Engineering Calculations

DEMOLITION DEBRIS
&
WASTE SOURCE VOLUME CALCULATIONS

Sunchief Mill Site
Tonto National Forest
Gila County, Arizona

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SECTION 1.0 PROBLEM STATEMENT

Objective: To estimate the volume of waste material (demolition debris, overburden/waste rock, tailings) located within the boundaries of the Sunchief Mill Site.

SECTION 2.0 ESTIMATING TECHNIQUE

Dimensions used to calculate volume of waste material are estimated based on field measurements and approximations, GPS data, and survey topographic data provided by the USFS. Surveyed measurements of the waste sources and structures were not taken. Structure footprint dimensions were gathered using a tape measure or measuring wheel or a combination thereof. Estimated depths and representative geometric shapes were of soil/rock materials were made through visual observation.

Given the deteriorating state and complex nature of the on-site structures, exact feature dimensions (support beams, roof trusses, staircases, etc.) were not taken for demolition debris estimating. Instead, Federal Emergency Management Agency (FEMA) (September 2010) and California Emergency Management Agency (CEMA) debris estimating techniques (January 2010) and equations were used for estimating structure demolition debris unless otherwise noted.

Due to the estimative nature of the volume estimates, all calculated volumes were rounded up 5-12%.

SECTION 3.0 ABBREVIATIONS AND CONVERSION FACTORS

Abbreviations

C&D	Construction and demolition
CY	Cubic yards
cf	Cubic feet
ea	Each
ft	Feet
ft^2	Square feet
ft^3	Cubic feet
SA	Surface area
SY	Square yards
V	Volume

Conversion Factors

$1\ ft^2 = 1/9$ SY
$1\ ft^3 = 1/27$ CY
1 ton of C&D debris = 2 CY (Per FEMA debris estimating field guide)
1 CY waste source material = 1.76 tons

SECTION 4.0 EMPERICAL EQUATIONS

General Building Debris Estimation Formula (Per FEMA, *Debris Estimating Field Guide,* FEMA Publication No. 329, September 2010):

$$\frac{Length\ x\ Width\ x\ Height\ x\ 0.33}{27} = CY$$

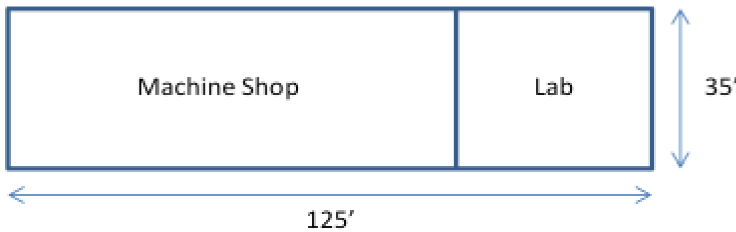
Mobile Home Debris Estimation Formula (Per CEMA, *Disaster Debris Management, Chapter 4, Debris Forecasting and Estimating*. Dated January 2010 [Rev.]):

$$\frac{Length\ x\ Width\ x\ Height}{27} = CY$$

SECTION 5.0 MACHINE SHOP

Objective: Calculate the estimated volume of C&D debris material that will result from the demolition of the Machine Shop (including the Lab area). The structure has a total length of 125 ft and width of 35 ft. The Machine Shop has estimated height of 30 ft.

Solution: Using the FEMA debris estimating empirical equation for General Buildings, calculate the estimated C&D debris for the structure. For volume estimating purposes, assume a uniform height across the length and width of the structure, including the laboratory area.



Plan View
(not to scale)

Dimensions:
Length = 125 ft
Width = 35 ft
Height = 30 ft

$$General\ Building\ C\&D\ Debris\ Volume = \frac{Length\ x\ Width\ x\ Height\ x\ 0.33}{27} = CY$$

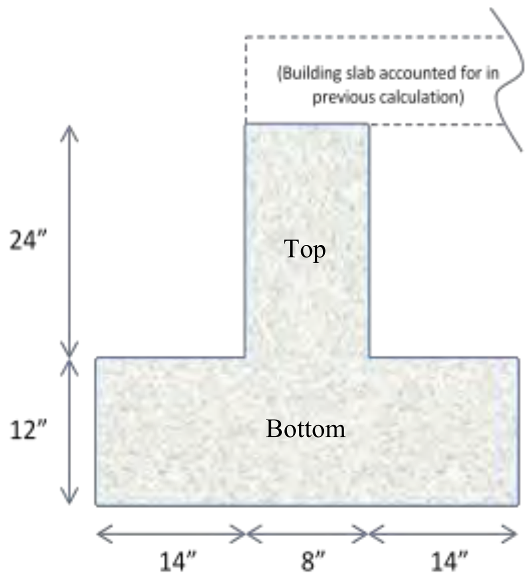
$$General\ Building\ C\&D\ Debris\ Volume = \frac{(125\ ft)x\ (30\ ft)x\ (30\ ft)\ x\ 0.33}{27} = CY$$

$$General\ Building\ C\&D\ Debris\ Volume = 1604\ CY \cong \mathbf{1650\ CY}$$

SECTION 6.0 MACHINE SHOP FOUNDATION

Objective: Calculate the estimated volume of C&D debris material that will result from the demolition of the Machine Shop foundation. The foundation is assumed to be a spread footing type running the length of the machine shop's east and west walls. Dimensions are as assumed in the drawing below.

