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French Underground Nuclear Testing: Environmentally Safe and Likely To Continue [redacted]

An Intelligence Assessment

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French Underground Nuclear Testing: Environmentally Safe and Likely To Continue [redacted]

Key Judgments

Information available as of 17 January 1985 was used in this report.

The French have conducted over 70 underground nuclear tests at their test sites on Mururoa and Fangataufa Atolls in the South Pacific since 1975. Antinuclear sentiments in the region are high, and there have been bitter protests and public outcries against the test program. These protests are fueled, in part, by sensational press reports that Mururoa Atoll is breaking apart and leaking large amounts of radioactive debris to the environment. We believe these reports are unfounded. [redacted]

Recent studies by both independent French and Pacific Basin scientists have confirmed claims by French nuclear-testing authorities that their operations do not pose a radiological threat to either human or marine populations in the Pacific region. Although there is some evidence for short-term venting of gaseous and volatile fission products from the underground tests, these releases are not of a magnitude to pose an off-site health hazard. The studies found no evidence of any leakage of particulate bomb debris into the environment. [redacted]

We believe the French will continue their nuclear test program through the 1990s, probably at the current rate of seven to 12 tests per year. Before 1987, the French almost certainly will reactivate their test site on the nearby Fangataufa Atoll, which was deactivated in 1976. They may conduct all their high-yield tests at Fangataufa and restrict tests at Mururoa to under 50 kilotons after 1986. Moving high-yield testing to Fangataufa would reduce the amount of future geological stress on Mururoa Atoll and, thus, would provide an additional measure of safety to the test program. Although there always is the possibility of an accident, we believe the French nuclear test program will continue to have an excellent safety record and a negligible effect on the South Pacific environment. [redacted]

There have been recurrent press reports that the French might move to a different test site. Such a move would be politically untenable for the French, and we consider such a move from the South Pacific to be very unlikely. It is even less likely that the French would return to atmospheric testing. Although they are not precluded by treaty from doing so, the political cost of such testing would almost certainly outweigh any technical advantage. [redacted]

