RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT
CALENDAR YEAR 2006

APRA HARBOR, GUAM

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I. SUMMARY

This report provides the results of radiological environmental monitoring performed during 2006 at Apra Harbor, Guam. The radiological environmental monitoring program included sampling of harbor sediment, harbor water, marine life, and exhaust stack discharges as well as shoreline surveys and monitoring of perimeter radiation levels. The results of the radiological environmental monitoring program confirm that radiological controls associated with Naval nuclear powered ships at Apra Harbor, Guam are effective in protecting the environment and the health and safety of the public.

II. INTRODUCTION

Nuclear-powered submarines were based at Apra Harbor in the 1960s. Maintenance support was provided by a tender and a floating drydock. Between the 1970s and 2002, submarines were no longer based at Guam, and limited radiological maintenance was performed on visiting submarines. Since 2002, submarines have again been homeported at Guam.

Radiological environmental monitoring was performed concurrent with the presence of nuclear ships at Apra Harbor in the 1960s and has continued through the present.

III. ENVIRONMENTAL MONITORING PROGRAM

The environmental monitoring program at Apra Harbor, Guam includes sampling harbor water, harbor sediment, marine life, and exhaust stack discharges, and performing shoreline radiation surveys and monitoring perimeter radiation levels. Environmental monitoring sampling locations and perimeter radiation monitoring locations for Apra Harbor, Guam are shown on Figure 1.

The detection of cobalt-60 is emphasized in the environmental monitoring program because this radionuclide is the predominant long-lived gamma-emitting radionuclide associated with the Naval Nuclear Propulsion Program and has the most stringent concentration limits. Therefore, cobalt-60 results are listed in the following tables providing environmental monitoring results. However, equipment and operating procedures are utilized to identify any radionuclide with gamma ray energies between 0.1 and 2.1 MeV. This range encompasses all of the significant gamma emitting radionuclides potentially of interest for Naval nuclear propulsion. If a non-naturally occurring radionuclide is detected in any sample, the detected concentration is reported.

A summary of the results for each type of monitoring is provided in Tables 1 through 6 in the main body of the report. The results of radiological environmental monitoring during 2006 are provided in detail in Appendices A through F.

For all of the environmental sampling tables, analysis results for cobalt-60 are provided even when no cobalt-60 was detected. When no cobalt-60 was detected, a sample specific cobalt-60 minimum detectable concentration (MDC) or gross gamma cobalt-60 equivalent decision level concentration (DLC) is listed in the table. The MDC is the smallest radioactivity concentration which can be reliably detected in a sample. The minimum detectable concentration for cobalt-60 varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, differences in the weight of samples, differences between detection equipment, and statistical

fluctuations. The DLC is the quantity of a radionuclide above which a decision is made that a detectable amount of radioactivity is present with a five percent probability of erroneously reporting detectable radioactivity when none is present. For gross gamma counting, radioactivity calculations are based on the conservative assumption that all the radioactivity of the sample is due to cobalt-60. Therefore, the radioactivity result is in terms of cobalt-60 equivalent (0.1 – 2.1 MeV) radioactivity.

A. Harbor Water Samples

Harbor water samples are collected during the first month of each calendar quarter. Six samples are collected at Apra Harbor, Guam. These samples are collected in areas where nuclear powered ships are berthed and from surrounding areas.

Each water sample is analyzed for gamma radioactivity using a solid state germanium detector with a multichannel analyzer. Counting and sampling procedures ensure that cobalt-60 radioactivity of 100 picocuries* per liter (pCi/L) or greater is detected.

Table 1 provides a summary of harbor water sampling results for Apra Harbor, Guam. Appendix A provides results for each water sample obtained. No cobalt-60 or other non-naturally occurring radionuclide was detected in any water sample during 2006.

Table 1: Summary of 2006 Harbor Water Results for Apra Harbor, Guam

Quarter	Number of Samples	Number of Samples with Detectable Cobalt-60	Range of Detected Cobalt-60 Results (pCi/L)	Range of Cobalt-60 MDC Values for Samples with No Detectable Cobalt-60 (pCi/L) [1]	Range of Other Detected Non-Naturally Occurring Radionuclides (pCi/L)
1	6	0	None	20 – 27	None
2	6	0	None	14 – 23	None
3	6	0	None	18 – 27	None
4	6	0	None	19 – 23	None

1. When no cobalt-60 is detected in a sample, the minimum detectable concentration (MDC) is reported. The MDC is the smallest radioactivity concentration which can be reliably detected in a sample. The MDC varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, detection equipment differences, and statistical fluctuations.

