Table 9
Assessed Source Parameters of Potential Chemical Releasesa (Unmodeled releases in *red italics*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
1. Khamisiyah Pit (30 45N 46 26E)				
Definite Release				
Current Assessment/ Modeling	10 Mar 1991/16:15	320 kg GB/GF (3:1 ratio)/ Some released instantaneously; the rest evaporated from wood and soil over time.[c]	New value is 45 percent of the previous assessment based on re-evaluation of number of damaged rockets assessed from a 1998 UNSCOM excavation.	Some soldiers likely to have been exposed. Results of 2000 DoD modeling using updated release amounts show a much smaller low-level contamination area than the 1997 model but about same number of US troops potentially exposed due to new troop location data.
1997 Assessment/ Modeling	10 Mar 1991/16:15	710 kg GB/GF(3:1 ratio)/ Some released instantaneously; the rest evaporated over time.	Worst case values based on intelligence and UNSCOM information, Dugway demolition tests, and evaporative tests.	1997 CIA/DoD modeling footprint published in *Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit*, 4 September 1997.
2. Khamisiyah Bunker 73 (30 46N 46 26E)				
Definite Release				
Current Assessment/ Modeling	4 Mar 1991/14:00	51 kg GB/GF (3:1 ratio)/ Instantaneous from bunker	New value is lower based on reassessments of number of rockets, agent purity, agent fill, and flying rockets.	No remodeling done. Exposure not expected because winds still blowing away from US troops[d] and factor of 20 reduction in release amount.
1996 Assessment/ Modeling	4 Mar 1991/14:00	1040 kg GB/GF to (3:1 ratio)/ Instantaneous distributed over a wide area	Worst case assumptions including large release from flyouts breaking within 2 km of bunker.	1996 CIA modeling and troop video indicates contamination northeast away from US troops. CIA modeled GPL contamination went 25 km.

Table 9
Assessed Source Parameters of Potential Chemical Releases[a] (Unmodeled releases in *red italics*) (*continued*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
3. Muhammadiyat Mustard Agent (33 15N 42 41E)				
Definite Release				
Current Assessment/ Modeling	10, 12, 16 Feb 1991	2,970 kg HD/ Uniformly over a one-hour period after bombing.	Release parameters derived jointly with OSAGWI. We determined a larger number of bombs—all undeclared—were damaged.	2001 DoD modeling results using updated release amounts do not indicate soldiers exposed.
1996 Assessment/ Modeling	16 Feb 1991/00:01 (Worst case) (15 Feb 1991/21:012)	1,520 kg HD/Instantaneous	Assumed all Iraqi-declared damaged bombs released agent.	1996 modeling went 134 km southwest, over 150 kilometers from US troops.
4. Muhammadiyat Nerve Agent (33 15N 42 41E)				
Likely Release				
Current Assessment/ Modeling	19 Jan-24 Feb 1991 (It is possible that Iraq damaged these bombs after the war.)	180 kg of GB/GF (1:1 ratio)/ Assumed instantaneous	Release parameters derived jointly with OSAGWI. Slightly lower release because of fewer bombs and lower purity agent combined with increased percent of agent surviving release.	2001 DoD modeling results using updated release amounts do not indicate exposure of soldiers in Saudi Arabia.
1996 Assessment/ Modeling	17 Feb 1991/00:01 (Worst case of those modeled) (16 Feb 1991/21:012)	290 kg GB/Instantaneous	Assumed all Iraqi-declared bombs released 100 percent pure agent and that 10 percent to survived fire.	1996 modeling indicated GPL contamination went maximum of 300 km south-southeast, about 50 km short of the border and about 100 km from US troops.

