Operation Crossroads

"Warfare, perhaps civilization itself, had been brought to a turning point by this revolutionary weapon."
--Vice Admiral William H. P. Blandy, Leader of Joint Task Force One, 1946

Institute for Science and International Security

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Operation Crossroads:
A Radiological Fallout Disaster

- Operation Crossroads was the first large-scale atomic weapons tests conducted by the United States military, principally the Navy. The name of the operation was chosen to signal that the atomic bomb was a "crossroads" from conventional to nuclear war.
- It was conducted in the summer of 1946 in the South Pacific on Bikini Atoll in the Marshall Islands and involved a large fleet of naval vessels, captured at the end of World War II or surplus to U.S. naval needs.
- As I will sketch, Operation Crossroads can be viewed as an example of a significant radiological disaster, showing the public for the first time the danger and damage of local radioactive fallout, in this case from a shallow underwater burst. Radioactive fission, plutonium, and activation particles were distributed primarily by a radioactive water surge. (In general fallout occurs in any above ground nuclear detonation but its severity depends on whether the blast's fireball intersects with the ground or water.)
- The extent and impact of the local fallout produced by Operation Crossroads and the ill-preparedness of the Navy to deal with it was hidden for decades, The full story came out only in the early 1980s.

Strategic Lessons

- A critical lesson, while not understood by the public at the time, was that a naval fleet, or a city by extrapolation, could survive physically but be lost to radioactive contamination.
- Rather than lead to stronger efforts toward the international control of nuclear weapons, or even their elimination, a hotly debated topic following World War II, Crossroads had the opposite effect on the U.S. military.
- The military became more convinced that the only path to avoid nuclear oblivion was to build up U.S. nuclear forces as rapidly as possibly.
- The military leadership also promoted a policy of preemptive strikes against those nations that threatened the United States with nuclear weapons.

One of Many Radiological Disasters

- The original radiological disaster should be viewed as the three initial nuclear explosions.
  - Damage wrought on the people of Hiroshima and Nagasaki by two fission weapons dropped by the United States in the closing days of World War II, detonated at an altitude of over 1500 feet to maximize the destructive effects of the blast wave. The deadly radiation posed by these bombings was the prompt radiation from the fissions in the blast itself and radioactive activation of elements in the ground; there was little fallout.
  - The Trinty explosion, detonated at only 100 feet, produced significant local fallout on the nearby communities, called "downwinders."
- Examples of later radiological disasters include Chernobyl nuclear reactor (1986) and the Fukushima nuclear reactor (2011) accidents.
- Operation Crossroads was also the first of more than 200 U.S. above ground nuclear weapons tests, many producing even more fallout, affecting nearby troops and civilian communities, some thousands of miles from the detonation.
- But Crossroads stands out as the first radiological disaster to show publicly the danger of local fallout. In fact, to many military officials at the operation, many saw for the first time that there was no way to deal with this intense local fallout in the event of a nuclear war.

Operations Crossroads

- In 1946, Joint Task Force 1 was established under the order of President Harry Truman to conduct the tests at Operation Crossroads.
- Its leader was Vice Admiral William Blandy.
- This operation, largely military in nature, but with the involvement of Los Alamos, planned for three tests of the plutonium weapon of the type used twice before in the Trinty Test and over Nagasaki.
- At the time, these three devices, each with a yield of 23 kilotons, constituted one-third of the U.S. stockpile, indicating the importance placed on this test series.
- The three tests were codenamed ABLE, BAKER, AND CHARLIE, aka Shot Able, Shot Baker, Shot Charlie.
- Shot Able was to be an air-drop while Shots Baker and Charlie were to be shallow and deep underwater detonations, respectively.

Goals of Operation Crossroads

- The military goal was to learn the effects of atomic explosions against naval ships and secondarily against ground targets, including aircraft,
- The Navy wanted to study the effects on its fleet from an airburst and underwater detonations.
- The Navy also wanted to show that naval vessels could withstand the forces generated by a nuclear explosion, fending off growing criticism that the fleet had become obsolete in the face of this new, terrible weapon, according to Lewis Strauss, then aide to Secretary of the Navy James Forrestal.
- The Navy hoped, naively as it would turn out, to demonstrate that the damaged target ships could be salvaged and sailed home triumphantly, disproving the critics.
- The Navy also intended to learn to fight in a nuclear weapons environment and adjust its ships and strategies accordingly.
- Regardless of public statements about the United States favoring a peace based on international cooperation, U.S. leaders were well aware of the effect of showing the might of these new weapons to the world.

Operations Crossroads

- Task Force 1 required a fleet of 242 ships, 42,000 personnel (40,000 military; 2000 civilian), 156 airplanes, and tens of thousands tons of equipment, ordnance, and material.
- The primary purpose was to learn about the effects of nuclear weapons, particularly on naval vessels.
- But the U.S. military wanted to publicize the tests. Observers came from Congress and eleven nations, including the Soviet Union.
- 168 journalists covered the tests from a base aboard the support ship USS Appalachian.

Robert Oppenheimer Opposed Crossroads, Excerpts from his May 1946 Letter to President Truman

- It has been stated that the tests would determine the effectiveness of atomic weapons in naval warfare…More useful information could be obtained by model tests and by calculations. These are difficult, but far less costly and, in my opinion, more likely to lead to useful insight than the tests contemplated. I believe that the cost of the tests as planned has been estimated at more than one hundred million dollars. For less than one per cent of this, one could obtain more useful information.
- It has been suggested that the tests will provide scientific data of great interest. Much of this information, such as the effect of radiation on equipment, poison gases, rations, animals, etc., can far better be obtained by simple laboratory methods. Much of it could be obtained better in a test designed specifically for that purpose and not complicated by the naval arrangements.
- Even if all components work correctly, the bombs which are scheduled for use in these tests have a chance of about one in fifteen of giving an ineffective explosion, that one might call a dud. Bombs have been designed which do not have this weakness, but it is not planned to use them. Surely this possibility should be born in mind in evaluating the effect on American and foreign opinion.
- Concern that has been expressed as to the appropriateness of a purely military test of atomic weapons, at a time when our plans for effectively eliminating them from national armaments are in their earliest beginnings.