* 1 picocurie = 1×10^{-12} Curie

B. Harbor Sediment Samples

Harbor sediment samples are collected during the first month of each calendar quarter at Apra Harbor, Guam . Twenty-seven samples were collected in areas where nuclear powered ships are berthed and from surrounding areas.

A Birge-Ekman dredge modified to sample a thirty-six square inch by about one inch deep layer of the harbor sediment is used to obtain each sample. The top layer is selected because it should be more mobile and more accessible to marine life than deeper layers. The sediment samples are drained of excess water and placed into 500 milliliter Marinelli counting containers for analysis. Each sediment sample is analyzed for gamma radioactivity using a solid-state germanium detector with a multichannel analyzer.

Table 2 provides a summary of harbor sediment sample results for Apra Harbor, Guam. Appendix B provides results for each sediment sample obtained.

During 2006, no cobalt-60 was detected in any sediment sample. The only non-naturally occurring radionuclide detected was cesium-137 and americium-241. The levels of the detected cesium-137 and americium-241 are attributable to fallout from past nuclear weapons testing.

Table 2: Summary of 2006 Harbor Sediment Results for Apra Harbor, Guam

Quarter	Number of Samples	Number of Samples with Detectable Cobalt-60	Range of Detected Cobalt-60 Results (pCi/g)	Range of Cobalt-60 MDC Values for Samples with No Detectable Cobalt-60 (pCi/g) [2]	Range of Other Detected Non-Naturally Occurring Radionuclides (pCi/g) [3]
1	27	0	None	0.01 - 0.03	Cesium-137: 0.02 - 0.03 Americium-241 [1]: 0.06
2	27	0	None	0.01 - 0.04	Cesium-137: 0.01 - 0.03
3	27	0	None	0.01 - 0.03	Cesium-137: 0.02 - 0.03
4	27	0	None	0.01 - 0.03	Cesium-137: 0.01 - 0.02

1. When only one concentration is listed, the radionuclide was detected in only one sediment sample that quarter.

2. When no cobalt-60 is detected in a sample, the minimum detectable concentration (MDC) is reported. The MDC is the smallest radioactivity concentration which can be reliably detected in a sample. The MDC varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, differences in sample size, detection equipment differences, and statistical fluctuations.

3. The detected cesium-137 and americium-241 are consistent with concentrations detected throughout the environment due to fallout from past nuclear weapons testing.

C. Marine Life Samples

Samples of marine life are collected during July of each year. Marine life samples are analyzed using a solid-state germanium detector with a multi-channel analyzer.

Table 3 provides a summary of marine life sample results for Apra Harbor, Guam. Appendix C provides results for each marine life sample obtained.

No cobalt-60 or other non-naturally occurring radionuclide was detected in any marine life sample.

Table 3: Summary of 2006 Marine Life Results for Apra Harbor, Guam

Sample Type	Number of Samples	Number of Samples with Detectable Cobalt-60	Range of Detected Cobalt-60 Results (pCi/g)	Range of Cobalt-60 MDC Values for Samples with No Detectable Cobalt-60 (pCi/g) [1]	Range of Other Detected Non-Naturally Occurring Radionuclides (pCi/g)
Marine Plant	2	0	None	0.02 – 0.02	None
Mollusk	1	0	None	0.01	None
Crustacean	1	0	None	0.01	None

1. When no cobalt-60 is detected in a sample, the minimum detectable concentration (MDC) is reported. The MDC is the smallest radioactivity concentration which can be reliably detected in a sample. The MDC varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, differences in sample size, detection equipment differences, and statistical fluctuations.

D. Shoreline Surveys

During the second and fourth quarter of each year, shoreline areas uncovered at low tide are surveyed for radiation levels to determine if any radioactivity from bottom sediment has been washed ashore.

A sensitive gamma survey instrument equipped with a 2" x 2" sodium iodide scintillation detector, calibrated to detect gamma rays above 0.1 MeV, is used to perform these surveys. Measurements are taken three feet above ground level.

Shoreline survey results for 2006 are summarized in Table 4. Appendix D provides survey measurement results for Apra Harbor, Guam.

