ESTIMATING EARTHWORK

Estimating Earthwork

Earthwork includes:

- 1. Excavation
- 2. Grading: Moving earth to change elevation
- 3. Temporary shoring
- 4. Back fill or fill: Adding earth to raise grade
- 5. Compaction: Increasing density
- 6. Disposal

Productivity Factors

A. Job conditions

- Material type
- Water level and moisture content
- Job size
- Length of haul
- Haul road condition (accessibility and load restrictions)

Productivity Factors (cont.)

B. Management conditions

- Equipment conditions and maintenance practices
- Skills of work force and management
- Planning, supervision and coordination of work.

Job Efficiency Factors for Earthmoving Operations

	Management Conditions*			
Job Conditions**	Excellent	Good	Fair	Poor
Excellent	0.84	0.81	0.76	0.70
Good	0.78	0.75	0.71	0.65
Fair	0.72	0.69	0.65	0.60
Poor	0.63	0.61	0.57	0.52

Units of Measure

- Cubic Yard (bank, loose, or compacted)

Bank (BCY):	Materials in its natural state before disturbance (in-place, in-situ)
Loose (LCY):	Material that has been compacted or disturbed or loaded
Compacted (CCY):	Material after compaction

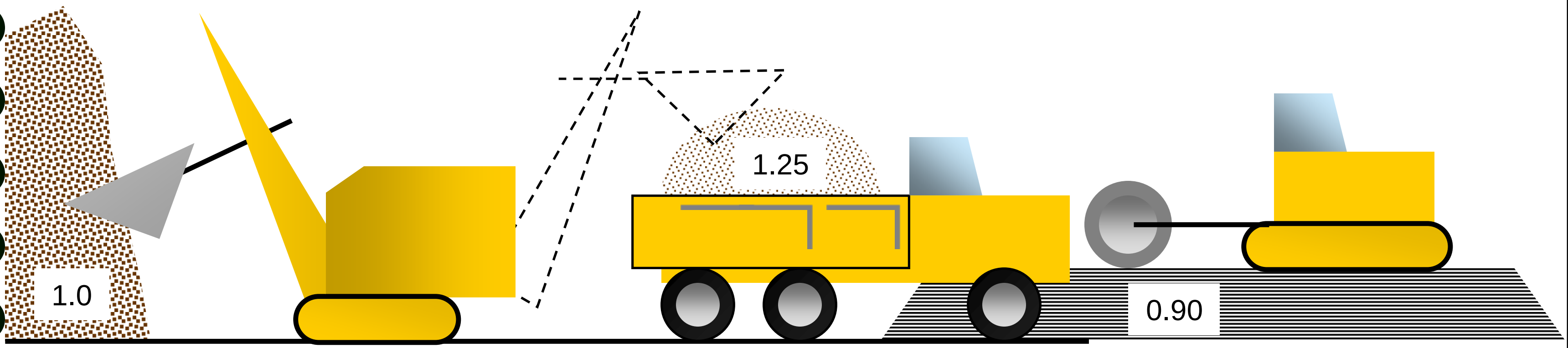
1.0 CUBIC YARD IN NATURAL CONDITION (IN-PLACE YARD)

=

1.25 CUBIC YARD AFTER DIGGING (LOOSE YARDS)

=

0.90 CUBIC YARD AFTER COMPACTED (COMPACTED YARDS)



In place

Loose

Compacted

Volume

Bank: V_B

- Bank cubic yards (BCY)
- Density B Lb /BCY

Loose: V_l

- Loose cubic yards (LCY)
- Density L Lb/LCY

Compacted: V_c

- Compacted cubic yards (CCY)
- Density C LB/CCY

Swell:

A soil increase in volume when it is excavated.

$$\text{Swell (\%)} = \left(\frac{\text{Bank density}}{\text{Loose density}} - 1\right) \times 100$$

$$\text{Load factor} = \frac{\text{Loose density}}{\text{Bank density}}$$

Bank Volume = Loose volume x Load factor

Shrinkage:

A soil decreases in volume when it is compacted

$$\text{Shrinkage (\%)} = \left(1 - \frac{\text{Bank density}}{\text{Compacted density}}\right) \times 100$$

