



Engineering Calculations

WASTE VOLUME

**Big Bug Mining District
Money Metals and Providence Mine Sites
Bradshaw Mountains
Prescott National Forest, Arizona**

Prepared for:

**USDA Forest Service
333 Broadway SE
Albuquerque, New Mexico 87102**

Prepared by:

**Weston Solutions, Inc.
960 West Elliot Road, Suite 201
Tempe, Arizona 85284
(480) 477-4900**

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE NO.</u>
SECTION 1.0 – PROBLEM STATEMENT	1
SECTION 2.0 – ESTIMATING TECHNIQUE	1
SECTION 3.0 – ABBREVIATIONS AND CONVERSION FACTORS	1
SECTION 4.0 – MONEY METALS MINE.....	2
SECTION 5.0 – PROVIDENCE MINE.....	3
SECTION 5.1 – PM-WS-1	3
SECTION 5.2 – PM-WS-2/3.....	4
SECTION 5.3 – PM-WS-4.....	4
SECTION 5.4 – PM-WS-5	5
SECTION 5.5 – PM-WS-6.....	5
SECTION 5.6 – PM-WS-7.....	6
SECTION 5.7 – PM-WS-8/9.....	6
SECTION 5.8 – PM-WS-10.....	7
SECTION 5.9 – PM-WS-11.....	7
SECTION 5.10 – PM-WS-13.....	8
SECTION 5.11 – PM-WS-14.....	8

Project Name: Big Bug Watershed
Task: Engineering Evaluation & Cost Analysis
Problem Statement: Waste Volume Calculations

Prepared by: Brendon Loucks, E.I.T.
Date: December 23, 2009
Checked By: D. Brennecke, P.E.
Date: July 5, 2010

SECTION 1.0 – PROBLEM STATEMENT

Objective: To estimate the volume of waste material (overburden, waste rock, road cut material, tailings, or a combination thereof) located within the boundaries of multiple sites in the Big Bug Mining District. The list of mine groups considered for site reconnaissance and engineering evaluation (EE) within the Big Bug Mining District are evaluated in the following subsections. The mine sites evaluated are: Money Metals and Providence.

SECTION 2.0 – ESTIMATING TECHNIQUE

Dimensions used to calculate volume of waste material are estimated based on field measurements and approximations, and GPS data. Surveyed measurements were not taken. Estimated depth of material was made through visual observation. The majority of the volume estimations for this EE (with the exception of PM-WS-1) were performed by using GPS data. For the waste piles estimated with GPS data, a handheld GPS unit was used to take GPS waypoints of the waste pile footprints. Using the GPS data, a geographic information system (GIS) program, ArcGIS v9.3.1 (Copyright 2009 ESRI), was then used to extrapolate the surface area of the waste pile footprints. Approximate depths and representative geometric shapes were estimated by visual observation.

NOTE: Although the handheld GPS unit records z values (elevations above mean sea level) these are considered to be highly erroneous measurements and not suitable for the purposes of height and volume estimation and are therefore not used.