Table 9
Assessed Source Parameters of Potential Chemical Releases[a] (Unmodeled releases in *red italics*) (*continued*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
5. Al Muthanna Bunker 2 (33 51N 43 49E)				
Definite Release				
Current Assessment/ Modeling	8 Feb 1991/02:30 (7 Feb 1991/23:30Z)	10 kg of GB/Instantaneous	Detailed modeling indicated less than 1 percent of agent survived the bunker fire. UNSCOM information indicates fewer rockets with agent of lower purity.	2001 DoD modeling results using the latest release amounts indicate maximum low-level contamination went only 65 km—far short of US troops.
1996 Assessment/ Modeling	8 Feb 1991/00:01 (Worst case) (7 Feb 1991/21:01Z)	420 kg GB/Instantaneous	Assumed all Iraqi rockets released 100 percent pure agent and that 2.5 percent survived fire.	1996 modeling went 160 km southeast, about 200 km short of the border and about 250 km from US troops.
6. *Al Muthanna Mustard Production Building* (33 51N 43 49E)				
Definite Release	Attack on one of the the following dates: 17, 19, 20 Jan, 3, 4, 5, 7, 8 Feb 1991	1000 kg HD/ Release rate unknown, but very slow release due to agent burial under building rubble.	Estimate of amount on this new release based on discussions with UNSCOM. Release probably from residual agent in production line plumbing or storage. Release amount assumed half of agent was neutralized or retained in the building material.	No modeling done. However, a worst-case release of 100 kg on the first day would leave contamination several hundred kilometers short of US troops based on other modeling.
7. Ukhaydir Aerial Bombing (32 23N 43 30E)				
Unlikely Release				
Current Assessment/ Modeling	No release	No release	Very unlikely release based on multiple reasons, including lack of evidence of damage seen during 1998 UNSCOM inspection. Non-aerial-bombing release still possible (see 9 below).	No release to model but previous model ing indicates contamination would have been short of troops.

Table 9
Assessed Source Parameters of Potential Chemical Releases[a] (Unmodeled releases in *red italics*) (*continued*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
1997 Assessment/ Modeling	20 Jan 1991	11 kg HD/Instantaneous	Assumed 94 burned shells released on this date.	40 km maximum downrange low-level contamination fell short of US troops.
	14 Feb 1991/00:01 (13 Feb 1991/ 21:01Z)	431 kg HD/Instantaneous and evaporation	Bomb impact caused 35 kg released instantaneously while rest spilled with evaporation scaled to lab tests	125 km maximum downrange low-level contamination fell short of US troops.
8. *Al Walid* (32 56N 39 45E)				
Suspect Release	Release from one of the attacks on 5 February 1991.	15 kg of GB/GF(50/50)/ Instantaneous	Perhaps as many as 12 bombs burst during intense fire that likely burned over 97.5 percent of agent based on 1960s US tests. 100-kg fill per bomb of about 50 percent pure agent.	No modeling done. However, 15 kg nerve agent release would leave contamination several hundred kilometers short of US troops based on other modeling.
9. Burned 155-mm Mustard Shells				
(Location unknown Prioritized possibilities:		16 kg HD/Instantaneous	Assumed 94 shells had 95 percent of the mustard agent burned (purity 95 percent). An intense fire is required to burst shells as seen in UNSCOM photographs. Locations and times are based on various Iraqi declarations to UNSCOM and informed speculation.	No modeling was done. However, 16 kg mustard agent release would leave contamination short of US troops based on other modeling.
1) Ukhaydir 32 23N 43 30E	1) Pre-1990			
2) Fallujah Proving Ground 33 08N 43 52E	2) Pre-1990			
3) Roadways from Al Muthanna to Ukhaydir 32 23N 43 30E	3) 10-15 Jan 1991			
4) Al Muthanna 33 51N 43 49E	4) Nov 1990- 10 Jan 1991			
5) Site of a trailer fire 32 28N 044 09E)	5) 10-31 Mar 1991			
Definite Release				

