Solving The Great Steel Caper:
DEW-Demolition Contrary Evidence

By Dr. Gregory S. Jenkins

Directed energy weapon (DEW) demolition proponents claim that a large majority of above-grade structural steel from the World Trade Center (WTC) towers was dissociated into dust and aerosols during and/or after collapse. However, multiple quantitative dust and aerosol measurements show that no significant fraction of structural steel was dissociated into dust or aerosols. A review of the photographic record (flickr)[20] shows no gas, dust, aerosols, or debris moved upwards during the collapse, and physical principles reveal that that no significant fraction of structural steel from the towers could reasonably be supported by air during or immediately after collapse. Visibility (optical path length) measurements, dust collected directly from the south tower debris cloud, and an analysis of the physical transport mechanisms for dust and aerosols prove that the debris which hung in the air after the collapse was miniscule compared to the amount of steel in the towers. A large fraction of steel in the towers could not be transformed into a gas due to the reactive nature of iron and oxygen which would have caused suffocation of anyone in the vicinity of ground zero.

The photographic record of debris removal from ground zero (GZ) reveals that the majority of the debris generated from the collapse of the WTC towers fell upon their footprints and filled sublevels. Other corroborating evidence from multiple independent sources quantitatively and explicitly indicates that sufficient amounts of debris and steel were removed from GZ. In short, no significant amount of steel from the towers was turned to dust or aerosols at anytime during and after the collapse. All of the steel may be accounted for if the sublevel collapses are included in the analysis which is corroborated by the photographic record and other quantitative evidence.

Introduction

At its core, a 'truth movement' necessarily involves vetting the credibility of ideas which are put forth. Gauging what arguments may be true often involves proving which arguments are false. That is, truth is necessarily that which is not false.

Many people involved in 9/11 research have sacrificed their time to cogently present their work on websites and journal publications so that the data and the concepts may be evaluated: dust and aerosol studies, building performance analyses, construction pictures and blueprints, flight trajectories, eyewitness testimonies, etc. The compiled resources save many thousands of people time in compiling and evaluating data. I know, personally speaking, that I owe many thanks to those researchers who have saved me much time from investigating blind alleys. By presenting my own work, I hope that I may amplify the time saved to me and pass it on to many others.

This paper primarily focuses upon the hard evidence which directly contradicts the notion that Directed Energy Weapons (DEWs) destroyed the WTC towers. The DEW-notion can hardly be called a hypothesis or theory since nothing specific has been proposed.[1] "Energy" is the cause of every physical action without exception. It makes *all* physical objects move, causes all damage and explosions, hurls planes into buildings, and fuels every life-giving process. The official story states that directed energy brought down the towers. The form of the energy was first the kinetic energy of the plane which caused impact damage to the floors and columns of the WTC tower, followed by exothermic energy release from fires, followed by the slow creep of the building caused by the conversion of potential energy into kinetic energy, and finally the ensuing 'global collapse' where all the potential energy of the building was released into heat energy, deformation energy, pulverization energy, sound and ground wave energy, etc. Stating that "energy" destroyed the towers conveys absolutely nothing. It is precisely the form of the energy which is at issue. DEW-demolition proponents have not even stated the form of "energy" manifested in a "directed beam." I address this issue directly in my previous publication where I consider all known forms of energy beams in physical existence, and show the impossibility of *any* of them to destroy the towers while remotely matching observations.[35]

DEW-demolition proponents claim that massive amounts of steel were implausibly turned into dust or aerosols. Estimates from different proponents of DEW-demolition vary, but the stated missing amount material is always over 50% and is usually more in the vicinity of 80%.[2] Each and every supporting reason cited has been extensively repudiated: erroneous scaling arguments applied to seismograph readings and the naturally resulting non-catastrophic damage to the bathtub, impulse damage to surrounding buildings from falling debris, the amount of debris expected from collapsed and partially collapsed WTC buildings is consistent with observation, inconsistency with observed damage from all known DEWs, astronomical power requirements, and other peripheral arguments.[35,3,4]

DEW-demolition proponents often cite photographs and videos as proof of their claims. Unaltered photographs and videos do represent factual evidence. However, the interpretation of photographs and videos can be highly subjective. Interpretations should not be conflated with factual evidence. For instance, videos of the North tower core column "spires" which were standing for multiple seconds after the collapse immediately before their own subsequent demise[5] are often interpreted by observers in one of two ways: 1) the spires fell while dust and debris were generated by crumbling concrete and wallboard which were built into the core as well as the liberated remnant dust which had settled upon the spires, or 2) the steel spires themselves turned to dust. I believe that all people who interpret the videos report what they observe. However, I do not conflate interpretations with facts. My personal observation, as well as many other witnesses, is that the spires fell. Other people observe spires spontaneously turning to dust. All observers are credible and report what they observe. The data is inherently ambiguous since it may be interpreted in more than one way. This is the definition of ambiguous data. Usually the demise of the spires is cited as the strongest evidence by DEW-demolition proponents, but the interpretation is hopelessly ambiguous as can be gauged by the people who report what they observe.

A second example of ambiguous data used to support the claims of DEW-demolition proponents are aerial and surface photographs of ground zero (GZ) after the collapse of the towers.[6] Some people interpret the photographs as evidence that only a tiny fraction of the debris is present at GZ since, they argue, little debris is observed on the surface compared to the total amount of material comprising the building. However, surface photographs taken before debris removal are ineffective in gauging the amount of debris which may reside in the sublevels. The interpretation of these photographs as proof that little debris was present after the collapse is inherently ambiguous. The methodology is explicitly flawed since the amount of debris which may reside in sublevels can not be gauged.

No matter what method is used to hypothetically dissociate the steel in the WTC towers, there should have been massive amounts of iron in the dust since the structural steel in the towers was composed of over 98% iron.[7] USGS,[8] EPA,[9] and McGee *et al*[10] independently sampled dust at many locations around the WTC site and lower Manhattan and quantitatively analyzed the iron content. All the quantitative dust samples are consistent with the amount of iron measured in bulk concrete (direct measurements performed by Dr. Steven Jones[11] as well as explicit validation by the McGee study) which is insignificant compared to the expected amount if a large fraction of above-grade structural steel was somehow dissociated.

The notion that debris, in the words of Dr. Wood, [12] "shot up into the upper atmosphere" during and immediately after collapse is not supported by the photographic record (flickr)[20] and violates the physics of all reasonable dust transport mechanisms. In particular, a 2250 year old law known as Archimedes principle (the concept of buoyancy) quantitatively shows that air can not buoy the immense weight of the towers even if the towers and all their contents were turned to dust. Explosive vertical air jets generated by the collapse (a notion which is directly contradicted by the photographic record) could not propel any significant amount of the weight of the towers into the air. Prevailing wind currents did not vertically transport a significant quantity of debris upwards. Visibility (optical path length) measurements through the debris cloud derived from various photographs show that the density of the dust which hung in the air during the collapse of the South tower, 30 minutes after the collapse, and 36 hours after collapse is miniscule compared to the total weight of a tower. No quantitative evidence exists that any significant amount of debris was, in fact, supported by air which contradicts quantitative measurements and basic physical principles. Qualitatively pointing to photographs of dust and debris which drifted from GZ is not evidence a significant fraction of the WTC towers were suspended in air, no more so than qualitatively pointing to clouds in the sky or a thick London fog.

Aerosol studies performed independently by both UC-Davis DELTA Group[13], EPA[14], and OSHA[17] measured the chemical constituents emanating from the smoldering rubble pile during the days, weeks, and months following 9/11. The aerosol data directly and quantitatively shows that *much* less than 4% of above-grade steel from the WTC towers was contained within the plume integrated over the entire lifetime of the plume.

Rust colored airborne dust produced during clean-up as depicted in photographs is not steel spontaneously transforming into dust. Photographs and written verification from the vice-president of Oxylance confirms that large amounts of iron-oxide dust, otherwise known as rust, were produced from burning Oxylances during steel cutting.

The obvious conclusion based on the hard evidence is that steel beams fell to the ground as large pieces and were subsequently removed during clean-up. At no time during or after collapse did any significant quantity of steel dissociate into dust or aerosols. Multiple measurements and estimates of the quantity of debris removed from GZ, the amount of debris located in the sublevels, and multiple reports of the amount of steel recycled all support the claim that steel fell in large pieces.

Amount of steel above grade in the towers

The total weight of above grade concrete and steel as well as estimates of live and dead loads has been compiled by Gregory Urich for a single WTC tower:[15]

Table 4: Mass above grade

Component	Mass (short tons)	Mass (metric tons)
Concrete floor inside core area	29 400	26 671
Concrete floor outside core area	56 600	51 347
Structural steel	89 416	81 117
Live-load inside core	8 075	7 326
Live-load outside core	38 850	35 244
Superimposed dead-load	17 600	15 966
Total mass above grade	**239 941**	**217 671**

Steel by weight above grade in the towers was 90,000 tons / 240,000 tons ~ 38% (and this ignores all the iron present in the live loads). Since all the structural carbon steel used in the towers was over 98% iron by weight[7], the amount of steel and the amount of iron can be thought of as synonymous.

Concrete in the tower represents 87,000/240,000 ~ 36% of the total above-grade mass. The percentage of iron by weight found in WTC bulk concrete based upon a measurement performed by Dr. Steve Jones[11] of the MacKinlay sample was found to be ~ 3.2%. So, the concrete in the towers can contribute up to 36% x .032 =1.2% to the total percentage of iron in the dust.

Take special note that literally all iron in the office material (live loads) and all duct work, plumbing, and wiring (superimposed dead load) have been ignored. Thus, a ***lower bound*** of iron expected in the dust from above-grade structural steel and concrete is found to be at least 38% + 1.2% ~ 39%.

If the structural steel was dissociated, the dust would contain at least 39% iron.

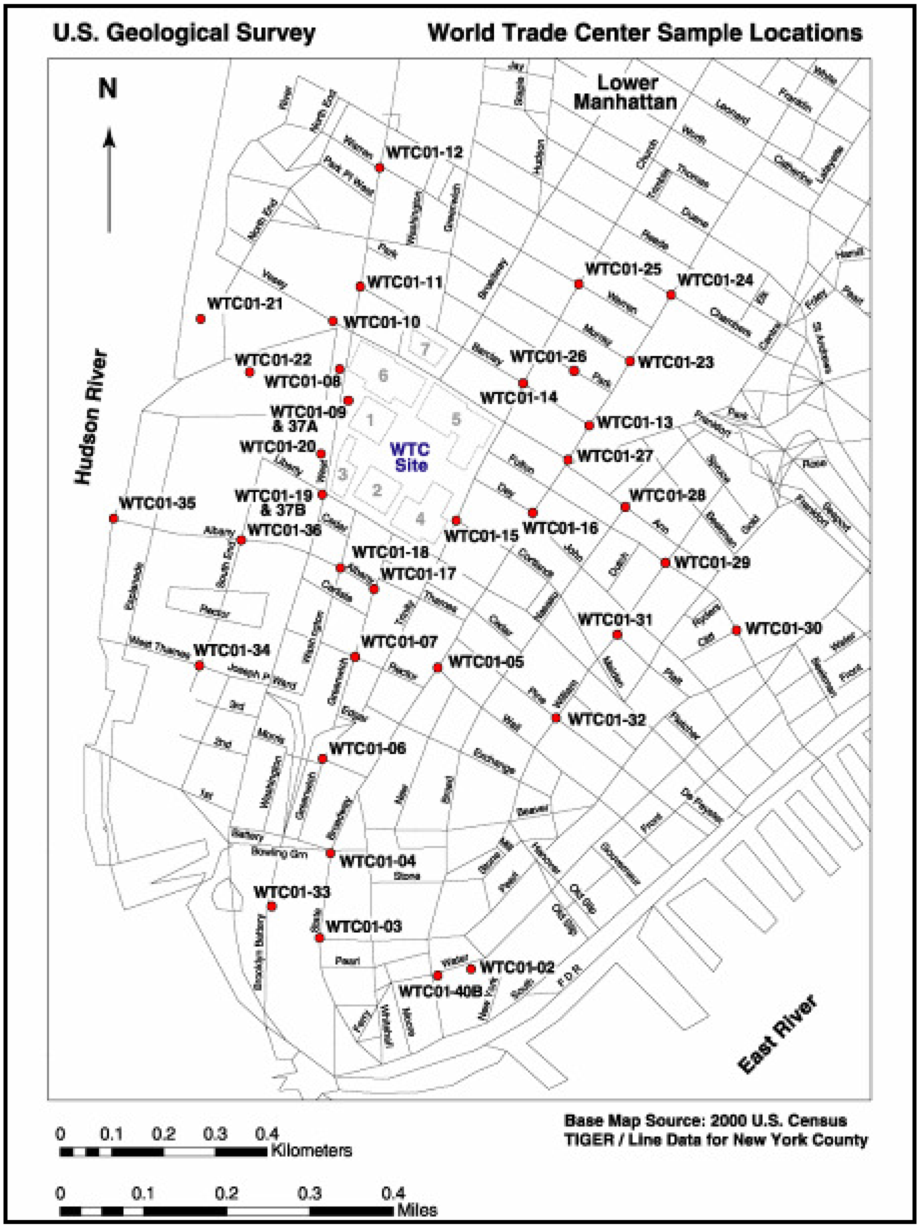
Since DEW-demolition proponents believe that the majority of the structural steel in the towers was turned into dust,[2] I will use this number as a reference for comparison to the actual amount of iron found in the dust and aerosol samples. This will allow the reader to quickly gauge the relative difference in magnitude. However, the percentage of iron physically measured in the dust and aerosol studies is so tremendously insignificant that a direct comparison is not even required.

Quantifying iron found in dust samples

The amount of iron measured in the WTC dust is consistent with the expected amount generated from concrete as reported by three independent bulk dust studies. The amount of iron measured in all three studies confirms that an insignificant fraction of above-grade structural steel was dissociated into dust, if at all. The following four sections investigate the results reported by the USGS, the EPA, and McGee *et al*.

Part I: USGS dust study results[8]

A 2-person USGS crew collected samples of dust and air-fall debris from more than 35 localities within a 1-km radius of the World Trade Center site on September 17 and 18, 2001. Twenty samples were chemically analyzed and the pertinent data (elements that are greater than .1% of the dust sample by weight) are summarized in the table below. The data clearly shows that only 1.6 +/- 0.7 %-weight of iron is found in the dust.



		Calcium %	Silicon %	Sulfur %	Aluminum %	Magnesium %	Carbon, organic %	Iron %	Carbon, Carbonate	Sodium %	Potassium %	Titanium %	Manganese %	Zinc %
	mean*	18.36	14.80	3.11	2.90	2.88	2.48	1.63	1.55	0.57	0.50	0.26	0.11	0.10
	Std Dev	3.46	3.59	1.73	0.45	1.04	0.71	0.73	0.23	0.25	0.10	0.04	0.03	0.07
	minimum	9.58	11.40	0.87	2.27	1.79	0.98	0.55	1.24	0.12	0.28	0.21	0.07	0.01
	maximum	26.01	26.30	5.77	4.13	6.94	4.02	4.13	1.89	1.16	0.69	0.39	0.19	0.30
	mean*	18.36	14.80	3.11	2.90	2.88	2.48	1.63	1.55	0.57	0.50	0.26	0.11	0.10
OUTDOOR SAMPLES	WTC 01-02	15.01	21.20	1.33	4.13	3.11	0.98	4.13	1.24	0.82	0.63	0.39	0.15	0.30
	WTC 01-03	9.58	26.30	0.87	2.75	2.23	3.55	2.16	1.63	0.76	0.69	0.25	0.08	0.12
	WTC01-05	20.94	11.40	nm	2.75	2.73	nm	1.41	nm	0.50	0.46	0.24	0.10	nm
	WTC01-06	20.58	11.40	nm	2.73	2.73	nm	1.42	nm	0.50	0.47	0.24	0.10	nm
	WTC 01-14	17.65	15.30	4.32	2.86	2.83	3.08	1.87	1.46	0.59	0.56	0.31	0.12	0.16
	WTC 01-15	18.58	13.60	5.40	2.59	2.64	2.30	1.87	1.48	0.66	0.49	0.25	0.10	0.11
	WTC 01-16	13.36	17.00	3.68	2.27	1.79	2.51	1.92	1.47	0.87	0.69	0.26	0.07	0.14
	WTC01-17	17.01	16.00	nm	2.30	2.06	nm	1.71	nm	0.93	0.54	0.25	0.07	nm
	WTC 01-21	18.94	12.80	5.10	2.73	2.68	4.02	1.49	1.44	0.50	0.50	0.24	0.12	0.15
	WTC 01-22	16.80	17.00	3.70	2.78	2.77	2.55	2.78	1.31	0.83	0.52	0.29	0.12	0.14
	WTC 01-25	20.37	13.20	4.03	3.28	3.29	2.94	1.33	1.87	0.62	0.56	0.29	0.15	0.19
	WTC 01-27	19.51	15.20	4.29	3.05	3.04	1.95	1.72	1.82	0.62	0.50	0.29	0.12	0.17
	WTC 01-28	19.65	13.80	4.56	2.95	2.83	2.42	1.80	1.68	0.76	0.54	0.26	0.12	0.17
	WTC01-30	19.73	15.10	nm	3.59	3.49	nm	1.85	nm	0.71	0.56	0.29	0.14	nm
	WTC01-34	20.51	12.20	nm	2.98	3.01	nm	1.45	nm	0.50	0.51	0.25	0.12	nm
Indoor	WTC 01-20	19.44	14.20	5.51	2.55	2.59	2.68	1.25	1.27	1.16	0.46	0.25	0.10	0.13
	WTC 01-36	21.30	11.70	5.77	2.86	2.88	2.32	1.38	1.50	0.58	0.46	0.23	0.11	0.14
Girder	WTC 01-08	20.73	15.00	1.39	2.92	6.94	2.48	1.25	1.89	0.12	0.28	0.21	0.14	0.01
	WTC 01-09	26.01	15.50	1.23	3.56	3.23	2.45	0.55	1.86	0.16	0.32	0.28	0.19	0.01

A summary of the pertinent results are as follows:

%-weight Fe expected from concrete	1.2%
%-weight Fe expected from dissociated steel	38%
USGS average %-weight Fe content	1.6 +/- 0.7%

As we can see, 1.6 +/- 0.7% is consistent with the 1.2% iron content expected from the bulk concrete aggregate contribution.

We can calculate how much structural steel may have been turned into dust based upon the USGS findings:

(1.6 +/- 0.7% – 1.2%)/38% = 1 +/- 2%

Proponents of DEW-demolition claim that the initial above-grade steel ‘missing’ from the WTC rubble is obvious to the point of being self-evident based upon photographs of ground zero (GZ).[2] This claim is in direct contradiction with the quantitative data: no significantly elevated levels of iron are found in the dust, and the level is consistent with what is found in the concrete aggregate.

Even if you consider the maximum error in favor of DEW-demolition (3% dissociation of structural steel), this amount of hypothetically ‘missing steel’ from ground zero is obviously not going to be qualitatively assessed based solely upon photographs.

Part II: McGee et al dust study results[10]

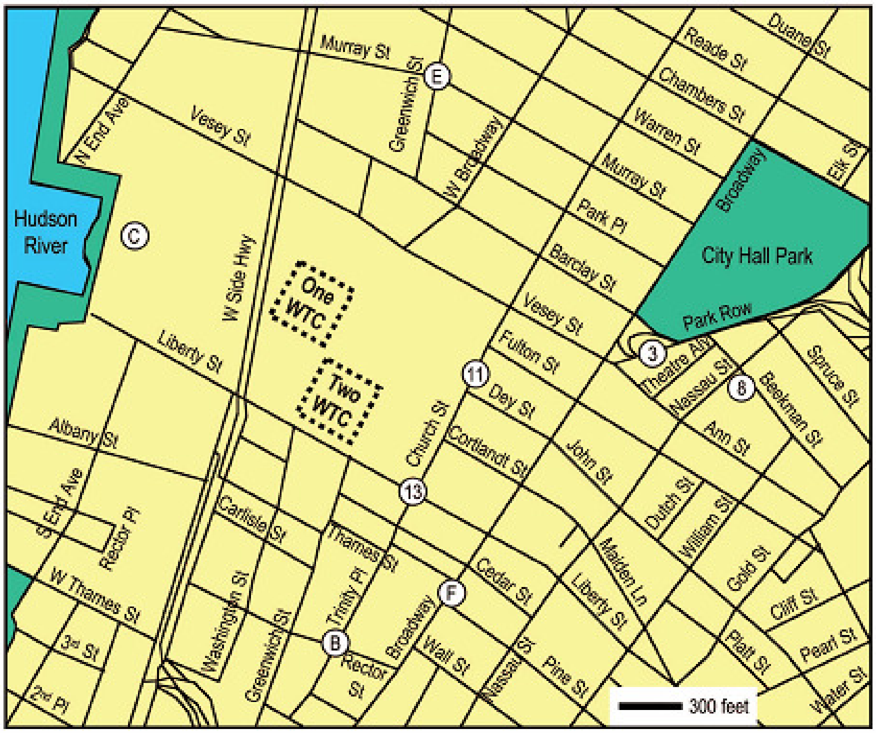


Figure 1. WTC dust samples were collected by New York University scientists from 13 sites on 12 September 2001 (numbers) and from 6 sites on 13 September 2001 (letters). Collection sites are shown only for samples reported in this article. Map reference: U.S. Census Bureau (2002).