SECTION 3.0 – ABBREVIATIONS AND CONVERSION FACTORS

Abbreviations

CY	Cubic yards
ft	Feet
ft ²	Square feet
ft ³	Cubic feet

Conversion Factors

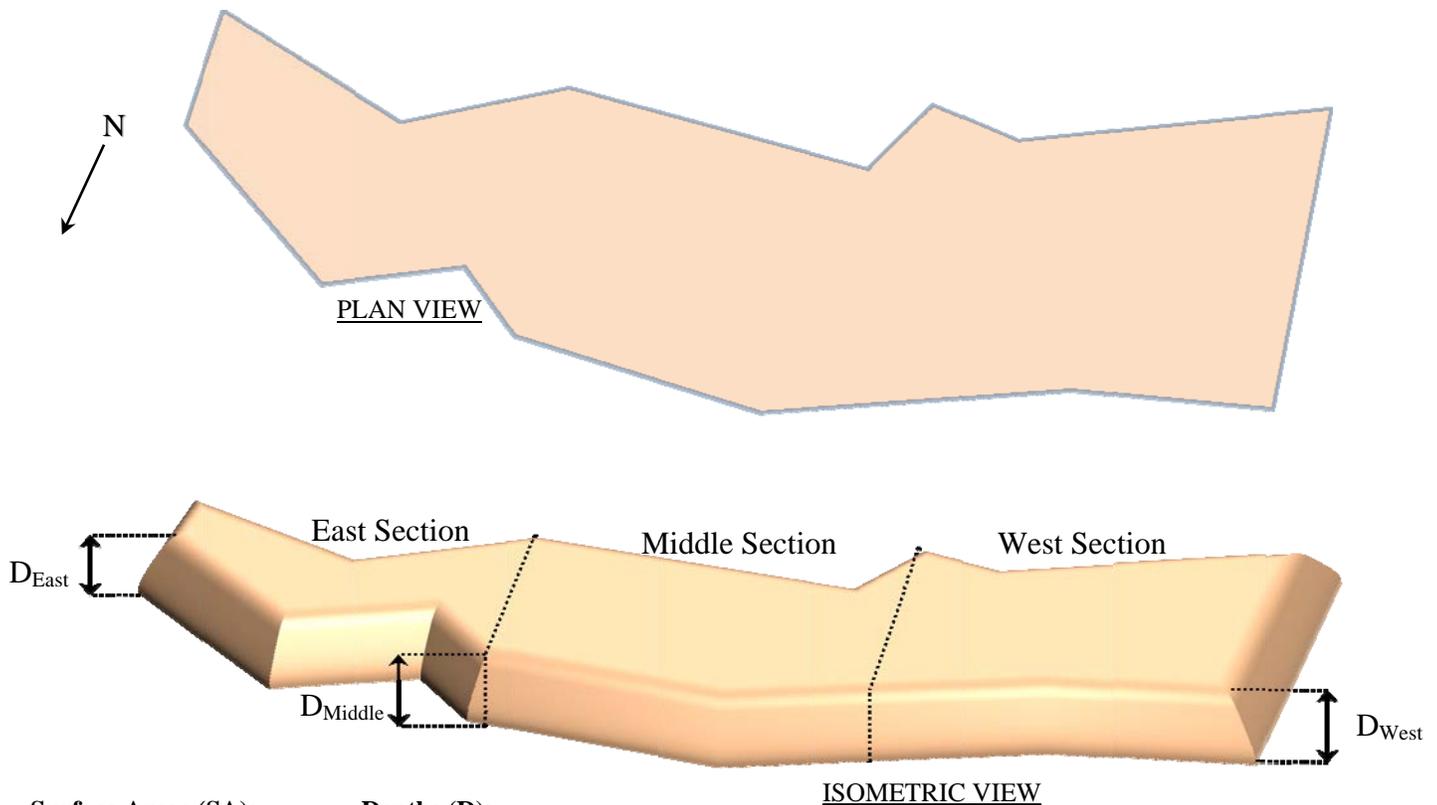
1 CY = 27 ft³

This area left intentionally blank.
(Calculations start on the following page.)

SECTION 4.0 – MONEY METALS MINE

Objective: Calculate the estimated volume of waste material located at Money Metals Mine. The pile has varying depths of approximately 8 feet at the west end, 25 feet in the middle section, and 30 feet at the east end. Divide the pile into three sections (East, Middle, and West), calculate the volume of each section and sum to arrive at the total volume.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the top of the pile. Using the GIS software, the shape file was divided into three portions: East, Middle, and West with surface areas of 1576 ft²; 2581 ft²; and 2684 ft², respectively. For volume estimating purposes, use the surface areas obtained from the shape file and the depths of 12 ft for the West, 25 ft for the Middle, and 30 ft for the East. The depths represent the estimated vertical difference between the top crest and the toe of the waste pile. Applying these depths to the area of the waste pile topslope should conservatively account for the volume of waste material that is on the sideslope which is estimated to be at an approximate 1.5H to 1V slope based on field observation and measurements off of photos of the waste pile. No pre-mine topography (before 1895) is available but it is estimated that the natural ground surface within the footprint of the waste pile probably slopes at a 2H:1V slope.



