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**Air Force Search & Recovery Assessment of the
1958 Savannah, GA B-47 Accident**

**AF Nuclear Weapons
And
Counterproliferation Agency**

12 April, 2001

EXECUTIVE SUMMARY

- On 5 February 1958, a B-47 returning from a simulated combat mission suffered a midair collision with an F-86. The B-47 was carrying a Mk 15 Mod 0 nuclear bomb in a training configuration (no nuclear capsule was on board). Because the bomb was incapable of a nuclear explosion, permission was granted to jettison the bomb, permitting the disabled B-47 to land without conventional explosive on board. The bomb fell into the waters off the coast of Georgia. An intensive, nine- plus week search failed to locate the bomb, and the bomb was declared irretrievably lost on 16 April 1958.
- The bomb contained approximately 400 lbs of conventional explosive as well as uranium (considered to be a heavy metal).
- In early August 2000, Congressman Jack Kingston (R-GA) requested the Air Force reinvestigate the accident following inquiries from constituents and the media.
- The Air Force consulted the Navy, the Department of Energy (DOE), the Savannah District Army Corps of Engineers, and the Skidaway Oceanographic Institute to investigate the details surrounding the incident, the most likely current condition of the bomb, associated hazards, and to determine whether search and subsequent recovery operations should be attempted.
- Assuming the bomb did not detonate on impact, the Department of Energy analysis concluded the bomb probably survived the accident intact and is believed to be resting 5-15 feet under the seabed. If the bomb did not survive intact, its components would have been dispersed and location/recovery is not possible.
- Assuming the bomb is intact, the DOE evaluated its status given the accident and subsequent 40 years of exposure to ocean water, silt and mud. The DOE determined that there is no current or future possibility of a nuclear explosion; the risk associated with the spread of heavy metals used in the bomb is low; and if undisturbed, the explosive in the bomb pose no hazard. However, intact explosive would pose a serious explosion hazard to personnel and the environment if disturbed by a recovery attempt.
- Cost estimates for search and recovery operations are difficult to pinpoint due to the uncertainty of the impact point and the uncertainty in the condition of the bomb. Search and recovery costs would most likely start at over \$5 Million.
- Based on the available data, the suspected orientation of the bomb, the search methods and available equipment, the Navy Supervisor of Salvage estimates there is a very low possibility of successfully locating the bomb.
- Recovery operations could not begin until after an approximate 2 plus year environmental decision making process.
- Disposition costs following a successful recovery are also difficult to quantify and would need to be determined by the Department of Energy.
- There could be substantial economic impact to the region if an accidental detonation of the conventional explosive occurred during search or recovery operations. The shipping, fishing and recreation industries in the area account for over \$28 million in annual economic activity.
- Impact to the regional aquifer and the local drinking water supply due to search and recovery operations could be significant.
- The Air Force concurs with expert conclusions that it is in the best interest of the public and the environment to leave the bomb in its resting-place and remain categorized as irretrievably lost.
- There may be unacceptable environmental impact associated with search and recovery operations.

BACKGROUND

The Accident

- On 5 February 1958, a B-47 bomber was on a simulated combat mission from Homestead AFB, FL.
 - The B-47 was carrying a single transportation configured (see Bomb description section below) Mk15 Mod 0 nuclear bomb.
 - The bomb weighed approximately 7600 lbs. The B-47 had a 10,000-lb. maximum payload capacity.
 - It was common practice to train with transportation configured bombs.
- The B-47 had a mid-air collision with an F-86 fighter at approximately 2:00 AM on 5 February 1958.
 - The F-86 crashed after the pilot successfully bailed out.
 - The F-86 was not directly involved with the B-47 simulated combat mission.
 - The B-47 was damaged but flyable.
 - Three attempts to land at Hunter AFB, GA were unsuccessful.
 - The Mk15 Mod 0 bomb was jettisoned to avoid possibility of conventional explosive detonation caused by a crash landing at Hunter AFB, GA.
 - The jettison location was several miles from Savannah, GA in the Wassaw Sound area of the Atlantic Ocean.
 - The drop elevation and air speed were approximately 7200 feet and approximately 200 knots respectively.
 - The B-47 crew did not see an explosion upon impact.
 - The B-47 landed safely at Hunter AFB, GA.
- Recovery efforts were conducted from 6 February 1958 until 16 April 1958.
 - A three square mile area was searched using the Air Force 2700th Explosive Ordnance Disposal Squadron and approximately 100 Navy personnel equipped with hand held sonar and galvanic drag and cable sweeps.
 - Water depth in the search area was approximately 8-40 feet.
 - The Air Force declared the bomb irretrievably lost on 16 April 1958.