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Contents

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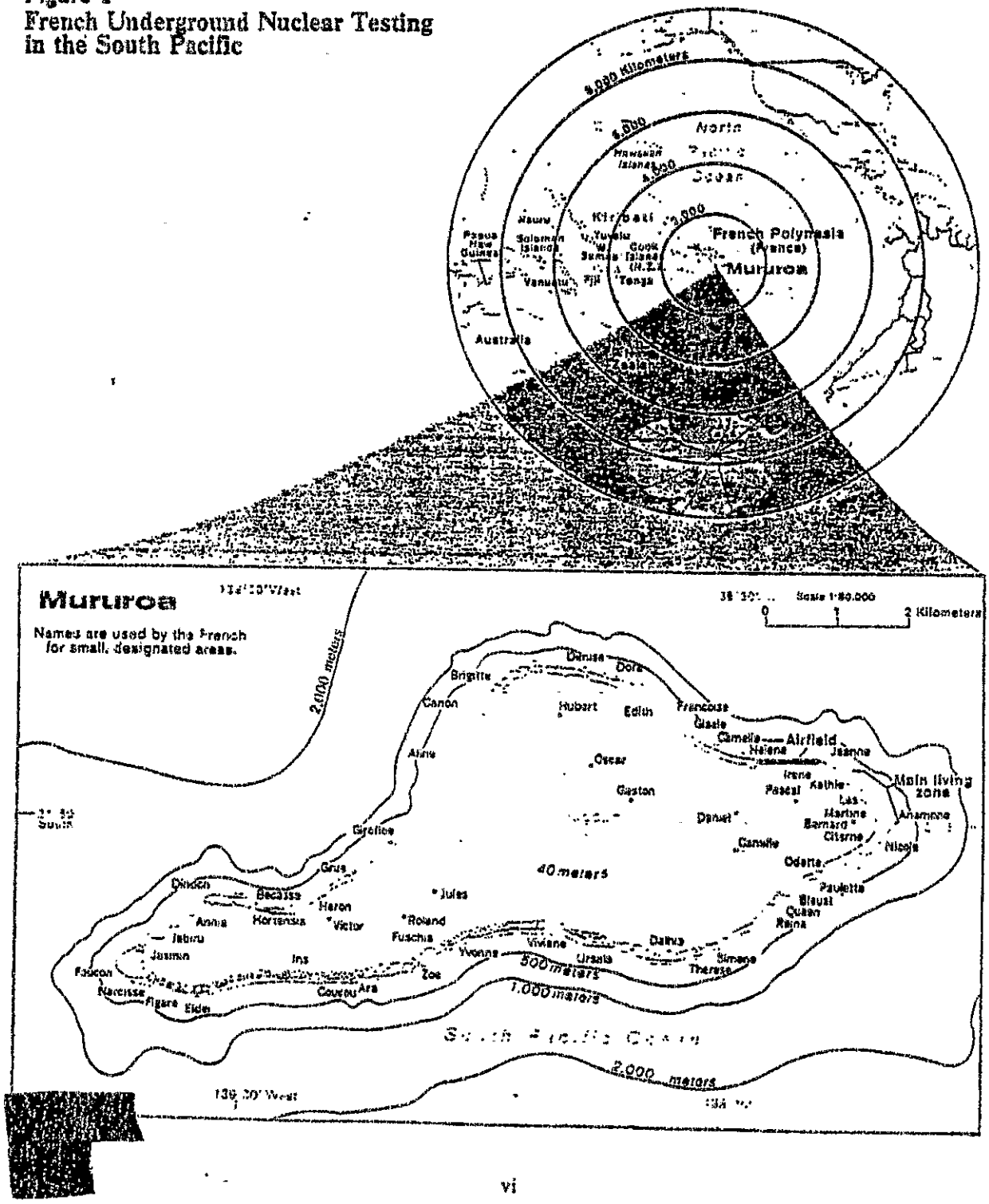
Figure 1
French Underground Nuclear Testing in the South Pacific



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French Underground Nuclear Testing: Environmentally Safe and Likely To Continue [redacted]

Introduction

Antinuclear sentiment has been widespread in the South Pacific Basin nations since France exploded its first nuclear bomb in the South Pacific above Mururoa Atoll (figure 1) in 1966. Between 1966 and 1974, the French conducted 41 nuclear tests in the atmosphere above Mururoa and the nearby Fangataufa Atoll, each explosion provoking a fresh round of bitter protests. There is little doubt that the radioactive debris generated by these tests posed an environmental threat to the area. [redacted]

The continuing public protests over the atmospheric tests—mainly from South Pacific Basin nations such as Australia, New Zealand, and Papua New Guinea (but sometimes from South American and European nations as well)—finally caused the French to shift their testing underground. They conducted two small underground tests at Fangataufa Atoll in 1975 and then deactivated that site, probably to reduce the cost of maintaining the test effort. The entire testing effort was shifted to Mururoa Atoll, and since 1975 over 70 underground explosions have been conducted there (appendix). [redacted]

The shift to underground nuclear testing has done little to quell protests from the South Pacific nations. Antinuclear protests continue to be fueled by sensational press reports of widespread leakage of radioactive debris and extensive geologic damage to Mururoa Atoll. The environmental impact of French nuclear testing has been one of the major complaints of the South Pacific Forum, an organization of regional governments such as Australia, New Zealand, Papua New Guinea, and Fiji. The Forum wishes to have the South Pacific declared a "nuclear free zone." Such a declaration would ban not only nuclear testing but also the stationing of nuclear weapons in the region, even in the case of nuclear-armed warships—an issue of major concern to the United States. This paper assesses the technical validity of the claims of geologic damage and environmental contamination from recent French nuclear testing and the future of the test program. [redacted]