Surface Areas (SA):

$SA_{East} = 1,576 \text{ ft}^2$
 $SA_{Middle} = 2,581 \text{ ft}^2$
 $SA_{West} = 2,684 \text{ ft}^2$

Depths (D):

$D_{East} = 30 \text{ ft}$
 $D_{Middle} = 25 \text{ ft}$
 $D_{West} = 12 \text{ ft}$

$$V_{East} = SA_{East} \times D_{East}$$

$$= (1,576 \text{ ft}^2) \times (30 \text{ ft})$$

$$= 47,280 \text{ ft}^3$$

$$= 1,751 \text{ CY} \cong 1,800 \text{ CY}$$

$$V_{Middle} = SA_{Middle} \times D_{Middle}$$

$$= (2,581 \text{ ft}^2) \times (25 \text{ ft})$$

$$= 64,525 \text{ ft}^3$$

$$= 2,390 \text{ CY} \cong 2,400 \text{ CY}$$

$$V_{West} = SA_{West} \times D_{West}$$

$$= (2,684 \text{ ft}^2) \times (12 \text{ ft})$$

$$= 32,208 \text{ ft}^3$$

$$= 1,193 \text{ CY} \cong 1,200 \text{ CY}$$

$$V_{Total} = V_{East} + V_{Middle} + V_{West}$$

$$V_{Total} = 1,800 \text{ CY} + 2,400 \text{ CY} + 1,200 \text{ CY}$$

$$V_{Total} = \mathbf{5,400 \text{ CY}}$$

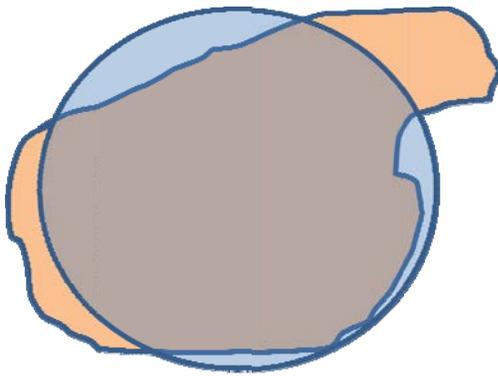
SECTION 5.0 – PROVIDENCE MINE

The Providence Mine site consists of multiple waste piles scattered throughout the site. The following subsections evaluate each waste pile at Providence Mine. Each waste pile is evaluated and named/identified by its sample identification (ID). For example, the waste source with sample ID, PM-WS-4, is evaluated as one waste pile named PM-WS-4. Where multiple samples were taken for a single waste pile, that pile is named accordingly. For example, waste source samples PM-WS-8 and PM-WS-9 are from the same contiguous pile and are evaluated as one waste pile named PM-WS-8/9.

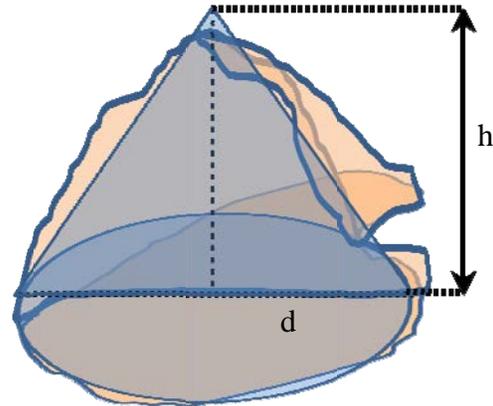
SECTION 5.1 – PM-WS-1

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-1 at the Providence Mine site. The PM-WS-1 pile lies in an approximately pyramid formation. For volume estimating purposes, assume a conical pyramid (cone) with a height of 15 ft and base with a diameter of 45 ft.

Solution: For volume estimating purposes assume a cone shape with a base diameter of 45 ft and a height of 15 ft.



