23.0 | 3.9 | 1.2 |
| 21 | 5.6 | 2.7 | 1.9 | 1.6 | 2.0 | 35.5 | 36.0 | 29.9 | 19.9 | 22.5 | 3.9 | 1.2 |
| 22 | 5.2 | 2.1 | 1.8 | 1.6 | 6.1 | 31.6 | 35.1 | 42.5 | 19.1 | 20.8 | 3.6 | 1.2 |
| 23 | 4.8 | 1.8 | 1.7 | 1.6 | 21.2 | 45.1 | 33.8 | 41.2 | 18.6 | 19.1 | 3.6 | 1.2 |
| 24 | 4.8 | 1.6 | 1.6 | 1.5 | 18.6 | 40.3 | 32.5 | 39.9 | 18.6 | 15.2 | 3.6 | 1.2 |
| 25 | 4.3 | 1.6 | 1.6 | 1.5 | 18.2 | 37.3 | 31.2 | 37.7 | 17.8 | 11.3 | 3.3 | 1.2 |
| 26 | 4.3 | 1.6 | 1.6 | 1.8 | 17.8 | 35.1 | 29.0 | 35.5 | 31.6 | 8.2 | 3.2 | 1.2 |
| 27 | 3.9 | 1.6 | 1.5 | 1.9 | 15.2 | 32.9 | 40.7 | 33.4 | 24.3 | 7.8 | 3.2 | 1.2 |
| 28 | 3.9 | 1.5 | 1.4 | 1.7 | 13.9 | 28.6 | 37.3 | 31.6 | 19.5 | 7.4 | 3.2 | 1.2 |
| 29 | 3.3 | | 1.4 | 1.6 | 11.7 | 33.8 | 34.7 | 28.6 | 16.9 | 6.9 | 3.2 | 1.2 |
| 30 | 3.3 | | 1.4 | 2.8 | 9.1 | 30.8 | 32.5 | 26.9 | 15.6 | 6.5 | 2.8 | 1.2 |
| 31 | 3.2 | | 1.4 | | 16.0 | | 30.3 | 24.7 | | 6.1 | | 1.2 |
| Avg. | 4.3 | 2.7 | 1.5 | 1.6 | 12.8 | 31.3 | 33.1 | 33.6 | 23.9 | 22.8 | 4.6 | 1.4 |
| Max. | 6.1 | 7.4 | 2.0 | 2.8 | 45.9 | 50.7 | 52.4 | 45.5 | 41.2 | 38.1 | 8.7 | 2.8 |
| Min. | 3.2 | 1.5 | 1.3 | 1.4 | 1.8 | 11.3 | 24.3 | 24.7 | 15.6 | 6.1 | 2.8 | 1.2 |
| | | | | | | | | | | | Ann. Avg. | 14.6 |
| | | | | | | | | | | | Ann. Max. | 52.4 |
| | | | | | | | | | | | Ann. Min. | 1.2 |

## Table II.1.6 Daily Mean Discharge ( 1980 )

Gauge Station : GS 730

Catchment area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | 1.4 | 0.9 | 0.9 | 0.9 | 0.8 | 2.8 | 16.0 | 11.7 | 21.2 | 6.9 | 2.1 | 1.1 |
| 2.0 | 1.4 | 0.9 | 0.9 | 0.9 | 0.9 | 4.8 | 11.3 | 10.8 | 20.4 | 7.4 | 2.0 | 1.1 |
| 3.0 | 1.4 | 0.9 | 0.9 | 0.9 | 0.9 | 3.3 | 8.7 | 8.7 | 18.6 | 7.8 | 1.9 | 1.1 |
| 4.0 | 1.3 | 0.9 | 0.9 | 0.9 | 0.9 | 3.2 | 2.7 | 6.5 | 18.2 | 7.4 | 1.9 | 1.1 |
| 5.0 | 1.3 | 0.9 | 0.9 | 0.9 | 1.9 | 1.9 | 3.2 | 6.5 | 26.0 | 6.5 | 1.8 | 1.1 |
| 6.0 | 1.3 | 0.9 | 0.9 | 0.9 | 1.2 | 2.1 | 5.2 | 6.1 | 22.1 | 6.1 | 1.7 | 1.0 |
| 7.0 | 1.2 | 0.9 | 0.9 | 0.9 | 1.1 | 2.3 | 2.8 | 5.6 | 21.7 | 14.3 | 1.7 | 1.0 |
| 8.0 | 1.2 | 0.9 | 0.9 | 0.9 | 1.0 | 2.4 | 4.8 | 5.2 | 20.8 | 9.1 | 1.6 | 1.0 |
| 9.0 | 1.2 | 0.9 | 0.9 | 0.9 | 1.0 | 1.6 | 4.3 | 31.6 | 34.7 | 8.7 | 1.6 | 1.0 |
| 10.0 | 1.2 | 0.9 | 0.9 | 0.8 | 0.9 | 1.4 | 3.9 | 19.9 | 34.7 | 7.8 | 1.5 | 1.0 |
| 11.0 | 1.2 | 0.9 | 0.9 | 0.8 | 0.9 | 1.3 | 5.2 | 19.5 | 30.8 | 8.2 | 1.5 | 1.2 |
| 12.0 | 1.2 | 0.9 | 0.9 | 0.8 | 0.9 | 1.9 | 4.3 | 19.1 | 24.7 | 7.8 | 1.4 | 1.1 |
| 13.0 | 1.2 | 0.9 | 0.9 | 0.8 | 0.9 | 1.7 | 10.0 | 18.6 | 22.5 | 9.5 | 1.4 | 1.1 |
| 14.0 | 1.2 | 0.9 | 0.9 | 0.8 | 1.2 | 1.9 | 13.0 | 21.2 | 21.2 | 13.4 | 1.4 | 1.1 |
| 15.0 | 1.2 | 0.9 | 0.9 | 0.8 | 1.1 | 1.7 | 11.3 | 20.8 | 19.5 | 13.4 | 1.3 | 1.1 |
| 16.0 | 1.2 | 0.9 | 0.9 | 0.8 | 1.0 | 1.6 | 11.3 | 19.9 | 21.2 | 8.7 | 1.3 | 1.1 |
| 17.0 | 1.2 | 0.9 | 0.9 | 0.8 | 0.9 | 1.6 | 42.0 | 45.1 | 17.8 | 10.0 | 1.3 | 1.0 |
| 18.0 | 1.1 | 0.9 | 0.9 | 0.8 | 0.9 | 1.5 | 28.6 | 39.4 | 17.3 | 6.5 | 1.2 | 1.0 |
| 19.0 | 1.1 | 0.9 | 0.9 | 0.8 | 0.9 | 3.6 | 30.3 | 30.3 | 16.5 | 5.6 | 1.2 | 1.0 |
| 20.0 | 1.1 | 0.9 | 0.9 | 0.8 | 0.9 | 4.3 | 31.2 | 29.5 | 14.3 | 4.8 | 1.2 | 1.0 |
| 21.0 | 1.1 | 0.9 | 0.9 | 0.8 | 0.9 | 4.3 | 30.8 | 28.6 | 13.4 | 4.3 | 1.3 | 1.0 |
| 22.0 | 1.1 | 0.9 | 0.9 | 0.9 | 1.0 | 8.2 | 23.0 | 27.7 | 13.4 | 3.9 | 1.3 | 1.0 |
| 23.0 | 1.1 | 0.9 | 0.9 | 0.9 | 1.0 | 7.4 | 26.4 | 26.9 | 11.7 | 6.1 | 1.2 | 0.9 |
| 24.0 | 1.1 | 0.9 | 0.9 | 0.8 | 1.0 | 5.6 | 21.2 | 24.7 | 10.8 | 4.3 | 1.2 | 1.1 |
| 25.0 | 1.1 | 0.9 | 0.9 | 0.8 | 1.4 | 7.8 | 19.9 | 23.4 | 10.4 | 3.6 | 1.2 | 1.1 |
| 26.0 | 1.1 | 0.9 | 0.9 | 0.8 | 1.0 | 3.6 | 18.2 | 22.5 | 9.1 | 3.3 | 1.1 | 1.1 |
| 27.0 | 1.1 | 0.9 | 0.9 | 0.8 | 2.1 | 6.1 | 16.9 | 22.1 | 8.7 | 3.0 | 1.1 | 1.0 |
| 28.0 | 1.1 | 0.9 | 0.9 | 0.8 | 1.6 | 3.0 | 16.0 | 21.7 | 8.2 | 2.8 | 1.1 | 1.0 |
| 29.0 | 1.1 | 0.9 | 0.9 | 0.8 | 1.2 | 2.2 | 15.6 | 20.4 | 7.8 | 2.7 | 1.2 | 1.0 |
| 30.0 | 1.1 | | 0.9 | 0.8 | 2.3 | 5.2 | 13.9 | 21.2 | 7.4 | 2.6 | 1.2 | 1.0 |
| 31.0 | 1.1 | | 0.9 | | 5.6 | | 13.4 | 19.9 | | 2.4 | | 1.0 |
| Avg. | 1.2 | 0.9 | 0.9 | 0.9 | 1.3 | 3.3 | 15.0 | 20.5 | 18.2 | 6.7 | 1.4 | 1.0 |
| Max. | 1.4 | 0.9 | 0.9 | 0.9 | 5.6 | 8.2 | 42.0 | 45.1 | 34.7 | 14.3 | 2.1 | 1.2 |
| Min. | 1.1 | 0.9 | 0.9 | 0.8 | 0.8 | 1.3 | 2.7 | 5.2 | 7.4 | 2.4 | 1.1 | 0.9 |

| | |
|---|---|
| Ann. Avg. | 6.9 |
| Ann. Max. | 45.1 |
| Ann. Min. | 0.8 |

## Table II.1.7 Daily Mean Discharge ( 1983 )

Gauge Station : GS 730
Catchment area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.8 | 2.8 | 19.1 | 16.4 | 13.6 | 3.7 | 2.0 |
| 2 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.9 | 10.0 | 18.7 | 15.5 | 11.8 | 3.7 | 2.0 |
| 3 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 1.1 | 9.1 | 18.2 | 15.0 | 11.4 | 3.7 | 1.8 |
| 4 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 1.1 | 12.7 | 18.2 | 23.2 | 10.9 | 3.7 | 1.8 |
| 5 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 1.0 | 11.8 | 17.7 | 19.6 | 10.0 | 3.4 | 1.8 |
| 6 | 0.7 | 0.6 | 0.6 | 0.6 | 0.7 | 1.0 | 13.6 | 17.7 | 18.7 | 9.6 | 3.4 | 1.8 |
| 7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.7 | 0.9 | 12.7 | 18.2 | 18.2 | 9.1 | 3.4 | 1.8 |
| 8 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.9 | 10.9 | 23.7 | 17.3 | 9.1 | 3.4 | 1.8 |
| 9 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.9 | 10.5 | 25.5 | 16.8 | 11.4 | 3.2 | 1.7 |
| 10 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 1.6 | 9.6 | 19.1 | 15.9 | 10.9 | 3.2 | 1.7 |
| 11 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.9 | 9.1 | 18.2 | 15.5 | 10.5 | 3.2 | 1.7 |
| 12 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.9 | 8.2 | 17.7 | 14.6 | 10.0 | 3.0 | 1.7 |
| 13 | 0.7 | 0.6 | 0.6 | 0.6 | 4.2 | 0.9 | 7.3 | 17.3 | 13.6 | 9.6 | 3.0 | 1.7 |
| 14 | 0.7 | 0.6 | 0.6 | 0.6 | 2.4 | 0.9 | 17.3 | 16.4 | 18.2 | 9.1 | 3.0 | 1.7 |
| 15 | 0.7 | 0.6 | 0.6 | 0.6 | 3.4 | 0.8 | 28.2 | 27.3 | 17.7 | 8.2 | 2.8 | 1.7 |
| 16 | 0.7 | 0.6 | 0.6 | 0.6 | 3.2 | 0.8 | 26.8 | 19.6 | 16.8 | 7.7 | 2.8 | 1.6 |
| 17 | 0.7 | 0.6 | 0.6 | 0.6 | 3.0 | 0.8 | 10.5 | 27.3 | 25.9 | 6.8 | 2.8 | 1.6 |
| 18 | 0.7 | 0.6 | 0.6 | 0.6 | 2.8 | 0.8 | 4.2 | 25.0 | 16.4 | 6.4 | 2.8 | 1.6 |
| 19 | 0.7 | 0.6 | 0.6 | 0.6 | 2.6 | 0.8 | 4.0 | 17.3 | 17.7 | 5.9 | 2.8 | 1.5 |
| 20 | 0.6 | 0.6 | 0.6 | 0.5 | 2.0 | 0.7 | 4.0 | 16.4 | 16.8 | 5.0 | 2.6 | 1.5 |
| 21 | 0.6 | 0.6 | 0.6 | 0.5 | 0.9 | 0.7 | 3.7 | 16.4 | 15.9 | 5.0 | 2.6 | 1.5 |
| 22 | 0.6 | 0.6 | 0.6 | 0.5 | 0.9 | 0.7 | 3.4 | 22.3 | 25.9 | 4.6 | 2.6 | 1.5 |
| 23 | 0.6 | 0.6 | 0.6 | 0.5 | 0.9 | 0.7 | 3.2 | 25.5 | 17.7 | 4.2 | 2.4 | 1.4 |
| 24 | 0.6 | 0.6 | 0.6 | 0.5 | 0.8 | 0.7 | 11.8 | 30.0 | 15.9 | 7.7 | 2.4 | 1.4 |
| 25 | 0.6 | 0.6 | 0.6 | 0.5 | 0.8 | 0.7 | 10.0 | 18.2 | 15.0 | 5.5 | 2.3 | 1.4 |
| 26 | 0.6 | 0.6 | 0.6 | 0.5 | 0.8 | 0.7 | 19.1 | 17.3 | 14.1 | 4.6 | 2.1 | 1.4 |
| 27 | 0.6 | 0.6 | 0.6 | 0.5 | 0.8 | 4.0 | 19.6 | 16.8 | 13.2 | 4.2 | 2.0 | 2.0 |
| 28 | 0.6 | 0.6 | 0.6 | 0.5 | 0.8 | 4.6 | 22.3 | 15.9 | 11.8 | 4.2 | 2.0 | 1.7 |
| 29 | 0.7 | | 0.6 | 0.5 | 0.8 | 3.0 | 21.4 | 15.5 | 10.9 | 4.0 | 2.0 | 1.6 |
| 30 | 0.7 | | 0.6 | 0.6 | 0.8 | 2.8 | 20.9 | 15.5 | 10.9 | 4.0 | 2.0 | 1.6 |
| 31 | 0.7 | | 0.6 | | 0.8 | | 20.0 | 17.3 | | 4.0 | | 1.5 |
| Avg. | 0.7 | 0.6 | 0.6 | 0.6 | 1.3 | 1.2 | 12.2 | 19.6 | 16.7 | 7.7 | 2.9 | 1.7 |
| Max. | 0.7 | 0.7 | 0.6 | 0.6 | 4.2 | 4.6 | 28.2 | 30.0 | 25.9 | 13.6 | 3.7 | 2.0 |
| Min. | 0.6 | 0.6 | 0.6 | 0.5 | 0.6 | 0.7 | 2.8 | 15.5 | 10.9 | 4.0 | 2.0 | 1.4 |

| | |
|---|---|
| Ann. Avg. | 5.5 |
| Ann. Max. | 30.0 |
| Ann. Min. | 0.5 |

## Table II.1.8 Daily Mean Discharge ( 1984 )

Gauge Station : GS 730
Catchment area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.5 | 1.3 | 1.0 | 0.9 | 1.0 | 1.4 | 12.7 | 23.2 | 7.3 | 15.1 | 4.4 | 3.6 |
| 2 | 1.4 | 1.3 | 0.9 | 0.9 | 1.0 | 1.0 | 11.4 | 21.8 | 6.8 | 15.1 | 4.4 | 3.5 |
| 3 | 1.4 | 1.2 | 0.9 | 0.9 | 1.0 | 1.0 | 13.2 | 20.5 | 9.6 | 14.3 | 4.3 | 3.5 |
| 4 | 1.3 | 1.2 | 0.9 | 0.9 | 1.0 | 1.1 | 13.2 | 19.6 | 15.5 | 14.0 | 4.3 | 3.5 |
| 5 | 1.3 | 1.2 | 0.9 | 0.9 | 2.1 | 1.2 | 18.7 | 19.1 | 10.9 | 13.6 | 4.3 | 3.3 |
| 6 | 1.3 | 1.2 | 0.9 | 0.9 | 1.3 | 1.1 | 17.3 | 17.3 | 10.0 | 13.6 | 4.3 | 3.3 |
| 7 | 1.3 | 1.1 | 0.9 | 0.9 | 1.2 | 1.8 | 15.9 | 15.5 | 10.0 | 12.8 | 4.1 | 3.3 |
| 8 | 1.3 | 1.1 | 0.9 | 0.9 | 1.8 | 1.7 | 26.8 | 14.1 | 14.1 | 12.1 | 4.1 | 3.2 |
| 9 | 1.2 | 1.1 | 0.9 | 0.9 | 1.7 | 3.4 | 13.6 | 13.2 | 11.8 | 11.4 | 4.1 | 3.2 |
| 10 | 1.2 | 1.1 | 0.9 | 1.2 | 1.6 | 6.8 | 17.7 | 12.3 | 10.0 | 10.8 | 4.1 | 3.2 |
| 11 | 1.2 | 1.0 | 0.9 | 0.9 | 1.8 | 6.8 | 11.8 | 11.8 | 12.3 | 10.5 | 4.1 | 3.2 |
| 12 | 1.2 | 1.0 | 0.9 | 0.9 | 2.4 | 3.7 | 23.7 | 11.4 | 10.9 | 9.8 | 3.9 | 3.1 |
| 13 | 1.2 | 1.0 | 0.9 | 0.9 | 1.7 | 6.8 | 14.1 | 10.9 | 11.4 | 9.3 | 3.9 | 3.1 |
| 14 | 1.2 | 1.0 | 0.9 | 0.9 | 1.6 | 4.2 | 10.5 | 10.0 | 11.8 | 8.7 | 3.9 | 3.1 |
| 15 | 1.2 | 1.0 | 0.9 | 0.9 | 1.4 | 4.0 | 10.5 | 10.0 | 31.4 | 8.4 | 3.9 | 3.1 |
| 16 | 1.2 | 1.0 | 0.9 | 0.9 | 1.3 | 9.1 | 10.9 | 9.6 | 47.6 | 7.9 | 4.1 | 3.1 |
| 17 | 1.7 | 1.0 | 0.9 | 0.9 | 1.1 | 5.0 | 9.6 | 14.1 | 43.6 | 7.6 | 4.1 | 2.9 |
| 18 | 1.6 | 0.9 | 0.9 | 0.9 | 1.0 | 16.4 | 10.9 | 10.0 | 35.1 | 7.1 | 4.1 | 2.9 |
| 19 | 1.5 | 0.9 | 0.9 | 0.9 | 1.3 | 17.7 | 9.1 | 8.2 | 31.6 | 6.9 | 3.9 | 2.9 |
| 20 | 1.5 | 1.3 | 0.9 | 0.9 | 1.2 | 16.4 | 8.2 | 10.0 | 26.7 | 6.4 | 3.9 | 2.9 |
| 21 | 1.5 | 1.3 | 0.9 | 0.9 | 1.1 | 12.7 | 7.7 | 15.5 | 21.4 | 6.2 | 3.9 | 2.9 |
| 22 | 1.4 | 1.2 | 0.9 | 1.0 | 1.0 | 23.7 | 18.2 | 16.4 | 19.6 | 6.0 | 3.8 | 2.8 |
| 23 | 1.4 | 1.1 | 0.9 | 0.9 | 1.0 | 14.1 | 19.1 | 14.6 | 19.1 | 6.0 | 3.8 | 2.8 |
| 24 | 1.4 | 1.1 | 0.9 | 0.9 | 1.0 | 10.0 | 16.8 | 13.6 | 19.1 | 5.4 | 3.8 | 2.8 |
| 25 | 1.4 | 1.0 | 0.8 | 0.9 | 0.9 | 10.5 | 18.2 | 12.3 | 17.8 | 5.0 | 3.8 | 2.8 |
| 26 | 1.4 | 1.0 | 0.9 | 0.9 | 0.9 | 8.2 | 20.0 | 10.9 | 17.8 | 5.0 | 3.8 | 2.8 |
| 27 | 1.3 | 1.0 | 0.9 | 2.1 | 0.9 | 6.8 | 23.2 | 11.8 | 16.5 | 4.6 | 3.8 | 2.8 |
| 28 | 1.3 | 1.0 | 0.9 | 1.2 | 1.8 | 10.9 | 21.8 | 10.9 | 16.5 | 4.6 | 3.8 | 2.7 |
| 29 | 1.3 | 1.0 | 0.9 | 1.1 | 1.6 | 14.6 | 20.9 | 10.0 | 15.6 | 4.6 | 3.8 | 2.7 |
| 30 | 1.3 | | 0.9 | 1.8 | 1.6 | 14.1 | 23.2 | 8.2 | 15.1 | 4.6 | 3.6 | 2.7 |
| 31 | 1.3 | | 0.9 | | 1.5 | | 25.5 | 7.7 | | 4.4 | | 2.7 |
| Avg. | 1.3 | 1.1 | 0.9 | 1.0 | 1.4 | 7.9 | 16.0 | 13.4 | 18.2 | 8.8 | 4.0 | 3.0 |
| Max. | 1.7 | 1.3 | 1.0 | 2.1 | 2.4 | 23.7 | 26.8 | 23.2 | 47.6 | 15.1 | 4.4 | 3.6 |
| Min. | 1.2 | 0.9 | 0.8 | 0.9 | 0.9 | 1.0 | 7.7 | 7.7 | 6.8 | 4.4 | 3.6 | 2.7 |

| | |
|---|---|
| Ann. Avg. | 6.4 |
| Ann. Max. | 47.6 |
| Ann. Min. | 0.8 |

## Table II.1.9 Daily Mean Discharge ( 1985 )

Gauge Station : GS 730
Catchment area : 125.8 $km^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.7 | 2.4 | 2.3 | 1.8 | 2.0 | 2.6 | 13.2 | 24.5 | 13.2 | 10.2 | 6.2 | 4.1 |
| 2 | 2.7 | 2.4 | 2.3 | 1.8 | 2.0 | 2.6 | 11.4 | 20.0 | 14.7 | 10.2 | 6.2 | 3.9 |
| 3 | 2.7 | 2.4 | 2.3 | 1.8 | 2.0 | 2.4 | 10.8 | 15.6 | 14.3 | 10.2 | 6.0 | 3.9 |
| 4 | 2.7 | 2.4 | 2.3 | 1.8 | 2.0 | 2.4 | 10.5 | 15.1 | 14.0 | 9.8 | 5.8 | 3.8 |
| 5 | 2.7 | 2.4 | 2.3 | 1.7 | 1.9 | 2.3 | 10.2 | 14.3 | 14.0 | 9.6 | 5.8 | 3.8 |
| 6 | 2.7 | 2.4 | 2.3 | 1.7 | 1.9 | 2.3 | 9.8 | 13.6 | 13.2 | 9.8 | 5.6 | 3.8 |
| 7 | 2.7 | 2.4 | 2.2 | 1.7 | 1.9 | 2.3 | 9.6 | 13.2 | 12.5 | 10.5 | 5.6 | 3.6 |
| 8 | 2.6 | 2.4 | 2.2 | 1.7 | 1.9 | 2.3 | 9.0 | 12.8 | 11.8 | 10.2 | 5.6 | 3.6 |
| 9 | 2.6 | 2.6 | 2.2 | 1.8 | 1.9 | 3.6 | 10.8 | 12.5 | 11.4 | 9.8 | 5.4 | 3.5 |
| 10 | 2.6 | 2.6 | 2.2 | 1.8 | 2.0 | 4.3 | 12.1 | 11.8 | 12.8 | 9.6 | 5.4 | 3.5 |
| 11 | 2.6 | 2.6 | 2.2 | 1.7 | 2.1 | 3.5 | 12.1 | 11.8 | 12.5 | 9.3 | 5.4 | 3.5 |
| 12 | 2.6 | 2.6 | 2.2 | 1.7 | 2.1 | 2.9 | 12.8 | 11.4 | 11.8 | 9.0 | 5.2 | 3.3 |
| 13 | 2.6 | 2.6 | 2.2 | 1.7 | 2.1 | 4.4 | 14.3 | 10.8 | 11.1 | 8.4 | 5.2 | 3.3 |
| 14 | 2.6 | 2.6 | 2.2 | 1.7 | 2.1 | 5.6 | 15.6 | 10.5 | 12.5 | 8.2 | 5.2 | 3.3 |
| 15 | 2.6 | 2.4 | 2.1 | 1.6 | 2.1 | 6.7 | 20.5 | 10.2 | 13.6 | 7.9 | 5.2 | 3.3 |
| 16 | 2.6 | 2.4 | 2.1 | 1.6 | 2.0 | 7.6 | 18.7 | 10.2 | 14.3 | 8.7 | 5.0 | 3.2 |
| 17 | 2.6 | 2.4 | 2.1 | 1.6 | 2.0 | 7.6 | 16.9 | 10.2 | 15.6 | 17.4 | 5.0 | 3.2 |
| 18 | 2.6 | 2.4 | 2.0 | 1.8 | 2.0 | 8.4 | 15.6 | 9.8 | 14.3 | 24.5 | 5.0 | 3.1 |
| 19 | 2.6 | 2.4 | 2.0 | 2.3 | 2.3 | 9.0 | 15.6 | 14.7 | 14.0 | 22.2 | 4.8 | 3.1 |
| 20 | 2.7 | 2.4 | 2.0 | 2.2 | 2.4 | 9.3 | 14.7 | 13.2 | 13.6 | 14.3 | 4.8 | 3.1 |
| 21 | 2.7 | 2.4 | 1.9 | 2.2 | 2.4 | 9.6 | 16.0 | 12.1 | 13.2 | 12.1 | 4.8 | 3.1 |
| 22 | 2.7 | 2.4 | 1.9 | 2.2 | 2.4 | 9.6 | 19.1 | 11.4 | 12.8 | 11.1 | 4.6 | 2.9 |
| 23 | 2.7 | 2.4 | 1.9 | 2.2 | 2.4 | 10.2 | 18.2 | 11.1 | 11.8 | 10.5 | 4.6 | 2.9 |
| 24 | 2.6 | 2.3 | 1.8 | 2.1 | 2.6 | 10.8 | 17.8 | 10.8 | 11.4 | 9.8 | 4.6 | 2.9 |
| 25 | 2.6 | 2.3 | 1.8 | 2.1 | 2.6 | 10.5 | 18.2 | 10.5 | 11.1 | 9.0 | 4.4 | 2.8 |
| 26 | 2.6 | 2.3 | 1.8 | 2.1 | 2.6 | 10.2 | 18.6 | 12.1 | 10.8 | 8.7 | 4.3 | 2.8 |
| 27 | 2.6 | 2.3 | 1.8 | 2.1 | 2.7 | 9.6 | 25.4 | 14.7 | 11.1 | 8.2 | 4.3 | 2.8 |
| 28 | 2.6 | 2.3 | 1.9 | 2.0 | 2.7 | 9.0 | 33.1 | 14.3 | 11.1 | 7.6 | 4.3 | 2.7 |
| 29 | 2.6 | | 1.9 | 2.0 | 2.7 | 8.7 | 29.1 | 14.0 | 10.5 | 7.4 | 4.1 | 2.7 |
| 30 | 2.6 | | 1.8 | 2.0 | 2.6 | 10.5 | 28.4 | 13.6 | 10.5 | 6.9 | 4.1 | 2.7 |
| 31 | 2.4 | | 1.8 | | 2.7 | | 27.8 | 12.8 | | 6.4 | | 2.7 |
| Avg. | 2.6 | 2.4 | 2.1 | 1.9 | 2.2 | 6.4 | 16.6 | 13.0 | 12.6 | 10.6 | 12.6 | 3.3 |
| Max. | 2.7 | 2.6 | 2.3 | 2.3 | 2.7 | 10.8 | 33.1 | 24.5 | 15.6 | 24.5 | 6.2 | 4.1 |
| Min. | 2.4 | 2.3 | 1.8 | 1.6 | 1.9 | 2.3 | 9.0 | 9.8 | 10.5 | 6.4 | 4.1 | 2.7 |