Solution: Using the surface area method volume method, calculate the estimated volume of material in the foundation.



Volume = Surface Area x Length x (2 ea.)
Volume = 4.33 ft^2 x 125 ft x 2
Volume = 1083.3 ft^3/27
Volume = 40.1 CY ≅ **45 CY**

Surface Area = $A_{top} + A_{bottom}$
Surface Area = 192 in^2 + 432 in^2
Surface Area = 624 in^2/144 in^2/ft^2
Surface Area = 4.33 ft^2

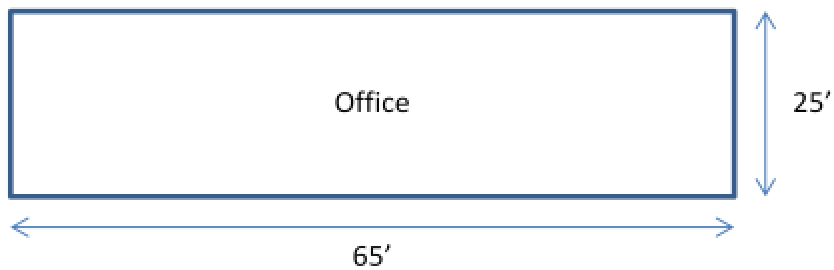
$\mathbf{A_{top}}$ = Length x Width
$\mathbf{A_{top}}$ = 24in x 8in
$\mathbf{A_{top}}$ = 192 in^2

$\mathbf{A_{bottom}}$ = Length x Width
$\mathbf{A_{bottom}}$ = 36in x 12in
$\mathbf{A_{bottom}}$ = 432 in^2

SECTION 7.0 OFFICE

Objective: Calculate the estimated volume of C&D debris material that will result from the demolition of the Office building. The structure has a total length of 65 ft and width of 25 ft. The Office has estimated height of 10 ft.

Solution: Using the FEMA debris estimating empirical equation for General Buildings, calculate the estimated C&D debris for the structure. For volume estimating purposes, assume a uniform height across the length and width of the structure.



Plan View
(not to scale)

Dimensions:
Length = 65 ft
Width = 25 ft
Height = 10 ft

$$General\ Building\ C\&D\ Debris\ Volume = \frac{Length\ x\ Width\ x\ Height\ x\ 0.33}{27} = CY$$

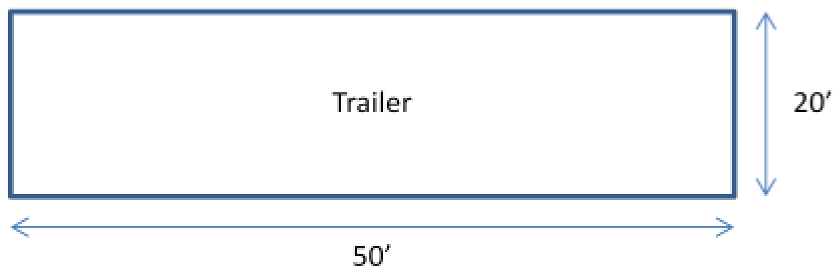
$$General\ Building\ C\&D\ Debris\ Volume = \frac{(65\ ft)x\ (25\ ft)x\ (10\ ft)\ x\ 0.33}{27} = CY$$

$$General\ Building\ C\&D\ Debris\ Volume = 198.6\ CY \cong \mathbf{225\ CY}$$

SECTION 8.0 TRAILER

Objective: Calculate the estimated volume of C&D debris material that will result from the demolition of the Office building. The structure has a total length of 65 ft and width of 25 ft. The Office has estimated height of 10 ft.

Solution: Using the CEMA debris estimating empirical equation for a Mobile Home, calculate the estimated C&D debris for the structure. For volume estimating purposes, assume a uniform height across the length and width of the structure.



Plan View
(not to scale)

Dimensions:
Length = 50 ft
Width = 20 ft
Height = 8 ft

$$Mobile\ Home\ C\&D\ Debris\ Volume = \frac{Length\ x\ Width\ x\ Height\ x\ 0.33}{27} = CY$$