PLAN VIEW



PROFILE

Cone Dimensions :
Diameter (d) = 45 ft
Radius (r) = d/2 = 22.5 ft
Height (h) = 15 ft

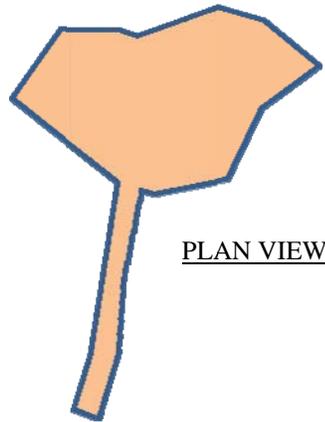
$$\begin{aligned} \text{Volume}_{\text{Cone}} &= 1/3\pi r^2 h \\ &= 1/3 \times \pi \times (22.5 \text{ ft})^2 \times 15 \text{ ft} \\ &= 7,953 \text{ ft}^3 \\ &= 295 \text{ CY} \approx \mathbf{300 \text{ CY}} \end{aligned}$$

This space intentionally left blank (section 5.2 on next page)

SECTION 5.2 – PM-WS-2/3

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-2/3 at the Providence Mine site. The pile is of fairly uniform depth ranging from 0.5 ft to 2 ft deep.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-2/3 is approximately 7,200 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 2 ft.



PLAN VIEW

Pile Dimensions:

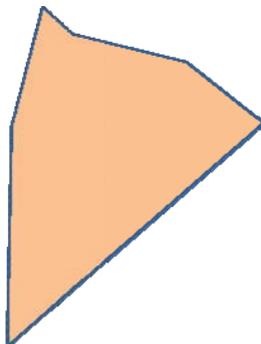
Surface Area (SA) = 7,200 ft²
Depth (D) = 2 ft

$$\begin{aligned} V &= SA \times D \\ &= (7,200 \text{ ft}^2) \times (2 \text{ ft}) \\ &= 14,400 \text{ ft}^3 \\ &= 534 \text{ CY} \approx \mathbf{600 \text{ CY}} \end{aligned}$$

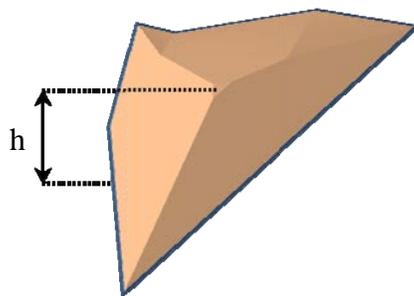
SECTION 5.3 – PM-WS-4

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-4 at the Providence Mine site. The pile lies in an approximately pyramid shape with a maximum depth of 4 ft.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-4 is approximately 10,079 ft². For volume estimating purposes, assume a pyramid with an irregular base and use the surface area obtained from the shape file and a maximum depth of 4 ft.



PLAN VIEW



ISOMETRIC VIEW

Pyramid Dimensions:

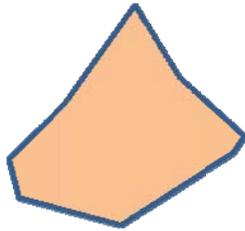
Surface Area of Base (SA_{Base}) = 10,079 ft²
Height of pyramid (h) = 4 ft

$$\begin{aligned} \text{Volume}_{\text{pyramid, irr.}} &= 1/3(\text{SA}_{\text{Base}})h \\ &= 1/3 \times (10,079 \text{ ft}^2) \times 4 \text{ ft} \\ &= 13,439 \text{ ft}^3 \\ &= 497 \text{ CY} \approx \mathbf{500 \text{ CY}} \end{aligned}$$

SECTION 5.4 – PM-WS-5

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-5 at the Providence Mine site. The pile is of fairly uniform depth ranging from 3 ft to 4 ft deep.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-5 is approximately 4,736 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 4 ft.



PLAN VIEW

Pile Dimensions:

Surface Area (SA) = 4,736 ft²

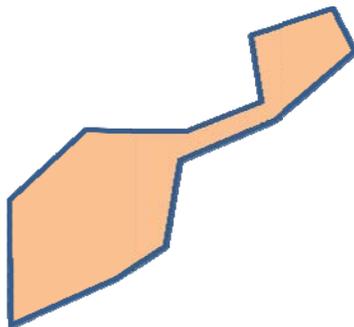
Depth (D) = 4 ft

$$\begin{aligned} V &= SA \times D \\ &= (4,736 \text{ ft}^2) \times (4 \text{ ft}) \\ &= 18,944 \text{ ft}^3 \\ &= 702 \text{ CY} \approx \mathbf{750 \text{ CY}} \end{aligned}$$

SECTION 5.5 – PM-WS-6

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-6 at the Providence Mine site. The pile has a depth ranging from 1.5 ft to 4 ft deep.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-6 is approximately 5,472 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 4 ft.