Table 4: Summary of 2006 Shoreline Survey Results

Facility	2nd quarter Average Count Rate (cpm)[1]	4th Quarter Average Count Rate (cpm)[1]
Apra Harbor, Guam	1300	1300
Background	1300	1200

1. cpm = counts per minute

The average count rate measured along the shorelines during these surveys was consistent with the average background count rate measured away from the shoreline. All areas showed only measurements characteristic of naturally occurring radionuclides.

Shoreline survey results for 2006 were consistent with results for previous years.

E. Airborne Radioactivity Monitoring

Air exhausted from facilities engaged in work which could cause airborne radioactivity is continuously sampled during the year. Particulate material from sampled air is collected on high efficiency sample filters and a gross gamma analysis, cobalt-60 equivalent (0.1 - 2.1 MeV) is performed using a sodium iodide detector connected to a multichannel analyzer.

For gross gamma counting, radioactivity calculations are based on the conservative assumption that all the radioactivity on the filter paper is due to cobalt-60. Therefore, the radioactivity result is in terms of cobalt-60 equivalent radioactivity.

For sample filters counted for gross gamma radioactivity, counting equipment and procedures are chosen to ensure a cobalt-60 equivalent radioactivity of 2.0×10^{-14} microcurie*/milliliter (μCi/ml) or greater will be detected for cumulative sampling times greater than a few days per quarter.

If no radioactivity is detected on the sample filter, the decision level concentration is used for calculating the radioactivity concentration.

Table 5 provides a summary of the 2006 airborne radioactivity results for Apra Harbor, Guam.

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* 1 microcurie = 1×10^{-6} Curie

Table 5: Summary of 2006 Airborne Particulate Radioactivity Results

Facility	Average Activity Concentration (μCi/ml) [1]	Average Activity Discharged (μCi) [1]
Apra Harbor, Guam	$<8.5 \times 10^{-12}$	$<4.0 \times 10^{-3}$

1. The "<" symbol indicates that the average was determined by using decision level concentration values for those samples with no detectable radioactivity.

Appendix E provides specific results for airborne particulate radioactivity measurements.

F. Radiation Monitoring

To provide additional assurance that operations at Apra Harbor, Guam do not cause increased radiation exposure to the general public, thermoluminescent dosimeters (TLDs) are posted at the perimeter locations shown on Figure 1 to measure the accumulated radiation exposure at these locations. Off-site control TLDs are posted at the locations shown on Figure 1. These control TLDs are posted in order to provide a comparison between perimeter TLD results and naturally occurring background radiation levels. TLDs are posted on a quarterly basis.

The TLDs used in this program contain two manganese activated calcium fluoride chips. It is a characteristic of this thermoluminescent material that radiation causes internal changes which make the material, when subsequently heated, give off an amount of light directly proportional to the radiation exposure experienced by the TLD. The two manganese activated calcium fluoride chips are secured to a heater strip, for reading the TLD's accumulated exposure, and sealed in a glass bulb. The glass bulb is placed inside a light-tight energy compensating case.

A summary of the 2006 results of perimeter and off-site radiation monitoring is provided in Table 6.

Table 6: Summary of 2006 Perimeter and Background Radiation Monitoring Results

Posting Period	Apra Harbor, Guam Perimeter Average (mrem[1]/quarter)	Apra Harbor, Guam Control Average (mrem[1]/quarter)
1st Quarter	16.6	18.4
2nd Quarter	16.2	17.5
3rd Quarter	19.7	19.5
4th Quarter	16.7	17.7

1. mrem = 1 x 10^{-3} rem.

Comparison of results from perimeter TLDs with the off-site control TLDs, shows that radiation exposure to the general public near this facility is not distinguishable from that due to natural background radiation. The results for 2006 are consistent with previous years results with no significant trends or variations.

Appendix F provides a detailed listing of TLD results.