Shrinkage factor = 1 - Shrinkage

Compacted volume

= Bank volume x Shrinkage factor

Approximate Material Characteristics

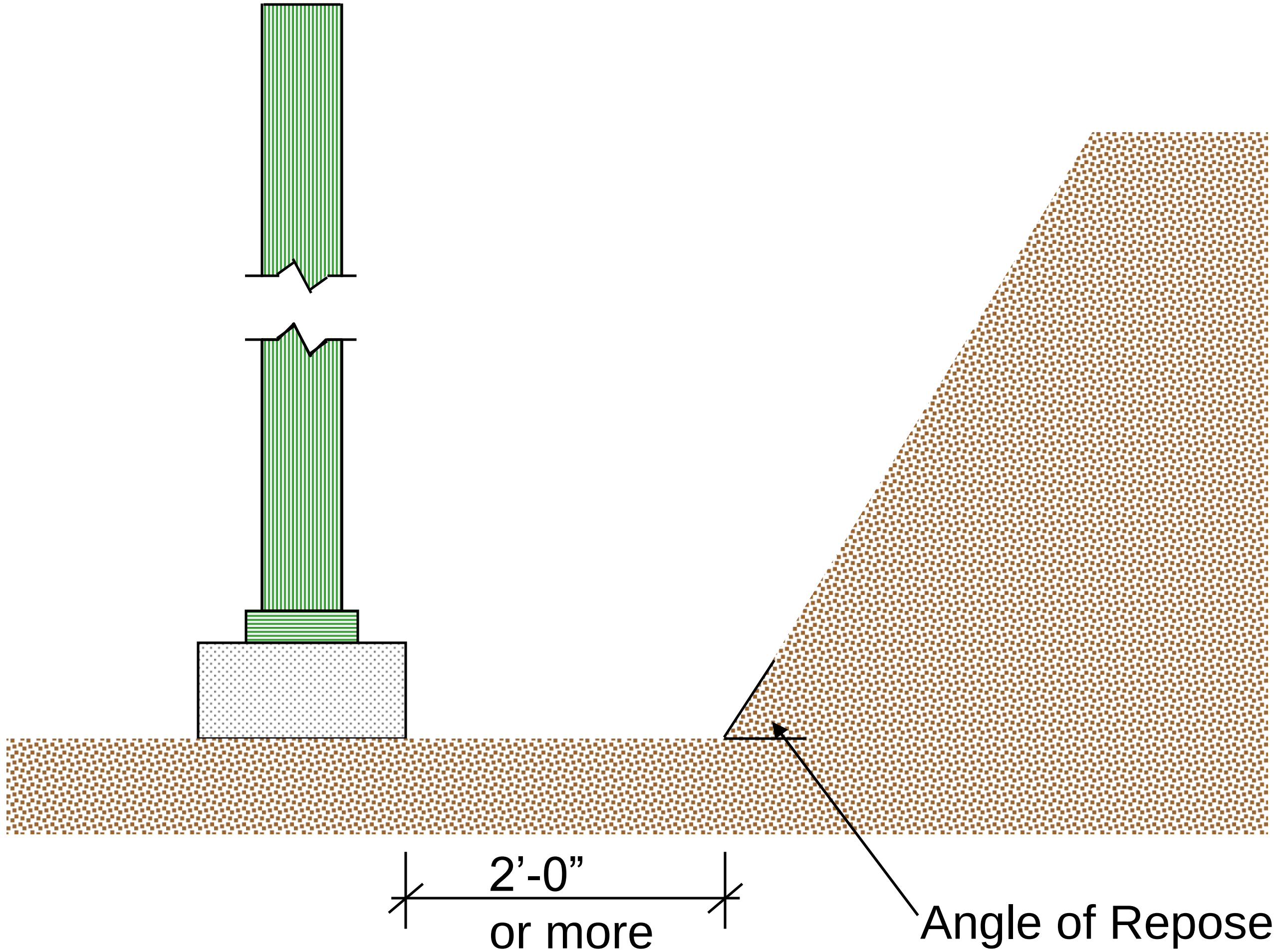
Material	Loose (lb/cy)	Bank (lb/cy)	Swell (%)	Load Factor
Clay, dry	2,100	2,650	26	0.79
Clay, wet	2,700	3,575	32	0.76
Clay and gravel, dry	2,400	2,800	17	0.85
Clay and gravel, wet	2,600	3,100	17	0.85
Earth, dry	2,215	2,850	29	0.78
Earth, moist	2,410	3,080	28	0.78
Earth, wet	2,750	3,380	23	0.81
Gravel, wet	2,780	3,140	13	0.88
Gravel, dry	3,090	3,620	17	0.85
Sand, dry	2,600	2,920	12	0.89
Sand, wet	3,100	3,520	13	0.88
Sand and gravel, dry	2,900	3,250	12	0.89
Sand and gravel, wet	3,400	3,750	10	0.91

- Exact values will vary with grain size, moisture content, compaction, etc. Test to determine exact values for specific soils.

