The Plowshare Program: Environmental Perceptions and Impacts

A research paper submitted to the faculty of
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degree

Master of Arts
in
Geography

by

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San Francisco, California

May, 1992

CERTIFICATION OF APPROVAL

I certify that I have read The Plowshare Program: Environmental Perceptions and Impacts by Stephen Skartvedt, and that in my opinion this work meets the criteria for approving a research paper submitted in partial fulfillment of the requirements for the degree: Master of Arts in Geography at San Francisco State University.

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The Plowshare Program: Environmental Perceptions and Impacts

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1992

This research paper examines environmental perceptions and landscape impacts of experiments conducted as part of the Atomic Energy Commission's Plowshare program. Environmental perceptions are investigated by evaluating Plowshare documents and military land use patterns. Maps, photographs and government documents provide the basis for determining the landscape impacts of the program's nuclear and high explosive experiments. Source material is drawn largely from Atomic Energy Commission and Department of Energy reports and memoranda.

I certify that this Abstract is a correct representation of the content of this thesis.

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Nancy Wilkinson Date

ACKNOWLEDGMENTS

Thanks to Vernon Brechin for photographs, research material and moral support. Eric Havel and Bob Bathrick provided much needed help with the maps. Thanks to Janet Fogg of the DOE and Yvonne Townsend of the CIC for their patience with my requests and support of my research efforts. Grateful appreciation to Larry Johns for the test site maps, without which most test locations would remain unknown to the author. Finally, thanks to my committee for their encouragement and help with this paper and, more broadly, to Nancy for introducing me to the field of environmental perception and to Hans for teaching me the art of cartography.

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SECTION I

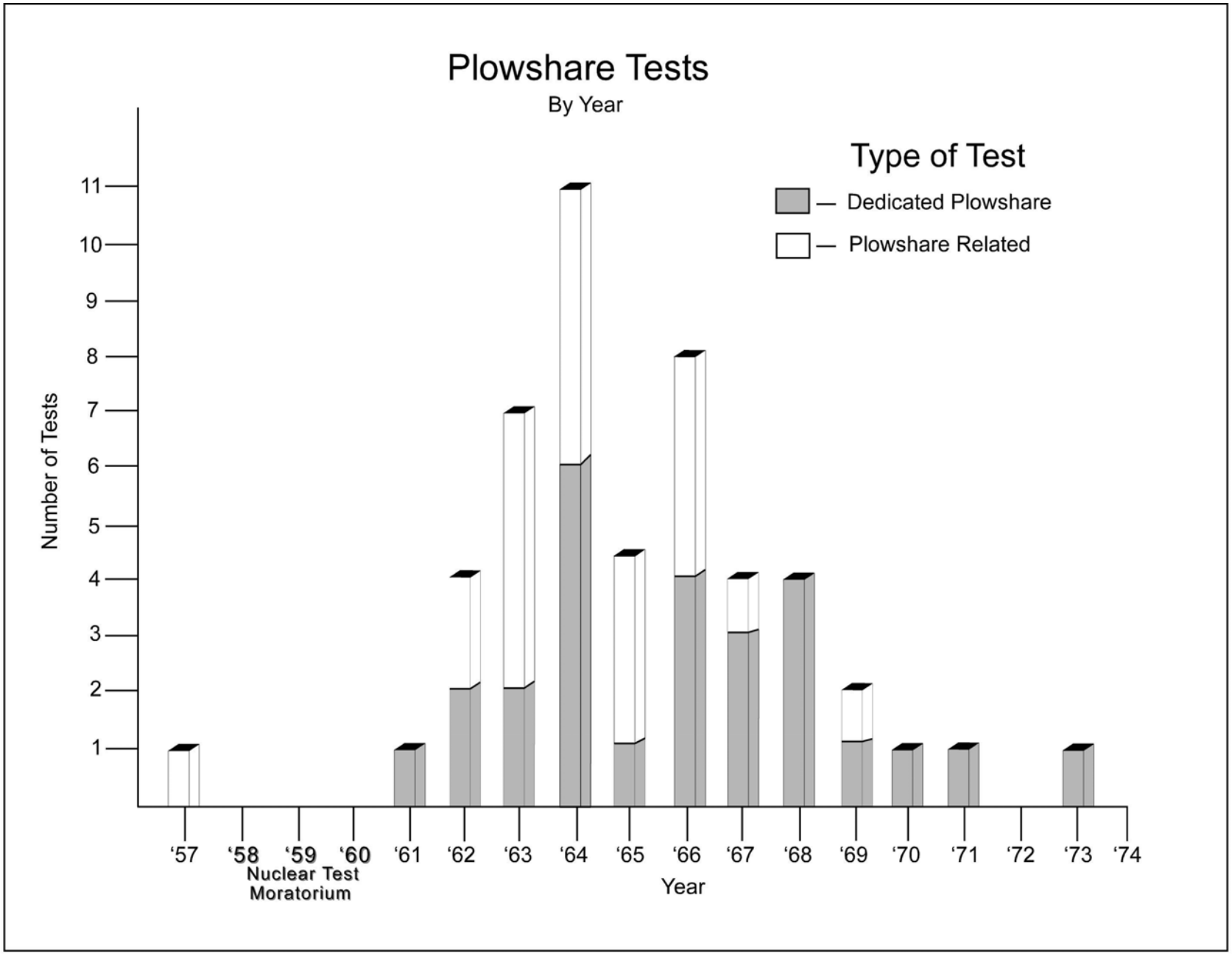
INTRODUCTION

This research paper discusses environmental perceptions and landscape impacts of United States military and nuclear related activities. It will focus on the proposed and actual nuclear and non-nuclear experiments conducted as part of the Atomic Energy Commission's (AEC) Plowshare program.

The Plowshare program, established by the AEC in 1957, was created to develop peaceful uses of nuclear explosives. It was believed these peaceful uses would benefit society in a myriad of ways. For example, world commerce would thrive as harbors and canals were built wherever they were deemed necessary, medicine and science would receive an inexhaustible supply of isotopes and the oil and gas industry would profit from production fields rendered more accessible and profitable through the use of nuclear explosives. It was envisioned that the Plowshare program would, in the words of Edward Teller, "extend our power over natural phenomena far beyond anything we can... imagine."{1} Eighteen years and more than 40 tests later the program's budget was eliminated due to technical and political obstacles [Figures 1a & lb].{2}

This paper begins with a discussion of the aims, objectives and justification for the research, followed by a description of the author's research goals. Next, a small part of the intermountain west - southern Idaho - is examined to illustrate the perceptual conflicts between the military and other groups. Southern Idaho has been chosen because it is a stage for

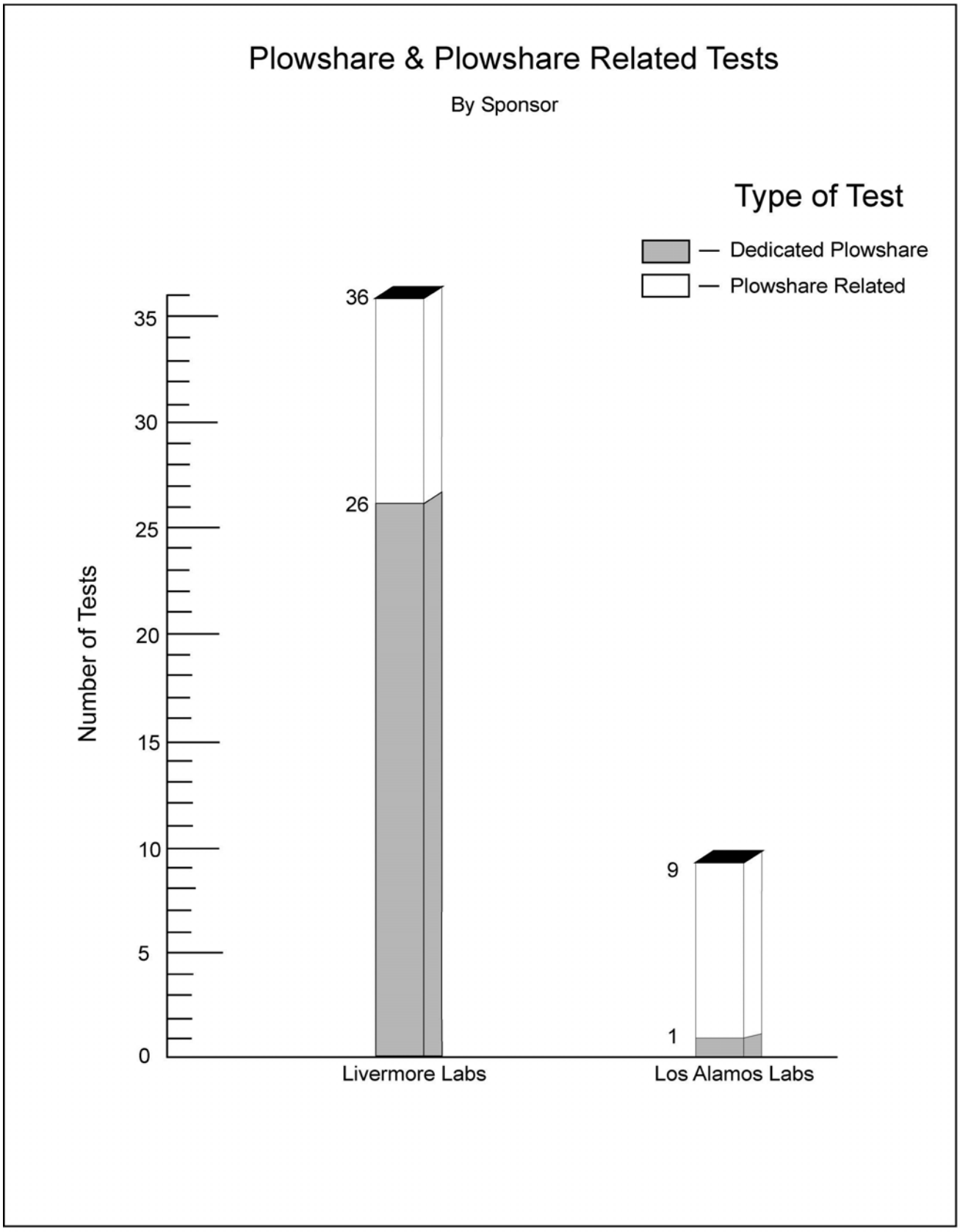
1. Findlay, T. Nuclear Dynamite, 1991, p. 3
2. Borg, I. "Nuclear Explosions For Peaceful Purposes", 1986, p. 11



Source: Findlay, T., Nuclear Dynamite, 1990, pp. 293-294

Figure 1a

Figure 1b



Source: Findlay, T., Nuclear Dynamite, 1990.

some of the common perceptual conflicts between these groups. The body of the paper discusses events leading up to the Plowshare program and Plowshare excavation, physics and extraction tests, emphasizing environmental perception and landscape impacts. Appendix A describes in detail source material relating to the Plowshare program, while Appendix B contains a complete listing of all Plowshare and Plowshare-related tests.

AIMS & OBJECTIVES

This study attempts to compile available Plowshare information in a useful overview, which highlights environmental perceptions, and landscape impacts. By assembling specific information about the Plowshare program, it is possible to illustrate the perceptual assumptions of Plowshare planners as reflected in Plowshare test site selection, as well as investigate the physical effects of the teats on the land itself. It is hoped this review of the Plowshare program will serve as a basis for further Plowshare research and alert the reader to the perceptual biases and landscape impacts inherent in nuclear testing.

Information about the Plowshare program is scarce and widely dispersed among various sources [see Appendix A]. Specific information regarding site selection is available for only a fraction of the Plowshare tests. Where available, direct quotes and citations concerning site selection will be used; where these are unavailable, inferences will be made based on other activities in the same area, or general patterns based on geographic region, land use, climate and population density.

The environmental impacts of Plowshare tests, due to the physical force of the explosions and the radioactive by-products created, are significant and should be more widely known and appreciated. The physical effects on the land are evaluated with topographic maps and, when available, photographs.

Finally, this paper underscores the importance of public participation and consent in current and future government programs, particularly when these programs are shielded from direct scrutiny by classification laws. It is likely the Plowshare program would not have gone beyond the planning stages had the public been more thoroughly involved and aware of the dangers inherent in nuclear testing.

RESEARCH GOALS

This paper grew out of an interest in differing attitudes towards desert landscapes, particularly the state of Nevada. The nation's view of Nevada and the state's self-perception intrigued me. For example, promotional billboards within Nevada humorously play on the state's image as an expanse of empty desert: Highway 50 is labeled "The Loneliest Road in America" while Winnemucca is "Always Open". This "empty desert" image is used in a less jovial light by Citizen Alert, a Reno-based environmental organization, which proclaims that "Nevada is Not A Wasteland" on its bumper stickers. However, the perception of Nevada as a wasteland or a "good place to throw used razor blades" is most dramatically exemplified by the existence of the Nevada Test Site (NTS), the nation's testing ground for nuclear weapons.{3} I wanted to determine why the Test Site had

3. U.S. Dept. of Defense, "Armed Forces Talk", 09/19/52; see Rosenburg, Atomic Soldiers , p. 17

been located in Nevada, and not, for example, North Dakota.

While researching NTS, it became clear that the Plowshare program is a more suitable research topic. First, the program rests on the assumption that technology exists to rework and thereby improve the existing environment. It therefore directly addresses environmental perception and “desirable” landscapes. Second, for the Plowshare program to be successful, public acceptance and support from industry was vital. This support required the disclosure of specific proposals, techniques and results of Plowshare tests. Therefore, although “the Plowshare program must always live with nuclear secrecy,” Plowshare-related literature was made available to the general public and the interested researcher in a manner unprecedented in the nuclear industry at that time.{4}

RESEARCH STRATEGIES

Plowshare information is still difficult to obtain. Nearly half of the Plowshare tests are “multipurpose shots”; that is, they have weapon design applications and information about these tests remains classified.{5} Further, much of the unclassified material given to or generated by private industry (such as Stanford Research Institute or CER Geonuclear Corp.) is proprietary information and remains off limits to the public.{6} In the public domain, a review of over forty popular books concerning the subject of nuclear testing found only a few that contained more than general information about the Plowshare program.{7}

While gathering general information about Plowshare

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4. See, for example, Joint Committee on Atomic Energy Hearing (hereafter JCAE) “Commercial Plowshare Services”, 1968, p. 8
5. Findlay, T., Nuclear Dynamite, 1991, p. 294
6. Phone conversation, SRI, 11/15/91
7. See Appendix A

experiments can be frustrating, obtaining specific details about Plowshare tests, such as the location, purpose, and environmental and health effects of proposed or actual tests requires still more diligent research. Maps disclosing the location of all Plowshare tests were only recently made available in response to a subpoena by the law firm Johns & Johns of Las Vegas [Map 63]. Likewise, information needed to correlate a particular Plowshare test name to its drillhole location (i.e. test “SWITCH” is located at drillhole “U9bv”) is first made explicit in this study. Documents describing the purpose of specific Plowshare tests are typically vague and, even when written by the same agency, often contradictory [Figure 2].{8} Also, no consensus exists as to which weapons development tests are Plowshare “related”; that is, which tests, while primarily related to weapons research, made a peripheral contribution to Plowshare technology [Figure 3].{9} Finally, comprehensive information concerning the environmental and health effects of Plowshare tests (i.e. radiation releases) is difficult to acquire. A particularly useful document, “Radiological Effluents Released From Announced Continental Tests, 1961-1988” was only made available to the public through the efforts of The Downwinders, an advocacy group based in Utah.{10} However, this document contradicts as often as it substantiates earlier published material regarding the same nuclear tests, highlighting the need for further research and government accountability in this area [Figure 4].{11}

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8. See, for example, US AEC, “STORAX Test Bulletin #42 [KENNEBEC]”, dated 6/27/63, and US DOE, “Announced United States Nuclear Tests”, (hereafter “Announced US Nuclear Tests”) rev. 11, 1991, NV-209, p. 27
9. See, for example, Findlay, T., Nuclear Dynamite, p. 294 and “Plowshare Chronology”, US AEC, 1969.
10. Interview with Preston Truman, Salt Lake City, 08/27/89
11. See, for example, “Radiological Effluents Released From Announced Continental Tests”(hereafter “Radiological Effluents”) [KAWEAH], US DOE, 1990 p. 41, and US DOE, “Announced US Nuclear Tests”, p. 25

Figure 2

Purpose of Selected Plowshare Tests

As Indicated by Various Sources

Test Name	Device Development	Heavy Element Production	Emplacement	Weapons Related	Phenomenology
Anacostia	b,c,h,n	a,g,k,l,j			
Kaweah	b,c,h,j,n	a,g,k,l,j			
Kennebec	j	a,g,j,k,m		c,h,l,n	
Tornillo	b,c,g,k,l				
Klickitat	b,c,g,k,l				
Ace	b,c,g,k,l				
Dub	b,c,h,l		a,g,j,l		
Par	b,c,g,,j	a,c,f,g,h,j,k,l,n			
Handcar				j	b,c,k,l,n
Templar	b,c,g,k,l				
Vulcan	a,c,k,j	b,c,f,h,j,k,l,n			
Saxon	b,c,g,k,l				
Simms	a,c,k,j				
Switch	b,c,g,k,l				
Marvel	a,g,l,k?		b,c,j,l		
Sloddard	b,c,g,k,l				
Flask	b,c?,g,k,l				
Minitia	b,c,k,l				

Note: For list of sources see index at end of bibliography

Figure 4

Radiation Release Discrepancies

Plowshare & Plowshare Related Tests

Series Name\Test Name	Radiation Release? Yes	No	Test Publicly Announced? Pre-Shot	Post-Shot
Plumbob\Rainier				yes
Nougat\Gnome	e,c		yes	
Nougat\Hard Hat	e,c,on			
Nougat\Danny Boy	e,c,off			
Storax\Sedan	e,c,off			yes
Storax\Anacostia	e,c,on		?	yes
Storax\Kaweah	e	c,m	?	yes
Storax\Gerbil			?	yes
Storax\Kennebec	e,c,on			yes
Niblick\Tornillo	e	c	no	yes
Niblick\Shoal			yes	
Niblick\Anchovy	e,c,on		?	yes
Niblick\Greys	e	c	?	yes
Niblick\Oconto	e,c,off	d	?	yes
Niblick\Klickitat	e	c	yes	
Niblick\Ace	e,c,on		?	yes
Niblick\Dub	e,c,on		?	yes
Whetstone\Bye	e	c	no	yes
Whetstone\Par	e	c	?	yes
Whetstone\Barbel	e	c		
Whetstone\Salmon			yes	
Whetstone\Handcar	e,c,off		yes	
Whetstone\Parrot	e,c,off			
Whetstone\Sulky	e,c,off			
Whetstone\Palanquin	e,c,off			
Whetstone\Scaup			?	yes
Whetstone\Tweed	e	c		
Whetstone\Petrel	d,on	c,e	?	yes
Flintlock\Templar	e	c		
Flintlock\Duryea	e	c		
Flintlock\Cyclamen			?	yes
Flintlock\Piledriver	e,c,on	m	no	yes
Flintlock\Kankakee	e	c,m	no	yes
Flintlock\Vulcan	e	c	no	yes
Latchkey\Saxon	e	c	?	yes
Latchkey\Simms	e	c	?	yes
Latchkey\Persimmon			no	yes
Latchkey\Switch	e	c	?	yes
Crosstie\Marvel	e,c,on			
Crosstie\Gasbuggy			yes	
Crosstie\Cabriolet	e,c,off			
Crosstie\Buggy	e,c,off			yes
Bowline\Stoddard	e	c		
Bowline\Schooner	e,c,off	c		yes
Mandrel\Hutch	e			
Mandrel\Rulison	e,c	d	yes	
Mandrel\Flask	e,c,on			
Grommet\Miniata	e	c		
Toggle\Rio Blanco			yes	

Bold - declared Plowshare test

Note: For list of sources see bibliography; on/off refers to release detected on or off the Nevada Test Site boundary.
Where no reference is cited, all sources agree there was no radiation release.

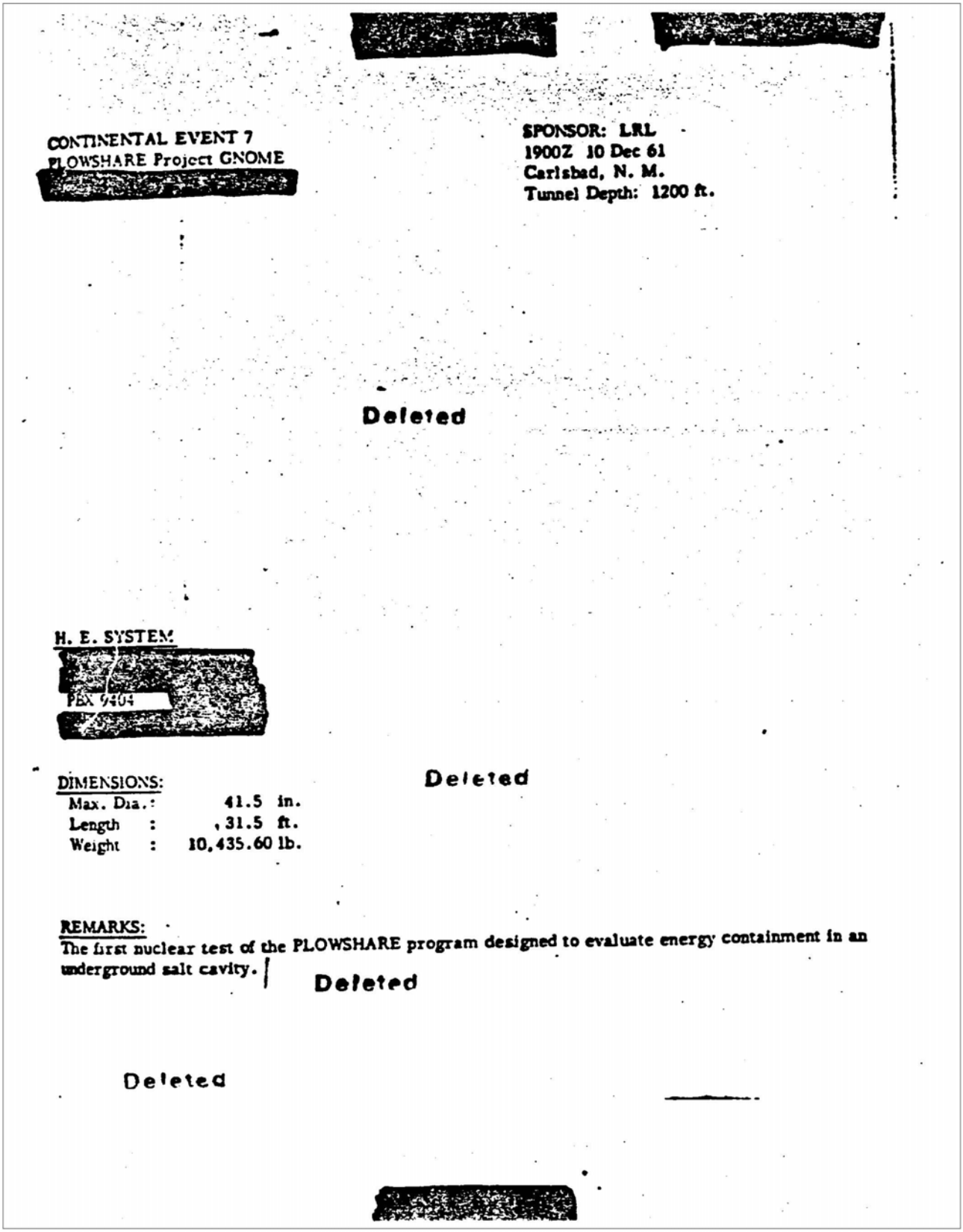
TECHNIQUES AND LIMITATIONS OF STUDY

I was initially intimidated by the technical and secret nature of the Plowshare program and nuclear weapons testing in general. As I grew more comfortable with the topic, it became easier to make calls to various people involved in the issue. While few of these calls were informative in the strict research sense, taken together they added to my confidence with the material. I became less defensive about being interested in something “nuclear” and being put on a government list of malcontents somewhere. I began to feel as entitled as anyone to dig around. Such a sense of entitlement is a necessary prerequisite for research that involves the Department of Energy.

As a way to organize my research, I initially focused on cataloguing basic facts about as many Plowshare tests as I could. In retrospect, this was a good approach. Tracking down a reference to one test would often reveal another Plowshare test unknown to me. Through this method, I assembled what I believe to be the most comprehensive list of actual and proposed Plowshare tests in the open literature [Appendix B]. Also, in the course of collecting facts, I gradually became acquainted with the technical and political aspects of the Plowshare program. Thus, cataloguing tests allowed me to assimilate many of the whys and wherefores of a program that had previously seemed inordinately complex.

The major limitation of a study such as this is government secrecy and bureaucracy. Documents are difficult to obtain or are “sanitized” and provide little information [Figure 5]. Another limitation of this study involves this researcher’s lack of background in the hard sciences. At best, this limitation

Figure 5



CONTINENTAL EVENT 7
PLOWSHARE Project GNOME
[redacted]

SPONSOR: LRL
1900Z 10 Dec 61
Carlsbad, N. M.
Tunnel Depth: 1200 ft.

Deleted

H. E. SYSTEM:
[redacted]
PEX 9404

Deleted

DIMENSIONS:

Max. Dia.	:	41.5 in.
Length	:	31.5 ft.
Weight	:	10,435.60 lb.

REMARKS:
The first nuclear test of the PLOWSHARE program designed to evaluate energy containment in an underground salt cavity.

Deleted

Deleted

[redacted]

Source: Defense Atomic Support Agency "Nuclear Test Summary: Nougat-Dominic (Sanitized)", DASA-1211-SAN,

made it difficult to independently assess impacts of Plowshare tests. At worst, it made it impossible to read certain documents. However, it is hoped that this paper will provide a template for further research into Plowshare or other nuclear testing topics. In the realm of government secrecy, where even the number of classified documents is a classified matter, such research is sorely needed.{12} Appendix A describes the availability and quality of source material available from government agencies, libraries, and citizen groups as well as sources not consulted by this researcher.

STUDY AREA

Most of the proposed and actual Plowshare sites are located in the intermountain west - the broad region delineated on the west by the Sierra Nevada and Cascade range and on the east by the Rocky Mountain range [Map 1a]. Within this region lies the Nevada Test Site - the specific location for most Plowshare tests [Map 1b & Map 2]. Areas discussed outside this region include Alaska, Pennsylvania and coastal California.

SOUTHERN IDAHO

As noted, southern Idaho has been chosen as a introductory case study because it serves as a typical example of the perceptual conflicts between the military and other groups in the intermountain west. Idaho was also chosen to emphasize a point: many sections of the intermountain west, not just the Nevada Test Site, have been and continue to be affected by military activities.{13}

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12. “Archivists Puzzle Over Unlocking Old Documents” S.J. *Mercury News*, 12/18/91
13. See, for example, Nash, G., The American West Transformed, 1985, p. ix

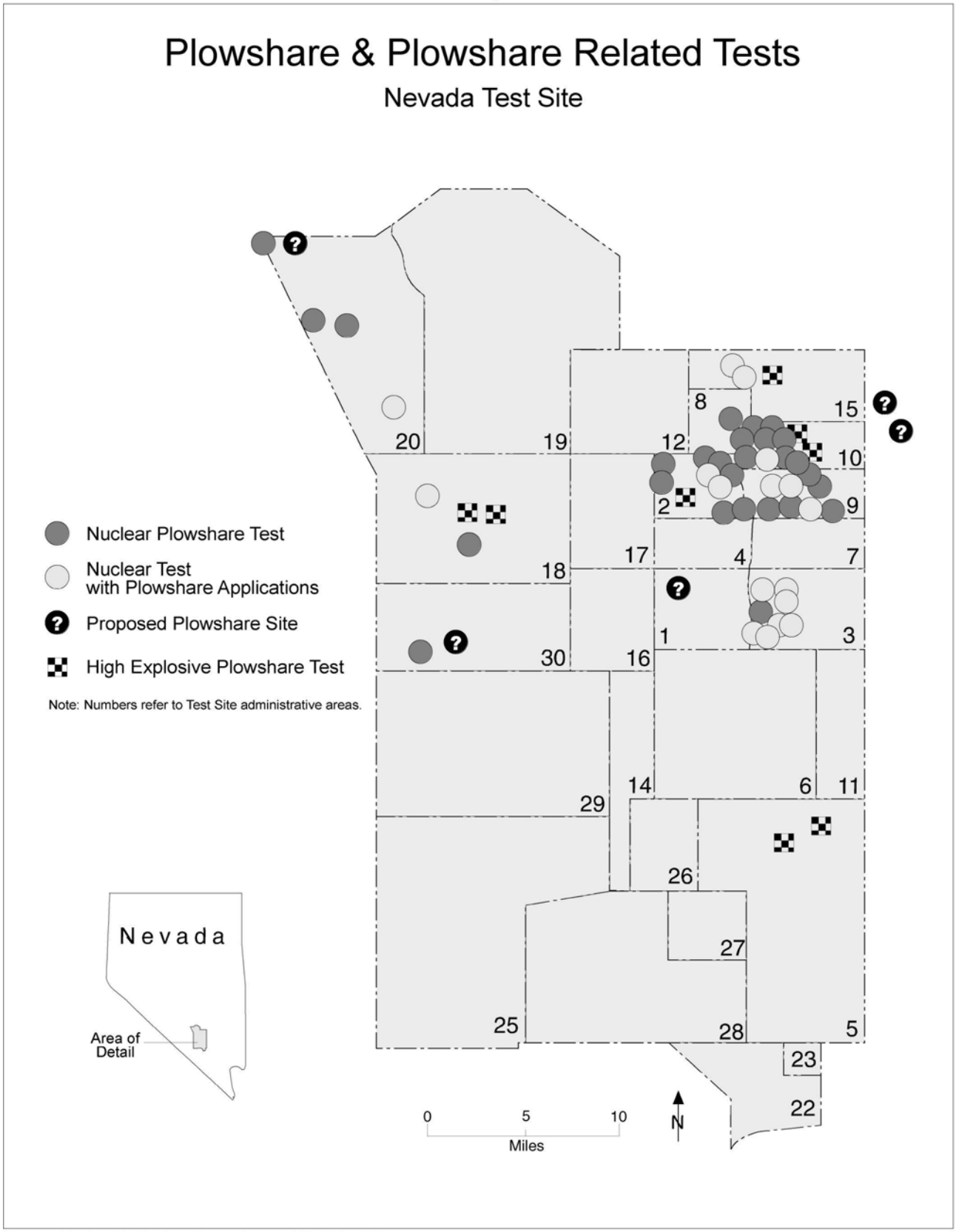
Plowshare and Plowshare Related Tests

Outside of the Nevada Test Site

Source: Borg, J.Y., "Nuclear Explosions for Peaceful Purposes", UCRL-95026, 11/86.

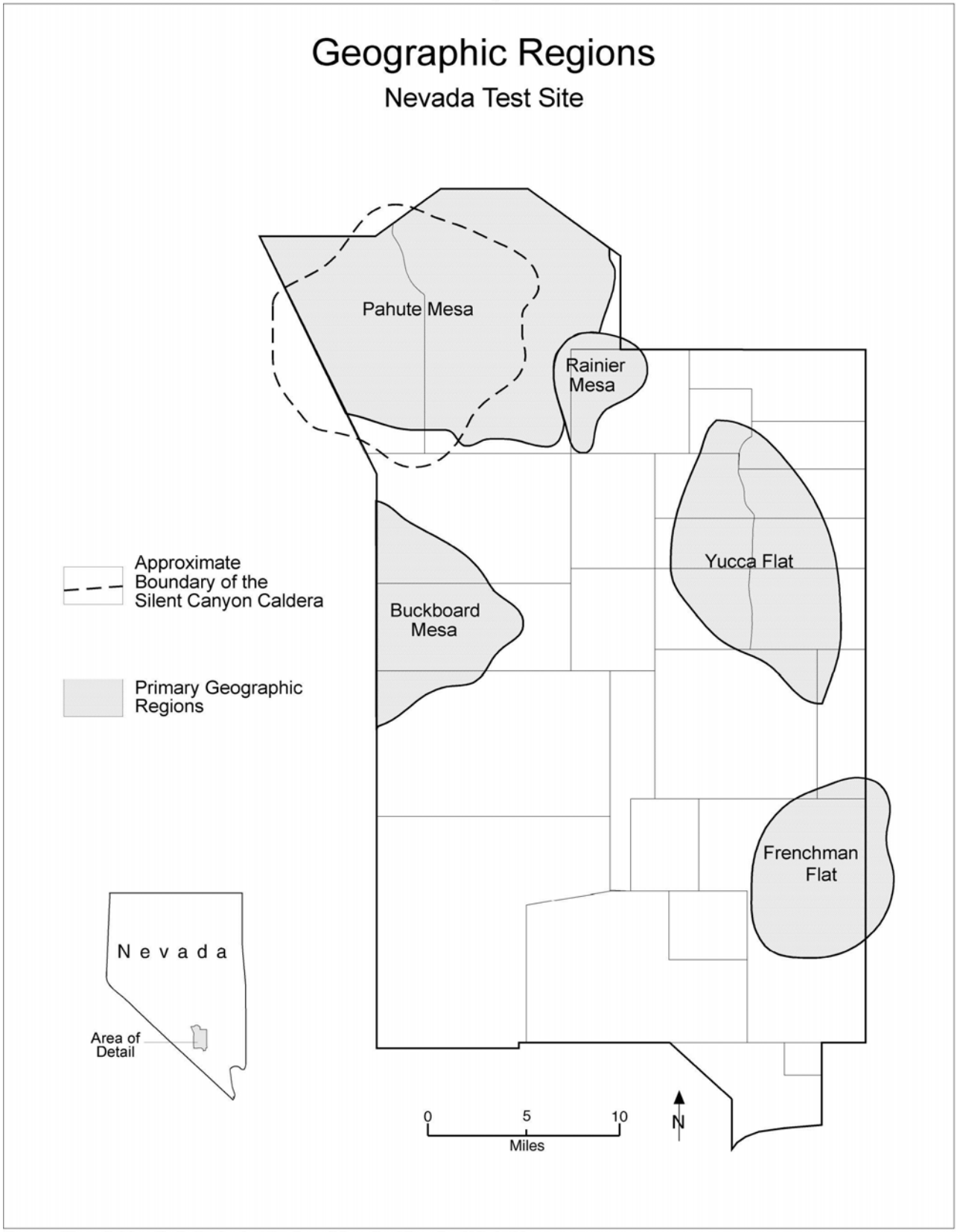
Map 1a

Map 1b



Source: Findlay, T., Nuclear Dynamite, pp. 293-294, 1990.

Map 2



Source: "Nevada Test Site", Geological Society of America Memoir #110, 1968.

THE BRUNEAU PLATEAU

The Bruneau plateau of southwestern Idaho is dry scrub and sage country with low relief, little water and few inhabitants. There are isolated ranches with occasional alfalfa farms as one drives north towards Twin Falls. Cattle grazing predominates. In the words of a local rancher “except for Envirosafe [a commercial hazardous waste dump], ranching’s about all there is in Owyhee county [Map 3].”{14}{15}

Other landuses include hunting in the fall for sage grouse and deer, and kayaking and rafting in the short - generally three week - period in the spring when snowmelt fills the Jarbidge and Bruneau river canyons. Camping and sightseeing are less common in the Bruneau plateau due to the area’s remoteness and extremes of climate.

Along Three Rivers Road, the rhythm of cattleguard, cows, and occasional glimpses of the Bruneau river gorge is interrupted by unnerving warning signs posted by the U.S. Air Force:

PROCEED AT YOUR OWN RISK
Look to your right for
low flying aircraft
carrying explosive objects
If you see an aircraft
wait till it passes
this position

For twelve miles Three Rivers Road bisects the Saylor Creek Bombing Range and skirts the active bombing area to the east. This twelve mile section gives one time to consider the opposing landuse perspectives at work on the Bruneau Plateau.

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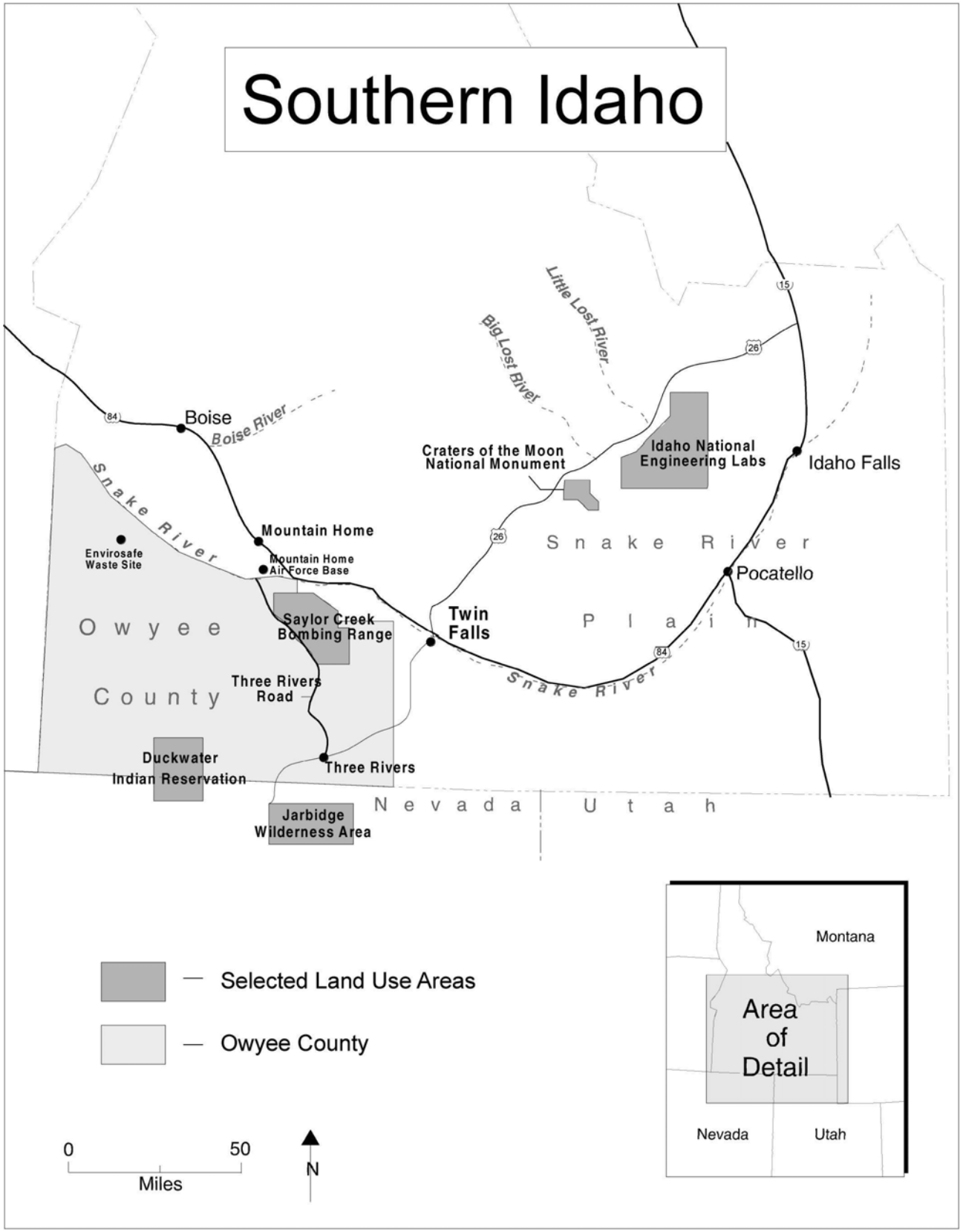
14. Ford, Pat “Now Idaho Wants National Parks”; From Reopening The Western Frontier, 1987, p. 187
15. Note: The Envirosafe site is a former Air Force Titan Missile complex decommissioned and sold by the Air Force in 1965.

Map 3



Source: *Skyguard* Newsletter, p. 3, Winter 1990, vol. 1, #3.

PERCEPTIONS AND LANDUSE CONFLICTS

A Washington DC based conservation group “American Rivers” cites the Bruneau and Jarbidge rivers in its 1990 survey as one of “the top five most endangered rivers in the country... encompassing one of the longest free flowing stretches of water in the US (over 100 miles).”{16} The river is home to golden eagles, cougar, river otters and half the worlds desert bighorn sheep population. Also present are untouched archeological remains such as Native American fish racks and woven sagebrush mats in various caves.{17} The plateau itself “if managed for wildlife... could be an American Serengeti”, according to conservationist Randy Morris.{18} Nineteenth century geologist I.C. Russell, describing the Snake River Plain, into which the Bruneau River eventually flows, makes the following observation:

> “One must become familiar with the characteristics [of this land]... and learn to judge them by their own standards before their beauties are revealed... As evening approaches there is a gradual change from glare to shadow. The broad plain becomes a sea of purple on which float the still shimmering mountains. The shadows creep higher and higher... margining rugged slopes on which every line etched through centuries by rills and creeks reveal its history... One marvels at the diversity and strength of the sculpturing of what but moments before appeared flat, meaningless surfaces.”{19}

An alternative perspective is poetically articulated by nineteenth century traveler, W. Irving:

> “A dreary desert of sand and gravel extends from the Snake River almost to the Columbia. Here and there is a thin and scanty herbage, insufficient for the pasturage of horse or buffalo. Indeed, these treeless wastes... must ever defy

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16. Black, L., “Idaho Rivers Listed As Endangered”, *Skyguard*, vol. I, #4, p. 19
17. Ford, P., “Now Idaho Wants National Parks”, p. 189
18. Ibid., p. 188
19. Young & Sparks, Cattle in the Cold Desert, 1985, p. 41

> cultivation, and interpose dreary and thirsty wilds between the habitations of man, in traversing which the wanderer will often be in danger of perishing."{20}

The perception articulated by Irving has been, until recently, the typical response to arid landscapes. Author and conservationists Charles Bowden describes one early effort to alter this opinion:

> "At the turn of the century, John Van Dyke wrote The Desert and explained to us that it was bad form to describe as Godforsaken every place that fails to look like Iowa. He saw the desert as a positive landscape rich with aesthetic values... [This and] similar books... diligently lecture us to appreciate the colors in the rocks, the power of the sunsets and to regret that we were not born Hopis."{21}

The tone of this piece purposely demonstrates that appreciating arid landscapes may not come naturally. After all, arid landscapes are by definition hot and dry and are usually not immediately perceived by visitors as hospitable environments. "Craters of the Moon National Monument", established in 1924 and located on the Snake River plain in Idaho, exemplifies this point. The monument, dubbed by one traveler as "the strangest 75 square miles" in North America, and by park literature as "closely resembl[ingl the surface of the moon," was established not to secure a fragile ecosystem but to highlight a perceived freak of nature, somewhat akin to the geysers fields of Yellowstone National Park.{22} It is an area of interest due to what it is not: not just treeless, but shrubless and grassless as well!

Like parks and monuments, sites chosen for military activities also reveal landscape perceptions. Due to the high

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20. Ibid., p. 40
21. Bowden, C., "Useless Deserts and Other Goals", 1987, p. 132, from Old Southwest, New Southwest, J. Lensink ed., 1987.
22. U.S. NPS, "Craters of the Moon Official Map & Guide", 1990.

impact, high risk activities undertaken on military training areas, site selection is given careful consideration by Pentagon planners. The military values the remote and “dreary” for the same reasons ranchers, hunters and campers do; it allows for activities unavailable or unacceptable in settled areas. Differing landuse values, however, set the stage for conflict.

A camper may be disappointed to be awakened at sunrise by two loud hunters and a dog trying to scare out sage grouse. The hunters may show their own surprise and dismay at the intrusion on *their* turf by checking the camper’s license plates and asking “Staying here or going cross country?” Likewise, ranchers feel a threat from conflicting landuse agendas by conservationists and the military. For example, Dave Tindall, a ranch owner near the Bruneau River, feels that conservationists attempting to limit grazing activities on the plateau don’t understand a rancher’s relationship to the land: “we’ve been ranching 104 years on this place, and if we’re doing such damage to the land, how come we’re still here?”{23} Another rancher, fearful of restricted grazing imposed by the military should Saylor Creek Bombing Range be expanded states: “I’m sick of hearing what the Air Force wants. What do they need?”{24}

While landuse conflict is inevitable between these groups, it is certain that the most profound and intractable conflicts will center around the military. Not only are military landuse needs (and wants) the most physically punishing to the land, but the military’s basic perception of the land is rarely shared by the hunter, rancher, or camper. And because of the

23. Ford, P., “Now Idaho Wants National Parks”, p. 188
24. Black L. ,”Saylor Creek Proposal Bombs With Public”, *Skyguard* ,vol. I, #4, p. 19

nature of military training activities, proving grounds and test ranges are strictly off limits to unauthorized visitors. This rift in perception and the exclusionary nature of military landuse makes it difficult to achieve compromise. The rancher's "shimmering mountain" may be the military's fenced and posted "treeless waste".

TECHNOLOGY AND PERCEPTIONS

Part of the disparity in perception is due to the tools used by each group to approach the land. The following two descriptions of a climb and descent over the Jarbidge mountains illustrate this point. Clearly, technology influences landscape perception. First, from the SPA writer's program comes this 1940 description of "Road Tour 1".

> "The ascent of the Jarbidge mountains... is very beautiful at any season, but especially during the fall when willow, aspen, and chokecherry are aflame.. The summit... offers magnificent views of the sunken gorges of southern Idaho and the dim Sawtooth Range northward... with Bear Creek pouring down to the Bruneau. The road drops 2,000 feet in 5.5 miles and provides a spectacular descent, breath-taking for persons not used to mountain driving. [At] the foot of the grade is a forest service campground... in a beautiful grove of aspen and mountain laurel. The whole region is in almost primitive state, with a heavy stand of timber unusual to northern Nevada. Deer and grouse are plentiful and fishermen describe the region as paradise. Coon Creek, Bear Creek, Jarbidge River, and other streams teem with trout. High above the conifers and red cedars is found the rare fox-tail pine. The wild red raspberries and black gooseberries of the thicket make delicious jellies"{25}

Next, this 1978 description of an F-111 training mission from a magazine article entitled "F-lll Fighter Role Being Expanded":

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25. WPA Program, Nevada, A Guide to the Silver State, 1940, p. 119

> "The mission involved automatic, terrain-following flight at 200 ft. in mountainous county with peaks in excess of 10,000 ft. and observation of or participation in 15 bomb deliveries employing both traditional and new F-111 tactics... Lead F-lllA is followed closely through flat desert terrain at 200 ft. altitude enroute to the Saylor Creek Bombing Range. Automatic terrain-following flight requires F-111 crews to watch their systems closely for hardware failure situations that could lead to ground impact... As the two aircraft approached the Ruby and Humboldt ranges, Myer guided the F-lllA over high terrain for a precise terrain-following demonstration in difficult topography while Mirehouse went low thru the narrow pass for maximum terrain masking... At that point the aircraft headed toward an 11,000 ft. mountain dubbed the Matterhorn [the heart of the Jarbidge wilderness area]. The F-lllA was pointed toward the steepest face of the mountain, and the afterburners ignited as the aircraft started up the side. The speed was pulled back as the F-lllA topped the snow capped peak and then pitched down into a 12-deg. dive toward the valley floor 6,000 ft. below [the Bruneau Plateau]."{26}

It is not possible, nor is it in the agenda, for a F-111 fighter pilot to appreciate a chokeberry bush at the speed of sound. The detail and scale of the environment are different when seen through a cockpit, a car windshield or from the back of a horse. But technology only partially accounts for these differences in perception and landuse.

OTHER FACTORS AND PERCEPTION

Economics, politics and socialization to a particular viewpoint also play a role. These factors surface in the debate over the expansion of Saylor Creek Bombing Range from 100,000 to 1.5 million acres.{27} The greatly expanded Range would include four live ordnance bombing areas and the use of supersonic flights over the Jacks Creek and Bruneau-Jarbidge wildlife study areas.

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26. *Aviation Week & Space Technology*, Covault, C., "F-11 Fighter Role Being Expanded", 02/06/78
27. Black, L., "Idaho Strengthens Opposition to Bombing Range", *Skyguard*, vol. I, #3, 1990, p. 3

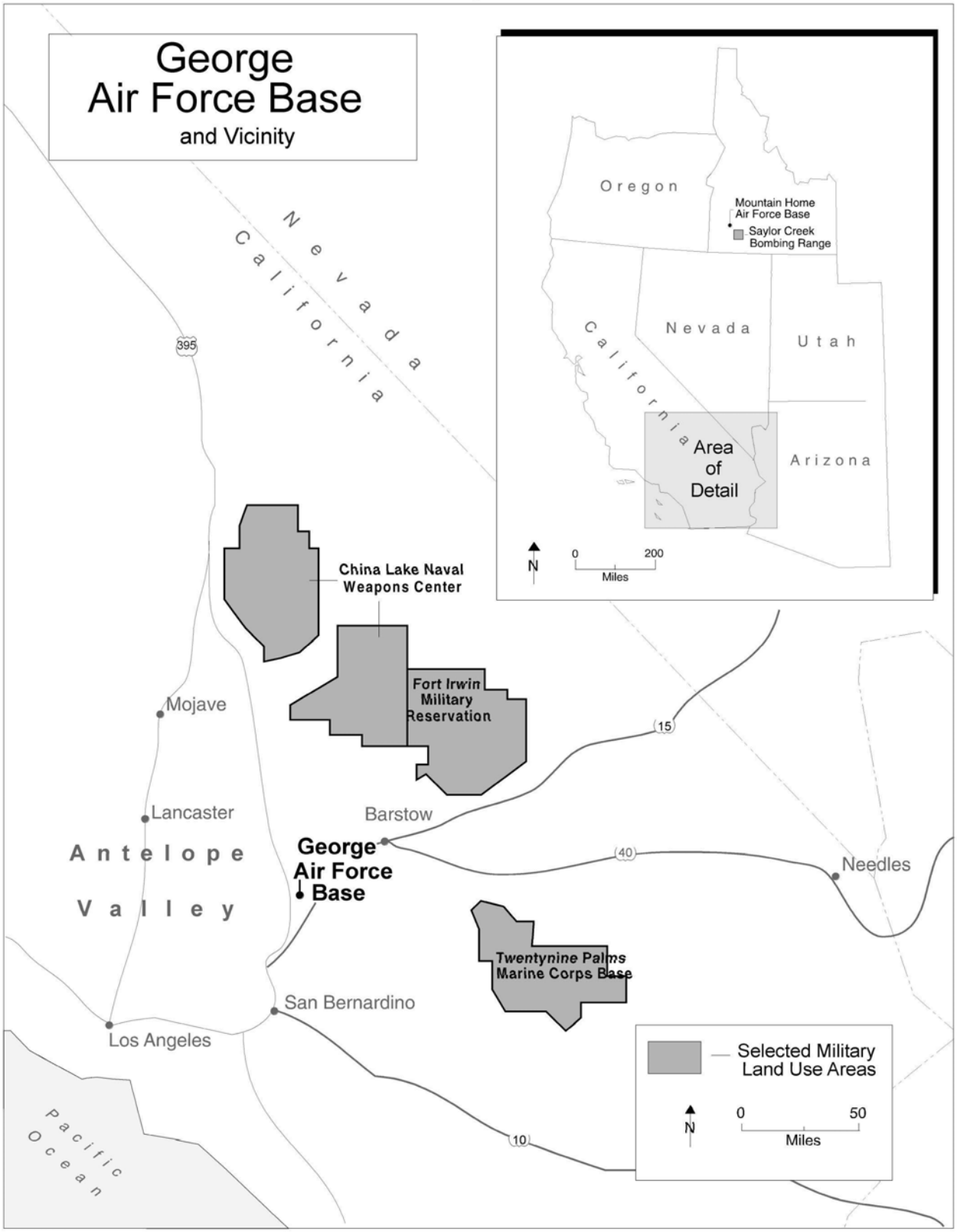
Why, with clear landuse conflicts, would the Air Force plan to expand this relatively minor bombing range?

Air Force base closures nationwide have dictated that other bases expand to take up the slack. In the case of Saylor Creek, this “slack” refers to 94 F-4G Phantom jets displaced by the closure of George Air Force Base in California [Map 4]. These jets would be relocated to Mountain Home Air Force Base, the primary user of Saylor Creek Bombing Range. Whereas Antelope valley, home of George Air Force Base, is one of the fastest growing areas in San Bernardino county, land values in Owyhee county have remained low. A subcommittee report during the expansion hearings stated: “The Air Force has been under pressure because of hazardous flying in populated areas... [which] make Idaho look very good. Plus the Air Force could sell some of its Sun Belt lands for a hefty profit.”{28} The Bruneau plateau is sparsely populated and the land is cheap.

And in the eyes of military planners, Saylor Creek bombing range is too contaminated with ordinance to be used for anything else anyway. At the expansion hearings, a Pentagon official stated, “once land is used for a bombing range, it is gone forever. We cannot sterilize a bombing range.”{29} This observation, while true in some cases, is also a justification for current and future military acquisitions. Understandably, the military prefers to expand high impact activities where land is already off limits or “gone forever”. But the definition of “gone forever” is a subjective perception. There are exceptions, such as the Jefferson Proving Ground where cleanup of unexploded artillery

28. “Saylor Creek Proposal Bombs with Idaho Public”, p. 19
29. Hayes, R., “War and Peace on the Idaho Range”, *Skyguard*, vol. II, #1, p. 15

Map 4



Source: San Bernardino Chamber of Commerce, "The Golden Opportunity in Aviation, 1991.

rounds is so problematic that it is “likely the whole base will be put off limits forever”.{30} But in many cases land is deemed off limits to facilitate military site selection, not because it cannot be reclaimed. These areas become the foreordained site for the next high impact activity, be it blasting, cratering, burning or chaining, and whether it is superimposed on or creates a bombing range, disposal site, maneuver area, radiological study area or toxicological exclusion zone. Thus, the label ‘sacrifice area’ is often self fulfilling. Expanding Saylor Creek, the reasoning goes, will spare 1.4 million acres of *desirable* land somewhere else.

Finally, one’s background and experience effects perception. Richard Bargen, an airspace activist, received the following anonymous comment chastising his attempts to challenge the military’s use of airspace over rural areas such as the Bruneau plateau: “Dr. Bargen: Those rattlesnakes are going to have hell, aren’t they? Who do you practice medicine on in that wilderness? Isn’t CANADA a better place for you to gripe?”{31}

The note, handwritten on House of Representatives stationary, gives the impression of communication between cultures worlds apart. Differences in class or political values cannot fully account for the tone. Rather, the note betrays a lack of comprehension or acceptance of an alternative perspective. Beatrice Brailsford, a coordinator for the Snake River Alliance, an Idaho conservation group, speaks to this issue of perceptual differences based on background, experience and community in her comments during the DOE sponsored hearings concerning nuclear

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30. Turner, T., “Ground Zero: The American Military vs. The American Land”, 1991, p. 14., from *Wilderness* magazine, Fall 1991.
31. Airspace Blues, p. 223

weapons production in the twenty-first century (known by the DOE as “Complex 21”).

> “Idaho, particularly eastern Idaho, is culturally homogeneous and culturally conservative. We do not live in Idaho because we are too poor or lazy or stupid to live somewhere else. We live there because we love our small communities, our clean air and water. We live there because we love Idaho, and we certainly do not want it transformed into somewhere else. DOE’s ‘bid’ for Weapons West describes the proposed project site as ‘barren ground’. It is not. It is Idaho’s high desert plain, covered with sage and grasses, a home for birds and wildlife. And it is our home, too. Let me describe what Idahoans think is barren. The asphalt pads at the Radioactive Waste Management Complex are barren. The percolation ponds and injection wells that have imperiled our aquifer are barren. Contaminated soil is barren. Projects and jobs whose sole purpose is to produce nuclear weapons we neither want nor need are barren. Let me close by telling you what people in Idaho really suspect about “Complex 21”. We suspect that the Department of Energy is moving through the country with its bomb production plans, looking for a stupid state. Let me assure you, Idaho is not a stupid state.”{32}

IDAHO NATIONAL ENGINEERING LAB

If approved, Idaho’s contribution to “Complex 21” would be located on the Snake River plain at the Idaho National Engineering Labs (INEL), a 900 square mile facility built on the site of a former artillery test range and a source of pride to many Idaho residents since 1949. Support for INEL has waned, however, with the discovery of tritium contamination of the Snake River Plain aquifer and possible contamination of Lost River, Little Lost River and Birch Creek, which flow 150 miles beneath the lava fields before emerging as springs to the south and west. Resistance to “Complex 21” is based on several factors. Farmer

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32. Statement before the DOE’s “Programmatic Environmental Impact Statement Scope Hearing”, 06/21/91, Washington D.C.

and army veteran Ernie France states: “I’m not anti-military... protecting [the aquifer] is an economic issue. Without this water we’d have no farming down here.” Protecting the aquifer is also a health and perceptual issue. Many Idahoans who depend on the Snake River Plain aquifer “do not think groundwater contamination beneath the Site is a [DOE] public relations problem. It is a drinking water problem.”{33}

The DOE has sought out a remote location for “Complex 21” because it involves the production and handling of plutonium. But in the words of Beatrice Brailsford: “If you’re sitting in Washington, DC, the Idaho National Engineering Laboratory looks like it’s in the middle of nowhere. But if you’re standing in Idaho, as six generations of my family have, INEL looks like it’s in the middle of Idaho.”{34} Site selection for a similar project proposed 1988, the Special Isotope Separator [SIS], was seemingly based on similar criteria. Senator Symms of Idaho, SIS’s strongest supporter stated: “If it can’t be built here [Idaho], it can’t be built anywhere.”{35}

HEALTH AND ENVIRONMENTAL IMPACTS

Clearly, perceptual differences, based on varying factors, influence landuse activities. However, as evidenced by resistance to “Complex 21”, it is the health and environmental impacts of military landuse that elevate the issue of perception and site selection above simple academic debate. Depending on the activity, the impacts to public health and environmental safety

33. Ibid.
34. Ibid.
35. Ridley, S., “Hot Potato in Idaho”, *Nuclear Times*, 1988, p. 28

take a variety of forma: groundwater contamination, airborne chemical and radiological contamination, sonic booms, electromagnetic transmissions, laser damage, disturbed habitat and loss of values such as solitude and peace.

EXPANSION OF SAYLOR CREEK

To take one example, the expansion of Saylor Creek Bombing Range would have multiple and widespread impacts due to the increase in sonic booms. These booms - the “sound of freedom” in military parlance - are both physically and psychologically damaging. The following examples are taken from states other than Idaho, but the effects of sonic booms are similar wherever they occur. And, as with the following examples, the Bruneau Plateau is used by recreationalists, ranchers and is the site of the Duck Valley Indian Reservation.

Areas beneath Military Training Areas are frequently avoided or abandoned due to sonic booms. Skyguard, a citizen’s group created to address military airspace concerns, received a letter from a cross country skier describing an encounter with four A-10’s while in the Spring Mountains of Nevada [Map 5]. The fear of sonic boom induced avalanches led the writer, his wife, and another couple in the canyon to end their trip early and “not return to Lee Canyon for skiing [that]... season.”{36} Likewise, Dixie valley in Nevada was abandoned by residents after the Navy brought a Supersonic Operations Area (SOA) into the valley in 1982. One former resident comments: “This valley shows little signs of war, but there was one. Over 500 sonic booms have rained

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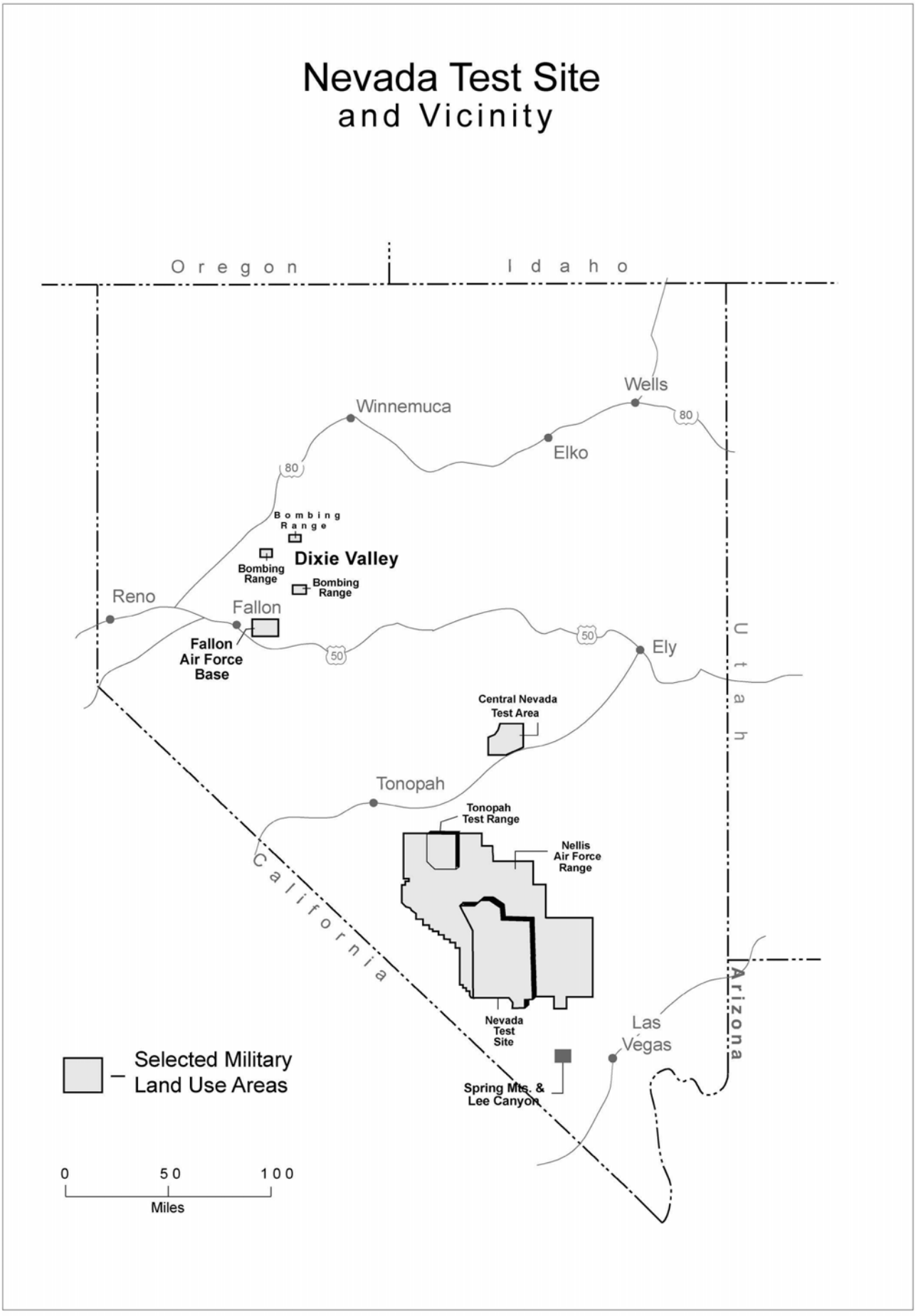
36. Letter to the Editor, *Skyguard*, vol. I, #4, p. 24

Map 5



Source: "Final Environmental Impact Statement - Nevada Test Site", p. 2-23, 9/77.

down on our heads, blowing out windows, moving and cracking walls, driving livestock from the range, killing animals...”{37} By 1987 Dixie Valley was deserted and remains uninhabited today.

Ranchers and their herds can be affected by sonic booms which cause “cattle to scatter into the brush [or]... knot up and not go anywhere at all.”{38}

> “It causes a lot more work out there if you’re heifering - pairing up mothers and calves - after the planes go over, they’re all mixed up and you have to start all over again. I’ve seen heifers calving get up and run to the other side of the corral and not go into labor again, so their calves are stillborn.”{39}

Cultural resources are impacted. A representative of the Papago tribe, in a hearing to eliminate air-combat training over their reservation, stated: “This isn’t just a big flat area. This is the ancestral homeland of the Papago people. The Papago people feel that they are being insulted. Every sonic boom is not only physical harm, it’s a cultural harm.”{40}

There are additional impacts to consider beneath the live ordnance areas of a bombing range. These impacts include groundwater and soil contamination from “M-2, napalm A & B. PCB oils, asbestos, malathion... diesel fuel, gasoline” and other material contained within targets, dummy bombs and live bombs.{41} Jet fuel is also routinely dumped by jets for safety and training requirements as they overfly bombing ranges. Of further concern is the damage potential of guidance lasers that produce a beam more intense than “the sun, nuclear weapons, burning magnesium or

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37. Robbins, E., *Citizen Alert* Newsletter, Fall 1988
38. Airspace Blues, p. 254
39. Ibid.
40. Bargen, R., Sonic Booms vs. The American Way, 1987, p. 29
41. U.S. EPA, “Preliminary Assessment/Site Inspection, Fallon NAS”, 04/88, from Bravo 20: The Bombing of the American West, 1990, p. 39

arc lights... [and] can cause possible severe and permanently damaging effects" up to thirty six miles away.{42} Electromagnetic radiation emitted from radar jamming and counterjamming equipment is likewise dangerous. The Department of Defense prohibits "fighter aircraft from approaching closer than three miles to actively jamming aircraft" to avoid radiation damage to the pilots.{43} Crews must also shut jamming equipment off "two miles before tanker rendezvous or risk igniting the tanker's fuel load with microwave emissions."{44} These electromagnetic emissions, which interrupt civilian telephone communication and television reception, are a potential health hazard to humans and animals near bombing ranges.

The impacts from bombing ranges, supersonic flight areas and processing and storage facilities for radioactive materials - the military activities present in southern Idaho - are common to many states in the intermountain west. Also common to these states are sites of proposed or actual Plowshare experiments. The following section, beginning again with southern Idaho and the Bruneau plateau, will describe these sites and their impacts in the context of the goals of the Plowshare program and the perception of the intermountain west by Plowshare planners.

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42. Airspace Blues, p. 171
43. Ibid., p. 182.
44. Ibid.

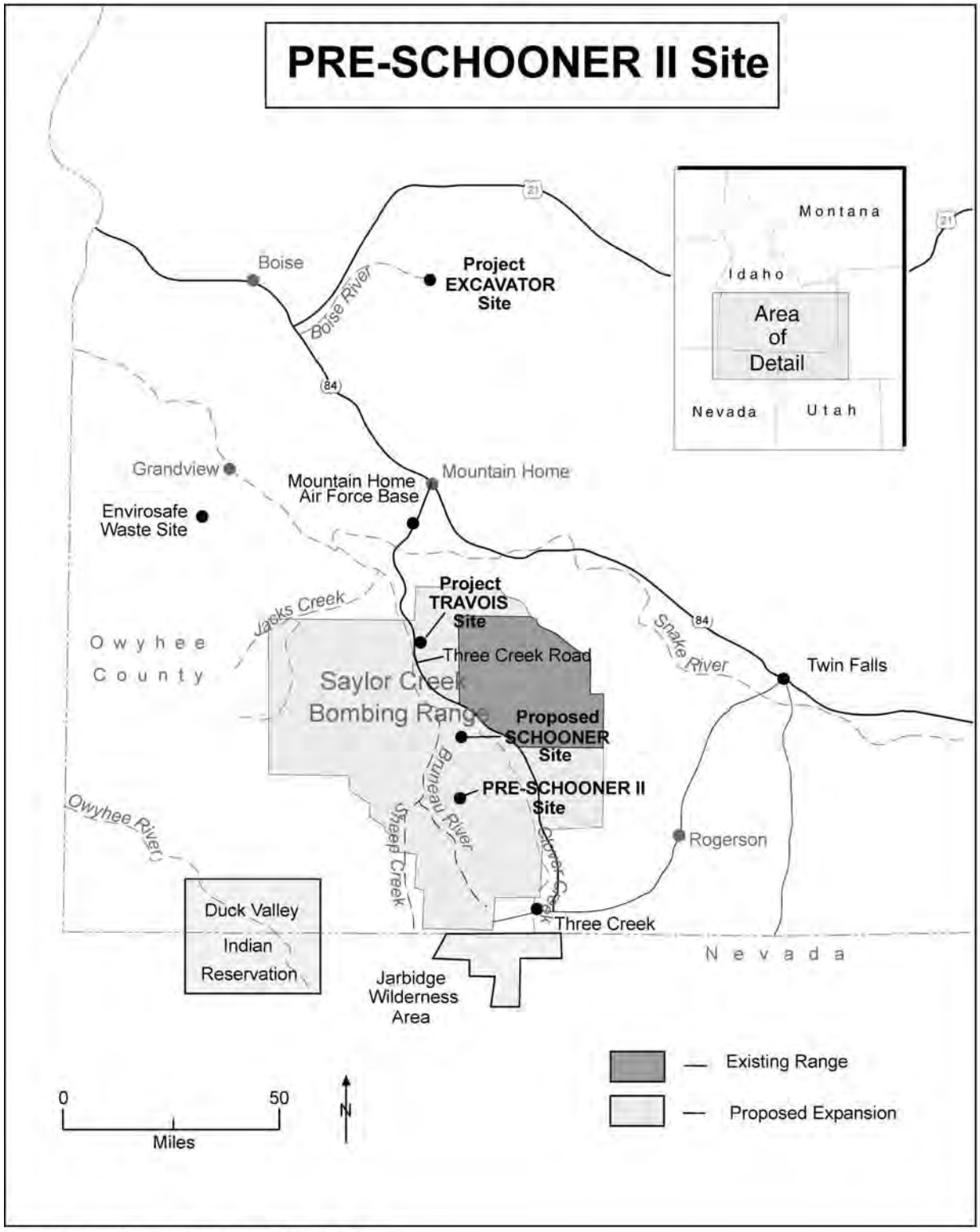
SECTION II

THE PLOWSHARE PROGRAM
PLOWSHARE PROJECTS IN IDAHO

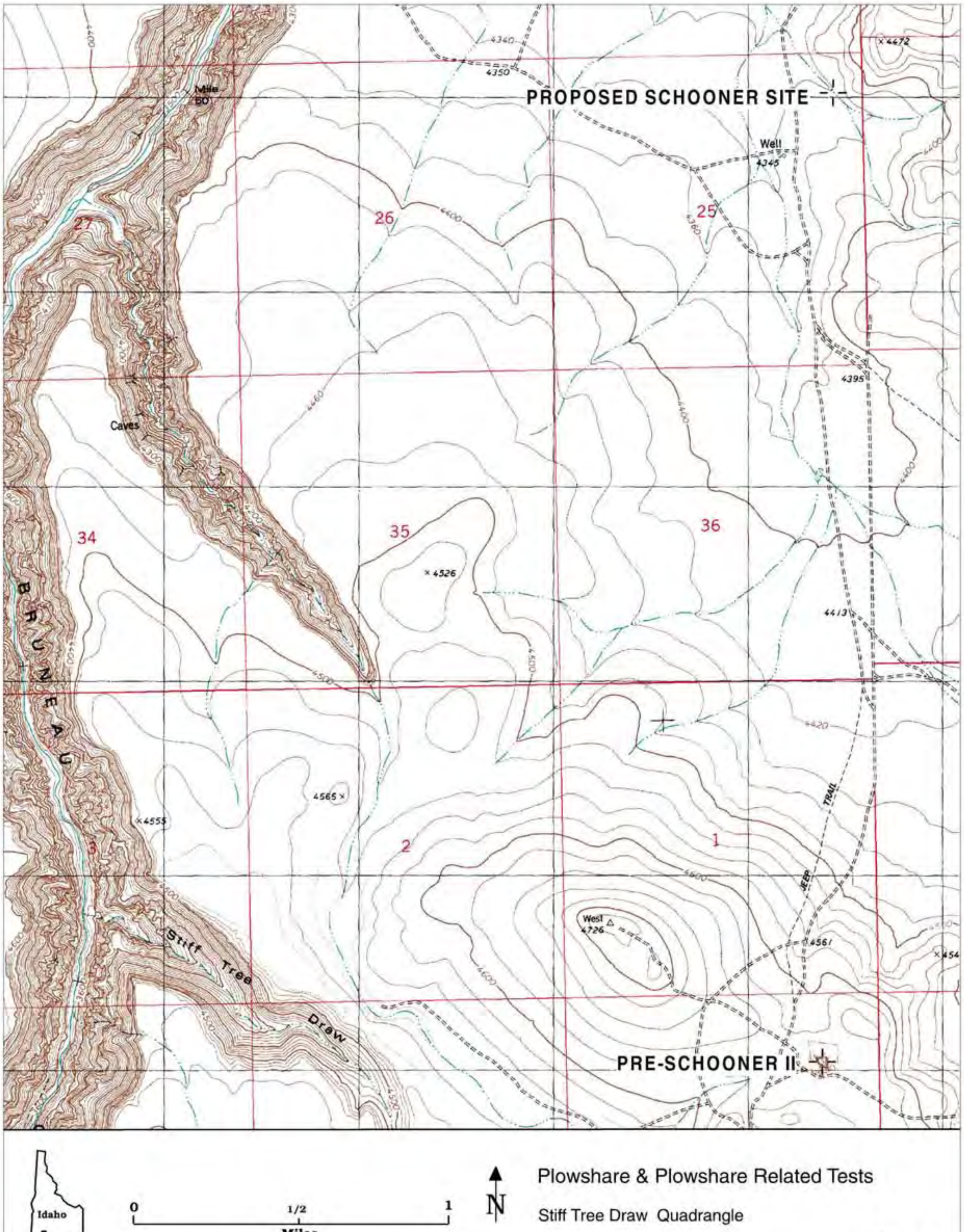
To the west of Saylor Creek Bombing Range, three major tributaries of the Bruneau River - the Jarbidge, Sheep Creek and Clover Creek - converge. South of this confluence the rivers fan out across the Bruneau Plateau, incising canyons nearly as formidable as the 900 foot Bruneau River Canyon itself. These sheer walls make trans-plateau travel difficult or completely impossible. The section of plateau thus enclosed by the Bruneau River and Clover Creek canyons is known as the Inside Desert. It feels isolated even by Idaho standards. The road traversing its length is by turns a sandy rut or a faintly visible track overgrown with cheatgrass and sage. At the crest of one small incline, the road approaches an incongruous series of rubble mounds surrounded by a barbed wire fence - the site chosen by the AEC for a high explosive Plowshare experiment known as PRE-SCHOONER II [Map 6a].

The landscape impacts of PRE-SCHOONER II are impressive. The explosion formed an elongated crater sixty feet deep and ninety feet in diameter [Map 6b][Figure 6]. The crater is encircled by a series of basalt mounds twenty feet high. The power of the explosion is evidenced by these piles of fragmented basalt. This rock, strongly resistant to erosion, and responsible for the vertical walls of the Snake and Bruneau rivers, is not easily broken or crushed. Visitors looking for an explanation find only a weather-beaten wooden sign warning: “DANGER - Unstable Slopes - KEEP OUT - AEC”. Not stated is that this 85 ton high explosive

Map 6a



Source: Skyguard Newsletter, p.3. Winter 1990, vol.1, #3.

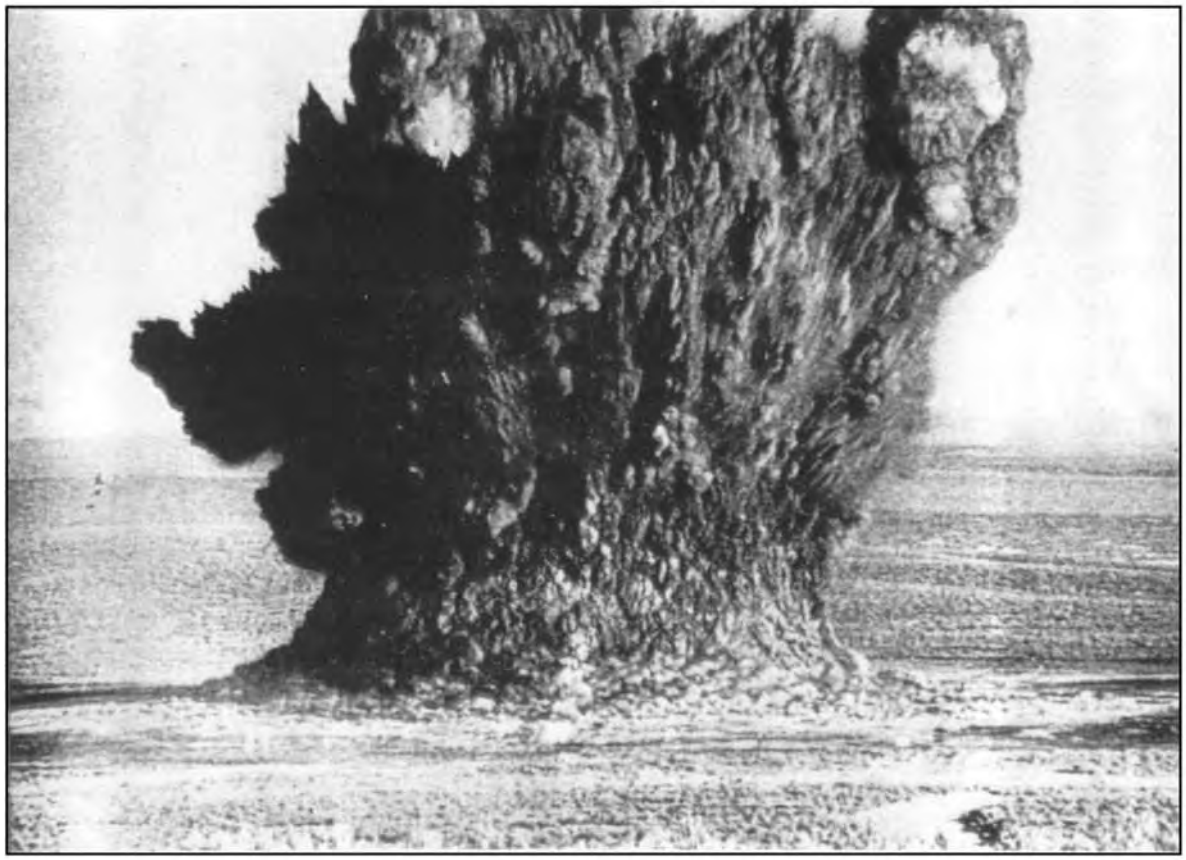


Plowshare & Plowshare Related Tests

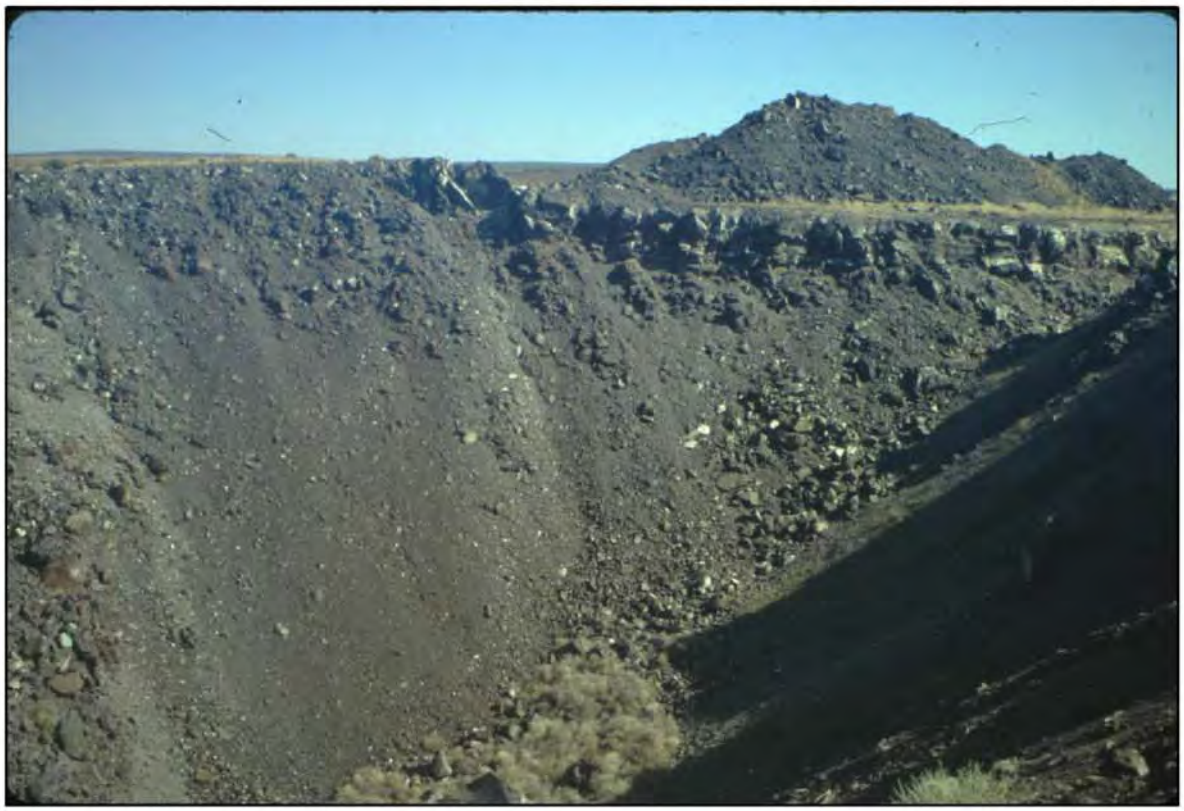
Stiff Tree Draw Quadrangle

Map 6b

Figure 6



PRE-SCHOONER II explosion. Idaho Falls *News* photo.



PRE-SCHOONER II crater. Author's photo.

experiment was the precursor to a proposed 100 kiloton nuclear explosion, SCHOONER, to take place in the same area.{1} Eighty miles to the north, at the fringe of the Snake River Plain, another Plowshare experiment was proposed but never carried out. Known as EXCAVATOR, the planned 40 kiloton nuclear explosion was to create a rockfill dam and reservoir on the Boise river.

