UNITED STATES AIR FORCE
GROUND ACCIDENT INVESTIGATION
BOARD REPORT

CONFINED SPACE MISHAP, SEWAGE CLEARING PROJECT

380th EXPEDITIONARY CIVIL ENGINEER SQUADRON,
380th AIR EXPEDITIONARY WING

LOCATION: USCENTCOM AOR

DATE OF ACCIDENT: 8 JULY 2018

BOARD PRESIDENT: COLONEL CHARLES M. DROUILLARD

Conducted IAW Air Force Instruction 51-503

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
JOINT BASE LANGLEY-EUSTIS VA

OFFICE OF THE COMMANDER
205 DODD BOULEVARD SUITE 200
JOINT BASE LANGLEY-EUSTIS VA 23665-2788

DEC 17 2018

ACTION OF THE CONVENING AUTHORITY

The report of the ground accident investigation board, conducted under the provisions of AFI 51-503, that investigated the 8 July 2018 confined space mishap in the United States Central Command Area of Responsibility, involving the fatality of an Airman deployed to the 380th Air Expeditionary Wing from the 4th Civil Engineer Squadron complies with applicable regulatory and statutory guidance, and on that basis it is approved.

General, USAF
Commander

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
GROUND ACCIDENT INVESTIGATION

CONFINED SPACE MISHAP, SEWAGE CLEARING PROJECT
USCENTCOM AOR
8 July 2018

On 8 July 2018, at approximately 1400 hours local time (L), a team of six Airmen assigned to the 380th Expeditionary Civil Engineer Squadron at a deployed location within the United States Central Command (USCENTCOM) area of responsibility (AOR), was working to clear a clogged sewage line. The team consisted of four Water and Fuel Systems Maintenance personnel (Mishap Airman (MA), Mishap Witness 1, Mishap Witness 2, Mishap Witness 3), and two Pavement and Equipment personnel (Mishap Witness 4, Mishap Witness 5). The MA was a United States Air Force Staff Sergeant assigned to the 4th Civil Engineer Squadron at Seymour Johnson Air Force Base, North Carolina.

To get the job done, the team needed to place equipment into a manhole that, unbeknownst to them, was contaminated with hydrogen sulfide gas. While the manhole cover was being removed, it fell to the bottom of the manhole. There was a discussion among the team about how to retrieve the fiberglass cover, which they needed to do before the work could continue. The team did not agree upon a solution for retrieval of the cover, nor was anyone nominated to retrieve it.

Before the plan was finalized, the MA went to his truck, grabbed his gloves, and proceeded into the manhole. Upon reaching the bottom, he grabbed the cover and began his ascent. About one third of the way up, he dropped the cover, began to hyperventilate, suffered a rapid loss of consciousness, and fell from the ladder. By then, he had been in the manhole for less than a minute.

The rest of the team immediately called out to the MA and alerted emergency services via handheld radio. Security Forces and the Fire Department responded within minutes. Two firefighters, each dressed in personal protective equipment and wearing a self-contained breathing apparatus, descended into the manhole to rescue the MA, who was unresponsive and not breathing. Immediately following extraction, Emergency Medical Technicians initiated cardiopulmonary resuscitation (CPR) and transported the MA to the base medical treatment facility. Following medical assessment and treatment by a doctor, the MA's heartbeat was reestablished, but he remained unresponsive and on artificial ventilation. The MA was transported to a civilian trauma center, where he underwent three days of intensive care while on life support, with no change in prognosis. Clinical assessments and test results showed no signs of brain activity. The MA was then airlifted to Landstuhl Regional Medical Center (LRMC), Germany. After medical care and further assessments, doctors declared the MA deceased on 12 July 2018. The next-of-kin were present with the MA at LRMC, and after being informed of his status, he was removed from life support.

SUMMARY OF FACTS
CONFINED SPACE ACCIDENT, SEWAGE CLEARING PROJECT
8 JULY 2018

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS ii
SUMMARY OF FACTS 1
1. AUTHORITY and PURPOSE 1
a. Authority 1
b. Purpose 1
2. ACCIDENT SUMMARY 1
3. BACKGROUND 2
a. Air Combat Command 2
b. Ninth Air Force 2
c. Fourth Fighter Wing 3
d. Fourth Civil Engineer Squadron 3
e. United States Air Forces Central Command 3
f. 380th Air Expeditionary Wing 3
g. Confined Space 4
h. Confined Space – Technical Rescue 4
i. Hydrogen Sulfide 4
4. SEQUENCE OF EVENTS 6
a. Summary of Accident 6
b. Recovery of Remains 12
5. MAINTENANCE 12
6. EQUIPMENT, VEHICLES, FACILITIES, AND SYSTEMS 12
7. ENVIRONMENTAL CONDITIONS 12
a. Forecast Weather 12
b. Observed Weather 12
c. Other Environmental Conditions 12
d. Restrictions, Warnings, and Procedures 13
8. PERSONNEL QUALIFICATIONS 14
a. Mishap Airman (MA) 14
b. Mishap Witness Number One (MW1) 14
c. Mishap Witness Number Two (MW2) 15
d. Mishap Witness Number Three (MW3) 15
9. MEDICAL FACTORS 15
10. OPERATIONS AND SUPERVISION 17
a. Operations 17
b. Supervision 17
11. GOVERNING DIRECTIVES AND PUBLICATIONS 17
a. Publicly Available Directives and Publications Relevant to the Mishap 17
b. Other Directives and Publications Relevant to the Mishap 18
c. Known or Suspected Deviations from Directives or Publications 18
INDEX OF TABS 19

ACRONYMS AND ABBREVIATIONS

380 AEW	380th Air Expeditionary Wing
380 ECES	380th Expeditionary Civil Engineer Squadron
380 EMDG	380th Expeditionary Medical Group 380 EMS
380th	Expeditionary Medical Squadron
4 CES	4th Civil Engineering Squadron
4 FW	4th Fighter Wing
9 AF	Ninth Air Force
A/C	Air Conditioning
ACC	Air Combat Command
ACLS	Advanced Cardiac Life Support
AED	Automated External Defibrillator
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFOSI	Air Force Office of Special Investigations
AFSAS	Air Force Safety Automated System
AFSC	Air Force Specialty Code
AOR	Area of Responsibility
ASAP	As Soon As Possible
BE	Bioenvironmental Engineering
BEE	Bioenvironmental Engineer
BVM	Bulb Valve Mask
C-Collar	Cervical Collar
CAC	Community Activity Center
CAC	Common Access Card
Capt	Captain
CBT	Computer-Based Training
CE	Civil Engineering
CFR	Code of Federal Regulations
CMS	Chip Measurement System
CMSgt	Chief Master Sergeant
Col	Colonel
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPR	Cardiopulmonary Resuscitation
CSP	Confined Space
CSPT	Confined Space Program Team
DANCON	Danish Contingent (25km event)
DHA	Deployment Health Assessment
DoD	Department of Defense
DoDI	Department of Defense Instruction
DSN	Defense Switched Network
ECES	Expeditionary Civil Engineer Squadron
ECP	Entry Control Point
EMS	Emergency Medical Service
EMT	Emergency Medical Technician
EOC	Emergency Operations Center
FD	Fire Department
FES	Fire and Emergency Services
FF	Firefighter
FS	Flight Surgeon
ft	Feet
FOIA	Freedom of Information Act
GAIB	Ground Accident Investigation Board
GS	Ground Safety
H2S	Hydrogen sulfide
HAPSITE	Hazardous Air Pollutants on Site
HAZCOM	Hazard Communication
hr	Hour
HRA	Health Risk Assessment
IC	Incident Commander
IDLH	Immediately Dangerous to Life and Health
IAW	In Accordance With
IO	Investigating Officer
ISB	Interim Safety Board
ISO	Incident Safety Officer
IV	Intravenous