Typical Soil Volume Conversion Factors

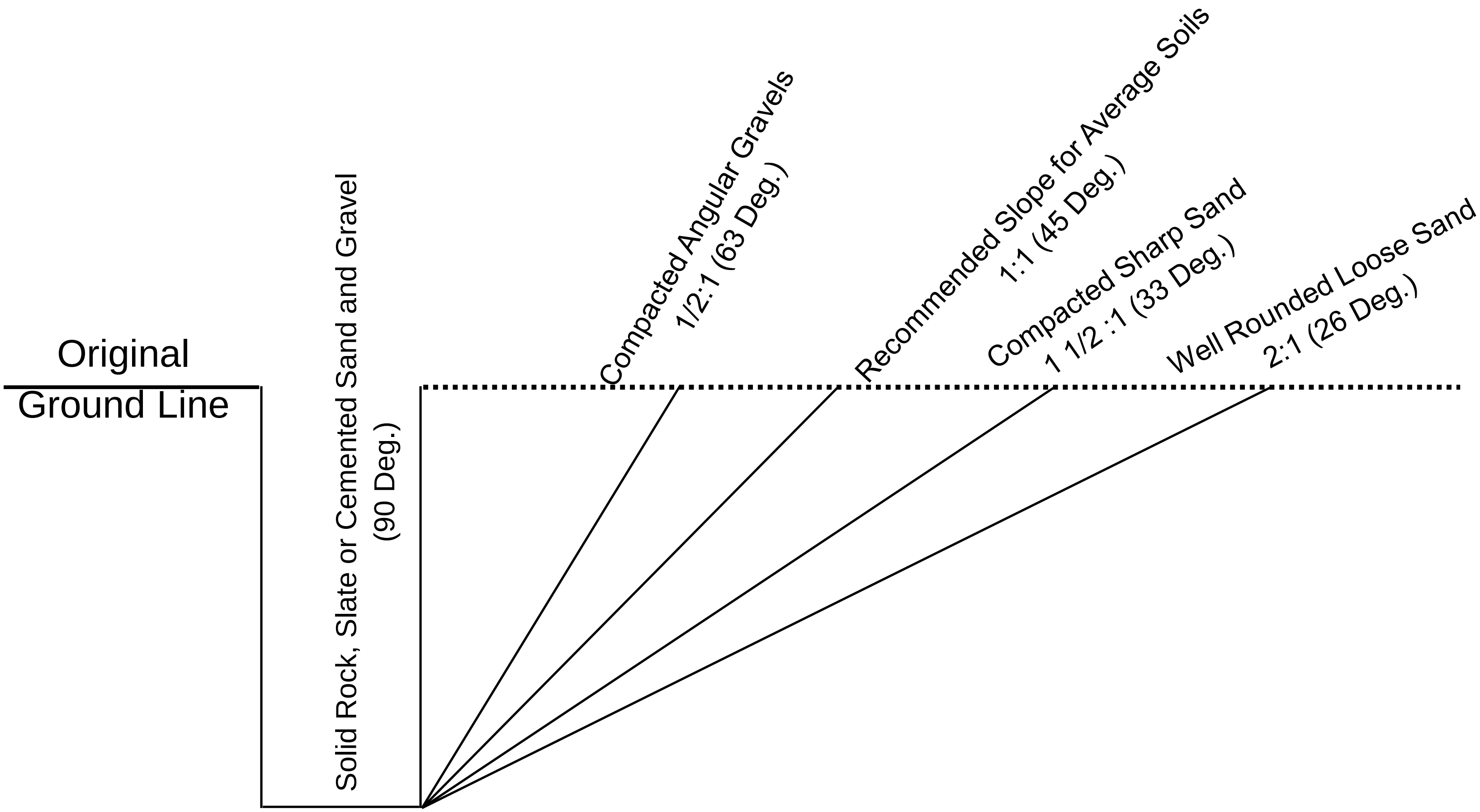
Soil Type	Initial Soil Condition	Bank	Convrted to: Loose	Compacted
Clay	Bank	100	127	0.90
	Loose	0.79	100	0.71
	Compacted	111	141	100
Common earth	Bank	100	125	0.90
	Loose	0.80	100	0.72
	Compacted	111	139	100
Rock (blasted)	Bank	100	150	130
	Loose	0.67	100	0.87
	Compacted	0.77	115	100
Sand	Bank	100	112	0.95
	Loose	0.89	100	0.85
	Compacted	105	118	100