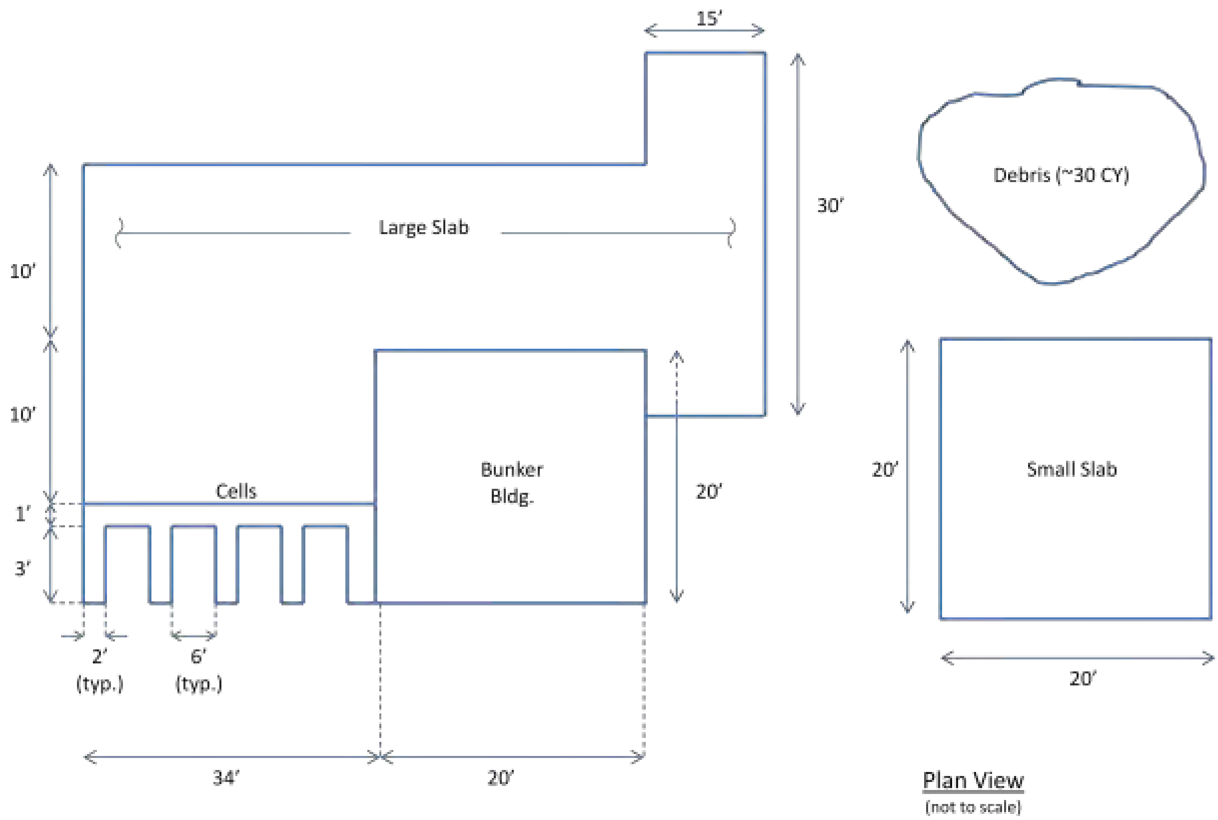
$$Mobile\ Home\ C\&D\ Debris\ Volume = \frac{(50\ ft)x\ (20\ ft)x\ (8\ ft)}{27} = CY$$

$$Mobile\ Home\ C\&D\ Debris\ Volume = 296.3\ CY \cong \mathbf{325\ CY}$$

SECTION 9.0 BUNKER COMPLEX

Objective: Calculate the estimated volume of C&D debris material that will result from the demolition of the Bunker Complex. The structure and concrete slabs have the dimensions shown below and discussed herewith. The bunker building itself has a height of 12 ft and maintains a 6-in concrete wall and floor thickness throughout. For estimating purposes, assume the bunker building has a door opening 9 ft tall by 8 ft wide. The bunker cells stand 4 ft above grade; assume the bunker cell concrete walls extend 3 ft bgs. The debris pile is estimated to be 30 CY.

Solution: Using geometric equations, calculate the estimated C&D debris for the structure. Split the large slab into 3 parts: left, middle and right. Split the bunker cells into two parts, the back knee wall and bunker cell walls.



Bunker Building

Dimensions:
Length = 20 ft
Width = 20 ft
Height = 12 ft
Door = 9 ft x 8 ft

$V_{WALLS} = [(20 \text{ ft} \times 12 \text{ ft}) \times 4 \text{ ea.} - (8 \text{ ft} \times 9 \text{ ft})]*0.5 \text{ ft}$
$V_{WALLS} = 444 \text{ ft}^3$

$V_{FLOOR} = 20 \text{ ft} \times 20 \text{ ft} \times 0.5 \text{ ft}$
$V_{FLOOR} = 200 \text{ ft}^3$

$V_{ROOF} = V_{FLOOR}$
$V_{ROOF} = 200 \text{ ft}^3$

$\text{Volume}_{BUNKER\ BLDG} = V_{WALLS} + V_{FLOOR} + V_{ROOF}$
$\text{Volume}_{BUNKER\ BLDG} = 444 \text{ ft}^3 + 200 \text{ ft}^3 + 200 \text{ ft}^3$
$\text{Volume}_{BUNKER\ BLDG} = 844 \text{ ft}^3/27$
$\text{Volume}_{BUNKER\ BLDG}$ = 31.3 CY ≅ **35 CY**

(Calculations continued on the next page)

Small Slab

Dimensions:
Length = 20 ft
Width = 20 ft
Thickness = 6 in

$Volume_{SMALL\ SLAB}$= L x W x t
$Volume_{SMALL\ SLAB}$= 20 ft x 20 ft x 0.5 ft
$Volume_{SMALL\ SLAB}$= 200 ft^3/27
$Volume_{SMALL\ SLAB}$= 7.4 CY ≅ **8 CY**

Large Slab

Dimensions:
Length = 20 ft
Width = 20 ft
Thickness = 6 in

$Volume_{LARGE\ SLAB}$= $V_{LEFT\ SLAB}$+ $V_{MIDDLE\ SLAB}$ + $V_{RIGHT\ SLAB}$
$Volume_{LARGE\ SLAB}$= ([20 ft x 34 ft]+[10 ft x 20 ft]+[30 ft x 15 ft]) x 0.5 ft
$Volume_{LARGE\ SLAB}$= 665 ft^3/27
$Volume_{LARGE\ SLAB}$= 24.6 CY ≅ **28 CY**