Crossroads

- Bikini Lagoon in the Marshall Islands in the South Pacific was selected as the test site.
- This atoll had been Japanese, but after World War II the United States administered it under a U.N. mandate.

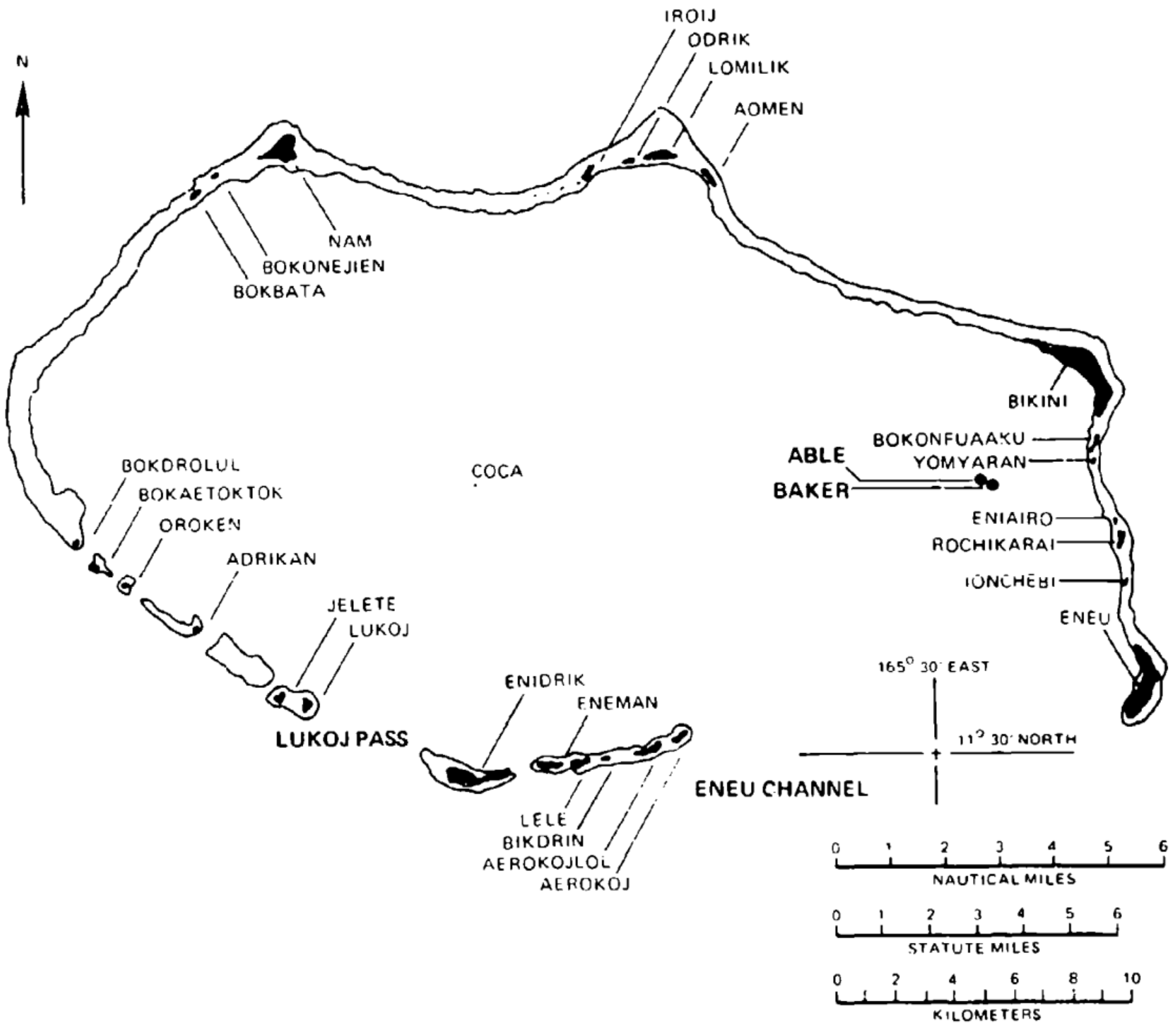


Figure 2. Bikini Atoll, 1946, showing ABLE and BAKER test sites.

Source: Defense Nuclear Agency, *Operations Crossroads, 1946,* DNAA 6032F, May 1, 1984, referred to as DNA report.

Test Location

- The first two tests were planned for a small section of the lagoon near Bikini island.
- The third test was meant to be conducted in deep-water (1000 feet) outside the atoll.
- Because of the danger posed to residents, the United States removed the 160 persons living on Bikini to another atoll, Rongerik, for their safety. They left voluntarily, expecting to return shortly.

Joint Task Force One press release photo of the target area of the first two tests at Bikini, 1946. *(U.S. Naval Institute)*

The lagoon was filled with target ships, surplus from WW II

- A fleet of more than 90 vessels was assembled in Bikini Lagoon as a target of the tests, consisting of older U.S. capital ships, three captured German and Japanese ships, surplus U.S. cruisers, an aircraft carrier, destroyers and submarines, and many auxiliary and amphibious vessels.
- Aircraft and a huge amount of other military equipment were placed on target ships.
- A support fleet of more than 150 ships provided quarters and workspace for most of the 42,000 men (more than 37,000 of whom were Navy personnel) of Joint Task Force I.
- The figure on the right shows the positioning of target fleet within the lagoon around the ground zero of Shot Able.