Estimating Earth work for Trenches and Foundation



Approximate Angle of Repose

For Sloping Sides of Excavation



Calculating Earthwork Quantities

1. End Area Method
2. Contour Line/ Grid Method

1. End Area Method

- Used in sites where length is much greater than width

CALCULATING EARTHWORK QUANTITIES

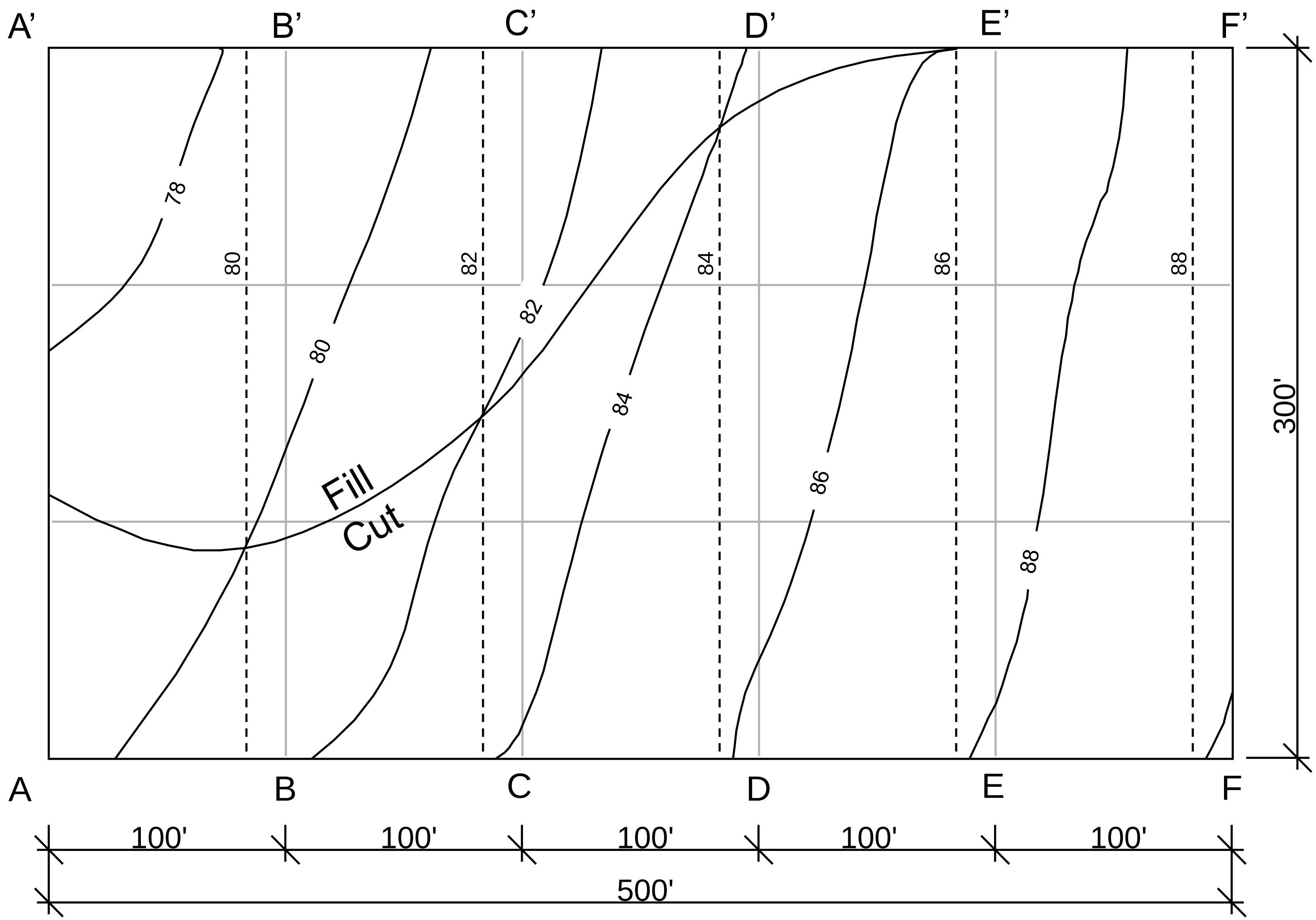
1. End Area Method

a. Take cross-sections at regular intervals, typically, 100’ intervals.