Bunker Cells

Dimensions:

Knee Wall:	Cell Walls:
Length = 34 ft	Length = 3 ft
Width = 1 ft	Width = 2 ft
Height = 7 ft	Height = 7 ft

$Volume_{CELLS}$= $V_{KNEE\ WALL}$ + $V_{CELL\ WALLS}$
$Volume_{CELLS}$= (34 ft x 1 ft x 7 ft) + (3 ft x 2 ft x 7 ft) x 5 ea
$Volume_{CELLS}$= 448 ft^3/27
$Volume_{CELLS}$= 16.6 CY ≅ **19 CY**

$Volume_{BUNKER\ COMPLEX}$ = $Volume_{BUNKER\ BLDG}$ + $Volume_{SMALL\ SLAB}$ + $Volume_{LARGE\ SLAB}$ + $Volume_{CELLS}$ + V_{DEBRIS}*
$Volume_{BUNKER\ COMPLEX}$ = 35 CY + 8 CY + 28 CY + 19 CY + 30 CY*
$Volume_{BUNKER\ COMPLEX}$ ≅ 120 CY

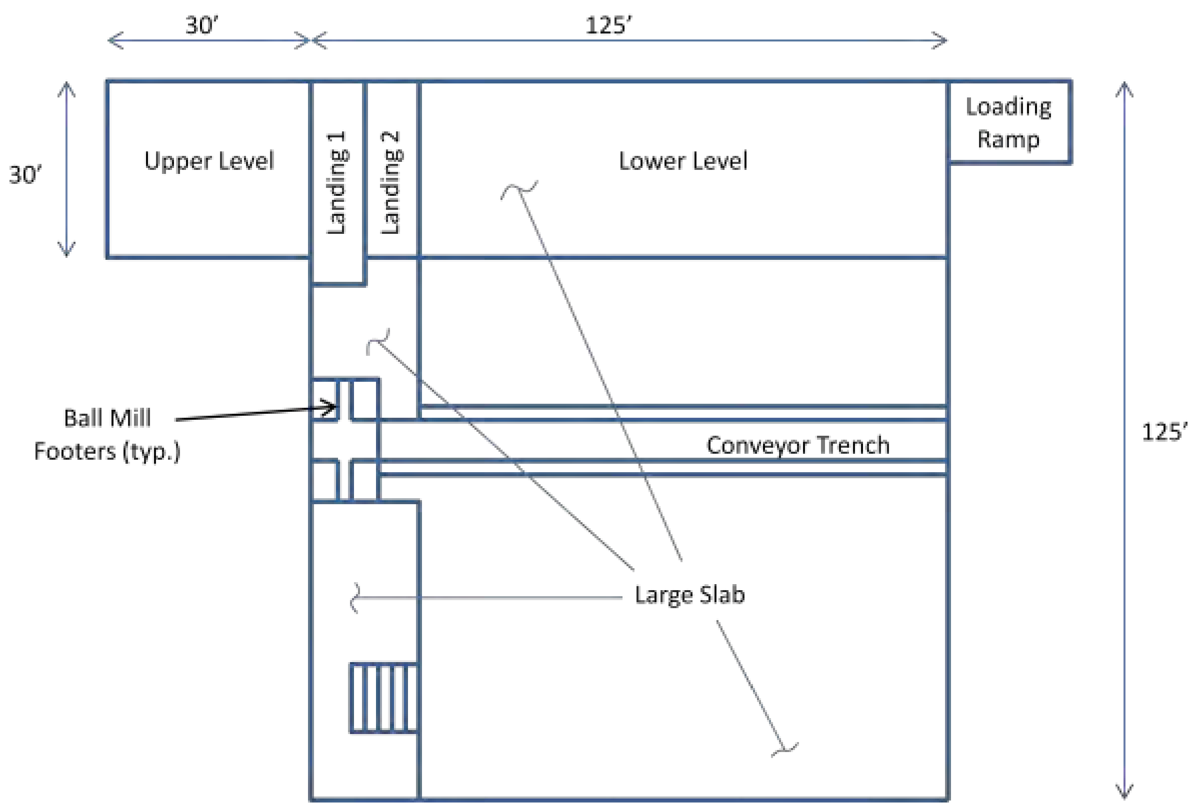
*Reference Objective statement and Plan View for volume estimate ≅ 30 CY

SECTION 10.0 MILL BUILDING COMPLEX

Objective: Calculate the estimated volume of C&D debris material that will result from the demolition of the Mill Building complex. The structures and concrete slabs have the dimensions shown below and discussed herewith.