PRE-SCHOONER II and EXCAVATOR are two of the more than forty Plowshare experiments conducted or proposed by the United States between 1957 and 1973. These experiments studied the ways in which nuclear explosions could transform the environment and can be subdivided into three groups - excavation projects, physics experiments and extraction projects.

Excavation projects comprised the majority of Plowshare experiments and investigated digging canals, blasting highway and railroad thoroughfares, excavating cavities for underground storage and creating dams and harbors.

Plowshare physics experiments investigated scientifically useful phenomena of underground nuclear explosions such as heavy element production or neutron physics experiments. Plowshare physics experiments were often “piggy backed” onto weapons related nuclear tests.

Plowshare extraction experiments were efforts to improve natural gas and oil shale recovery, facilitate hard rock mining, alter aquifer flow patterns, and produce energy from the heat created by a nuclear blast.

Whatever the purpose, Plowshare experiments are nearly always referred to as “demonstration projects”, “investigative

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1. See, for example, US AEC press release dated 08/20/65. CIC #0172744

studies” or of “exploratory use”, underlining the uncertain nature of digging ditches or extracting resources with nuclear explosives.{2} The Idaho projects are typical in this regard in that their usefulness is merely to demonstrate or determine if certain techniques are possible. The following statement summarizes the EXCAVATOR project:

> “The Twin Springs project [EXCAVATOR] is a... preliminary feasibility study of the use of nuclear quarrying techniques... Information obtained would be useful in that it would expand current experience on such blasts into granite-type rock and areas of steep terrain. The product of the detonation, i.e. broken rock, would be incorporated into construction of a dam, thus demonstrating the usefulness of Nuclear Excavation for Civil Works.”{3}

If EXCAVATOR proved successful, further studies would investigate “the feasibility of using a deeply buried nuclear detonation to produce an ejects dam on the Bruneau River, in a narrow, steep walled canyon [Project TRAVOIS]”.{4}

The radiation effects of Plowshare explosions were as uncertain as the “usefulness” of the landscape impacts. A memo describing the “new Saylor Creek site” for SCHOONER illustrates this point:

> “An arbitrary line bearing 110° from GZ [ground zero] passes about three miles south of Rogerson [Idaho]. Therefore, let us say here that under no circumstances can fallout pass north of the 110° line... [F]urther... a 10° cushion is required because of uncertainty in prediction.. For technical reasons we would prefer that the other boundary line be no farther west than 160°. However, with severe operational pain and with a compromised technical fallout studies program we can tolerate a line to 185°...

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2. See, for example, “Nuclear Explosions In Science and Technology”, *Bulletin of Atomic Scientists* (hereafter *B.A.S.*), vol.16, #5, pp. 155-161
3. JCAE, “Commercial Plowshare Services”, 1968, p. 412
4. “Project Excavator - Preliminary Planning Concept”, US NCG, 05/68, TECR-15413, p. 5

> I understand that the USWB will pass to each of us the wind probabilities based on these considerations."{5}

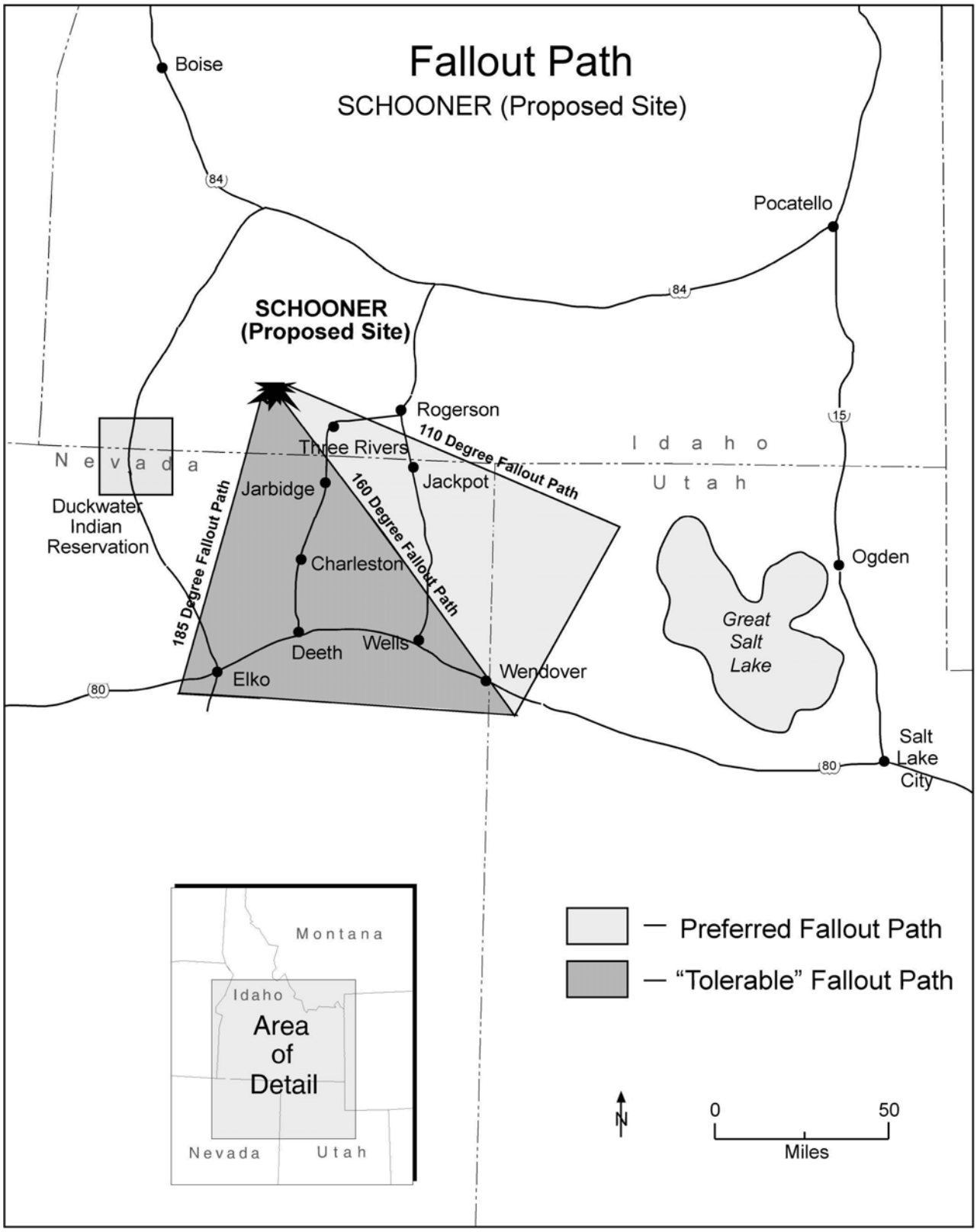
The difference between a 160° and 185° "boundary line" determines whether the towns of Jarbidge, Charleston and Elko lie in the path of radioactive fallout [Map 7]. SCHOONER was eventually relocated to the Nevada Test Site, partly due to concern over this fallout path and high risk "wind probabilities". When finally detonated at the Test Site, SCHOONER's fallout cloud unexpectedly "surged north to Idaho, then east across Montana and North Dakota" and into Canada, raising concerns that the test violated the test ban treaty by sending fallout across an international border.{6} Such uncertainties and problems concerning the impacts and effects of Plowshare experiments, despite intensive study and preparations, were inherent to the program. Thus, remote locations and demonstration projects were emphasized over centrally located projects which offered tangible benefits, such as reservoirs or road cuts near urban areas. In other words, Plowshare site selection was based on the same criteria used for any other high impact, high risk military activity.

BEGINNINGS OF THE PLOWSHARE PROGRAM

From the beginning of the nuclear weapons testing program it was obvious that nuclear "devices", as they are referred to in the literature, could dramatically alter the landscape. For example, several tests in the Pacific in the early 1950's completely destroyed the target islands. An eyewitness account of one such test, shot MIKE, describes the destruction of

5. LRL correspondence, E.H. Fleming to M.L. Merritt, 06/21/63, CIC #17211
6. "Radiological Effluents", p. 109

Map 7



Source: LRL correspondence, E.H. Fleming to M.I. Merritt, 06/21/63, CIC #17211

Elukalb island on the northern edge of Enewetak atoll.

> “The shot, as witnessed aboard the various vessels at sea, is not easily described... Accompanied by a brilliant flash, the heat wave was felt immediately at distances of thirty to thirty five miles (vegetation was charred 10 miles away). [A] mushroom shaped cloud soon appeared, seemingly balanced on a wide dirty stem... [made up of] coral particles, debris and water which were sucked high into the air. Around the base of the stem, there appeared a curtain of water which soon dropped back around the area where the island of Eluklab had been [Figure 7].”{7}

A total of five islands in Enewetak atoll were destroyed by nuclear explosives between 1951 and 1958: Elugelab, Bocinwotme, Teiteiripucchi, Bokaidrik and Eleron [Map 8a].{8} Further physiographic changes to the atoll were caused by the underwater craters which formed where islands had stood. “Wave patterns and water currents were changed by the presence of the craters, resulting in erosion... [of nearby islands] and the development of... [new sand bars].”{9} Likewise, 130 miles to the east, the topography of Bikini atoll was also permanently altered by nuclear events. Shot BRAVO in 1954, for example, excavated a crater on the lee side of Nam island 200 feet deep and over one mile in diameter [Map 8b][Figure 8]. The heat and blast from BRAVO “stripped the nearby islands of vegetation”, and considerably damaged the buildings on Enemean island.{10} The fallout inadvertently drifted to a military installation 135 miles to the east depositing radioactive coral ash to a “depth of ¼ to ½ inch deep in places” and leaving a visible layer on tables in the mess hall and barracks.{11}

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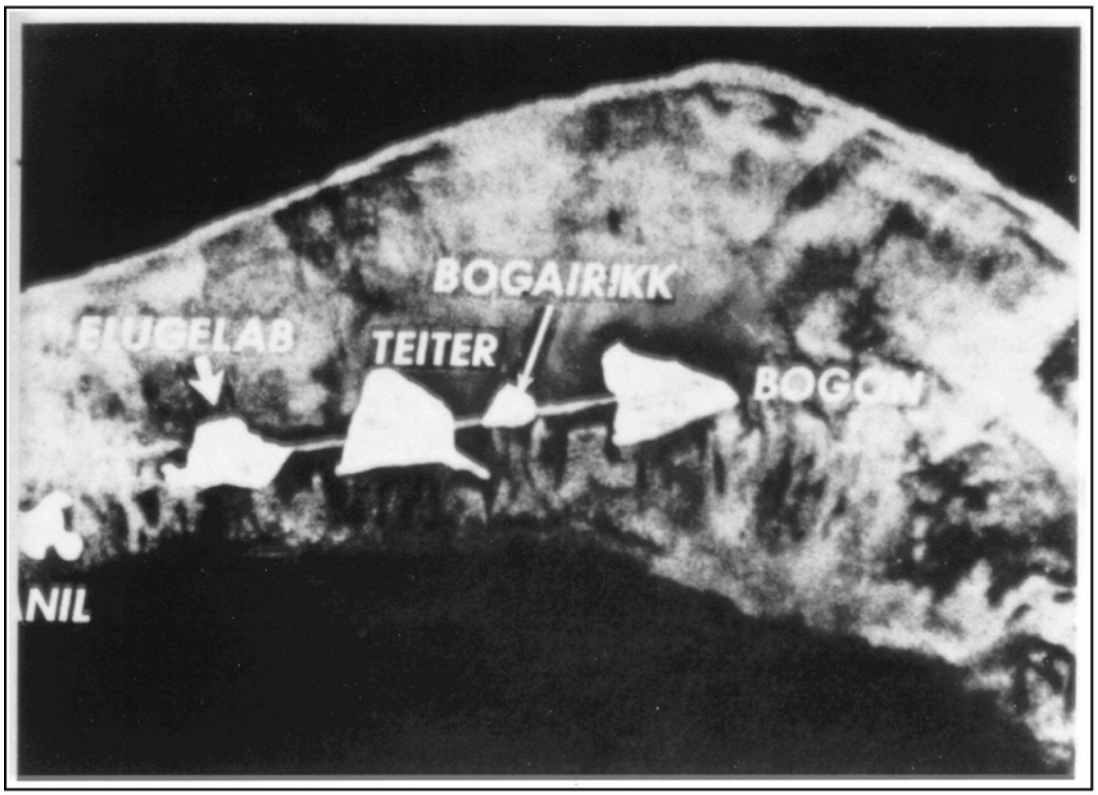
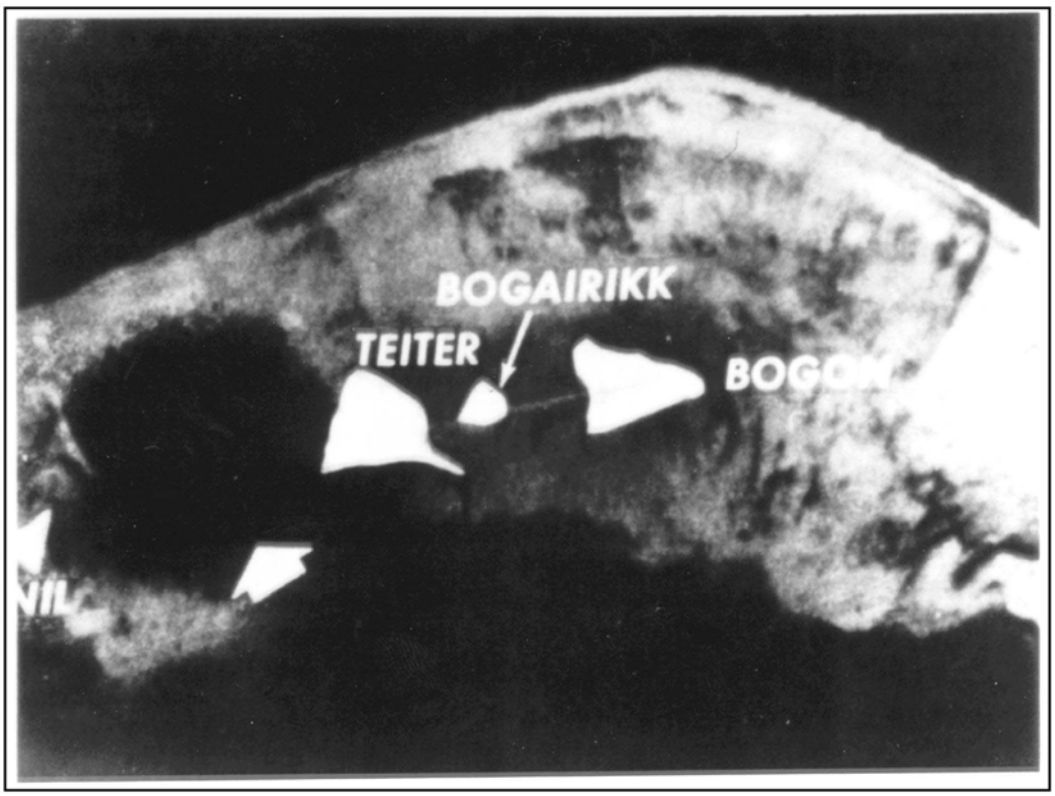
7. Defense Nuclear Agency, “Operation Ivy”, DNA-6036F, 1952, p. 187
8. “Enewetok Radiological Support Project”, US DOE, 1982, p. 8. The specific explosions are: GEORGE(1951) & MOHAWK(1956) - Eleron; MIKE(1952) - Elugelab & Bocinwotme; SEMINOLE(1956) - Bokaidrik; and KOA(1958) - Teiteiripucchi.
9. “Enewetok Radiological Support Project, Final Report”, NVO-213, 1982, p. 21
10. “Operation Castle”, 1954, p. 205
11. Ibid., p. 217

Figure 7

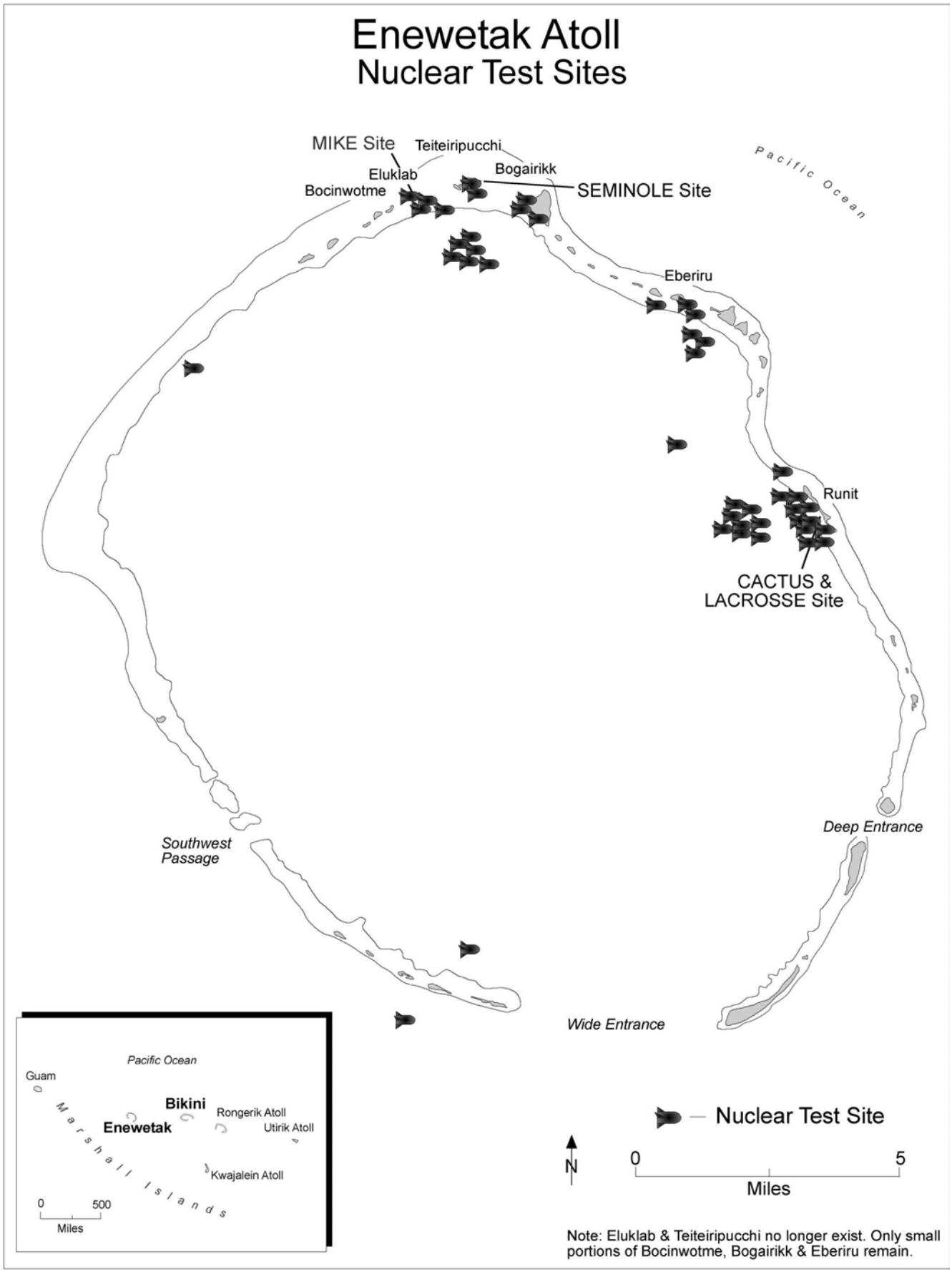


Elukalb Island - Pre-IVY/MIKE, 10/52. AEC photo.

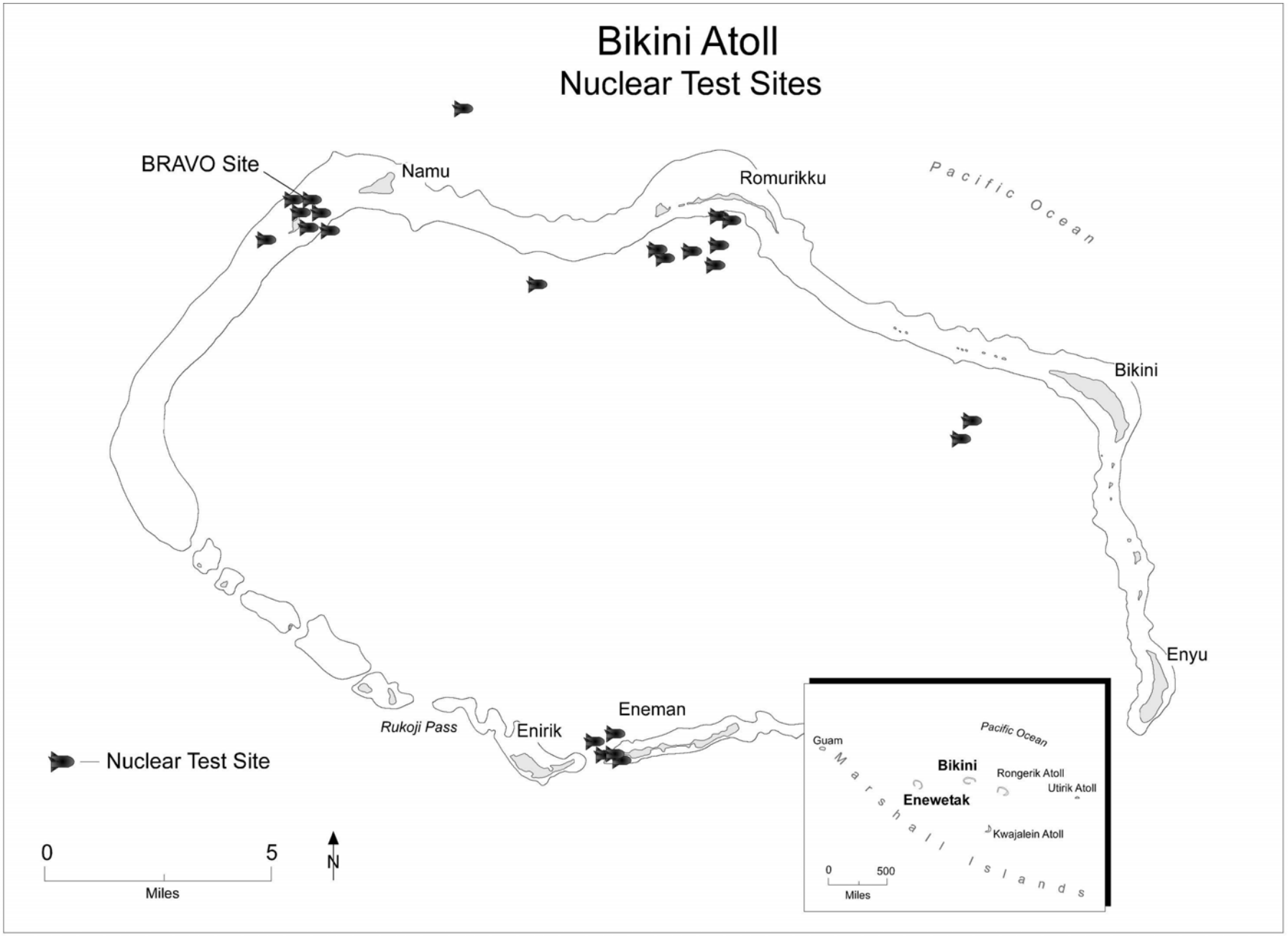


"One of our islands is missing." Post-IVY/MIKE, 11/52. AEC photo.

Map 8a



Source: "Compilation of Local Fallout Data", DNA 1251-2-EX, 05/79.

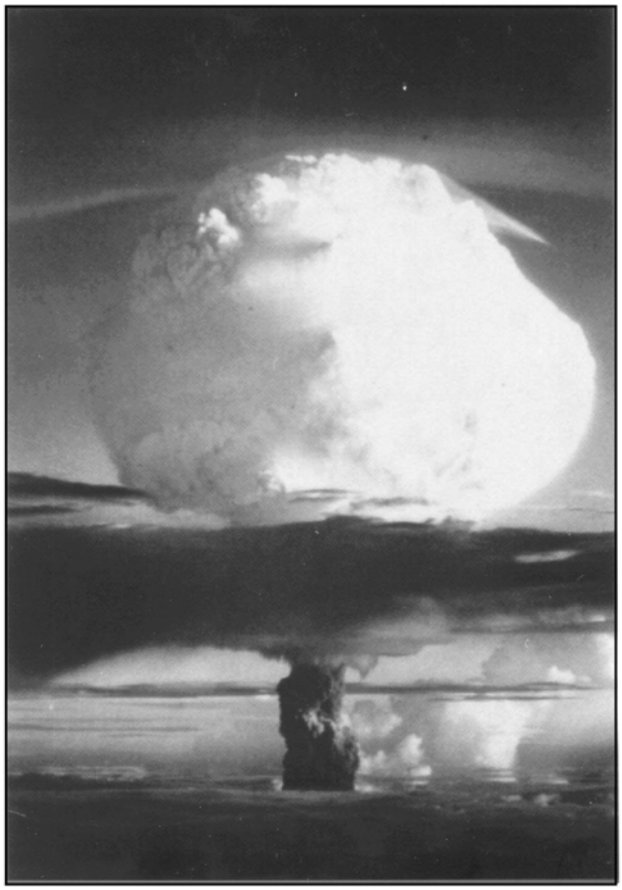


Source: "Compilation of Local Fallout Data", DNA 1251-2-EX, 05/79.

Map 8b

Figure 8

CASTLE/BRAVO shot area. Array of mirrors on right reflect early explosion effects to cameras stationed miles away. AEC photo.



IVY/MIKE mushroom cloud from fifty miles away. Cloud climbed to a height of ten miles and spread out over 100 miles. AEC photo.

The widespread and unintended impacts of nuclear tests in the Pacific, as evidenced by BRAVO and MIKE, “surprised and astonished” nuclear physicists [Figure 9].{12} However, they were also clearly pleased by the sheer power of what they had created as evidenced by a telex to Washington entitled “One of Our Islands is Missing:” The telex reads in part: “From early and incomplete evaluation of results, the yield [explosive power of MIKE] is estimated roughly to have been more than 6 megatons, possibly as high as 12 megatons... The detonation exceeds what we had anticipated... The shot island Elugelab is missing, and where it was is now an underwater crater of some 1,500 yards in diameter.”{13} The gleeful tone describing the power of shot MIKE is due to the achievement felt by the scientists involved in the shot. Those on the scene were privileged to witness the explosion of the first hydrogen or fusion bomb anywhere in the world.

THEORY AND DISCOVERY OF FUSION

Fusion plays an important role in the Plowshare program and will therefore be briefly discussed. While a conventional atomic bomb derives its energy from the splitting of uranium or plutonium atoms, a hydrogen bomb is powered by the energy created when isotopes of hydrogen atoms are fused together. This fusion reaction, requiring temperatures in the tens of millions degrees and immense compressing pressure, can only be triggered by the heat and force of an exploding fission bomb. In the words of one researcher: “It is as though whoever designed the universe wanted

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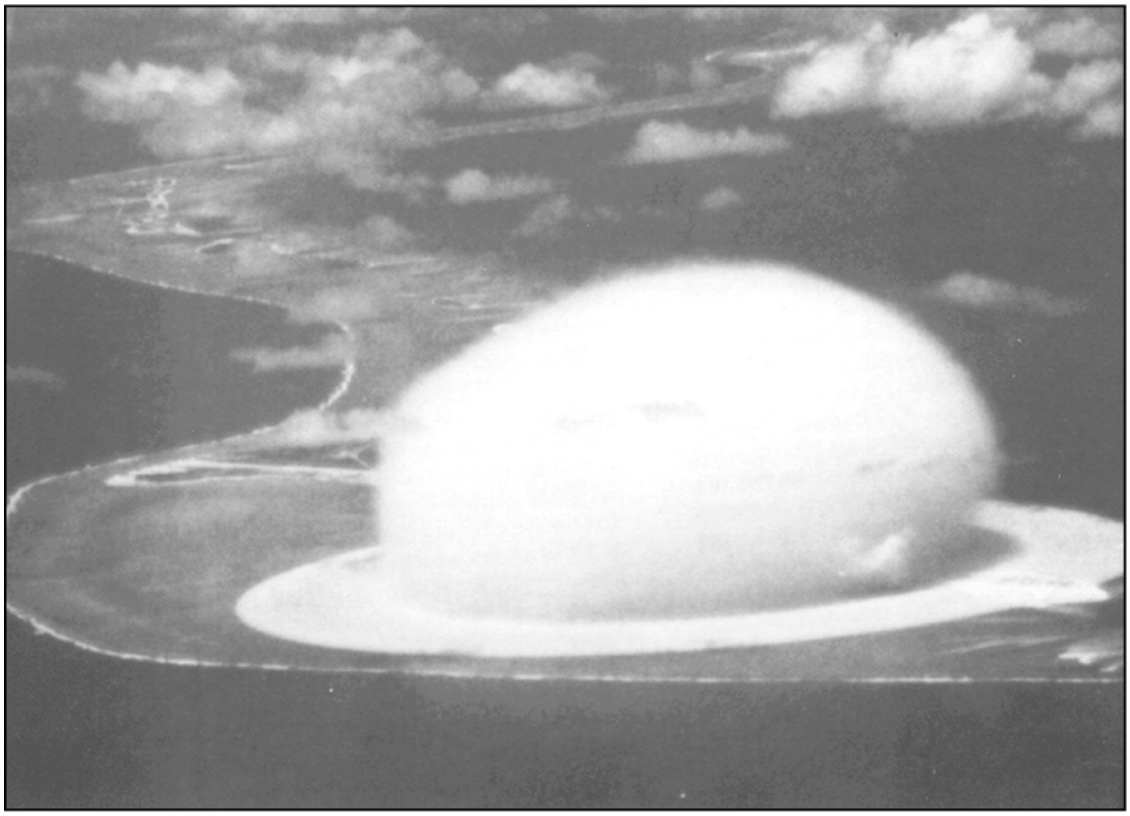
12. Under The Cloud, 1986, p. 188
13. AEC preliminary report to the President (11/01/52), quoted in US Nuclear Weapons. the Secret History, p. 95

Figure 9



Thirteen kiloton SEMINOLE shot, June 1956. SEMINOLE was detonated in a tank of water to simulate a subsurface blast. AEC photo.

CACTUS and LACROSSE craters on Enewetak atoll. The CACTUS crater has since been filled with radioactive waste and encased in concrete. AEC photo.

us to build nuclear weapons; fission and fusion made a yin-and-yang-like pair."{14} But to early physicists, fusion appeared both theoretically dubious and technically arduous to initiate. Edward Teller recounts: "One day the job [fusion] looked hopeless, the next day it seemed easy, only to turn out again to be practically impossible on account of some considerations that had not been previously included."{15} The physicist Hans Bethe elaborates on the discovery of harnessing the fusion process in a bomb:

> "It is difficult to describe to a non-scientist the novelty of the new concept. It was entirely unexpected from the previous development. It was also not anticipated by Teller, as witness his despair immediately preceding the new concept. I believe that this very despair stimulated him to an invention that even he might not have made under calmer conditions. The new concept was to me, who had been rather closely associated with the program, about as surprising as the discovery of fission had been to physicists in 1939. Before 1939 scientists had a vague idea that it might be possible to release nuclear energy but nobody could think even remotely of a way to do it."{16}

Thus, the destruction of Elugelab island became physical proof of "a brilliant discovery for which you cannot plan, one of the discoveries like the discovery of the relativity theory."{17}

This "discovery for which you cannot plan", opened the door to an assortment of nuclear milestones. But for fusion, there would have been no fear of a cobalt or doomsday bomb, the neutron bomb would be an impossibility and the Plowshare program would have been far more limited in scope, if it had been developed at all.

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14. Morland, H., The Secret That Exploded, 1981, p. 92
15. "The Work of Many People", E. Teller, *Science*, vol. 121, p. 269, 02/25/55
16. *Los Alamos Science*, Fall 1982, pp. 43-53, quoted in The American Atom, 1984, p. 136
17. "In the Matter of J. Robert Oppenheimer", GPO, 1954, pp. 170-171, quoted in The American Atom, 1984, p. 136

FUSION AND THE PLOWSHARE PROGRAM

Thermonuclear or fusion reactions are important to the Plowshare program for two reasons: projects on a huge scale are possible with fusion reactions, and the promise of “clean” fusion explosives provided a rationale and public relations tool for many Plowshare projects.

ECONOMY OF SCALE

A brief technical description is necessary to understand why conventional explosives and fission reactions were theoretically and economically unsuited for massive earthmoving and other Plowshare projects. To use an example, two of the more noteworthy Plowshare projects, a plan to excavate a harbor in Alaska [Project CHARIOT] and a plan to dig a sea-level canal through Panama [the ‘PANATOMIC’ canal] required 2.4 and 300 megatons [million tons TNT equivalent] respectively.{18}{19} Simply transporting the required amount of conventional explosives to these sites would have been a logistical nightmare. And economically, “a 100 kiloton ... nuclear explosion can be carried out for perhaps three million [dollars], whereas an explosion of the same intensity using TNT would cost about 100 million [dollars],” a savings of billions of dollars on the proposed canal project.{20}

As for using fission explosives, “fusion fuels [deuterium and lithum] are both cheaper and more abundant than fission fuels [uranium and plutonium].{21} Also, the hundreds of

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18. “The Disturbing Story of Project CHARIOT”, *Harpers Magazine*, April 1962, pp. 60-67
19. “Nuclear Excavation of a Sea-Level Canal”, 1966, Col. E. Graves, p. 3
20. “New Horizons in Resource Development”, *The Geographical Review*, 01/62, p. 1
21. “Nuclear Explosions in Science and Technology”, *B.A.S.*, vol. 16, #5, p. 155

megatons needed to excavate canals and harbors is impractical using fission explosives. Fission bombs not only create more dangerous radioactivity than fusion bombs, but more of them are needed to accomplish the same effect. Fission bombs with yield of over 50 kilotons are impractical due to an inefficient use of expensive fissile fuel materials.{22} On the other hand, fusion bombs with yields up to 58 megatons have been tested and their theoretical yields are limitless.{23} One well placed fusion bomb could do the job of ten fission devices. Further, a substantial increase in fusion yield only slightly increases the price of a fusion explosion [Figure 10].{24} Finally, reducing the number of explosives fielded saves time and resources at the weapons labs, and limits the number of expensive and delicate emplacement procedures required to position and lower the explosives into the ground.

Thus, fusion allowed Plowshare planners to conceive of ‘planetary engineering’ projects that were theoretically and economically impossible with conventional or fission explosives.{25} And, importantly, projects at such a massive scale caught the imagination of engineers, the public and Congress, providing an economic justification and moral boost to the program. The chairman of the Joint Committee on Atomic Energy, J. Pastore, stated that the scheme to create a canal with nuclear explosives “is the one thing that has given this thing [plowshare] life and the one thing that has more or less enthused this

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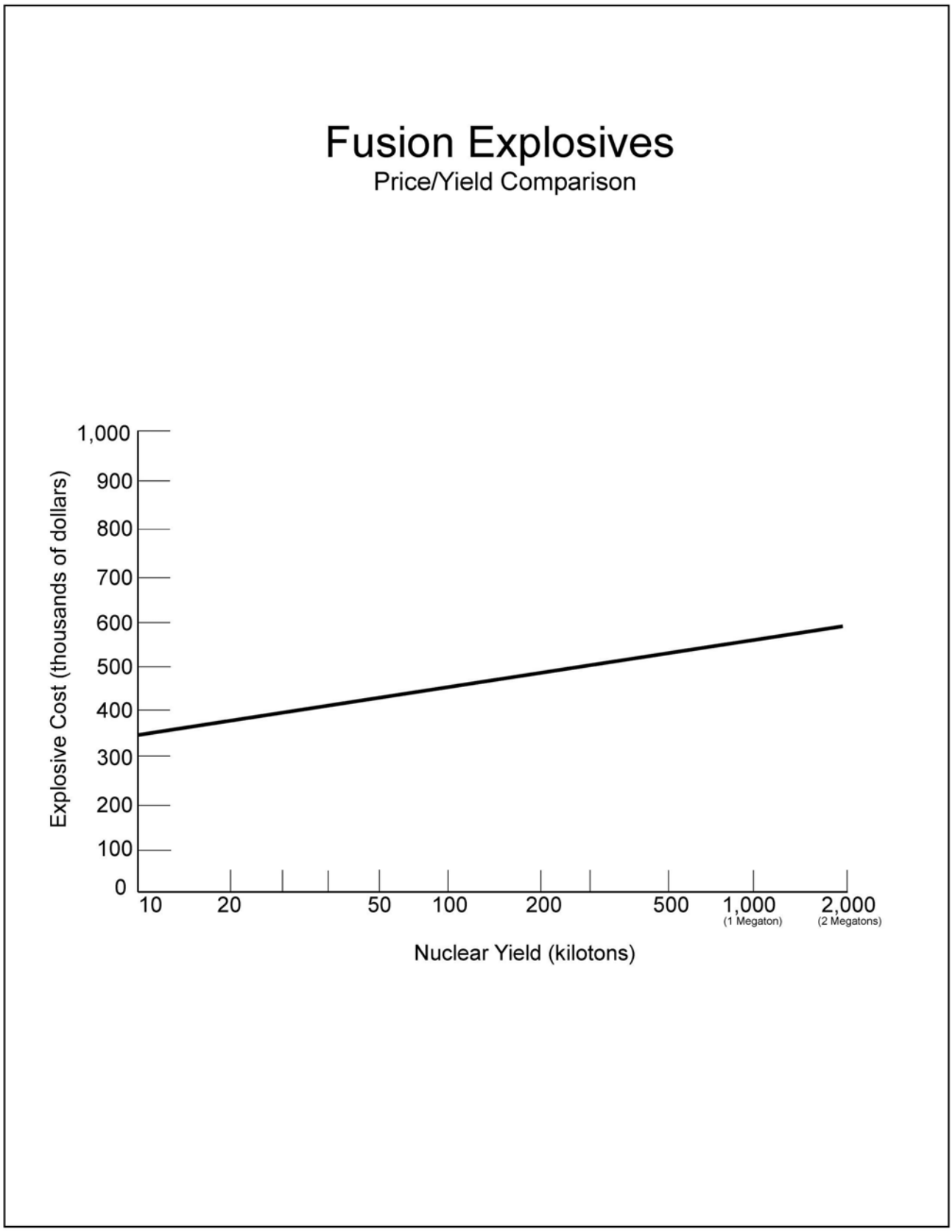
22. The Making of the Atomic Bomb, p. 563
23. The Curve of Binding Energy, McPhee, J., 1973, pp. 149-150; [Note: The largest nuclear bomb ever exploded was a 58 megaton airdrop (10/30/61) over Novaya Zemlya, USSR.]
24. Final Report to U.S. Arms Control & Disarmament Agency, “An Analysis of the Economic Feasibility, Technical Significance, and Time Scale for Application of Peaceful Nuclear Explosions in the U.S.”, (“The Long Report”), 04/75, p. 4
25. Planetary engineering”, Nuclear Dynamite, 1990, p. 174

Figure 10



Source: "Engineering With Nuclear Explosives", TID-7695, p. 9

committee to give money for Plowshare."{26} Blasting a sea level canal through Panama or digging a harbor off the coast of Alaska were exciting projects that were perceived to demonstrate American ingenuity and technical superiority on a grand scale. A 1958 report by the Presidents Science Advisory Committee stated: "A soundly prosecuted Plowshare program might be of value to U.S. prestige."{27} Optimistic engineers and physicists were excited and motivated by what nuclear explosives might accomplish in their peaceful form. While touring Alaska in 1959 to drum up support for a nuclear excavated shipping harbor [Project CHARIOT], Edward Teller told the crowd, "If your mountain is not in the right place, just drop us [the AEC] a card."{28} Others joked that the Plowshare program was designed to make "molehills out of mountains."{29} Former AEC chairman Glen Seaborg waxed enthusiastic that 'geographic engineering' schemes "stirred the world's imagination" and allowed humanity to fix up a "slightly flawed planet."{30}{31}

"CLEAN" BOMBS

Schemes to fix up a "flawed planet" gained currency with skeptics due to another aspect of the massively powerful fusion bomb. A pure fusion reaction theoretically creates no radioactive isotopes or dangerous fallout. Such a radioactively-free explosion, in nuclear jargon, is "clean". A "clean" explosive eliminates the need for "excessively large control of areas for a long time after the event to wait for radioactivity to decay or

26. JCAE "Authorizing Legislation FY 1966", p. 25
27. The President's Science Advisory Committee, "Nuclear Test Ban Negotiations", Doc. #85-253, exact date unknown, declassified 10/07/87.
28. "Expert Quiet on Red Issue of 'H-Bomb"', Anchorage *Daily Times*, 06/26/58
29. Nuclear Dynamite, p. 64
30. "stirred imagination", Nuclear Dynamite, p. 5
31. "slightly flawed", Ibid.

disperse. [And] the magnitude of the area and time required for control clearly would have a major impact on feasibility and cost."{32} In other words, nuclear engineering projects with "clean" bombs is cheaper and environmentally less hazardous than similar projects using "dirty" fission bombs. Testifying before the Joint Committee on Atomic Energy in 1960, Edward Teller states: "I can say, not with certainty, but with quite a bit of hope, that we can make nuclear explosives for peaceful purposes so clean that the worry about radioactivity in its peaceful applications may disappear completely." Teller's colleague Freeman Dyson writes at the same period: "There appears to be no law of nature forbidding the construction of a fission free ["clean"] bomb. Should the United States solve this problem it would... increase the applicability of nuclear explosives to industrial and civil problems."{33}

The belief on the part of certain physicists of a perfectible "clean" bomb was fueled by its public relations appeal. In the view of Carol Cohn, a psychologist and author of "Nuclear Language and How we Learned to Pat the Bomb", "clean bombs may provide the perfect metaphor for the language of defense analysts and arms controllers... 'Clean' bombs... also tell us that radiation is the only dirty part of killing people."{34} The phrase, in her view, laid the groundwork for other Orwellian terms such as "surgically clean strikes".{35} But in the late 1950's and 1960's, the Atomic Energy Commission and Plowshare planners presented fusion or "clean" bombs to the public as an imminent reality, not calculated 'nukespeak', to reassure those concerned

32. "The Work of Many People", p. 3
33. "Project Plowshare", Sanders, R., 1964, p. 12
34. "Nuclear Language and How We Learned to Pat the Bomb", C. Cohn, in *B.A.S.*, 06/87, p. 18
35. Ibid.

about health hazards.{36}

For example, the fallout pattern of SEDAN, a 100 kiloton Plowshare test detonated in July of 1962 at the Nevada Test Site and one of the “dirtiest” continental tests of the 1960’s, was frequently used as a baseline to compare with “clean” bombs under development [Figure 11]. But the outwardly reassuring nature of graphs and quantitative measurement had a misleading aspect to it. Due to the immensity of SEDAN’s fallout cloud, comparisons to other tests were disingenuous as nearly any test’s fallout look minor compared to the wake of radiation left by SEDAN:

> “The main body of the [SEDAN] cloud crossed Highway 25 four miles west of Queen City Summit and Highway 6... A ‘finger’ of the cloud crossed Highway 6... and then apparently rejoined the main body somewhere north of Duckwater. Aerial monitoring last located the cloud as it crossed Highway 50 between Eureka and Ely [streetlights in Ely were turned on at 4 p.m. as the cloud passed through]. At this point it was 35 to 40 miles wide, having narrowed down a bit from a 55 mile width in the Currant vicinity [Map 9].”{37}{38}

Despite the widespread fallout, which required seven miles of contaminated highway to be hosed down by fire trucks, SEDAN was perceived by Livermore scientists to be “clean... [just] not clean enough.”{39}{40} SEDAN, to “clean” bomb advocates and Plowshare planners, was a necessary experimental stepping stone. The blast received 30% of its power from fission reactions; it was believed if this percentage was reduced to just a few percent, cratering blasts could be safely performed anywhere.{41} However,

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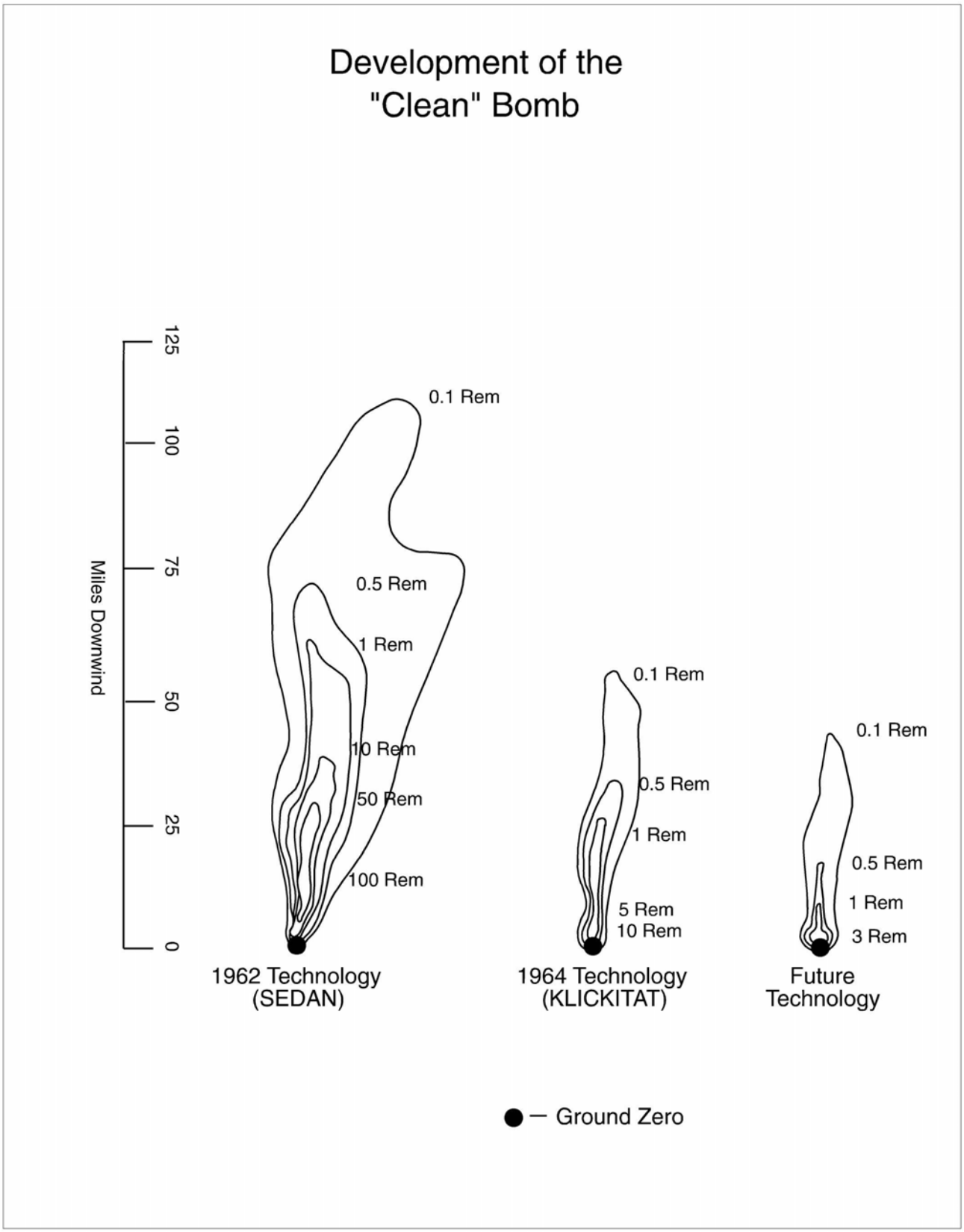
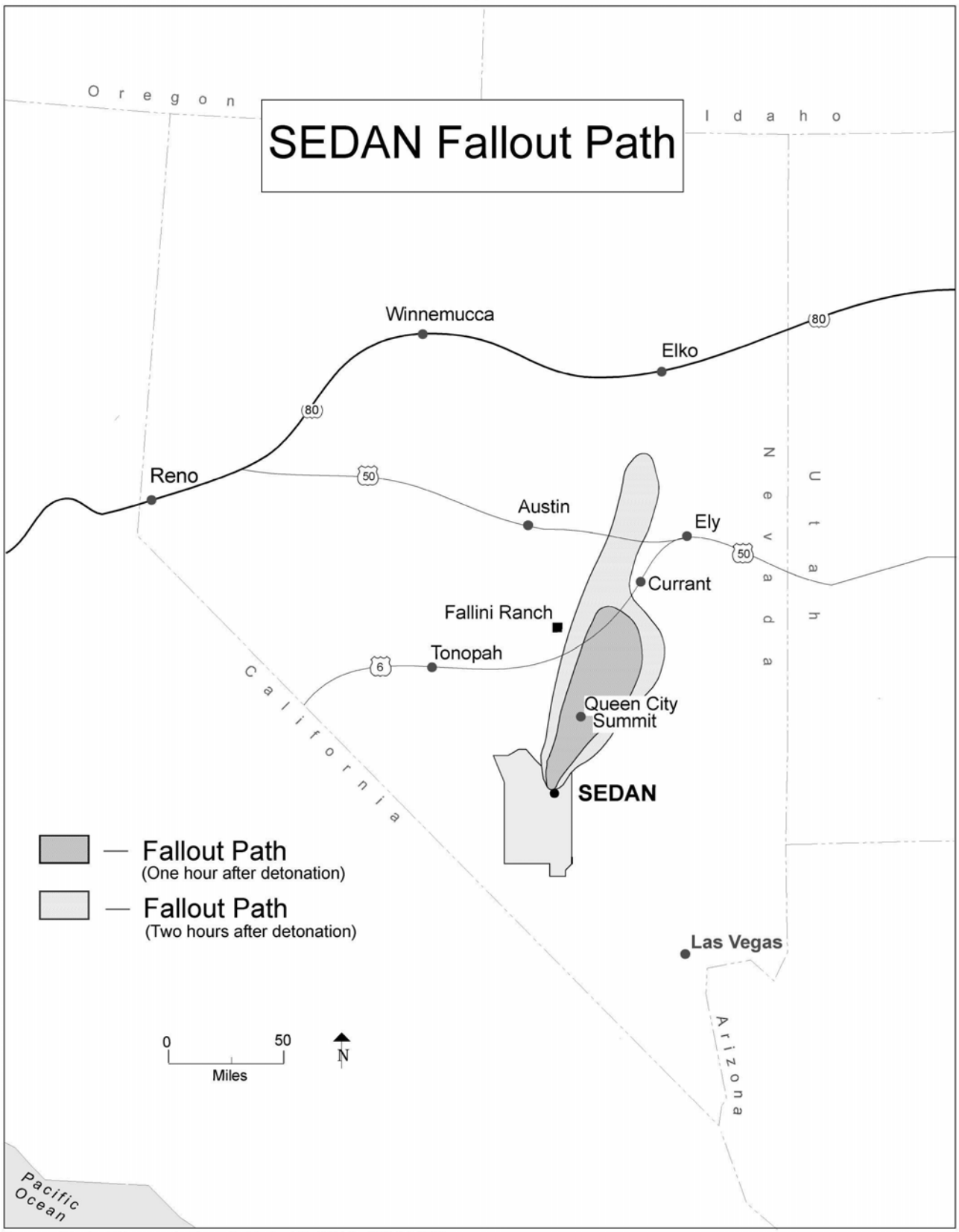
36. See, for example, JCAE, “Authorizing Legislation FY”, p. 1110
37. “Project Manager’s Report: SEDAN”, p. 39
38. “streetlights”, Fallout, p. 136
39. “fire trucks”, Ibid., p. 38
40. “clean enough”, Fallout, p. 136
41. See, for example, “Project Plowshare” R. Sanders, US AEC Public Affairs

Figure 11



Source: "Nuclear Applications & Technology", vol. 7, No. 3, Sept. 1969, p. 191

Map 9



Source: "Project Manager's Report - Project SEDAN", CIC #15336.

much of the public, including members of Congress, did not see “clean” bombs in the same optimistic light of Plowshare planners and believed the AEC was “applying advertising techniques... to alleviate fears of destruction.”{42} In 1957, the JCAE attempted to clarify the definition of “clean” which was already being satirized in the popular press [Figure 12]:

> “Rep. Holifield:...This committee is not responsible for the phrase “clean bomb.” We are not responsible for it. But there are millions of people throughout the world that may be hanging their hopes upon the fact that we have a humanitarian hydrogen bomb.
>
> Dr. Graves: I am afraid the only comment one can make on it is that “cleanliness” is a little bit relative anyway. What you mean by “cleanliness” in this case is a question of degree.
>
> Rep. Holifield: You would not say in this case that cleanliness is next to godliness
>
> Dr. Graves: No... [C]omplete cleanliness is next to impossible to achieve.
>
> Rep Holifield:...Therefore, the conclusion we can reach is that there is a dirty bomb and there is no such thing as a clean bomb...
>
> Dr. Graves: There are dirtier bombs, and some that are less dirty.”{43}

To this day, it is impossible to make a “clean” nuclear bomb of any type. Dangerous radiation is created in an assortment of unavoidable ways by fusion reactions. Fusion reactions are contaminated by [1] fission products from the fission ‘trigger’, [2] the residual or ‘unburned’ fusion fuel [tritium], [3] the residual or unburned fission fuel [plutonium and uranium], [4] “side reactions... in the thermonuclear fuel” and [5] neutrons

42. Nukespeak, p. 51
43. JCAE, “The Nature of Radioactive Fallout”, 1957, p. 74

Figure 12

Source: "Herblock's Special For Today ", (Simon & Schuster, 1958).

captured by reactive materials [Figure 13].{44} A “clean” bomb was and remains an impossibility. Its appeal as a term in the nuclear jargon can be attributed to technological optimism by physicists and the desire to alleviate public concern over testing. The 1965 congressional testimony of Glenn Seaborg, then chairman of the AEC, reveals the persistence of “clean” bombs in a manner strikingly similar to Dr. Graves testimony eight years earlier:

> “Rep. Hosmer: [Dr. Seaborg] you have made constant reference to clean devices. Are you able to tell us what you are talking about?
>
> Dr. Seaborg: Yes, but not in detail. By clean device, I mean a device where the proportion of energy compared to the overall energy produced by the device - the proportion produced by the fission reaction as compared to the fusion reaction - is at the absolute minimum.
>
> Rep. Hosmer: You are not talking about a pure fusion reaction?
>
> Dr. Seaborg: No.
>
> Rep. Hosmer: You are not talking about a clean device but a cleaner device, then, are you not?
>
> Dr. Seaborg: Yes.”{45}

TESTING NUCLEAR WEAPONS UNDERGROUND

Also of importance to the Plowshare program was the first successful underground containment of a nuclear explosion. Up to September 1957, only four nuclear tests had taken place underground; all were small yield tests that were expected to vent radiation to the atmosphere - which they did.{46} No one knew at this time if it was possible to contain the blast and radiation of

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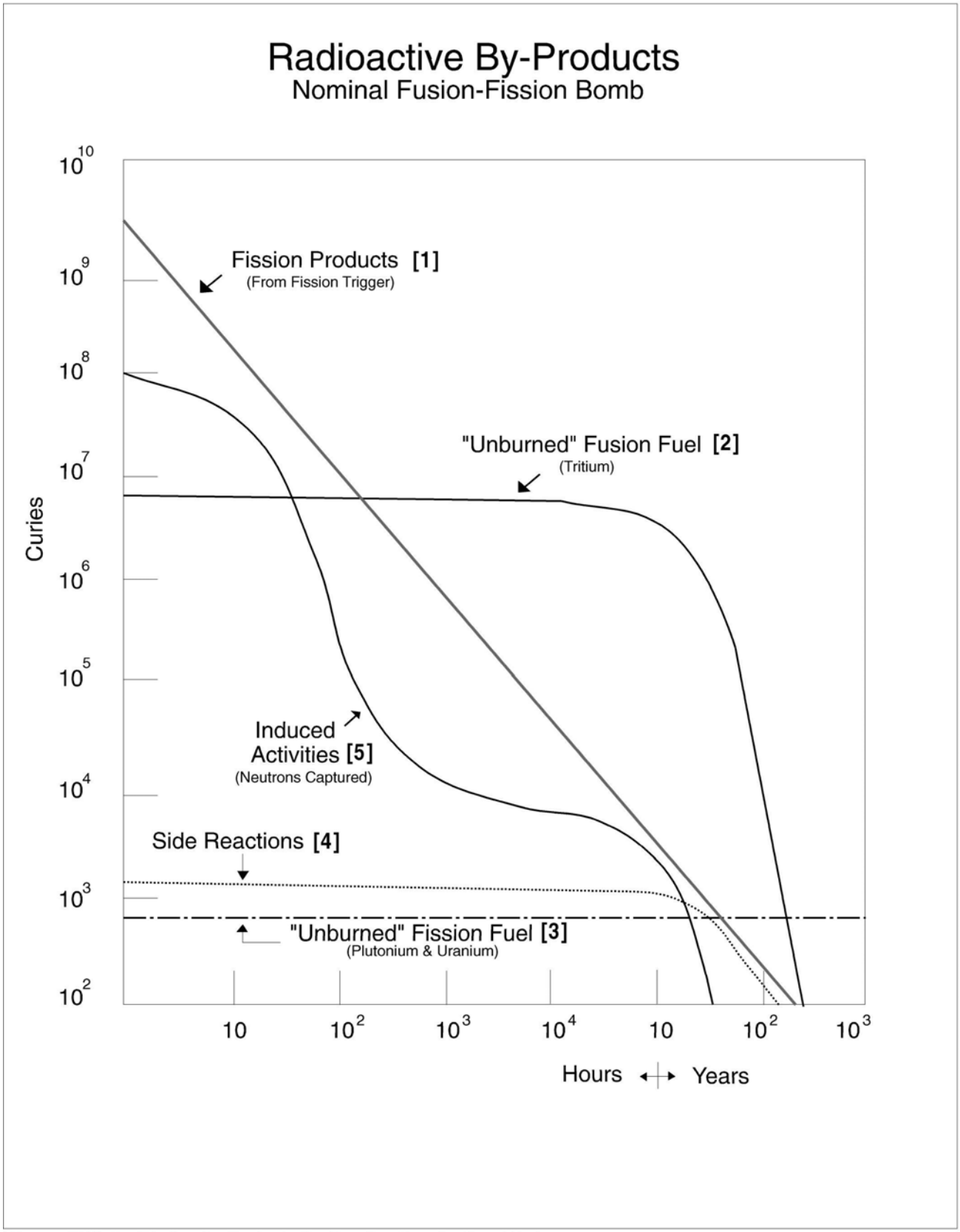
44. “Reduction of Radioactivity Produced by Nuclear Explosions”, LLL, 1970, p. 1562; see also “The Long Report” pp. 4-5
45. JCAE, “Peaceful Applications of Nuclear Explosives”, 1965, pp. 28-29
46. US DOE, “Announced US Nuclear Tests” & DNA, “Compilation of Local Fallout Data From Test Detonations 1945-1962: Vol.1 Continental Tests”, (hereafter “Local Fallout Data, vol. 1”) DNA 1251-1-EX, 05/79. These four tests are: UNCLE, ESS, PASCAL-A, SATURN & PASCAL-B.

Figure 13



Source: "A Study of Radioactive Contamination Resulting From the Use of Nuclear Explosives for Stimulating Petoleum Production", TECP-6036, 09/87, p. 4

a nuclear explosion underground. But there were several pressing reasons to try. The AEC was hoping to initiate a viable underground testing program that would end delays due to unfavorable weather and shifting wind patterns which often threatened to send fallout over populated areas. Scientists were curious as to the seismic effects of an underground blast and the possibilities of concealing such tests from the Soviet Union. Finally, many physicists and politicians were anticipating a worldwide ban on atmospheric testing and it was hoped that contained underground explosions, if they were possible, would be less charged politically and allow the testing program to continue.

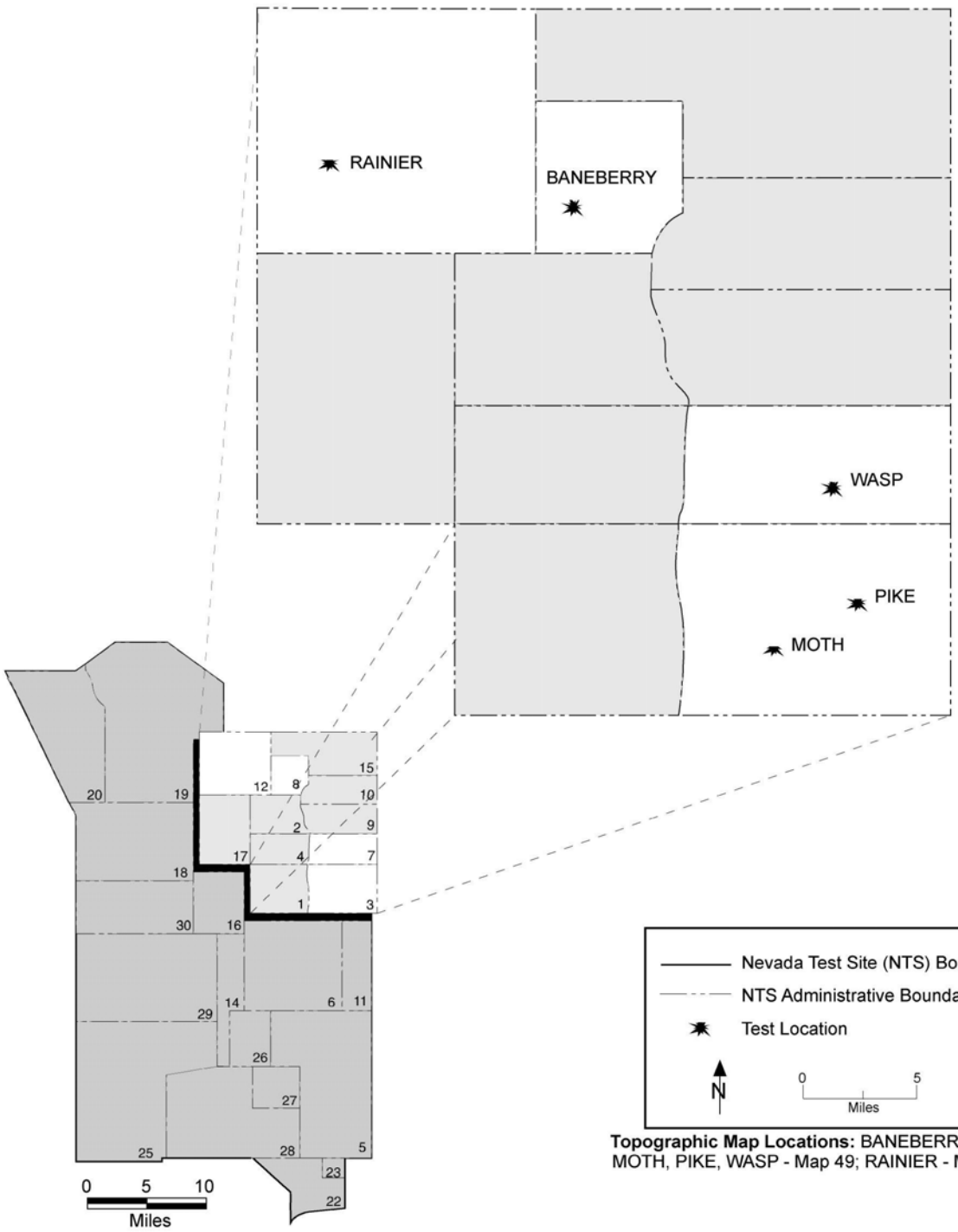
PROJECT RAINIER

Project RAINIER was the first attempt by the United States to completely contain an underground nuclear explosion. Conducted at the Nevada Test Site in 1957, RAINIER was deemed an unqualified success [Maps 10 & 11][Figure 14]. Valuable seismic data was gathered and no radiation was detected above ground; it had been trapped underground in the molten rock created milliseconds after the blast.{47} The results of RAINIER opened the door to the modern weapons testing program in which nuclear tests are conducted solely in underground shafts or tunnels. Within ten years of the RAINIER test the subsurface rock of the Nevada Test Site was riddled with hundreds of underground shafts and tunnels. The importance of underground testing to weapons development led one AEC sponsored geologist to refer to the subsurface rock of the

47. Ibid., p. 359

Map 10

Selected Nuclear Tests
Nevada Test Site



Topographic Map Locations: BANEBERRY - Map 21; MOTH, PIKE, WASP - Map 49; RAINIER - Map 11.

Source: "Compilation of Local Fallout Data", DNA 1251-1-E, & Springer, D., "Seismic Source Summary", UCRL-73036, 02/71.

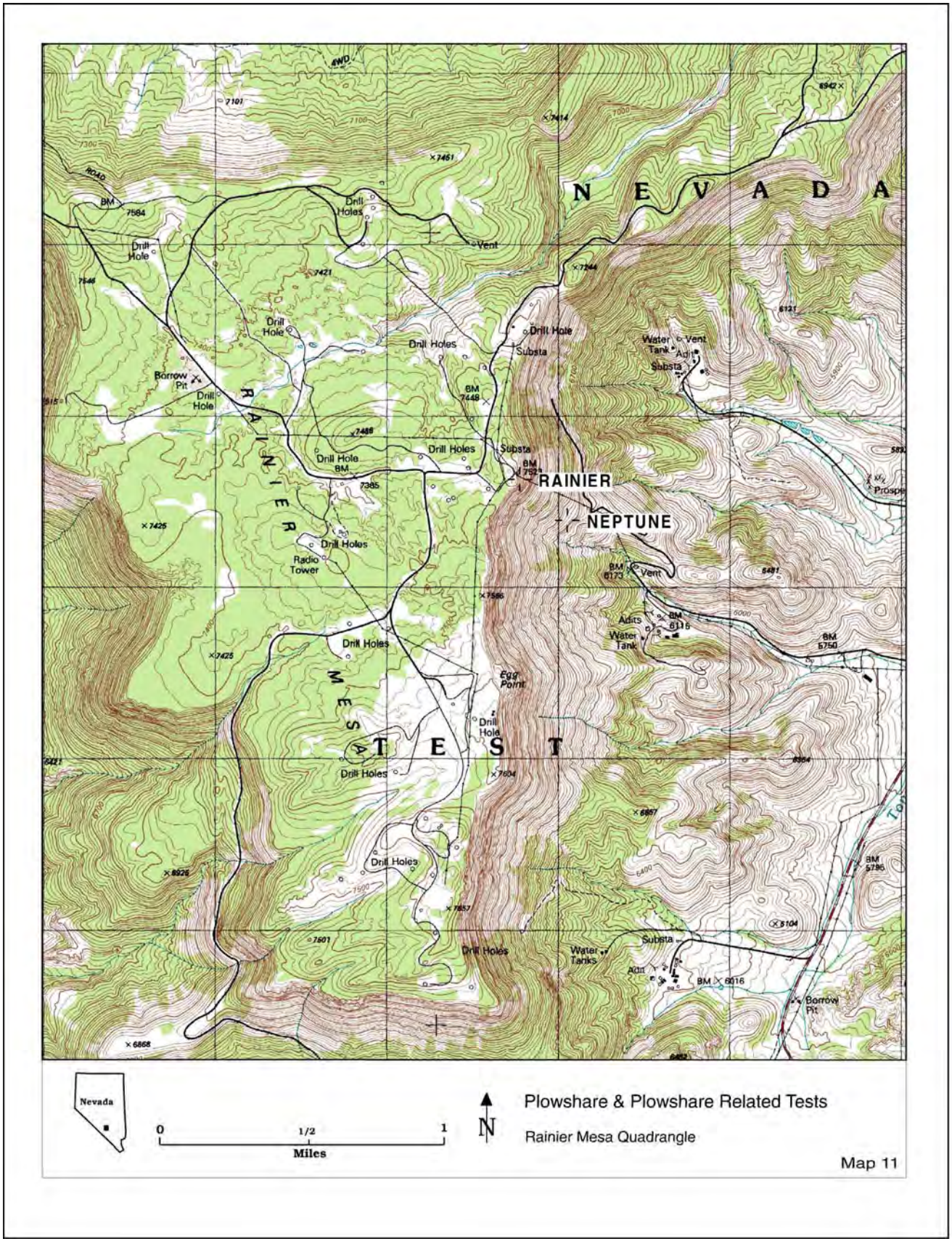
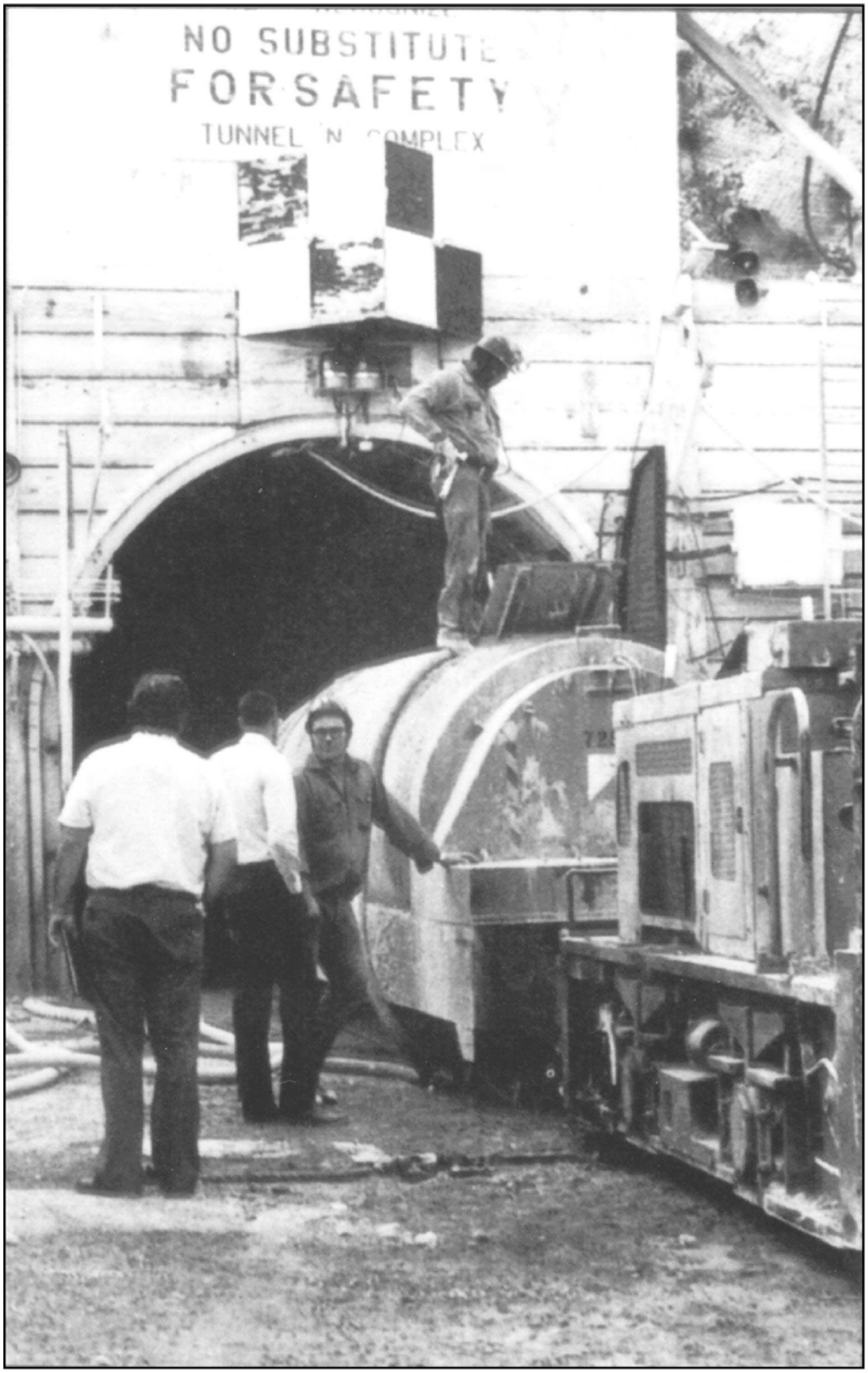

NEVADA
RAINIER MESA TEST
RAINIER
NEPTUNE
Drill Holes
Drill Hole
Vent
Water Tank
Adits
Substa
Borrow Pit
Radio Tower
Egg Point
Water Tanks
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Rainier Mesa Quadrangle
Map 11

Figure 14



N-Tunnel entrance. This tunnel is similar to B-Tunnel which was used for shot RAINIER. AEC photo.

test site as a “non-renewable national resource”.{48}

RAINIER conclusively demonstrated that it is possible to contain a nuclear explosion underground. It also led to serious planning for the peaceful Plowshare program. The blast effects and the sealed underground cavity created by the explosion brought up intriguing civil engineering possibilities such as underground storage, mineral extraction and storage of thermal energy. These potential uses of nuclear explosions, not fully anticipated by physicists before RAINIER, led to proposals for further study. For example, a *Scientific American* article published shortly after RAINIER based its optimistic discussion of non-military nuclear explosions solely on the results of this one test. The authors discussed applying “the RAINIER experience... directly to the technology of mining” and using “the RAINIER [experience]... to trap the heat in a natural formation underground.”{49} Previous to RAINIER, the scope of discussion concerning possible applications of peaceful nuclear explosions had been limited largely to ditch digging applications. The AEC, “greatly encouraged by the preliminary studies at Livermore and by RAINIER”, formally established the peaceful nuclear explosive (PNE) or Plowshare program in late 1957.{50} In October 1957, the Army Corps of Engineers agreed to support this effort, and within a year the AEC had a similar agreement with the uses and the Bureau of Mines. The development and use of nuclear explosions for peaceful purposes appeared to be an imminent reality, as presaged by Section 1 of “The Atomic Energy Act of 1946”:

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48. “Development of Knowledge at the Nevada Test Site”, E. Eckell, from Geological Society of America Memoir 110, 1968, p. 6
49. “Non-Military Uses of Nuclear Explosives”, Scientific American, vol. 199, #6, 12/58, p. 32
50. See, for example, “NVOO Factbook”, 1969, p. 54

> "The significance of the atomic bomb for military purposes is evident. The effect of the use of atomic energy for civilian purposes upon the social, economic, and political structures of today cannot now be determined... It is reasonable to anticipate, however, that tapping this new source of energy will cause profound changes in our present way of life. Accordingly, it is hereby declared to be the policy of the United States that, subject at all times to the paramount objective of assuring the common defense and security, the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace."{51}

NUCLEAR TESTING NOMENCLATURE

Before proceeding, it is useful to know a bit regarding nuclear testing nomenclature. All United States nuclear tests are designed by either Los Alamos National Laboratory (LANL) or Lawrence Livermore National Laboratory (LLNL). Nuclear explosions, therefore, are "sponsored" by one of these two labs.{52} For example, Livermore Labs, which initiated the Plowshare program, sponsored most Plowshare tests [Figure 1b]. Further, nuclear tests always have code names associated with them. Potential names are submitted to the DOE office of Military Application for "screening and selection."{53} Code names are applied to, among other things, nuclear "devices" (the type of bomb), nuclear "events" (the actual explosion), and each series of nuclear "events". For example, the ZOMBIE "device" was used in the LANL sponsored NECTAR "event" of the CASTLE series. For the purpose of communicating with the press and public, "event" and series names are generally announced, although there have been exceptions. "The code name FULCRUM, defined as the United States underground

51. "Atomic Energy Act of 1946", Public Law 585, 08/01/46, Section l.(a)
52. See, for example, "Known U.S. Nuclear Tests", (rev. 2C) NRDC, 1989, p. 5
53. "Frequently Asked Questions About the Nevada Test Site", NVOO, 04/89

nuclear detonation program for FY 1977", was unclassified only after the series had ended in November 1976.{54} However, the code name of the "device" used for a particular nuclear test is rarely revealed, as the DOE feels that even this type of general information could reveal design failures or weaknesses.

Code names are not always (or perhaps ever) randomly assigned. For this reason, they lend coherency to the reading of nuclear testing documents and are a useful research tool. At times, code names merely reflect a natural grouping of particular tests. For example, the 1956 REDWING series tests were named after Indian tribes [SEMINOLE, MOHAWK etc.].{55} In the 1957 PLUMBOB series, Livermore tests were named after mountain peaks [LASSEN, WHITNEY etc.] while the Los Alamos tests were named after dead physicists [NEWTON, DOPPLER etc.].{56} Tests in the 1958 HARDTACK I series adopted the names of trees [ASPEN, REDWOOD etc.].{57} Recent fiscal year series names have referred to warrior groups [PHALANX (1983), GRENADIER (1985), MUSKETEER (1987), etc.].{58}

Code names also give an indication of the purpose of particular tests, information that is usually highly classified. For instance, BRIE and COTTAGE were the last of six tests in the 'Cheese Series' to continue research on the x-ray laser, one of the components of the Strategic Defense Initiative (SDI) or Star Wars.{59} It seems logical that other 'Cheese' tests [MUENSTER, ROMANO, etc.] likewise involve the x-ray laser. Test TAPESTRY, part of the 'fabric series', follows a similar pattern:

"TAPESTRY... investigated the vulnerability of AEC and DOD

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54. "Code name FULCRUM", ERDA memo, 11/26/76, CIC #0159492
55. See "Announced US Nuclear Tests", p. 6
56. Ibid., p. 7
57. Ibid., p. 9
58. Ibid., pp. 55-59
59. *Testing News*, The Downwinders, vol.V,#3,05/89, pp. 6-7

> warhead componentry” [deleted deleted]. The [deleted]device, previously tested in the CASHMERE and PLAID events served as the [deleted deleted etc.] which was to be winched clear after the event.”{60}

It is likely that “events” WOOL and TWEED, also named after fabrics, tested warhead componentry or used the same “[deleted] device” as well. Finally, weapon effects tests - tests designed by the Defense Nuclear Agency (DNA) to evaluate the effects of a nuclear blast on hardware - are almost always given a two word code name such as HUSKY PUP, HURON LANDING or MISTY RAIN.{61}

Plowshare test names also follow a pattern. Nearly all Plowshare excavation experiments are named after a conveyance, perhaps to imply the envisioned role of nuclear excavation in transportation projects such as canals [GONDOLA], harbors [CHARIOT], and highway construction [CARRYALL]. The first Plowshare test, GNOME, was named after “dwarflike creatures who live underground and guard treasure” to indicate the unknown and unexplored side of nature that might be revealed by the test.{62} Two of the three gas stimulation tests were named after the community nearest to the explosion [RULISON, RIO BLANCO] while the third was named after a conveyance [GASBUGGY]. Many tests are also linked with ‘mascots’ to visually represent the tests in reports and on test site worker’s hardhats [Figures 15a & 15b].{63}

Nuclear test code names [MILK SHAKE, SARDINE etc.], testing jargon [“device”, “event”] and the ‘mascots’ chosen to depict nuclear tests, besides being helpful research tools, are

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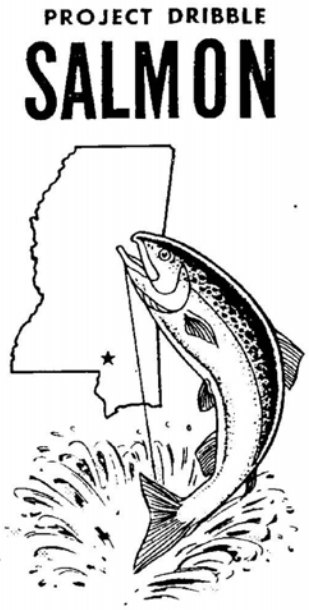
60. “FLINTLOCK Test Bulletin No. 28”, US AEC, 05/13/66, declassified with deletions 07/29/81
61. See “Announced US Nuclear Tests”, pp. 1-62
62. “Peace Bomb Gets Into Air”, *The Morning Sun* (Baltimore, MD), 01/11/61, CIC#35457
63. See, for example, equipment display, National Atomic Museum, Kirtland Air Force Base, Albuquerque, NM.

Figure 15a

Note: Nearly all Plowshare excavation projects, such as those referenced above, were named after conveyances. Other excavation projects with conveyance names include: CABRIOLET, CARRYALL, CHARIOT, COACH, DOGSLED, FLIVVER, GALLEY, OXCART, PHAETON, ROWBOAT, SCOOTER, STAGECOACH, STREETCAR, TOBOGGAN, TRAVOIS, TUGBOAT, WAGON and YAWL.

Figure 15b



Examples of logos and mascots for proposed Plowshare tests (BRONCO, WAGON WHEEL), Plowshare tests (GNOME) and nuclear tests with Plowshare applications (SALMON).

also indications of how the DOE and the weapons labs perceive nuclear tests. To illustrate, tests in the previously mentioned ‘Cheese Series’ and ‘Wine Series’ [BORDEAUX, CHARTREUSE] were celebrated by Lab physicists with “wine and cheese part[ies].”{64} The environmental and health implications of nuclear testing lose their significance when blended with language usually reserved for hors d’oevres and refreshments:

> “As long as words a diff’rent sense will bear, And each may be his own Interpreter, Our airy faith will no foundation find: The word’s a weathercock for ev’ry wind...”{65}

Nuclear testing’s misappropriation of language serves to buffer its proponents against the reality of nuclear destruction. Thus, a knowledge of nuclear jargon adds to an understanding of how Plowshare planners could blithely propose nuclear tests throughout the intermountain west and elsewhere.

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64. “Anthropologist Studies Lab Man”, S. Rubin, SF *Chronicle*, 09/11/89
65. “The Hind and the Panther”, Dryden, lines 452-455; quoted in Standing By Words, W. Berry, 1983, p. 133

SECTION III

PLOWSHARE EXCAVATION PROJECTS

Plowshare experiments, as previously mentioned, were primarily “demonstration projects” designed to test the feasibility of particular civil engineering proposals. Plowshare proponents believed that as peaceful nuclear explosive techniques became more refined and accepted, large scale engineering projects, and their accompanying benefits, would quickly follow. Proposed projects included building harbors and canals wherever they were deemed necessary, producing isotopes for medical and scientific uses and developing oil shale and gas fields more efficiently. It was this vision - a landscape tailored to suit the needs of all - that gave the Plowshare program its resilience and vitality.