McGee states in the discussion section of his paper, "Levels of elements that could be attributed to metal wiring (Cu), plumbing (Fe, Cu, Pb), structural steel (Fe, Mn), and communication and computer equipment (Cu, Fe, Zn, others) are also low. This may be attributed to the relatively small proportion of metal-containing building contents compared with the building itself, or perhaps these materials resisted crumbling and pulverization into the PM2.5 fraction." Furthermore, he reported that "**the relative weight-percent ratios of Al, Mg, and Fe are in the range of those found in Portland cement, a major component of concrete**." This is, of course, perfectly consistent with the analysis in the previous section where we found that the USGS data was consistent with the iron content expected from bulk concrete as measured by Dr. Steven Jones. Even though McGee explicitly states that the iron level in the dust is consistent with that found in concrete, we will analyze the raw data reported by McGee and compare the results directly to the measured iron content in bulk concrete.

Seven dust samples were collected at various locations around lower Manhattan as indicated in the above map (the numbered samples were collected on 9-12-01 and the lettered samples were collected on 9-13-01). McGee presents quantitative amounts of Fe as well as other metals for all 7 samples in the PM2.5 fraction (less than 2.5 μm).

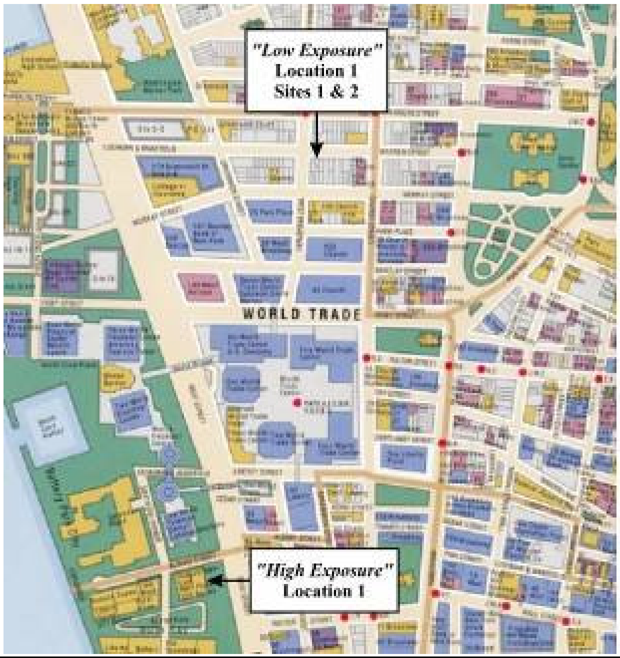
	WTC 8	WTC 11	WTC B	WTC C	WTC E	WTC F	WTC 3	Mean %-Wt	Std Dev %
Ca	242000	226000	333000	257000	205000	243000	265600	25.31	4.05
S							187650	18.77	
Si							30000	3.00	
Al	15400	13500	7560	10600	23900	16000	9930	1.38	0.54
Fe	8360	7360	3630	4480	15100	6930	6290	0.75	0.38
Mg	7040	5340	2870	4540	9070	5150	6550	0.58	0.20
Cl	19040	3580	1460	1570	1710	2100	3330	0.47	0.64
K					4660		2690	0.37	0.14
Ti	2630	5730	1230	1820	4920	2640	1450	0.29	0.17
Zn	2310	1960	1380	1280	5860	2020	1760	0.24	0.16

The table above summarizes the pertinent results taken directly from the McGee publication ("*D. McGee10 bulk dust samples: table 3*" in reference section). The units in the table are μg/g, and the average percent weight and standard deviation is reported per element in the last 2 columns. The amount of $S0_4$ and Si content were not measured for any sample except for the *WTC 3* sample since a different measurement technique was employed (x-ray fluorescence). Note that $S0_4$ has been converted to S for easy comparison between studies.

%-weight Fe expected from concrete	1.2%
%-weight Fe expected from dissociated steel	38%
McGee average %-weight Fe content	0.8 +/- 0.4%

Notice the Fe content is consistent with the USGS findings, 1.6 +/- 0.7%, as well as the amount of iron expected from the concrete aggregate.

Part III: EPA dust study results[9]



	High Dust Building 250 South End Ave		Low Dust 45 Warren St		
	Exterior Window Ledge (BD2)	Table Top (10DPB1)	Roof Top (BD1)	Mean %-Wt	Std Dev %
Calcium	190000	91000	170000	15.03	5.23
Magnesium	24000	7800	40000	2.39	1.61
Aluminum	2200	6900	31000	1.34	1.55
Iron	8600	4100	12000	0.82	0.40
Potasium	2700	1400	6400	0.35	0.26
Sodium	3500	1800	3400	0.29	0.10
Zinc	820	730	1600	0.11	0.05
Manganese	810	270	1600	0.09	0.07
Barium	210	100	500	0.03	0.02
Lead	220	96	140	0.02	0.006
Copper	70	67	140	0.009	0.004
Chromium	75	47	110	0.008	0.003
Antimony	24	9	40	0.002	0.002
Nickel	22	13	33	0.002	0.001
Vanadium	23	9.7	31	0.002	0.001
Arsenic			11	0.001	
Cobalt	5.9	2.7	13	7.2E-04	0.0005
Cadmium		4		4.0E-04	
Beryllium	2.1	0.6	3.6	2.1E-04	0.0002
Silver		1.2		1.2E-04	
Mercury		0.38		3.8E-05	

Three bulk dust samples from two different buildings were collected by the EPA on September 17, 2001. The two locations are listed on the map above and are labeled 'high exposure' and 'low exposure' buildings. Two samples were from the 'high exposure' building and one sample was from the 'low exposure' building. The results are summarized in the above table which is taken directly from the report (see "*E. EPA9 bulk dust samples: table 5*" in the reference section).

%-weight Fe expected from concrete	1.2%
%-weight Fe expected from dissociated steel	38%
EPA average %-weight Fe content	0.8 +/- 0.4%

The EPA results are in excellent agreement with that found by McGee (0.8 +/- 0.4%) and are consistent with USGS (1.6 +/- 0.7%) as well as the iron content expected from concrete (1.2%). The amount of iron found in the EPA dust samples pales in comparison to the total amount expected if the steel from the WTC tower was turned into dust, namely 39%.

Part IV: Summary of all three dust studies

We may average the dust results from all three bulk dust studies. The resulting iron content by weight from three independent studies totaling thirty dust samples is the following:

%-weight of Fe in bulk dust samples	1.4 +/- 0.8 %

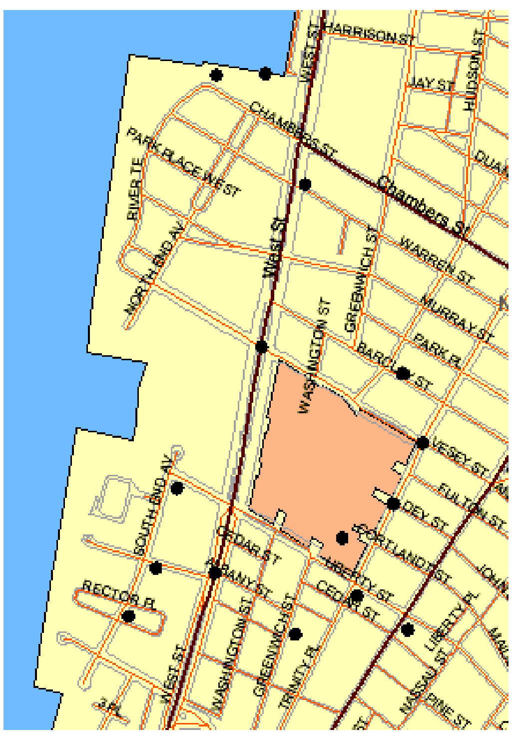
The amount of steel possibly dissociated based upon all 3 dust studies can be calculated by subtracting the amount expected from concrete, ((1.4 +/- 0.8%) – 1.2%)/ 38%:

average %-weight of above grade structural steel found in dust	0.6 +/- 2 %

No appreciable percentage of structural steel is found in the dust samples. DEW-demolition proponents claim much more than 0.6% (or even 3%) of the structural steel is missing from photographs. It is obvious that no significant quantity of steel was located in the dust. Not one solitary quantitative dust study in the literature substantiates the claim that any appreciable fraction of steel dissociated into dust.

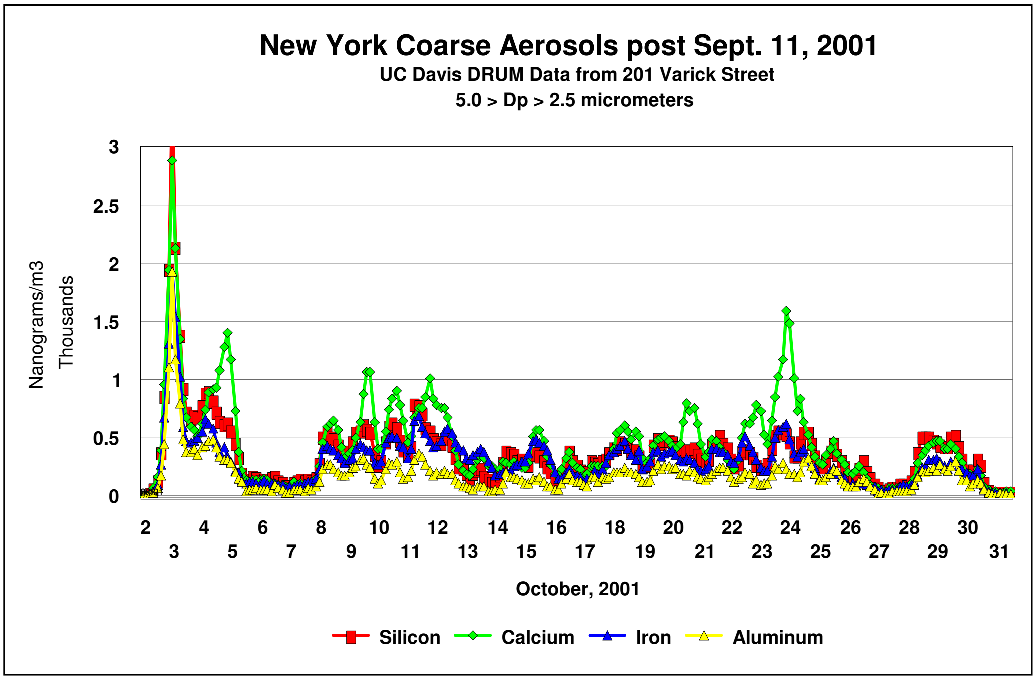
Quantifying iron found in aerosol studies

Part I: EPA[14] and UC Davis[13]



The EPA measured iron density in the aerosols rising from the debris pile in the PM10 fraction (effectively PM12 as explained by the UC-Davis publication). The EPA published the raw data on their website[14] from 15 locations in the vicinity of ground zero, which is shown on the adjoining map. Data was recorded during the period of September 16, 2001 through May 2002 (see "*C. Data from reported EPA aerosol study in lower Manhattan*" in the reference section). A peak iron density reading of 25 $\mu g/m^3$ was recorded in November at the *Albany and Greenwich* location as well as *WTC 5 – SW* location. A global peak reading for all locations over the entire measurement period was 27 $\mu g/m^3$ recorded in November at *Church and Dey*.

The UC Davis study (DELTA Group) measured aerosols rising from the debris pile from October 2^{nd} to October 30^{th} on the rooftop at 201 Varick Street which was 50m above street level.[13] They measured the PM5 fraction. The following graph shows a maximum of about 2 $\mu g/m^3$ iron emission recorded on October 3^{rd}. The material in the ultra-fine region (.25 to .09 µm) as reported by UC-Davis, including the directly measured iron content, is insignificant compared to the coarser material.



One major contributing factor for the large discrepancy between the EPA maximum readings and the UC Davis maximum reading is due to the differences in location of the detectors. The UC Davis group was located 1.8 km north-northeast of ground zero which is much further away than the EPA detectors. As the plume travels away from ground zero, it spreads out somewhat becoming less dense. If the cross-sectional area increases by a factor of 5 or 10 by the time it reaches Varick Street, for instance, then the density of the plume would be 5 to 10 times lower.

We want to find an upper bound on the weight of iron contained in the entire plume using the aerosol emission studies in order to directly compare to the weight of above-grade steel from the towers. Therefore, the largest EPA iron density measurement will be used in the calculation of the total amount of iron contained in the plume.

To find the amount of iron emitted from the rubble, we need to estimate the plume size as it passes by the detector. We know that smoke and debris emanated from an area no larger than 10 times the footprint of a WTC tower, or 4 x 10^4 m^2. The plume traveled with a lateral wind speed of about 10 mph (see "*A. Manhattan wind-speeds from EPA*" reference section for a wind velocity chart in lower Manhattan), and rose vertically with a velocity no greater than 10 mph (the angle of the plume with the horizontal was no larger than 45 degrees). The volume per second passing the sampling stations is then (4 x 10^4 m^2) x Sqrt(2) x 4.5m/sec ~ 2.2 x 10^{10} m^3/day. Combining this exaggerated plume volume with the maximum measured density of iron measured by EPA gives an upper bound on the total amount of iron emitted per day from the rubble:

$$27\ \mu g/m^3 \times (2.2 \times 10^{10}\ m^3/day) \sim 600\ kg/day$$

Remember that this is an upper bound. Even with these exaggerations, this quantity of iron represents no significant amount of steel from the two towers whose initial above-grade steel weight was about 2 x (8.1 x 10^7 kg):[15]

$$(600 \text{ kg / day}) / (2 \times 8.1 \times 10^7 \text{ kg}) \sim \boxed{0.0004\% \text{ per day}}$$

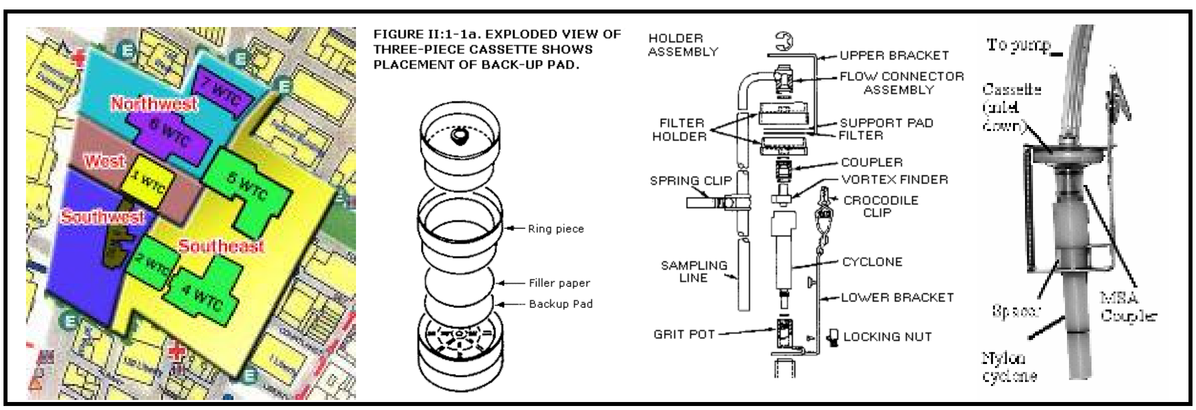
If the rubble emitted iron at this grossly exaggerated level for an entire year, it would only represent about 0.1% of the above-grade structural steel in the two towers.

The UC Davis Group and the EPA aerosol studies quantitatively support the claim that no significant amount of steel was turned into dust from the rubble pile during the days, weeks, and months following 9/11.

Part II: OSHA

OSHA acquired more than 6,500 air and bulk samples in lower Manhattan during the entire clean-up operation. A subset was used to monitor metal exposure:[16]

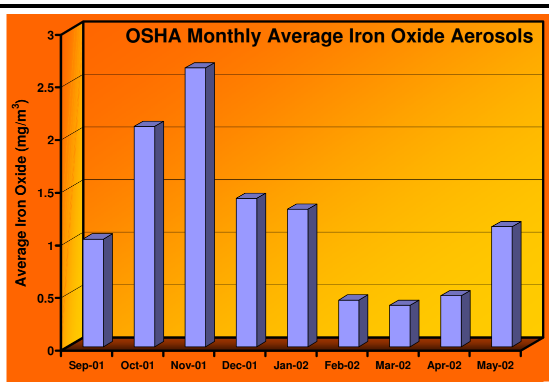
> *OSHA has taken a total of 1331 samples (excluding bulk and blank samples) to monitor worker exposures to dusts, fumes, oxides, and other compounds of metals such as antimony, beryllium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, vanadium, zinc, cadmium, magnesium, and arsenic. To minimize the length of the "WTC OSHA Heavy Metal Monitoring Data tables"* ***only the samples that showed detected results for these metals are listed****. Results from these samples are generally well below the applicable OSHA limits. However, torch cutting and burning structural steel at the rubble pile have resulted in instances of overexposures as follows: copper (17); iron oxide (28); lead (19); zinc oxide (1), antimony (1); and cadmium (3). Accordingly, OSHA is recommending that workers engaged in these operations wear appropriate respiratory protection. See information below for the specific counts in regards to mercury.*

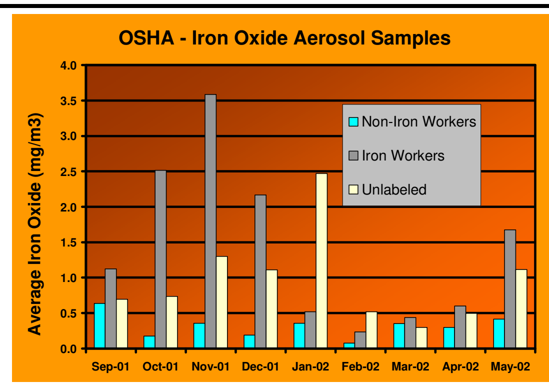


Over 640 aerosol samples which report iron-oxide content[17] were taken in the immediate vicinity of and directly on the debris pile beginning on September 22nd and continuing through June 12th. Sampling consisted of a filter canister which was fitted in-line (as depicted above) and either affixed to clean-up personnel or mounted in various places on the rubble pile. The actual filter was either a mixed cellulose ester (MCE) filters (0.8-µm pore size) or 37-mm polyvinyl chloride (PVC) filters with a pore size designed to capture welding fumes.[18] It is ambiguous in the reports which filter was actually used at ground zero. A battery operated pump set to about 2 L/min pump rate forced air through the filter canister.[19] Each aerosol sample is representatively labeled as depicted below.

Quad	Date	Sampling#	Task/Operation	Sample Type	Substance	Duration (min.)	Result mg/m3
SW	9/22/2001	20010922M41	TORCH CUTTER/BURNING	Personal	Iron Oxide Fume	201	0.2935

The fields are mostly self-explanatory. The 'Sample Type' field only included the description 'Personal' or 'Area.' The 'task/Operation' field was many times left blank. I subdivided the 'Task/Operation' into three categories: Iron workers, non-iron workers, and unlabeled. I calculated the average density of iron oxide fume (weighted by the duration of the sample) for each month. I did this for each category individually as well as combined. The two resulting graphs are depicted below.





All samples which showed no detectable level of exposure of iron oxide were not reported. Also notice that the *iron workers were much more exposed to iron oxide fumes* than non-iron workers. This strongly suggests that the iron workers were generating large amounts of iron oxide --- a rather obvious conclusion. Iron cutting produces massive densities of iron oxide in the vicinity of the iron workers. Also, the tens-of-thousands of Oxylance burning bars produced large amounts of iron oxide fumes (see supplemental section "*Rust-colored smoke*"). All of these facts will result in a gross overestimate of the actual iron oxide density emitted from the rubble pile directly.

The total average iron oxide exposure measured from the non-iron worker samples (which does not preclude being in the vicinity of steel cutters) is 316 $\mu g/m^3$, the total for non-iron workers together with the unlabeled samples yields 835 $\mu g/m^3$, and the total for all 640 samples (left graph) is 1470 $\mu g/m^3$. Since iron oxide is Fe_2O_3, this corresponds to a density 221, 585, 1029 $\mu g/m^3$ of elemental Fe.

Even though we know that the samples are grossly exaggerated due to the proximity of workers to iron cutting as evidenced from the overexposure of iron workers, we use the value of 1029 $\mu g/m^3$ using the same assumptions as the previous section to calculate the total weight of iron in the plume.

For a plume emanating from an area 10 times the footprint of a tower at a velocity of 10 mph with a cross wind of 10 mph at a density of 1029 $\mu g/m^3$, we find the grossly overestimated daily iron emission to be:

0.014% of above grade steel per day

If the rubble emitted iron at this grossly exaggerated level for the entire 9 months for which sampling data exists, it would represent less than 4% of the above-grade structural steel in the two towers.

For the non-iron workers who may have been less exposed to the direct effects of iron cutting who measured an average exposure of 221 $\mu g/m^3$ of iron, yields a plume emission of 0.003% of above-grade steel per day, or about 0.8% of above grade steel if integrated over the entire 9 month period.

The first 36 hours

Introduction

The previous sections reviewed quantitative dust and aerosol studies which show that no significant amounts of iron were present. If steel was dissociated into dust and aerosols, you would expect to physically find it! Literally none of the reported dust and aerosol studies report any significant amounts of iron.