The Bomb

- The bomb contained approximately 400 lbs of conventional explosive as well as uranium (considered to be a heavy metal).
- The Mk15 bomb type utilized a removable nuclear capsule, which was required for a nuclear explosion, but was not present in this transportation-configured bomb.
- An Atomic Energy Agency (AEC) to Air Force “Transfer of Custody” receipt, dated 4 February 1958, confirms no nuclear capsule was present, therefore no nuclear yield was possible.

- The Mk15 bomb was produced in two versions; the Mod 0 and Mod 2. The Mod 2 version of this bomb type replaced the removable nuclear capsule of the Mod 0 with a non-removable nuclear capsule, thus making the Mod 2 version a self-contained fully functional nuclear bomb.
- Concern has been raised as to which version of the bomb was present. The AF and DOE have concluded that the bomb was a Mod 0, based on the following facts:
 - Maintenance records for this specific bomb indicate the only maintenance activity during which the Mod 0 to Mod 2 conversion might have been completed took place in July 1956.
 - AEC production records indicate Mod 2 conversion kits were not ready until December 1957.
 - AEC production records indicate Mod 0 to Mod 2 conversions did not begin until March 1958.
 - As the accident occurred in Feb 1958, the evidence is conclusive that the bomb involved was a Mod 0.

DOE BOMB IMPACT ASSESSMENT

A team of engineers from Sandia and Los Alamos National Laboratories developed the best estimate of the possible condition of the bomb. The analyses and calculations were based upon detailed bomb design information, reports on the accident and information provided by the Army Corps of Engineers and the Skidaway Oceanographic Institute. There are many sources of uncertainty in the initial conditions, the aerodynamic and hydrodynamic models developed, and soil conditions; hence, these results should be viewed as “reasonable estimates,” the best that could be done with the information and time available.

- Bomb Condition Assessment is dependent on several interrelated evaluations
 - Aerodynamic and hydrodynamic trajectory calculations.
 - Structural analysis of the response of the bomb case to these impacts and potential damage to bombs internals.
 - Evaluation of the expected penetration depth into the seabed.
 - Potential corrosion of the case and the internals from prolonged exposure to the seabed environment.
 - Evaluation of the condition of the explosive and the potential for explosion.
 - Evaluation of the potential for criticality.
- The bomb is predicted to have survived the accident, assuming it did not explode on impact.
- Based on the expected depth of water in the impact region, the 12-foot long bomb is expected to be buried nose-down, probably 5-15 feet below the seabed (depth from the seabed to the tail of the bomb). See appendix A
 - Substantial internal damage is expected.

- It is possible portions of the bomb internals could have breached the nose of the case and have been separated from the case in the seabed.
- The seabed/seawater environment has minimal effect on the bomb case:
 - Corrosion rates are such that the integrity of the case would currently not be compromised but instead the case would merely be pitted.
 - The internal components would be fully saturated in a salt-water environment and would also be subject to corrosion. Leaching of the materials is expected to remain within a few feet of the bomb.
 - Selected components within the conventional explosive are water-soluble; however, the explosive is expected to remain viable but somewhat less sensitive than the original formulation.

NAVY SUPERVISOR OF SALVAGE SEARCH ASSESSMENT

The Supervisor of Salvage was requested to assess the technologies available for a future search of the lost bomb.