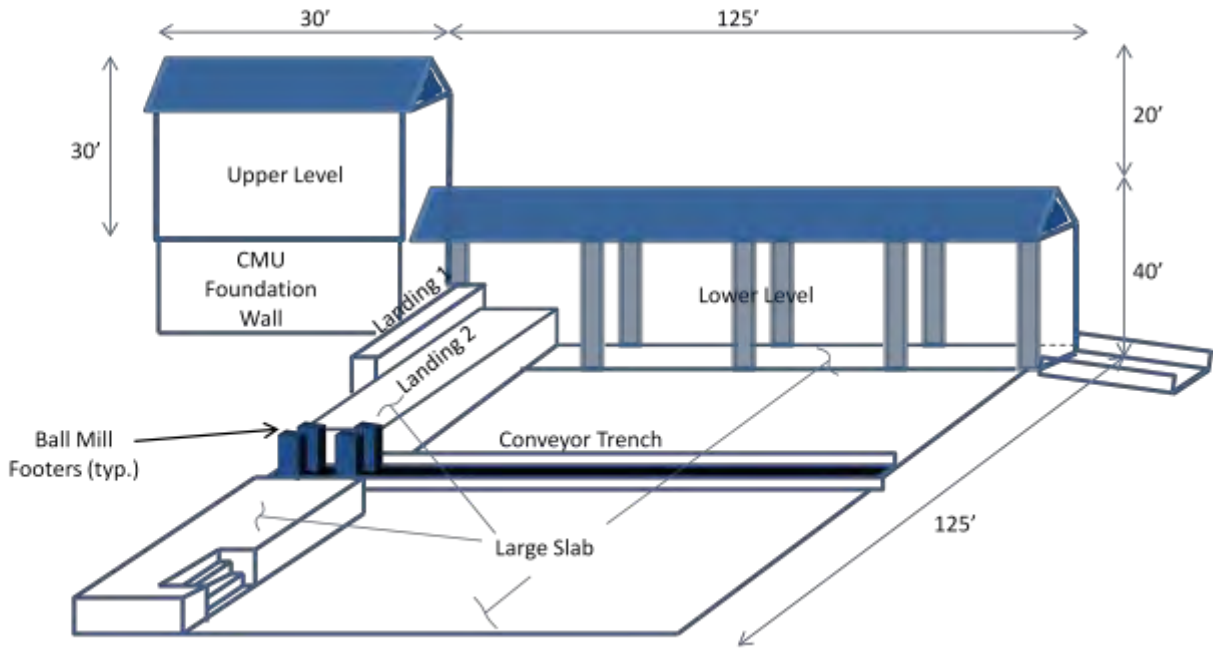
Solution: Using the FEMA debris estimating empirical equations for General Buildings and geometric equations, calculate the estimated C&D debris for the structure. Do to the dilapidated and 'open air' condition of the structure, apply a 0.10 multiplier to the FEMA debris estimating formula as opposed to the 0.33 multiplier used for more standard, robust structures. To estimate the volume of the spread footing foundation, use the surface area method.

For volume estimating purposes, assume that the slab is 12 in thick. There are 15 visible courses of 8-in tall concrete masonry units (CMU) serving as the Upper Level foundation; for volume estimating purposes assume the CMU foundation wall extends an additional 5 CMU courses bgs onto a spread footing. The assumed spread footing is assumed to have the dimensions shown below. Assume a 100 CY contingency for unknown subgrade conditions and miscellaneous foundations (i.e., ball mill footers, conveyor trench, loading ramp, stairs and landings, etc). Assume 125 CY of miscellaneous debris (i.e., metal, trash, etc.) are present.

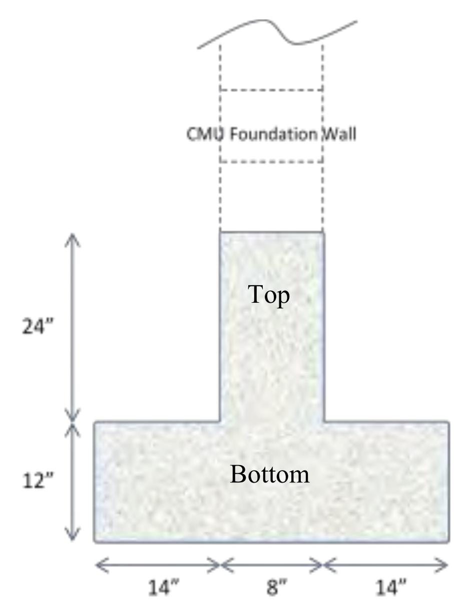


Plan View
(not to scale)

(Mill Building Complex figures continued on the next page)



Isometric View
(not to scale)



CMU Foundation
(not to scale)

(calculations begin on the next page)

Upper Level

Dimensions:
Length = 30 ft
Width = 30 ft
Height = 30 ft

$$General\ Building\ C\&D\ Debris\ Volume = \frac{Length\ x\ Width\ x\ Height\ x\ 0.10}{27} = CY$$

$$General\ Building\ C\&D\ Debris\ Volume = \frac{30\ ft\ x\ 30\ ft\ x\ 30\ ft\ x\ 0.10}{27} = CY$$

$$General\ Building\ C\&D\ Debris\ Volume = 100\ CY\ \cong\ \mathbf{110\ CY}$$

Lower Level

Dimensions:
Length = 125 ft
Width = 30 ft
Height = 40 ft

$$General\ Building\ C\&D\ Debris\ Volume = \frac{Length\ x\ Width\ x\ Height\ x\ 0.10}{27} = CY$$

$$General\ Building\ C\&D\ Debris\ Volume = \frac{125\ ft\ x\ 30\ ft\ x\ 40\ ft\ x\ 0.10}{27} = CY$$

$$General\ Building\ C\&D\ Debris\ Volume = 555.6\ CY\ \cong\ \mathbf{575\ CY}$$

CMU Foundation Wall

Dimensions:
Length = 30 ft
Width = 0.667 ft (8 in)
Height = 15 ea x (8 in/12 in/ft) + 5 ea x (8 in/12 in/ft) = 13.33 ft

Volume = L x W x H
Volume = 30 ft x 0.667 ft x 13.33 ft x 2 ea
Volume = 533.46 ft^3/27
Volume = 19.8 CY ≅ **22 CY**

CMU Wall Spread Footing Foundation

Dimensions:
*As shown in figure.