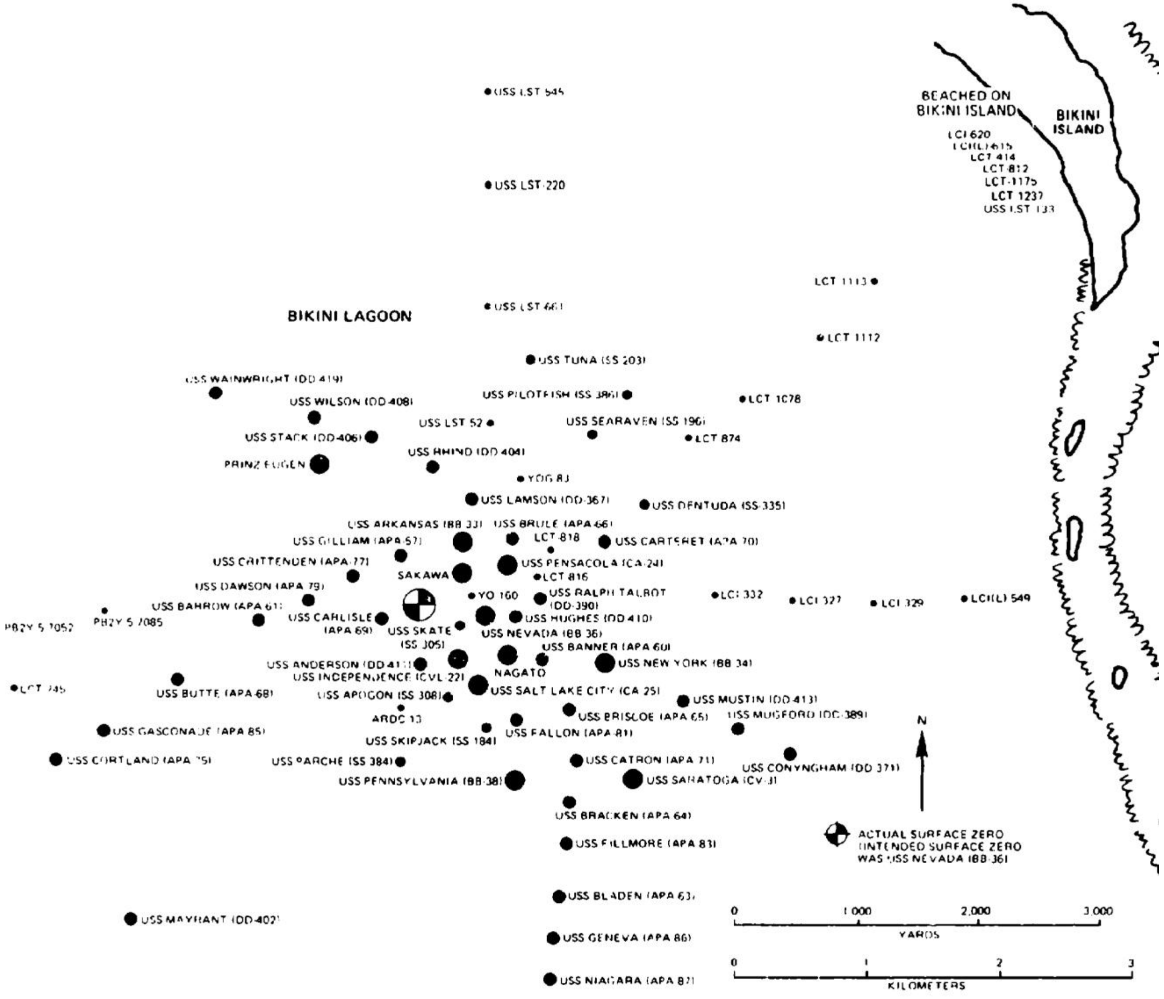
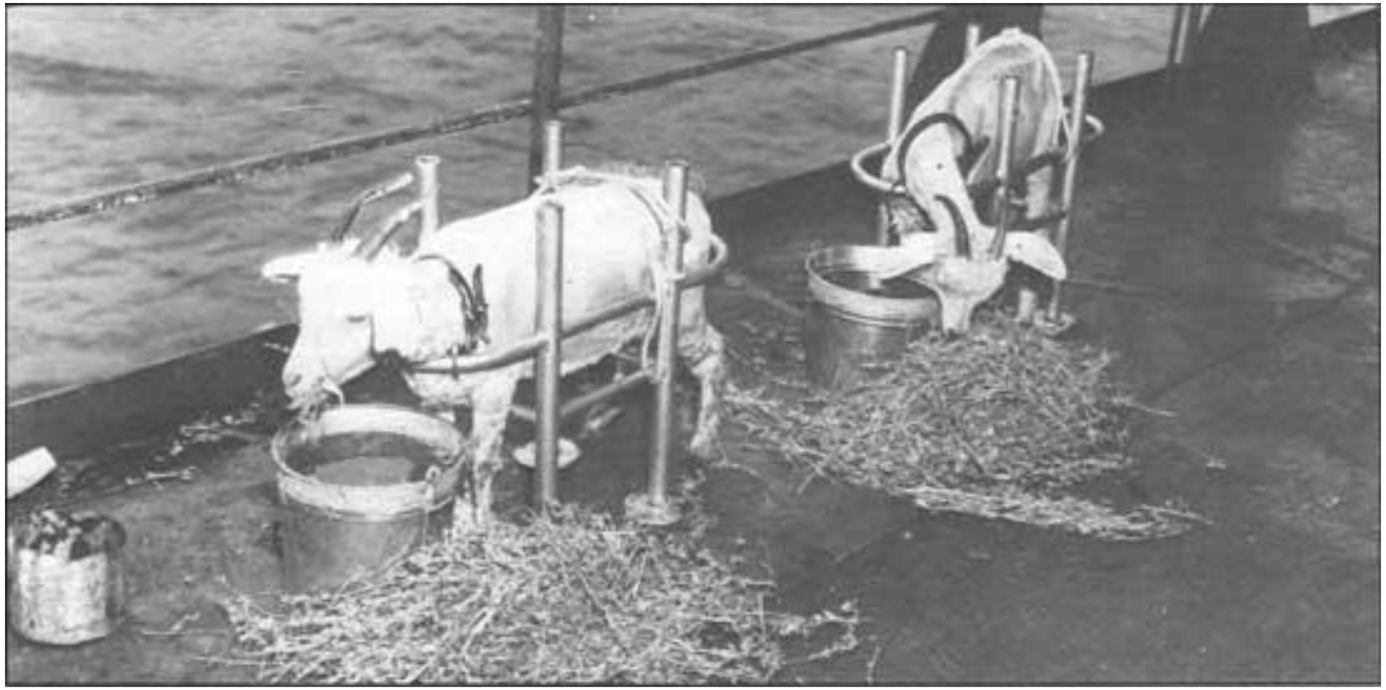