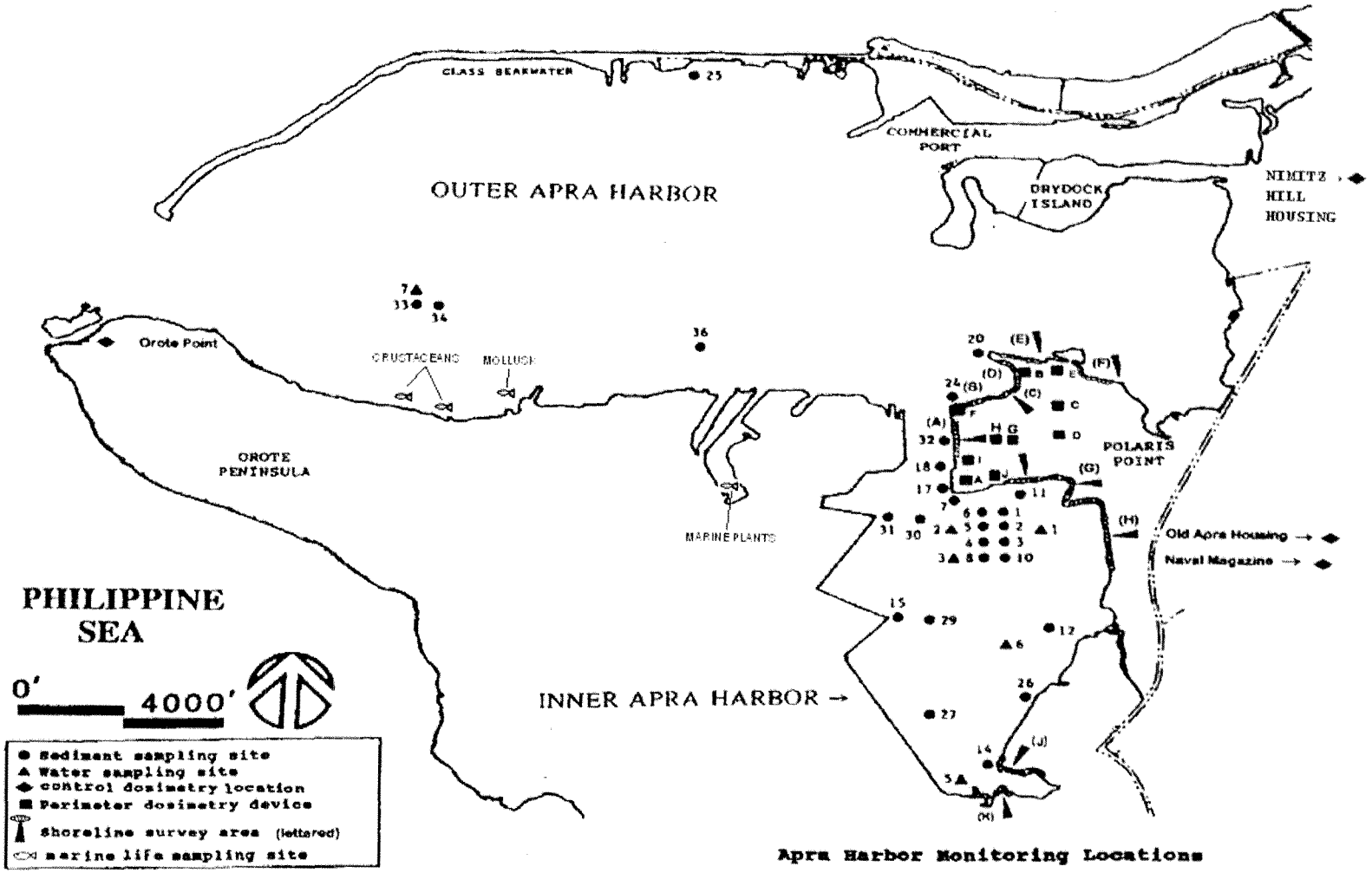
IV. QUALITY CONTROL

Knolls Atomic Power Laboratory (KAPL), a U. S. Department of Energy Laboratory, analyzes all water, sediment and marine life samples from Apra Harbor, Guam. The KAPL results demonstrate that the procedures used by the U.S. Navy to control radioactivity are effective in protecting the environment at Apra Harbor, Guam.

V. CONCLUSION

The results of the environmental monitoring program conducted during 2006 confirm that radiological controls associated with Naval nuclear powered ships at Apra Harbor, Guam are effective in protecting the environment and the health and safety of the general public. This report shows that Apra Harbor, Guam operations have not caused an increase in the general background radioactivity of the environment that can be measured, and that radiation exposure to the general public is not distinguishable from that resulting from natural background radiation.