The photographic record shows that the debris on the ground the day after the collapses was very similar to the amount of debris on the ground for the entire week. Since the first dust samples were collected on 9-12 and 9-13 by McGee, if the steel vanished, it would have had to be within the first 36 hours.

This section will systematically consider the following scenarios:

1. steel was turned into a gas and the hydrostatic pressure suspended the particulates
2. the iron in steel was turned into a different element
3. steel was aerosolized and/or turned to dust during the collapse and went somewhere else besides downward, meaning transported upwards and outwards, and subsequently drifted on ambient air currents.
4. steel fell to the ground as large pieces and was transformed into aerosols during the first 36 hours after the collapse
5. steel fell to the ground as large pieces and remained large pieces

The pertinent characteristics of the plume and dust clouds generated by the collapse of the two towers are thoroughly reviewed in the photographic record as a slideshow (flickr[20]). A variety of points will be emphasized, but particularly important is the fact that nothing --- gas, aerosols, dust, nor debris --- shot upwards during either WTC tower collapses.

In a previous paper, I showed the physical impossibility of vaporizing the steel in the towers into a gas.[35] Ignoring this fact, the consequences of transforming the above-grade steel into gaseous iron is the mass suffocation of everyone in the vicinity of ground zero. The sudden generation of this massive amount of gas would result in a pressure of 42,000 lb/in^2 throughout a volume the size of a WTC tower, the energy equivalent of blasting an entire WTC tower to an altitude of 5000 m.

Changing the iron in steel into other elements involves nuclear reactions. This is shown to be energetically impossible, and the radiation fallout from such an endeavor would annihilate all life on earth.

The remainder of the section will analyze in detail the dust clouds and plume in order to prove that the weight of the massive amount of steel in the WTC towers could not be supported by air in any reasonable estimation during the collapses, and that *measurements* of the debris clouds density quantitatively prove that no significant amount of steel hung in the air during and after collapse, or drifted away on the prevailing winds.

The visibility (optical path length) through the generated dust clouds is directly measured from photographs. The spires of the South tower are visible through the dust which hangs in the air yielding the density of the cloud. Furthermore, Bill Biggart's last surviving photograph at approximately half an hour after the south tower collapse gives a direct optical path across ground zero. Both measurements show that the dust in the air is an insignificant amount compared to the weight of the towers.

All pertinent dust transport mechanisms are considered. By considering hypothetical violently explosive vertical air jets and hot buoyant gases generated during the collapse, it is quantitatively shown that no significant amount of weight of the towers could be supported by air during collapse.

Dust was physically captured from the south tower debris cloud. The results reported by Cahill (UC Davis group) from a shirt and a cloth carry-bag which suffered a direct hit from the south tower debris cloud are consistent with both the size distribution and chemical constituency of the bulk dust samples presented earlier in the paper.

Quantitative methods of estimating the size of particles from the post-collapse dust clouds show that the vast majority of particles were larger than 1 μm. Since no significant amount of weight of particles was located in the dust clouds which hung in the air nor in the remnants from the low density turbidity flows (which I will also henceforth refer to as "pyroclastic surge" clouds, a commonly known type of low density turbidity flow in air, understood to mean without the usual accompanying high gaseous temperature) after the larger debris settled (after about 5 or 10 minutes post-collapse), the average sized particle generated from the collapses are found in the bulk dust samples. Therefore, average particle sizes from bulk dust samples will be reviewed (EPA/McGee, USGS, and Cahill). Rayleigh scattering effects are utilized to verify the particle sizes from photographs of the debris clouds and plume. The white appearance of the post collapse dust cloud (after the first few minutes when the larger particles have settled) when viewed from all angles demonstrates that the vast majority of particles from the pyroclastic surge generated clouds were larger than 1 μm. This is consistent with the bulk dust sample reports. The plume emanating from ground zero a day or two after the collapses shows a bluish hue indicating that smaller particles less than 1 μm were in abundance. This is consistent with quantitative aerosol studies.

By the end of the section, all listed scenarios except the last are eliminated. By process of elimination, the conclusion is the steel from the WTC towers merely fell to the ground in large pieces. An exploration of the supporting evidence of this conclusion is reviewed later in the paper.

Photographically characterizing dust clouds

I have chronologically organized 110 photographs from various perspectives to illustrate various points. By navigating to the flickr[20] website and clicking the "view slideshow" button, all the time-stamped photographs with in-line notes can be chronologically viewed. ***As soon as the slideshow begins, hit the "pause button" and click on the "i"*** (which interactively appears superimposed on the photograph) ***to show the annotations***. The chronology with the associated time-stamp allows the viewer to intuitively gauge the variations in perspective even though the differing views are of the same event. True differences in the character of the debris plumes and clouds which develop over time can be quickly and directly observed. Misleading perspectives as well as artifacts produced by lighting and camera settings can easily be judged based upon other corroborating photographs.

For completeness, I have appended in the reference section all of the thumbnail photographs comprising the annotated slideshow. The main points emphasized are as follows:

- The north and south tower plumes before collapse traveled virtually horizontally with the prevailing wind over lower Manhattan
- ***The smoke emanating from the north tower blew directly over the south tower and remained completely unperturbed during and after the collapse of the south tower***
- ***During the collapse of the north tower, no significant upward movement from the generated debris is witnessed, and certainly never rose above the position of the pre-collapse plume***
- During and immediately after both collapses, all debris moved horizontally outward and downward due to the expulsion of air from the collapsing buildings. Clouds of dust moved outward resembling a pyroclastic surge, a specific type of low density flow to be discussed later, engulfing lower Manhattan. Generated air currents responded to the local topology with some currents moving upward along the face of buildings, while other air currents were channeled through the canyons of NYC. Turbulence maintained particles in suspensions while concurrently transporting the particles horizontally.
- As the debris flows slowed, the larger particles settled quickly leaving behind the finer particles giving the debris clouds the appearance of a 'diffuse' cumulus-like cloud. The resemblance, which will be discussed later, is not serendipitous: the cloud density and particle sizes are comparable.
- Some of the smaller particles continued to be carried by the prevailing air currents.
- The wind currents at 1400' were about the same as those at 600' since no significant sheer forces manifested in elongated clouds.
- Fires in surrounding buildings began developing after the collapse of the north tower which increased in intensity. As the original debris cloud settled and drifted from ground zero, the whitish plume was replaced by a carbonaceous plume mainly from fires in the vicinity of WTC 5, 6, and 7.

No debris, dust, aerosols, or gas shot upwards during the collapse of either tower!

Particle sizes

Obtaining an estimate of the size of the dust and aerosol particles becomes important in our upcoming analysis regarding dust transport. The average particle size will impact the following:

- estimates of the plume density based upon contrast measurements from photographs
- the terminal velocity and the resulting effectiveness of wind currents to transport the particles
- hydrostatic pressure and diffusion as dust transport mechanisms
- characterization of the horizontal dust transport mechanisms

The average particle size of the dust which settled on the ground will be reviewed which was analyzed by EPA using samples collected by McGee, Lioy, and USGS. Dust trapped in clothing as well as a cloth carry-bag directly impacted from the debris cloud generated by the collapsing South Tower was analyzed by Cahill (UC Davis group).

The particle sizes measured in bulk dust and aerosol studies, as well as Cahill's measurement of the particles within the South tower debris cloud, will be shown to be consistent with measurements of particle sizes derived directly from photographs utilizing known Rayleigh scattering effects. All results will be shown to be consistent.

There is a distinct difference in scattering effects associated with particles smaller than the wavelength of light compared to particles larger than the wavelength of light. Rayleigh scattering is a very general phenomenon and explains why the sky is blue. The lack of Rayleigh scattering explains why cumulus clouds and fog are white. The dust particles created by the collapses were generally larger than the wavelength of visible light and show no Rayleigh scattering effects, but the aerosols emitted by the plume during the days and weeks following the collapse were much finer and clearly exhibit Rayleigh scattering effects.

Part I: EPA and the McGee samples

We know from bulk dust sample studies that most of the dust which was collected on the ground was of the very coarse variety. For instance, EPA acquired the same samples as used in the McGee study (*Part II: McGee et al dust study results10*) and reported the distribution of particle sizes by %-weight:[21]

> *Bulk samples of dust were sieved with a 53 micro-mesh screen …Analysis of the weights found in the 4 size fractions showed that roughly half of the sample was in the PM53 sieved fraction. Of the PM53 fraction, about 80-89% was in the 10 - 53 u size range… The amount of the 2.5 - 10 u fraction was very small (0.04 - 1.14 % of the PM53 fraction, except 3.23% in sample 13) and was therefore not feasible to study. The PM2.5 fraction, however, was present in large enough amounts (2.29 - 4.06% of PM53 fraction) to study for potential respiratory health effects, and is toxicologically relevant since it is associated with epidemiological findings of health effects in humans (Dockery et al., 1993). [The sum of the size fraction percentages does not total 100% of the original PM53 fraction because of loss of sample during fractionation steps.]*

Summarizing, half the sampled dust (~50%) was larger than 53 µm, about 45% was between 10 and 53 µm, about ½% between 2.5 and 10 µm, ***and about 1 to 2% smaller***

than 2.5 **µm**. Some relatively small amount was lost in the filtering process but is inconsequential for our purposes.

For the more discerning reader, let me emphasize that the distribution of particle sizes is quoted as percent *weight*! This is distinctly different than the relative percentages which will result in optical scattering effects. Optical scattering effects will depend directly upon the average *surface area* of the particles (number density multiplied by the average cross-sectional surface area which is proportional to r^2), while percent weights are averages over volume (mass density multiplied by the average particle volume which is proportional to r^3).

Part II: USGS[22]

Seven collected bulk dust samples were analyzed to determine the distribution of particle sizes. Samples labeled *USGS 4*, *6*, and *12* (see map in section *Part I: USGS dust study results8*) were collected from ground level between September 16 and 17, 2001. Sample *USGS 36*, was collected on September 12, 2001, from inside an apartment on the 30th floor of a building. Samples *LM2* and *L18-2* refer to samples collected by Lioy:[23**Error! Bookmark not defined.**] sample *LM2* is an outdoor sample collected on September 16 or 17, 2001, approximately 0.70 km east of the center of the WTC site, and sample *L18-2* was collected indoors on November 19, 2001, from an area adjacent to the WTC site (0.25 km west).

The dust samples were sieved through a 100-mesh screen. A scanning electron microscope was used in the laborious process of measuring the area of many individual particles. The resulting graph shows the relative percent abundance versus the cross sectional area of the particle.

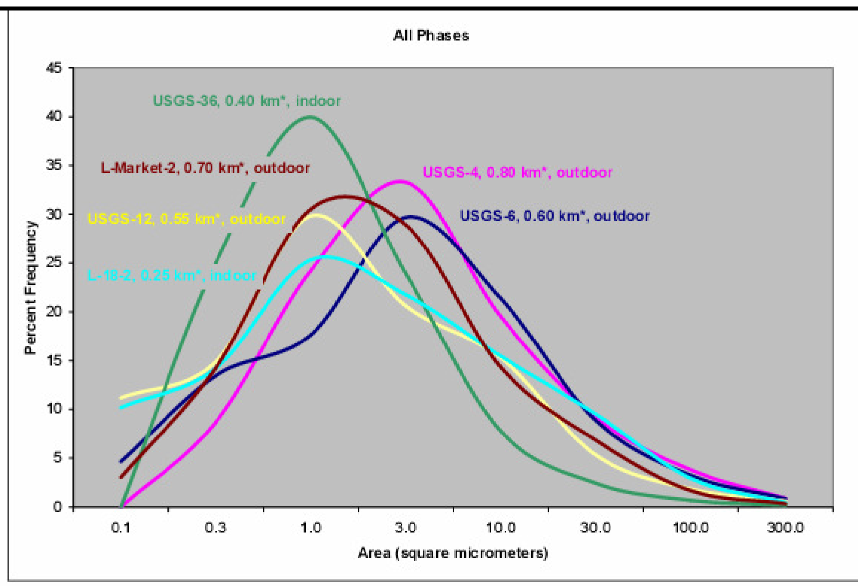
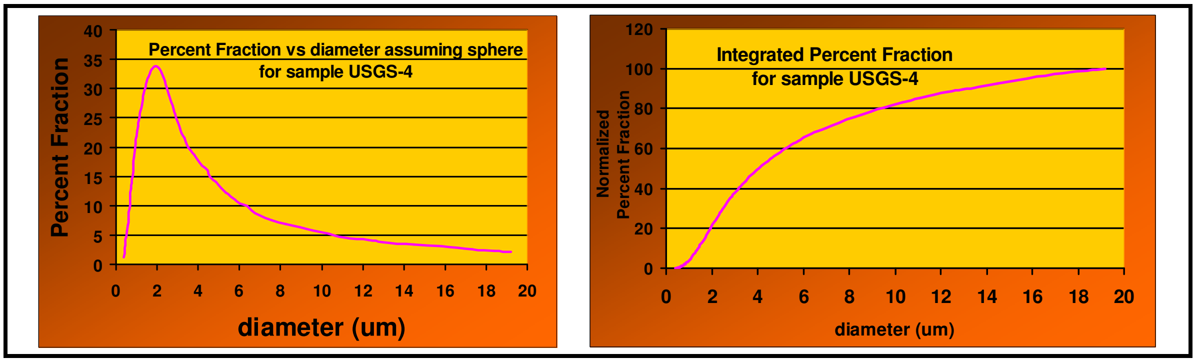


Figure 8. Particle size data for each sample presented as area (length x average width) vs. percentage frequency. *All distances are approximate kilometers from the center of WTC plaza.

The particles are in a variety of shapes: fibers, spheres, flakes, vesicles, etc. For simplicity, we would like to approximate the dust particles as spheres. We only require a very rough approximation of the actual particle sizes in terms of the approximate diameter of the particle. Since the above graph is plotted on a logarithmic scale, it is difficult to judge the number of particles in a specified range of diameters. I replot the above graph for sample *USGS-4* (represented by the lavender curve):



The plot on the left is the approximate distribution of diameter sizes for the *USGS-4* sample. The plot on the right is the integration of the left graph normalized to 100% at 20 µm. The right graph shows that 50% of the particles are less than 4 µm in diameter, and very few (<3%) are less than 1 µm. This is exactly what we need. The diameter of the lighter dust which settled in great quantity is effectively in the vicinity of 1 to 10 µm. Note that the particles larger than 20 µm were sieved from the sample, and represent the majority of dust. ***The vast majority of the dust (>>99%) is substantially larger than the wavelength of visible light (~0.5um). This distribution directly relates to the optical scattering cross section.*** The percent fraction of the optical cross sectional area was actually *measured* in this study, and the distribution plotted versus diameter directly relates to this measured scattering area.

We should note in passing that experimentally it is found that the higher elevation and more distant samples from GZ are skewed toward finer dust size. This is consistent with precipitated facies produced from low density flows which will be discussed later. That is, lighter particles settle to the ground more slowly and are therefore transported further before settling.

Although the USGS results are presented in terms of percent cross-sectional area, we see that very little iron was measured compared to the abundant gypsum and concrete. Little iron located in the bulk dust samples is completely congruous with our previous discussion regarding bulk dust samples.

Table 1. Range in area percent of major and minor components for all samples.

Particle Type	Comment	Percent Range, Outdoor	Percent Range, Indoor
Gypsum	Includes all Ca sulfate particles	26.3 – 53.3	63.3 – 63.7
Concrete	All phases compatible with hydrated cement	19.3 – 30.8	14.0 – 21.0
MMVF* Total		20.3 – 40.6	9.5 – 19.2
Slag wool	Based on table 2, field 2	91.7 – 98.1	89.5 – 93.3
Rock wool	Based on table 2, field 2	0 – 6.6	5.2 – 5.8
Soda-lime glass	Based on table 2, field 2	0 – 6.0	0.9 – 5.3
Chrysotile	Bundles and single fibers	0.4 – 1.8	0 – 0.1
Silica	Primarily crystalline	0.8 – 3.4	0.4 – 0.7
Ti-rich	Primarily Ti and Ti oxide	0 – 0.1	0 – 0.6
Zn-rich	Primarily Zn and Zn oxide	0.2 – 0.4	0.1 – 0.6
Pb-rich	Primarily Pb and Pb oxide	N.D.	0 – 0.03
Fe-rich	Primarily Fe and Fe oxide	0.2 – 1.3	0.1 – 1.1
Other	Identified but not binned	2.6 – 5.9	1.4 – 2.6
Unidentified	Could not be classified based on bulk chemistry	0.2 – 1.4	0 – 0.1

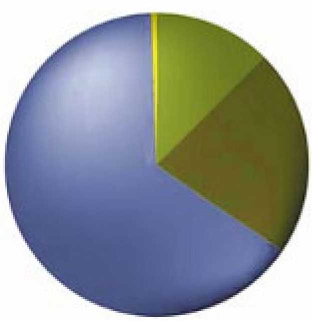
*Man-made vitreous fibers (MMVF)

Part III: Cahill and UC Davis Group – South Tower dust cloud sampling[24]

The UC Davis group acquired dust samples from a cloth carry-bag as well as a shirt that was directly hit by the expanding south tower dust cloud *during* collapse. Their results are tabulated below as well as a relevant synopsis of their aerosol study presented earlier in this paper (*Part I: EPA14 and UC Davis13*).

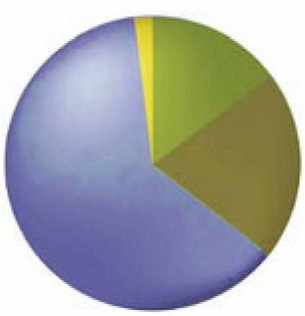
[Data from Dr. Cahill's shirt analysis he had included as graphic excerpted in 3/20/07 Esquire Magazine article]

Initial Dust Cloud, 9/11/01



Coarse particles (12 to 2.5 microns), 85 percent of sample ...

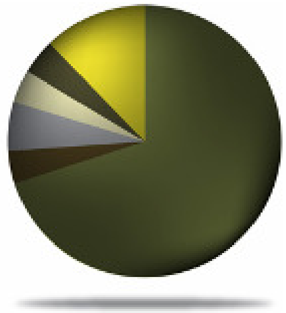
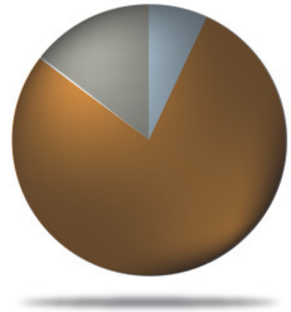
- 65% gypsum
- 22% cement
- 12.5% aggregate (sand and gravel particles)
- 0.5% other



Very fine aerosols (0.26 to 0.09 microns), 0.02% [*of sample*] ...

- 63% Gypsum ...
- 21% Cement ...
- 15% Aggregate Sand and gravel that were mixed to form the World Trade Center's concrete.
- 2% Other ...

Around the Pile, 10/3/01	
Coarse particles (12 to 2.5 microns), 11% of sample	Very fine aerosols (0.26 - 0.09 microns), 20% of sample

	70. 1% aggregate 5.8% gypsum 4% cement 4% chlorine 3.9% sulfur 12.2% other		78% Sulfuric. 14% Metals 7% Glass fumes 0.5% Chlorine, cement, and gypsum

The airborne debris directly emanating from the south tower which was in the PM10-2.5 fraction was 85% of the sample, leaving the PM2.5-.26 fraction in the vicinity of 15%. This quantitatively shows that the dust directly emanating from the south tower at ground level was very similar to the settled dust since the large majority of particles by weight were much larger than the wavelength of visible light.

This is in stark contrast to the aerosol plume produced by the smoldering debris pile. In the Cahill aerosol study, we note that our previous analysis showed that very little weight was associated with the smoldering plume. The particles in the plume consisted of mostly finer particles: the PM2.5-.26 fraction composed about 70% of the sample and the PM0.26-.09 fraction was about 20%. Many more particles were smaller than the wavelength of visible light in the aerosol plume emitted by the rubble pile during the days and weeks following the collapse of the towers. The large number of particles which are less than the wavelength of visible light will affect the scattering properties which we now explore.

Part IV: Characterizing approximate particle sizes from photographs

Rayleigh scattering is a type of scattering which involves particles which are substantially smaller than the wavelength of light (particles less than ~ 0.05 µm).[61] The intensity of scattered light from such small particles is a strong function of angle and wavelength of light. The geometry is shown in the diagram below:[25]

$\frac{I}{I_o} \propto (1+\cos^2\theta)\frac{d^6}{\lambda^4}$ where d is the particle diameter, Θ is the angle depicted, λ is the wavelength of light from the sun, and I/I_o is the intensity of light scattered to the observer.

Rayleigh scattering favors shorter wavelengths at large off-angles and explains why the sky is blue! In relevance to our particular circumstances, Rayleigh scattering is maximized at 90 degrees and strongly favors blue light.

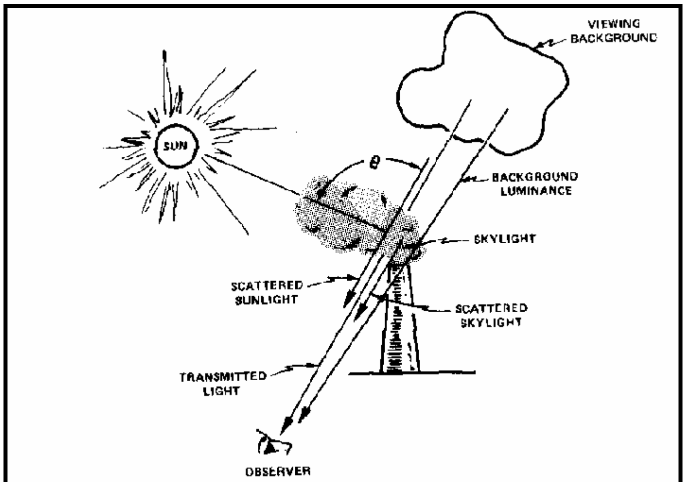


Figure 2-25. Appearance of a plume (Charlson et al., 1978).