- Three technologies were considered for use in search operations - 1) Side Scan Sonar (high frequency acoustic waves), 2) Magnetometer (magnetic signature) and 3) Sub-Bottom Profiler (low frequency acoustic waves).
 - Side-scan sonar, although widely used as a primary search tool, is not applicable due to the belief that the bomb is buried beneath the seabed.
 - The magnetometer would not be well suited due to the lack of ferrous materials in the bomb and the impact orientation of the bomb.
 - The Sub-Bottom Profiler was deemed to be the most effective technology due to the likely burial depth of the bomb and the lack of ferrous materials.
 - Sub-bottom profiling utilizes low frequency “acoustic image” of content below the seafloor. A range of equipment within this category is readily available and commonly utilized for applications at depths of penetration well beyond the depths believed involved with this search.
 - The disadvantage of sub-bottom profiling is the narrow swath or width covered with each sweep.
- Search operations with a sub-bottom profiler are estimated to cost \$10,000 per day with a search rate of 1 square mile per 12 days. This estimate only includes the search activities (based on 24-hour operations) and does not include the time and resources required for personnel and equipment mobilization. Weather related delays would extend the search time. The \$10K per day search cost accrues whether searching or not.
- Based on the data reviewed, the suspected physical condition and orientation of the bomb, the search methods and available equipment, the Navy Supervisor of Salvage estimates there is a very low probability of successfully locating the bomb.
- In addition, such a search would undoubtedly indicate the presence of many targets, which would then need to be characterized and prioritized for follow-up investigation.

- These targets would need to be sufficiently uncovered and investigated by divers to allow for clear identification. This could cause an unacceptable environmental impact and would be dangerous to personnel involved.
- Navy Supervisor of Salvage Conclusion
 - Completing a search for the lost bomb is certainly within the capabilities of the U.S. Navy. However, given the limited amount of information available, the area to be searched and the number of false targets that would have to be prosecuted would be unreasonably large when compared to an average search operation.
 - From a technical standpoint, the Navy Supervisor of Salvage does not recommend undertaking this effort.

CONSIDERATION OF OPTIONS

There are a number of general issues to consider as well as option specific issues prior to recommending a course of action.

- Given the previously discussed information, there are two possible courses of action:
 - Leave the bomb in its resting location.
 - Pursue a search and subsequent recovery attempt.
- The following criteria should be used to determine the most prudent path forward.
 - Economic - The potential economic impacts to the region (e.g. tourism, shipping, fishing) of the various courses of action.
 - Environmental - The National Environmental Policy Act (NEPA) implications (e.g., the potential impacts to human and natural environments) associated with each course of action.
 - Costs - The costs for each course of action as well as the likelihood of success.
 - Disposal - If recovered, how will the bomb be disposed of and what are the costs associated with disposition.

EVALUATION OF OPTIONS

- General Public Safety Considerations - There is no possibility of nuclear explosion due to conclusive evidence of the absence of a nuclear capsule.
 - Four primary hazards were identified for consideration.
 1. Conventional Explosives
 2. Potential for environmental contamination
 3. Safety hazards to personnel
 4. Potential for criticality
 - Situations in which the bomb might be disturbed were evaluated.
 - Hurricane - Hurricanes typically only disturb the first 2 to 3 feet of the seabed. Initial assessment of this scenario does not indicate a problem.