One image in particular brought excitement, energy and financial backing to the excavation studies undertaken by the Plowshare program; a plan to build a sea-level canal through the isthmus of Central America using nuclear explosives [Map 12a]. This proposal captured the imagination of Plowshare planners and became the implicit focus of research for essentially every Plowshare excavation experiment. The canal proposal was, in Edward Teller’s words, “central in guiding the research and development program for nuclear technology.”{1} Ed Fleming, formerly Assistant Director for the Plowshare program at Livermore, states: “the [canal] project was the ‘chief driving force behind Plowshare.’”{2} And political scientist Mason Willrich felt a nuclear excavated canal was “a ‘major incentive’ for Plowshare, providing it with

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1. Nuclear Dynamite, p. 25
2. Ibid.

Map 12a

Source: "Status of the Interoceanic Canal Study", ICSC, January 1970.

most of its ‘political momentum”’.{3} So while this proposed ‘PANATOMIC’ canal was never constructed, its impact on the Plowshare program was significant. Following is a brief history of Panama to provide a background for the discussion of canal-related excavation experiments carried out in the United States.

PANAMA AND THE CANAL

The border region of Panama and Colombia, the connection between Central and South America, is comprised of the Atrato Swamp to the south and the Darien highlands to the north. Crossing this area, known as the Darien Gap, is possible to this day only by canoe along the Atrato and Tuira rivers [Map 12b].{4} This 150 mile swath of rainforest stands as the last barrier to a long envisioned Pan-American highway - a continuous thoroughfare stretching from Alaska to Chile. This ‘gap’, one of three main sites considered for a ‘PANATOMIC’ canal, is also noteworthy for its political significance.

In 1903, Theodore Roosevelt negotiated with Columbia’s President, F. Marroquin, for the use of a strip of land in Panama, a territory of Columbia, to build a canal. The president approved the terms, but the Columbian congress voted against the canal, leading to a revolt by those Columbians who lived north of the Darien Gap in present day Panama. Isolated from Columbia by the Darien Highlands, residents of Panama had long felt neglected by the rest of Columbia, and saw the canal as a means to better their economic and political influence in Bogota.{5} When the treaty

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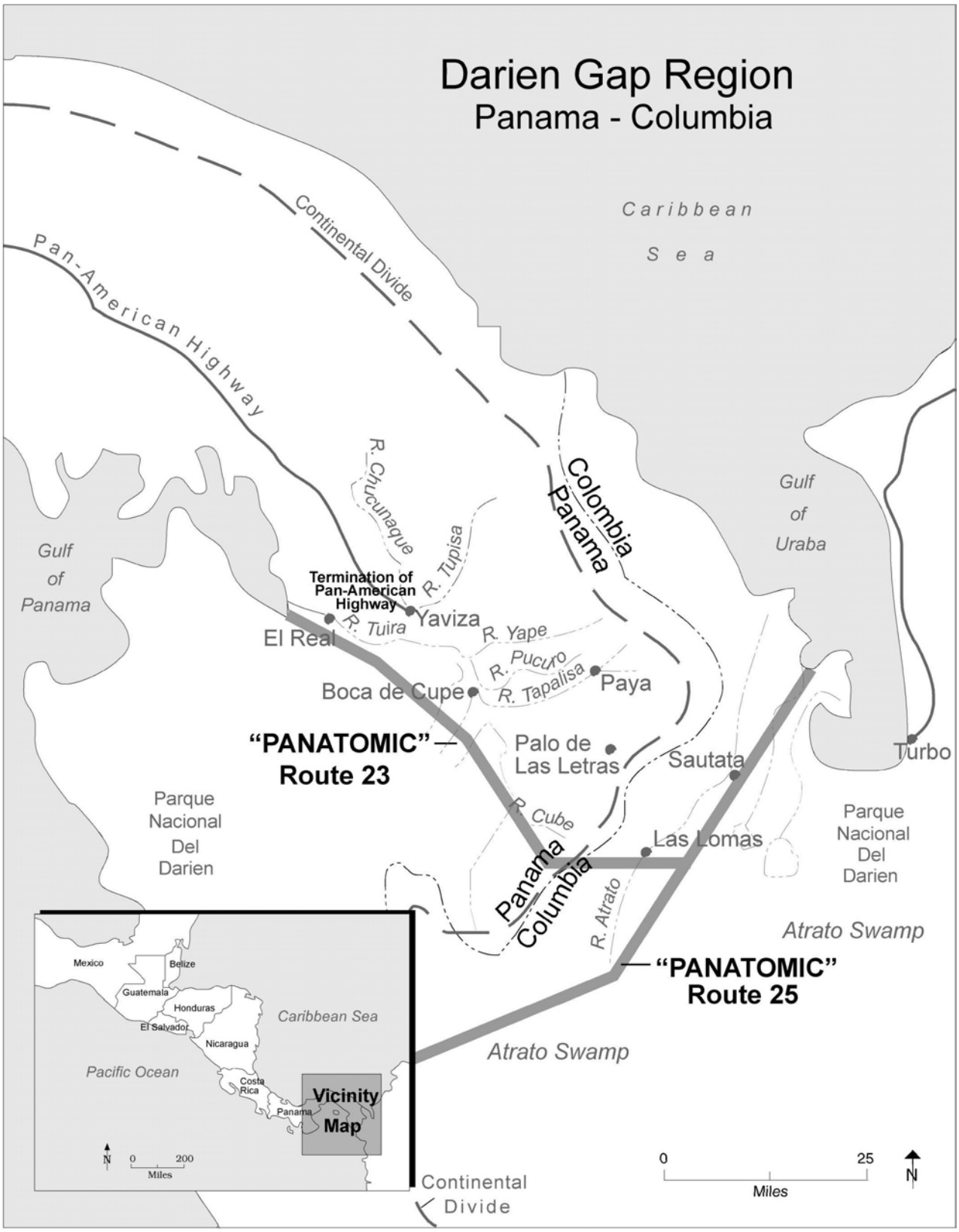
3. Ibid.
4. Bradt, H., “Tree by Tree - Walking the Darien Gap”; included in Trekking - Great Walks of the World, 1988, p. 114
5. “Congressional Record - Senate”, January 4, 1904, p. 420

Map 12b



Source: "Status of the Interoceanic Canal Study", ICSC, Jan. 1970.

was rejected, the Panamanians revolted to form an independent state that could negotiate for a canal on its own. The rebellion was supported by the United States, which used gunboats to prevent Columbian troops from reaching the rebels by ship, as overland troop travel through the Darien Gap was impossible. The insurgents, backed by the United States government and insulated from Columbia by “an impassable region... [of] swamps and jungles... and hostile Indians,” accepted the terms of Roosevelt’s treaty of Hay-Herran and declared their liberation from Columbia.{6} An American canal zone was created, and by 1914 trans-oceanic ship travel was possible through an independent Panama.

However, by the late 1950’s, it was feared that the volume of shipping traffic would soon outgrow the original canal. In addition, a number of modern tankers and military ships could not fit into the existing locks at all. The trend looked ominous for commerce and the military. Also of concern was, in the words of one American journalist, the “nationalism... grow[ing] even in a lawless, third rate, artificial country like Panama.”{7} Panama, it appeared, would risk revolution to regain sovereignty over the canal zone ceded to the Americans.

‘PANATOMIC’ CANAL PROPOSAL

Plowshare planners offered a solution: a sea level canal, created by nuclear explosives. Such a canal would be economically feasible and strategically superior to the existing six lock canal. A nuclear excavated canal would be four to eight

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6. Ibid., p. 430
7. Fire Down Below, 1988, p. 106

times cheaper than a conventionally built canal.{8} Eliminating locks would reduce ship transit time from twelve to eight hours, and make the canal less vulnerable in time of war.

Also, by building, or even *promising* to build a new canal with nuclear explosives, the United States could exert political pressure on the Panamanian government. Panama, “more a geographical area than a viable country”, knew its greatest resource was its location.{9} Any conventionally built trans-isthmus canal had to follow the path of least resistance and pass somewhere through Panama, the narrowest section of Central America. With nuclear explosives, however, site possibilities expanded to include Mexico, Nicaragua and Columbia. Politicians hoped Panama would acquiesce to a continuing American presence in the canal zone once the Panamanians realized their geographic superiority had been overcome by modern technology.

There was also a less tangible motive for building a sea level canal with nuclear explosives: a means to gain international prestige. Edward Teller elaborates:

> “The Communists might develop Plowshare before we do... Cheap, safe, and ‘clean’ nuclear explosives in Communist hands would carry a most important implication: if the Soviet Union has surpassed America in the peaceful uses of the greatest force on earth, Russia certainly must be ahead of the United States in military applications. As a propaganda weapon, Plowshare could finish the work begun with the launching of Sputnik.”{10}

A Canal Zone official put the matter in less adversarial terms: “While digging a sea-level canal... may not be as spectacular as putting a man on the moon... it could be equally

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8. “A Second Canal?”, *New Republic*, 03/28/64, p. 23
9. “Storm Over the Panama Canal”, *New York Times Magazine*, 05/08/60, p. 92
10. The Legacy of Hiroshima, 1982, p. 87; quoted in Nuclear Dynamite, p. 79

important for U.S. prestige throughout the world."{11} This interest in advancing U.S. prestige went hand in hand with comments that denigrated the character of Panama, the country most likely to 'host' the nuclear excavated canal. For example, "[In Panama], instead of order, there is unpredictability... and a sparsely populated hinterland of jungle and cane field and cattle ranch. [Panama] could not exist economically - and probably not politically - without the ... canal and the United States."{12}

Parallel arguments were made to promote the original Panama canal in 1904. To whit: "A canal to connect the Atlantic and Pacific oceans must be built by the United States or not at all," and "To say this [canal] cannot be successfully made... to admit the passage of the largest battle ships is, in my judgement, an insult to the intelligence and advancement of the engineering skill of... [the American] people."{13} Furthermore, "Panama - that is, the better class of Panamanians - has for years dreamed of independence of [sic] Columbia... but they lacked the power of initiative, preferring to put off until 'manana' the attempt another people would have made today."{14}

These strikingly similar comments, made sixty years apart, emphasize the influence of prestige and nationalism over environmental safety and project necessity in regards to a Panama canal. Certainly the 'PANATOMIC' canal, a proposal to evacuate thirty-four thousand people from their homes and detonate three hundred megatons worth of nuclear explosives in the rainforests of Central America, merits a more thoughtful discussion. However, because of the strategic, political and nationalistic appeal of

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11. *New York Times Magazine*, 05/08/60, p. 92
12. Ibid.
13. "Congressional Record - Senate", January 4, 1904, p. 424
14. Ibid., p. 535

the proposal, the scope of debate concerning the canal often misses the big picture. For example, to blast a sea-level canal through the mountainous region of Panama, the AEC planned bury the nuclear explosives as much as 2,000 feet into the ground. Senator Anderson, following this discussion during a 1965 JCAE hearing, interjects: “You are going to leave a bunch of 2,000 foot holes around the country [Panama]. Who would be happy with that?”{15} Recognizing the role of prestige and nationalism lends some sense to the misplaced priorities of Plowshare supporters and planners.

Thus, in September 1964, Public Law 88-609 was enacted which stipulated that the United States “determine a site for the construction of a sea level canal connecting the Atlantic and Pacific Oceans... whether by conventional or nuclear excavation.”{16} The reference to “conventional excavation” was for appearance only. It had already been decided that any attempt to complete such a project would of necessity include “a few hundred thermonuclear explosives”[Figure 16].{17}

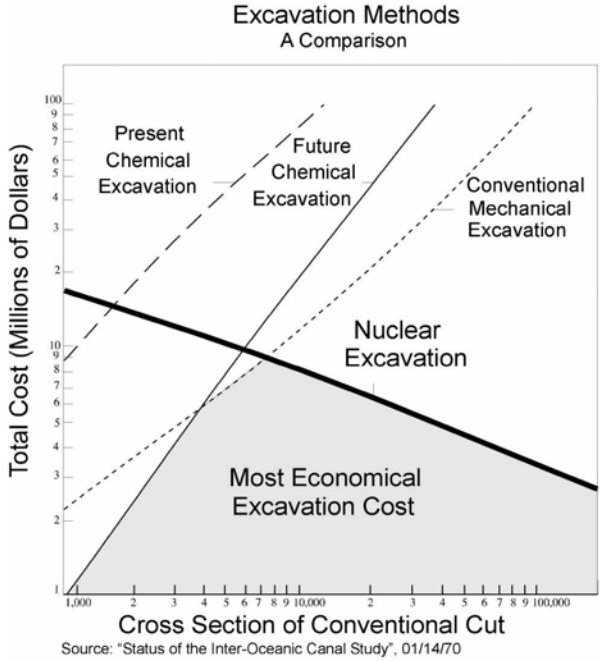
CANAL EXPERIMENTS

Of course, before blasting a canal through Central America, experiments were required to test the untried technology. Ideally, Plowshare planners hoped to experiment with high yield nuclear explosives in rock type that closely matched that found along the proposed canal routes. However, due to radiological hazards and limited site selection, most Plowshare excavation experiments used either low yield nuclear explosives or chemical explosives in whatever rock type was available at the Nevada Test Site. The following section will describe these experiments. For

15. JCAE “Peaceful Applications of Nuclear Explosives”, 1965, p. 27
16. Stemming The Tide, p. 313
17. “A Second Canal?”, *The New Republic*, 03/28/64, p. 21

Figure 16

"First-Pass" mock-up for "PANATOMIC" canal. AEC photo.



Source: "Status of the Inter-Oceanic Canal Study", 01/14/70

organizational purposes, chemical or high explosive excavation experiments will be described first, followed by nuclear excavation experiments, although both types occurred concurrently during the Plowshare program.

HIGH EXPLOSIVE EXCAVATION TESTS

Hundreds of high explosive Plowshare and military related tests have taken place at various testing grounds throughout the intermountain west. These testing areas include the Nevada Test Site, the Tonopah Test Range, the Dugway Proving Grounds, the Yakima Firing Range, Sandia's Coyote Test Range near Albuquerque, various Technical areas (TA's) surrounding Los Alamos Labs, and Site 300 east of Livermore Labs [Map 13]. High explosive experiments were also conducted during the nuclear test moratorium of 1958, when nuclear Plowshare and weapons related tests were prohibited.

The majority of these high explosive tests have been military related. A typical example is the 1964 test code named AIR VENT. This series of eleven high explosive cratering blasts was used to "calibrate a new medium planned for use in a... series of military sponsored... high-explosive and nuclear explosive [shots] proposed for Frenchman Flat."{18} Another example is PRE-MILL YARD, a 1985 high explosive test at the Nevada Test Site to aid in designing super hardened ICBM silos.{19}

Of the Plowshare high explosive tests, most were "motivated by possible excavation of a sea-level canal."{20} While some useful excavation data was collected from military related high explosive tests, certain inadequacies of th[is] earlier work

18. "Nuclear Applications & Technology" - "High Explosive Chemical Craters", p. 272
19. From NTIS document abstract listing, "PRE-MILL YARD", 1985.
20. "Nuclear Applications" - "High Explosive Chemical Cratering", p. 288

High Explosive Test Areas

Source: U.S. Nuclear Warhead Facility Profiles, NRDC, 1987.

Map 13

were evident."{21} New tests were designed that addressed these inadequacies and met the needs of Plowshare planners and excavation studies. These needs were: 1) higher yield tests whose results could be scaled up to large excavation projects, 2) tests in medium resembling that found in Central America and 3) investigations in ditch digging using multiple explosives.{22} None of these issues had been studied in previous military related tests. High explosive Plowshare tests were sponsored primarily by Livermore Labs, Sandia Labs, the U.S. Army Corps of Engineers Nuclear Cratering Group (NCG) and Stanford Research Institute (SRI).{23} Plowshare related high explosive tests, like their nuclear counterparts, were also often named after conveyances (TOBOGGAN, ROWBOAT, etc.) [Map 14].

HIGH YIELD TESTS: The MOLE and STAGECOACH series and the SCOOTER and YO-YO tests were Plowshare related high explosive experiments of a higher yield than previous military high explosive tests. These Plowshare experiments were used to "extrapolate... energy levels anticipated for nuclear [canal] excavation."{24} YO-YO was also designed to "estimate quantities of radiation released... by a [nuclear] cratering detonation."{25} SCOOTER, a 500 ton (.5 kiloton) blast at the Nevada Test Site, made the biggest landscape impact by digging a crater seventy-five feet deep that is indistinguishable from nearby nuclear craters [Map 21].

PARTICULAR ROCK MEDIUM: BUCKBOARD and PRE-SCHOONER I were two high explosive tests detonated on Buckboard Mesa at the

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21. Ibid., p. 271
22. Ibid.
23. "NCG Technical Report No. 21", 06/71, p. 144
24. "Cratering Experience With Explosives, 1964, p. 52
25. "An Annotated Bibliography", TID-3522 (9th rev.), p. 322

High Explosive Experiments
Plowshare Related

* The following experiments were carried out at the Nevada Test Site: BUCKBOARD I & II, PRE-SCHOONER I, ROWBOAT, SCOOTER, STAGECOACH, and TOBOGGAN.

Note: Locations of LITTLE DITCH & YO YO are unknown to the author.

Source: Post, R., "Nuclear Applications & Technology", 01/69.

Map 14

Nevada Test Site in basalt that “was the closest thing to the Punta Sabana basalt from Panama that could be found on the Nevada Test Site [Map 15]”.{26} The previously mentioned PRE-SCHOONER II was detonated in the basalt flows of southern Idaho for similar reasons. Likewise, the PRE-GONDOLA series, which will be discussed in greater detail below, was detonated in a wet shale medium in eastern Montana (Bear Paw Shale) that approximated the Sabana shale found in the swampy regions of Panama [Map 17].{27} TUGBOAT was an underwater test in Hawaii to investigate cratering characteristics in coral.{28}

DITCH DIGGING: DUGOUT, LITTLE DITCH, PRE-BUGGY I & II, PRE-GONDOLA, MIDDLE COURSE II, ROWBOAT, TOBOGGAN, TRENCHER I & II, and TRINIDAD all investigated ditch digging using a series of high explosives set in a row and detonated simultaneously [Figure 17].{29} John Kelley, then Director of Peaceful Nuclear Explosions at Livermore Labs, sums up the results of some of these experiments in his 1965 testimony before the JCAE, and explains why nuclear explosives are required for any large scale projects:

> “Mr. Kelley: We have done a number of cratering shots with chemical explosives... [to] produce a ditch. This is a picture [Figure 30] of a crater that was produced - in this manner. If you look at the far end of that ditch, you notice there is very little or no throwout material on the end of the crater. This is a real dandy effect if you have to dig a long ditch in sections. When you dig the second section you don’t fill up the first one... You [also] get nice smooth edges... We believe that these same phenomena will scale to the nuclear yield range, but this is yet to be done and it is a part of our plan that we would have to

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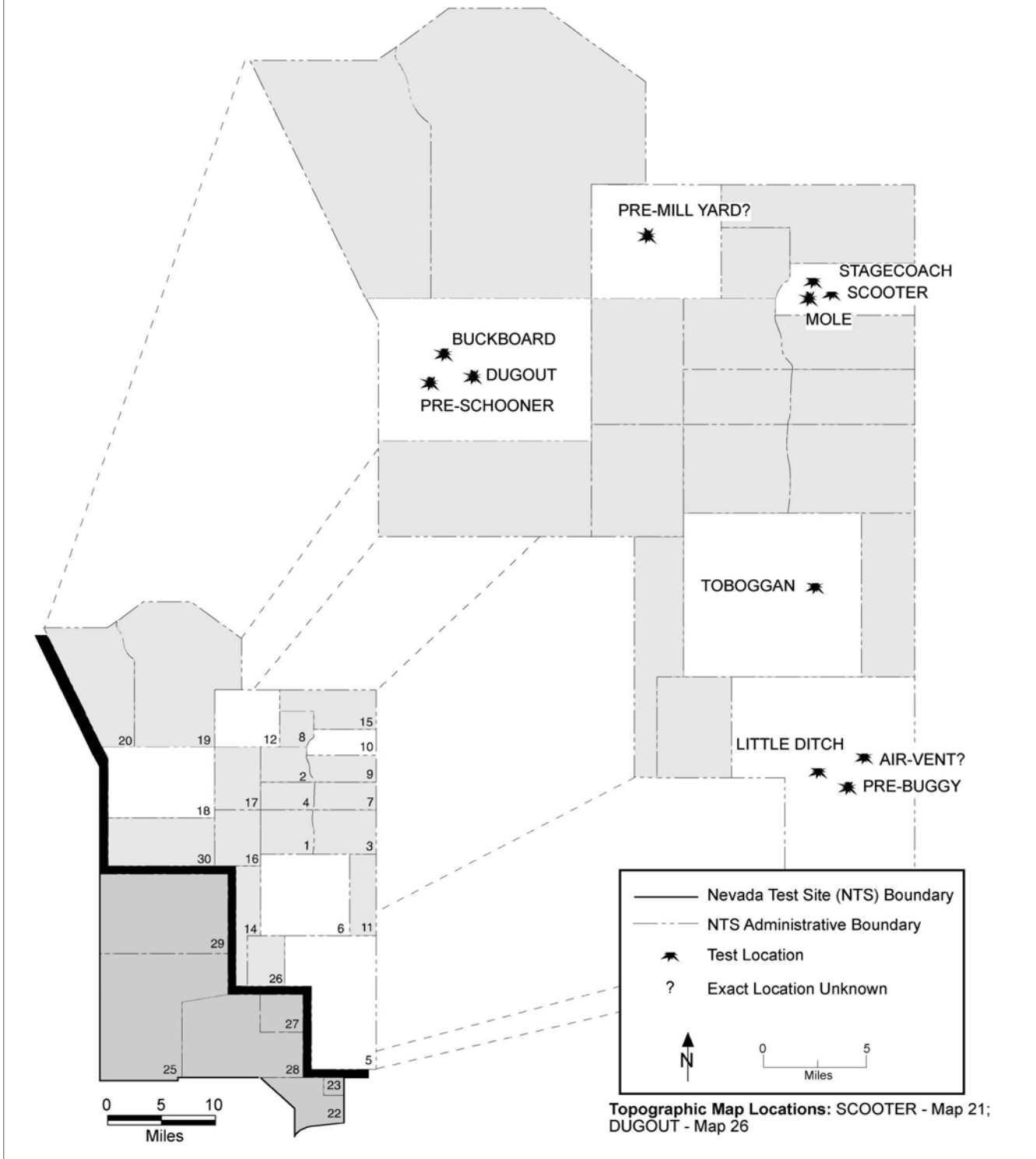
26. “NGC Technical Report No. 21, p. 150
27. Memo - Southwestern Radiological Health Laboratory to M. Carter, “GONDOLA Site Selection”, 01/17/69, CIC#38199, p. 1
28. “NCG Technical Report No. 21 - Explosive Excavation Technology”, 06/71, pp. 163-173
29. See JCAE, “Commercial Plowshare Services”, 1968, p. 334 for DUGOUT, PRE-BUGGY, PRE-GONDOLA, ROWBOAT and TOBOGGAN. See “Preliminary Technical Concept for Project TRINIDAD”, US NCG, 05/70, TECP-5943. See “Nuclear Applications and Technology”, vol. 7, 09/69, p. 300 for LITTLE DITCH. See “NCG Technical Report No. 28 - Project TRENCHER.”. See “NCG Technical Report No. E-74-3 - Fallout Stimulation: Nuclear Cratering Device Stimulation” for Project MIDDLE COURSE II.

Map 15

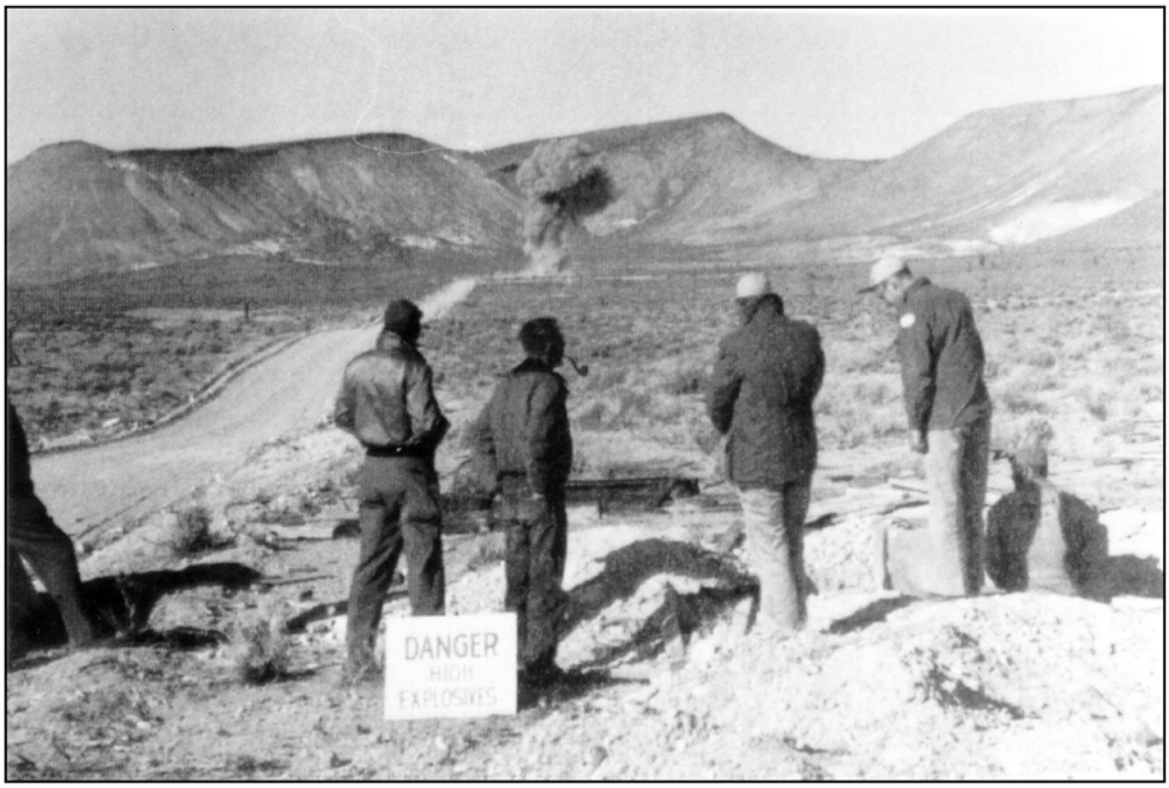
High Explosive Tests
Nevada Test Site



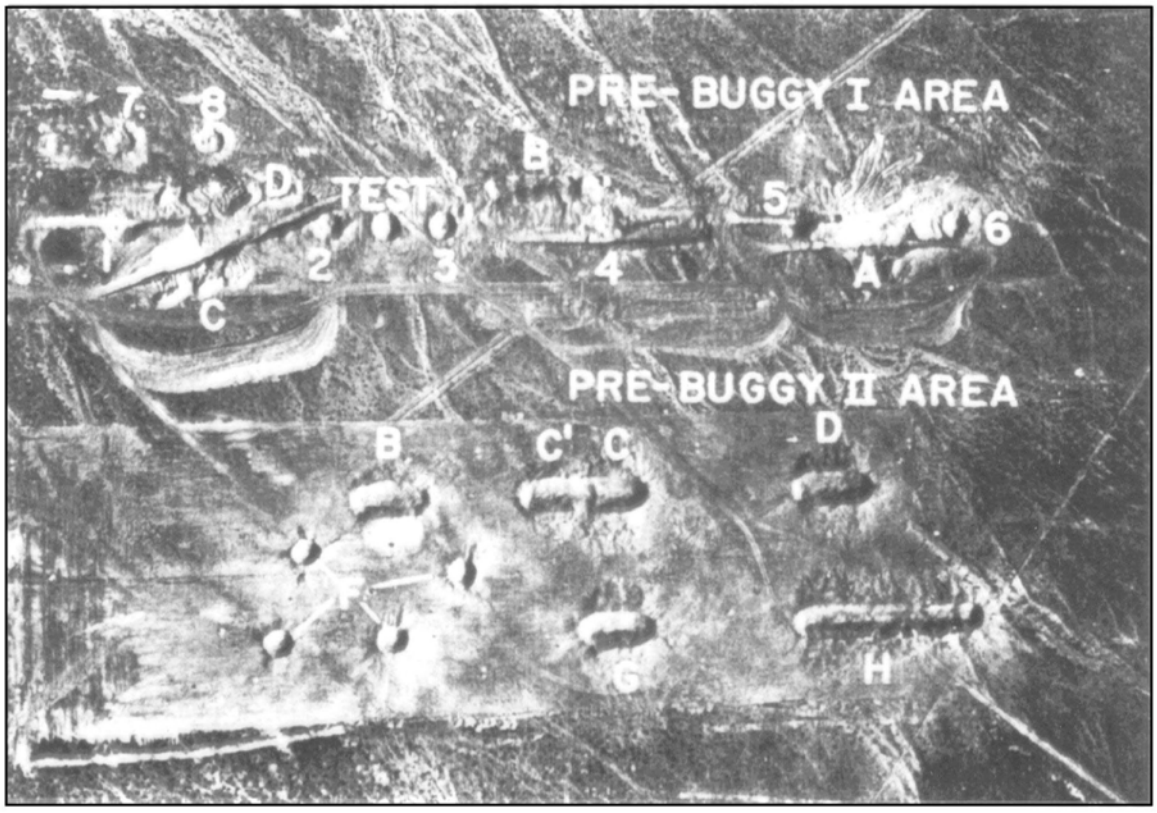
Topographic Map Locations: SCOOTER - Map 21; DUGOUT - Map 26

Source: Post, R., "Nuclear Applications and Technology", 10/69.

Figure 17



Sandia Labs high explosive test at the Nevada Test Site, Spring 1953. Sandia photo.



Aerial view of PRE-BUGGY area, Frenchman Flat. AEC photo.

> do to get ready for digging this canal that was discussed earlier.
>
> Chairman Pastore: Let me ask you a question, then, in view of your optimism about these chemical explosions, what is wrong with building a canal with chemical explosions?
>
> Mr. Kelley: The economics are horrible.
>
> Chairman Pastore: That is the answer? It is too expensive?
>
> Dr. Seaborg: Yes. The answer is simple."{30}

Before proceeding to nuclear excavation experiments, the previously mentioned PRE-GONDOLA high explosive series will be described in more detail. This series is singled out because, like other "PRE" tests (PRE-SCHOONER, PRE-BUGGY, PRE-MILL YARD) it is directly associated to a follow up nuclear test (SCHOONER, BUGGY, MILL YARD). Due to this direct link, documents and memorandum concerning site selection, purpose and effects of these tests are relatively more available than what is typically the case for high explosive experiments. PRE-GONDOLA is also one of a handful of high explosive experiments to take place outside of an established test range, and, therefore, adds to an understanding of the AEC's site selection process. The landscape impacts of PRE-GONDOLA, and the potential impacts from the proposed follow up nuclear test series GONDOLA, are also noteworthy and merit discussion. Finally, in the context of impacts, the GONDOLA series provides the opportunity to examine the AEC's attitude toward radioactive fallout and public relations, an issue of prime importance to the Plowshare program as a whole.

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30. JCAE, "Authorizing Legislation FY 1965", pp. 1207-1208

GONDOLA SERIES

Extensive swampy areas make up sections of each of the three main canal routes considered by the AEC, and an economical sea-level canal required that even these low lying saturated areas, such as the Atrato sweep, be excavated using nuclear explosives. However, Plowshare planners had little experience with explosions in wet rock. The primary high explosive testing areas in California, Nevada, New Mexico, Utah and Washington were comprised of dry rock in generally arid environments. Therefore, to proceed with canal studies, wet rock - specifically wet shale such as that found in the Atrato swamp of Panama - was required as a testing medium. A wet environment was also needed to "determine the effect of high water content on the release of radioactive material."{31} In other words, it was unknown whether soggy ground would increase or decrease radioactive fallout. And precise fallout characteristics were crucial for planning the evacuation of residents near the proposed 'PANATOMIC' canal.

SITE SELECTION

The GONDOLA family of tests, beginning with PRE-GONDOLA I, was initiated to study these questions. Site selection for GONDOLA, to reiterate, required wet shale in a remote area due to uncertain fallout characteristics. All told, the series, spanning several years, was to include numerous high explosive and "an undetermined number" of nuclear detonations.{32}

The site selection committee for "the GONDOLA concept" was comprised of members from NVOO [Nevada Operations Office], LRL

31. Memo, Dept. of Health to Dr. M. Carter, 01/17/69, CIC#38199, p. 1
32. Ibid.

[Livermore Labs, Sandia, NCG [Nuclear Cratering Group], and USGS.{33} Site selection, as with most Plowshare experiments, centered on the intermountain west. In the words of the committee, "since there are many potential sites which could satisfy technical criteria... some safety requirements, with minimum and maximum limits, should be established to... [reduce] the number of sites under consideration."{34} Two safety considerations were identified:

> "l. Fallout - if possible, the downwind sector selected, in accordance with LRL criteria, should avoid land that is used for grazing, farming, recreation, or similar purposes.
>
> 2. Test-Ban Treaty - trajectory or "cloud" should stay within U.S. boundaries for 50 hours."{35}

Using this criteria, six areas in Colorado, Montana, South Dakota, Utah and Wyoming were identified by the committee for further investigation [Map 16]."{36} Later, the field was narrowed to two states, Montana and South Dakota, with the final determination favoring a site in eastern Montana along the northern edge of Fort Peck Reservoir [Map 17].

PUBLIC RELATIONS AND FALLOUT

Despite plans for several high explosive tests and at least one 200 kiloton blast on public land adjacent to a major watershed (the Missouri River), the public remained completely unaware of the existence of GONDOLA. This secrecy reflects the

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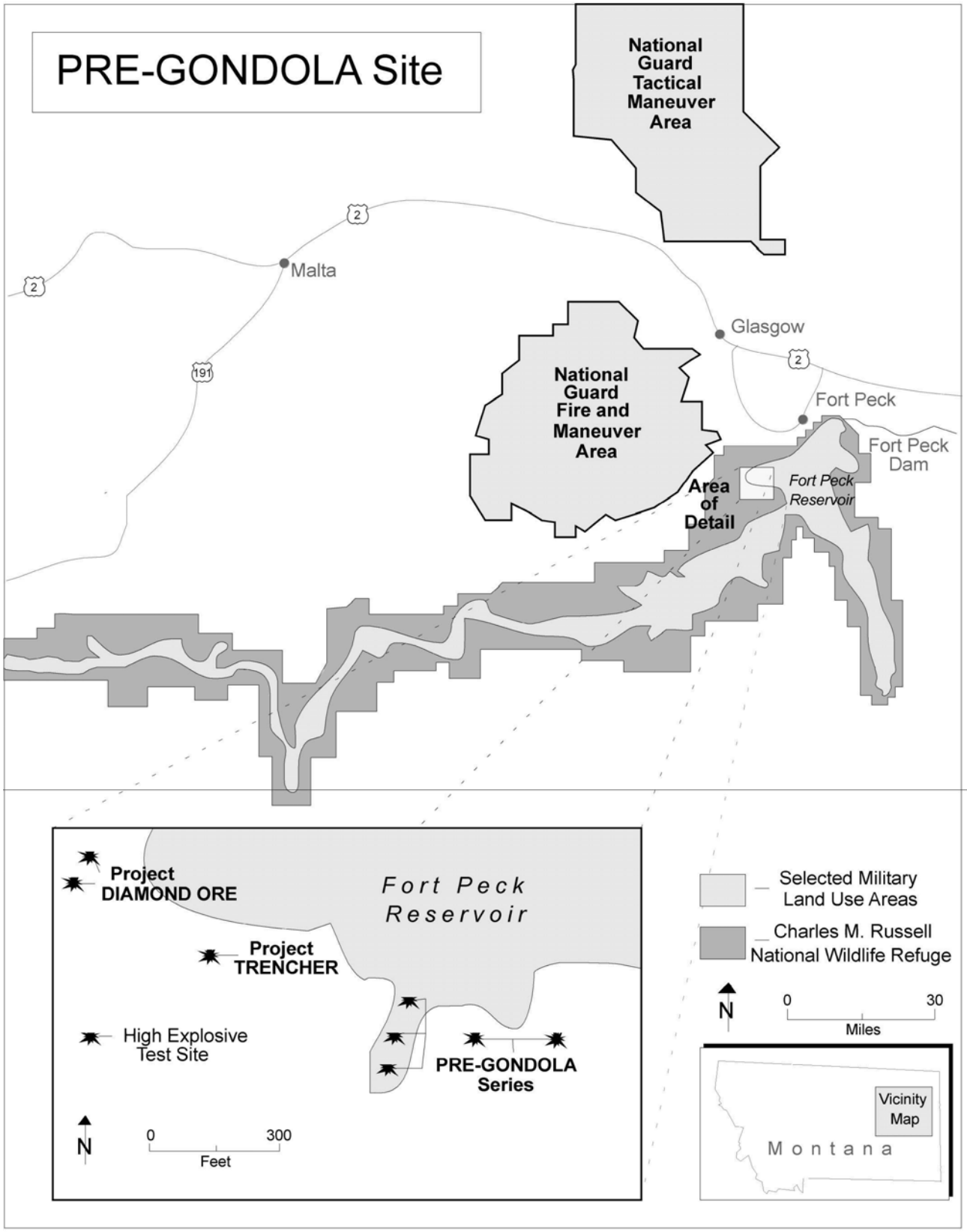
33. "Planning Directive For GONDOLA Site Selection, PL-2-11-68", 11/14/68, CIC#38200, p. 7; committee, p. 4
34. "Summary Minutes of GONDOLA Site Selection Committee Meeting", US AEC, 10/08/68, CIC#38201, p. 5
35. Ibid
36. Ibid., pp. 7-8

Site Selection
Pre-Gondola

Source: Memo - "Summary Minutes of GONDOLA Site Selection Committee Meeting", CIC #38201, 11/68.

Map 16

Map 17



Source: *Skyguard* Newsletter, p.10, Winter 1990, vol. 1, #3.

AEC's attempt to limit protests concerning health effects of nuclear explosions and follows a historical pattern. Part of a 1968 AEC planning directive for GONDOLA entitled "Public Affairs Guidance" elaborates on this process:

> "In the early GONDOLA site selection process during the collection of information about various sites, those engaged in collecting information at various localities of interest will avoid disclosing the nature of their interest. Inquiries simply expressing curiosity can be turned aside with a comment such as 'We're here collecting data on a government survey', or the like. More pressing inquires should be directed to NVOO... It is unlikely that pressing inquires will be made."{37}

The rationale for this secrecy follows:

> "Until a public announcement is made, persons engaged in field site selection activities should be discreet in talking with any member of the public, since premature disclosure of interest could result in prejudicial news media treatment and flawed relationships with State and local-elected officials."{38}

An undated (perhaps 1966) memo describing proposed cratering-(Plowshare) tests outside of the test site elaborates on what is meant by "prejudicial treatment" and "flawed relationships":

> "HGV/ - FYI Allaire [Director, Project Operations NVOO] has fits at the idea of a cratering shot in our CN [Central Nevada] Test area [Map 5] on grounds of opposition it would raise from sportsmen, conservationists etc., whom we have assured that any release of r.a. [Radiation?] would be "accidental." Plus, problems with people who are inclined to be somewhat hysterical about "fallout" - what they've heard from Pendleton's [author of thyroid studies and critic of AEC] outbursts - the Fallini [ranch family north of NTS affected by fallout] boy, the Fallini dog etc etc - dix"{39}

A host of statements made concerning nuclear weapons

37. Ibid., p. 10
38. Ibid.
39. "Note on Central Nevada Testing", date unknown, CIC #16556.

testing at the Nevada Test Site are remarkably similar to the preceding remarks concerning Plowshare tests. For example, the 1957 pamphlet entitled “Atomic Tests In Nevada”, printed by the AEC for residents downwind of the Test Site, was intended to “turn aside” curiosity:

> “Fallout can be inconvenient... Many persons in Nevada, Utah, Arizona, and nearby California have Geiger counters these days. We can expect many reports that ‘Geiger counters were going crazy here today.’ Reports like this may worry people unnecessarily. Don’t let them bother you... Your best action is not to be worried about fallout.”{40}

Likewise, a 1987 statement from the “Offsite Emergency Response Plans and Procedures” guidebook emphasizes the importance of public relations:

> “A major dynamic venting would attract widespread public and media interest. Under these conditions, the implementation of an Emergency Media Center (EMC) may be directed under the EMERGENCY PUBLIC AFFAIRS PLAN [DOE emphasis]. Implementation of this plan will allow controlled release of information... to the public, thus lessening possible confusion by minimizing informational outlets and assuring continual coordination of informational releases in order to avoid inadvertent inconsistencies.”{41}

Fear of “inadvertent inconsistencies” arise from the fact that since the beginning of weapons testing the AEC knew fallout was dangerous, not just “inconvenient.” However, continued experimentation with weapons or Plowshare tests required downplaying the dangers of fallout to the public. This view is candidly expressed in 1955 by the commissioners of the Atomic Energy Commission. At this meeting, the topic for discussion is a letter received from the JCAE which questions the safety and

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40. “Atomic Tests In Nevada”, US AEC, March, 1957, pp. 22-23, This 4 by 6 inch booklet was widely distributed to ‘downwinders’ in Nevada and Utah.
41. “Off Site Emergency Plans & Procedures For an Accidental Venting or Seepage At the Nevada Test Site”, July 1987, p. 53

necessity of exploding nuclear bombs in Nevada:

> “Commissioner Libby: Maybe the furor will die down as we go through the series [TEAPOT], after we have had the bomb [MOTH] on Monday or Tuesday.
>
> Chairman Strauss: Yes, and it was a little one yesterday [WASP, 1 kiloton]. But they made as much fuss about it as if it had been a big one... There is a Nevada legislator who has introduced a bill... asking us to move out of the state. Both of the Las Vegas papers, which seldom agree on anything, published editorials agreeing that this was nonsense, that we brought a lot of prosperity to the state. This was a fine thing for national defense, and they rather laughed this fellow out of court.
>
> Commissioner Libby: That is a sensible view. People have got to learn to live with the facts of life, and part of the facts of life are fallout.
>
> Chairman Straus: It is certainly all right they say if you don’t live next door to it.
>
> Mr. Nichols: Or live under it...
>
> Commissioner Murray: We must not let anything interfere with this series of tests - nothing...
>
> Commissioner Libby: I think we ought to talk about this. I don’t want radioactivity falling on people’s necks, but it [eliminating testing in Nevada] is an awfully serious thing.
>
> Chairman Straus: Another thing about it is... the fallout patterns have been established pretty well... East they go over Pioche [Nevada] and over St. George [Utah], which they apparently always plaster... South is a very narrow corridor where if the wind shifts ten degrees in either direction, then they are in trouble again. Of course, they never really paid much attention to that before... I have always been frightened that something would happen which would set us back with the public for a long period of time [Map 18].”{42}

Five years after this Commission meeting, the Plowshare Advisory Committee (PAC) praised the extent to which the AEC had gone to “assure itself of the safety of Plowshare experiments...

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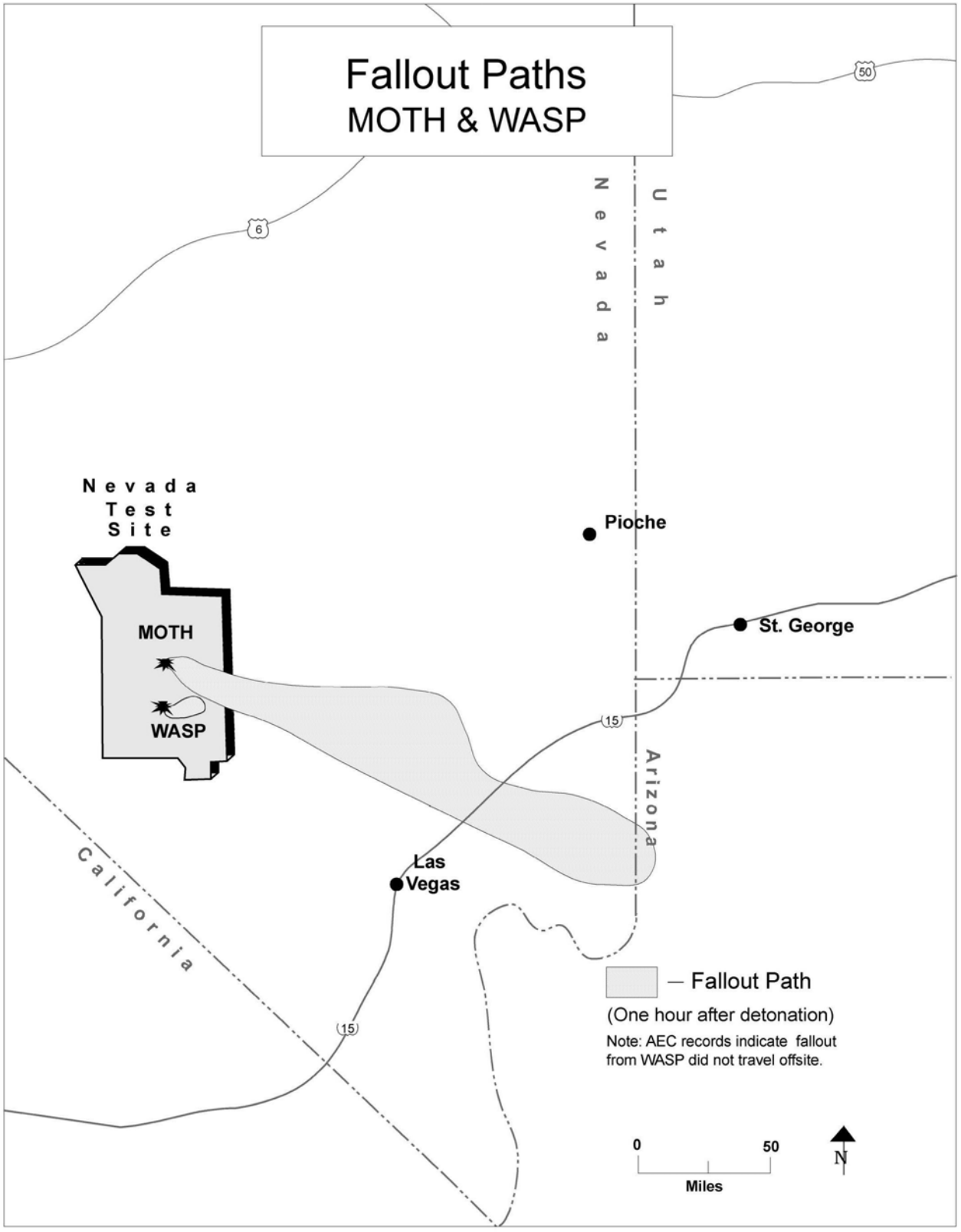
42. AEC Commission Meeting No. 1062, 02/23/55, CIC#14021, declassified with deletions, 04/14/79.

Map 18



Source: "Compilation of Local Fallout data", DNA 1251-1-E, 05/79.

and [hoped] this information... [would] be used to allay fears and create good will in the public mind."{43} From the preceding statements it appears that the PAC itself had been lulled by the AEC into a false sense of confidence regarding the safety of Plowshare events.

PUBLIC INPUT

A premise of the democratic process is that informed and effective public participation requires access to information. "Turning aside" public inquires, emphasizing media relations, dismissing fallout concerns as "hysterical", letting "nothing interfere with tests" and misleading a committee designed to oversee the Plowshare program. are all antithetical to encouraging public input. Especially because of the hazards involved, such input should not have been considered dispensable by Plowshare planners.

In regards to GONDOLA, after months of clandestine study by the AEC in January a "GONDOLA public announcement was issued... in conjunction with Montana and South Dakota [the remaining sites under consideration] field information activities... Most of those individuals contacted were receptive to the possibility of the experiment."{44} By March, however, plans to explode any nuclear "device" as part of GONDOLA was cancelled due to the "reassessment" of the "acceptability of nuclear cratering [in] a wet, weak medium."{45} The reasons for this "reassessment" are

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43. "Recommendation Made by the Plowshare Advisory Committee at its Meeting of October 19-20, 1960", p. 3, CIC#137438.
44. "Termination of GONDOLA Site Selection Committee and the Manager's Review Group", 02/20/70, CIC#38196, attachment, p .1
45. Ibid., attachment, p. 2

unknown to this researcher. What is clear is public input was curtailed up to the last minute in decisions affecting the proposed GONDOLA nuclear explosions.

It is unknown to this researcher the extent to which the public was involved regarding PRE-GONDOLA high explosive experiments at the Fort Peck site, but the scope and landscape impacts of these tests are noteworthy. The PRE-GONDOLA series (I, II, & III) extended from mid 1966 to late 1969 and involved over twenty high explosive point and row charges whose landscape impacts are readily visible on topographic maps [Map 19][Figure 18].{46} Project TRENCHER, detonated adjacent to the PRE-GONDOLA site in 1970, was comprised of multiple row charge and point experiments. {47} Finally, in 1971 a “series of multi-ton cratering experiments” known as Project DIAMOND ORE was detonated slightly west of the PRE-GONDOLA site to conclude high explosive cratering experiments along Fort Peck reservoir.{48} Today, most of these craters are difficult to spot from the ground owing to wind and water erosion.{49}

A final irony regarding the Fort Peck site is appropriate at this point. Going back to the beginnings of the nuclear age, in April 1948 the AEC began investigating seventy-two sites for a ‘Reactor Test Station’. After several months, the field was narrowed to two sites: one along Fort Peck Reservoir in Montana (the same area used for PRE-GONDOLA experiments), and another in southern Idaho on the Snake River Plain which

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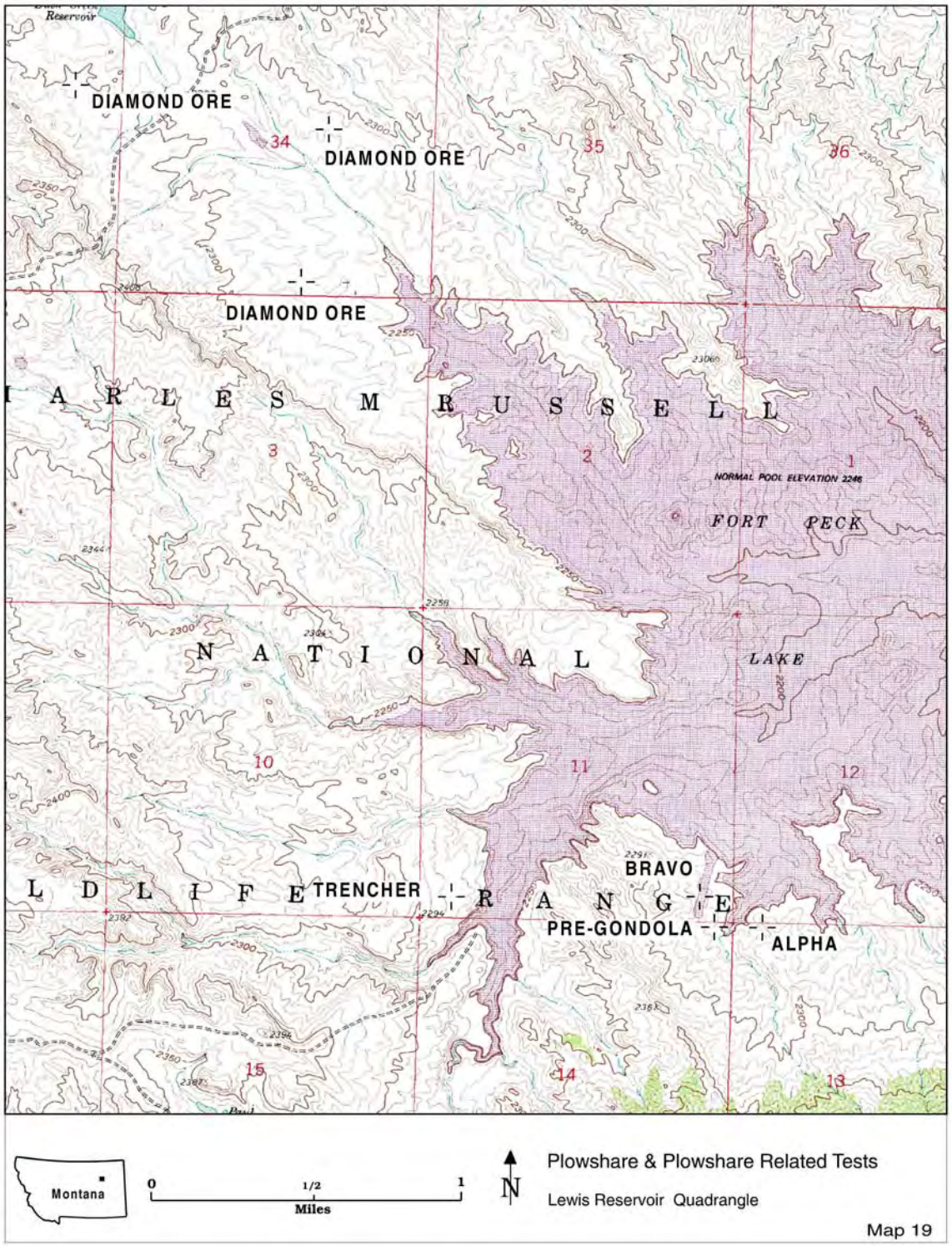
46. “Project PRE-GONDOLA III, PHASE III, Connection of a Row Crater to a Reservoir”, EERO Tech. Report #38, August, 1971, p. 1
47. “Project TRENCHER - Evaluation of Aluminized Blasting Agents for Cratering and Hole Springing”, NCG Technical Report No. 28, November, 1970.
48. “Project DIAMOND ORE, PHASE IIA: Close-in Measurements Program”, NCG Technical Report, May, 1972.
49. Site visit, 08/12/91


DIAMOND ORE
DIAMOND ORE
DIAMOND ORE
34
35
36
3
2
1
10
11
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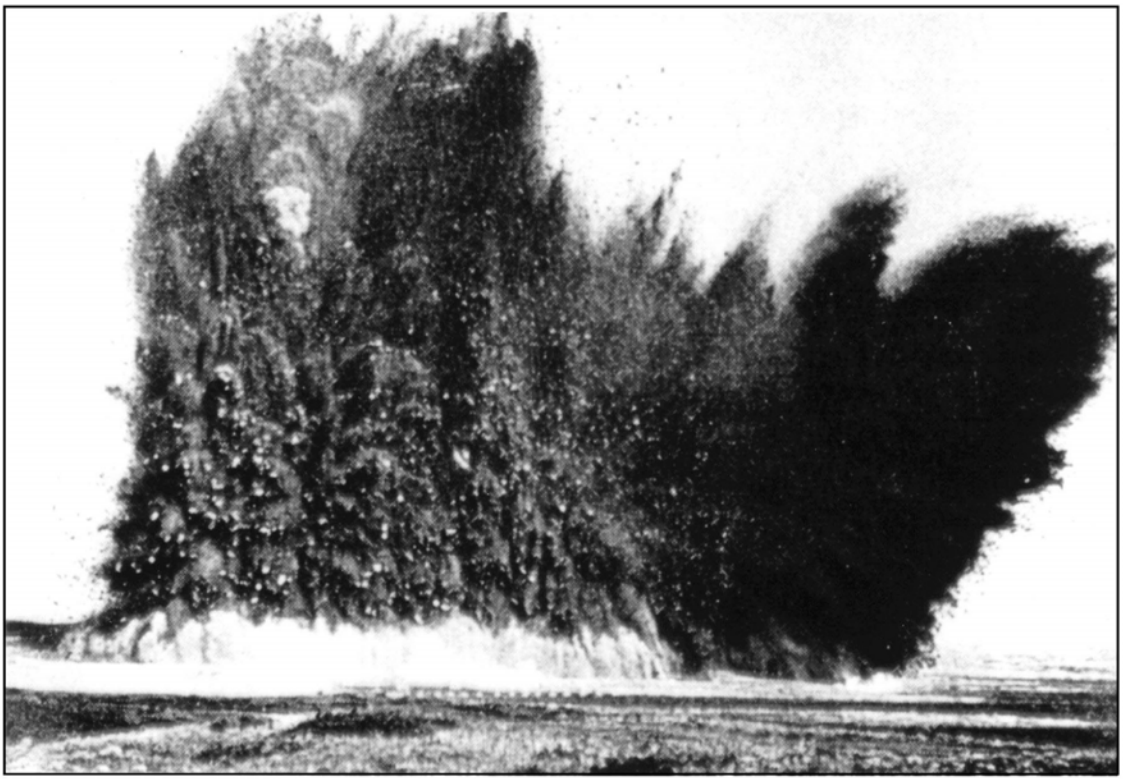
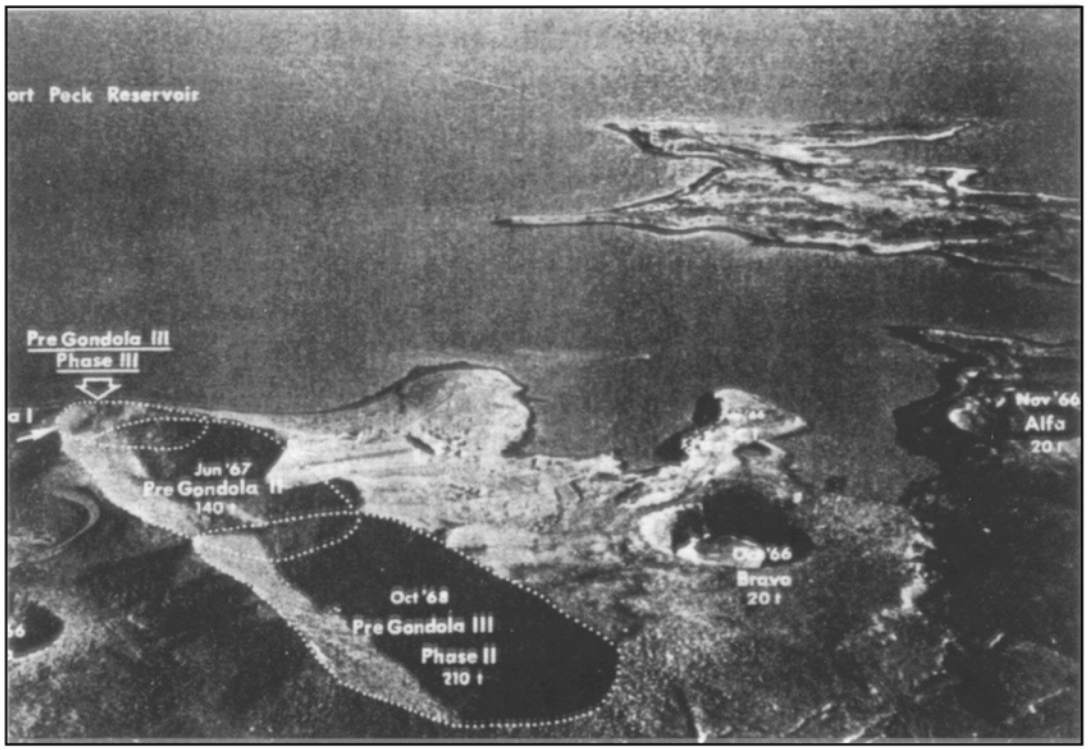
14
13
NORMAL POOL ELEVATION 2246
FORT PECK
LAKE
NATIONAL
CHARLES M RUSSELL
WILDLIFE RANGE
TRENCHER
BRAVO
PRE-GONDOLA
ALPHA
Montana
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Lewis Reservoir Quadrangle
Map 19

Figure 18



PRE-GONDOLA II explosion, 06/28/67. AEC photo.



Aerial view of the GONDOLA family of craters, looking north-east. AEC photo.

overlapped the Navy's Arco Proving Grounds. It is noteworthy that the need for a Reactor Test Station - along with any mention of a site selection study - was not announced to the press, the public or state delegations until February of 1949. The final siting decision was finalized by the AEC one month later in March 1949. The site in Idaho was chosen and is today known as the Idaho National Engineering Labs (INEL), site "of more nuclear reactors... [over 50] than anywhere else in the world" and over 400 active hazardous waste sites.{50}{51}

The Montana delegation, upset at losing a competition they had barely been made aware of, attempted to persuade the AEC to change their minds. They noted that an architectural firm hired by the AEC to evaluate each site had determined that Fort Peck was more isolated than the Idaho site; a characteristic the AEC was seeking.{52} The representative from the Montana Chamber of Commerce elaborated by stating that the land "is not good for much" besides "throw[ing] a few cows or sheep out in" and "not a soul lives in that area of 457,000 acres."{53} The delegation also attempted to temper this image, stating Reactor Test Station workers would have access to a "back-yard fishing pond [Fort Peck reservoir]" and in any case the "weather was so hot in Arco [Idaho] that even the rivers [the Lost River and the Little Lost River] run underground."{54} The Committee minutes are an interesting look at a community attempting (and failing) to attract an AEC project using an incongruous mix of factors: environmental desolation, physical isolation and recreational

50. JCAE, "Selection of Site for Reactor Test Station", 1949
51. Roadside marker, Arco, Idaho; *Snake River Alliance* newsletter, 09/91, vol. 5 #7.
52. JCAE, "Selection of Site for Reactor Test Station", 1949, p. 3
53. Ibid., p. 22
54. Ibid., p. 55

opportunities for workers.

What is also noteworthy, however, is the speed and secrecy with which such a far-reaching decision was made. Within a month of announcing plans for a Reactor Test Station, a final site was decided upon. Furthermore, despite the objections of the Montana delegation, the primary source document for determining the final site was (and may still be) classified 'secret':

> "Senator Hickenlooper: Where is that report?
>
> Mr. Warner [Director of Engineering, AEC]: It is here in the room, sir, if you would like to see it.
>
> Senator Hickenlooper: Has it ever been made public, or turned over?
>
> Mr. Warner: No, sir. It is classified 'secret', because it contains information on the Hanford operation, which was used as a comparison, or to get some handles to see what it was we might need... I have not actually spotted myself the points which cause it to be classified 'secret'."{55}

Due to the environmental problems at INEL, including contamination of the Snake River aquifer, chemical waste lagoons, plutonium contaminated soil and an estimated cleanup bill of between two and five billion dollars, the state of Montana may feel fortunate that its 1949 delegation was not given more time or resources to protest the AEC's selection of Idaho as host for the 'Reactor Test Station'.{56} In this particular case, due to the tenor of the times, increased public input may have only been in the form of heightened boosterism by the Montana and Idaho delegations. However, any increase in participation would have set a precedent that is lacking throughout the Plowshare program:

---

55. Ibid. p. 68
56. See, for example, "DOE Calls Cleanup Tune", *Snake River Alliance* newsletter, vol. 5, #7, 09/91

community involvement and honest discourse regarding health and environmental effects by the AEC and its successor agencies.

NUCLEAR EXCAVATION PROGRAM

Although GONDOLA was cancelled, an assortment of nuclear excavation experiments were eventually conducted as part of the 'PANATOMIC' canal studies. These experiments can be divided into three groups: "device development" tests, "emplacement" tests, and cratering tests. These three types of tests, conducted exclusively at the Nevada Test Site, are described below.

"DEVICE DEVELOPMENT" TESTS

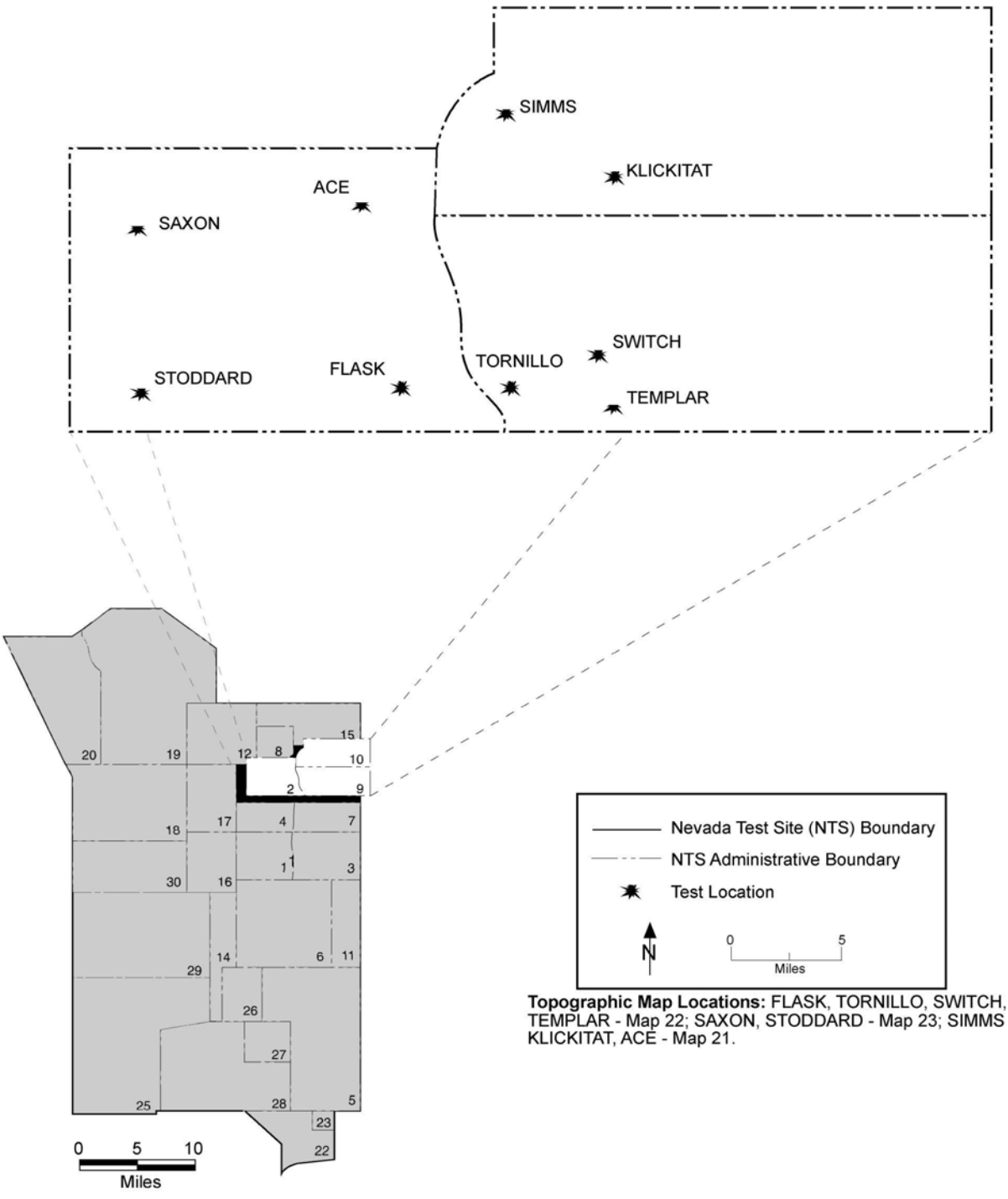
Plowshare "device development" tests [TORNILLO, KLICKITAT, ACE, TEMPLAR, SAXON, SIMMS, SWITCH, STODDARD and FLASK] were nuclear experiments exploded hundreds of feet underground in the alluvium at the Nevada Test Site [Map 20]. These tests, sponsored by Livermore Labs, were efforts to develop the previously mentioned "clean" bomb and tailor it to excavation projects. Peripheral technical goals included reducing the complexity and cost while increasing the reliability of the "nuclear system," as an inexpensive, rugged and reliable explosive was needed for support from private industry.{57}

A description of the SAXON test is typical of the general information concerning these experiments: "SAXON... a follow-on test to TEMPLAR... [had] the specific objective of developing a clean, reliable nuclear explosive for excavation

57. JCAE, "Authorizing Legislation FY 1966", p. 176 for discussion of TORNILLO, KLICKITAT and ACE

Map 20

Plowshare "Device Development" Tests
Nevada Test Site



Topographic Map Locations: FLASK, TORNILLO, SWITCH, TEMPLAR - Map 22; SAXON, STODDARD - Map 23; SIMMS KLICKITAT, ACE - Map 21.

Source: Springer, D., "Seismic Source Summary", UCRL-73036, 02/71.

purposes."{58} It is unclear from available information what degree of progress was actually made in developing a "clean" nuclear explosive for excavation projects. First, as previously stated, a bomb can only be made cleaner", not "clean". Second, results of "device development" tests are difficult to obtain. Third, a widely used comparison diagram used by the AEC to illustrate progress in "device development" testing remained unchanged over a period of several years [Figure 19].

The environmental effects of "device development" tests are more widely known. All nine "device development" tests released radiological effluents into the atmosphere. The DOE has categorized radiological releases from underground tests into five groups: EVENT, CONTROLLED, DRILLBACK, GAS SAMPLING and LATETIME SEEPAGE.

In the microseconds following an underground nuclear detonation, sensors around the bomb transmit information to recording trailers at the surface via wire and fiber optic cables [Figure 20]. Certain information about a nuclear blast, however, can only be obtained by drilling back into the nuclear cavity and taking samples. It is during these drillback operations that DRILLBACK releases occur and radioactive material escapes to the atmosphere. All of the "device development" tests experienced DRILLBACK releases, the most common type of release among all underground nuclear tests. DRILLBACK releases from "device development" tests have lasted a matter of minutes [TEMPLAR] to more than three days [SAXON].{59}

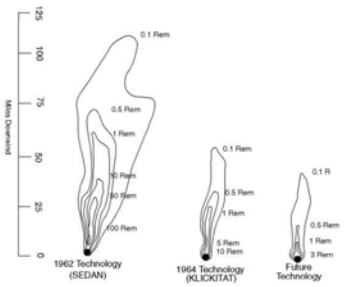
Two of the "device development" tests were also

58. "LATCHKEY Test Bulletin No. [deleted], [SAXON]", 07/29/66, declassified with deletions, 08/19/81.
59. "Radiological Effluents", 1990, p. 83 & p. 90

Figure 19

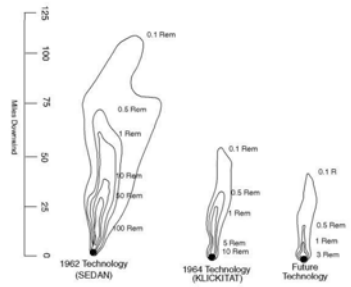
“Clean” Bomb Development?
1964-1969

March 1964



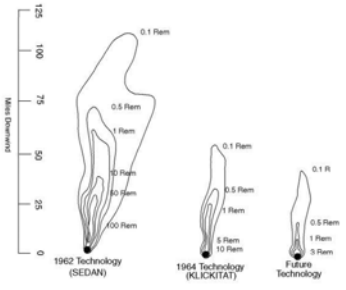
Source: JCAEHearing "Authorizing Legislation FY 1965", p.1203.

January 1965



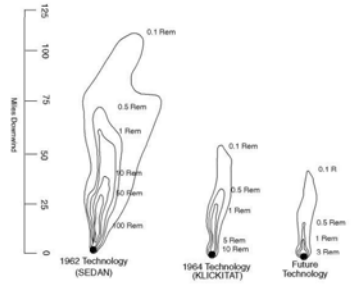
Source: JCAE Hearing, "Peaceful Applications of Nuclear Explosives - Plowshare", January 1965 , p.35.

March 1965



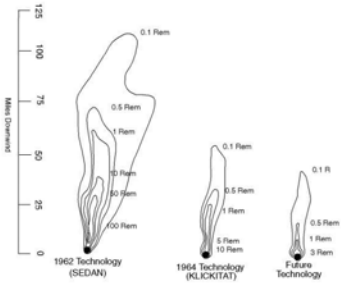
Source: JCAE Hearing, "Authorizing Legislation FY 1966", p.180.

April 1966



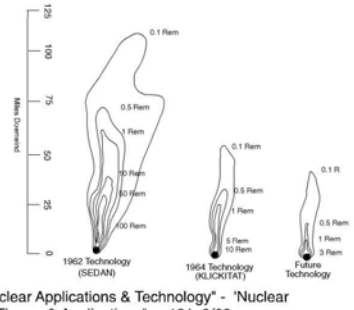
Source: "Nuclear Excavation of an Isthmian Canal Sea-Level Canal", TECP-14397, 4/66, p.13.

June 1968



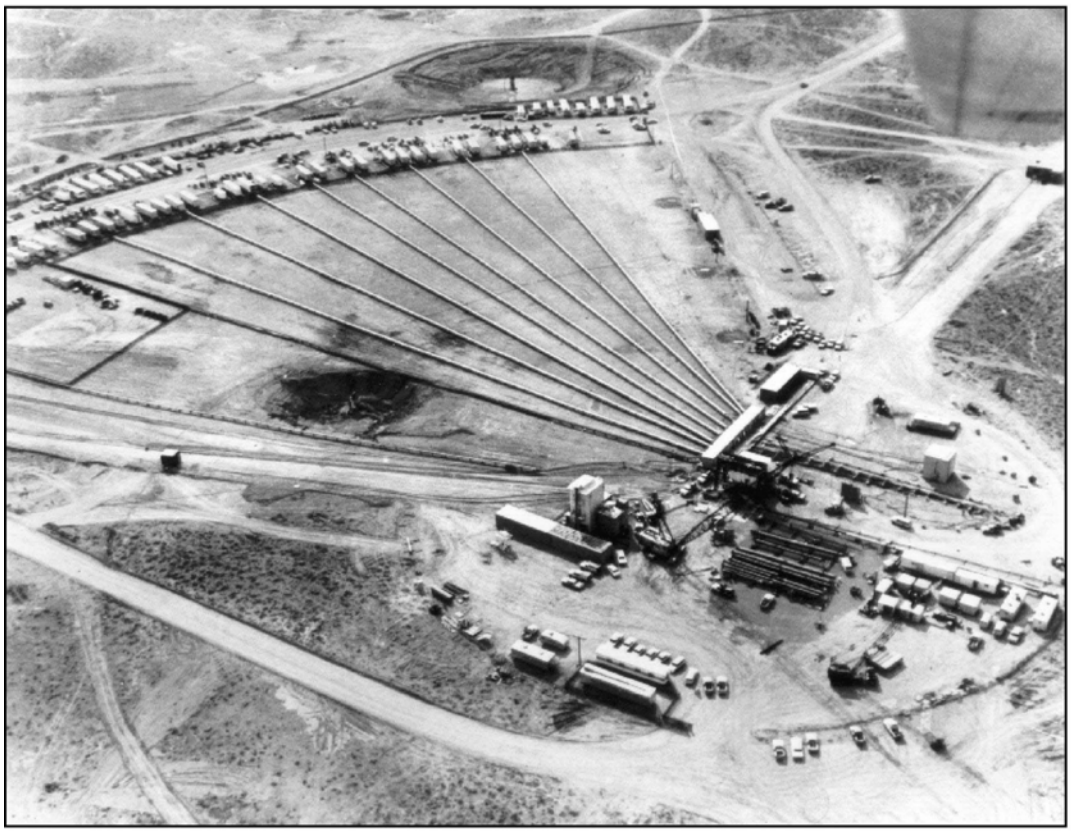
Source: "Project WAYOUT", TECP-5945, 6/19/68, p.7

September 1969

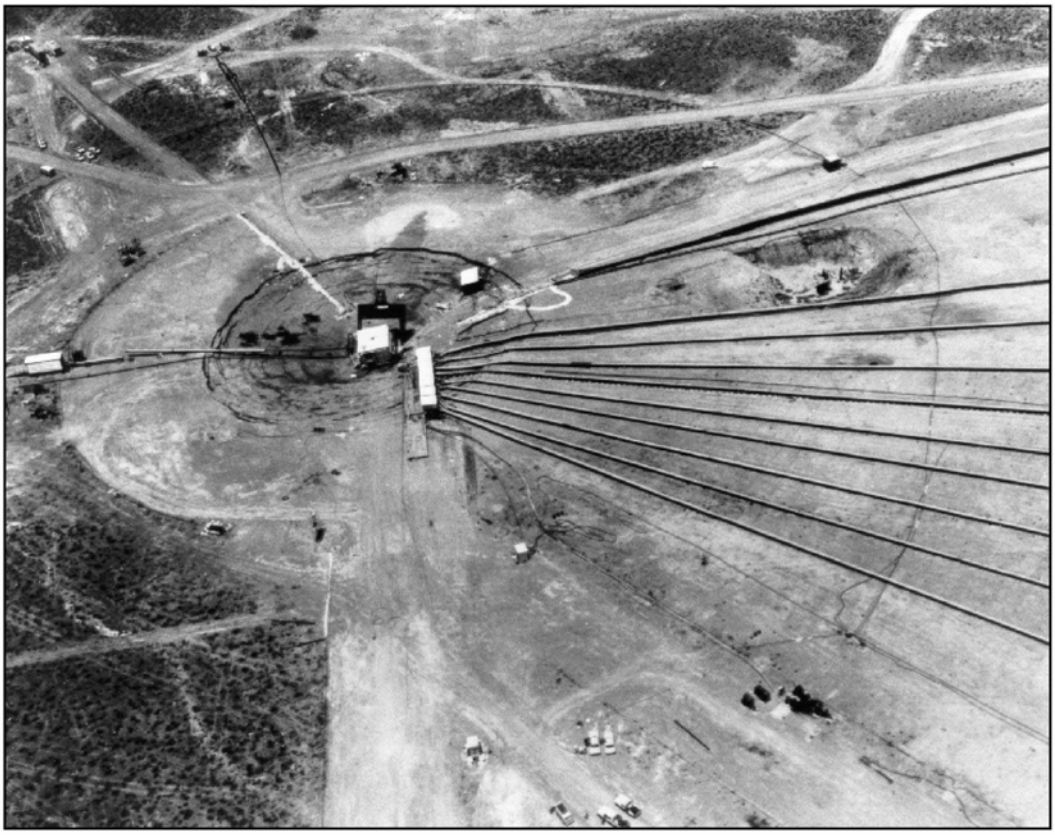


Source: "Nuclear Applications & Technology" - 'Nuclear Excavation Theory & Applications", p.191, 9/69.

Figure 20



Weapons related test TAPESTRY, 5/12/66. Cables are fed from emplacement hole to instrumentation trailers. LLNL photo.



TAPESTRY post-shot. Subsidence occurred five minutes after blast. TAPESTRY had both EVENT and DRILLBACK releases. LLNL photo.

categorized as EVENT releases [ACE and FLASK], in which trapped radioactive gases vent to the surface along rock fractures, improperly sealed drill holes or sensor cables. Such releases are spontaneous and can vent tremendous amounts of radioactive material to the atmosphere. Most EVENT releases occur immediately after the bomb has exploded, although EVENT releases have occurred hours after detonation.{60} Figure 21 shows the worst EVENT release on record, the 1970 BANEBERRY weapons related test.

No Plowshare tests are labeled by the DOE as having CONTROLLED, GAS SAMPLING or LATE-TIME SEEPAGE releases. These other releases involve, respectively, radioactive gases purged through a filtering system from a tunnel or shaft system to allow worker access (CONTROLLED), gas escaping from sampling equipment as part of drillback operations (GAS SAMPLING), or effluent leakage along rock fractures and/or the drill shaft after all operations have ceased (LATE-TIME SEEPAGE).{61} Such releases are far less common than EVENT or DRILLBACK releases.