For particles larger than ~5 µm, the scattering intensity is wavelength independent for visible light. That is, the scattered light is white when viewed from all angles. Cumulus clouds are white since the water particles are typically between 3 and 30 µm.[55]

In the intermediate range, between about 1 and .1 µm, there is weaker wavelength dependent scattering which gives rise to possible bluish hues associated with an aerosol plume.

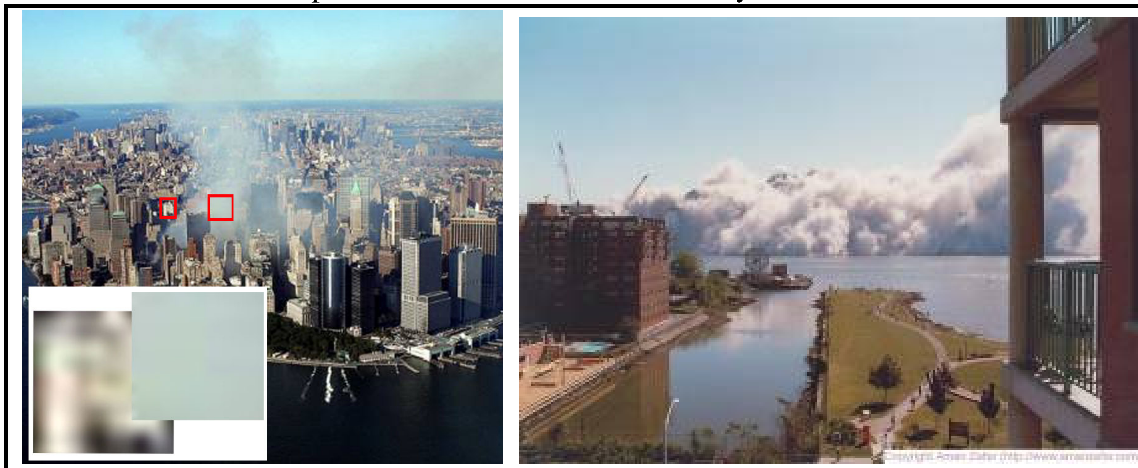
Summarizing, if a cloud viewed at a 90 degree angle is bluish, the particle sizes are submicron. If the debris cloud appears white from many different angles in direct sunlight, then the abundance of particles are larger 1 µm.

Before recklessly evaluating the color and brightness of debris clouds generated by a WTC tower collapse based upon photographs, there are some very important considerations:[61]

> *The plume air light is a strong function of scattering sun angle. A plume viewed in forward scatter will appear bright against the sky or background targets. The same plume can appear dark against the sky and bright against dark targets at scattering angles greater than 30 degrees. Detailed calculation for models requires particle concentration and size information for the plume and similar information or extinction measurements for the surrounding atmosphere. Increases in extinction resulting from plume absorption, from soot or NO_2, for example, will make the plume darker at all sun angles.*
>
> *Suspended particles generally scatter much more in the forward direction than in other directions. This fact means a plume or haze layer can appear bright in forward scatter (sun in front of observer) and dark in back scatter (sun in back of observer) because of the angular variation in scattered air light (Figure 2-24). This effect can vary with background sky and objects.*

Objects in the shade will appear bluish since they are mainly illuminated by the ambient scattered light in the sky which is predominantly blue.

Here is a picture of the aerosol plume emanating from the GZ rubble pile following a day or two after 9-11 viewed at an angle of about 90 degrees (Rayleigh scattering effects will be maximized at this angle). Direct sunlight illuminates the plume as well as a white reference building which has about the same optical path length which we use as a white reference. Definitively, the particles in the aerosol are in abundance below 1 µm due to the bluish color of the plume. This measurement visually verifies Cahill's results.



(Left) A day or two after 9-11, the plume has an obvious bluish tint in direct sunlight when viewed at an angle of 90 degrees with respect to the sun demonstrating that a significant fraction of particles in the plume are smaller than 1 µm. The inset shows the plume color compared to a white reference, both of which have about the same optical path length. (Right) Although only one angle is depicted (west and slightly south of GZ), the white color of the debris cloud when viewed at all angles in direct sunlight show that the particles which hung in the air after the collapse of both towers were greater than 1 µm.

The picture on the right is taken a few minutes after the north tower collapsed which was initially located at the approximate center of the photograph and stood twice as high as the depicted debris cloud. The time is approximately 10:30 AM, so the sun-cloud-camera angle is around 40 degrees. Some forward scattering is occurring causing the cloud to look a little brighter against the blue sky. However, the resemblance to a cumulus cloud is obvious from multiple camera angles. Although some camera views show the cloud to be grayish which is wholly expected from variations in background and viewing angle, there is no direct sunlit view (out of the shadows) showing a blue tint. This means that the majority of particles during and immediately after collapse are larger particles (greater than ~1 µm). Most of this dust eventually settles to the ground as observed from photographs and videos, and reinforced by physical principles --- the mass supportable by non-turbulent air currents is miniscule as will be shown later. The bulk dust samples show the vast majority of particles are much larger than 1 µm which is certainly consistent with the observed white debris clouds.

The particles in a typical cumulus cloud are anywhere from 3 to 30 µm in diameter, so the white appearance is an inherent optical scattering effect. After the turbulent winds generated from the collapse died down and coarser material settled from the air, the similarity to a cumulus cloud is uncanny. For the sake of comparison, the density of a cumulus cloud is 1.0 g/m^3 of water.[26] Later in this section, we will use optical path length measurements from photographs to derive the density of the debris cloud which hung in the air is less than 0.6 g/m^3, less dense than a cloud!

All known vertical dust transport mechanisms

All mechanisms in which air might vertically lift dust and aerosols will be explored in this section. If the above-grade steel in the towers were instantly aerosolized, is there any reasonable method in which the air could support the weight? The answer is a resounding negative.

Diffusion and hydrostatic pressure as mechanisms of dust and aerosol transport will be shown to be negligible. Air currents are the dominating modes of dust transport which can be generated by buoyant forces (leading to convection), explosive events, or ambient weather conditions.

In a previous publication, I show the impossibility of vaporizing the WTC towers by any known directed energy beam and the absurdly large power requirements.[35] In reference section "*H1. Gases and hydrostatic pressure gradients*," the consequences of vaporizing the above-grade steel into a gas are considered. A solid is much denser than gas. Instantly converting the above-grade solid steel to a gas would create a very dense gas or, equivalently, a gas under incredible pressures. The sheer number of particles, if transformed from a solid to a gas, would exert a pressure of 42,000 lbs/in^2 over the entire volume of the WTC tower! This pressure would be energetically capable of launching a tower like a bottle-rocket to an altitude of 5000m! Furthermore, iron is extremely reactive with oxygen. The elemental iron gas would explode outward in all directions and immediately combine with the oxygen in the air. All the ambient oxygen in the vicinity of GZ would have literally been sucked out of the air, tightly locked-up in iron-oxide (Fe_2O_3) molecules, suffocating thousands of people. ***None of this was observed, so the steel was not turned to a gaseous state.*** Hydrostatic pressure gradients only apply to gases, and in references section "*H1. Gases and hydrostatic pressure gradients*," it is shown that the tiniest of particles (greater than a few nanometers) do not behave like a gas.

Diffusion is a phenomenon which results from Brownian motion-type collisions. As it turns out, a 1nm size particle only travels about 1.3mm in an hour via diffusion (see reference section *"H2. Diffusion and terminal velocity"* for details). The diffusion rate decreases as particle size increases. Obviously, dust and smoke clouds which begin to look hazy after about a half hour after collapse is not due to diffusive processes. Turbulent mixing as well as the larger debris settling out of the debris cloud resembles a "diffusively generated" cloud. For the sake of our discussion, diffusion does not play a significant role in dust transport.

How fast do dust particles settle out of the air? The speed at which dust particles settle, or the terminal velocity, is directly dependent upon the particle size. The smaller the particle, the longer it will take for the particles to settle from air since the viscous drag forces increasingly dominate. The terminal velocity is the same as the vertical wind velocity needed to exactly levitate a particle.

The terminal velocity for a particle in air is proportional to r^2 where r is the radius of the particle (see reference section *H2. Diffusion and terminal velocity for details*). For a 100 µm sphere of iron, the terminal velocity is approximately 5 mph. A 1 µm sphere would only travel at 0.2 mm/sec! ***Clearly, vertical components of air velocity can easily suspend µm size particles***. However, there are limitations to the total weight supportable by air currents regardless of particle size which we now consider.

Since vertical air currents of sufficient velocity are able to suspend large dust particles, what net weight can be suspended by an explosive event at the towers? Even though the photographic record conclusively demonstrates that no significant vertical air currents were generated in the upward direction during collapse (flickr[27]), if a massive hypothetical air jet in the upward direction is considered, how much weight of dust could be physically support?

An upper bound on the net weight of particles which can be levitated by a vertical air jet can be calculated. This is an upper bound since supporting the maximum weight would completely halt the upward moving air current. Suppose an air jet shoots straight up uniformly across the area of a tower footprint. Since we are only interested in an upper bound, we ignore that the air jet would slow down due to drag with the surrounding air as well as the drag experienced from any stationary air above the jet. If the net upward momentum from all the air particles in the vertical jet is completely consumed by supporting a maximum weight of particles, what mass would it be? In the reference section "*H3. Air jets,*" we find that the maximum mass supportable by the pressure generated by the air jet obeys the relation $M \sim \rho_{air}\, v^2$ *area* where ρ_{air} is the density of air, v is the velocity of the air jet, and *area* is footprint of a tower. **A *100 mph air jet emanating across the entire footprint of the tower shooting straight up would only be able to levitate a maximum of half a percent of the weight of a tower.***

Another way to analyze the same phenomenon is to calculate the energy flux associated with the same air jet. Again, we assume a lossless air jet which converts the kinetic energy of the air jet into lifting power. ***The energy of the same 100 MPH air jet would only be able to lift a maximum of 1% of the total mass of above grade steel the height of 1 tower during the collapse time*** (see *" H3. Air jets"*).

Obviously, no where near a 100 mph velocity air jet shot upwards during or after collapse as evidenced by the photographic record (flickr). ***The immediate conclusion is extraordinarily large vertical air currents hypothetically generated during the collapse could not physically support or vertically transport a significant amount of weight of the towers upwards.***

In normal prevailing wind currents, updrafts can occur for several reasons, but there exists only two fundamental forcing factors.[28] The *topology* on a large scale (landscape) and small scale (texture of landscape) can force a horizontal laminar air current to acquire vertical velocity components. Laminar air flows which encounter an uphill grade, for instance, will force the air upwards. A laminar air current flowing over a rough surface will produce turbulent flow which causes local, time dependent vertical components of velocity. The turbulence can completely dominate the terminal velocity entraining and lifting particles that would otherwise quickly settle.

In the specific case of the WTC towers, topological forcing factors (pyroclastic surges which flow over adjacent buildings) obviously lift horizontally moving particles upwards. However, the topology only lifts the low density flow to a maximum altitude of roughly half the original height of the WTC towers as may be verified by the photographic record (flickr). The prevailing wind currents were very much horizontal at that altitude in the vicinity of GZ as evidenced by many photographs (in particular, see photographic number 2a, and 13c through 14c).

The outward turbulent air flow in the pyroclastic surge is the main mechanism for transporting large dust and debris outwards. The horizontal transport, or low density flow, of dust and debris will be explored later in the supplemental section entitled "Horizontal dust transport: Low density flows".

The second forcing mechanism creating updrafts in the prevailing winds is associated with changes in air density. This concept is expressed as Archimedes principle, also known as buoyancy. Hot air is less dense than cool air, and humid air is less dense than dry air. Less dense air rises and can cause vertically moving convective air currents.

If the "hot air + dust" weighs less than the surrounding cooler air, then the dust will be lifted. The air ejected from the towers is presumed to be warmer than the surrounding air. The size of the particle is irrelevant to the argument. The maximum ***weight*** of debris that can be lifted is the difference in weight between the hot air generated and the surrounding air.

If this maximal weight is hypothetically suspended in the buoyant air plume, then the air would not rise but would remain stationary. If the net weight of all the particles is less than the maximum amount of weight supportable by the ambient air, then the air would rise. Rising hot air can cause vertical air currents which then can entrain other particles. However, the maximal net amount of energy (work) which the rising buoyant plume consumes, including the energy lost in generating vertical air currents, can not exceed the maximum work performed by the buoyant force. This maximum calculable work energy achievable by the hot air is equivalent to the maximum debris carrying capacity times the debris displacement.

The density of air as a function of temperature is listed in the reference section "*G. Air Properties*".[29] The table indicates the density of air changes by 0.26 kg/m^3 when the air temperature increases from 20°C to 100°C, the boiling point of water. The air could not have become much hotter than 100°C since many people survived the debris cloud without suffering heat strokes and burns. The maximum weight of dust that the air can lift during collapse is found by estimating the volume of the dust cloud during collapse and multiplying by the change in air density generated by the heat. The dust cloud volume *during* collapse was no greater than 10 times the volume of the tower (~1.7 x 10^6 m^3). The maximum weight supportable by the warmer, less dense air is 10 x 1.7 x 10^6 m^3 x 0.26 kg/m^3 = 4900 tons. A tower weighed 240,000 tons,[15] so the air could only support approximately 4900/240,000 ~ 2% of the weight of the building during collapse.

Even if we consider that the temperature rose to 100°C during the collapse (which is much higher than expected based upon the existence of people who survived the dust cloud), the percentage of the towers which could be buoyed by air during collapse is only 2%. The above-grade steel accounted for less than half of the weight of the towers. Since at least half of the dust was other pulverized material like concrete and wallboard, ***the result is that much less than 1% of the structural steel could have been buoyed by air during the collapse.*** More than 99% of the structural steel from the towers had to move downward based upon Archimedes principle.

Some people may get the idea that I am stating that dust can not be transported upwards. Nothing could be further from the truth. What I have done in the above analysis is show that the towers are indeed massive, and that all known transport mechanisms which may lift dust and aerosols vertically are miniscule in comparison to the energy required to lift a significant fraction of the weight of the towers during collapse.

Visibility measurements (optical path length)

Photographic evidence shows that no significant amount of dust or debris rose above the original height of the towers during or immediately after collapse. Debris was transported outwards and downwards. It was shown in the previous sections that all known dust transport mechanisms could only support a tiny fraction of a tower's weight even if the entire tower was unrealistically aerosolized. The vast majority of debris must have physically moved downward. In this section, specific optical *measurements* of the density of the debris cloud during and after the collapse are consistent with our previous analysis --- the amount of weight in the air during and after collapse is miniscule compared to the weight of the towers.

In this section, we analyze three photographs and measure a quantitative upper bound on the amount of steel in the dust cloud and plume. The first is a measurement of the density of the debris cloud which hangs in the air around the spires of the South tower *during* collapse. The second measures density of the dust in the air at GZ 30 minutes after the collapse of the South tower. The third measures the density of the plume emanating from the rubble in the late evening of the following day.

By measuring the relative intensity of light which traverses a cloud of particulates, an upper bound on the density of the cloud or plume can be acquired. If one can recognize shapes through the cloud of particulates, then at least some of the photons must have traversed the cloud ballistically from the object to the observer. By measuring the relative intensity of the object from photographs, one can derive the density of the plume. However, there are some pitfalls to be avoided in performing an estimate of the amount of iron which may hypothetically be located in the air:

1) Firemen spraying the debris with water will generate large amounts of steam and will lead to a gross overestimate.
2) Any carbon-combustion smoldering underneath the debris pile will lead to an overestimation since carbon aerosols are very absorbing in the visible spectrum.
3) Inhomogeneous clouds may lead to errors.
4) Massive fires which occurred after the collapse of the North Tower from WTC 5, 6, and 7, as well as smaller localized fires from Banker's Trust and peripheral fires need to be avoided since they literally pump tons of absorbing carbon soot into the air.
5) Lighting angle of the dust can greatly affect the contrast between an object and the background. When light is back reflected off of the dust and into the camera, it can washout the effect since more light will be reflected off the dust in the air and into the camera. Consideration must be given to the amount of light backscattered off of particles. This effect will overestimate the density of particles in the plume.
6) To estimate the density of particulates which hang in the air for extended periods of time, a sufficient amount of time needs to have elapsed after the collapse to allow the very coarse particles to settle from the debris clouds.
7) The analysis will assume a perfectly black object on a perfectly white background which is not the case in actuality; the real life conditions decrease the optimal contrast between background and object which increases the minimum visibility threshold.

Every single one of these effects (with the possible exception of point 3) will overestimate the density of the iron particulates produced by the collapse and rubble pile.

The photographic record reveals that the debris cloud and plume change character over time. Also, the characteristic shade depends upon the camera angle relative to the sun (see section "*Part IV: Characterizing approximate particle sizes from photographs*"). However, some generalizations can be made based upon the photographic record (flickr).[20] The pertinent sequence is as follows:

1) Pre-collapse, a mostly horizontal carbonaceous plume was generated from fires from both towers.
2) Collapse of the south tower generates airborne dust, but a thick fire generated plume continues emanating from the north tower. There is about 30 minutes for much of the dust to settle and blow southwardly before the north tower collapse.
3) During and immediately after the north tower collapse which generated dust, the remnant plume from the upper level fire remained for a time until it is gradually blown southwardly.
4) Dust begins to settle from the north tower collapse, but concurrently fires grow in intensity from WTC 5, 6, and 7.
5) Smoke profusely emanates from WTC 5, 6 and 7 from about 1 hour after the collapse of the north tower until WTC 7 collapses about 7 hours after the north tower collapse. Most firefighting occurs on the north side of GZ apart from extinguishing smaller peripheral fires. The wind direction shifts about 30 degrees eastward in the late afternoon before WTC 7 collapses.
6) Dust is generated from the collapse of WTC 7 while WTC 5 and 6 remain burning for some time.
7) Nightfall, and no useful photographs characterizing dust occurs during this time.
8) The day after 9/11, all above ground fires are extinguished and the smoldering rubble piles are hosed down with water generating much water vapor.

I have found three photographs which circumvent many of the above-mentioned problems. The first is a photograph by Aman Zafar showing the remaining south tower core columns in the middle of the remnant dust cloud *during* collapse. The density of the surrounding dust cloud hanging in the air around the spires is measured. The second photograph is Bill Biggert's last surviving photograph a minute before the collapse of the north tower, and about 30 minutes after the collapse of the south tower. No large fires are burning above ground, no fire responders are extinguishing fires on the rubble generating steam, the distance of objects in the photograph can be measured, little backscattering occurs washing out the effect, 30 minutes worth of coarse dust has settled from the air after the collapse of the South Tower, and the plume emanating directly from the South Tower's footprint (blowing in a southwardly direction) as well as from much of the scattered rubble is sampled along the optical path. The wind is known to be blowing directly from the north tower to the south tower from the pre-collapse plume, and this prevailing wind direction would have blown any plume generated from the south tower rubble directly at the Banker's Trust building.

An upper bound on the mass density of the dust cloud based upon the optical scattering is given by the following (see reference "*H4. Optical path lengths in dust clouds"*):

$$\rho = 4/3\ \rho_P\ Ln(I_0 / I)\ r / x$$

From photographs, we can measure a lower bound on the relative drop in intensity I/Io. The distance that the light travels through the dust suspended in air, x, can be measured. The density of the particles is assumed to be huge, the density of iron which is 7800 kg/m^3. The diameter of particles will be assumed to be the average size particle analyzed in the previous section (see section *"Particle Size"*), ~4 μm. All numbers will be exaggerated to find an upper bound on the density of the dust cloud.

During the collapse of the south tower, spires remained standing for a number of seconds after the rest of the building had collapsed. Forward scattering from the sun enhances the brightness of the cloud which maximizes the contrast with the standing spires. Here, we ignore the bottom part of the building obscured by the horizontal outward debris cloud which obscures about 20% of the base of the tower and only consider the debris which is hanging in the air above that point. The outline of the core structure can easily be made out. The contrast is measured to be very small, so I use the minimum I/I_o of 2% (see "*H4. Optical path lengths in dust clouds"* for details). The width of the debris cloud can be seen based upon how much of the 1 Liberty Street building is blocked out by the illuminated debris cloud. The radius of the debris cloud is about 2 WTC widths. Using these numbers, I find a debris cloud density of 5.7×10^{-4} kg/m^3. The debris cloud generated from the collapse occupies a volume of less than 10 WTC volumes**; *therefore, the debris hanging in the air around the spires during the collapse of the South Tower is only 0.004% of the weight of the entire tower.***

The photograph is Bill Biggart's last surviving photograph which was taken about 30 minutes after the collapse of the South tower just before the North tower collapse. The amount of dust in the air is mixed with particles which are still settling from the South tower collapse. Fires and the smoldering rubble eject particles which we assume to be iron particles. These effects will grossly overestimate the amount of steel which may be hypothetically dissociating.