- Dredging activities - The area in question supports local fishing and pleasure boating. There are no current or planned dredging activities in this area to support either the fishing industry or the pleasure-boating industry.
- Fishing and pleasure boating - Due to the estimated depth of the bomb in the seabed, and the weight of the bomb (7600 lbs), fishing and boating activities are unlikely to disturb the bomb. Los Alamos scientists believe that even if the bomb was accessible and a boat anchor was dropped on it, a violent reaction of the explosive is very unlikely.
- General Environmental implications and issues.
 - Search and recovery operations could cause unacceptable environmental impacts.
 - NEPA requires Federal Agencies to make environmentally informed decisions prior to any irrevocable or irretrievable commitment of resources (resources are defined as personnel, facilities, or money).
 - The NEPA process would involve creation of either an Environmental Assessment or Environmental Impact Statement.
 - Regional Aquifer (Floridian)
 - In the Wassaw Sound area, the top of the Floridian aquifer (limestone) would generally be expected to be encountered at about 90 to 100 feet below mean low water (MLW). The Floridian aquifer is overlain by about 40 to 50 feet of Miocene layer confining material (clayey sand), depending on water depth. The top of the Miocene layer would be expected to be encountered about 40 feet below MLW, with the exception of areas where the Miocene may have been scoured away by old river channels. In the scour areas, the Miocene could be encountered as deep as 60 to 70 below MLW. Dredging or removal of the Miocene confining material above the aquifer would need to be limited, to insure minimum impact on the aquifer from salt-water intrusion due to a thinned confining unit. The vertical hydraulic conductivity of the Miocene unit is currently under further investigation, but in no case should the entire thickness of the confining material be completely removed.
 - Should invasive search or recovery operations entail dredging, either by clamshell or cutterhead dredge, the maximum depth will be restricted by the presence of the Floridian aquifer.
 - If the confining material above the aquifer is breached, it will allow seawater to enter the fresh water aquifer. The degree of damage to the aquifer would depend on the aerial extent and depth of the breach. Since water in the aquifer is under a downward gradient, due to the cone of depression from pumping at Savannah, seawater would be pulled down into the aquifer, where it would then travel toward Savannah. Since the Floridian aquifer is the principal source of fresh water in coastal Georgia, the potential effect could be significant.

- General Economic Impact Factors

- Activities along the Georgia coast include commercial fishing, recreation (both general and specialized), and deep and shallow draft navigation. Any event occurring in Wassaw Sound would likely impact the entire coastal region of Georgia as the expected event site is in the upper coastal region and littoral drift would carry the impact southward. Specific impacts are as follows and only represent a portion of potential economic impact.
 - Economic impact to the local shipping industry (deep and shallow draft vessels) is unlikely. However, it cannot be completely ruled out and the impact would depend on the context and extent of an accidental detonation of the conventional explosive.
 - The local commercial fishing industry would likely be impacted by search and recovery operations.
 - In 1997 commercial fishing on the Georgia coast produced \$28.5 million in seafood. The heart of the Georgia seafood industry occurs near or south of the site of concern. Shrimp made up the largest portion of this value with an estimated value of \$22.3 million.
 - With littoral drift, dredging activities and/or an explosion or leakage could impact a significant portion of the fishery. The Georgia fishery supports no less than 75 local, regional, and national seafood dealers.
 - The following local recreation will be impacted during search and recovery operations and certainly be impacted in the event of an inadvertent explosion.

- Public Beaches

- Tybee Island
 - St Simons Island
 - Jykell Island

- Coastal Island and main use or purpose (north to south along coast)

- Tybee Residential, Recreation
 - Little Tybee State controlled natural area
 - St Catherine’s Island State controlled natural area
 - Sapelo Island State controlled natural area
 - St Simons Island Residential and recreation
 - Jekyll Island State controlled recreation
 - Cumberland Island National seashore and wildlife management

- Other areas of concern

- Kings Bay Submarine facility, St Mary’s, Georgia

- Impact to the regional aquifer and the local drinking water supply due to search and recovery operations could be significant.

Leave Bomb in place

Experts considered the current state of the bomb, the range of possible damage states, and the technical risks associated with leaving it in place, recovery and ultimate disposition; but did not consider legal or sociopolitical aspects of any such operations.

- Specific environmental & regulatory considerations

Advantages

- There is no possibility of contamination of the drinking water supply given the region's hydrology.
- If left undisturbed, there is no reason to expect the explosives to spontaneously explode.

Disadvantages

- There will be continuing doubt surrounding the bomb should it not be recovered.
 - Left undisturbed in its current state, the principal risk to the environment is from localized heavy metal contamination due to corrosion and leaching of materials.
 - With regard to potential criticality, it is judged that there are no practical criticality concerns with this bomb under any foreseen scenario.
- Cost Considerations -
 - None identified except for avoidance of economic impacts to shipping, fishing and local recreation industries from an accidental explosion during search and recovery operations.