Figure 1


GLASS BREAKWATER
25
COMMERCIAL PORT
OUTER APRA HARBOR
DRYDOCK ISLAND
NIMITZ HILL HOUSING
Orote Point
CRUSTACEANS
MOLLUSK
OROTE PENINSULA
MARINE PLANTS
POLARIS POINT
Old Apra Housing
Naval Magazine
INNER APRA HARBOR
PHILIPPINE SEA
0'
4000'
Sediment sampling site
Water sampling site
control dosimetry location
Perimeter dosimetry device
Shoreline survey area (lettered)
marine life sampling site
Apra Harbor Monitoring Locations

APPENDIX A

2006 Harbor Water Sampling Data

2006 HARBOR WATER SAMPLING DATA
APRA HARBOR, GUAM

Sample Number-Quarter	Cobalt-60		Other Non-naturally Occurring Radionuclides		K-40 [4]
	Radioactivity Concentration [1] (pCi/L) [3]	MDC [2] (pCi/L) [3]	Radionuclide	Radioactivity Concentration [1] (pCi/L) [3]	Radioactivity Concentration [1] (pCi/L) [3]
1-1	ND	23	ND	ND	370
1-2	ND	23	ND	ND	292
1-3	ND	18	ND	ND	ND
1-4	ND	22	ND	ND	ND
2-1	ND	24	ND	ND	398
2-2	ND	22	ND	ND	290
2-3	ND	27	ND	ND	ND
2-4	ND	20	ND	ND	ND
3-1	ND	27	ND	ND	398
3-2	ND	20	ND	ND	367
3-3	ND	24	ND	ND	ND
3-4	ND	19	ND	ND	ND
5-1	ND	21	ND	ND	ND
5-2	ND	19	ND	ND	298
5-3	ND	22	ND	ND	345
5-4	ND	22	ND	ND	ND
6-1	ND	24	ND	ND	430
6-2	ND	14	ND	ND	ND
6-3	ND	20	ND	ND	408
6-4	ND	22	ND	ND	332
7-1	ND	20	ND	ND	304
7-2	ND	19	ND	ND	388
7-3	ND	18	ND	ND	ND
7-4	ND	23	ND	ND	330

1. ND = Not Detected. Sample analysis showed no photopeak. If a photopeak is detected, the radioactivity concentration is provided.

2. The minimum detectable concentration (MDC) of cobalt-60 is the concentration at which cobalt-60 could be detected with 95% certainty if cobalt-60 is present at the minimum detectable concentration. The minimum detectable concentration for cobalt-60 varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, differences between detection equipment, and statistical fluctuations.

3. 1 pCi = 1 x 10^{-12} Curie
L = Liter

4. The concentration of naturally occurring potassium-40 is presented in order to provide perspective on the amount of naturally occurring radioactivity in the sample. Potassium-40 was selected since this naturally occurring radionuclide is detectable in many environmental samples.

APPENDIX B

2006 Harbor Sediment Sampling Data

2006 HARBOR SEDIMENT SAMPLING DATA
APRA HARBOR, GUAM

Sample Number-Quarter	Cobalt-60		Other Non-naturally Occurring Radionuclides		K-40 [5]
	Radioactivity Concentration [1] (pCi/g) [3]	MDC [2] (pCi/g) [3]	Radionuclide [4]	Radioactivity Concentration [1] (pCi/g) [3]	Radioactivity Concentration [1] (pCi/g) [3]
1-1	ND	0.024	Cs-137	0.030	1.36
1-2	ND	0.016	Cs-137	0.012	1.73
1-3	ND	0.027	ND	ND	1.99
1-4	ND	0.019	ND	ND	1.54
2-1	ND	0.021	Cs-137	0.018	1.48
2-2	ND	0.019	ND	ND	1.78
2-3	ND	0.021	ND	ND	1.65
2-4	ND	0.025	ND	ND	1.74
3-1	ND	0.017	ND	ND	1.66
3-2	ND	0.018	ND	ND	1.46
3-3	ND	0.027	Cs-137	0.015	1.54
3-4	ND	0.020	ND	ND	1.66
4-1	ND	0.016	ND	ND	1.55
4-2	ND	0.016	ND	ND	1.27
4-3	ND	0.020	ND	ND	1.53
4-4	ND	0.025	ND	ND	1.65
5-1	ND	0.022	Cs-137	0.020	1.63
5-2	ND	0.017	Cs-137	0.021	1.59
5-3	ND	0.023	Cs-137	0.027	1.82
5-4	ND	0.022	ND	ND	1.66
6-1	ND	0.021	Cs-137	0.015	1.46
6-2	ND	0.016	Cs-137	0.011	1.61
6-3	ND	0.022	ND	ND	1.66
6-4	ND	0.023	Cs-137	0.016	1.77
7-1	ND	0.019	ND	ND	1.07
7-2	ND	0.018	ND	ND	1.18
7-3	ND	0.021	ND	ND	ND
7-4	ND	0.018	Cs-137	0.016	1.28
8-1	ND	0.015	ND	ND	1.36
8-2	ND	0.019	ND	ND	1.46
8-3	ND	0.022	ND	ND	1.58
8-4	ND	0.022	ND	ND	1.15

ND = Not Detectable. Sample analysis detected no photopeak.