The height of the Banker's Trust building is 570'.[30] The horizontal distance between Biggart and the base of the Banker's Trust building is about 4 WTC tower lengths, so the angle of inclination to the top of the building is about 35 degrees. The optical path length, x, is underestimated to be the path length between the Banker's trust building roof and WTC 3 which gives a length of about 230 meters (which includes the angle of inclination). The contrast between the lighter background and the black Banker's trust building is measured to be 18% which is equal to I/I_o (see reference *H4.* Optical path lengths in dust clouds for the procedure). Using the aforementioned values for the radius of particles and density of iron, the density of the cloud is found to be 1.0×10^{-4} kg/m^3. Remember, this is a gross over-estimation of the density of the dust cloud. This optical path directly samples the particles in the plume generated by dust emitted from South tower debris field since the prevailing winds would carry the south tower emission directly into the Banker's Trust building.

If this density of debris cloud is assumed to be completely composed of iron and emitted from an area defined by 10 times the footprint of a WTC tower at a vertical ascent rate of 10 mph upwards (the angle of the plume compared to the horizontal prevailing winds --- which were less than 10 mph --- was less than 45 degrees) for a duration of 24 hours (all exaggerations), the weight of emitted particles is calculated by

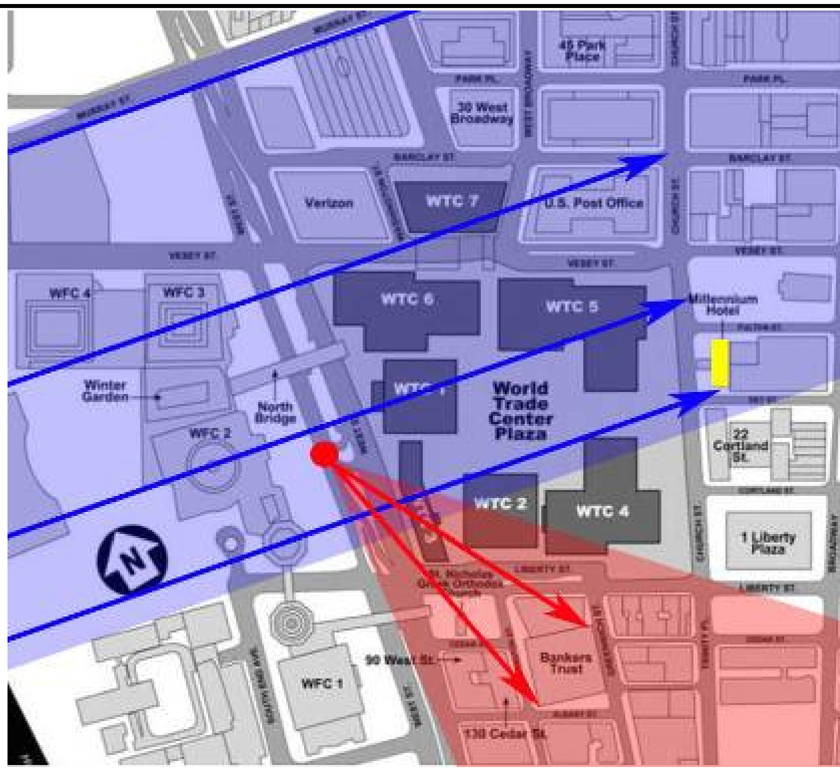
$$M = \Delta t \; Area \; v \; \rho$$

resulting in a value of 2.3×10^6 kg/day, or 1.4 % above-grade steel/day. This is a gross overestimate, a ridiculously large upper bound on the amount of steel directly measured in the plume based upon the optical path length. ***We see that 30 minutes after the south tower collapsed, the amount of dust in the air which was entrained in the air currents, even if all of it was considered to be steel particles, was less than 1.4% above-grade steel/day.***

The following evening of September 12th, another photograph was taken in which little backscattering occurs and the visibility through the dust cloud can be estimated. The photograph of the USNS Comfort arrives at sunset on September 12th.[31] Much water is being sprayed upon the rubble generating a large amount of water vapor, and the rubble pile smolders from large amounts of fuel load (the aerosol studies clearly evidence a lot of plastics, paper, office furniture, etc. burning). The Millennium Hilton Hotel is used as the black reference object. The outline of the building is clearly visible. The optical path length, x, through the aerosol cloud is estimated to be 4 WTC tower widths and I/Io is measured to be 5%. Note that the background is dark giving a much smaller contrast which will greatly overestimate the aerosol density (see reference *"H4. Optical path lengths in dust clouds"* for details). With all other values assumed the same as previously discussed and assuming all particulates in the air are iron, we find a similar cloud density upper bound of 1.7 x 10^{-4} kg/m^3 translating to 1.7 % of above grade-steel from both towers per day.

From all optical path-length measurements, much less than 1.7% of above grade steel per day could have been emitted from the debris once it hit the ground during the first 24 hours based upon representative optical path length measurements. Please keep in mind that this is a wildly over exaggerated upper bound, where we assume all the emitted dust and aerosols in the air are iron! The cloud literally hanging in the air during the collapse of the South tower shows a miniscule, insignificant amount of debris by weight in the air surrounding the spires.

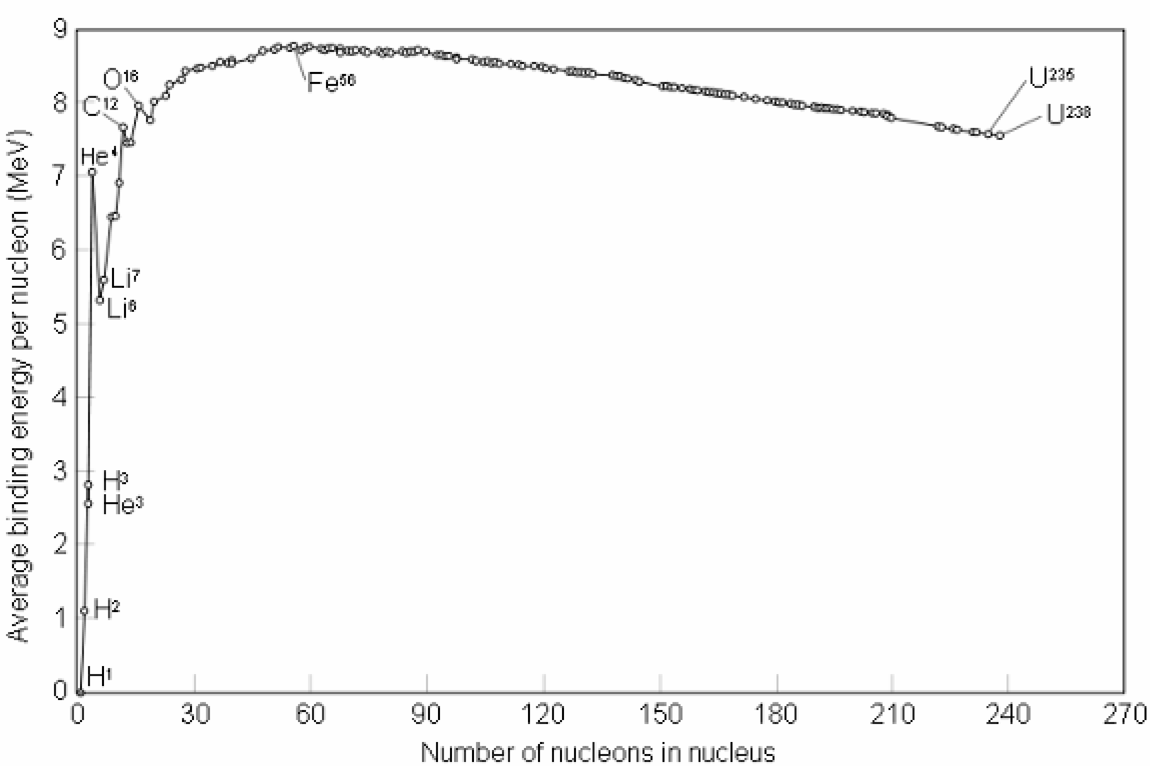
After the first 24 hours, it is apparent based upon comparing photographs of the rubble to photographs taken on 9-11 and 9-12 that no appreciable amount of steel then disappeared or disintegrated.



(Top) layout of ground zero with pertinent viewing angles shown. Red depicts the view perspective for the bottom picture, and blue depicts the view on the next two photograph on the next page (Bottom) Bill Biggart's last photograph after the South Tower collapse and about 1 minute before the North Tower collapse. Foreground building is WTC 3 with the visible background Banker's Trust building. The white smoke cloud appears whiter nearer the bottom due to light scattering effects rather than gross density effects. The face of the Banker's trust building is slightly illuminated due to backscattering from the south-eastern morning sun direction.

(Top) During the collapse of the South Tower, the core columns can be observed within the dust cloud (Bottom) USNS Comfort arrives in NYC during sunset on 9/12/01. The World Financial center buildings are in the foreground, and the tall skinny black building on the far right behind the plume is the Millennium Hilton Hotel.

Alchemy and nuclear reactions



Transforming one element into another is historically known as alchemy. Since the 1930s, it has been known that transforming one element into another element is accomplished via nuclear reactions. The idea that large amounts of iron atoms transformed into other elements through the use of a 'secret weapon' blatantly violates tenets of known nuclear physics. In this section, I will illustrate but a few of these violations.

An element is defined by the number of protons in the nucleus. The number of neutrons defines the isotope. For example, hydrogen has 1 proton, helium has 2 protons, and iron has 26 protons. The most common isotope of iron found at about 92% abundance contains 30 neutrons. The number of nucleons (protons plus neutrons) in an iron nucleus is 56 also known as the atomic number. The only way to convert iron into a different element involves either fusing or splitting the nuclei of iron atoms.

The nuclear binding energy per nucleon of all the elements is plotted versus atomic number. The nuclear binding energy is a measure of how tightly the nucleus is held together. As depicted, iron has the strongest nuclear binding energy per nucleon of all the elements.

Fission reactions (splitting nuclei) used in nuclear reactors release a net amount of energy only if the reaction products have a higher binding energy than the initial reactants. Therefore, heavy elements like plutonium-239 or uranium-235 are used in nuclear fission reactors. The resulting fission products from such reactions have atomic masses around 100. The difference in nuclear binding energy per nucleon can be read off the graph and is roughly ½ MeV per nucleon. If uranium is used as a fuel, then the total amount of energy released per atom by a fission reaction would be about 235 x ½ MeV.

However, since iron is at the peak of the graph, any kind of fission reaction would necessarily cost a huge net amount of energy. There is no way around this fact.

For instance, any method of splitting an iron nuclei (breaking it into at least two other elements) will cost *at least* 1 MeV per nucleon. Since iron has 56 nucleons, this is at least 56 MeV per iron atom. One iron atom weighs ~56 amu ~ 9.3 x 10^{-26} kg. The number of iron atoms in the above-grade steel from both towers is ~2 x 8.1 x 10^{7}/(9.3 x 10^{-26}) ~ 1.7 x 10^{33}. The minimum energy required to cause the structural steel in the towers to transform via any fission reaction would necessarily be at least 1.7 x 10^{33} x 56 MeV ~ 1.6 x 10^{22} J. ***This is equal to the total energy harnessed by human beings over the entire globe integrated over the next 50 years or, equivalently, the energy released by 37 thousand of the largest nuclear bombs ever built***![32]

Fusion occurs when two nuclei are combined. For instance, if two hydrogen-2 nuclei were hypothetically fused together to form Helium-4, the energy released per nucleon can be read off the graph, namely 7-1=6 MeV per nucleon. This would be 24 MeV per atom released.

However, for fusion to occur at room temperature, atomic nuclei must overcome the repulsive Coulomb energy (like charges repel). The minimum amount of energy required for a hydrogen nuclei (one proton of positive charge) to overcome the Coulomb repulsion of an iron nuclei can be calculated. Since an elemental iron has a nuclear radius, r, of about 4.5 fm,[33] the energy required to overcome the Coulomb energy per iron atom is proportional to Q_{proton} x Q_{iron} / r ~ 1.3 x 10^{-12} J where Q_{proton} is the charge of a proton and Q_{iron} is 26 times Q_{proton}. The total energy required to overcome the repulsive Coulomb energy for all the above-grade steel in the towers would be equivalent to at least 70 years of the total energy output of the earth! ***The associated temperature of atoms with the required average kinetic energy to overcome the Coulomb energy for fusion to occur would be 7000 times the temperature in the core of the sun.***[34]

Besides the absurd energy requirements to split or fuse iron nuclei (the most tightly bound nuclear element), there are many other problems associated with massive numbers of nuclear reactions which would be required to convert the structural steel into other elements. The nuclear reactions and resulting ‘excited state’ product nuclei would assuredly emit massive amounts of high energy radiation and particles. The energy scale we are talking about is literally tens of thousands of 100 mega-ton nuclear bombs. Imagine the nuclear radiation and fall out! The inevitable result of such a device would have been the complete and utter instantaneous annihilation of all life in lower Manhattan, and most likely all life on earth.

Summary of section

A review of the photographic record shows that no debris launched vertically upwards during either collapse of the WTC towers. The steel could not have been vaporized to a gaseous state and maintained consistency with observations. An analysis of all the physical mechanism which can transport dust and aerosols upwards prove that no significant amount of weight of the towers could be supported by air during the collapse. Cahill obtained samples which were directly hit by the dust cloud from the South tower collapse, and no significant levels of iron were detected. Iron in steel could not have been transformed into another element. Visibility measurements showed that the density of the cloud which hung in the air during the collapse of the South tower was miniscule, and the amount of debris emanating from the rubble measured 30 minutes and 36 hours after the collapse of the South tower at GZ was insignificant.

Over the first 36 hours, no appreciable amount of steel disappeared into the air. Bulk dust samples and aerosol studies prove than no steel was subsequently present in elevated quantities.

In short, the steel did not dissociate in any significant quantities. The only conclusion is that the steel fell to the ground in large pieces.

Evidence steel fell as large pieces

As I have definitively demonstrated, the structural steel did not dissociate. In this section, I present all the physical evidence that steel fell in large pieces. Photographs of the amount of debris in sublevels across the footprint of the tower show that the majority of the debris from the towers fell straight down. Measurements of the net amount of debris and the net amount of steel removed from GZ are consistent with the weight expected if no material disappeared.

Some proponents of DEW-demolition persistently cling to the notion that photographs of the rubble at GZ do not show sufficient debris to account for the WTC towers and conclude that something mysterious must have happened to it.

Most of the debris from the towers likely occupied the sublevel collapses as has been quantitatively explained.[35] Damage assessment schematics issued by the Mueser Rutledge Consulting Engineers[36] clearly show approximately 1/3rd of the total volume of the sublevels was collapsed or heavily damaged while another 1/3rd of the total volume was not assessed. If only 1/3rd of the volume was filled with debris, then this would assuredly account for all the 'missing' debris. Furthermore, at least 350,000 tons of steel were reported to be removed from GZ to landfills and recycle centers.[37] The number of truck loads (over 100,000)[38] which transported material from GZ is consistent with the expected amount of debris generated. Martin J. Bellew, Director of the Bureau of Waste Disposal at the New York City Department of Sanitation, reports over 1900 barges were used to transport the material from 59th Street and Hamilton Avenue Marine Transfer Stations, Pier 6, and Pier 25 totaling 1.6 millions tons of debris removed from GZ:[39]

> *At the peak of the operation, approximately 10,000 tons of material were delivered daily to the [Fresh Kills] site…* ***approximately 200,000 tons of steel were recycled directly from Ground Zero to various metal recyclers. The Fresh Kills Landfill received approximately 1.4 million tons of WTC debris of which 200,000 tons of steel were recycled by a recycling vendor*** *(Hugo Neu Schnitzer). The remaining material, approximately 1.2 million tons of WTC debris, was landfilled on the western side of Section 1/9 at the Fresh Kills Landfill in a 40-acre site.*
>
> *The project had come up to speed quickly, processing from 1,750 tons per day of debris in mid-September to 17,500 tons per day by mid-October.* ***Average throughput over the duration of the project was 4,900 tons of debris processed per day.***
>
> *The last WTC debris was received at the Fresh Kills Landfill on July 29, 2002. On September 3, 2002 the project was completed.*

The United States Army Corp of Engineers (USACE) immediately arrived on the scene and helped organize and coordinate the debris removal from GZ:[40]

> *During the next couple days, the debris team coordinated with NYC to devise a Debris Removal Action Plan for FEMA that would show the progress of debris removal and would allow tracking the tonnage of debris being removed. On Sept.17th, 10 debris specialists were deployed to work with Allen Morse and Beau Hanna in monitoring the debris operations for FEMA. On Sept.19th, the debris team was tasked to provide 15,000 load tickets and train the city personnel in their use and 4 engineers were deployed to develop an overall debris estimate. Two days later, the possibility of dumping the debris to the ocean was explored but the EPA rejected the idea and Staten Island was chosen as the landfill area. On Sept. 23rd, 12 debris specialists started debris monitoring. USACE completed its part of the Debris Operations Plan on Sept. 23rd and turned the operations over to FEMA at the DFO.* ***The official joint estimate of the total debris amount was released at 1.2 million tons.*** *The discussions with NYC and FEMA regarding the City's request for the USACE to manage the debris disposal site began on 25 Sept. By the end of 29 Sept., approximately 145,000 tons of debris was removed from the WTC site inclusive of the steel designated for recycling.* ***As of 21 May 2002, 1,625,550 tons of debris had been removed from the WTC site.***

The Mueser Rutledge Consulting Engineers damage assessment schematics show that all 6 sublevels (7 stories) across the entire footprint of the towers likely collapsed. I will show in the remainder of this section that the photographic record of GZ debris removal from September 2001 through May 2002 clearly depicts all sublevels directly beneath both towers collapsed and filled with debris. The amount of debris which compacted into the sublevels across the footprints of the towers will be shown to be the majority of the material associated with the towers.

Many DEW-demolition proponents use erroneous interpretations of photographs to argue that a massive amount of debris from ground zero is 'missing' which inherently assumes that almost no sublevel collapses occurred. Most of the photographs that are used to justify this claim do not offer insight into the amount of debris located in the sublevel collapses for the simple reason that visible light can not penetrate the rubble pile.

However, as GZ debris removal progressed, debris from the collapse of the towers and surrounding buildings was unearthed and photographs were taken. A time-lapsed record graphically shows the debris located within the footprint of the towers. As it turns out, debris filled nearly the entire volume beneath the footprint:

Un-sourced picture of the WTC tower lobby. Notice the location of the cross supports along the exterior column 'tridents' with respect to the ground level.

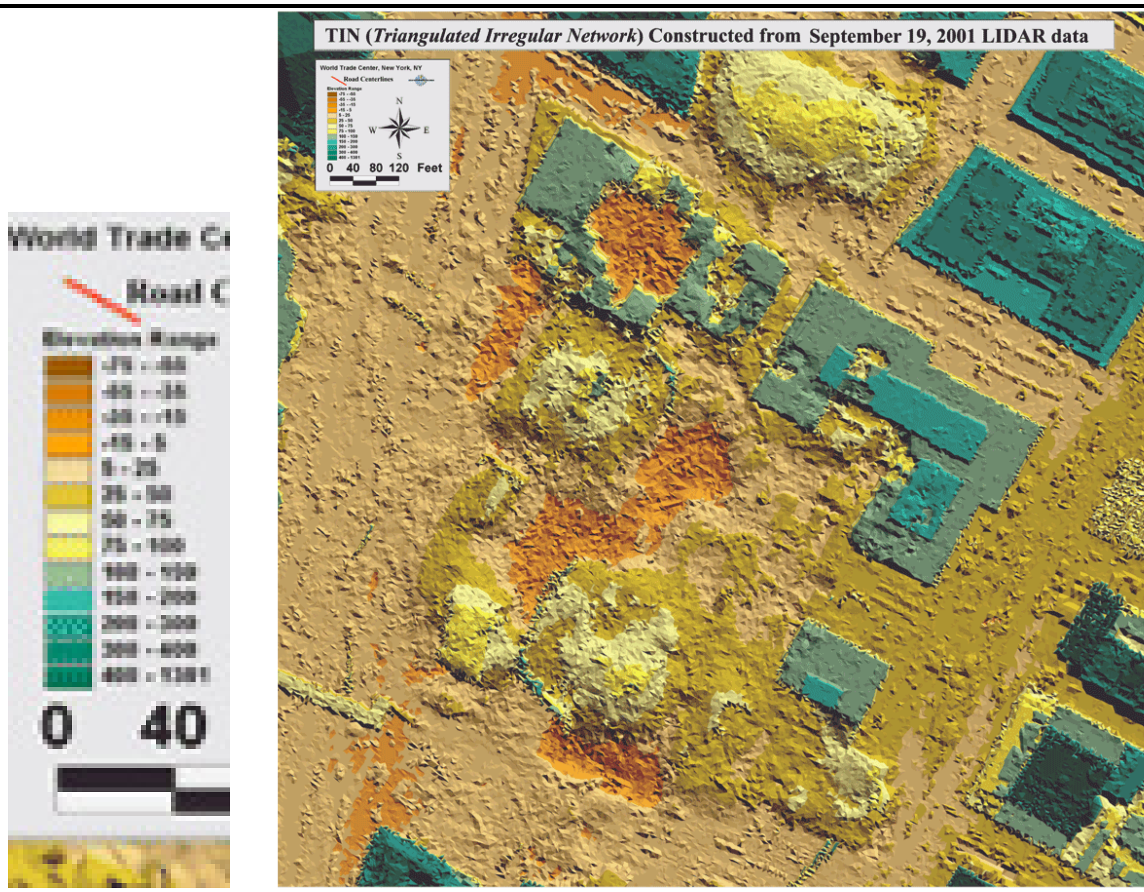
South Tower viewed from the south on Warrington Street. Note the debris stack is at least two to three stories above street level when viewed from this perspective. Photo was taken well before 9/23/01 (compared to the 9/23/01 NOAA satellite image[41]).[42]

October 5, 2001: South tower (looking east). Note the debris stacks are well above the ground level associated with the lobby.[43]

October 17, 2001: North tower. Much surface debris has been removed, but notice the compacted debris in the sublevels.[44]

October 17, 2001: South tower. It is evident that debris resided at least in the first few sublevels as well as filling 1 to 2 levels of the lobby based upon this photograph.[45]

(Left) Foundation of exterior columns during construction (right) 3-11-02: South tower lower level. All levels down to the foundation were filled with debris.