Search and Recovery

- Specific Environmental & Regulatory Considerations

Advantages

- Should the explosive detonate the shock wave and debris would be limited to less than 1000 feet.

Disadvantages

- There are potential environmental and safety hazards associated search operations.
 - Subsequent invasive search operations to distinguish between the Mk 15 bomb and other identified targets, may create cultural resource, and public safety concerns. Completion of the NEPA process and documentation as well as obtaining all Federal (Corps) and State permits or approvals would be required. For instance, all of the ocean south of Tybee Island is subject to the Coastal Barrier Resources Act (COBRA). Also, it is a certainty that coordination under Section 7 of the Endangered Species Act will have to be completed due to the presence of Right Whales and various endangered sea turtle species such as the Loggerhead, Kemps Ridley and Green turtles.
 - Assuming all hazards were characterized and controlled, complete mitigation of risk would be unlikely; the bomb would still be hazardous to recovery personnel.
 - Recovery would entail the potential for explosion due to the unpredictable response of the explosive to being disturbed during recovery operations.
 - Impact to the Floridian aquifer could be substantial if the bomb's conventional explosives detonated during search and/or recovery operations.
 - Subsequent to recovery, the materials would need proper disposition.
 - The conventional explosive is the primary hazard for recovery operations.
 - Assuming the nuclear materials (uranium categorized as a heavy metal) could be separated from the explosive, it is expected they could be safely packaged and disposed of. However, safe separation of the nuclear materials is questionable.
 - An approved method for packaging and shipping the damaged bomb would also be required.
- Cost Considerations - see Appendix B for Rough Order of Magnitude (ROM) cost estimates

Advantages

- None identified

Disadvantages

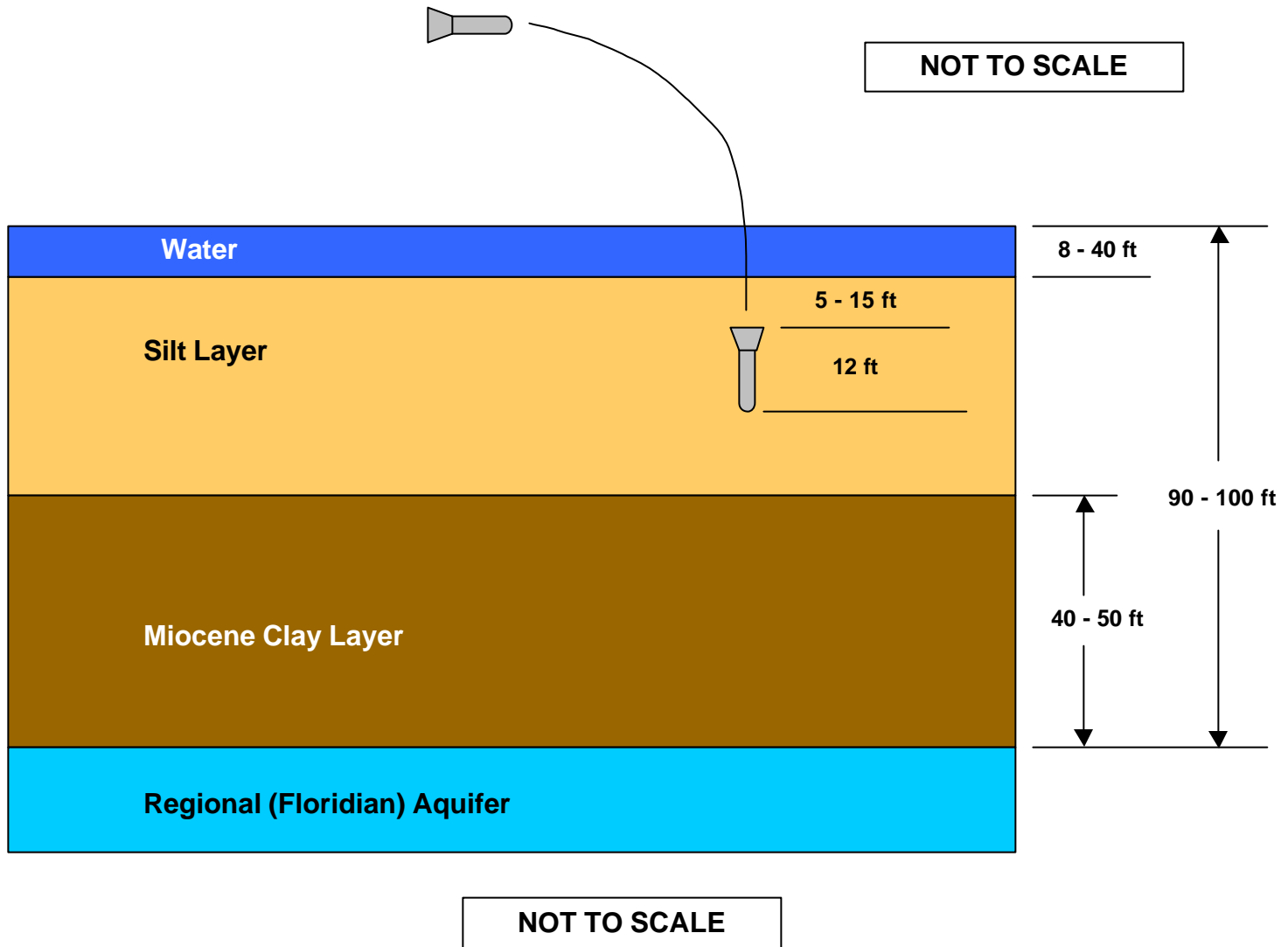
- Environmental Assessments/Impacts are complex, lengthy and expensive - on the order of several years and involving several hundred thousand dollars. If a full Environmental Impact Statement is required, the cost could be in the million-dollar range.
- Cost estimates for a search operation are difficult to quantify due to the uncertainty in the impact point and the likely vertical impact orientation.