| | |
|---|---|
| Ann. Avg. | 6.6 |
| Ann. Max. | 33.1 |
| Ann. Min. | 1.6 |

## Table II.1.10 Daily Mean Discharge ( 1986 )

Gauge Station : GS 730
Catchment area : 125.8 km$^2$

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.6 | 1.5 | 1.2 | 1.0 | 2.3 | 1.9 | 7.9 | 39.6 | 9.8 | 10.2 | 6.0 | 2.8 |
| 2 | 2.6 | 1.5 | 1.2 | 1.0 | 3.1 | 2.8 | 6.9 | 22.7 | 16.0 | 9.8 | 5.8 | 2.8 |
| 3 | 2.6 | 1.5 | 1.2 | 1.0 | 3.6 | 2.3 | 10.2 | 18.7 | 24.0 | 9.6 | 5.8 | 2.7 |
| 4 | 2.6 | 1.5 | 1.2 | 1.0 | 2.1 | 2.4 | 10.2 | 15.6 | 18.2 | 9.3 | 5.8 | 2.7 |
| 5 | 2.4 | 1.5 | 1.2 | 1.0 | 1.5 | 2.3 | 16.9 | 13.2 | 14.3 | 9.0 | 5.6 | 2.6 |
| 6 | 2.4 | 1.5 | 1.2 | 1.0 | 1.5 | 2.2 | 14.7 | 11.1 | 11.8 | 11.8 | 5.4 | 2.6 |
| 7 | 2.4 | 1.5 | 1.2 | 1.0 | 1.5 | 2.0 | 11.4 | 9.3 | 12.1 | 12.8 | 5.4 | 2.6 |
| 8 | 2.4 | 1.5 | 1.2 | 1.0 | 1.4 | 2.8 | 33.8 | 8.2 | 11.4 | 12.1 | 5.2 | 2.6 |
| 9 | 2.3 | 1.4 | 1.2 | 0.9 | 1.4 | 2.4 | 35.6 | 7.6 | 12.1 | 11.4 | 5.0 | 2.6 |
| 10 | 2.3 | 1.4 | 1.2 | 0.9 | 1.3 | 2.2 | 24.9 | 12.5 | 13.2 | 11.1 | 5.0 | 2.4 |
| 11 | 2.3 | 1.4 | 1.2 | 0.9 | 1.2 | 2.0 | 12.5 | 9.8 | 75.2 | 10.8 | 4.8 | 2.4 |
| 12 | 2.2 | 1.4 | 1.2 | 1.4 | 1.1 | 2.6 | 8.7 | 8.4 | 50.7 | 10.5 | 4.6 | 2.4 |
| 13 | 2.2 | 1.4 | 1.2 | 1.4 | 1.1 | 3.3 | 13.2 | 7.6 | 22.7 | 9.8 | 4.6 | 2.4 |
| 14 | 2.2 | 1.3 | 1.2 | 1.2 | 6.4 | 2.7 | 14.3 | 7.4 | 17.8 | 9.6 | 4.4 | 2.3 |
| 15 | 2.1 | 1.3 | 1.2 | 1.2 | 7.1 | 2.6 | 10.5 | 7.4 | 22.2 | 9.3 | 4.3 | 2.3 |
| 16 | 2.1 | 1.3 | 1.2 | 1.2 | 4.3 | 2.3 | 9.3 | 7.1 | 17.4 | 9.0 | 4.3 | 2.3 |
| 17 | 2.0 | 1.3 | 1.2 | 1.1 | 5.2 | 2.2 | 11.4 | 7.6 | 14.7 | 8.4 | 4.1 | 2.3 |
| 18 | 2.0 | 1.3 | 1.2 | 1.1 | 8.4 | 2.0 | 17.8 | 7.9 | 12.8 | 8.2 | 4.4 | 2.2 |
| 19 | 1.9 | 1.3 | 1.2 | 1.0 | 5.0 | 5.6 | 15.1 | 10.5 | 12.1 | 7.6 | 4.4 | 2.2 |
| 20 | 1.9 | 1.3 | 1.2 | 1.0 | 2.9 | 4.1 | 11.8 | 14.7 | 11.4 | 7.4 | 4.3 | 2.2 |
| 21 | 1.8 | 1.3 | 1.2 | 1.0 | 2.4 | 3.3 | 12.1 | 11.1 | 15.6 | 7.1 | 4.1 | 2.1 |
| 22 | 1.8 | 1.3 | 1.2 | 1.0 | 1.8 | 2.6 | 13.6 | 12.5 | 17.8 | 6.7 | 3.9 | 2.1 |
| 23 | 1.8 | 1.2 | 1.2 | 0.9 | 1.8 | 4.4 | 15.1 | 15.6 | 16.0 | 6.4 | 3.9 | 2.0 |
| 24 | 1.7 | 1.2 | 1.2 | 4.6 | 1.7 | 8.7 | 12.1 | 12.1 | 14.0 | 6.4 | 3.8 | 2.0 |
| 25 | 1.7 | 1.2 | 1.1 | 1.2 | 1.6 | 7.1 | 10.5 | 9.8 | 13.2 | 6.4 | 3.6 | 2.0 |
| 26 | 1.7 | 1.2 | 1.1 | 1.1 | 2.6 | 10.8 | 9.8 | 10.5 | 12.8 | 6.4 | 3.5 | 2.0 |
| 27 | 1.7 | 1.2 | 1.1 | 2.2 | 2.2 | 16.0 | 11.1 | 50.7 | 11.8 | 6.4 | 3.3 | 2.0 |
| 28 | 1.6 | 1.2 | 1.1 | 1.8 | 2.1 | 11.1 | 10.8 | 47.6 | 11.4 | 6.2 | 3.2 | 1.9 |
| 29 | 1.6 | | 1.0 | 2.3 | 1.9 | 9.0 | 10.8 | 36.9 | 10.5 | 6.2 | 3.1 | 1.9 |
| 30 | 1.6 | | 1.0 | 2.6 | 1.8 | 8.7 | 10.8 | 24.9 | 10.5 | 6.2 | 2.9 | 1.9 |
| 31 | 1.5 | | 1.0 | | 2.3 | | 39.6 | 13.2 | | 6.0 | | 1.8 |
| Avg. | 2.1 | 1.4 | 1.2 | 1.3 | 2.7 | 4.5 | 14.6 | 15.9 | 17.8 | 8.7 | 4.5 | 2.3 |
| Max. | 2.6 | 1.5 | 1.2 | 4.6 | 8.4 | 16.0 | 39.6 | 50.7 | 75.2 | 12.8 | 6.0 | 2.8 |
| Min. | 1.5 | 1.2 | 1.0 | 0.9 | 1.1 | 1.9 | 6.9 | 7.1 | 9.8 | 6.0 | 2.9 | 1.8 |

| | |
|---|---|
| Ann. Avg. | 6.4 |
| Ann. Max. | 75.2 |
| Ann. Min. | 0.9 |

## Table II.1.11 Daily Mean Discharge ( May 1992 ~ April 1993 )

Gauge Station : GS 730
Catchment area : 125.8 $km^2$

| | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec | Jan | Feb. | Mar. | Apr. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.3 | 1.1 | 3.0 | 10.6 | 8.5 | 6.2 | 3.4 | 2.2 | 1.8 | 1.8 | 1.4 | 1.6 |
| 2 | 2.5 | 1.1 | 15.8 | 9.3 | 8.1 | 5.8 | 3.2 | 2.2 | 1.8 | 1.8 | 1.4 | 1.5 |
| 3 | 2.2 | 1.1 | 5.1 | 10.8 | 7.6 | 5.5 | 3.1 | 2.4 | 1.8 | 1.8 | 1.4 | 1.5 |
| 4 | 1.6 | 1.1 | 4.2 | 9.5 | 7.1 | 5.2 | 3.1 | 2.6 | 1.8 | 1.7 | 1.4 | 1.5 |
| 5 | 1.5 | 1.0 | 4.1 | 9.1 | 6.9 | 5.2 | 3.1 | 2.5 | 1.8 | 1.7 | 1.4 | 1.5 |
| 6 | 1.4 | 1.0 | 3.3 | 9.1 | 7.9 | 5.1 | 3.1 | 2.4 | 1.9 | 1.6 | 1.3 | 1.4 |
| 7 | 1.3 | 1.1 | 7.9 | 8.5 | 8.1 | 4.8 | 3.2 | 2.4 | 1.9 | 1.6 | 1.3 | 1.4 |
| 8 | 1.3 | 1.6 | 6.6 | 8.1 | 7.1 | 4.8 | 3.2 | 2.3 | 2.2 | 1.6 | 1.3 | 1.4 |
| 9 | 1.3 | 1.3 | 5.7 | 7.9 | 7.6 | 4.5 | 3.1 | 2.3 | 2.2 | 1.6 | 1.3 | 1.4 |
| 10 | 1.2 | 1.2 | 8.3 | 7.7 | 6.6 | 4.3 | 3.1 | 2.2 | 2.1 | 1.5 | 1.3 | 1.4 |
| 11 | 1.2 | 3.3 | 8.9 | 7.2 | 7.1 | 4.5 | 3.2 | 2.2 | 2.0 | 1.5 | 1.3 | 1.3 |
| 12 | 1.2 | 2.2 | 22.2 | 7.1 | 10.8 | 4.6 | 3.1 | 2.2 | 2.0 | 1.5 | 1.3 | 1.4 |
| 13 | 1.2 | 2.0 | 12.2 | 6.7 | 10.3 | 4.6 | 3.1 | 2.2 | 2.0 | 1.5 | 1.3 | 4.1 |
| 14 | 1.1 | 2.0 | 8.5 | 6.2 | 9.3 | 5.2 | 3.0 | 2.1 | 2.1 | 1.5 | 1.3 | 2.2 |
| 15 | 1.1 | 2.0 | 9.7 | 7.9 | 8.7 | 4.8 | 3.0 | 2.1 | 2.1 | 1.5 | 1.3 | 2.1 |
| 16 | 1.1 | 2.0 | 26.3 | 7.2 | 8.3 | 7.4 | 2.8 | 2.1 | 2.0 | 1.5 | 1.3 | 2.0 |
| 17 | 1.1 | 1.7 | 20.7 | 6.9 | 9.3 | 5.7 | 2.8 | 2.0 | 2.0 | 1.5 | 1.2 | 2.0 |
| 18 | 1.0 | 1.6 | 17.3 | 7.2 | 7.9 | 4.8 | 2.7 | 2.0 | 2.0 | 1.5 | 1.2 | 2.0 |
| 19 | 1.0 | 1.5 | 13.3 | 6.7 | 7.2 | 4.7 | 2.9 | 2.0 | 2.0 | 1.5 | 1.2 | 1.9 |
| 20 | 1.5 | 2.3 | 11.0 | 6.7 | 6.7 | 4.5 | 2.6 | 2.0 | 2.0 | 1.4 | 1.2 | 1.8 |
| 21 | 1.4 | 2.0 | 9.5 | 6.4 | 6.6 | 4.5 | 2.6 | 2.0 | 1.9 | 1.4 | 1.2 | 2.6 |
| 22 | 1.4 | 2.0 | 8.5 | 11.7 | 6.2 | 4.3 | 2.6 | 2.0 | 1.9 | 1.4 | 1.2 | 2.0 |
| 23 | 1.3 | 2.3 | 7.4 | 16.4 | 5.9 | 4.2 | 2.5 | 2.0 | 1.9 | 1.4 | 1.2 | 1.6 |
| 24 | 1.3 | 2.0 | 14.6 | 11.7 | 5.9 | 4.2 | 2.5 | 1.9 | 1.9 | 1.4 | 1.2 | 3.1 |
| 25 | 1.3 | 3.7 | 9.5 | 12.2 | 5.8 | 4.1 | 2.5 | 1.9 | 1.9 | 1.4 | 1.2 | 3.1 |
| 26 | 1.3 | 2.8 | 8.1 | 21.1 | 6.9 | 4.0 | 2.4 | 1.9 | 1.8 | 1.4 | 2.2 | 4.7 |
| 27 | 1.3 | 7.2 | 16.4 | 15.2 | 7.2 | 3.9 | 2.4 | 1.9 | 1.8 | 1.4 | 2.5 | 2.7 |
| 28 | 1.2 | 3.2 | 9.7 | 13.0 | 6.9 | 3.8 | 2.3 | 1.8 | 1.8 | 1.4 | 1.8 | 2.3 |
| 29 | 1.2 | 2.4 | 8.5 | 11.3 | 6.7 | 3.8 | 2.3 | 1.8 | 1.8 | | 1.6 | 2.2 |
| 30 | 1.2 | 2.8 | 12.2 | 9.7 | 6.4 | 3.7 | 2.2 | 1.8 | 1.8 | | 1.6 | 2.1 |
| 31 | 1.1 | | 13.0 | 9.7 | | 3.6 | | 1.8 | 1.8 | | 1.6 | |
| Avg. | 1.3 | 2.0 | 10.7 | 9.6 | 7.3 | 4.7 | 2.7 | 2.1 | 1.9 | 1.4 | 1.4 | 2.0 |
| Max. | 2.5 | 7.2 | 26.3 | 21.1 | 10.8 | 7.4 | 3.4 | 2.6 | 2.2 | 1.8 | 2.5 | 4.7 |
| Min. | 1.0 | 1.0 | 3.0 | 6.2 | 5.8 | 3.6 | 2.2 | 1.8 | 1.8 | 1.4 | 1.2 | 1.3 |

| | |
|---|---|
| Ann. Avg. | 4.0 |
| Ann. Max. | 26.3 |
| Ann. Min. | 1.0 |

## II.2 Monthly Mean Discharge at Gauging Station GS 730 (Puwa Khola) (From 1972 ~ to 1986 and From May 1992 to April 1993)