The key on the left, measured in feet, shows ranges of elevation of the debris which are color-coded: -75 to -55, -55 to -35, -35 to -15, -15 to 5, 5 to 25, 25 to 50, 50 to 75, 75 to 100, 100 to 150, 150 to 200, 200 to 300, 300 to 400, 400 to 1381. Although the LIDAR maps are coarsely quantized in height, note the excellent agreement with WTC 7 debris mound and the contour plot compiled by the author from photographs.[35] The estimate of an average 2 story debris height for the North Tower and 1 story debris height for the South Tower based upon photographs of the rubble are consistent with the LIDAR topology map.[46]

If all the sublevels beneath the footprint of the towers were filled with material as the above photographs show, how much debris does this represent?

Using a volumetric compression ratio of 11.6% based upon the collapse of WTC 7,[35] and knowing the original volume of the WTC tower was 110 stories + 7 stories of sublevels, the amount of debris occupying the sublevel collapses across the footprint of a tower was:

7 stories/.116/(110+7 stories) = 52%

In the case of the North tower, I conservatively estimate the surface debris pile to be at least 2 stories high on average across the footprint:

9 stories/.116/(110+7 stories) = 66%

In the case of the South tower, I conservatively estimate the surface debris pile to be at least 1 story high on average across the footprint:

8 stories/.116/(110+7 stories) = 59%

The results show that the majority of the material from the towers fell on their footprints. A significant percentage (~40% to 35%) landed outside the footprint. Certainly, some of this debris caused collapses and filled some of the surrounding sublevels as assessed by the Mueser Rutledge Consulting Engineers[36] and affirmed by the reported 350,000 tons of steel removed from GZ to landfills and recycle centers[37] as well as the total number of truck loads (over 100,000)[38] and barges (over 1900)[39] which transported over 1.6 million tons of material[39,40] from GZ.

Conclusion

DEW-demolition proponents argue that the vast majority of the steel in the WTC towers was turned into dust. USGS, McGee, and EPA quantitatively measure and report that no significant amount of steel was dissociated into dust. A review of the photographic record clearly shows that no gas, dust, or aerosols shot upward during or after the collapse. An analysis of all reasonable dust transport mechanisms which might have lifted dust vertically prove that air could not support a significant amount of weight of the towers during or immediately after collapse. Visibility measurements performed during the collapse of the South tower, thirty minutes after the collapse, and 36 hours after the collapse show the density of the dust which hung in the air was miniscule. UC Davis, EPA, and OSHA aerosol studies quantitatively prove that no significant amount of steel was aerosolized in the rubble pile during the days and months which followed the collapse. Iron in the steel was not transformed into another element. In short, there was no significant amount of steel dissociated at any time at Ground Zero.

The steel simply fell to the ground in large pieces during the collapse. More than 50% of the debris generated from the collapse of the towers was located in the 6 sublevels directly beneath the towers as revealed by photographs of debris removal and corroborated by damage assessment schematics produced by the Mueser Rutledge Consulting Engineers.[36] The expected amount of steel removed from GZ is affirmed by the reported minimum of 350,000 tons of steel removed from GZ to landfills and recycle centers[37] as well as the total number of truck loads (over 100,000)[38] and barges (over 1900)[39] which transported 1.6 million tons of material[39,40] from GZ.

A summary of the current arguments compiled from the author's current and previous reports[35] which have not been addressed by DEW-proponents are as follows:

- Quantitative dust measurements by the USGS, EPA, and McGee prove that only 0.6% +/- 2% of the structural steel dissociated into dust. A thorough analysis of all vertical debris transport mechanisms quantitatively proves that less than 1% of the structural steel could be supported by air during collapse. EPA, UC-Davis, and OSHA aerosol studies quantitatively prove that only a tiny fraction of 4% could have dissociated in the rubble during the days, weeks, and months following the collapses.
- The photographic record contradicts the notion that gas, dust, aerosol, or debris shot upwards during either collapse of the WTC towers (flickr[20]).
- All dust transport mechanisms considered are utterly incapable of vertically lifting any significant fraction of the tower's weight (diffusion, hydrostatic pressure, massive air jets, buoyancy and convective air currents, and topological forcing factors from prevailing air currents).
- Visibility measurements of the density of the debris clouds surrounding the South Tower spires during collapse, the dust cloud at ground zero 30 minutes after the collapse of the south tower, and the plume emitted from the rubble pile 36 hours later all were quantitatively shown to be miniscule compared to the weight of a tower.
- Dust sampled directly from the south tower pyroclastic surge showed no significant level of elevated iron content.
- Elemental iron could not be transformed into other elements due to the energy requirements: at least 37,000 100 mega-ton nuclear warheads worth of energy for fission to occur, and an average particle energy equivalent of 7000 times the temperature of the sun's core to overcome the Coulomb energy for fusion to occur.
- The amount of power required to dissociate the steel in one WTC tower, not including any energy loss mechanisms, is well over 5 times the power output harnessed by human beings from the entire globe. Conservative estimates of energy losses swell the power requirements to at least 1000 times the earth's power output. Obviously, no known power source is even remotely capable of accomplishing this feat.
- No aircraft or space-based platform could reflect (or generate) such a beam since the opposing thrust would be equivalent to over 1100 (or 500) space shuttles at maximum burn, respectively. No known reflector could survive the intense energy flux.
- If steel was dissociated into a gaseous state, a massive pressure equivalent of 42,000 lb/in^2 over the entire volume of a WTC tower would have developed which is the energy equivalent of launching the tower like a bottle-rocket 5000m straight up into the air. The elemental iron would have immediately reacted with the oxygen in the area, locking it away in Fe_2O_3 molecules, over a volume 75 times as large as the volume of a tower suffocating anyone in the vicinity of ground zero.
- Sublevel collapses together with minimal surface debris easily account for all the debris from the WTC towers, WTC 4, WTC 3, and holes in WTC 6. The sublevel volume directly beneath the towers which was filled with debris accounts for more than 50% of the debris from the towers. The total amount of steel removed from ground zero as recorded by landfills and recycle centers (350,000 tons) and the total number of truckloads (over 100,000)[38] and barges (over 1900)[39] which transported over 1.6 million tons of material[39,40] from GZ are consistent with the amount of debris expected.
- No known directed energy beam can possibly match the observed destruction of the WTC towers:

    - Symmetry of collapse
    - No expected optical effects were manifested from the astronomical intensity: air ablation, optical distortions from heated air, bright flashes from super-heated steel, etc.
    - No known energy beam could simultaneously penetrate the thick dust during collapse, energetically heat steel sufficiently, and not massively scatter into the surrounding area.
    - In the case of the North Tower, the antenna dropped first; indicating an internal structural failure.
    - Eyewitness testimonies of explosions occurring before collapse initiation
- The volumetric compression expected from collapsed steel-framed buildings matches the amount of debris observed in the holes in surrounding buildings as well as from partially collapsed surrounding buildings. Furthermore, the damage is consistent with the impulse forces generated from falling debris. The presence of jagged edges, rectangular holes, and right-angle corners in photographs directly contradict the claims of proof as a result of DEW damage: circular holes. However, the entire methodology is hopelessly flawed as shown by other isometric photographic perspectives of building damage.
- Seismograph readings do not directly correlate to the potential energy of a building in any fundamental way for reasons which have previously been cogently explained.[35] Applying the same erroneous scaling arguments used by DEW-proponents (scaling the potential energy and the consequent hypothetical release of seismic energy in a linear fashion) to WTC 7 leads to the conclusion that less than 6% of the building hit the ground: the seismic energy readings were 87 times less and the potential energy was 5 times less that of the WTC towers, so 5/87 ~ 5.7%. If we then use the arguments from DEW proponents that 80% of the towers did not hit the ground, then only 1% of WTC 7 hit the ground and was present in the rubble pile!
- Non-catastrophic bathtub damage is a natural result of minimal surface waves generated during the collapse of the WTC towers as recorded by seismograph readings.
- Other phenomena which have been ascribed to DEWs which supposedly support the hypothesis such as burning vehicles, spontaneous disintegration of materials, intact paper, ‘dirt,’ rust-colored smoke, and videos allegedly showing disappearing acts of steel, were either shown to be egregiously wrong or that much more plausible explanations exist.

References

A. Manhattan wind-speeds from EPA[47]

ATTACHMENT 4

New York City Weather September 11 - October 23

Date	Mean Temperature (F)	Wind Speed (mph)	Conditions
11-Sep-01	73.5	8.77	Partly Cloudy
12-Sep-01	70.5	10.59	Partly Cloudy
13-Sep-01	74.8	9.74	Partly Cloudy
14-Sep-01	60.3	9.29	Rain and then Partly Cloudy
15-Sep-01	62.3	7.98	Mostly Clear
16-Sep-01	63.1	5.44	Partly Cloudy
17-Sep-01	70.8	7.41	Partly Cloudy
18-Sep-01	70.3	5.09	Partly Cloudy
19-Sep-01	70.2	8.54	Partly Cloudy
20-Sep-01	69.7	12.70	Rain
21-Sep-01	72.9	6.33	Partly Cloudy
22-Sep-01	72.1	6.41	Partly Cloudy
23-Sep-01	77.0	6.90	Partly Cloudy
24-Sep-01	72.3	10.22	Light Rain
25-Sep-01	67.4	11.97	Partly Cloudy
26-Sep-01	56.3	10.67	Partly Cloudy
27-Sep-01	60.9	9.29	Partly Cloudy
28-Sep-01	57.9	7.37	Partly Cloudy and then Rain
29-Sep-01	NA	NA	NA
30-Sep-01	53.7	15.80	Rain
1-Oct-01	55.1	11.36	Rain
2-Oct-01	61.0	4.22	Partly Cloudy
3-Oct-01	71.3	7.60	Partly Cloudy
4-Oct-01	75.3	10.28	Partly Cloudy
5-Oct-01	70.7	9.06	Clear
6-Oct-01	65.4	18.36	Partly Cloudy and then Rain
7-Oct-01	52.3	18.33	Partly Cloudy
8-Oct-01	46.6	12.66	Clear
9-Oct-01	54.3	7.37	Partly Cloudy
10-Oct-01	60.7	9.13	Partly Cloudy
11-Oct-01	65.9	8.34	Partly Cloudy
12-Oct-01	62.2	6.21	Clear
13-Oct-01	NA	NA	NA
14-Oct-01	NA	NA	NA
15-Oct-01	64.0	8.52	Clear
16-Oct-01	62.4	11.62	Partly Cloudy and then Rain
17-Oct-01	51.4	11.28	Partly Cloudy and then Rain
18-Oct-01	51.4	12.81	Partly Cloudy
19-Oct-01	54.8	9.11	Partly Cloudy
20-Oct-01	63.3	7.57	Partly Cloudy
21-Oct-01	64.2	10.24	Partly Cloudy
22-Oct-01	NA	NA	NA
23-Oct-01	60.5	8.63	Partly Cloudy

NA - Not available

B. Manhattan wind-speeds from Cahill et al[13]

Table 2

Comparison of the chosen aerosol events versus all nonevent hours

Episode #	Day Oct	Time	VF mass ($\mu g/m^3$)	Wind direction	Wind velocity (km/h)	Lapse rate (γ-γ_d)	Calcium nonsoil (ng/m^3)	Coarse Sulfur (ng/m^3)	Haze LGA (<15 km)
Bkgd	6, 7	48 h	0.3	280	28.5	+	60	6.5	No
1	3	10:10	63.5	235	12.2	−−	1510	485	Yes
2	4	10:30	9.4	225	15.7	−−	313	172	Yes
3	5	14:15	5.4	225	16.2	−	1154	455	Yes
4	8	12:00	8.8	320	20.3	−	450	240	No
5	10	12:45	5.1	220	14.6	0	851	416	No
6	11	12:45	9.0	225	13.3	−−	914	318	No
7	12	12:00	8.6	220	6.2	0	795	396	No
8	13	23:15	4.3	180	low	−	105	166	No
9	15	11:15	5.0	300	13.6	++	424	160	No
10	18	03:00	5.7	Zzz	20.5	0	428	158	No
11	19	10:30	7.8	220	14.6	0	403	175	No
12	20	10:30	6.3	260	12.2	+	638	283	No
13	21	11:15	9.9	210	16.3	− −	311	267	No
14	22	11:15	5.2	300	Na	+	462	59	No
15	23	19:30	5.7	150	13.8	−	678	301	Yes
16	24	05:15	4.4	225	12.8	− −	1381	465	Yes
17	26	11:15	5.9	260	30.4	+	163	52	No
18	28	11:15	4.2	340	16.9	++	291	44	No

One hour peak values are used for mass, wind direction and wind velocity, and approximate 11 AM lapse rate (−−, very stable, descending isentropic trajectories; −, stable; 0, neutral; +, unstable; ++, very unstable with rapidly rising isentropic trajectories) except for Episodes 8, 10, 15, and 16. Three hour averaging times for species are used, but background values are a 2 day average. Mass is in $\mu g/m^3$ and other concentrations are in ng/m^3. We have also included the presence of ground level haze at LaGuardia (LGA) airport at an angle of 235° from the WTC.

C. Data from reported EPA aerosol study in lower Manhattan

http://www.epa.gov/wtc/metal/

EPA Aerosol Study, Measured Iron density in ug/m^3

Date	Barkely and west broadway
23-Sep	17
27-Sep	10
2-Oct	7
4-Oct	16
8-Oct	13
11-Oct	6.7
15-Oct	3.7
18-Oct	2.8
26-Oct	4.2
30-Oct	1.9
2-Nov	11
6-Nov	2.5
12-Nov	2
15-Nov	10
19-Nov	12
21-Nov	8.8
27-Nov	7.4
4-Dec	7.5
6-Dec	8.2
11-Dec	3.5
19-Dec	12
27-Dec	12
3-Jan	1.9
8-Jan	11
10-Jan	14
15-Jan	9.3
18-Jan	7.6
22-Jan	4.5
25-Jan	2.8
29-Jan	11
31-Jan	2.6
5-Feb	8.1
8-Feb	4.25
14-Feb	4.96
21-Feb	2.83
26-Feb	6.6
28-Feb	ND
5-Mar	ND
7-Mar	6.4
12-Mar	4.96
14-Mar	5.07
19-Mar	1.7
21-Mar	12
26-Mar	1.8
28-Mar	11
2-Apr	5.2
4-Apr	ND
9-Apr	10
11-Apr	6.95
16-Apr	8.45
16-Apr	14.13
18-Apr	4.1
18-Apr	5.7
23-Apr	ND
25-Apr	9.9
30-Apr	ND
8-May	1.75
10-May	3.1
17-May	4.32
21-May	0.74
23-May	ND
29-May	6
MAX:	17

Date	Albany and West
10-May	2.7
15-May	ND
17-May	1.73
21-May	ND
21-May	ND
23-May	ND
29-May	3.05
	3.05

Date	Albany and South End
23-Sep	2.5
27-Sep	2.2
2-Oct	2.9
4-Oct	4.1
8-Oct	2.9
11-Oct	2.3
15-Oct	0.88
18-Oct	0.71
18-Oct	4.6
26-Oct	2.6
30-Oct	2.5
2-Nov	1.8
6-Nov	1.6
8-Nov	1
12-Nov	2
15-Nov	2.9
19-Nov	1.3
21-Nov	1.6
27-Nov	1.5
4-Dec	2.8
6-Dec	4.2
11-Dec	3
19-Dec	2.3
27-Dec	5.4
3-Jan	4.2
8-Jan	0.8
10-Jan	2.6
18-Jan	2.7
22-Jan	2.2
25-Jan	2.3
29-Jan	4.4
31-Jan	5.7
5-Feb	5.4
8-Feb	ND
14-Feb	2.59
21-Feb	4.7
26-Feb	2.4
28-Feb	ND
5-Mar	ND
5-Mar	ND
7-Mar	1.5
7-Mar	1.5
12-Mar	1.79
14-Mar	1.59
19-Mar	3.5
21-Mar	4.3
26-Mar	1.3
28-Mar	ND
2-Apr	0.96
4-Apr	ND
9-Apr	4.1
11-Apr	2.82
16-Apr	2.62
18-Apr	0.98
23-Apr	3
25-Apr	1.8
30-Apr	ND
8-May	1.17
	5.7

Date	Albany and Greenwich
16-Sep	4.6
23-Sep	7.2
27-Sep	2.2
2-Oct	3.2
4-Oct	9.4
8-Oct	8.1
11-Oct	5.6
15-Oct	ND
18-Oct	6.4
26-Oct	3.8
30-Oct	17
2-Nov	4.3
6-Nov	25
8-Nov	3.2
12-Nov	2.6
15-Nov	3.7
19-Nov	1.9
21-Nov	2.2
27-Nov	7.8
4-Dec	1.4
6-Dec	13
11-Dec	12
19-Dec	ND
27-Dec	1.5
3-Jan	21
8-Jan	1
10-Jan	1.2
18-Jan	2
22-Jan	1.9
25-Jan	2.3
29-Jan	2.7
31-Jan	5.4
5-Feb	2.9
8-Feb	ND
14-Feb	1.53
14-Feb	1.99
21-Feb	ND
26-Feb	3
28-Feb	ND
5-Mar	ND
7-Mar	1.5
12-Mar	1.61
14-Mar	2.73
19-Mar	3
19-Mar	4.2
21-Mar	1.4
21-Mar	1.7
26-Mar	3.8
28-Mar	3
2-Apr	2.2
4-Apr	ND
9-Apr	0.82
11-Apr	3.19
16-Apr	2.36
18-Apr	2.5
23-Apr	ND
25-Apr	1.8
30-Apr	ND
8-May	1.57
10-May	1.6
15-May	ND
17-May	0.52
21-May	ND
23-May	ND
29-May	2.02
29-May	2.31
	25

Date	Broadway and Liberty
23-Sep	5.1
27-Sep	1.8
2-Oct	3.5
4-Oct	3.1
8-Oct	8.9
11-Oct	1.7
15-Oct	ND
18-Oct	5.3
	8.9

Date	Church and Dey
16-Sep	5.1
23-Sep	6.6
27-Sep	5.4
2-Oct	3.4
4-Oct	7.9
8-Oct	ND
11-Oct	4.2
15-Oct	4.5
18-Oct	2.4
26-Oct	7.4
30-Oct	5
2-Nov	18
6-Nov	1.3
8-Nov	27
12-Nov	2
15-Nov	12
19-Nov	24
21-Nov	19
27-Nov	13
4-Dec	8.7
6-Dec	12
11-Dec	8.1
19-Dec	6.4
27-Dec	5.6
3-Jan	11
8-Jan	3.2
10-Jan	2.1
10-Jan	2.2
15-Jan	4.7
15-Jan	5.6
18-Jan	5
18-Jan	5.7
22-Jan	4.7
29-Jan	4.7
31-Jan	3.2
5-Feb	4.4
8-Feb	ND
14-Feb	3.52
21-Feb	ND
26-Feb	15
28-Feb	ND
5-Mar	ND
7-Mar	7.5
12-Mar	7.97
14-Mar	15.45
19-Mar	4.7
21-Mar	9.1
26-Mar	13
28-Mar	4.8
2-Apr	13
2-Apr	18
4-Apr	0.43
4-Apr	ND
9-Apr	8.9
11-Apr	11.3
16-Apr	19.35
18-Apr	11
23-Apr	ND
25-Apr	1.2
30-Apr	1.7
8-May	5.02
10-May	2.7
15-May	ND
15-May	ND
17-May	3.4
17-May	5.1
21-May	0.77
23-May	ND
	27

Date	Church and Vesey
15-Nov	6.6
19-Nov	8.1
21-Nov	7.9
27-Nov	12
4-Dec	9.1
6-Dec	11
11-Dec	4.2
19-Dec	15
27-Dec	11
3-Jan	6.7
8-Jan	3.1
10-Jan	3.5
	15