Continued:

Sample Number-Quarter	Cobalt-60		Other Non-naturally Occurring Radionuclides		K-40 [5]
	Radioactivity Concentration [1] (pCi/g) [3]	MDC [2] (pCi/g) [3]	Radionuclide [4]	Radioactivity Concentration [1] (pCi/g) [3]	Radioactivity Concentration [1] (pCi/g) [3]
10-1	ND	0.021	Cs-137	0.020	2.10
10-2	ND	0.016	Cs-137	0.012	2.14
10-3	ND	0.023	ND	ND	1.80
10-4	ND	0.016	Cs-137	0.014	1.59
11-1	ND	0.026	Cs-137	0.019	1.89
11-2	ND	0.020	ND	ND	1.44
11-3	ND	0.028	ND	ND	2.00
11-4	ND	0.022	Cs-137	0.021	1.66
12-1	ND	0.019	ND	ND	3.05
12-2	ND	0.023	ND	ND	2.80
12-3	ND	0.024	Cs-137	0.025	3.77
12-4	ND	0.022	Cs-137	0.019	2.61
14-1	ND	0.024	ND	ND	1.58
14-2	ND	0.025	Cs-137	0.017	1.54
14-3	ND	0.021	ND	ND	ND
14-4	ND	0.019	ND	ND	1.77
15-1	ND	0.022	ND	ND	1.15
15-2	ND	0.019	ND	ND	1.53
15-3	ND	0.023	ND	ND	ND
15-4	ND	0.019	ND	ND	1.18
17-1	ND	0.017	ND	ND	0.98
17-2	ND	0.015	Cs-137	0.009	0.90
17-3	ND	0.022	ND	ND	0.76
17-4	ND	0.015	ND	ND	0.90
18-1	ND	0.014	ND	ND	0.59
18-2	ND	0.012	ND	ND	0.61
18-3	ND	0.015	ND	ND	ND
18-4	ND	0.016	ND	ND	0.52
20-1	ND	0.015	ND	ND	0.39
20-2	ND	0.012	ND	ND	0.42
20-3	ND	0.013	ND	ND	ND
20-4	ND	0.019	ND	ND	1.27

ND = Not Detectable. Sample analysis detected no photopeak.

Continued:

Sample Number-Quarter	Cobalt-60		Other Non-naturally Occurring Radionuclides		K-40 [5]
	Radioactivity Concentration [1] (pCi/g) [3]	MDC [2] (pCi/g) [3]	Radionuclide [4]	Radioactivity Concentration [1] (pCi/g) [3]	Radioactivity Concentration [1] (pCi/g) [3]
24-1	ND	0.017	ND	ND	1.18
24-2	ND	0.016	Cs-137	0.027	1.06
24-3	ND	0.021	Cs-137	0.032	ND
24-4	ND	0.021	ND	ND	1.08
25-1	ND	0.012	ND	ND	0.16
25-2	ND	0.013	ND	ND	ND
25-3	ND	0.013	ND	ND	ND
25-4	ND	0.015	ND	ND	0.32
26-1	ND	0.016	ND	ND	1.70
26-2	ND	0.022	Cs-137	0.017	2.06
26-3	ND	0.022	ND	ND	2.90
26-4	ND	0.024	ND	ND	1.81
27-1	ND	0.023	ND	ND	1.46
27-2	ND	0.018	ND	ND	1.78
27-3	ND	0.026	ND	ND	1.59
27-4	ND	0.020	ND	ND	1.55
29-1	ND	0.021	ND	ND	1.35
29-2	ND	0.021	ND	ND	1.43
29-3	ND	0.021	ND	ND	ND
29-4	ND	0.018	ND	ND	1.37
30-1	ND	0.018	ND	ND	1.36
30-2	ND	0.018	Cs-137	0.024	1.10
30-3	ND	0.020	ND	ND	1.25
30-4	ND	0.016	ND	ND	1.45
31-1	ND	0.015	ND	ND	0.88
31-2	ND	0.017	ND	ND	0.96
31-3	ND	0.020	ND	ND	1.08
31-4	ND	0.021	ND	ND	0.92
32-1	ND	0.019	ND	ND	0.52
32-2	ND	0.019	ND	ND	0.45
32-3	ND	0.016	ND	ND	ND
32-4	ND	0.016	ND	ND	0.54

ND = Not Detectable. Sample analysis detected no photopeak.