Volume = Surface Area x Length x 2 ea
Volume = 4.33 ft^2 x 30 ft x 2 ea
Volume = 259.8 ft^3/27
Volume = 9.6 CY ≅ **11 CY**

Surface Area = $A_{top} + A_{bottom}$
Surface Area = 192 in^2 + 432 in^2
Surface Area = 624 in^2/144 in^2/ft^2
Surface Area = 4.33 ft^2

A_{top} = Length x Width
A_{top} = 24 in x 8 in
A_{top} = 192 in^2

A_{bottom} = Length x Width
A_{bottom} = 36 in x 12 in
A_{bottom} = 432 in^2

Large Slab

Dimensions:
Length = 125 ft
Width = 125 ft
Height = 12 in = 1 ft

Volume = L x W x H
Volume = 125 ft x 125 ft x 1 ft
Volume = 15625 ft^3/27
Volume = 578.7 CY ≅ **625 CY**

$Volume_{MILL\ BLDG\ COMPLEX} = V_{UPPER\ LEVEL} + V_{LOWER\ LEVEL} + V_{CMU\ WALL} + V_{CMU\ FOOTING} + V_{SLAB} + V_{CONC\ CONTINGENCY} + V_{DEBRIS}$
$Volume_{MILL\ BLDG\ COMPLEX}$ = 110 CY + 575 CY + 22 CY + 11 CY + 625 CY + 100 CY + 125 CY
$Volume_{MILL\ BLDG\ COMPLEX}$ ≅ 1568 CY

SECTION 11.0 WASTE SOURCE, ASBESTOS

Objective: Calculate the estimated volume of waste material with asbestos detections at the Sunchief Mill Site. For volume estimating purposes, assume the piles lie in approximate geometric shapes as observed and noted during the field investigation or as observed in available photographs.

Solution: Use approximate geometric shapes and estimated dimensions observed during the field investigation to calculate estimated volumes of material. Shapes, dimensions, and associated notes gathered from the field log book/documents are presented in Table 1. For unnamed piles, utilize available figures and photographs to scale approximate dimensions. Pile IDs correlate to waste pile source identifications presented on Figure 8, in the EE/CA report.

Table 1 – Summary of Waste Source Piles, Asbestos Detections

Pile ID (Figure 8)	Type	Shape	Length (ft)	Width (ft)	Height/ Depth (ft)	Diameter (ft)	Footprint (ft^2)	Surface Area (ft^2)	Volume (cf)	Volume (cy)	Volume, rounded up 5-12% (cy)	Notes
C	Waste Source	Rectangle	25	10	7	-	250	990	1750	64.8	**70**	
E	Waste Source	Rectangle	30	15	3	-	450	1170	1350	50.0	**55**	
G	Waste Source	Rectangle	75	50	12	-	3750	2100	9000	333	**350**	Only southern portion of pile had asbestos detection. Assumed as 20% of total volume of Pile G.
M	Waste Source	Rectangle	30	18	15	-	540	2520	8100	300	**325**	
O	Waste Source	Rectangle	150	6	5	-	900	3360	4500	167	**175**	
GG	Waste Source	Rectangle	20	15	2	-	300	740	600	22.2	**25**	Dimensions and shape were estimated from Figure 8 and photos.
HH	Waste Source	Cone	-	-	5	20	314	1904	524	19.4	**22**	Dimensions and shape were estimated from Figure 8 and photos.
II	Waste Source	Cone	-	-	5	20	314	1904	524	19.4	**22**	Dimensions and shape were estimated from Figure 8 and photos.
						TOTALS	6818	14689	26347	976	**≅ 1044**	

Surface Area (SA) Formulas Used:

$$SA, Rectangle = 2([h \text{ x } w] + [l \text{ x } h] + [l \text{ x } w])$$

$$SA, Cone = \pi r s + \pi r^2 \quad where \;\; s = \sqrt{r^2 + h^2} \quad \& \quad r = d/2$$

l = Length
w = Width
h= Height
d = diameter

Volume Formulas Used:

$$Volume, Rectangle = l \text{ x } w \text{ x } h$$

$$Volume, Cone = \left(\frac{1}{3}\right)\pi r^2 h \quad where \;\; r = d/2$$

SECTION 12.0 WASTE SOURCE, METALS

Objective: Calculate the estimated volume of waste material with metals detections above nrSRLs at the Sunchief Mill Site. For volume estimating purposes, assume the piles lie in approximate geometric shapes as observed and noted during the field investigation or as observed in available photographs.

Solution: Use approximate geometric shapes and estimated dimensions observed during the field investigation to calculate estimated volumes of material. Shapes, dimensions, and associated notes gathered from the field log book/documents are presented in Table 2. For unnamed piles, utilize available figures and photos to scale approximate dimensions. Pile IDs correlate to waste pile source identifications presented on Figure 8, in the EE/CA report.