JPED	Joint Personal Effects Depot
JSTO	Job Safety Training Outline
L	Local
LEL	Lower Explosive Limit
LRMC	Landstuhl Regional Medical Center
lpm	Liters per Minute
MA	Mishap Airman
Maj	Major
MAJCOM	Major Command
MCST	Mobile Confined Space Trailer
MEP	Master Entry Plan
MHA	Mental Health Assessment
MC	Medical Corp
MD	Medical Doctor
min	Minute
MSgt	Master Sergeant
MTF	Military Treatment Facility
MW	Mishap Witness
NCO	Noncommissioned Officer
NFPA	National Fire Protection Agency
O/S	On scene
O2	Oxygen
OEH	Occupational and Environmental Health
Ops	Operations
OSHA	Occupational Safety and Health Administration
OSI	Office of Special Investigations
PHA	Periodic Health Assessment
PPE	Personal Protective Equipment
ppm	Parts per Million
PSI	Pounds per Square Inch
pt	Patient
RIC	Rapid Intervention Crew
RIT	Rapid Intervention Team
RM	Roommate
ROSC	Return of Spontaneous Circulation
SBAFSEC	Safety Board, Air Force Safety Center Representative
SBB	Safety Board, Bioenvironmental Engineering Technical Expert
SBCE	Safety Board, Civil Engineering Technical Expert
SBIO	Safety Board Investigating Officer
SBMO	Safety Board Medical Officer
SBP	Safety Board President
SBR	Safety Board Recorder
SCBA	Self-Contained Breathing Apparatus
SF	Security Forces
SFS	Security Forces Squadron
Sgt	Sergeant
SIB	Safety Investigation Board
SJA	Staff Judge Advocate
SMSgt	Senior Master Sergeant
SrA	Senior Airman
SSgt	Staff Sergeant
SV	Supervisor
TSgt	Technical Sergeant
USAF	United States Air Force
USAFCENT	United States Air Forces Central Command
USCENTCOM	United States Central Command
Vac-Con/VACCON	Sewer Cleaning Truck
VOC	Volatile Organic Compounds
WFSM	Water and Fuel Systems Maintenance

The above list is compiled from the Summary of Facts, the Index of Tabs, and Witness Testimony (Tab V and Tab R).

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 17 July 2018, General James M. Holmes, Commander, Air Combat Command (ACC), appointed Colonel Charles M. Drouillard as president of a ground accident investigation board (GAIB) convened to investigate a confined space mishap, which occurred on 8 July 2018, at an undisclosed location in the United States Central Command (USCENTCOM) area of responsibility (AOR) (Tabs X-3, Y-3, and Y-5). Following a safety investigation board, the accident investigation was conducted pursuant to the provisions of Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations*, and took place at Seymour Johnson Air Force Base (AFB), North Carolina, from 17 August 2018 through 8 September 2018 (Tab Y-3). Board members included a Medical Member (Captain), a Legal Advisor (Major), a Bioenvironmental Engineering Member (Major), and a Recorder (Technical Sergeant) (Tab Y-5).

b. Purpose

In accordance with AFI 51-503, GAIB conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force ground accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

On 8 July 2018, at approximately 1330 local time (L), a 4-person Water and Fuel Systems Maintenance (WFSM) team arrived at their job site to continue work to clear a clogged sewage line (Tab R-13, R-20, and R-34). The mishap Airman (MA), assigned to the 4th Civil Engineer Squadron (4 CES), was deployed to the 380th Expeditionary Civil Engineer Squadron (380 ECES) at an undisclosed location in the USCENTCOM AOR (Tabs G-3, T-8, and V-3.2). The MA entered a hydrogen sulfide (H_2S) gas-contaminated manhole to retrieve a square fiberglass cover that had fallen in and needed to be removed in order to continue work (Tabs R-13 to R-14, S-12, S-21, V-19.2). At approximately 1400L, while climbing the ladder to exit the manhole, the MA lost consciousness, fell from the ladder, and remained at the bottom of the manhole until retrieved by emergency response personnel (Tabs N-5, R-28, R-62 to R-63, and R-127). During initial contact by rescue personnel, the MA was unresponsive, not breathing, and his skin appeared blue (Tabs R-111 and X-3). Firefighters initiated Cardiopulmonary Resuscitation (CPR) immediately upon extraction (Tab R-127). Medical personnel used advanced cardiac life support to re-establish a heartbeat at the base medical treatment facility (MTF), but he remained unresponsive and on artificial ventilation (Tab X-3). The MA was transported to a local civilian trauma center for further care (Tab X-3). The MA remained in the intensive care unit (ICU) for three days with no improvement in prognosis (Tab X-3). Clinical assessments and test results showed no signs of brain activity (Tab X-3). On 11 July 2018, the MA was airlifted to Landstuhl Regional Medical Center (LRMC) in Germany (Tab X-3). Shortly after his arrival, medical personnel initiated brain

activity protocols and concluded the MA had no brain activity (Tab X-3). Medical personnel pronounced the MA dead on 12 July 2018 at 1240L (Tab X-3). The next-of-kin were present with the MA at LRMC, and after being informed of his status, he was removed from life support (Tab X-3, X-4).

3. BACKGROUND

The MA was assigned to the 4 CES, which falls under the 4th Fighter Wing (4 FW), both located at Seymour Johnson AFB, North Carolina (Tabs Q-6, CC-3, and CC-13). The 4 FW is under the operational control of Ninth Air Force (9 AF) and ACC (Tab CC-9).

The mishap occurred while the MA was deployed to the 380 ECES, 380 AEW, located in the USCENTCOM AOR (Tabs R-87 to R-88, R-98, and CC-6 to CC-8). The 380 AEW is an expeditionary unit of United States Air Forces Central Command (USAFCENT) (Tab CC-6). USAFCENT is the air component of USCENTCOM (Tab CC-11).

a. Air Combat Command

ACC, headquartered at Joint Base Langley-Eustis, Virginia, is a major command created on 1 June 1992 (Tab CC-9). ACC is the primary provider of air combat forces to America's warfighting commanders (Tab CC-9). The mission of ACC is to support global implementation of national security strategy (Tab CC-9). ACC operates fighter, reconnaissance, battle-management, and electronic-combat aircraft (Tab CC-9). It also provides command, control, communications and intelligence systems, and conducts global information operations (Tab CC-9).