Geology of Mururoa Atoll

The structures of Mururoa and Fangataufa Atolls are extremely similar and differ mainly in the depth at which the various geologic zones are located. For simplicity, we will discuss only Mururoa, but the same geologic data apply to Fangataufa.[1] Tables 1 and 2 show the basic structure of Mururoa. [redacted]

Mururoa is a coral atoll built upon a volcanic (basalt) base (figure 2). The French conduct their nuclear tests in the volcanic base. French geological studies indicate that the volcanics rise from a depth of roughly 3,000 to 4,000 meters to approximately 500 meters below the surface. Although the slope of the side of the base is generally gentle, rising at 15 to 40 degrees, certain portions are locally steep, rising at angles greater than 60 degrees. Both the side and the base tend to alternate compacted and fractured layers. Fracturing has severely limited the available testing space at Mururoa; safety precautions preclude testing near fractured layers. The central massif of the atoll—the section under the lagoon—although still slightly fractured, is more dense and homogeneous than the sides. This area has a higher safety factor and more available space. [redacted]

A transition zone composed of welded conglomerates (pebbles adhering to each other) is atop the volcanics. This zone, thick on the sides of the atoll and thinner in the lagoon, has a large amount of void space and has produced numerous problems in drilling. The material is very crumbly, and the French usually stabilize the zone with cement when drilling through it. [redacted]

[redacted]

[redacted]

Table 1
Major Geological Structures of Mururoa Atoll [a]

Approximate Depth (*meters*)	Composition
0 to 130	Detrital coral
130 to 360	Thick, massive dolomites
360 to 420	Sandy gravel and coral debris
420 to 510	Basaltic conglomerates with calcareous cement
>510	Lavas and volcanic breccias with alternating compact and scoriacious layers; aerial volcanics atop deep submarine volcanics

[a] The transition zone (the zone between the loose, coralline rocks and the underlaying volcanics) extends from roughly 400 to 500 meters in depth and is extremely inhomogeneous; it is quite treacherous from both a drilling and a safety point of view.

Fangataufa Atoll has a similar overall structure, although the individual layers are at different depths.

[redacted]

Layers of limestones and dolomites, the remains of coral, are atop the transition zone. These layers are extremely inhomogeneous, ranging in composition from hard and marbled to chalky. Because the sides of the atoll are so steep, this limestone and dolomite zone tends to flake and crumble under shock. The zone gradually merges into detrital coral on the sides of the atoll. The coral is poorly consolidated and contains voids which are, in many cases, open to the ocean. The limestones under the lagoon are covered by a thin layer of sand. [redacted]

Normal Containment Practice

French nuclear tests now are conducted in shafts drilled vertically into the volcanic base of Mururoa Atoll. According to reliable sources, the shafts typically are 600 to 1,100 meters deep, with the exact depth depending on the yield of the explosive device and the local geology. (As was noted in the previous section, safety constraints do not allow the explosion to be conducted in a fractured basaltic layer.) [redacted]

Table 2
Major Geological Structures of Mururoa Lagoon [a]

Approximate Depth (*meters*)	Composition
40 to 170	Limestone (some circulation layers)
170 to 270	Dolomites (varying from crumbly to massive)
270 to 550	Aerial volcanics
>550	Compact submarine volcanics (lavas and volcanic breccia)

[a] The transition zone (the zone between the loose, coralline rocks and the underlaying volcanics) under the lagoon is thin in most places and occurs at roughly 260- to 285-meter depth.

Fangataufa Atoll has a similar overall structure, although the individual layers are at different depths.