Figure 23. CROSSROADS, ABLE target ship locations.

Source: DNA report

Joint Task Force 1

- Military equipment was arrayed on the ships as well as amphibious craft that were beached on Bikini Island.
- Technical experiments were also conducted to study nuclear weapon explosion phenomena.
- Some experiments, including those aimed at understanding human radiation causalities, included the use of live animals.



Two goats aboard ship USS Niagara, exposed to radiation during Shot Able . (National Archives)

Shot Able, July 1, 1946

- Before the Able test, all personnel were evacuated from the target fleet and Bikini Atoll. These men were placed on units of the support fleet, which sailed from Bikini lagoon and took safe positions at least 18.5 kilometers east of the atoll.
- Shot Able was dropped from a B-29 on July 1, 1946. It was nicknamed “Gilda” after the movie starring Rita Hayworth; the bomb had the actress’ picture stenciled onto it.
- It was detonated at about 520 feet above target fleet. Although the bomb missed its planned detonation point by about 1500 to 2000 feet, it sank several ships and caused considerable top-side damage to other ships.
- The fireball likely just touched the surface of the water, causing some local fallout.
- However, the height of burst was high enough to cause it to act mostly like an airburst combined with intense initial radiation.
- The radioactivity created by the burst was judged by the military to have had only a transient effect, and within a day nearly all the surviving target ships were reboarded. Given the lack of adequate radiation monitoring this was a questionable assessment.

Damage From the Able Test, according to the DNA report referenced earlier

- The damage to the ships:
  - 5 ships were sunk
  - 6 ships seriously damaged;
  - 8 ships seriously Impaired
- 43 ships with negligible damage and 22 landing craft beached at Bikini Island showed no damage.
- On aircraft,
  - 14 aircraft destroyed
  - 30 aircraft seriously damaged
  - 110 aircraft lightly damaged
  - 19 aircraft no damage.
- In general, target vessels within 500 yards of "surface zero" were sunk or seriously damaged. Those beyond 1500 yards received minor damage. Those ships beyond 750 yards had little induced activity or contamination.
- Much of the damage was top-side, due to Shot Able being an air burst.
- Later, it became apparent, confirmed by the effects on the animals on the target ships, that if the ships had been crewed, there would have been massive casualties from prompt radiation from the detonation, even when the ships survived the blast.

Damage Assessments

- By July 5, all target vessels, except those sunk, had been sufficiently rehabilitated to be ready for the upcoming Baker test.
- Despite the damage, there was a general sense among the media that the event had been overhyped and many left.
- But it is important to remember just how powerful these airbursts can be.

Aftermath of Bombing of Nagasaki on August 9, 1945, U.S. Army Signal Corp Image

- An airburst can be immensely destructive.
- The Nagasaki blast was an airburst detonated at 1650 ft or 503 meters, involving the same “Fat Man” bomb as used in Shot Able and Baker.
- The nature of the housing and other buildings added to the level of destruction.

Preparations for Shot Baker

- For Shot Baker, nicknamed Helen of Bikini, target ships were re-positioned to better study effects with distance.
- There were 68 target vessels in the array for Test Baker. Twenty-four small craft were beached on Bikini Island. Their positions are shown in the figure. Of the eight target submarines, six were submerged and two were on the surface for the test.
- The bomb was contained in a watertight, steel caisson, suspended via a coaxial cable 90 feet beneath the surface of the lagoon from landing ship, LSM-60. (The water depth at this spot was 180 feet.)
- The crews of the target ships that had been remanned following ABLE were evacuated before BAKER to the support fleet east of the atoll.