Date	EPA TAGA Lab River Terrace
27-Sep	0.42
27-Sep	1
2-Oct	1.1
2-Oct	1.2
4-Oct	0.61
4-Oct	1.1
8-Oct	ND
8-Oct	ND
11-Oct	0.75
11-Oct	1
15-Oct	ND
15-Oct	ND
26-Oct	1.1
26-Oct	1.6
30-Oct	0.57
30-Oct	0.82
2-Nov	1.2
2-Nov	1.5
6-Nov	0.5
6-Nov	ND
8-Nov	1.3
8-Nov	1.4
12-Nov	0.63
15-Nov	1.7
15-Nov	1.8
19-Nov	0.96
19-Nov	1.3
21-Nov	0.99
21-Nov	1.5
27-Nov	1.2
27-Nov	1.3
4-Dec	2
4-Dec	3.5
6-Dec	2.2
6-Dec	3
11-Dec	0.87
11-Dec	0.98
19-Dec	1.3
19-Dec	1.4
27-Dec	0.98
27-Dec	1.4
3-Jan	0.71
3-Jan	0.93
8-Jan	0.15
8-Jan	ND
10-Jan	0.57
15-Jan	1.4
18-Jan	0.64
22-Jan	ND
25-Jan	0.91
29-Jan	ND
31-Jan	0.62
5-Feb	0.85
8-Feb	ND
14-Feb	0.88
21-Feb	ND
26-Feb	0.67
28-Feb	ND
5-Mar	ND
7-Mar	2.1
12-Mar	0.99
14-Mar	0.91
19-Mar	0.96
21-Mar	0.38
26-Mar	ND
28-Mar	ND
2-Apr	ND
4-Apr	ND
9-Apr	1.6
11-Apr	1.04
16-Apr	1.95
18-Apr	0.44
23-Apr	ND
23-Apr	ND
25-Apr	0.75
25-Apr	0.91
30-Apr	ND
8-May	0.54
	3.5

Date	Liberty and South End
17-Sep	0.71
23-Sep	2.3
2-Oct	2.4
4-Oct	3.4
8-Oct	4.1
11-Oct	1.9
15-Oct	3.2
26-Oct	2.1
30-Oct	1.9
2-Nov	2.2
6-Nov	ND
8-Nov	1.3
12-Nov	1.9
15-Nov	4.4
19-Nov	4
21-Nov	3.5
27-Nov	1.6
4-Dec	0.19
6-Dec	2.8
11-Dec	2.5
19-Dec	1.4
27-Dec	2.6
3-Jan	1.9
8-Jan	ND
10-Jan	0.97
15-Jan	2.3
18-Jan	1.8
22-Jan	ND
25-Jan	ND
29-Jan	2
29-Jan	2.4
31-Jan	2.1
31-Jan	2.7
5-Feb	4.3
8-Feb	ND
14-Feb	1.26
21-Feb	ND
26-Feb	2
28-Feb	ND
5-Mar	ND
7-Mar	0.99
12-Mar	0.97
14-Mar	2.22
19-Mar	0.66
21-Mar	1.3
26-Mar	0.62
28-Mar	ND
2-Apr	0.67
4-Apr	ND
9-Apr	2.1
11-Apr	2.4
16-Apr	2.38
18-Apr	1.4
23-Apr	ND
25-Apr	1.4
30-Apr	ND
30-Apr	ND
8-May	0.73
10-May	1.2
15-May	ND
15-May	ND
17-May	0.59
21-May	ND
23-May	ND
23-May	ND
29-May	1.37
	4.4

Date	Liberty and Trinity
16-Sep	4.6
26-Oct	2.3
30-Oct	5.8
2-Nov	1.8
6-Nov	3.8
8-Nov	5.2
12-Nov	1.8
15-Nov	7.5
19-Nov	8.9
21-Nov	11
27-Nov	7.4
4-Dec	8.7
6-Dec	8.2
11-Dec	6.4
19-Dec	9.7
27-Dec	6.2
3-Jan	6
8-Jan	2.1
10-Jan	2.6
15-Jan	6.8
18-Jan	2.9
22-Jan	4.3
25-Jan	1.9
25-Jan	2.8
29-Jan	4.2
5-Feb	8.1
8-Feb	ND
14-Feb	11.2
21-Feb	5.99
26-Feb	3.7
26-Feb	3.8
28-Feb	ND
28-Feb	ND
5-Mar	ND
7-Mar	6.3
12-Mar	5.73
14-Mar	7.58
19-Mar	2.2
21-Mar	5.5
26-Mar	3.2
26-Mar	ND
28-Mar	13
28-Mar	15
2-Apr	5.3
4-Apr	ND
9-Apr	8.2
16-Apr	11.5
18-Apr	6.6
23-Apr	ND
25-Apr	3.7
30-Apr	3.9
8-May	3.72
10-May	3.9
15-May	ND
17-May	8.2
21-May	ND
23-May	0.64
29-May	5.58
29-May	21.1
	21.1

Date	Recter and South End
23-Sep	2.4
27-Sep	2.8
2-Oct	1.2
4-Oct	3.5
8-Oct	1.1
11-Oct	1.4
15-Oct	0.24
26-Oct	2.3
30-Oct	2.1
2-Nov	2.2
6-Nov	0.16
8-Nov	1.6
12-Nov	0.72
15-Nov	2.8
19-Nov	1.2
21-Nov	1.3
27-Nov	2.1
6-Dec	3.4
11-Dec	1.8
19-Dec	2.3
27-Dec	5.8
3-Jan	3.6
8-Jan	0.62
10-Jan	1.5
15-Jan	2.4
18-Jan	2.3
22-Jan	ND
25-Jan	0.99
29-Jan	2.9
31-Jan	1.5
5-Feb	0.54
5-Feb	0.72
8-Feb	ND
14-Feb	1.78
21-Feb	ND
26-Feb	1.5
28-Feb	ND
5-Mar	ND
7-Mar	1.5
12-Mar	1.57
12-Mar	1.84
14-Mar	1.43
14-Mar	1.45
19-Mar	1.1
21-Mar	1.1
26-Mar	7.5
28-Mar	ND
2-Apr	0.66
4-Apr	ND
9-Apr	1.7
11-Apr	2.04
16-Apr	3.03
18-Apr	2.4
23-Apr	ND
25-Apr	1.7
30-Apr	ND
8-May	2.11
8-May	2.49
10-May	1.1
10-May	2.2
15-May	ND
21-May	ND
23-May	ND
29-May	2.36
	7.5

Date	Stuyvesant High (North Side)
10-May	0.49
15-May	ND
	0.49

	Vesey and West
16-Sep	17
27-Sep	11
	17

Date	WTC Building 5 - SW
23-Sep	4.4
2-Oct	9.1
4-Oct	4.3
8-Oct	4.2
11-Oct	7.1
15-Oct	16
18-Oct	14
26-Oct	22
30-Oct	6.6
2-Nov	25
6-Nov	0.71
8-Nov	2.9
15-Jan	6.9
18-Jan	16
22-Jan	8.8
22-Jan	9.2
25-Jan	1.5
25-Jan	5
29-Jan	4.9
31-Jan	1.5
5-Feb	4.4
8-Feb	ND
8-Feb	ND
14-Feb	6.73
21-Feb	5.6
21-Feb	6.13
26-Feb	3.7
28-Feb	ND
5-Mar	ND
7-Mar	2.8
12-Mar	4.33
14-Mar	1.97
19-Mar	1.3
21-Mar	5.4
26-Mar	2.1
28-Mar	4.6
2-Apr	3.3
4-Apr	ND
9-Apr	3.2
9-Apr	6.5
11-Apr	3.35
11-Apr	3.58
16-Apr	4.48
18-Apr	4.3
23-Apr	ND
30-Apr	ND
8-May	7.84
10-May	1.5
15-May	ND
17-May	1.66
21-May	ND
23-May	ND
29-May	2.59
	25

Date	Warren and West
17-May	2.02
21-May	2.07
23-May	ND
29-May	4.24
	4.24

D. McGee[10] bulk dust samples: table 3

Table 3. Analysis of WTC and control $PM_{2.5}$ samples by XRF or NAA (micrograms analyte per gram solid sample).[a]

Sample:	WTC8	WTC11	WTCB	WTCC	WTCE	WTCF	WTCXb	WTC3c	SRM 1649a	MSH	ROFA
Method:	NAA	NAA	NAA	NAA	NAA	NAA	NAA	XRF	NAA	NAA	NAA
Analyte											
SO_4^{-2}								375,300			
Ca	242,000	226,000	333,000	257,000	205,000	243,000	287,000	265,600		29,800	
Si								30,000			
Al	15,400	13,500	7,560	10,600	23,900	16,000	5,810	9,930	37,600	97,200	27,700
Mg	7,040	5,340	2,870	4,540	9,070	5,150	2,900	6,550		6,900	
Fe	8,360	7,360	3,630	4,480	15,100	6,930	2,730	6,290	30,500	29,200	30,900
Cl	1,940	3,580	1,460	1,570	1,710	2,100	3,310	3,330	2,790	1,680	1,030
K					4,660		2,890	2,690	15,300	8,880	
Zn	2,310	1,960	1,380	1,280	5,860	2,020	813	1,760	1,330	56	9,760
Ti	2,630	5,730	1,230	1,820	4,920	2,640	1,130	1,450	3,550	3,060	
PO_4^{-3}								779			
Na	2,030	1,700	760	1,250	1,520	2,070	1,250	725	4,420	38,500	32,400
Mn	358	295	136	257	302	340	107		268	770	1,000
Cu		428			560	484			306		
Ba					84.7	344.0	97.0		958	371.0	762
Sb	102	63.0	64.2	59.3	308	81.8	49.3		73.1		681
Mo	48.7	35.7	29.3	19.9	125	36.5	23.8				355
Ni									252		20,500
Cr	178	196	62.3	78.9	225	131	56.4		302	17.9	582
As	3.5	3.6	2.2	2.9	6.1	4.0	2.2		102		82.7
V	65.7	280	29.5	72.0	158	103	38.3		583	75.3	45,400
Sr		826			1,100	506	557		422	646	
Total µg/g	282,466	267,297	352,213	283,030	274,609	281,940	308,764	704,404	98,756	217,157	171,153
% Total mass	28.3	26.7	35.2	28.3	27.5	28.2	30.9	70.4	9.9	21.7	17.1

[a]WTC $PM_{2.5}$ samples were extracted and lyophilized. Analytes are arranged in order of decreasing content in WTC3 sample (including liquid extract samples; Table 6) by whatever analysis provided highest content. S and P measured by XRF were oxidized and assumed to be SO_4^{-2} and PO_4^{-3}, respectively. Sample WTC13 was not analyzed because of insufficient sample quantity. Missing values were either not determined or below detection limit. [b]WTCX = pooled sample of WTC8, WTC11, WTC13, WTCB, WTCC, WTCE, and WTCF. [c]WTC3 was size-separated to $PM_{2.5}$ using nose-only inhalation exposure system; average values are shown ($n = 5$).

E. EPA[9] bulk dust samples: table 5

TABLE 5. CONCENTRATIONS OF METALS IN DUST SAMPLES

	"High Dust Building"		"Low Dust Building"
	250 South End Ave., 10th Floor		45 Warren Street
	Exterior Window Ledge (250SEABD2)	Table Top (250SEA10DPB1)	Roof Top (45WARBD1)
Metal	Concentration - µg/g (ppm)		
Aluminum	22,000	6,900	31,000
Antimony	24	9.0	40
Arsenic	ND[a]	ND	11
Barium	210	100	500
Beryllium	2.1	0.6	3.6
Cadmium	ND	4.0	ND
Calcium	190,000	91,000	170,000
Chromium	75	47	110
Cobalt	5.9	2.7	13
Copper	70	67	140
Iron	8,600	4,100	12,000
Lead	220	96	140
Magnesium	24,000	7,800	40,000
Manganese	810	270	1,600
Mercury	ND	0.38	ND
Nickel	22	13	33
Potassium	2,700	1,400	6,400
Selenium	ND	ND	ND
Silver	ND	1.2	ND
Sodium	3,500	1,800	3,400
Thallium	ND	ND	ND
Vanadium	23	9.7	31
Zinc	820	730	1,600

[a] Denotes that the concentration is below the analytical limit of detection.

F. Oxylance materials data safety sheet excerpt[48]

1. Hazardous Ingredients

Chemical Name/Common Name	(CAS No.)	%	Exposure Limits ACGIHTLV	Exposure Limits OSHA PEL
BASE METAL				
Iron	7439896	99 max	as Iron Oxide Fume 5	10
Alloying Elements:				
Carbon	7440440	.08 - 0.18	--	--
Manganese	7439965	.30 - .60 (dust)	5 (fume) 11	5 (c) 5 (c)
Phosphorus	7723140	.015 - .035 (yellow)	.1	.1
Sulfur	7704349	.02 max	as Sulfur Dioxide 5.2	13
Silicon	7440213	.02 max (dust) (respirable fraction)	10 --	15 5
Aluminum	7429905	.02 - .07 (dust)	10 (fume) 5	15 5
Copper	7440508	.10 max (dust)	1 (fume) .2	1 .1
Nickel	7440020	.06 max	1	1
Chromium	7440473	.05 max	.5	1
Molybdenum	7439987	.05 max	10	15
Metallic Coating: (Galvanized Pipe Only)				
Zinc	7440666	.70 - 6.0	as Zinc Oxide (fume) 5 (dust) 10	5 15

G. Air Properties[29]

Temperature - t - (oC)	Density - ρ - (kg/m3)	Specific heat capacity - cp - (kJ/kg.K)	Thermal conductivity - l - (W/m.K)	Kinematic viscosity v x 10-6 (m2/s)	Expansion coefficient b x 10-3 (1/K)	Prandtl's number Pr
-150	2.793	1.026	0.0116	3.08	8.21	0.76
-100	1.98	1.009	0.016	5.95	5.82	0.74
-50	1.534	1.005	0.0204	9.55	4.51	0.725
0	1.293	1.005	0.0243	13.3	3.67	0.715
20	1.205	1.005	0.0257	15.11	3.43	0.713
40	1.127	1.005	0.0271	16.97	3.2	0.711
60	1.067	1.009	0.0285	18.9	3	0.709
80	1	1.009	0.0299	20.94	2.83	0.708
100	0.946	1.009	0.0314	23.06	2.68	0.703
120	0.898	1.013	0.0328	25.23	2.55	0.7
140	0.854	1.013	0.0343	27.55	2.43	0.695
160	0.815	1.017	0.0358	29.85	2.32	0.69
180	0.779	1.022	0.0372	32.29	2.21	0.69
200	0.746	1.026	0.0386	34.63	2.11	0.685
250	0.675	1.034	0.0421	41.17	1.91	0.68
300	0.616	1.047	0.0454	47.85	1.75	0.68
350	0.566	1.055	0.0485	55.05	1.61	0.68
400	0.524	1.068	0.0515	62.53	1.49	0.68

H. Derivations

H1. Gases and hydrostatic pressure gradients

Why do gas particles like oxygen (O_2) and nitrogen (N_2) remain 'airborne' in the atmosphere? After all, gravity is constantly pulling them down, so what is keeping the particles from accelerating straight down? Collisions with other particles! Since these particles are extremely light, their kinetic energy dominates over the gravitational potential energy. However, even gases such as oxygen and nitrogen are affected by gravity which is demonstrated by the lower density of particles at higher altitudes. The density gradient, synonymous with the 'hydrostatic pressure' gradient, can be calculated via the well-known thermodynamically derived expression:[49]

$$\eta(y)/\eta_0 = e^{-mgy/kT} \rightarrow \Delta\eta(y)/\eta_0 = 1 - e^{-mgy/kT}$$

That is, the change in density of gas particles $\Delta\eta(y)$ decreases as a function of height y relative to the density at ground level η_o. T is the temperature of the gas and m is the mass of a gas particle, and g and k are the gravitational acceleration and Boltzmann constants, respectively. For O_2, the difference in density between the bottom and the top of a WTC tower is about 5%.

NASA measured the changes in air pressure (which is exactly equivalent to relative changes in density) which show that air pressure is halved with an increase in altitude of 5400m.[50] This result agrees well with our formula. The discrepancy between measurements and the formula is mainly due to variations in the relative amounts of the constituent elements which compose air as a function of altitude. However, if we consider oxygen and nitrogen, the formula yields a composition in gas density of 51% and 46%, respectively. This is in good agreement with the NASA measurements.

Larger particles which weigh significantly more than elemental or diatomic gases can not remain airborne by the same mechanism as lighter gas particles (Brownian motion-type collisions). For 'still' air (no air currents) at room temperature, the density of an iron oxide (Fe_2O_3) gas would be 24% less at the height of the tower compared to the ground! The density of iron oxide particles which are ~10 nm in diameter at a height of 1 meter would only be 0.1% of the density compared to ground level (using a density of iron oxide of 5250 kg/m^3)[51]. Obviously, particles greater than about 1 nm or so in diameter are much too heavy to behave as a gas and to remain suspended in a colloid due to Brownian motion.

What would happen if all the steel in the towers was vaporized and turned into elemental iron? Recall, I show in my previous paper that the physical process of performing such a feat is impossible.[35] However, ignoring the physical impossibility, what would one expect to observe if the iron were actually dissociated into a gas?

If the steel in the entire volume of a tower were suddenly converted into gaseous elemental iron, the gas would exert a pressure of about ~42,000 lb/in^2 exploding in all directions! This pressure is about 10 times the pressure in a common compressed gas cylinder! The derivation of this result is straight forward. The ideal gas law is given by PV=NkT where P is pressure, V is volume, N is the number of particles, T is the temperature, and k is the Boltzmann constant. The number of iron particles in the above-grade steel from a WTC tower is equal to the weight of above-grade steel divided by the weight of an iron particle, or $8.1\text{x}10^7$ kg/56 amu = $8.7 \text{ x } 10^{32}$ Fe particles. At a temperature of 20°C and a volume of 1 WTC tower (~$1.7x10^6$ m^3), the partial pressure is approximately 42,000 lb/in^2.

This large pressure would cause a massive thrust in all directions, hurling elemental iron in all directions. The massive number of highly reactive elemental iron particles would quickly combine with any oxygen with which it collided. In fact, iron smelting is the reverse of this process: removing oxygen (among other impurities) from iron ore which is usually in the form of an iron oxide. Taking the density of air at 20°C, 1.2 kg/m^3, and knowing that diatomic oxygen and nitrogen make up (approximately) 21% and 79% of the air, the volume of air which would react with the elemental iron around ground zero to form Fe_2O_3 can be calculated.

The law of partial pressures states that the pressure of ambient air, 1 atmosphere, is equal to the sum of the pressures exerted by nitrogen and oxygen. This is equivalent to the total density equaling the sum of the densities of nitrogen and oxygen. We also know that the total density of particles is the average mass times the total number density:

$$\rho_{Total} = 1.2 kg/m^3 = (0.79 m_{N_2} + 0.21 m_{O_2})\eta_{Total}, \text{ and } \eta_{O_2} = 0.21\eta_{Total}$$

Substituting the values for m_{N2}=28 amu, m_{O2}=32 amu gives $\eta_{O2}=5.3x10^{24}$ O_2 particles/m^3. The total volume that can be emptied by combining all the gaseous iron with oxygen to form Fe_2O_3 is 3/2 x (8.7 x 10^{32} Fe particles)/($1.1x10^{25}$ O particles/m^3) ~ 75 WTC tower volumes. ***The oxygen would have been literally sucked out of the air suffocating everyone in the immediate vicinity of the collapse.***

Even if the particles were larger than single iron oxide particles but small enough to be considered a gas, the huge surface area would still react with about the same amount of oxygen.

It is interesting to consider how much energy is stored in a gas pressurized to 42,000 lb/in^2 confined to a volume of one WTC tower. Combining the ideal gas law with the work relation (integral of force multiplied by distance), one can derive the following expression for the energy contained in a pressurized gas:

$$\text{Energy} = NkT \ln(P/P_0)$$

Taking P=42,000 lb/in^2, P_0= 1 atm, and N = 8.7 x 10^{32} Fe particles, the energy is 10^{13} Joules. ***This is the energy equivalent of blasting a WTC tower to an altitude of 5000m!***

H2. Diffusion and terminal velocity

For low Reynold's number (which is the case for small particles in air), the viscous coefficient is given by Stokes Law, $\gamma = 6\pi\eta r$ where η is the viscosity of air ($1.51x10^{-5}$ Ns/m^2 at 20°C)[29] and r is the radius of a particle

The viscous force is γ multiplied by velocity, so the terminal velocity is given by:

$$v_t = mg / 6\pi\eta r$$

Where g is the gravitational constant and m is the mass of the particle. The diffusion coefficient is given by the Stokes-Einstein relation:

$$D = kT/\gamma$$

where k is the Boltzman constant and T is temperature. The root-mean-square change in position as a function of time t for diffusive processes involving small particles is given by:

$$X_{RMS} = \sqrt{2D\,t}$$

For a 1 nm size particle at room temperature, X_{RMS} = 1.3 mm/hour. For larger particles, the diffusion length is even less since $X_{RMS} \propto \sqrt{1/r}$. For dust and aerosols in the case of the WTC tower collapse, the diffusion lengths are negligible compared to other transport mechanisms.