Table 2 Summary of Waste Source Piles, Metal Detections Above nrSRLs

Pile ID (Figure 8)	Type	Shape	Length (ft)	Width (ft)	Height/ Depth (ft)	Diameter (ft)	Footprint (ft^2)	Surface Area (ft^2)	Volume (cf)	Volume (cy)	Volume, rounded up 5-12% (cy)	Notes
G	Waste Source	Rectangle	75	50	12	-	3750	8400	36000	1333	**1400**	Only northern portion of pile had metals detection above nrSRL. Assumed as 80% of total volume of Pile G.
H	Waste Source	Rectangle	30	150	8	-	4500	11880	36000	1333	**1400**	
Q	Waste Source	Cone	-	-	5	20	314	1904	524	19.4	**22**	
U	Waste Source	Cone	-	-	12	25	491	3052	1963	72.7	**80**	
V	Waste Source	Rectangle	60	12	5	-	720	2160	3600	133	**150**	
W	Waste Source	Rectangle	60	15	2.5	-	900	2175	2250	83.3	**90**	
X	Waste Source	Rectangle	20	5	2	-	100	300	200	7.41	**10**	
Y	Waste Source	Cone	-	-	12	20	314	1989	1257	46.5	**50**	
Z	Waste Source	Cone	-	-	5	18	254	1546	424	15.7	**18**	TCLP exceeds RCRA limits for Lead
AA	Waste Source	Rectangle	15	10	3	-	150	450	450	16.7	**19**	TCLP exceeds RCRA limits for Lead
DD	Waste Source	Rectangle	30	8	2.5	-	240	670	600	22.2	**25**	
EE	Waste Source	Rectangle	30	20	0.25	-	600	1225	150	5.56	**6**	
						TOTALS, All Piles	12334	35752	83418	3090	**≅ 3233**	
						Lead TCLP Totals	404	1996	874	32.4	**≅ 37**	

Surface Area (SA) Formulas Used:

$$SA, Rectangle = 2([h \times w] + [l \times h] + [l \times w])$$

$$SA, Cone = \pi r s + \pi r^2 \quad where \ \ s = \sqrt{r^2 + h^2} \quad \& \quad r = d/2$$

l = Length
w = Width
h= Height
d = diameter

Volume Formulas Used:

$$Volume, Rectangle = l \times w \times h$$

$$Volume, Cone = \left(\frac{1}{3}\right)\pi r^2 h \qquad where \ \ r = d/2$$

SECTION 13.0 TOTAL VOLUME OF WASTE MATERIALS

Objective: Calculate the total volume of waste materials at the Sunchief Mill Site. Provide a segregation of material type into C&D debris versus waste source material.

Solution: Sum the totals from the previous calculation to determine the total C&D debris and total waste source material. Sum the total C&D debris and total waste source material to determine the total volume waste present at the Sunchief Mill Site.

C&D Debris

C&D Quantities:

$V_{\text{MACHINE SHOP}} = 1650$ CY
$V_{\text{MACHINE SHOP FOUNDATION}} = 45$ CY
$V_{\text{OFFICE}} = 225$ CY
$V_{\text{TRAILER}} = 325$ CY
$V_{\text{BUNKER COMPLEX}} = 120$ CY
$V_{\text{MILL BLDG COMPLEX}} = 1568$ CY

$V_{\text{TOTAL, C\&D DEBRIS}} = V_{\text{MACHINE SHOP}} + V_{\text{MACHINE SHOP FOUNDATION}} + V_{\text{OFFICE}} + V_{\text{TRAILER}} + V_{\text{BUNKER COMPLEX}} + V_{\text{MILL BLDG COMPLEX}}$
$V_{\text{TOTAL, C\&D DEBRIS}} = 1650\text{ CY} + 45\text{ CY} + 225\text{ CY} + 325\text{ CY} + 120\text{ CY} + 1568\text{ CY}$
$\mathbf{V_{\text{TOTAL, C\&D DEBRIS}} \cong 3933\text{ CY}}$

$\mathbf{V_{\text{TOTAL, C\&D DEBRIS}}}$ **(tons) =** $3933\text{ CY}/(2\text{CY/tn}) \cong$ **1967 tons**

Waste Source Material

Waste Source Quantities:

$V_{\text{WASTE SOURCE, ASBESTOS}} = 1044$ CY
$V_{\text{WASTE SOURCE, METALS}} = 3233$ CY

$V_{\text{TOTAL, WASTE SOURCE}} = V_{\text{WASTE SOURCE, ASBESTOS}} + V_{\text{WASTE SOURCE, METALS}}$
$V_{\text{TOTAL, WASTE SOURCE}} = 1044\text{ CY} + 3233\text{ CY}$
$\mathbf{V_{\text{TOTAL, WASTE SOURCE}} \cong 4277\text{ CY}}$

$\mathbf{V_{\text{TOTAL, WASTE SOURCE}}}$ **(tons) =** $4277\text{ CY} \times (1.76\text{ tons}/1\text{ CY}) \cong$ **7528 tons**

Total Waste Material

$$V_{\text{TOTAL}} = V_{\text{TOTAL, C\&D DEBRIS}} + V_{\text{TOTAL, WASTE SOURCE}}$$
$$V_{\text{TOTAL}} = 3933\text{ CY} + 4277\text{ CY}$$
$$\mathbf{V_{\text{TOTAL}} = 8210\text{ CY}}$$

or

$$V_{\text{TOTAL}} = 1967\text{ tons} + 7528\text{ tons}$$
$$\mathbf{V_{\text{TOTAL}} = 9495\text{ tons}}$$

SECTION 14.0 ON-SITE REPOSITORY VOLUME ESTIMATES

Objective: Estimate the following quantities for the proposed on-site repository at the Sunchief Mill Site. The existing tailings pond in Area 5 is proposed as the on-site repository location.