A further environmental impact of “device development” tests, and most underground nuclear tests, is the formation of subsidence craters. Subsidence craters are created when the ground above a nuclear explosion slumps into the nuclear cavity:

> “When a nuclear device is detonated underground... the temperature is high enough to vaporize the surrounding solid material. Pressures exceeding a million atmospheres are produced. An outgoing shock wave develops that is initially so strong that it vaporizes most of the surrounding material. As the shock wave expands, its intensity weakens until the surrounding rock and soil are melted rather than vaporized... The generally spherical cavity is filled with vaporized material and lined with

60. See, for example, BOOMER, “Radiological Effluents”, p. 8
61. “Radiological Effluents”, 1990, pp. 3-4

Figure 21

BANEBERRY venting as viewed from the east looking towards Rainier Mesa. This December 1970 venting was detected in snowfall over Utah the next day. Fallout eventually reached the Canadian border, violating the limited test ban treaty. LLNL photo

> melted rock. After the cavity forms, the vaporized rock condenses and the molten rock flows towards the bottom, the residual gases cool, the pressures subsides, and collapse of the upper walls of the cavity begins... [O]nce started, the collapse proceeds rapidly... [and] progresses upward, producing a vertical, rubble-filled column known as a chimney... The process terminates by the formation of a conical or bowl-shaped depression [subsidence crater] ranging from several tens of feet to a few hundred feet in diameter and up to 165 feet deep [Figures 22 & 23]."{62}

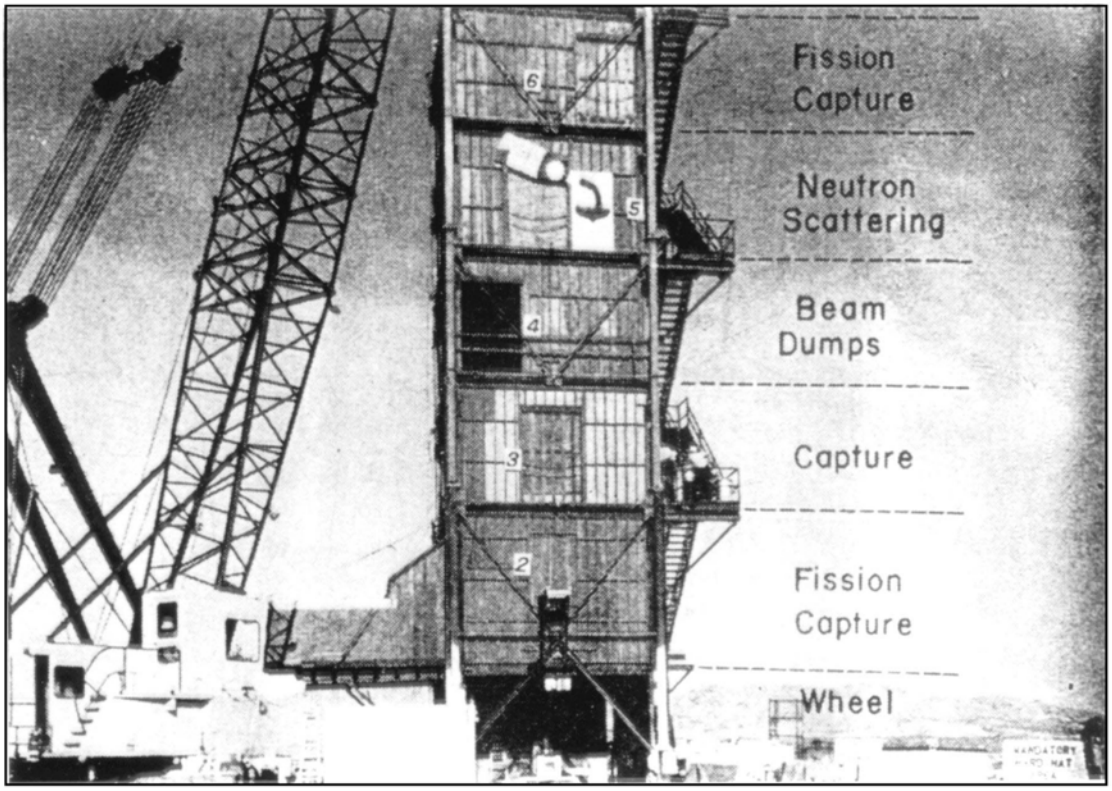
All but three of the "device development" tests [ACE, TEMPLAR, and SWITCH] produced subsidence craters ranging from two [TORNILLO] to 160 feet deep [FLASK].{63} Typically, these craters develop within minutes or hours after the explosion. Occasionally ground collapse occurs months or years later; the ground above SAXON collapsed six months after the explosion. Thus, for safety reasons, areas above uncollapsed tests are fenced off. "Device development" subsidence craters, and hundreds of others from weapons related nuclear tests, are visible from the air and on topographic maps [Maps 21, 22 & 23][Figure 24]. Several of these craters are former or current radioactive waste disposal sites, including the subsidence crater formed by MINIATA, a Plowshare test to be discussed later.{64}

EMPLACEMENT TESTS

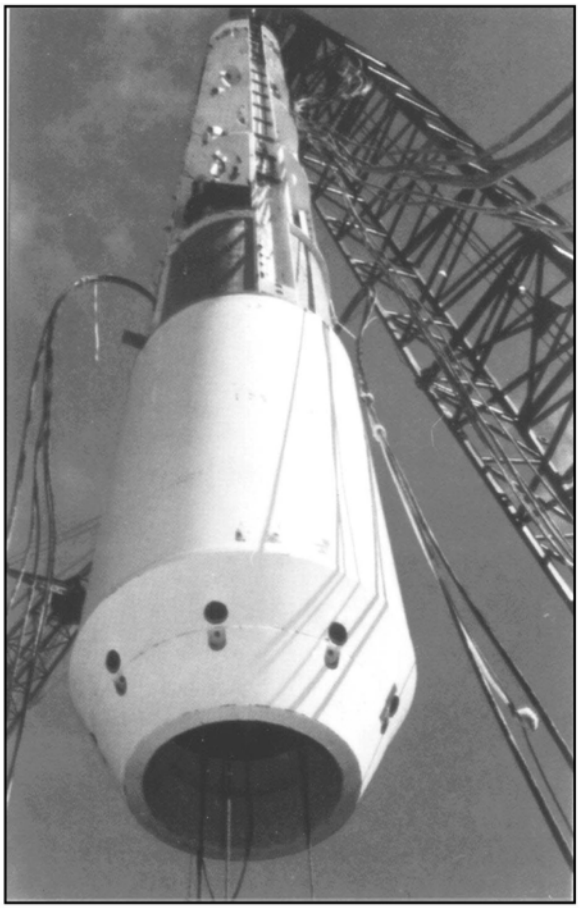
Developing a "clean" bomb is one way to reduce radioactive fallout. Another method is to bury - "emplace" in nuclear jargon - the bomb in such a way that the radiation produced is largely confined underground. This is achieved by attenuating or directing the shock wave of the blast in a particular direction. The success of "emplacement" is also contingent on the methods used to "stem" the nuclear drillhole.

62. Special Nevada Report, 09/23/91, pp. 5-8
63. "Seismic Source Summary for U.S. Underground Nuclear Explosions", (hereafter "Seismic Summary") 02/71, UCRL-73076, pp. 11-28; also available in The Parted Veil, 1976, Appendix A
64. Special Nevada Report, 09/23/91, pp. 5-34

Figure 22



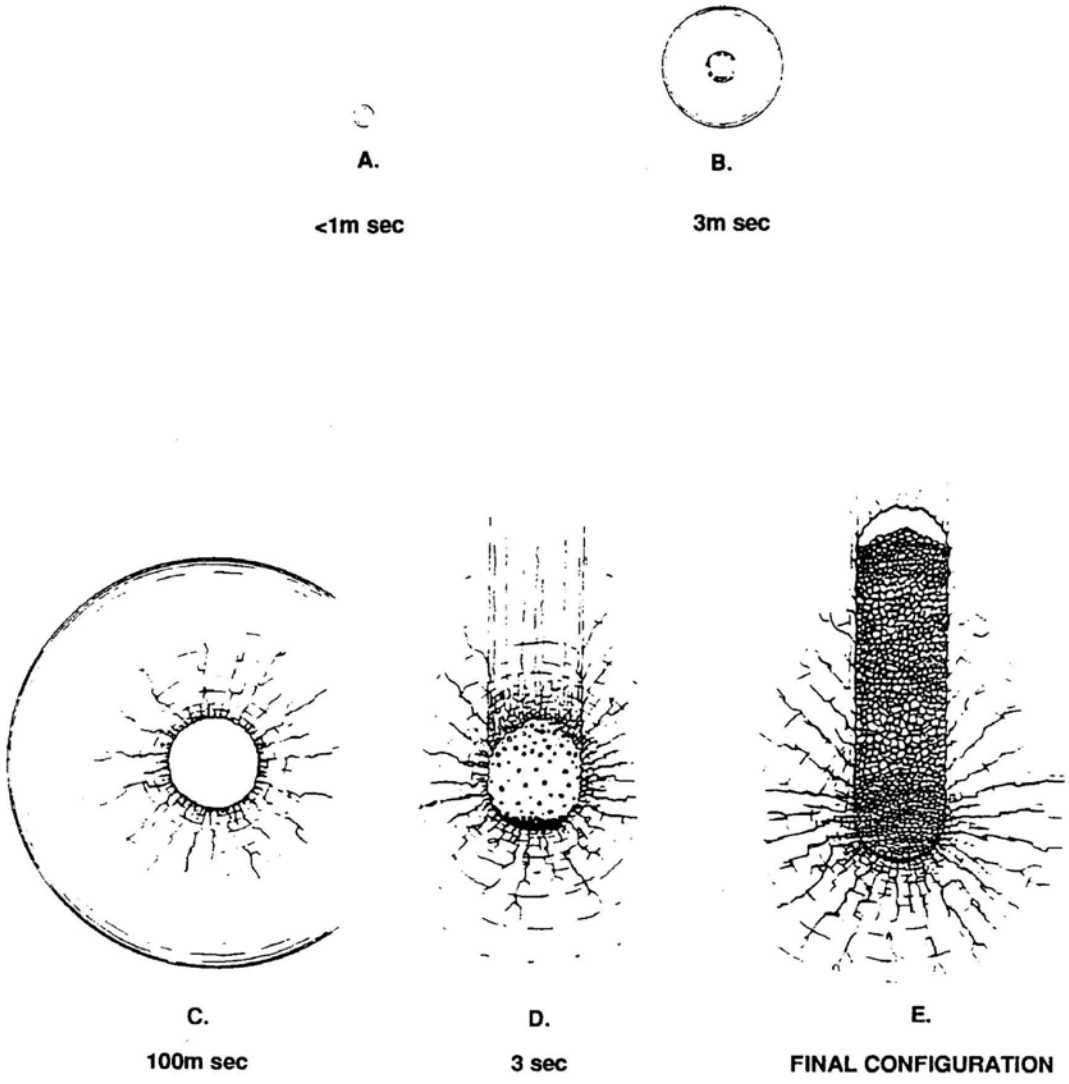
"Piggy-Backed" experiments on weapons-related test POMMARD. Bomb is emplaced 700 feet beneath tower. See figure 24 for aerial view of similar tower. AEC photo.



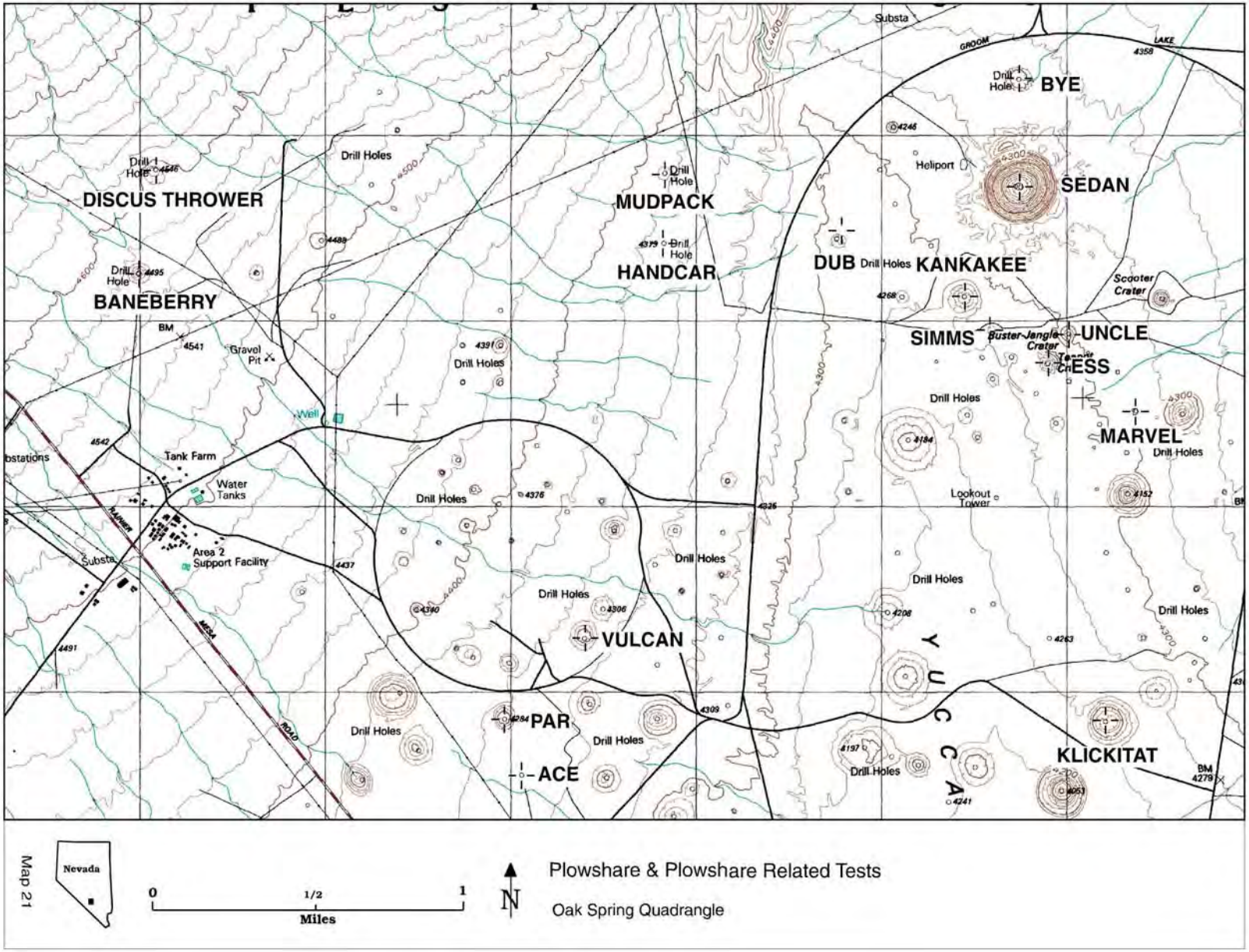
Heart of the bomb being lowered into drillhole. Livermore Lab "device" (at bottom) with associated diagnostic package and cables above. LLNL photo.

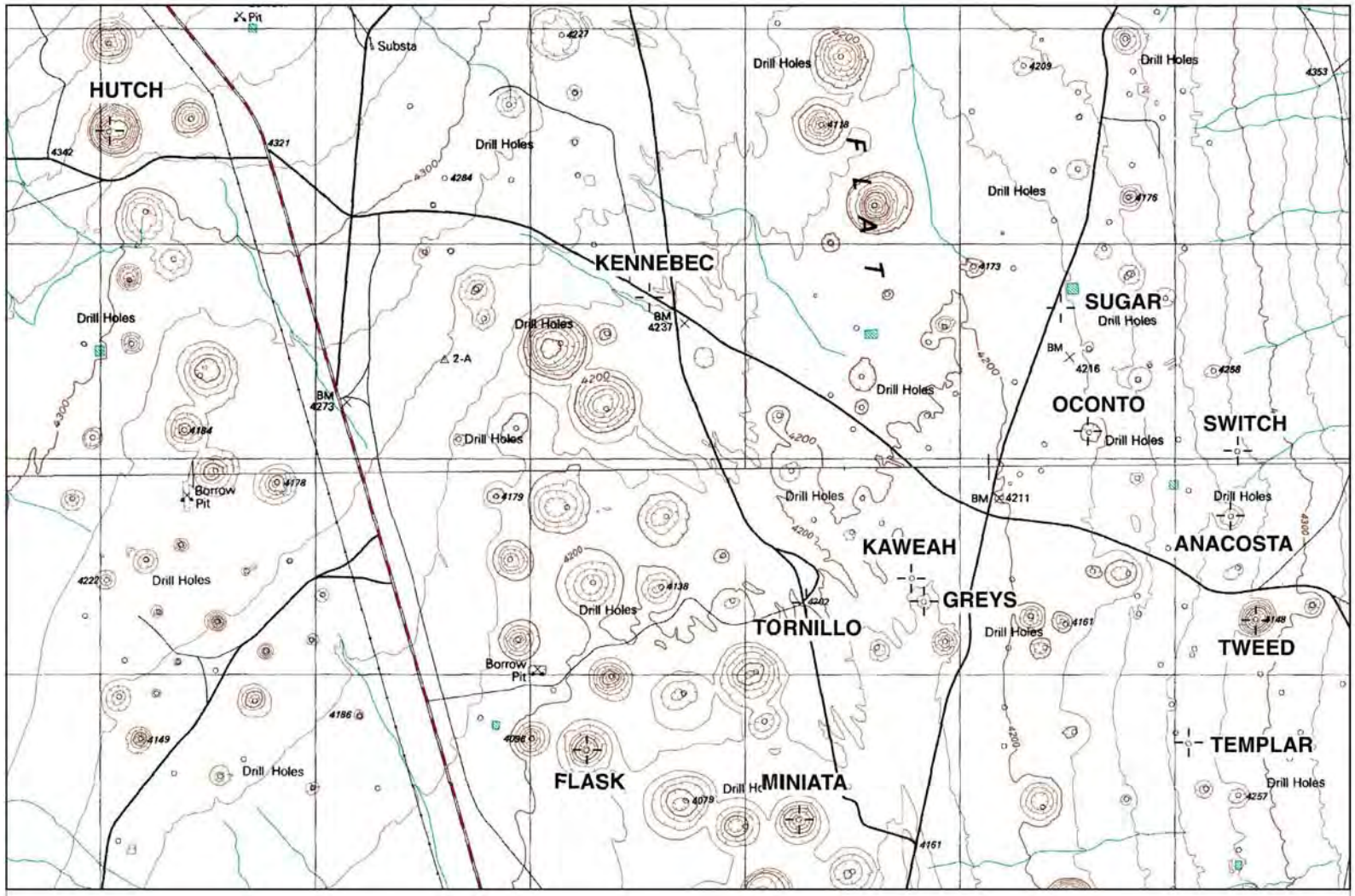
Figure 23

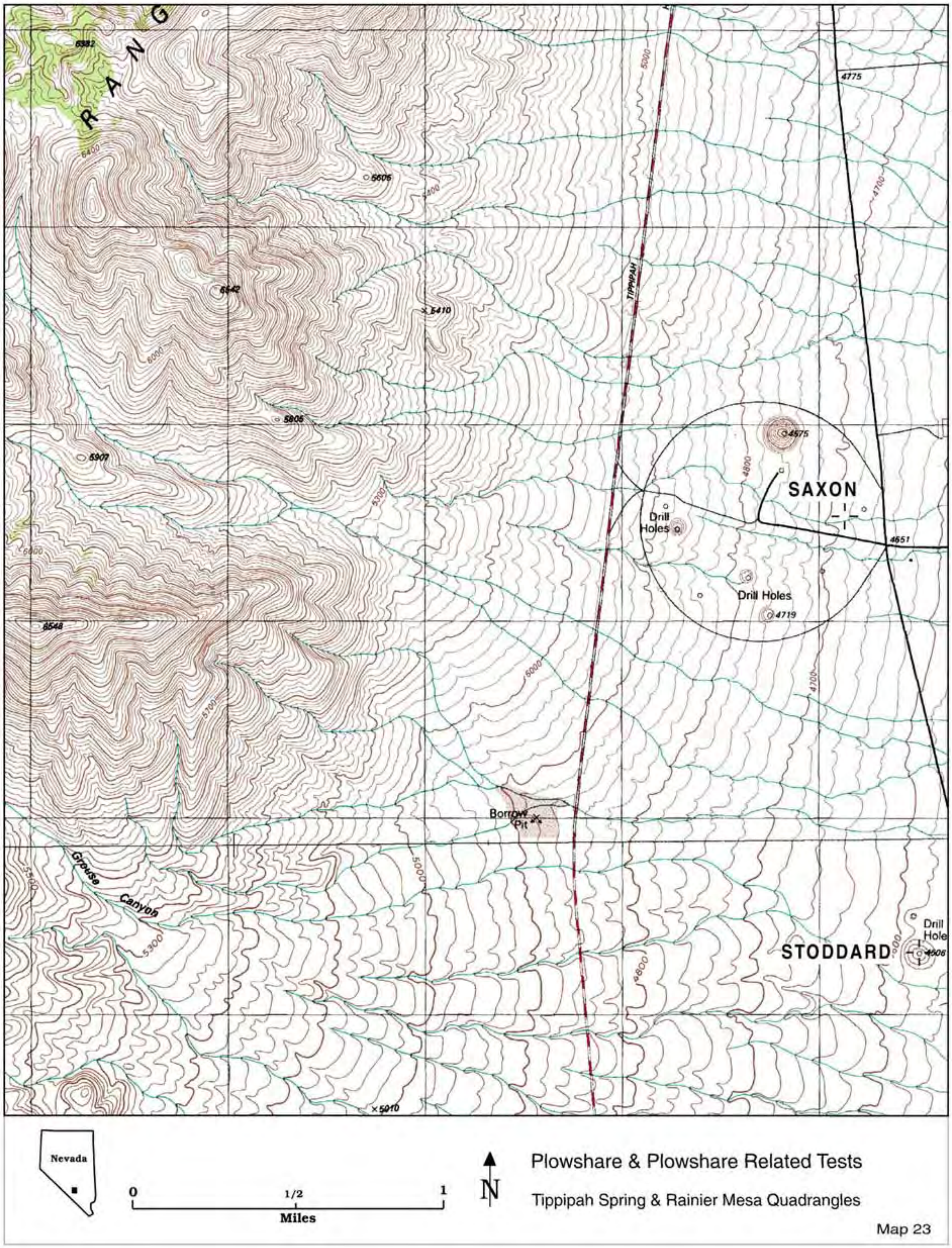
Rubble Chimney Formation



Source: FEIS "Nevada Test Site", Sept. 1977, p.2-45.


DISCUS THROWER
BANEBERRY
MUDPACK
HANDCAR
DUB
KANKAKEE
SEDAN
BYE
SIMMS
UNCLE
ESS
MARVEL
VULCAN
PAR
ACE
KLICKITAT
Drill Holes
Tank Farm
Water Tanks
Area 2 Support Facility
Gravel Pit
Well
Heliport
Lookout Tower
Scooter Crater
Buster-Jangle Crater
Substa
MESA ROAD
YUCCA
Nevada
Map 21
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Oak Spring Quadrangle


HUTCH
KENNEBEC
SUGAR
OCONTO
SWITCH
KAWEAH
GREYS
ANACOSTA
TORNILLO
TWEED
FLASK
MINIATA
TEMPLAR
Drill Holes
Pit
Substa
Borrow Pit
BM 4237
BM 4273
BM 4216
BM 4211
Z-A
Map 22
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Yucca Flat & Oak Spring Quadrangle



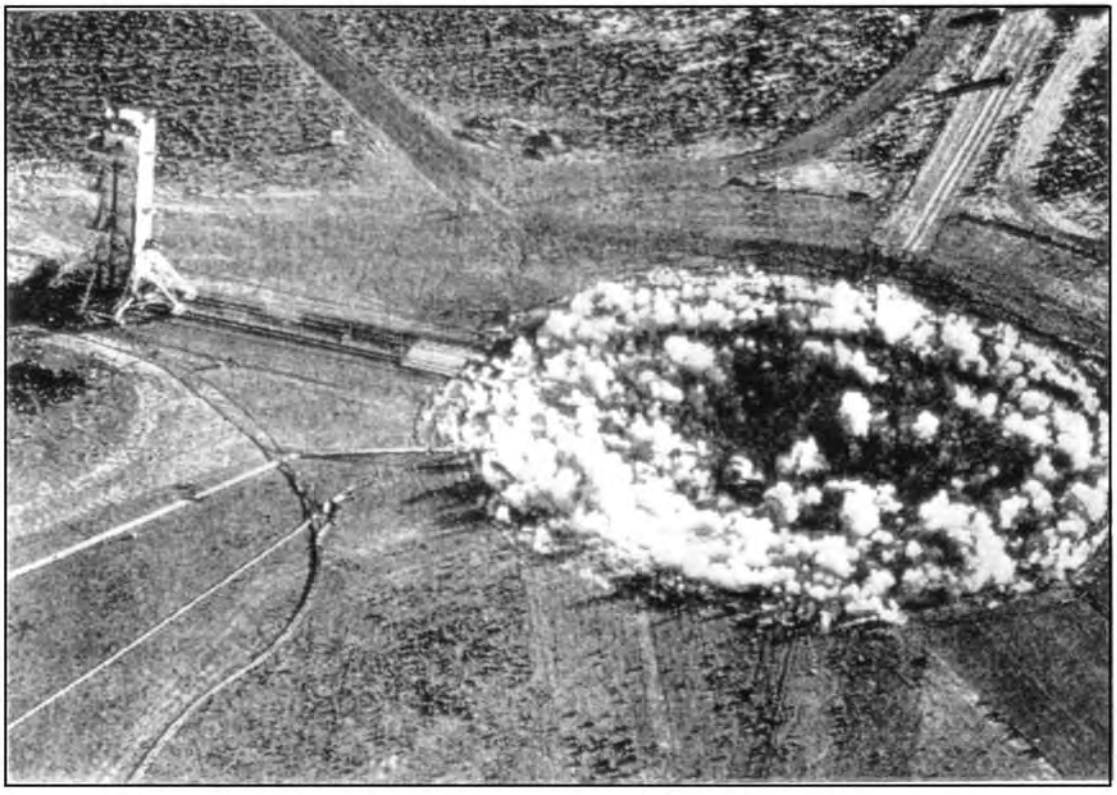
Plowshare & Plowshare Related Tests

Tippipah Spring & Rainier Mesa Quadrangles

Map 23

Figure 24

North end of Yucca Flat looking south. Several Plowshare craters are visible near the semi-circle road. LLNL photo



The ten story tall instrumentation tower on the left was winched away from the drillhole before subsidence. LLNL photo.

“Stemming” is the process of backfilling the drillhole used to “emplace” the nuclear explosive. In cratering experiments, for example, it is important that “the stemming prevent premature release of radioactive gasses... and approximate the characteristics of the surrounding media to prevent... abnormal cavity shapes.”{65} Two “emplacement” experiments were conducted by Plowshare planners, although these tests [DUB and MARVEL] are also referred to as “device development” experiments by several sources [Map 24][Figure 2].

DUB, the first “emplacement” test, did, in fact, test a “clean” bomb. But its primary purpose was to examine “technique[s] in which most of the fission products would be forced down into the open hole below the device,” thereby “enhancing the trapping of radioactivity underground in cratering events.”{66} Exploded 850 feet below the surface, DUB created a “unique surface collapse... spread over a twenty minute interval which produced a cylindrical crater [with] vertical sides [and] a flat bottom [Map 21].”{67} DUB was also responsible for an EVENT release which began five hours after detonation and lasted eighty-three hours. Drillback activities initiated two days after the explosion led to a DRILLBACK release that lasted more than three days.{68} Despite these releases, DUB was considered a “highly successful experiment... regarding emplacement techniques” and the “most significant” Plowshare test of 1964.{69}{70}

MARVEL, the second and last “emplacement” test was detonated in September, 1967. The bomb was placed in a “working room” 570 feet beneath Yucca Flat. From this room, a 400 foot

65. “Emplacement and Stemming of Nuclear Explosives for Plowshare Applications”, CONF-700101 (vol. 2), 1970, p. 974.
66. “NIBLICK Test Bulletin No. 52 [DUB]”, 07/02/64, CIC#29444, declassified with deletions, 08/19/81.
67. Ibid. p. 68. “Radiological Effluents”, 1990, p. 60
69. JCAE, “Peaceful Applications of Nuclear Explosives - Plowshare”, p. 35
70. JCAE, “Authorizing Legislation FY 1966”, p. 181

Map 24

"Emplacement" Tests
Nevada Test Site

Topographic Map Locations: DUB, MARVEL - Map 21

Source: Springer, D., "Seismic Source Summary", UCRL-73036, 06/71.

horizontal tunnel was mined that contained sensors to measure the shock wave produced by the blast [Figure 25].{71} It was hoped that the tunnel would “preferentially channel” energy from the blast away from the surface, which it did.{72} Perhaps due to this channeling, MARVEL, like DUB, created an unusually shaped subsidence crater [Figure 26]. According to the AEC, the MARVEL experiment was a success, although it also vented radiation in EVENT and DRILLBACK releases.{73}{74}

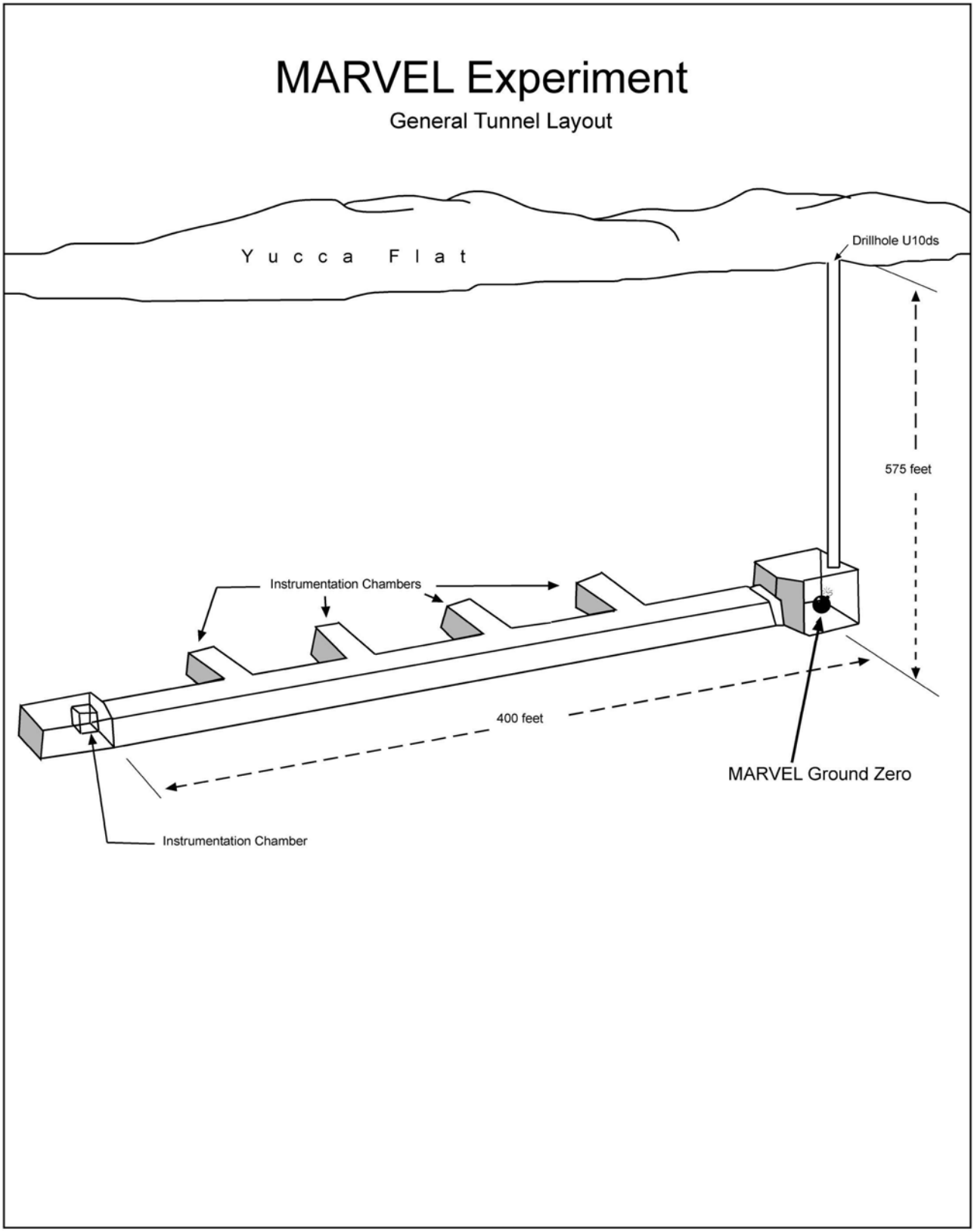
NUCLEAR EXCAVATION TESTS WEAPONS RELATED

As with high explosive excavation tests, early nuclear excavation tests by the United States were weapons related [Map 25]. The first two tests, SUGAR and UNCLE of the JANGLE series, were conducted in 1951 to “determine the militarily useful effects of surface and underground nuclear detonations” and the utility of “penetrating weapons.”{75} SUGAR created a twenty foot crater, while the UNCLE blast left a sixty foot depression. The third cratering test at the Nevada Test Site, test ESS of the TEAPOT series, was detonated in 1955 to test an “atomic munition”.{76}

NEPTUNE, a 1958 “safety test” at NTS of a Polaris missile warhead, had a larger yield than expected and accidentally created a crater. As it turned out, this accident revealed some “important news to Plowshare promoters.” NEPTUNE showed that “up to a point, crater size increased with depth of burial, while the release of radiation decreased... [Map 11].{77} It was believed

71. “MARVEL: Studies in a Shock Tube Experiment”, LLL, May, 1968, pp. 279-282
72. Ibid., p. 277
73. JCAE, “Authorizing Legislation FY 1969”, p. 1137
74. “Radiological Effluents”, 1990, p. 100
75. “Engineering With Nuclear Explosives”, CONF-700101, vol.2, p. 1892I
76. “Known US Tests”, NRDC, p. 22
77. “Project Plowshare”, R. Sanders, AEC Press Release

Figure 25

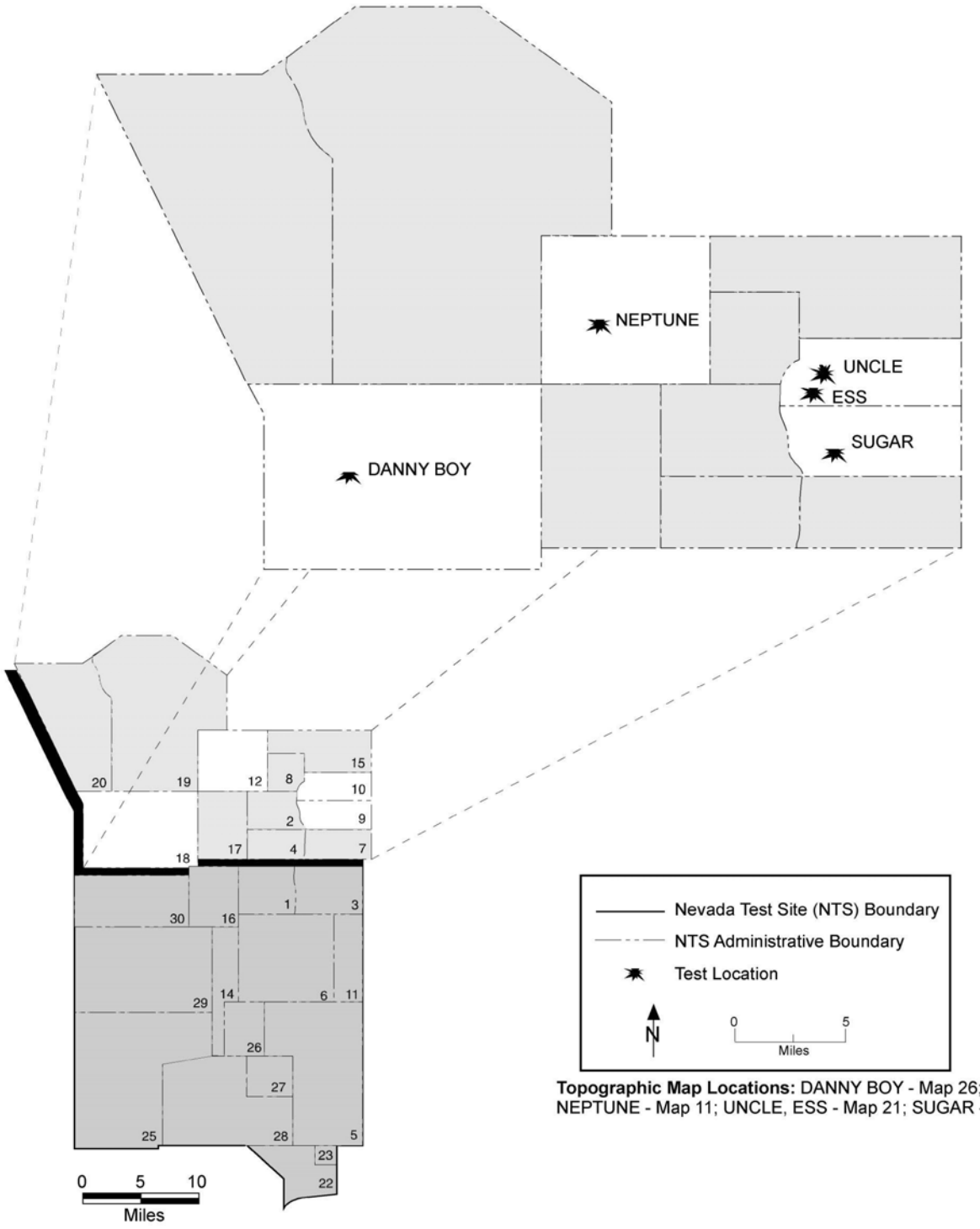


Source: "An Analysis of MARVEL - A Nuclear Schock Tube Experiment", IAEA-PL-388, p. 279

Map 25

Weapons-Related Excavation Tests

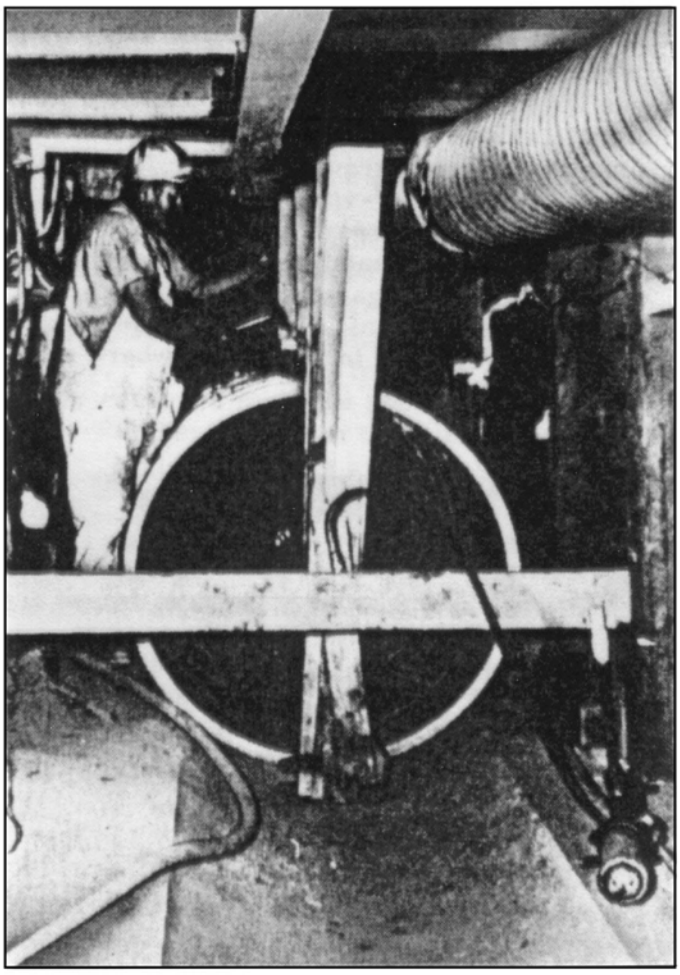
Nevada Test Site



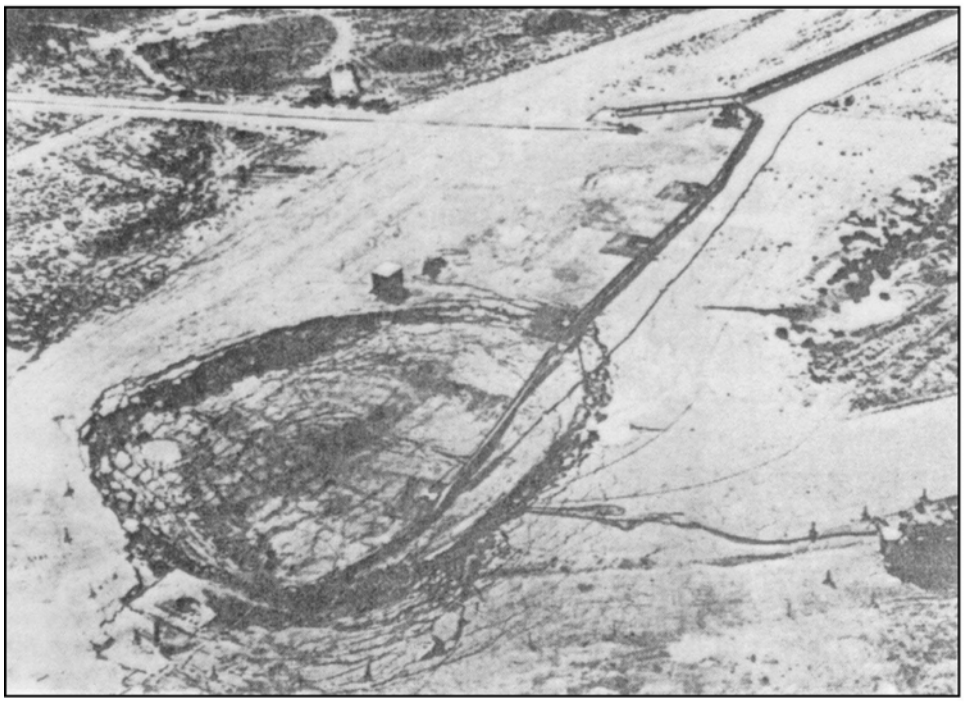
Topographic Map Locations: DANNY BOY - Map 26; NEPTUNE - Map 11; UNCLE, ESS - Map 21; SUGAR - Map 22.

Source: "Compilation of Local Fallout Data", DNA 1251-1-E, 05/79.

Figure 26



Test Site worker inside main tunnel used for MARVEL experiment. AEC photo.



MARVEL subsidence crater. Collapse was three minutes after detonation.
EVENT and DRILLBACK releases took place after detonation. AEC photo.

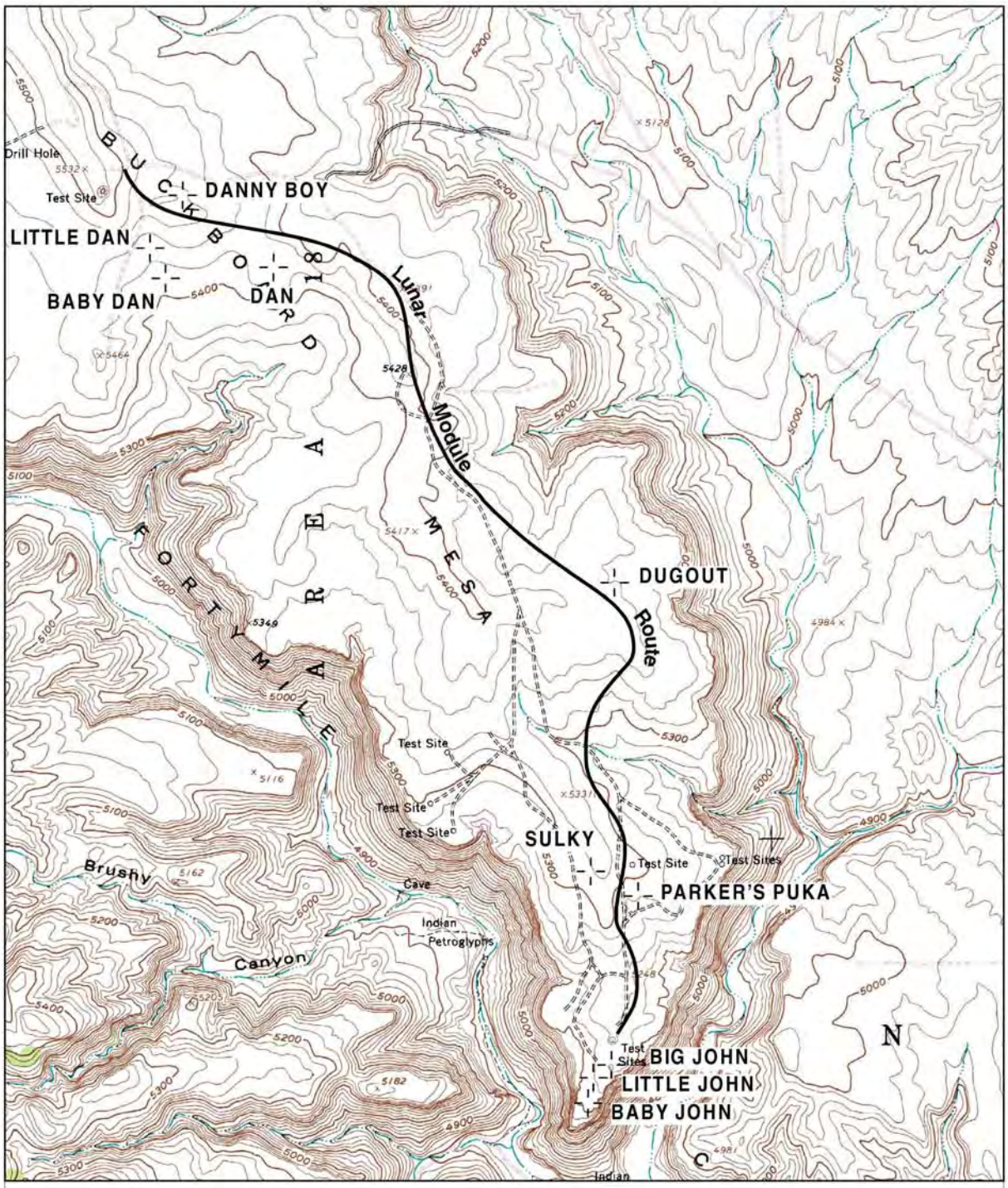
that by fine tuning the depth of burial, radiation releases from excavation tests could be nearly eliminated. DANNY BOY, another military related cratering test, was fielded after a minimum of pre-planning following the end of the voluntary test moratorium of 1958. Many tests in this period were conducted on a “crash” basis to empirically verify nuclear theories that had remained untested during the moratorium. For this reason, DANNY BOY, while primarily weapons related, was also used to investigate Plowshare applications [Map 26].{78} Thus, both NEPTUNE and DANNY BOY made explicit the overlap between “peaceful” and weapons related nuclear explosions. This topic is discussed further in relation to Plowshare physics tests.

SUGAR, UNCLE, ESS, NEPTUNE and DANNY BOY were followed by the six dedicated Plowshare nuclear excavation tests, conducted between 1962 and 1968. These tests [SEDAN, SULKY, PALAQUIN, CABRIOLET, BUGGY and SCHOONER] represent the culmination of the Plowshare excavation program: both the theory accumulated from high explosive and military related cratering tests and the bombs developed in the “device development” tests were put to use in these cratering shots. These excavation tests are also noteworthy because their environmental and immediate health effects are more significant than other Plowshare tests.

DEDICATED PLOWSHARE TESTS

The 1962 SEDAN test was the first dedicated Plowshare cratering experiment. The previously mentioned military related

78. See, for example, “Project DANNY BOY: Engineering Geologic Investigations” March 1962, p. iii, and “Investigation of Manufacture of Aggregate and Riprap by Nuclear Means”, US AEC, PNE-5003, 02/65.


DANNY BOY
LITTLE DAN
BABY DAN
DAN
Lunar Module Route
DUGOUT
SULKY
PARKER'S PUKA
BIG JOHN
LITTLE JOHN
BABY JOHN
Test Site
Test Sites
Drill Hole
Cave
Indian Petroglyphs
Brushy Canyon
FORTY MILE
BUCKBOARD MESA
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Buckboard Mesa Quadrangle
Map 26

cratering tests had been in the one kiloton range. However, an interoceanic canal required blasts in the 100 kiloton to ten megaton range to cut through the continental divide region in central Panama.{79} SEDAN, at 100 kilotons, would test excavation theory at the high yields needed to dig a trans-isthmus canal and “develop the techniques of nuclear excavation over the next four to five years”.{80} SEDAN, the 166th continental nuclear test, would, in fact, be the highest yield test up to that time to take place at the Nevada Test Site

SEDAN was detonated 635 feet underground in the immediate vicinity of the UNCLE and ESS craters [Map 21][Figure 27]. The explosion created a crater 320 feet deep and 1,200 feet in diameter. A visit to this crater, the largest at the Nevada Test Site, is included in virtually every public tour of the test site. A platform and descriptive plaque has been erected at the edge of SEDAN crater to help visitors assess the power of the blast: “In the first three seconds after the detonation, a roughly hemispherical dome of earth [800 feet] in diameter rose 300 feet.”{81} Chunks of earth continued to rise another 1,700 feet before falling back to earth. The radioactive cloud itself rose 12,000 feet above the ground where it hit an inversion layer and gradually spread out in a northeasterly direction.{82} As described in section 2, the cloud was massive enough to require streetlights in Ely, Nevada (over 200 miles away) to be turned on at four in the afternoon. In addition, “the cloud deposited nearly five times as much fallout on and near the test site than had been

79. “Nuclear Excavation of an Isthmian, Sea-Level Canal”, TECP14397, 4/66, p. 11. It was predicted that cutting through the divide - “an engineering achievement of the first magnitude” - would require several blasts totaling 30 to 35 megatons.
80. “Project Manager’s Report - Project SEDAN”, 05/63, CIC#15336, p. 5
81. “Projects GNOME and SEDAN”, DNA 6029F, p. 70
82. Ibid.

Figure 27

SEDAN crater

February 1963. First descent into SEDAN crater. Reports state it took fifteen minutes to climb down and one hour to climb out through rubble “up to your knees.” AEC photo.

predicted [Map 9]."{83}

Because of the high yield and experimental nature of SEDAN, the Nevada Test Site was the only site considered for the detonation. For similar reasons, the remaining five Plowshare nuclear excavation experiments were also conducted inside the borders of the Nevada Test Site [Map 27]. It is useful, therefore, to briefly recount the considerations which led to establishing a nuclear testing area in Nevada and, by association, conducting cratering experiments within its borders.

SITE SELECTION: THE NEVADA TEST SITE

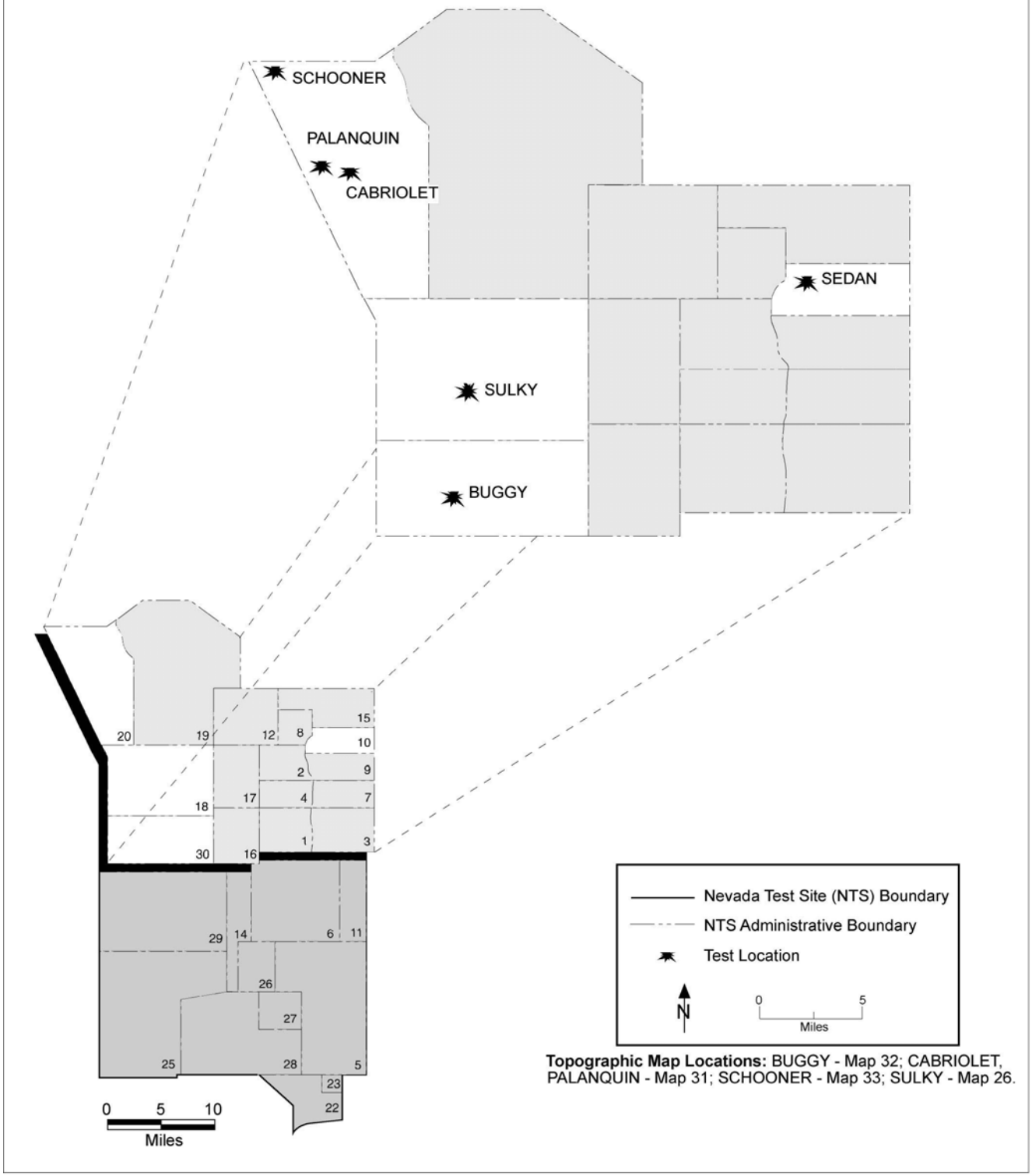
The first series of atomic tests, Operation CROSSROADS and SANDSTONE, were conducted at Bikini and Enewetok atolls in the Pacific. It was soon realized, however, that nuclear tests conducted near or within the United States would save in transportation costs, logistical problems, security concerns and scheduling restraints. Project NUTMEG was secretly initiated in 1948 to study "the outstanding advantages in having a continental test site for all atomic weapons tests."{84} NUTMEG's sponsor, the Air Force Special Weapons Project (AFSWP), was assisted by the USGS and the Department of the Interior. Sites in Alaska (excluding Amchitka Island) and Canada were discarded, despite their "advantages of remoteness," due to "inaccessibility, lack of required harbors or facilities, unsuitability of the physical features, or adverse geographical environment."{85}{86} Other

83. Ibid., p. 73
84. Memo, "US AEC to Special Committee of the NSC – Additional Test Site", dated 12/13/50, p. 1, declassified 08/21/89
85. "advantages of remoteness", "AEC Commission Meeting 141/7", 12/13/50, p. 1413, declassified with deletions 11/30/78
86. "adverse environment" - "Continental Test Site", DOE archives, DMA files, CIC#28597, p. 2, declassified 04/29/85

drawbacks to these northern sites included "expense, limited working

Map 27

Plowshare Excavation Tests
Nevada Test Site



Topographic Map Locations: BUGGY - Map 32; CABRIOLET, PALANQUIN - Map 31; SCHOONER - Map 33; SULKY - Map 26.

Source: Springer, D., "Seismic Source Summary", UCRL-73036, 02/71.

season... and control of wandering groups such as trappers, prospectors, etc.”{87} Locations also considered but eliminated - due to probable radiological “contamination [of]... pelagic fishes” - were sites in the Caribbean and the Galapagos Islands.{88}

It was also preferred to establish a continental test site for the attending “psychological benefits” to the American public. The following excerpt from a 1948 memo to the commander of Joint Task Force Seven explains this interpretation:

> “There is no question that there will be difficult local and general public relations problems [regarding continental atomic testing]. These difficulties stem in part from the vagueness of public knowledge of the facts of atomic energy and radiation hazards but they are certainly not decreased by the postwar pattern of conducting atomic weapon tests in the remote Marshall Islands... I submit that this pattern has already become too firmly fixed in the public mind and its continuation can contribute to an unhealthy, dangerous and unjustified fear of atomic detonations... Therefore, on a psychological basis alone, I believe that it is high time to lay the ghost of an all-pervading lethal radioactive cloud [to rest].”{89}

The memo concludes that the “public relations difficulties caused by testing atomic bombs within the continental limits... are more than offset by the fundamental gain from increased realism in the attitude of the public”; this realism being the acceptance of “an atomic explosion within a matter of a hundred or so miles from... [one’s] home.”{90}{91}

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87. Ibid.
88. “Appendix - Memo to Office of the Deputy Commander Joint Task Force Seven”, 05/12/48, pp. 4-5, declassified 03/02/76
89. Ibid p. 7
90. “Memo, Joint Task Force Seven - Location of Proving Ground for Atomic Weapons”, 05/12/48, p. 8, declassified 03/02/76
91. Ibid., p. 3

The NUTMEG committee narrowed the search to five areas in the continental United States. The main considerations used to rank these sites were radiological safety, physical requirements, availability of land and operational facilities.{92} The stated primary criteria was radiological safety. Four sites in the west - the White Sands Missile Range in New Mexico, the Dugway Proving Ground in Utah, the Tonopah Bombing Range and Las Vegas Aerial Gunnery Range in Nevada, and public land in south central Nevada between Fallon and Eureka - were chosen on the basis of “sparse population, averaging less than one person per square mile... and vast areas of sparsely populated land in sectors extending from... [potential blast] centers.”{93}{94} The only other site that met the radiological safety criteria was the Pamlico Sound area of coastal North Carolina [Map 28]. According to NUTMEG, westerly winds would carry radioactive material from a nuclear blast in North Carolina “out over the Gulf Stream where any fallout would pass rapidly to the open Atlantic.”{95}

However, the committee finally concluded that “a twenty kiloton underground test could not be made in the continental United States at present due to lack of accurate data on fallout patterns.”{96} In a separate memo, the National Security Council added that “the lack of knowledge as to the size of the area which would be rendered radioactive by an underground atomic explosion [makes] the selection of a site within the continental United States doubtful from the outset.”{97}

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92. “AEC Commission Meeting 141/7”, 12/13/50, p. 1413, declassified with deletions 11/30/78
93. Ibid. p. 1416
94. “Continental Test Site”, DOE archives, DMA files, CIC#28597, declassified 04/29/85, p. 1
95. Ibid.
96. Memo, “US AEC to LASL”, dated 04/21/50, CIC#125673, p. l, declassified 10/09/85
97. Memo, “NSC to the Secretary of State, Secretary of Defense and Chairman AEC”, dated 10/30/50, p. 3, declassified with deletions 08/29/89

Continental Test Sites
Areas Considered

Source: AEC Meeting 141/7, 12/13/50.

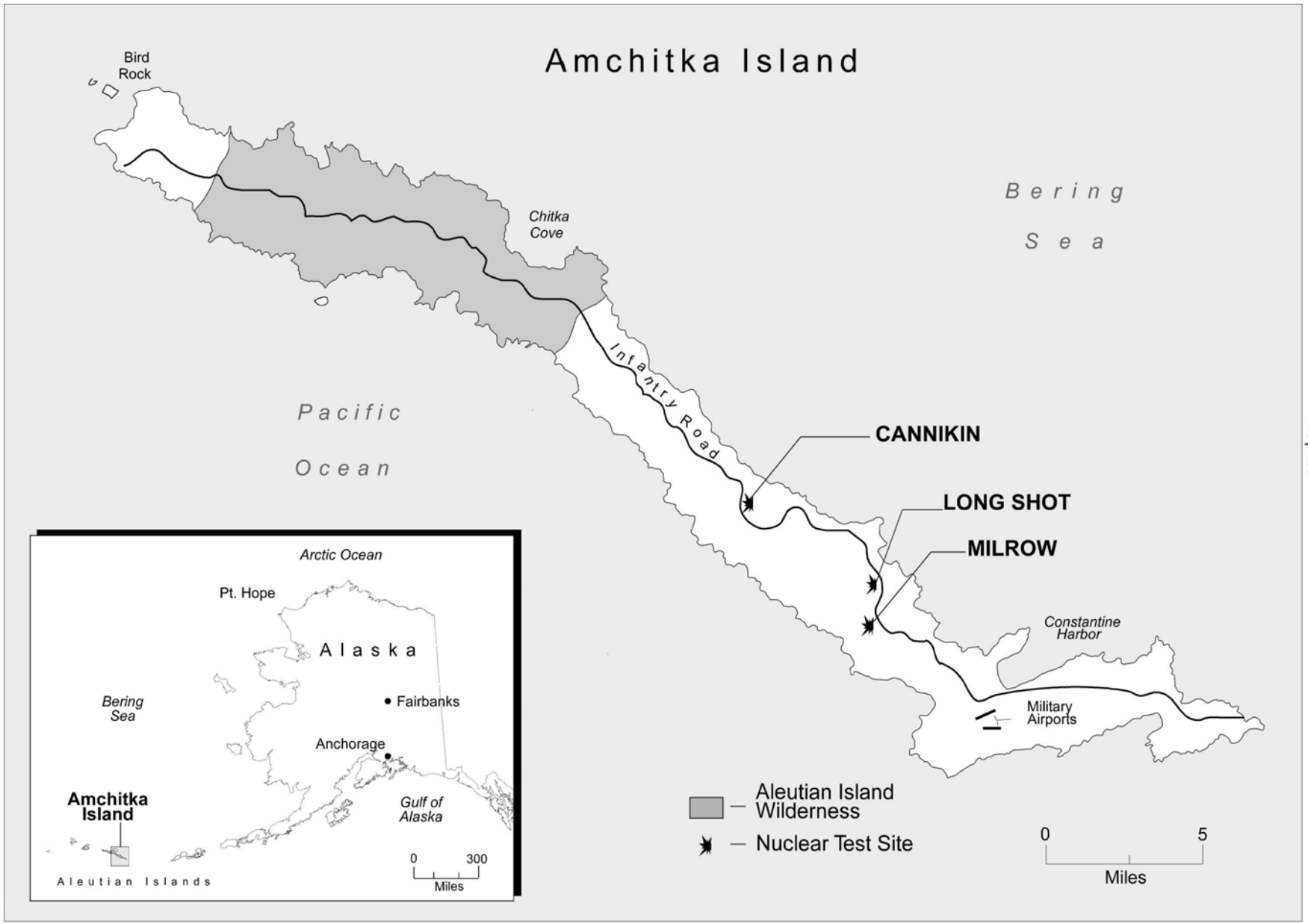
Map 28

As an interim measure, it was decided to perform a series of test shots, known as Operation WINDSTORM, at Amchitka Island in the Aleutian islands off Alaska. Amchitka was chosen because it "is completely uninhabited, yet has a war time air field, piers... and other improvements."{98} The prevailing winds, while presenting a hazard east of the island, would prevent "the USSR from detect[ing] the tests by radiological means."{99} Drawbacks to the site included its harsh climate, a less than ideal geology, and wildlife values that would be affected by testing. For example, Amchitka is "the principal concentration center for the total existing population of [the endangered] sea otter,"... and "a haven for falcons, an endangered species, and over 100 other bird species."{100}{101} After detailed study the AEC decided to scrap WINDSTORM, not for its wildlife impacts, but because "the effects of small detonations fired under... favorable conditions [within the continental US] can be extrapolated... with greater accuracy than can full-scale weapons fired under poor conditions [Amchitka]."{102}

Parenthetically, between 1965 and 1971 Amchitka was used as the site for three underground nuclear weapons tests [LONGSHOT, MILROW, and CANNIKIN][Map 29][Figure 28]. CANNIKIN, at over five megatons, is the largest yield underground test ever conducted by the United States. The day before the test, the Anchorage *Daily Times* ran a photo entitled "CANNIKIN Surrounded by Bleakness." The caption states:

98. Memo, "NSC to the Secretary of State, Secretary of Defense and Chairman AEC", dated 10/30/50, p. 4, declassified with deletions 08/29/89
99. Ibid., p. 5
100. Memo, "US Dept. of Interior to M. Lay", 10/13/50, p. 1, declassified 08/29/85
101. "AEC Continues Amchitka Cleanup After CANNIKIN", Anchorage *Daily Times*, p. 2, 11/09/71
102. Memo, "NSC to the President - Operation WINDSTORM", 06/04/51, p. 2, declassified 06/16/80

"The complete bleakness of Amchitka Island is shown in

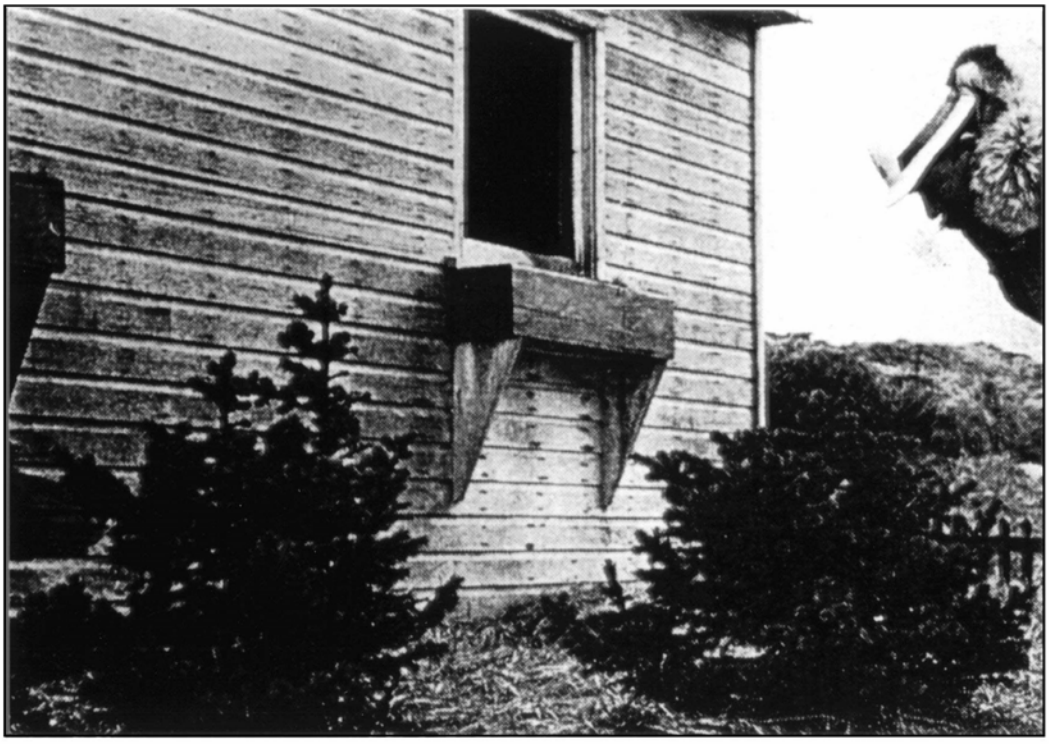


Source: "NVO Factbook", NVO-52, 1969.

Map 29

Figure 28

Archaeologist from the University of Alaska unearths skeletal remains on Amchitka island. The last native Amchitkans were evacuated from the island during World War II. The island is now unpopulated. AEC photo.



"Amchitka National Forest" - These two blue spruce were planted outside the officers club during the World War II occupation. They are the only trees on the island and are "carefully tended by men engaged in developing the AEC supplemental testsite." AEC photo.

> this picture showing the CANNIKIN project in which an atomic bomb will be exploded tomorrow [11/6/71]. Only the construction by man disturbs the treeless island of rock in the Aleutian chain. This photo... was released by the Atomic Energy Commission."{103}

Not all Alaskans agreed with this assessment. The day of the test, the Anchorage *Daily News* ran the following "Open Letter to the AEC" penned by Jay Hammond, President of the Alaska State Senate:

> "Alaskans are told there's no reason for panicin' Just 'cause you're pushing the button on CANNIKIN... Our distress, unlike some, is caused by the fact That endangered Sea Otter might suffer impact. We'd rather instead you'd trigger the Bomb In some area where we knew without qualm *Unendangered* species were found to abound. We suggest Manhattan Island as prime "zero ground..."{104}

To return to the continental site selection, Amchitka was rejected in the 1950's because the results of weapon tests could be more accurately determined in the continental United States. North Carolina, the preferred continental site from a radiological safety standpoint, was rejected because of its distance from Los Alamos Labs and because testing could proceed "more quickly... [at a] site already in military hands."{105} Thus, efficient and rapid weapon testing overrode the radiological safety concerns highlighted by the NUTMEG site selection report.

The AEC finally concluded that a portion of the Las Vegas Aerial Gunnery Range, a "waste desert land", was the "best of the remaining sites."{106}{107} In this area the "population density is so very small that suitable controls can be established

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103. "CANNIKIN Surrounded By Bleakness", Anchorage *Daily Times*, 11/05/71
104. "Open Letter to the AEC", Anchorage *Daily Times*, 11/06/71
105. "Continental Test Site", CIC#28597
106. "waste desert" - "Desirability of an Area in the Las Vegas Bombing Range to be Used as a Continental Proving Ground For Atomic Weapons", 11/22/50, declassified 07/30/80, p. 2
107. "best site" - "AEC Commission Meeting 141/7", 12/13/50, p. 1417, declassified with deletions 11/30/78

with very little logistical effort," whereas Dugway and White Sands had more people in their "90 degree possible fall-out sectors."{108}{109} The Fallon to Eureka site was eliminated because it was not government controlled land; the Las Vegas Gunnery Range was already under full government control. The Gunnery Range site was also relatively more developed in terms of existing roads and airstrips than the other continental sites considered. Thus, in December 1950, the Nevada Proving Ground, carved out of the Las Vegas Aerial Gunnery Range, was formally approved by President Truman as the nation's continental nuclear test site. The press and public was informed of this choice on January 11th, 1951, and sixteen days later a one kiloton bomb was exploded over the Nevada desert (shot ABLE of the RANGER series).{110}

This first series of five tests at the Nevada Proving Ground, later renamed the Nevada Test Site, was judged a success by the AEC, and plans were made for additional tests in the fall (Operation BUSTER-JANGLE).{111} By the time of the second Plowshare excavation experiment, SULKY, in 1964, there had been 256 nuclear explosions at the test site, or more than one nuclear explosion every three weeks for thirteen years. This long history of testing within the Nevada Test Site lent nuclear excavation experiments, and other nuclear tests, an acceptability they would not have had in Montana, Idaho or any other state. It is primarily for this reason that all six Plowshare excavation tests were eventually conducted within the confines of the Nevada Test Site.

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108. "logistical effort" - "Desirability of an Area in the Las Vegas Bombing Range to be Used as a Continental Proving Ground For Atomic Weapons", p. 3
109. See "Continental Test Site", DOE archives, DMA files, CIC#28597, pp. 3-4 declassified 04/29/85
110. Memo, "NSC to the President", with attached draft press release, dated 01/10/51, p. 1 declassified 08/30/85
111. The series was praised for its "efficiency, safety and speed", Bombs in the Backyard, 1986, p. 59

POST SEDAN: THE LIMITED TEST BAN TREATY

Shortly after the SEDAN explosion, the Limited Test Ban Treaty of 1963 was ratified by the United States, Great Britain and the Soviet Union. This treaty, an initial step towards ending the arms race and "the contamination of man's environment by radioactive substances", prohibits nuclear explosions underwater, in the atmosphere, or in space.{1} It also prohibits dispersal of radioactive debris from underground tests beyond the territorial boundaries of the country responsible for the explosion. No one, including Glenn Seaborg, Chairman of the AEC, or Gerald Johnson, Director of the Plowshare program for Livermore Labs, was certain how Plowshare cratering tests would be defined under the Limited Test Ban Treaty:

> "Representative Hosmer: All this dust and blast in the air [referring to excavation tests], wouldn't that fall into the category of an atmospheric nuclear explosion?
>
> Dr Johnson: Sir, I don't know.
>
> Representative Hosmer: Does anybody know, in terms of the [Limited Test Ban] treaty?
>
> Dr. Johnson: There is one precedent, and it was very low yield. [DANNY BOY]... was ruled an underground shot even though it was known to be a cratering event.
>
> Dr. Seaborg: I think that the legal interpretation of the treaty is that these are not atmospheric shots. They are underground... even though they break the surface.
>
> Representative Hosmer: ... In other words, the fireball, so called, is what determines whether it is atmospheric or underground. As long as the fireball is not above the surface, it is considered underground?
>
> Mr. Palfrey: Those who have looked at the test ban treaty and how to interpret it have felt that there is no

1. "Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water", 08/05/93; quoted in The American Atom.

> possibility to make a very clear definition between what is and what is not. But... [a] fireball might be one of the characteristics."{2}

A weapons related experiment, code named PIKE, further underscored fears that Plowshare cratering experiments, even those with underground "fireballs", would be incompatible with the Limited Test Ban Treaty because of their venting characteristics.{3} PIKE, intended to be a fully contained underground test, vented "a dense black cloud of radiation... resembling a huge frankfurter" which traveled from the test site towards the Mexican border [Map 30].{4} A memo to President Johnson stated: "the possibility cannot be excluded that measurable quantities of debris did, in fact, cross into Mexico... and Mexican Health Authorities... might have detected radioactive iodine in milk."{5} The "likelihood of international embarrassment" from future PIKE-like ventings led to a recommendation by the Division of Classification for stricter controls over radiation release figures and a misleading AEC press release which "emphasized... that the fallout cloud had not floated across any [international] borders" but had dissipated in Arizona.{6}{7} To reiterate, although PIKE was designed to be fully contained, its radioactive by-products contaminated milk at least as far away as Yuma, Arizona.{8} How, then, could Plowshare cratering tests, which were expected to release radiation, be conducted without violating the Limited Test Ban Treaty?

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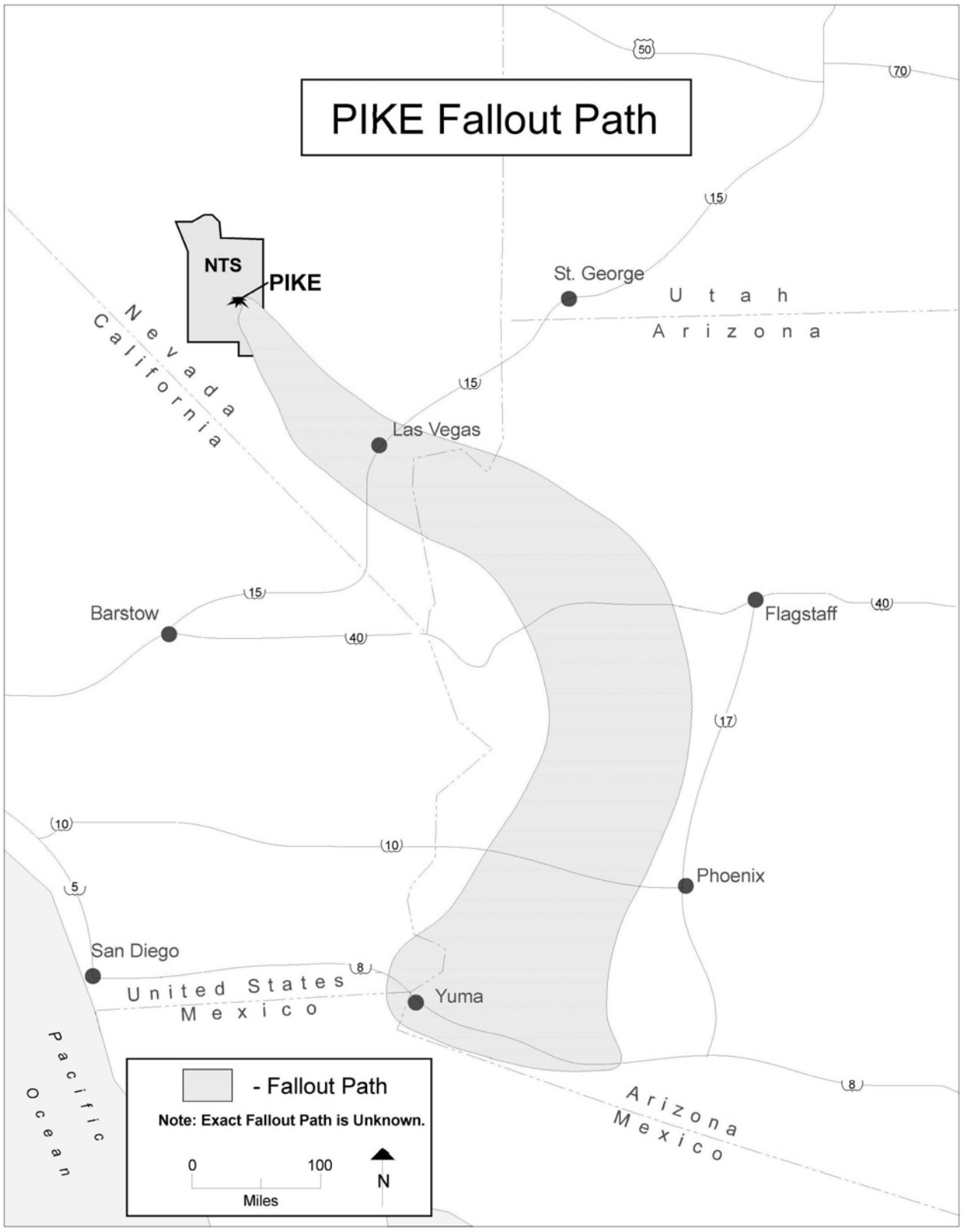
2. JCAE, "Authorizing Legislation FY 1965", p. 1223
3. See, for example, "AEC Program for Peaceful Nuclear Explosives Slowed Down by Test Ban Treaty", *Science*, vol. 143, p. 1153
4. "A Radiation Briefer's Guide to the PIKE Model", US DOE, 1990, p. 73
5. "Memorandum for the President", 3/25/64, declassified with deletions
6. Memo - C. Marshall to M. Kratzer, "Classification of Information Related to Possible Venting of Nuclear Tests", 09/21/64, CIC#104511, declassified 01/27/88
7. "The Talk of the Town", *The New Yorker Magazine*, 04/04/64, CIC #106169
8. "Radiological Effluents", 1990, p. 57

Map 30



Source: Steadman, C., "A Radiation Briefer's Guide to the PIKE Model", DOE/NV-335, 03/90.

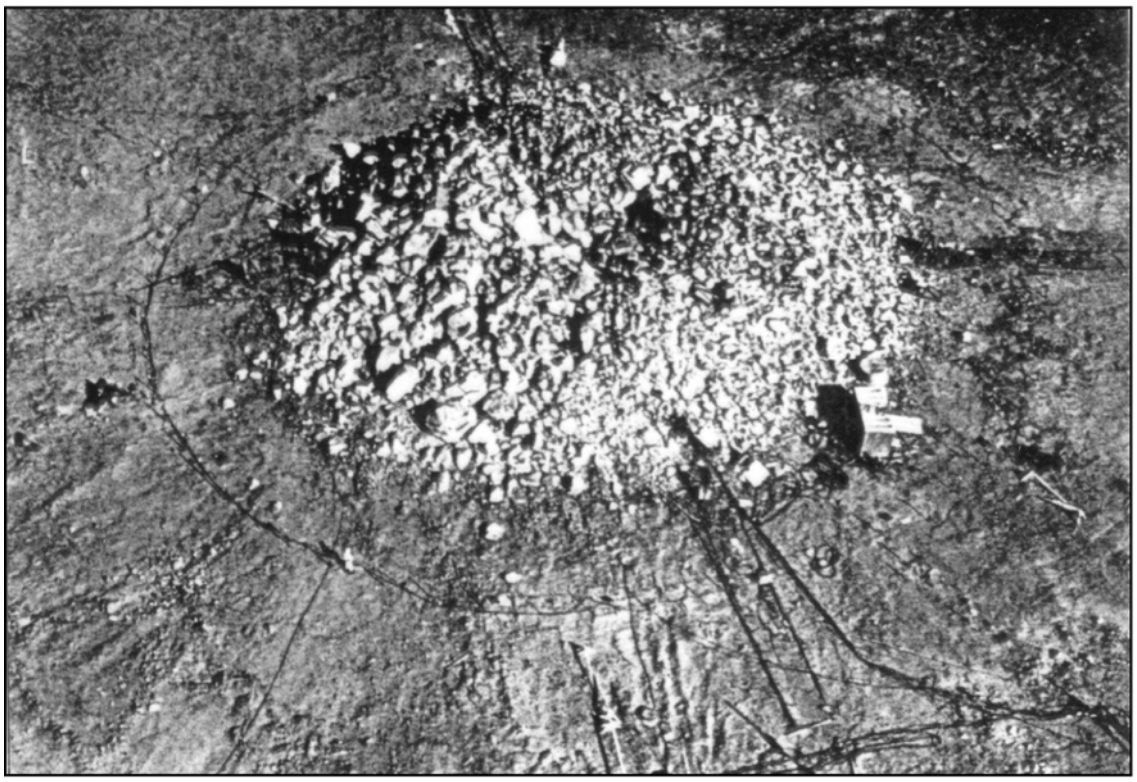
This is the question that worried Plowshare planners and put significant restraints on the Plowshare excavation program. SCHOONER, at 100 kilotons, was delayed indefinitely and SULKY, a 0.1 kiloton blast, was scheduled in its place. SULKY was “about the smallest scale experiment from which useful cratering information could be obtained.”{9} But, in the words of the Atomic Energy Commission, “to continue a meaningful [Plowshare] program, a way must be found to carry out such experiments.”{10} As a further guard against violating the Limited Test Ban Treaty, SULKY was also buried at “an overly conservative depth.”{11} Due to these constraints, SULKY produced a mound of broken rock instead of a crater [Figure 29].

The failed SULKY experiment became indicative of the status of the ‘PANATOMIC’ canal and the Plowshare program as a whole. After SULKY, Glen Seaborg, chairman of the AEC, stated before the JCAE that a trans-isthmian canal project would “definitely require a modification of the Limited Test Ban Treaty,” a highly unlikely event. If the treaty could not be modified, a ‘PANATOMIC’ canal was out of the question.{12} Chairman Pastore responded:

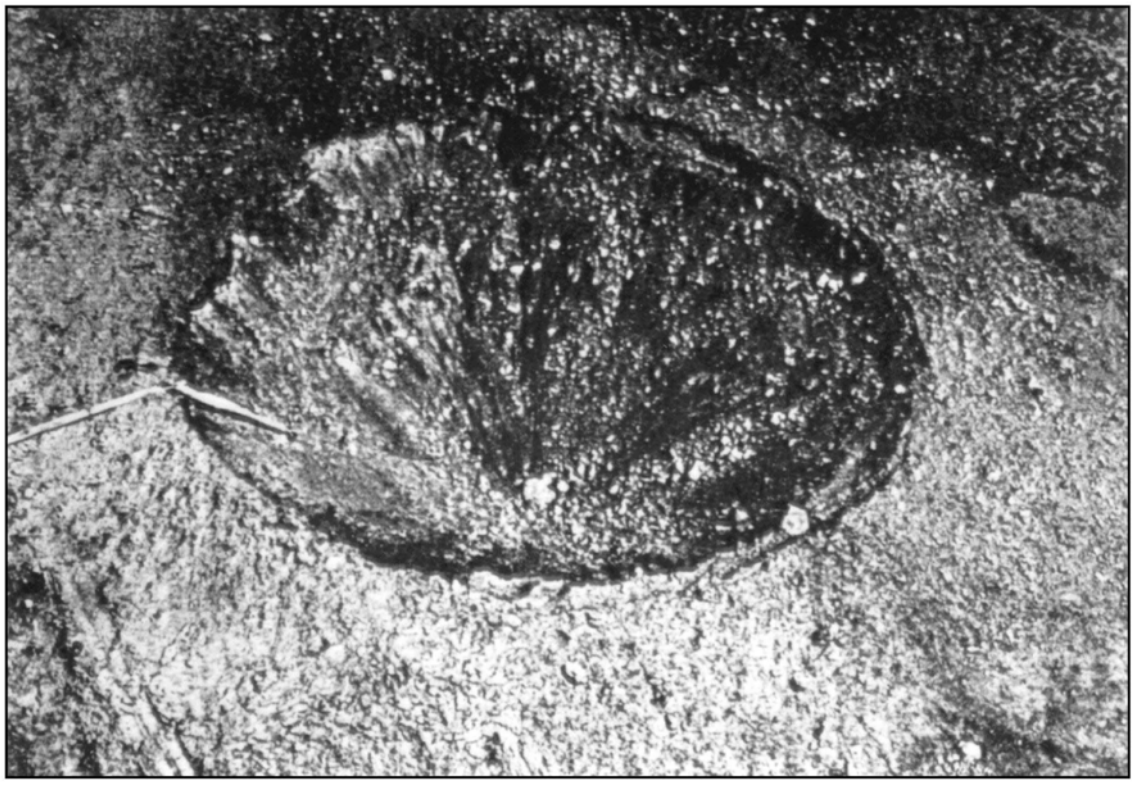
> “I think if we... remove from this whole scene the use of nuclear devices to build a canal, I think myself we have weakened the whole spirit and initiative to Plowshare... Once you have ruled [the canal] out, I am afraid interest is going to drop off. I am perfectly willing to double, treble, or quadruple the appropriation if we are going to use nuclear devices for the building of the canal. If we are not, I would like to take a second look at the size of the budget. That is all it amounts to.”{13

9. Stemming the Tide, 1987, p. 318
10. Ibid.
11. Ibid., p. 319
12. See, for example JCAE, “Authorizing Legislation FY 1967”, p. 1349
13. JCAE, “Peaceful Applications of Nuclear Explosives”, 1965, pp. 25-26

Figure 29



SULKY mound. LLNL photo.