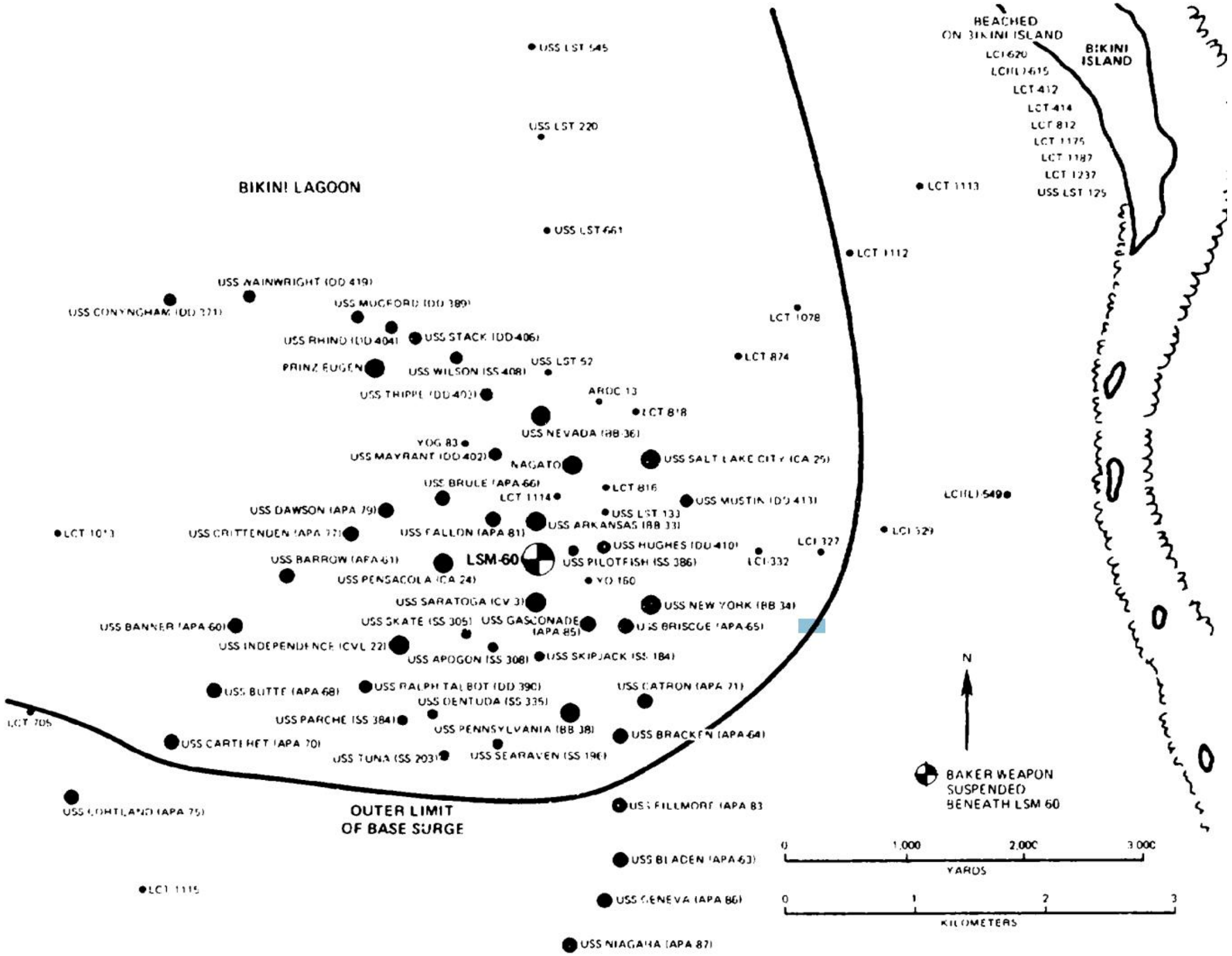


Figure 28. Target ship locations for CROSSROADS, Test BAKER.

Source: DNA report

Baker shot

- Shot Baker was detonated at 0835 on July 25th.
- here for a video clip of the Baker test. (Source: https://www.osti.gov/opennet/manhattan-project-history/Events/1945-present/crossroads.htm)
- Long version of Crossroads https://www.youtube.com/watch?v=2HkLZekOZLU start at about 27:30 minutes.

Baker Test

- Shot Baker sank eight ships and damaged more ships than Shot Able.
- But the dominant effect of this detonation was the bathing of most of the target fleet in a radioactive water and radioactive debris from the lagoon bottom.
- Shot Baker produced a 25 foot-deep crater on the sea floor, with much of that material dispersed throughout the lagoon.
- Wayne Guthrie of the *Indianapolis News* was on-board the USS Appalachian and witnessed both detonations. He described the immediate after effects of Baker:

  > "The water column seemed to hang in the air for some time," he wrote, "pouring thousands of tons of poison rain and deadly mist down on the vessels like many Niagaras. Then it dissipated and fell. A creamy cloud hovered over the array for several minutes and then was blown away by the wind."

- Members of the Joint Chiefs of Staff Evaluation Board were blunt: "These contaminated ships became radioactive stoves and would have burned all living things aboard them with invisible and painless but deadly radiation."
- Unexpectedly, Crossroads had fully exposed for the first time one of the most terrifying aspects of the Atomic Age—localized and intense radioactive fallout.

Unexpected Radioactive Contamination

- BAKER deposited radioactive products on the target fleet in amounts far greater than had been predicted, with the radiation spread out on the ships unevenly and unpredictably.
- The detonation lifted millions of tons of water in a column about 2200 feet in diameter to a height of 5500 feet, according to a July 30th Joint Chiefs of Staff Evaluation Board's preliminary dispatch.
- About two million tons of that water came back down into the lagoon mixed with radioactive coral and sand from the sea floor.
- Surrounding the base of the column was a foaming water wall several hundred feet in height.
- Waves outside the water column were 80-100 feet in height, diminishing in size to about seven feet at Bikini Island, about 5000 yards away (2.84 miles).
- This water contained a dangerous amount of fission products and leftover plutonium. One estimate was that half or more of the fission products would be deposited in the area of the lagoon within a few minutes of the explosion (DNA report).