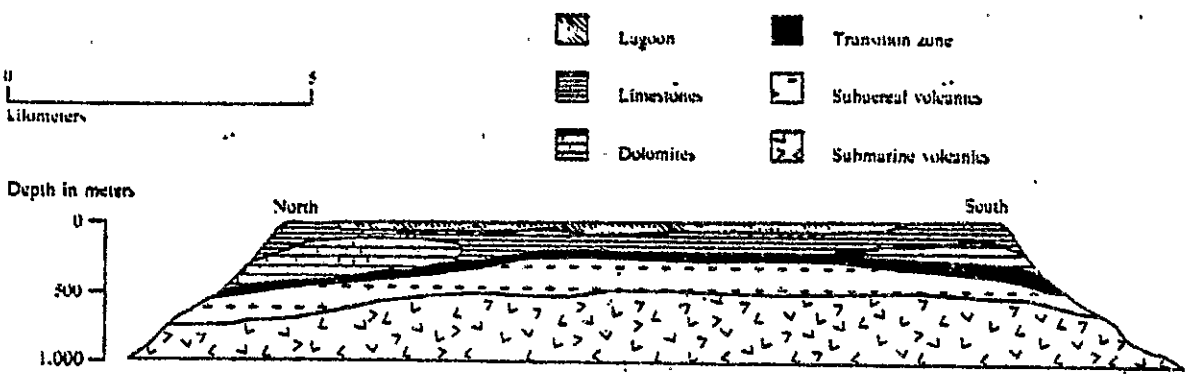
[redacted]

Because of the weak and crumbly nature of the transition zone and coralline structures, the French have stated that they do not consider them to have any ability to contain bomb debris. Thus, a depth of detonation is chosen that will not allow the cracks and fissures created by the explosion out of the transition zone, and preferably not out of the basalt. Although the saturated limestones and dolomites do provide overburden weight, they do not have sufficient structural integrity to be an effective part of the containment. [redacted] once a burial depth is determined and the device in place, the shaft is backfilled with stemming material and plugs of either cement or epoxy. All the materials used in the backfilling operation are chosen to prevent the release of radioactive debris. At least two different types of stemming material are used, depending on the surrounding geologic zone. Reportedly, in the volcanic zone, a basalt/sand/gravel mixture is used; a mix of crushed coral, sand, and gravel is used in the coralline structures. Although these mixtures retard particulate

[redacted]

[redacted]

Figure 2
Mururoa Cross Section



Unclassified

debris, they do not stop the percolation of gases. The cement and epoxy plugs are used as gas blocks and effectively prevent the movement of radioactive gas up the hole. Gas blocks also are used to prevent the flow of gas up the diagnostics and device-suspension cables. [redacted]

This containment system probably is not completely effective. [redacted] French do not put steel liners in their emplacement shafts, and some minor gas leakage into the surrounding geologic structures is inevitable. Such leakage, however, will be minor because of slow percolation rates, and much of that leakage will be dispersed in the deep ocean layers. [redacted]

Current Status of Mururoa Atoll

Although Mururoa has sustained damage from nuclear testing, our analysis indicates that the damage has not been as extensive as reported in the regional press and has not impaired the overall structural integrity of the atoll. The extent of damage, however, has been a matter of concern to the French and was one of the reasons they began testing under the lagoon in 1981. [redacted]

The sedimentary material and chalky limestones on the sides of the atoll have received the most damage. This material tends to crack, crush, and slide when subjected to the shock from a nuclear explosion. This tendency is increased by the steep slope of the atoll and worsens in proportion to the yield of the explosion and its proximity to the edge of the atoll. For instance, a reliable source indicated that a 180-kiloton blast in 1979 caused a massive layer of limestone and coral to break off the edge of the atoll. The material fell into the lagoon and produced a large wave, which washed over the atoll. This event gave rise to sensational reports in both the Pacific Basin and French presses that the atoll was crumbling and breaking apart. The damage actually was localized and not significant. [redacted]

[redacted]

[redacted]

Geological studies have indicated that damage to the atoll has not been significant enough to pose either a long-term safety or radiological hazard. Damage to the surface and upper layers of the atoll has thus far been both localized and minimal and has not affected normal operations. Damage to the underlying volcanics also has been minimal, consisting of the normal fissures and voids caused by any nuclear explosion. Because the explosions are laterally far from the sea, there is little chance of a breakout in that direction. [redacted]