As a force provider and Combat Air Forces lead agent, ACC organizes, trains, equips, and maintains combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense (Tab CC-9). Additionally, ACC develops strategy, doctrine, concepts, tactics, and procedures for air and space-power employment (Tab CC-9). The command provides conventional and information warfare forces to all unified commands to ensure air, space and information superiority for warfighters and national decision-makers (Tab CC-9). ACC numbered air forces provide the air component to United States Central, Southern, and Northern Commands (Tab CC-9). The command operates more than 1,300 aircraft, 34 wings, 19 bases, and has more than 70 worldwide operating locations with 94,000 active-duty and civilian personnel (Tab CC-9).

b. Ninth Air Force

9 AF, headquartered at Shaw AFB, South Carolina, is responsible for organizing, training, and equipping Airmen to meet the demands of today's expeditionary taskings while preparing for tomorrow's challenges (Tab CC-9). 9 AF is responsible for ensuring the agile combat support capabilities of eight wings and three direct reporting units. These units encompass more than 400 aircraft, and 29,000 active-duty and civilian

personnel (Tab CC-9). 9 AF is also responsible for the operational readiness of 16 National Guard and Air Force Reserve units (Tab CC-9).

c. Fourth Fighter Wing

4 FW is responsible for the organization, training, and deployment of one of the largest fighter wings in the United States Air Force, consisting of nearly 6,000 Airmen and civilians in 19 squadrons (Tab CC-14). 4 FW is home to the multi-role, all-weather F-15E Strike Eagle aircraft flying more than 12,000 sorties and 21,000 hours a year (Tab CC-14). 4 FW teams with and provides overall host support for the 916th Air Refueling Wing, an Air Force Reserve Command KC-135R wing (Tab CC-14 to CC-15).

d. Fourth Civil Engineer Squadron

4 CES directly supports F-15E Strike Eagle operations of the 4 FW (Tab CC-3). The squadron improves, maintains, and operates more than 373 facilities, 10 dormitories, and 686 housing units to include a geographically separated recreational site and county training range (Tab CC-3). 4 CES provides fire protection, disaster preparedness, explosive ordnance disposal and environmental protection, and maintains mobility readiness (Tab CC-3).

e. United States Air Forces Central Command

USAFCENT is the air component of USCENTCOM, a regional unified command (Tab CC-11). USAFCENT is responsible for air operations, either unilaterally or in concert with coalition partners, and developing contingency plans in support of national objectives for USCENTCOM's 20-nation AOR in Southwest Asia (Tab CC-11). Additionally, USAFCENT manages an extensive supply and equipment-prepositioning program at several AOR sites (Tab CC-11).

f. 380th Air Expeditionary Wing

Established at an undisclosed base in Southwest Asia on 25 January 2002, 380 AEW is one of the most diverse combat wings in the Air Force (Tab CC-6). The wing is comprised of 5 groups and 16 squadrons (Tab CC-6). Its mission partners include an Army air defense battalion, an Air Force training group and a Navy aerial maritime surveillance detachment (Tab CC-6). The wing's mission is to conduct combat operations directed by the President to provide high altitude all-weather intelligence, surveillance, reconnaissance, airborne command and control, and air refueling for Operations Inherent Resolve and Resolute Support (Tab CC-6).

g. Confined Space

A *confined space* is a specific term used by the Occupational Safety and Health Administration (OSHA) and is defined as a space that meets the following criteria:

(1) Is large enough and accessible so a person can enter,
(2) Has limited or restricted means for entry or exit, and
(3) Is not designed for continuous human occupancy (Tab BB-107).

There are two types of confined spaces: non-permit and permit-required (Tab BB-107). A *non-permit* confined space does not contain or have the potential to contain any hazard capable of causing death or serious physical harm (Tab BB-107). A *permit-required* confined space includes space that contains or has the potential to contain a hazard or hazards capable of causing death or serious physical harm (Tab BB-107). These definitions are incorporated into AFI 91-203, *Air Force Consolidated Occupational Safety Instruction,* when governing Air Force training and response in confined space mishaps (Tab BB-15, BB-20, BB-26, BB-27, BB-39, and BB-41).

h. Confined Space – Technical Rescue

Department of Defense Instruction (DoDI) 6055.06 dictates that firefighters responding to a technical rescue have seven minutes from the time they are dispatched, to have four firefighters on scene (Tab BB-74 to BB-75 and BB-78). A full alarm assignment of 13 firefighters is required to be on scene within 22 minutes (Tab BB-78). A full alarm assignment is those personnel, equipment, and resources ordinarily dispatched upon notification of a structural fire (Tab BB-78). When entering an unknown and potentially toxic atmosphere, firefighters are required to have a positive pressure self- contained breathing apparatus (Tab BB-51).

Per Title 29 of the Code of Federal Regulations (CFR) part 1910.120 (29 CFR 1910.120), an OSHA regulation pertaining to hazardous waste operations and emergency response, back-up personnel are required to be in place prior to conducting rescue operations in confined spaces where a toxic atmosphere may exist (Tabs V-8.2 and BB-51). A Rapid Intervention Team (RIT), or back-up team, consists of two or more firefighters with appropriate PPE and training, dedicated solely to the search and rescue of other firefighters (Tabs V-8.2, V-10.2, V-14.2, and BB-51).

i. Hydrogen Sulfide (H_2S)

Hydrogen Sulfide (H_2S) is a colorless gas with a distinct "rotten eggs" odor produced primarily by the decomposition of organic matter (Tab DD-3, DD-25 to DD-28, DD-30, DD-36, and DD-44). H_2S is a relatively common, frequently lethal hazard in certain occupations to include sewage treatment, petroleum refinement, and several others (Tab DD-3 and DD-12). It is the second most common cause of fatal gas inhalation incidents following only carbon monoxide (Tab DD-12). Most cases of lethal H_2S exposure are associated with individuals working within a heavily contaminated confined space (Tab DD-3). Injuries and/or deaths suffered after H_2S exposure typically occur in multiples of two or more as would-be rescuers attempt to save their co-worker(s) without appropriate protective equipment (Tab DD-12). Additionally, many injuries and/or deaths included individuals who suffered H_2S exposure in a confined space (Tab DD-12 and DD-30 to DD-58). In a study of H_2S exposure published by the American Journal of Industrial Medicine, during a 7-year period, analysts found that 21% of deaths were from co-workers who died

simultaneously or in the attempt to save a coworker (Tab DD-25 and DD-28).

Similar to other toxic occupational events, H_2S exposures are sporadic, unpredictable, and less common than traumatic injuries (Tab DD-12). This means that clinical information must be obtained from individual case reports and animal studies (Tab DD-12, DD-30 to DD-58, and DD-71 to DD-75). These case reports all present multiple characteristic symptoms of H_2S toxicity (Tab DD-13 and DD-30 to DD-60). Clinical outcomes vary, depending primarily on the concentration of H_2S the individual was exposed to rather than duration of exposure (Figure 1) (Tab DD-13 and DD-30 to DD-58).

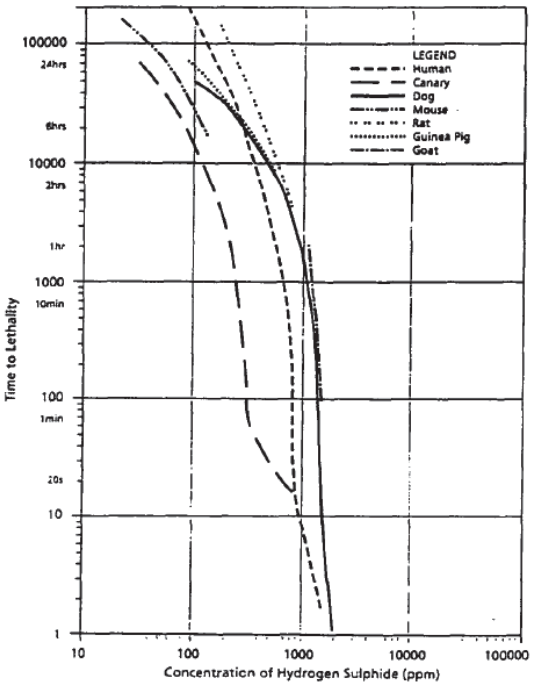

Figure 1 (Tab DD-60)
Graph depicting time to lethality at various concentrations of H_2S