PALANQUIN crater. LLNL photo.

Seaborg and other Plowshare planners banked that the treaty would be modified rather than accept the end of the excavation program. Further Plowshare excavation studies proceeded cautiously, looking for ways to carry out a meaningful Plowshare program while avoiding anything resembling the PIKE incident. PALANQUIN, a four kiloton Plowshare cratering experiment, was the next tentative step taken by Plowshare planners. This test, exploded four months after SULKY, was designed to test the "cratering mechanism in hard dry rock as might be encountered in Panama."{14} This time, however, physicists hoped and expected that the blast would create a rubble pile similar to the one accidentally created by SULKY. Such a rock mound, physicists believed, would give the necessary cratering information while preventing a large release of radiation. But due to a miscalculation, PALANQUIN instead created a crater over 230 feet deep and released a cloud that "rose to a height of eight thousand feet, and contained higher-than-expected levels of radioactivity."{15} The cloud traveled north, skirting Spokane, Washington and then turned east towards Butte, Montana. Plowshare planners feared the cloud might eventually cross into Canada and violate the Limited Test Ban Treaty as PIKE had the year before. Ironically, the violation showed up weeks later in another direction. Glenn Seaborg, chairman of the AEC, writes in his journal:

> "Indications are that some radioactive debris from PALANQUIN, a few counts of Barium-140, have been detected by our Air Force over Bermuda."{16}

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14. Stemming The Tide, 1987, p. 322
15. Ibid., p. 323
16. Ibid.

The United States issued a press release that neither confirmed nor denied “any escape of radioactivity from the United States” due to PALANQUIN.{17} The government, in fact, pursued another tack. Seaborg writes: “And then, pursuant to the old legal dictum, ‘If you have a weak defense, attack!’, our government chose to revive the issue about the escape of radioactivity from [a] Soviet weapon test” that had taken place earlier that year.{18} Seaborg considered this approach “childish... damaging... and certainly not helpful to the future the AEC had in mind for international cooperation in PNE’s [peaceful nuclear explosions].” It would be three years before another Plowshare excavation experiment was conducted by the United States.

PROJECT CABRIOLET

CABRIOLET, like SULKY and PALANQUIN, was developed as an alternative to the continually postponed high yield SCHOONER test. At 2.7 kilotons, the radioactive debris from CABRIOLET explosion was not expected to cross an international border and thus violate the Limited Test Ban Treaty. Also, a smaller test such as CABRIOLET was needed to help understand way PALANQUIN had created a crater and not a rubble mound.{19}

One variable in the PALANQUIN equation was the type of rock used for the experiment. PALANQUIN was the first test ever detonated in a region of the Nevada Test Site known as Pahute Mesa. Pahute Mesa, comprised of thick layers of volcanic rock, is part of an ancient formation known as the Silent Valley Caldera [Map 2]. Most experiments planned for this part of the test site

17. Ibid., p. 324
18. Ibid.
19. JCAE, “Authorizing Legislation FY 1967”, p. 1693

were high yield weapon tests that could not safely or effectively be conducted elsewhere. First, the volcanic formation allowed tests to be buried more than one mile underground, thereby reducing seismic shock and chances of radioactive ventings. Second, large yield tests typically create large subsidence craters, and Yucca Flat, already overcrowded with such craters, could not spare the room.{20} For Plowshare purposes, though, Pahute Mesa was useful in that it contained rock type expected to be found along proposed transisthmian canal routes.

The CABRIOLET experiment was thus sited a half mile east of the PALANQUIN crater on Pahute Mesa, and would again investigate cratering explosions in hard rock [Map 31]. However, due to several factors the test was delayed. There was concern by the administration over “diplomatic embarrassment” should the test violate the Limited Test Ban Treaty, a risk weighed at 50-50 by the AEC.{21} Also, referring to the Vietnam War, Secretary of Defense Cyrus Vance thought it “unwise to open another propaganda front on which the U.S. could be attacked.{22} Finally, as with all other Plowshare cratering tests (except for SEDAN which had been conducted on a “crash” basis), the test had to be conducted before cattle grazing season began in late Spring. Otherwise, there was a risk radioactive fallout from the test would contaminate milk supplies with iodine-131.{23}

The test was postponed for three years. The delay began to seriously compromise the Plowshare excavation program. John Pastore, the Chairman of the JCAE, refers to the problem in a 1967

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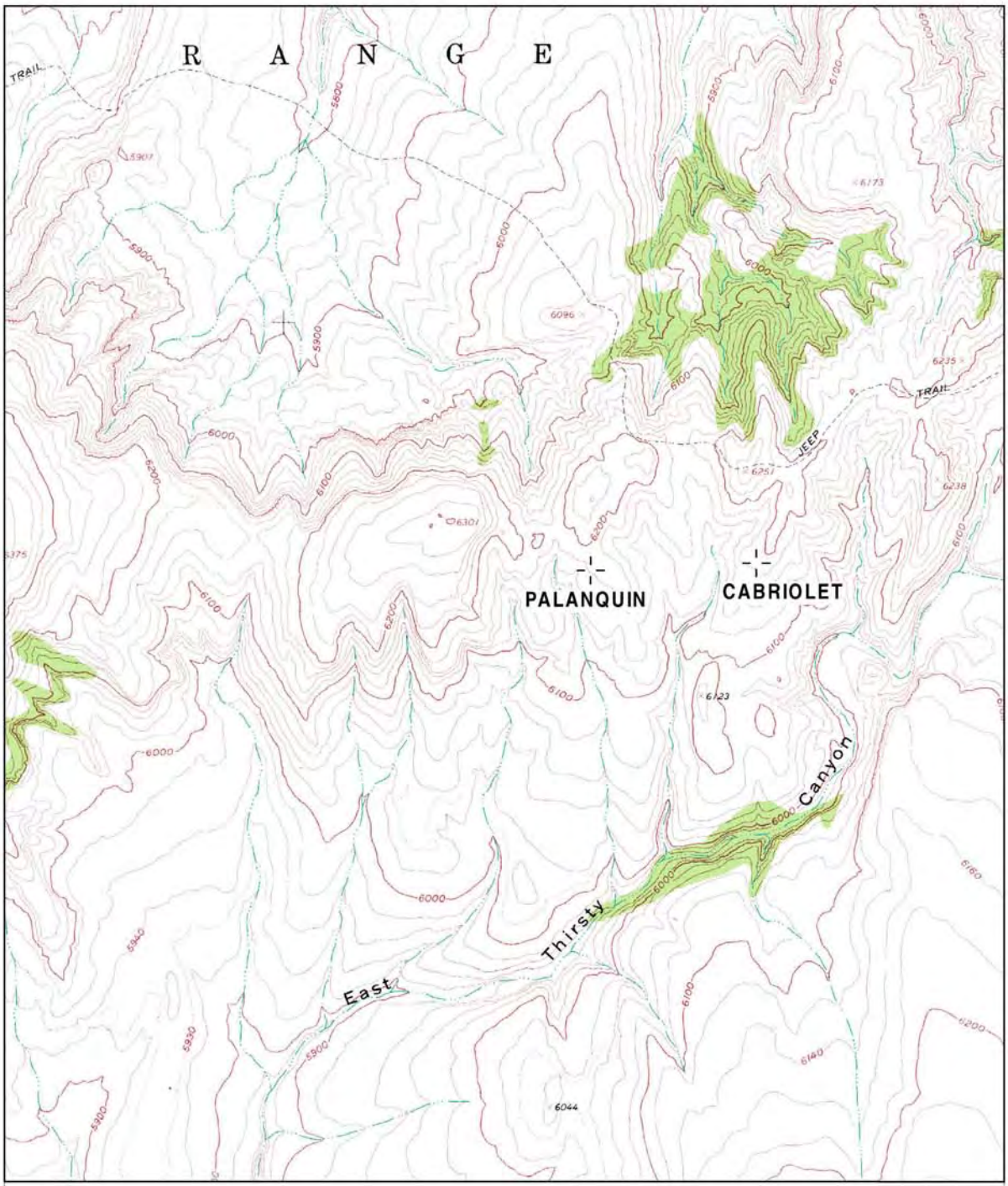
20. “Application of Geology to Underground Nuclear Testing”, in Geological Society Memoir 110, 1968, p. 30
21. Stemming The Tide, 1987, p. 336
22. Ibid., p. 328
23. Ibid., p. 330


R A N G E
TRAIL
JEEP
PALANQUIN
CABRIOLET
Thirsty
Canyon
East
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Trail Ridge Quadrangle
Map 31

letter to Glen Seaborg:

> "I understand that if CABRIOLET is not carried out in the very near future, it will not be possible to determine the technical feasibility of using nuclear explosives to excavate a sea-level canal for the Atlantic-Pacific Interoceanic Canal Study Commission to consider in its final report to the President even with the extension of its reporting date to December 1, 1970. Please advise me as to the action you are taking to resume the nuclear excavation experiment program."{24}

Pressure to test CABRIOLET eventually overcame earlier objections. Canceling the test would "mean the end of the excavation program" and further canal studies. In the words of Senator Anderson, a Plowshare supporter:

> "Panama would know there was no alternative to a... conventionally built canal in Panama and would therefore be more difficult than ever to deal with, whereas Columbia might feel we had been dealing with them in bad faith."{25}

Completing the test after such a lengthy delay required an additional $1.4 million. The original CABRIOLET "device" - buried so long it could no longer be trusted - had to be destroyed in place as removing it was too difficult. A second drillhole was dug and a second "device" fabricated and lowered into the ground.{26}

The AEC publicly announced the existence of CABRIOLET on January 25th 1968. The next day CABRIOLET was detonated, creating a crater 400 feet across and 125 feet deep. The radioactive debris cloud was tracked to Idaho and then northeast as far as Big Timber, Montana. A snowstorm in northern Nevada (termed "a stroke of-good luck!" by Seaborg) brought down much of the fallout before

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24. JCAE, "Authorizing Legislation FY 1969", p. 2023
25. Stemming the Tide, 1987, p. 337
26. JCAE, "Authorizing Legislation FY 1968", p. 1962

it could cross the Canadian border.{27}

CABRIOLET, considered a success by the AEC, led the way for the final two Plowshare nuclear excavation experiments, BUGGY and SCHOONER. BUGGY, like the high explosive tests PRE-BUGGY I & II, was a ditch digging experiment in which five 1.1 kiloton explosives were lined in a row and detonated simultaneously. The site chosen was five miles south of the SULKY experiment in rhyolite rock of the type expected to be found along the 'PANATOMIC' canal route [Map 32]. BUGGY, detonated three months after CABRIOLET, created a ditch over 800 feet long and 65 feet deep; the fallout cloud was tracked to Montana, and may have crossed the border into Canada [Figure 30].{28}

PROJECT SCHOONER

SCHOONER was to be the last Plowshare excavation experiment. As stated, the proposed 100 kiloton test had been delayed since 1963 due to concerns it would violate the Limited Test Ban Treaty. These concerns were alleviated somewhat by moving the explosion from Idaho's Bruneau Plateau to Pahute Mesa at the Nevada Test Site (a site outside of Winnemucca, Nevada was also considered) [Map 33]. Both areas were comprised of hard volcanic rock, suitable for the 'PANATOMIC' canal study, but the Pahute Mesa site was 300 miles farther south of the Canadian border. A memo from the SCHOONER site selection committee reveals another concern about the experiment as well as the condescending tone taken by the AEC towards those downwind of the blast:

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27. Stemming The Tide, 1987, p. 339
28. "Radiological Effluents", 1990, p. 102

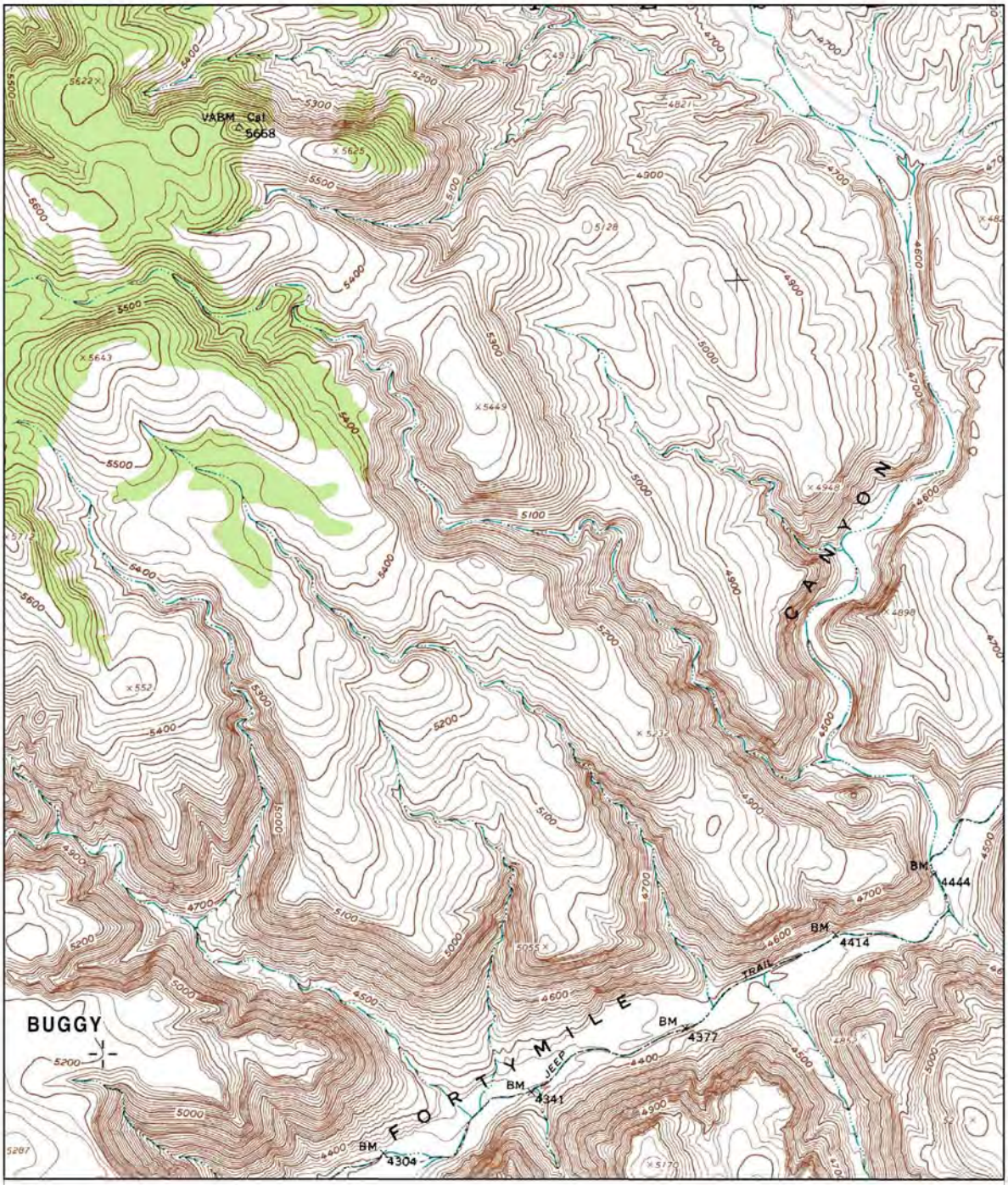
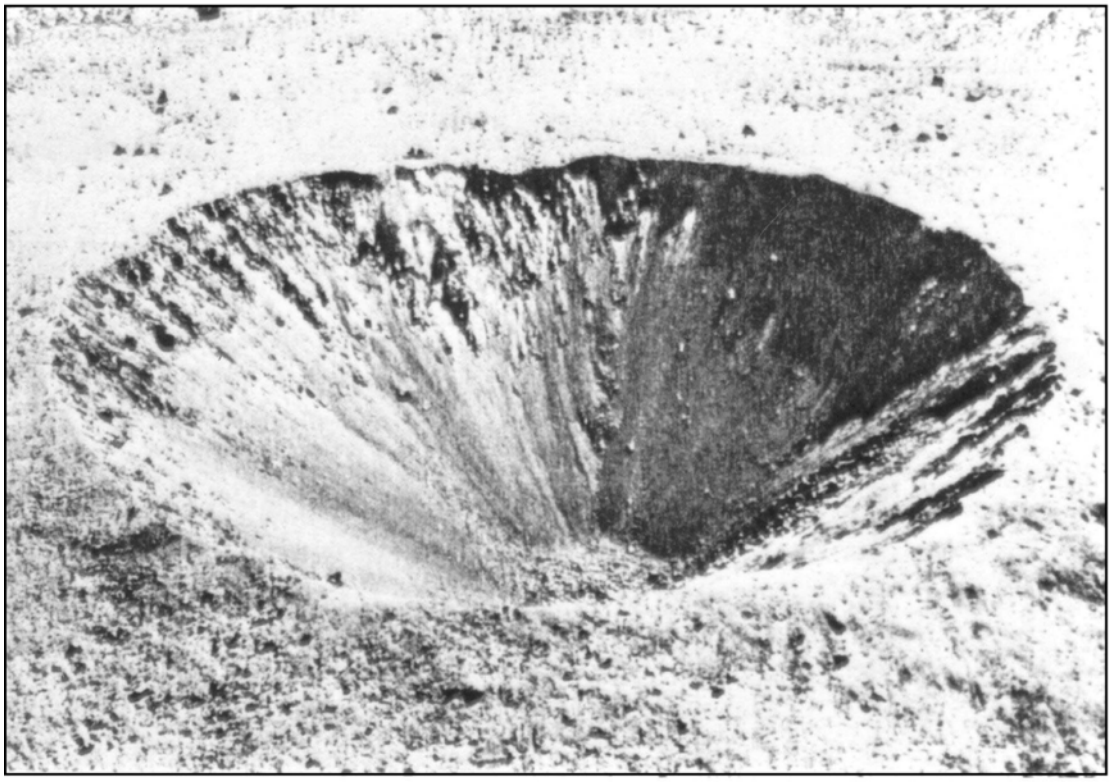
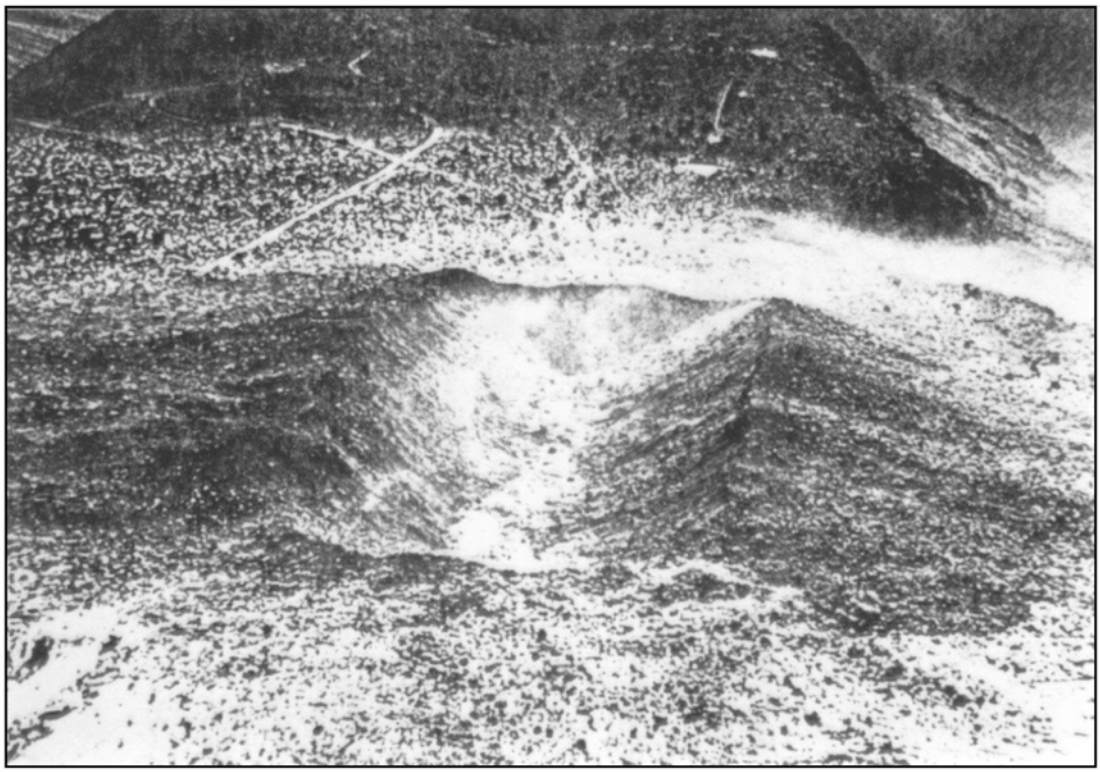

VABM
Cal
5668
BUGGY
FORTYMILE
CANYON
JEEP
TRAIL
BM
4444
BM
4414
BM
4377
BM
4341
BM
4304
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Buckboard Mesa Quadrangle
Map 32

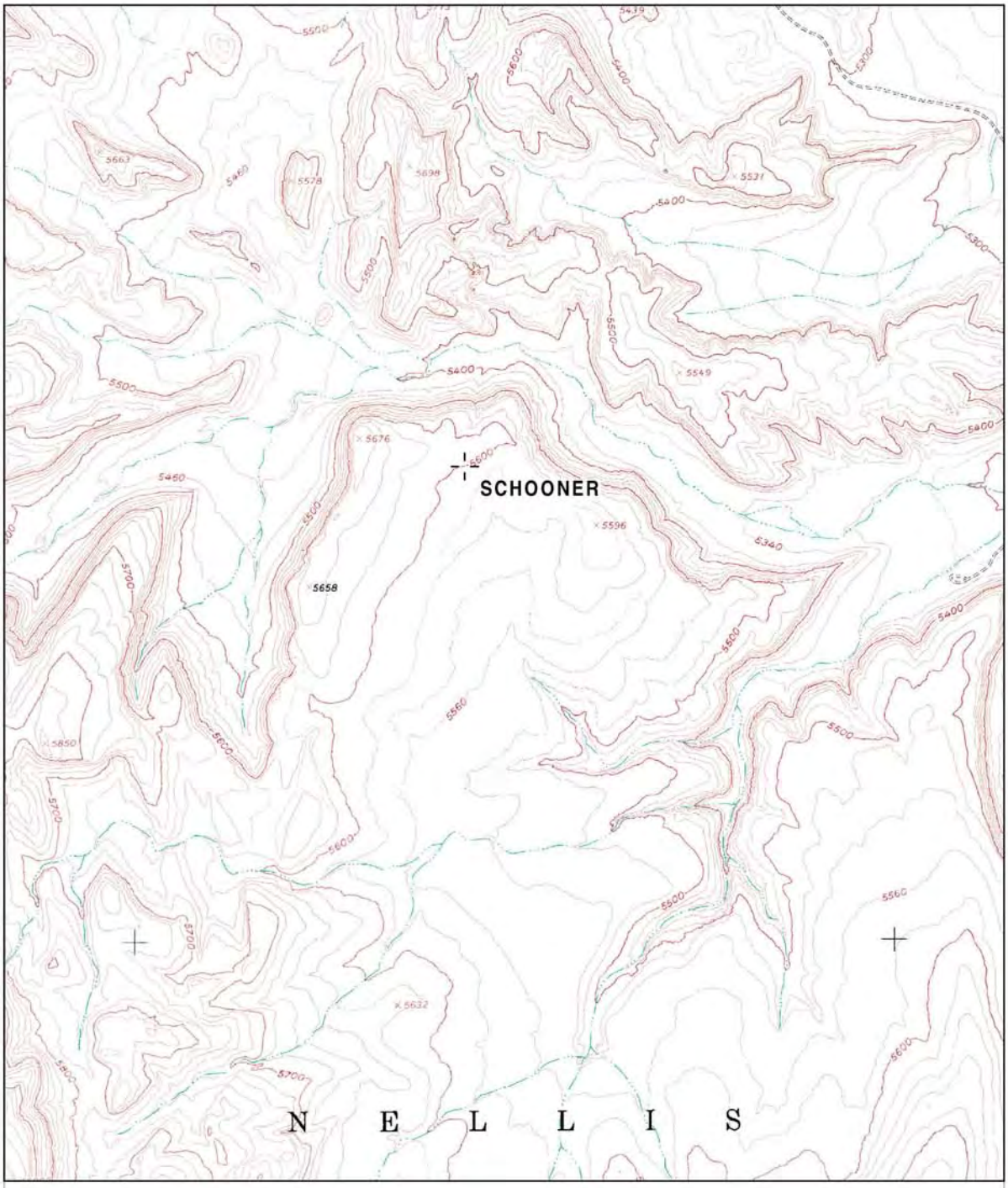
Figure 30



CABRIOLET crater. LLNL photo.



BUGGY crater. LLNL photo.


SCHOONER
N E L L I S
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Trail Ridge Quadrangle
Map 33

> "The committee recognized a potential problem in that it may be necessary to evacuate people and cattle in the downwind sector [of SCHOONER]... However... it was generally felt that the potential involvements with public and cattle are not insurmountable."{29}

As a final safeguard, SCHOONER's explosive power was scaled back to 35 kilotons and used the relatively "clean device" developed in the STODDARD "device development" test.{30} Ten months after BUGGY, SCHOONER was detonated in the northern reaches of Pahute Mesa, four miles from the CABRIOLET and PALANQUIN craters.

Despite these precautions, SCHOONER created an immense fallout cloud [Figure 31]. The upper portion of the "1,000 foot thick cloud" reached Milford, Utah five hours after the explosion and continued to drift eastward over Colorado and the central plains.{31} The base of the cloud traveled north to Idaho, Montana and North Dakota, eventually being detected five days later by Canadian monitors in Toronto, Ottawa and Montreal.{32}

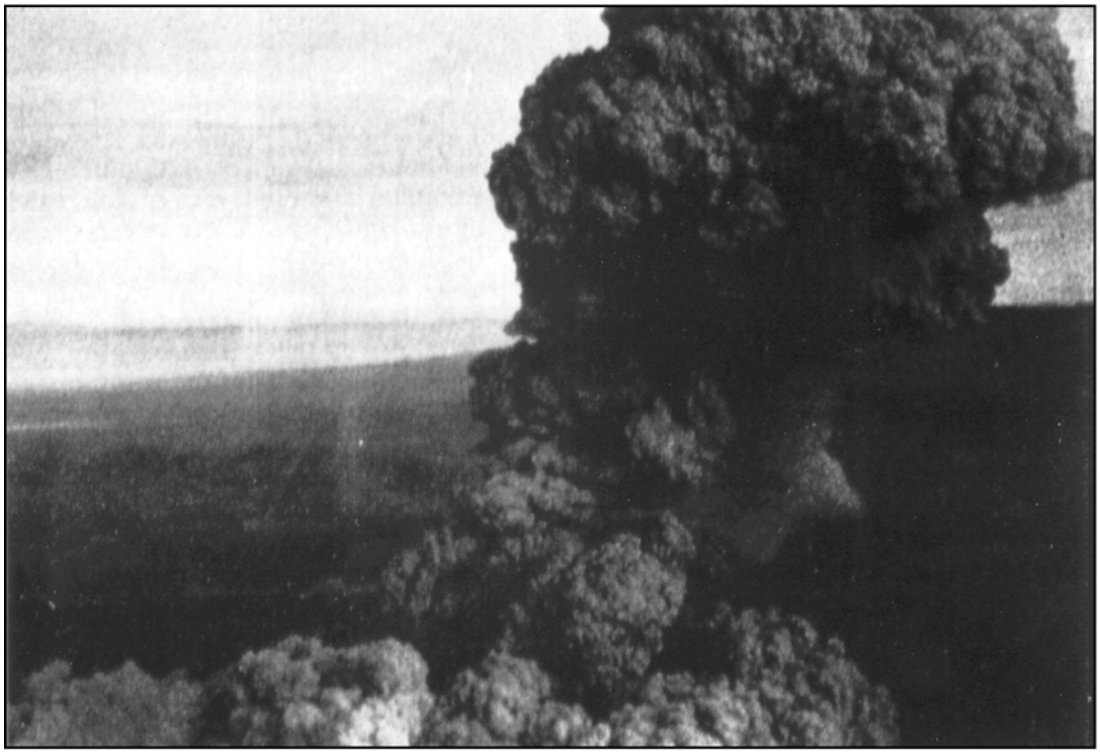
The crater created by SCHOONER is commensurate with its fallout cloud. The blast displaced nearly eight million cubic feet of earth and rock. The crater itself measures 200 feet deep by 725 feet in diameter, second in size only to the SEDAN crater created six years earlier.{33} Ejecta, or rock fragments thrown out by the blast, were as large as nineteen feet across and found as far as one and one-quarter mile from ground zero. A USGS report states:

> "Thick continuous eject deposits extend from the rim outward in lobes to distances of [l,700 feet] from the crater center. Beyond the lobes of continuous ejecta, scattered angular blocks and fragments of ash-flow tuff are strewn across the surface, and secondary craters produced by the impact of the debris abound."{34}

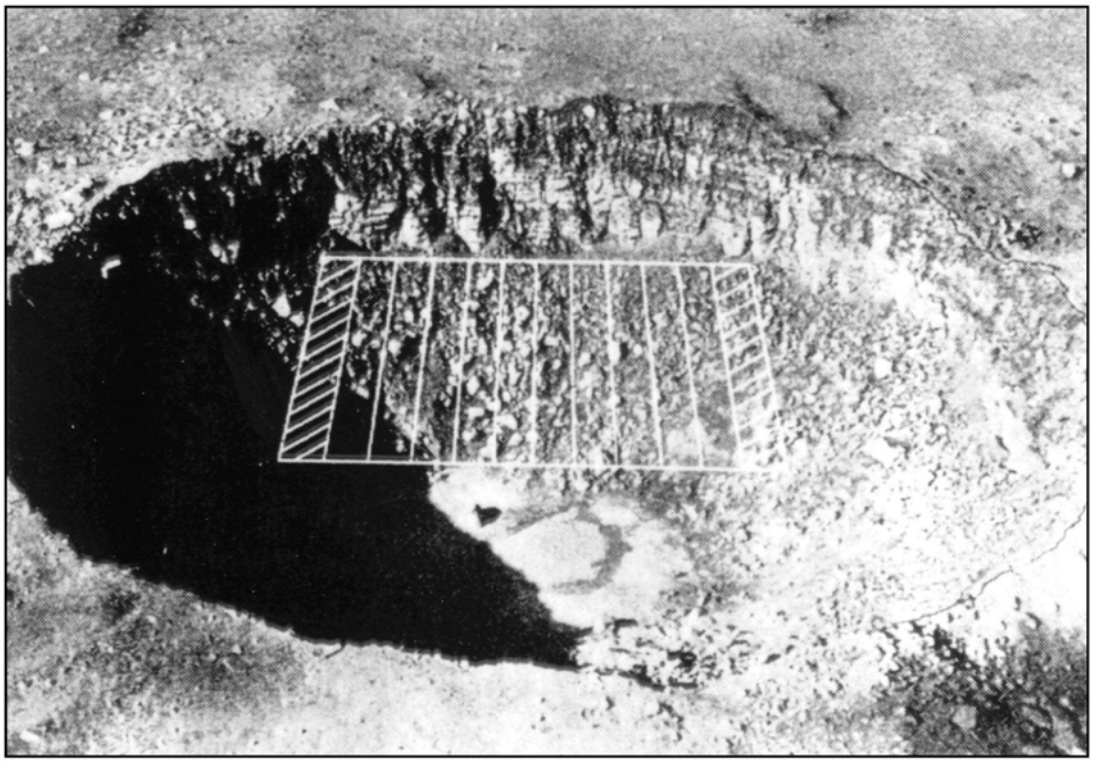
---

29. "SCHOONER Site Selection", 7/26/63, p. 3, CIC #38414
30. JCAE, "Authorizing Legislation FY 1970", p. 330
31. "Nuclear Cover Up", *Utah Holiday*, 02/82, p. 40
32. "Radiological Effluents", 1990, p. 109
33. AEC, "Annual Report to Congress - 1969", p. 201 (A football field is superimposed on a photograph of the SCHOONER crater for scale).
34. "Nevada Test Site Used for Astronaut Training", H Moore, *Journal of Research*, U. S. Geological Survey, vol. 5, #6, 12/77, p. 719

Figure 31



SCHOONER fallout cloud seven and one half minutes after detonation. LLNL photo.



SCHOONER crater with superimposed football field. LLNL photo.

The secondary craters, the glass-coated rocks fused by the heat of the nuclear explosion, and the rock blocks and fragments which smothered nearby vegetation conspire to create a moonscape appearance near the blast. Due to these “features common on the Moon”, astronauts for Apollo 14, 16, and 17 used the SCHOONER crater and vicinity for training exercises.{35} Buckboard Mesa, with its own extensive network of craters, was also used by the Apollo 17 lunar module for a lunar “test run”. The module visited SULKY - “an unusual landform” - as well as several craters produced by high explosives [among them: LITTLE & BABY DAN, DUGOUT, PARKER’S PUKA, and BIG, LITTLE & BABY JOHN] [Map 26].{36} Apollo 17 astronauts utilized their training at the Nevada Teat Site while on the Moon. Astronaut H. Schmidt describes a lunar crater west of Sulpicius Gallus using a crater on Buckboard Mesa for comparison:

> “... looks similar to - Yes, it’s about a 600 meter crater. And it looks very much like... that crater out in the Nevada Test Site.”{37}

The subjective view of the Nevada Test Site by the AEC as a “barren desert land” and a “genuine wasteland” had moved towards an objective reality.{38} Radioactive contamination, barren ejecta flows, excavation craters, secondary craters and subsidence sinks created by Plowshare and weapons related experiments had made comparisons to the Moon not only credible, but, in the case of Apollo missions, scientifically useful.

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35. Ibid., pp. 719-733
36. Ibid., p. 728
37. Ibid., p. 732
38. “Armed Forces Talk”, 09/19/52; quoted in Atomic Soldiers, 1980, p. 17

PROPOSED CANAL EXCAVATION TESTS

To accommodate the AEC, the Canal Study Commission (CSC) had twice extended its report to the Congress on the feasibility of a nuclear excavated canal. The original deadline of June 1968, discussed below, was eventually extended to December, 1970.

> "Representative Hosmer: You simply cannot get them [canal data] in those four shots, can you?
>
> Mr. Kelly: No, we cannot get all of it.
>
> Representative Hosmer: If you are going to meet your Canal Commission schedule, it looks like you are going to have to load an awful lot of things in the 1967-68 period.
>
> Mr. Kelly: The schedule is very, very tight."{39}

The schedule remained very tight even with the new deadline. The AEC needed five more experiments to convince the CSC as to the viability of a 'PANATOMIC' canal. These tests were YAWL, STURTEVANT, PHAETON, GALLEY, FLIVVER, GONDOLA, and BUGGY II [Map 34].{40}

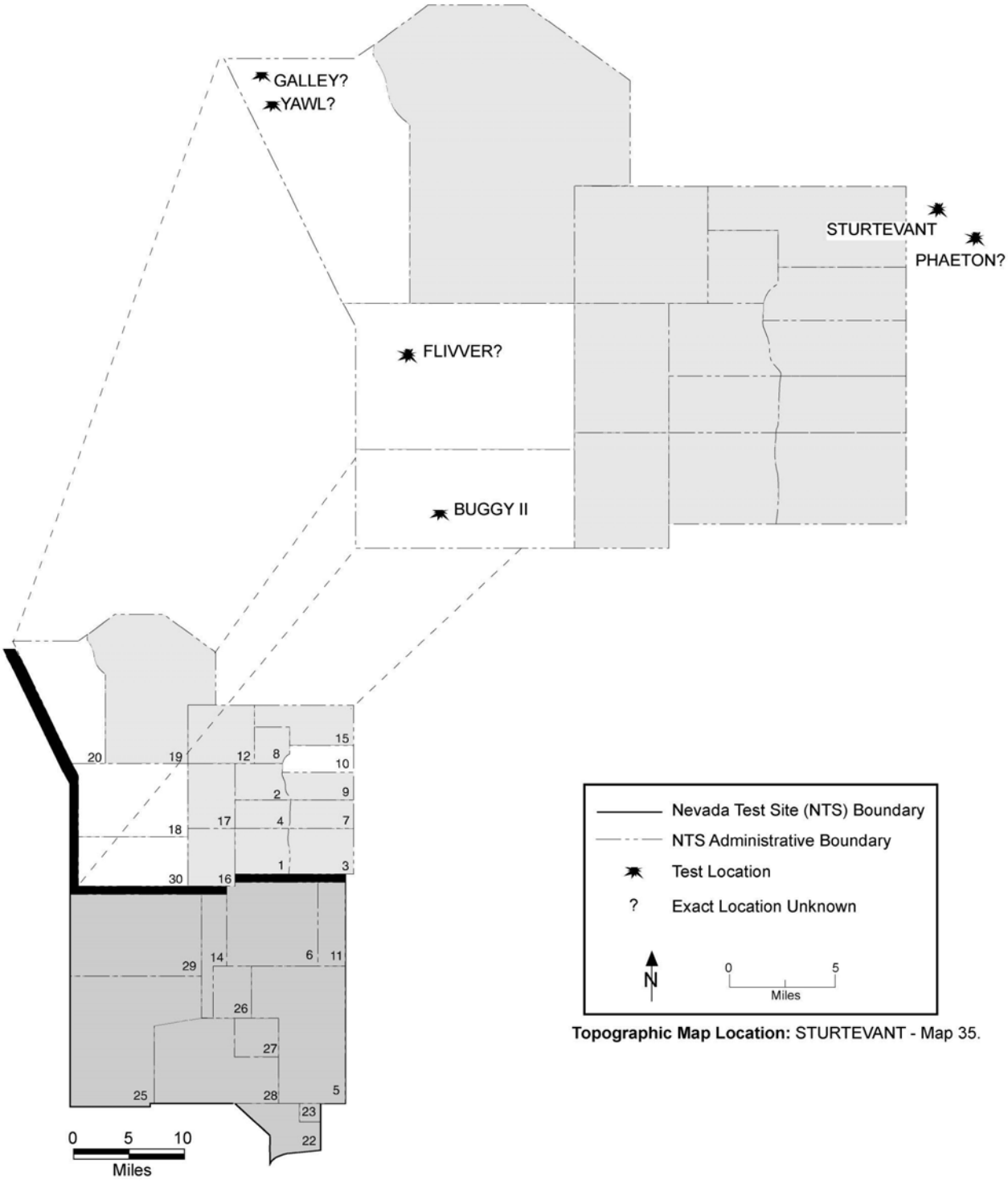
YAWL was a follow up test to SCHOONER at a much higher yield - hundreds of kilotons as opposed to SCHOONER's 35 kilotons. It would test cratering theory in hard, wet rock.{41} STURTEVANT was the "device development" experiment that would test the "device" used for YAWL.{42} However, due to budget and time constraints, it was decided to bury STURTEVANT a little less deeply and make it both a "device development" test and a YAWL - type excavation experiment. Because "dense, saturated rock" is not available inside the boundaries of the Nevada Test Site, a drillhole for the 170 kiloton explosive was dug just outside the

---

39. JCAE, "Authorizing Legislation FY 1967", p. 1364
40. JCAE, "Authorizing Legislation FY 1970", p. 304
41. Ibid., p. 329
42. JCAE, "Authorizing Legislation FY 1971", p. 969

Map 34

Proposed Plowshare Excavation Tests
Nevada Test Site



Topographic Map Location: STURTEVANT - Map 35.

Source: JCAE "Authorizing Legislation FY 1970", pp. 304-336.

test site, within the boundaries of Nellis Air Force Range [Map 35].{43}

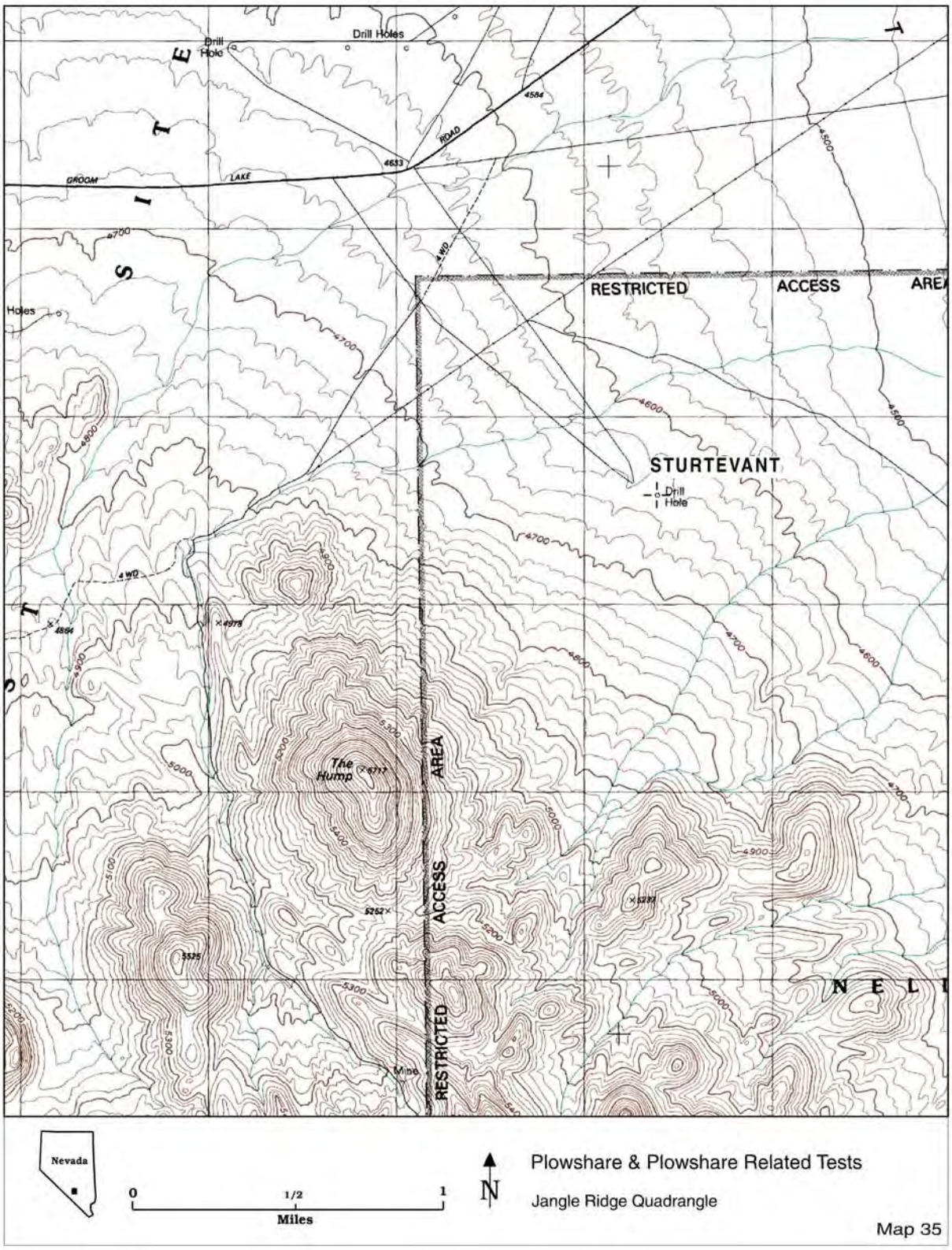
Plans were made to evacuate, temporarily house and reimburse for lost time those living downwind of STURTEVANT. Other costs factored into the explosion included replacing “grade-A dairy losses,” manning roadblocks, and finding and alerting sheepherders and hunters of the blast.{44} Nearly twice as big as SEDAN, STURTEVANT was expected to create considerable fallout. Ironically, Richard Peterson, chief of the AEC’s nuclear weapons research and development branch, was critical of the possible impacts of STURTEVANT:

> “I... see the STURTEVANT experiment as having, quite possibly, a very adverse effect on the AEC Weapons Development Test Program. I think that there is a substantial risk that STURTEVANT would... cause some appreciable damage, or at least give the impression to the public that the AEC was once again being careless with the public health and the quality of the environment. This could be the last straw as far as public tolerance of nuclear testing is concerned... Lest this be thought a case of the ‘pot calling the kettle black’, my point is not that STURTEVANT or other (even larger) Plowshare cratering events shouldn’t be done. It is that a careful weighing of benefits vs risks is in order... I wonder whether continued large scale experimenting with nuclear excavation techniques in hopes of some future cost - savings or other gains is advisable.”{45}

Because of budget constraints and concern that the blasts would violate the Limited Test Ban Treaty, STURTEVANT and YAWL were cancelled. PHAETON, contingent on the results of these tests, was likewise scrapped.{46} It was to have been a one megaton cratering explosion in rock similar to that found in the “higher elevations of a sea-level transisthmian canal... where the potential

---

43. “STURTEVANT Radiological Plan Proposed Locations”, CIC#134570
44. “Anticipated Unusual Problems - Project STURTEVANT”, 09/29/69, pp. 1-4, CIC#16629
45. “Safety of Plowshare STURTEVANT Event”, 11/16/69, CIC #30231, declassified with deletions
46. For a discussion of “event” priorities see JCAE, “Authorizing Legislation FY 1970”, p. 310 & p. 336


Drill Holes
Drill Hole
4584
ROAD
4633
GROOM
LAKE
RESTRICTED ACCESS
Holes
STURTEVANT
Drill Hole
4WD
The Hump
AREA
ACCESS
RESTRICTED
Mine
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Jangle Ridge Quadrangle
Map 35

advantages of nuclear excavation over conventional excavation are the greatest."{47} On December 1, 1970, the Canal Study Commission, not to be delayed any longer, issued its final report. It begins with a cover letter to President Nixon:

> "We have the honor to submit herewith the final report of the Atlantic-Pacific Interoceanic Canal Study Commission as required by Public Law 88-609... One provision of the law required us to determine the practicability of nuclear canal excavation. Unfortunately, neither the technical feasibility nor the international acceptability of such an application of nuclear excavation technology has been established at this date... Although we are confident that someday nuclear explosions will be used in a wide variety of massive earth-moving projects, no current decision on United States canal policy should be made in the expectation that nuclear excavation technology will be available for canal construction."{48}

The remaining tests, and the Plowshare excavation program as a whole, became moot at this point. Descriptions of the cancelled tests are nonetheless interesting. GALLEY, a follow up to BUGGY, was planned as a row charge experiment in uneven terrain using explosives in the 100's of kilotons as opposed to BUGGY's 1.1 kiloton charges. This ditch was planned to "possibly connect to a crater from the SCHOONER or YAWL" explosions and facilitate planning for the CARRYALL project (discussed below).{49} BUGGY II was also a row charge experiment to connect one nuclear excavated ditch [BUGGY] to another.{50} FLIVVER was planned as a low yield cratering test, perhaps similar to SULKY.{51} Finally, GONDOLA, as previously mentioned, was to be a 200 kiloton explosion in weak, wet rock, similar to that found in the low lying areas of Panama. The primary site investigated for GONDOLA was along the shores of Fort Peck Reservoir, Montana [Map 17].

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47. JCAE, "Authorizing Legislation FY 1970", p. 330
48. Final Report, APICSC, 12/01/70, p. 1
49. JCAE, "Authorizing Legislation FY 1970", p. 330
50. JCAE, "Authorizing Legislation FY 1968" p. 1958
51. Ibid.

OTHER PROPOSED EXCAVATION TESTS

While the ‘PANATOMIC’ canal proposal had been the driving force behind the Plowshare excavation program, other nuclear excavation projects had been studied during the course of the canal studies [Map 36]. Many of these projects never went beyond an initial write-up and likely received minimal funding and consideration. These include STREETCAR, an experiment to test cratering theory in limestone, “a new and substantially different medium from those in which prior detonations have been conducted”, and DOGSLED, a 100 kiloton cratering experiment in the sandstone of Arizona or Utah to improve the “meager” cratering data in “one of the most common rock types occurring in nature.”{52}{53} OXCART and WAGON were two tests planned as precursors to a larger cratering experiment, Project CHARIOT (to be discussed below). Both OXCART and WAGON were to take place at the Nevada Test Site.{54} All of these experiments were delayed and finally cancelled in deference to tests with more direct applications to the ‘PANATOMIC’ canal.

Information concerning other proposals is more extensive and provides clues concerning environmental perceptions and impacts. For example, Project WAYOUT was a 1968 proposal to build a new Suez canal using several 700 kiloton explosives. Fallout was discounted in the study as “no population agglomerations of any consequence [are] located east (downwind) of the proposed canal”.{55} This description is reminiscent of AEC literature

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52. “new and different”, AEC Commission Meeting #1872, 11/09/62, p. 18, declassified with deletions 05/27/81
53. “common rock”, memo, “R. Miller - Project DOGSLED”, 04/30/63, p. 2, CIC#18528, declassified 09/03/81
54. For WAGON see memo, “J. Reeves - Planning Directive - Project WAGON”, 01/31/61, CIC#64256, declassified 07/20/81. For OXCART see “Public Safety Plan - Project OXCART”, 08/59, CIC#77657, declassified 10/22/63
55. “Project WAYOUT: A Proposal for an Early Execution of the Plan to Excavate a New Suez Canal”, A. Keller, 06/68, KK-6805/6703

Excavation Tests

Proposed

Source: See footnotes pp. 52-54 & 57.

Map 36

describing the area downwind the Nevada Test Site as “virtually uninhabited”, leading to the sardonic description of residents in the fallout area of NTS as “virtual inhabitants.”{56}

Also of interest is a 1962 proposal in “landforming”, articulated in the “Journal of the American Institute of Architects”. The paper proposed using nuclear explosives to dig a huge basin in what is now the Golden Gate National Recreation Area of Marin county. The author states:

> “This bare hilly land, fifteen minutes from San Francisco, is still in the hands of the military, largely because the wind howling up its valleys from the Pacific, and a thick summer blanket of fog, render it almost uninhabitable.”{57}

This nearly “uninhabitable” land could become more like the ‘banana belt’ region of Sausalito, the author states, if fog were blocked with a man-made mountain. The resulting crater would be ringed by a freeway serving the 400,000 inhabitants at the crater’s bottom. The constrictions of the crater would help increase residents “sense of community.”{58} Following this paper, the author was granted a Fellowship from the American Institute of Architects to pursue further “land-forming” studies while travelling in Europe. Reaction to the article was mixed. Charles Moore, Chairman of the Department of Architecture at UC Berkeley mailed a supportive one sentence letter to the Journal: “If man doesn’t move mountains, who will?”{59} Others felt the proposal was “horrifying” and “arrogant”.{60}

The KRA CANAL project, sponsored by Livermore Labs, and made noteworthy by the late date in which it was proposed. A

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56. *Testing News*, Downwinders newsletter, 09/88
57. “Man’s Use of Landform”, *Journal of the American Institute of Architects*, December 1962, p. 31
58. Ibid.
59. *American Institute of Architects*, January 1963, p. 10
60. Ibid.

preliminary survey of the project was initiated in 1973, three years after the ‘PANATOMIC’ canal was scuttled and five years after SCHOONER, the last Plowshare excavation test. Undeterred by the cancelled ‘PANATOMIC’ canal, the Lab concluded that a nuclear excavated canal could be constructed through the isthmus of Kra in Malaysia with “no technical, safety, or operational” difficulties [Map 37].{61} The project would require the evacuation of 200,000 people and the detonation of 139 bombs totaling forty-one megatons.{62} This project may have been proposed because, according to the AEC, the isthmus of Kra is one of only two sites in the world [the other being the isthmus of Panama] for which a sea-level canal fulfills “the criteria of remoteness and practical value.”{63} “Practical value” seems to refer to the fact the narrow isthmus could be breached by nuclear explosives and hence serve as a demonstration project; not that the canal was of economic value to the region.

Project CARRYALL was a 1963 proposal by Livermore Labs to blast a railroad and highway thoroughfare through the Bristol Mountains in the Mojave desert of California [Map 38][Figure 32].{64} The rational for this project, which required twenty-two explosions totaling nearly two megatons, as well as a 100 kiloton blast to create a drainage crater”, was identical to that used for the ‘PANATOMIC’ canal: a more direct transportation route would save time and money.{65} Did economic considerations justify this proposal, or was the Mojave being used as a testing ground?

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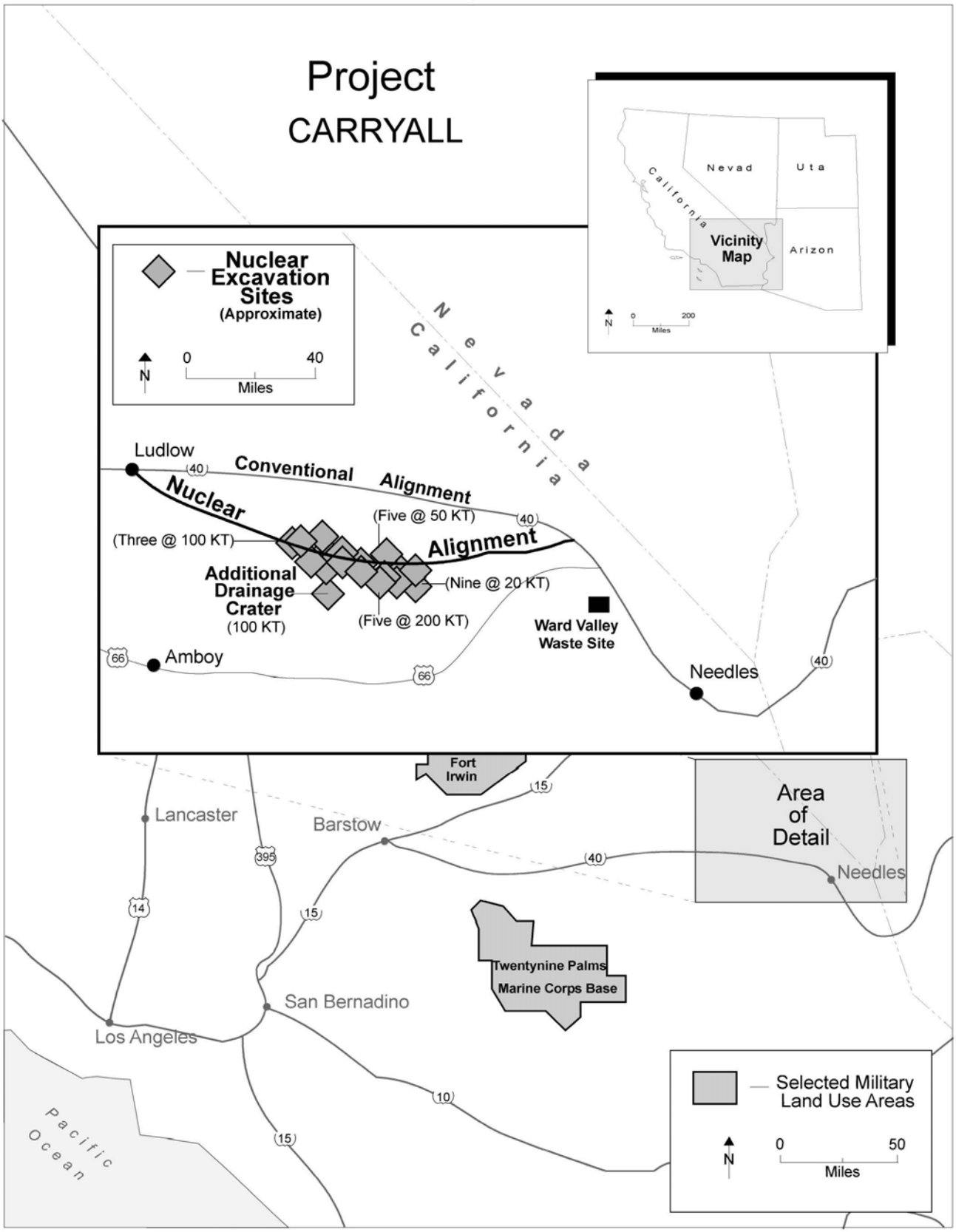
61. “KRA Canal Project: A Preliminary Assessment of Nuclear Excavation Feasibility for Route 5A”, LLL, April 1973, p. 1
62. Ibid., p. 7
63. Nuclear Dynamite, 1990, p. 175
64. JCAE, “Authorizing Legislation FY 1965”, pp. 1614-1618
65. “Application of a Nuclear Explosive for a Mountain Pass Highway and Railroad”, CA State Division of Highways, 11/63, p. 310

Map 37

Source: "KRA Canal Project", LLL, April 1973.

Map 38



Source: "Project CARRYALL", TECP-6816, UCRL, 12/63.

Figure 32

CARRYALL mock-up. Proposed 100 kiloton “drainage” crater is to right of road cut. LLNL photo.

Most indications point to the latter; CARRYALL appears to be a high risk experiment that required a remote area in case of miscalculation. First, the proposed nuclear route was fifteen miles shorter than Highway 66, which it was intended to replace, but only five miles shorter than what was to become Interstate 40. It is unlikely a five mile shortcut justified twenty-two nuclear detonations. Second, the site chosen is sparsely populated, ensuring minimal local opposition to the plan as well as a fallout buffer zone. Indeed, CARRYALL is only forty miles east along the Interstate from the proposed Ward Valley low-level radioactive waste dump, another project predicated on minimal local opposition.{66} Finally, in case the 'PANATOMIC' canal proved infeasible, other projects, useful or not, were needed to keep Plowshare excavation funding alive. Glenn Seaborg's response to Chairman Pastore of the JCAE makes this point:

> "Chairman Pastore: Would we have wasted a lot of money, then [if the canal is dropped]! Wouldn't we have wasted a lot of money in these experiments that we are not going to end up using?
>
> Dr. Seaborg: No, sir. Which experiments?
>
> Chairman Pastore: Cratering.
>
> Dr. Seaborg: No, no, no. Because there are so many other applications where... nuclear excavation technology might be useful.
>
> Chairman Pastore: Like what, for instance, aside from building a canal?
>
> Representative Hosmer: Highway 66...
>
> Chairman Pastore: Is that a television program?
>
> Dr. Seaborg: That is 'Route 66.'"{67}

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66. See, for example, "Last Stand for the Nuclear Industry?", *Green Consensus*, August, 1991, p. 1
67. JCAE, "Peaceful Applications of Nuclear Explosives", 1965, p. 24

The AEC termed CARRYALL “technically feasible” and safe “owing to its remote location,” despite an expected fallout cloud 12,000 feet high, seven miles in diameter and dense enough to obscure vision and present a traffic hazard within 100 miles of ground zero.{68}{69} Dispute as to the safety of the blast eventually led to its cancellation. One of the most vocal opponents of the experiment, Professor C.D. Calsoyas, resigned his post at Livermore Labs due to concern over CARRYALL. In a letter to the director of the Lab he writes:

> “Dr. [deleted], Head of the theoretical division of [LRL]... made several coercive remarks to me. In particular, Dr. [deleted] warned me against making any public statements concerning the low-level radiation hazards of the Carry-All nuclear blast and the Plowshare program in general before submitting my resignation... I... once again request you to publish the documentation that led you to approve the readying of the Carry-All nuclear blast.”{70}

In a separate letter to the AEC Commissioners, Professor Calsoyas states that a “basic part of the mission of the Division of Biology and Medicine of the Lawrence Radiation Laboratory is to provide estimates of the number of casualties that the population will sustain from low-level radiation effects of Plowshare nuclear blasts.”{71} The author concludes that the “Carry-All blast was known to be hazardous” by the Lab.{72} Side-stepping this issue, the Lab claimed CARRYALL was cancelled “because it ran afoul of the time schedule for completion of the Interstate Highway system.”{73}

Livermore Labs also proposed creating a harbor off the

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68. JCAE, “Authorizing Legislation FY 1965”, p. 1614 & p. 1618
69. Fallout cloud description - “Project CARRYALL”, TECP-6816, 12/63, p. 57
70. Letter, C. Calsoyas to D. McMillan, 04/08/67, CIC#75775
71. Letter, C. Calsoyas to AEC Commissioners, 05/10/67, CIC#75783, p. 1
72. Ibid., p. 4
73. The Nuclear Oracles, p. 204

coast of western Australia using five 200 kiloton nuclear explosives.{74} The site chosen was described as an “ideal location for a nuclear excavation experiment... isolated and barren, with little ecological value” and a “poorly indented coastline.”{75}{76} The area also had a previous history with nuclear experiments: three atmospheric nuclear tests were conducted by the United Kingdom on nearby Monte Bello islands, 150 miles to the west of Cape Keraudren, during the 1950’s [Map 39]. These experiments account for at least one resident’s blase attitude towards the proposed nuclear harbor:

> “It’s just another big bang. We had one [sic] in the Monte Bellos off the coast a few years ago, you know, when they tested the atomic bomb.”{77}

In any case, the Cape Keraudren Project, as it was known, was scheduled to take place in March of 1970. Australian officials toured the SEDAN, CABRIOLET and BUGGY craters at the Nevada Test Site to get a preview of what was in store. The officials and Australian press were favorably impressed, expressing “honour and excitement” at being chosen to host the “dummy run” for the ‘PANATOMIC’ canal.{78} However, due to several factors -restraints of the Limited Test Ban Treaty, poor economics, and concerns by many Australians that they would be Plowshare ‘guinea pigs’ - the project was cancelled. Other Plowshare projects would be proposed for Australia; projects, for example, to reroute rivers in eastern Australia where “too much

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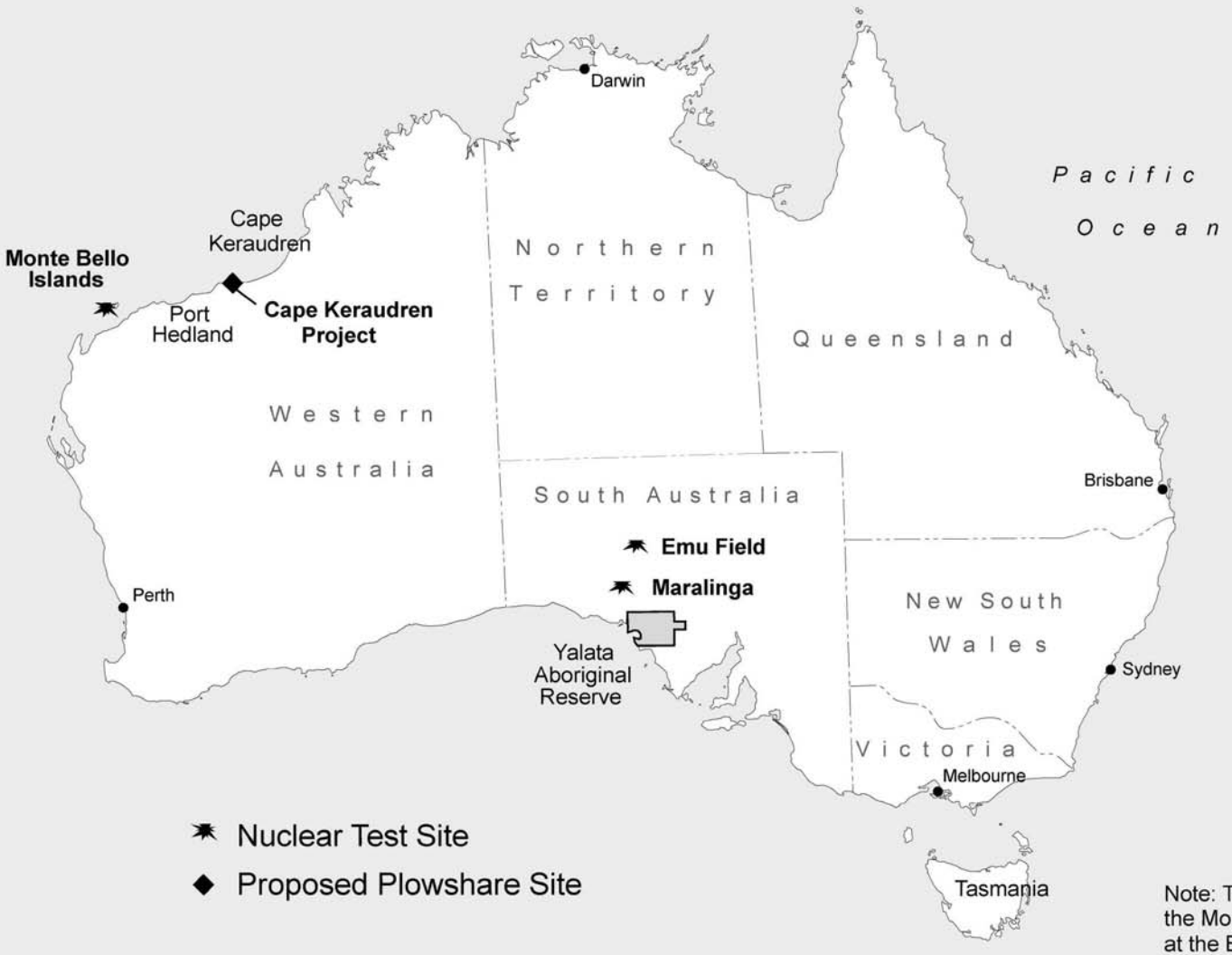
74. The Parted Veil, 1976, p. 197
75. Ibid.
76. Nuclear Dynamite, 1990, p. 142
77. Ibid., p. 149
78. Ibid., p. 149

Nuclear Test Sites
Australia



Note: There were three nuclear tests at the Monte Bello Islands site, two tests at the Emu Field site, and seven tests at the Maralinga site.

Source: Findlay, T., Nuclear Dynamite, 1990, pp. 141-163.

Map 39

water runs the wrong way."{79} But the reaction of many Australians to these proposals is summed up by Senator Cant of Western Australia:

> "Remember that this area is 7,000 miles from the coast of America... Their people will not be affected. This would be a good experiment to enable them to find out whether or not there is any contamination because it would be 7,000 miles away from their homes."{80}

PROJECT CHARIOT

Another harbor excavation project was also considered in depth by Livermore Labs - Project CHARIOT. CHARIOT was one of the first Plowshare projects discussed by the AEC. The 1958 proposal called for exploding six bombs totaling 2.4 megatons along the northwestern coast of Alaska [Map 40]. Edward Teller, then director of Livermore Labs and a staunch Plowshare supporter, encouraged Alaskans to support this "geographic engineering" project which would "reshape the earth to your pleasure."{81}

Why Alaska? Teller explains: "We looked at the whole world - almost the whole world - and tried to pick a spot where we could most effectively demonstrate the peaceful uses of [atomic] energy."{82} "Alaska was chosen", Teller continues, "because you have the fewest people and you have the most reasonable people."{83} At another point, Teller states: "anything new that is big needs big people in order to get going... and big people are found in big states."{84} More convincingly, Alaska was remote. In

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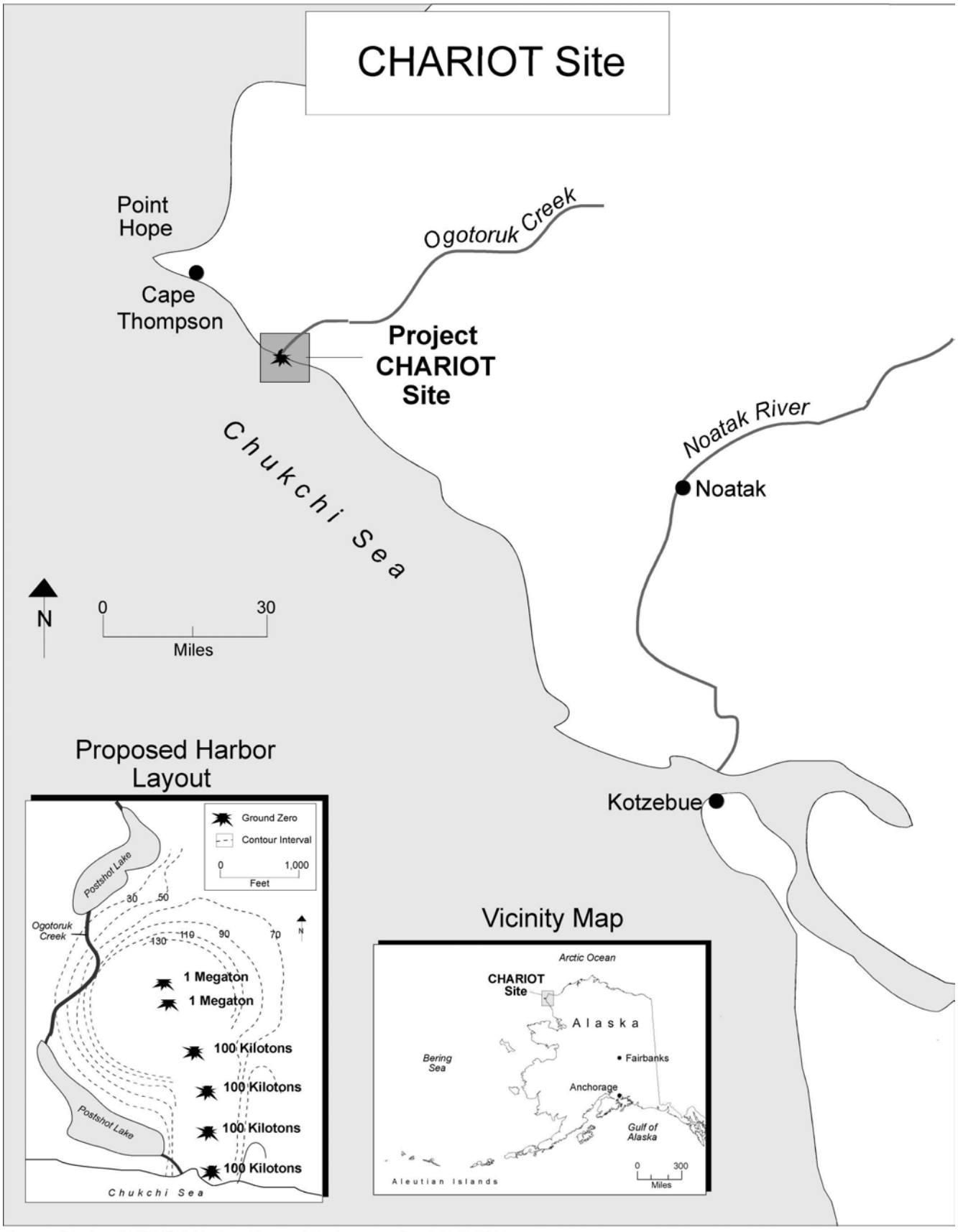
79. Ibid., p. 159
80. Ibid. p. 158
81. "Project CHARIOT: Alaskan Roots of Environmentalism" P. Coates, *Alaska History*, vol. 4, #2, Fall 1989, p. 10
82. "AEC Plans for Harbor Discussed", Fairbanks *Daily News-Miner*, 07/15/58
83. "Physicists Here For Discussion", Fairbanks *Daily News-Miner*, 07/16/58
84. "Project CHARIOT: Alaskan Roots of Environmentalism", p. 10

Map 40



Source: "Project CHARIOT: Alaskan Roots of Environmentalism", Fall, 1989.

1959 the Committee for the Study of Atomic Testing in Alaska asked the AEC why the state was chosen for CHARIOT. Alaska, the committee was told, was chosen over Texas and California (the other sites suggested) because of its “technical suitability... sufficient isolation... and [uncertainties of] excavation work near population centers.”{85} To sum up: “the remoteness of the country makes it ideal for the experiment.”{86} Statements from the Anchorage *Times* and the Fairbanks *Daily News-Miner* support this perception; the papers describe the CHARIOT site as “one of the three least known sections of the world”, “a little known dot on the earth’s surface”, “a bleak spot” and “a wilderness with no trees, no nothing! Nobody would want to live there.”{87}{88}{89}{90}

These descriptions of the site ignore the presence of Inupiat Eskimos in the Cape Thompson region. Other reports occasionally acknowledge the Eskimos’ existence but in an offhand or belittling way: “As for humans, there are no permanent residents between Pt. Hope to the north and Kivalina to the south. Only a few natives pass by.”{91} The Fairbanks *Daily News-Miner*, notes that Eskimos in the “bleak northwest coast... [are] under observation” by the AEC:{92}

> “If an Eskimo takes a notion to go hunting, the investigators note and record where he went, what he bagged and when he returned. If a whale shows up, its... movements are made a matter of record. The same goes for caribou that may wander in from the hills... or fish that may struggle in and out of the dismal little creek mouth.”{93}

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85. Ibid., p. 9
86. “May Create New Harbor On Arctic Coast” Fairbanks *Daily News Miner*, 08/30/59
87. Ibid.
88. Ibid.
89. “Project CHARIOT: How Alaska Escaped Nuclear Excavation” D. O’Neill in *B.A.S.*, December 1989, p. 33
90. Ibid.
91. Fairbanks *Daily News-Miner*, 08/20/59
92. “Cape Thompson Blast Preparations Entail Census of Wilderness Area”, Fairbanks *Daily News-Miner*, 12/05/60
93. Ibid.

In fact, what the Inupiat Eskimos “bagged” was important. The Inupiat often eat caribou which, in turn, graze on lichen. Lichen - which lack roots - rely on particles in the air for food. Thus, of all plants, lichen absorb a disproportionate amount of radioactive fallout. In turn, caribou feeding on lichen were found to have seven times as much strontium 90, a radioactive isotope, in their flesh as other grazers (cattle) in the continental United States.{94} Likewise, the Inupiat people have above-normal levels of strontium 90 in their bones.{95} CHARIOT, at 2.7 megatons, would certainly increase these already elevated strontium levels. Further, for political reasons, CHARIOT was to be exploded only when the wind blew inland. Fallout “will land on the snow and ice... When the snow melts the radioactivity will have decayed or will have gone into the sea... so as to cause no radioactivity in foreign countries.”{96}

ABORIGINAL RIGHTS

In response to the potential impacts of CHARIOT, the Inupiats began to organize and voice their protests. One told the AEC publicity chief:

> “We really don’t want to see Cape Thompson blasted because it is our homeland. I’m pretty sure you don’t like to see your home blasted by some other people who don’t live in your place like we live in Point Hope.”{97}

The 300 Inupiats of Point Hope wrote letters to the AEC, the Department of the Interior, the Bureau of Indian Affairs and

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94. “The Disturbing Story of Project CHARIOT”, *Harpers Magazine*, April, 1962, p. 66
95. Ibid.
96. Anchorage *Daily Times*, 06/28/58
97. “Project CHARIOT: Alaskan Roots of Environmentalism”, p. 13

President Kennedy. In 1961 they organized a native rights conference which re-claimed the Cape Thompson area under aboriginal rights, stating the Bureau of Land Management did not have the jurisdiction to allow the AEC on the land.{98} Eventually, their appeals were instrumental in stopping the project. A caustic 1962 article in the Anchorage *Times* begins:

> "Alaskan Eskimos won a victory over atomic science today. Their great white father isn't going to order any time soon, if ever, a big nuclear boom on their happy hunting grounds. The Atomic Energy Commission has shelved long laid plans to blast out a new harbor above the Arctic Circle... These plans - known as project CHARIOT - had disturbed the Eskimos no end."{99}

Because the sites selected for nuclear tests are typically perceived as 'unclaimed' by the government in charge of testing, disputes concerning aboriginal rights are repeated worldwide [Map 41]. For example, the United Kingdom exploded nine nuclear bombs between 1953 and 1957 at Woomera and Maralinga, Australia, sacred land to the Pitjantjatjara Aborigines [Map 39]. At the time of the tests, the "Aborigine's land claims were not recognized by the government, state or federal. They had no vote and were not even included in the national census."{100} A belated clean-up was attempted in 1967, but over 50 pounds of plutonium remains scattered about the sites. Seeking compensation for permanent displacement from their contaminated land and ill health effects, the Pitjantjatjaras sued the British government for $35 million dollars in 1991.{101} This case has not yet been settled by

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98. "Aboriginal Rights Claimed by Eskimos", Fairbanks *Daily News-Miner*, 11/18/61
99. "Strong Eskimo Protest Shelves 'Atomic' Harbor", Anchorage *Daily Times*, 08/24/62
100. "Australia's Nuclear Graveyard", *B.A.S.*, 04/87, p. 43
101. "Aborigines' 'Hot' Homes", SF *Chronicle*, 02/23/92, and "Britain asked to Foot its Nuclear Cleaning Bill", *New Scientist*, 08/31/91, p. 9

Primary Nuclear Test Sites
Active & Inactive as of June 1992

Source: Radioactive Heaven and Earth, IPPNW, p. 160, 1991.

Map 41

the court. In addition, the United Kingdom has tested twenty-three bombs at the Nevada Test Site, an area also claimed by indigenous people.

France exploded seventeen bombs in Algeria before the Algerian revolution for independence. In 1964 they moved their test site to Te Ao Maohi, otherwise known as French Polynesia. Shortly thereafter, De Gaulle dissolved the “first fully-fledged political party” in Polynesia, Rassemblement Democratique des Populations Tahitiennes (RDPT), because it objected to nuclear tests in Polynesia. Jacques Ihorai, a Polynesian, explains the RDPT position:

> “The traditional spirit of Polynesians is that the land is like our mother. People come from the land. We must respect our mother, not explode bombs in her belly. Our good way of life comes from the land. destruction of the land will lead to the destruction - of life, and the way of life of Polynesian people.”{102}

By 1991, over 170 nuclear bombs had been exploded above and below atolls in the Tuamotu Archipelago of French Polynesia. A1984 Australian report to the Disarmament Advisory Committee states:

> “The territory which France utilizes as its testing site is part of French ‘dominion’ territory. It is far removed from metropolitan France, where it is clear that such a testing programme would be unacceptable to both French and European publics... The French nuclear testing programme has ensured that the worst features of European colonization have been inflicted on the Polynesian people.”{103}

Likewise, the primary nuclear test site in the former

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102. “Testimonies: Witnesses of French Nuclear Testing”, 1990, p. 3
103. Poisoned Reign, Danielsson, 1986, p. 313

Soviet Union is located in the homeland of a group of traditional herders known as Kazakhs. The Kazakhs, who “may have received more radiation over a longer period of time than any other people on earth”, knew little about the tests until “glasnost... made it possible for [testing] information to reach the public.”{104} After two February 1989 tests vented radiation into the atmosphere, the Kazakhs mobilized and formed the “Nevada-Semipalatinsk Movement,” named in solidarity with efforts by United States citizens to close the Nevada Test Site. Two additional tests in October of 1989 prompted widespread public demonstrations by the Nevada-Semipalatinsk Movement [Figure 33]. These demonstrations, in conjunction with strikes by workers, led to a temporary closure of the Semipalatinsk site. The Soviet government was forced to acknowledged Kazakh sovereignty in the area and offered the Kazakh parliament 5.1 billion rubles to allow two more tests. The parliament refused and the site was closed permanently in August of 1990.

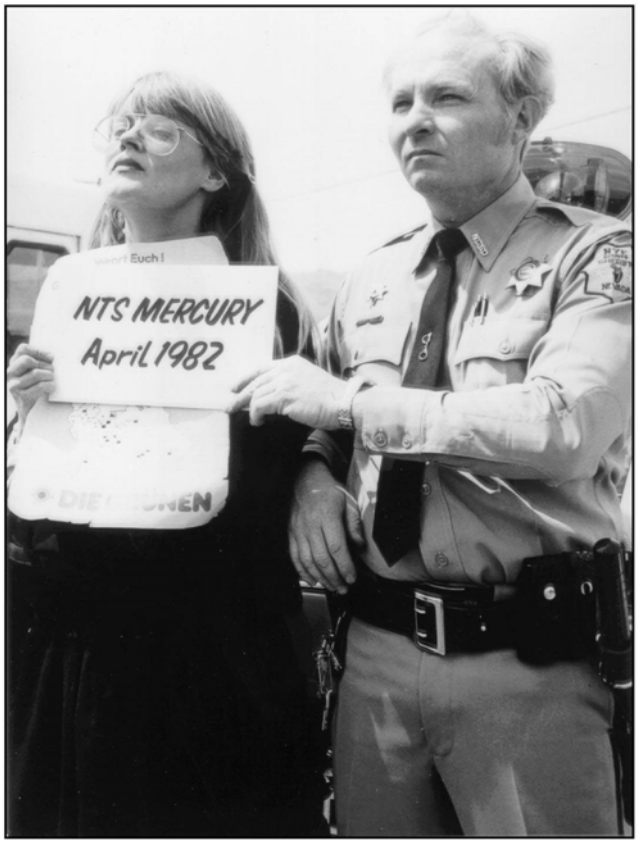
The United States government has also tested on land claimed by indigenous peoples. From the late 1940’s to the 1950’s, the United States exploded sixty-six nuclear bombs at Bikini and Enewetok atolls in the Marshall Island of Micronesia [Maps 8A & 8B]. The hundreds of Marshallese living on these atolls were relocated to neighboring islands. Due to radioactive contamination, these relocations became permanent. A 1956 petition from the Marshall Islands to the United Nations states:

> “Land means a great deal to the Marshallese. It means more than just a place where you can plant your food crops and build your houses; or a place where you can bury your

104. “Second Sunset”, J. Lerager, *Sierra*, March 1992, p. 64

Figure 33

Anti-nuclear demonstration, Kazakhstan, USSR, May 1990. James Lerager photo.