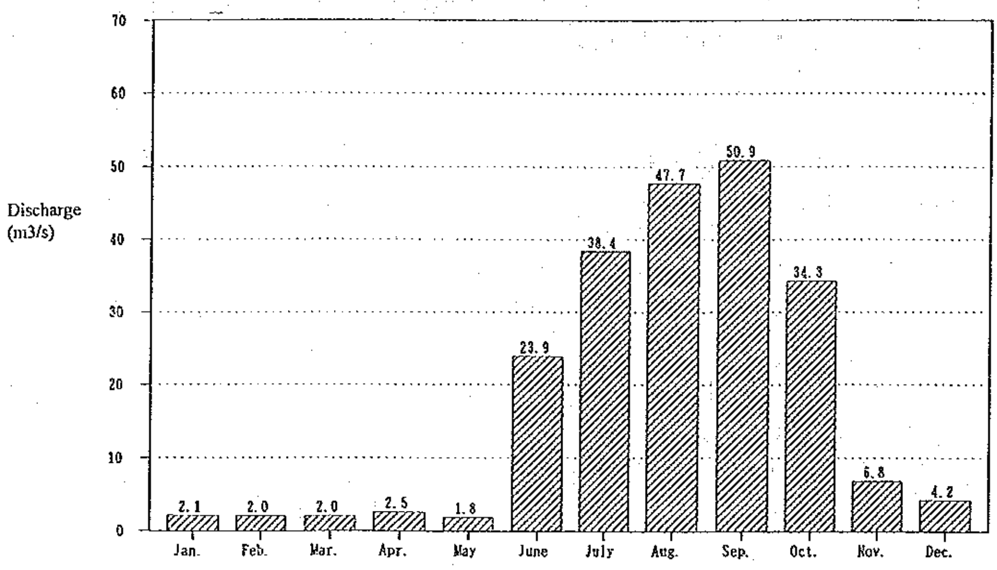



**Fig. II.2.1 Monthly Mean Discharge ( 1972 )**

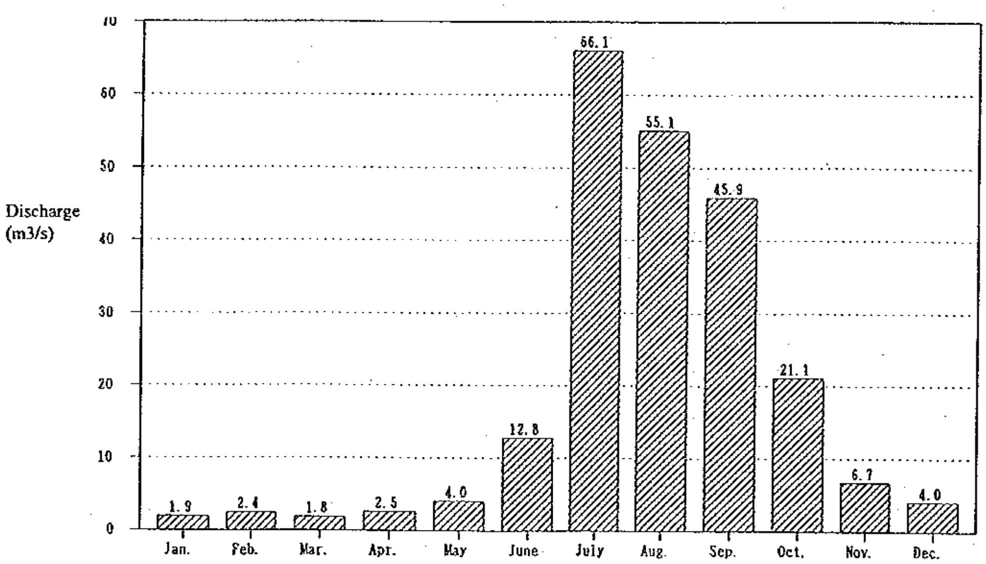



**Fig. II.2.2 Monthly Mean Discharge ( 1974 )**

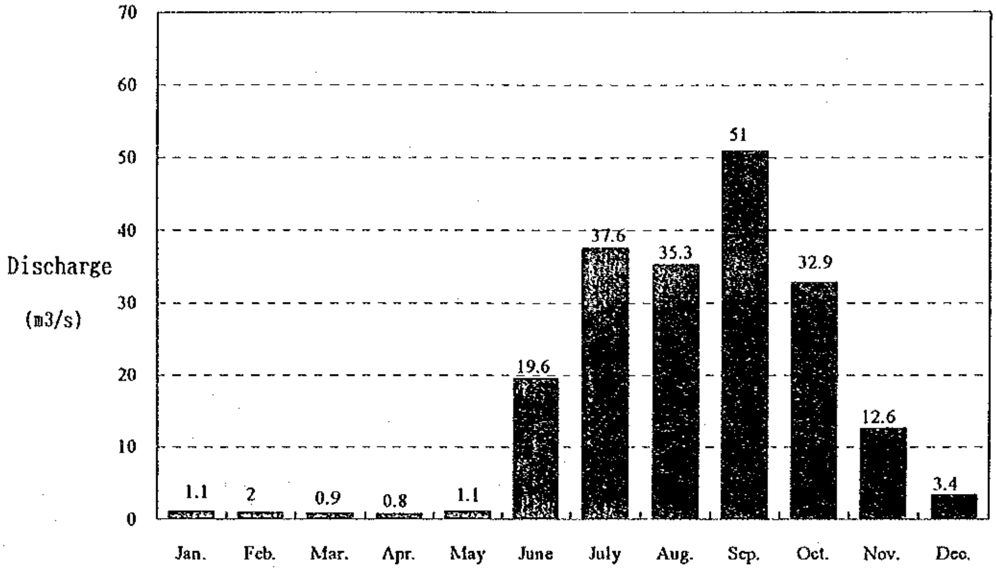



**Fig. II.2.3 Monthly Mean Discharge ( 1975 )**

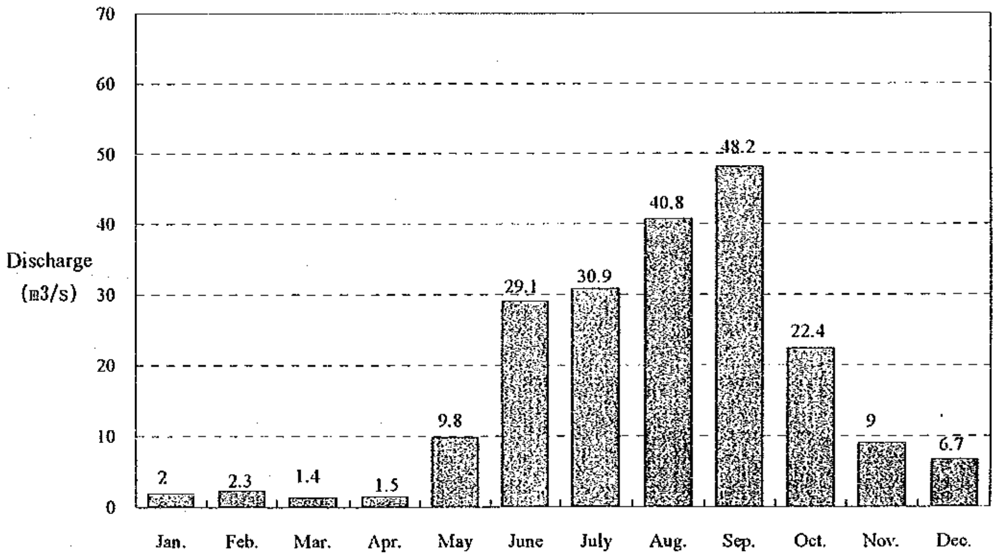



**Fig. II.2.4 Monthly Mean Discharge ( 1976 )**

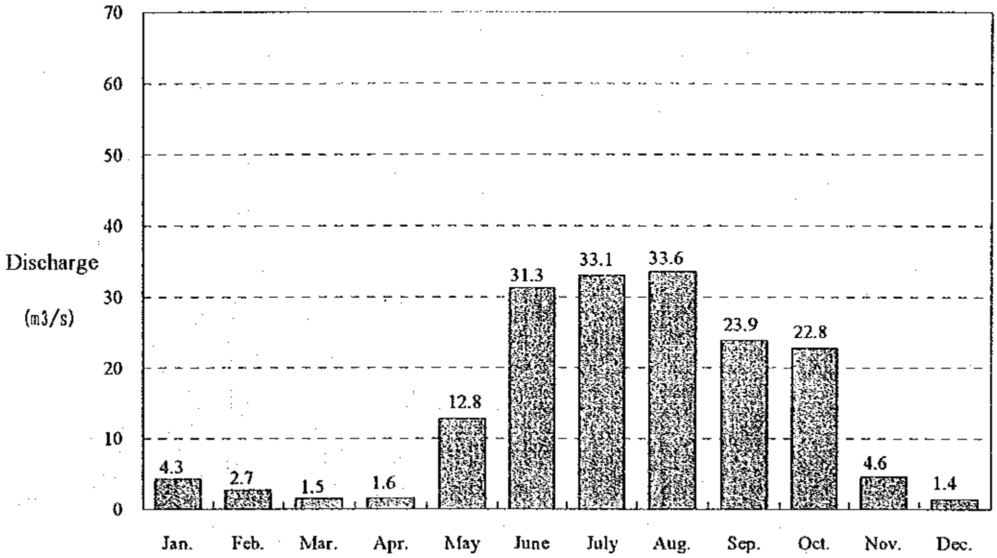



**Fig. II.2.5 Monthly Mean Discharge ( 1978 )**

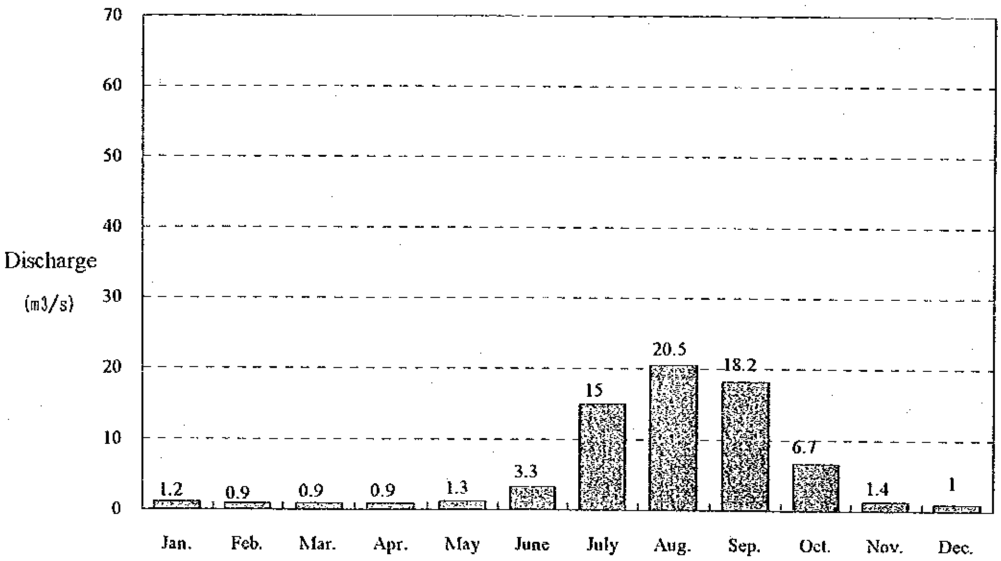



**Fig. II.2.6 Monthly Mean Discharge ( 1980 )**

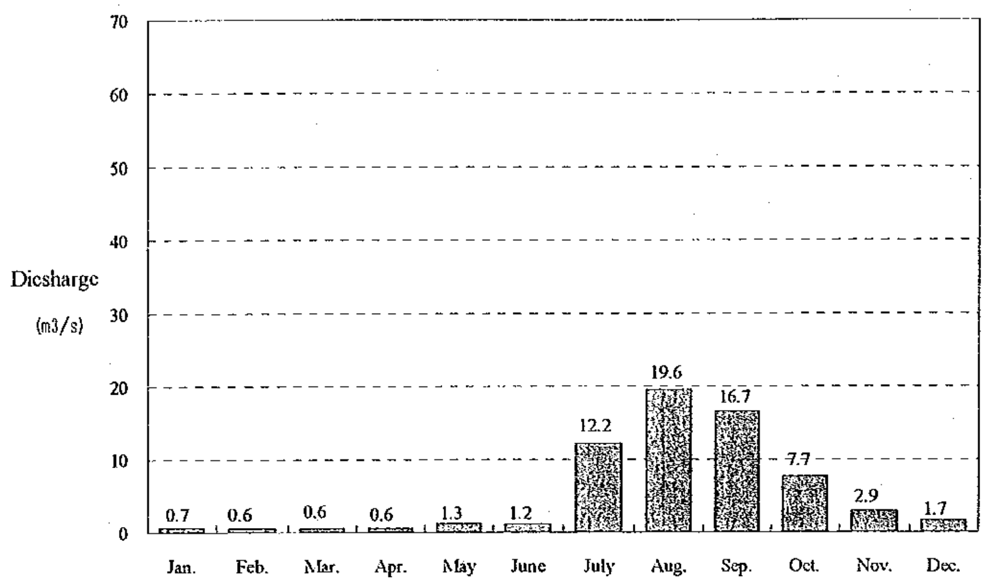



**Fig. II.2.7 Monthly Mean Discharge ( 1983 )**

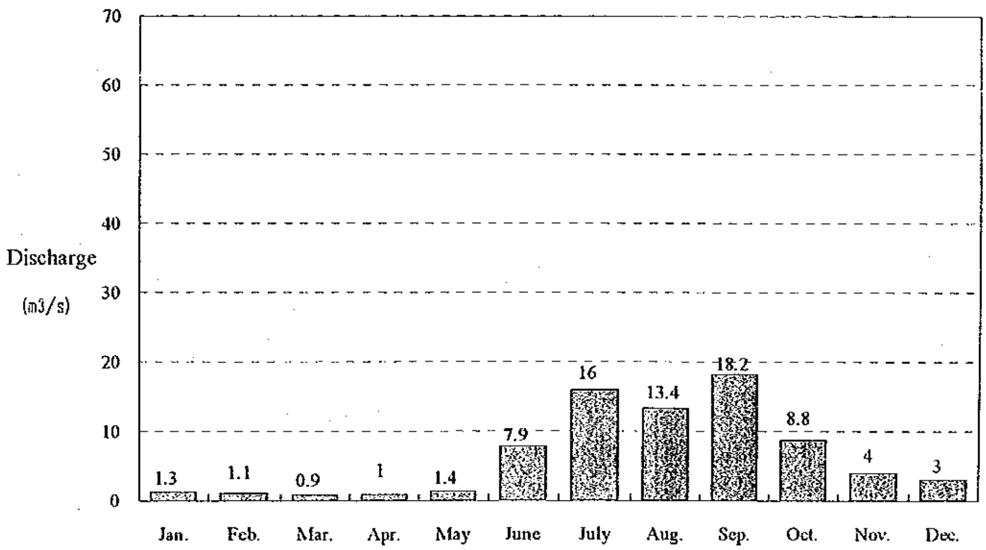



**Fig. II.2.8 Monthly Mean Discharge ( 1984 )**

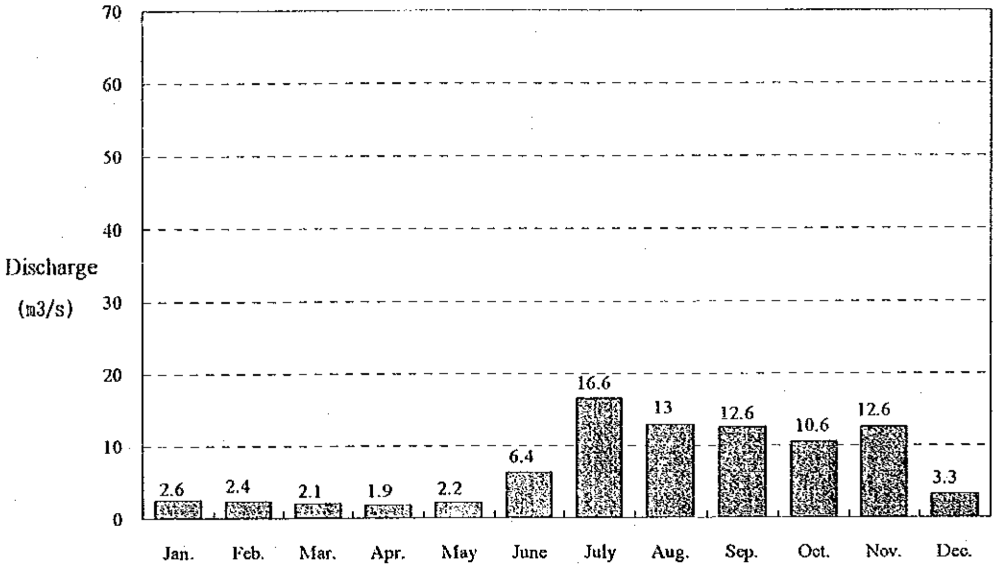



**Fig. II.2.9 Monthly Mean Discharge ( 1985 )**

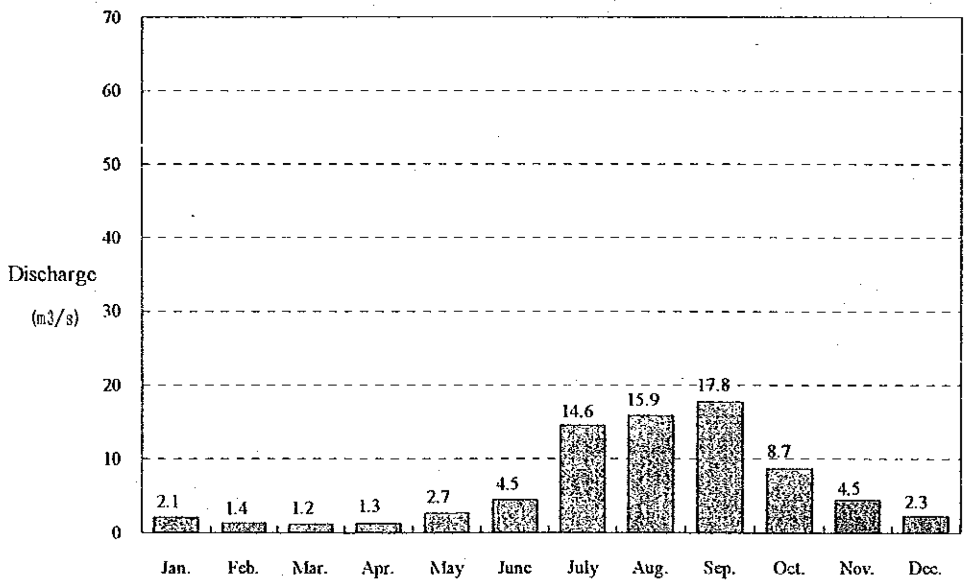



**Fig. II.2.10 Monthly Mean Discharge ( 1986 )**

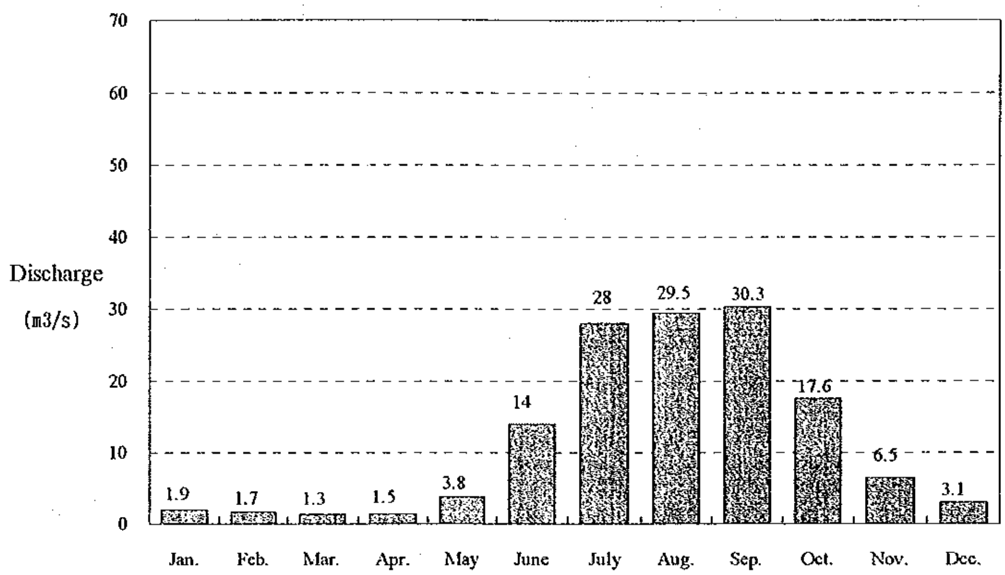



**Fig. II.2.11 Monthly Mean Discharge (mean value between 1972-1986)**

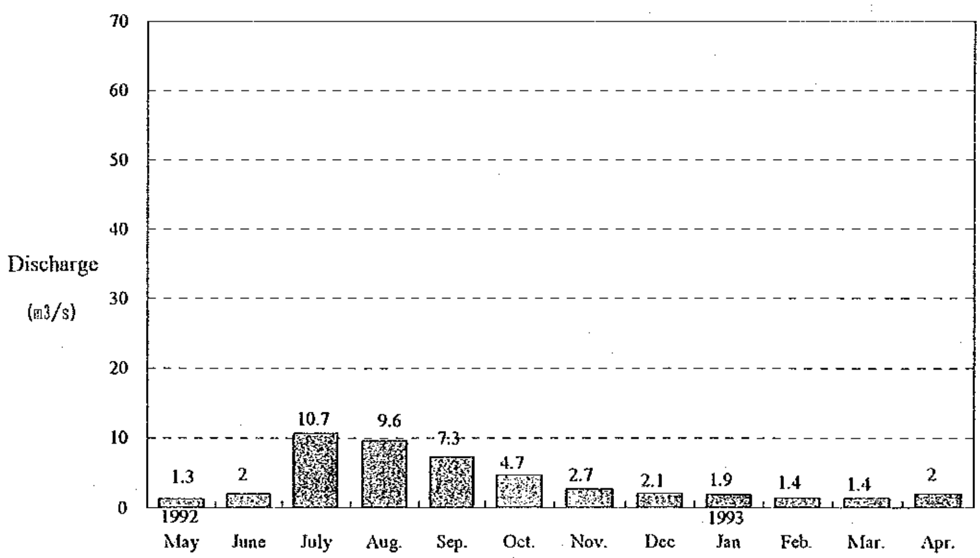



**Fig. II.2.12 Monthly Mean Discharge (May 1992 - April 1993)**

## II.3 Design Flood Discharge at the Intake for Puwa Khola

### II.3.1 Rational Formula Calculation

(1) Precipitation

100 year probable maximum daily precipitation will be calculated by precipitation data from the vicinity. There is only one station for precipitation measurement near the catchment area of the Project area, and this Station No. 1411 located at Soktim Tea Estate. Table II.3-1 shows the maximum daily precipitation each year from 1971 to 1990.

**Table II.3-1 Year Wise Maximum Daily Precipitation at Soktim Tea Estate (Station No. 1411)**

| Date | | | Max. Daily Precipitation (mm/day) |
|---|---|---|---|
| 1971 | Aug | 17 | 180 |
| 1972 | Sep | 26 | 161 |
| 1973 | Jun | 12 | 133 |
| 1974 | Jul | 28 | 274 |
| 1975 | Sep | 1 | 182 |
| 1976 | -- | -- | -- |
| 1977 | -- | -- | -- |
| 1978 | Sep | 19 | 119 |
| 1979 | Jul | 24 | 215 |
| 1980 | Oct | 7 | 178 |
| 1981 | Jul | 3 | 143 |
| 1982 | Jul | 24 | 119 |
| 1983 | Sep | 4 | 90 |
| 1984 | Jul | 8 | 159 |
| 1985 | Jul | 28 | 278 |
| 1986 | Sep | 4 | 225 |
| 1987 | Aug | 10 | 187 |
| 1988 | Jul | 8 | 145 |
| 1989 | Jul | 26 | 185 |
| 1990 | Aug | 12 | 258 |

Probability for maximum daily precipitation is assumed as per the following table in accordance with Iwai's method.

**Table II.3-2 Probable Maximum Daily Precipitation at ST 1411**

| Probability | Return Period (yrs) | Maximum Daily Rainfall (mm/day) | | |
|---|---|---|---|---|
| | | ST 1411 | ST 1417 | ST 1410 |
| 1/10 | 10 | 252 | 148 | 222 |
| 1/20 | 20 | 278 | 172 | 249 |
| 1/30 | 30 | 292 | 186 | 265 |
| 1/50 | 40 | 310 | 203 | 284 |
| 1/100 | 100 | 33 | 227 | 311 |
| 1/200 | 200 | 356 | 252 | 337 |

Table II.3-2 includes maximum rainfall for ST 1417 and ST 1410 as well; however, values for ST 1411 are higher.

Design maximum precipitation at the Puwa Khola is 333 mm/day for a return period of 100 years, as computed from data from ST 1411.

(2) Time Until Arrival of Flood Peak

Time until arrival of flood peak at the intake site is as follows according to Bayern's formula:

$$T = \frac{L}{W}$$

$$W = 72\left(\frac{H}{L}\right)^{0.6}$$

where : T = time until arrival of flood peak (h)
L = horizontal distance (km)
H = vertical distance (km)
W = flood approach velocity (km/h)

Longitudinal profile for the riverbed is shown in Figure II.3-1, and flood approach velocity is calculated as follows.

$$W_1 = 72\left(\frac{0.14}{6.20}\right)^{0.6} = 7.41 \ (km/h)$$

$$T_1 = \frac{6.20}{7.41} = 0.84(h)$$

$$W^2 = 72\left(\frac{0.24}{6.08}\right)^{0.6} = 10.35\ (km/h)$$

$$T_2 = \frac{6.08}{10.35} = 0.59\ (h)$$

$$W_3 = 72\left(\frac{0.49}{7.15}\right)^{0.6} = 14.42\ (km/h)$$

$$T_3 = \frac{7.15}{14.42} = 0.50\ (h)$$

$$W_3 = 72\left(\frac{0.60}{5.12}\right)^{0.6} = 19.89\ (km/h)$$

$$T_4 = \frac{5.12}{19.89} = 0.26\ (h)$$

$$W_5 = 72\left(\frac{0.64}{3.00}\right)^{0.6} = 28.49\ (km/h)$$

$$T_5 = \frac{3.00}{28.49} = 0.11\ (h)$$

Accordingly:

$$\begin{aligned} T = T_1 + T_2 + T_3 + T_4 + T_5 &= 2.3\ (h) \\ &= 138.0\ (\text{min}) \end{aligned}$$

Time until arrival of flood peak is calculated by the following equation:

$$\frac{Rt}{R_{24}} = \frac{34710}{T^{1.35} + 1502}\ (\%)$$

| | | | |
|---|---|---|---|
| Where : | T | = | time until arrival of flood peak (min) |
| | $R_t$ | = | total precipitation within arrival time (mm/hour) |
| | $R_{24}$ | = | design max. daily precipitation (mm/day) |

$$\frac{R_t}{333} = \frac{34710}{(138)^{1.35} + 1502} \div 100 = 0.152$$

$\therefore\ R_t = 0.152 \times 333 = 50.6$ (mm/h)

## (3) Design Flood discharge

Peak flood discharge is calculated as follows :

$$Q = \frac{1}{3.6} \times f \times Rt \times A$$

where :

| | | |
|---|---|---|
| Q | = | peak flood discharge ($m^3/s$) |
| f | = | discharge coefficient (0.8 from Table II.3-3) |
| $R_t$ | = | total precipitation within arrival time (50.6 mm/hour) |
| A | = | catchment area (125.1 $km^2$) |

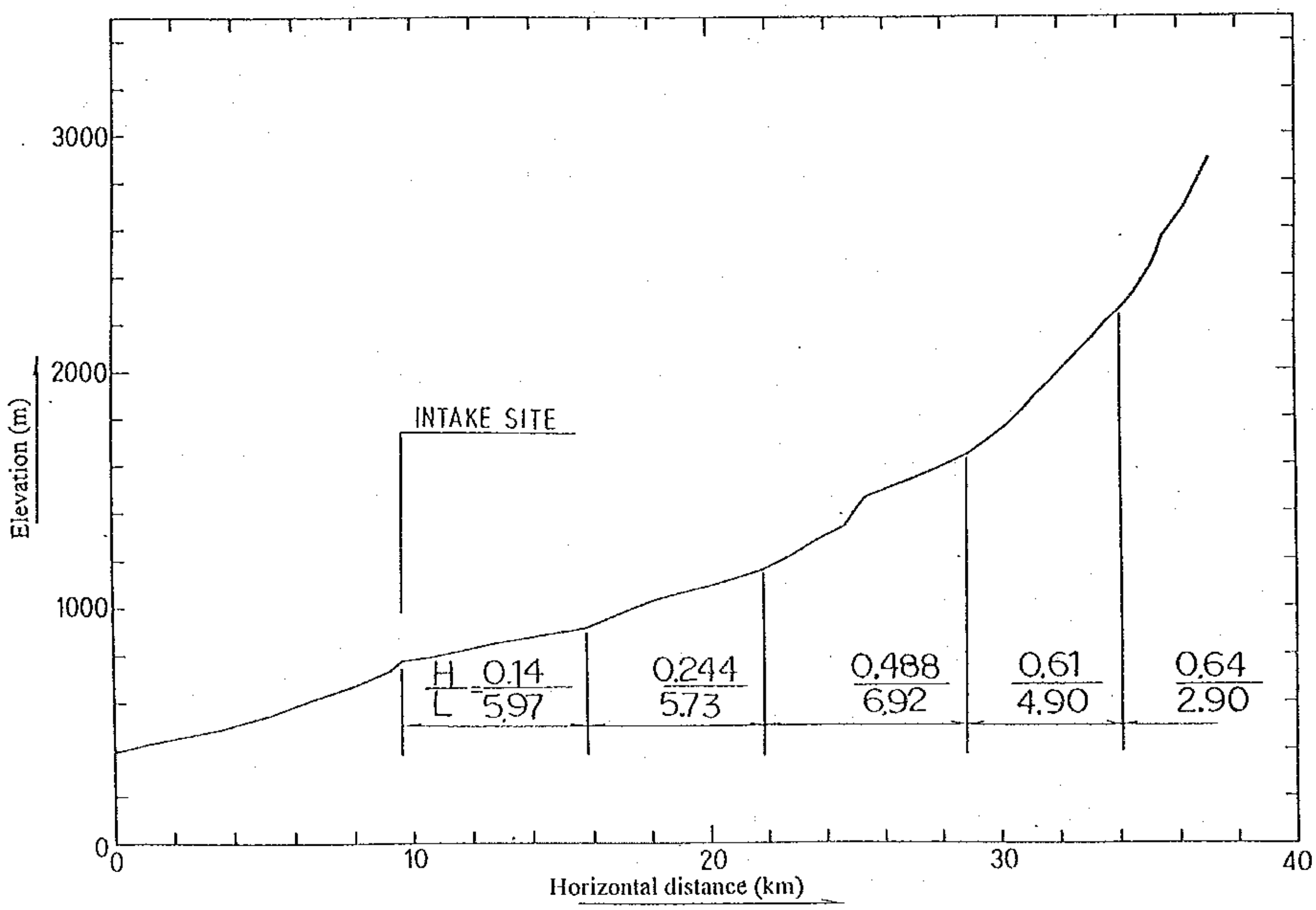
**Table II.3-3 Discharge Coefficient f**

| Topographic Condition | Discharge Coefficient f |
|---|---|
| River in steep mountain area (← Project area) | 0.75 ~ 0.90 |
| River in hilly area | 0.75 ~ 0.85 |
| Small river with flat catchment area | 0.45 ~ 0.75 |
| Large river with over half of catchment as flat area | 0.50 ~ 0.75 |

$$Q = \frac{1}{3.6} \times 0.8 \times 50.6 \times 125.1 = 1{,}407 \ m^3/s$$

$$\cong 1{,}450 \ m^3/s$$

**Figure II-3-1 River Section for Puwa Khola**



## II.3.2 Actual Trace of Flood level

Flood discharge is assumed from actual trace of flood level. Figure II.3.2 shows the river section at the intake site, and the past trace of maximum high water level.

Flood discharge is calculated as follows:

$$Q = V \cdot A$$

where : Q = flood discharge ($m^3/s$)
V = stream velocity (m/s)
A = sectional area of the river ($m^2$)

Stream velocity V is given as follows:

$$V = \frac{1}{n} \cdot (R)^{\frac{2}{3}} \cdot (I)^{\frac{1}{2}}$$

where : n = roughness coefficient
R = depth radius ($= \frac{A}{\ell} = \frac{\text{sectional area}}{\text{river bed length}}$)
I = water surface gradient

Roughness coefficient is determined as 0.05 from Table II.3-4, on the basis of stream being mountain stream with boulders in the stream channel.

