



# Debris Estimating Field Guide

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# FEMA



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# INTRODUCTION

The Robert T. Stafford Disaster Relief and Emergency Assistance Act, (Stafford Act), Public Law 93-288, as amended, 42 U.S.C. §5121, et seq., authorizes the Federal Emergency Management Agency (FEMA) Public Assistance (PA) Program to award Federal funding to State and local governments, Federally recognized Tribes, and certain eligible private non-profit organizations in order to assist them in their disaster response and recovery activities. Under the Stafford Act, FEMA provides PA program grant funding for debris clearance, removal, and monitoring efforts to eligible applicants following a Presidential emergency or disaster declaration.

Timely, accurate, and consistent estimates of debris quantities and types are an important aspect of FEMA debris operations. FEMA uses debris estimates obtained during Preliminary Damage Assessment (PDA) activities to provide part of the basis for its recommendation as to whether a disaster declaration should be approved. FEMA also uses PDA debris estimates to identify potential needs for Mission Assignments for Technical and Direct Federal Assistance to PA applicants.

The FEMA PA Debris Task Force Leader (DTFL) relies on PDA debris estimates to make informed decisions concerning staffing levels, required technical expertise, organizational

structure, and geographic distribution of the FEMA PA Debris Task Force. The DTF also uses debris estimates to update senior FEMA management, the State, applicants, and the general public regarding the status of debris operations. Finally, the FEMA PA Debris Task Force relies heavily on accurate debris estimates to define eligible scopes of work during project formulation and Project Worksheet development for an applicant's debris-related activities.

Section 407(e) of the Stafford Act establishes deadlines for FEMA to provide funding for debris removal activities. The complete text of Section 407(e) is as follows:

**(e) Expedited Payments –**

(1) Grant Assistance – In making a grant under subsection (a)(2), the President shall provide not less than 50 percent of the President's initial estimate of the Federal share of assistance as an initial payment in accordance with paragraph (2).

(2) Date of Payment – Not later than 60 days after the date of the estimate described in paragraph (1) and not later than 90 days after the date on which the State or local government or owner or operator of a private nonprofit facility applies for assistance under this section, an initial payment described in paragraph (1) shall be paid.

FEMA Debris Technical Specialists must work closely with the State, Tribal governments, and applicants to achieve reasonable, consensus-based debris estimates.

This document is intended for use as a supplement to the Public Assistance Debris Management Guide (FEMA 325) to ensure that FEMA Debris Technical Specialists apply a consistent methodology to obtain accurate debris estimates in accordance with PA program eligibility criteria.

# DEBRIS ESTIMATING CONSIDERATIONS

**T**he DTFL should clearly define the accuracy and precision requirements for disaster debris estimates in the FEMA Debris Operations Strategy to achieve the desired results. A key consideration in defining estimate requirements is how the estimate will be used, e.g., if a debris estimate is only used for a PDA, the level of accuracy and precision required is less than that required to develop a Project Worksheet.

The formulas, assumptions, and conversions used by the FEMA Debris Task Force must be applicable to the circumstances of the disaster and be consistently applied.

FEMA Debris Technical Specialists should confirm with the DTFL which formulas, assumptions, and conversions should be used and remember to check all work for accurate math and units of measure. FEMA Debris Technical Specialists should document the basis of the debris estimate, including the methodology and equipment used, formulas, assumptions, and conversions to support decision making.

The equipment and resources required will depend on the type of estimating method used. Examples of possible equipment include cameras, measuring tapes, and GPS units. Examples of possible resources include the personnel required to develop the estimates, Geographic Information System (GIS) data, aerial photos, and debris modeling information.

# DEBRIS ESTIMATING METHODS

**T**here are several methods available to develop debris estimates. The DTFL should select the method based on the accuracy, precision, and schedule requirements of the operation, and by the availability of resources such as personnel and equipment.

- Ground measurements of debris can be taken to develop estimates, using visual observation and detailed data collection with equipment such as measuring tapes and GPS units
- Aerial and satellite photographs of areas taken before and after the disaster event may be used to estimate debris quantities and types, based on the structures, features, and debris observed in the photos
- Computer models, including those developed by the U.S. Army Corps of Engineers (USACE) and FEMA

The FEMA Debris Task Force may use a combination of estimating methods, if necessary, to meet the requirements of the operation.