European protestor at the Nevada Test Site. Las Vegas *Sun* Collection photo.

> dead. It is the very life of the people. Take away their land and their spirits go also."{105}

In 1961, Kwajalein atoll was evacuated for use as an "impact zone" for Inter-Continental Ballistic Missiles (ICBM's) fired from Vandenburg Air Force Base in California. A 1982 statement to the World Council of Churches for the Kwajelein people echoes the 1956 United Nations petition:

> "They [the Marshallese] are deeply concerned about their young people and their future. They love their islands and want them back. Many of them are genuinely troubled about the use to which their islands are being put."{106}

Comments during a 1956 meeting of the Advisory Committee on Biology and Medicine exemplify the condescending attitude taken by the United States government towards the Marshallese:

> "Mr. Eisenbud:... [The Marshallese] had been living on that island; [Utirik Island, 300 miles downwind of Bikini Atoll] now that island is safe to live on, but it is by far the most contaminated place in the world and it will be very interesting to go back and get good environmental data... so as to get a good measure of the human uptake... Now data of this type has never been available. While it is true that these people do not live, I would say, the way Westerners do, civilized people, it is nevertheless also true that these people are more like us than the mice... We are very much impressed by the fact that this may be the last decade maybe only the last few years in history when it will be possible to really get some good data on natural radiation... In ten years from now it may be too late to ever know what people were exposed to back in the aboriginal days of 1945 and 1950 [Map 42]."{107}

Land ownership of the Nevada Test Site is also disputed. The Western Shoshone Nation claims aboriginal rights to a large swath of land which overlaps the test site [Map 43]. This land, known as Newe Sogobia to the Shoshone, legally belongs to the

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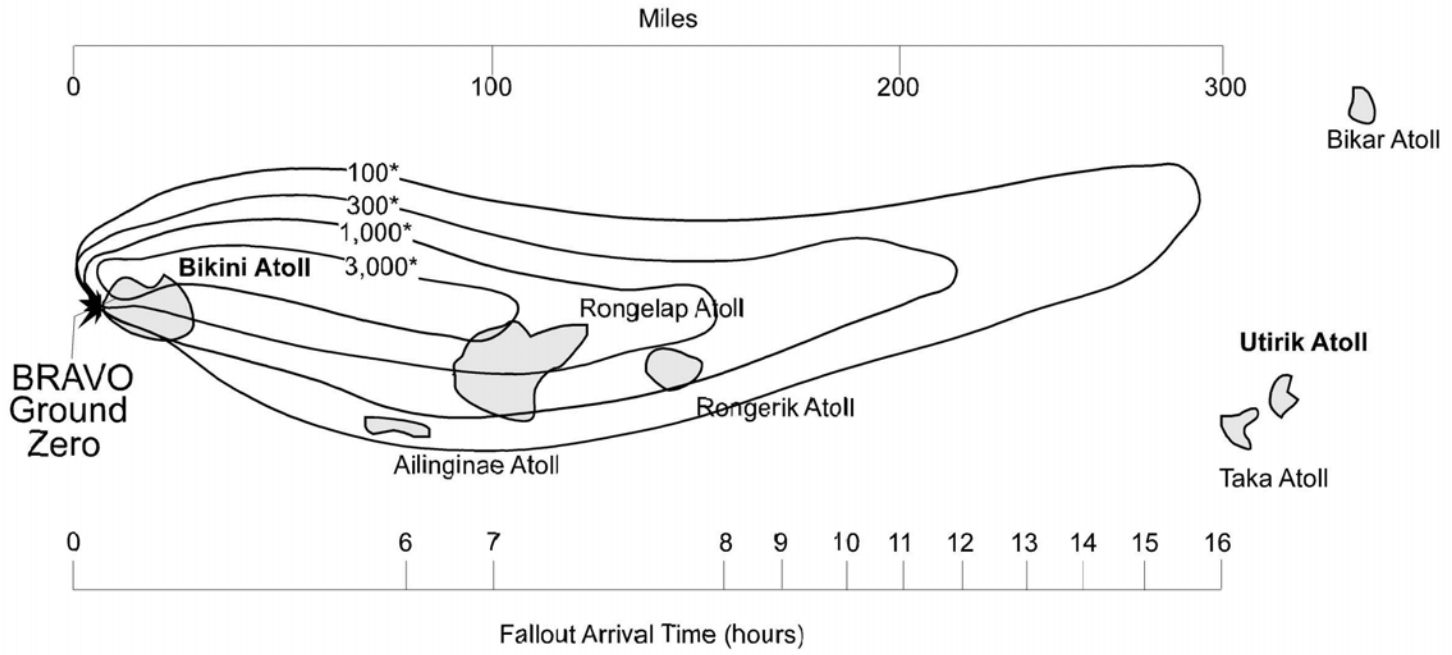
105. "Marshall Islands: A Chronology - 1944-1983", p. 29
106. Ibid., p. 20
107. Advisory Committee on Biology & Medicine, 01/56, pp. 232-233, declassified with deletions

BRAVO Fallout Pattern

From Bikini to Utirik Atoll



* Cumulative dose in REMS ninety-six hours after BRAVO detonation.

Source: S. Drell & F. Von Hippel: *Scientific American*, 235:27-37 (1975).

Map 42

Map 43

Western Shoshone Nation

Note: The boundary of Newe Sogobia is affirmed by the 1863 Treaty of Ruby Valley - ratified by the U.S. Senate (1866) and the President (1869).

Source: Western Shoshone National Council. Bernard Nietschmann, U.C. Berkeley. Original map by William Le Bon, 05/87.

tribe under the provisions of the 1863 Treaty of Ruby Valley.{108} While the treaty stipulates that Indian hostilities towards travelers should cease and that “routes of travel through the Shoshone country, now or hereafter used by white men, shall be forever free,” it does not question or revoke Shoshone ownership of the land.{109} Since 1863, therefore, all governmental claims to the land have been legally invalid. In 1946, the Indian Claims Act created the Indian Claims Commission, which filed a claim on behalf of the Western Shoshone. The commission ruled that the Shoshone should be compensated $26 million dollars for their lands lost in practice, if not in theory. However, this money remains unclaimed by the Shoshone Nation, as accepting it would be a legal affirmation that the tribe had relinquished their aboriginal rights to the land.

The Shoshone continue to press their claim. Currently, access to the Nevada Test Site and Nellis Air Force Range is highly restricted by the United States government. Occasionally, activists will attempt to walk to the ‘ground zero’ of an upcoming test and delay the explosion [Map 44]. More often, protectors cross into the Test Site at the main gate where they are arrested for trespassing. In either case, Shoshone leaders distribute permits to “gather, go and come” within the area enclosed by the test site [Figure 34]. The application for the permit states:

> “A permit must be carried at all times when within the resource zone... Upon request by a duly authorized officer of the Western Shoshone Nation, this permit must be made available for inspection.”{110}

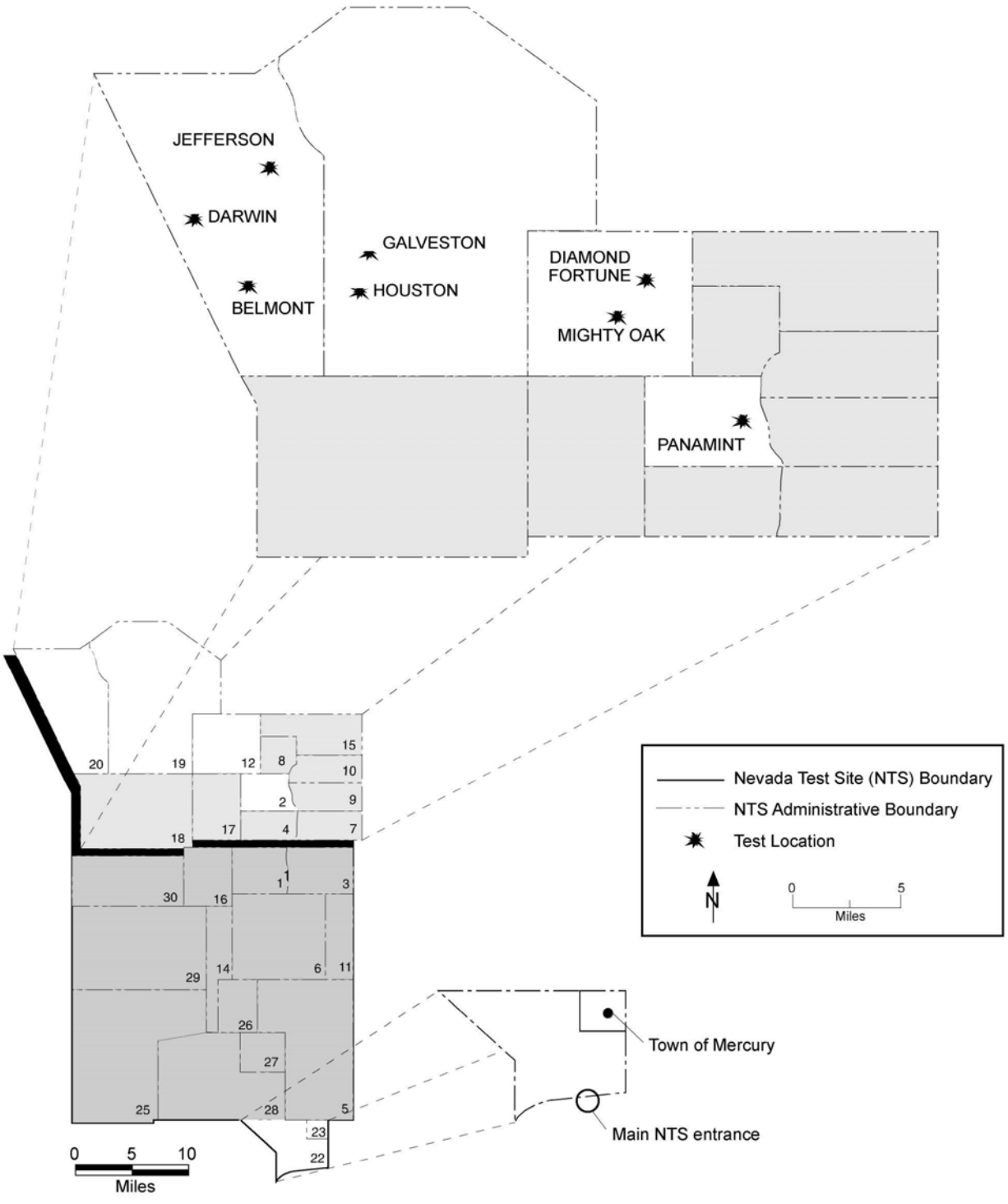
Those who arrested for trespassing are asked to present their

108. “Treaty of Ruby Valley of 1863”, October l, 1863, Proclaimed 10/21/1869
109. Ibid.
110. “Western Shoshone Nation Application for Permit”

Map 44

Tests Delayed by 'Backcountry Actions'

Nevada Test Site



Source: "American Peace Test Nonviolence Trainers Manual", 11/87.

Figure 34

- P E R M I T -

for
Exempt non-Western Shoshone
to
Gather, Go and Come
by issue from
the

WESTERN SHOSHONE NATIONAL COUNCIL

P. O. Box 69 Duckwater, Nevada 89314 (702) 863-0227

ZONE: G-0 Nº 3197

NAME _____
Last First Middle

STREET ADDRESS _____

COUNTRY _____

CITY _____ STATE _____ ZIP _____

SEX M F HEIGHT ' " WEIGHT LBS

BIRTHDATE / / HAIR EYES

DRIVER'S LICENSE NO. STATE

SOC. SEC. NO.

DATE ISSUED / / EXPIRES / /

PERMITEE SIGNATURE X _____

WSNC AUTHORIZED OFFICER X _____

This permit must be signed by an officer of the Western Shoshone Nation to be valid and must be carried at all times when within the resource zone indicated. Upon request, this permit must be made available to an officer of the Western Shoshone National Council (WSNC) and may be revoked at any time by the officer or the W.S.N.C.

permit to DOE security personnel and state that they are guests of the Western Shoshone Nation.

ENVIRONMENTAL ACTIVISM

Related to aboriginal rights and landuse are the environmental and health effects associated with Plowshare and other nuclear tests. As with aboriginal rights, project CHARIOT brought this issue to the forefront.

CHARIOT was originally publicized as a useful harbor project. According to the AEC, the lack of a harbor on the northwest coast of Alaska "had hampered development of [coal] deposits" and impeded the fishing industry.{111} Gerald Johnson, head of the Plowshare division at Livermore Labs, reassured Alaska residents in 1958: "The economic aspect [of CHARIOT] is vital to our planning. We don't want just a hole in the ground."{112}

However, there were indications all along that CHARIOT was not an economically viable project, but was simply a five million dollar ditch. First, the Cape Thompson region was locked in ice nine months of the year, and the nearest coal deposits were on the other side of the Brooks Range, requiring the construction of a railway line to reach them should CHARIOT be approved. Not surprisingly, when the plan was unveiled in 1958, "there was not immediate agreement among leaders of territorial and federal agencies and industry spokesmen... that the proposed harbor [CHARIOT] would serve any useful purpose."{113} The ability to dig a harbor took precedence over questioning if a harbor was

111. *Harpers Magazine*, April, 1962, p. 62
112. "Dr. Teller and Team Study Use of Nuclear Power Here", *The Daily Alaska Empire* (Juneau), 07/15/58
113. Fairbanks *Daily News-Miner*, 07/15/58

necessary. For example, an ebullient Edward Teller, in a 1959 commencement address at the University of Anchorage, told the graduates: “[The AEC] could dig a harbor in the shape of a polar bear if required.”{114} Gradually, however, statements by the AEC came to acknowledge a widespread public sentiment - a hole in the ground, even one in the shape of a polar bear, was still a hole in the ground. Russell Ball, the AEC executive in charge of CHARIOT told a crowd Inupiat Eskimos in 1960 that: “We no longer have any expectation that there will be any commercial value to the hole that will be produced.”{115} AEC commissioner Willard Libby noted: “The only trouble with the plan is we haven’t been able to find anyone who really wants a harbor there.”{116} A 1960 article on CHARIOT in the Fairbanks *Daily News-Miner* ends with the paragraph:

> “Paradoxically, there is no real need for a harbor at the bleak site... The big reason for the project is to find out just what can and can’t be done with nuclear blasts for excavation, to do it in a thoroughly isolated area and to have changes wrought.”{117}

Even without “horses to pull it”, CHARIOT still had the support of many Alaskans as well as scientists within the AEC.{118} A Fairbanks *Daily News-Miner* editorial entitled “Atomic Harbor O.K. Vital” presents this view:

> “While the harbor may have no great immediate economic value... Alaskans should get behind this move for more far-reaching reasons... The project... will open the door to a wide range of peaceful uses for atomic energy... What objections could there possibly be to this large scale atomic harbor blasting project?”{119}

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114. “Project CHARIOT: Alaskan Roots of Environmentalism”, p. 10
115. Ibid., p. 13
116. Ibid., p. 6
117. Fairbanks *Daily News-Miner*, 12/05/60
118. “Project CHARIOT: Alaskan Roots of Environmentalism”, p. 13
119. “Atomic Harbor O.K. Vital”, Fairbanks *Daily News-Miner*, 01/10/59

Another editorial makes a similar argument:

> "We feel that an undertaking of the kind proposed would center world scientific and economic attention on Alaska just at the time when we are moving into statehood and inviting development. We think the holding of a huge nuclear blast in Alaska would be a fitting overture to the new era which is opening for our state. We say to Dr. Teller and his fellow scientists: Alaska welcomes you. Tell us how we can help."{120}

However, several factors conspired to cancel project CHARIOT and turn it into "a landmark in the history of conservation".{121} First, mixed signals from the AEC made many Alaskans suspicious of the agency's motives. A 1959 letter to the editor of the Fairbanks *Daily News-Miner* states:

> "It is interesting to note the shift in emphasis that has taken place since last summer [CHARIOT as useful harbor to CHARIOT as nuclear experiment]... It would appear, perhaps, that all the AEC is really interested in is a new testing ground now that Nevada and Los Angeles are objecting to the radiation fallout... If this should be the case, are we not setting a precedent of turning Alaska into a experimental ground for atomic bomb testing, both 'peaceful' and military?"{122}

These suspicions led to a successful call for increased citizen oversight of the project and a more conciliatory attitude by the AEC. For example, the AEC agreed to a comprehensive biological and social study of the Cape Thompson region, enlisting the help of scientists from the University of Alaska. John Wolfe, in charge of the AEC study, felt CHARIOT was "the first opportunity to do a good biological study prior to a nuclear explosion and... [possibly] our last."{123} It should be remembered that CHARIOT was the first unclassified nuclear experiment ever

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120. "Nuclear Engineering in Alaska", Fairbanks *Daily News-Miner*, 07/24/58
121. "Project CHARIOT: Alaskan Roots of Environmentalism", p. 17
122. Letter to the Editor, Fairbanks *Daily News-Miner*, 01/19/59
123. "Project CHARIOT: Alaskan Roots of Environmentalism", p. 21"

proposed by the AEC.{124} Before long, the fate of project CHARIOT became contingent upon the results of this comprehensive baseline survey of the region.

The survey was controversial. Leslie Viereck, the senior investigator in botanical studies, resigned from the CHARIOT study because “its conclusions were predetermined... and intimately connected with AEC politics.”{125} However, by the time it was published, the twelve hundred page survey, entitled “Environment of the Cape Thompson Region, Alaska”, was hailed as “the most comprehensive bioenvironmental survey ever done,” and “the best overall fact finding job that any of our government agencies has ever done.”{126} Even Viereck conceded that the study was “one of the best ever conducted in an Arctic region.”{127} To many, the survey is also the first de-facto environmental impact statement. The Cape Thompson Report brought a new level of sophistication to environmental studies; it combined the “conventional... concerns of conservation and preservationism with the larger and more complex issues engendered by mid-twentieth century science, technology, and industrial culture.”{128} For example, the project’s impact to the native Inupiats was discussed, linking the natural and human environment in a way that had not been done before.

CHARIOT was important to the nascent environmental movement in other ways as well. For example, the CHARIOT debate marked the first time the Sierra Club explicitly criticized

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124. Ibid.
125. “Why Researcher Resigned”, Fairbanks *Daily News-Miner*, 08/22/61
126. *B.A.S.*, December 1989, p. 35
127. “Project CHARIOT: Alaskan Roots of Environmentalism”, p. 21
128. Ibid., p. 20

nuclear technology. Previous to CHARIOT, Richard Leonard, the secretary of the Sierra Club, had warned: “We must be careful not to get into genetic and other fields we are not expert in.”{129} CHARIOT had a profound impact on individuals as well. When asked when his career as an environmentalist began, Barry Commoner, a planner for Earth Day 1970 and the “Paul Revere of Ecology” replied:

> “It is absolutely certain that it began when I went to the library to look up the behavior of lichen in connection with the CHARIOT program. That’s a very vivid picture in my mind. I realized that we’re dealing with an ecosystem here... Project CHARIOT can be regarded as the ancestral birthplace of at least a large segment of the environmental movement.”{130}

Further, CHARIOT, unlike other bomb tests, was not necessary for national defense. Thus, criticism and concern about the project’s radioactive fallout was more impassioned and thoroughly argued than had the project been laden with patriotic overtones. It was this type of debate that historians T. Dunlap and R. Lutts contend “prepared Americans for Rachel Carson’s Silent Spring... and contributed to its enthusiastic reception.”{131} Silent Spring, published in 1962, was arguably the most influential environmental book of its time.

CHARIOT, the plan to build a remote harbor with no customers using untried technology, was cancelled in 1963. Unfortunately, CHARIOT did leave environmental impacts. The Ogotoruk Creek wilderness was spoiled by the construction of over

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129. Project CHARIOT: Alaskan Roots of Environmentalism”, P. Coates, *Alaska History*, vol. 4, #2, Fall 1989, p. 20
130. “Project CHARIOT: How Alaska Escaped Nuclear Excavation”, p. 36
131. “Project CHARIOT: Alaskan Roots of Environmentalism”, p. 36 and Dreamers and Defenders, 1971, p. 177

forty buildings, two airstrips, and an extensive network of tracks in the tundra from personnel carriers used by Plowshare planners.{132} Most of the camp material was left at the site: “It appears quite likely that the majority of material at the camp is of insufficient value to justify the high cost of packing and backshipping to the Continental U.S.... Whatever the outcome, disposal of facilities and property will be done in accordance with established procedures, and following the path of minimum cost to Plowshare.”{133}

Also, as part of 1963 CHARIOT fallout studies, radioactive isotopes were used at the Cape Thompson site. These isotopes came from the 1962 SEDAN Plowshare test. Ironically, SEDAN was designed and exploded out of “frustration [as] an alternative to CHARIOT.”{134} An AEC inspector reports on the condition of this material:

> “Contrary to my earlier belief, I find that the contaminated earth was not enclosed in steel drums at the time of burial, but was merely piled on the ground and a mound of earth formed over it. This would make recovery of the radioactive material very difficult... [A] decision should be reached whether to attempt recovery of the remaining radioactive material prior to the abandonment of the site.”{135}

If the “path of minimum cost to Plowshare” was followed, it is likely this material remains at the Cape Thompson site. However, relative to what had been planned, forty quonset huts and a mound of radioactive earth are minor disturbances. The Committee

132. “Project CHARIOT: Alaskan Roots of Environmentalism”, p. 19
133. “Plans for Cancellation of Project CHARIOT”, 06/15/62, CIC #18550, declassified 09/03/81
134. “Project CHARIOT: How Alaska Escaped Nuclear Excavation”, p. 37
135. “Radioactive waste mound at Project CHARIOT Site”, 04/10/63, CIC #16850, declassified 08/21/81

on Environmental Studies concluded its 1962 report on CHARIOT as follows:

> “Such massive techniques in projects of great scope everywhere need to be geared to a basic understanding and appreciation for the total ecology... For ignorance of man’s bioenvironment at an ecological level, especially in a technologically enlightened age, can result only in extended disaster, culminating in a tragic end to his dominion over the earth.”{136}

Rachael Carson echoes this sentiment in a passage written the same year:

> “We still talk in terms of ‘conquest’ - whether it be of the insect world or of the mysterious world of space. We still have not become mature enough to see ourselves as a very tiny part of a vast an incredible universe, a universe that is distinguished above all else by a mysterious and wonderful unity that we flout at our peril.”{137}

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136. “Bioenvironmental Features of the Ogotoruk Creek Area. Cape Thompson, Alaska”, US AEC, 1962, p. 166
137. Carson, R., Of Man and the Stream of Time, 1962, p. 8; quoted in Dreamers & Defenders, D. Strong ed., 1971, p. 195

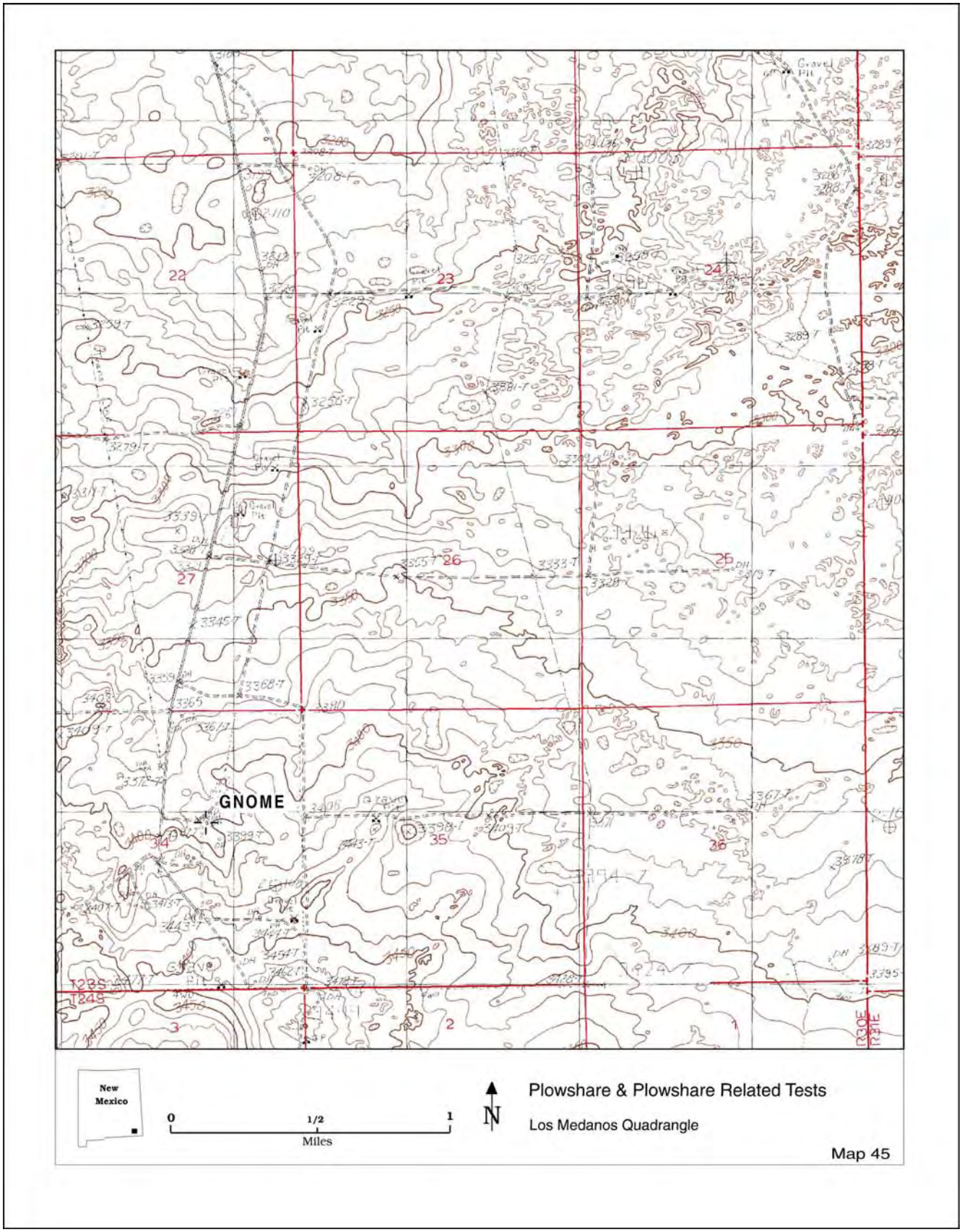
PLOWSHARE PHYSICS PROJECTS

As previously mentioned, Plowshare physics experiments investigated scientifically useful phenomena of underground nuclear explosions such as heavy-element production or neutron physics experiments. These Plowshare physics studies were often “piggy backed” onto weapons related nuclear tests.{1} All of the dedicated Plowshare physics experiments and roughly half of the “piggy-backed” tests were sponsored by Livermore Labs, and all but one of these tests [GNOME], took place at the Nevada Test Site [Map 45]. Beginning with GNOME, the five dedicated Plowshare physics tests [GNOME, ANACOSTIA, KAWEAH, PAR, and VULCAN] will be discussed [Map 46]. The sixteen “piggy-backed” tests [GERBIL, KENNEBEC, ANCHOVY, GREYS, OCONTO, BYE, BARBEL, PARROT, SCAUP, TWEED, PETREL, DURYEA, CYCLAMEN, KANKAKEE, PERSIMMON, and HUTCH] will also be briefly reviewed.

PROJECT GNOME

The AEC announced plans for GNOME in August 1958. The ten kiloton blast was scheduled for detonation in New Mexico the next year. However, the nuclear test moratorium of 1958 delayed the experiment until December 1961.{2} During the moratorium, high explosive tests were conducted in Louisiana [COWBOY, PLOWBOY and WINNOW], New Mexico [PRE-GNOME] and the Nevada Test Site as part of the preparations for GNOME.{3} As the first nuclear Plowshare experiment planned by the United States, GNOME test’s objectives were broad and ambitious. Several of these objectives relied on

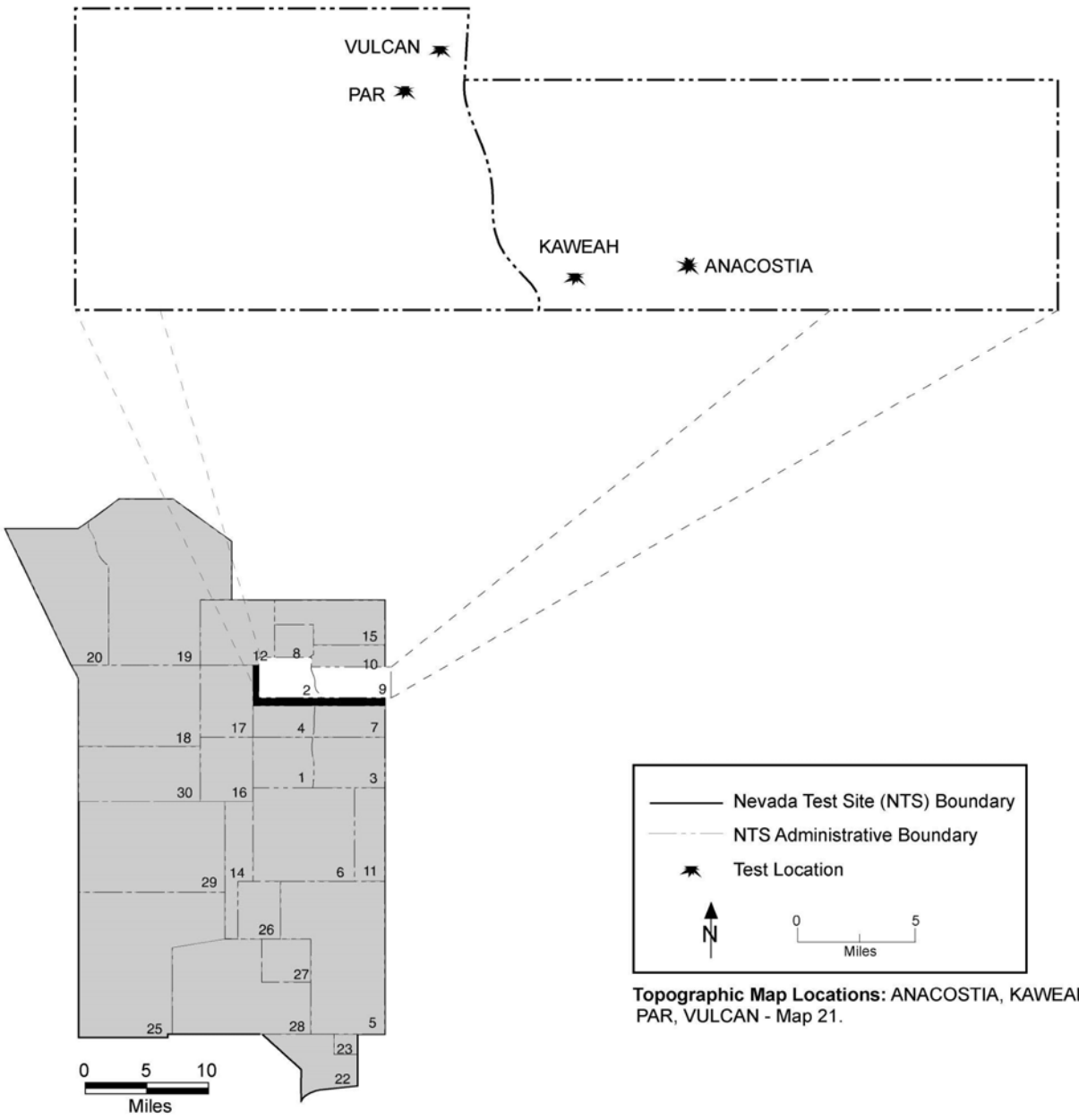
1. See, for example, JCAE, “Authorizing Legislation FY 1967”, p. 1347
2. JCAE, “Authorizing Legislation FY 1965”, p. 3
3. For COWBOY see memo, “G. Johnson to J. Reeves - Probability of Venting - Projects LOLLIPOP and GNOME”, 9/30/60, CIC#78638; for PLOWBOY see “Plowboy News Release”, 03/30/60, CIC#69366, declassified 05/05/81; for PRE-GNOME see “An Annotated Bibliography”, TID-3522(9th rev.), p. 325.


GNOME
22
23
24
25
26
27
34
35
36
T23S
T24S
R30E
R31E
New Mexico
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Los Medanos Quadrangle
Map 45

Map 46

Physics Tests

Nevada Test Site



Topographic Map Locations: ANACOSTIA, KAWEAH, PAR, VULCAN - Map 21.

Source: Springer, D., "Seismic Source Summary", UCRL-73036, 02/71.

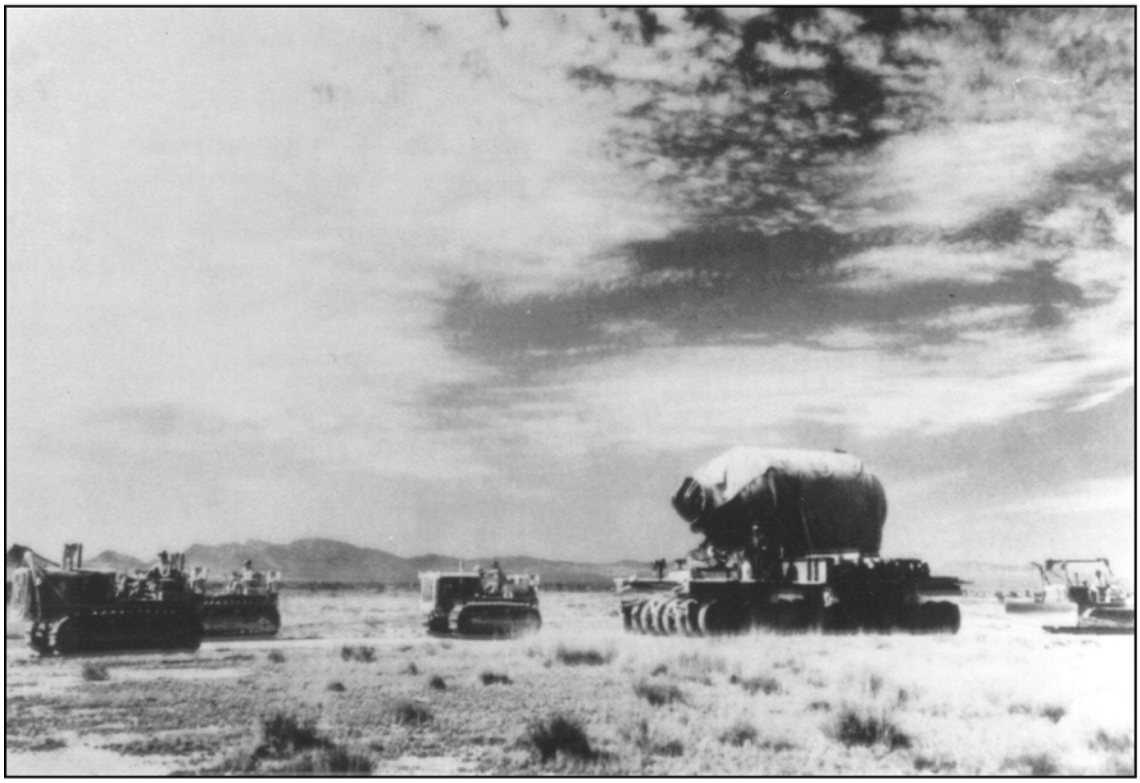
the anticipated characteristics of a nuclear explosion in an underground salt formation, particularly the Salado salt formation in southeastern New Mexico - the site chosen for the GNOME explosion.

The New Mexico site was chosen for its shallow underground formation of “relatively pure salt... [with] a low water content.”{4} Also, as with all nuclear tests, the Carlsbad site was an “area of low population... on government land (or land easily acquired by the government).”{5} The GNOME site selection committee chose the area twenty-five miles southeast of Carlsbad despite protests by the potash industry concerning possible impacts of the blast on “mines and refineries... gas wells. farmlands , groundwater and Carlsbad Caverns”{6} It is possible the site was chosen over similar salt formations in Louisiana and Mississippi because of New Mexico’s past experience with nuclear bombs; the TRINITY site, location of the world’s first atomic blast, is 170 miles to the west of GNOME [Figure 35].

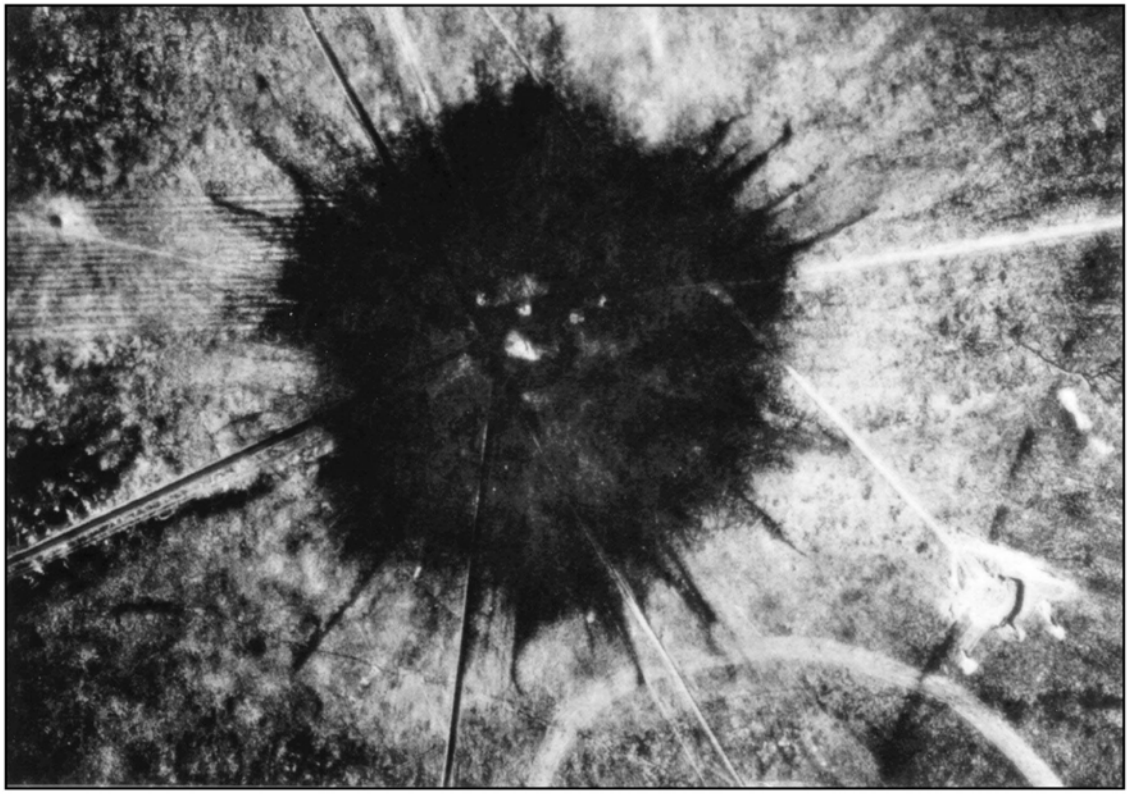
Salt had never been used to contain a nuclear explosion It was, in the words of the AEC, a new “medium” that offered intriguing possibilities The code name GNOME referred to “mythical dwarfs who guard underground treasure”, and reflected the expectant feeling of Plowshare planners towards the blast.{7} A twelve hundred foot shaft was dug into the salt. At the bottom of the shaft a horizontal tunnel led to an eight by ten foot chamber where GNOME would be detonated. Scientists hoped to collect scientifically useful isotopes after the blast, “where the

4. “Projects GNOME and SEDAN”, DNA-6029F, p. 33
5. Ibid.
6. Ibid., p. 32
7. “Peace Bomb Unleashes Atom Cloud”, Baltimore *Sun*, 12/11/61, p. 1

Figure 35



Steel vessel designed to contain a TRINITY misfire being towed to th
TRINITY site. The cask was never used. LANL photo.



Crater and heat effects at TRINITY ground zero. LANL photo.

products could be more easily recovered because of the volubility of the salt."{8} Also planned were neutron physics experiments that would contribute to nuclear reactor development, and tests to utilize the heat from GNOME as a long-term energy source. It was believed the salt would fuse into impenetrable rock after the blast, trapping the heat created by GNOME and establishing a cheap energy source.{9} GNOME was also an experiment to determine if a nuclear explosion could be muffled in a salt cavity. As with shot RAINIER, scientists were intrigued with the possibilities of concealing such tests from the Soviet Union as well as developing techniques to detect Soviet underground tests. This line of experimentation was known as the VELA UNIFORM program.{10} Finally, data from GNOME would help in the design of future Plowshare "devices".

GNOME, scaled back to five kilotons, was detonated on Sunday, December 10th, 1961.{11} To publicize the beginning of the Plowshare program, three hundred observers were invited to watch the blast, including officials and press from ten foreign nations. The crowd waited four hours for southeasterly winds to shift away from Carlsbad and toward less populated areas. The wind shift came, and at twelve noon GNOME was exploded. Efforts to contain the blast were unsuccessful:

> "At approximately seven minutes after the detonation, grey smoke, steam, and associated radioactivity surged from the shaft opening. By eleven minutes following the explosion, copious quantities of steam were issuing from both shaft and ventilation lines. A large flow continued for about 30 minutes... A small flow was still detected the following day [Map 47]."{12}

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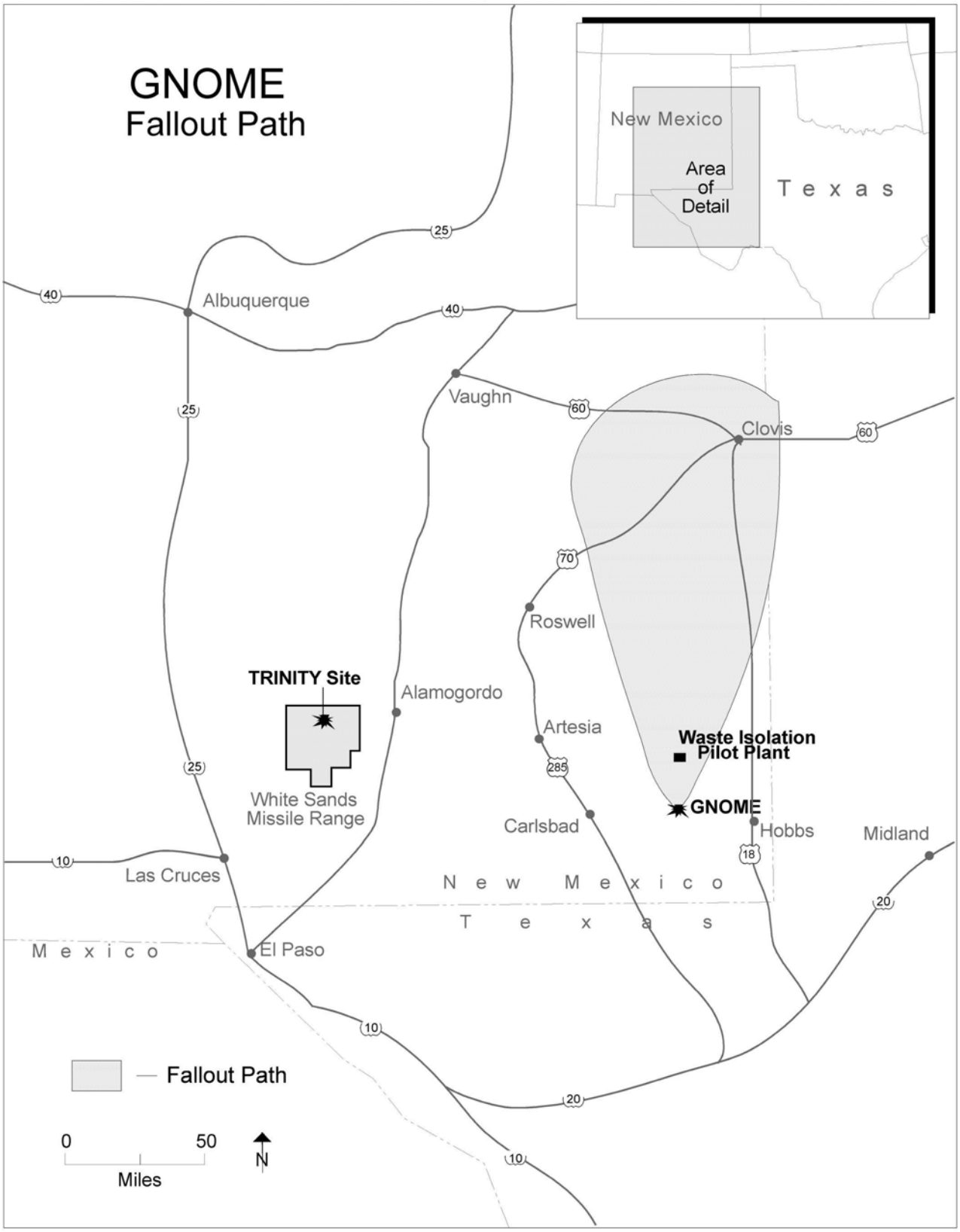
8. JCAE, "Authorizing Legislation FY 1965", p. 12
9. See, for example, "Nuclear Explosions in Science and Technology", *B.A.S.*, vol. 16, #3, p. 158
10. See "Known US Nuclear Tests", NRDC, p. 4
11. Baltimore *Sun*, 12/11/61
12. "Radiological Effluents", 1990, p. 10

Map 47



Source: "Compilation of Local Fallout Data", DNA 1251-1-E, 05/79.

Radioactive debris from the “peace bomb”, as GNOME was called at the time, contaminated “ten cars caught between roadblocks... and one helicopter.”{13} The debris may have also caused health problems in Carlsbad, notwithstanding a Livermore program to “orient the people in Carlsbad area and, if possible, gain their acceptance of this condition [fallout from GNOME].”{14} During a 1963 congressional hearing on “Fallout, Radiation Standards and Countermeasures”, Dr. Eric Reiss testified that GNOME had “delivered sufficient fallout to the vicinity of Carlsbad, New Mexico, to cause thyroid dose levels of from 7 to 55 reds to children” [1985 standards limit public exposure to 0.1 rems per year, equivalent to a thyroid dose of 0.1 rads.]{15} “In 1981, a Carlsbad pediatrician, Dr. Catherine Armstrong, reported an increase in ‘congenital heart diseases, bone defects, severely immature livers and jaundice’ among the offspring of people who were children when GNOME was detonated.”{16}

Months after the blast, scientists re-entered the GNOME cavity, expanded by the force of the blast to the height of an eight story building. The salt walls had turned various shades of deep blue, yellow and black from the gamma radiation. Wendell Weart, a Sandia scientist who re-entered the still radioactive cavity recalls: “It was 130 degrees and the air was as full of moisture as it would hold... You could go in, but you didn’t stay very long [Figure 36].”{17} Despite the unusual characteristics of GNOME’s cavity, the test was not considered a success. In fact

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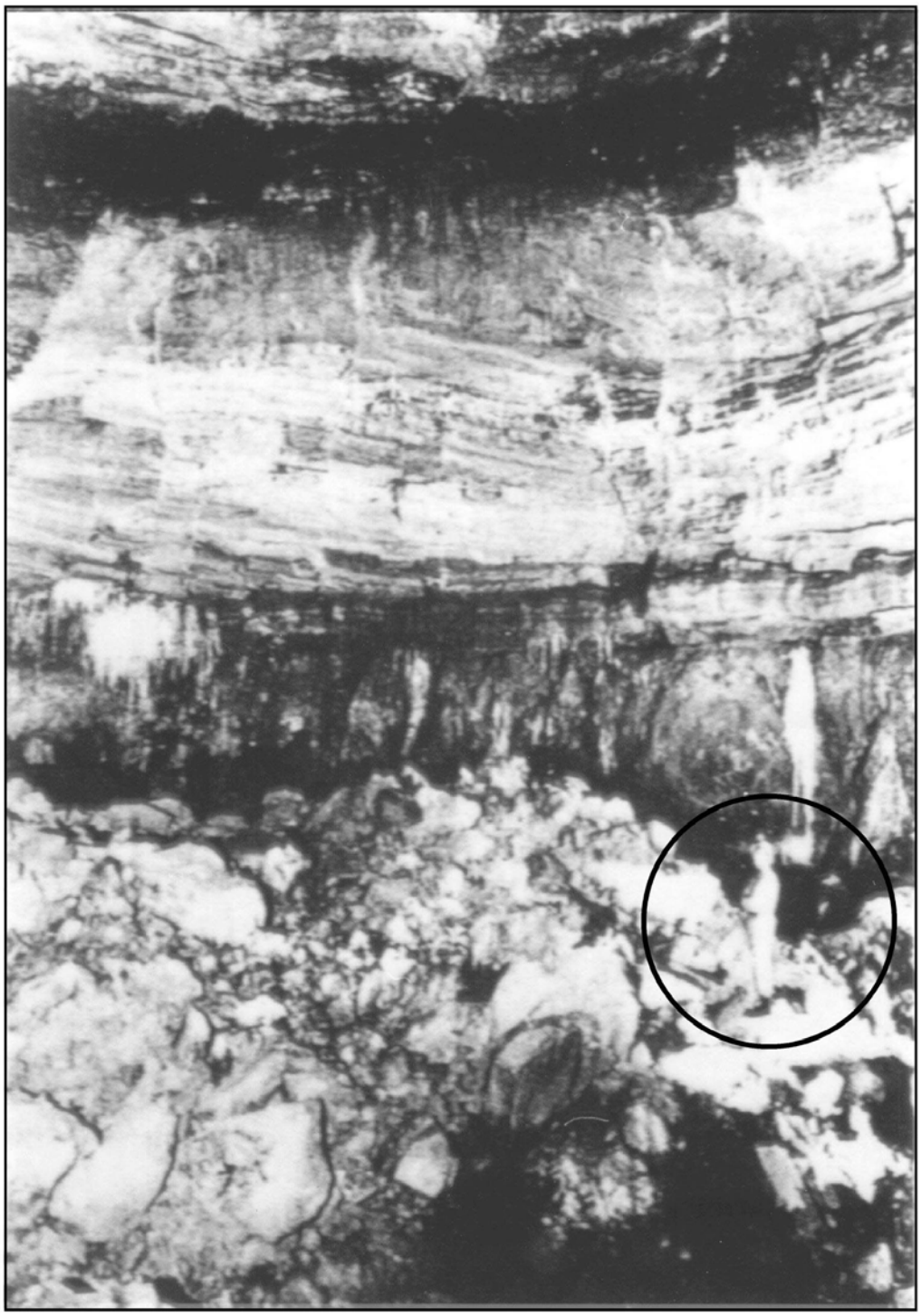
13. Baltimore *Sun*, 12/11/61
14. Memo, “G. Johnson to J. Reeves - Probability of Venting - Projects LOLLIPOP and GNOME”, 09/30/60, p. 2, CIC#78638
15. Killing Our Own, p. 122
16. Under The Cloud, p. 313
17. “New Mexico’s Blast From the Past”, Albuquerque *Journal*, 07/07/91

Figure 36



"You could go in, but you didn't stay very long."
GNOME cavity with standing figure. LLNL photo.

Gerald Johnson, head of the Plowshare program for Livermore Labs, felt some embarrassment about the disappointing results of GNOME.{18} Another experiment, COACH, of a higher yield and more deeply buried than GNOME, was planned as a follow-up.{19}

To ensure that the well publicized encore to GNOME would be a success, several less visible Plowshare physics experiments were planned at the Nevada Test Site.{20} It was also cheaper to perform these tests at the Nevada Test Site.{21} Although NTS lacked a salt formation, “in the course of developing... very high-neutron flux nuclear devices, methods were finally worked out for recovering samples in the less advantageous environment of the underground in Nevada.”{22} However, the results of these four tests [ANACOSTIA, KAWEAH, PAR and VULCAN] was disappointing. Representative Morris, at a 1965 JCAE hearing, questions whether more money should be spent on developing COACH: “Representative Morris: ... It doesn’t seem to me that project COACH is very much alive. I must have misunderstood Dr. Seaborg’s letter.

> Mr. Kelly [AEC Director of Plowshares]: No, I think project COACH is alive. It is only that -
>
> Representative Morris: - It is awfully short of breath.”{23}

Test PAR was the only ‘PRE-COACH’ test considered marginally successful:

> “Mr. Kelley: This work is proceeding very satisfactorily from the point of view of making new elements.
>
> Mr. Conway: Is this the new element 104 –

18. Nuclear Dynamite, p. 25
19. Albuquerque *Journal*, 07/07/91
20. Purpose of ANACOSTIA & KAWEAH given in memo, “Updating List of Nuclear Events at Nevada Test Site”, 08/09/63, CIC#27209. Purpose of PAR in JCAE, “Authorizing Legislation FY 1966”, p. 177
21. JCAE, “Peaceful Applications of Nuclear Explosives”,1965, p. 46
22. Ibid.
23. JCAE, “Authorizing Legislation FY 1966”, p. 177

> Mr. Kelly: That was the PAR event of last October [1964]. Unfortunately, to get the results we got in PAR we had to go to about 30 kilotons [38 kilotons] of yield. And somehow before we can take the PAR device or the PAR follow-on back to Carlsbad and make a few grams of some difficult to make isotope, we will have to learn to scale that yield down to something in the range of 10 kilotons or less. So we have been carrying this Carlsbad site for - I don't know - $60.000 a year."{24}

All four 'PRE-COACH' experiments vented radioactive isotopes into the atmosphere from DRILLBACK releases, while test ANACOSTIA had an EVENT release of radioactivity as well.{25} All but KAWEAH created subsidence craters averaging 500 feet in diameter and 65 feet deep [Maps 21 & 22].{26}

The initial optimism of Plowshare planners towards the COACH experiment gradually faded. In 1963, $800,000 dollars was spent on access tunnel through the salt to the proposed COACH ground zero chamber, and for many years money was budgeted to maintain the Carlsbad site.{27} But by 1970, further research on producing isotopes through nuclear explosions was suspended indefinitely. As an aside, two other nuclear tests, SALMON and STERLING, were later conducted in a salt formation in Mississippi, although these were part of the previously mentioned VELA UNIFORM program and were not isotope production tests [Map 1a].

PLOWSHARE & LONG TERM ENVIRONMENTAL IMPACTS

Eight miles north of the GNOME site lies the Waste Isolation Pilot Plant (WIPP), a DOE facility proposed as the nation's first permanent underground radioactive waste burial site [Map 47]. The Salado salt formation which initially attracted

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24. Ibid., p. 178
25. Radiological Effluents", 1990
26. "Seismic Summary", pp. 11-28
27. Money was budgeted up until FY 1970; see JCAE, "Authorizing Legislation FY 1970", p. 611

Plowshare planners to the area was chosen by the DOE as the best medium for containment of six million cubic feet of radioactive waste to be stored 2,000 feet underground in 120,000 fifty-five gallon drums.{28} This waste will contain plutonium with a half-life of 24,000 years; that is, half of the total mass stored will have decayed to a non-radioactive state in 24,000 years. Put another way, had the ancient Egyptians stored plutonium inside the pyramid of Cheops, it would still be ninety percent radioactive today. The efforts to contain radioactive waste at the WIPP repository highlight the long term environmental impacts of Plowshare tests. For example, it is likely that some of the radioactive waste sent to WIPP includes materials contaminated during the fabrication, assembly and testing of Plowshare tests over thirty years ago - materials that are now temporarily stored at other DOE facilities in Idaho (INEL) or Colorado (Rocky Flats). WIPP is also a reminder that every nuclear Plowshare test is a de-facto high level waste repository. It can be assumed that most, if not all, of the radioactive isotopes to be buried at the WIPP site are also present in the underground cavities of Plowshare and weapons tests located in Nevada, New Mexico, Colorado, Mississippi and Alaska.{29} These sites, unlike WIPP, are infrequently monitored and poorly marked. No one knows what will become of this waste as time goes by. Speculating is similar to pondering the fate of the Voyager 2 spacecraft, sent on an endless mission through space in the hopes that an alien race will trace its path back to our world. However, Voyager 2 does not have the potential

28. “The WIPP Repository”, DOE handout, 1988
29. Presence assumed because the exact contents are classified. Letter, NVOO to V.J. Brechin, 09/12/91

to contaminate soil and groundwater thousands of years hence.

WIPP - “DON’T EVEN THINK OF PARKING HERE”

Sandia Labs commissioned a study in which four “expert--judgement” teams examined the possibility of inadvertent or purposeful human contact with the radioactive waste buried at WIPP within the next 10,000 years. As stated, 10,000 years from now much of this waste will be essentially as radioactive as it is today. How can this danger be communicated to future societies? Under what circumstances might waste spread to the surface? One scenario postulates that waste would escape from WIPP due to vibrations from nearby underground weapons testing. The area near WIPP would be chosen for weapons testing “because of pre-existing radioactive contamination.”{30} The possibility of waste leaking from WIPP is disregarded “as would be the case when... military needs... override safety concerns.”{31} In this scenario, the future would appear to repeat the past.

Other “intrusion” scenarios include treasure hunters purposely digging into the repository thousand of years from now under the conviction, prompted by local folklore, that something valuable was buried there. Radionuclides would be released during this excavation. Another scenario describes a high speed tunnel built between Houston and Los Angeles in the year 2991 passing near or through the repository. The existence of the WIPP repository had long since been forgotten: surface markers warning of buried radioactive waste “had been hauled away for their intrinsic value... They now stood as proud status symbols on

---

30. “Expert Judgement on Inadvertent Human Intrusion Into the Waste Isolation Pilot Plant”, Sandia Labs, SAND90-3063, 1991, pp. IV-24
31. Ibid., p. C-34

entrances to... buildings... just as artificial pink flamingos used to be placed on suburban lawns in the 20th century."{32} Another scenario, set in 2091, describes a world dominated by women:

> "Twentieth-century science was discredited as misguided male aggressive epistemological arrogance. The Feminist Alternative Potash Corporation began mining the WIPP site [and discovered]... surfacemonoliths warning of radioactive waste buried at the former WIPP site. After studying the historical records of the age/gender/racial distributions of the major decision-makers... connected with the design and construction of the WIPP repository, they found that 97 percent of them had been middle aged... white males. Moreover, they found no evidence of surveys in which women's or... minorities opinions had been sought on plans for WIPP. Thus, on the grounds of the obvious male (and class and race) biases that must have gone into the original thinking, they decided that the warnings were simply another example of inferior, inadequate, and muddled masculine thinking... They proceeded to mine... penetrating a disposal room and releasing radionuclides into the accessible environment."{33}

A few scenarios describe successful efforts to thwart access to the waste buried at WIPP. One example describes a plan to retain the cultural memory of WIPP by creating a nuclear waste theme park - "Nickey Nuke and WIPP Worlds":

> "[The] legends of Nickey Nuke remained in people's minds everywhere on earth. Fictional Nickey Nuke -stalwart, heroic, and duty-bound - carried the memories of WIPP and its dangers into the collective consciousness of the peoples of the Earth, forevermore."{34}

The range of scenarios demonstrates that no one knows whether radioactive waste from the WIPP site, Plowshare tests or other nuclear tests will be contained or dispersed thousands of

32. Ibid., p. C-49
33. Ibid., p. C-40
34. Ibid., p. C-57

years from now. Furthermore, institutional memory, especially of disagreeable subjects, can be quite short. For example, a salt dome in Kansas, recommended as a radioactive waste site by the AEC in the early 1970's, turned out to be riddled with holes from a previously unknown drilling operation. Likewise, a plan to dump earth in Massachusetts Bay was scuttled when it became apparent the dumping area contained numerous fragile drums of "hazardous and radioactive waste... from the late 1940's."{35} Reminiscent of the barrels of waste dumped near the Farallon Islands in California, no records could be found describing the contents or the number of barrels resting on the seabed. As a final example, in 1982 sewer line workers inadvertently broke open a poison gas container "buried by the Army when it closed an airfield in 1945. No records were available to the... workers, a loss of 'history' within 37 years."{36} Indeed, the 1961 GNOME Plowshare site is singled out in the Sandia WIPP report under the heading "Out of Sight, Out of Mind":

> "[GNOME] left a concentrated region of intense, long-lived radioactivity at a depth of 1,250 feet... Less than thirty years later, and only about six miles from WIPP, there is clearly little interest in controlling and marking the site. The single GNOME marker already shows signs of weathering and has obviously shifted from its original location. In any case, the marker contains much more information about the test than about any underground hazard. It is difficult to imagine a similar lack of interest if that site were, for example, fifty miles from Washington D.C. [Figure 37]"{37}

ISOTOPE PRODUCTION

Considering the environmental dangers and high costs of

35. Ibid., p. C-74
36. Ibid. See also, "Radioactive Threat to the Farallones", SF *Chronicle*, 05/06/90
37. Ibid., p. D-15

Figure 37

GNOME marker. WIPP site is eight miles directly over the horizon. V.J. Brechin photo.

WIPP facility. DOE photo.

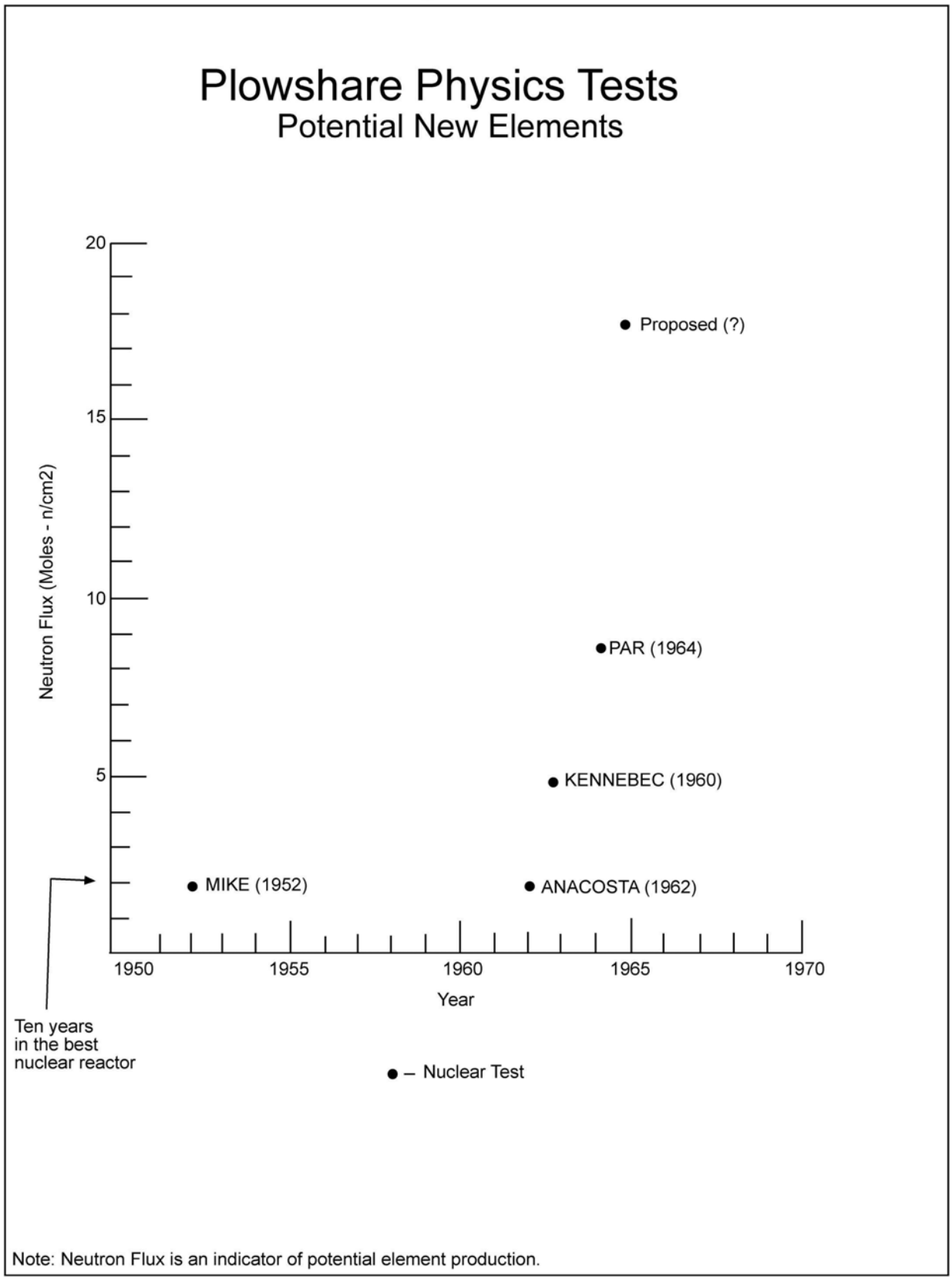
nuclear explosions, why were they ever used in attempts to produce isotopes? Was the effort and hazard justified? Three primary considerations kept the Plowshare physics program active. First, unlike excavation experiments, underground Plowshare physics tests were not affected by the Limited Test Ban Treaty of 1963. Thus, these experiments were leas politically controversial and provided an additional source of funding for the Plowshare program. Second, there was genuine hope that an unexpected scientific breakthrough might arise from these tests. The 1952 test MIKE, which vaporized Elukalb island, created the previously unknown elements 99 (Einsteinum) and 100 (Fermium).{38} And, as mentioned, PAR created element 106 [Figure 38]. Glenn Seaborg explains this hope to a caustic Chairman Pastore during a 1965 JCAE hearing:

> "Chairman Pastore: Project COACH was designed to investigate the production of transplutonium elements [above 94] and other isotopes through the use of nuclear explosions. Does Plowshare hope to compete economically with reactors in quantity production of transplutonium elements and other isotopes?
>
> Dr. Seaborg: May I answer that?
>
> Chairman Pastore: Yes, I was waiting for a Nobel Prize winner.
>
> Dr. Seaborg: ...Some of them [isotopes] produced in this manner might prove to have practical applications. It might be that we could produce some of the already known isotopes more economically in quantity this way. Perhaps the main use, however, would be increasing our knowledge of atomic structure and nuclear structure.... The study of these radioactive properties leads to knowledge about nuclear structure that you can't get any other way."{39}

Finally, Plowshare physics experiments could be carried out expediently and economically by "piggy-backing" the test

38. "The Present Status of Scientific Applications of Nuclear Explosions", G. Cowan et. al., LANL, 1970, p. 1246
39. JCAE, "Authorizing Legislation FY 1965", pp. 1211-1212

Figure 38



Source: "Peaceful Applications of Nuclear Explosives - Plowshare", JCAE Hearing, 1st Session, 1/5/65, p. 3

apparatus onto already planned weapons development tests. This type of arrangement was not possible with Plowshare excavation or extraction tests. Hence, while there were only five dedicated Plowshare physics tests [GNOME, ANACOSTIA, KAWEAH, PAR and VULCAN], there were sixteen “piggy-backed” tests or weapons related tests with Plowshare physics applications [Map 48].

Of these sixteen tests, ten [ANCHOVY, KENNEBEC, GREYS, OCONTO, BYE, BARBEL, TWEED, DURYEA, KANKAKEE and HUTCH] released radioactive isotopes into the atmosphere from DRILLBACK releases.{40} Test PETREL may also have had a DRILLBACK release. KENNEBEC, ANCHOVY and PARROT had EVENT releases as well. The PARROT EVENT release lasted eight days.{41} Only GERBIL, SCAUP, CYCLAMEN and PERSIMMON were completely contained underground. All but one of the sixteen tests [DURYEA] created a subsidence crater [Maps 49 & 50]. While usually occurring within minutes, ground collapse took more than a day for several tests [BYE, SCAUP and HUTCH]. KANKAKEE’s 1,300 foot diameter crater did not form until seven days after the explosion [Map 21].{42}

PROJECT HANDCAR & “PEACEFUL” NUCLEAR EXPLOSIONS

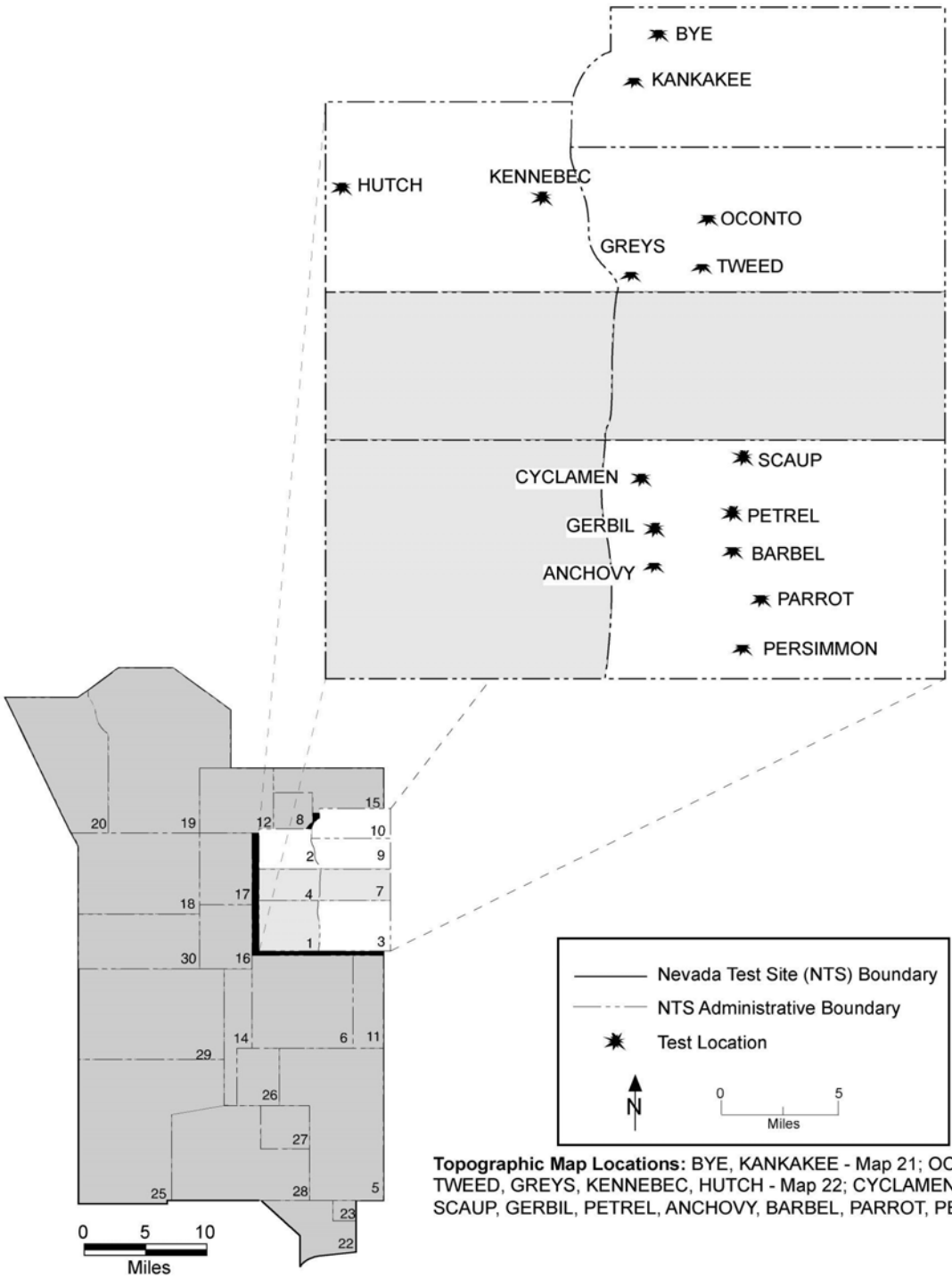
Plowshare physics experiments highlight the contradictions inherent to “peaceful” nuclear explosions. As stated, at least sixteen weapons-related tests had Plowshare physics applications as well. One of these tests, shot KENNEBEC, is described in a 1963 AEC bulletin as a dedicated Plowshare test, yet it is now categorized as a weapons-related test with Plowshare

40. “Radiological Effluents”, 1990
41. Ibid., p. 67
42. “Seismic Summary”, pp. 11-28

Map 48

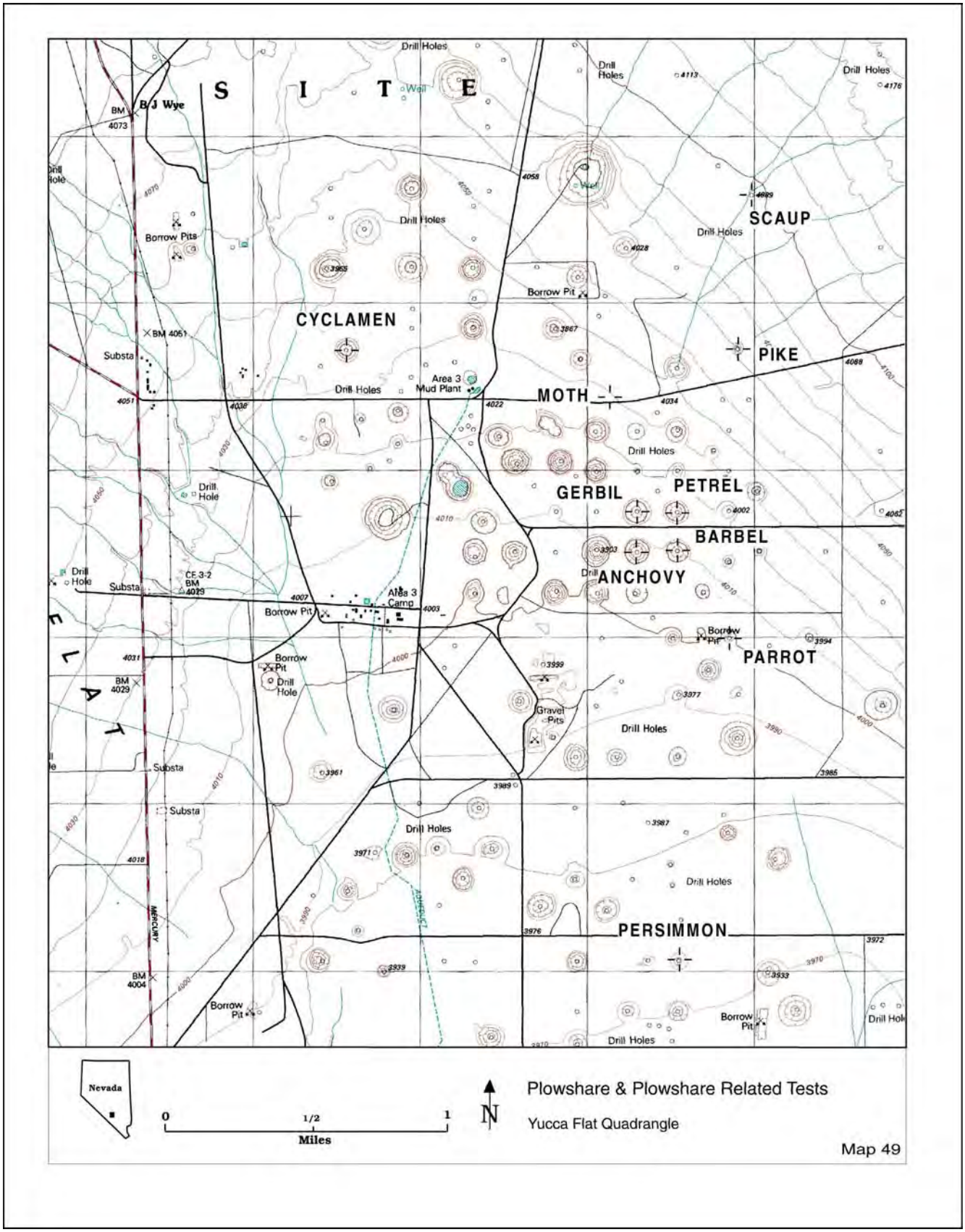
Physics “Piggy-Backed” Tests

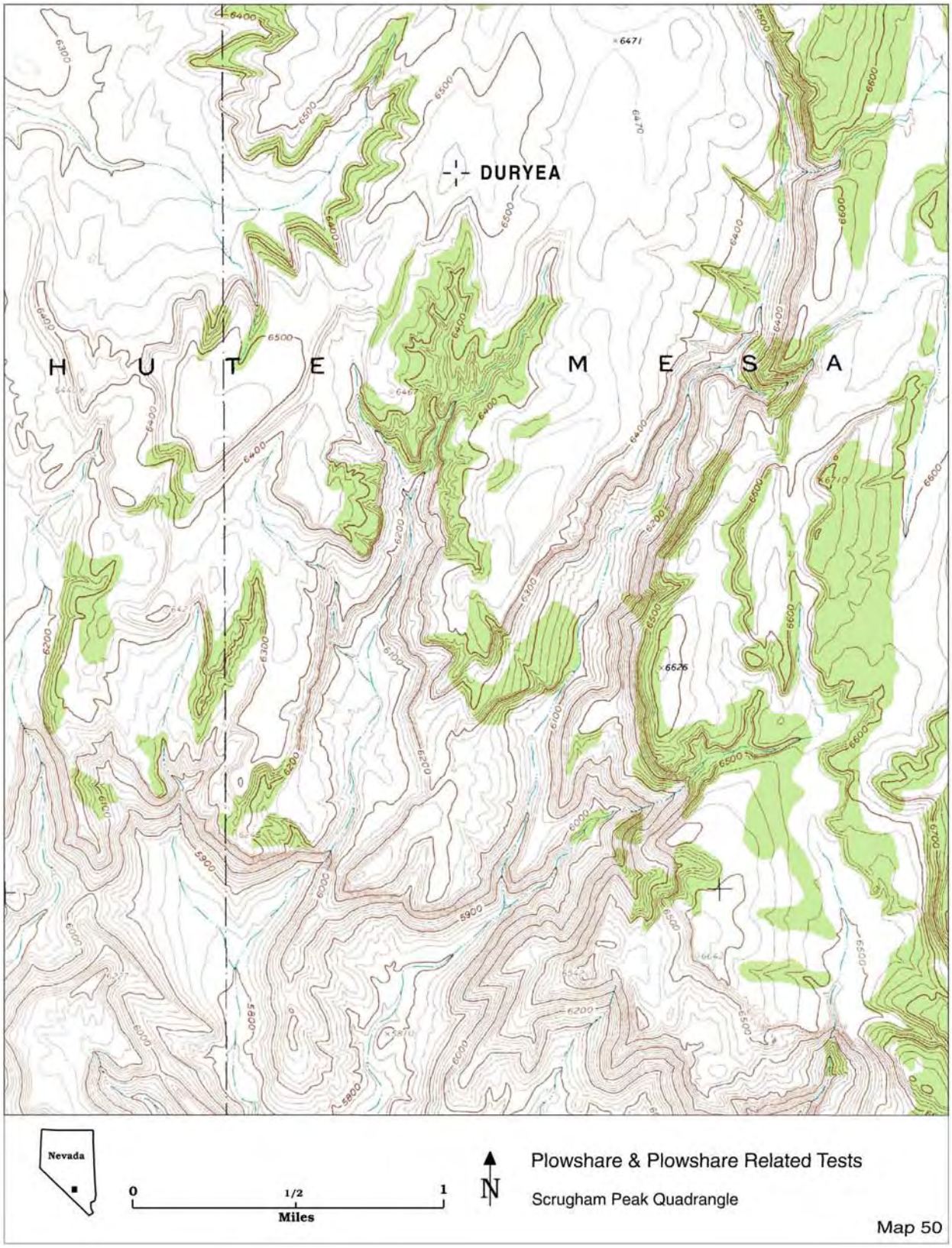
Nevada Test Site



Topographic Map Locations: BYE, KANKAKEE - Map 21; OCONTO, TWEED, GREYS, KENNEBEC, HUTCH - Map 22; CYCLAMEN, SCAUP SCAUP, GERBIL, PETREL, ANCHOVY, BARBEL, PARROT, PERSIMMON - Map 49.

Source: Springer, D., “Seismic Source Summary”, UCRL-73036, 02/71.


S I T E
Well
B J Wye
BM 4073
Drill Holes
Drill Holes
Drill Holes
Borrow Pits
Drill Holes
SCAUP
Drill Holes
Borrow Pit
CYCLAMEN
BM 4061
Substa
PIKE
Drill Holes
Area 3 Mud Plant
MOTH
Drill Holes
GERBIL
PETREL
Drill Hole
BARBEL
Drill Hole
Substa
CE 3-2 BM 4029
Area 3 Camp
Borrow Pit
ANCHOVY
Borrow Pit
PARROT
Borrow Pit
Drill Hole
BM 4029
Gravel Pits
Drill Holes
Substa
Substa
Drill Holes
Drill Holes
PERSIMMON
MERCURY
BM 4004
Borrow Pit
Borrow Pit
Drill Holes
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Yucca Flat Quadrangle
Map 49


DURYEA
H U T E M E S A
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Scrugham Peak Quadrangle
Map 50

applications.{43}{44} “Peaceful” Plowshare and VELA UNIFORM tests often had militarily useful applications and vice-versa. For example, HARD HAT and PILE DRIVER were two weapons effects tests detonated in a granite outcropping on the northern edge of the Nevada Test Site [Maps 51 & 52][Figure 39]. Although their primary purpose was to develop underground bunkers that could withstand a “large yield surface detonation”, these tests also had Plowshare applications. For instance, the cavity created by HARD HAT was huge, measuring 225 feet across and 485 feet high. It was thought a cavity this large would be useful as an underground storage vault for natural gas, or as a means to break up rock beneath a gas field to allow more gas flow to the surface.{45} Both tests are frequently referred to in this regard in Plowshare literature. Likewise, test SHOAL was a “peaceful” VELA UNIFORM experiment conducted in a granite formation of the Sand Spring Range thirty miles southeast of Fallon, Nevada [Map 53][Figure 40]. It is likely information from SHOAL has been used by silo and bunker designers because, along with HARD HAT and PILE DRIVER, it is one of the few United States nuclear tests ever exploded in granite.