PLAN VIEW

Pile Dimensions:

Surface Area (SA) = 5,472 ft²

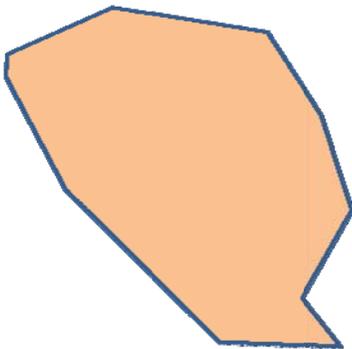
Depth (D) = 4 ft

$$\begin{aligned} V &= SA \times D \\ &= (5,472 \text{ ft}^2) \times (4 \text{ ft}) \\ &= 21,888 \text{ ft}^3 \\ &= 811 \text{ CY} \approx \mathbf{850 \text{ CY}} \end{aligned}$$

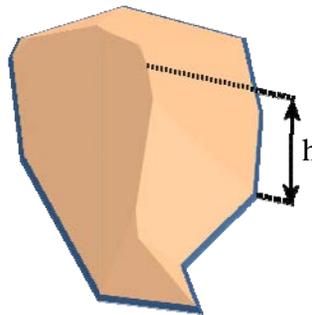
SECTION 5.6 – PM-WS-7

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-7 at the Providence Mine site. The pile lies in an approximately pyramid shape with a maximum depth of 8 ft.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-7 is approximately 7,840 ft². For volume estimating purposes, assume a pyramid with an irregular base and use the surface area obtained from the shape file and a maximum depth of 8 ft.



PLAN VIEW



ISOMETRIC VIEW

Pyramid Dimensions:

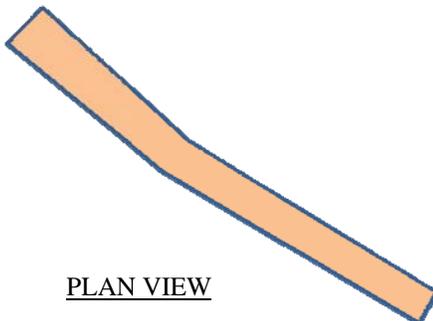
Surface Area of Base (SA_{Base}) = 7,840 ft²
Height of pyramid (h) = 8 ft

$$\begin{aligned} \text{Volume}_{\text{pyramid, irr.}} &= 1/3(\text{SA}_{\text{Base}})h \\ &= 1/3 \times (7,840 \text{ ft}^2) \times 8 \text{ ft} \\ &= 20,907 \text{ ft}^3 \\ &= 775 \text{ CY} \approx \mathbf{800 \text{ CY}} \end{aligned}$$

SECTION 5.7 – PM-WS-8/9

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-8/9 at the Providence Mine site. The pile has a depth ranging from 1 ft to 2 ft deep.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-8/9 is approximately 7,884 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 2 ft.



PLAN VIEW

Pile Dimensions:

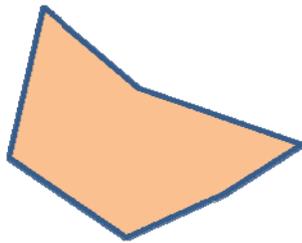
Surface Area (SA) = 7,884 ft²
Depth (D) = 2 ft

$$\begin{aligned} V &= \text{SA} \times D \\ &= (7,884 \text{ ft}^2) \times (2 \text{ ft}) \\ &= 15,768 \text{ ft}^3 \\ &= 584 \text{ CY} \approx \mathbf{600 \text{ CY}} \end{aligned}$$

SECTION 5.8 – PM-WS-10

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-10 at the Providence Mine site. The pile is surface lying only with a depth of 0.5 ft.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-10 is approximately 1,743 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 0.5 ft.