Concentration (ppm)	Effects
.01-.3	Odor threshold (highly variable)
1-5	Moderate offensive odor, may be associated with nausea, tearing of the eyes, headaches, or loss of sleep with prolonged exposure; healthy young male participants experience no decline in maximal physical work capacity
10	8-hour occupational exposure limit in Alberta, OSHA PEL; anaerobic metabolism threshold during exercise
15	15-minute occupational exposure limit in Alberta
20	Ceiling occupational exposure limit evacuation level in Alberta, odor very strong; conjunctivitis may occur
20-50	Conjunctivitis (eye irritation) and lung irritation. Possible eye damage after several days of exposure; may cause digestive upset and loss of appetite
100	Eye and lung irritation; olfactory paralysis, odor disappears
150-200	Sense of smell paralyzed; severe eye and lung irritation
250-500	Pulmonary edema may occur, especially if prolonged
500	Serious damage to eyes within 30 minutes; severe lung irritation; "knockdown" (sudden unconsciousness) and death within 4- to 8-hours; amnesia for period of exposure
1000	Breathing may stop within 1 or 2 breaths; immediate collapse

Abbreviation: OSHA, Occupational Safety and Health Administration; PEL, permissible exposure limit.

Figure 2 (Tab DD-13)
Health effects of H_2S at various approximate exposure levels

H_2S toxicity occurs via inhalation of the gas (Tab DD-3 to DD-7). Upon inhaling the gas, it enters blood where it interacts with multiple proteins and enzymes (Tab DD-59 to DD-60). One enzyme in particular that H_2S interacts with causes the inability to utilize oxygen, leading to a change in breathing pattern and an ultimate inability to breathe (Tab DD-13, DD-16, DD-57, and DD-68). This has the same effects as suffocation; however, it may occur more rapidly (Tab DD-60). It can lead to an abrupt loss of consciousness and falling, commonly referred to as the "knockdown" effect (Figure 2) (Tab DD-12 to DD-17). Most fatalities suffered from H_2S toxicity are believed to be from respiratory paralysis or the resulting complications (Tab DD-28).

H_2S exposure at high enough levels leads to rapid loss of consciousness and severe inability to breathe properly (Figure 2) (Tab DD-13). Typically, H_2S has a very distinct and offensive odor at relatively low concentration levels (Figure 2) (Tab DD-13, DD-37, and DD-60 to DD-61). However, as concentration levels increase, the ability to smell the odor disappears, thus removing a vital warning sign (Figure 2) (Tab DD-13, DD-37, and DD-60 to DD-61). As the concentration of H_2S increases, the time to lethality rapidly decreases to the point where death can occur in seconds (Figure 1) (Tab DD-60). At non-lethal levels, this gas is also well known to cause characteristic symptoms such as eye and lung irritation, nausea, and dizziness. (Figure 2) (Tab DD-13 and DD-32). Some other non-specific symptoms seen inconsistently are headache, vomiting, and short-term memory loss (Tab DD-15 to DD-17, DD-27, and DD-30 to DD-56).

4. SEQUENCE OF EVENTS

a. Summary of Accident

(1) Mission

On 8 July 2018, 380 ECES personnel were continuing a project that had been ongoing for a few days (Tab R-5 and R-89). The task was to clear a sewage line by jetting out (clearing using high- pressure water) the clogged line via manhole access to ensure unimpeded wastewater flow (Figure 3) (Tab R-13, R-28, and R-89). The sewage line in question had a history of clogging (Tabs R-89 and V-7.2). The project did not require any member to enter a manhole, as they could lower their equipment into each manhole from the surface above (Tabs R-90 and V-7.2). Supervision provided no specific guidance on confined space entry for this project since entry into a manhole was not required (Tab V-7.2).

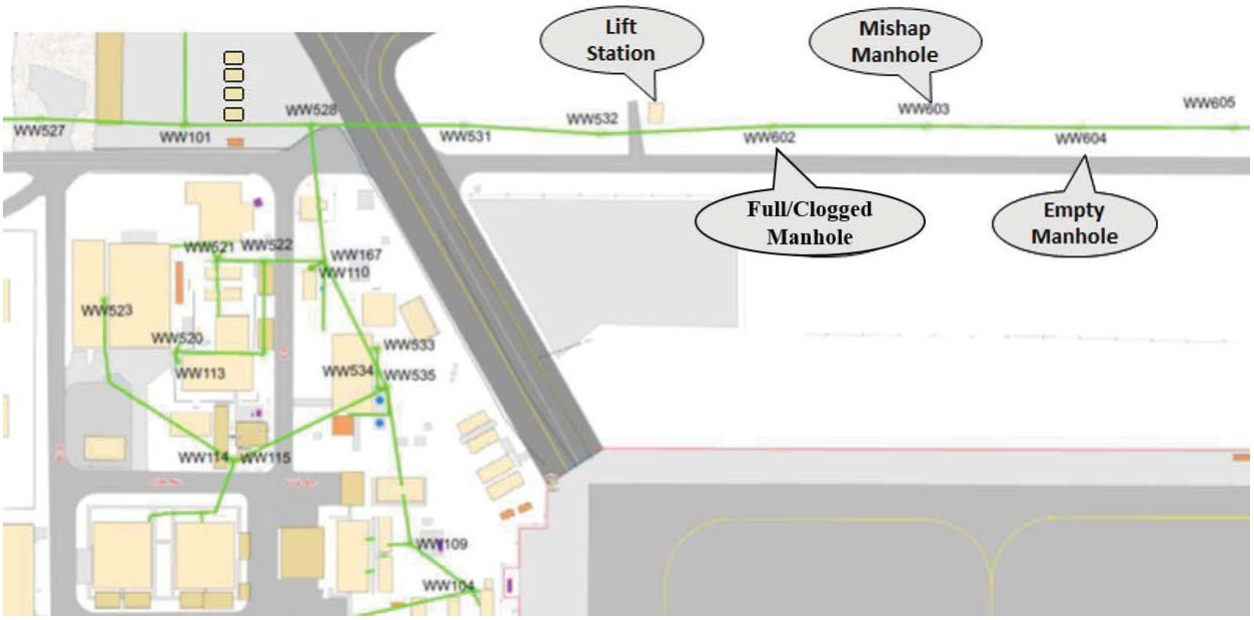

Figure 3 (Tab Z-3)
Partial overview of wastewater line

(2) Crew Composition

There were two separate crews working in the immediate area of the mishap (Tab R-61 to R-62). One crew was the pavement and equipment team consisting of two individuals, Mishap Witnesses 4 and 5 (MW4 and MW5) (Tab R-61). Their role was to locate one of the manholes, clear the surrounding area of rock and concrete, and make the manhole accessible for the sewage clearing effort (Tab R-61). MW4 and MW5 were using two machines that day (Tab R-61). MW4 was driving a backhoe (Figure 4), while MW5 was on a skid steer (referred to by the brand name "Bobcat") that had a jackhammer attachment on it (Figure 5) (Tab R-61).

Figure 4 (Tab Z-3)
Backhoe used at mishap site

Figure 5 (Tab Z-4)
Example skid steer with jackhammer attachment.
Photo credit: High Contrast

The other crew involved consisted of four WFSM personnel - the MA and Mishap Witnesses 1, 2 and 3 (MW1, MW2, and MW3), who were at the jobsite attempting to clear the clogged sewage line using a high pressure hose to dislodge any obstructions (Tab R-41 to R-42 and R-89).