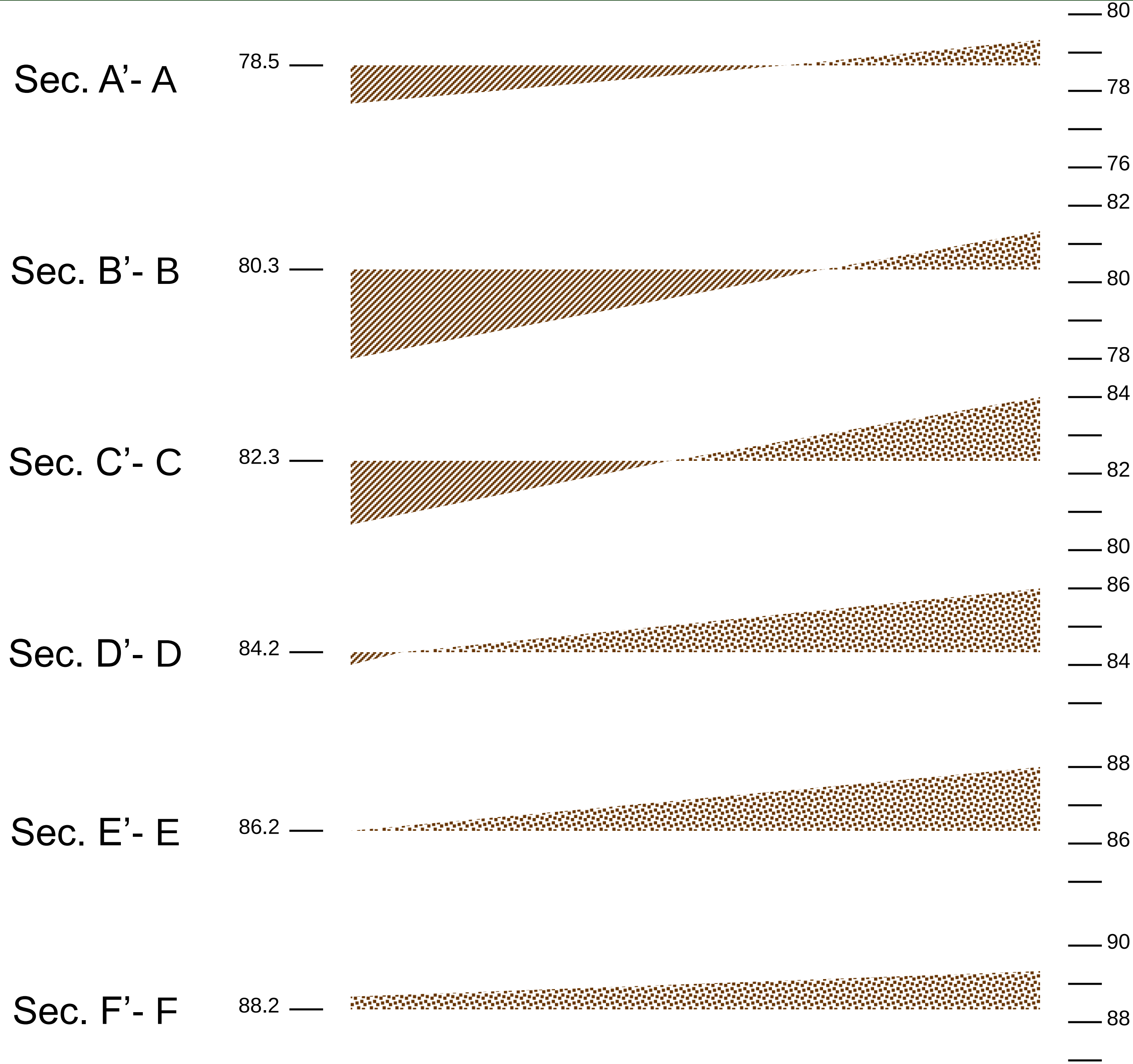
b. Calculate the cross-section end areas

c. The volume of earthwork between sections is obtained by taking the average of the end areas at each station in square feet multiplied by the distance between sections in feet and dividing by 27 to obtain the volume in cubic yards.