Continued:

Sample Number-Quarter	Cobalt-60		Other Non-naturally Occurring Radionuclides		K-40 [5]
	Radioactivity Concentration [1] (pCi/g) [3]	MDC [2] (pCi/g) [3]	Radionuclide [4]	Radioactivity Concentration [1] (pCi/g) [3]	Radioactivity Concentration [1] (pCi/g) [3]
33-1	ND	0.016	ND	ND	0.54
33-2	ND	0.014	ND	ND	0.34
33-3	ND	0.017	ND	ND	ND
33-4	ND	0.014	ND	ND	0.37
34-1	ND	0.014	Am-241	0.060	0.30
34-2	ND	0.038	ND	ND	ND
34-3	ND	0.015	ND	ND	ND
34-4	ND	0.017	ND	ND	0.63
36-1	ND	0.012	ND	ND	0.86
36-2	ND	0.019	ND	ND	0.77
36-3	ND	0.024	ND	ND	ND
36-4	ND	0.015	ND	ND	0.83

1. ND = Not Detected. Sample analysis showed no photopeak. If a photopeak is detected, the radioactivity concentration is provided.

2. The minimum detectable concentration (MDC) of cobalt-60 is the concentration at which cobalt-60 could be detected with 95% certainty if cobalt-60 is present at the minimum detectable concentration. The minimum detectable concentration for cobalt-60 varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, differences in the weight of samples, differences between detection equipment, and statistical fluctuations. For samples with detectable cobalt-60, an MDC value is not provided.

3. 1 pCi = 1×10^{-12} Curie
g = gram

4. The detected cesium-137 concentrations are consistent with concentrations of cesium-137 detected throughout the environment due to fallout from nuclear weapons testing. The detected americium-241 concentration is related to early nuclear weapons testing.

5. The concentration of naturally occurring potassium-40 is presented in order to provide perspective on the amount of naturally occurring radioactivity in the sample. Potassium-40 was selected since this naturally occurring radionuclide is detectable in many environmental samples.

APPENDIX C

2006 Marine Life Sampling Data

2006 MARINE LIFE SAMPLING DATA
APRA HARBOR, GUAM

Sample Type, Number	Cobalt-60		Other Non-naturally Occurring Radionuclides		K-40 [4]
	Radioactivity Concentration [1] (pCi/g) [3]	MDC [2] (pCi/g) [3]	Radionuclide	Radioactivity Concentration [1] (pCi/g) [3]	Radioactivity Concentration [1] (pCi/g) [3]
Marine Plant 1	ND	0.015	ND	ND	0.80
Marine Plant 2	ND	0.017	ND	ND	0.78
Mollusk 1	ND	0.010	ND	ND	0.48
Crustacean 1	ND	0.012	ND	ND	1.02

1. ND = Not Detected. Sample analysis showed no photopeak. If a photopeak is detected, the radioactivity concentration is provided.

2. The minimum detectable concentration (MDC) of cobalt-60 is the concentration at which cobalt-60 could be detected with 95% certainty if cobalt-60 is present at the minimum detectable concentration. The minimum detectable concentration for cobalt-60 varies from sample to sample and location to location due to differences in the amount of naturally occurring radioactivity in each sample, differences in the weight of samples, differences between detection equipment, and statistical fluctuations.

3. 1 pCi = 1 x 10^{-12} Curie
g = gram

4. The concentration of naturally occurring potassium-40 is presented in order to provide perspective on the amount of naturally occurring radioactivity in the sample. Potassium-40 was selected since this naturally occurring radionuclide is detectable in many environmental samples.

APPENDIX D

2006 Shoreline Survey Data

Shoreline Survey Discussion

During the second and fourth quarter of each year, shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive scintillation detectors to determine if any radioactivity from bottom sediment washed ashore. During 2006, all survey results were consistent with background measurements.

It is well documented that natural radiation levels vary significantly over time and from one location to another due to environmental factors such as rock and soil characteristics and atmospheric conditions. One example of this variation in natural background radioactivity can be seen in the harbor water and sediment sampling data tables in Appendices A and B. These analysis results show a wide variation in the amount of naturally occurring potassium-40 (K-40).