The French have taken two steps to enhance the safety of the atoll. Since the beginning of 1981, they have conducted 14 tests under the lagoon, roughly alternating with tests under the atoll. Testing under the lagoon reduces the stress on the coralline atoll structure and makes use of a more compact and homogeneous volcanic structure than that available under the atoll proper. All of the higher yield (greater than 20 kilotons) tests since 1981 have been conducted under the lagoon. [redacted]

The French also have limited the size of the explosions they conduct at Mururoa. A reliable source reported in 1980 that the French would no longer conduct tests above 100 kilotons at Mururoa. Since 1980, there has been one test with a central-value yield of 100 kilotons; the rest have been less than 60 kilotons. Tests under the atoll proper have all been under 20-kiloton yield since that time. [redacted]

Environmental Status

The South Pacific Basin countries have made almost continual protests about nuclear testing since the French effort was moved to the area in 1966. The antinuclear protests have centered on fears of both short- and long-term health hazards and on marine contamination. These protests seem to have little technical basis. The French repeatedly have denied claims of contamination and damage to the atolls and have stressed their excellent safety record. The Basin countries have countered with the argument that the French claims were based on French data and were not susceptible to independent verification. The French Government took two major steps in response to this criticism. [redacted]

Study by French Scientists

According to a reliable source, a team of reputable French scientists, not connected with the nuclear-testing program, was invited to Mururoa in 1982. The team studied the geological integrity of the site, the possibility of widespread radioactive contamination, and the safety procedures of the test operations. [redacted]

Although the team expressed some minor concerns, they concluded that the Mururoa operations did not pose a risk to either the environment or the public safety. They said that the atoll was structurally sound and that there was no evidence that the underground tests were an off-site threat. They expressed a slight concern that earlier atmospheric tests contaminated the lagoon sediments but presented no data on radiation levels in those sediments. We do not know why such data were not collected. [redacted]

Study by Pacific Basin Scientists

The French also invited a scientific team from the South Pacific Forum countries to visit the site in 1983. Although stressing that participation would not lessen their opposition to nuclear testing, the Governments of New Zealand, Australia, and Papua New Guinea accepted the invitation. In October 1983, a team of six scientists from those countries toured Mururoa and examined both radiation monitoring and geophysical records. They also were allowed to collect extensive physical samples of sea life, vegetation, soil, coral, and seawater for radiological examination. The study conducted by this team probably is the most extensive independent study ever of another country's nuclear test site. [redacted]

Although the South Pacific team disagreed with some of the French claims and were not able to verify others, their report generally concluded that the current test program appears to pose no radiological threat to the environment or surrounding population. Radiation doses affecting the population in the area generally are well below those in other areas of the world, and any traces of fallout, even from the earlier atmospheric tests, are far below those levels posing any health hazards. There also was no evidence of increased rates of radiation-induced diseases in the French Polynesian population (and by analogy in the South Pacific Basin). [redacted]

[redacted]

The South Pacific team studied geological and hydrological data on the atoll in detail, commenting on the wealth of material available. They also were provided drilling core samples for study. They concluded that the structural integrity of the atoll as a whole, and the underlying volcanic base in particular, had not been damaged seriously. They did estimate, however, that the transition zone was not as impermeable to leakage as the French had claimed and also concluded that there had been substantial localized damage to the coralline structures. Although not currently a problem, the team noted that the creation of fissures in both the limestones and the volcanics could open a path for potential future leakage.

The South Pacific team concluded that there was some evidence of short-term venting of gaseous and volatile fission products after a test. A review of this evidence, however, suggests that the amount of venting is not significant from a radiological health or safety standpoint.[4] There was no geological evidence of any short-term leakage of nonvolatile debris.

The South Pacific team was unable to investigate completely the concern of the 1982 French survey group regarding the contamination of the sediments in Mururoa Lagoon. The French have estimated that there are 10 to 20 kilograms of plutonium in the sediments. This contamination apparently resulted from the atmospheric tests and from poor waste-handling procedures before 1981. Although the team was not allowed to sample the sediments or coral in certain portions of the lagoon, their estimates were in basic accord with the French claim. They also estimated that less than 10 grams of plutonium were transported from the lagoon to the ocean each year. This amount should not be a health hazard. The team similarly concluded that the uptake of the plutonium by local sea life would not be a health hazard.