**Table 1.4-3 Roughness Coefficient**

| Type of River Channel | Condition | Roughness Coefficient | |
|---|---|---|---|
| | | Upper | Lower |
| Small and flat | -without grass, straight , no valleys or peaks in the river cross section | 0.025 | 0.033 |
| | -without grass, however, meandering and with some peaks and valleys in the river cross section | 0.033 | 0.045 |
| | -same as above, and with much stone and grass | 0.045 | 0.060 |
| Mountain river | -with gravel, rubble stone and some boulder | 0.030 | 0.050 |
| (Project area →) | -with rubble stone and large boulders | 0.040 | 0.070 |
| Large river | -regular form | 0.025 | 0.060 |
| | -irregular section | 0.035 | 0.100 |

In the case of the Project:

$I = {}^{1}/_{40}$ according to topographical mapping
A = 44.8 $km^2$ (according to Figure II.3-2)

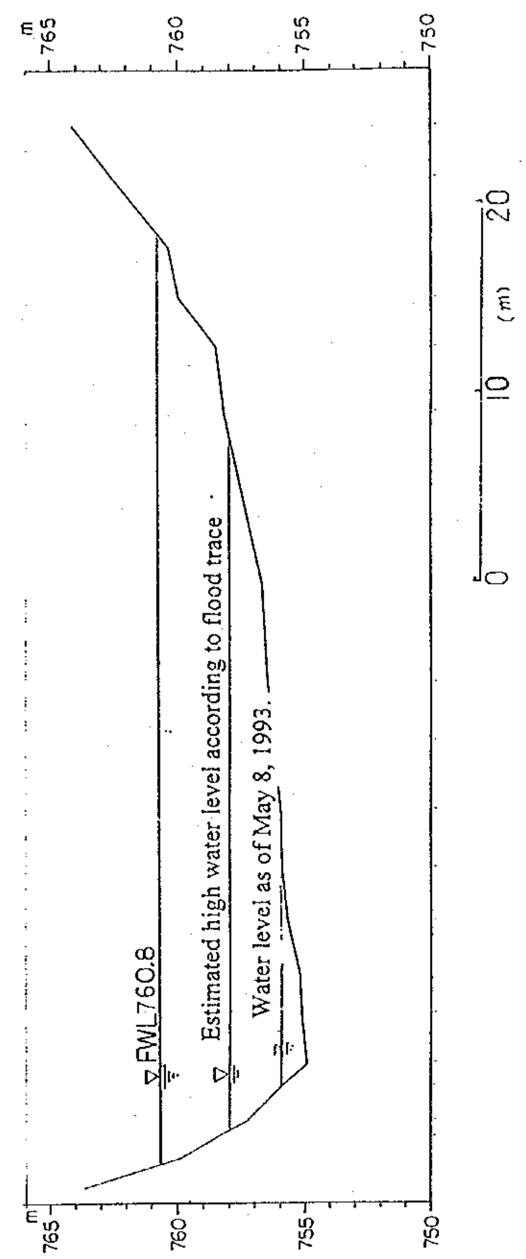
$\ell$ = 28.5 m (according to Figure II.3-2)

$$V = \frac{1}{0.05} \times \left(\frac{44.8}{28.5}\right)^{\frac{2}{3}} \times \left(\frac{1}{40}\right)^{\frac{1}{2}}$$
$$= 4.28(m/s)$$

$$\begin{aligned} Q &= 4.28 \times 44.8 \\ &= 181.7 \\ &\cong 190\ (m^3/s) \end{aligned}$$

Design discharge is determined at 1,450 $m^3/s$ by applying the rational formula adopting the higher value.

## Figure II.3-2 Cross Section of Puwa Khola at Diversion Point



## II.4 Design Flood Discharge at the Power House Site for Mai Khola

### II.4.1 Rational Formula Calculation

(1) Precipitation

As in the case of the Puwa khola, rainfall at ST 1411 (Soktim Tea Estate) is adopted yielding a design maximum rainfall of 333 mm/day.

(2) Time Until Arrival of Flood Peak

Time until arrival of flood peak at the power house site is as follows:

$$T = \frac{L}{W}$$

$$W = 72\left(\frac{H}{L}\right)^{0.6}$$

where :

| | | |
|---|---|---|
| T | = | flood arrival time ($h$) |
| L | = | horizontal distance (km) |
| H | = | vertical distance (km) |
| W | = | Flood approach velocity (km/$h$) |

Longitudinal profile of the river bed is shown in Figure II.4-1, and flood approachvelocity is calculated as follows:

$$W_1 = 72\left(\frac{0.18}{8.35}\right)^{0.6} = 7.20 \ (km/h)$$

$$T_1 = \frac{8.35}{7.20} = 1.16 \quad (h)$$

$$W_2 = 72\left(\frac{0.31}{8.33}\right)^{0.6} = 9.99 \ (km/h)$$

$$T_2 = \frac{8.33}{9.99} = 0.83 \quad (h)$$

$$W_3 = 72\left(\frac{0.91}{12.80}\right)^{0.6} = 14.74 \ (km/h)$$

$$T_3 = \frac{12.80}{14.74} = 0.87 \quad (h)$$

$$W_4 = 72\left(\frac{0.49}{3.75}\right)^{0.6} = 21.23 \ (km/h)$$

$$T_4 = \frac{3.75}{21.23} = 0.18 \quad (h)$$

$$W_5 = 72\left(\frac{1.04}{2.23}\right)^{0.6} = 45.56 \ (km/h)$$

$$T_5 = \frac{2.23}{45.56} = 0.50 \quad (h)$$

Accordingly:

$$T = T_1 + T_2 + T_3 + T_4 + T_5$$
$$= 3.09\ (h)$$
$$=185.4\ (\text{min})$$

Flood arrival time is calculated by the following equation.

$$\frac{R_t}{R_{24}} = \frac{34710}{T^{1.35} + 1502}\quad (\%)$$

| | | | |
|---|---|---|---|
| where : | $T$ | = | flood arrival time (185.4 min) |
| | $Rt$ | = | total precipitation within arrival time (mm/h) |
| | $R_{24}$ | = | design max. daily precipitation (333 mm/day) |

$$\frac{R_t}{333} = \frac{34710}{(185.4)^{1.35} + 1502} \div 100$$
$$= 0.131$$
$$\therefore\ R_t = 0.131 \times 333 = 43.6\ (mm/h)$$

(3) Design Flood Discharge

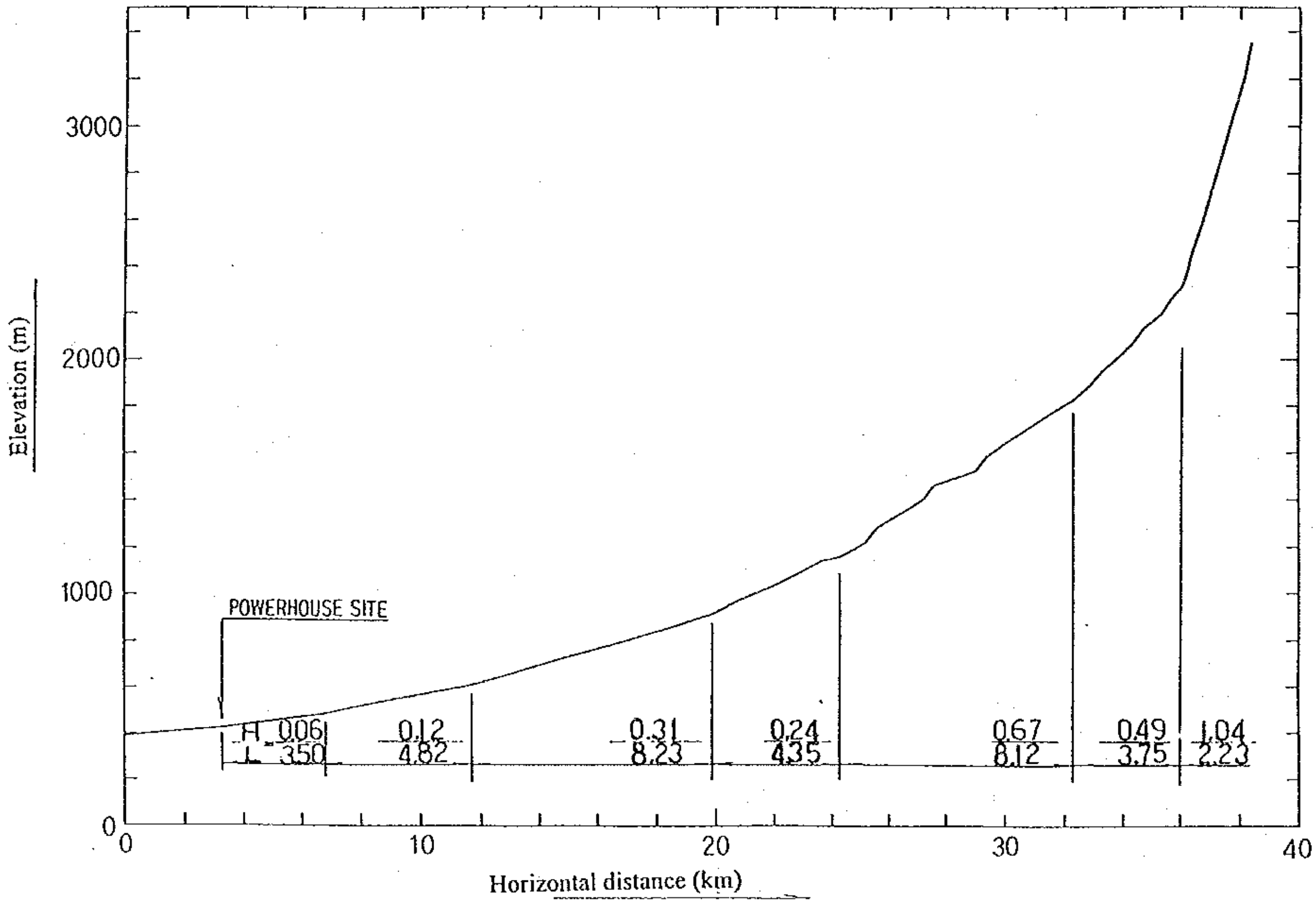
Peak flood discharge is calculated as follows:

$$Q = \frac{1}{3.6} \times f \times R_t \times A$$

| | | | |
|---|---|---|---|
| where : | Q | = | peak flood discharge ($m^3/s$) |
| | f | = | discharge coefficient (0.08 from Table II.3-3) |
| | $R_t$ | = | Total precipitation within arrival time (= 43.6 mm/$h$) |
| | A | = | catchment area (= 386.2 $km^2$) |

$$Q = \frac{1}{3.6} \times 0.8 \times 43.6 \times 386.2 = 3{,}742\, m^3/s$$
$$\cong 3{,}750\, m^3/s$$

**Figure II.4-1 Longitudinal Profile of Mai Khola at Diversion Point**



## II.5 Water Level - Discharge Curve

### II.5.1 Intake Site

Water level - discharge curve is prepared on the basis of topo-section at the intake site and applying the following formula for each water level:

$$Q = A \cdot V$$

where
- $Q$ = discharge ($m^3/s$)
- $V$ = stream velocity (m/s)
- $A$ = sectional area of river ($m^2$)

V is computed as follows:

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

where
- $n$ = roughness coefficient (= 0.05 according to Table 1.4-3)
- $R$ = river radius ($= \frac{A}{\ell} = \frac{\text{cross-sectional area}}{\text{river bed length}}$)
- $I$ = water surface gradient (= 1/40)

River section is shown in Figure II.3-2, and the relation between water level and discharge is calculated in Table II.5-1.

**Table II.5-1 Relation between Water Level and Discharge at Intake Site**

| | Water Level (m) | Sectional Area ($m^2$) | Velocity (m/s) | Discharge ($m^3/s$) |
|---|---|---|---|---|
| 756 | 1.0 | 22.6 | 2.89 | 65.3 |
| 757 | 2.0 | 50.2 | 4.40 | 220.9 |
| 758 | 3.0 | 81.4 | 5.63 | 458.3 |
| 759 | 4.0 | 115.1 | 6.73 | 774.6 |
| 760 | 5.0 | 151.2 | 7.61 | 1,150.6 |
| 761 | 6.0 | 189.9 | 8.38 | 1,591.4 |
| 762 | 7.0 | 231.4 | 9.09 | 2,103.4 |
| 763 | 8.0 | 276.7 | 9.59 | 2,653.6 |

Water level elevation - discharge curve is shown in Figure 3.7-8. From the figure, maximum high water at 100 year's return period of 1,450 $m^3/s$ is assumed to be EL 760.8 m.

## II.5.2 Power House Site

Discharge at the power house site is according to the following equation:

$$Q = A \cdot v$$

*where:*

| | | |
|---|---|---|
| $Q$ | = | *discharge* ($m^3/s$) |
| $v$ | = | *discharge velocity* ($m/s$) |
| $A$ | = | *sectional area of river* ($m^2$) |

Discharge velocity is according to the following equation:

$$v = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

where:

| | | |
|---|---|---|
| n | = | 0.04 according to Table II.4-3 for river channel in mountainous area with gravel, rubble stone and some boulders |
| R | = | depth radius $(= \frac{A}{\ell} = \frac{\text{cross-sectional area}}{\text{river bed length}})$ |
| I | = | water surface gradient (= 1/70) |

The sectional area of the river is shown in Figure II.5-1.

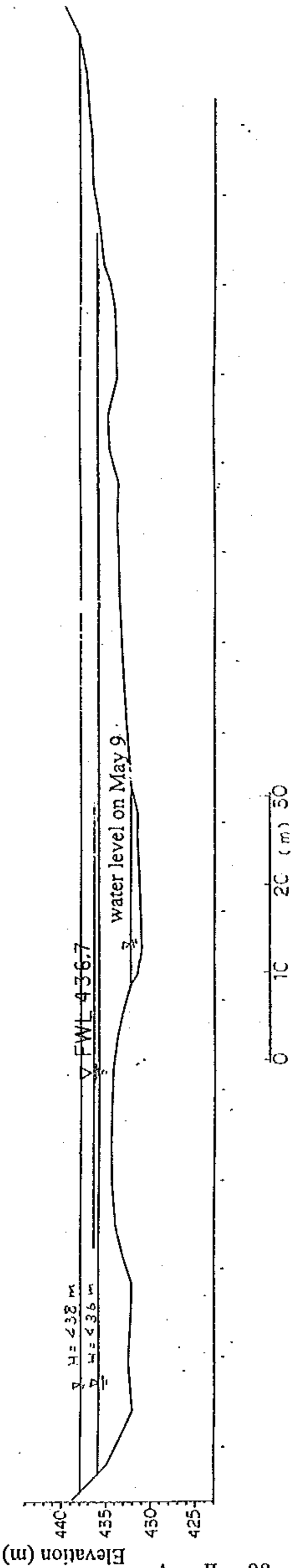
Relationship between water level and discharge is calculated in Table II.5-2.

**Table II.5-2 Relation between Water Level and Discharge**

| Elevation (m) | Water Level (m) | Sectional Area ($m^2$) | Discharge Velocity (m/s) | Discharge ($m^3/s$) |
|---|---|---|---|---|
| 443 | 2.0 | 64.1 | 3.04 | 220 |
| 444 | 3.0 | 156.7 | 3.52 | 551 |
| 445 | 4.0 | 290.6 | 4.75 | 1,380 |
| 446 | 5.0 | 437.2 | 6.13 | 2,680 |
| 447 | 6.0 | 586.4 | 7.36 | 4,310 |
| 448 | 7.0 | 737.9 | 8.47 | 6,250 |

The water level - discharge curve determined from Table II.5-2 is shown in Figure 3.7-9, and maximum high water level at 100 year's return period of 3,750 $m^3/s$ from the figure is assumed to be EL 436.7 m.

**Figure II.5-1** **River Cross Section for the Power House Site on the Mai Khola (N.T.S. )**



## ANNEX - III CIVIL WORKS

## ANNEX III CIVIL WORKS

### III-1 Intake Weir

1) Length of Crest

(1) Design conditions :
Flood discharge : Q = 1,450 $m^3/s$
Type of weir : Ogee type, trapezoid concrete weir

(2) Overflow discharge :

$$Q = \mu \cdot B \cdot h_1 \sqrt{2g \cdot h_1} \quad (m^3/s) \quad : \text{ Honma's formula}$$

Where $\mu$ : Coefficient of discharge $(0.29 + 0.32 \frac{h_1}{D})$
$h_1$ : Water depth at upstream side = (m)
B : Breadth of weir = 33 m
g : Acceleration of gravity = 9.8 $m/sec^2$
D : Mean height of weir = 3.0 m

Assuming $h_1$ = 5.7 m (→ HWL at weir EL. 764.500)

$$\mu = 0.31 + 0.23 \times \frac{5.7}{3} = 0.73$$

$$Q = 0.73 \times 33 \times 5.7 \times \sqrt{2 \times 9.8 \times 5.7} = 1{,}451.3 m^3/s \rangle 1{,}450 m^3/s \qquad \text{OK}$$

(Velocity load is ignored.)

2) Tyrollean Type Intake

(1) Design conditions :

Design intake discharge : Q = 2.5 $m^3$/sec
Size of grating : FB 30 × 15 ctc 25mm

Formula : $\dfrac{dQ}{dx} = -q = -\mu \cdot B \cdot \psi \cdot \sqrt{2g \cdot h_0}$ .............(1)

Where $\mu$ : Coefficient of discharge (0.4)
B : Length of gallery (m)
$\psi$ : Slot ratio ($\Sigma s$/B)
$s$ : Slot width

(2) Required length of gallery (Le)

Slot ratio

$$\psi = \frac{\frac{1.0}{0.025} \times 0.01}{1.0} = 0.4$$

Upstream overflow depth ($H_0 = H$)

From $Q = C \cdot B \cdot H^{3/2}$

| | | | |
|---|---|---|---|
| Where | C | : | Coefficient of discharge = 1.552 |
| | B | : | Unit Width = 1.0m |
| | H | : | Overflow depth |
| | Q | : | Discharge = 2.5 m³/sec |

$$\therefore \quad H = \left(\frac{C \cdot B}{Q}\right)^{2/3} = \left(\frac{1{,}552}{2.5}\right)^{\frac{2}{3}} = 0.73m$$

From equation (1)

$q = 0.4 \times 1.0 \times 0.4 \times \sqrt{2 \times 9.8 \times 0.73} = 0.605 m^3/s/m$

Assuming the slot closed by 70 %

$q_{30} = 0.3 \times 0.605 = 0.18$ m³/s/m

∴ Required gallery length:

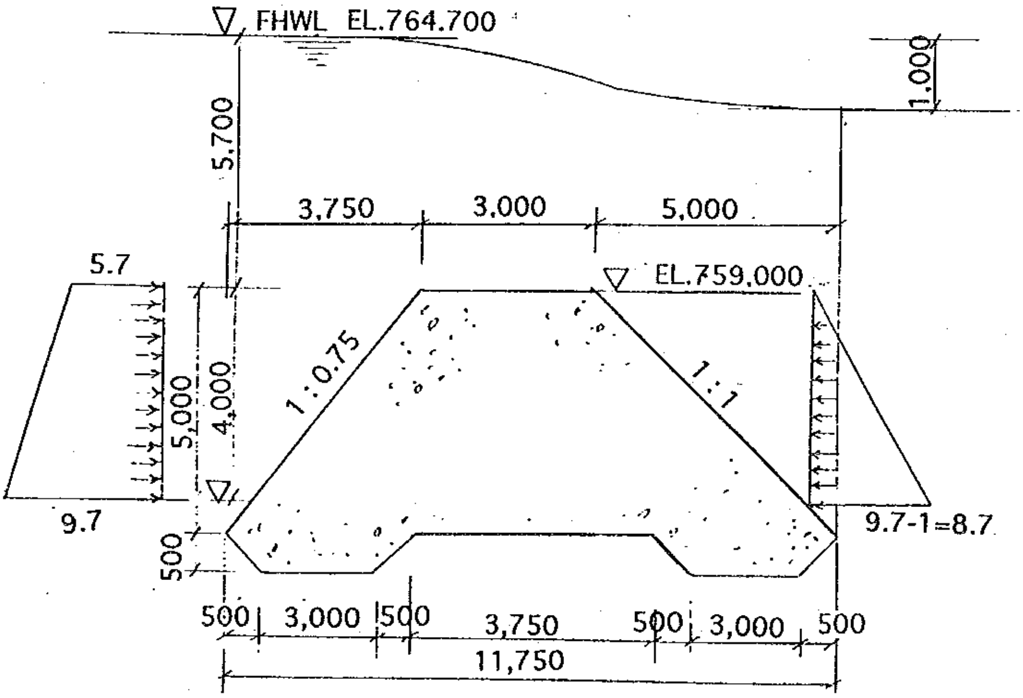
$Le = \frac{2.5}{0.18} = 13.88\ m$

use 16.5 m (≅ increased 20 %)

## 3) Stability of Intake Dam

### (1) Design condition

| | | |
|---|---|---|
| Unit weight of dam | : | Ws = 2.35 t/m³ |
| Specific gravity of sediment | : | λs = 2.70 |
| Co, of uplifting | : | ψ = 0.50 |
| Co, of soil pressure | : | Ks = 0.50 |
| Seismic Co. | : | $K_H$ = 0.12 |
| Bearing capacity | : | *qa* = 2.0 t/m² |
| Safety factor of sliding | : | $f_a$ = 0.85 |
| Calculated condition | : | Flood & seismic condition |
| Calculated cross section | : | vide below figure |
| acting point of resultant force | : | within middle third |



(2) Stress calculation

(a) Dead weight

$$V_1 = \frac{3 \times 11.75}{2} \times 5 + 2 \times \left( \frac{3+4}{2} \times 0.5 \right) = 40.375\ m^2$$

$$W_1 = 2.35 \times 40.375 = 94,881t$$

Gravity center

$$y = \frac{93.304}{40.375} = 2.319\ m$$

$$x = \frac{246.448}{40.375} = 6.104\ m$$

(b) Seismic force

$$F_1 = K_H \cdot W_1 = 0.12 \times 94.881t = 11.386t$$

$$y = 2.319\ m$$

(c) Water pressure and weight

(i) Water static pressure (upstream side)

$$P_1 = \frac{5.7 + 9.7}{2} \times 4.0 = 30.8t$$

$$y = \frac{4}{3} + 1.5 = 2.833\ m$$

(downstream side)

$$P_2 = 8.7 \times 4 \times 0.5 = 17.4\text{t} \quad (-)$$

$$y = 2.833\ \text{m}$$

(ii) Water weight

$$W_2 = 3.75 \times 5.7 = 21.375\ \text{t}$$

$$x = 11.75\ \text{m}$$

$$W_3 = 3.75 \times 4 \times 0.5 = 7.5\text{t}$$

$$x = 11.75 - 3.75/3 = 10.5\ \text{m}$$

(d) Sediment pressure and weight :

$$w = 1.8 \times (2.7-1)/2.7 = 1.133 \text{ t/m}^3$$

(i) Sediment pressure

$$P_3 = 0.5 \times \frac{\left(1.133 \times 5^2\right)}{2} = 7.081t$$

$$y = 0.5 + 5/3 = 2.167\ m$$

(ii) Sediment weight

$$W_4 = \frac{1.133 \times 5 \times 3.75}{2} = 10.622t$$

$$x = 10.5\ m$$

(e) Uplifting force

$$U_1 = \frac{1}{2} w_0 \cdot \mu \cdot B \cdot H_1$$

$$= \frac{1}{2} x 1 \times 0.5 \times 11.75 \times 11.2 = 32.9t$$

$$W_5 = 32.9t\ (-)$$

$$x = \frac{11.75}{2} = 5{,}875\ m$$

(3) Calculation of stability

| Loads | N (t) | H (t) | X (m) | Y (m) | $M_x$ | $M_y$ |
|---|---|---|---|---|---|---|
| Dead weight | 94.881 | | 6.104 | | 579.154 | |
| Seismic force | | 11.386 | | 2.319 | | 26.404 |
| Water weight | 21.375 | | 11.75 | | 251.156 | |
| ditto | 7.5 | | 10.5 | | 78.75 | |
| Water pressure (upstream) | | 30.8 | | 2.833 | | 87.256 |
| ditto (downsteram) | | -17.400 | | 2.833 | | -49.294 |
| Sediment | | 7.081 | | 2.167 | | 15.345 |
| ditto | 10.662 | | 10.5 | | 111.531 | |
| Uplift | -32.9 | | 5.875 | | -193.288 | |
| | 101.478 | 31.867 | | | 827.303 | 79.711 |

$$\Sigma M = Mx - My = 827.303 - 79.711 = 747.592^{t\cdot m}$$

(a) Stability against overturning

$$\chi_0 = \frac{\Sigma M}{\Sigma N} = \frac{747,592}{101,478} = 7.367m$$

$$e = \left|\chi_0 - \frac{B}{2}\right| = \left|7.367 - \frac{11.75}{2}\right| = 1.492m \ \langle\ \frac{B}{6} = 1.958m$$ OK

(b) Stability for sliding

$$f_a = \frac{\Sigma M}{\Sigma N} = \frac{31.867}{101.478} = 0.314 \ \langle\ 0.85$$ OK

(c) Bearing capacity

$$q_{max} = \frac{\Sigma N}{B}\left(1 + \frac{6e}{B}\right) = \frac{101,478}{11.75}\left(1 + \frac{6 \times 1.492}{11.75}\right) = 15.217t/m^2$$

$\langle\ 20t/m^2$ OK

## III-2 Effective Head

### 1. Design Conditions

Effective heads are calculated for both cases of maximum discharge (Q=2.5 $m^3$/sec) and firm discharge (Q=1.1$m^3$/s).