The Dire Situation

- The radiological contamination of the target vessels which followed Shot Baker was the most startling and threatening aspect of either test, according to E.H. Batcheller, Chief of the Bureau of Ships, reflecting a widespread view.
- He further observed:

  ‘Whereas indications of radioactivity on target vessels after the air burst [Shot Able] were confined to vessels close to the point of burst and dropped to within the permitted tolerance on all vessels within three days, the radiological contamination which followed the subsurface burst extended to vessels beyond the 4000 yards radius and was so heavy and persistent that most target vessels could be boarded for only brief intervals over a period of weeks and in some cases months.”

What had been predicted?

- Planners were aware of the risk of a rising column of radioactively contaminated water but focused on the destruction that could be caused by an underwater shockwave on ships' hulls.
- Moreover, early planning had calculated that the column would reach a height of 12,000 to 20,000 feet. At this height, the radioactive intensity of the falling water would have caused far less intense contamination of the ships and lagoon. It would have been more spread out, over a wider area, in essence reducing the level of radioactive contamination via dilution.
- One scientist in JTF-1, Dr. Penney warned in a June 19, 1946, memo that the methodology for the above result was flawed; he estimated the true height would be closer to 8000 feet. His warning was ignored.
- The Radiological Safety Section of JTF-1 had predicted that if the radioactive column from the explosion did not rise more than 10,000 feet, the radiological conditions would be "extremely serious."
- The height, as mentioned above, was only 5500 feet, causing much more intense radioactive contamination locally than planned for.

What were the types of radiation encountered during Crossroads?

- The personnel at Operation Crossroads were exposed to alpha, beta, and gamma radiation from fission and activation products and unfissioned plutonium, all of which can cause radiation sickness and cancer.
- Alpha radiation results when a radioactive nuclei decays, producing a positively charged, high-energy particle consisting of two protons and two neutrons tightly bound together. These particles result from the decay of plutonium 239. They can penetrate only the outer layers of skin, but if ingested or inhaled, are extremely damaging to cells.
- Beta radiation consists of electrons, several thousand times lighter than alpha particles, and more penetrating. Beta radiation can damage cells on or near the surface of the skin and be ingested or inhaled, causing damage to cells. The exposure of the skin can lead to what are called “beta burns.” A source of beta radiation is strontium 90, a long-lived fission product, which migrates to bones. Another is sodium 24 which was produced in large quantities in the sea water by neutrons from fissioning during the Able and Baker detonations activating a huge amount of the sodium in sea water. Sodium 24 has a half-life of 15 hours, making it a risk to the skin and via inhalation or ingestion for up to a week.
- Gamma radiation is high energy electromagnetic radiation that can penetrate the body and deliver a radiation dose to the whole body. An example source is long-lived cesium 137.

Unpreparedness of the Military

- Regardless of the advance estimates of the height of the water column, the Joint Task Force 1 was not prepared to handle the widespread radioactive contamination or the immense decontamination effort needed to safely crew the remaining target ships.
- According to the Navy's *Radiological Decontamination of Target and Non-Target Vessels*, Operation Crossroads official decontamination report:
    - "Since the nature and extent of the decontamination was completely unexpected, no plans had been prepared for organized decontamination."
- Instrumentation to detect radiation was limited and focused on detecting gamma radiation. There were no instruments able to detect beta radiation reliably or detect alpha radiation at all.
- The deployed instruments were poor at measuring the rate of radiation exposure from gamma rays, an extremely important measurement for determining how long personnel could stay on a ship or in an area of the ship without risking overexposure.
- There were far too few radiation safety monitors.
- There was disregard for then existing radiation safety by navy officers and crew.

The U.S. military was also unprepared to manage radiation exposures through radiation standards

- The typical way to protect workers is to limit exposure based on a radiation standard, such as this is how long you can spend in a radiation environment of a given intensity to ensure you do not receive a dangerous amount of radiation.
- Today, radiation standards are highly developed. However, at Crossroads, radiation standards were in their infancy and poorly implemented or enforced.
- A limit was established for gamma exposure, but it quickly became apparent that this standard was difficult to use or enforce in practice and it provided no guidance on beta or alpha exposures.
- Colonel Stafford Warren, Chief, Radiological Safety Section of JTF-1, became extremely disheartened by the whole Crossroads exercise, reflected after the test in January 1947:

  "In view of the experience with this whole subject [of radiation standards] in the past, it is my recommendation that no attempt be made to fix a range of tolerances for military operation....They would hardly be worth the paper they are printed on."

Decontamination of the Ship Starts

- Within a few days the nontarget ships were moved back into the lagoon.
- Decontamination of the target vessels started in earnest by August 1st, a week after the Baker test.
- Initially, decontamination was slow as the safe time aboard some of the target ships was measured only in minutes.
- Complicating the situation, relatively rapidly, the support ships also became contaminated by radioactivity in marine growth and irradiated coral on the ships' hulls and in the ships’ seawater piping systems used in their distilling plants and evaporators to generate freshwater for use shipboard.

Decontamination Methods

- The decontamination effort initially involved washing the ships' exteriors using work crews drawn from the target ships' companies under radiological supervision of monitors equipped with radiation detection and measurement devices.
- Many decontamination methods were tried, ranging from spraying of contaminated lagoon water by salvage tugs to scrubbing with water, soap, and lye.

A Navy tug sprays down USS *New York* after Baker to decontaminate the battleship. *(U.S. Naval Institute)*

Sailors Decontaminating a Ship

"The chief turned his booted, sweating, profane, and laughing crew loose with brushes, water, and a barrel of lye." Decontamination efforts aboard Prinz Eugen. (National Archives; from National Park Service)

- Sailors were generally unaware of the radiation risks.
- There was inadequate supervision of men doing decontamination work, including on the Prinz Eugen
- Notice no protective equipment on the Prinz Eugen sailors in the image and the jokey tone suggested in the caption and image.
- A radiological safety officer for the ship complained about an "attitude of indifference on the part of the ship's officers of the Prinz Eugen to the safety standard set by RadSafe."
- He continued: "Men were being kept aboard for longer periods than they should be," based on the radiation standard for gamma exposures.