These two studies have not reduced the number or the intensity of the antinuclear protests in the South Pacific region, even though the results of the studies have been given worldwide distribution and have been extensively quoted in the press. The nuclear-testing issue has now become a very emotional one and probably can no longer be dealt with on a purely scientific basis. Despite the good safety record of the French operations, nuclear testing remains, and will likely remain, a rallying point for antinuclear forces in the region.

The recent decision of New Zealand to ban nuclear-armed or nuclear-powered warships from its waters is only another example of this regional feeling, albeit of a much higher profile than the periodic skirmishes with France. The two issues are not directly connected, and resolution of one will not resolve the other.

Although there always is a possibility that a nuclear test will result in a massive blowout of radioactive debris, the French emphasis on safety makes this extremely unlikely. The test site would be extremely difficult to evacuate in an emergency, so the degree of French precautions regarding test safety (particularly emphasis on conducting explosions far from potentially hazardous geologic areas and the environment) are quite understandable. The French also maintain a strict, continuing, on-site radiation-monitoring system. Data from this system indicate that individuals on Mururoa actually receive a smaller radiation dose than they might receive elsewhere in the world.

Future Prospects

The French are unlikely to stop nuclear testing in the near future. Four major, new French weapons systems currently are scheduled to be deployed during the 1990s. Although two of these systems—the M-5 submarine-launched ballistic missile and the SX mobile ground-launched missile—reportedly will be based upon the 150-kiloton warhead currently in the M-4 SLBM, some testing still will be required to "custom tailor" the systems. The other two systems—the Hades missile and another reportedly using an enhanced radiation warhead—already are under development but will require further testing. These existing requirements for warheads for new systems indicate that testing will continue at least through the

1990s, even precluding any new weapons designs. The rate of testing probably will remain close to the present level—roughly seven to 12 tests per year. We believe that all the tests will be conducted underground; political considerations almost certainly preclude a return to testing in the atmosphere.

The French are refurbishing the facilities on Fangataufa Atoll. A test could be conducted there by the end of 1986, but we do not know whether the entire testing effort will be moved from Mururoa to Fangataufa. Although more than 70 tests have been conducted at Mururoa, there seems to be room for additional emplacement shafts. The space problem on the atoll also has been eased by testing under the lagoon. We do not believe continued testing will pose a significantly greater safety or radiological risk than in the past. Mururoa probably is the most extensively studied coral atoll in the world, and we believe the risk associated with continued testing is low.

Although the French may be preparing for an eventual move from Mururoa to Fangataufa, it is more likely that the latter site will be used solely for high-yield tests. Such a move would provide increased safety at both locations. The risk of venting or damage to the atoll would be lessened at Mururoa, because the shock and fissure radius from a low-yield test is less than from a high-yield test. High-yield tests at Fangataufa could be placed farther apart to assure that there would be less likelihood of induced collateral damage. There also would be very few tests at Fangataufa, possibly only one or two each year. The risk of venting, therefore, also would be decreased. It is unclear, however, whether the French would accept the economic cost of maintaining two test sites.

We discount the recurrent rumors that France has been exploring the possibility of opening a new test site. These rumors have focused on the French-held Kerguelen Islands in the Indian Ocean and have been denied repeatedly by French Defense Minister Charles Hernu. There are several reasons for the French not to move. Such a move probably would actually increase environmental and safety hazards. In the Kerguelens, the French do not have the considerable background in site geology, in drilling, and in test experience that they have at the current site. Further, weather would be less hospitable in the Kerguelens and possibly would limit the testing season. Most important, the political problems would increase rather than decrease. Several countries have hinted that they would drop diplomatic recognition of France should nuclear testing be moved to the Kerguelens.