Similarly, MUDPACK and DISCUS THROWER were exploded in a dolomite formation south of Rainier Mesa at the Nevada Test Site [Map 21]. These weapons tests were used to design hardened military command and control structures that could survive a nuclear war. Livermore Labs also exploded HANDCAR, a dedicated Plowshare test, in the same dolomite formation because many

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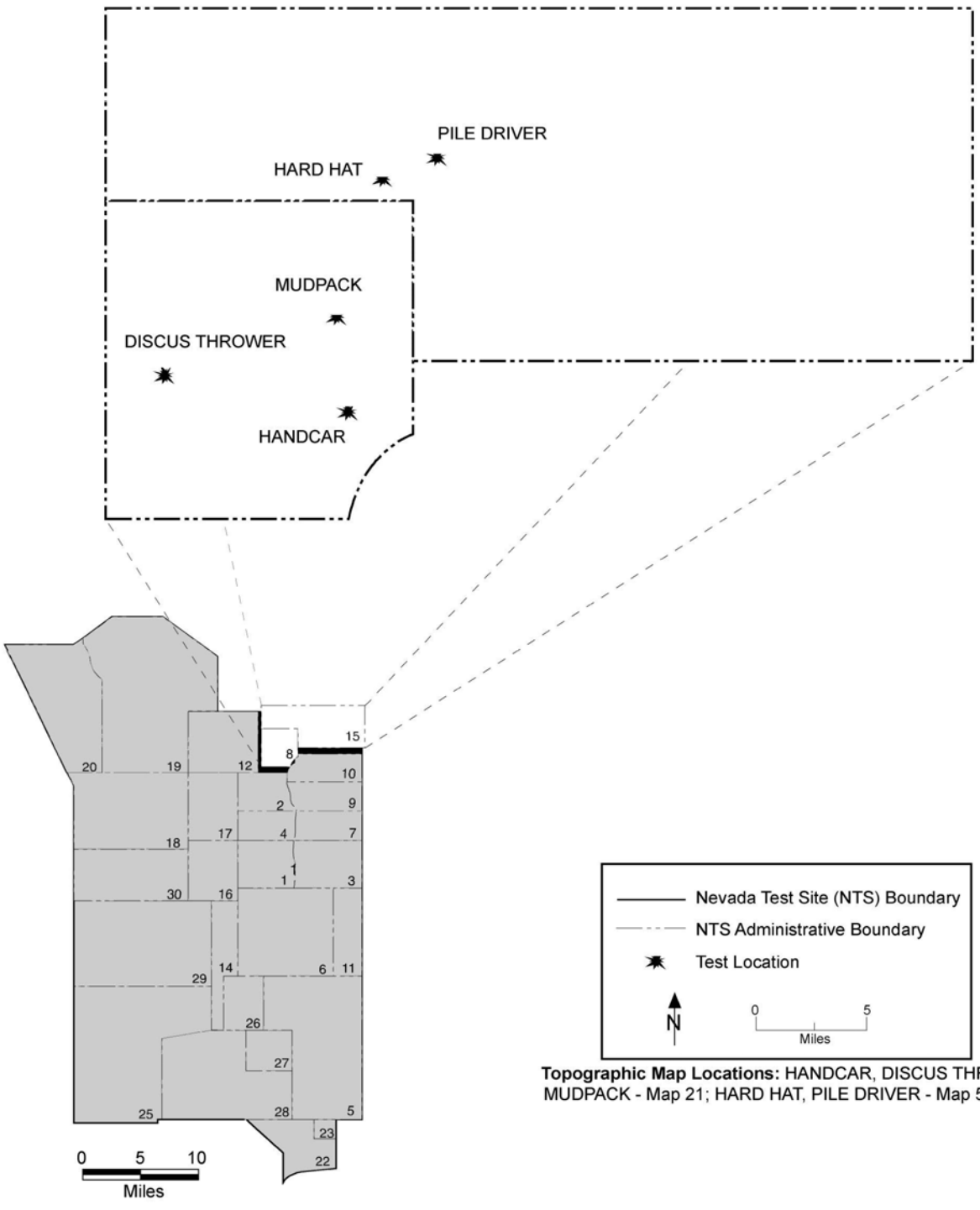
43. “STORAX Test Bulletin No. 42”, US AEC, 06/27/63, declassified with deletions 07/22/81
44. “Announced US Nuclear Tests”, p. 92
45. See, for example, JCAE, “Commercial Plowshare Services”, 1968, p. 435 [PILE DRIVER] and JCAE, “Authorizing Legislation FY 1967”, p. 1355 [HARD HAT]

Map 51

HANDCAR and Plowshare Related Tests
Nevada Test Site



Topographic Map Locations: HANDCAR, DISCUS THROWER, MUDPACK - Map 21; HARD HAT, PILE DRIVER - Map 52.

Source: Springer, D., "Seismic Source Summary", UCRL-73036, 02/71.

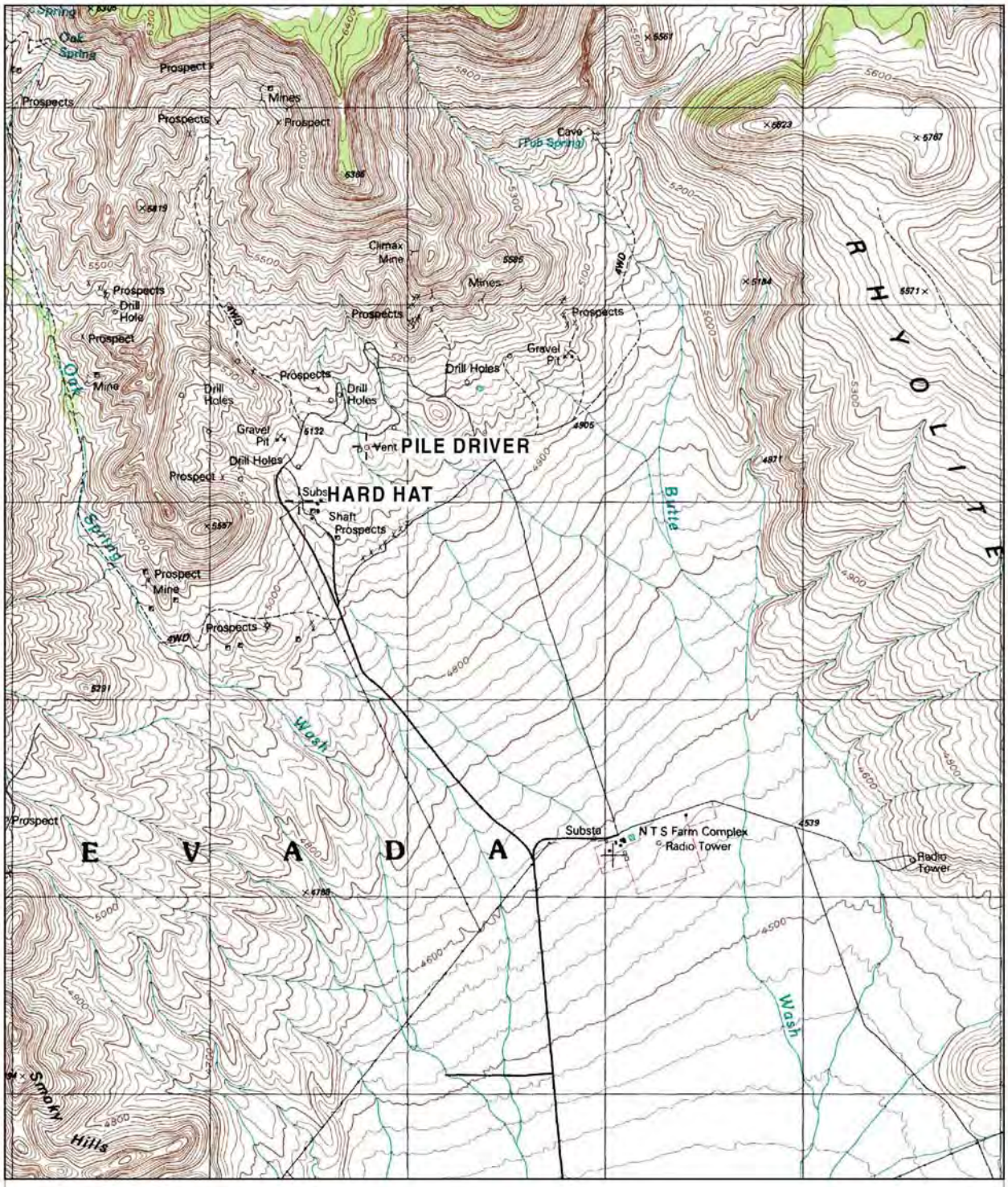
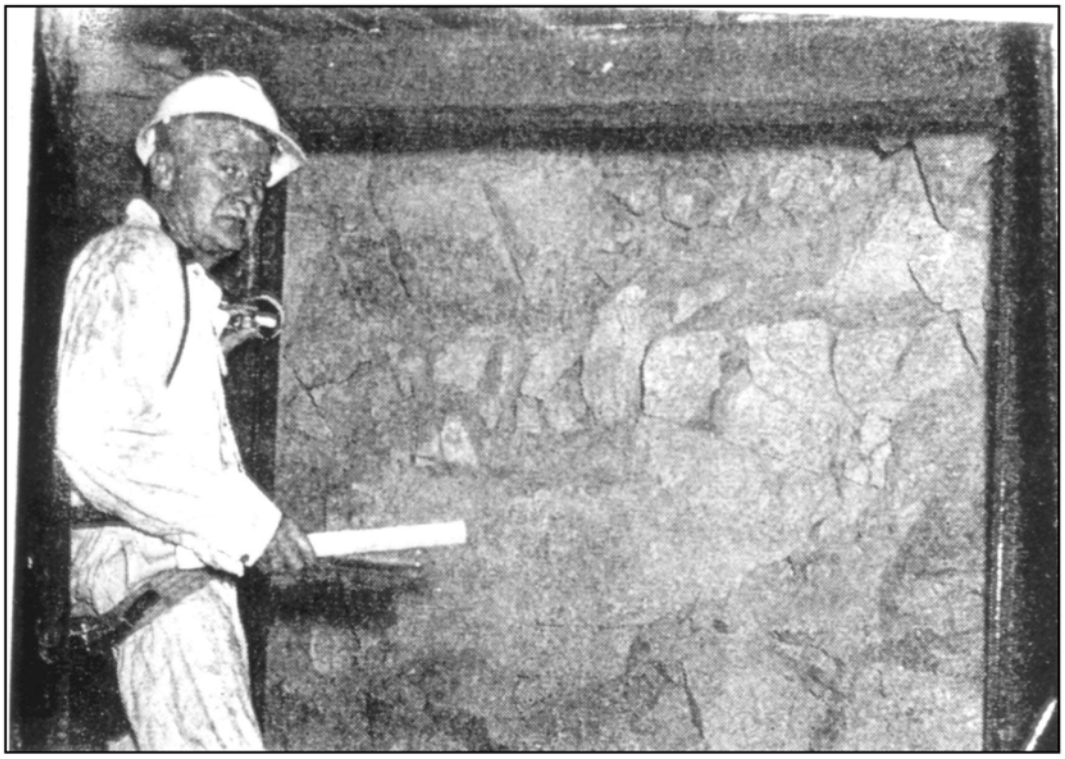

Oak Spring
Prospect
Prospects
Mines
Prospect
Cave
Climax Mine
Mines
Prospects
Drill Hole
Prospect
Mine
Drill Holes
Prospects
Drill Holes
Gravel Pit
Drill Holes
Prospects
Gravel Pit
Drill Holes
Vent
PILE DRIVER
Prospect
Subs
HARD HAT
Shaft
Prospects
Prospect
Mine
Prospects
Oak Spring
Butte
Wash
Prospect
E V A D A
Substa
N T S Farm Complex
Radio Tower
Radio Tower
Wash
Smoky Hills
R H Y O L I T E
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Oak Spring Quadrangle
Map 52

Figure 39

HUTCH subsidence crater. LLNL photo.



Fractured rock from PILE DRIVER chimney as viewed
from side tunnel 600 feet below the surface. LLNL photo.

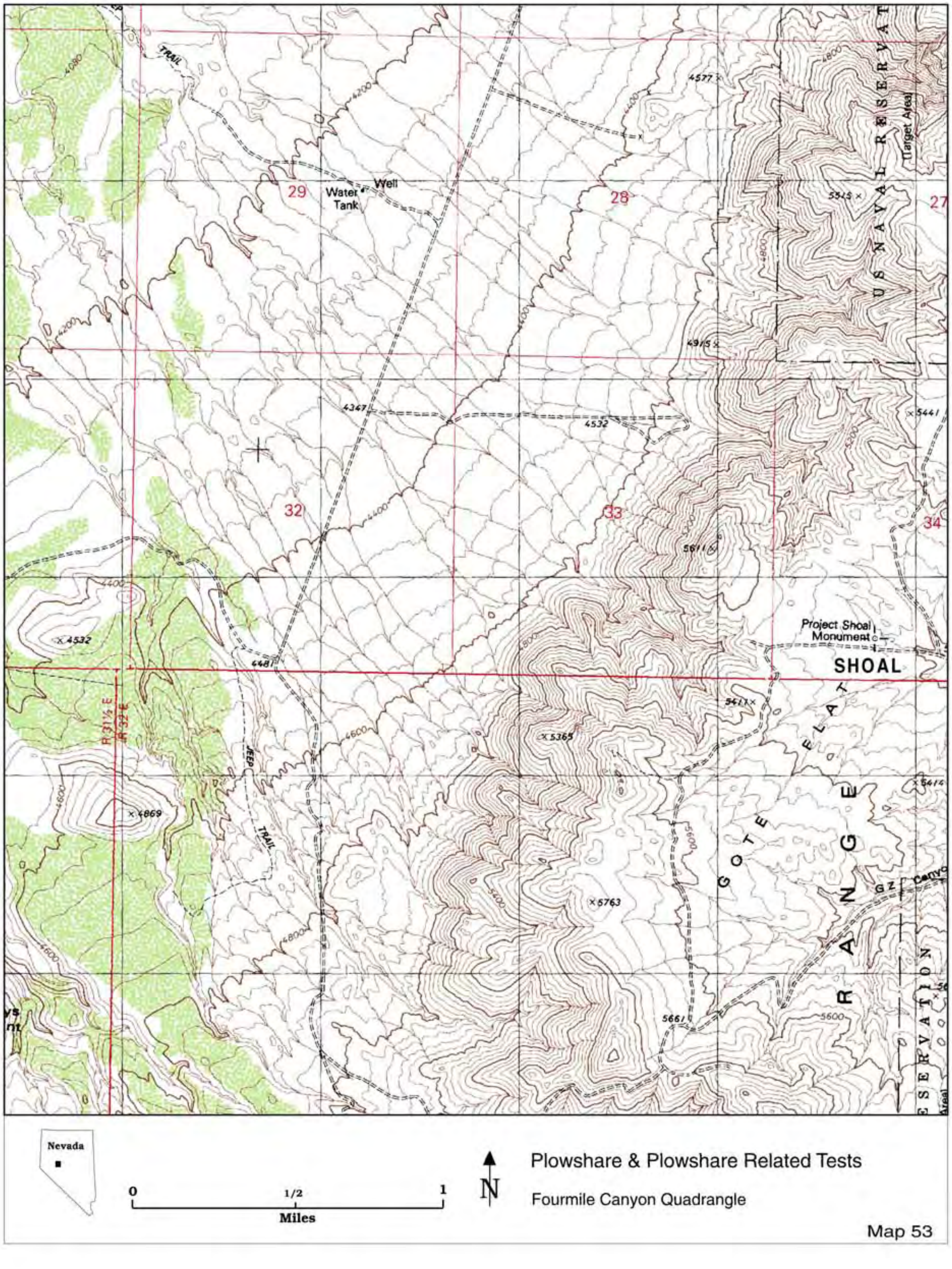

29
Water Tank
Well
28
27
32
33
34
4577
5515
4915
4347
4532
5441
5611
Project Shoal Monument
SHOAL
4532
4481
5411
5365
R 31½ E
R 32 E
JEEP
TRAIL
4869
5414
5763
5661
5600
U S NAVAL RESERVATION
(Target Area)
GOTE FLAT
RANGE
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Fourmile Canyon Quadrangle
Map 53

Figure 40

The remains of the SHOAL monument. The date or manner in which the monument was destroyed is unknown. Ironically, SHOAL is the only nuclear test outside of the Nevada Test Site specifically designated on topographic maps (see Map 53). V.J. Brechin photo.

underground resources such as oil and gas deposits are associated with this rock.{46} Thus, a Plowshare test, HANDCAR, detonated a month apart and eleven hundred feet to the north of a weapons related test, MUDPACK, used the same dolomite formation for presumably opposite goals. Not surprisingly, however, HANDCAR also had a Department of Defense (DOD) experiment "piggy-backed" onto it. This experiment, code-named PAINTED PONY, was part of the MUDPACK and DISCUS THROWER series.{47}

Plowshare excavation tests also had military applications. A troop maneuver was proposed for the SULKY excavation experiment because "the use of high explosive charges to simulate a nuclear explosion is a poor substitute for the real thing."{48}

> "[SULKY] would provide... field measurements on the responses of military equipment to flying rock and dust. It would also permit training of troops in measurements and operations in the radioactive environment... Finally, a great deal would be learned psychologically simply through exposure of troops at close, but of course, safe ranges."{49}

Thus, there is a distinct overlap between "peaceful" Plowshare tests and weapons related experiments. Occasionally, as with the previous examples, the overlap is made explicit in government documents and congressional testimony. More often, the contradictions inherent in the term "peaceful" nuclear explosions are only reluctantly admitted:

> "Representative Hosmer: ...This Plowshare program which, I believe, $56 million thus far has been spent, has it been a weapons program?

46. JCAE, "Peaceful Applications of Nuclear Explosives", 1965, p. 33
47. JCAE "Authorizing Legislation FY 1966", p. 195, and "FLINTLOCK Test Bulletin No. 28", 05/13/66, declassified with deletions
48. Letter to General Crowson, 10/13/64, CIC#104128, declassified with deletions
49. Ibid

> Dr. Seaborg: No.
>
> Representative Hosmer: Has it had military applications?
>
> Dr. Seaborg: You can use nuclear explosions for cratering, for demolition operations and so forth, but largely speaking, it is pointed toward peaceful applications.
>
> Representative Hosmer: You would not put one of these devices for cratering on the tip of an ICBM, would you? That is an entirely different breed of cat.
>
> Dr. Seaborg: I don't know what the purpose of that question is.
>
> Representative Hosmer: What I am trying to establish, Dr. Seaborg, is that if in fact this program is a totally peaceful one, then it has no bearing upon the generally emotional approach to the nuclear weapons problem.
>
> Dr. Seaborg: ... But it is tied in this way... the development of these advanced types of nuclear explosives might be considered to have relevance to the improved weapons, because the same principles might be used. [Also]... some might argue that if you allow the development of nuclear explosives for Plowshare under a comprehensive test ban treaty, this might be used as a front for the improvement of nuclear weapons for military purposes."{50}

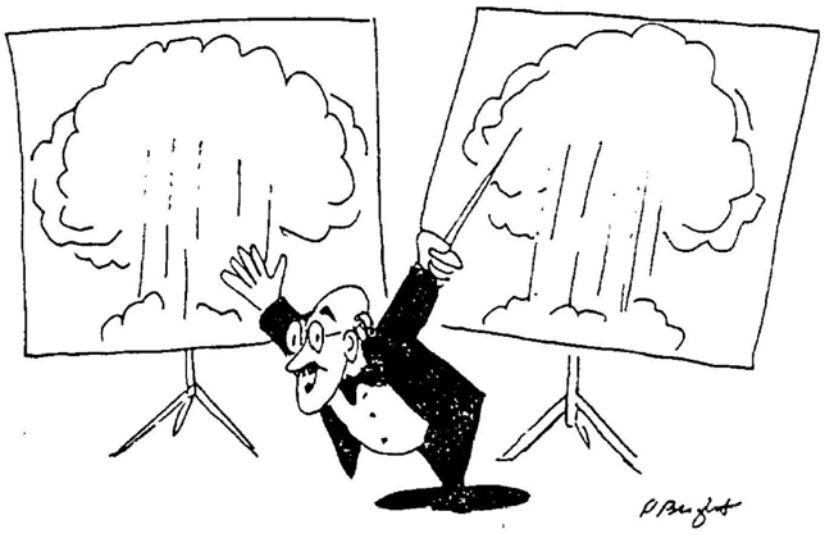
Whether a nuclear explosion is "peaceful" or not is clearly a matter of perception [Figure 41]. In the words of Dr. Robert Kuckuck of Livermore Labs: "We don't really test bombs, we do physics experiments."{51} According to the Threshold Test Ban Treaty of 1974, a "peaceful" test is literally determined by where one stands:

> "Senator Church: What is a peaceful test? How is it to be distinguished from a test for other purposes? India when it exploded its first device declared it was a peaceful test.
>
> Mr. Warnke: ... Under the treaty the distinction is in terms of location. In other words, any nuclear explosive

50. JCAE, "Peaceful Applications of Nuclear Explosives", 1965, p. 30
51. Quoted in Nevada Desert Experience flier, 03/92.

Figure 41

"Peaceful" Explosions?



And here we have a peaceful nuclear explosion. Please, notice the peaceful posture of this device, not like this warlike device on my right.

Source: "Peaceful Nuclear Explosions", B.A.S., May, 1975, p.33.

> device which is exploded on a nuclear weapons test site is counted as a weapons test. Anything that takes place outside that location is a peaceful nuclear explosion."{52}

The uneasy relationship between peaceful tests and weapons related tests is summarized well by two biblical verses, the first of which gave the Plowshare program its name:

> "They shall beat their swords into plowshares and their spears into pruning-hooks." Isaiah 2:4
>
> "Beat your plowshares into swords, and your pruning-hooks into spears." Joel 4:10

52. Committee on Foreign Relations Hearing, "Threshold Test Ban And Peaceful Nuclear Explosions Treaties", 1977, p. 12

PLOWSHARE EXTRACTION PROJECTS

The Plowshare excavation program was effectively ended in 1970 by political, environmental and health concerns. Likewise, funding for Plowshare physics experiments was cut due to disappointing test results. For Plowshare planners, one area of research still appeared promising - Plowshare extraction projects. As stated, Plowshare extraction experiments were efforts to improve natural gas and oil shale recovery, facilitate hard rock mining, alter aquifer flow patterns, and produce energy from the heat created by a nuclear blast. The only tests actually carried out under the Plowshare program were those involving the recovery of natural gas. These nuclear experiments, GASBUGGY, RULISON and RIO BLANCO, will be examined, while various other extraction proposals will be briefly reviewed.

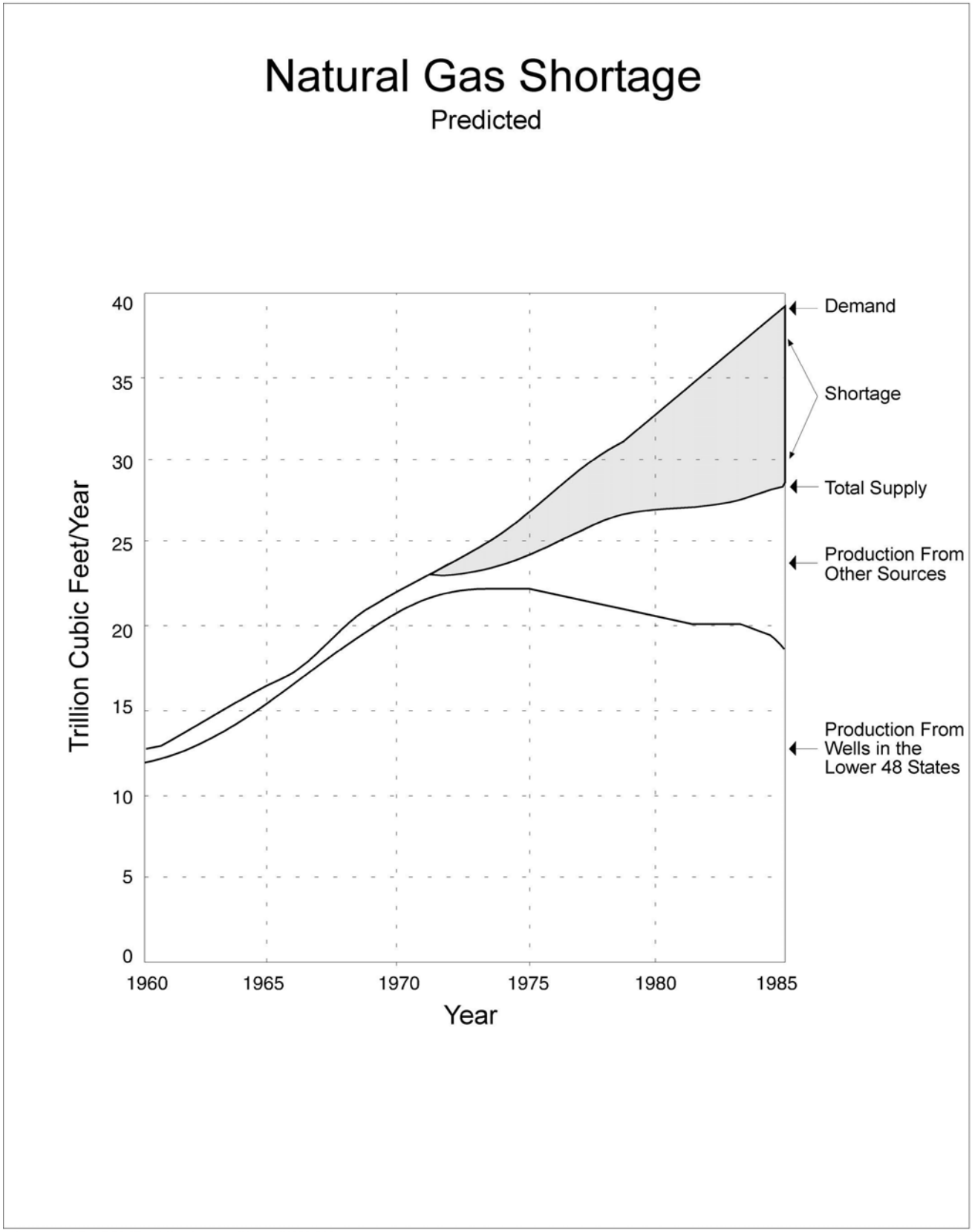
PROJECT GASBUGGY

By the mid 1960's, it appeared that the United States was running headlong into a severe energy crisis [Figure 42]. Plowshare planners proposed alleviating this crisis by using nuclear explosives to open "tight" gas formations that were uneconomical using conventional methods.{1} The Plowshare experiment code-named GASBUGGY was the first of three nuclear experiments to develop this technology [Map 54].

The criteria used to select a site included finding a "tight" gas reservoir within 4,000 feet of the surface to limit drilling expenses. The site was also required to be "reasonably

1. See, for example, JCAE, "Authorizing Legislation FY 1972", p. 2336

Figure 42



Source: JCAE "Authorizing Legislation FY 1972",

Map 54

Gas Stimulation Sites

Completed Projects

Plowshare Site

Basins with Potential Gas & Oil Producing Strata

N

0 100 200

Miles

Source: JCAE "Authorizing Legislation FY 1972".

remote from habitation, but easily accessible."{2} The Green River Basin was initially considered for oil shale or gas field experiments because "the site is so far removed from surface and underground water and habitation - [it] is extremely rugged country out there."{3} However, by the summer of 1964, an area overlying the San Juan Basin gas field was selected and survey teams began gathering data on the number and distribution of people, cattle and milk cows within a hundred mile radius of the proposed ground zero.{4} Ground zero itself was twenty miles northeast of the town of Dulce, New Mexico, tribal headquarters of the Jicarilla Apache Indian Reservation. Perhaps due to leasing restrictions, the emplacement hole was one-half mile outside the Indian reservation boundary [Map 55][Figure 43].

It appears there was little, if any, public opposition to the blast. A 1991 article in the Santa Fe Reporter states: "press coverage of the experiment was extremely positive and would be considered blatant boosterism by today's standards."{5} An Albuquerque *Tribune* article published in November 1967, one month before the blast, illustrates this boosterism. Entitled "Blast Good for Hunters, Forest Service Says", the article argues that the road building necessary for GASBUGGY will help hunters track deer more easily. The article reassures the reader that wildlife will not be harmed by the blast because: "Wildlife, especially the herd of mule deer is very important. They must be preserved for the more than 5,000 hunters who come here each fall." The cattle industry would benefit from the blast, according to the article,

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2. "Project GASBUGGY, US AEC, 05/14/65, p. 8
3. JCAE, "Authorizing Legislation FY 1967", p. 1380
4. "Report of Population and Agriculture Survey PRE-GASBUGGY", 07/14/64, CIC#36026
5. "Nuclear Slag in Rio Arriba", P. Wolff, Santa Fe *Reporter*, 07/17/91

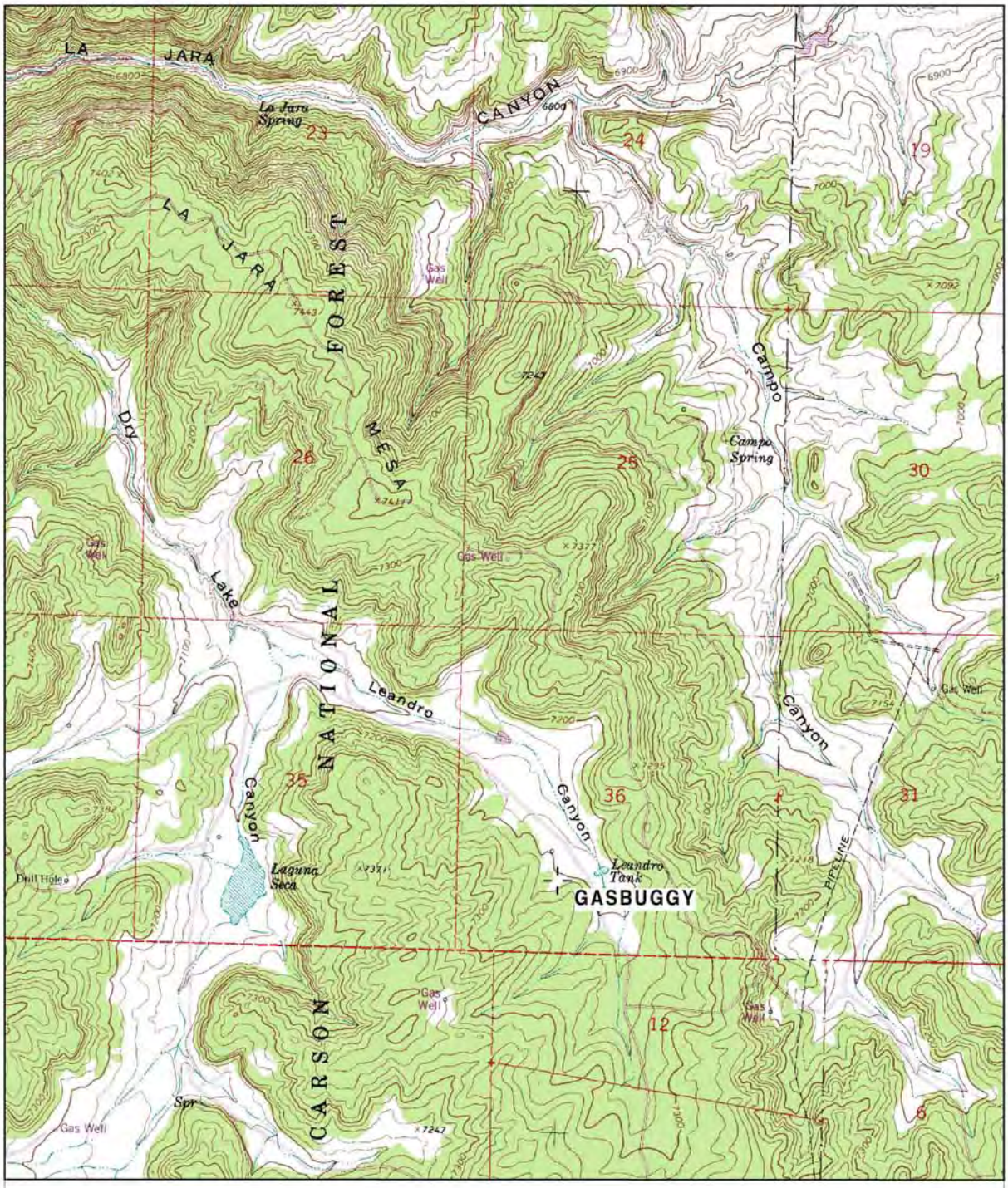
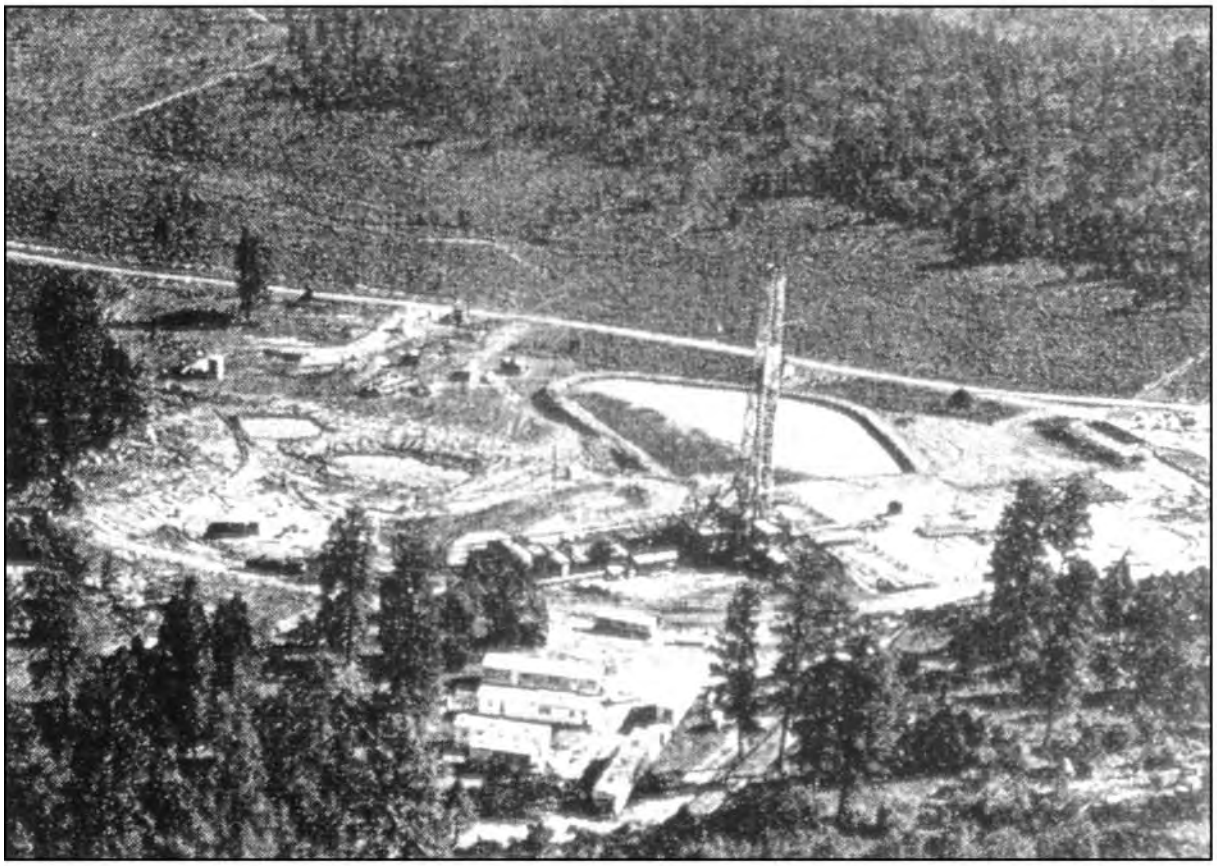

LA JARA CANYON
La Jara Spring
LA JARA MESA
CARSON NATIONAL FOREST
Dry Lake
Leandro Canyon
Campo Canyon
Campo Spring
Laguna Seca
Leandro Tank
GASBUGGY
PIPELINE
Drill Hole
Gas Well
Spr
New Mexico
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Leandro Canyon Quadrangle
Map 55

Figure 43



Overview of GASBUGGY site. LLNL photo.

GASBUGGY today. V.J. Brechin photo.

because of reseeding efforts on land cleared for drilling equipment. Even the trees cleared around ground zero were sent to a post-making firm in Aztec, New Mexico, so “nothing was wasted”, the article concludes.{6} As another example, a rather inappropriate mix of images was presented by *Petroleum Today*, in an article promoting GASBUGGY:

> “A gentle breeze blows through stands of juniper and ponderosa pine in New Mexico’s Carson National Forest. The sun moves serenely among scattered clouds. On such a day this fall, far beneath the surface of a forest clearing, the detonation of a nuclear device bearing the power of 26,000 tons of TNT will signal man’s first use of an atomic explosion for industrial purposes.”{7}

Behind the scenes, the AEC was determining “acceptable fallout sectors” should GASBUGGY vent radiation. The GNOME venting was used as a model, although it was scaled down “tenfold to allow for dilution due to the natural gas that would have to accompany venting from GASBUGGY.”{8} The GASBUGGY explosion, at 29 kilotons, was six times larger than GNOME. Originally proposed as a ten kiloton experiment, the yield of GASBUGGY was increased for fear a smaller blast might not “open” the gas formation.{9} It should be emphasized that GASBUGGY was an experiment only and the area around Dulce was to be the testing ground. In the words of a Livermore employee: “GASBUGGY could never be economic from the standpoint of the value of the gas produced, nor was it ever meant to be economic.”{10}

On December 10th, 1967, GASBUGGY was detonated 4,200 feet beneath the surface. As with the other Plowshare extraction

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6. “Blast Good for Hunters, Forest Service Says”, Albuquerque *Tribune*, 11/07/67
7. Quoted in “Isaiah’s Prophecy”, C. Buys, *Colorado Heritage*, Issue #1, 1989, p. 30
8. Memo, “Gary Niggins, LRL to Robert Miller, NVOO - GASBUGGY venting model”, 11/22/66, CIC#35352
9. JCAE, “Authorizing Legislation FY 1967”, p. 1705
10. The Nuclear Impact, p. 67

projects, it was buried too deeply to create a subsidence crater. A small amount of radioactivity leaked into the atmosphere through a cable in the emplacement hole.{11} This leak was sealed but later tests to determine gas flow brought up large quantities of tritium contaminated water. Thirty-six 55-gallon drums of this water was "gelled" and sent to the Nevada Test Site for disposal.{12} An additional 118,440 gallons of contaminated water, the equivalent of 2,725 55-gallon drums, were vaporized on site by GASBUGGY's gas flare, releasing the tritium into the atmosphere. It was considered too costly to dispose of the water by other means.{13} GASBUGGY was considered a success, although the contaminated water highlighted an irony of the Plowshare program. While a pure fusion or "clean" bomb was the ideal explosive for Plowshare excavation projects, for extraction projects it was the worst. Fusion bombs create large amounts of radioactive tritium, which bonds readily with natural gas, making it impossible to market. The next Plowshare extraction test, RULISON, would use an "old fashioned" 40 kiloton fission bomb.{14}

PROJECT RULISON

The RULISON project was voted news story of 1969 by newspaper editors in Colorado, the state chosen by the AEC to host the experiment.{15} A local paper gives one reason:

> "Due to a number of federal blunders in recent months - sheep killed by nerve gas at the Dugway Utah, proving

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11. "GASBUGGY Preliminary Postshot Summary Report", F. Holzer, 01/68, PNE-1003, pp. 3-4 [note: this release is not mentioned in "Radiological Effluents"]
12. "GASBUGGY On-Site Radiological Safety During Production Testing", US AEC, 1971, PNE-1006, p. 5
13. Ibid.
14. "Plowshare Technology Assessment", 1973, pp. III-7
15. The Nuclear Impact, 1976, p.73

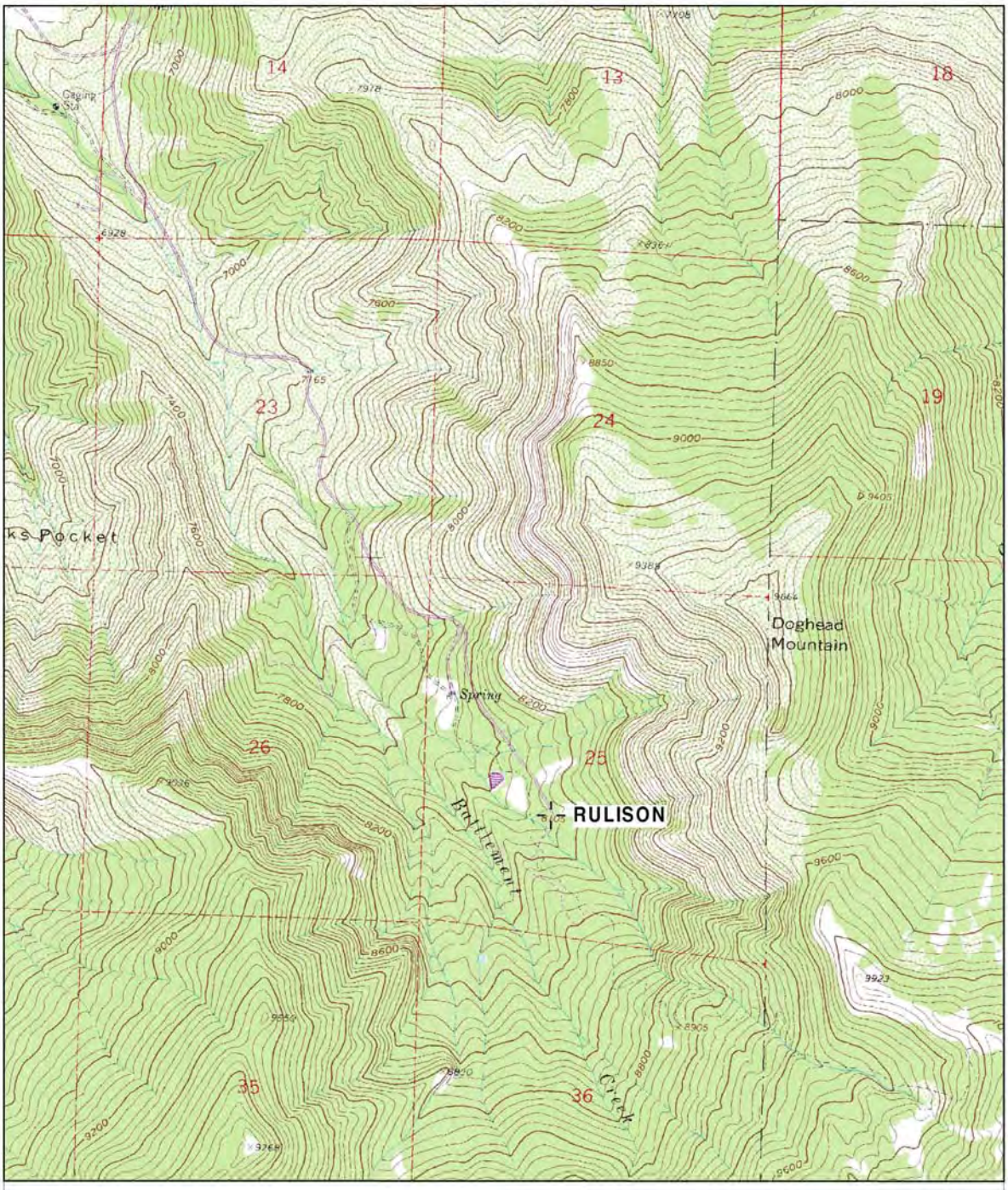
> ground; nerve gas stored in Denver; and the fire at Rocky Flats Plant - RULISON is getting much closer scrutiny by the state, the press and outside scientists."{16}

RULISON was originally intended as two 50 kiloton explosions buried 1,000 feet apart in the same hole. Due to engineering difficulties with this approach, the proposal was changed to one 40 kiloton bomb which would be buried over a mile and a half beneath the surface.{17} RULISON, like GASBUGGY, was an experiment only. Its purpose was to provide data on a new gas formation (the Piceance Basin) with different characteristics at a much greater depth [Map 56].{18}

RULISON was jointly sponsored by the AEC, Los Alamos Labs and the Austral Oil Company. Austral Oil, for example, was responsible for drilling the 8,500 foot RULISON emplacement hole, the deepest hole ever used for a nuclear blast. Incredibly, the 1,500 pound bomb fashioned for the experiment was only nine inches in diameter and fifteen feet long.{19}

As stated, public debate concerning RULISON was much more heated than had been the case with either GNOME or GASBUGGY. Several lawsuits were filed to delay or cancel the test by various groups such as the Colorado Open Space Coordinating Council and the American Civil Liberties Union. Literature distributed by the Colorado Committee for Environmental Information, another group opposed to the blast, stated: "The people of Colorado have never been given the opportunity to consent or refuse to be experimented on."{20} Mark Hogan, Lt. Governor of Colorado, echoed this sentiment: "Colorado must make it forcefully clear to the Federal

16. Meeker *Herald*, "Rulison Underground Test Shot is Given Go Ahead", 08/14/69
17. JCAE, "Authorizing Legislation FY 1969", p. 1139
18. Ibid.
19. "Plowshare Technology Assessment", 1973, pp. III-7
20. The Nuclear Impact, 1976, p. 90



Plowshare & Plowshare Related Tests

Rulison Quadrangle

Map 56

government that we do not want this state to be used as an experimental area."{21} A letter to a local paper asked: "What has Colorado done to itself, in alluring this ghastly outrage?... No tourists are going to come here. It's too risky."{22} The blast was, in fact, delayed several times. These delays infuriated Representative Aspinall, a congressman from Colorado who vigorously supported RULISON:

> "Representative Aspinall: Now as I understand it, Mr. Kelly, some of the reasons given for the postponement of the shot were first, that because of the area concerned, a shot at this time of year could cause land and rockslides... and also because of the approaching tourist season... Let me ask you this, Mr. Commissioner: Who in the name of commonsense ever advised you that this was an area where tourists went?... For what purpose would they go into this particular area within 5 or 10 miles of the shot site.?
>
> Mr. Miller: These people include campers and hikers. There are also something in the order of 9,200 cattle units... which would be moving into the area about the same time."{23}

Representative Aspinall follows up this line of discussion with the head of the Department of the Interior:

> "Representative Aspinall: You apparently got some information about this being one of the real pretty playgrounds out in that area just recently?... As far as this particular location where the shot is to be fired, if it ever is fired, who was it that led somebody in the Department of the Interior to believe that this is a recreation area?... Of course, you can understand how embarrassing this is to me as a member of the committee, having the preservationists and the professors, most of them now wearing long hair, objecting to it [RULISON] because they have some exaggerated feeling about environmental quality."{24}

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21. Ibid., p. 92
22. Letter to the Editor, *The Daily Sentinel* (Grand Junction), 08/18/69, CIC#0171974
23. JCAE, "Nuclear Explosion Services For Industrial Applications", 1969, p. 83
24. Ibid., p. 109

After some last minute weather delays to allow for a wind shift to an “acceptable fallout sector”, RULISON was set to explode on September 10, 1969. In case of rockslide, temporary roadblocks were set up on all nearby state and county roads, as well as 50 miles west and east of ground zero on Interstate 70. The California Zephyr was stopped forty miles from the blast site. Bulldozers stood at the ready to clear roads and railroad track of any rockfall.{25} Photographers “fashioned a pyramid of cans... with the idea of photographing it as the shock wave sent it crashing to earth.”{26} The Meeker *Herald* describes a group of protectors on the scene:

> “Some 30 to 40 young people, many of them carrying expensive looking cameras and commonly referred to as hippies from Aspen, 75 miles to the east, had stationed themselves as protestors... near the observation tent [Figure 44].”{27}

The test appeared to go off without a hitch. Rockfall and seismic shock created $120,000 dollars worth of damage, less than what some feared [Figure 45].{28} However, the complete results of the experiment would not be known for six more months, when sampling equipment was lowered into the RULISON cavity. As it turned out, gas production was disappointing, “not nearly as successful as GASBUGGY.”{29} During the sampling operations, RULISON vented radioactivity from a DRILLBACK release.{30} And, as with GASBUGGY, radioactive tritium produced by the blast was released into the atmosphere during “flaring” operations, despite

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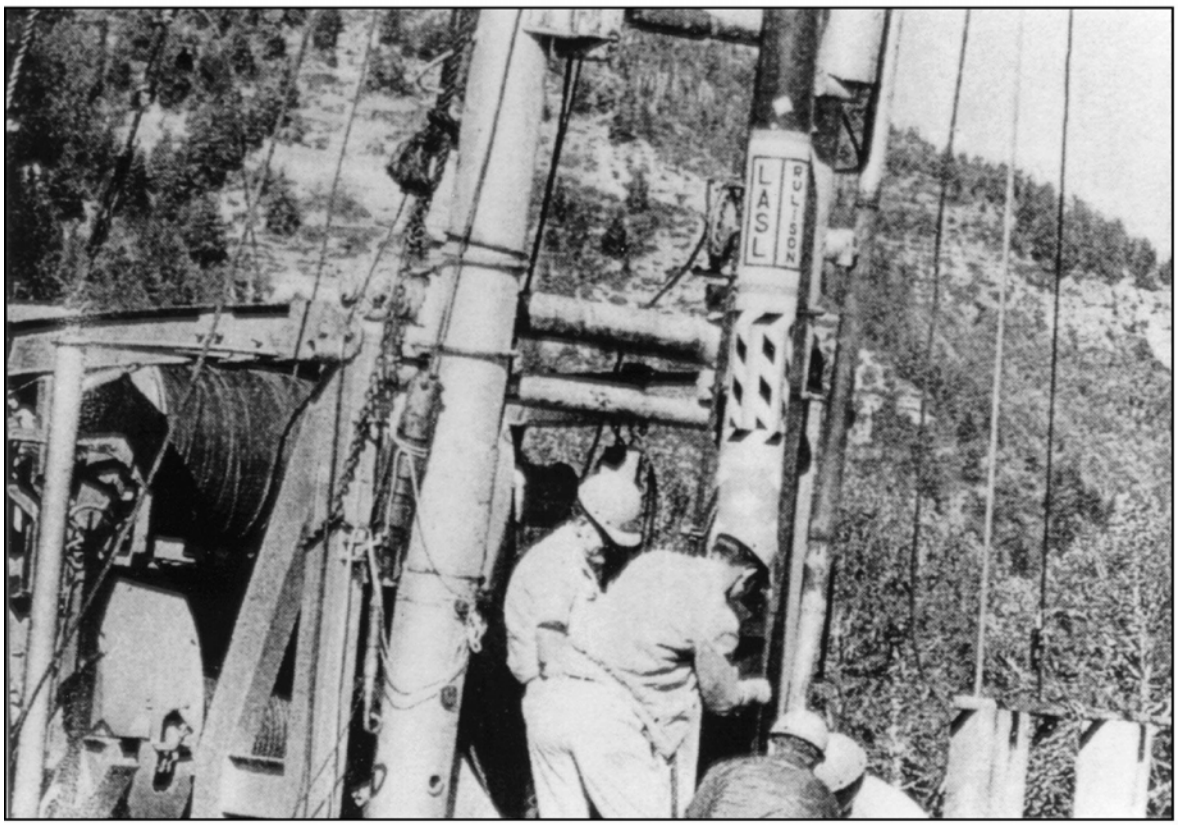
25. “Isaiah’s Prophecy: Project Plowshare in Colorado”, *Colorado Heritage*, 1989, Issue #1, p. 35
26. Ibid.
27. “RULISON Nuclear Shot Fired Wed.” Meeker *Herald*, 09/11/69
28. Committee on Commerce, “Natural Gas Supply for Utah”, 08/24/74, p. 10
29. JCAE, “Authorizing Legislation FY 1970”, p. 12
30. “Radiological Effluents”, 1990, p. 113

Figure 44

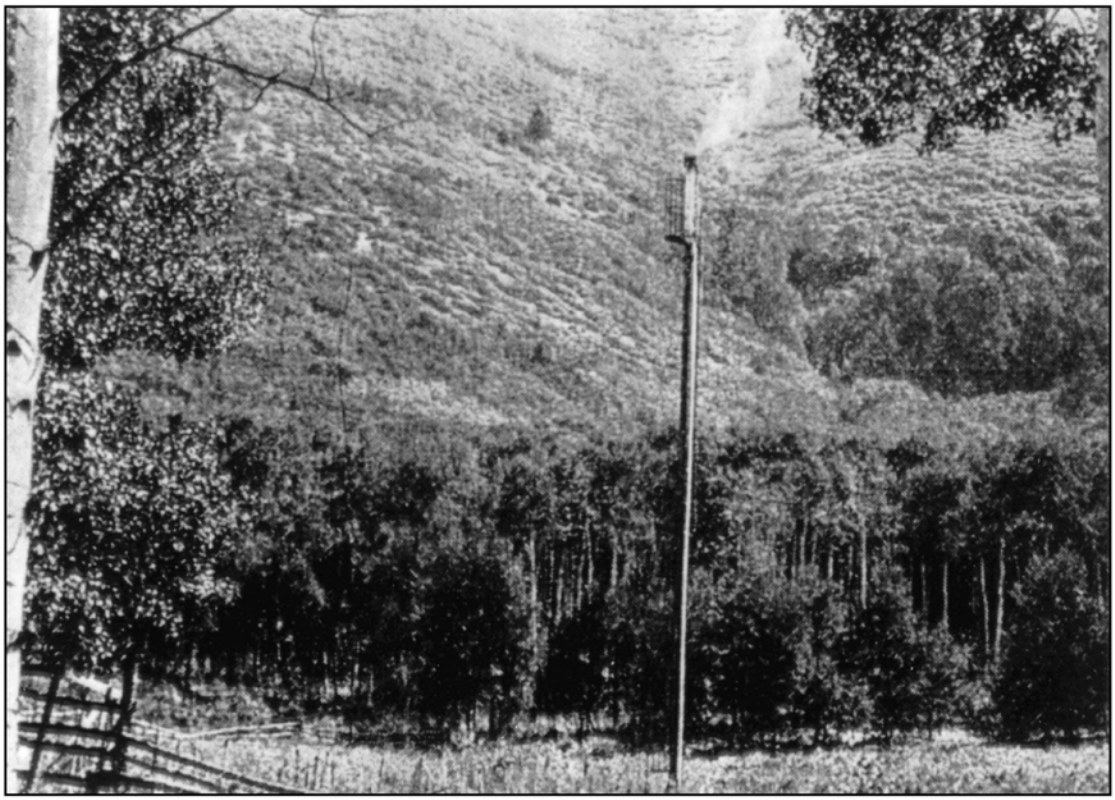
Sign Protesting RULISON Experiment

Source: "Isaiah's Prophecy: Project Plowshare in Colorado", *Colorado Heritage*, 1989, p.35.

Figure 45



Forty kiloton RULISON explosive being lowered into 8,430 foot drillhole. LLNL photo.



RULISON natural gas and tritium flaring, October 1970. LLNL photo.

protests and lawsuits to prevent this activity [Figure 46].{31}

A "DEVICE" IN SEARCH OF A TEST: MINIATIA & YACHT

Four times less tritium was produced by RULISON than GASBUGGY.{32} However, "the image of a woman in the kitchen with a baby on her knee and radioactive gas burning on the stove was a powerful deterrent to the commercial use of nuclear-stimulated gas in the home."{33} For commercial success, Plowshare planners had to find a way to eliminate nearly all of the tritium from gas released by nuclear explosions. It was also determined that to effectively "open" tight gas formations, more than one explosion per drillhole was required. A fission "device", code-named DIAMOND, was developed by Livermore Labs that would address these issues.{34} DIAMOND was engineered to produce a minimum amount of tritium. It also came equipped with a shield to absorb the small quantities of tritium that would be produced. Further, the DIAMOND "device" was small - 7.8 inches in diameter - and rugged enough to withstand the multiple explosions envisioned for each drill hole.{35} The MINIATA experiment, conducted at the Nevada Test Site in 1971, tested the DIAMOND "device" for the first time.{36} Along with testing the "device" itself, the AEC wanted to experiment with a "turn-key" system known as the "Plowshare Streamlined Operational System" that would allow industry to more expediently carry out nuclear gas stimulation projects in the field.{37}

MINIATA created a subsidence crater 800 feet in diameter

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31. The Nuclear Impact, p. 58
32. "Current Status of Projects GASBUGGY, RULISON, and RIO BLANCO", 1977, ERA-03-016767, p.708 (RULISON produced 10,000 Ci of tritium, GASBUGGY 40,000 Ci and RIO BLANCO 1,000 Ci)
33. Nuclear Dynamite, 1990, p. 191
34. JCAE, "Authorizing Legislation FY 1971", p. 20
35. "Plowshare Technology Assessment", pp. III-7
36. JCAE, "Authorizing Legislation FY 1971", p. 20
37. Ibid.

Figure 46

RULISON marker at center of photo. The area leveled for test operations is now a private pasturage. V.J. Brechin photo.

RULISON marker close-up. V.J. Brechin photo.

and 33 feet deep [Map 57]. It released radioactive isotopes into the atmosphere from DRILLBACK operations.{38}

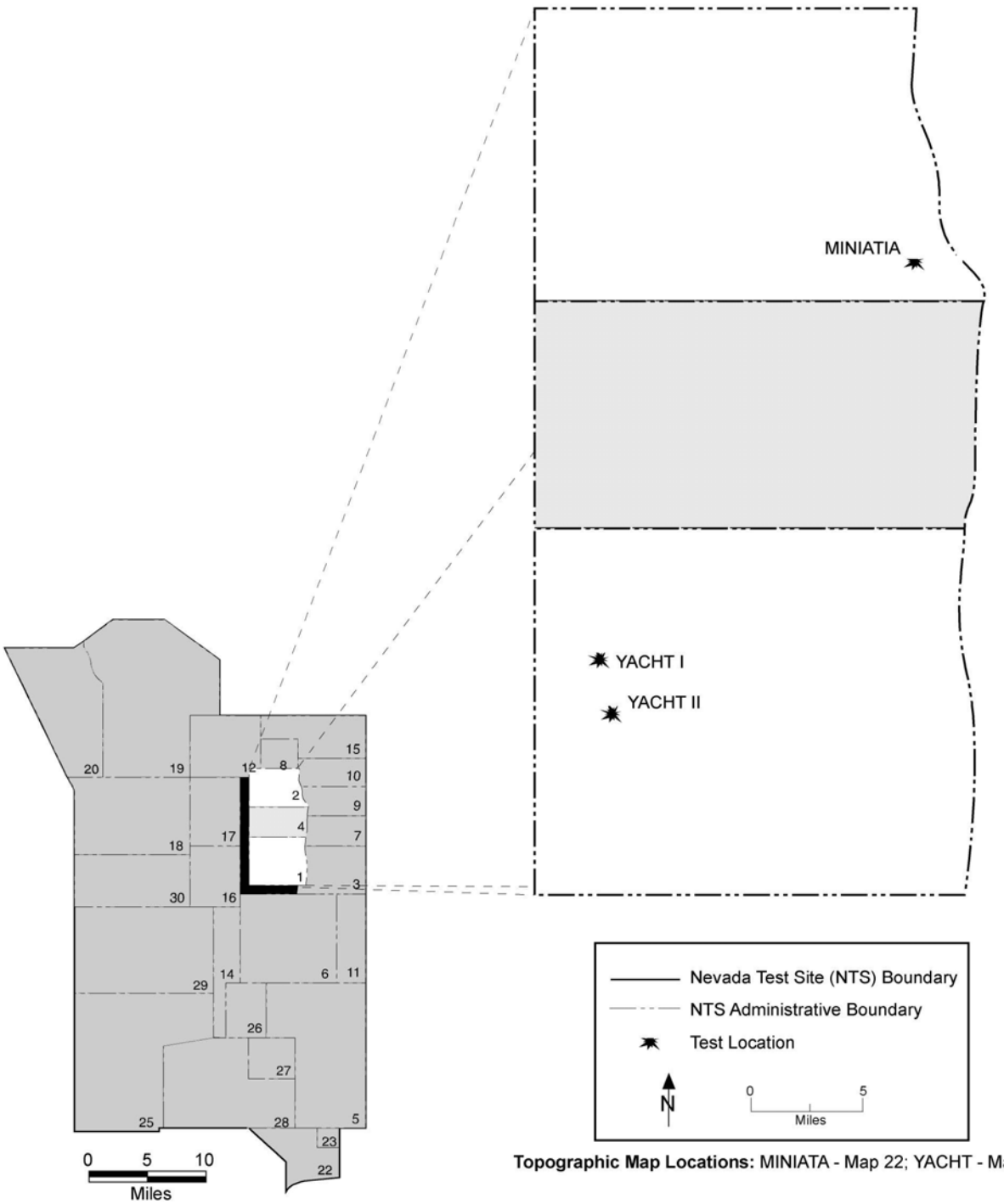
A similar test, code named YACHT, was prepared the year after MINIATA. This test would explode a DIAMOND “device” below an empty DIAMOND canister to “check shock loads” and damage to the empty canister.{39} Should the test be successful, another test, YACHT II, would explode two DIAMOND “devices” sequentially, the preferred technique for future Plowshare gas extraction projects.{40} The first YACHT drillhole was completed at the Nevada Test Site in 1972 [Map 58]. However, the YACHT tests were never carried out due to economic and political factors. As an aside, the unused YACHT drillhole was later proposed for a VELA UNIFORM test in the 1980’s. Presumably, the shale formation chosen by YACHT planners was very similar to the rock type at the main Soviet test site in the republic of Kazakhstan.{41} This proposed VELA UNIFORM test to check seismic characteristics was also cancelled.

Despite the MINIATA test, it seemed the DIAMOND “device” would never be used in an actual field experiment. Several proposed gas development tests, DRAGON TRAIL, RULISON II and RIO BLANCO in Colorado, and PINEDALE, WASP and WAGON WHEEL in Wyoming were on hold indefinitely due to public concern and technical uncertainties [Map 59].{42} However, in what would prove to be the last experiment of the Plowshare program, one of these proposed tests, RIO BLANCO, was approved in 1973. The site chosen for RIO

38. “Seismic Summary”, pp. 11-28; “Radiological Effluents”, 1990, p. 125
39. Haskell Hearing, 1973, p. 280
40. Ibid.
41. “Site Characteristics Report - UE11 (YACHT Hole)”, LLNL, December 1986
42. See, for example, JCAE, “Commercial Plowshare Services”, 1968, pp. 361-372 for DRAGON TRAIL, p. 388 for PINEDALE, p.389 for WASP (Wyoming Atomic Stimulation Project) and JCAE, “Authorizing Legislation FY 1972”, p. 2317 for RULISON II.

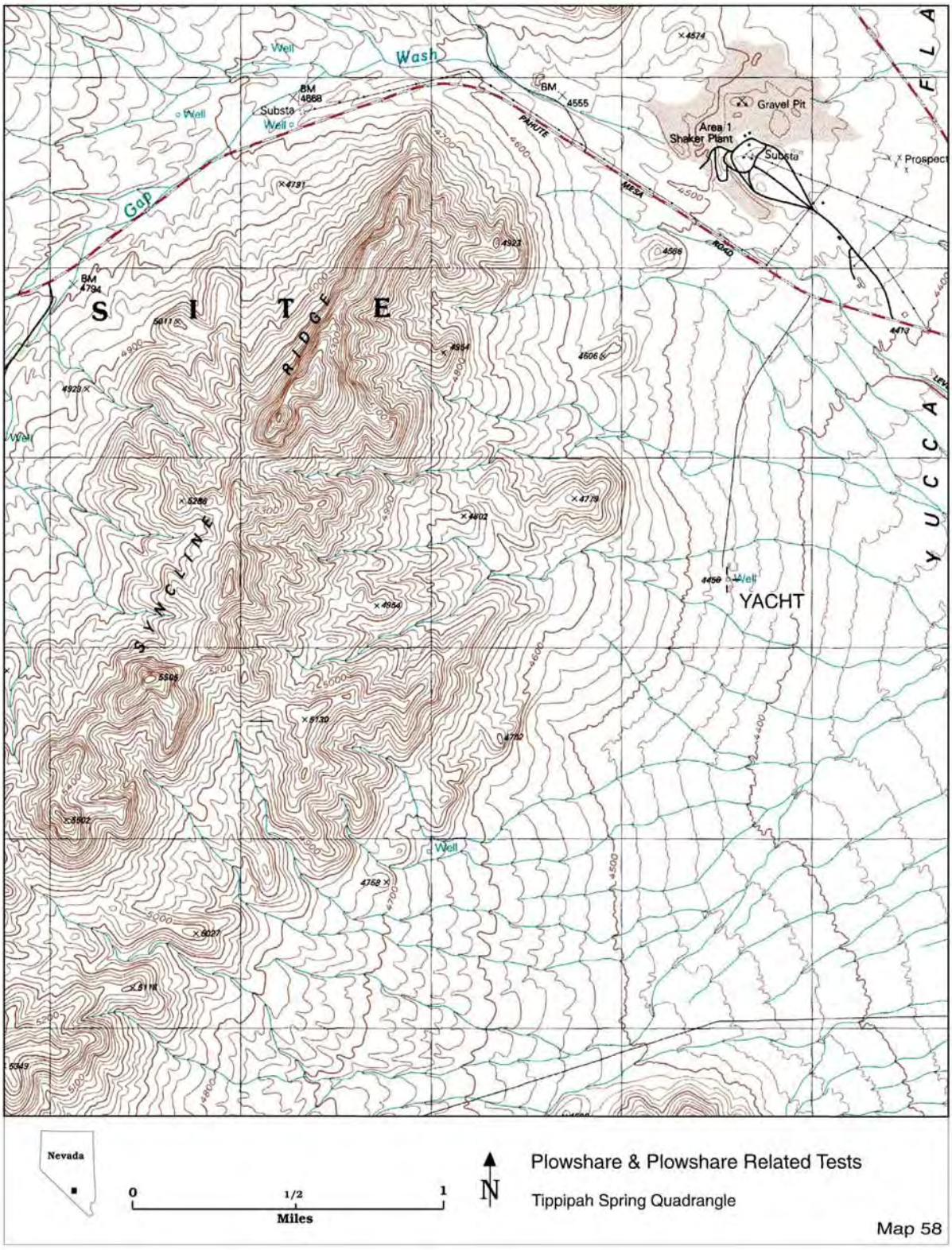
Map 57

MINIATA and YACHT Tests
Nevada Test Site



Topographic Map Locations: MINIATA - Map 22; YACHT - Map 58.

Source: Springer, D., "Seismic Source Summary", UCRL-73036, 02/71 & Site Characteristics Report - UE1l", LLNL, 12/86.


Wash
Well
BM 4868
Substa
Well
BM 4555
Gravel Pit
Area 1
Shaker Plant
Substa
Prospect
PAHUTE
MESA
ROAD
Gap
BM 4794
S I T E
RIDGE
SYNCLINE
YUCCA FLA
YACHT
Well
Nevada
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Tippipah Spring Quadrangle
Map 58

Map 59

Gas Stimulation Sites

Proposed

Proposed Site

Basins with Potential Gas & Oil Producing Strata

N

0 100 200

Miles

Source: JCAE "Commercial Plowshare Services", 1968, pp. 361-389.

BLANCO was thirty miles north of RULISON in the Piceance Basin region [Map 60].

PROJECT RIO BLANCO

RIO BLANCO was formally proposed after the enactment of the National Environmental Policy Act of 1969 (NEPA). Therefore it was the first Plowshare test to require an environmental impact statement, as it was to take place on public land and not within the Nevada Test Site.{43} RIO BLANCO was also the first nuclear test to be questioned under the Classification and Multiple Use Act (CMU Act) of 1964. The Colorado Open Space Council argued that, under the terms of the CMU Act, RIO BLANCO was not "the highest and best use of the western slope of Colorado."{44} In addition, Senator Floyd Haskell of Colorado called a hearing before the Subcommittee on Public Lands to discuss the "use of public lands for nuclear stimulation of natural gas".{45} The focus of the testimony and exhibits was solely on the RIO BLANCO proposal. Coloradoans began to consider legislation which would require a statewide vote prior to any nuclear detonation within state boundaries during this period as well.{46} In short, no other Plowshare test had undergone such public scrutiny or met with such resistance. Public antipathy towards the Plowshare program had grown. Whereas GASBUGGY had been greeted with indifference, and RULISON with skepticism, RIO BLANCO was met with hostility in many quarters.

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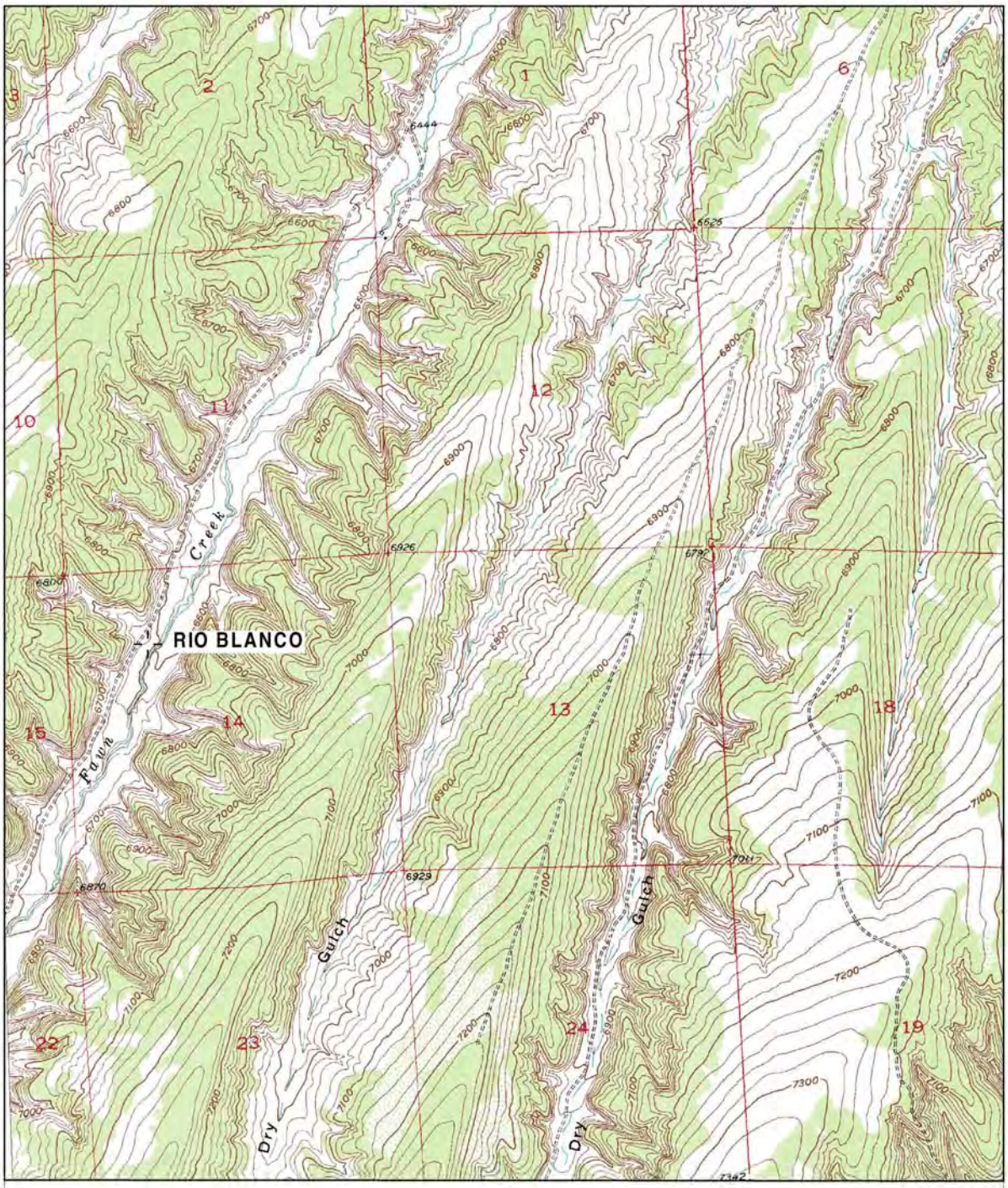
43. Environmental Statement, "Rio Blanco Gas Stimulation Project", WASH-1519, addendum, 03/73, pp. 1-1
44. Ibid. p. 97
45. Hearing before the Committee on Interior and Insular Affairs, "Nuclear Stimulation of Natural Gas", 1973. (hereafter 'Haskell Hearing')
46. State bill H.B. 1018 was designed to create the Colorado Atomic Energy Act - an unsuccessful bid to give the state more control over nuclear activities within its borders. Eventually, Amendment 10 was passed in November 1974, which required a statewide vote for any nuclear explosions in Colorado, Nuclear Impact, p. 18 & p. 202


RIO BLANCO
Pawn Creek
Dry Gulch
Dry Gulch
Colorado
0
1/2
1
Miles
N
Plowshare & Plowshare Related Tests
Rock School Quadrangle
Map 60

Many were angered by the scale of the RIO BLANCO proposal, which consisted of three “phases”. In PHASE I, three thirty kiloton bombs would be exploded in one drillhole. In PHASE II, three to five bombs would be exploded in four to six drill holes each, for a maximum of thirty explosions. To reduce the inconvenience to area residents, all PHASE II bombs would probably be detonated on the same day.{47} PHASE III or “full field development”, proposed a “minimum of 148 wells, stimulated by three to five nuclear explosives in each.” The arithmetic was sobering. PHASE III, if approved, would explode more bombs within Rio Blanco county than had been detonated in the entire history of U.S. nuclear weapons testing. Dr. Schlesinger, Chairman of the AEC after Glenn Seaborg, discusses the implications of PHASE III in a 1973 JCAE hearing:

> “Dr. Schlesinger: ...I believe it can be said that the gas component of the Plowshare program is economically attractive and it is technically attractive. There are some questions with regard to the environmental esthetics of the program, if I can put it that way. A production program of this sort would require a considerable number of shots - perhaps 100 or 200 a year - to have a meaningful program. Whether that is something that the public would welcome at this time is an open question.”{48}

Those opposed to RIO BLANCO included members of a grassroots movement in Wyoming where test WAGON WHEEL was being considered. An EIS had already been prepared for this experiment, which called for five 100 kiloton explosions in a single gas well [Map 59].{49} The group, known as the WAGON WHEEL Information

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47. See, for example, Haskell Hearing, 1973, p. 46
48. JCAE, “Authorizing Legislation FY 1974”, p. 76
49. “Environmental Impact Statement: Project WAGON WHEEL”, WASH 1524, 1973

Committee (WWIC), traveled to Washington D.C. to directly lobby AEC headquarters. It was felt the best way to stop WAGON WHEEL was to stop RIO BLANCO, which was scheduled to go off first. An AEC official recounts the meeting as: “Totally emotional. No rational arguments, including economic justifications, were entertained.”{50} For example, Floyd Bousman, chairman of the WWIC, called the proposed blast “an act of injustice to the local residents.”{51} He further stated: “We feel we are being discriminated against because our area is sparsely populated.”{52} This sentiment was echoed by a local resident opposed to RIO BLANCO:

> “I will not go into the details of the reason for our opposition to being guinea pigs of our country in the RULISON and RIO BLANCO experiments... However... it seems timely for government representatives to address themselves once again to the people and in this instance ask the public if they will accept the proposed calculated risk where, in the words of Dr. Peter Metzger, the AEC does the calculations and we take the risks.”{53}

For example, Dr. Scoville, a scientist testifying at the Haskell hearing, discusses one of the risks associated with RIO BLANCO:

> “The final and perhaps greatest risk, certainly the most insidious, can result from the seepage of radioactive materials into the water table.... The AEC disregards this hazard because it has not succeeded in hypothesizing any mechanism whereby these materials can get into ground water... [However] I would like to make reference to a case in the past. That was the so called LONG SHOT underground nuclear explosion... where every prediction indicated that there would be no radioactivity in the water. Yet, 3 months after the shot the AEC has reported

50. Nuclear Dynamite, 1990, p. 196
51. Haskell Hearing, 1973, p. 40
52. Ibid., p. 39
53. Haskell Hearing, 1973, p. 234

> that they found radioactive materials in the water on the surface... [Map 29]
>
> Senator Haskell: Where was this?
>
> Dr. Scoville: Up in the Aleutians, Amchitka, which is perhaps a little more representative of the Colorado situation... Fortunately, Amchitka is not an inhabited island.
>
> Senator Haskell: Colorado is."{54}

As a result of the confrontation with WWIC and others, some Plowshare planners "began to see the personal side of 'going into someone's backyard and letting one of those things off."'{55}

Others welcomed the blast. For example, several local ranchers supported RIO BLANCO in all its phases because "it would be of benefit to the counties as a tax base."{56} Other Meeker residents were reassured by a Nevada Test Site tour coordinated by the AEC. A headline in the Meeker Herald states: "AEC Test Site Impresses Meekerites". One tour participant recounts:

> "I was impressed by SEDAN crater. It is about 300 feet deep and 1,000 feet wide. The debris from the shot has left a wall around the hole and it could be a big reservoir. They told us that Russia is using shallow nuclear shots to create reservoirs and canals and using the water out of them."{57}

The tour also included a visit to the PILE DRIVER tunnel and the test site experimental farm, a working dairy farm used for fallout studies on animals and milk. For example, forage was exposed to fallout from the Plowshare excavation tests and fed to lactating cows and goats.{58} Levels of iodine-131 were then

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54. Ibid., pp. 147-1481
55. Nuclear Dynamite, 1990, p. 197
56. Haskell Hearing, 1973, p. 203
57. Meeker *Herald*, 03/15/73
58. "Nevada Test Site Experimental Farm: Summary Report", US DOE, pp. 5-6

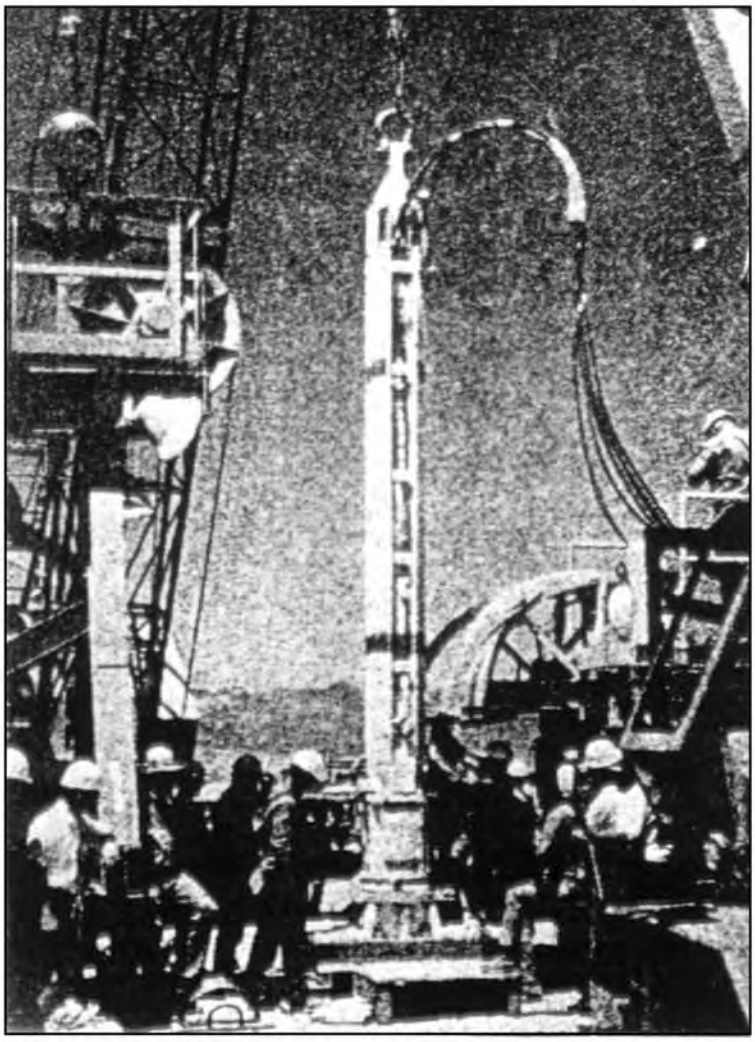
measured in the milk. Other than test SULKY, in which too little radioactivity was released to noticeably contaminate the feed, the results were “essential” to Plowshare studies.{59} After the tour, W. Joslin of Meeker stated: “If more people could see the tests [at the farm] made to assure protection for people, animals and property, they wouldn’t be so scared of project RIO BLANCO.”{60}

Before the final arguments against the test had gone through the courts, the AEC lowered the three thirty-three kiloton “devices” that comprised RIO BLANCO into the ground. Once in place, such bombs are exceedingly difficult to remove. One need only recall the CABRIOLET experiment, in which a second “device” was fabricated at great expense rather than attempt to unearth the original explosive. Arguing against RIO BLANCO under such circumstances was, according to Dr. Scoville, like “testifying not with a gun at your head but with a nuclear explosive at your head.”{61} Thus, confirming a foregone conclusion, RIO BLANCO was detonated on May 5, 1973 [Figure 47]. As with RULISON, the press, unofficial observers, and protectors were present for the blast. Just prior to the explosion, some of the protesters hung an ‘engineer’ in effigy and set it on fire on top of their VW bus. The flames spread to the bus and panic ensued to put the fire out. Meanwhile, the earth shock from RIO BLANCO failed to topple the now traditional ‘pyramid of cans’, prompting a photographer to yell over the commotion, “Kick the damn cans, I need a picture!”{62}

It appeared no one was happy with RIO BLANCO. Post shot studies by the AEC showed the three underground cavities, created

59. Ibid., p. 32
60. Meeker *Herald*, 03/15/73
61. Haskell Hearing, 1973, pp. 148-149
62. “Isaiah’s Prophecy”, 1989, p. 38

Figure 47



DIAMOND "device" being lowered for MINIATA experiment. LLNL photo.