PLAN VIEW

Pile Dimensions:

$$\text{Surface Area (SA)} = 1,743 \text{ ft}^2$$

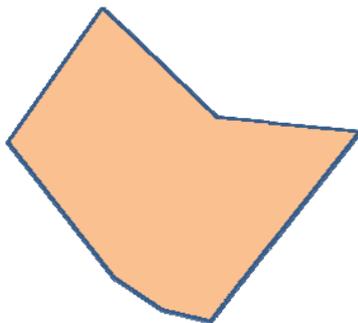
$$\text{Depth (D)} = 0.5 \text{ ft}$$

$$\begin{aligned} V &= SA \times D \\ &= (1,743 \text{ ft}^2) \times (0.5 \text{ ft}) \\ &= 872 \text{ ft}^3 \\ &= 33 \text{ CY} \approx \mathbf{40 \text{ CY}} \end{aligned}$$

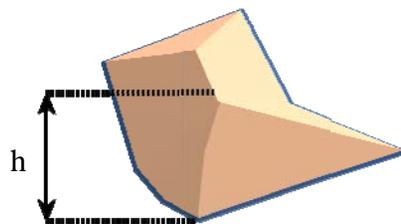
SECTION 5.9 – PM-WS-11

Objective: Calculate the estimated volume of waste rock and tailings of PM-WS-11 at the Providence Mine site. The pile lies in an approximately pyramid shape with a maximum depth of 8 ft.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-11 is approximately 3,287 ft². For volume estimating purposes, assume a pyramid with an irregular base and use the surface area obtained from the shape file and a maximum depth of 8 ft.



PLAN VIEW



ISOMETRIC VIEW

Pyramid Dimensions:

$$\text{Surface Area of Base (SA}_{\text{Base}}) = 3,287 \text{ ft}^2$$

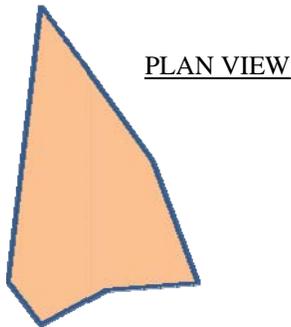
$$\text{Height of pyramid (h)} = 8 \text{ ft}$$

$$\begin{aligned} \text{Volume}_{\text{pyramid, irr.}} &= 1/3(\text{SA}_{\text{Base}})h \\ &= 1/3 \times (3,287 \text{ ft}^2) \times 8 \text{ ft} \\ &= 8,766 \text{ ft}^3 \\ &= 325 \text{ CY} \approx \mathbf{350 \text{ CY}} \end{aligned}$$

SECTION 5.10 – PM-WS-13

Objective: Calculate the estimated volume of waste rock of PM-WS-13 at the Providence Mine site. The pile is surface lying only with a depth of 0.5 ft.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-13 is approximately 6,982 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 0.5 ft.



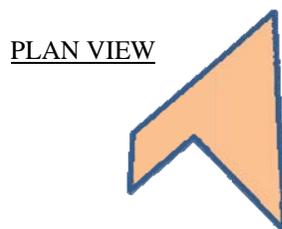
Pile Dimensions:
Surface Area (SA) = 6,982 ft²
Depth (D) = 0.5 ft

$$\begin{aligned} V &= SA \times D \\ &= (6,982 \text{ ft}^2) \times (0.5 \text{ ft}) \\ &= 3,491 \text{ ft}^3 \\ &= 130 \text{ CY} \approx \mathbf{150 \text{ CY}} \end{aligned}$$

SECTION 5.11 – PM-WS-14

Objective: Calculate the estimated volume of waste rock of PM-WS-14 at the Providence Mine site. The pile is surface lying only with a depth of 0.5 ft.

Solution: Using the GPS data collected on October 22, 2009, a shape file was created using the GIS mapping software. The shape file outlines the footprint of the pile. Using the GIS software, the footprint surface area of PM-WS-14 is approximately 311 ft². For volume estimating purposes, use the surface area obtained from the shape file and the maximum depth of 0.5 ft.



Pile Dimensions:
Surface Area (SA) = 311 ft²
Depth (D) = 0.5 ft

$$\begin{aligned} V &= SA \times D \\ &= (311 \text{ ft}^2) \times (0.5 \text{ ft}) \\ &= 156 \text{ ft}^3 \\ &= 6 \text{ CY} \approx \mathbf{10 \text{ CY}} \end{aligned}$$