The water levels for both cases are as follows ;

Max. discharge WL = 756.90 m

Firm discharge WL = 755.58 m (bed elevetion at the end of tunnel EL = 755.00m + uniform flow depth 0.58m)

Head from head tank WL. to T-G centre (EL.438.7) for each case are EL.318.20 at max.discharge and EL.316.88 at firm discharge.

### 2. Symbols in Calculation

Symbols and their units used in calculation are as follows ;

| | | |
|---|---|---|
| V | : | Flow velocity (m / s) |
| Q | : | Flow discharge (flow rate) ($m^3$ / s) |
| A | : | Flow sectional area( $m^2$) |
| f | : | Head loss coefficient |
| g | : | Gravity accelaration (=9.8m / $sec^2$) |
| n | : | Roughness coefficient |
| L | : | Canal length (m) |
| θ | : | Pipe bent angle (° ) |
| D | : | Pipe innner dia. (m) |
| ρ | : | Curvature radius (m) |
| h | : | Head loss (m) |

## 3. Calculation of Head Loss

Head loss is obtained by means of totaling the following individual losses.

### 1) Head Losses at Head Tank :

(1) Screen loss

$$h_{1-(1)} = fr\frac{V^2}{2g} = \beta \sin\theta \left(\frac{t}{b}\right)^{4/3} \frac{1}{2gA^2} Q^2$$

| | | | |
|---|---|---|---|
| Where | $\beta$ | : | Shape coefficient of screen bar = 2.34 |
| | $\theta$ | : | Inclined angle of screen = 75° |
| | t | : | Thickness of bar = 1.0 cm |
| | b | : | Slot width |
| | A | : | Flow sectional area of screen |
| | | | Max. discharge A=2.4 × 5.0 = 12.0 cm² |
| | | | Firm discharge A=1.08 × 5.0 = 5.4 cm² |

a. at max. discharge

$$h_{1-(1)} = 2.34 \times \sin 75° \times \left(\frac{1}{4}\right)^{4/3} \times \frac{1}{2*9.8*12.0^2} \times Q^2$$
$$= 1.261 \times 10^{-4} Q^2$$

b. at firm discharge

$$h_{1-(1)} = 2.34 \times \sin 75° \times \left(\frac{1}{4}\right)^{4/3} \times \frac{1}{2*9.8*5.4^2} \times Q^2$$
$$= 6.229 \times 10^{-4} Q^2$$

(2) Total of head losses at head tank

$$h_1 = h_{1-(1)}$$

$\therefore$ at max.discharge $h_1 = 1.261 \times 10^{-4} Q^2$

at firm discharge $h_1 = 6.229 \times 10^{-4} Q^2$

## 2) Head Losses at Penstock

(1) Head loss at inflow

$$h_{2\text{-}(1)} = fe\frac{V^2}{2g} = fe\frac{1}{2gA^2}Q^2$$

| | | | |
|---|---|---|---|
| Where | fe | : | Coefficient of inflow loss |
| | A | : | Flow sectional area after inflow |

$$\therefore\ h_{2\text{-}(1)} = 0.20 \times \frac{1}{2 \times 9.8 \times 0.95^2} \times Q^2$$
$$= 113.065 \times 10^{-4} Q^2$$

(2) Head losses due to friction

$$h_{2\text{-}(2)} = f\frac{L}{D}\frac{V^2}{2g} = 124.5n^2\frac{L}{D^{4/3}}\frac{Q^2}{2g\left(\frac{\pi D^2}{4}\right)^2}$$

| | | | |
|---|---|---|---|
| Where | f | : | Coeffient of loss |
| | D | : | Pipe inner dia. (m) |
| | L | | Pipe length (m) |

Therefore

$$h_{2\text{-}(2)} = 124.5n^2 \times \frac{4^2}{2 \times 9.8 \times \pi} \times \frac{L \cdot Q^2}{D^{16/3}}$$
$$= 14.828 \times 10^{-4} \times \frac{L \cdot Q^2}{D^{16/3}}$$

note : Average value of pipe dia. is adopted at transition section flow rate after diversion Q'= Q / 2.

| D (m) | $D^{16/3}$ (m) | L (m) | $\frac{L}{D^{16/3}}$ | $h_{2-(2)}$ (m) | |
|---|---|---|---|---|---|
| 1.100 | 1.662 | 284.00 | 170.878 | 2533.779 $\times 10^{-4} Q^2$ | Steel pipe (n=0.012) |
| 1.100~1.050 (1.075) | 1.471 | 2.000 | 1.360 | 20.167 $\times 10^{-4} Q^2$ | " |
| 1.050 | 1.297 | 298.00 | 229.761 | 3406.896 $\times 10^{-4} Q^2$ | " |
| 1.050~0.950 (1.000) | 1.000 | 2.000 | 2.000 | 29.658 $\times 10^{-4} Q^2$ | " |
| 0.95 | 0.761 | 150.00 | 197.109 | 2922.732 $\times 10^{-4} Q^2$ | " |
| 0.950~0.850 (0.900) | 0.570 | 2.000 | 3.509 | 52.035 $\times 10^{-4} Q^2$ | " |
| 0.85 | 0.420 | 240.50 | 572.619 | 8490.795 $\times 10^{-4} Q^2$ | " |
| 0.850~0.600 (0.725) | 0.180 | 4.000 | 22.222 | 329.508 $\times 10^{-4} Q^2$ | " |
| 0.6 | 0.066 | 7.500 | 113.636 | 1684.995 $\times 10^{-4} Q^2$ | Steel pipe (n=0.012) |
| Total | | 990.000 | | 19470.565 $\times 10^{-4} Q^2$ | |

$$\therefore \quad h_{2\text{-}(2)} = 19{,}470.565 \quad \times 10^{-4}\, Q^2$$

(3) Head losses of bent pipe

$$h_{2-(3)} = f_{b1} \cdot f_{b2} \cdot \frac{V^2}{2g} = f_{b1} \cdot f_{b2} \frac{Q^2}{2g\left(\frac{\pi D^2}{4}\right)^2}$$

$$= 0.08271 \times f_{b1} \times f_{b2} \times \frac{1}{D^4} Q^2$$

Where $f_{b1}$ : Head loss at pipe bent of 90°
$f_{b2}$ : coefficient of correction for any bent angle

note : Flow rate after diversion Q' = Q/2

| Pipe dia. D (m) | Center angle q (°) | Curvature radius ρ (m) | ρ / D | b1 | b2 | h 2-(3) (m) | Remarks |
|---|---|---|---|---|---|---|---|
| 1,100 | 18°, 0' | 5.0 | 4.550 | 0.08 | 0.35 | $15.817 \times 10^{-4} Q^2$ | |
| " | 12°, 2' | " | " | " | 0.22 | 9.942 " | Compound angle |
| 1,050 | 10°, 30' | " | 4.760 | " | 0.20 | 11.976 " | |
| " | 13°, 0' | " | " | " | 0.23 | 12.520 " | |
| " | 22°,22' | " | " | " | 0.40 | 21.774 " | Compound angle |
| " | 8°, 30' | " | " | " | 0.18 | 9.798 " | |
| 0.950 | 15°, 2' | " | 5.260 | " | 0.30 | 24.371 " | Compound angle |
| " | 18°, 30' | " | " | " | 0.35 | 28.433 " | |
| " | 15°, 0' | " | " | " | 0.28 | 22.746 " | |
| " | 7°, 7' | " | " | " | 0.17 | 13.810 " | Compound angle |
| 0.850 | 10°, 0' | " | 5.880 | " | 0.20 | 25.351 " | |
| " | 63°, 26' | " | " | " | 0.84 | 106.477 " | Compound angle |
| " | 10°, 0' | " | " | " | 0.20 | 25.351 " | |
| " | 54°, 43' | " | " | " | 0.78 | 98.871 " | Compound angle |
| 0.600 | 39°, 0' | " | 8.330 | " | 0.61 | 311.438 " | after diversion |
| Total | | | | | | 738.675 " | |

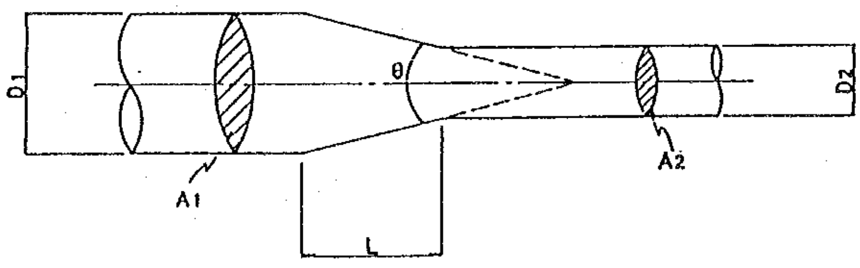
$\therefore\ h_{2-(3)} = 738.675 \times 10^{-4} Q^2$

(4) Head loss due to gradual contraction

$$h_{2-(4)} = f_{gc} \cdot \frac{V^2}{2g} = f_{gc} \cdot \frac{Q^2}{2g\left(\frac{\pi D_2^{\ 2}}{4}\right)^2}$$

$$= 0.08271 \times f_{gc} \times \frac{1}{D_2^{\ 4}} Q^2$$

$f_{gc}$ ; Head loss coefficient of gradual contraction
V ; Flow velocity after gradual contraction (m/s)



| D1 (m) | D2 (m) | L (m) | $\theta = 2\tan^{-1}\left(\frac{D_1-D_2}{2L}\right)$ | $\frac{A_2}{A_1}$ | $f_{gc}$ | $h_{2\text{-}(4)}$ (m) |
|---|---|---|---|---|---|---|
| 1,100 | 1.050 | 2.00 | 0 °, 43' | 0.911 | 0.0001 | 0.068 $\times 10^{-4}$ Q² |
| 1,050 | 0.950 | 2.00 | 1 °, 26' | 0.819 | 0.0001 | 0.102 " |
| 0.950 | 0.850 | 2.00 | 2 °, 26' | 0.801 | 0.0001 | 0.158 " |
| 0.850 | 0.600 | 4.00 | 3 °, 35' | 0.498 | 0.0005 | 2.317 " |
| Total | | | | | | 2.645 " |

$$h_{2\text{-}(4)} = 2.645 \times 10^{-4} Q^2$$

(5) Head loss due to diversion

$$h_{2-(5)} = f_B \cdot \frac{V^2}{2g} = f_B \cdot \frac{Q^2}{2g\left(\frac{\pi D_1^2}{4}\right)^2}$$

$$= 0.08271 \times f_B \times \frac{1}{D_1^4} Q^2$$

Where $f_B$ : Head loss coefficient due to diversion

= 0.50 (Y shaped diversion)

V : Flow velocity after diversion (m/s)

$$\therefore\ h_{2-(5)} = 0.8271 \times 0.50 \times \frac{1}{0.85^4} Q^2 = 792.232 \times 10^{-4} Q^2$$

(6) Head loss due to inlet valve

$$h_{2-(6)} = f_r \cdot \frac{V^2}{2g} = f_r \cdot \frac{\left(\frac{1}{2}Q\right)^2}{2gA^2}$$

Where $f_r$ : Valve head loss = 0.30

A : Sectional area =1/4 ×π×0.60² = 0.283 m²

$$\therefore\ h_{2\text{-}(6)} = 0.30 \times \frac{1}{2 \times 9.8 \times 0.283^2 \times 4} \times Q^2$$

$$= 477.783 \times 10^{-4} Q^2$$

(7) Total head loss at penstock

| | | | | | |
|---|---|---|---|---|---|
| Inflow loss | $h_{2-(1)}$ | = | 113.065 | × | $10^{-4}Q^2$ |
| Friction loss | $h_{2-(2)}$ | = | 19,470.565 | × | $10^{-4}Q^2$ |
| Bend loss | $h_{2-(3)}$ | = | 738.675 | × | $10^{-4}Q^2$ |
| Gradual Contraction | $h_{2-(4)}$ | = | 2.645 | × | $10^{-4}Q^2$ |
| Diversion | $h_{2-(5)}$ | = | 792.232 | × | $10^{-4}Q^2$ |
| Inlet valve | $h_{2-(6)}$ | = | 477.783 | × | $10^{-4}Q^2$ |
| Total | $h_2$ | = | 21,594.965 | × | $10^{-4}Q^2$ |

3) Total head loss

(1) At max. discharge

| | | | | |
|---|---|---|---|---|
| Head loss at head tank | $h_1$ | = | 1.264 | $\times 10^{-4}Q^2$ |
| Head losses at penstock | $h_2$ | = | 21,594.965 | $\times 10^{-4}Q^2$ |
| Allowance | $h_3$ | = | 1,123.774 | $\times 10^{-4}Q^2$ |
| Total | h | = | 22,720.000 | $\times 10^{-4}Q^2$ |

(2) At firm discharge

| | | | | |
|---|---|---|---|---|
| Head loss at head tank | $h_1$ | = | 6.229 | $\times 10^{-4}Q^2$ |
| Head losses at penstock | $h_2$ | = | 21,594.965 | $\times 10^{-4}Q^2$ |
| Allowance | $h_3$ | = | 2,198.806 | $\times 10^{-4}Q^2$ |
| Total | h | = | 23,800.000 | $\times 10^{-4}Q^2$ |

Therefore, total head losses are as follows :

| | | | | |
|---|---|---|---|---|
| At max. discharge | Q | = | 2.50 | $m^3/sec$ |
| | $\therefore$ h | = | $2,272 \times 2.50^2$ | = 14.20 m |
| At firm discharge | Q | = | 1.10 | $m^3/sec$ |
| | $\therefore$ h | = | $2,380 \times 1.10^2$ | = 2.88 m |

## 4. Effective Head

### 1) Features

| | | | |
|---|---|---|---|
| (1) | Intake water level | 759.00 m | |
| (2) | Water level at head tank | 756.90 m | (at firm water level 755.58 m) |
| (3) | Turbine center level | 438.70 m | |
| (4) | Gross head | 320.30 m | |
| (5) | Max. design discharge | 2.50 $m^3$/sec | |

### 2) Effective head He

He = (2) - (3) - h

At max. power output He = 756.90 - 438.70 - 14.20 = 304.00 m

At firm power output He = 755.58 - 438.70 - 2.88 = 314.00 m

### 3 Power output

$$P = 9.8 \cdot Q \cdot He \cdot \eta t \cdot \eta g$$

| | | | |
|---|---|---|---|
| Where | Q | ; | Discharge ($m^3$/sec) |
| | He | ; | Effective head (m) |
| | $\eta_t$ | ; | Efficiency of turbine |
| | $\eta_g$ | ; | Efficiency of generator |

(1) At max. power output

$$P_{max} = 9.8 \times 2.50 \times 304.00 \times 0.85 \times 0.98$$
$$= 6{,}204.2 \text{ — } 6{,}200 \text{ kW}$$

(2) At firm power output

$$P = 9.8 \times 1.10 \times 314.00 \times 0.84 \times 0.96$$
$$= 2{,}729.5 \text{ — } 2{,}700 \text{ kW}$$

## III-3 Water Hammer and Penstock Strength Calculation

### 1) Water Hammer Calculation

Water hammer value is obtained from the Allievi's calculation diagram.

(1) Basic values :

| | | |
|---|---|---|
| Water level at head tank | WL | 756.90 m |
| Elevation of turbine center | EL | 438.70 m |
| Elevation of valve to be closed | EL | 437.10 m |
| Max. design discharge | Q | : 2.5 $m^3$/sec |
| Penstock length | L | : 990 m |
| Valve closing time | T | : 30 sec |

(2) Formula to be applied :

Water hammer value is obtained from the Allievi's calculation diagram.

(3) Mean flow velocity in penstock pipe

$$V_o = \frac{Q}{A_o}$$

$$A_o = \frac{L}{\Sigma(\ell_i / A_i)}$$

| | | |
|---|---|---|
| $V_o$ | : | Mean flow velocity (m/sec) |
| $A_o$ | : | Average sectional area |
| $\ell_i, A_i$ | : | No. *i*-th section length (m) and sectional area |

| D (m) | $A_i$ ($m^2$) | $\ell_i$ (m) | $\ell_i / A_i$ |
|---|---|---|---|
| 1.10 | 0.950 | 284.0 | 298.95 |
| 1.10 ~ 1.05 | 0.908 | 2.0 | 2.20 |
| 1.05 | 0.866 | 298.0 | 344.11 |
| 1.05 ~ 0.95 | 0.785 | 2.0 | 2.55 |
| 0.95 | 0.709 | 150.0 | 211.57 |
| 0.95 ~ 0.85 | 0.636 | 2.0 | 3.14 |
| 0.85 | 0.567 | 240.5 | 424.16 |
| 0.85 ~ 0.60 | 0.413 | 4.0 | 9.69 |
| 0.60 | 0.283 | 7.5 | 26.50 |
| Total | | 990.0 | 1,322.87 |

$$A_\circ = \frac{990}{1{,}322.87} = 0.748\,m^2$$

$$V_\circ = \frac{2.5}{0.748} = 3{,}342\,m/\sec$$

(4) Velocity of pressure wave

$$a = \frac{1}{\sqrt{\frac{w}{g}\left(\frac{1}{k}+\frac{1}{E}\times\frac{D}{t}\right)}}$$

$$= \frac{1}{\sqrt{\frac{1}{9.8}\left(\frac{1}{2\times10^5}+\frac{1}{2.1\times10^7}\times\left(\frac{0.976}{0.012}\right)\right)}}$$

$$= 1{,}050\ m/\sec$$

$$\frac{2L}{a} = \frac{2\times990}{1{,}050} = 1.89 \langle\ T = 30^{\sec}$$

There is slow closing.

| | | |
|---|---|---|
| a | : | Velocity of water hammer wave (m/s) |
| D | : | Average pipe dia. (0.976 m) |
| t | : | Pipe thickness (0.012 m) |
| w | : | Unit weight of water ($1t/m^3$) |
| g | : | Acceleration of gravity ($9.8\ m/sec^2$) |
| K | : | Coefficient. of water volumetric elasticity ($2\times10^5\ t/m^2$) |
| E | : | Coefficient of pipe elasticity ($2.1\times10^7\ t/m^2$) |
| $H_o$ | : | Static pressure at valve (319.8 m) |

(5) Calculation of water hammer

$$\rho = \frac{av_\circ}{2gH_\circ} = \frac{1{,}050\times3{,}342}{19.6\times319.8} = 0.56$$

$$\theta = \frac{T}{\left(\frac{2L}{a}\right)} = \frac{30}{1.89} = 15.9$$

$$\Sigma = \frac{h_m + H_\circ}{H_\circ} = 1.05, \qquad h_m = 1.05\times319.8 - 319.8 \cong 16.0$$

Water hammer at the end valve of penstock is $hm = 20$ m with allowance.

## 2) Strength of Penstock Pipe

(1) Design water pressure at main points :

The max. water pressure due to water hammer comes to 20m at the lower end of penstock. This calculation was made assuming the increasing pressure at the port of penstock is zero and the pressure increases varying straightly from the port to the end of pipe. The calculated figures are given as follows.

| Main points | Accumlated distance (m) | Pipe center elevation | Static pressure (m) | Water hammer (m) | Design water pressure (m) |
|---|---|---|---|---|---|
| Start point | 0 | 751.3 | 5.6 | 0 | 560 |
| IP1 | 120.0 | 715.0 | 41.4 | 2.42 | 43.82 |
| 6' | 308.5 | 636.0 | 120.9 | 6.23 | 127.13 |
| 8' | 427.5 | 598.5 | 158.4 | 8.64 | 167.04 |
| IP2 | 483.5 | 954.0 | 162.9 | 9.77 | 172.67 |
| 12' | 518.5 | 585.5 | 171.4 | 10.47 | 181.87 |
| IP3 | 589.0 | 579.5 | 177.4 | 11.9 | 189.3 |
| 15' | 647.0 | 560.5 | 196.4 | 13.07 | 209.47 |
| 16' | 669.0 | 560.5 | 196.4 | 13.52 | 209.92 |
| IP4 | 695.0 | 553.0 | 203.9 | 14.04 | 217.94 |
| 18' | 803.0 | 524.0 | 232.9 | 16.22 | 249.12 |
| IP5 | 845.0 | 520.5 | 236.4 | 17.07 | 253.47 |
| 20' | 934.0 | 471.5 | 285.4 | 18.87 | 304.27 |
| IP6 | 982.0 | 437.1 | 319.8 | 19.84 | 339.64 |
| End point | 990.0 | 437.1 | 319.8 | 20 | 339.8 |

(2) Allowable water head

The water head is calculated by the following equation :

$$P = 2(t-\varepsilon)\cdot\delta_a\cdot\frac{\eta}{D}$$

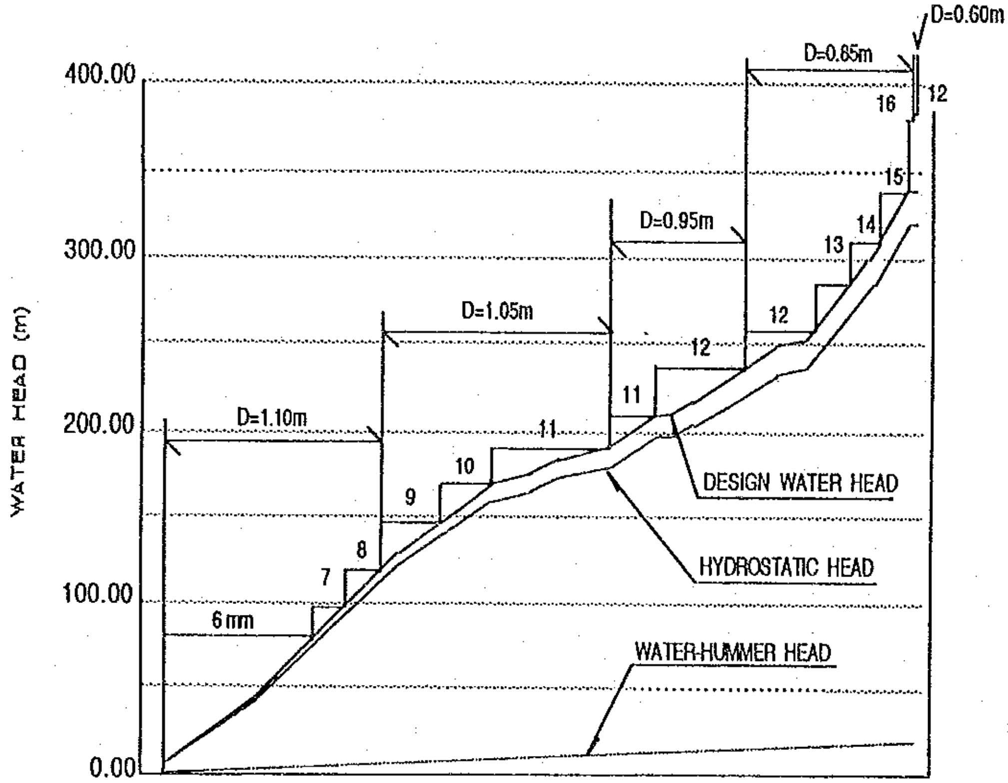
| | | |
|---|---|---|
| P | : | Allowable water head (kg/cm²) |
| t | : | Plate thickness (cm) |
| ε | : | Allowance of thickness 0.20 cm |
| $\delta_a$ | : | Allowable tension stress of steel (1,300 kg/cm². sm41) |
| D | | Pipe inner dia. (cm) |
| η | | Efficiency of joint 0.85 |

Min. plate thickness shall be bigger than the following value.

$$t' = \frac{D+800}{400} \geqq 6mm$$

$t'$ : Plate thickness with allowance (m/m)
Min. Plate thickness

DESIGNED WATER HEAD AND PIPE THICKNESS




| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESIGNED WATER HEAD (m) | 5.50 | 43.82 | 127.13 | 167.04 | 172.67 | 181.87 | 189.30 | 209.47 | 209.92 | 217.94 | 249.12 | 253.47 | 304.27 | 339.54 | 339.80 |
| ACCUMULATED DISTANCE (m) | 0.0 | 120.0 | 308.5 | 427.5 | 483.5 | 518.5 | 589.0 | 647.0 | 669.0 | 695.0 | 803.0 | 845.0 | 934.0 | 982.0 | 990.0 |
| STATION | START | IP1 | 8' | 8 | IP2 | 12' | IP3 | 15' | 16' | IP4 | 18' | IP5 | 20' | IP6 | VALVE |

**Minimum Plate Thickness**

| Pipe inner dia. | Min. plate thickness |
|---|---|
| 1,100 | 6 |
| 1,050 | 6 |
| 950 | 6 |
| 850 | 6 |
| 600 | 6 |

**Allowable Head for Penstock Pipe**

| Pipe dia. (m) | Allowable stress δa (kg/cm²) | Plate thickness t (mm) | Calculated Plate thickness t - ε (mm) | Allowable water head (m) |
|---|---|---|---|---|
| 1.1 | 1,300 | 6 | 4 | 80.36 |
| " | " | 7 | 5 | 100.45 |
| " | " | 8 | 6 | 120.55 |
| 1.05 | " | 9 | 7 | 147.33 |
| " | " | 10 | 8 | 168.38 |
| " | " | 11 | 9 | 189.43 |
| 0.95 | " | 11 | 9 | 209.37 |
| " | " | 12 | 10 | 232.63 |
| 0.85 | " | 12 | 10 | 260.00 |
| " | " | 13 | 11 | 286.00 |
| " | " | 14 | 12 | 312.00 |
| " | " | 15 | 13 | 338.00 |
| " | " | 16 | 14 | 364.00 |
| 0.6 | " | 12 | 10 | 368.33 |