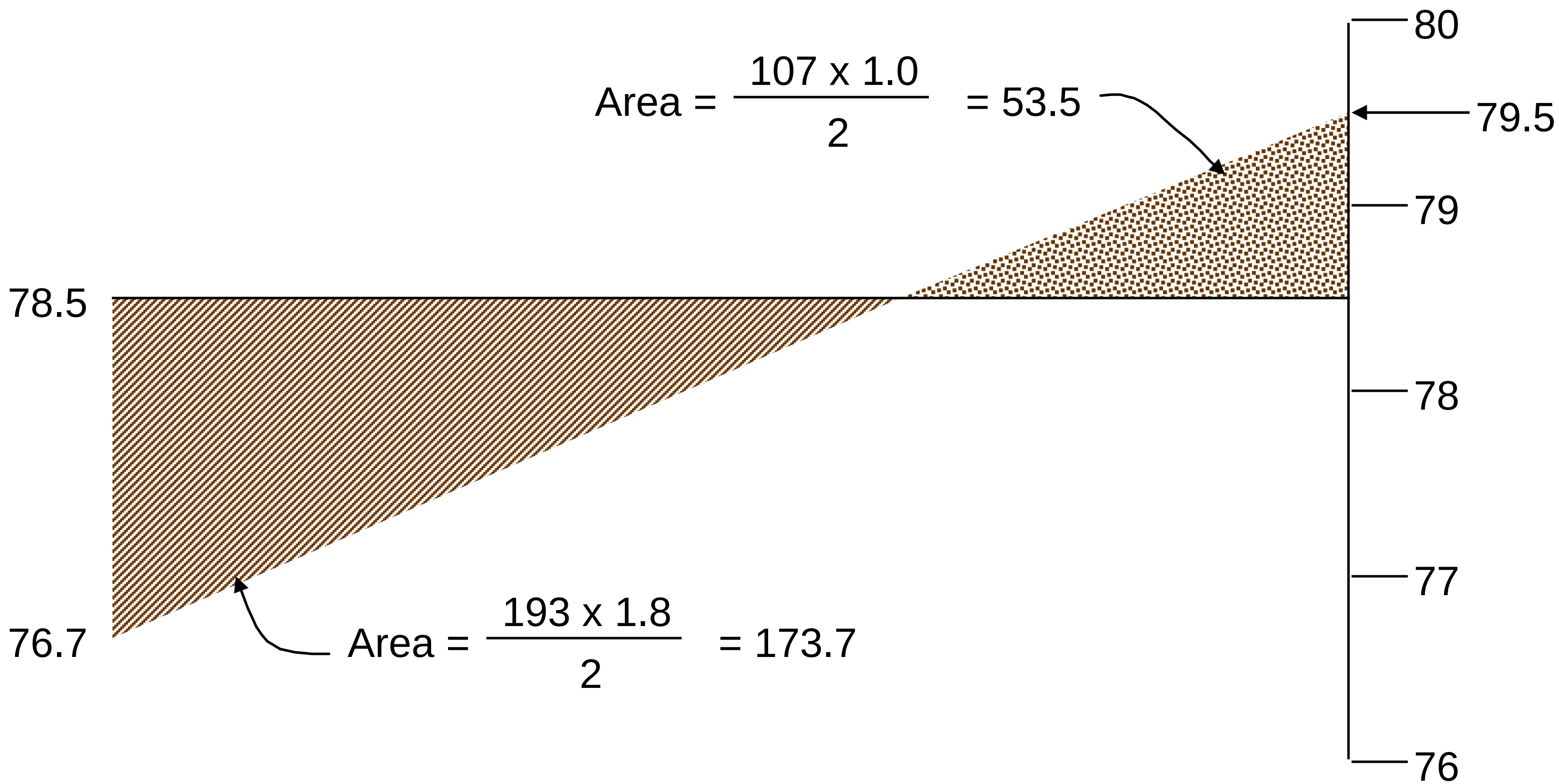
Project Site Showing 100' Stations



Project Cross Sections

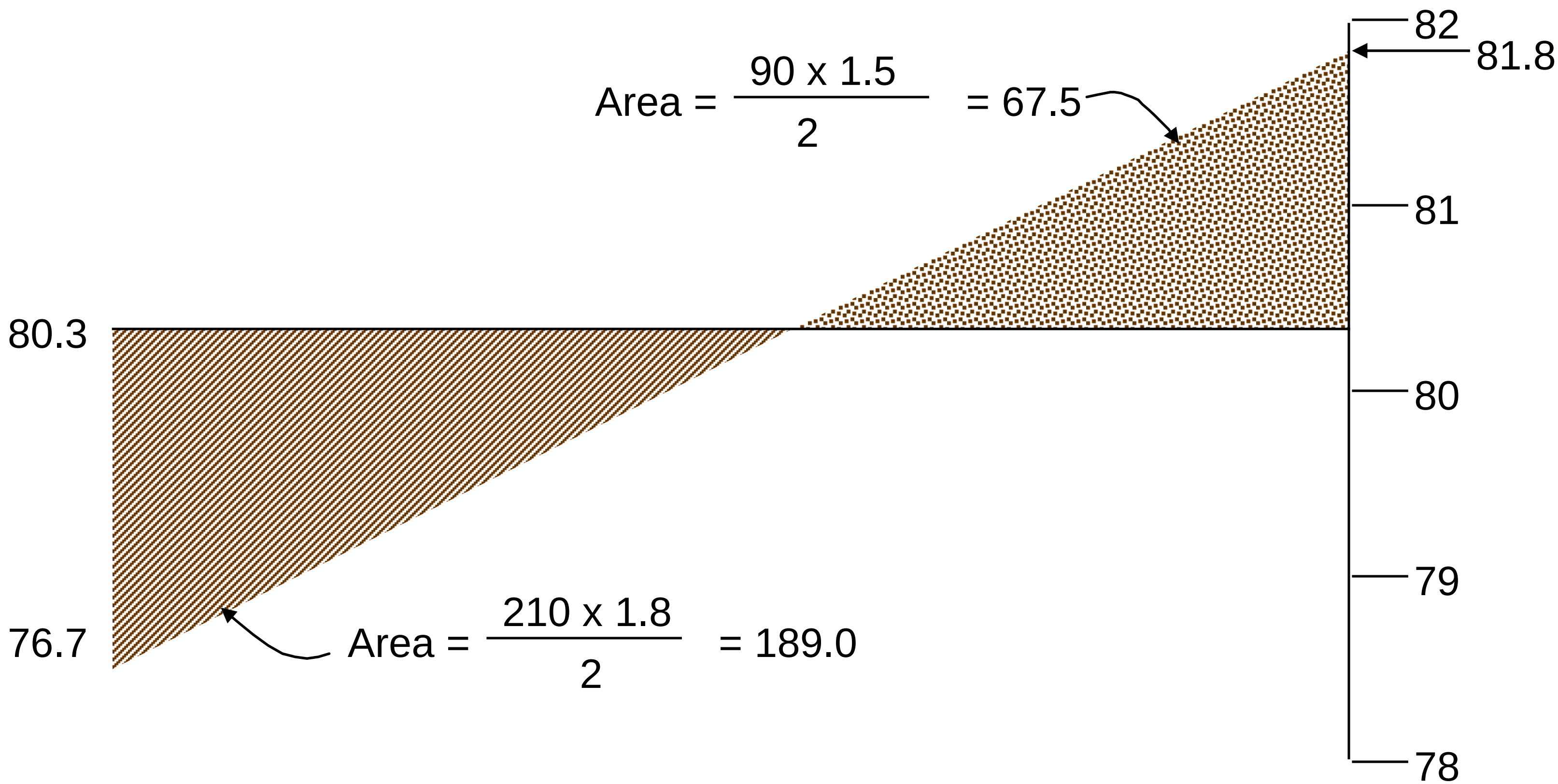


Cross-Section @ A’- A



Section A’- A

Cross-Section @ B’- B



Section B’- B

Table 1. Cumulative Earthwork Quantities

Section	Emb (CCY)	Exc. (BCY)	Exc. x B/C (CCY)	Net Exc. (CCY)	Cum Exc (CCY)
A-B	672	224	254	- 418	- 418
B-C	567	441	499	- 68	- 486
C-D	215	791	896	681	195
D-E	0	1031	1167	1167	1362
E-F	0	1222	1384	1384	2746

2. Contour Line/ Grid Method

- Used for parking lots and site “leveling”
- Grid size from 10’x10’ to 50’x50’
- the greater the terrain variance the smaller the grid

2. CONTOUR LINE/GRID CELL METHOD(cont.)

Step I

Determine by visual study of the site drawing if the net total will be an import (more fill required than cut) an export (less fill required than cut) or a blend (cut and fill about equal)

Step 2

Determine the pattern of calculation points or grid size.