## GROUND MEASUREMENTS

The basic steps and considerations when completing debris estimates using ground measurements include:

1. Define the area covered by the debris estimate:
  - a. Divide the area, as needed, to differentiate differences in debris types and amounts, which may be influenced by items such as differences in land use (e.g., rural versus urban) within the area
  - b. Division of the area into sections should take into account how the applicant may have divided the area into sections, either for the purpose of developing debris estimates or for planning the execution of debris removal activities
2. Determine whether comprehensive debris measurements (e.g., street-by-street) or measurement of a representative sample is appropriate for the estimate requirements
3. Identify and obtain the personnel and equipment necessary to complete the estimate:
  - a. The number of personnel used depends on the area to be covered, ease of access to the area, schedule to complete the estimate, and availability of personnel resources
  - b. The equipment used for ground measurements commonly includes a digital camera, measuring tape or roll-off wheel, calculator, sketch pad and note

paper, maps, GPS unit, laser rangefinder, and equipment needed for logistics and safety (e.g., vehicle, cell phone, first aid kit)

4. Engage the State and applicant in the ground measurement process:
  - a. The applicant is generally a source of information used for the estimate, such as locations of public property and rights-of-way, and planned debris removal activities
  - b. Proactively engaging the State and applicant will also facilitate achieving earlier, consensus-based debris estimates.

Additional considerations regarding debris estimates based on ground measurements include:

- Ensure the measurements include all eligible debris
  - Eligible debris may include disaster-generated debris located in the yards or inside of residences that has not yet been placed on the right-of-way
  - Limbs hanging in trees that will likely be placed on rights-of-way should be included
  - Flood disasters may produce personal property debris (e.g., household furnishings, clothing) that may still be in residences at the time of the debris estimate

- The estimate should not include any ineligible debris (e.g., old tires, residential construction materials, and white goods awaiting disposal prior to the disaster event), but ineligible debris (estimated quantity and location) should be noted so that it can be properly addressed during project formulation
- Recognize that debris may undergo changes in volume during the handling process
  - Flood-deposited sediment may be naturally compacted in place, and the volume may increase when it is removed
  - Leafy vegetative debris located on public property and rights-of-way may experience a significant reduction in volume when it is mechanically loaded into trucks
- One acre of debris 10 feet high converts to 16,133 CY

$$\frac{43,560 \text{ SF} \times 10 \text{ FT}}{27} = 16,133 \text{ CY}$$

**FEMA Debris Technical Specialists should approximate the volume of debris piles using cubes when conducting ground measurements, as opposed to using formulas to approximate the volumes of debris piles as cones or pyramids.**

## BUILDINGS AND RESIDENCES

### *General Building Formula*

To estimate the amount of debris generated by a building, multiply the building length, width, and height in feet by a constant of 0.33 to account for the air space in the building, and divide the resulting number by 27 to convert from cubic feet to cubic yards:

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

### *Single Family Residence Formula*

FEMA conducted an empirical study following Hurricane Floyd in North Carolina in 1999, and developed a formula for estimating debris associated with demolished single family residences:

$$\text{Length} \times \text{Width} \times S \times 0.20 \times \text{VCM} = \text{CY}$$

Length and Width must be in feet

S = number of stories in the building

0.20 = a constant based on the study data

VCM = a vegetative cover multiplier

The building square footage used in the formula is the total living space at and above ground level and includes attached garages.

If buildings or residences are completely destroyed, square footage can still be calculated by measuring the length and width of the foundation and inquiring about the number of stories that were present before the disaster.

*Note: The two formulas above provide different results if applied to the same building because the general building formula was developed using a basic volume calculation and assumed air space, while the demolished single family home formula was developed using field data. The DTFL should select the formula for calculating debris volumes for buildings and residences based on which formula provides the most accurate debris estimate given the circumstances and data available from the particular disaster.*

FEMA developed Vegetative Cover Multipliers (VCM) for use in combination with the formula for a demolished single family residence, to estimate the quantity of vegetative debris that should be added to the quantity of debris estimated for demolished homes within a subdivision or neighborhood:

**Light** (1.1 multiplier) includes new home developments where more ground is visible than trees and canopy cover is sparse

**Medium** (1.3. multiplier) generally has a uniform pattern of open space and tree canopy cover, and is the most common description for vegetative cover

**Heavy** (1.5 multiplier) is found in mature neighborhoods and woodlots where the ground or houses cannot be seen due to the tree canopy cover

The table on the opposite page is based on the application of the vegetative cover multipliers to the debris estimating formula for a demolished single-family, single-story home.

**Table for Single Family, Single Story Homes**

Typical House (Square Feet)	Vegetative Cover Multiplier			
	None	Light (1.1)	Medium (1.3)	Heavy (1.5)
1000 SF	200 CY	220 CY	260 CY	300 CY
1200 SF	240 CY	264 CY	312 CY	360 CY
1400 SF	280 CY	308 CY	364 CY	420 CY
1600 SF	320 CY	352 CY	416 CY	480 CY
1800 SF	360 CY	396 CY	468 CY	540 CY
2000 SF	400 CY	440 CY	520 CY	600 CY
2200 SF	440 CY	484 CY	572 CY	660 CY
2400 SF	480 CY	528 CY	624 CY	720 CY
2600 SF	520 CY	572 CY	676 CY	780 CY

For multiple-story residences, the debris generated by the demolished residence should be calculated using the total number of stories (as the formula dictates), however, the amount of vegetative debris calculated should be determined by applying the VCM to the amount of debris generated by just the first story square footage of the residence, i.e., the amount of debris calculated if  $S = 1$ .