## III-4 Settling Basin

1) Design Conditions :

Critical settling velocity for minimum particle size of 0.2mm : $V_o \leq 0.03$m/s

2) $L = k \cdot \dfrac{H}{V_o} \cdot \mu$

Where L = Min. required length of basin (m)

k = Safety design factor (=2.0)

μ = Mean velocity of flow inside basin (μ=0.3m/s)

H = Water depth at the down stream end of basin = =1.98 m)

$$L = 2.0 \times \frac{1.98}{0.1} \times 0.3 = 39.6m \ \langle \ 40.0m \quad \text{OK}$$

3) $B = \frac{Q}{H \cdot \mu}$

| | | | |
|---|---|---|---|
| Where | B | = | Width of basin |
| | H | = | 1.98 m |
| | μ | = | 0.3 m/s |
| | Q | = | 2.5 m³/s |

$$B = \frac{2.5}{1.98 \times 0.3} = 4.2m \ \langle \ 5.0m \qquad \text{OK}$$

## III-5 Headrace Tunnel

1) Scale of tunnel

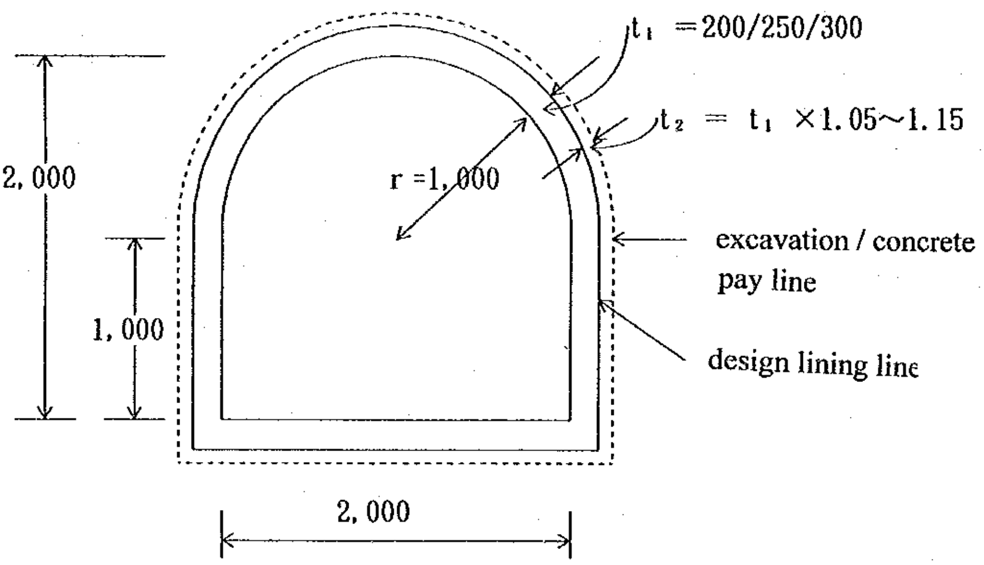
Elongation : 3,230 m

Section type : Hood type (2r)

Height 2m × Width 2m

Slope : 1/1,000 ($\ell$ = 51.0 m) 1/1,660 ($\ell$ = 3,138)

Roughness Co,: 0.013

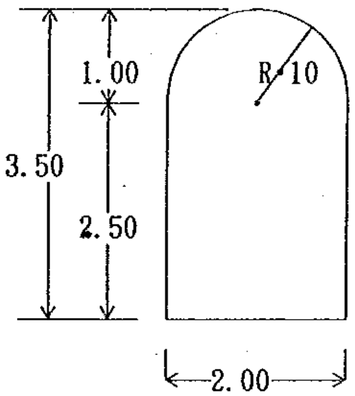


## III-6 Uniform Flow Calculation for Tunnel Cross Sections

(1) Range between intake and settling basin

1. Design condition — Bed slope I = 1/1000
   Cross section — Co.of roughness n = 0.013
   Formula : Manning's

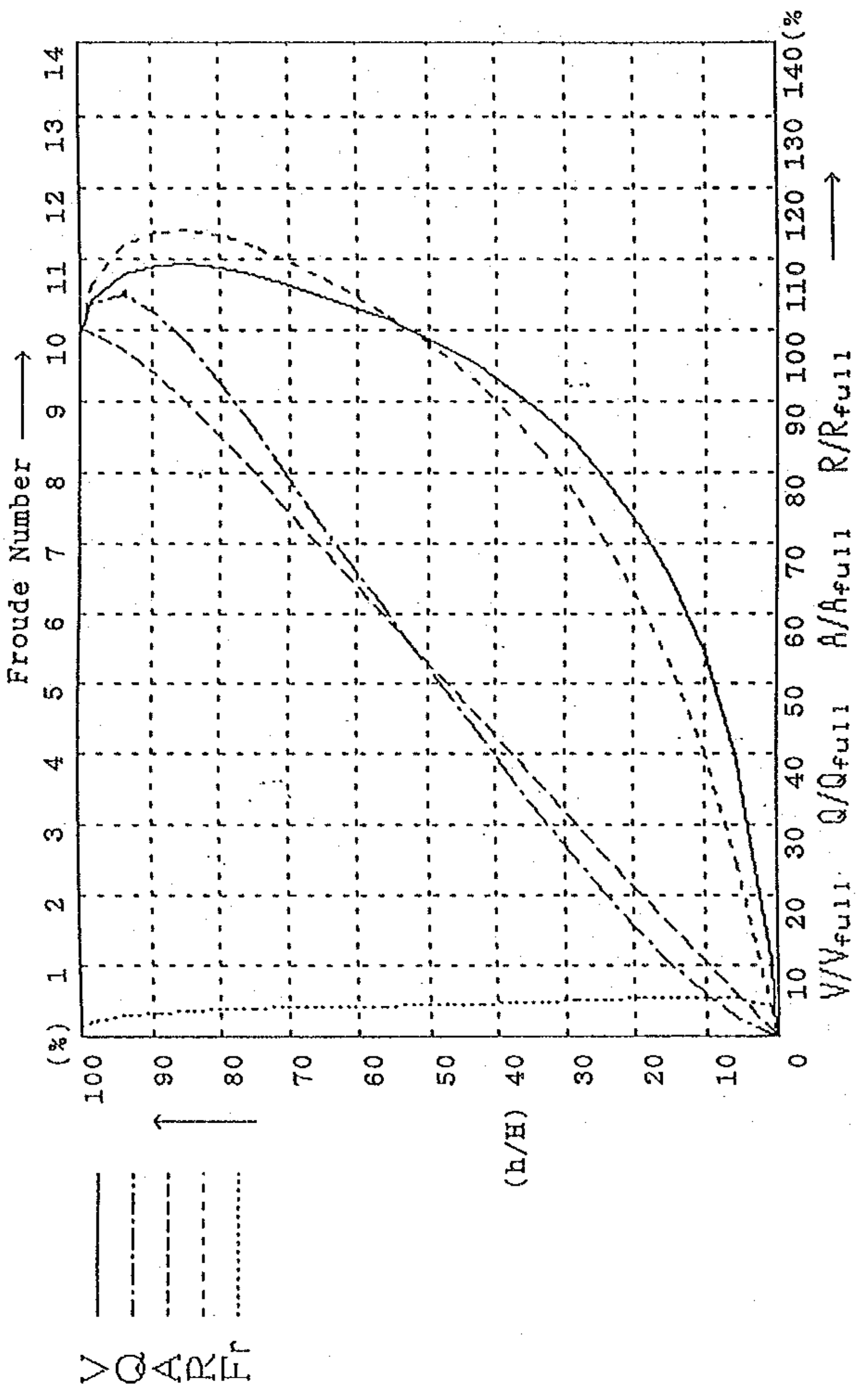
$$Q = A \cdot V \ (m^3/s)$$
$$V = 1/n \cdot R^{2/3} \cdot 1^{1/2} \ (m/s)$$
$$R = A / P \ (m)$$




2. Uniform flow table

| Water depth H (m) | Sectional flow area A (m²) | Water perimeter P (m) | Hydraulic radius R (m) | Flow velocity V(m / s) | Flow rate Q (m³ / s) |
|---|---|---|---|---|---|
| 0.50 | 1.000 | 3.000 | 0.333 | 1.169 | 1.169 |
| 0.86 | 1.719 | 3.719 | 0.462 | 1.454 | 2.500 |
| 1.00 | 2.000 | 4.000 | 0.500 | 1.532 | 3.065 |
| 1.50 | 3.000 | 5.000 | 0.600 | 1.730 | 5.191 |
| 2.00 | 4.000 | 6.000 | 0.667 | 1.856 | 7.425 |
| 2.50 | 5.000 | 7.000 | 0.714 | 1.944 | 9.719 |
| 3.00 | 5.957 | 8.047 | 0.740 | 1.990 | 11.857 |
| 3.35 | 6.464 | 9.032 | 0.716 | 1.946 | 12.580 |
| 3.50 | 6.571 | 10.142 | 0.648 | 1.821 | 11.968 |

3. Hydraulic characteristics



(2) Range between settling basin and head tank

1. Design condition

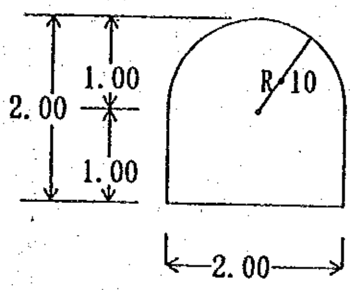
Cross section

Bed slope $I = 1/1660$

Co.of roughness $n = 0.013$

Formula : Manning's

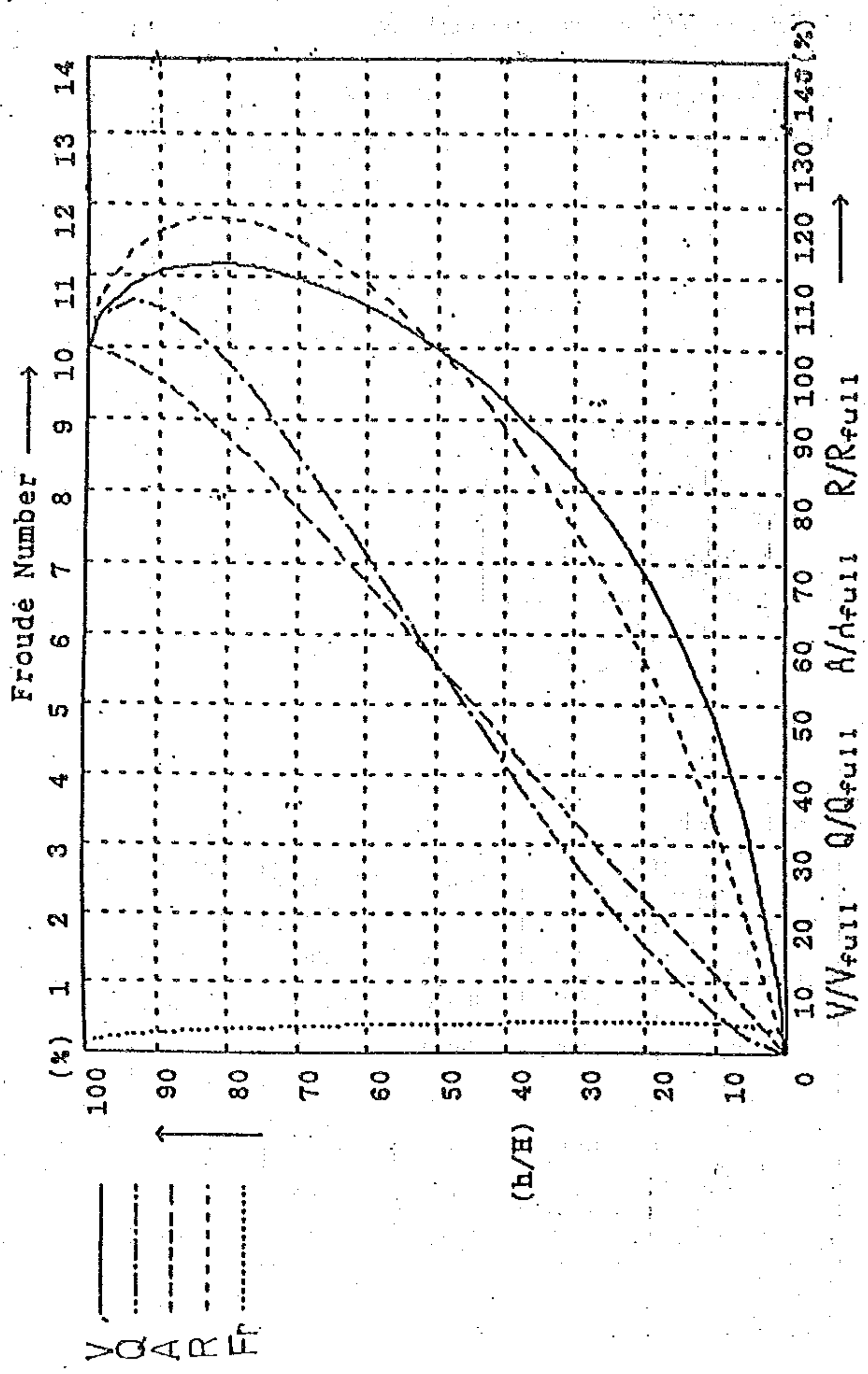
$$Q = A \cdot V \ (m^3/s)$$
$$V = 1/n \cdot R^{2/3} \cdot I^{1/2}$$
$$R = A / P \ (m)$$



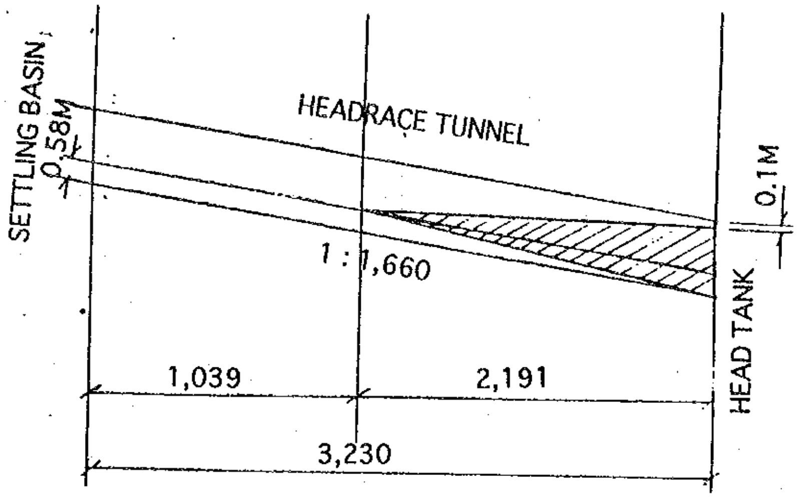

2. Uniform flow table

| Water depth H (m) | Sectional flow area A ($m^2$) | Water perimeter P (m) | Hydraulic radius R (m) | Flow velocity V(m / s) | Flow rate Q ($m^3$ / s) |
|---|---|---|---|---|---|
| 0.500 | 1.000 | 3.000 | 0.333 | 0.908 | 0.908 |
| 1.000 | 2.000 | 4.000 | 0.500 | 1.189 | 2.379 |
| 1.038 | 2.076 | 4.076 | 0.509 | 1.204 | 2.500 |
| 1.500 | 2.957 | 5.047 | 0.586 | 1.322 | 3.908 |
| 1.880 | 3.494 | 6.152 | 0.568 | 1.295 | 4.524 |
| 2.000 | 3.571 | 7.142 | 0.500 | 1.189 | 4.247 |

3. Hydraulic characteristics



## III-7 Storage Capacity in Headrace Tunnel for Water Regulation




note : uniform flow depth at flow rate of 1.1 $m^3/s$ is 0.58 m

Intersection point of water flow level at uniform flow rate of 1.1 $m^3/s$ and reservoir water level will be at distance from head tank of 2,191m. Under this condition, the slope of water level of this section comes to 1.9/2,191 =1/1,153 and water rate of 1.35 $m^3/s$ which is less than 2.5 $m^3/s$. However the shortage of 1.15 $m^3/s$ will be supplemented from reservoir. Therefore, storage capacity in headrace tunnel is the volume of hatched portion.

(1) Rough calculation

① Storage capacity at headrace tunnel

Clearance at top of tunnel : 0.10 m

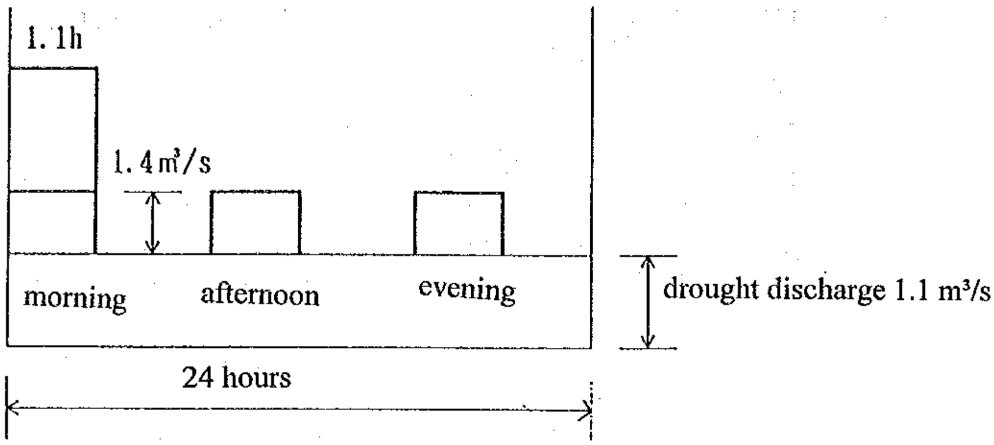
Sectional area at point ① 0
<u>Sectional area at point ② 3.52</u>
Storage capacity 3.5212 × 2,191 = 3800 $m^3$

② Storage capacity at reservoir

Water area : 1063 $m^2$
Available depth: 1.9 m

Available capacity: 1,063 × 1.9 = 2020 $m^3$
≅ 2000 $m^3$

① + ②Total 3500 + 2000 = 5500 $m^3$




(2) Available hours for peaks output at dry season :

$$(2.5 - 1.1) \times x \times 3600 = 5500 \text{ m}^3$$
$$x = 1.09 \text{ hours}$$

Storage hours:

$$1.1 \times 3600 \times y = 5500 \text{ m}^3$$
$$y = 1.39 \text{ hours}$$

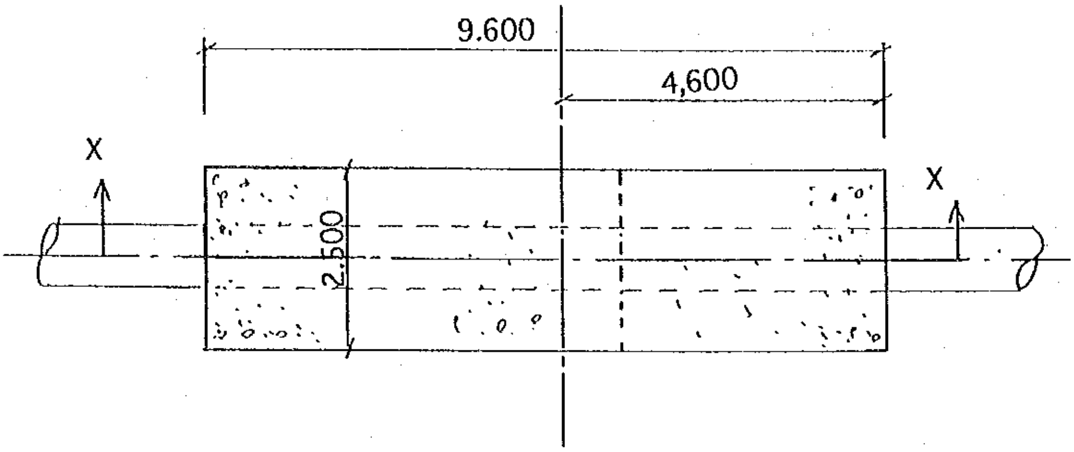
At flow discharge 1.1 m³/s in the headrace tunnel, the flow velocity comes to 0.97 m/s. Under this condition, water takes about one hour to pass the 3,335 m long water conduit. Accordingly water storage is available at least three times in a day.

Since this calculation is made on the basis of firm discharge of 1.1 m³/sec, the bigger the discharge the longer the peak output.

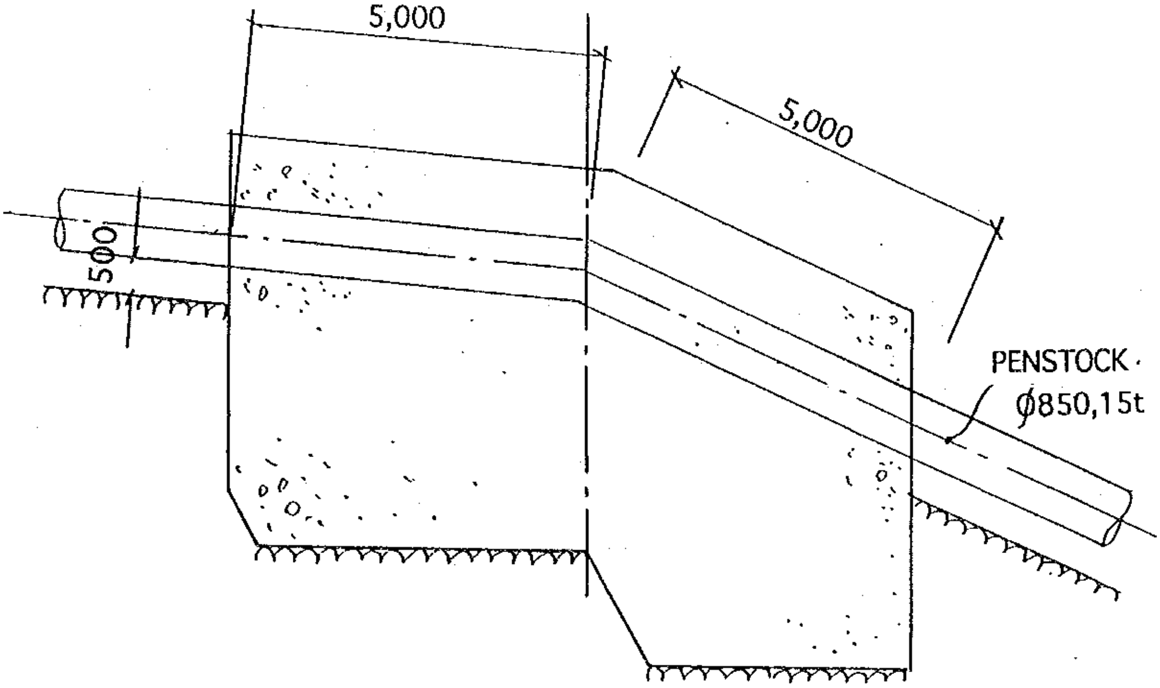
## III-8 Penstock Anchor Block

Trial calculation for the stability of penstock anchor block of typical anchor block "T" is given as follows :

Plan Scale 1 : 100




SECT. X-X Scale 1 : 100




Typical Anchor Block " T " (EL. 524,000)

See Design Calculation Sheet

b. Symbols and Figures

| Symbol | Description | unit | No. ( )<br>Anchor Block |
|---|---|---|---|
| D | Pipe dia. | M | 0.85 |
| H | Max. design head | M | (756.9-524)+16 =248.9 |
| L1 | Distance to upper expansion joint | " | 36.6 |
| L2 | Distance to lower expansion joint | " | 1.5 |
| $\ell_1$ | Distance to upper support | " | 8.0 |
| $\ell_2$ | Distance to lower support | " | 8.0 |
| $\alpha_1$ | Angle upper pipe and horizontal plane | 0' | 5.0° |
| $\alpha_2$ | Angle lower pipe and horizontal plane | | 25.0° |
| $\delta$ | Angle of pipe and vertical plane | | 0 |
| $\theta$ | Angle of pipe bend | | 20° |
| $Q$ | Max. design discharge | $m^3/s$ | 2.5 |
| $A$ | Cross sectional area | $M^2$ | 0.567 |
| $v$ | Mean flow velocity | m/s | 4,409 |
| t | Pipe thickness | M | 0.015 |
| $\rho$ | Unit weight of penstock | t/m | 0.314 |
| $W$ | Unit weight of water | t/m | 0.567 |
| $fw$ | Coefficient of roughness | | 0.02 |
| $C$ | Coefficient of friction of support | | 0.6 |
| $g$ | Acceleration of gravity | $m/s^2$ | 9.8 |
| $Ps$ | Specific gravity of steel | | 7.85 |
| $Wc$ | Unit weight of concrete | $t/m^3$ | 2.3 |
| $Fo$ | Coefficient of friction between Concrete and subsoil | | 0.5 |
| $q_a$ | Allowable bearing capacity | $t/m^2$ | 25.0 |

d. Stability analysis

| | | | |
|---|---|---|---|
| 1 | External force Y-axis component<br>(Py) | <br>56,7368 | |
| | $X_1 = 4.6$ m (Py · $X_1$) | 260.9893 | |
| 2. | Dead load of anchor block (Wt) | -300.4076 | |
| | $X_2 = 4{,}759$ m (Wt · $X_2$) | -1429.639 | |
| 3. | Dead load of pipe/water (W′) | -8.81 | |
| | $X_3 = 4.6$ m (W′ · $X_3$) | -40.526 | |
| 4. | (ΣV) | -252.4808 | |
| | (ΣMy) | -1209.1757) | |
| 5. | External force X-axis component<br>(Px) | <br>34.4338 | |
| 6. | Y = 5.5 m (Mx = Px · Y) | 189.3859 | |
| 7. | External force (seismic) | | |
| | 252.4808 × 0.15 (PE) | 37.8721 | |
| | y = 5.5 m (M = P · y) | 208.2966 | |
| 8. | ΣM | -811.4932 | |
| 9. | $\sum M / \sum V = X = \frac{811.4932}{252.4808} = 3.214 \quad (x)$ | 3.214 | |
| | $e = \left\lvert \frac{B}{2} - x \right\rvert = \left\lvert \frac{9.6}{2} - 3.214 \right\rvert = 1.586$ | 1.586 | For overturning<br>$e < B/6$ |
| | $\frac{B}{6} = \frac{9.6}{2}$ $\left(B/6\right)$ | 1.6 | |
| 10. | $(Px + P_E) / \sum V = 72.3059 / 252.4808$ | 0.286 | For sliding<br>< 0.5 |
| 11. | $A_b = 9.6 \times 2.5$<br>$\frac{\sum V}{A_b}\left(1 \pm 6 \cdot e/B\right) = \frac{252.4808}{24}\left(1 \pm 6 \times \frac{1{,}586}{9.6}\right)$ | 24 m²<br>0.1 t/m²<br>20.94 | For sub-ground<br>Bearing capacity<br><25 t/m² |