- Estimated search area is at least one square mile and could easily be as large as 20 square miles. See Appendix B for breakdown of costs for various activities.
- The Navy Supervisor of Salvage estimates there is a very low probability of successfully locating the bomb.
- Recovery and disposition related costs cannot be accurately estimated until the bomb is positively identified and its condition assessed. ROM cost estimates are included in Appendix B.
- Costs for disposition of the bomb would also have to be taken into consideration.
- Once a search operation is initiated, will it be possible to stop it? Identification of the stoppage criteria (e.g., cost, time) will be difficult.
- If the bomb were located, site monitoring and protection would be required to prevent unauthorized recovery efforts prior to recovery if undertaken.
- A complete site protection, recovery and disposition plan would have to be developed and approved prior to initiating search activities.

Recommendation

- For the following reasons, the Air Force recommends the bomb be left in its resting place and remain categorized as irretrievably lost.
 - No possibility of nuclear explosion.
 - No risk to public.
 - Avoids potential for unacceptable impact to the environment.

APPENDIX A - Hydrological Cross-Section with Bomb Impact Location



APPENDIX B
Table of ROM Cost Estimates

	Rate (K)	Estimated time/qty	Total (K)
Pre-planning (data review, search area, etc)		2 days	\$10 - 20
Search activities (incl. suitable boat, sub-bottom profile, 26-30' fishing boat w low speed)	\$10/day	12-220 days	\$120 - \$2,200
Target Characterization & Prioritization - not quantifiable			Not quantifiable
NEPA related activities (813/CATEX)		1 year	\$300
Target Investigation (core samples)	\$50 Each	25 - 100	\$1,250 - \$5,000
Search total			>\$1,695 - \$7,525
Pre-planning for decision to recover			\$100
Develop recovery options			\$100
NEPA related activities		2 years	\$2,000
Disposition preparations		2 years	\$1,000
Recovery		30 days	\$150
Disposition (DOE incurred cost)			TBD
Pre-recovery protection of bomb	\$250/yr	1 - 3 yrs	\$250 - \$750
Recovery & Disposition total			\$4,350
Grand Total		~ 5 yrs	>\$5,065 - \$11,425