RIO BLANCO monument - the only visible reminder of the three DIAMOND "devices" exploded beneath the surface. V.J. Brechin photo.

by the three thirty-three kiloton explosions, had not connected as theorized. Unconnected cavities were useless for the purpose of this experiment. Also, the gas field under RIO BLANCO was discovered to be rather small and unsuited for nuclear gas stimulation. Incredibly, the gas field was first carefully surveyed by the AEC after the blast. Because of these factors, only limited production tests were attempted on RIO BLANCO. For the AEC, RIO BLANCO became a $1.5 million dollar hole in the ground; both the RULISON and RIO BLANCO wells were abandoned in 1977.{63} Meanwhile, those opposed to RIO BLANCO were disappointed as well. They were dismayed by their inability to stop the test. Edward Strohbehn of the Natural Resources Defense Council (NRDC) articulates this frustration:

> "Mr. Strohbehn: I will speak briefly on one point and that is the absurdity of the situation with the AEC proceeding with this project in light of the available information they have. I find myself wholly exasperated with the situation we face. The AEC is determined to detonate the device. No public official, not even from the public agencies involved in participating in the project, the AEC and the Interior Department, are committed to the ultimate purpose of this project, to detonate thousands of nuclear devices in order to produce natural gas for commercial use."{64}

Even though full field development (PHASE III) was losing support within the AEC, opponents of RIO BLANCO would take no chances. In November of 1974, Colorado citizens passed Amendment 10, which required a statewide vote for any further nuclear tests.

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63. The Nuclear Impact, p. 107
64. Haskell Hearing, 1973, p. 157

OTHER PROPOSED EXTRACTION TESTS

RIO BLANCO, according to one AEC staffer, “spelled the death knell” for gas stimulation projects.{65} The only other likely gas stimulation project, WAGON WHEEL, had since been declared “dead as a doornail” by Dixie Lee Ray, chairman of the AEC.{66} However, other types of extraction tests had been proposed by the AEC that did not involve gas stimulation. It should be noted, however, that for economic and technical reasons none of the following proposals were considered as thoroughly, or considered to be as viable, as gas extraction proposals.

PINOT was a 1960 Plowshare high explosive oil shale experiment conducted near the RULISON and RIO BLANCO sites in Colorado.{67} Two nuclear experiments, VINTAGE and BRONCO, were proposed for the same area [Map 61].{68} Two other oil shale extraction proposals were considered for Utah [UTAH] and Alberta, Canada [OILSAND] [Map 62].{69} None of these nuclear oil shale proposals were ever carried out. Further study convinced the U.S. oil industry that “nuclear dynamite was inappropriate for oil stimulation because it could result in serious oil reservoir damage, to the detriment of long term production.”{70}

A water diversion project - AQUARIUS - and a cooper mining experiment - SLOOP - were proposed for southern Arizona [Map 62].{71} AQUARIUS was only briefly considered. SLOOP was cancelled because fracturing the Arizona copper deposits with a nuclear blast would contaminate the ore with ruthenium-106.

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65. Nuclear Dynamite, p. 199
66. JCAE, “Authorizing Legislation FY 1975”, p. 1091
67. For PINOT see “NVOO Factbook”, 01/70, p. 4-37
68. For VINTAGE see memo, “J.G. Le Sier - Projects PINOT and PRE-VINTAGE”, CIC#69210; for BRONCO see JCAE, “Commercial Plowshare Services”, 1968, pp. 51-123
69. For UTAH see AEC, “Annual Report to Congress, 1969”, p. 200; for OILSAND see “The Constructive Uses of Nuclear Explosives”, pp. 259-262
70. Nuclear Dynamite, 1990, p. 183
71. See, for example, JCAE, “Commercial Plowshare Services”, 1968, p. 390 for AQUARIUS, pp. 123-166 for SLOOP.

Oil Shale Development Sites

Proposed

Plowshare Site

Basins with Potential Gas & Oil Producing Strata

N

0 100 200

Miles

Source: JCAE "Authorizing Legislation FY 1972", & JCAE "Commercial Plowshare Services", 1968.

Extraction Tests
Other Proposals

Source: JCAE, "Commercial Plowshare Services", 1968.

Map 62

Since copper tends to be recycled, the SLOOP experiment would eventually “contaminate the national copper supply”, and many uses of copper, such as photographic supplies and medical equipment, cannot tolerate any radioactivity.{72}

KETCH was a 1967 proposal to store material inside a nuclear cavity, as opposed to extracting material out of it.{73} This proposal was inspired by the 1964 SALMON VELA UNIFORM experiment in Mississippi. SALMON had created a nearly spherical cavity in the underground salt formation.{74} It was hoped the 24 kiloton KETCH explosion would create a similar cavity suitable for storing gas. This experiment is unusual because the site selected was in Pennsylvania, far from the intermountain west [Map 62]. Pennsylvania was chosen because gas storage projects only made sense if they were close to market areas. However, these were “precisely the places where public opposition would be the greatest.”{75} Therefore, a feasibility experiment was requested in a remote area:

> “Experiments to establish the feasibility of a high degree of “cleanliness” should be carried out in a remote area far more distant than the proposed test site, which is located less than 200 miles from major diary-farming regions and large population centers such as Pittsburgh, Philadelphia, New York, Baltimore and Washington. Thus, experiments to establish feasibility could endanger many tens of millions of individuals as a result of the internal and external radiation from a possible leak to the environment.”{76}

KETCH was cancelled in 1968 due to “opposition from conservationists, coal interests and residents.”{77} No other

72. Nuclear Dynamite, 1990, p. 184
73. See, for example, JCAE, “Commercial Plowshare Services”, 1968, pp. 167-224 for KETCH.
74. Borg, I.Y., “Nuclear Explosions for Peaceful Purposes”, 1986, p. 9
75. “KETCH File”, CIC#0162643, excerpt from *Nucleonics Week*, 08/08/68
76. “Potential Health Hazards of Project KETCH”, 01/25/68, CIC#75922, p. 68
77. *Nucleonics Week*, 08/08/68

extraction projects were considered in any detail by Plowshare planners. The technology was running out of applications.

THE DEMISE OF PLOWSHARE

For a variety of reasons, VINTAGE, BRONCO, UTAH, OILSAND, AQUARIUS, SLOOP and KETCH proved to be even more untenable than gas stimulation experiments. The public no longer supported the Plowshare program with the enthusiasm that had greeted the 'PANATOMIC' canal proposal. The Plowshare program was slowly losing the support of industry as well. Industry was unsure of the technical and economic viability of any extraction project:

> "Representative Aspinall: ...Now let me ask you, what has happened to BRONCO and what happened to DRAGON TRAIL?
>
> Mr. Kelley: DRAGON TRAIL was a gas stimulation project that we looked at jointly with Continental Oil Co. some years ago. For reasons which I don't recall right now, they decided to drop it. BRONCO, as you know, was a proposed experiment to use nuclear explosives to fracture oil shale for possible subsequent in situ retorting. Arrangements for BRONCO broke down because of complications in the contracting provisions and terms.
>
> Representative Aspinall: Industry got out of it entirely, didn't they?
>
> Mr. Kelley: That's a way of saying it.
>
> Representative Aspinall: Industry said, 'We don't want to have anything more to do with it,' and they backed off of it."{1}

Even the AEC began to back away from the Plowshare program. The chairman of Austral Oil, which had co-sponsored RULISON with the AEC, speaks to this at the same 1971 JCAE hearing:

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1. JCAE, "Authorizing Legislation FY 1972", p. 2331

> "Mr. Leisk: I am trying to tell you how industry feels. We are not real happy that our partner [the AEC] seems to be slackening off and yet they keep telling us, 'Come on with more.' We have spent large sums of money in this experiment [RULISON] and that is why I hoped I could testify. When you put large sums of money into something, I think you have something to say. We have done some good here. We have darn sure done that, and I know the gas can be recovered."{2}

The increase in public scrutiny, the loss of industry confidence and the subtle retreat by the AEC fatally weakened the Plowshare program. The failure of RIO BLANCO and the reorganization of the AEC (which became the Energy Research and Development Administration (ERDA) in 1974) "put the last nail in the coffin" of Plowshare.{3} ERDA, unlike the AEC, was a "multiple-mission energy agency that relegated atomic energy programs to a somewhat diminished proportion."{4} A 'diminished proportion' of the meager support Plowshare received in the early 1970's was essentially nothing. But the most important factor in the demise of the program was loss of public confidence. "Bombs in the backyard" - anyone's backyard - was no longer trivialized as had been the case in the 1950's [Figure 48].

A PLOWSHARE RESURGENCE?

Jonathan Schlefer, editor of *Technology Review*, describes a visit paid by a Livermore physicist to his office. The physicist:

> "proposed generating power by dropping H-bombs in holes. Actually, the idea wasn't exactly that, he said - and wasn't as preposterous as it sounded - but he couldn't explain much more until his paper got security clearance."{5}

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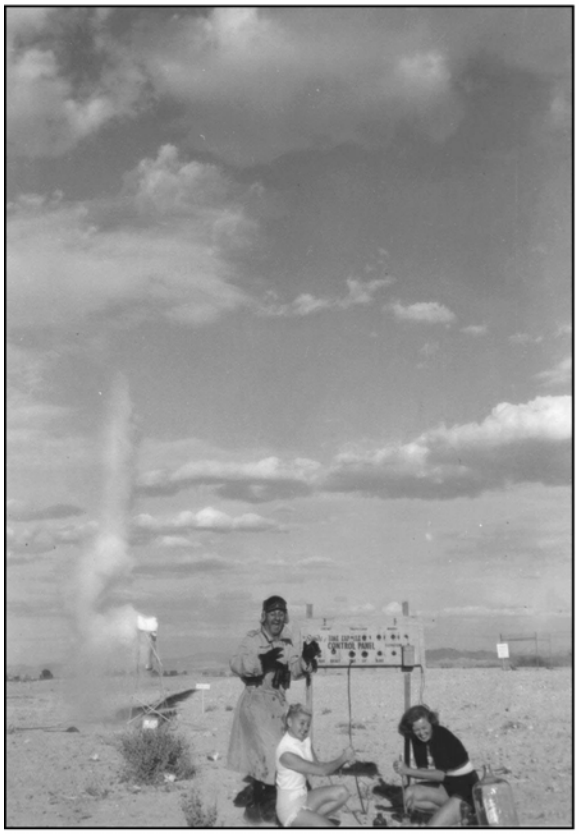
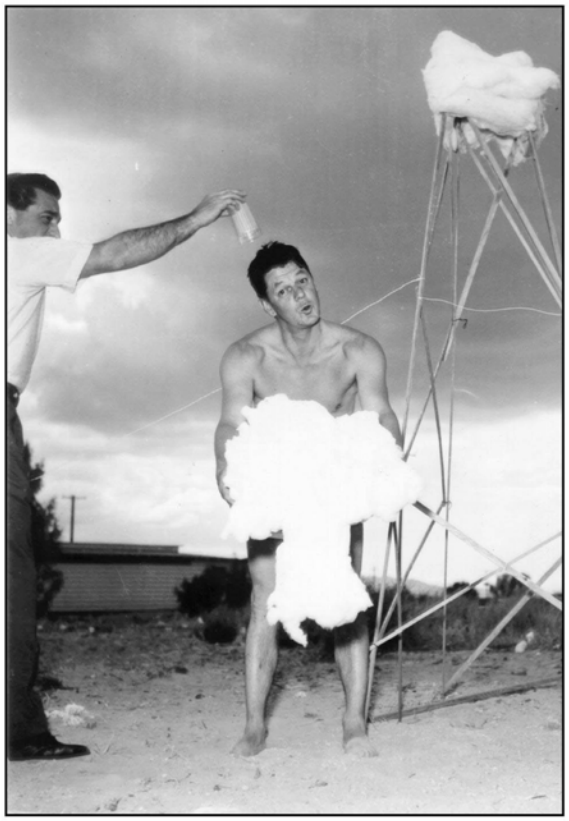
2. Ibid., p. 2377
3. Nuclear Dynamite, p. 233
4. The Nuclear Oracles, p. 211
5. "A Practical Route to Fusion Power", *Technology Review*, July, 1991, p. 5

Figure 48



"Explosion" at "Yuk-Yuk" flats a few days before the start of the sixth series of atomic tests at the Nevada Test Site, 1957. Las Vegas *News* Bureau photo.



Mr. "Atomic Bomb 1957" in front of mock test tower. Las Vegas *News* Bureau photo.

What is surprising about this conversation is the date it occurred - January 1990. The paper was eventually published in the July 1991 issue of *Technology Review*. This GNOME-like proposal is as follows: bombs explode in a steel container with molten salt flowing along the sides. The salt absorbs the heat, the heat generates steam, and the steam creates electricity.{6} This “practical route to fusion power”, known as PACER technology, is taken as seriously as GNOME or GASBUGGY was in the 1960’s.

Chetek, founded in 1990, is a Soviet corporation that offers to dispose of “chemical or radioactive wastes, chemical weapons, decommissioned nuclear reactors, and retired warheads” by burying them underground alongside a “peaceful” nuclear bomb.{7} The bomb is detonated and everything - good, bad, and indifferent - melts into the surrounding rock. The explosions proposed by Chetek are “nearly identical to the garden-variety underground nuclear weapons test.”{8} Chetek, though, claims their bombs are “peaceful” and thus exempt from the current Soviet moratorium on testing. The justifications, rhetoric, and concerns are identical to those raised by the original Plowshare program. While some early Plowshare proposals may have been more outlandish [Figure 49], the current crop is equally controversial. Will these or other “peaceful” projects take place? As stated in the conclusion, several factors indicate they will .

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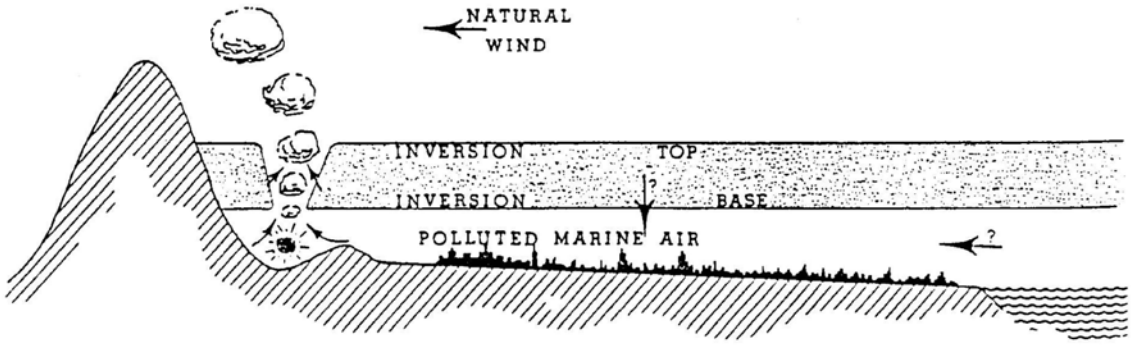
6. Ibid., p. 23
7. “Cleaning Up With A Bang”, *B.A.S.*, January, 1992, p. 9
8. Ibid., p. 47

Figure 49

Weather Modification & Nuclear Explosives



This 1959 Plowshare proposal suggested using nuclear explosives to breakup inversion layers over Los Angeles.

Source: "The Use of Nuclear Explosives in Meteorology", UCRL-5579, 05/15/59, p.61.

SECTION IV

CONCLUSIONS & FUTURE RESEARCH NEEDS

This paper focused on the environmental perceptions and landscape impacts of the Plowshare program. Assessing the aboveground landscape impacts is a straightforward task. For example, an underground Plowshare test might cause the ground to slump fifty feet, or an excavation crater might be 200 feet deep and 1,000 feet in diameter. Further, it is usually known what type of radioactive isotopes were released by a test and under what circumstances. However, environmental perceptions are more difficult to describe. Future research needs to address the 'hidden' side of Plowshare testing, environmental perceptions and underground blast effects being two of these hidden factors.

This paper addressed perceptions and their influence on site selection. The sites chosen for Plowshare tests were typically remote and regarded as barren or disposable by Plowshare planners. Thus, the impacts of the tests were also regarded as negligible. Robert Nelson, deputy manager for the Nevada Test Site, explained two accidents - the 1984 MIDAS MYTH/MILAGRO test in which ground collapse killed a test site worker and the 1986 MIGHTY OAK test which released radiation offsite - with the following words:

> "It's a test program. We really don't know all the answers. If you don't have a problem with fifty percent of your tests, its not a test program."{1}

The Plowshare program surely qualifies under this criteria as a test program. Plowshare test sites were regarded as outdoor

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1. "Testing Ground", J. Hanrahan, *Common Cause* Magazine, 01/89, p. 16

laboratories useful for perfecting dangerous technologies by many Plowshare proponents. This perception runs counter to the view of local inhabitants who have a long-term stake in the land and cannot afford a mistake. The concept of a “testing ground” continues to confront a land ethic that sees land as a resource that has worth beyond its use as an experimental sandbox.

Another perceptual approach might be to ask: ‘Why do Plowshare proposals continue to resurface?’ Hugh Gusterson, an anthropologist, has argued that bomb designers are a tribe that affirms its identity with nuclear tests. The tribe is threatened by attempts to end weapons testing. The tribe is resourceful, however, and proposes “peaceful” nuclear explosions that are immune from a test ban.{2} Steven Kull, a psychotherapist, has argued that nuclear testing satisfies a deep psychological need. In the words of one weapons designer he interviewed: “You build them to impress yourself.”{3} Carol Cohn, a psychologist, has emphasized the role of denial. The language and concepts are so abstract, Cohn states, that ultimately the consequences of full scale nuclear war, let alone a contaminated aquifer, become abstract as well.{4} Writer Jeffrey Klein offered another perspective on the Plowshare program. The following passage refers to the Star Wars program, but it could also apply to Plowshare planners stubborn efforts at ‘geographic engineering’:

> “I think one of the big problems is that although we won the arm’s race, we’ve become something of a dysfunctional family. We live in a big house and a lot of people look up to and admire us. But at home, at night - in the black

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2. “Life Among The Nuke Men”, SF *Chronicle*, 09/11/89
3. Minds At War, S. Kull,, 1988, p. 232
4. See “Nuclear Language”, C. Cohn, *B.A.S.*, June 1987, pp. 17-24

> budget - Dad is obsessed with playing with his guns and his lasers and his microwave weapons. And this would just be a dangerous obsession, but maybe we could live with it if it weren't for the fact that the kids aren't getting educated. They're actually getting phony degrees, and Dad doesn't care. And he doesn't care that some of the family is out of work and can't get health insurance or health care, and that parts of the structure of the house and its driveway are falling apart - and that the Japanese and some of the other houses are beginning to look better and their kids are getting better educations."{5}

Perhaps efforts to remake the world with nuclear explosives are fueled by guilt. Edward Teller, the 'father of the H-Bomb' and staunch Plowshare supporter, confided in an interview that "a good part, an important part, of my own psychology" is to negate the horror of nuclear annihilation he had given the world.{6} These and other perceptual issues need further research.

The landscape impacts of the Plowshare program need more research as well. It would be wise, before the United States or the former Soviet Union exhumes the Plowshare program, to know what is buried. Taken literally, the amount and type of radioactive material in Plowshare cavities is classified and therefore inaccessible to most planners, biologists, environmentalists and the public at large. The explosive yield of many of the explosions that created this waste is also classified under national security guidelines.{7} Has waste migrated out of underground cavities and into aquifers? Is waste being monitored? Even the location of most Plowshare tests and hence the location of these waste sites was until recently known only to a few.

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5. "The Star Wars Encounter", *East Bay Express* Interview with Jeffrey Klein, 09/13/91, p. 21
6. Teller's War, W. Broad, 1992, p. 273
7. Note: The yields of eleven [ANACOSTIA, KAWEAH, TORNILLO, KLICKITAT, ACE, DUB, TEMPLAR, SAXON, SIMMS, SWITCH and STODDARD] of the twenty-seven dedicated Plowshare tests remain classified as of June 1992.

This lack of general knowledge highlights the lack of specific information about these tests.

Also of interest is what can be unearthed in a figurative sense from the Plowshare program. For example, what lessons were learned from the Plowshare program? What tests were successful? Under what criteria? Are the new Plowshare proposals incorporating past experience? Will the public be included in siting decisions? Will industry be responsible for cleanup? Will other countries follow India's lead and use "peaceful nuclear explosions" as a pretext for a weapons development program?

In sum, the Plowshare program, current and past, is a great unknown. It only appears to be open and accessible when compared to its cohort, the weapons testing program. This paper has approached the program from one perspective: environmental perceptions of Plowshare planners and the landscape impacts of Plowshare tests. In the end, the most dangerous perceptual bias revealed by this research is one common to us all; 'out of sight, out of mind'. Patricia Wolff makes this point in a 1991 article on Project GASBUGGY:

> "After finding out what Project GASBUGGY was all about, I asked many others, including anti-nuclear activists, reporters and Los Alamos National Laboratory employees if they were familiar with the event. Ninety-nine percent had never heard of it."{8}

Is it realistic to expect ourselves to learn from our mistakes? Perhaps in thirty years some graduate student may chose to write about an obscure program in the 1990's that attempted to create energy and dispose of waste using nuclear bombs. Hopefully not.

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8. "Project GASBUGGY - Atomic Blast in the Carson Nation Forest", *The Rio Grande Sierran*, September, 1991, p. 9

APPENDIX A

SOURCES

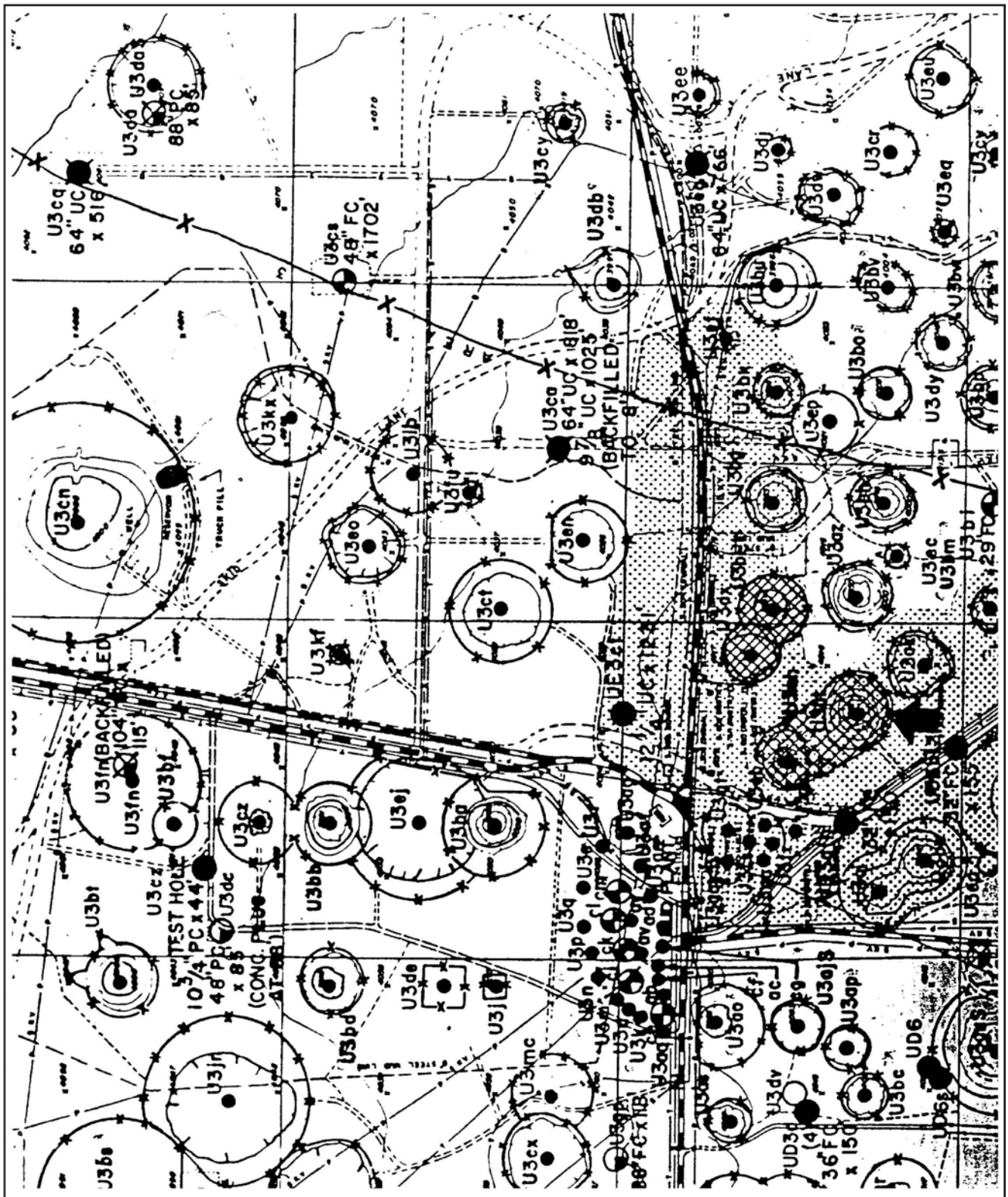
MAPS AND SITE VISITS

Base maps, locations of the test sites and drillhole designations were obtained from the USGS, the law office of Johns & Johns, the National Technical Information Service and Freedom of Information Act (FOIA) requests by the author [Map 63]. A site visit to the Nevada Test Site was arranged through the DOE public affairs office. Research also included site visits to many of the proposed and all four of the actual Plowshare test sites outside of the Nevada Test Site. The visits included, when possible, discussion with local residents and visits to county museums. These museums often housed material difficult to access elsewhere, such as local newspaper articles about the tests or plaques awarded to the community for their participation in the Plowshare program [Figure 50]. Site visits were an invaluable means to get a subjective and objective feel for the type of landscape favored by Plowshare planners, and the attitudes of the local residents.

GOVERNMENT AGENCIES AND SUBCONTRACTORS

Much source material is drawn from the Atomic Energy Commission and its successor agency’s files (Energy Research & Development Administration [ERDA] and the Department of Energy [DOE] in the form of agency reports to Congress, Congressional Hearings and communications with the DOE Office of External Affairs and Freedom of Information Act officer. Of particular interest are hearings before the Joint Committee on Atomic Energy

Map 63



Portion of map obtained from law office of Johns & Johns of Las Vegas

Source: "Drillhole Planning Map - Areas 1, 3, 11, 6 & 7 - Current Status as of 10-01-89", Holmes & Narver Map #JS-090-094-C30, 10/89.

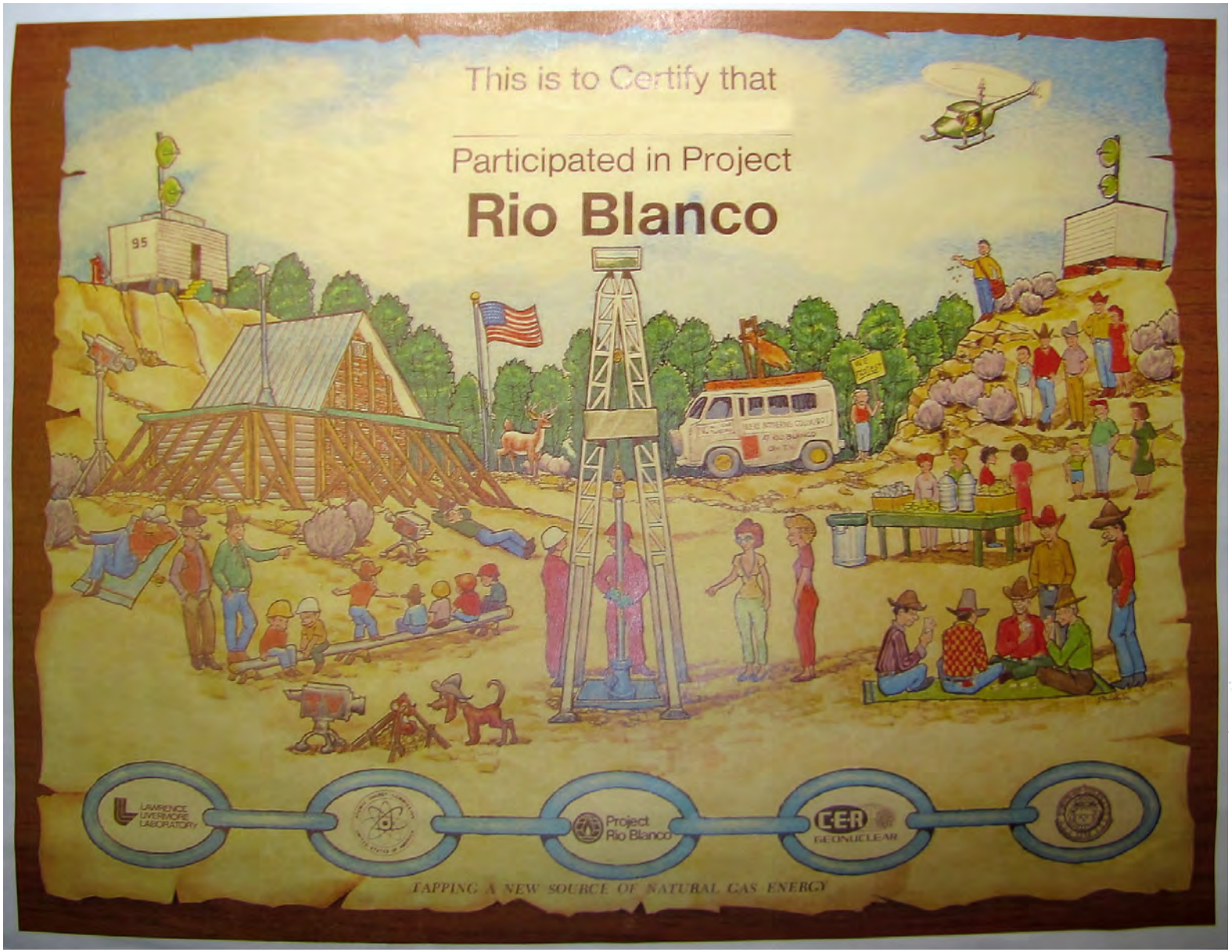


Figure 50

Source: Meeker, CO County Museum. Thanks to V. J. Bechin for reproduction.

(JCAE) entitled: “Peaceful Applications of Nuclear Explosives -Plowshare [1965]”. “Commercial Plowshare Services [1968]”, “Nuclear Explosion Services for Industrial Applications [1969]”. “AEC Authorizing Legislation [various fiscal years]”, and the AEC’s “Annual Report to Congress [various calendar years]”. Also of interest are “Nuclear Stimulation of Natural Gas [1973]”, and “Threshold Test Ban and Peaceful Nuclear Explosion Treaties [1977]”, published from hearings before the Subcommittee on Public Lands and the Committee on Foreign Relations respectively. These reports provide details that are difficult or impossible to glean from other sources, often because it is at these hearings that the AEC must account for and request funding for specific Plowshare projects.

Additional information regarding nuclear testing and the Plowshare program was obtained through the National Technical Information Service (NTIS) - a document clearinghouse of domestic and foreign government sponsored research located in Springfield, Virginia. NTIS is run by the Department of Commerce and adds approximately 70,000 titles to its database every year.{1} Most of the documents pertinent to this study are reports published by the weapons labs and their subcontractors. Titles and availability of specific documents from NTIS are available through various online computer databases, such as DIALOG information service.

An excellent source for memoranda relating to government and subcontractor testing activities is the Coordination and Information Center (CIC) located in Las Vegas. This center was established in 1978 by the DOE and is operated by Reynolds

1. U.S. Dept. of Commerce, “NTIS Catalog of Products & Services”, 1991, p. 3

Electrical and Engineering Company (REECo) to serve as a nationwide repository for documents pertaining to nuclear fallout. The repository has over 200,000 titles, some one page and barely legible, while others are hundreds of pages long [Figure 51]. Many of these documents are used as source material for the forty-one volume, 9,029 page history of the United States atmospheric testing program published by the Defense Nuclear Agency (DNA) and available through NTIS.{2} Plowshare projects GNOME and SEDAN are discussed in volume 29 (DNA 6029F) of this series.

Livermore Labs, responsible for designing 70% of all tests related to the Plowshare program and the “chief idea factory” of the program, has, according to the “Guide to Archival Collections Relating to Radioactive Fallout, a “very rich collection” of “essential” Plowshare records.{3}{4}{5} However, most of this collection, 60 cubic feet, is classified Secret.{6} In any case, a security clearance is required to get past the visitor’s center to browse the unclassified portion of the archives. The Livermore office of “Offsite Requests/Unclassified” will mail documents to interested researchers if provided with an unclassified document number.

Los Alamos Labs, responsible for designing the remaining Plowshare tests, holds “the largest single collection of records outside the CIC related to fallout.”{7} This collection is likewise difficult to access. A “mistakenly declassified” document found by

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2. For overview see DNA 6041F, “For the Record - A History of the Nuclear Test Personnel Review Program”, 1986
3. Percent figure from a variety of sources compiled in Appendix B.
4. “idea factory”, Findlay, T., p. 4
5. “very rich”, “A Guide to Archival Collections Relating to Radioactive Fallout From Nuclear Weapons Testing”, History Associates, 1989, p. 16
6. Ibid.
7. Ibid., 18

REYNOLDS ELECTRICAL & ENGINEERING CO., INC.
DATE RUN - 910214

FALLOUT DOCUMENTS
CROSS REFERENCE GUIDE BY TITLES

HDLS-8626F-01

KO5
PAGE 878
TIME RUN - 1605

DOCNO	KEYWORD	TITLE
0161694	- CARRY WATER FROM WELL AT	NEWS NOTES, SUBJECT: OPENING OF BIDS BY LVFO ON NINE MILES OF PIPE TO CARRY WATER FROM WELL AT SITE TO CAMP MERCURY
0136973	- CARRY, SUBJECT: REPLY TO	TELETYPE TO C R CARRY, SUBJECT: REPLY TO LTR DTD 5/14/55 RE INFORMATION ON BOSS MISSION
0070276	- CARRY'S CONVERSATION (MONI	MEMO TO FILES, SUBJECT: POST WIGWAM MONITORING PROGRAM; MCKINNON'S REPORT OF SAN FRANCISCO BAY AREA ; CARRY'S CONVERSATION (MONITORING OF TUNA)
0075775	- CARRY-ALL NUCLEAR BLAST	LETTER TO E M MCMILLAN, SUBJECT: DR. FERNBACH'S WARNING AGAINST MAKING PUBLIC STATEMENTS CONCERNING THE LOW-LEVEL RADIATION HAZARDS OF THE CARRY-ALL NUCLEAR BLAST
0075785	- CARRY-ALL NUCLEAR BLAST	LETTER TO THE BOARD OF REGENTS, SUBJECT: PETITIONS REGARDING THE LOW-LEVEL RADIATION EFFECTS OF THE CARRY-ALL NUCLEAR BLAST
0075782	- CARRY-ALL NUCLEAR CRATERING B	LETTER TO J JAVITS, SUBJECT: LETTER OF MAY 10, 1967 CONCERNING THE COMPLETE IRRESPONSIBILITY OF THE AEC IN READYING THE 1.7 MEGATON CARRY-ALL NUCLEAR CRATERING BLAST DURING THE YEAR 1965
0075783	- CARRY-ALL NUCLEAR CRATERING B	LETTER TO COMMISSIONERS, AEC, SUBJECT: LETTER OF APRIL 7, 1967 CONCERNING THE LOW-LEVEL RADIATION E FFECTS OF THE 1.7 MEGATON CARRY-ALL NUCLEAR CRATERING BLAST
0037970	- CARRYALL	MEMO TO O N ROEHIK, SUBJECT: WIND PROBABILITIES - PROJECT CARRYALL
0075622	- CARRYALL	LETTER TO J S KELLY, SUBJECT: PROJECT CARRYALL
0037966	- CARRYALL (ALSO SEE A003-051	KINGMAN MAP PROJECT CARRYALL (ALSO SEE A003-0518)
0001978	- CARRYALL)	MISCELLANEOUS EVENTS CATHAY, CARPETBAG, CREAM, CYPRESS, CREW, COBBLER EVENTS (OFFSITE SURVEILLANCE , CROSSTIE SERIES, PROJECT CARRYALL)
0161188	- CARRYALL BIOLOGICAL EVALUATI	CARRYALL BIOLOGICAL EVALUATION PROGRAM
0173343	- CARRYALL COST ESTIMATES AND	TELEX, SUBJECT: PROJECT CARRYALL COST ESTIMATES AND LOGISTICS REQUIREMENTS (PLOWSHARE)
0037968	- CARRYALL FEASIBILITY STUDY	CORRESPONDENCE: PROJECT CARRYALL FEASIBILITY STUDY
0075788	- CARRYALL FEASIBILITY STUDY	LETTER TO F SELLA, SUBJECT: ENCLOSED COPY OF PRESS RELEASE CONCERNING THE CARRYALL FEASIBILITY STUD Y
0161185	- CARRYALL FEASIBILITY STUDY	MEMO TO O H ROEHLK, SUBJECT: COMMENTS CONCERNING PROJECT CARRYALL FEASIBILITY STUDY
0037967	- CARRYALL FEASIBILITY STUDY (	MEMO TO M L MERRITT ET AL, SUBJECT: REVIEW OF PROJECT CARRYALL FEASIBILITY STUDY (ATTACHMENT ENCLO SED)
0161186	- CARRYALL FEASIBILITY STUDY (	MEMO TO O H ROEHLK, SUBJECT: PROJECT CARRYALL FEASIBILITY STUDY (COST ESTIMATES FOR THE PROGRAM)
0161184	- CARRYALL FEASIBILITY STUDY -	MEMO TO P W ALLEN, SUBJECT: PROJECT CARRYALL FEASIBILITY STUDY - REQUEST FOR REVIEW AND COMMENTS
0161187	- CARRYALL PRELIMINARY POPULAT	MEMO TO O H ROEHLK, SUBJECT: PROJECT CARRYALL PRELIMINARY POPULATION AND DAIRY CATTLE CURVEY
0037969	- CARRYALL PRELIMINARY SITE IN	MEMO TO O H ROEHLK, ET AL, SUBJECT: PROJECT CARRYALL PRELIMINARY SITE INVESTIGATION PROGRAM
0161183	- CARRYALL PRELIMINARY SITE IN	MEMO, SUBJECT: PROJECT CARRYALL PRELIMINARY SITE INVESTIGATION PROGRAM

Sample document listing from the Coordination & Information Center (CIC), las Vegas

Figure 51

a researcher in 1980 and used against the government in a highly publicized court case led to the firing of a guard, the reprimanding of a staff member, and revamping library procedures by the Lab.{8} Currently, access to the library is through two doors which lead to completely separate areas; at one door a guard checks for security clearances while the other door is open to all. The public use area of the library resembles a standard university library anywhere. The card catalog, with few exceptions, references only material available in the public use section. For example, the search terms “nuclear testing” brought up twelve entries. A search for core documents I knew had to be in the library came up empty handed. The Los Alamos archives, located in a separate building, also requires a security clearance or an escort who will scan the requested documents before passing them to the researcher.

Conducting research at DOE headquarters in Washington D.C. requires an escort to a reading room where one must literally request permission to get a drink of water. The scant materials available are not worth the effort. Most are cleanup reports and Environmental Impact Statements available elsewhere.

The DOE office in Nevada, also known as the Nevada Operations Office (NVOO), has a reading room containing biological reports by the University of Utah and the Desert Research Institute at University of Nevada at Las Vegas (UNLV), studies on the waste repository at Yucca Mountain, and little else. While the office of external affairs is generally helpful, a typical

8. *The Progressive Magazine*, “The H-Bomb Scapegoats”, 05/79, p. 9

written response for specific information reads: “For security reasons, we cannot release information that could reveal data about specific results of particular nuclear tests. Therefore, we are unable to provide the information you seek (i.e. did a particular Plowshare test contain plutonium?).”{9} The single Freedom of Information Act officer at NVOO is quite helpful and accommodating but also overworked. Due to the work backlog and a slow response by Los Alamos Labs to forward documents, a FOIA request by this researcher took over eleven months to complete.

The National Archives Pacific Branch in San Bruno contains three cubic feet of tedious progress notes concerning the experimental PLUTO and SNAP nuclear reactors located at the Nevada Test Site and operated during the 1960’s. The Federal Records Center, located in the other half of the building, contains Atomic Energy Commission and Lawrence Radiation Lab files that are classified Secret. A small portion of these documents have been sent to the CIC in Las Vegas.{10}

LIBRARIES

Much valuable information was obtained from the Paul Kruger papers located in the Stanford physics library. Paul Kruger was a Stanford professor of physics who served as general chairman of the Plowshare organizing committee. In the 1960’s he taught a class in Plowshare technology which included explosive experiments in a “sandbox” located in the Stanford hills.

The United States Geological Survey (USGS) library in Menlo Park contains many titles unavailable or prohibitively

9. DOE office of External Affairs, response to query by V.J. Brechin, 1991
10. “Guide to Archival Collections”, p. 67

expensive through NTIS. Most of these documents are reports

published by Livermore or Los Alamos Labs. Also of tangential interest in this library is the “Preliminary Determination of Epicenters” published weekly by the USGS. This publication lists seismic events worldwide, and includes the code name, longitude and latitude, depth of burial, surface elevation, time and seismic magnitude of every announced nuclear test since September 1968 powerful enough to create a seismic disturbance [Figure 52]. (A small percentage of nuclear tests leave no seismic signature due to their relatively small explosive force; for example, two of the eight United States nuclear tests of 1990 - LADOUX and SUNDOWN - went undetected by seismic monitoring.)

The Index of Declassified documents, available through the main library of the University of California at Berkeley (UCB), is also a useful research tool, although search categories are broadly defined. Most of these documents are meeting minutes taken from presidential library collections. They are of interest for their immediacy. There is a sense of excitement that somewhere in the microfiche is a recently declassified document no other researcher has seen before.

The Special Collections department at the UNLV library is of interest for its files of photographs relating to nuclear testing. Much of the written material in Special Collections, however, relates to the gaming industry and not testing. Nuclear testing photographs are also available from the Las Vegas News Bureau. Don English, one of the primary photographers during atmospheric testing, still works at the Bureau.

Figure 52

Day	Time	Lat	Long	Depth	Mag	SD	Sta	Region / Comments
16	21 55 29 2•	16 687 S	167 219 E	33 N	4 9	1 4	50	VANUATU ISLANDS
16	21 55 58 5•	13.346 N	144 682 E	55	4 9	1 1	23	MARIANA ISLANDS Felt (IV) on Guam
16	22 14 02 4?	40.09 N	23.86 E	10 G		0.9	4	GREECE MD 2.9 (ATH)
16	23 05 49.2	40.120 N	23.793 E	10 G		0.5	7	GREECE MD 3.3 (ATH)
16	23 08 40.2	0.923 N	28 009 W	10 G	4.7 4.4	0.8	57	CENTRAL MID-ATLANTIC RIDGE
16	23 46 54.6%	38.614 N	14.819 E	10 G		0.9	11	SICILY
17	01 47 15.6	12.185 N	88.038 W	33 N	4.8 4.1	1.2	50	OFF COAST OF CENTRAL AMERICA
f 17	01 59 07.7	7.698 S	107.150 E	27 G	6.1 5.8	1.0	351	JAVA. Ms 5.5 (BRK). Felt in the Jakarta area. Depth from broadband displacement seismograms.
17	02 10 37.0	37.258 N	26.900 E	10 G		0.8	10	DODECANESE ISLANDS. ML 3.8 (ATH).
17	03 11 09.2&	36.568 N	121 188 W	4			18	CENTRAL CALIFORNIA <BRK>. ML 2.6 (BRK).
17	04 43 53.5•	51.406 N	178.100 E	64 •	4.6	0.7	27	RAT ISLANDS, ALEUTIAN ISLANDS
17	05 52 35.6•	17.598 S	178 930 W	571	4.6	0.6	30	FIJI ISLANDS REGION
17	07 04 27.6&	39.143 N	110 848 W	12			14	UTAH <SLC-P>. CL 2.1 (SLC).
o 17	08 16 22.9	27 040 S	70.974 W	30 D	5.4	0.9	147	NEAR COAST OF NORTHERN CHILE
17	08 31 51.3%	59.413 N	5.815 E	10 G		0.8	5	SOUTHERN NORWAY. MD 2.5 (BER).
17	08 53 17.2•	21.195 S	168.743 E	41 D	4.8	1.1	43	LOYALTY ISLANDS
17	10 21 53.5?	15.54 S	167.59 E	122 ?	4.6	1.3	41	VANUATU ISLANDS
17	10 24 35.4	63.259 N	150.476 W	114	4.2	1.0	22	CENTRAL ALASKA
17	11 26 12.6	40.067 N	23.976 E	10 G		1.0	9	GREECE. ML 3.4 (ATH).
o 17	11 34 52.2	27.001 S	70.948 W	39 D	5.5 5.7	1.0	198	NEAR COAST OF NORTHERN CHILE. Ms 5.7 (BRK), 5.6 (PAS).
17	12 07 13.7•	0.715 N	96.936 E	140 ?		0.7	6	OFF W COAST OF NORTHERN SUMATERA
17	12 31 30.5•	21.496 S	178.768 W	544 •	4.8	1.2	59	FIJI ISLANDS REGION
o 17	12 38 15.5	26.924 S	70.985 W	37 D	5.4 5.5	1.1	88	NEAR COAST OF NORTHERN CHILE
17	13 47 53.1•	27.717 S	70.405 W	33 N	4.8	1.3	17	NEAR COAST OF NORTHERN CHILE
17	13 59 28.7•	27.027 S	71.243 W	33 N	4.7	1.4	14	NEAR COAST OF NORTHERN CHILE
o 17	14 26 03.5	27.062 S	71.060 W	31 D	5.2 4.7	1.0	64	NEAR COAST OF NORTHERN CHILE
17	14 52 27.1•	12.204 N	87.930 W	54 •	5.0 4.0	1.1	45	NEAR COAST OF NICARAGUA
17	14 56 34.6	39.267 N	72.291 E	59 •	4.9 4.4	1.1	57	KIRGHIZ SSR. Felt (IV) at Daraut-Kurgan; (III) at Gulcha, Sufi-Kurgan, Dzhirgatal and Fergana; (II) at Andizhan and Tashkent.
17	15 12 18.6•	65.330 N	146.289 W	10 G		1.5	6	ALASKA. ML 3.9 (PMR).
(17) KEARSARGE detonation	17 00 00.0&	37.297 N	116.307 W	0	5.5 4.2		312	SOUTHERN NEVADA. <DOE>. ML 5.4 (BRK). "Joint Verification Experiment." 36° 17' 49.77" N., 116° 18' 23.54" W., Surface Elev. 2129 m., Depth of Burial 600 m., Shot Time 170000.095, "KEARSARGE," Nevada Test Site (Dept. of Energy).
17	17 29 18.9?	26.92 S	70.21 W	33 N		1.5	4	NEAR COAST OF NORTHERN CHILE
17	17 34 30.8%	43.434 N	5.476 E	10 G		0.3	6	NEAR SOUTH COAST OF FRANCE. MD 2.0 (STR).
17	17 49 54.1?	60.58 N	5.05 E	10 G		0.2	4	SOUTHERN NORWAY. MD 2.1 (BER).
17	19 34 31.0?	35.13 N	141.35 E	33 N	4.0	1.3	5	NEAR EAST COAST OF HONSHU, JAPAN
17	19 35 12.8?	36.07 S	68.86 W	33 N		1.2	9	MENDOZA PROVINCE, ARGENTINA
17	19 40 35.7	20.335 S	178.120 W	547	4.8	1.0	87	FIJI ISLANDS REGION
17	19 45 24.5	19.156 N	121.099 E	31	5.0 4.5	1.3	78	PHILIPPINE ISLANDS REGION
17	21 02 43.0•	14.987 N	94.740 W	33 N	4.9	0.9	54	OFF COAST OF CHIAPAS, MEXICO
17	22 05 56.5•	59.907 N	153.360 W	142 ?		0.6	8	SOUTHERN ALASKA
17	22 14 49.0	42.726 N	144.008 E	120	4.1	0.6	7	HOKKAIDO, JAPAN REGION. Felt (II JMA) at Hiroo and (I JMA) at Kushiro.
(17)	22 21 53.0&	37.297 N	116.307 W	0			10	SOUTHERN NEVADA. <SPEC>. ML 3.6 (NEIS). NTS Collapse, held to "KEARSARGE" location.
a 17	KEARSARGE subsidence			33 N	5.3 4.5	1.3	56	MINAHASSA PENINSULA. Several buildings damaged at Manado, Sulawesi.
18	02 47 32.2•	63.191 N	151.113 W	33 N		1.4	5	CENTRAL ALASKA. ML 3.1 (PMR).
18	04 28 23.0?	52.04 N	17.22 E	10 G		0.3	8	POLAND. ML 3.7 (VKA), 3.5 (KBA).
18	05 33 47.0?	40.07 N	24.19 E	10 G		1.2	7	AEGEAN SEA
a 18	06 32 18.6	4.129 S	153.585 E	260	5.4	1.0	93	NEW IRELAND REGION
18	06 58 34.9•	44.663 N	140 947 E	278 ?	4.2	0.8	14	EASTERN SEA OF JAPAN
18	07 20 00.4•	31.891 N	142.666 E	33 N	4.2	0.9	7	SOUTH OF HONSHU, JAPAN
18	07 33 57.2•	42.782 S	85 647 W	10 G	5.2	0.9	43	WEST CHILE RISE
18	07 39 45.0•	33.043 S	116 671 E	10 G		0.8	5	WESTERN AUSTRALIA
18	07 40 13.2•	61.881 N	7.474 E	10 G		0 8	7	SOUTHERN NORWAY. MD 2.6 (BER).
18	08 39 52.1&	10.767 N	84.891 W	180			7	COSTA RICA. <HDC>. MD 4.1 (HDC).
18	08 48 53.2?	6.43 S	142.56 E	33 N	3.8	1.5	7	PAPUA NEW GUINEA
18	09 01 46.8	37.038 N	26 690 E	10 G		0.7	6	DODECANESE ISLANDS. ML 4.2 (ATH).
18	09 16 57.4?	28 84 S	72 11 W	33 N		1.4	10	OFF COAST OF CENTRAL CHILE
18	09 51 49.5	27 036 S	71 095 W	32 D	5.0	1.0	37	NEAR COAST OF NORTHERN CHILE
18	10 56 53.0	60 880 N	151 297 W	56 •	3 8	1 0	14	KENAI PENINSULA, ALASKA. Felt (III) at Anchorage.
18	11 01 21.4%	40 387 N	29 499 E	20 •		0.6	7	TURKEY
18	12 44 53 4&	39 132 N	110 867 W	12	4.5		58	UTAH. <SLC-P>. ML 4 4 (SLC). Felt (V) at Castle Dale, Elmo, Ferron, Huntington, Sunnyside and Wellington. Felt (IV) at Clawson, Cleveland, East Carbon, Kenilworth and Price. Felt throughout much of central Utah and in parts of western Colorado including Grand Junction and Fruita.
18	12 46 02.5%	40.236 N	28.681 E	10 G		1.2	5	TURKEY
18	13 10 46.8•	34 751 N	23.101 E	33 N	3.8	1.5	9	CRETE. ML 4.0 (ATH).
18	13 21 37.8	50.464 N	7 387 E	10 G		1.7	16	GERMANY. ML 3.0 (LDG), 2.3 (BNS).
18	14 46 57.3%	60.562 N	5.070 E	0 G		0.8	7	SOUTHERN NORWAY. MD 2.3 (BER). Probable explosion.
18	14 59 49.6	61.765 N	150.191 W	33 N		0.3	6	SOUTHERN ALASKA. ML 3.5 (PMR). Felt (II) at Anchorage.
18	15 36 32.7%	44.165 N	8.620 E	10 G		1.0	6	NORTHERN ITALY. ML 2.3 (GEN).
18	17 19 46.7&	39.160 N	110.864 W	11			14	UTAH. <SLC-P>. CL 1.9 (SLC).
18	17 37 44.6	42.088 N	24.052 E	10 G		1 1	11	BULGARIA. MD 3.0 (ATH).
18	19 11 55.1•	30.788 S	68.913 W	125 ?		1 2	10	SAN JUAN PROVINCE, ARGENTINA
18	19 12 45.7•	23.729 N	120.495 E	33 N		0.2	5	TAIWAN
18	19 54 43.8?	27.17 S	71.65 W	33 N		1 7	5	NEAR COAST OF NORTHERN CHILE
18	21 25 14.3	38.854 N	114 639 W	5 G		0 5	29	NEVADA. ML 3.7 (NEIS)
18	21 34 22.9	46.565 N	153 761 E	33 N	5.0	0.8	60	KURIL ISLANDS
18	21 36 43.1•	27.122 S	71.423 W	33 N	4.8	1.4	21	NEAR COAST OF NORTHERN CHILE
18	22 48 01.7	27.195 S	71.262 W	32 D	4.8	1.3	31	NEAR COAST OF NORTHERN CHILE
18	22 48 42.1?	44.76 N	17.08 E	10 G		2.1	5	YUGOSLAVIA. ML 3.0 (ZAG).
19	00 40 31.8?	33.92 S	72.57 W	18		0.4	9	OFF COAST OF CENTRAL CHILE
19	00 40 39.5?	38 68 N	21 42 E	10 G		0.2	4	GREECE. MD 2.9 (ATH)

Seismic data from the United States nuclear test KEARSARGE. Note collapse of subsidence crater five hours twenty-three minutes after detonation.

Source: "Preliminінary Determinination of Epicenters", 08/17/88, available from USGS.

BOOKS, PROCEEDINGS & MAGAZINES

The best overview of the nuclear weapons industry as a whole is available through the Natural Resources Defense Council (NRDC) and its Nuclear Weapons Databook Project. The project is an eight volume set that profiles facilities, production and testing nationally and internationally. Currently, volume five is nearly complete. Also of great value is the redundantly titled U.S. Nuclear Weapons: The Secret History (1988) by Chuck Hanson. This book is an inspiration by relying on obscure government memos (a great many from the CIC) to flesh out a detailed and fascinating picture of weapons testing. The best book in print to focus on the Plowshare program is Nuclear Dynamite (1990) by Trevor Findlay. This work addresses the political implications of the Plowshare program as opposed to the technological or environmental impacts.

The proceedings from the three symposiums on "Engineering with Nuclear Explosives" provide an overview of the state of the art as presented by Plowshare proponents.{11} The *Bulletin of Atomic Scientists*, published since 1945, is the most consistently informative and engaging magazine to address nuclear weapons issues, including the Plowshare program.

CITIZEN GROUPS

Research material regarding a broad aspects of military activities was obtained from the "Snake River Alliance" and "Committee for Idaho's High Desert". These citizen groups were originally formed to address environmental degradation at Idaho National Engineering Labs (INEL), a DOE sponsored weapons facility. Other information was drawn from Richard Bargen's

11. See, for example, US AEC CONF-700101(vol.2), "Engineering With Nuclear Explosives", January 14-16, 1970, Las Vegas, Nevada

Airspace Blues and the excellent case study of military malfeasance by Richard and Myriam Misrach entitled Bravo 20. Skyguard and Citizen Alert, two environmental groups based in Nevada, publish newsletters with information concerning military land use and environmental impacts that is difficult to obtain anywhere else. Up to date United States testing information is available through American Peace Test of Las Vegas. American Peace Test monitors test site worker radio transmissions to determine the date of upcoming announced and unannounced nuclear tests. The Downwinders, a small non-profit based in Salt Lake City, has been extremely effective in educating the public about the environmental and health effects of nuclear testing. They also have what is probably the most complete set of documents relating to nuclear testing in private hands anywhere. However, they are difficult to reach, and, for reasons unknown to this author, have stopped publishing their newsletter *Testing News*.

SOURCES NOT CONSULTED

Several important sources were not consulted or approached for this study due to time and logistical constraints. The history division of the DOE, located in Maryland, contains a vast amount of information related to nuclear testing; in particular information about the AEC from 1946 through 1975. Some of this material has been sent to the CIC in Las Vegas. Department of State files in Washington D.C. containing important Plowshare information have, unfortunately, “not been screened, are classified, and are not open to the public.”{12} The Eisenhower Library in Abilene, Kansas “contains a substantial amount of ...

12. “Guide to Archival Collections”, p. 50

material on nuclear testing."{13} Access to a portion of these records is limited to government employees. The National Archives Headquarters holds tens of thousands of cubic feet worth of testing documents, both classified and unclassified. Security clearances from the publishing agencies are required to view the classified material.

13. Ibid., p. 55

APPENDIX B

DEDICATED PLOWSHARE NUCLEAR TESTS

1. NOUGAT\GNOME 12/10/61 SPONSOR - LRL CARLSBAD, NM
(WELL ?) SHAFT -1,184 FT.
YIELD - 3.1 KT. EVENT RELEASE NO COLLAPSE

2. STORAX\SEDAN 07/06/62 SPONSOR - LRL
NTS Ul0h CRATER -635 FT.
YIELD - 104 KT. EVENT RELEASE CRATER 1,280 FT. X 320 FT.

3. STORAX\ANACOSTIA 11/27/62 SPONSOR - LRL
NTS U9i SHAFT -747 FT.
YIELD - LOW. EVENT & DRILLBACK RELEASE SURFACE COLLAPSE
4. STORAX\KAWEAH 02/21/63 SPONSOR - LRL
NTS U9ab SHAFT -745 FT.
YIELD - LOW. DRILLBACK RELEASE NO COLLAPSE

5. NIBLICK\TORNILLO 10/11/63 SPONSOR - LRL
NTS 09aq SHAFT -489 FT.
YIELD - LOW. DBILLBACK RELEASE SURFACE COLLAPSE

6. NIBLICK\KLICKITAT 02/20/64 SPONSOR - LBL
NTS UlOe SHAFT -1,616 FT.
YIELD - 20-200 KT. DRILLBACK RELEASE SURFACE COLLAPSE

7. NIBLICK\ACE 06/11/64 SPONSOR - LRL
NTS U2n SHAFT -862 FT.
YIELD - LESS THAN 20 KT. EVENT & DRILLBACK RELEASE NO COLLAPSE

8. NIBLICK\DUB 06/30/64 SPONSOR - LRL
NTS U10a SHAFT -847 FT.
YIELD - LESS THAN 20 KT. EVENT & DRILLBACK RELEASE SURFACE COLLAPSE

9. WHETSTONE\PAR 10/09/64 SPONSOR - LRL
NTS U2p SHAFT -1,325 FT.
YIELD - 38 KT. DRILLBACK RELEASE SURFACE COLLAPSE

10. WHETSTONE\HANDCAR11/05/64 SPONSOR - LRL
NTS UlOb SHAFT -1,319 FT.
YIELD - 12 KT. EVENT & DRILLBACK RELEASE NO COLLAPSE

11. WHETSTONE\SULKY 12/18/64 SPONSOR - LRL
NTS U18d SHAFT -90 FT.
YIELD - 0.092 KT. CONTAINED RUBBLE MOUND 158 FT. X 21 FT.

12. WHETSTONE\PALANQUIN 04/14/65 SPONSOR - LBL
NTS U20k CRATER -280 FT.
YIELD - 4.3 KT. EVENT RELEASE CRATER 339 FT.X 79 FT.

13. FLINTLOCK\TEMPLAR 03/24/66 SPONSOR - LRL
NTS U9bt SHAFT -495 FT.
YIELD - LESS THAN 20 KT. DRILLBACK RELEASE NO COLLAPSE

14. FLINTLOCK\VULCAN 06/25/66 SPONSOR - LRL
NTS U2bd SHAFT -1,057 FT.
YIELD - 25 KT. DRILLBACK RELEASE SURFACE COLLAPSE

15. LATCHKEY\SAXON 07/28/66 SPONSOR - LRL
NTS U2cc SHAFT -500 FT. YIELD - LESS THAN 20 KT. DRILLBACK RELEASE SURFACE
COLLAPSE

16. LATCHKEY\SIMMS 11/05/66 SPONSOR - LRL
NTS U10w SHAFT -650 FT. YIELD - LESS THAN 20 KT. DRILLBACK RELEASE SURFACE
COLLAPSE

17. LATCHKEY\SWITCH 06/22/67 SPONSOR - LRL
NTS U9b’ SHAFT -990 FT. YIELD - LES9 THAN 20 KT. DRILLBACK RELEASE NO COLLAPSE

18. CROSSTIE\MARVEL 09/21/67 SPONSOR - LRL
NTS UlOdS SHAFT -572 FT. YIELD - 2.2 KT. EVENT & DRILLBACK RELEASE SURFACE COLLAPSE

19. CROSSTIE\GASBUGGY 12/10/67 SPONSOR - LRL/EPNG/USBM
FARMINGTON, NM (WELL GB-ER) SHAFT -4,240 FT.
YIELD - 29 KT. EVENT RELEASE? NO COLLAPSE

20. CROSSTIE\CABRIOLET 01/26/68 SPONSOR - LRL
NTS U201 CRATER -170 FT.
YIELD - 2.3 KT. EVENT RELEASE CRATER 359 FT. X 116 FT.

21. CROSSTIE\BUGGY 03/12/68 SPONSOR - LRL
NTS U30a,b,c,d,e CRATER -135 FT.
YIELD - 5.4 KT. EVENT RELEASE CRATER 433 FT. X 127 FT.

22. BOWLINE\STODDARD 09/17/68 SPONSOR - LRL
NTS U2caS SHAFT -1,535 FT.
YIELD - 20-200 KT. DRILLBAC6 RELEASE SURFACE COLLAPSE

23. BOWLINE\SCHOONER 12/08/68 SPONSOR - LRL
NTS U20u CRATER -200 FT.
YIELD - 35 KT. EVENT RELEASE CRATER 852 FT. X 208 FT.

24. MANDREL\RULISON 09/10/69 SPONSOR - LASL/Austral Oil/USBM
GRAND VALLEY, CO (WELL R-E) SHAFT -8,443 FT.
YIELD - 40 KT. DRILLBACK RELEASE NO COLLAPSE

25. MANDREL\FLASK 05/26/70 SPONSOR - LRL
NTS U2as SHAFT -1,743 FT.
YIELD - 105 KT. EVENT & DRILLBACK RELEASE SURFACE COLLAPSE

26. GROMMET\MINIATA 07/08/71 SPONSOR - LRL
NTS U2bu SHAFT -1,735 FT.
YIELD - 83 KT. DRILLBACK RELEASE SURFACE COLLAPSE

27. TOGGLE\RIO BLANCO 05/17/73 SPONSOR - LRL/Equity Oil/SLC/CER
RIFLE, CO (WELL RB-E-01) SHAFT -6,350 FT.
YIELD - THREE 33 KT. CONTAINED NO COLLAPSE

PLOWSHARE RELATED NUCLEAR TESTS

1. NOUGAT\HARD HAT 02/15/62 SPONSOR - DNA
NTS U15a SHAFT -943 FT.
YIELD - 5.7 KT. EVENT h DRILLBACK RELEASE SURFACE COLLAPSE

2. NOUGAT\DANNY BOY 03/05/62 SPONSOR - LRL/DNA
NTS U18a CRATER -110 FT.
YIELD - 0.43 KT. EVENT RELEASE CRATER 265 FT. X 84 FT.

3. STORAX\GERBIL 03/29/63 SPONSOR - LASL
NTS U3bp SHAFT -917 FT.
YIELD - LOW. CONTAINED SURFACE COLLAPSE

4. STORAX\KENNEBEC 06/25/63 SPONSOR - LRL
NTS U2af SHAFT -740 FT.
YIELD - LOW. EVENT & DRILLBACK RELEASE SURFACE COLLAPSE

5. NIBLICK\SHOAL 10/26/63 SPONSOR - ARPA/DNA/LASL
NEAR FALLON, NV.(WELL ?) SHAFT -1,205 FT.
YIELD - 12 KT. DRILLBACK RELEASE NO COLLAPSE

6. NIBLICK\ANCHOVY 11/14/63 SPONSOR - LASL
NTS U3bq SHAFT -854 FT.
YIELD - LOW EVENT & DRILLBACK RELEASE SURFACE COLLAPSE

7. NIBLICK\GREYS 11/22/63 SPONSOR - LRL
NTS U9ax SHAFT -987 FT.
YIELD - LOW. DRILLBACK RELEASE SURFACE COLLAPSE

8. NIBLICK\OCONTO 01/23/64 SPONSOR - LRL
NTS U9ay SHAFT -868 FT.
YIELD - LESS THAN 20 KT. DRILLBACK RELEASE SURFACE COLLAPSE
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9. WHETSTONE\BYE 07/16/64 SPONSOR - LRL
NTS UlOi SHAFT -1,277 FT.
YIELD - 20-200 KT. DRILLBACK RELEASE SURFACE COLLAPSE

10. WHETSTONE\BARBEL 10/16/64 SPONSOR - LASL
NTS U3bx SHAFT -849 FT.
YIELD - LESS THAN 20 KT. DRILLBACK RELEASE SURFACE COLLAPSE

11. WHETSTONE\SALMON 10/22/64 SPONSOR - ARPA/DNA/LRL HATTIESBURG, MS.(WELL ?)
SHAFT -2,717 FT.
YIELD - 5.3 KT. DRILLBACK RELEASE? NO COLLAPSE

12. WHETSTONE\PARROT 12/16/64 SPONSOR - LASL
NTS U3dk SHAFT -592 FT.
YIELD - 1.3 KT. EVENT RELEASE SURFACE COLLAPSE

13. WHETSTONE\MUDPACK12/16/64 SPONSOR - DNA/LRL
NTS UlOn SHAFT-498 FT.
YIELD - 2.7 KT. CONTAINED SURFACE COLLAPSE

14. WHETSTONE\SCAUP 05/14/65 SPONSOR - LASL
NTS U3das SHAFT-1,401 FT.
YIELD - LESS THAN 20 KT. CONTAINED SURFACE COLLAPSE

15. WHETSTONE\TWEED 05/21/65 SPONSOR - LRL
NTS U9bn SHAFT -922 FT.
YIELD - LESS THAN 20 KT. DRILLBACK RELEASE SURFACE COLLAPSE

16. WHETSTONE\PETREL 06/11/65 SPONSOR - LASL
NTS U3dy SHAFT -593 FT.
YIELD - 1.3 KT. DRILLBACK RELEASE? SURFACE COLLAPSE

17. FLINTLOCK\DURYEA 04/14/66 SPONSOR - LRL
NTS U20a SHAFT -1,786 FT.
YIELD - 70 KT. DRILLBACK RELEASE NO COLLAPSE

18. FLINTLOCK\CYCLAMEN 05/05/66 SPONSOR - LASL
NTS U3cx SHAFT -1,001 FT.
YIELD - 12 KT. CONTAINED SURFACE COLLAPSE

19. FLINTLOCK\DISCUS THROWER 05/27/66 SPONSOR - DNA/LASL/SANDIA
NTS U8a SHAPT -1,105 FT.
YIELD - 22 KT. CONTAINED SURFACE COLLAPSE

20. FLINTLOCK\PILE DRIVER 06/02/66 SPONSOR - DNA/LASL/SANDIA
NTS U15a.01 TUNNEL -1,518 FT.
YIELD - 62 KT. EVENT RELEASE NO COLLAPSE

21. FLINTLOCK\KANKAKEE 06/15/66 SPONSOR - LRL
NTS UlOp SHAFT -1,491 FT.
YIELD - 20-200 KT. DRILLBACK RELEASE SURFACE COLLAPSE

22. LATCHKEY\STERLING 12/03/66 SPONSOR - ARPA/DNA HATTIESBURG, MS.
(WELL ?) SHAFT -2,717 FT.
YIELD - 380 TONS. DRILLBACK RELEASE? NO COLLAPSE

23. LATCHKEY\PERSIMMON 02/23/67 SPONSOR - LASL
NTS U3dn SHAFT -981 FT.
YIELD - LESS THAN 20 KT. CONTAINED SURFACE COLLAPSE

24. MANDREL\HUTCH 07/16/69 SPONSOR - LRL
NTS U2df SHAFT -1,800 FT.
YIELD - 20-200 KT. DRILLBACK RELEASE SURFACE COLLAPSE

NUCLEAR TESTS WITH PLOWSHARE APPLICATIONS

1. JANGLE\SUGAR 11/19/51 SPONSOR - DNA
NTS AREA 9 SURFACE - 3.5 FT.
YIELD - 1.2 KT. ATMOSPHERIC

2. JANGLE\UNCLE 11/29/51 SPONSOR - DNA/LASL
NTS U10 CRATER -17 FT.
YIELD - 1.2 KT. EVENT RELEASE CRATER APPROX. 80 FT. DEEP

3. TEAPOT\ESS 03/23/55 SPONSOR - DNA/LASL
NTS AREA T-lOa CRATER -67 FT.
YIELD - 1 KT. EVENT RELEASE CRATER APPROX. 80 FT . DEEP

4. PLUMBBOB\RAINIER 09/19/57 SPONSOR - UCRL
NTS U12b TUNNEL-899 FT.
YIELD - 1.7 KT. CONTAINED NO COLLAPSE

5.HARDTACK II\NEPTUNE 10/14/58 SPONSOR - UCRL
NTS U12c.03 TUNNEL -110 FT.
YIELD - 115 TONS. EVENT RELEASE SURFACE COLLAPSE

PLOWSHARE HIGH EXPLOSIVE TESTS

1. TOBOGGAN 1959? SPONSOR - ?
NTS AREA ? YIELD - ?

2. TOBOGGAN PHASE I 1959 SPONSOR - ?
AREA ? YIELD - ?

3. SANDIA SERIES I 01/20-01/27 1959 SPONSOR - SANDIA LABS
NTS AREA 10 YIELD - ?

4. PRE-GNOME FEBRUARY 1959 SPONSOR - ?
NEAR CARLSBAD, NEW MEXICO YIELD - ?

5. TOBOGGAN PHASE II 1960? SPONSOR - ? 297
AREA ? YIELD - ?

6. BUCKBOARD JUNE - SEPTEMBER 1960. SPONSOR - ?
NTS AREA ? YIELD - TEN 1,000 POUND AND THREE 20-TON SHOTS BASALT.

7. STAGECOACH 03/15-03/25 1960 SPONSOR - SANDIA LABS
NTS AREA 10 YIELD - THREE 20? (MAYBE 40,000 LB) SHOTS

8. PINOT AUGUST ? 1960 SPONSOR - ?
NEAR RIFLE, COLORADO YIELD - ?

9. YO-YO SUMMER 1961 SPONSOR - LRL
NEVADA? YIELD - ?.

10. ROWBOAT 06/26-06/28 1961 SPONSOR - LRL
AREA ? YIELD - 8 DETONATIONS OF SERIES OF 4 278 LB. CHARGES.

11. PRE-BUGGY DECEMBER 1962 - FEBRUARY 1963 SPONSOR - ?
NTS AREA 10 YIELD - ? MULTIPLE SHOTS

12. PRE-BUGGY I NOVEMBER, DECEMBER 1962 AND JANUARY 1963 SPONSOR - ?
NTS AREA 5 YIELD - ?

13. PRE-BUGGY II MAY - AUGUST 1963. SPONSOR - ?
NTS AREA 5 YIELD - ? MULTIPLE SHOTS

14. PRE-SCHOONER 02/06-02/27 1964 SPONSOR - ?

BUCKBOARD MESA YIELD - ? FOUR SHOTS

15. DUGOUT 10/24/1964 SPONSOR - LRL
NTS U18g-p -59 FEETYIELD - FIVE 20 TON CHARGES.

16. PRE-SCHOONER II 09/30/1965 SPONSOR - ?
NEAR MOUNTAIN HOME, ID YIELD - 86.5 TONS

17. PRE-GONDOLA 06/20-06/23 1966 SPONSOR - LLNL?
FORT PECK, MONTANA YIELD - ? MULTIPLE SHOTS

18. PRE-GONDOLA I OCTOBER - NOVEMBER 1966. SPONSOR - LLNL?
FORT PECK, MONTANA YIELD - ? MULTIPLE SHOTS

19. PRE-GONDOLA II 06/28/1967 SPONSOR - LLNL?
PORT PECK, MONTANA YIELD - / MULTIPLE SHOTS

20. PRE-GONDOLA III 09/25/1968 SPONSOR - ?
MONTANA? YIELD - ?

21. PRE-GONDOLA III 10/30/1968 SPONSOR - ?
AREA ? YIELD - 7 THIRTY TON CHARGES IN SINGLE ROW.

22. TUGBOAT APRIL ?, 1970 SPONSOR - ?
KAWAIHAE BAY, HAWAIIYIELD - ?

23. TRINIDAD D-4 DECEMBER? 1970. SPONSOR - LRL
NEAR TRINIDAD, CO YIELD - ? DOUBLE ROW HE.

24. TRENCHER NOVEMBER 1970. SPONSOR - LLNL
PORT PECK, MONTANA YIELD - ? MULTIPLE SHOTS

25. MIDDLE COURSE II SEPTEMBER 1971 SPONSOR - ?
TRINIDAD, CO YIELD - SIXTEEN 907 KG (1 TON) SHOTS

PLOWSHARE RELATED HIGH EXPLOSIVE TESTS

1. DUGWAY 300 SERIES 1951? SPONSOR - ?
DUGWAY, UTAH YIELD - ?

2. DUGWAY 100 SERIES 1951? SPONSOR - ?
DUGHAY, UTAH YIELD - ?

3. DUGWAY 800 SERIES 1961? SPONSOR - ?
DUGWAY, UTAH YIELD - ?

4. JANGLE HE 08/25-10/14 1951 SPONSOR - DOD/SRI
NTS AREA 10 (ALLUVIUM) YIELD - ? SERIES

5. LITTLE DITCH 1959? SPONSOR - ?
AREA ? YIELD - ?

6.COWBOY 1959-1960 SPONSOR - ?
WINNFIELD, LA YIELD - ? SERIES

7. SCOOTER CAL JULY 1960 SPONSOR - ?
NTS AREA ? YIELD - 3,000 POUNDS

8.SCOOTER 10/13/1960 SPONSOR - ?
NTS AREA 10 -125 FT.YIELD - 500 TONS.

9. LOLLIPOP 1962? SPONSOR - ?
NTS AREA 15 YIELD - ?

10. AIR VENT I 10/14/1963 SPONSOR - DASA/SANDIA LAB
NTS AREA ? (FRENCHMAN FLAT) YIELD - ?

11. AIR VENT III 1964 SPONSOR - ?
NTS AREA ? YIELD - ?

12. FLAT TOP I FEBRUARY - JUNE 1964 SPONSOR - ?
NTS AREA ? YIELD - 20 TONS.

13. FLAT TOP II FEBRUARY - JUNE 1964? SPONSOR - ?
AREA ? YIELD - 20 TONS.

14. AIR VENT II 1964 SPONSOR - ?
NTS AREA ? YIELD - ?

15. FLAT TOP III FEBRUARY - JUNE 1964? SPONSOR - ?
NTS AREA ? YIELD - 20 TONS.

16. SNOWBALL 07/17/1964 SPONSOR - ?
CANADA YIELD - 500 TONS.

17. SAILOR HAT SEPTEMBER 1965 SPONSOR - ?
HAWAII YIELD - 500 TONS.

18. DIAMOND ORE 1971? SPONSOR - LRL
SITE 300 (LLNL) YIELD - SERIES OF 6 LB EXPLOSIVE TESTS

19. DIAMOND ORE OCTOBER 1971. SPONSOR - LLNL
FORT PECK, MONTANA YIELD - ? MULTIPLE SHOTS

PROPOSED PLOWSHARE TESTS

1. CHARIOT\EXCAVATION 1958 SPONSOR - ?.
CAPE THOMPSON, AK YIELD - 2.5 MT

2. OXCART\EXCAVATION 1959 SPONSOR - ?
NTS AREA 10 SHAFT -275 FEET AND -400 FEET YIELD - TWO 2.5 KT.

3. PRE-VINTAGE\OIL SHALE DEVELOPMENT 1960 SPONSOR - ?
GARFIELD COUNTY, CO YIELD - ?

4. WAGON\EXCAVATION 1961 SPONSOR - ?
NTS - BUCKBOARD MESA YIELD - PROBABLY LESS THAN 1 KT.

5. CARRYALL\EXCAVATION 1963-1964 SPONSOR - UCRL
MOHAVE DESERT, CA YIELD - ?

6. STREETCAR\EXCAVATION F.Y. 1964 SPONSOR - ?
NEVADA? YIELD - ?

7. MOSES\WATER DEVELOPMENTPROPOSED 1965? SPONSOR - ?
UNDERGROUND LUNAR SHOTYIELD - ?

8. QATTARA DEPRESSION\CANAL EXCAVATION 1965 SPONSOR - ?
EGYPT YIELD - 181 EXPLOSIONS BETWEEN 150-600 KTS.

9. PANATOMIC CANAL\EXCAVATION1965 SPONSOR - ?
PANAMA/NICARAGUA YIELD - 300 MT?

10. DOGSLED\EXCAVATION 1965 SPONSOR - ?
AZ OR UT YIELD - 100 KT.

11. COACH\PHENOMENOLOGY 1965? SPONSOR - ?
NH YIELD - AROUND 10 KT?

12. DRAGON TRAIL\GAS STIMULATION1966 SPONSOR - CONT. OIL/GEONUCLEAR
DOUGLAS CREEK AREA, WESTERN CO SHAFT - 2,700 FT. YIELD - 40 KT.

13. KETCH\STORAGE 1967 SPONSOR - LRL/COLUMBIA GAS SERVICE
NEAR RENOVO, PA YIELD - ?

14. SLOOP\MINING 1967 SPONSOR - LRL/KENNRCOTT COPPER CO.
SOUTHERN AZ YIELD - ?

15. BRONCO\OIL SHALE DEVELOPMEN1967 SPONSOR - LRL/CER GEONUCLEAR
NORTHWESTERN CO YIELD - ?

16. TRAVOIS\EXCAVATION 1968? SPONSOR - LRL
NORTH OF BOISE, ID YIELD - 40 KT.

17. WAYOUT\EXCAVATION 1968? SPONSOR - SWISS?
NEW SUEZ CANAL YIELD - ?

18. EXCAVATOR\EXCAVATION 1968? SPONSOR - LRL
NORTH OF BOISE, ID YIELD - 40 KT.

19. FLIVVER\EXCAVATION 1968 SPONSOR - ?
NEVADA? YIELD - LOW YIELD.

20. PINEDALE\GAS STIMULATION 1969? SPONSOR - INT'L NUCLEAR CORP,?
PINEDALE AREA, WY YIELD - ?

21. STURTEVANT\EXCAVATION 1969 SPONSOR - LRL
NTS UNa (SOUTH OF AREA 51) YIELD - BETWEEN 170 AND 250 RT.

22. WASP\GAS STIMULATION 1969 SPONSOR - INT'L NUCLEAR CORP.
PINEDALE AREA, WY YIELD - ?

23. UTAH\OIL SHALE DEVELOPMENT 1969 SPONSOR - ?
UTAH YIELD - ?

24. BUGGY II\EXCAVATION 1969 SPONSOR - ?
NTS AREA 30 YIELD - ?

25. YAWL\EXCAVATION 1970 SPONSOR - LLL?
NEAR AREA 51 NTS? YIELD - 900 KT.

26. GALLEY\EXCAVATION 1971? SPONSOR - ?
NEVADA? YIELD - FROM FEW 10'S TO FEW 100'S KT.

27. PHAETON\EXCAVATION 1971? SPONSOR - ?
NEVADA? YI U D - 1 MT.

28. CAPE KERAUDREN\EXCAVATION 1971? SPONSOR - LRL
CAPE KERAUDREN, AUSTRALIA YIELD - FIVE 200 KT EXPLOSIVES.

29. RULISON II\GAS STIMULATION 1972? SPONSOR - ?
COLORADO YIELD - ?

30. KRA CANAL\EXCAVATION 1973 SPONSOR - LLL
THAILAND YIELD - ?

31. OILSAND\OIL SHALE DEVELOPMENT 1973? SPONSOR - ?
ALBERTA, CANADA YIELD - ?

32. AQUARIUS\WATER DEVELOPMENT1973? SPONSOR - UNIV OF AZ/AZ.AEC
ARIZONA YIELD - ?

33. YACHT I\GAS STIMULATION 1973 SPONSOR - LLL
NTS UEll YIELD - ?

34. YACHT II\GAS STIMULATION 1974 SPONSOR - LLL
NEAR UEll? YIELD - ?

35. WAGON WHEEL\GAS STIMULATION 1975 SPONSOR - EL PASO NATURAL GAS CO
PINEDALE AREA, WY YIELD - FIVE 100 KT. EXPLOSIONS

APPENDIX C

ABBREVIATIONS

AEC - Atomic Energy Commission

CIC - Coordination and Information Center

DNA - Defense Nuclear Agency

DOE - Department of Energy

ERDA - Environmental Research & Development Administration

JCAE - Joint Committee on Atomic Energy

LANL - Los Alamos National Laboratory

LASL - Los Alamos Scientific Laboratory

LLL - Lawrence Livermore Laboratory

LLNL - Lawrence Livermore National Laboratory

LRL - Lawrence Radiation Laboratory

NTS - Nevada Test Site

NVOO - Nevada Operations Office

PNE - Peaceful Nuclear Explosion

REECo - Reynolds Electrical and Engineering Company

UCRL - University of California Radiation Laboratory

US NCG - U.S. Army Engineer Nuclear Cratering Group

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