(3) Timeline of the Accident

On the day of the mishap, MW4 and MW5 were clearing the area to locate a manhole (Tab R-49, R-55, R-61, and R-68). At approximately 1300L, MW4 successfully located the manhole and MW5 called WFSM personnel to let them know they could come out to the jobsite (Tab R-20, R-49 to R-50, and R-68). MW4 then removed concrete and rocks from the top of and around the manhole to make it accessible for the WFSM personnel (Tab R-49 to R-50 and R-68).

At approximately 1330L, the 4-person WFSM team arrived at the jobsite to continue sewage line clearing efforts (Tab R-5 and R-68). The MA and MW2 removed a metal outer cover (Figure 6) from the manhole and discovered there was a second square manhole cover made of fiberglass (Figure 7), designed to prevent sand and dirt from getting into the manhole (Tab R-5 and R-28). The WFSM team attempted to remove the fiberglass cover unsuccessfully and eventually had MW4 use the small bucket on the backhoe to remove it (Tab R-62). MW4 broke a handle off the cover on his first attempt to remove it and then used the small bucket to push the cover (Tab R-62 and R-78). MW4 was able to dislodge the cover; however, it fell to the bottom of the manhole (Figures 8 and 9) (Tab R-41 and R-62). There was a noticeable smell when the cover was removed (Tab R-14, R-63, and R-80).

Figure 6 (Tab Z-4)
Example metal manhole cover and manhole opening

Figure 7 (Tab Z-5)
Example fiberglass manhole cover

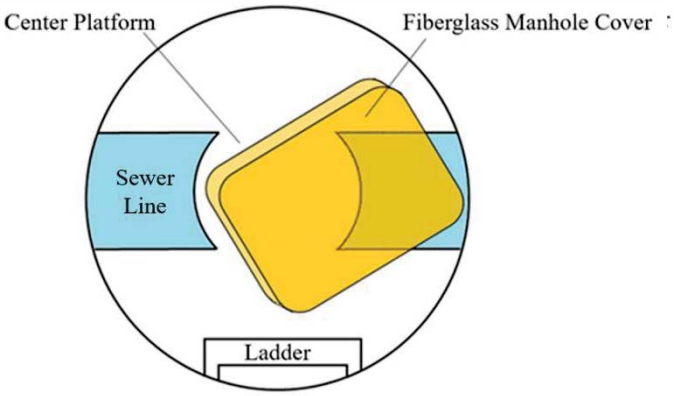

Figure 8 (Tab Z-5)
Notional diagram of manhole from above prior to entry of the MA. Not to scale. Side on which fiberglass manhole cover rested is unknown.

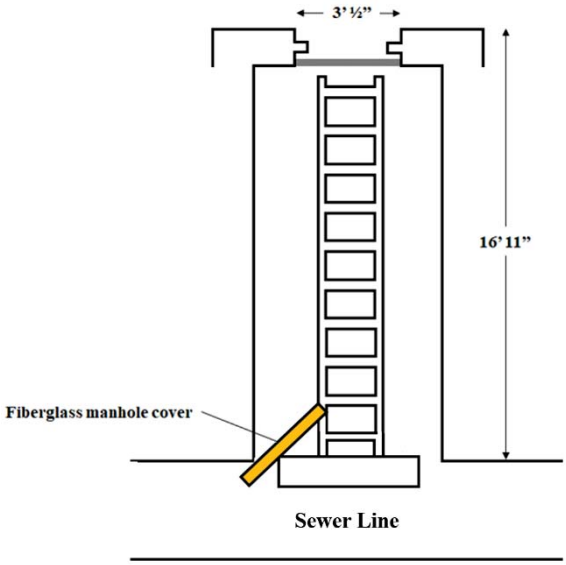

Figure 9 (Tab Z-6)
Notional diagram of manhole cross-section prior to entry of the MA. Not to scale. Side on which fiberglass manhole cover rested is unknown. Measurements reflect those of manhole in which mishap occurred.

The witnesses provided testimony regarding the sequence of events leading up to the MA's decision to enter the manhole (Tabs R-5, R-14, R-34, R-41, R-43, V-1.3, V-2.3, V-3.2, V-4.2, and V-5.2). According to MW1, MW3, and MW4, discussion that included the MA about methods to retrieve the cover took place but there was no resolution, and no one verbally volunteered or was

nominated to enter the manhole to retrieve the cover (Tabs R-5, R-12, R-14, R-41, R-58, R-79, V-1.3, V-3.2, V-3.3, V-4.2, and V-5.3). MW1 additionally testified that all present agreed verbally that no one was going to enter the manhole, and he then returned to his truck to get water (Tabs R-12, R-14, R-15, and V-1.3). MW5 testified he only talked to MW4 but other discussions were going on that he was not paying attention to (Tabs R-79 and V-5.2). MW2 remained in the area, but did not recall any discussions taking place about retrieving the cover before the MA made the decision to enter the manhole (Tab V-2.3). At some point, the MA left the group, went to his work truck, grabbed his gloves, and proceeded toward the manhole (Tab R-41 and R-79). MW1 and MW3 agreed that MA went to his truck at the end of their discussion (Tab R-5 and R-41).

Witnesses provided testimony about what was said to the MA as he was preparing to enter the manhole (Tabs R-31, R-62, V-1.3 to V-1.4, V-3.3, V-4.3, and V-5.3). While MW2, MW3, and MW5 testified no one said anything to the MA, MW4 testified MW3 told the MA to come right back out of the manhole if the MA felt dizzy or ill and that MW1 and MW2 were in the general area where he believed they should have been able to hear this statement (Tabs R-31, R-62, V-3.3, V-4.2 to V-4.3, and V-5.3). MW1 testified he was at his truck getting water, did not hear that statement, and was in fact unaware the MA was preparing to enter the manhole (Tab V-1.3 to V-1.4).

The MA descended the rungs of the manhole ladder to retrieve the cover (Figures 9 and 10) (Tab R-34 and R-79). At the bottom of the manhole, the MA grabbed the cover and began his ascent (Tab R-79). Approximately one third of the way up the ladder, he dropped the cover, appeared to lose consciousness, and fell to the bottom of the manhole (Tab R-20, R-34, R-62, and R-69). At this point, the MA had been in the manhole for less than one minute (Tab R-5, R-63).