Due to this variation in naturally occurring background radiation levels, shoreline survey measurements are compared to background measurements taken at the same time at nearby locations. The background survey measurements are performed near shoreline survey areas but approximately 30 feet inland from the high water mark. The shoreline surveys are taken at regular intervals below the high water mark.

If a shoreline measurement is anomalous, an investigation is performed to determine if the measurement is attributable to Naval nuclear propulsion operations. For 2006, the survey measurements were characteristic of naturally occurring radionuclides at all locations.

Shoreline Survey Measurement Data
(counts per minute)

Apra Harbor, Guam

Second Quarter 2006

Area	Shoreline [1]	Background [1]
A	1000	1040
B	1400	1032
C	1400	1600
D	1400	1800
E	1400	1200
F	1200	1200
G	1000	1150
H	1600	1160
J	1600	1400
K	1200	1650

Fourth Quarter 2006

Area	Shoreline [1]	Background [1]
A	1200	860
B	1600	1120
C	1200	1067
D	1400	1267
E	1200	1200
F	1300	1167
G	1300	1100
H	1400	1240
J	1300	1367
K	1200	1475

1. Readings are the average radiation level measured.

APPENDIX E

2006 Airborne Radioactivity Monitoring Data

2006 AIRBORNE RADIOACTIVITY MONITORING DATA
APRA HARBOR, GUAM

BRAVO RECIRCULATION VENTILATION (AS 40)		
Quarter	Activity Concentration [1] (μCi/ml) [2]	Activity Discharged (μCi) [2]
1	<3.13E-15 <3.02E-15 <3.22E-15	<2.07E-3 <2.14E-3 <2.00E-3
2	<2.82E-15 4.12E-15 <2.98E-15	<2.00E-3 1.95E-3 <2.10E-3
3	5.21E-15 2.71E-15 <4.19E-15	1.99E-3 2.00E-3 <2.13E-3
4	4.50E-15 <3.49E-15 <2.86E-15	1.98E-3 2.03E-3 1.96E-3
Average	<3.52E-15	<2.03E-3

BRAVO AUGMENT VENTILATION (AS 40)		
Quarter	Activity Concentration [1] (μCi/ml) [2]	Activity Discharged (μCi) [2]
1	None [3]	None [3]
2	<1.25E-10	<1.11E-2
3	<8.04E-12 <9.19E-13	9.61E-3 9.48E-3
4	<1.79E-12	9.67E-3
Average	<3.39E-11	<9.97E-3

Bravo Recirculation and Bravo Augment Average	<8.49E-12	<4.01E-3

1. For gross gamma counting, radioactivity calculations are based on the conservative assumption that all the radioactivity on the filter paper is due to cobalt-60. Therefore, the radioactivity result is in terms of cobalt-60 equivalent (0.1 - 2.1 MeV) radioactivity. The "<" symbol indicates that a decision level concentration value was used to calculate radioactivity concentration for those samples with no detectable radioactivity.

2. 1 μCi = 1 x 10^{-6} Curie
   ml = 1 x 10^{-3} Liter

3. "None" indicates the exhaust was not operated and/or there was insufficient volume accumulated for air filter replacement.

APPENDIX F

2006 RADIATION MONITORING DATA

2006 RADIATION MONITORING DATA
APRA HARBOR, GUAM

PERIMETER RADIATION MONITORING RESULTS				
Perimeter TLD Location	1st Quarter (mrem/quarter)	2nd Quarter (mrem/quarter)	3rd Quarter (mrem/quarter)	4th Quarter (mrem/quarter)
A	17.2	16.4	18.9	16.6
B	16.5	16.2	21.8	16.2
C	17.1	15.9	17.8	16.1
D	16.6	15.8	18.1	17.4
E	12.8	15.8	22.1	16.9
F	17.7	15.8	18.9	16.8
G	16.5	17.0	21.0	15.8
H	16.8	15.4	19.5	16.1
I	17.2	16.3	18.9	17.0
J	17.1	16.9	19.5	18.1
AVERAGE	16.6	16.2	19.7	16.7

TLD CONTROL GROUP RESULTS				
TLD Control Group Location	Average 1st Quarter (mrem/quarter)	Average 2nd Quarter (mrem/quarter)	Average 3rd Quarter (mrem/quarter)	Average 4th Quarter (mrem/quarter)
A	20.8	18.9	22.0	18.7
B	18.1	17.5	19.7	17.5
C	17.6	16.9	16.7	16.9
D	17.2	16.5	19.5	17.7
AVERAGE	18.4	17.5	19.5	17.7