Table 9
Assessed Source Parameters of Potential Chemical Releases[a] (Unmodeled releases in *red italics*) (*continued*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
10. *Iraqi Unilateral Destruction of VX warheads for Al Husayn Missile* (Al Nebai 33 41N 44 06E)				
Unlikely Release	Unknown (Iraq declared July 1991)	None	UNSCOM indicated that VX would have completely degraded, though byproducts sometimes toxic.	We assess there was no release.
11. *Iraqi Unilateral Destruction of R-400 Binary Bombs* (Saddam Airbase 35 43N 43 16E, Qadisiyah Airbase 33 48N 42 22E, Airfield 37 33 27N 42 51E)	Unknown	Unknown	UNSCOM information indicated that 12 bombs at an unknown deployment site had DF added to the alcohols to form GB/GF.	No modeling was done. Sites are distant for this possible release related to explosive destruction well after the war. Large uncertainties on whether the release occurred. If a release occurred, contamination would be unlikely to reach US troops.
Suspect Release	(Iraq declared July 1991.)	(Iraq indicated only alcohol fill. It filled with GB/GF, Iraq may have decontaminated prior to destruction. See Al Walid for estimate of a spill involving 12 bombs in a fire.		
12. *Leaking Munitions/Bulk Agent Al Muthanna*				
(Multiple locations near 33 51N 43 49E)	Unknown (Leaky munitions and production accidents have occurred since the mid-'80s and leakage noted by UNSCOM in mid-1991.)	Unknown (Assumed releases of as much as 300 kg of HD or 15 kg GB/GF Some agent neutralized or retained during release. Slow release likely.)	Site was littered with various defunct munitions and containers, some defective and some emptied but not fully decontaminated.	Exposure is unlikely because it would have taken thousands of kilograms of rapidly aerosolized mustard to reach troops hundreds of kilometers away in Saudi Arabia, based on previous modeling. Impossible to precisely model this and other leaking munitions due to uncertainty in release date.
Definite Release				

Table 9
Assessed Source Parameters of Potential Chemical Releases[a] (Unmodeled releases in *red italics*) (*continued*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
13. *Leaking Munitions Al Tuz Airbase* (34 56N 44 29E)				
Definite Release	Late January or early February 1991	72 kg HD/Slow evaporation from the soil	Assumed 20 250-gauge bombs (76 kg per bomb) of 95 percent pure mustard were punctured with half the agent neutralized or retained in wood/soil. Only 10 percent of remaining agent released due to rapid Iraqi burial of munitions. Burial could have effectively stopped release.	Exposure is unlikely. See comment for 12.
14. *Leaking Munitions Tammuz Airbase* (33 19N 43 35E)				
Definite Release	Unknown (Assumed Mar-Oct 1991	38 kg HD/Assumed slow and continuous throughout period.	Assumed one bomb (76 kg) of agent total with half the agent neutralized or retained in wood/soil. Mustard stained the soil around several of the bombs found by UNSCOM 9. At least one of the bombs was found to be leaking.	Exposure is unlikely. See comment for 12.
15. *Leaking Munitions Al Mutasim Airbase* (34 09N 44 15E)				
Definite Release	Unknown (Iraq indicated bombs ruptured due to heat in August 1991.)	290 kg HD/Slow release from evaporation from a puddle and from wood crates	Assumed four bombs (152 kg each) of agent, with half the agent neutralized or retained in wood/soil. Several bombs leaked around corrosion at the filling plug. Four 500-gauge bombs had ruptured.	Exposure is unlikely. See comment for 12.

Table 9
Assessed Source Parameters of Potential Chemical Releases[a] (Unmodeled releases in *red italics*) (*continued*)

Release Name (location)	Start Date/Local Time of Release	Conservative Estimate of Agent Released[b]/Release Rate	Comments on Release Estimate	Comments on Modeling
16. *Leaking Munitions Muhammadiyat* (33 15N 42 41E)				
Definite Release	Unknown (Assumed Mar 1991 to Oct 1991)	500 kg HD and 20 kg GB/GF/Constant over several months.	Assumed slow leakage of a number of mustard bombs and one DB-2 bomb (240 kg fill). Nerve agent was 15 percent pure in February 1991. The wood/soil neutralized or retained half of the agent.	Exposure is unlikely. See comment for 12 for mustard. Previous modeling similarly indicates nerve agent GPL contamination would be several hundred kilometers short of troop locations due to small release amount.
17. *Leaking Munitions Khamisiyah* (30 46 N 46 23E)				
Definite Release	Mid-Feb to Oct 1991	Insignificant (Estimated to be less than one ounce over eight months.)/Constant over eight months.	UNSCOM inspector detected mustard vapors around the loosened threads of one shell using a chemical agent monitor.	Release amount is insufficient to expose anyone even in the local area, especially considering the shell was under a tarp.

[a] This table has more entries than table 1 because some grouped releases are addressed individually.
[b] The number of significant figures in the values is not representative of the accuracy of the estimate.
[c] See figure 14 of *Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit*, 4 September 1997.
[d] This study examines US troops in allied Persian Gulf countries, southern Iraq, and Kuwait. DoD handles potential exposure of special operation forces located elsewhere.