Figure 10 (Tab Z-6)
Example manhole near location of mishap

As soon as the MA fell, the other team members yelled to the MA and immediately contacted emergency services (Tab R-14, R-44, and R-69). MW1 and MW4 testified that the MA initially

mumbled but was unresponsive after two or three minutes (Tabs R-63, V-1.5, and V-4.4). MW1 and MW2 remained over the top of the manhole to maintain visual contact with the MA and kept talking to the MA (Tab R-5 and R-28). MW1 testified that the odor intensified when he laid down at the top of the manhole (Tab R-14). MW2 got up and ran to MW3, who was on the radio talking to emergency services (Tabs N-5 and R-28). On his way, MW2 began to pass out, but MW1 and MW4 caught him before he could collapse to the ground (Tab R-16, R-28, and R-63). MW2 received assistance and sat in an air-conditioned vehicle and drank water (Tab R-20). MW2 was assessed at the local medical facility and cleared for release without medical intervention or hospital admission (Tab X-4). Based on review of MW2's medical records, the exact cause for his apparent loss of consciousness is unknown (Tab X-4).

b. Search and Rescue

Emergency services received the initial radio call from MW3 at 1359:27L (Tab N-5). MW3 made additional transmissions to describe the situation and relayed their location at 1401:09L (Tab N-5). Firefighter 1 (FF1) initiated a response at 1401:22L, and at least 21 firefighters ultimately responded to the scene (Tabs N-5, R-98 to R-102, R-109 to R-111, R-116 to R-134, and R-148 to R-149). FF1 also called for the mobile confined space trailer at 1401:39L (Tabs N-5 and R-133). Security Forces arrived on scene first, followed shortly by the first fire truck (Engine 12) at 1403:58L, crewed by four firefighters (Tabs N-5, R-115, and R-133). Prior to arrival on scene, the crew of Engine 12 was aware they were responding to a medical emergency involving personnel working around a manhole (Tab V-17.3). Upon arrival, firefighters confirmed an individual was in the manhole and that it was a real-world situation (Tab R-16 and R-133). FF10, who was acting as the initial incident commander, attempted to make verbal contact with the MA, but the MA did not respond (Tabs R-133 and V-17.3). After donning personal protective equipment (PPE), FF2 and FF4 had to wait approximately two to three minutes until the RIT was in place, and then they entered the manhole (Tabs N-6, R-98, R-133, and V-10.2). For this mishap, the RIT consisted of two firefighters, FF7 and FF21, who were in place between 1409:12L and 1411:00L (Tabs N-6 and R-127).

FF2 and FF4 entered the manhole at approximately 1411L (Tab N-6). Upon reaching the MA, FF2 stepped over the MA to make room for FF4 (Tab V-9.4). FF2 and FF4 checked for a pulse, breathing, and responsiveness (Tab R-109 and R-120). Initial assessment revealed the MA was unresponsive, not breathing, and had a weak or faint pulse (Tab V-9.2 and V-11.2). Immediately after primary assessment, FF2 placed a cervical collar on the MA (Tabs V-9.5 and V-11.5). On subsequent pulse checks in the manhole, FF2 detected no pulse (Tab V-9.2). Conditions within the manhole were such that FF2 and FF4 could not perform CPR, and the priority was to extract the MA from the manhole as quickly as possible (Tab V-9.5 and V-11.5). Conditions also prevented FF2 and FF4 from safely bringing equipment down upon initial entry (Tab V-9.5 to V-9.6 and V-11.5). At 1412:19L, firefighters began assembly of the tripod (confined space retrieval equipment) at the manhole (Figure 11) (Tab N-6). As FF2 and FF4 were attending to the MA, the tripod assembly was completed and firefighters lowered the rescue harness into the manhole (Tab V-9.6 and V-11.6). FF2 and FF4 maneuvered the MA in order to place the harness on him (Tab V-9.6 and V-11.5). FF2 and FF4 secured the MA into the harness and firefighters above began raising the MA (Tab V-9.5, V-9.6 and V-11.5). FF4 climbed the ladder following the MA and kept a hand on him to minimize sway (Tab V-11.5). FF2 followed FF4 as they exited the manhole (Tab V-9.5). During the rescue, firefighters attempted to ventilate the manhole using a fan from above (Tab R-101).

Figure 11 (Tab Z-7)
Example of confined space rescue tripod

Firefighters extracted the MA from the manhole at 1419:57L (Tab N-7). A pulse was still absent and CPR was initiated (Tab R-127). Firefighters and medical personnel placed the MA on a stretcher and put him into an ambulance (Tab R-127). The MA was in the manhole for approximately 20 minutes total, 11 of which were without emergency responders (Table 1) (Tab N-5 to N-7). Physical conditions in the manhole necessitated firefighters using a confined space rescue tripod and pulley system to extract the MA (Tab V-9.5 and V-11.5).

The ambulance departed the scene at 1421:57L, with five medical attendants working on the MA while en route to the base MTF for further care (Tabs N-8 and R-127). Upon arrival at the MTF at 1432L, CPR efforts continued and medical personnel initiated advanced cardiac life support efforts on the MA (Tab X-3). At 1446L, medical personnel reestablished the MA's heartbeat; however, he remained unresponsive and unable to breathe on his own (Tab X-3). Base medical personnel prepared and transferred the MA to a local host-nation trauma center at 1454L, where the MA remained in intensive care with no change in prognosis (Tab X-3). Clinical assessments and test results performed at the trauma center showed no signs of brain activity (Tab X-3). On 11 July 2018, the MA was airlifted to LRMC in Landstuhl, Germany (Tab X-3). Medical personnel noted the flight to LRMC was medically uneventful (Tab X-3). At LRMC, medical personnel initiated brain activity protocols (Tab X-3). Medical personnel found no brain activity and pronounced the MA dead on 12 July2018 at 1240L (Tab X-3). After medical personnel advised the MA's next of kin of his status, the decision was made by MA's family to remove the MA from life support, which occurred at 1958L (Tab X-3 to X-4).

Local time 8 July 2018	Event
1359:27	MW3's initial radio call to emergency services
1401:09	Mishap description and location relayed to emergency services
1401:22	FF1 directed firefighters to respond
1401:39	FF1 directed mobile confined space trailer to mishap location
1403:58	Security Forces and Fire Engine 12 (four firefighters) arrived at mishap location
1408:22	*Time limit for four firefighters to be on scene per DoDI 6055.06 Table E3.T1 (Tab BB-78)*
Between 1409:12 and 1411:00	RIT team in place with PPE
1411:00	FF2 and FF4 entered manhole
1412:19	Confined Space Rescue Tripod assembly initiated
1419:57	Firefighters extracted the MA from manhole
1421:57	Ambulance departed scene to take the MA to base MTF
1423:22	*Time limit for full complement of 13 firefighters to be on scene per DoDI 6055.06 Table E3.T1 (Tab BB-78)*

Table 1 (Tab Z-6)
Response Timeline Summary

c. Recovery of Remains

The MA's body was released from LRMC and transferred to the Office of the Armed Forces Medical Examiner at Dover Air Force Base, Delaware (Tab X-4). As of the completion date of this GAIB, an autopsy report was not available (Tab X-4). Personal effects were processed through the Joint Personal Effects Depot (JPED) (Tab X-4).

5. MAINTENANCE

No aircraft or related maintenance equipment were involved in the mishap.

6. EQUIPMENT, VEHICLES, FACILITIES, AND SYSTEMS

No equipment, vehicles, facilities, or systems were factors in the mishap.

7. ENVIRONMENTAL CONDITIONS

a. Forecast Weather

Forecast weather was not applicable to this mishap.

b. Observed Weather

At the time of this mishap, observed weather was within operational limits (Tab F-3). The temperature was 116.6 degrees Fahrenheit (47 degrees Celsius), with a heat index of 114.8 degrees Fahrenheit (46 degrees Celsius) (Tab F-3).

c. Other Environmental Conditions

As the mishap occurred under normal afternoon daylight conditions, illumination and visibility at the time and location of the mishap were within operational limits (Tab F-3). The surface around the manhole was uneven, with piles of dirt and concrete (Tab S-4). Visibility was limited inside the manhole due to lack of light, which impeded the ability to check the MA's pupils for dilation (Tab R-111).

OSHA classifies atmospheres containing 100 ppm or more of H_2S as Immediately Dangerous to Life and Health (IDLH) (Tab BB-53). OSHA defines IDLH as an atmospheric concentration of any toxic, corrosive, or asphyxiant substance that poses an immediate threat to life or would interfere with an individual's ability to escape from a dangerous atmosphere (Tab BB-50).