Step 3

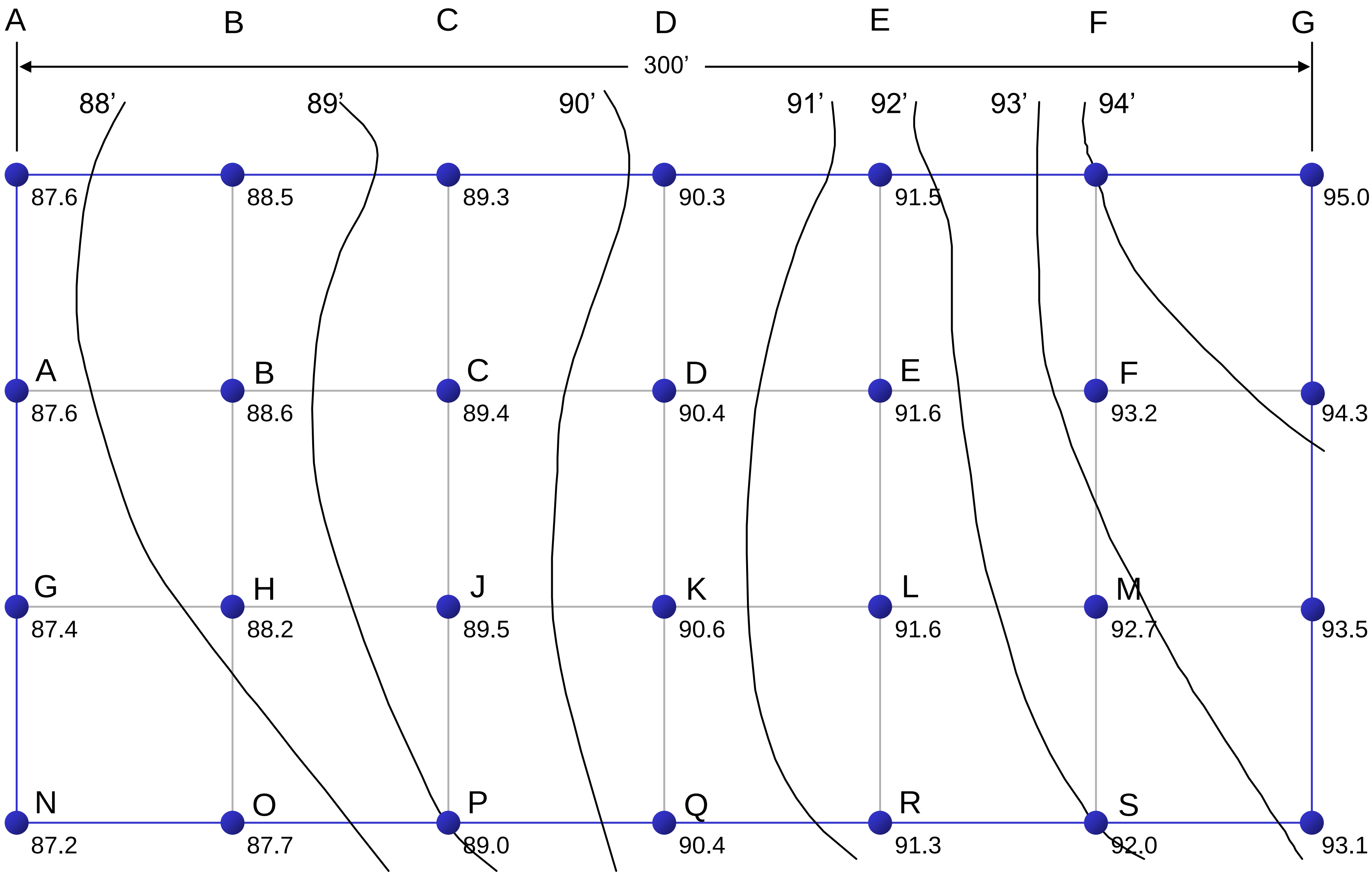
Determine elevations at each calculation location, the corners of each grid.

Step 4

Calculate the cubic yards of cut or fill required in each grid cell.

Step 5

Add the individual Grid Cell quantities together to arrive at the total cut, total fill volume and the import or volume export yardage required for the job.

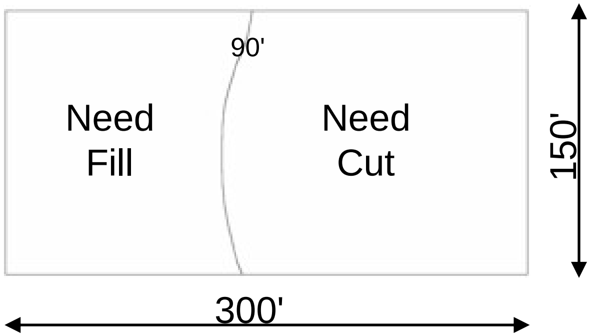


No Scale

Notes:
1. Bring the entire site to elevation 90.
2. All grids are 50'x 50' = 2500 sq. ft.
3. Present contours

Purpose

Grade the entire site to grade 90’



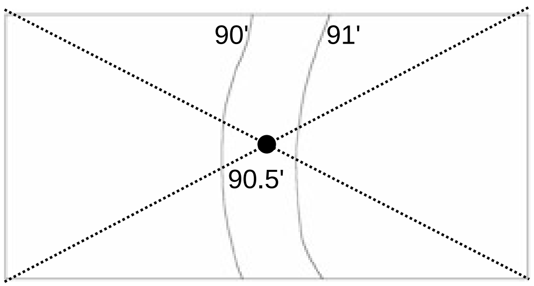
Quick and Dirty

Assume one grid

Existing 90.50

Proposed 90.00

Cut 0.50



$$\text{Total Cost} = \frac{150 \times 300 \times 0.50}{27} = 833\text{CY}$$

If we choose the grid size to be 50'x50'

Average elevation

$$= \frac{87.6+88.5+87.6+88.6}{4}$$

= 88.08

change = 90-88.08

= 1.92

cut =

= 177.77 CY

and so on.