## III-9 Power House

### 1) Standards

AIJ (Architecture Institute of Japan)
JIS (Japanese Industrial Standard of Japan)

### 2) Design Criteria

(1) Concrete strength $Fc = 150\ kg/cm^2$

(2) Rebar strength $Ft = 1{,}600\ kg/cm^2$ (MS ROD)

(3) Seismic load $k = 0.15$

(4) Unit Dead load

| | | |
|---|---|---|
| Concrete | (plain) | $2.3\ t/m^3$ |
| | (RCC) | $2.4\ t/m^3$ |
| Brick | (normal) | $1.9\ t/m^3$ |
| Steel | | $7.8\ t/m^3$ |

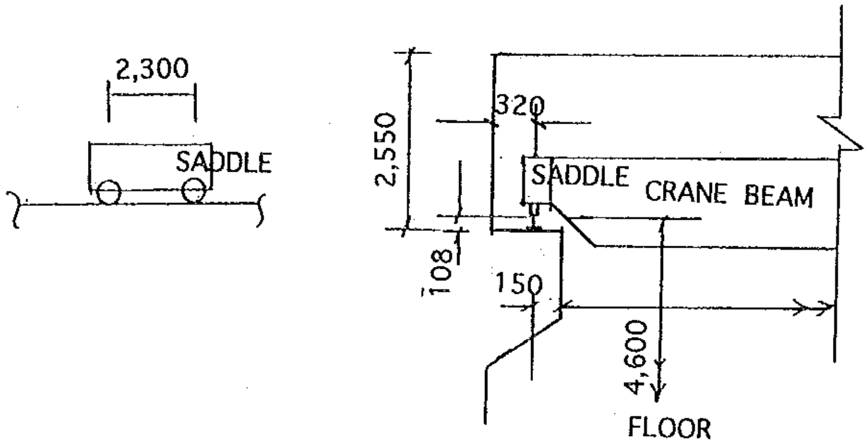
(5) Allowable stress

| | | Ordinary | Short time loading |
|---|---|---|---|
| a. | Concrete | | |
| | Compressive | 1/3 Fc = 50 kb/cm² | 2 × ordinary = 100 kg/cm² |
| | Tensile | | |
| | Shear | Fc/30 = 5 kg/cm² | 1.5 × ordinary = 7.5 kg/cm² |
| b. | Rebar (MS ROD) | | |
| | Compressive tensile | 1,600 kg/cm² | 1.5 × ordinary = 2,400 kg/cm² |
| | Bond stress | 7 kg./cm² | 10.5 km/cm² |
| c. | Structural steel | | |
| | (SS 41 or equivalent) | | |
| | Tensile | 1.6 t/cm² | 2.4 t/cm² |
| | Shear | 0.9 t/cm² | 1.35 t/cm² |

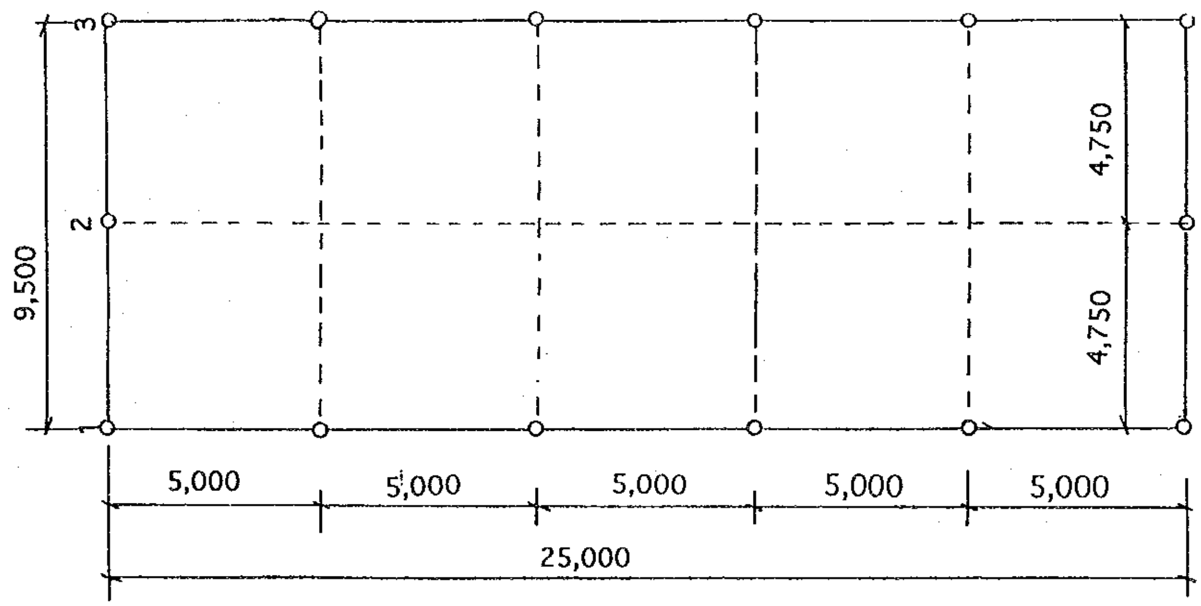
3) Size of Power House :

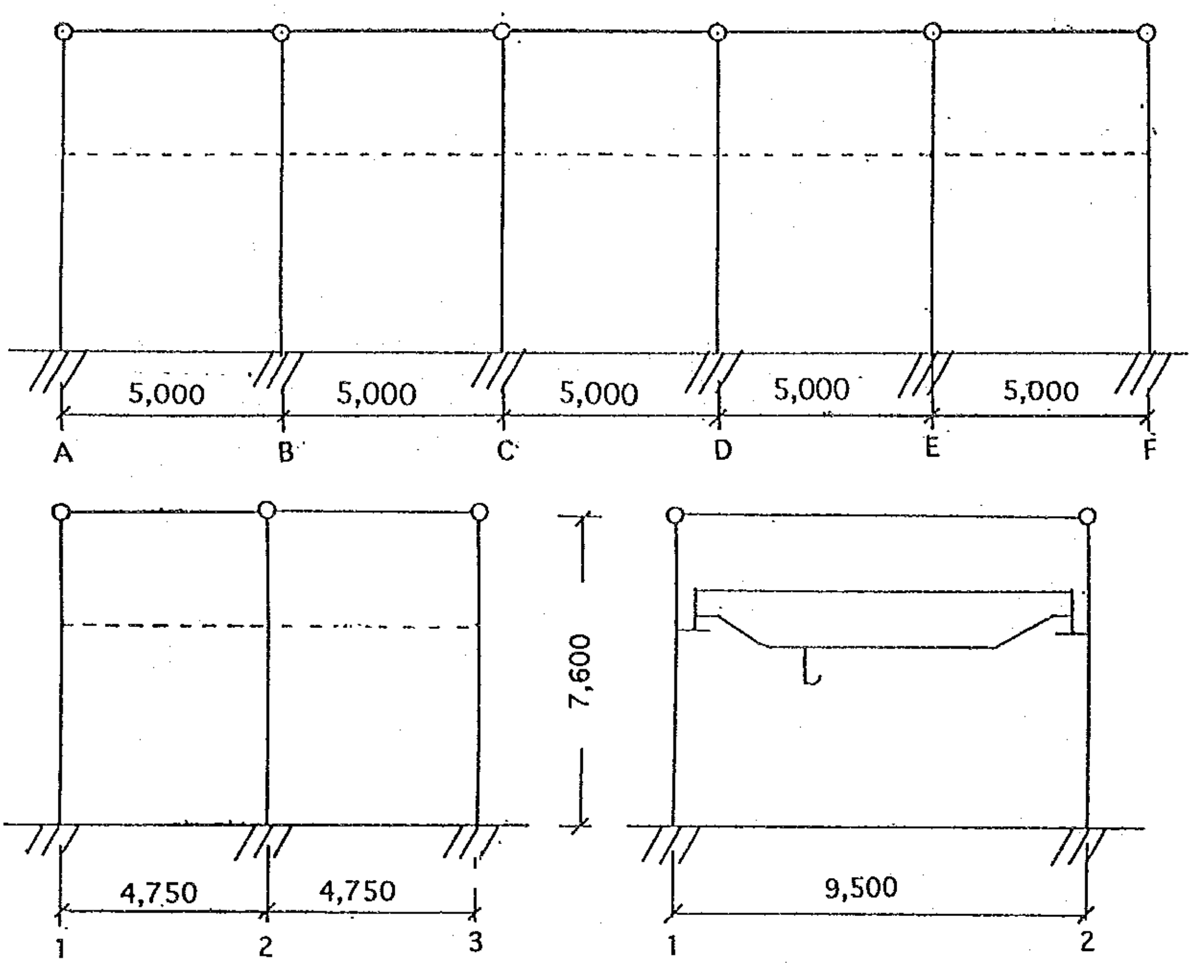
W L
9,500 × 25,000

Overhead Traelling
Crane (16 t lift load)
34 t weight (max. wheel load 8.5 t
number of wheels 4
rail size 30 kg)




4) RC Structure



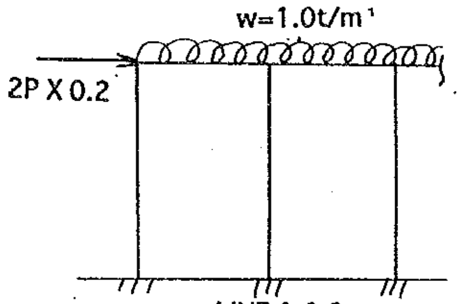

5,000
5,000
5,000
5,000
5,000
A
B
C
D
E
F
7,600
4,750
4,750
1
2
3
9,500
1
2

## 5) Loading Condition

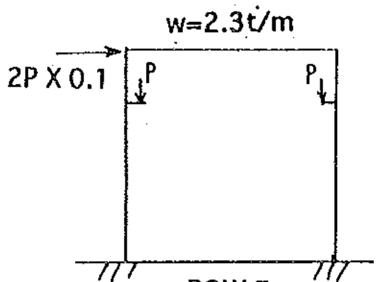
(1) Ordinary

Roof Slab $\dfrac{5\times2.5\times0.5\times0.43}{5}=0.537\,{}^{t}\!/_{m}$ Roof $\dfrac{\left(\dfrac{9.5+4.5}{2}\right)\times2.5\times0.43\times2}{9.5}=1.58\,{}^{t}\!/_{m}$

Beam $0.4\times0.48\times2.4=0.641\ {}^{t}\!/m$ Beam $0.5\times0.58\times2.4=0.696\ {}^{t}\!/m$



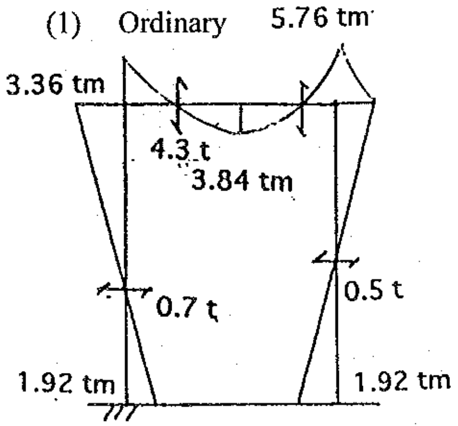

LINE 1 & 3



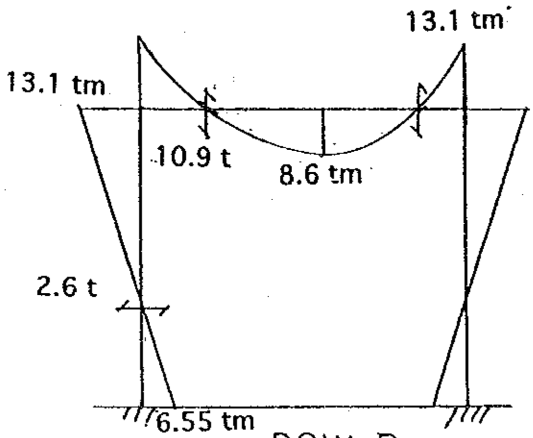

ROW B

## 6) Stresses

(1) Ordinary



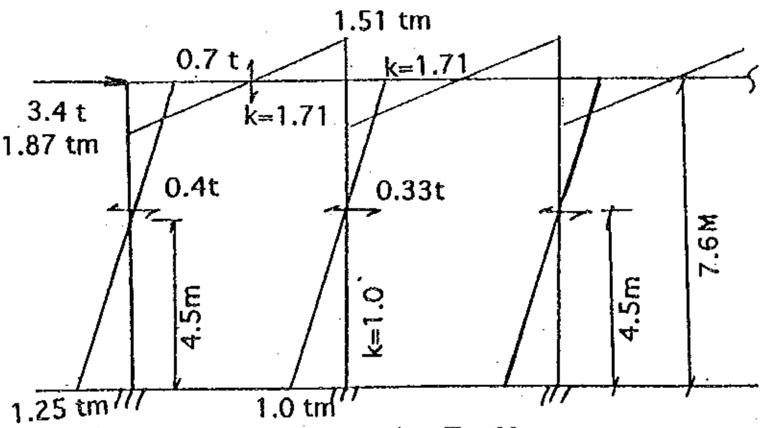

LINE 1, 3



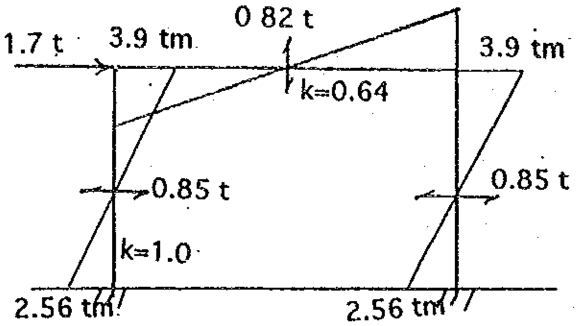

ROW B

Crane Load (P = 17 ton)

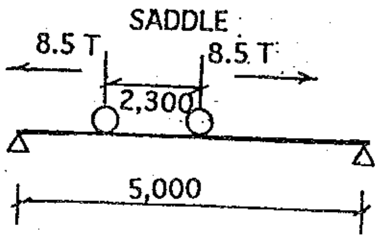
(1) Br aking Load (P × 20 %)



(2) Lateral Load (P × 10 %)




(3) Crane Beam Load




$$M_{max} = \frac{P}{8\ell}(2\ell - a)^2$$
$$= \frac{8.5}{8 \times 5}(2 \times 5 - 2.3)^2$$
$$= 12.6tm$$
$$P_{max} = \frac{P}{\ell}(2\ell - a)$$
$$= \frac{8.5}{5}(2 \times 5 - 2.3) = 13.1t$$

$$w = 0.4 \times 0.6 \times 2.4 = 0.6\, {}^{t}\!/_{m}$$
$$Mc = \frac{w\ell^2}{8} = 1.9tm$$
$$R = \frac{w\ell}{2} = 1.5t$$

## 7) Design of Beams

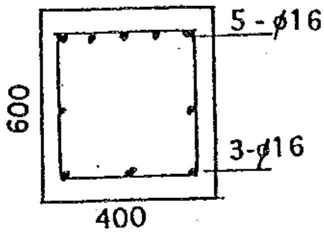
(1) B1 (400 × 600 ×5000) : Line ① and ②

| | Ordinary | +Crane |
|---|---|---|
| Beam ends | 5.76 t·m | 7.27 t·m |
| Beam center | 3.84 t·m | 3.84 t·m |
| Shear | 4.3 t· | 5.0 t· |

Beam end

$$a_t = \frac{M}{f_t \cdot j} = \frac{7.27 \times 10^2}{2.4 \times 0.875 \times 55} = 6.29^{cm^2}$$

USE $5-\phi 16 = 10.05^{cm^2}$




Beam Center

$$a_t = \frac{M}{f_t \cdot j} = \frac{3.84 \times 10^2}{1.6 \times 0.875 \times 55} = 3.32^{cm^2}$$

USE $3-\phi 16 = 6.03^{cm^2}$

(2) B2 (500 × 700) : Row B C D & E

| | Ordinary | +Crane |
|---|---|---|
| Beam ends | 3.9 t·m | 17.0 tm |
| Beam center | 8.6 t·m | 8.6 tm |
| Shear | 8.6 t· | 9.42 t |

Beam end

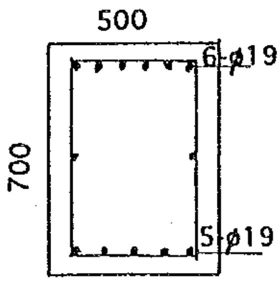
$$a_t = \frac{M}{f_t \cdot j} = \frac{17.0 \times 10^2}{2.4 \times 0.875 \times 65} = 12.45^{cm^2}$$

USE $6-\phi 19 = 17.02^{cm^2}$

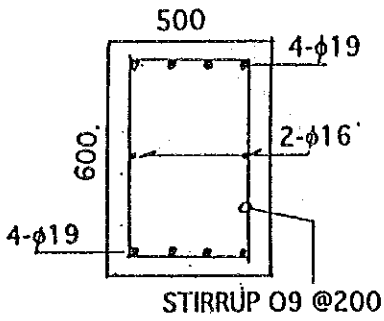
Beam Center

$$a_t = \frac{M}{f_t \cdot j} = \frac{8.6 \times 10^2}{1.6 \times 0.875 \times 65} = 9.45^{cm^2}$$

USE $4-\phi 19 = 11.34^{cm^2}$



(3) Design of Grade Beam




| | $M_{max}$ |
|---|---|
| Ordinary | 6.55 *tm* |
| + Crane | 9.11 *tm* |

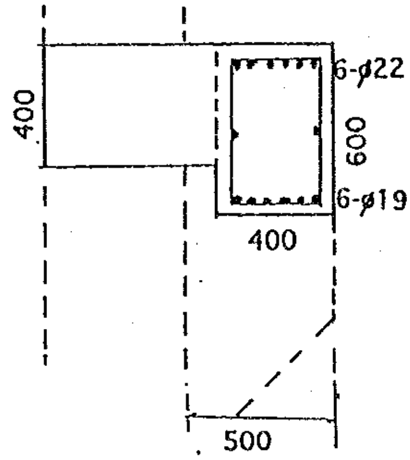
$$a_t = \frac{M}{f_t \cdot j} = \frac{8.6 \times 10^2}{1.6 \times 0.875 \times 65} = 9.45^{cm^2}$$

USE $4 - \phi 19 = 11.34^{cm^2}$

(4) Crane Beam (400 × 400)

| | Ordinary |
|---|---|
| Beam | 12.6 + 1.9 = 14.5 *tm* |

$$a_t = \frac{M}{f_t \cdot j} = \frac{14.5 \times 10^2}{1.95 \times 0.875 \times 55} = 15.45^{cm^2}$$




USE 6 - $\phi$22 = 22.8 cm² (END)
6 - $\phi$19 = 17.02 cm² (CENTER)

## 8) Design of Column

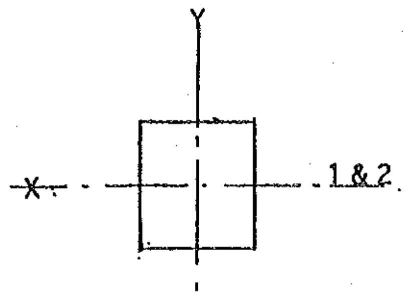
### (1) Axial Force (ordinary)

Row B C D and E

$$N = 0.43\times 5\times \frac{9.5}{2} + 2.4\times 0.68\times 0.5\times \frac{9.5}{2} + 2.4\times 0.3^2\times \frac{5}{2}$$

$$+ 2.4\times 0.58\times 0.4\times 5 + 2.975 + 2.4\times 0.6^2\times 7.6 + 34\times \frac{1}{2}$$

$$= 43.96t = 44.0t$$



B, C, D & E

Row A and C

### (2) Combination Forces

Row B C D and E

| | | | |
|---|---|---|---|
| Ordinary | N = 44 t | M = 13.1 tm | Q = 2.6 t |
| + Crane | N = 44 t | M = 13.1 tm +3.9 | Q = 2.6 + 0.85 |
| | | = 17.0 tm | = 3.45 t |

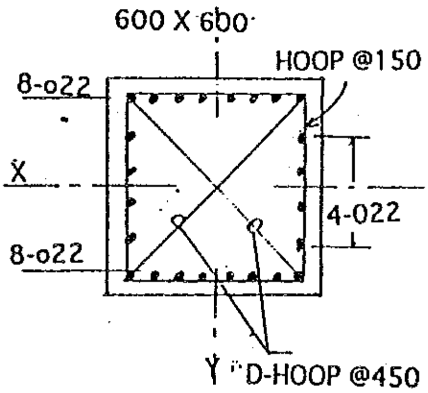
X-direction

| | | | |
|---|---|---|---|
| Ordinary | N = 44 t | M = 5.76 tm | Q = 0.5 t |
| + Crane N = 44 t | N = 44 t | M = 5.76 tm +1.51 | Q = 0.5+0.33 |
| | | = 7.27 tm | = 0.83 t |

### (3) X - Direction — Row B + Cran (From Table)

$$\frac{N}{bD} = \frac{44000}{60^2} = 12.2\,{}^{kg}\!/_{cm^2}$$

$$\frac{M}{bD^2} = \frac{727000}{60^3} = 3.36\,{}^{kg}\!/_{cm^2} \qquad P_t = 0.17$$




Y - direction — (From Table)

$$\frac{N}{bD} = \frac{44000}{60^2} = 12.2\,{}^{kg}\!/_{cm^2}$$

$$\frac{M}{bD^2} = \frac{1700000}{60^3} = 7.9\,{}^{kg}\!/_{cm^2} \qquad P_t = 0.75$$

X - X $60^2 \times 0.0017 = 6.12\ cm^2$
USE 4 - $\phi$22 = 12.21 $cm^2$

Y - Y $60^2 \times 0.0075 = 27.0\ cm^2$
USE 8 - $\phi$22 = 30.41 $cm^2$

## 9) Design of Foundation

| | |
|---|---|
| Ordinary | $N_{max} = 44\ t$ |
| + Crane | $N_{max} = 44\ t$ |

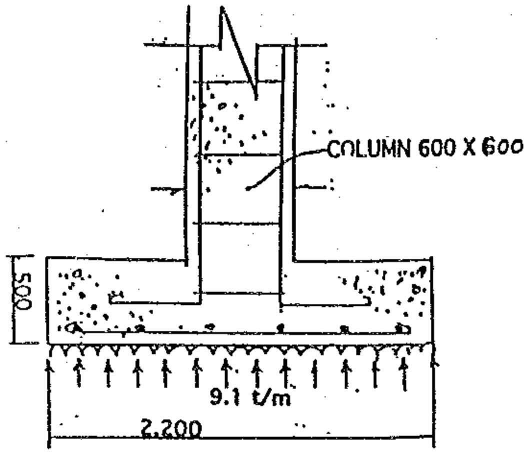
$$\alpha = \frac{N}{A} = \frac{44}{2.2^2} = 9.1\ {}^{t}/_{m^2}$$

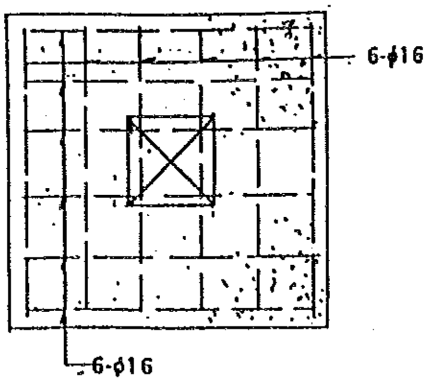
$$M_{max} = \frac{1}{2}\alpha \ell^2$$

$$= \frac{1}{2} \times 9.1 \times 1.0^2 = 4.6 tm$$

$$a_t = \frac{4.6 \times 10^2}{1.6 \times 0.875 \times 45} = 7.3 cm^2$$

USE $6-\phi 16 = 12.06 cm^2$



## ANNEX - IV POWER FLOW AND TRANSMISSION LINE

## ANNEX - IV POWER FLOW AND TRANSMISSION LINE

### IV.1 Power Flow

As the 7th Power Project will be completed in 1996, power flow analysis for the subject Project is performed on the assumption that the Ilam small hydropower station will be connected to the national grid when completed.