Decontamination was failing

- Extensive contamination was being found throughout the target ships. The contamination was not uniform but spread out unevenly, with many “hot” spots giving off larger amounts of radiation. Examples included rusty spots, paint, tar, grease, wooden decks, ropes, crevices, and canvas.
- Few methods were working to decontaminate the ships.
- The only effective means of decontamination was sandblasting surfaces of the ships to bare metal, removing highly contaminated materials, such as wooden decks and ropes, and using nitric acid to decontaminate other metal objects made from brass or copper.

Problems Intensify, according to Col. Stafford Warren, Chief, Radiological Safety Section, JTF-1

- "The initial contamination of surfaces was so great that reduction on the deck and other surfaces of 90% or more still leaves large and dangerous quantities of fission [products] and alpha emitters scattered about."
- "Contamination of personnel, clothing, hands, and even food can be demonstrated readily in every ship in the JTF-1 in increasing amounts day by day."
- As decontamination continued, he further observed, personnel exposure levels climbed.

Radiation Exposure Pathways

- The indications are that the overwhelming majority of military personnel involved received doses of radiation from a number of pathways:
  - Living and working aboard non-target ships in the Bikini lagoon:
  - Retrieving experimental animals, important instrumentation that had recorded data during the Baker detonation, and other equipment aboard the target ships and from the lagoon and beaches;
  - Measuring the radioactivity in the area of the explosion and on the target ships:
  - Attempting to decontaminate the target ships: and
  - Preparing target ships for towing both within the lagoon and out of it.

Detection of Plutonium

- Plutonium [alpha emitter] was discovered in samples taken on some of the ships.
- On the ship Prinz Eugen, plutonium was determined to be in inner areas of the ship where instruments showed gamma radiation intensities sufficiently low to permit extended personnel exposure [8 hours] without danger of injury from gamma radiation.
- Plutonium was viewed as an extremely dangerous source of radiation exposure to lungs and bones.
- This plutonium was not detectable with monitoring instruments in use at Bikini. It was discovered by analyzing samples, a method difficult to implement at Bikini, or by inference.
- Further investigation showed probable widespread presence of the alpha emitter [plutonium] in the target area even in areas of ships not obviously contaminated.
- Stafford Warren worried that every contaminated surface could harbor many lethal doses of plutonium.

Halting Decontamination Efforts in the Lagoon

- Radiation doses were increasing among navy personnel but in ways that were not covered by radiation standards or detected by instruments at Bikini.
- Radiation monitors were reaching their allowed radiation limits.
- There was a growing recognition of the need for special clothing and intensive training for major work on the target ships to continue.
- Stafford Warren concluded that the task force faced "great risks of harm to personnel engaged in decontamination and survey work unless such work ceases within the very near future."
- By August 10th, the JTF-1 leader Vice Admiral Blandy was convinced to call off the decontamination effort.

Shot Charlie “Indefinitely Postponed”

- CHARLIE was originally planned to involve a small flotilla of ten target ships, (five submarines and five capital ships) in deep water outside the Bikini Atoll.
- Decontaminating and preparing these ten ships after Shot Baker for the Charlie test was posing a serious challenge.
- With the delays and hardships, there was a concern that this test would require too many personnel from Los Alamos, interfering in advancing research and development of nuclear weapons. Los Alamos would need to send many key personnel to place and detonate the Test Charlie device. This concern was a particular reason for opposition to the third test by the leadership of the Manhattan Engineering District.
- Despite the lack of data whether a deep underwater test could more effectively destroy ships than either an airburst or shallow underwater test, U.S. military leadership became opposed to a third test, arguing that the first two tests had provided sufficient information for the time being.
- Senior U.S. military officials recommended to the President to indefinitely postpone the third test, despite dissent from the Commander of JTF-1. He did so in early September.
- A deep underwater test finally took place in 1955 during Operation Wigwam, conducted off the coast of Mexico.

Fate of the Fleet

- A decision was made to tow the surviving target fleet to Kwajalein Atoll where work could be done in uncontaminated water.
- Nonetheless, Admiral Blandy reported that "only 9 of 92 [target] ships escaped at Bikini."
- Almost all target ships that left Bikini Atoll were ultimately sunk in deep water at sea as too contaminated to scrap or otherwise use, except for target practice. (Fifty of the target ships were sunk after being used for target practice.)
- After a year of complicated decontamination efforts, all the support ships received a radiological clearance and returned to service.

If sailors had been on the ships during detonation?

- Shot Able, which was an air-burst, would have exposed the sailors to heat and blast, as well as prompt neutron and gamma radiation. If unprotected, casualties would have been high within one mile of the blast. Fallout would not have been a factor on the ships, since the radioactive fission products and plutonium were injected high into the atmosphere and distributed regionally and globally.
- Shot Baker produced fallout significantly different from an air or surface burst. The water absorbed most of the initial radiation and thermal energy, and radioactive fission, plutonium, and activation particles were distributed primarily by a radioactive water surge rather than a large atmospheric cloud
- A Major Young provided commentary of the expected casualties after Baker:
  - The explosion produced intense radioactivity in the waters of the Lagoon. Part of this was by reason of the neutron bombardment of the sodium in the salt, contained in sea water, but the water was further dangerously contaminated by fission products from the bomb itself. Radioactivity immediately after the burst is estimated to have been equal to many hundred tons of radium. A few minutes exposure to this intense radiation at its peak, would, within a brief interval, have incapacitated human beings and have resulted in their death in days or weeks.
- The danger was vividly portrayed by the fate of the hundreds of test animals after Test Able. According to a short, July 15th Associated Press report, quoted in the National Park Service report (see reference slide), noted that the test animals were "dying like flies.... Animals that appear healthy and have a normal blood count one day, 'drop off the next day,' an officer said...."