The terminal velocity associated with a specific material whose density is ρ with a radius r can be found as follows:

$$M = \rho \cdot volume, \quad volume = (4/3)\,\pi r^3 \Rightarrow v_t = \frac{2}{9}\frac{\rho g r^2}{\eta}$$

This result agrees with the reported settle time for a 10 and 0.5 um soot particles falling 1 foot (using the density of carbon which is approximately 2267 kg/m^3)[52] of just under 1 minute and about 5 hours, respectively.[53] Also, if we compare with the terminal velocity of a 10 μm radius water particle (density of water is about 1 g/cm^3), we arrive at 0.3 cm/sec consistent with other authors.[54]

H3. Air jets

If all the upward momentum from all the air particles in a vertical jet is completely consumed by supporting a maximum weight of particles, what mass would it be? The air jet would cease moving upwards since all the net upwards momentum would be consumed in supporting this maximum weight. We now calculate that maximum mass. The force exerted by the jet is given by the following:

$$F_{Jet} = \Delta P / \Delta t = M_{Jet} \Delta v_{Jet} / \Delta t$$

ΔP is the net change in momentum of the vertical component of the air jet occurring in the time interval Δt. The maximum amount of weight supportable, M_{max}, is given by the force balance F_{Jet}= g M_{max}. Note that Δv_{Jet} is the initial velocity of the jet, $M_{Jet} = \rho_{air} V_{air}$, where V_{air} = *area* x Δy is the volume of air which is arrested in time Δt. Combining gives the following:

$$F_{Jet} = \rho_{Airt} v_{Jet}\, area\;\; \Delta y / \Delta t \Rightarrow M_{\max} = \frac{area}{g}\, \rho_{Air} v_{Jet}^2$$

For a jet of cross sectional area of a tower (~4000 m^2) traveling at a velocity of 100 mph vertically upward with an air density at STP ~ 1.2 kg /m^3 and g =9.8 m/s^2 gives M_{max} ~10^6 kg ~0.5% of the total weight of a tower.

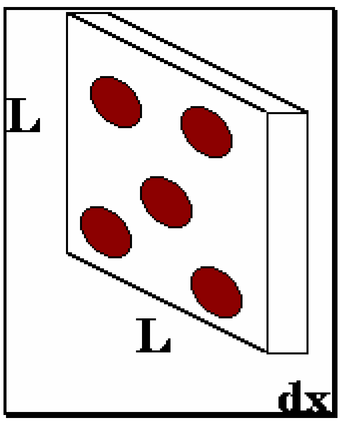
The above is an upper bound since all the upward momentum of the jet is consumed in levitating mass M_{max}.

Another way to approach the same problem is to consider the rate of energy flux from such a jet of air, and compare that to the rate of energy required to lift the building mass. The energy flux associated with a stream of air is given by the following expression:

$$Power / area = \Delta KE / (area \cdot \Delta t) = (1/2)\, M_{Jet} v_{Jet}^2 / (area \cdot \Delta t) = (1/2)\; \rho_{Air} v_{Jet}^3$$

If all of this energy is consumed, then the air current will stop moving, so we calculate an upper bound on the amount of work which can be used to lift a given mass. For the same air jet (100 mph across the footprint at STP), then the power per footprint = 2.5 x 10^8 Watts. If this jet was emitted straight up for the duration of the collapse time of about 13 seconds, then the net energy associated with the jet is 3.2 x 10^9 Joules. The amount of mass which may be lifted a height h is given by E = m g h, or h = E / m g. For the entire mass of the building, the amount of energy associated with our jet would only lift the building up 1.5 meter, or the above-grade steel mass about 4 meters. The amount of energy in the jet would only lift 1% of the mass of above-grade steel the height of 1 tower (1350'). Please keep in mind that these results are upper bounds since it is assumed that no energy is lost from viscous effects between the jet and entraining air or air above the jet, heat loss, or turbulence, and the total amount of energy in the jet is completely converted into lifting energy which would complete halt the flow.

H4. Optical path lengths in dust clouds



A photon is normally incident on a slab of area L^2 and width dx. The volume contains a certain number density of particles, η, whose average cross sectional area is σ_P. The photonic wavelength is assumed to be the smallest length scale in the problem and is considered to travel ballistically. The probability of the photon being stopped by the particles is given by:

Probability of stopping photon in length dx = area occupied by particles/ total area $= L^2(\eta\sigma_P\, dx)/L^2 = \eta\sigma_P\, dx$

The transmitted intensity is proportional to the number of photons which make it through the slab. The drop in the number of photons after traversing the slab is given by:

$$-dI = I\eta\sigma_P\, dx\ ,$$

or upon integration and applying the condition that the initial intensity is I_o and the slab has a total thickness x gives:

$$I = I_0 e^{-\eta\sigma_P x}\text{, or equivalently, } \eta = Ln(I_0/I)/(\sigma_P x)$$

Note that the optical path length is defined as 1/ η σ_P. We want to calculate the total mass in a dust cloud given that shapes are optically discernable after traversing the cloud. The decrease in contrast of the object behind the cloud compared to the reference background will measure the drop in intensity.

However, first we need to do some re-arranging and some substitutions. We begin by defining ρ as the mass density of the cloud of particles, V_p as the volume of an average size particle, ρ_p as the density of the particle itself, and r as the radius of a particle. Re-arranging the previous equation gives:

$$\rho = \eta\, \rho_P\, V_P = \rho_P (4/3)\pi r^3\, \eta \quad \text{and} \quad \sigma_P = \pi r^2$$

Using the above two relations to eliminate σ_p and η from our previous formula gives:

$$\rho = (4/3)\ \rho_P\ Ln(I_0 / I)\ r / x$$

If we consider a moving cloud which emanates from a surface of a specified area at a vertical velocity v, then the rate of volume emission is dV/dt = Area v. The rate of mass emission is then given by dM/dt = ρ dV/dt = ρ Area v. Integrating over some finite time duration, Δt, we find the total mass emitted from the surface:

$$M = \Delta t\ Area\ v\ \rho \text{ , or more explicitly, } M = \frac{4}{3}\rho_P\ \Delta t\ Area\ v \frac{r}{x} Ln(I_0 / I)$$

For a cumulous cloud, the density of water is ρ = 16 g/m^3 and the size of the typical water particle is in the range of r = 3 to 30 µm.[55] The density of water is about ρ_p ~ 1 g/cm^3=10^6 g/m^3 (ice is about 10% less dense). [56,57]

The optical path length in a cumulous cloud is then given by:

$$l = (\eta \sigma_p)^{-1} = \frac{\rho_P (4/3)\pi r^3}{\rho \pi r^2} = \frac{4}{3}\frac{\rho_P}{\rho} r = 1.3\times 10^6\, r$$

Therefore, $x = -l\ Ln(I / I_0) = -1.3\times 10^6\, r\ Ln(I / I_0)$. For the ballistic intensity to drop to I/I_o=0.01, and r=10 µm, we find x = 61 meters. Making out features in a cumulus cloud out to 60 meters is near impossible as anyone who has ascended in a plane through a cloud has witnessed. At best, to see any features on the ground when ascending through a cloud would be more likely in the vicinity of 30 meters at most.

As an aside, the weight of a cumulous cloud is miniscule compared to the weight of a tower. The weight of a cumulus cloud which occupies a volume of 100 world trade center towers would only weigh about 0.08% of the weight of 1 tower.

Experimentally, the drop in intensity in which an object might barely be seen in a cloud of particulates has been found to be 2% under ideal conditions, but most modern studies use 5% in real-life situations. [58,59,61] This is known as the visibility threshold. Note that the visibility threshold can be experimentally found by analyzing the contrast of a black object located some distance from a viewer compared to a bright background. *Brightness* is defined as proportional to the intensity and *contrast* is defined as the relative difference in brightness between object and background. Although the visibility threshold depends upon the f-number of the optical system, usually the naked eye or camera, changing the f-number only affects the derived result logarithmically. This means that the visibility threshold will not change appreciably with geometry.

Please note that for the case of a black object, the *contrast* between a white background and a black object is derived elsewhere to be -I/I_o, known as the Lambert-Beer law.[59] I quote the result since the derivation is a bit involved and defer the interested reader to the references.[60 and 61] The criteria used here was originally formulated by Koschmieder in 1924 but shown to be correct in a variety of circumstances:

$$Visibility \equiv x_{Threshold} = 3.921\times l$$

What this formula physically means is that for the threshold intensity given by $I / I_0 = e^{-3.921 \times l / l} \sim 2\%$, the black object will just barely be visible with respect to a perfectly white background. Note that the *contrast* is defined as the (brightness of the building) – (brightness of the background) / (brightness of the background).

In order to experimentally measure the contrast, we can manually adjust the brightness until the background brightness equals the original building brightness or, equivalently, until the adjusted building brightness equals the background brightness. Pragmatically, this is accomplished by opening two Microsoft Office Picture Manager windows with the same picture in both windows, and adjusting the brightness of one picture until the shade of the black building equals the shade of the light background, or until the light background equals the shade of the black building.

H5. Thumbnails of the flickr[20] annotated slideshow:

Below are the thumbnails of the 110 photographs composing the flickr[20] slideshow. The numbers connote the row, and letters connote the columns. For example, the "2c" means the third picture from the left following the "2". This labeling corresponds with the uploaded pictures on flickr, so scanning the thumbnails for any interesting photographs makes it easy to pick and choose which photographs to download.

The green framed photographs were taken from a digital camera in a helicopter and were originally time stamped. Although the time was off by a few hours, the relative time was normalized to the NIST collapse times to yield a completely accurate chronological record. The time reference was developed by noting the South Tower plane strike occurred at 9:02:59, the South Tower collapse began at 9:59:07, and the North Tower collapse began at 10:28:50 as reported by NIST.[62] The blue framed photographs were taken by Aman Zafar (www.amanzafar.com). The photographs were not originally time stamped since they were scanned from prints but were numbered sequentially. The two cyan framed photographs were taken by Bill Biggart minutes before the collapse of the North Tower. The remaining red framed photographs are of various known and unknown origin. The derived timestamps are tabulated in the below table.

1

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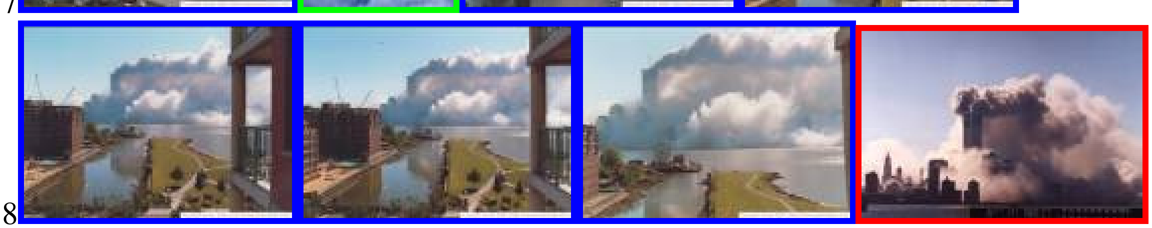
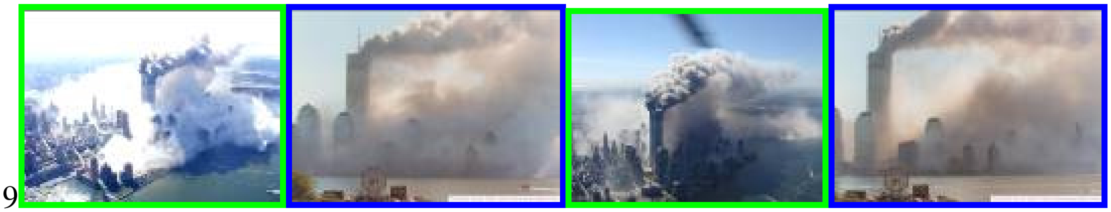
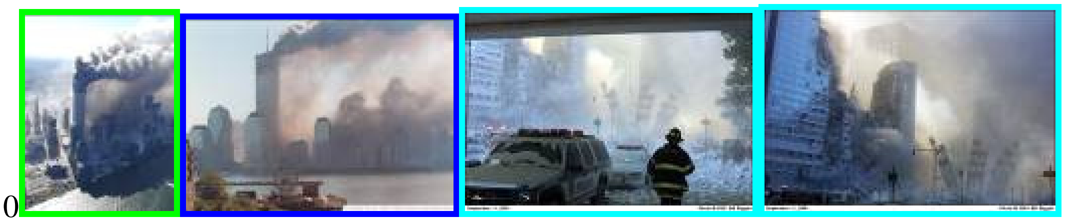


8

9



10



11

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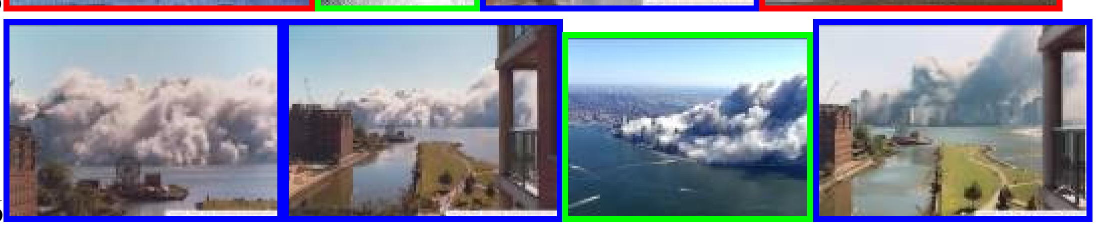

17


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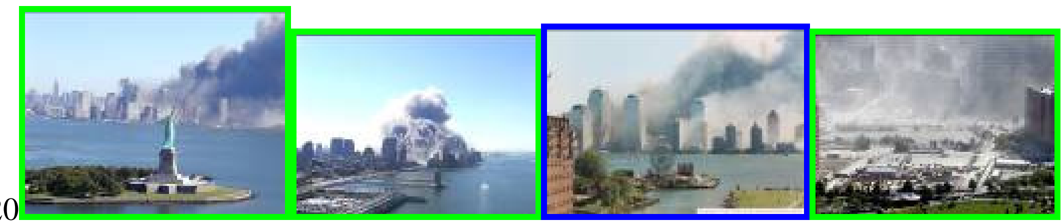
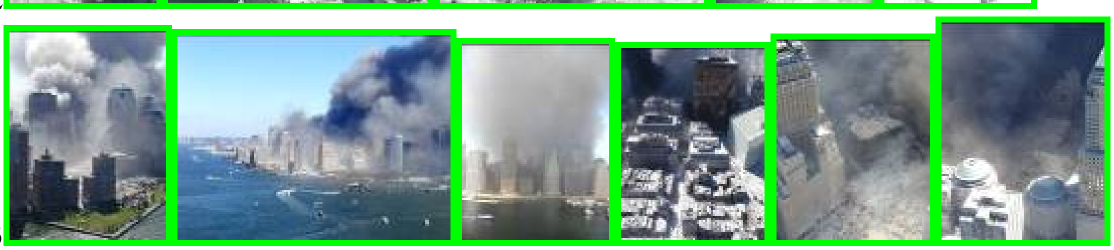
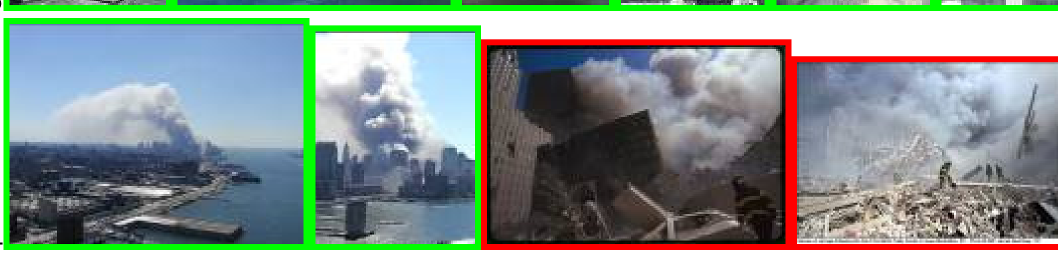
19


20


21


22


23


24


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September 12th:

28 

Photograph Number	Type	Description	Time (accuracy of 5 seconds)	Time since collapse
02a	X	South Tower Strike	9:04:29 AM	-54:38
03b	Marvin	South Tower Collapse	9:59:07 AM	00:00
03c	Aman Zafer		9:59:11 AM	00:04
03d	X		9:59:13 AM	00:06
04a	Aman Zafer		9:59:15 AM	00:08
04b	Aman Zafer		9:59:22 AM	00:15
04c	Aman Zafer		9:59:52 AM	00:45
04d	helicopter		9:59:52 AM	00:45
05a	helicopter		10:00:12 AM	01:05
07b	helicopter		10:04:39 AM	05:32
09a	helicopter		10:07:15 AM	08:08
09c	helicopter		10:17:53 AM	18:46
10a	helicopter		10:22:40 AM	23:33
10c	Biggart		10:26:50 AM	27:43
10d	Biggart		10:27:50 AM	28:43
11a	Marvin	North Tower Collapse	10:28:50 AM	00:00
11b	X		10:28:53 AM	00:03
11c	X		10:28:54 AM	00:04
11d	X		10:28:55 AM	00:05
12a	X		10:28:55 AM	00:05
12b	Aman Zafer		10:28:57 AM	00:07
12c	Aman Zafer		10:28:58 AM	00:08
12d	X		10:29:00 AM	00:10
13a	helicopter		10:29:03 AM	00:13
13b	helicopter		10:29:16 AM	00:26
15b	helicopter		10:30:41 AM	01:51
16c	helicopter		10:36:28 AM	07:38
18b	helicopter		10:41:32 AM	12:42
18c	helicopter		10:41:58 AM	13:08
18d	helicopter		10:42:19 AM	13:29
18e	helicopter		10:42:30 AM	13:40
19a	helicopter		10:45:15 AM	16:25
19b	helicopter		10:53:45 AM	24:55
19c	helicopter		10:53:50 AM	25:00
20a	helicopter		10:53:57 AM	25:07
20b	helicopter		11:00:11 AM	31:21
20d	helicopter		11:01:25 AM	32:35
21a	helicopter		11:01:29 AM	32:39
21b	helicopter		11:07:08 AM	38:18
21c	helicopter		11:11:15 AM	42:25
21d	helicopter		11:34:14 AM	1:05:24
21e	helicopter		11:34:50 AM	1:06:00
22a	helicopter		11:35:12 AM	1:06:22
22b	helicopter		11:36:07 AM	1:07:17
22c	helicopter		11:43:11 AM	1:14:21
22d	helicopter		11:43:37 AM	1:14:47
22e	helicopter		11:43:44 AM	1:14:54
23a	helicopter		11:49:15 AM	1:20:25
23b	helicopter		11:53:14 AM	1:24:24
23c	helicopter		11:55:26 AM	1:26:36
23d	helicopter		11:58:51 AM	1:30:01
23e	helicopter		11:59:10 AM	1:30:20
23f	helicopter		11:59:31 AM	1:30:41
24a	helicopter		12:07:00 PM	1:38:10
24b	helicopter		12:08:47 PM	1:39:57
27b	X		After 5:21 PM	

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[1]http://drjudywood.com/articles/DEW/StarWarsBeam7.html: "Our critics have accused us of insisting that beam weapons did their damage from outer space, yet we make no claim about whether the directed energy weapon operated from a space-, air-, or ground-based platform. Nor do we make any claim about what wavelength(s) was used, what the source(s) of energy was, whether it involved interference of multiple beams, whether it involved sound waves, whether it involved sonoluminescence, whether it involved antimatter weapons, whether it involved scalar weapons, whether it was HAARP (more here and here), whether it involved a nuclear process (e.g. NDEW, more info), whether it involved conventional directed energy weapons (cDEW), whether it involved improvised directed energy weapons (iDEW), nor what kind of accelerator was used, nor do we claim to know what the serial numbers of the parts that were in the weapon(s). What we do claim is that the evidence is consistent with the use of high-energy weapons that go well beyond the capabilities of conventional explosives and can be directed."

[2]http://drjudywood.com/articles/DEW/StarWarsBeam3.html: "While it has been reported that much of the steel was removed from the site, sold to China, and loaded onto barges, and sent to China to be melted down, the steel could not have been removed this fast. So, if it was not shipped to China overnight, where did the steel go? **Most of it was not on the ground, initially**; so it had to have been suspended in the air."; http://drjudywood.com/articles/DEW/StarWarsBeam2.html : using a flawed analysis of the Ricther scale readings, Wood concludes "**2/11th of the mass of WTC1 would have the same PE as the Kingdome**" and, therefore, this is the amount of mass corresponding to large chunks from the tower which hitt theground. That is, Wood erroneously concludes that 9/11th, or 81%, of the towers either never hit the ground or landed as dust. http://drjudywood.com/articles/DEW/StarWarsBeam4.html: "Figure 57. Some debris has been cleared, but the pulverized dust is still emerging. **If most of the steel from the upper floors of WTC1 and WTC2 was pulverized, then how much steel was really shipped as scrap to China**?"; http://drjudywood.com/articles/DEW/StarWarsBeam6.html "Figure 87(d). On the afternoon of 9/11/01 the "rubble pile" left from WTC1 is **essentially non-existent**." & "Figure 87(e). The "rubble pile" from WTC1 is **essentially non-existent**." http://drjudywood.com/articles/DEW/StarWarsBeam7.html: "7. **The upper 80 percent, approximately, of each tower was turned into fine dust and did not crash to the earth**" as stated in her 'conclusion' section. Also quoted: "In fact, the data refute theories a to e–natural, arson, official, conventional and thermite demolition–**in particular the intact bathtub, minimal seismic impact, and "dustification" prove nothing close to 1 million tons of material slammed down on the WTC foundation and its sub-basements. The debris stacks left where the Twin Towers once stood hardly covered the ground.**"

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[6] http://www.noaanews.noaa.gov/wtc/images/wtc-photo.jpg

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