As discussed earlier with regards to power demand forecast, Ilam N.P., and Paspatinagar / Gorkhe are at present serviced by isolated power sources. Latest power demand for both systems is estimated at 456 kW and 212 kW, respectively. Numbers of dwellings in both areas are 2,427 and 1,829 (Paspatinagar: 1,197 and Gorkhe: 632), respectively, or a total of 4,256 (1991 statistics). Total number of dwellings in Ilam district as a whole subject to electrification is 13,482. The number of such dwellings excepting Ilam N.P., Paspatinagar and Gorkhe is 9,228.

Simply assuming that the power demand for households in the said remaining area is half that for the area already receiving power supply, total demand therein is as follows:

$$456kw + 212kw + \frac{(456+212)kw}{4,256} \times 9,228 \div 2 = 1,392kw$$
$$\cong 1,400kw$$

If the demand at tea estates and other industries is estimated at 300 kW, total demand within Ilam district for power under the Project is assumed at approx.1,700 kW.

Peak demand at the existing Anarmani substation is approximately 2,000 kw. Using this as a basis, demand for the Ilam area and the vicinity of Anarmani substation is forecast as follows:

| Demand Forecast (kw) | | | |
|---|---|---|---|
| Year | Ilam substation | Ilam district w/o Ilam substation | Anarmani vicinity |
| 1996 | 1,490 | 450 | 2,000 |
| 2001 | 2,120 | 1,043 | 2,940 |
| 2006 | 3,004 | 1,632 | 4,320 |

Power flow analysis is accordingly carried out on the basis of the above criteria.

### IV.1.1 Output of 6,200 kW at Ilam Small Hydropower Station

Figure IV.1.1 shows power flow in the case where generation at the Ilam small hydropower station is 6,200 kW. In 1996, the Ilam small hydropower station will be capable of inputting 1,570 kW to the national grid via the Anarmani substation.

### IV.1.2 In the Case of Shut Down of the Ilam Small Hydropower Station

Figure IV.1.2 shows power flow in the case where, although connected to the national grid, the Ilam small hydropower station experiences shutdown.

## IV.2 Transmission Line Analysis

### IV.2.1 Conductor Specifications

ACSR dog (100 mm² cross section) generally used by NEA for 33 kV transmission line will be adopted.

(1) Continuous Allowable Current

Maximum capacity for transmission is determined at 7,300 kVA assuming conditions of 6,200 kW maximum output at the power plant and a power factor of 0.85.

Maximum current ($I_{max}$) is thus:

$$I_{max} = 7{,}300(kVA) \div 33(kV) \div \sqrt{3} = 128(A)$$

Allowable current I (A) which can be continuously passed by the conductor is:

$$I = \sqrt{\frac{\{hw + (hr + \frac{Ws}{\pi\theta})\eta\}\pi\theta}{r}}$$

where:

| | | |
|---|---|---|
| d | = | diameter of conductor (= 1.416 cm) |
| θ | = | allowable temperature rise (= 50°) |
| hr | = | heat-radiative coefficient due to radiation |

$$hr = 0.000567 \frac{(\frac{273+T+\theta}{100})^4 + (\frac{273+T}{100})^4}{\theta} (w/{}^\circ C\,cm^2)$$

| | | |
|---|---|---|
| T | = | (4°C) surrounding temperature |
| hw | = | heat conductive coefficienct |

$$hw = 0.000572 \frac{\sqrt{\frac{V}{d}}}{(273 + T + \frac{\theta}{2})^{0.123}} (w/^\circ C\ cm^2)$$

| | | |
|---|---|---|
| v | = | wind speed (= 0.5 m/sec) |
| r | = | conductor resistance at utilization temperature (90 °C) (= $3.443 \times 10^6$ Ω/cm) |
| Ws | = | sunshine amount (= 0.1 w / $cm^2$) |
| η | = | heat radiative coefficient ratio for transmission line and black body (= 0.9) |

On the basis of the above values I is computed at:

I = 327 (A)

This is ample capacity for maximum design current of 128 (A).

(2) Voltage Drop

The length of the transmission line from the Ilam small hydropower plant to the Ilam substation is 4.7 km. Voltage drop (E) over this distance is estimated as follows:

$$\begin{aligned} E &= I_{max} \times r \times l \\ &= 128(A) \times 0.3443(\Omega / km) \times 4.7(km) \\ &= 207V \end{aligned}$$

This represents 0.6% against the transmission line rating of 33 kV and therefore does not present a problem.

However, the length of transmission line between the Ilam small hydropower station and the Anarmani substation is 60 km. Voltage drop in this case is:

$$\begin{aligned} E &= I_{max} \times r \times l \\ &= 128(A) \times 0.3443(\Omega / km) \times 60(km) \\ &= 2,644V \end{aligned}$$

This represents 8% against the transmission line rating and therefore voltage must be stepped up at transmission.

However, under actual operating conditions, 1,500 kW will be consumed even in the 1st year at the Ilam substation, with the remaining 4,700 kW (5,530 kVA). Accordingly:

$$I_{\max} = 5{,}530(kVA) \div 33(kV) \div \sqrt{3} = 97(A)$$
$$\therefore E = 97(A) \times 0.3443(\Omega / km) \times 56$$
$$= 1870(V)$$

The above voltage drop is 5.7 % of the 33 kV rating, and therefore does not pose a problem.

(3) Momentary Current Capacity

With transformer capacity at 7,400 kVA and impedance at 7%, short circuit current in case of shorting at the Ilam transformer's secondary side $I_{S1}$(transmission line side) is as follows:

$$I_{S_1} = \frac{7{,}400(kVA)}{33(kV) \times 0.07 \times \sqrt{3}} = 1{,}850(A)$$

Short circuit current in the case of shorting at the secondary side of the Anarmani substation $I_{S2}$ main transformer (7,500 kVA, impedance = 9.43%) is as follows:

$$I_{S_2} = \frac{7{,}500(kVA)}{33(kV) \times 0.0943 \times \sqrt{3}} = 1.392(A)$$

Momentary current capacity ($I_a$) of the transmission line is as follows:

$$\frac{\rho T \cdot \alpha}{\sigma \cdot S_o} \cdot t\left(\frac{Ia}{s \times 10^{-2}}\right)^2 = \log_e \frac{(\alpha\theta + 1)}{(\alpha\theta_o + 1)}$$

where:

| | | |
|---|---|---|
| S | = | cable cross section ($mm^2$) |
| t | = | passing time of current (sec) |
| $\alpha$ | = | resistance temperature of cable ($°C^{-1}$) |
| $\theta_0$ | = | initial temperature rise of cable (°C) due to surrounding temperature |
| $\theta$ | = | temperature rise of cable (°C) due to surrounding temperature (assumed at 0°C) |
| $S_0$ | = | heat ratio (Jule/g°C) |
| $\sigma$ | = | density ($g/cm^3$) |
| $\rho T$ | = | inherent resistance at surrounding temperature $T_0$ ($\Omega /cm^2$) |

If initial cable temperature is assumed at 40°C (surrounding temperature = 40°C ; initial temperature rise = 0), then:

$$I_a = 93\frac{s}{\sqrt{t}}$$

If $t = 2$ sec, and $s = 100$ mm², then:

$$I_a = 6{,}570 \text{ (A)}$$

The above value for momentary current $I_a$ is sufficiently higher than the short circuit current, and is therefore considered safe in this regard.

### 2.3 Voltage Drop at the Anarmani Substation

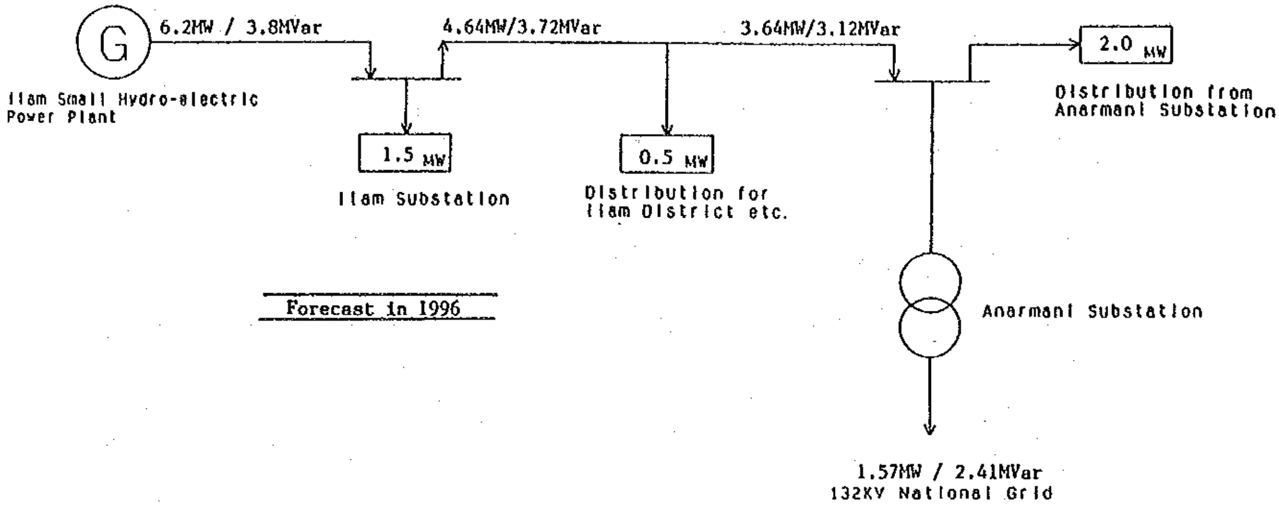
Extreme voltage drops are periodically observed at the Anarmani substation (step-up voltage rating: 132 kV) located at the terminus of the national grid.

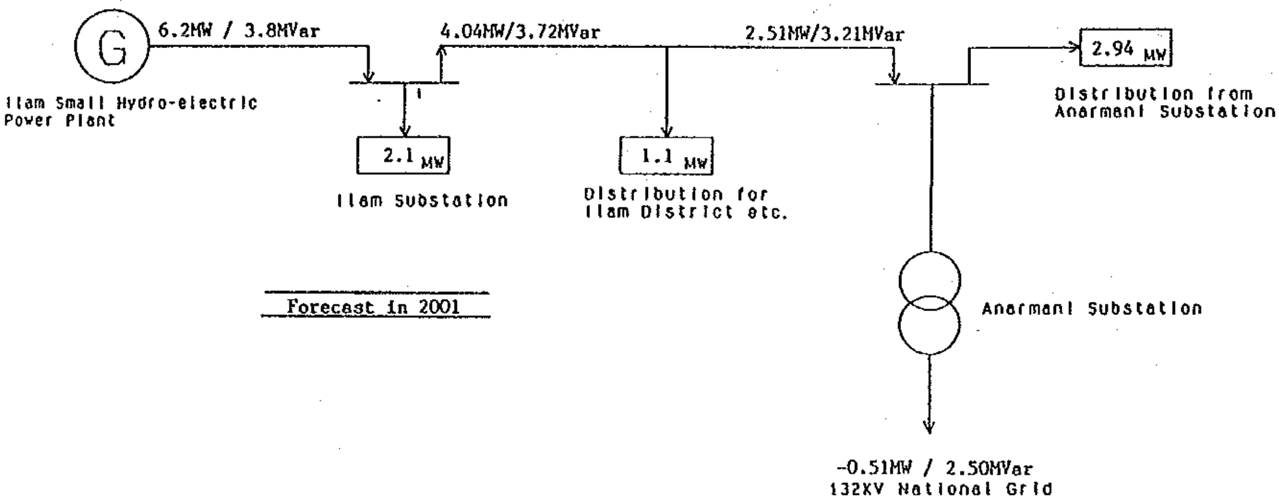
Particularly at peak hours (18:00~20:00) in the dry season, voltage may drop nearly 10% to around 120 kV.

Figures IV.3-1 and IV.3-2 show daily voltage fluctuations during normal operation and during load shedding (due to voltage drop), respectively.

It is accordingly necessary to plan facilities under the Project assuming that voltage drop of 10% may occur in the national grid to which the Ilam small hydropower station is to be connected upon completion.

## Figure IV.1-1 Power Flow Under Normal Operation



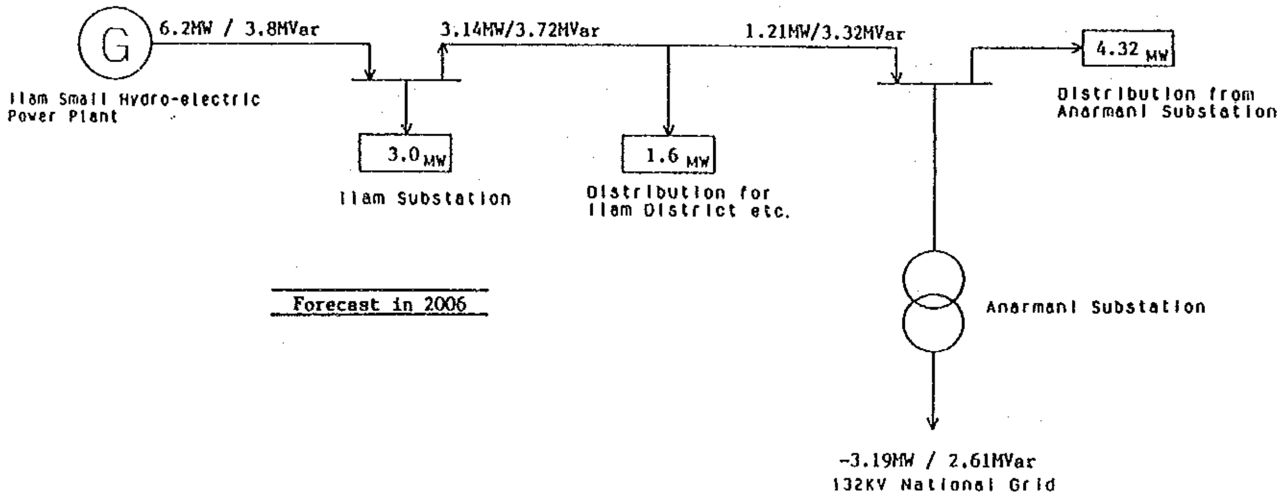



**Figure IV.1-2 Power Flow in the Case of Plant Shut Down**

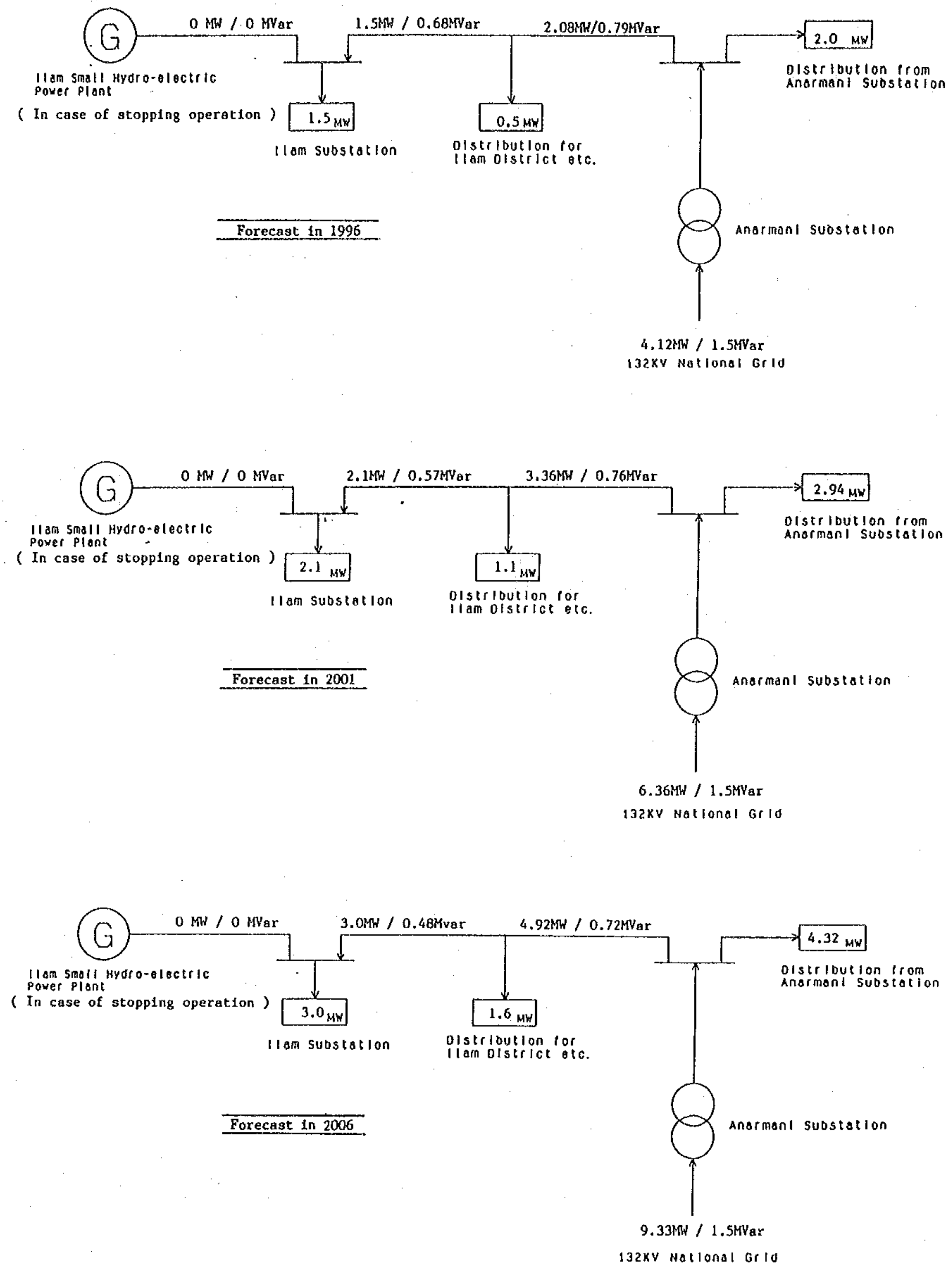


Figure IV.3-1 Voltage at Anarmani Substation (with Normal Operation)

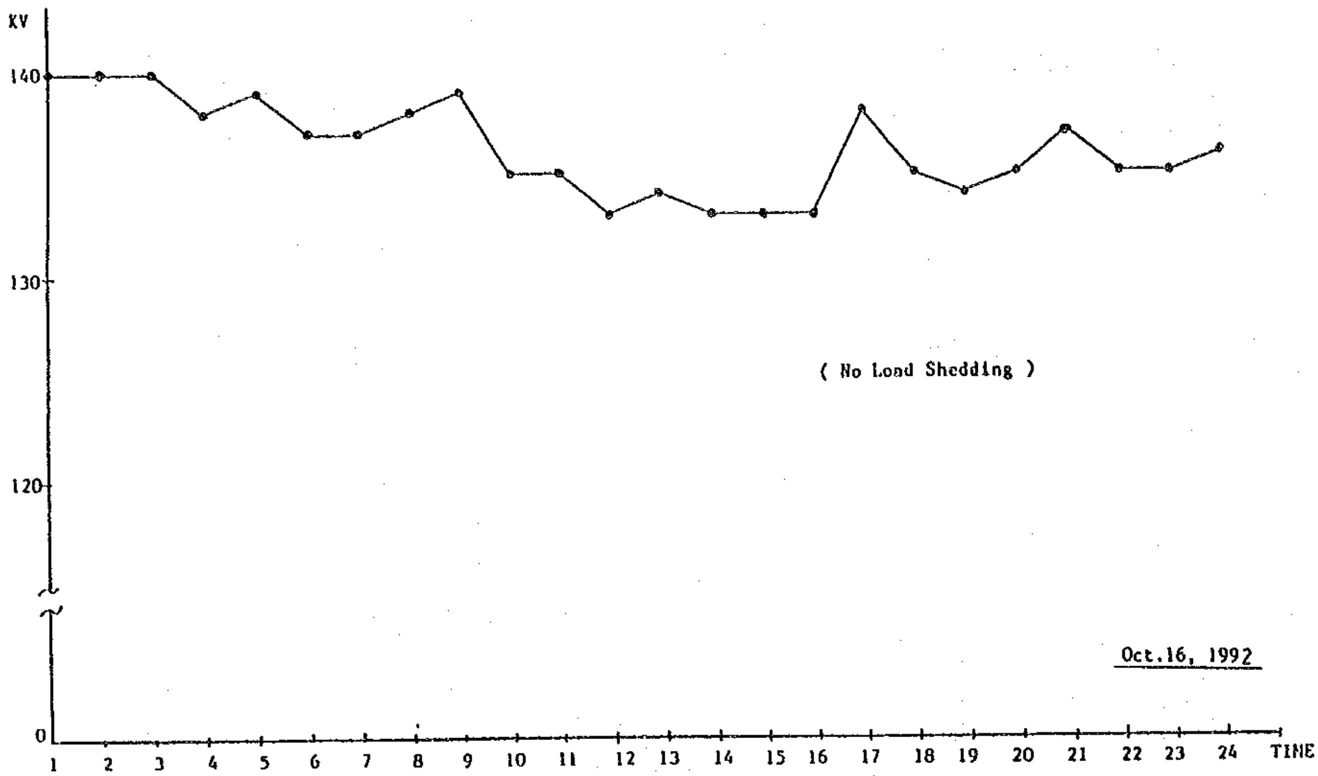
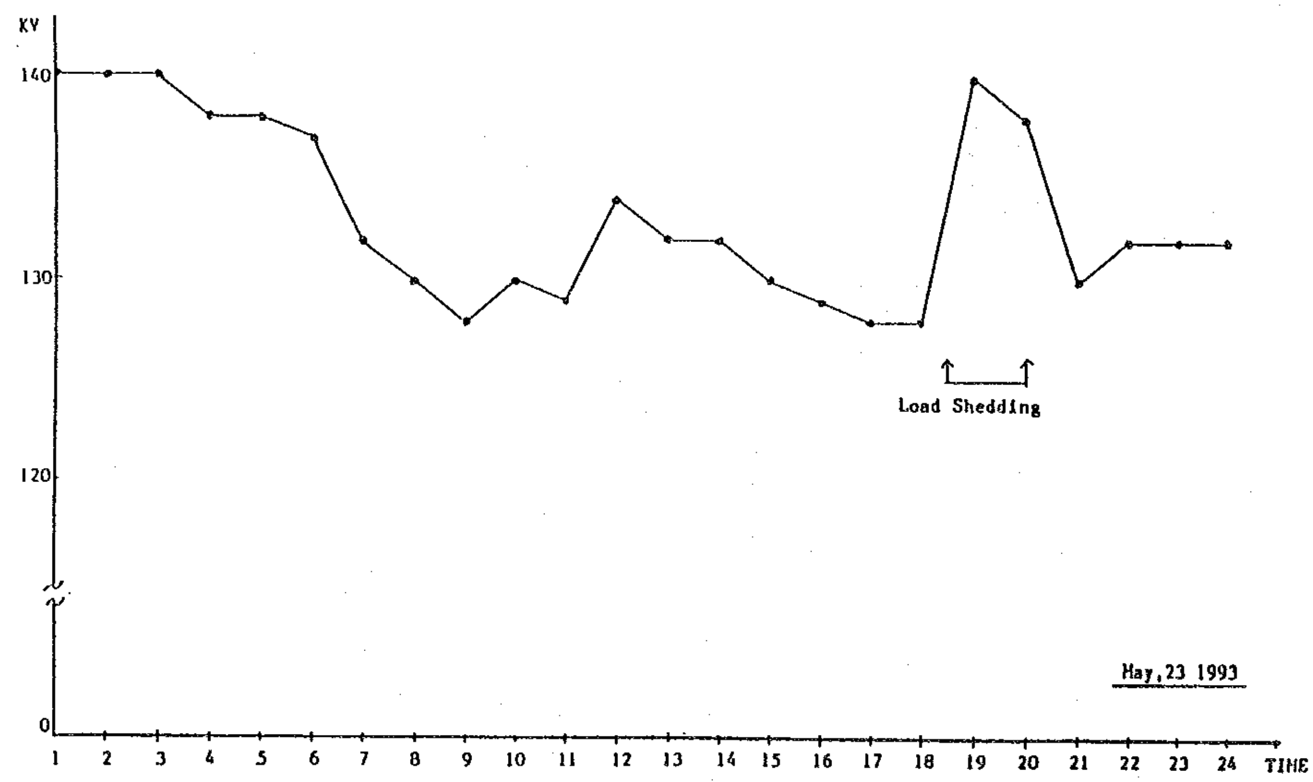



Figure IV.3-2 Voltage at Anarmani Substation (with Load Shedding)



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