Sobering Realizations by the Joint Chiefs Of Staff Evaluation Board, excerpts from its1947 final Operation Crossroads report

- The correlation of the results of the explosions of atomic bombs over Japanese cities and against naval vessels, at Bikini, gives ample evidence that the bomb is pre-eminently a weapon for use against human life and activities in large urban and industrial areas, as well as seaports.
- “Passive defense measures" such as bomb-proofing and underground construction, are impracticable for the defense of cities.
- TEST BAKER gave evidence that the detonation of a bomb in a body of water contiguous to a city would vastly enhance its radiation effects by the creation of a base surge whose mist, contaminated with fission products, and dispersed by wind over great areas, would have not only an immediately lethal effect, but would establish a long-term hazard through the contamination of structures by the deposition of radioactive particles.
- The Board is emphatic in its assertion that if used in suitable numbers, atomic weapons can destroy nations and that the one and only safeguard mankind can have against the fear of the destruction of civilization is the outlawing of war in all forms.
- Until such circumstances existed, “this nation can hope only that an effective deterrent to global war will be a universal fear of the atomic bomb as the ultimate horror in war.”

Realizations (Cont.)

- The Board concluded that the “immediate and continuous preparation for the contingencies of atomic warfare is the part of prudence.”
- Offense, recognized in the past as the best means of defense, in atomic warfare will be the only general means of defense.
- The Board proposes that Congress define, and, from time to time, redefine what constitutes an "aggressive act" and that it direct the President, as Commander in Chief, to launch an attack against any nation when in his opinion and in that of his cabinet, that nation is preparing an atomic attack upon the United States. Preemptive attacks to prevent an adversary obtaining nuclear weapons need to be considered and justified legally.

Final Observations

- The risk of fallout was lost to successive U.S. officials, leading to over two hundred more above ground nuclear tests.
- Operation Crossroads showed the horror to be expected in any war involving nuclear weapons, even these relatively low yield weapons, as judged by later standards.
- Marginal changes were made to U.S. naval ships to better protect against the effects of a nuclear blast, although most of the Navy's interest laid in outfitting its ships with nuclear weapons.

Atomic Guinea Pigs

- The tests ushered in an era of the use of military personnel to do the “grunt” work at nuclear tests and serve as “guinea pigs” during simulated nuclear battlefield maneuvers following a nuclear blast, unknowingly being exposed to dangerous amounts of radiation
- In all, about 250,000 Department of Defense (DOD) participants, both military and civilian, were present at the above ground tests that stretched to 1962 in the Pacific, the Atlantic, and the Nevada Test Site.
- The truth about the level of radioactive contamination and radiation exposures at Operation Crossroads was hidden from the public for decades, revealed eventually as Crossroads veterans started to seek assistance or compensation for their illnesses, which they linked to radiation exposure at Crossroads.
- It was the belated discovery of the papers of Stafford Warren at the UCLA library that first revealed publicly and definitely the full radiological disaster that was Operation Crossroads.
- Ultimately, partial compensation was provided for certain cancers via the 1990 Radiation Exposure Compensation Act (RECA). It provides one-time payments to individuals who developed certain illnesses after exposure to radiation from U.S. nuclear weapons testing or uranium industry work. Efforts at compensation for others exposed continue.
- Bikini Atoll remains highly contaminated and the originally displaced inhabitants, who thought they would soon return, could not because of extensive contamination. In 1972, about 100 residents returned but had to leave again several years later, as abnormally high levels of long-lived radionuclides were measured in the lagoon and in their bodies.

Selected References

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Effects of Radiation Exposure (from AI)

- Radiation can harm humans through both acute and long-term effects, depending on the dose and duration of exposure. Acute effects from high doses include nausea, vomiting, hair loss, and potentially fatal acute radiation syndrome (ARS) or cutaneous radiation injury. Long-term risks from lower doses include an increased risk of developing cancer later in life, cataracts, and potential effects on the reproductive system.
- Acute effects (high-dose, short-term exposure)
  - Acute Radiation Syndrome (ARS): Occurs from high levels of radiation in a short time, causing symptoms like nausea, vomiting, fatigue, and in severe cases, can be fatal.
  - Cutaneous Radiation Injury (CRI): Radiation burns to the skin, which can range from temporary redness and blistering to severe, long-lasting damage like ulcers, hair loss, and necrosis.
  - Other symptoms: Include headaches, dizziness, and confusion.
- For more information on high dose exposure and acute effects, see https://www.cdc.gov/radiation-emergencies/signs-symptoms/acute-radiation-syndrome.html

Radiation Effects (lower doses)

- Long-term effects (lower-dose, chronic or delayed exposure)
  - Cancer: Radiation exposure, especially at high doses, significantly increases the risk of developing cancer years or decades later. Studies have shown increased risk even at lower doses, particularly in children.
  - Cataracts: High doses to the eyes can cause cataracts, a clouding of the lens that impairs vision.
  - Thyroid damage: Exposure to radioactive iodine can specifically damage the thyroid gland.
  - Blood disorders: Lower levels of exposure can reduce the number of blood cells, leading to immune problems.
  - Effects on the reproductive system: Fast-dividing cells in the reproductive organs are particularly sensitive to radiation, which can cause temporary or permanent sterility