While no reliable readings for H_2S were taken at the time of the mishap, air samples from within the manhole were taken on 9, 22, and 30 July 2018 with a Multi-Rae gas meter, which measures carbon monoxide, H_2S, lower explosive limit, oxygen, and volatile organic chemicals (Tabs S-21 and V-13.2). All measurements taken on those dates indicated a maximum reading for H_2S at depths lower than the top 1/3 of the manhole (Tab S-21). The highest reading of H_2S the Multi-Rae is capable of reporting is 99.9 parts per million (ppm) (Tab V-19.2). Although the Multi- Rae was only able to give a partial indication of the H_2S concentrations, the actual H_2S may have been substantially higher than 99.9 ppm, or the 100 ppm that would establish them as IDLH according to the OSHA standard (Tabs S-21 and V-19.2).

The air samples indicated that, at the bottom of the manhole, there was sufficient oxygen (>19.5%) to breathe (Tabs S-21 and BB-107). Additionally they indicated 5-24 ppm of carbon monoxide (IDLH is 1200 ppm) and 4.9-123.5 ppm of volatile organic compounds (IDLH level differs depending on compound) (Tabs BB-109, BB-114 to BB-115, and S-21).

H_2S is 20% heavier than air, meaning higher concentrations are expected at increasing depths (Tab BB-92). The air samples taken on 22 July and 30 July 2018 indicated that H_2S concentrations in the middle third and bottom third of the manhole were at least 99.9 ppm (Tab S-21). More accurate measurements were later taken within the manhole using a Chip Measurement System (CMS) kit once a required attachment was obtained (Tabs S-21 and V-19.3). CMS measurements were taken at a depth of 16 feet, which was 11 inches above the bottom of the manhole (Tab S-9 and S-21). The reported H_2S concentration on 30 July, 22 days following the mishap, was 282 ppm (Tab S-21). It is likely that the H_2S concentration at the time of the mishap was significantly higher, as the MA went unconscious after less than a minute in the manhole (Tab R-5 and R-63). Symptoms of exposure to H_2S at concentrations of 700-1000 ppm include rapid unconsciousness and immediate collapse within one to two breaths (Tabs BB-54 to BB-55).

d. Restrictions, Warnings, and Procedures

At the time of the mishap, the location was under "Black Flag" heat conditions (Tabs F-3 and BB-7). In this condition, personnel performing under a moderate workload (such as light maintenance work) are advised by AFI 48-151, *Thermal Injury Prevention Program*, to work for 20 minutes and break for 40 minutes every hour and drink one quart of water per hour (Tab BB-7).

8. PERSONNEL QUALIFICATIONS

In order to earn a 5-level Journeyman (moderate proficiency skill level) rating, WFSM enlisted personnel are required to be trained on procedures for: 1) applying safety practices when working with confined space entries, and 2) how to inspect, use, and maintain confined space entry PPE (Tab G-49, G-50, and G-58). AFI 91-203, *Air Force Consolidated Occupational Safety Instruction*, paragraph 23.2.7.2, states Commanders and/or Functional Managers will:

> "[E]nsure all personnel assigned duties and responsibilities that support permit-required confined space program tasks are properly trained, equipped and qualified…Training may be accomplished via the [computer-based training], *Confined Space Series General Worker: Entrant, Attendant, Supervisor*, OSHA Course 226, *Permit-Required Confined Space Entry*, or equivalent, or by the installation [Confined Space Program Team]" (Tab BB-20).

AFI 91-203, paragraph 23.2.11.2 states that the shop supervisor will "include specific confined spaces requirements and safety training in the Job Safety Lesson Plan…" (Tab BB-24). The training records of the WFSM personnel involved in the mishap do not indicate they received any specific training on H_2S hazards or how to operate equipment to detect hazards in confined spaces, nor are any such requirements stipulated by AFI 91-203 (Tab G-1 to G-476). MW1 testified that Bioenvironmental Engineering would normally be called out perform air sampling at home station prior to confined space entry (Tab R-10). Local Hazard Communication (HAZCOM) training in the WFSM unit identifies "vapor inhalation" hazards and appropriate controls and/or PPE that apply to work involving sewer main repairs (Tab AA-8). All individuals had completed the required training and there is no evidence to indicate any training or qualifications issues were relevant to the mishap (Tab G-1 to G-476).

a. Mishap Airman (MA)

The MA was in the WFSM (3E4) career field for 6 years and was a fully qualified 7-level Craftsman (higher proficiency skill level) (Tabs G-3 and T-8). His supervisor lauded him for his strong work ethic and reliability, and noted that he worked well with MW3 (Tab R-92).

The MA completed initial certification on how to inspect, use, and maintain confined space entry PPE on 15 October 2013 (Tab G-29). The MA completed initial certification on applying safety practices when working with confined space entries on 27 November 2013 (Tab G-58). The MA completed the computer-based training *Confined Space Series General Worker: Entrant, Attendant, and Supervisors Course* on 13 March 2018 (Tab G-454). The MA completed local HAZCOM training on 21 May 2018 (Tab G-2). The MA completed the training outlined in the WFSM Job Safety Lesson Plan (referred to on their training forms as the Job Safety Training Outline (JSTO) for 380 AEW) on 15 June 2018 (Tab G-2 and G-363 to G-371).

b. Mishap Witness Number One (MW1)

MW1 was in the WFSM (3E4) career field for four years and was a fully qualified 5-level Journeyman (moderate proficiency skill level) (Tabs G-237 and V-1.2).

MW1 completed initial certification on applying safety practices when working with confined

space entries on 29 January 2016 (Tab G-283). MW1 completed initial certification on how to inspect, use, and maintain confined space entry PPE on 16 August 2016 (Tab G-275 to G-276). MW1 completed the training outlined in the WFSM Job Safety Lesson Plan on 15 June 2018 (Tab G-236 and G-363 to G-371). MW1 did not complete the computer-based training *Confined Space Series General Worker: Entrant, Attendant, and Supervisors Course*, though completion of annual confined space training on an unspecified day was documented on his Air Force Form 55 (Tabs G-236 and T-3). MW1's training records indicate he completed local HAZCOM training; however, they do not indicate where the training occurred (Tab G-236).

c. Mishap Witness Number Two (MW2)

MW2 was in the WFSM (3E4) career field for five and a half years and was a fully qualified 5-level Journeyman (moderate proficiency skill level) (Tabs G-77 and V-2.2).

MW2 completed initial certification on applying safety practices when working with confined space entries on 1 October 2014 (Tab G-123 to G-124). MW2 completed initial certification on how to inspect, use, and maintain confined space entry PPE on 25 March 2014 (Tab G-132). MW2 completed the computer-based training *Confined Space Series General Worker: Entrant, Attendant, and Supervisors Course* on 9 March 2018 (Tab G-444). MW2 completed the training outlined in the WFSM Job Safety Lesson Plan on 15 June 2018 (Tab G-76 and G-363 to G-371). MW2's training records do not indicate that he completed local HAZCOM training at his deployed location (Tab G-76).

d. Mishap Witness Number Three (MW3)

MW3 was in the WFSM (3E4) career field for eight years and was a fully qualified 7-level Craftsman (higher proficiency skill level) (Tabs G-151, T-10, and V-3.2). His supervisor lauded him for his strong work ethic and reliability, and noted that he worked well with the MA (Tab R-92).