The following numbers should be used to estimate the quantity of debris generated by a typical mobile home:

Typical single-wide mobile home:  
290 CY

Typical double-wide mobile home:  
415 CY

Because mobile homes have less air space due to their construction and layout, the numbers provided above are larger than those calculated using the general building formula.

### ***Personal Property Placed on Public Rights-of-Way***

FEMA and USACE have conducted empirical studies on the average amount of personal property brought to public rights-of-way from residences following flooding disasters:

Personal property for a slab on grade home:  
25–30 CY

Personal property for a home with a basement:  
45–50 CY

## CONVERSION FACTORS

USACE has developed several conversion factors for converting between tons and cubic yards of debris that FEMA has determined are reasonable:

Construction and demolition debris:

1 ton = 2 CY

Mixed debris:

1 ton = 4 CY

Vegetative debris:

Hardwoods: 1 ton = 4 CY

Softwoods: 1 ton = 6 CY

**Actual conversion values for a particular disaster may be very different; therefore, field tests coordinated with the State and applicant may be necessary to confirm an appropriate conversion factor.**

## AERIAL ESTIMATES

Applications where debris estimates based on aerial or satellite photography may be appropriate include:

- Rough estimates that must be developed quickly, such as for a PDA
- Validation or extrapolation of debris estimating information obtained through ground measurements or computer models



- Debris estimates for areas that are difficult to access
- Cases where it is difficult to gain a good perspective on debris quantities from the ground, e.g., estimating the size of very large debris piles at debris management sites

Basic steps involved in using aerial or satellite photographs to develop debris estimates include:

- Obtain aerial photos of all or a representative sample of the area
  - Recent aerial photos from both before and after the disaster may be useful
  - Sources of aerial photos could include the FEMA Planning Section, other Federal agencies (e.g., USACE), the State, applicants, and the press

To analyze an individual photo:

- Select an object of reference with known dimensions (e.g., vehicles, garage doors) to establish a dimensional scale
- Apply the dimensional scale to determine the size of objects in the photo, and apply the appropriate debris estimating formulas to estimate debris quantities

## COMPUTER MODELS

There are a variety of computer models that have been developed for estimating debris. FEMA developed the HAZUS-MH software which includes models for estimating potential damages and losses (including debris generated) from floods, earthquakes, and hurricanes. Additional information can be found at (<http://www.fema.gov/plan/prevent/hazus/#1>). Additionally, USACE has developed and continues to refine a debris estimating model that focuses primarily, although not exclusively, on hurricanes. Additional information, including model output data, can be found at <http://www.englink.usace.army.mil/>.

Debris estimates generated by models are based on items such as:

- Historic information on debris quantities generated by similar disaster events
- GIS data on topography, land use, and level of development
- Information on the disaster, such as the extent of flooding or Hurricane Category

- Formulas that mathematically combine the information to generate an estimate

FEMA continues to develop and refine its debris estimating tools and processes to enhance the timeliness, accuracy, consistency, and efficiency of debris estimates. FEMA Debris Technical Specialists should refer to the Debris Task Force Leader for guidance on the status and use of new tools such as handheld data collection tablets in the field.

# SAFETY

**YOU are responsible for your personal safety at all times.**

***Health/Safety Risks:***

- Isolated and/or not readily accessible areas
- Heavy machinery, loud equipment, traffic
- Limited communication
- Extreme weather
- Large debris piles
- Waterborne, vector-borne, and blood-borne disease
- Rabid animals, infectious reptiles and plants
- Downed power lines and cables
- Gas leaks
- Natural and wildlife hazards
- Hazardous material

Any hazards posing an immediate threat to public health and safety should be reported to the appropriate authority immediately.

**If you are faced with an emergency in the field:**

- **Remove yourself from the situation**
- **Call 911 if appropriate**
- **Contact your direct supervisor immediately**

### ***Field Safety Gear/Supplies:***

- Appropriate clothing, footwear, and gloves
- Eye and ear protection
- Hardhat
- Respiratory protection
- Personal meds & Rx drugs
- Bottled water
- Maps and/or GPS device
- Cell phone
- Sunscreen, lip balm, insect repellent
- First aid kit

Proper FEMA identification should be visible at all times while on site.













Disaster recovery assistance is available without regard to race, color, national origin, sex, age, religion, disability, or economic status. Anyone who believes he/she has been discriminated against should contact the FEMA Helpline at 1-800-525-0321.

Report fraud, waste, and abuse to the Office of Inspector General on the Hotline at 1-800-323-8603.



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