1. Available volumetric capacity for use as a repository.
2. Thickness of the waste material proposed for consolidation within the repository.
3. Volume of material needed for use as general fill (minimum of 2 feet general fill required).
4. Volume of berm material available for 'knock down' use as general fill.
5. Conclude if the available berm material is sufficient for use as general fill.

Solution: Using measurements collected during the field investigation and available maps, figures, and survey data calculate the required quantities. For estimation purposes assume the interior side walls of the pond are vertical (no slope). Use the following values for calculations (data sources where values were gather are listed in parenthesis to each value):

Pond Berm Profile
(not to scale)

l = Length
w = Width
h= Height

Bottom of Repository:
l = 215 ft (field logbook)
w = 285 ft (field logbook)
h= 15 ft (field logbook)

$SA_{TOP\ OF\ BERM}$ = 21185 ft^2 (figures)

1. Available volumetric capacity for use as a repository.

Solution: Determine the surface area of the bottom of the repository. Extrude the surface area by the height of the repository to calculate volumetric capacity.

$SA_{REPOSITORY} = l \times w$
$SA_{REPOSITORY}$ = 215 ft x 285 ft
$SA_{REPOSITORY}$ = 61275 ft^2

$V_{REPOSITORY} = SA_{REPOSITORY} \times h$
$V_{REPOSITORY}$ = 61275 ft^2 x 15 ft
$V_{REPOSITORY}$ = 919125 ft^3/27
$V_{REPOSITORY}$ = 34042 CY

2. Thickness of the waste material proposed for consolidation within the repository.

Solution: Using the assumption that the interior side walls are vertical, determine the cubic yard per foot incremental capacity (IC) of the repository. Divide the total volume of waste to be consolidated into the repository (V_{TOTAL} = 7804 CY) by the incremental capacity to determine the height/thickness (t_{WASTE}) of the waste material.

$IC_{REPOSITORY} = V_{REPOSITORY} / h$
$IC_{REPOSITORY}$ = 34042 CY / 15 ft
$IC_{REPOSITORY}$ = 2269 CY/ft

$t_{WASTE} = V_{TOTAL} / IC_{REPOSITORY}$
t_{WASTE} = 8210 CY / 2269 CY/ft
t_{WASTE} = 3.62 ft

3. Volume of material needed for use as general fill (minimum of 2 feet general fill required).

Solution: Extrude the surface area of the repository by the depth of general fill materials needed to determine the volume of material needed for use as general fill. Include a swell factor of 20% and assume recompaction of 95%.

$V_{GENERAL\ FILL} = SA_{REPOSITORY}$ x 2 ft
$V_{GENERAL\ FILL} = 61275\ ft^2$ x 2 ft
$V_{GENERAL\ FILL} = 122550\ ft^3/27$
$V_{GENERAL\ FILL} = 4538$ CY x (1+20% for swell) x 95% compaction
$\mathbf{V_{GENERAL\ FILL} = 5173\ CY}$

4. **Volume of berm material available for 'knock down' use as general fill.**

Solution: Determine the effective thickness ($t_{EFFECTIVE}$) of berm material that can be utilized as general fill by subtracting the waste material thickness and general fill thickness from the berm height. The cover soil material thickness (6 inches of topsoil) will not affect the effective thickness because the disturbed top of berm area will also receive a topsoil cover. Extrude the top of berm surface area by $t_{EFFECTIVE}$ to determine the volume of berm material that can be used as general fill. For estimation purposes use a waste material thickness of 4 ft.

$t_{EFFECTIVE} = h - t_{WASTE} - t_{COVER}$
$t_{EFFECTIVE} = 15\ ft - 4\ ft - 2\ ft$
$t_{EFFECTIVE} = 9\ ft$

$V_{AVAILABLE\ BERM\ MATERIAL} = SA_{TOP\ OF\ BERM} \times t_{EFFECTIVE}$
$V_{AVAILABLE\ BERM\ MATERIAL} = 21185\ ft^2 \times 9\ ft$
$V_{AVAILABLE\ BERM\ MATERIAL} = 190665\ ft^3/27$
$\mathbf{V_{AVAILABLE\ BERM\ MATERIAL} = 7062\ CY}$

5. **Conclude if the available berm material is sufficient for use as general fill.**

Solution: Compare the volume of general fill needed to the volume of berm material available.

$$\mathbf{V_{GENERAL\ FILL} = 5173\ CY < V_{AVAILABLE\ BERM\ MATERIAL} = 7062\ CY}$$

Therefore there is sufficient quantity available within the existing berm for use as 'knock down' general fill material.