We believe it is even less likely that the French would return to atmospheric testing, although there is no treaty prohibition against their doing so. Atmospheric testing would significantly raise the level of environmental hazard and would provide the basis for much increased—and highly justified—antinuclear protest. We believe that this political liability would far outweigh any technical advantage to be gained by atmospheric testing.

[redacted]

Appendix

French Underground Nuclear Tests in the South Pacific

Test Number	Date	Yield (*kilotons*) [a]	Location
59 [b]	5 Jun 75	2.8	Atoll
60 [b]	26 Nov 75	4.3	Atoll
61	11 Jul 76	12	Atoll
62	19 Feb 77	10	Atoll
63	19 Mar 77	110	Atoll
64	6 Jul 77	10	Atoll
65	12 Nov 77	6	Atoll
66	24 Nov 77	100	Atoll
67	17 Dec 77	6	Atoll
68	27 Feb 78	2	Atoll
69	22 Mar 78	7	Atoll
70	19 Jul 78	4	Atoll
71	26 Jul 78	2	Atoll
72	2 Nov 78	3	Atoll
73	30 Nov 78	120	Atoll
74	17 Dec 78	8	Atoll
75	19 Dec 78	10	Atoll
76	1 Mar 79	5	Atoll
77	9 Mar 79	6	Atoll
78	24 Mar 79	10	Atoll
79	4 Apr 79	7	Atoll
80	18 Jun 79	5	Atoll
81	29 Jun 79	15	Atoll
82	25 Jul 79	180	Atoll
83	28 Jul 79	5	Atoll
84	22 Nov 79	5	Atoll
85	23 Feb 80	2	Atoll
86	3 Mar 80	3	Atoll
87	23 Mar 80	51	Atoll
88	1 Apr 80	15	Atoll
89	4 Apr 80	5	Atoll
90	16 Jun 80	25	Atoll
91	21 Jun 80	5	Atoll
92	6 Jul 80	4	Atoll
93	19 Jul 80	74	Atoll
94	25 Nov 80	0.5	Atoll
95	3 Dec 80	43	Atoll
96	27 Feb 81	3	Atoll
97	6 Mar 81	3	Atoll
98	28 Mar 81	6	Atoll
99	10 Apr 81	6	Lagoon
100	8 Jul 81	14	Atoll
101	11 Jul 81	1	Atoll
102	18 Jul 81	2	Atoll
103	3 Aug 81	14	Atoll
104	6 Nov 81	1	Atoll
105	11 Nov 81	6	Atoll
106	5 Dec 81	4	Atoll
107	8 Dec 81	13	Lagoon
108	20 Feb 82	1	Atoll
109	24 Feb 82	1	Atoll
110	20 Mar 82	7	Lagoon
111	23 Mar 82	0.5	Atoll
112	27 Jun 82	1	Atoll
113	1 Jul 82	14	Atoll
114	21 Jul 82	3	Atoll
115	25 Jul 82	48	Lagoon
116	27 Nov 82	0.5	Atoll
117	16 Apr 83	57	Lagoon
118	25 Apr 83	0 25	Lagoon
119	25 May 83	100	Lagoon
120	18 Jun 83	1	Atoll
121	28 Jun 83	24	Lagoon
122	20 Jul 83	4	Atoll
123	4 Aug 83	16	Lagoon
124	3 Dec 83	2	Atoll
125	7 Dec 83	8	Lagoon
126	8 May 84	4	Atoll
127	12 May 84	40	Lagoon
128	12 Jun 84	6	Atoll
129	16 Jun 84	20	Lagoon
130	27 Oct 84	4	Atoll
131	2 Nov 84	45	Lagoon
132	1 Dec 84	<0.5	Atoll
133	6 Dec 84	41	Lagoon

[a] US Atomic Energy Detection System (AEDS) derived central-value yield.

[b] All tests except 59 and 60 were conducted at Mururoa.

[redacted]

[redacted]