MW3 completed initial certification on applying safety practices when working with confined space entries of 7 October 2011 (Tab G-206). MW3 completed initial certification on how to inspect, use, and maintain confined space entry PPE on 27 February 2012 (Tab G-197 to G-198). MW3 completed the computer-based training *Confined Space Series Worker: Entrant, Attendant, and Supervisors Course* on 25 October 2017 (Tab G-466). MW3 completed the training outlined in the WFSM Job Safety Lesson Plan on 15 June 2018 (Tab G-150 and G-363 to G-371). MW3's training records do not indicate that he completed local HAZCOM training at his deployed location (Tab G-150).

9. MEDICAL FACTORS

The GAIB medical member reviewed the medical records of the MA to assess overall health and determine whether any duty limiting conditions were present (Tab X-3). Additionally, the GAIB medical member reviewed relevant witness testimony (Tab X-3).

a. Qualifications

At the time of the mishap, the MA was medically qualified for duty without any restrictions (Tab X-3).

b. Health

The MA experienced acute H_2S inhalation leading to injuries related to the mishap (Tab X-3). Based upon review of the MA's post mishap medical evaluations, the exposure to H_2S led to rapid loss of consciousness, lack of oxygen to the brain and other vital organs, and ultimately cardiac arrest (Tab X-4). CPR began at the scene of the mishap and the MA was transported to the base MTF where Advanced Cardiac Life Support (ACLS) was initiated resulting in the return of a spontaneous heartbeat (Tab X-3). However, the MA still required artificial ventilation (Tab X-3). The MA was then transferred to a local trauma center, where further resuscitative efforts were continued and a higher level of care was established (Tab X-3). Clinical assessments and test results showed no signs of brain activity (Tab X-3). The MA was airlifted from this location to LRMC, where he was eventually pronounced dead after medical evaluation determined he had no signs of brain function (Tab X-3).

MW2 had a brief loss of consciousness during the mishap (Tab X-4). He was evaluated by the local MTF the day of the mishap and cleared without any necessary medical intervention or hospital admission (Tab X-4).

c. Pathology

The MA died from anoxic brain injury and ultimately hypoxemic cardiac arrest (Tab X-4). The official autopsy report from the office of the Armed Forces Medical Examiner was not completed by the time of this investigation (Tab X-4).

d. Lifestyle

There is no evidence to suggest that lifestyle factors were relevant to the mishap.

e. Crew Rest and Crew Duty time

WFSM workers typically worked six eight-hour shifts, with one day off per week (Tabs R-92 and V-7.2). The two primary shifts for WFSM personnel were from 0700-1500L (day shift) and 1500-2300L (mid shift) (Tab V-7.2). There was also a stand-by shift from 2300-0700L (Tab V-7.2). The individuals on stand-by were on-call to respond to any calls that came in between 2300 and 0700L (Tab V-1.2 and V-7.2). Witnesses testified that on occasion WFSM workers would arrive early or work late as the job required, but the option for day shift to pass work along to mid shift was completely acceptable and sometimes necessary (Tab V-7.3). Individuals assigned to the stand-by shift were typically scheduled for the day shift the following day, but were not always required by supervisors to work the day shift depending on how much of the stand-by shift they actually worked (Tab V-7.2).

The MA had the day prior to the mishap off and was placed on the stand-by shift that night starting at 2300L (Tab R-47). The MA was called around 0500L for a water pipe break behind the main command building the morning of the mishap (Tab R-42). Upon completing the job, the MA had breakfast and began his scheduled day shift at 0700 (Tab R-13). The WFSM team took a lunch break; however, it could not be confirmed whether the MA ate lunch (Tab R-13, R-32, and R-42).

10. OPERATIONS AND SUPERVISION

a. Operations

WFSM operated on a manpower surge schedule with six days on duty and one day off due to operational requirements for the duration of the deployment (Tabs R-92 and V-7.2). The MA worked eight- hour shifts, six days per week, with one day off (Tabs R-92 and V-7.2).

The WFSM supervisor described the operations tempo for the WFSM unit as moderate (Tab V-7.3). They consistently had work to do, but had enough down time during their shift to take breaks and cool off back in their office (Tab V-7.3).

The unit has sufficient equipment and personnel available at any given time to accomplish mission requirements (Tab V-7.3).

b. Supervision

WFSM jobs were periodically spot checked by the WFSM supervisor (Tab V-7.3). On-site non-commissioned officers (NCO) would close out completed jobs in the job order tracking system (Tab V-7.3). There were two NCOs on-site at the time of the mishap (Tab R-40 to R-41).

11. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

(1) AFI 48-151, *Thermal Injury Prevention Program*, 7 April 2016

(2) AFI 91-202, *The U.S. Air Force Mishap Prevention Program*, 24 June 2015 (as revised by Air Force Guidance Memorandum 2018-01, 21 May 2018)

(3) AFI 91-203, *Air Force Consolidated Occupational Safety Instruction,* 15 June 2012

(4) AFI 91-204, *Safety Investigations and Reports*, 27 April 2018

(5) AFI 51-503, *Aerospace and Ground Accident Investigations*, 14 April 2015

(6) AFI 51-503, ACC Supplement, *Aerospace and Ground Accident Investigations*, 28 January 2016

(7) 29 CFR 1910.146, *Permit-required confined spaces*, 27 December 2011

(8) 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*, 8 February 2013

(9) DoDI 6055.06, *DoD Fire and Emergency Services Program*, 21 December 2006

NOTICE: All directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at: http://www.e-publishing.af.mil, the OSHA website at: https://www.osha.gov, or the DoD Directives Division website at: http://www.esd.whs.mil/DD/.

b. Other Directives and Publications Relevant to the Mishap

None.

c. Known or Suspected Deviations from Directives or Publications

AFI 91-203, paragraph 23.2.8.13, specifies that prior to entry into a confined space, the on-site supervisor will ensure atmospheric monitoring is conducted by qualified personnel (Tab BB-22). Witnesses testified that there was no clearly established on-site supervisor as required by AFI 91-203, paragraph 23.2.8, though they acknowledged MW3 was a more senior Staff Sergeant than MA (Tab R-14, R-29, and R-43). Additionally, there is no evidence of atmospheric monitoring prior to the MA entering the manhole (Tab R-39).

10 December 2018

CHARLES M. DROUILLARD, Colonel, USAF
President, Ground Accident Investigation Board

INDEX OF TABS

Distribution Memorandum and Safety Investigator Information ..... A

Not Used ..... B

Not Used C

Not Used ..... D

Not Used ..... E

Weather and Environmental Records and Data ..... F

Personnel Records ..... G

Not Used ..... H

Not Used I

Not Used ..... J

Not Used ..... K

Not Used L

Not Used ..... M

Transcripts of Voice Communications ..... N

Any Additional Substantiating Data and Reports ..... O

Not Used ..... P

Legal Board Transfer Documents ..... Q

Releasable Witness Testimony ..... R

Releasable Photographs, Videos, and Diagrams ..... S

Personnel Records Not Included in Tab G ..... T

Not Used ..... U

Witness Testimony and Statements V

Not Used .....W

Statements of Injury and Death..... X

Legal Board Appointment Documents ..... Y

Photographs, Videos, Diagrams, and Animations Not Included in Tab S ..... Z

Accident Related Duty Documents.....AA

Applicable Regulations, Directives, and Other Government Documents ..... BB

Fact Sheets CC

Medical Research.....DD